#04-94

ESTIMATES OF TOTAL NITROGEN, TOTAL PHOSPHORUS, AND TOTAL SUSPENDED SOLIDS LOADINGS TO TAMPA BAY, FLORIDA

Prepared for:

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EXECUTIVE SUMMARY

The overall objective of the work described below was to develop technically-defensible estimates of total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS) loadings to Tampa Bay for existing conditions, defined for this study as 1985 through 1991. In addition, TN, TP, and TSS loadings for other time periods, including historical/benchmark (circa 1940), "worst case" (mid-1970's), and future conditions (circa 2010) were made.

Five categories of potential major sources of TN, TP, and TSS loading were identified. These included nonpoint sources (stormwater runoff and base flow), point sources (domestic and industrial), atmospheric deposition (wetfall-rainfall and dryfall-dust, delivered to the open water estuary), groundwater, and fugitive emissions (unpermitted losses during handling and shipping of phosphate rock and fertilizer products). Loads from these sources were developed aided by the use of Geographic Information System (GIS) mapping and analytical techniques. The contributions from each source to the total load to Tampa Bay were estimated using the methods described below. Measured data were used to develop these estimates to the greatest extent possible. In those cases where measured data were not available, modeling techniques or other methods of estimation were used.

For nonpoint source loads from gaged portions of the watershed, measured streamflow and water quality data were used to develop monthly TN, TP, and TSS loading estimates. An empirical hydrologic model was developed using measured streamflow from tributaries in the Tampa Bay watershed. This model was used to estimate monthly flows from portions of the watershed with no streamflow data (ungaged areas), based on land use composition of major subbasins, current month's rainfall, and two previous month's rainfall. Measured and modeled flows for major subbasins were apportioned to specific land uses, based on literature values of runoff coefficients and land use-specific water quality concentrations. Using these results, total nonpoint source TN, TP, and TSS loads to the estuary were estimated.

Point source contributions to the total load were estimated by using monthly operating records from Florida Department of Environmental Protection and US Environmental Protection Agency permitting files. Monthly flows and effluent quality data for direct (surface water) discharges were used to estimate monthly TN, TP, and TSS loads. Indirect discharges were estimated using permit file data and the results of an analysis of local groundwater monitoring data from land application sites.

The wetfall component of atmospheric deposition loading was estimated using measured rainfall quantity and chemistry data. Dryfall contributions to the total atmospheric load were estimated using ratios of wetfall to dryfall that have been developed from extensive monitoring within the state.

Groundwater loads were based on previously developed estimates and additional measured groundwater quality data. Fugitive emission loads were estimated based on data provided by the phosphate industry and local governmental agencies.

The pollutant loading estimates developed in this work will be used as input for the Tampa Bay National Estuary Program (TBNEP) statistical modeling project (Implementation of Modeling Strategy). Using these watershed-based pollutant loads, the statistical modeling work will investigate potential relationships between nutrient loadings and in-bay water quality (primarily nitrogen and chlorophyll concentrations, as they relate to eutrophication processes). These loading estimates will also be used as input for the Tampa Bay Box Model project, currently being completed for Southwest Florida Water Management District (SWFWMD) Surface Water Improvement and Management (SWIM), which is also examining the response of Tampa Bay water quality to pollutant loading levels.

Additionally, estimates of land use-specific TN, TP, and TSS loadings were developed for individual subbasins, to establish priority areas for nonpoint source pollution control. This subbasin prioritization will be used by on-going TBNEP projects to investigate the effectiveness, and potential maximum treatment levels, of best management practices for individual subbasins and land uses.

In this report, loading estimates were compared to examine relative differences between existing, historical ("benchmark"), "worst case," and projected future loadings to the Tampa Bay estuary and tributary system. Benchmark loadings estimate TN, TP, and TSS inputs to Tampa Bay during periods of relatively low water quality impacts. Worst case loadings have been estimated to reconstruct the approximate total nutrient loading to the bay before current pollution abatement measures were implemented, such as advanced levels of treatment for wastewater treatment plants and stormwater management permitting requirements. Future loadings were projected for the 2010 time period to estimate the potential severity of the effects of increased urbanization on the estuary.

Finally, reported incidents of industrial chemical spills of nitrogen and phosphorus were inventoried to supply an additional potentially major input of nutrients to the bay. The spill inventory was developed for use with the bay modeling efforts to enhance estimates of nutrient loads for the period 1985-1991.

A relative comparison of TN, TP, and TSS loadings for the four time periods can be made based on these analyses. Benchmark TN, TP, and TSS loads were estimated to be approximately 50%, 35%, and 25%, respectively, of current loads. Estimated mid-1970's "worst case" loads of TN, TP, and TSS were about 250%, 140%, and 180%, respectively, of existing condition loads. Projected future TN, TP, and TSS loads were estimated to be about 150%, 120%, and 140%, respectively, of current loads.

Of the three most significant sources of TN loading (point source, nonpoint source, and atmospheric deposition), point sources exhibited the most significant change over time. Worst case point source loads were estimated to have been almost 30 times higher than benchmark loads, and almost ten times higher than existing condition loads. Atmospheric deposition had the least relative change of the three largest sources. Benchmark atmospheric deposition loads were approximately 60% of existing conditions, and 40% of projected future loads. For TN loading under future conditions, atmospheric deposition is estimated to be 50% higher, point source loadings are approximated to be 40% higher, nonpoint source loadings are estimated to be about 70% higher, and fugitive emissions are estimated to be almost ten times lower, relative to existing conditions.

A summary of estimated TN loadings to Tampa Bay segments for historical, mid-1970's, existing, and projected future conditions is presented in Table ES-1. For this presentation, loads were rounded to the nearest whole number. Therefore, some of the totals listed do not match the summed rounded numbers.

TABLE ES-1
ESTIMATED TOTAL NITROGEN LOADING TO TAMPA BAY (TONS/YEAR)
(Loading components are rounded to the nearest whole number.)

Bay Segment	Source	Historical (ca. 1938)	Worst Case (ca. 1976)	Existing (1985-91)	Future (ca. 2010)
Old Tampa Bay	Atmospheric Deposition	137	225	225	337
	Fugitive Losses	0	0	0	0
	Groundwater	0	1	1	1
	Nonpoint Source	96	263	219	417
	Point Source	16	325	65	197
	TOTAL	251	814	510	952
Hills. Bay	Atmospheric Deposition	64	106	106	162
	Fugitive Losses	0	450	272	3
	Groundwater	0	1	1	1
	Nonpoint Sources	570	959	799	1,125
	Point Sources	183	4,006	404	433
	TOTAL	818	5,524	1,584	1,724
Middle Tampa Bay	Atmospheric Deposition	182	306	306	460
	Fugitive Losses	0	0	0	0
	Groundwater	0	1	1	1
	Nonpoint Sources	150	484	403	654
	Point Sources	2	840	24	37
	TOTAL	334	1,631	734	1,152
Lower Tampa Bay	Atmospheric Deposition	159	269	269	404
	Fugitive Losses	0	39	19	0
	Groundwater	0	1	1	1
	Nonpoint Source	6	49	41	118
	Point Source	1	2	12	16
	TOTAL	166	360	342	539

TABLE ES-1 ESTIMATED TOTAL NITROGEN LOADING TO TAMPA BAY (TONS/YEAR) (Loading components are rounded to the nearest whole number.)					
Bay Segment	Source	Historical (ca. 1938)	Worst Case (ca. 1976)	Existing (1985-91)	Future (ca. 2010)
Boca Ciega Bay	Atmospheric Deposition	57	96	96	144
	Fugitive Losses	0	0	0	0
	Groundwater	0	0	0	0
	Nonpoint Source	10	180	150	231
	Point Source	1	695	3	61
	TOTAL	68	971	249	436
Terra Ceia Bay	Atmospheric Deposition	10	18	18	27
	Fugitive Losses	0	0	0	0
	Groundwater	0	0	0	0
	Nonpoint Source	13	14	12	24
	Point Source	0	5	6	6
	TOTAL	23	37	36	57
Manatee River	Atmospheric Deposition	27	46	46	69
	Fugitive Losses	0	0	0	0
	Groundwater	0	0	0	0
	Nonpoint Source	225	421	351	757
	Point Source	2	100	91	88
	TOTAL	256	567	488	915
TAMPA BAY	TOTAL	1,915	9,904	3,943	5,774

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

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1.0 INTRODUCTION

1.1 Purpose and Objectives

The overall objective of the work described below was to develop technically-defensible estimates of total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS) loadings to Tampa Bay. The pollutant loading estimates developed in this work will be used as input for the Tampa Bay National Estuary Program (TBNEP) statistical modeling project (Implementation of Modeling Strategy). Using these watershed-based pollutant loads, the statistical modeling work will investigate potential relationships between loadings and in-bay water quality. These loading estimates will also be used as input for the Tampa Bay box model project, currently being completed for SWFWMD SWIM Department, which is also examining the response of Tampa Bay water quality to pollutant loading levels.

Additionally, loading estimates were developed for individual subbasins, to establish priority areas for nonpoint source pollution control. This subbasin prioritization will be used by on-going TBNEP projects to investigate the effectiveness, and potential maximum treatment levels, of best management practices for individual subbasins and land uses.

The loading estimates will also be used to examine relative differences between existing and historical ("benchmark," as described below) conditions, as shown in Figure 1-1. Loading estimates for "worst case" and projected future conditions to the Tampa Bay estuary and tributary system were also developed. Worst case loadings have been estimated to reconstruct the approximate total nutrient loading to the bay before current pollution abatement measures were implemented, such as advanced levels of treatment for wastewater treatment plants and stormwater management permitting requirements. Future loadings were projected for the 2010 time period, to estimate the potential severity of the effects of increased urbanization on the estuary.

Finally, reported incidents of industrial chemical spills of nitrogen and phosphorus were inventoried to supply an additional potentially major input of nutrients to the bay. The spill inventory was developed for use in the SWIM box model to enhance loading estimates for the period 1985-1991.

The choice of total nitrogen, total phosphorus, and total suspended solids as the water quality constituents of interest was made for several reasons. SWFWMD SWIM has recognized the importance of nitrogen and phosphorus loadings to eutrophication processes within Tampa Bay (Stevens et al., 1992). Chlorophyll *a* levels in Tampa Bay have been shown to be closely related to total nitrogen loads to Hillsborough Bay (Johansson, 1991). The interim nutrient budget developed by SWIM (Morrison, 1991)

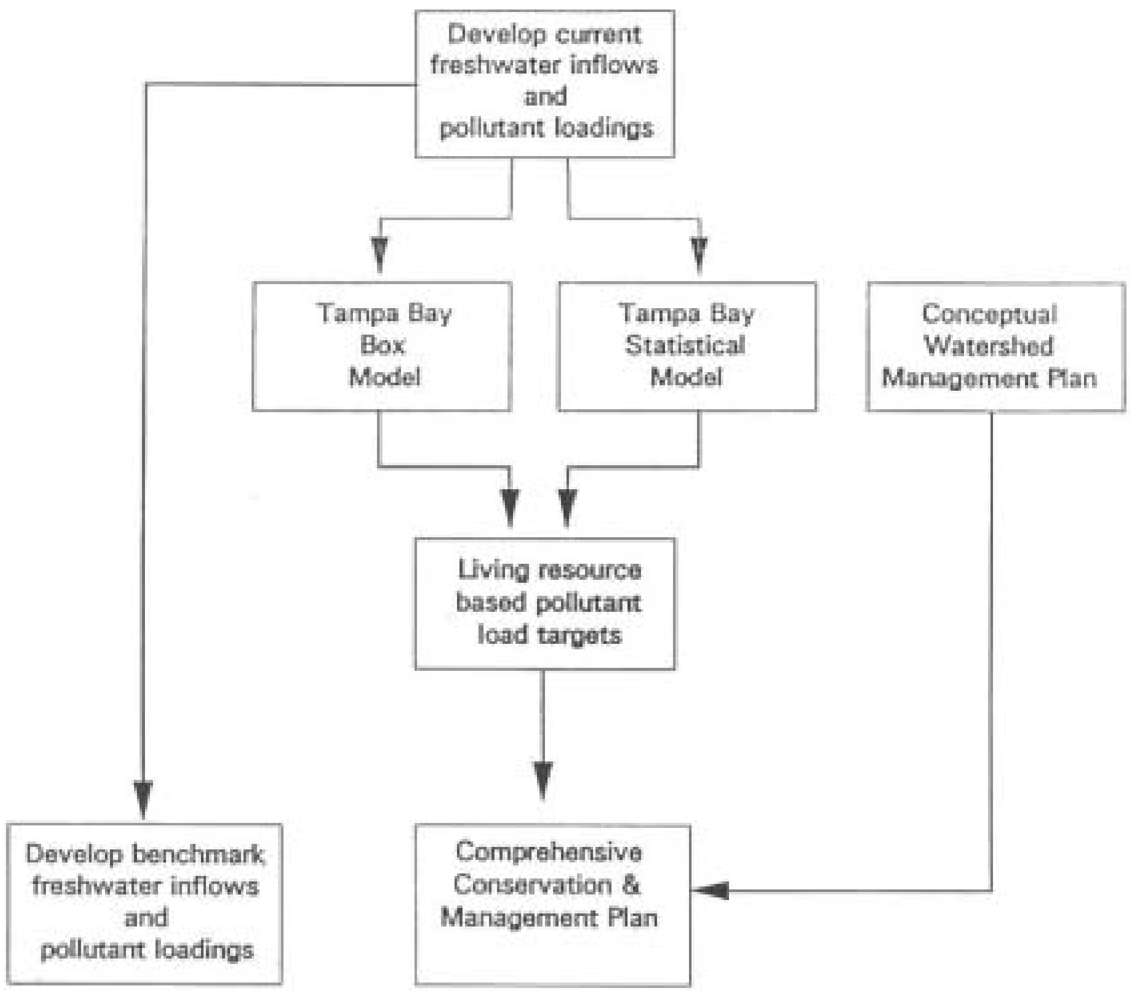


Figure 1-1 Project Overview.

also examined total nitrogen loading in support of the above observation that TN and chlorophyll *a* levels are related. In addition, regionally-based literature values for land use-specific TN concentrations, which are used to calculate nonpoint source loadings, are generally better documented than are data for other nitrogen forms.

Phosphorus is also a primary nutrient required by phytoplankton and other submerged aquatic vegetation for growth. Although Tampa Bay is recognized as a generally nitrogen-limited water body, the management of phosphorus loadings is important to overall in-bay conditions. TSS has a profound influence on light attenuation; as TSS concentrations affect the depth to which light, particularly photosynthetically active radiation (PAR), can penetrate. Thus, all other factors being equal, TSS likely influences the water column depth at which seagrasses can grow. TSS also can be viewed as a surrogate indicator of toxics, as many toxic pollutants enter estuaries associated with suspended solids.

Measured streamflow and water quality data were available for over half of the land area of the watershed for existing conditions, and considerably less for benchmark conditions. However, estimates of streamflow and pollutant loading needed to be made for the entire watershed, including the ungaged areas. The required modeling for estimating loadings for gaged and ungaged areas of the watershed is shown in Table 1-1.

For this work, it was necessary to use a model that would be accurate enough to simulate flows and pollutant loads with an acceptable degree of certainty, yet be flexible enough to be applied to a wide spatial and temporal domain. One approach to obtaining a model with these attributes is to use a complex, data-intensive model. Although this type of approach, properly executed, can yield good results, the time and effort involved with data collection and model set-up and running, precludes its use in many circumstances.

Existing models have been used to estimate watershed-generated (nonpoint source) flows for the Tampa Bay watershed with varying degrees of success. Section 2, below, includes the description of the evaluation of a spreadsheet model that has previously been used to estimate nonpoint source flows and loadings to Tampa Bay. The results of this evaluation indicated that the spreadsheet model was not suitable for use to estimate flows over the entire ungaged portion of the watershed area.

Therefore, an empirical model was developed using measured data and regression relationships to describe the response of the watershed with respect to generating nonpoint surface water flow, given a set of rainfall and land use conditions. The empirical hydrology model produced much improved estimates of runoff in the Tampa Bay watershed. Pollutant loadings were estimated in a manner similar to the spreadsheet model, by multiplying empirically derived flows by literature values of land use-specific pollutant concentrations for nonpoint source flow. This model must be able to quantify differences in benchmark and existing pollutant loadings for the entire Tampa Bay watershed.

Table 1-1 Modeling Requirements for Watershed Loading Analysis

Loading and Flow Calculations	Gaged Area	Ungaged Area
Benchmark (ca. 1940)	modeled flow, modeled water quality	modeled flow and water quality
Worst case (ca. 1976)	modeled flow, modeled water quality	modeled flow and water quality
Existing (1985-1991)	measured flow and water quality	modeled flow and water quality
Future (ca. 2010)	measured flow and water quality	modeled flow and water quality

Because a significant part of the development of TN, TP, and TSS loads to Tampa Bay depends on the accurate estimation of nonpoint flows, much effort was put into developing and testing a model that would fit the needs of the work. A description of the flow model development and validation is given in Section 2.

Subsequent to the development of the nonpoint source portion of the model, estimates were made of the nutrient loading contributions from some of the unique features of the Tampa Bay watershed. Such pollutant sources as fugitive losses from bulk cargo transfer facilities, land application of treated wastewater effluent, springs, atmospheric deposition, and other sources were inventoried and quantified. This modeling effort resulted in the best estimate available, using existing data, of pollutant loads generated within the Tampa Bay watershed.

In summary, loading estimates for TN, TP, and TSS for the four scenarios (benchmark, worst case, current, and future) have been developed with the use of measured nutrient concentration and streamflow data, a statistical model that relates watershed characteristics to streamflow, and other analytical methods. The overall model has been developed to examine streamflow and pollutant loading characteristics for the entire watershed, with results presented on a bay segment and major drainage basin scale. However, to effectively manage potential pollutants, a more detailed examination of potential load reduction strategies and specific best management practices (BMP) must be completed. An evaluation of individual BMPs is beyond the purpose and scope of the work described herein. The model, as described below, is most appropriate for setting goals on a larger scale, (watershed-wide, or for major watershed subdivisions), rather than as a tool to examine smaller subbasins and specific land use management practices. The potential benefits of implementing various BMPs within the watershed are presently being investigated through other TBNEP work.

1.2 Time Frame and Geographic Extent of Model Results

1.2.1 Time Frame of Model Results

Existing Conditions Period of Analysis

Monthly and annual streamflow and pollutant loading estimates for both existing and benchmark conditions have been developed. The current or "existing" time period was defined as 1985-1991. This span of years was chosen to represent current or very recent conditions in Tampa Bay and the watershed, and was deemed appropriate because land use, water use, wastewater treatment practices, and other relevant characteristics have not changed radically during that time period. Recently available information, such as land use coverage based on 1990 aerial photographs, and U.S. Geological Survey (USGS) subbasin delineations was used to develop a data base of watershed characteristics.

Benchmark Conditions Period of Analysis

The "benchmark" time period was defined as 1938-1940. The benchmark time period was designated as a reference point from which to gage the relative changes in freshwater inflow and pollutant loading to Tampa Bay. Two major factors influenced this choice of benchmark time period. The first was that activities in the watershed for the chosen benchmark period were sufficiently different from existing conditions to allow the changes in streamflow and pollutant loadings to be measurable and significant with respect to living resource requirements. The second major factor is that there must be enough information available to develop the watershed characteristics data base for benchmark conditions with some degree of certainty.

Information from a variety of sources was reviewed during the process of choosing a benchmark period, including locally-available references such as data from county and city agencies (Hillsborough County, Pinellas County, Manatee County, City of Tampa, City of St. Petersburg, City of Clearwater, City of Bradenton), U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS) aerial maps, and historical mapping and land use references from public and private libraries.

In addition, other data, such as aerial photographs, bathymetric charts of Tampa Bay, land use and land cover maps, and agricultural inventories from the National Archives and other sources were obtained and reviewed. A set of aerial photographs made in 1938-40 that provided complete coverage for the Tampa Bay watershed was located at the National Archives in Washington, D.C. These black and white photos have been printed at a scale of 1 inch = 660 feet, and are available in a 1 inch = 20,000 inches (1:20,000) scale index map mosaic. This source of information satisfied the historical land use data requirement of the task.

A review of precipitation and streamflow data was completed for the 1940 time period. Several National Weather Service (NWS) rainfall recording sites were identified as having a period of record that included this time period. In addition, period streamflow records from several USGS gage sites within the watershed were obtained. These data were reviewed and found to be sufficient to satisfy the hydrological data requirements of the task.

Many factors were examined to assess the appropriateness of using the 1940 era for the benchmark period, which represents relatively unimpacted conditions with respect to existing levels of development. To pick the most appropriate benchmark period, factors such as population characteristics and the areal extent of urbanization and infrastructure were examined. Period aerial photographs give a clear picture of the watershed as much less developed in 1938 than presently, with only a few urban centers, such as Tampa and St. Petersburg, in existence. Soon after this period, the Tampa Bay area population began the rapid levels of growth that have continued to the present day.

Additionally, the seagrass restoration targets currently being developed for Tampa Bay are based on a 1950 benchmark period. Assuming that conditions in the bay are manifested based on a response lag of several years with respect to inflow conditions, the 1950 seagrass coverage is likely, at least in part, a reflection of water quality conditions from the preceding years. This assumption was made recognizing that much of the documented seagrass loss in the estuary, especially in Old Tampa Bay and Hillsborough Bay, has resulted from physical displacement, such as from dredge and fill activities. Therefore, based on the availability of land use, streamflow, and precipitation data, and the documented level of development in the Tampa Bay watershed in 1940, the 1938-40 period was chosen by TBNEP for use as the time period representing "benchmark" conditions for this study.

"Worst Case" Period of Analysis

The circa 1976 time period was used as a basis for developing worst case nutrient loading estimates because it is the time during which the highest loadings of TN and TP are thought to have been generated within the watershed (see Appendix 13). This period occurred just prior to the institution of several major pollution abatement measures in the watershed. These measures included providing advanced wastewater treatment at domestic plants, implementing stormwater management and treatment regulations, increased regulations on phosphate mining and processing activities, and improvements to phosphate rock and fertilizer transfer and shipping facilities. Additionally, soon after this period the phosphate industry experienced a decrease in activity that has generally continued to the present. These loading estimates were developed to document the great improvements that have been made in limiting nutrient loadings to the bay in the past fifteen years.

Future Conditions Period of Analysis

Projected nutrient loadings from the watershed were estimated for future conditions (see Appendix 14). The period ca. 2010 was used because it represents a commonly used planning horizon for local governments to use in projecting level of services for wastewater, land use and other infrastructure issues. Loading estimates utilized a future land use map, projected wastewater flows obtained from local governments, and estimates of projected loadings from other nutrient sources.

1.2.2 Geographic Extent of Model Results

Streamflow and pollutant loading estimates have been made for the entire Tampa Bay watershed. For this work, Tampa Bay was defined as the open water and littoral estuary and its tributaries up to the limit of usage by aquatic estuarine dependent species. In addition to watershed-wide estimates, pollutant loadings have been summarized by several geographic subdivisions, including:

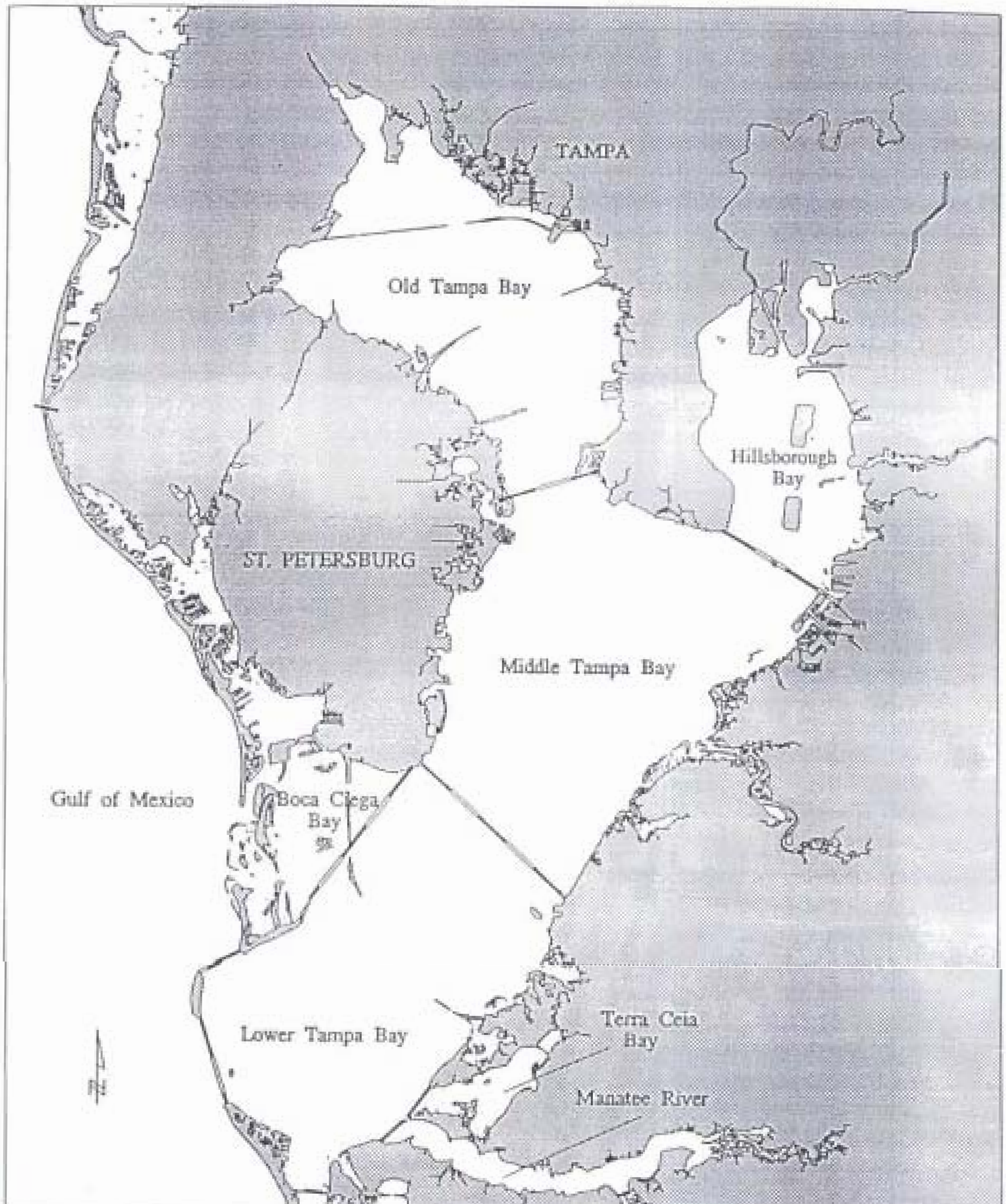
- **Bay Segments** - The seven bay segments as defined by Lewis and Whitman (1985) have been used to summarize streamflow inputs and pollutant loadings. Bay segments include Old Tampa Bay, Hillsborough Bay, Middle Tampa Bay, Lower Tampa Bay, Boca Ciega Bay, Terra Ceia Bay, and the Manatee River, as shown in Figure 1-2.

- **Major Drainage Basins** - Major drainage basins in the Tampa Bay watershed include the four major river basins (Hillsborough, Alafia, Little Manatee, and Manatee Rivers), and collections of coastal streams, as shown in Figure 1-3.

- **USGS Subbasins** - A total of 435 individual subbasins within the watershed (425 excluding open water bay sub-segments) have been delineated by USGS for existing conditions. Although developing estimates of overall loads does not require that pollutant loadings from each of these individual subbasins be calculated, this has been completed to assist with other on-going studies that are examining the potential effectiveness of the use of best management practices (BMP) to control surface water pollution in individual subbasins and for specific land uses.

TAMPA BAY SEGMENTS

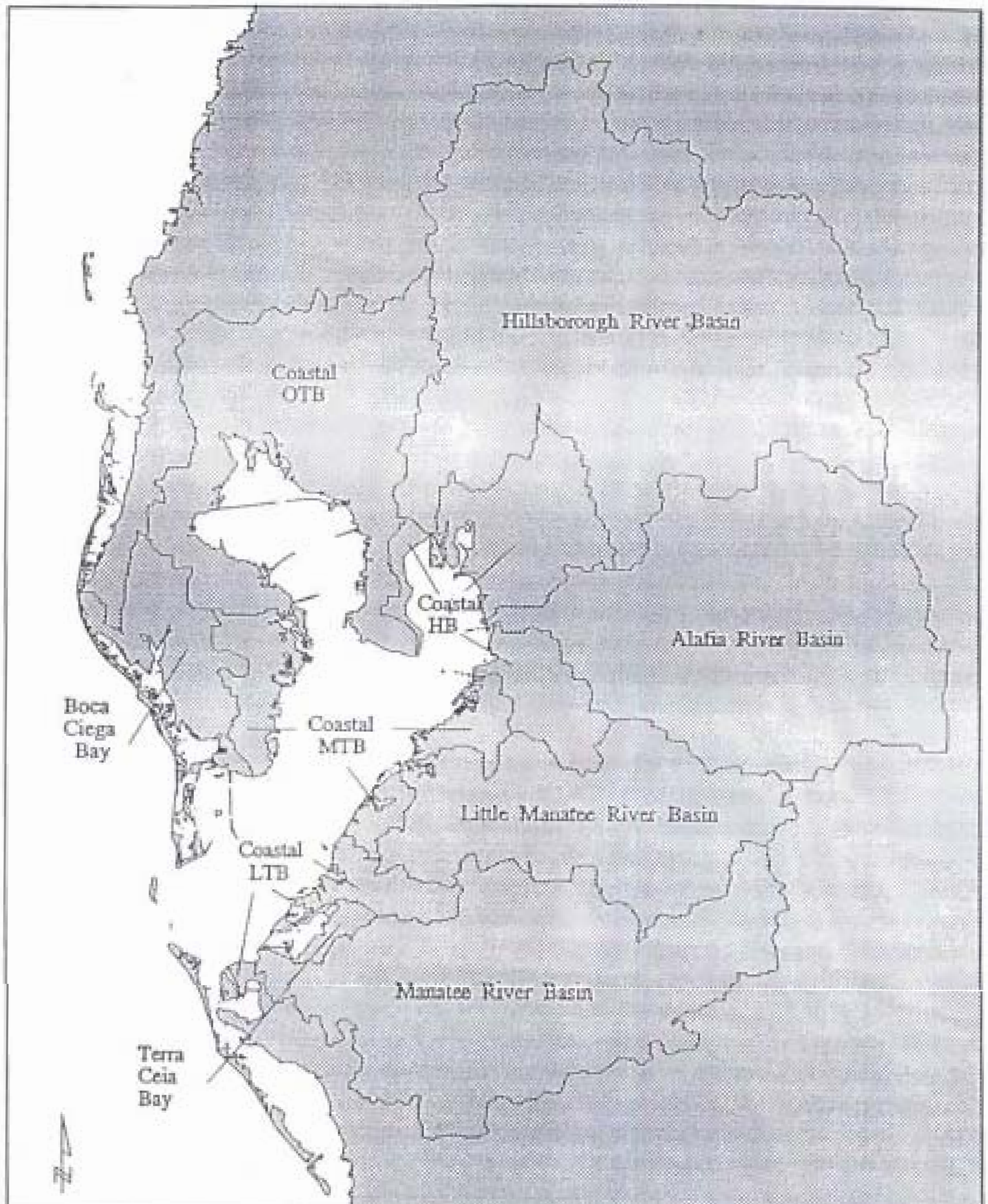
Based on Lewis and Whitman, 1985



Map Prepared by Coastal Environmental, Inc.

Figure 1-2 Tampa Bay Segments.

MAJOR DRAINAGE BASINS OF TAMPA BAY
Modified from USGS



Map Prepared by Coastal Environmental, Inc.

Figure 1-3 Tampa Bay watershed major drainage basins.

Using these temporal and spacial scales, methods for estimating both existing and benchmark freshwater inputs and pollutant loadings were developed. The methods used to calculate loadings from each source, the data sources, and the critical assumptions are described below. Following this introduction, Section 2 discusses the development and validation of the hydrologic model, Section 3 details methods for calculating existing streamflow and pollutant loadings, Section 4 addresses benchmark loading estimation techniques, and Section 5 describes the results of the loading analysis, summarizes the project review process, and makes recommendations for refining the loading estimates during future study. Section 6 lists cited literature.

2.0 DEVELOPMENT AND TESTING OF HYDROLOGIC MODEL

Estimates of total streamflow and TN, TP, and TSS loads for the Tampa Bay watershed cannot be completed without modeling surface water hydrology. Although measured data were used in this investigation to the fullest extent possible, it was necessary to use modeling methods to estimate streamflow inputs and water quality loadings for that portion of the watershed that was not gaged.

2.1 Selection of Modeling Approach

It was desired to use a relatively simple model that could yield acceptably accurate results using only existing data, but that was flexible enough to be used over the entire watershed. A balance must be reached between providing enough variables in the model construction to adequately simulate existing conditions, and not including excess variables that may improve model performance for one area, but reduce its ability to mimic conditions on a broader scale (Draper and Smith, 1981).

To this end, three models were evaluated - two deterministic models of spreadsheet construction, and a statistical regression model. This section describes the evaluated alternatives to the selection of a hydrologic model to predict streamflow.

2.1.1 Existing Alternatives

Computations Based on Literature Values of Runoff Coefficients and Watershed Characteristics

An existing spreadsheet model - Nonpoint Source Load Analysis Model (NPSLAM) (Dames & Moore, 1991; Dames & Moore, 1992) - was previously developed to model stormwater runoff using literature values for runoff coefficients and watershed characteristics. The original version of this model was similar in construct to other spreadsheet models previously used in west-central Florida, such as the Sarasota Bay watershed assessment model (Camp, Dresser & McKee, 1992) in that they assume a linear relationship between rainfall and stormwater runoff.

The NPSLAM model had been used to predict relative levels of nonpoint source pollutant loading to Tampa Bay for eight parameters, including TN, TP, TSS, BOD, metals, and bacteria (Dames & Moore, 1991). This application was uncalibrated, and was intended to provide estimates of relative pollutant loadings of individual subbasins in the watershed. Land use-specific runoff coefficients were used, to estimate stormwater runoff in amounts proportional to the size of the subbasin, its land use and soils composition, and rainfall amounts. When the model was used in an application requiring an accurate simulation of measured data, results were unacceptable. Subsequently, modifications were made to improve its performance.

NPSLAM Modified Version

In an effort to improve the spreadsheet model performance, modifications were made to NPSLAM. The first was a seasonal adjustment that was developed using measured rainfall and runoff data from the Little Manatee River. This factor allowed a unique monthly rainfall/runoff relationship to be used, depending on the long term seasonal and monthly rainfall/runoff characteristics of the basin, and improved the model fit.

A second adjustment factor was developed to account for short-term antecedent soil moisture conditions. Using soil moisture characteristics from Chow (1964), a set of multiplication factors was developed to apply to the initial runoff volume, based on preceding rainfall conditions. Validation results showed that model fit was improved. However, when a review of the ability of the modified NPSLAM model to predict flows in seven basins other than those used for the initial validation work was completed, the overall goodness of fit of modeled values to measured flows was only marginally acceptable. Resulting r^2 values ranged from 0.39 to 0.80. The r^2 of 0.80 was obtained for the Little Manatee River. This relatively good fit may be partially attributable to the fact that long-term streamflow data from this water body was used to develop the seasonal adjustment factor incorporated into the model.

Figure 2-1 shows the overall fit of modeled values versus observed data for monthly flows estimated by the spreadsheet model, and Figure 2-2 presents comparisons between predicted and observed monthly flows using the modified NPSLAM model for monthly flows between zero and four inches (the 95th percentile for observed flows). A generally limited agreement was observed between the model predictions and the observed flows for the tested subbasins. Overall, the model predictions showed a positive bias - that is, it tended to overpredict flow for a given rainfall amount, especially for low flow conditions.

2.1.2 Need for Further Refinement of Hydrologic Model

To improve upon the spreadsheet modeling methodology, an alternative to this model formulation was investigated. The methods focused on the use of available measured flow data from the Tampa Bay watershed. Initially, the relationship between measured monthly flow and rainfall was examined. Nonlinear relationships between rainfall and streamflow are often suggested by measured data, as shown in Figure 2-3. This characteristic appears to contribute to the bias (i.e., overprediction of low flows) in the original version of the NPSLAM model. Figure 2-4 illustrates how, if a linear model (straight diagonal line) is used to fit what is actually a nonlinear relationship (curved line), the predicted values in the lower range of values will be overestimated.

There also appeared to be a relationship between the existing month's streamflow and the previous month's rain, as suggested from the earlier work by Dames & Moore

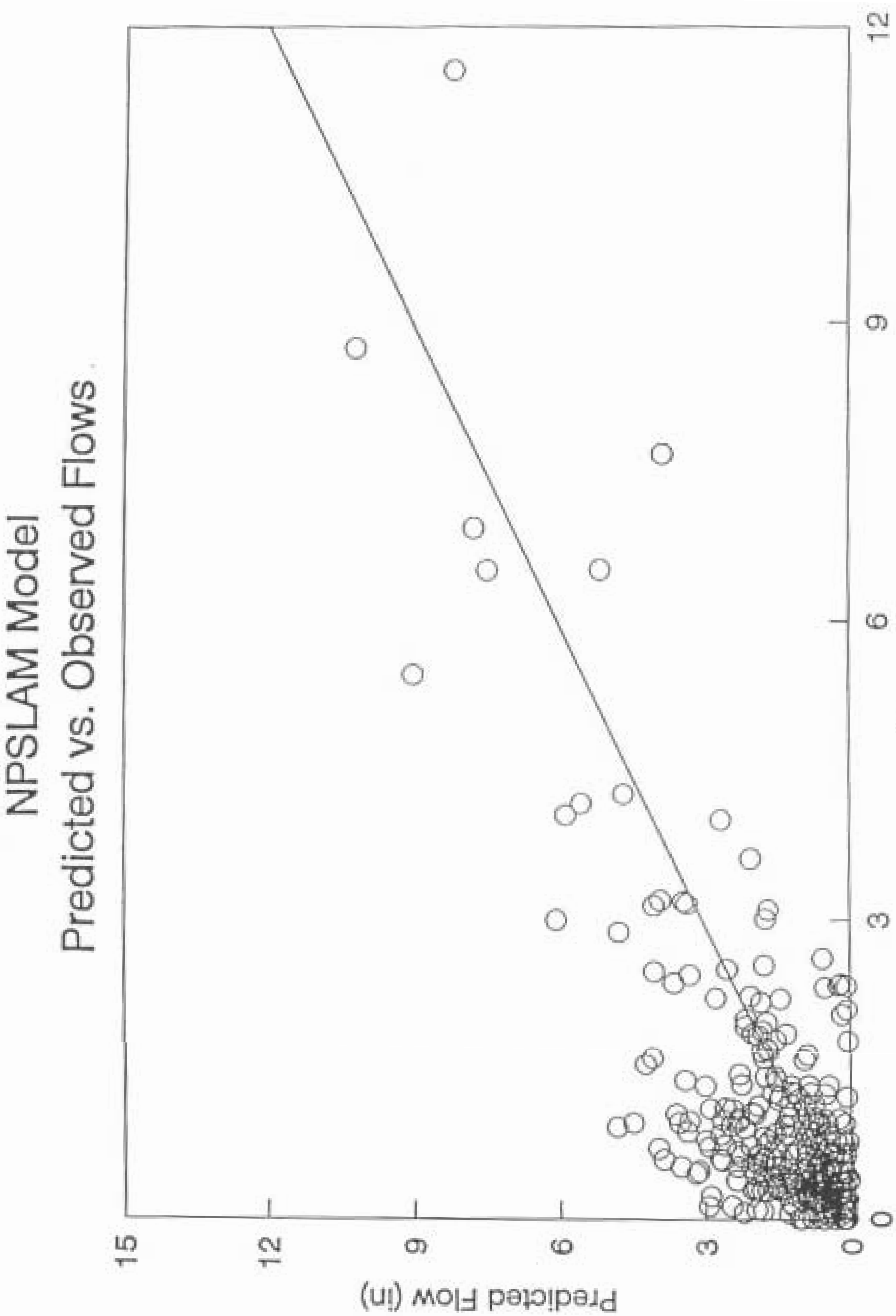


Figure 2-1 Modified NPSLAM Model - overall fit.

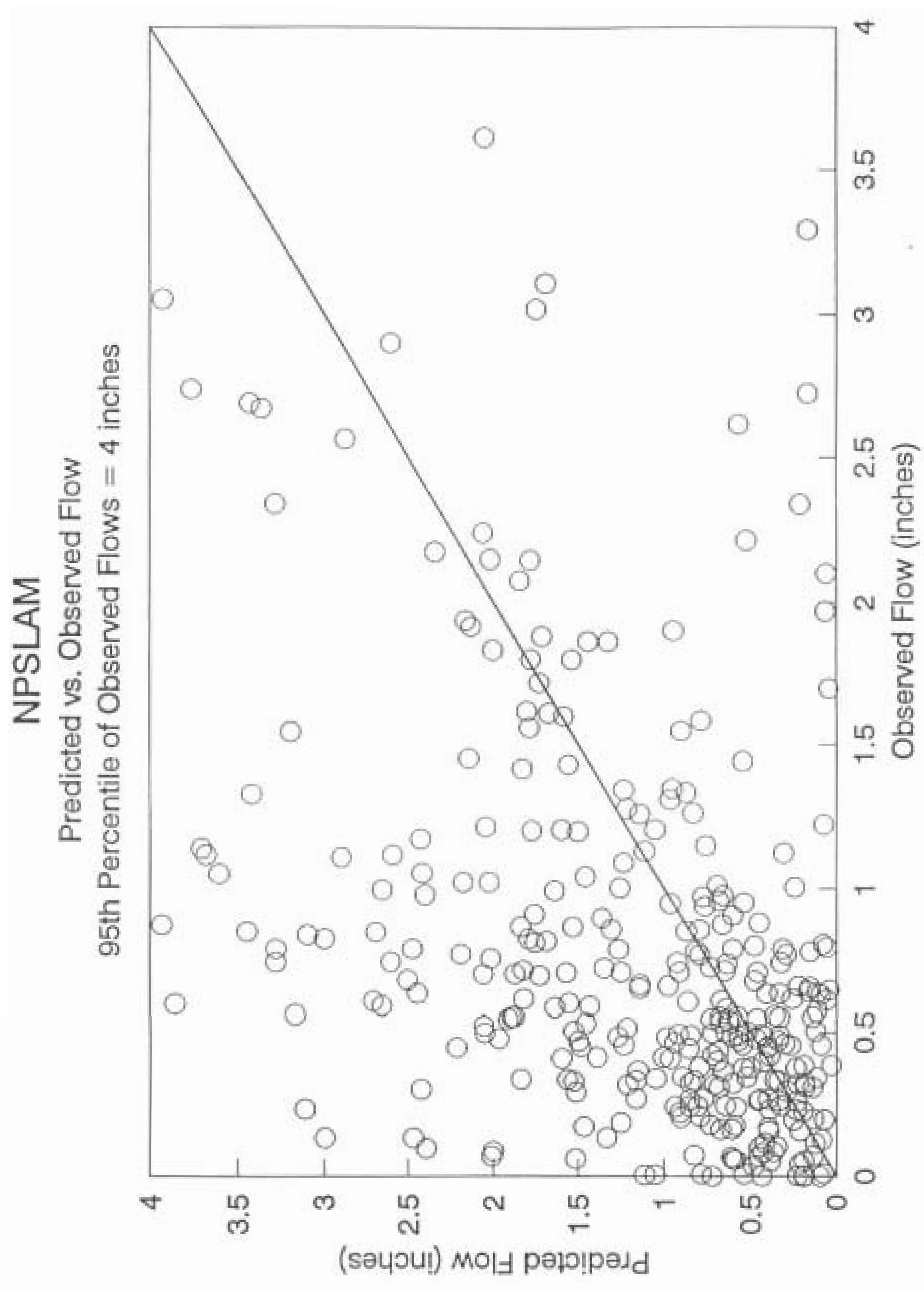


Figure 2-2 Modified NPSLAM Model - 95th percentile fit.

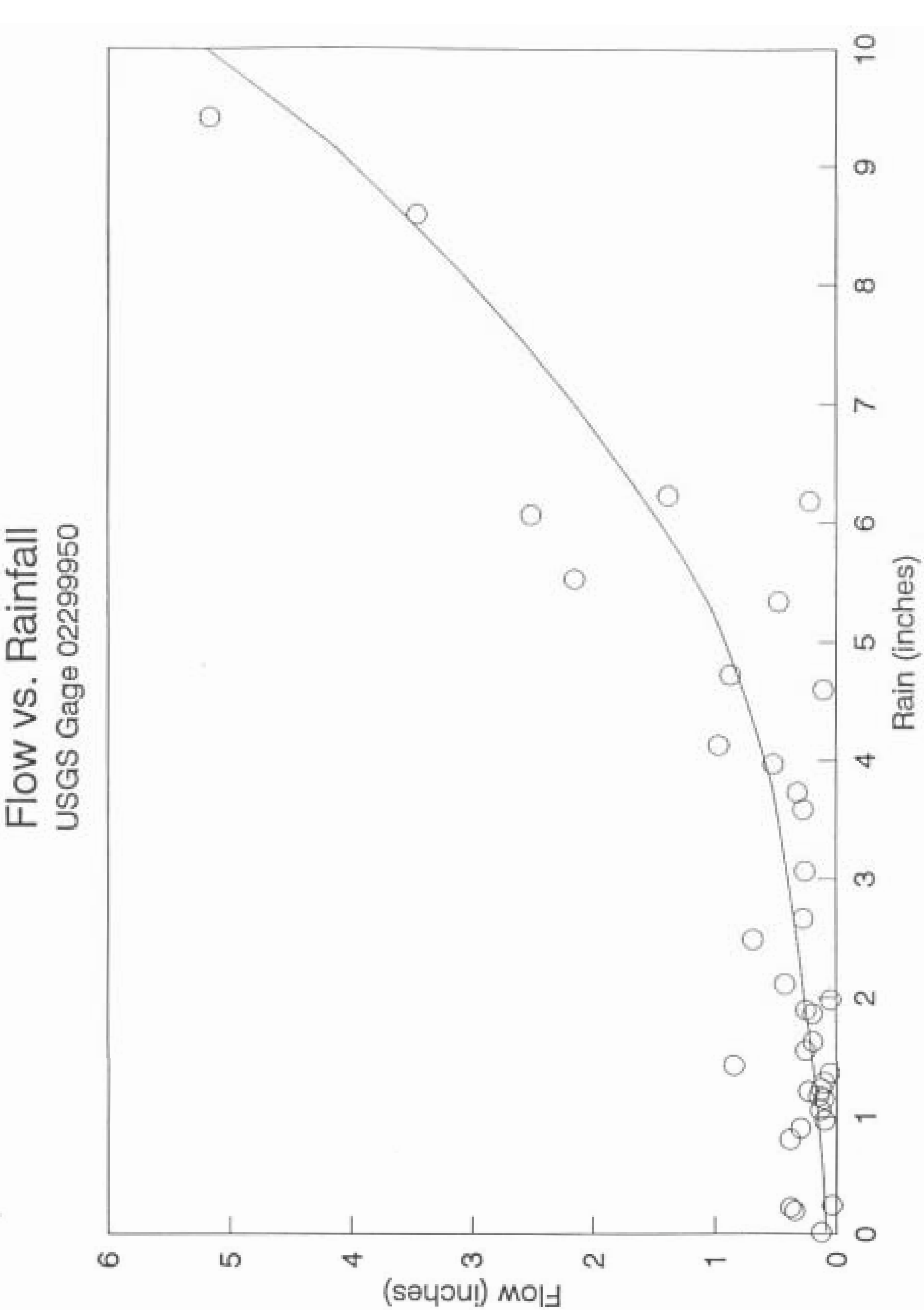


Figure 2-3 Nonlinear rainfall/runoff data

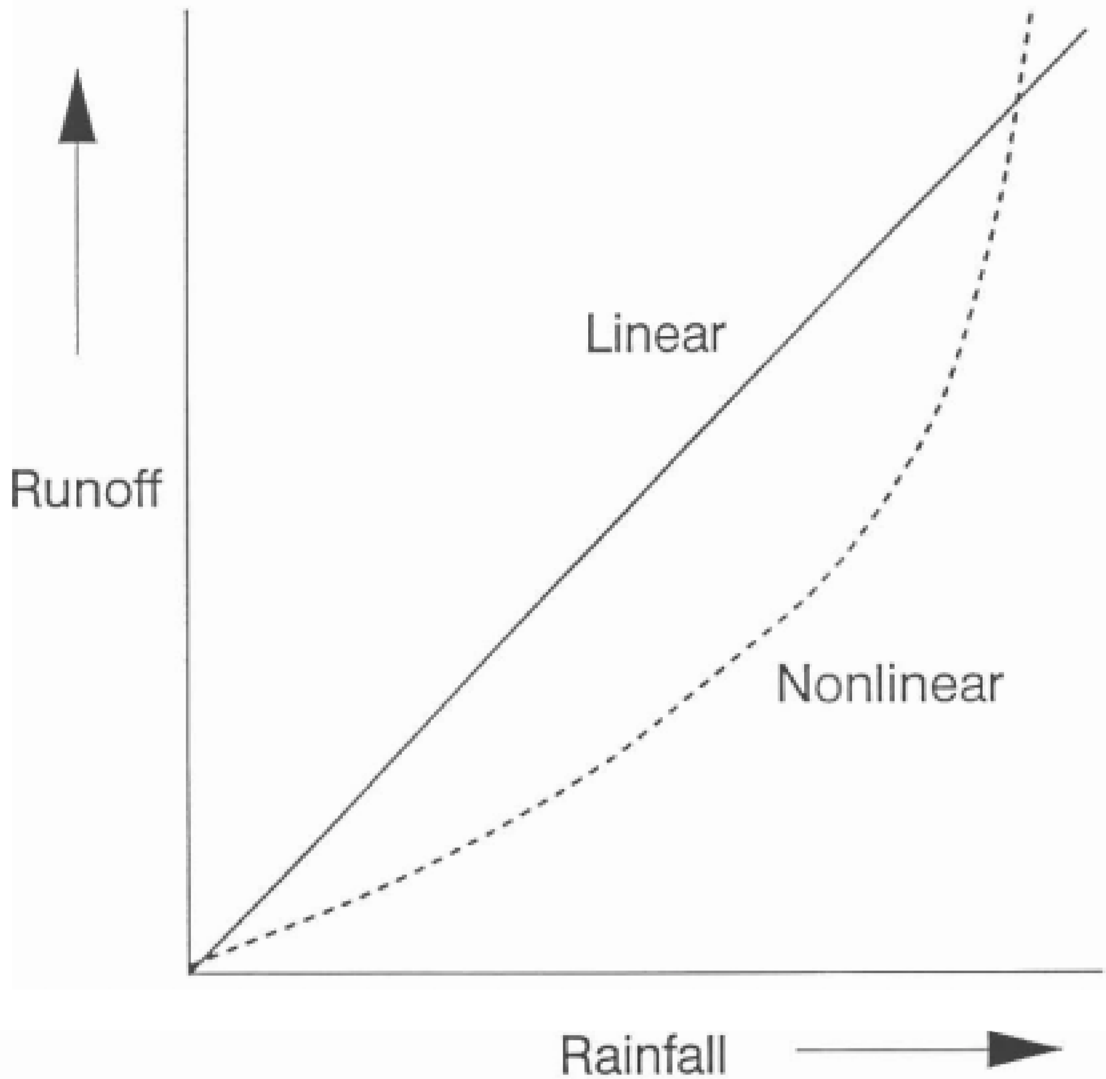


Figure 2-4 Consequences of fitting a linear model to data having a nonlinear relationship.

(1992). This relationship may be due to the lag in release of rainfall stored in wetlands and surface water bodies, groundwater interflow, or other factors. As has been pointed out in the Dames & Moore work, flows are often observed during months with little or no rainfall. Thus, it was concluded that a non-zero intercept for a model which relates flow to rainfall was appropriate. Based on these data analyses, a modeling approach using available empirical data was developed as described below.

2.1.3 Selected Modeling Approach

As previously discussed, a minimum number of parameters was used in model construction to ensure that it would be capable of adequately predicting flows in all ungaged areas in the watershed. Initial testing of the alternative modeling approach indicated the need to predict total monthly runoff magnitudes for a basin as a nonlinear function of 1) rainfall for the present month and two previous months, and 2) the percent coverage in a basin of each of four major land use groups. The four classes were urban, agricultural, forest/undisturbed, and wetland/water. The distribution of these four classes is presented below in Section 2.3.4. The use of the percent coverage of these four classes in the hydrology model was found to improve the fit of the rainfall/runoff relationships without compromising the predictive capacity of the model.

Model development resulted in the definition of four separate rainfall/runoff relationships, varying with season and basin land use characteristics. The four cases were 1) wet season, more urban basin; 2) dry season, more urban basin; 3) wet season, less urban basin; and 4) dry season, less urban basin.

Based on long-term rainfall records for the watershed, the wet season was defined as July through October, and the dry season was November through June. Although long-term rainfall data from Tampa International Airport suggests a June-September wet season, the July-October period accounted for approximately 55% of the annual precipitation on a watershed-wide basis.

"More urban" basins were defined as having greater than 19% urban land use, and "less urban" basins had less than 19% urban land use. The selection of the 19% level was based on an investigation of the distribution of urban land cover and the goodness of fit of the rainfall/runoff relationships.

Another objective of this modeling was to apportion total estimated runoff in a basin to constituent land uses, based on their relative frequency of occurrence in the basin. This was accomplished through the use of land use-specific runoff coefficients that allocated fractions of total streamflow to the individual land uses based on the extent of their coverage and the literature values of land use-specific runoff coefficients.

2.2 Model Formulation

As described in the previous section, empirical data analyses indicated that the preferred model for predicting runoff was based on a log-linear relationship with rainfall and land use categories as independent variables. Rainfall for two previous months was included in the model in addition to that for the present month. The land use composition of each basin was included through an adjustment factor (a). The model used is:

$$\text{FLOW} = \exp[a + (b_0 \cdot \text{RAIN}_0 + b_1 \cdot \text{RAIN}_1 + b_2 \cdot \text{RAIN}_2)] \qquad \text{(Equation 1)}$$

and,

$$a = (c_1 \cdot L_1) + (c_2 \cdot L_2) + (c_3 \cdot L_3) + (c_4 \cdot L_4)$$

where

FLOW = nonpoint source flow (meters per month) for a given basin, year, and month,

RAIN_0 = rainfall (meters per month) in the month,

RAIN_1 = rainfall (meters per month) in the month before the present month,

RAIN_2 = rainfall (meters per month) two months before the present month,

L_1 = the fraction of the basin acreage in the URBAN land use category,

L_2 = the fraction of the basin acreage in the AGRICULTURAL land use category,

L_3 = the fraction of the basin acreage in the WETLANDS land use category,

L_4 = the fraction of the basin acreage in the FORESTS land use category, and

c_1, c_2, c_3, c_4, b_0, b_1, and b_2 are parameters to be estimated.

The parameters associated with rainfall (b_0, b_1, and b_2) act as weighting factors when averaging rainfall over three months. Their absolute magnitude also affects the slope of the relationship between rainfall and runoff (Figure 2-5a). The parameters associated with land use categories (c_1, c_2, c_3, and c_4) define an aggregate adjustment factor (a) that affects both the slope and the intercept of the relationship between rainfall and runoff (Figure 2-5b).

The units of flow and rainfall listed above, meters per month (m/mo), were chosen for computational purposes. For flow, m/mo represents the total flow from a land area over the time period (month), expressed as a volume of water with an area equal to the land area, and the depth in meters. Although the unit is listed as depth, the volume is implicitly accounted for in the land area. For rainfall, m/mo represents the depth of rainfall over the land area during the time period (month), although it may also be expressed as a volume, such as cubic meters/month, acre-feet/month, etc.

A least squares regression with no intercept was used to estimate the seven parameters in Equation (1) after taking the natural logarithm of both sides of the equation:

$$\log(\text{FLOW}) = (c_1 \cdot L_1) + (c_2 \cdot L_2) + (c_3 \cdot L_3) + (c_4 \cdot L_4) + (b_0 \cdot \text{RAIN}_0 + b_1 \cdot \text{RAIN}_1 + b_2 \cdot \text{RAIN}_2) \qquad \text{(Equation 2)}$$

Basins were classified into two categories based on land use category: greater than 19% urban or less than 19% urban. The distribution of subbasins through this category is shown in Figure 2-6. Months were classified into two categories based on rainfall: dry (November through June) or wet (July through October). The model was run for each combination of these categories, resulting in four complete sets of parameter estimates:

- ≤ 19% urban, dry season
- ≤ 19% urban, wet season
- > 19% urban, dry season
- > 19% urban, wet season

Total monthly flow was estimated for each basin using Equation (1) with the appropriate parameter estimates. Flow was then apportioned among the constituent land use categories within each basin as follows:

$$\text{FLOW}_i = \frac{\text{FLOW} \cdot A_i \cdot R_i}{\sum_i A_i \cdot R_i} \qquad \text{(Equation 3)}$$

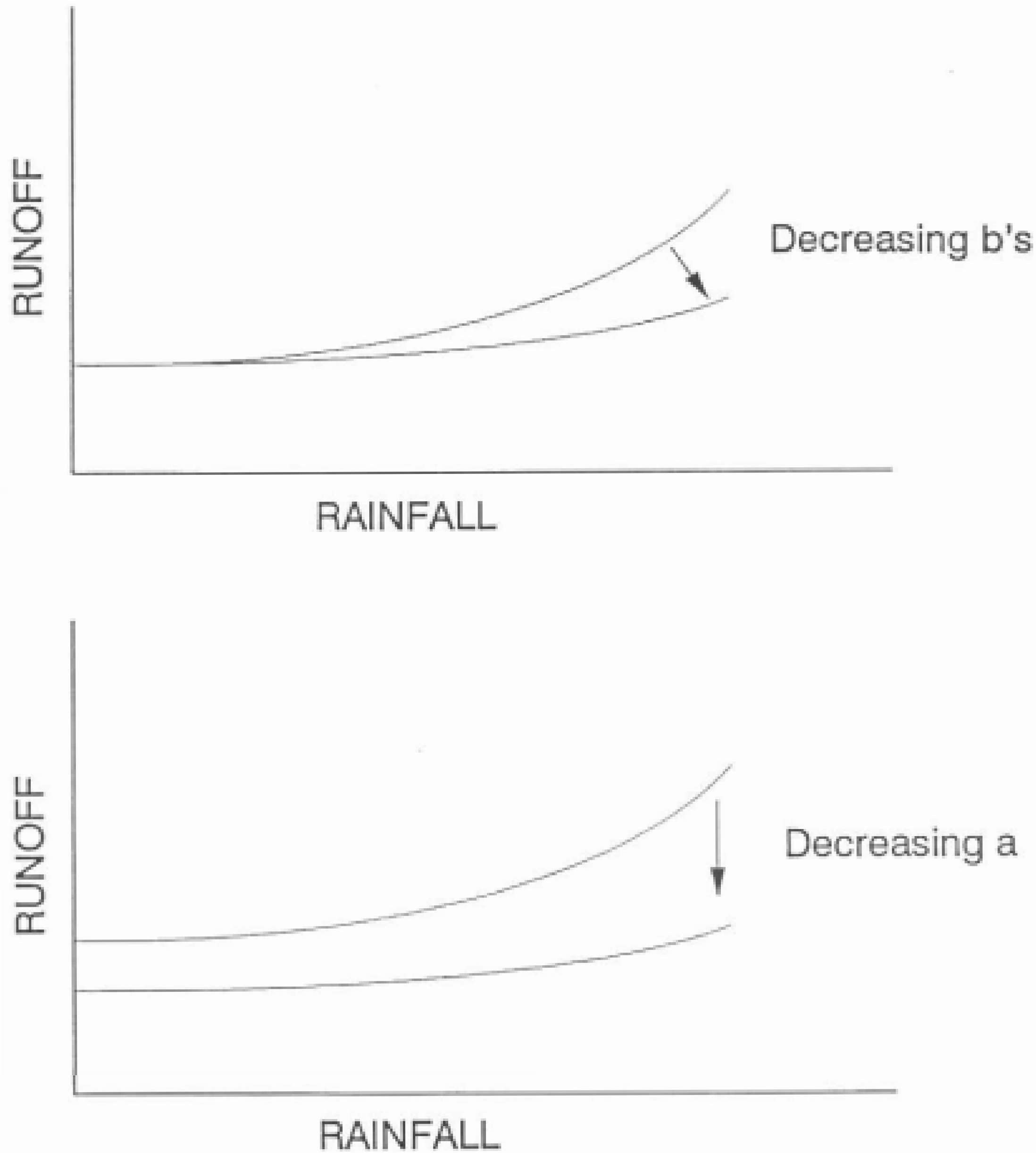
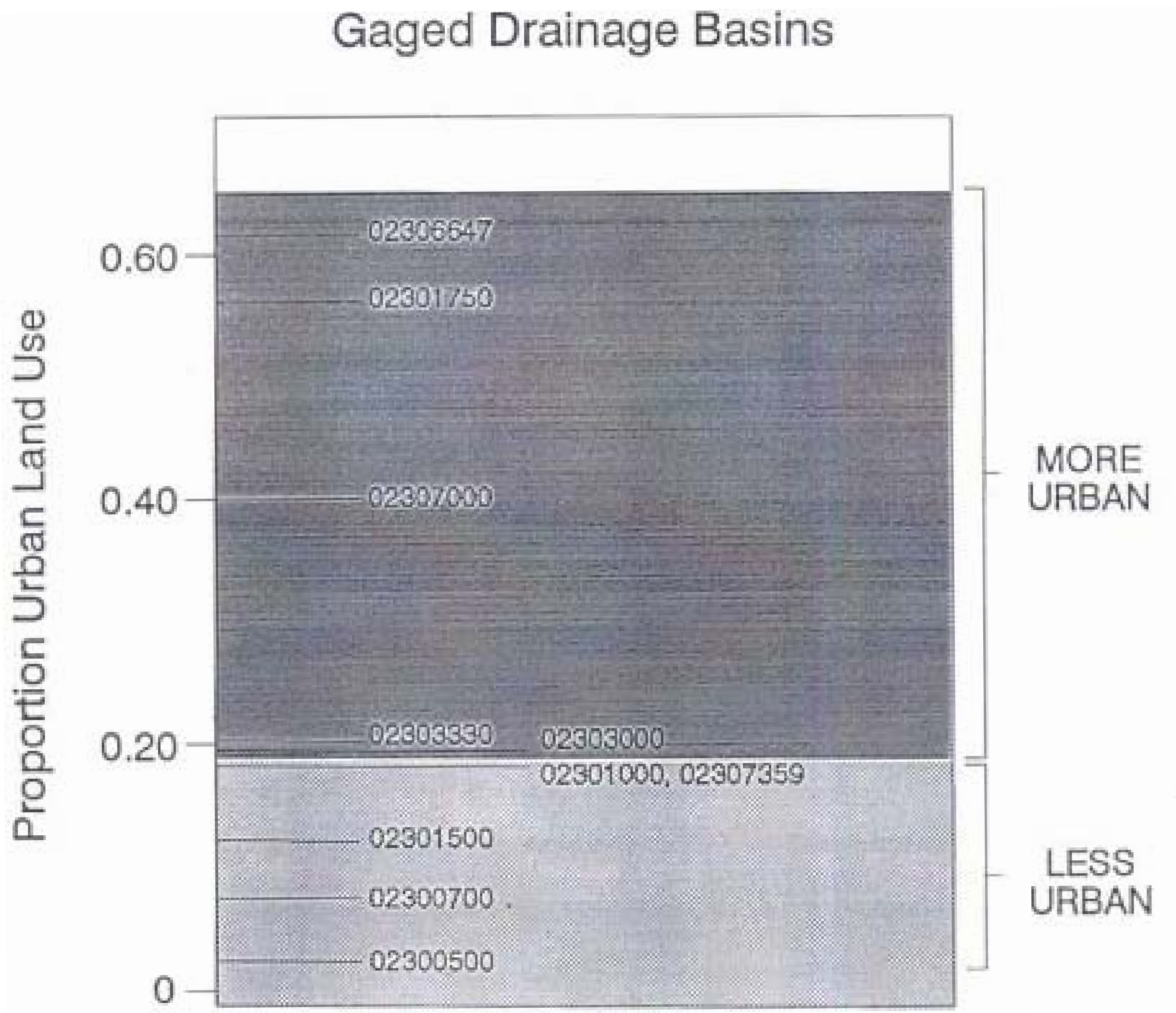


Figure 2-5 (a and b) Effects of varying model parameters.



NOTE: Basins are identified by USGS gaging station numbers.

Figure 2-6 More urban and less urban basins.

where

$FLOW_i$ = the total nonpoint source flow (cubic meters per month) from land use category *i*,

FLOW = the total nonpoint source flow (cubic meters per month) from a subbasin,

A_i = area (acres) in land use category *i*, and

R_i = the runoff coefficient (fraction of rainfall that runs off) for land use category *i*.

Runoff coefficients for each land use category were developed based on a literature review. The proportion of runoff attributed to each land use category for a given basin remains constant as total runoff increases (Figure 2-7).

2.3 Data used for Parameter Estimation and Distribution of Total Nonpoint Source Flow for Land Use Groups

2.3.1 Stream Flow Measurements

Total monthly streamflow data were obtained from United States Geological Survey (USGS) monitoring records for the Tampa Bay watershed. Data from water years 1985 through 1991 were used to calculate existing streamflow inputs. The USGS streamflow recording stations shown in Figure 2-8 and Table 2-1 were used for model development.

In addition, data from other gaged sites monitored by SWFWMD, Manatee County or others were obtained, as listed in Section 3. Data from these sites were chosen either for model development, or to provide measured data for gaged area streamflow and pollutant loading calculations.

2.3.2 Drainage Basin Boundaries

Drainage basin boundaries were incorporated into all geographically-based data used for this project (e.g., land use data, precipitation data, drainage areas, point source locations). The drainage area boundaries were based on data obtained from SWFWMD (1992(a)). Modifications were made to the basin boundaries for the development of the surface water hydrology model. These modifications include the correction of minor coding errors, the subdivision of coastal basins following the bay segmentation scheme used by TBNEP, and the subdivision of gaged and ungaged portions of the watershed.

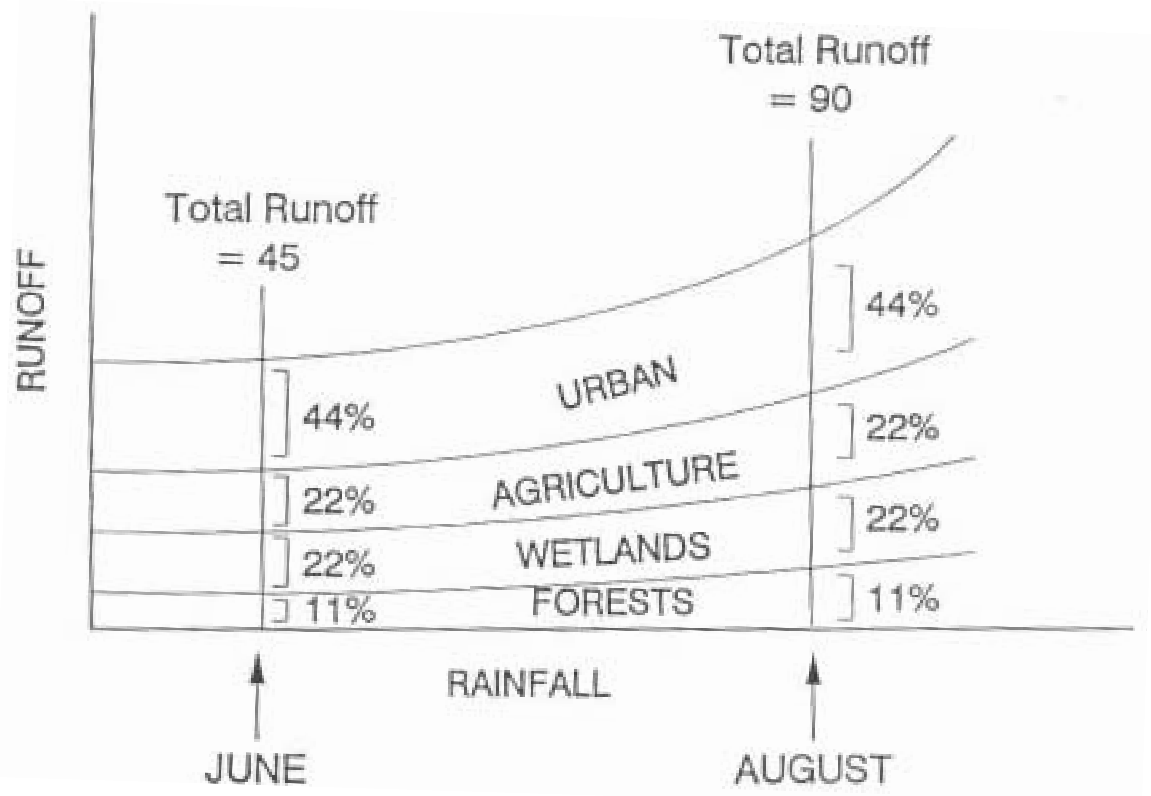


Figure 2-7 Effect of increasing total runoff on proportion of runoff attributed to each land use category.

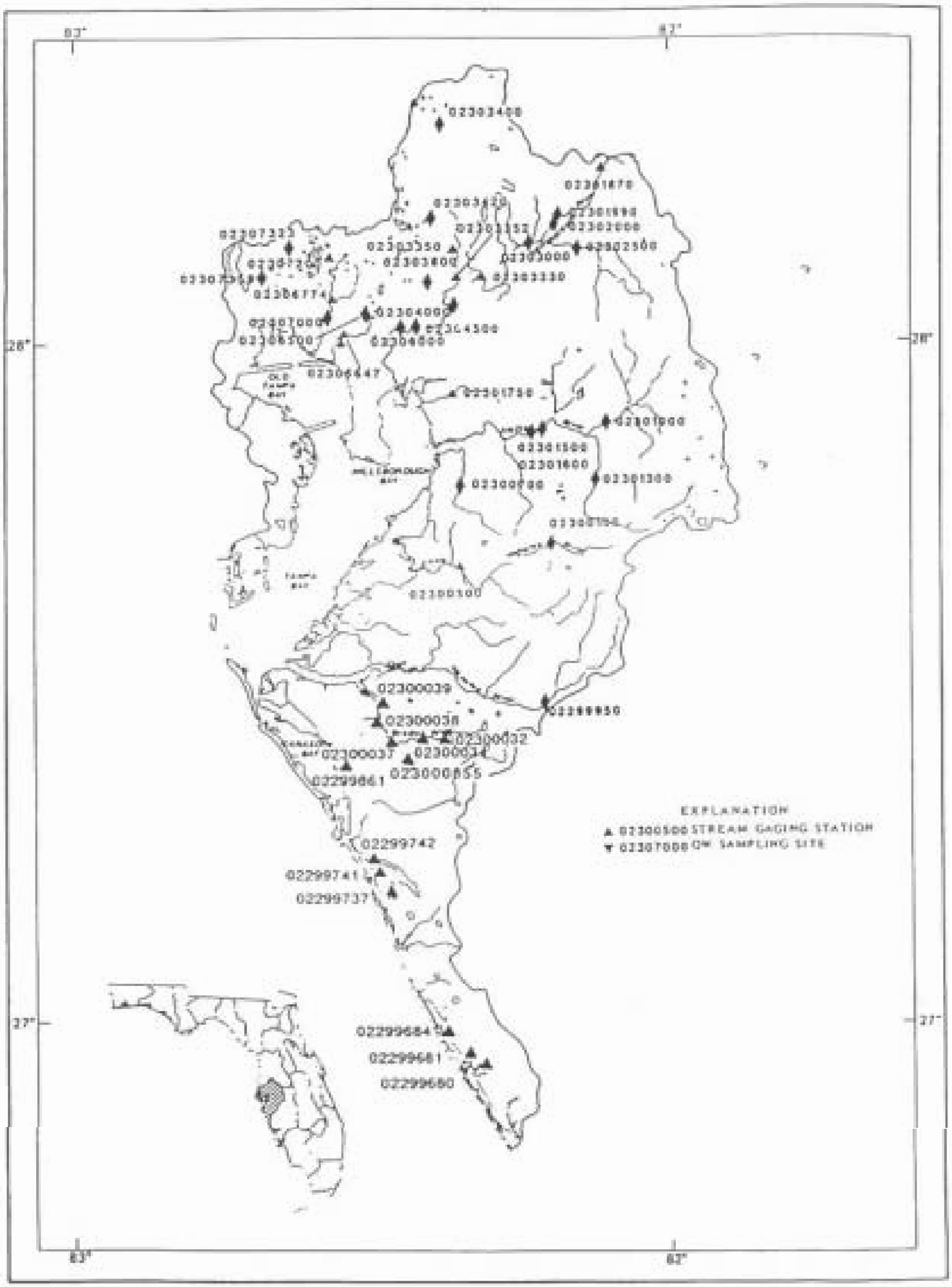


Figure 2-8 Location of USGS gaging stations.

(Refer to Table 2-1 for identification of stations used in hydrologic model development. - from USGS, 1992)

Table 2-1 Streamflow Monitoring Stations Used for Hydrologic Model Development

USGS Gage Number	Site Name
02300500	Little Manatee River near Wimauma
02300700	Bullfrog Creek
02301000	North Prong Alafia River
02301500	Alafia River at Lithia
02301750	Delaney Creek
02303000	Hillsborough River near Zephyrhills
02303330	Hillsborough River at Morris Bridge
02306647	Sweetwater Creek near Tampa
02307000	Rocky Creek near Sulphur Springs
02307359	Brooker Creek near Tarpon Springs

A total of 435 subbasins, including ten subbasins comprising open water areas of Tampa Bay, have been delineated, encompassing an area of approximately 2,646 square miles (sq. mi.), or 6,835 square kilometers (sq. km.). Excluding open waters of the bay, the watershed includes 425 subbasins covering approximately 2,276 sq. mi. (5,895 sq. km.).

These subbasins were delineated by USGS (Foose, 1993), however, some of the subbasins were further subdivided to break out gaged and ungaged areas. For example, if a streamflow gage was located in the midpoint of a USGS subbasin, that subbasin was divided into two parts. The upstream portion of the original subbasin included the gaged area, and the downstream portion would be ungaged. This was necessary for streamflow estimate computation, which used a different method of calculation for gaged and ungaged areas.

Each of the 425 individual subbasins that comprise the 2,276 sq. mi. watershed has been assigned an extended Hydrologic Unit Code (HUC) by USGS. This eight-digit code indicates hydrologic linkage between catchments, making it possible to trace upstream subbasins to their ultimate outfall at the estuary. In addition, internally drained ("hydraulically noncontributing") areas have been delineated by USGS. These internally drained lands, which include 22 subbasins, encompass 125 sq. mi., or slightly more than 5% of the watershed area. These areas may be expected to retain initial rainfall volumes, and provide surface discharge only after internal storage areas are filled. For nonpoint source load modeling, these noncontributing subbasins were removed from the land area that generated stormwater runoff.

2.3.3 Rainfall Records

The precipitation data used for modeling surface water hydrology were obtained from the National Climatic Data Center of the National Weather Service (NWS) (National Weather Service, 1993). Total monthly precipitation data were obtained for the existing period (1985-91) for 22 long-term stations within and near the Tampa Bay watershed. The names and locations of these stations are presented in Table 2-2 and Figure 2-9, respectively.

Total monthly precipitation values were estimated for each subbasin, month, and year of the existing period. Subbasin estimates were interpolated from a precipitation response surface which was fit to the entire watershed for each month and year of the existing period. The response surface was fit by computing an inverse-distance-squared, weighted-average of precipitation measurements within a search radius of 50 kilometers for each subbasin. This method of estimating rainfall for a subbasin accounts for regional patterns, but gives more emphasis to local conditions. Using this method the total monthly precipitation for each subbasin was computed as follows:

$$\hat{p}_j = \frac{\sum_{k=1}^{K_j} p_k \left[\frac{1}{D_k^2}\right]}{\sum_{k=1}^{K_j} \left[\frac{1}{D_k^2}\right]} \qquad \text{(Equation 4)}$$

where $\hat{p}_j$ = estimated total monthly precipitation for the jth subbasin

K_j = the number of NWS stations within 50 kilometers of the geographic center of the jth subbasin,

p_k = the total monthly precipitation recorded at the kth NWS station, and

D_k = the distance (meters) between the geographic center of the jth subbasin and the kth NWS station.

Table 2-2 Long-Term National Weather Service Precipitation Stations

Precipitation Site Number	Site Name
228	Arcadia
478	Bartow
520	Bay Lake
940	Bradenton
945	Bradenton 5ESE
1046	Brooksville
1163	Bushnell
1632	Clearwater
1641	Clermont
3153	Ft. Green
3986	Hillsborough
4707	Lake Alfred
5973	Mountain Lake
6065	Myakka
6880	Parrish
7205	Plant City
7851	St. Leo
7886	St. Petersburg
8788	Tampa International Airport
8824	Tarpon Springs
9176	Venice
9401	Wauchula

Figure 2-9 Location of National Weather Service precipitation monitoring stations.

2.3.4 Land Use/Land Cover Data

Land use/land cover GIS data were obtained from SWFWMD (1992(b)), and incorporated into the surface water hydrology model. The SWFWMD data were interpreted from 1:24,000 and 1:40,000 scale, color infrared aerial photographs. The photographs were made during December of 1989 and January of 1990. The land use data were recorded following the Florida Land Use Cover Classification System (FLUCCS) level 3 developed by the Florida Department of Transportation Thematic Mapping Section (FDOT, 1985).

For the purpose of assigning land use-specific runoff and pollutant loading factors, the land use data were aggregated into 21 classes as shown in Appendix 1 and described in Section 3. This classification system was developed by examining the source literature for the FLUCCS land use classification scheme, land use specific runoff factors, and land use specific pollutant loading factors, as referenced in Section 3.

In order to compute parameters for the surface water hydrology model, the land use data were further aggregated into four major classes as described in Section 3. The classes were urban, agricultural/mining, forest/undisturbed, and wetland/water. The areal extent of each of the four aggregated land use classes for each of the basins used to fit the surface water hydrology model is listed in Table 2-3. For pollutant loadings estimates, these land use categories were disaggregated into 21 classes.

As described in the previous section, the areal percent of urban land use was used to divide the basins into a less urban group (group A) and a more urban group (group B). The classification of basins into these two groups is summarized above in Figure 2-6.

2.3.5 Land Use-Specific Runoff Coefficients

Land use-specific runoff coefficients were obtained from published literature, including references for the west-central and south Florida geographic area (Chow, 1964; USDA, 1975; Harper, 1991). A range of coefficient values for each land use was developed to account for seasonal changes in rainfall/runoff relationships, and for local soils conditions, as shown in Appendix 2. These coefficient ranges reflect higher rates of runoff during the wet season when soils are more saturated, water table elevations are higher, and depressional storage availability is lower.

The soils coverage includes discrete polygons of individual soil series (types) as identified by the USDA SCS in the county soil surveys. This coverage was obtained from SWFWMD in ARC/INFO format. Each discrete polygon represents a soil series, which was aggregated by hydrologic soil groups (A - D). The SCS has assigned a hydrologic group identification to each soil series to indicate runoff generating

Table 2-3 Distribution of Land Use Categories in Gaged Basins

USGS Gaged Basin	Percent Urban	Percent Agri.	Percent Forest/ Open Space	Percent Water/ Wetland
02300500	2	57	26	15
02300700	7	54	25	14
02301000	19	52	15	14
02301500	12	56	16	16
02301750	55	12	25	8
02303000	19	35	24	22
02303330	20	33	24	23
02306647	61	05	13	21
02307000	40	12	20	28
02307359	19	19	27	35

characteristics. "A" soils, in general, generate the least, and "D" soils the most amount of runoff for a given rainfall. The soils coverage was intersected with the land use coverage to provide the GIS layer used to estimate runoff coefficients. Each unique combination of land use type, soil series, and season has been assigned an associated runoff coefficient value.

2.4 Parameter Estimates for Tampa Bay Watershed

The hydrologic model includes seven parameters associated with three rainfall categories and four land use categories. The values of these parameters were estimated using least squares regressions after log transforming the log-linear model (Equation 2). Parameter estimates were made for each of four categories of basin type, defined by land use ($\leq$19% urban or $>$19% urban) and season (wet or dry).

Results from Regression Analyses

Least squares regressions were highly significant for each category of basin type, with the model accounting for 52-66% of the variance in the data (Table 2-4). The parameter estimates used in predicting runoff are presented in Table 2-5, with their

Table 2-4 Results of least squares regression analyses for the model predicting runoff from rainfall and land use

Basin Land Use	Season	F Value	Prob > F	r^2
≤ 19% Urban	Dry	588.42	0.0001	0.60
≤ 19% Urban	Wet	378.14	0.0001	0.64
> 19% Urban	Dry	1608.33	0.0001	0.52
> 19% Urban	Wet	806.56	0.0001	0.66

standard errors. When viewed as weighting factors, the parameters associated with rainfall (b_0-b_2) generally placed greatest weight on the present month, as expected. The preceding two months do contribute significantly to the model, however, especially during dry season months.

2.5 Hydrologic Model Validation

The predicted flows from the hydrologic model described above were compared to measured flows in ten basins in the Tampa Bay watershed. These model predictions compare more favorably to the observed flows than did the modified NPSLAM Model predictions discussed above. Therefore, it appears that the empirical model provides better estimates of flows in the range of typical flows for these basins. The bias in the NPSLAM predictions averaged approximately 1500%, due in great part to extreme overprediction of flows in Brooker Creek. Exclusion of the Brooker Creek data from the NPSLAM model results in an average bias of approximately 300%. The average bias in the predictions of the empirical hydrologic model prepared for this project was 33%. Figure 2-10 shows the overall relationship between the predicted and observed flows. Figure 2-11 compares predicted and observed flows in the range of 0-4 inches (the 95th percentile of observed flows). Plots of observed versus predicted flows are shown in Appendix 3. The correlation coefficient (r^2) for these relationships ranged from 0.5 to 0.89, with an average r^2 of approximately 0.7, with the poorest fit observed for Brooker Creek. The r^2 for the relationship between NPSLAM predictions and observed flows ranged from 0.39 to 0.8, with an average of 0.54.

Table 2-5 Parameter estimates and standard errors (in parentheses) for hydrologic model

Parameter	≤ 19% Urban Dry	≤ 19% Urban Wet	> 19% Urban Dry	> 19% Urban Wet
b_0	4.59 (1.04)	7.22 (1.09)	5.93 (1.07)	7.60 (1.05)
b_1	6.27 (1.23)	3.59 (1.16)	6.17 (1.19)	1.71 (1.19)
b_2	4.30 (0.85)	2.25 (1.25)	3.58 (0.85)	2.79 (1.33)
c_1	-4.86 (1.51)	-5.63 (2.10)	-5.98 (0.58)	-4.67 (0.85)
c_2	-2.97 (0.49)	-3.85 (0.74)	-5.49 (1.29)	-5.39 (1.78)
c_3	-16.91 (1.97)	-11.77 (2.77)	-1.45 (0.72)	-2.79 (1.04)
c_4	-3.04 (1.95)	-5.00 (2.75)	-10.15 (1.92)	-10.22 (2.67)

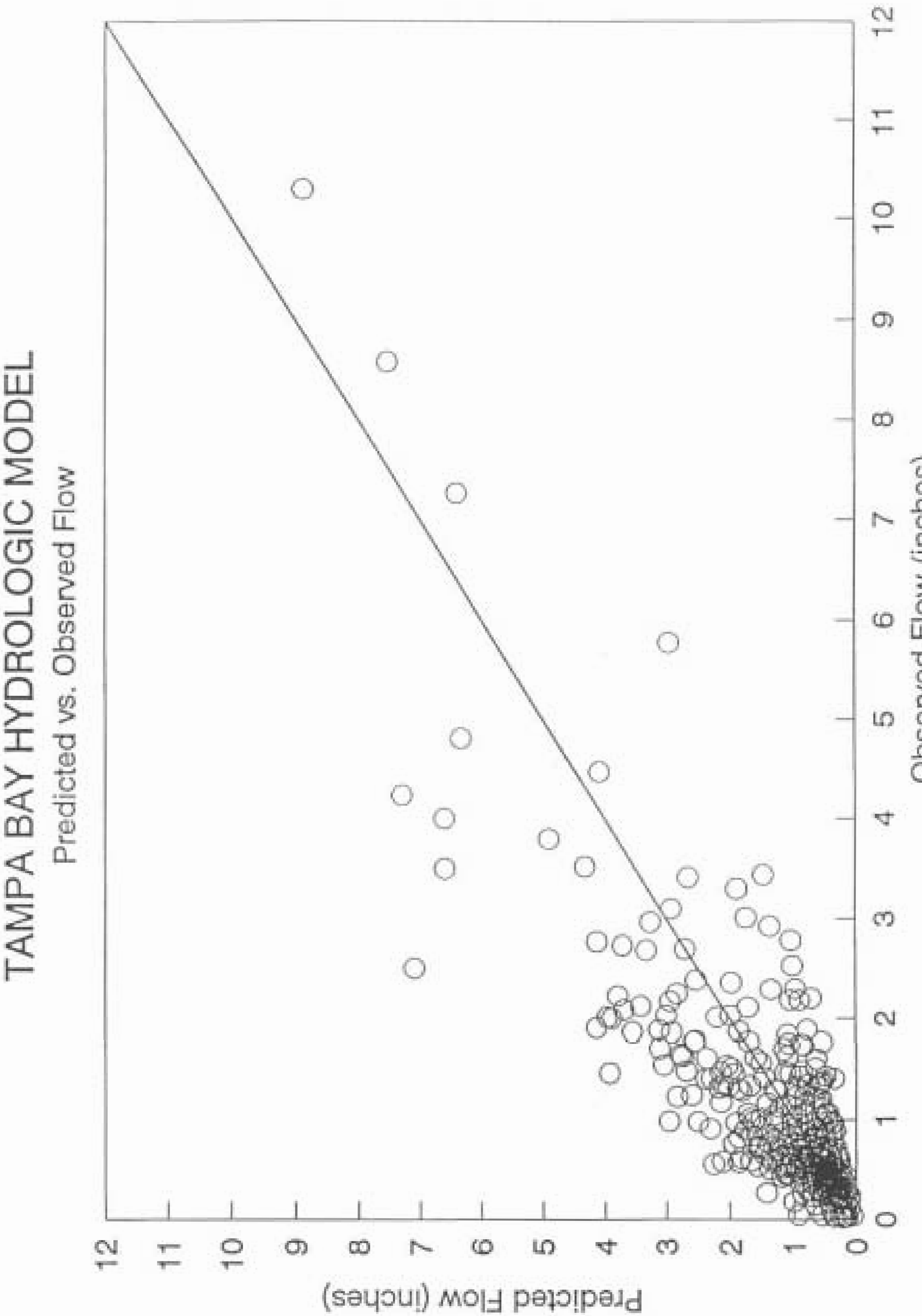


Figure 2-10 Tampa Bay Hydrologic Model - overall fit.

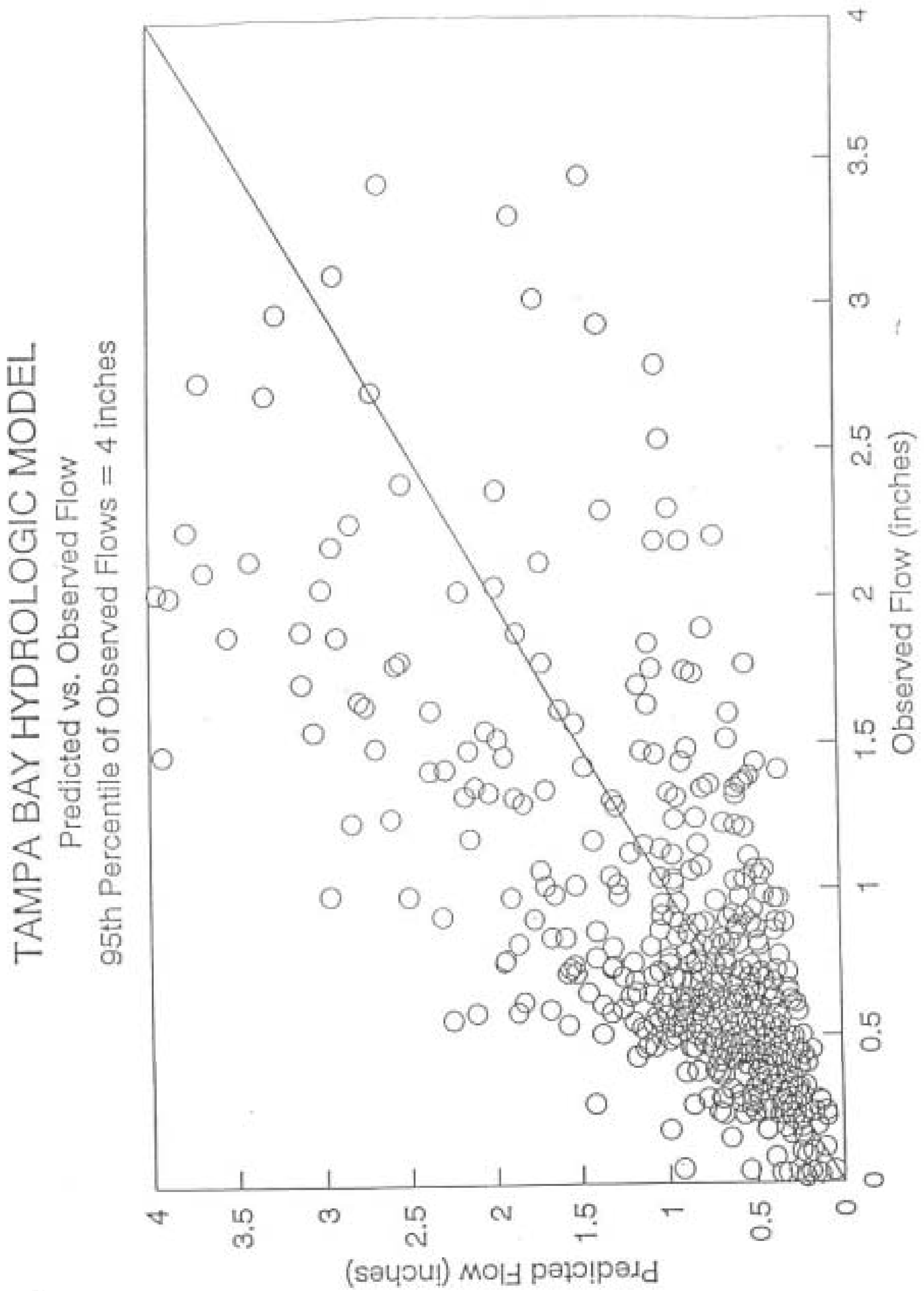


Figure 2-11 Tampa Bay Hydrologic Model - 95th percentile fit.

3.0 DEVELOPMENT OF ESTIMATES OF NUTRIENT AND SUSPENDED SOLIDS LOADINGS FOR EXISTING CONDITIONS

The Tampa Bay Pollutant Loading Model (model) has been designed to estimate freshwater inflow and pollutant loadings delivered to Tampa Bay and its tributaries from the watershed. The diverse sources of these loadings include:

- nonpoint sources,
- point sources, including domestic and industrial inputs and springs,
- atmospheric deposition,
- groundwater, and
- fugitive losses from bulk cargo transfer facilities.

Additionally, an inventory of industrial chemical spills was completed, although nutrients from that source are not included in the overall loading estimates presented in Section 5. Both streamflows and pollutant loadings were calculated for all areas without regard for their relative location within the watershed. For example, loadings for an ungaged area in the headwaters of a drainage catchment were calculated in the same manner as loadings from the downstream-most portion of the basin. This loading assessment does not account for in-stream assimilation, overland flow effects, or other processes that may affect the quality of nonpoint source flows before they discharge into the bay proper. This is typical of watershed assessment loading models, and provides useful information for planning and management purposes.

The freshwater inflow and pollutant loading estimates developed in this work are also to be used as input for the Tampa Bay Box Model project for SWFWMD-SWIM; as inputs for the TBNEP statistical modeling project; and to examine the difference in existing and benchmark loadings to the Tampa Bay estuary and tributary system.

The following describes methods used to calculate estimates of streamflow and pollutant loading from each of the major components. Figure 3-1 illustrates the overall construction of the model, showing inputs, calculation processes, and outputs. For total freshwater inputs and pollutant loadings, empirical data were used to the greatest extent possible, and modeling techniques were used to estimate flows and loadings where measured data were not available.

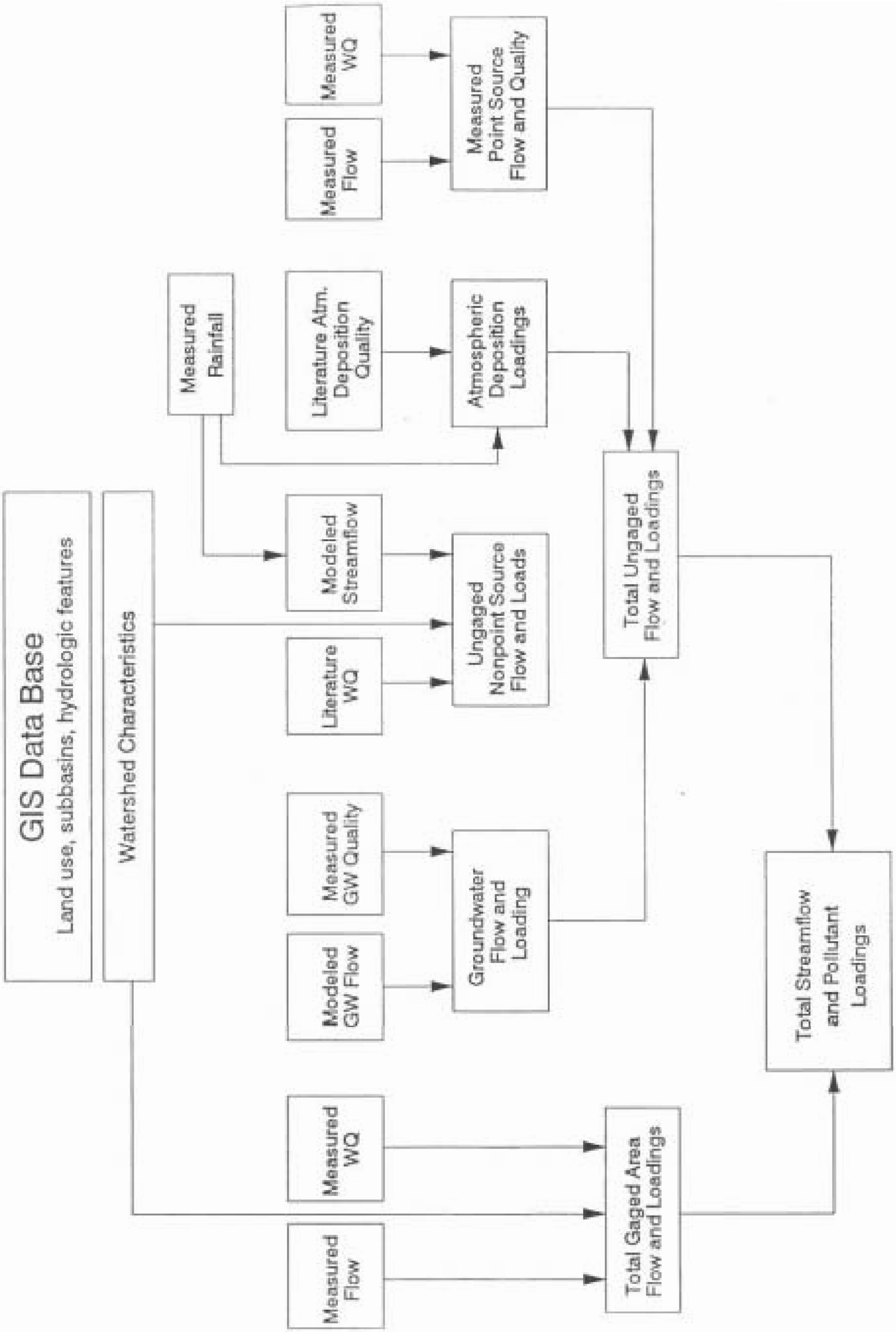


Figure 3-1 Loading model construction

3.1 Nonpoint Sources

TN, TP, and TSS loads for the gaged and ungaged portions of the watershed were estimated using measured data and the empirical model. Nonpoint source loads include streamflow (stormwater runoff and baseflow) and direct overland flow, and were estimated for general land use categories. It should be remembered that nonpoint source loads, as estimated for this study, reflect the quantity and quality of surface water inputs to Tampa Bay as estimated using the best available data. These calculations do not identify the true sources of nitrogen and phosphorus that make up the nonpoint source loads. Atmospheric deposition to the watershed, fertilizer application, and animal waste are all sources of nutrients that may influence the quality of nonpoint sources from any land use. Therefore, the loads attributed to a particular land use in this analysis may be only partially intrinsic to that land use, and partially from other sources and processes.

For example, stormwater runoff originating from a particular land use will exhibit a range of concentrations of TN and TP. The sources of the nitrogen and phosphorus that make up that concentration include both those attributable to the land use itself (e.g., landscape fertilizer for urban, and crop fertilizer and animal waste for agriculture), as well as sources that are unrelated to those specific land use activities (e.g., atmospheric deposition from distant sources). Therefore, although management practices such as stormwater treatment facilities can mitigate the impacts of pollutant loading from specific land uses, it should not be implied that the total pollutant load from that land use is a result of local activities.

3.1.1 Watershed Characteristics

Nonpoint source loads include stormwater runoff and base flow, and enter the receiving water either as streamflow or as direct overland flow. To calculate this loading component, the watershed was divided into gaged and ungaged areas. Gaged areas included all tributary subbasins that drain to a point of measured discharge, such as a USGS stream gage site or a dam. The gaged portion of the drainage area was defined by the most downstream gages in the Tampa Bay watershed. The downstream gages in the Tampa Bay watershed that were used to define the extent of the gaged drainage area, and the agencies responsible for collecting the flow and water quality data, are shown below in Table 3-1.

The ungaged portions of the watershed included the near-coastal areas, and land downstream of all gaging stations. Gaged and ungaged streamflow and pollutant loading calculations were developed using different techniques, as described below. Data used to calculate nonpoint source loads include land use, soil series, and subbasin boundaries.

3.1.2 Gaged Area Streamflow and Pollutant Loading Estimates

The primary method of calculating hydrologic and pollutant loadings from the gaged areas was based on measured flow and water quality data. Primary data sources included USGS for basin-wide streamflow and water quality data; SWFWMD for streamflow and water quality data from the Little Manatee River (Flannery, 1991),

Table 3-1 Downstream Stream Gage Stations

Stream Gage Site Name	Streamflow (Agency/Site Number)	Water Quality (Agency/Site Number)
Lake Tarpon Outfall Canal	SWFWMD/FLO12 S-551)	No data
Rocky Creek	USGS/02307000	EPCHC/103
Sweetwater Creek	USGS/02306647	EPCHC/104
Hillsborough River at Dam	USGS/02304500	EPCHC/105
Tampa Bypass Canal	SWFWMD/FLO13 (S-160)	EPCHC/147
Delaney Creek	USGS/02301750	EPCHC/138
Alafia River at Lithia	USGS/02301500	EPCHC/114
Bullfrog Creek	USGS/02300700	EPCHC/132
Little Manatee River at Wimauma	USGS/02300500	EPCHC/113
Manatee River at Lake Manatee Dam	Manatee County/Lake Manatee Dam	Manatee County/Lake Manatee Dam

Lake Tarpon Outfall and Tampa Bypass Canal (SWFWMD, 1993); the Environmental Protection Commission of Hillsborough County (EPCHC) for water quality data for the Hillsborough River, Alafia River, and Little Manatee River, as well as several smaller tributaries (Boler, 1986; 1988; 1990; 1992); Pinellas County Department of Environmental Management for Lake Tarpon; and Manatee County for flows and water quality at the Lake Manatee Dam. Table 3-1 above summarizes site identification numbers and data sources for the individual water bodies that were used to develop gaged area streamflow and pollutant load estimates.

Monthly average streamflow data for each month for the period of interest were obtained for these most downstream gages within the watershed. These data were used to develop a continuous record of streamflow from the gaged areas. Pollutant loading from the gaged areas for which measured water quality data exist were calculated on a monthly basis, according to the following equation:

$$\text{Pollutant loading for gaged area } i = Flow_i * PC_i \qquad \text{(Equation 5)}$$

where:

$Flow_i$ = Total measured monthly flow for gaged area i

PC_i = Average measured monthly pollutant concentration for gaged area i

Measured flow is the recorded stream flow expressed as volume per unit time, such as cubic feet per second (cfs) averaged over the representative time period (month); *measured concentration* of a pollutant is a monthly average, expressed as milligrams per liter (mg/L); and pollutant loading is expressed as mass per unit time, such as tons per year (tons/year). It should be noted that the loading from the gaged areas includes nonpoint source, point source, atmospheric, septic tank, and groundwater inputs. All these sources contribute to gaged flow and water quality characteristics, and are accounted for in the measured water quality and quantity data.

In addition to this calculation method, streamflow and pollutant loads can be calculated using land use/soil-specific runoff coefficients and land use-specific pollutant concentrations, as conceptually illustrated in Figure 3-2. Nonpoint source runoff generated by an individual land use type within a basin was calculated by prorating the total flow using land use-specific runoff coefficients and the area of that land use type within the basin (Equation 3). To estimate the nonpoint component of stream flow in the gaged areas accurately, point source discharges (the estimation methods for these are discussed below) must be subtracted from the measured flows for the gaged basins to calculate land use-specific flows. The remaining flow equals stormwater runoff plus base flow.

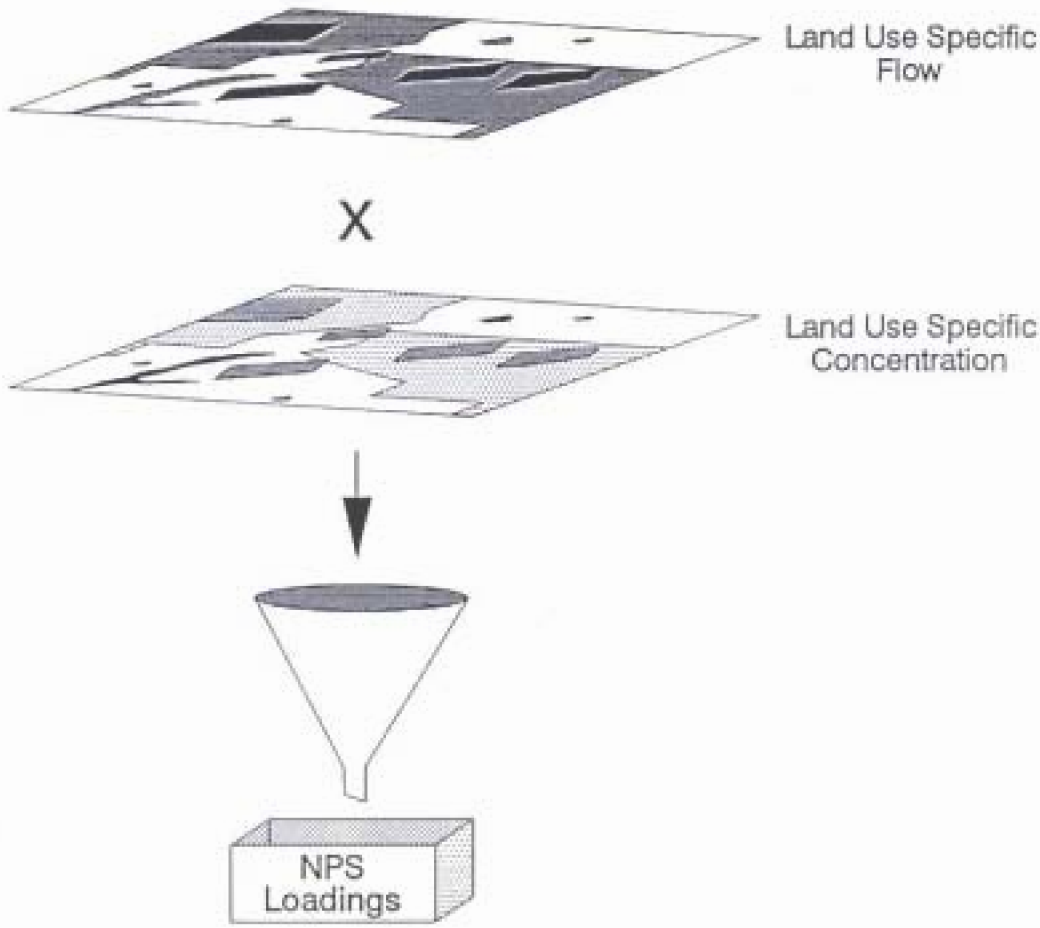


Figure 3-2 Conceptual illustration of nonpoint source loading modeling method.

Using this method, flow was calculated using Equation 1. Nonpoint source pollutant loads for specific land uses were estimated for the desired time period according to the following equation:

$$\text{Pollutant loading for land use } i = Flow_{LU_i} \cdot PC_{LU_i} \qquad \text{(Equation 6)}$$

where:

PC_{LU_i} = Average pollutant concentration for land use i

$Flow_{LU_i}$ = Total flow land use i

This calculation results in the disaggregation of the total nonpoint source flow into flows generated by individual land use types.

An extensive list of regionally-appropriate water quality concentration data for nonpoint source total nitrogen, total phosphorus, and total suspended solids was compiled for this modeling effort, and is summarized and cited in Appendix 4. The values are from a number of stormwater sampling programs and represent averaged values from multiple samples from each program. Because base flow is a component of water sampled in channels during periods of runoff, base flow characteristics are represented in these storm samples, especially those taken on the falling limb of the storm hydrographs.

The status of nonpoint source loadings discharging from wetlands is subject to widely divergent characterization. Wetlands may act as nutrient sinks, sources, or both, depending on the season. These nonpoint source loading estimates use available unit area loading rates, based on numerous field sampling programs completed in the central and south Florida region. These monitoring data were collected under a variety of conditions and reflect diverse sampling situations, which is appropriate for use in an analysis of this scale.

However, accurately tracking the various nutrients measured in outflow from wetlands is difficult. The numerous sources, pathways, transformations and fates of nitrogen and phosphorus in wetlands has been and is a subject of widespread research for many years. Because of the site-specific nature of these processes, the characterization of loadings from wetlands should be regarded with caution. To address the potential effect that this uncertainty may have on overall nutrient loading estimates, a sensitivity analysis was completed in which the wetland loadings for TN, TP, and TSS were set equal to zero, and are discussed below.

To test the goodness of fit of the predicted pollutant loads, the predicted nonpoint source loadings were compared to measured loads using water quality data from the EPCHC water quality monitoring program and flow data from USGS. The basins examined included the Alafia River, Little Manatee River, Bullfrog Creek, and Brooker Creek and covered the time period of 1985 through 1991. Figures 3-3 and 3-4 present the relationship for TN and TP loadings, respectively. There was good agreement between the predicted and measured total nitrogen loadings, with an r^2 of 0.90. In comparison, the relationship between predicted and measured total phosphorus loadings had an r^2 of 0.62. There was clearly a negative bias in the predicted total phosphorus loadings, especially in the high range of observed loadings. This was largely due to negative bias in the total phosphorus loadings for the Alafia River (Gage 02301500), and is possibly the result of point source loadings that are reflected in the measured loadings but not included in the nonpoint source predictions.

3.1.3 Ungaged Area Streamflow and Pollutant Loading Estimates

Streamflow and pollutant loadings for the different land use types in the ungaged basins were calculated using the methods outlined above. Parameters were computed for the surface water hydrology model using data from gaged basins as described above, and the model was then used to predict surface water hydrology for the ungaged basins. Streamflow and pollutant loadings from nonpoint sources were calculated for each major drainage basin and bay segment by summing the contributions from the gaged and ungaged areas.

3.2 Point Sources

Point sources of flow and pollutant loadings are defined as discharges that originate at a discrete location, such as from a pipe or a small, definable land area (such as for land application of treated wastewater effluent). The two traditional categories of point sources are known as "domestic" and "industrial." Domestic sources include publicly and privately owned wastewater treatment plants. Industrial sources include dischargers of process water and other effluent not categorized as domestic sewage.

Domestic and industrial point sources identified for this study are shown in Appendix 5, and include all direct surface discharges, and all land application discharges within the ungaged area, with a permitted average daily flow of 0.1 million gallons per day (mgd) or greater.

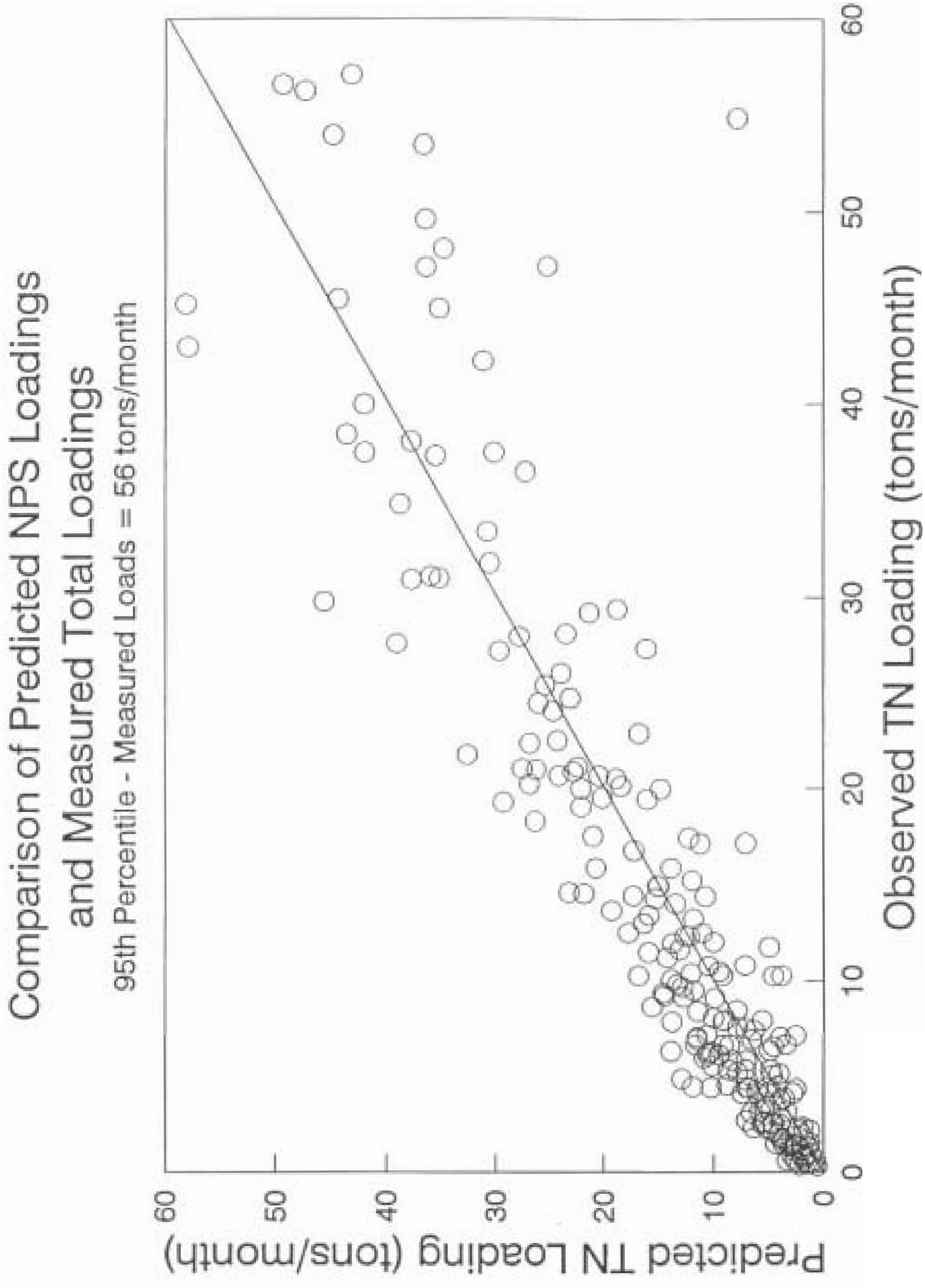


Figure 3-3 Predicted and observed loads for total nitrogen.

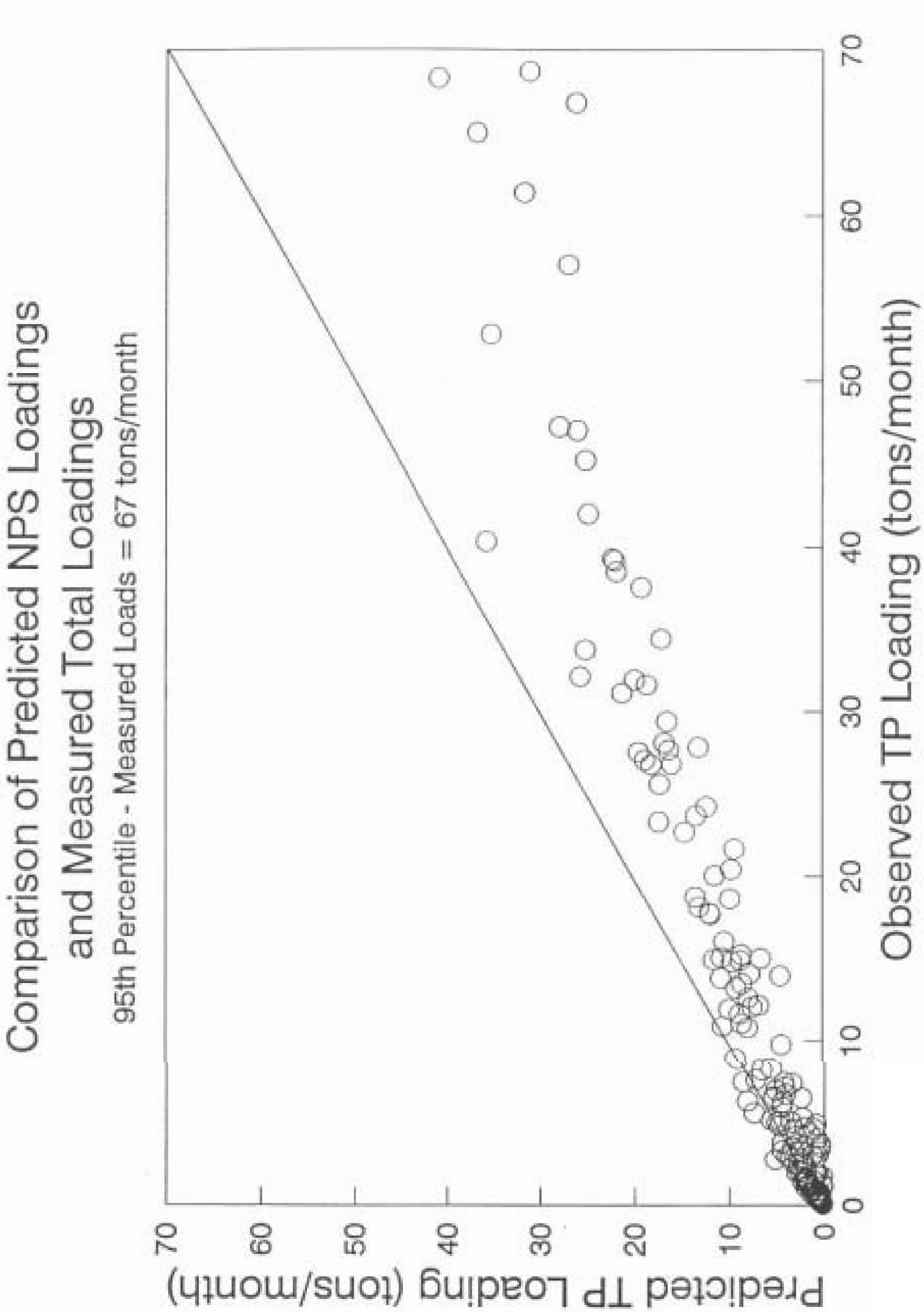


Figure 3-4 Predicted and observed loads for total phosphorus.

Although not commonly classified as such, springs are identified as a third category of point sources for this work. Springs can be very important both as a source of freshwater inflow, and nutrient loading (most commonly nitrate). For this analysis, fugitive losses from bulk material loading docks were classified separately.

3.2.1 Domestic and Industrial Sources

3.2.1.1 Data Sources and Quality Control

Domestic and industrial point sources were identified by reviewing Florida Department of Environmental Protection (FDEP, 1992) point source discharge permit conditions and monthly operating records (MOR). These records are located in FDEP's Tampa and Tallahassee offices. Also, U.S. Environmental Protection Agency's (EPA) National Pollution Discharge Elimination System (NPDES) Major Discharger data base provided additional data for industrial sources (AScI, 1993(a)). In addition, the EPCHC (1993) maintains readily-available copies of FDEP records for facilities in Hillsborough County. A data base of domestic point source discharge information was developed, listing monthly discharge rates and total nitrogen, total phosphorus and total suspended solids concentration data. Both surface water dischargers, and facilities with land application of effluent were included. Monthly data from a total of 39 major domestic point source dischargers were included. These represent all facilities with an average daily flow of 0.1 million gallons per day (mgd) or greater that either 1) discharge effluent to surface waters within the Tampa Bay watershed, or 2) are located in the ungaged portion of the watershed.

Most MORs for domestic wastewater treatment plants had complete records, with facilities reporting flow rate and concentrations for TN, TP, and TSS on a monthly basis. Industrial records were very inconsistent, with most facilities lacking complete records. AScI Corporation (1993(a)), through work being completed for SWFWMD-SWIM, developed a data base of major industrial point source discharges in the Tampa Bay watershed. Monthly records for 32 major industrial point sources, all with surface discharge of effluent (shown in Exhibit 5), were used for the calculation of nutrient loading estimates.

The data bases were subjected to quality control measures to ensure that the most accurate flows and concentrations obtainable were used in the loading estimates. The entries were scanned for incongruous data points. Obvious outliers, (such as flows of two or three orders of magnitude higher than the design capacity of the facility), were removed from the record. Attempts were made to locate sources of valid data to replace missing or invalid values. If data gaps could not be filled with actual recorded data, the available data were averaged, and the averaged values were used.

In some cases, a form of nutrient other than total nitrogen or total phosphorus was reported. Many facility operators were contacted to verify their facility's data. If the data were accurate, then one of two methods was used to complete the data base. For example, if both total nitrogen and nitrate nitrogen were recorded for some months at a facility, but only nitrate nitrogen was recorded for most months, the average ratio of nitrate to total nitrogen was calculated for those months with both values. The resulting ratio was applied to the other months, resulting in an estimate of total nitrogen for those months. These entries were flagged in the data base as estimated values.

If no data for a certain parameter were available for a facility and it was known or suspected that loadings of that chemical did occur, then other, similar facilities were examined. Typical or averaged data from these facilities were used to fill data gaps if no other source of information was available. This method was chosen as an alternative to showing missing data for loads from major point sources.

All flow and nutrient data for the period 1985-91 were obtained for the inventoried facilities. However, the loading estimates presented in Section 5 reflect only data from 1991. This represents the most current state of point source discharges, accounting for any improvements in treatment method that may have occurred since 1985.

3.2.1.2 Estimation of Point Source Loadings

Existing condition point source loading estimates were developed as overall average monthly loads, to reflect the most recent upgrades to treatment facilities and disposal methods and are summarized in Section 5. Point source loads were also estimated as a time series of monthly values for the period January 1985 through December 1991. These time series will provide input to the TBNEP statistical nutrient-chlorophyll model and the SWIM box model, as discussed in Section 1.

Surface Discharge

Many of the inventoried facilities utilize direct surface discharge for effluent disposal. Surface water inputs from point sources were estimated for both the gaged and ungaged basins of the watershed, expressed as a volume per unit time, such as millions of gallons per day (mgd). The flows from each point source were assigned to the subbasin that receives the discharge, allowing the aggregation of point source flows for each major drainage basin and each bay segment. All of the effluent released via surface discharge was assumed to reach the Tampa Bay system.

Estimates of point source pollutant loading for surface water discharges were calculated by multiplying the flow (expressed as volume per unit time, such as mgd), by the reported concentration (mg/L) for the pollutant of concern. With appropriate conversion factors, this calculation yields a mass per unit time, such as pounds per month of pollutant (TN, TP, TSS).

Land Application

Treated effluent from domestic wastewater treatment plants is frequently discharged onto the land, most commonly by either spray irrigation or in percolation ponds. The applied effluent either evaporates, is taken up by vegetation, becomes surface runoff (generally a very small component of the total volume), or infiltrates to the water table. Therefore, pollutant loadings that reach the bay generally do so via groundwater. In this loading analysis, effluent loads are calculated separately from groundwater loads. Different water quality information was used in the calculation of both of these inflow pathways. Measured groundwater quality data from wells not located adjacent to a known pollution source were used for the groundwater loadings.

Land application loadings were estimated using recorded effluent quality data from specific facilities, with "typical" reduction rates applied to the nitrogen and phosphorus once in the environment. These reduction rates, discussed below, account for uptake of nitrogen and phosphorus in the environment prior to the effluent flow reaching the receiving water of Tampa Bay.

Calculation of Loadings from Land Application

The determination of the amount of land-applied effluent that is delivered to the Tampa Bay system was not as straightforward as for surface discharge loadings (Anderson et al., 1991; 1993; Cherry et al., 1973). Both the hydraulic inflow and the pollutant loadings from the effluent that reaches Tampa Bay are reduced from the amount that leaves the treatment plant because of a variety of natural processes. Because potential nutrient loadings from land application (reuse) is quantifiable, and attributable to a definable area, this source of nitrogen and phosphorus is accounted for separately from overall groundwater loadings, as discussed below.

Because a portion of the point source effluent discharged as land application is lost due to evaporation, transpiration, and infiltration, inflow estimates were corrected for this loss. Casseaux (1985) estimates that approximately one-quarter (26%) of rainfall falling in Pinellas County reaches Tampa Bay - either as streamflow, direct runoff, or groundwater flow. Based on these findings, it was assumed that 26% of the hydraulic load of treated wastewater effluent from land application facilities reached the bay. To account for variability within the watershed, a range was estimated of 15% and 35% of the total discharged land application flow to be delivered to the bay.

In addition, TN, TP, and TSS concentrations were assumed to be reduced through assimilation, uptake, and filtering of the effluent during its path from the point of discharge to the receiving water. These values were developed as a result of the review of numerous references on the behavior of nitrogen and phosphorus in the environment.

- Nitrogen

Land application of wastewater effluent can utilize percolation ponds or spray irrigation facilities. Percolation ponds behave much like septic tank systems, (on-site wastewater treatment systems, or OWTS) in that the effluent from the pond is discharged directly to the unsaturated zone above the water table. Sprayed effluent has the benefit of increased evaporation, volatilization of ammonia nitrogen, vegetative uptake, and chemical conversion from bacteria in the soil. These processes can greatly reduce the amount of nitrogen remaining in the effluent when it reaches the shallow groundwater.

In the infiltration system, effluent-borne nitrogen travels downward through the unsaturated zone towards the water table. Volatilization, adsorption, mineralization, biological uptake, and denitrification occur at the land surface and in the root zone. However, the major transformation process in the unsaturated soil zone is nitrification. During this process, aerobic bacteria transform organic and ammonia nitrogen into nitrate. The nitrate ion is very soluble, and moves freely with the groundwater flow (Otis et al., 1993; Cantor et al., 1986). These processes are illustrated in Figure 3-5. Although nitrification does change the form of nitrogen, it does remain in solution. If conditions favorable for denitrification are present, up to 20% of the nitrate can be volatilized to elemental nitrogen gas during the infiltration period (Otis et al., 1993). Volatilization and biological uptake rates are generally higher for sprayed effluent because of prolonged exposure to the atmosphere and vegetation. Because of its solubility and anionic nature, nitrate is very stable in the aqueous environment and can migrate great distances in groundwater with little transformation or attenuation.

- Phosphorus

In contrast, phosphorus is usually effectively retained in soils, with only low concentrations typically reaching the water table (Cantor et al., 1986). Many monitoring programs have documented only minimal migration of phosphorus through the subsurface media. In the unsaturated zone, phosphorus is found in proportions of approximately 85% ortho-P and 15% organic-P. As shown in Figure 3-6, at low concentrations phosphorus is subject to sorption to carbonate minerals. At high concentrations, phosphorus may precipitate, forming a variety of relatively insoluble compounds. This constrains the migration of phosphorus in groundwater under most circumstances. However, under low-term or high application rates, the retention capacity of the soils may become exceeded. Under these conditions, phosphorus may migrate within the groundwater environment (Otis et al., 1993).

- Suspended Solids

Subsurface migration of suspended solids is constrained mainly by physical process. Solids that are discharged with the treated effluent are mainly retained at the soil surface, although some migration may occur under high flow conditions or if the soils are very coarse and lacking in organic material.

Loading Rates for Land Application of Nutrients

Based on these chemical characteristics and a review of the literature, it was estimated that between 70 and 95% of the TN was removed for spray irrigation facilities. The City of St. Petersburg wastewater treatment facilities are operated so as to maximize the ammonia content of nitrogen in effluent.

A high ammonia content increases the rate of volatilization and plant uptake of nitrogen from the effluent. Therefore, a nitrogen attenuation rate of 95% was used for St. Petersburg plants. A nitrogen attenuation rate of 90% was used for all other spray irrigation facilities because much of the nitrogen in the sprayed effluent is in a form less available for volatilization and plant uptake (nitrate).

Also, between 50% and 70% of nitrogen in percolation ponds was removed, between 70% and 95% of the TP was removed, and between 70% and 95% of the TSS was removed. For the computations described below and the results presented in Section 5, the low end of the range of loadings (highest *removal) was used. Literature references used to develop these TN and TP* removal efficiency rates are summarized below, and listed in Section 6.

Therefore, to estimate nutrient loads from domestic wastewater land application facilities, the following computational steps were used. The hydraulic loading from land application, (the total flow rate of effluent discharged from a treatment plant) was multiplied by 0.26 based on the findings of Casseaux (1985). The concentrations of TN, TP, and TSS, were multiplied by the higher estimates of chemical removal. The removed fraction

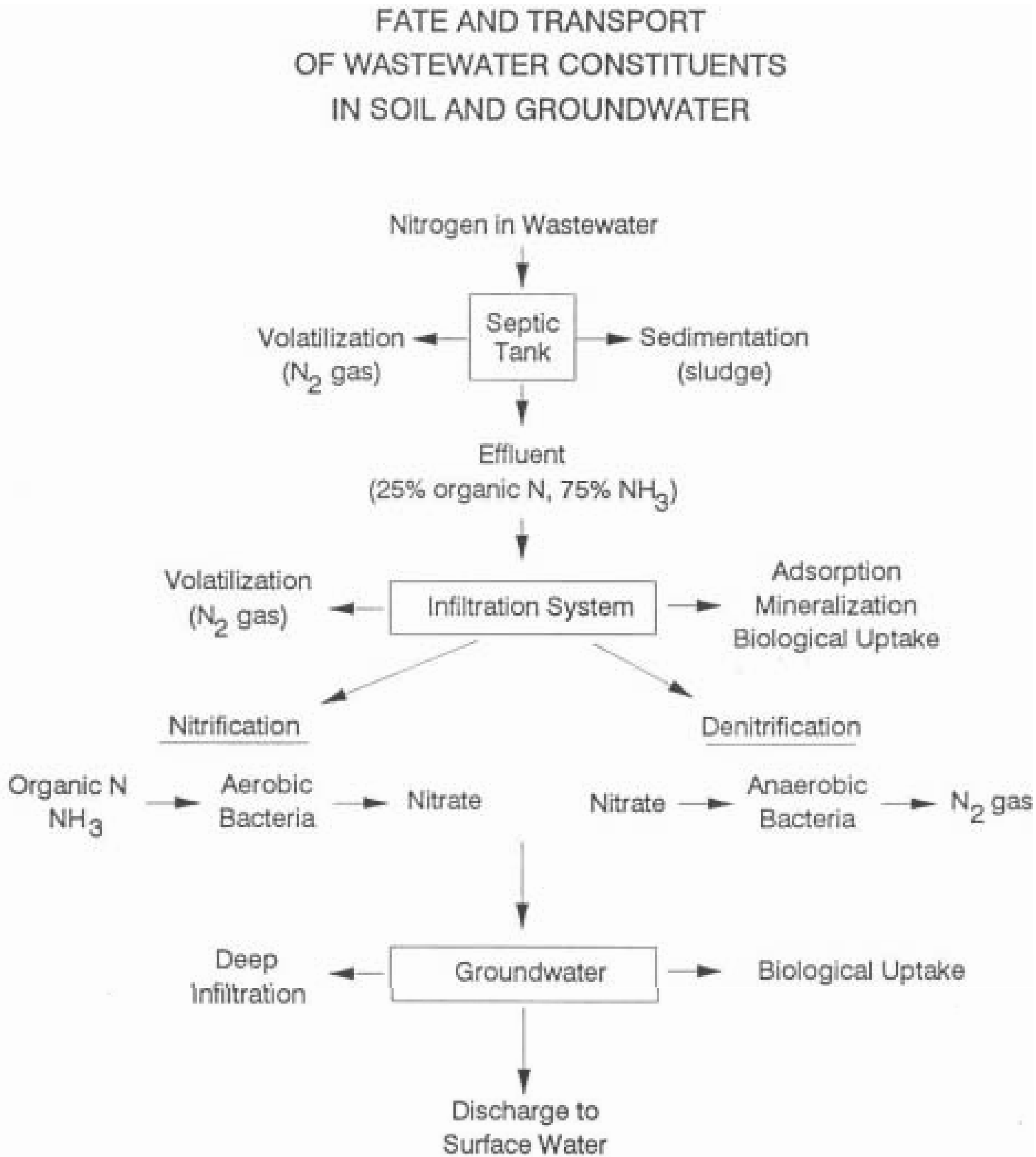


Figure 3-5 Fate and transport of wastewater constituents in soil and groundwater - nitrogen.

FATE AND TRANSPORT OF WASTEWATER CONSTITUENTS IN SOIL AND GROUNDWATER

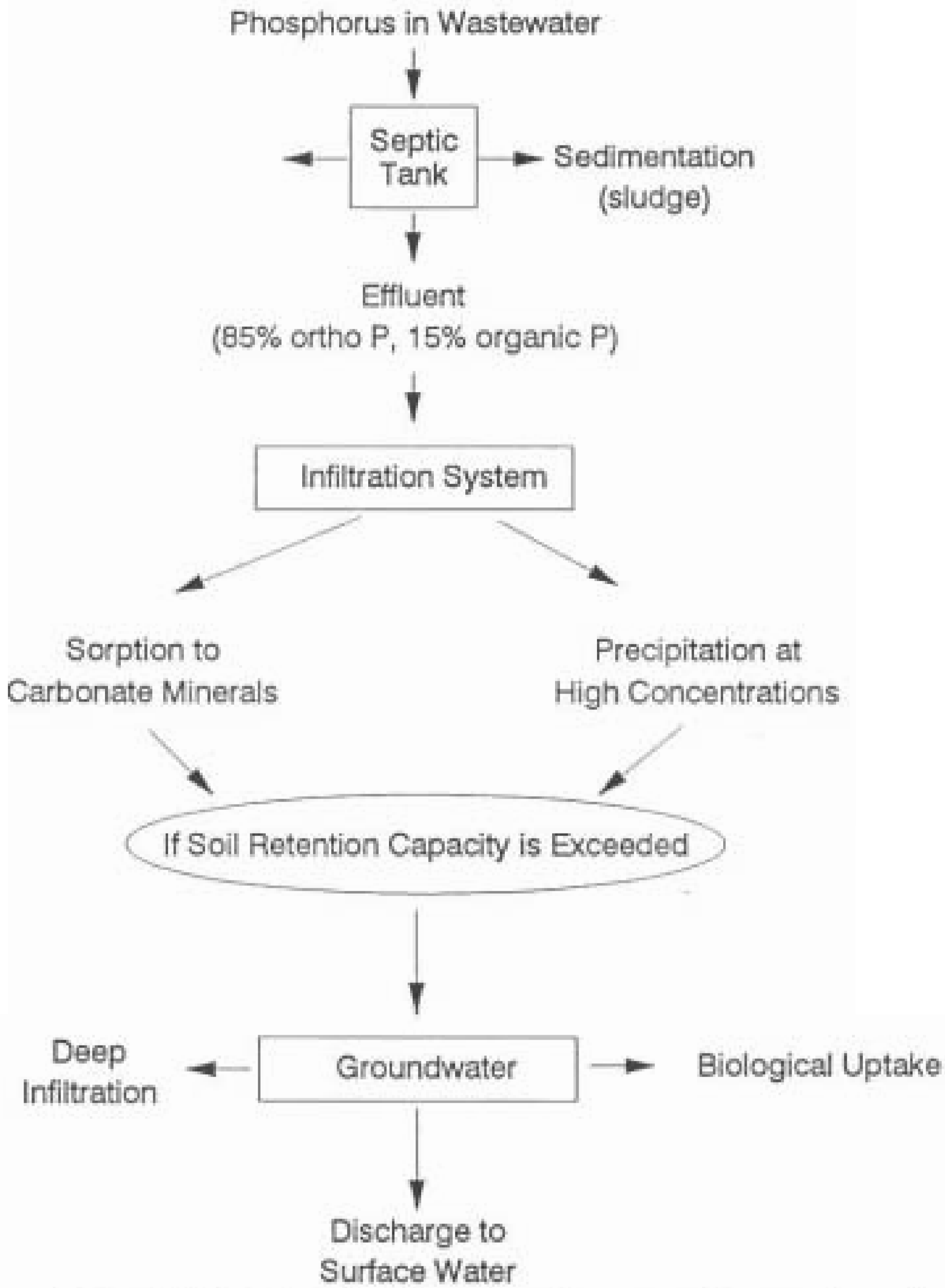


Figure 3-6 Fate and transport of wastewater constituents in soil and groundwater - phosphorus

was subtracted from the total. For computational purposes, this is the equivalent of multiplying the "end of the pipe" monthly average concentrations of TN by the attenuation factor (0.9 to 0.95 for spray irrigation, 0.7 for percolation ponds), TP by 0.95, and TSS by 0.95. The point source loading results shown in Section 5 include only 1991 data for surface discharges, to account for improvements to treatment or disposal components of the point sources made during the 1980's, as discussed above.

One pollutant source that may be included with point source loading estimates is septic tank (OWTS) loadings. OWTS are regulated to minimize the potential for groundwater and surface water contamination, but site specific conditions or lack of maintenance leading to failure of the OWTS may produce locally significant pollutant loadings. Although domestic waste loads for the benchmark period were estimated as originating from septic tanks as described in Section 4, no explicit accounting for septic tank loads from the existing period was completed. However, it is assumed that septic tank effects are implicitly accounted for in the gaged portion of the watershed by use on measured streamflow and water quality data.

As described above, the separation of nonpoint and point sources of water in the measured flow data were necessary whenever estimates of the nonpoint source component of streamflow were desired. In these cases, the point source flow estimate was subtracted from the measured flow. Whenever the regression model was used to estimate flows for either gaged or ungaged areas, the point source flow was added to the model estimates of nonpoint source flow to provide estimates of total streamflow.

Assumptions for Land Application Loading Calculations

TN, TP, and TSS loads to Tampa Bay were estimated for existing condition point source facilities with land application of effluent. For these estimates, it was assumed that not all of the nutrient and solids loads (loads) that were applied to the land, were delivered as loads to the bay. Loads were calculated based on a reduction to both flows and constituent concentrations. The following ranges of reduction factors were developed:

TN (spray irrigation)	: 70 - 95% reduction
TN (percolation pond)	: 50 - 70% reduction
TP (all)	: 70 - 95% reduction
TSS (all)	: 70 - 95% reduction
Flow (all)	: 65 - 85% reduction

TN, TP, and TSS reductions were based on literature values for nutrient behavior in the subsurface environment and local groundwater monitoring data. General assumptions include:

- Recorded monthly values for domestic effluent for facilities with land application were used as the "influent" value.

- Initial concentration reductions result from above-ground and root zone processes, followed by downward migration through the unsaturated zone, to the water table.

- Some additional removal of TN, TP, and TSS may occur during waste stream movement towards the receiving water (surface water), through the surficial aquifer. However, this additional removal is thought to be relatively small, so there was no accounting for varying distances of effluent travel among individual sources.

- Removal rates for nitrogen in effluent are higher for spray irrigation than for percolation ponds because of enhanced volatilization and plant uptake that occurs with spray facilities. The City of St. Petersburg wastewater treatment plants operate to maximize the ammonia proportion of nitrogen in the effluent. This enhances plant uptake and volatilization of nitrogen, and supports the estimated 95% removal rate calculated using monitor well data, as discussed in Appendix 6.

Literature References

Several references were reviewed to determine a range of TN, TP, and TSS removal rates and efficiencies for domestic waste effluent. Summaries of findings or excerpts of these studies listed below:

Reichenbaugh et al. (1979) - TN concentrations were shown to be reduced by 50 to 100%, and TP by 15 to 93% in samples from some monitoring wells downgradient from a domestic spray irrigation site in St. Petersburg, Florida. Other monitor wells at the site yielded samples showing no increase in TN concentrations.

Yurewicz & Rosenau (1986) - Sampling monitoring wells downgradient from a domestic spray irrigation site in Tallahassee, Florida found TN concentrations were reduced by 33 to 80%, and TP by 100% in samples from wells downgradient from the application site.

Franks (1981) - A review of spray irrigation sites in Florida found that at a spray irrigation site in Tarpon Springs, both TN and TP had 90% removal after

900 feet of travel. A site in Lakeland showed TN concentrations reduced to background levels after 8 feet of travel, and TP reduced to background levels after 4 feet of travel. A site in Eustis showed 0% TN removal after 4 feet of travel, and TP removal of 50% after 4 feet of travel.

Martin (1990) - This model septic tank ordinance, produced for SWFWMD/SWIM states that typical TP removal rates can vary from 85 to 95%, and that TSS reduction is typically 50 to 60%.

Cantor et al. (1986) - Reports 20 - 35% as typical removal rates for TN in the soil unsaturated zone, on a nationwide basis. This removal rate does not account for above-ground processes such as volatilization and biological uptake by plants.

Otis et al. (1993) - States that nitrification is the major process that transforms nitrogen in the subsurface environment. Because the resulting nitrate is very soluble and chemically stable, very little transformation occurs once the water table is reached. He states that (for OWTS), "...it is usually assumed that all the nitrogen applied to subsurface wastewater infiltration systems ultimately reaches the groundwater." However, denitrification can be a significant process if anaerobic conditions exist, resulting in up to 20% reduction in nitrate levels within the soil layers, especially in fine-grained systems of clays and silts.

Postma et al. (1992) - Lists OWTS TN reduction rates as low, typically 10%, again on a national scale and not accounting for above-ground and root zone processes.

Camp, Dresser & McKee (1992) - Assumes 90% reduction in both TN and TP concentrations for land application of effluent in Sarasota Bay watershed.

Analysis of City of St. Petersburg Reuse Monitor Wells

The City of St. Petersburg Public Utilities Department maintains and monitors a network of monitor wells located at selected spray irrigation reuse sites. Water quality samples from these wells provide data that are used to determine what, if any, impact the reuse water has on local groundwater quality. An analysis of monitoring results was completed to determine if any increase in nitrogen or phosphorus in groundwater should be attributed to the application of reuse water. This is an empirical means of estimating nitrogen removal rates for nutrients introduced into the environment through the application of reuse water. A summarization of the analysis and results of the monitor well data is presented in Appendix 6. The nutrient removal rates obtained from that analysis are used in this loading analysis, as described above.

3.2.2 Springs

Although not usually identified as point sources, springs have been so classified for computational purposes in this work. Springs identified as significant point source discharges in the Tampa Bay watershed include Crystal Springs, Sulphur Springs, Buckhorn Springs, and Lithia Springs. Other springs do exist in the watershed, but have relatively small discharges and were not considered in this loading analysis. As with domestic and industrial point sources, recorded flows and water quality data were used to estimate freshwater inflow rates and pollutant loadings. The methods used to calculate flows and pollutant loadings from springs follow those described above for other point sources. Average TN, TP, and TSS concentrations were multiplied by average monthly flows to yield monthly TN, TP, and TSS loading.

Spring discharge data were obtained from USGS, including site 02302000 at Crystal Springs, site 02306000 at Sulphur Springs, site 02301695 at Buckhorn Springs (Buckhorn Creek), and site 02301600 at Lithia Springs. Crystal Springs is located in a gaged basin within the Hillsborough River watershed and its flow was accounted for by the downstream gage. Buckhorn and Lithia Springs (tributary to the Alafia River), are themselves gaged, but are not within any other gaged areas. Likewise, Sulphur Springs is gaged, but is not in the gaged portion of the Hillsborough River. Therefore, these three springs were treated as direct surface discharge point sources. Water quality data from USGS data reports and SWFWMD (DeHaven, 1991; Jones, 1993) were used to develop these flow and loading estimates. For these four springs, only periodic flow and water quality data were available. Most sites had four or less discharge and water quality records per year. To estimate monthly flows, water quality values for the period 1985 through 1991 were averaged, and the average value was used. Discharge values were estimated by linearly interpolating between the recorded flow values.

3.3 Atmospheric Deposition

Atmospheric deposition is that fraction of the total pollutant load delivered to a receiving water body from the fallout of airborne pollutants. This includes input from both rainfall (wetfall) and airborne (dryfall) pollutants. Major sources of atmospheric nutrients include stationary sources such as power plants and other industries, and mobile sources, mainly automobiles (Molesch, 1991). Natural sources of atmospheric nutrients are not well quantified, but are believed to be less significant than other sources. Both phosphorus and nitrogen are transported and deposited to water bodies via atmospheric routes.

For these loading estimates, only nutrients delivered to the open water estuary were accounted for as atmospheric input. Atmospheric deposition to the watershed is a major contributor of nutrients in stormwater runoff, but is difficult to quantify.

Precipitation volume (rainfall depth times the open water area of the bay) and pollutant concentration data were used to estimate pollutant loads delivered directly to the estuary via atmospheric deposition. Loadings were calculated on a monthly basis for each bay segment by multiplying the precipitation volume (expressed as volume per unit time) by the pollutant concentration (expressed as mg/L) to obtain a wet deposition load.

Pollutants are also delivered to a watershed via dry deposition (dryfall). Accurate estimates of dry deposition are extremely difficult to obtain. A generally accepted approach to estimating total atmospheric loading is to multiply the wet deposition loading by a factor which accounts for the fraction of the total deposition load which is delivered as dry deposition. Regional estimates of the ratio of dryfall to wetfall vary from 0.30 (CH2M Hill, 1992) to 2.04 (Environmental Science & Engineering, 1987). The Florida Power Coordinating Group (FCG) sponsored the Florida Acid Deposition Study (FADS), a multi-year (1980-1985) sampling and modeling program. Their results, for several sites in Florida (including Hillsborough County), suggest that wet to dry deposition ratios within Florida fall within a fairly narrow range (1.4-2.04), with the Hillsborough County ratio among the higher values (2.04). Because this value was determined through a long-term monitoring program, and is for local conditions, a wet to dry deposition ration of 2.04 was used. Therefore, measured wetfall concentrations were multiplied by 3.04 to account for the dry deposition component, yielding an estimate of total atmospheric deposition.

Data for wet deposition concentrations were obtained from two sources. Because field data collection is very difficult for this pollutant source, only data sets with a high level of quality control and confidence were used. One of these is the National Atmospheric Deposition Program (NADP), which continues to monitor rainfall quality across the country. Monthly values for TN and TP for the period 1985 through 1991 were obtained. Data from the NADP sampling site located closest to Tampa Bay (Verna Wellfield, in south central Manatee County) were used. The other source of rainfall quality data were the Tampa National Urban Runoff Study (NURP). Data from four sites in Tampa were collected during the mid 1980's (Metcalf & Eddy, 1983).

The values for wetfall (rain) loading from the two sources were compared. NURP *reported a range of TN values of 0.1-7.27 mg/L, with a mean of 0.99 mg/L.* The range for TP concentrations was reported in NURP as 0.01-0.62 mg/L, with a mean of 0.195. The mean value represents an average concentration of 8-10 events at each of the four sampling sites. NADP does not sample for phosphorus, so no data for that parameter exist from that program. However, the NADP mean total nitrogen concentration of 0.86 mg/L compares very well with the NURP mean concentration, and was therefore used. The NADP mean nitrogen value is the mean monthly value for all storms occurring at the Verna Wellfield site between 1985 and 1991.

3.4 Groundwater

Groundwater provides another source of freshwater and nutrient loading to Tampa Bay. The surficial (water table) aquifer, intermediate aquifer, and Floridan aquifer all contribute freshwater to Tampa Bay. Estimates of groundwater inflow rates were obtained from Hutchinson (1983) and Brooks et al. (1993). Flow estimates for both investigations were calculated using Darcy's equation (Walton, 1970), a well-recognized analytical method for estimating groundwater flow.

These reports provide estimates of wet and dry season groundwater inflow to Tampa Bay. Brooks et al. also estimated seasonal nutrient loadings to the bay. Results of Hutchinson and Brooks were graphically displayed as arrows showing general inflow zones to the bay, with the arrows sized proportionally for the amount of flow, which was provided in numeric form. For the purposes of this model these estimates were apportioned to each of the bay segments.

Only groundwater inflow that entered the bay directly from the shoreline or bay bottom was considered. Groundwater inflow to streams in gaged portions of the watershed was accounted for in the measured streamflow data. Groundwater inflow to streams in the ungaged portion of the watershed was not included in this analysis.

This summary of Floridan aquifer inflows used information from both referenced studies, and included data from 1978, 1985, and 1990. Surficial aquifer data from 1982 were used. These were stated to be the most recent available data suitable for these calculations (Brooks et al., 1993).

Using data on TN and TP concentrations for groundwater (DeHaven, 1991; Jones, 1993; Watson, 1988; Kelly, 1988(a and b); Jones, 1990) and the flow estimates, the groundwater loading component for each aquifer was estimated. For these loadings, the seasonal estimated groundwater flow rate (expressed as volume per unit time such as million gallons per day) was multiplied by the overall average pollutant concentration (mg/L). The resulting loads were expressed in mass/time, such as kg/month or tons/year on a monthly basis for wet and dry seasons. Estimates of groundwater inflows were in the range of two orders of magnitude lower than the other major sources. Calculations summarizing estimates of existing groundwater inflows and TN and TP loadings are shown in Appendix 7.

3.5 Fugitive Losses of Fertilizer

Fugitive losses from loading docks at port facilities constitute another source of industrial nutrient loading, and is classified as a point source for this analysis. In particular, bulk phosphate fertilizer is subject to product losses ("shrinkage") during its transfer from land carrier to storage facility, and onto vessels for shipping. Product is lost both through washing into the bay with stormwater runoff, and via fugitive dust. Fugitive losses occur at facilities at the Port of Tampa, in the Coastal Hillsborough Bay basin, and at Port Manatee, in the Coastal Lower Tampa Bay basin.

Estimates have been made of the volume of fertilizer lost during these material transfers, expressed as a percentage of the shipped tonnage. In response to initial fugitive emission loading estimates (AScI, 1993(b)) based on a previously developed loss rate of 0.05% (Cardinale and Dunn, 1991), IMC-Agrico, Inc. submitted a detailed estimate of losses of phosphate rock and fertilizer products from their Tampa Bay facilities at Port Redwing and Big Bend (IMC-Agrico, 1994). Using annual data for tons of phosphate rock and fertilizer products shipped from the Port of Tampa and Port Manatee, refined estimates of fugitive emission losses were completed (Morrison and Eckenrod, 1994). These estimates suggest an overall loss rate of 0.02% of product shipped.

Short-term nutrient loading can also occur in the event of a major spill of fertilizer product or processing chemical. Although major spills are rare, significant amounts of nitrogen or phosphorus can enter the bay in their event. An inventory of reported spills of nutrient-rich material was completed, and is summarized in Appendix 15. Two major potential spills were reported during the time period 1985-91, one of ammonia and one of phosphoric acid. The spill data were not used in the average annual loading estimates discussed in this report. However, they are included in a time-series analysis of total TN and TP loading used as input for the TBNEP statistical model and the SWIM box model.

4.0 DEVELOPMENT OF ESTIMATES OF NUTRIENT AND SUSPENDED SOLIDS LOADINGS FOR BENCHMARK CONDITIONS

As discussed in Section 1, the benchmark period includes the years 1938-40, and was used as a reference point from which to compare changes in freshwater inflow and pollutant loadings from existing levels. As with the existing condition analysis, benchmark freshwater inflows and pollutant loadings were estimated for all major sources, and are summarized on a bay-wide, bay segment, and major drainage area basis. Data and methods used to derive these estimates are described below.

4.1 Nonpoint Sources

Nonpoint source inflows and loadings were calculated in much the same way as for existing conditions. Because current rainfall was used for the benchmark calculations, period streamflow data are not appropriate for use, and the watershed must be analyzed as an ungaged area. Freshwater inflow and pollutant loading calculations are developed using techniques similar to the existing conditions analysis, as described below. Current precipitation data were used to generate nonpoint source flows for the benchmark period so that a direct comparison could be made to changes in flows and loadings, having removed any variation attributable to changing rainfall patterns.

4.1.1 Subbasin Delineation

The watershed characteristics data base used to calculate nonpoint source loads includes land use and subbasin boundaries. Major subbasin boundaries for the Tampa Bay watershed have sustained only minor local changes, with few exceptions, so that the current GIS coverage was also used. Minor subbasins boundaries, in contrast, have undergone extensive changes over the past fifty years. Examples include the coastal streams in northwest Hillsborough County and central Pinellas County. However, these drainage divides do not impact this analysis, which is on the bay segment and major drainage basin scale.

4.1.2 Land Use

Period land use information was developed from aerial photographs produced by the SCS during 1938-40 (SCS, 1940) which were obtained from the National Archives. The areal distribution of each of four major land use categories (urban, agriculture, water/wetland, and undeveloped land - "forest") was determined. These four land use categories were chosen because all of the FLUCCS and aggregated land use types could be assigned to one of these four major categories by virtue of their runoff quantity and quality characteristics. Additionally, the level of detail in the aerial photographs was not sufficient to delineate more than these four groups without introducing substantial uncertainty. Therefore, "urban" land included all residential, commercial, industrial, mining, and other developed or impacted areas. "Agriculture" included only groves and row crops. Because pasture and rangeland were less managed in the benchmark period, these areas were included with the undeveloped land, "forest." "Forest" included all upland areas that did not fall into the urban or agriculture categories. "Water/wetland" included all freshwater open water bodies and wetlands.

The benchmark land use coverage for the entire watershed was estimated using a stratified systematic sample. The strata were based on major land cover patterns observed on the period photographs, and were recorded in a GIS coverage. Estimates of percent coverage of each of the four land use categories were computed from a systematic grid sample for all areas. The grid spacing was chosen subsequent to an analysis that was completed to assess changes in the precision of estimates of land use percent area that would result from different sampling intensities (grid spacings). In this analysis, a base grid of one kilometer (1 km) square was overlaid on an aerial photograph of a region of the watershed. The test area, near the eastern limits of the 1940 Tampa urban area, had a wide range of land use type areas. This ensured an appropriate grid spacing for all portions of the watershed. The percent land use of the four major categories (urban, agriculture, water/wetlands, and forest) for this region was estimated by sampling at each node of the grid and calculating the proportion of samples within each land use type.

The precision of estimates based on a 2 km grid was assessed by estimating percent land use using only the grid nodes from the base grid that are 2 km apart. This resulted in four different sets of node points (realizations) of the 2 km grid. The range of estimates for each land use type was calculated based on the four realizations. This analysis was repeated for 3 km and 4 km grids, as shown on Figure 4-1 resulting in 9 and 16 realizations, respectively. Ranges of land use estimates were compared across grid sizes.

The results indicate that precision decreases as grid size increases. For all land use types, precision decreased significantly as grid spacing increased from 2 km to 3 km. The greatest reduction can be seen in Figure 4-1 for the forest land use, which had the largest land area coverage in the test area. Reduction in precision between the 3 km to 4 km grid was not as drastic. Therefore, a 2 km systematic sample spacing was used, and this produced acceptable estimates of the land use coverage in each stratum.

The results of this land use coverage sampling were incorporated into a GIS layer, and the land use acreage were used to generate streamflow estimates using methods described in Section 3-1. In this procedure, the statistical regression model was used to estimate streamflow volumes for a given rainfall. The variables and methods used

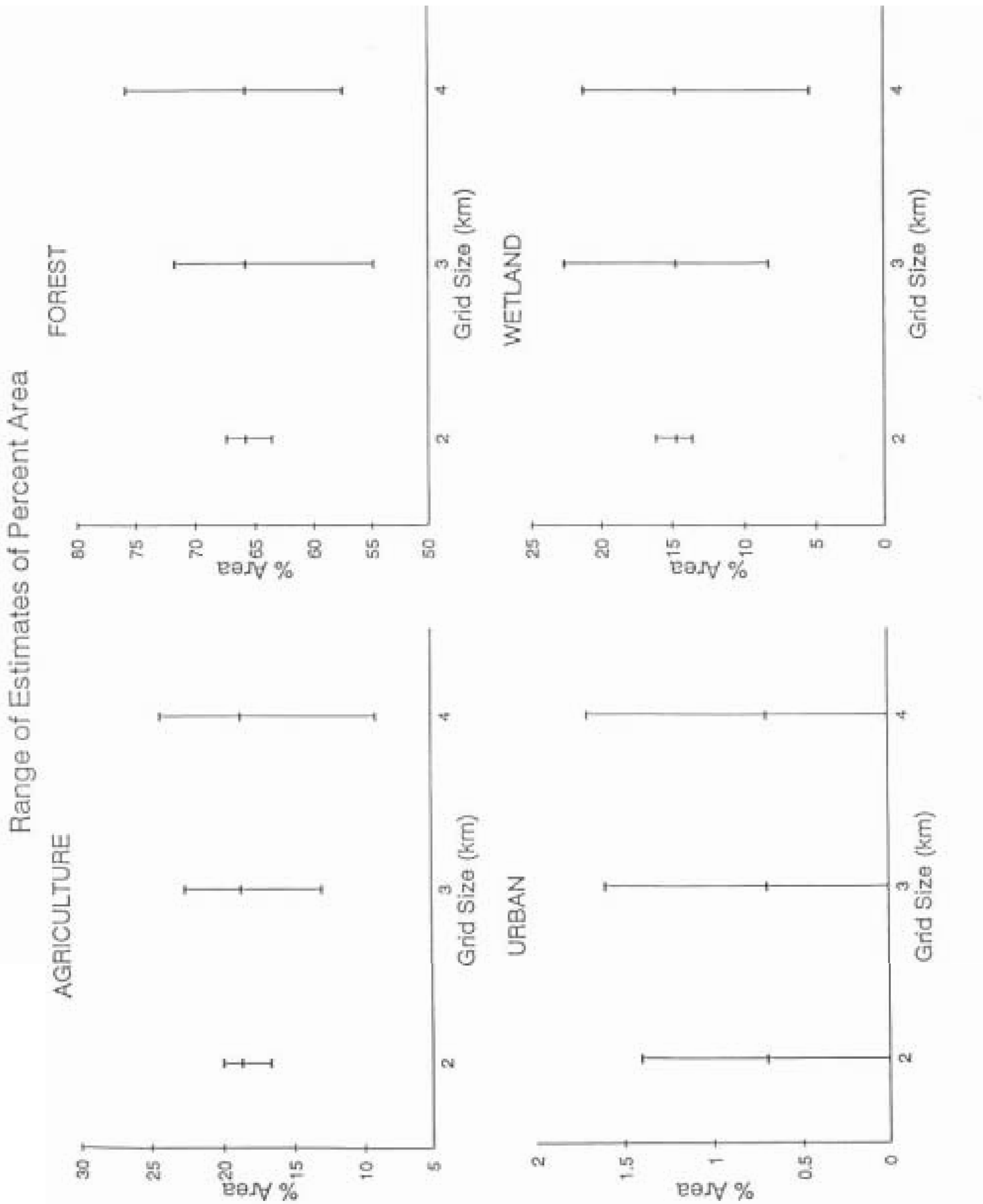


Figure 4-1 Effect of systematic sample spacing on precision of benchmark period land use estimates.

to generate benchmark streamflow estimates are the same as for existing conditions. To estimate pollutant loads, TN, TP, and TSS concentration values for each of the four major land use types (urban, agriculture, water/wetlands, and forest), were developed by adjusting the existing land use-specific water quality concentrations to account for changing land use practices. Changes in land use practices include variations in agricultural fertilizer and irrigation methods and the general lack of domestic landscaping irrigation and fertilization. The benchmark water quality concentrations for the four land use groups are shown in Appendix 8.

For the purpose of this investigation, the benchmark streamflow and pollutant load estimates were made using the existing rainfall amounts. This allowed a direct comparison of benchmark and existing streamflow and loadings to be made, having removed any variation attributable to changing rainfall patterns and amounts.

4.1.3 Gaged Area Streamflow and Pollutant Loading Estimates

The gaged portion of the Tampa Bay watershed was much smaller in the benchmark period, because there were far fewer stream gage sites than currently exist. Four USGS gaging stations were identified with data for part or all of the benchmark period (USGS, 1993), including the following sites shown in Table 4-1:

Table 4-1 Benchmark Gaged Stream Flow Stations

USGS Gage Number and Name	Beginning of Period of Record
02300500 Little Manatee River near Wimauma	1939
02303000 Hillsborough River near Zephyrhills	1940
02304000 Hillsborough River at Fowler Avenue	1934
02304500 Hillsborough River near Tampa	1939

Monthly average flows for these stations were obtained for the benchmark period, and used to develop monthly streamflow estimates for the gaged portion of the watershed. No measured surface water quality data were found for this period. Therefore, land use-specific water quality loading coefficients were revised for benchmark conditions, as described below. These coefficients (TN, TP, and TSS concentrations in mg/L), were multiplied by the average monthly flow rate generated in each major drainage area by each land use to develop estimates of gaged area pollutant loading, expressed as mass/time, such as pounds/month.

4.1.4 Ungaged Area Streamflow and Pollutant Loading Estimates

As with the existing condition analysis, benchmark loading estimates for ungaged basins were made using the regression analysis that relates rainfall, land use, and soil types to stream flow. The benchmark land use and existing precipitation data were applied to the regression equations shown in Section 2 to develop streamflow and nonpoint source pollutant loading estimates. The benchmark loadings were calculated using rainfall from the existing conditions period so that changes in pollutant loadings will not be due to variation in rainfall between the benchmark and existing periods.

As described in Section 2, the regression model, as developed for the existing condition analysis, was used with coefficients that are specific to either of two basin types - more (greater than 19%) urban or less (less than 19%) urban. Regression coefficients were also determined for wet and dry seasons. Benchmark streamflow and pollutant loads were estimated for the gaged and ungaged areas using Equations 2 and 3 from Section 2.

4.2 Point Sources

4.2.1 Domestic Point Sources

Loadings from point sources from the 1938-40 period were difficult to quantify. Reporting requirements for facility operation were few, and only limited records were kept. However, very few facilities generated point sources discharges during this period. Based on extensive interviews, the few domestic wastewater treatment plants that were in operation during this period were identified. Wide-scale centralized wastewater facilities were first operated in the Tampa Bay watershed in the early 1950's. The information obtained suggested that very few, probably less than 5,000, of the bay area's residents had centralized sewer in 1940, and that the treatment provided included only screening, and in a few cases, chlorination. Therefore, the benchmark domestic point source inputs were treated as if they were entirely generated by septic tanks, cesspools or direct discharge. A description of wastewater treatment facilities that were operating in the watershed during the benchmark period is included as Appendix 8.

Population estimates of the benchmark period were used to calculate potential total domestic loadings to the bay segments. The Florida Statistical Abstract (Biscoe et al., 1967) lists 1940 population estimates for counties, cities, towns and unincorporated areas within the watershed. The estimated 1940 population for the respective portions of the watershed tributary to the seven bay segments is shown in Table 4-2.

As stated above, the great majority of residential areas used septic tanks, cesspools, or had direct discharge of sewage to the nearest surface water body. Estimates for domestic waste contributions to loadings were made using analytical techniques and values for effluent quality and quantity that were developed based on per-capita water use and typical waste stream components from this period. Based on the assumption that benchmark per capita water usage was less than existing rates (100 or more), a value of 50 gallons per day per capita (gpdpc) was used (SWFWMD, 1992).

Table 4-2 Tampa Bay Watershed Estimated 1940 Population

BAY SEGMENT	ESTIMATED 1940 POPULATION
Old Tampa Bay	128,706
Hillsborough Bay	98,702
Middle Tampa Bay	11,201
Lower Tampa Bay	3,991
Boca Ciega Bay	5,581
Terra Ceia Bay	2,500
Manatee River	12,722
WATERSHED TOTAL	263,403

Benchmark effluent quality parameters were developed using existing estimates of septic tank effluent quality, and adjusting them based on assumed components of the domestic waste stream from the 1940 period. The following table compares existing typical septic tank effluent quality (Cantor, 1986), with estimates of 1940 effluent characteristics. The reductions in flow and TP concentrations are based on 1) a lower per capita use of products with these materials in them, such as detergent (Austin, 1984), and 2) changes in waste stream types that are directed to the septic systems as shown in Table 2-3.

These potential domestic loads were subject to factors to account for uptake and assimilation of both the hydrologic and chemical components of the waste stream. The hydrologic flow was reduced by a factor to account for evaporation, transpiration and recharge. This "flow reduction factor" ranged from 0.6-0.8, and represents a reduction in flow of between 20% and 40%. The flow reduction factor was developed for each bay segment's tributary area, and was based on such factors as size of the sub-watershed, the location characteristics of the population, and overall

Table 4-3 Existing and Estimated Benchmark Septic Tank System Effluent Characteristics

Time Period	Flow (gpdpc)	TN (mg/L)	TP (mg/L)	TSS (mg/L)
Existing	100-150	40	13	40
Benchmark	50	40	5	50

land form. Therefore, between 60% and 80% of the total 50 gpdpc effluent flow entering the domestic waste stream was allocated to the bay and tributaries.

In addition, TN, TP, and TSS concentrations were assumed to be reduced by assimilation, uptake and filtering of the effluent during its path from the point of discharge to the receiving water. Based on the same assumptions as described in Section 3 for land application (percolation pond) of domestic waste effluent, it was assumed that between 30% and 70% of the TN was removed, between 70% and 95% of the TP was removed, and between 50 and 95% of the TSS was removed. These values were developed as a result of the review of numerous references on the behavior of nitrogen and phosphorus in groundwater (Section 3).

To estimate the benchmark domestic point source loading, the total flow rate of effluent discharged to a bay segment or within a major drainage basin was estimated by multiplying the per capita flow times the estimated number of people, and summarized on a monthly basis. This "gross" flow was then multiplied by the flow reduction factor to derive the total flow delivered to the bay and tributaries. For these calculations, it was assumed that 75% of domestic waste disposal was via septic tank or other on-site treatment facility, and that 25% of the waste stream was directly discharged into open water bodies.

The concentrations of TN, TP, and TSS listed above were multiplied by the high and low end estimates of chemical removal, and the removed fraction was subtracted from the total. For computational purposes, this is the equivalent of multiplying the septic system effluent average estimated concentrations TN by 0.3 and 0.7, TP by 0.7 and 0.95, and TSS by 0.5 and 0.95 to estimate a high and low end of a range of effluent concentrations. The revised overall average concentrations were multiplied by the revised average flow rate to develop a range of loadings delivered to the bay and tributaries by domestic point sources, on a monthly basis. The benchmark domestic point source loading results shown in the graphs in Section 5 include the low end of the loading estimates. The spreadsheet calculations for this loading estimation are shown in Appendix 9.

4.2.2 Industrial Point Sources and Fugitive Emissions

Industrial point sources including phosphate mining and fugitive emissions (phosphate shipping facilities), were in existence in 1940, but no discharge records for these activities were located. Based on the best available information, estimates of industrial point source discharges and fugitive emissions were made, as described below.

A review of historical shipping tonnages for the Port of Tampa gives an indication of the level of mining activity from the benchmark period. In 1940, approximately four million tons of cargo were shipped from Tampa, with at least half of that phosphate rock (Fehring, 1985). This is consistent with anecdotal reports that at least three mines were active in the Alafia River basin in 1940, each producing approximately 2 million tons/year (Florida Institute of Phosphate Research (FIPR, 1993). Additionally, Corps of Engineers records (1948) report that 1,383,923 short tons of phosphate rock were shipped from Tampa during 1940.

During the benchmark period, no shipping facilities existed at East Bay, or at Port Manatee. Bulk material handling was done at docks at Port of Tampa - Seddon Island (now Harbour Island) near downtown Tampa, and at the Port Tampa facility on the southwest tip of Interbay Peninsula near Picnic Island. Additionally, Boca Grande was a busy port for phosphate products until the early 1970's, and received some of the phosphate mined in the Alafia basin for shipping.

Based on this information, it was estimated that an average of two million tons per year of phosphate rock were shipped from Tampa during the benchmark period. A breakdown of the composition of phosphate rock suggests that it is composed of approximately 14% phosphorus by weight. It was assumed that the value of 0.05% loss by weight for all product shipped (Cardinale and Dunn, 1991) was appropriate for benchmark conditions. It was further assumed that one-half the phosphate rock was shipped from Seddon Island, and one-half from Port Tampa. This results in a phosphate input from shipping losses to Hillsborough Bay and Middle Tampa Bay of 63,636 kilograms (70 tons) per year each.

Phosphate mining during the benchmark period also undoubtedly resulted in phosphorus loading to the Alafia River, and Hillsborough Bay. There is much uncertainty associated with developing these estimates. A minimum of three mines are said to have operated in the Alafia Basin during this period (FIRP, 1993). Although the mines were smaller than modern mines, they were essentially unregulated, and most likely discharged more water and phosphate per acre of mine than presently. This is fairly certain, since water was not recycled, and no limits on water quality were in enforced. Therefore, to estimate benchmark loadings from phosphate mines, it was assumed that three mines operated in the Alafia River basin (one on the South Prong, and two on the North Prong), and that each facility generated the same flow and nutrient loading as occur presently. Flow and loadings from existing facilities were averaged and rounded to develop these flows and concentrations, which are:

Flow = 2.0 mgd
TN = 2.0 mg/L
TP = 4.0 mg/L
TSS = 5.0 mg/L

These industrial point source freshwater flows and pollutant loadings were added to the other source loads, in the same manner as for existing conditions. No other industrial inputs were considered for the benchmark analysis.

4.2.3 Springs

Spring flow in urbanized or agricultural areas often diminishes with time. This may often be related to lowering of the potentiometric surface of the confined aquifer caused by pumping of groundwater. Of the four major springs in the watershed, three (Crystal, Lithia, and Sulphur) had regular measurements dating from the benchmark period. Additionally, a few water quality measurements were taken at these sites, usually only one or two within or near the benchmark period (Rosenau et al., 1977). These measurements were used to calculate spring discharge and loading for the benchmark period. As with the existing period analysis, discharge and chemical concentrations were interpolated between instantaneous discharge measurements.

4.3 Atmospheric Deposition

Atmospheric loadings of nitrogen and phosphorus during the benchmark period are not documented. However, the U.S. Congress Office of Technology Assessment (1984) has reported that atmospheric loadings have shown an approximately linear relationship with stationary point source discharges (factories, power plants, etc). They report that these fixed sources were approximately 40% of existing levels in the southeast U.S. in 1940. Therefore, existing atmospheric concentrations were multiplied by 0.4 to derive a benchmark *rainfall concentration for TN. Existing* precipitation values were used, so that a direct comparison could be made between existing and benchmark loads, by removing any variation from rainfalls trends.

4.4 Groundwater

Groundwater provides another source of freshwater and nutrient loading to Tampa Bay. The surficial (water table) aquifer, intermediate aquifer, and Floridan aquifer all contribute freshwater to Tampa Bay. Several factors most likely have influenced the amount of freshwater inflow and pollutant loadings to Tampa Bay in the benchmark period as compared to estimates of existing conditions. Coastal wells - used for agricultural, industrial, and potable uses - were not numerous until the late 1950's and early 1960's, and would not have had a significant impact groundwater flow patterns until that time (Hutchinson, pers. comm.). In addition, the Port of Tampa harbor ship channels were not as deep during this period, so the potential for the interception of horizontal groundwater flow and the promotion of upwards migration of groundwater through the confining layer was not as great.

However, the level of detail of groundwater levels during this period is not great. Older potentiometric contour maps of the Floridan aquifer do exist, but they are very regional in scale, and based on relatively few data points. To estimate benchmark groundwater flow conditions, both the flow and quality characteristics were revised. Intensive groundwater pumping in south Hillsborough and Manatee counties has resulted in a significant drawdown of the Floridan aquifer in the southeast portion of the watershed (Brooks et al., 1993). As reported in Brooks et al. (1993), this essentially pulls groundwater away from the bay, and towards the depression. Brooks et al. estimated that this results in a reduction in groundwater inflow to the bay of over 60%.

To account for increased flow to the bay without the groundwater depression, calculations from Brooks et al. (1993) were reviewed. For the benchmark flow estimates, flow volumes that had been identified as moving towards the depression were allocated to Hillsborough Bay, Middle Tampa Bay and Lower Tampa Bay. This resulted in a net increase of flow to the total bay of over 200% (from an annual average flow of 98 mgd to 236 mgd). This estimate is consistent with recent estimates of groundwater flow to Tampa Bay made by SWFWMD (Barcelo and Basso, 1993). Computer modeling for the Eastern Tampa Bay Water Use Caution Area study suggests that approximately 63 mgd of groundwater flowed into eastern Middle and Lower Tampa Bay during pre-development conditions, as opposed to 2 mgd under existing conditions.

Nitrate concentrations were also adjusted to reflect benchmark conditions. Existing Floridan aquifer nitrate levels in relatively pristine areas are often lower that 0.001 mg/L. Therefore, that value was used for the entire benchmark groundwater analysis. Also, benchmark phosphorus levels were halved from existing concentrations. This resulted in a commensurate lowering of nutrient loading, despite the increased flows, as shown in Appendix 10. As can be seen in the resultant graphs of existing loadings, groundwater inputs account for an insignificant portion of the total pollutant loading for all bay segments.

This concludes the description of the estimation of streamflow and pollutant loadings for the benchmark period. Section 5, below, summarizes the results of the existing conditions and benchmark conditions loading estimates.

5.0 RESULTS AND DISCUSSION

The following text discusses the results of the estimates of TN, TP, and TSS loads for existing and benchmark conditions. Data used to develop the existing conditions figures are presented in tabular form in Appendix 12.

5.1 Existing Loads

The loading estimates for existing conditions used the most recent complete data available, as described in Section 3. Nonpoint source, atmospheric deposition, and fugitive emission loads were calculated using averaged data from 1985-91. Point source loadings were calculated using 1991 data, to account for recent improvements to treatment and effluent disposal systems. However, major improvements to some phosphate rock and fertilizer manufacturing and shipping facilities have occurred since 1991. Therefore, changes in nutrient loads resulting from these improvements are not accounted for here. Also, accidental spills of fertilizer chemicals are not accounted for in the following figures. Spills are discussed in Appendix 15, and are included in the time series estimates of TN and TP loads used as input to the TBNEP statistical model and the SWIM box model for Tampa Bay. Estimates of "worst case" and projected future loads are not addressed in this section, but are discussed in Appendices 13 and 14, respectively.

5.1.1 Total Bay Loads

Estimated mean annual loads of TN,TP, and TSS were calculated for the period 1985-91, and are referred to as "existing conditions" loads. Figure 5-1 presents the percent contribution to the total TN, TP, and TSS loads to Tampa Bay for this period for the seven pollutant sources examined. Nonpoint sources and atmospheric deposition (to the open water bay only) are the two largest sources of TN and TP loading for the 1985-91 period, and are estimated to contribute 50% and 27% of the TN load and 25% and 31% of the TP load to Tampa Bay, respectively. Fugitive emissions from the two major Tampa Bay ports contribute 7% and 15% of the total TN and TP load to Tampa Bay, respectively. Permitted domestic point sources contribute 9% of the TN load and 18% of the TP load to the bay. Permitted industrial point sources contribute 4% and 9% of the total TN and TP load to the bay, respectively. Springs contributes an estimated 3% of the TN load, and less than 1% of the TP load. Other groundwater loads have negligible influence on bay-wide loadings.

Nonpoint sources are the major source of TSS loads to Tampa Bay, accounting for 85% of the total TSS load to the bay. Industrial point sources are the only other significant TSS source, and contribute an estimated 14%. Domestic point sources contribute only 1% of the total TSS load to Tampa Bay.

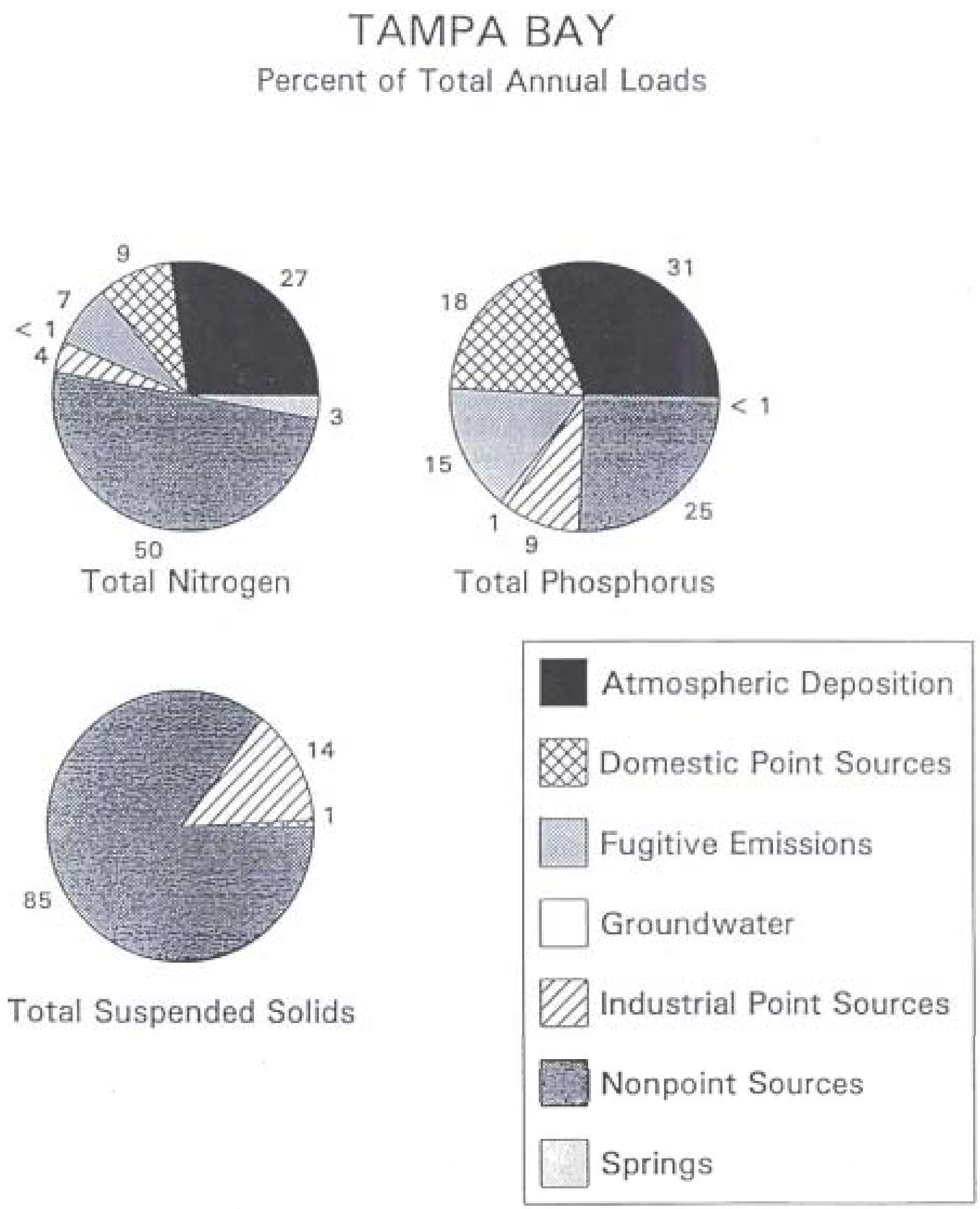


Figure 5-1 Existing total annual loads to Tampa Bay by source

5.1.2 Bay Segment Loads

Figures 5-2 through 5-4 present the mean annual TN, TP, and TSS loads by bay segment and source. Factors that influence the size of the TN load include bay segment size, drainage basin size, land use composition, and point source discharges. Hillsborough Bay receives the largest TN load of any segment (over 1,500 tons/year). Middle Tampa Bay receives the next largest load - about 750 tons/year. Old Tampa Bay and the Manatee River are estimated to receive about 500 tons/year each. Lower Tampa Bay, Boca Ciega Bay, and Terra Ceia Bay all receive 350 tons/year or less.

Nonpoint sources contribute an estimated 50% or more of the TN load to Hillsborough Bay, Middle Tampa Bay, Boca Ciega Bay, and the Manatee River. Atmospheric deposition contributes the highest TN load to the larger segments - Old Tampa Bay, Middle Tampa Bay, and Lower Tampa Bay. In contrast, only 7% and 10% of the TN loads to Hillsborough Bay and Manatee River, respectively, can be attributed to atmospheric deposition because of the relatively smaller surface area, larger drainage area, and higher point source contributions. The largest point source TN loads occur in Hillsborough Bay, Manatee River, and Old Tampa Bay, and are estimated to contribute about 25%, 20%, and 17%, respectively, of the TN load to those segments. Point sources contribute less than 10% of the TN load to the other segments.

The major sources of TP loading to Tampa Bay are estimated to be atmospheric deposition, nonpoint sources, and domestic point sources. Hillsborough Bay receives by far the largest (over 1,600 tons/year) TP load of all segments - almost 60% of the total load. Atmospheric deposition is highest in the larger bay segments. Domestic point sources are most prominent in Hillsborough Bay, where they contribute about 45% (700 tons/year) of that segment's annual TP load. Fugitive emissions from the phosphate handling facilities are also a major source in Hillsborough Bay, accounting for 25% (400 tons/year) of the segment's annual TP load, (almost equal to the nonpoint source load).

Most of the TSS load to the Tampa Bay segments can be attributed to nonpoint sources. The Manatee River segment is the major exception, where over half of the TSS load is contributed by industrial point sources. Note that this represents 1991 conditions. Since that time, improvements to a large industrial treatment facilities have greatly reduced that portion of the TSS loading to the Manatee River.

5.1.3 Major Drainage Basin Loads

As discussed in Section 3, the TN, TP, and TSS load from each of the major drainage basins can be estimated for only fugitive emissions, point sources, and nonpoint sources. Atmospheric deposition and groundwater loads are estimated solely on a bay

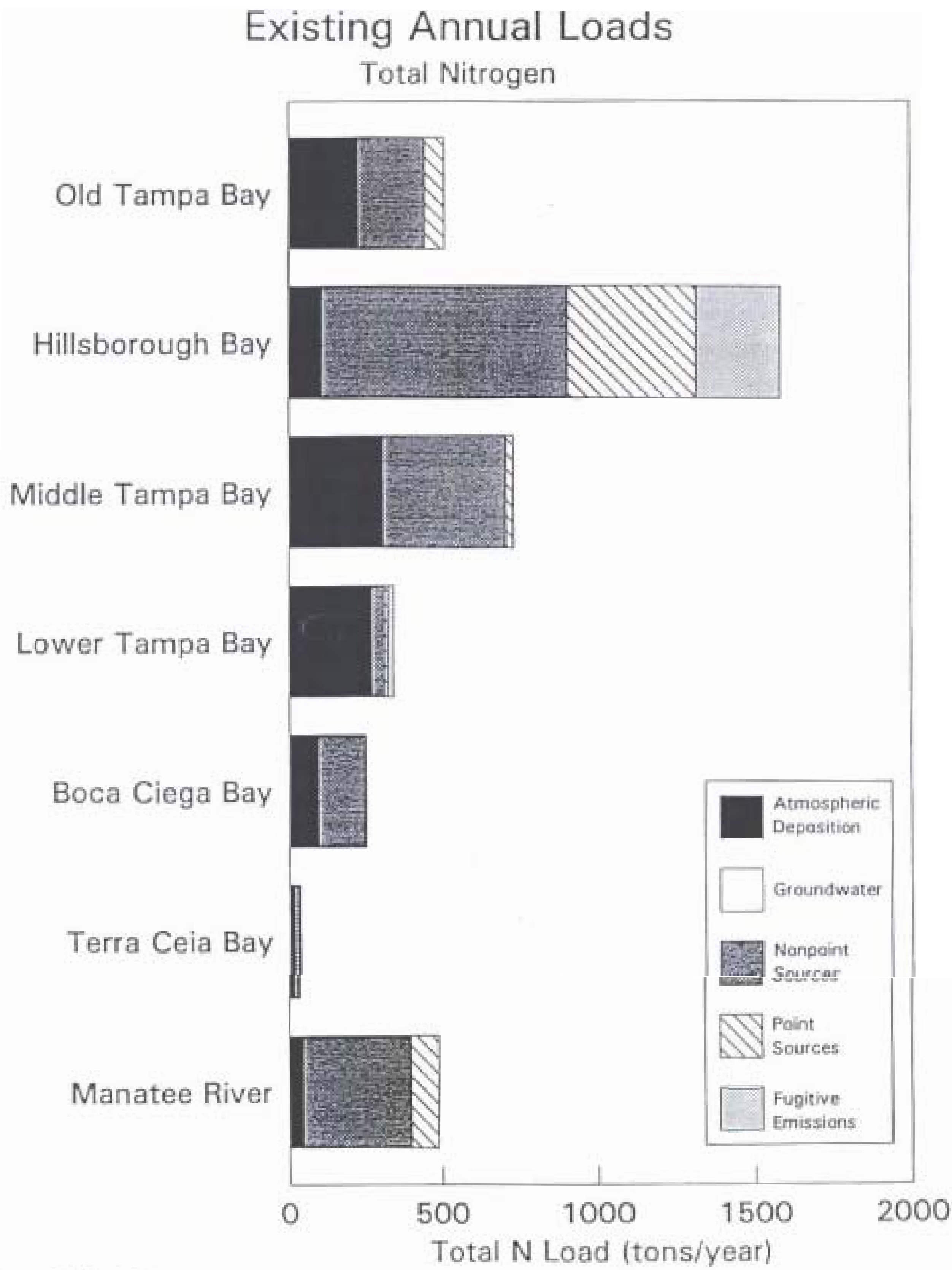


Figure 5-2 Existing annual loads of TN by bay segment

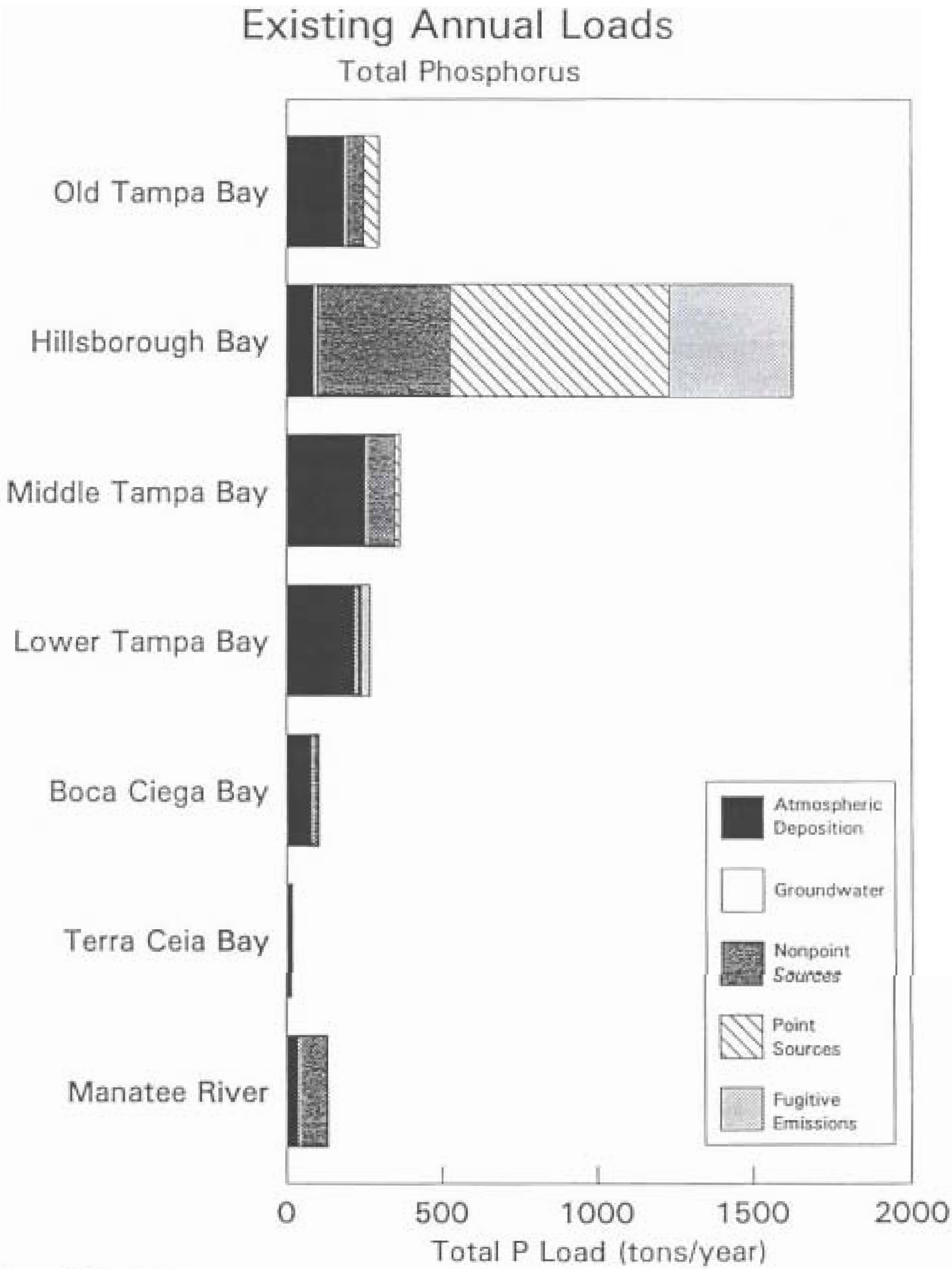


Figure 5-3 Existing annual loads of TP by bay segment

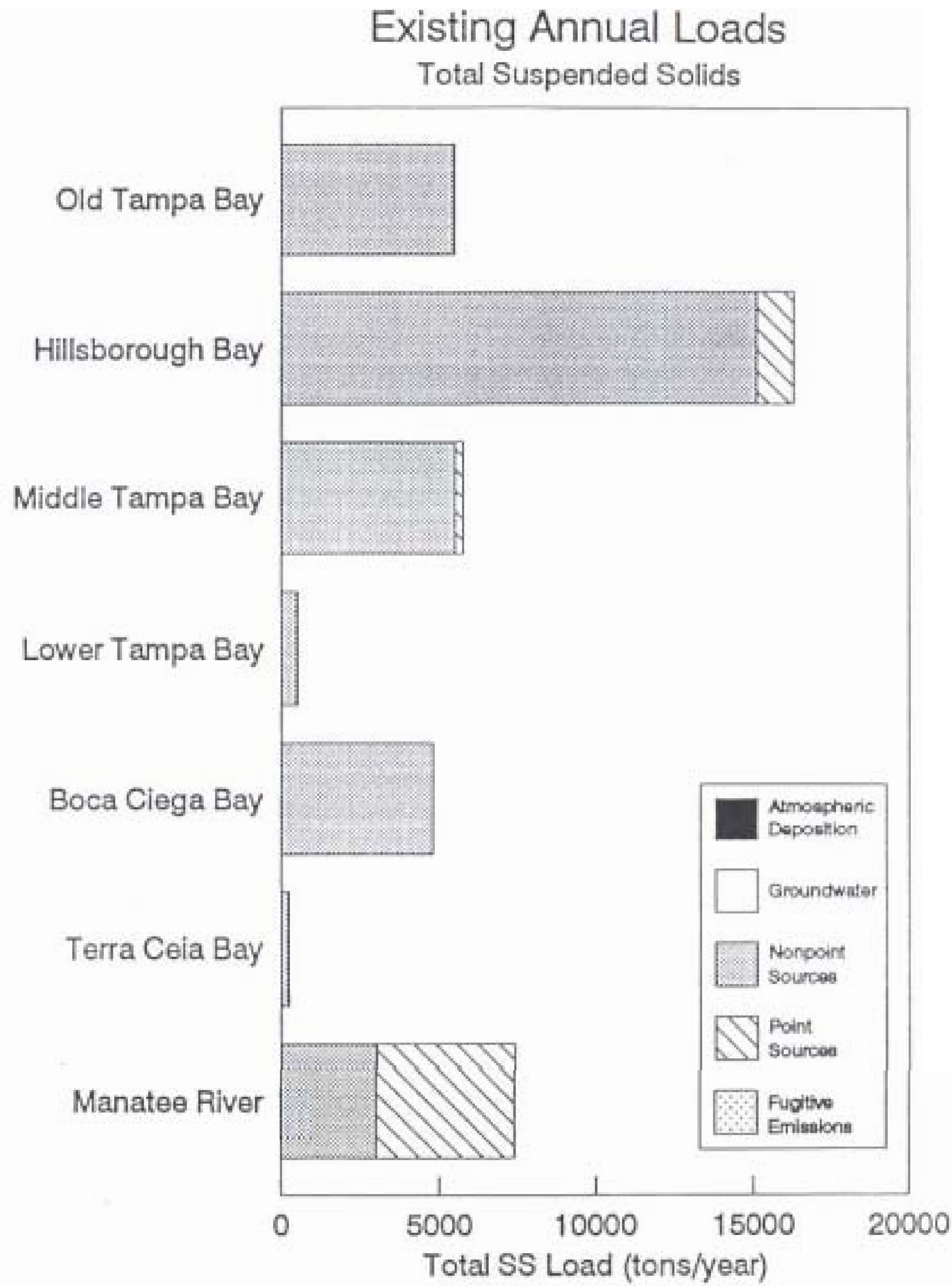


Figure 5-4 Existing annual loads of TSS by bay segment

segment basis. Figures 5-5 through 5-7 present these TN, TP, and TSS loads from each of the ten major drainage basins, by source.

The TN load from Coastal Hillsborough Bay (600 tons/year) accounts for the largest TN load (approximately 20% of the total) of all major drainage basins. The other major contributors of TN loads are the Alafia River (550 tons/year) and Manatee River (450 tons/year). Fugitive emissions are estimated to account for about 45% of the TN loads from the Coastal Hillsborough Bay basin and about one-quarter of the TN load from the Coastal Lower Tampa Bay basin. Nonpoint sources are estimated to contribute much of the drainage basin TN load, ranging from over 20% (120 tons/year) in the Coastal Hillsborough Bay basin to about 95% in the Little Manatee River (300 tons/year) and Boca Ciega Bay (150 tons/year) basins.

The TP load from Coastal Hillsborough Bay is also the largest of any major basin, accounting for nearly 45% (over 800 tons/year) of the total TP load from all major drainage basins. The Alafia River drainage basin, the next largest contributor, accounts for about 30% (550 tons/year) of the total TP load from the major drainage basins. Fugitive emissions are estimated to account for about 45% and 60%, respectively, of the TP load from the Coastal Hillsborough Bay and Lower Tampa Bay drainage basins. With the exception of the Alafia River and Coastal Hillsborough Bay basins, all the other major basins contribute 100 tons/year or less of TP to the bay.

Major contributors of TSS loads to Tampa Bay, include the Hillsborough River (8,000 tons/year), Manatee River (7,400 tons/year), Alafia River (5,500 tons/year), Coastal Old Tampa Bay (5,300 tons/year), and Boca Ciega Bay (5,000 tons/year) basins. As seen above, nonpoint sources account for most of the TSS loads bay-wide. However, approximately 40% of the TSS load from the Manatee River basin is from nonpoint sources - the balance is attributable to point sources in this basin. In Coastal Hillsborough Bay, about 80% of the TSS load is from nonpoint sources and 20% is estimated to come from point sources. Over 90% of the TSS loads from the other eight major drainage basins is estimated to come from nonpoint sources.

- Point Source Loads

The proportion of the total annual point source TN, TP, and TSS loads for each of the major drainage basins from industrial, domestic (land application and surface water discharges), and springs is shown in Figures 5-8 through 5-10. The surface water discharge component of domestic point source loads of TN accounts for over 300 tons/year or about 50% of the point source load (8% of the total overall TN load) from the ten major drainage basins (Figure 5-8). The major surface water discharges originate in the Coastal Hillsborough Bay basin (200 tons/year) and the Coastal Old Tampa Bay basin (50 tons/year). The Alafia River and Manatee River basins also have significant surface water discharges. Land-application of domestic effluent is

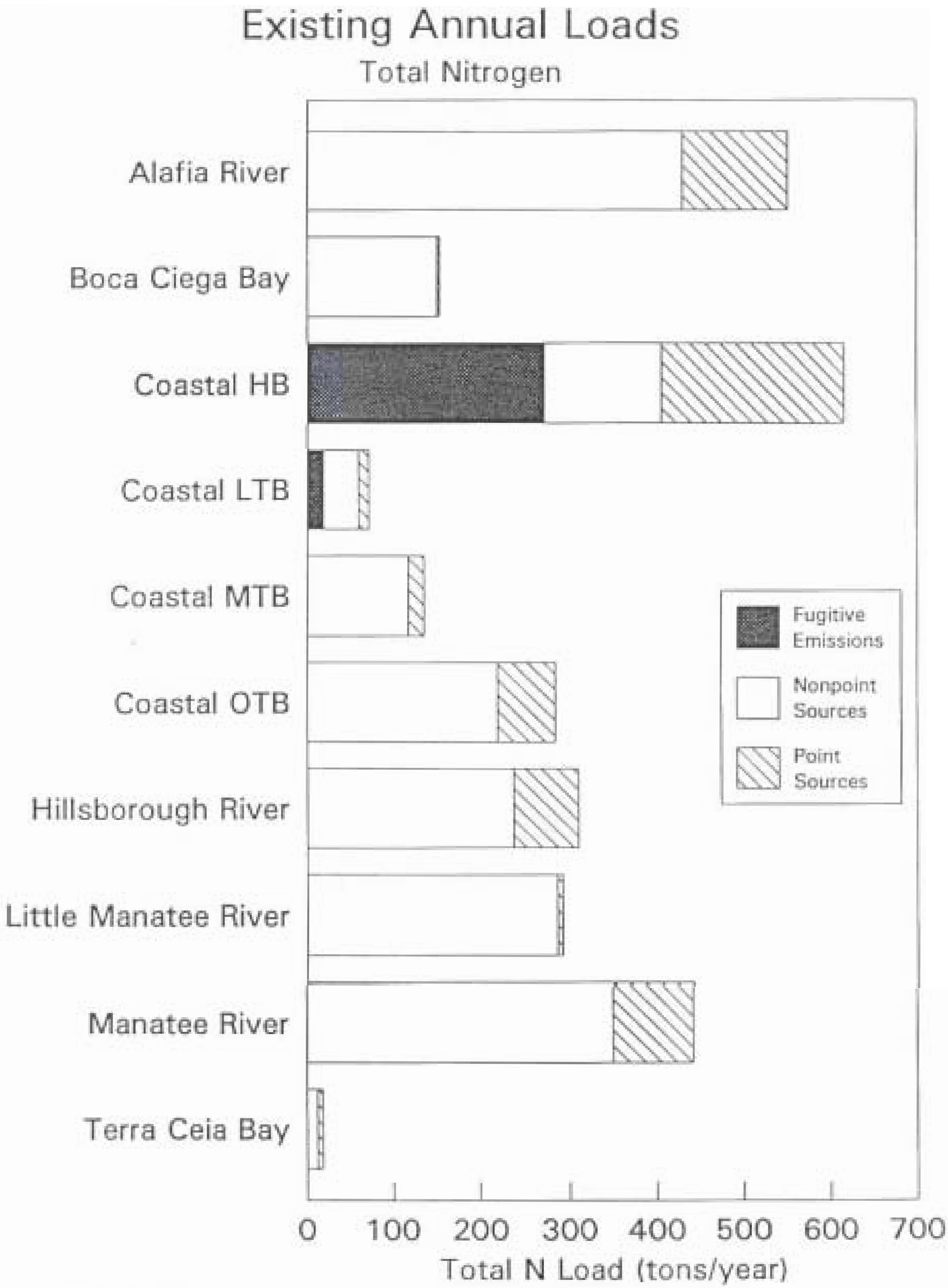


Figure 5-5 Existing annual loads of TN by major drainage basin

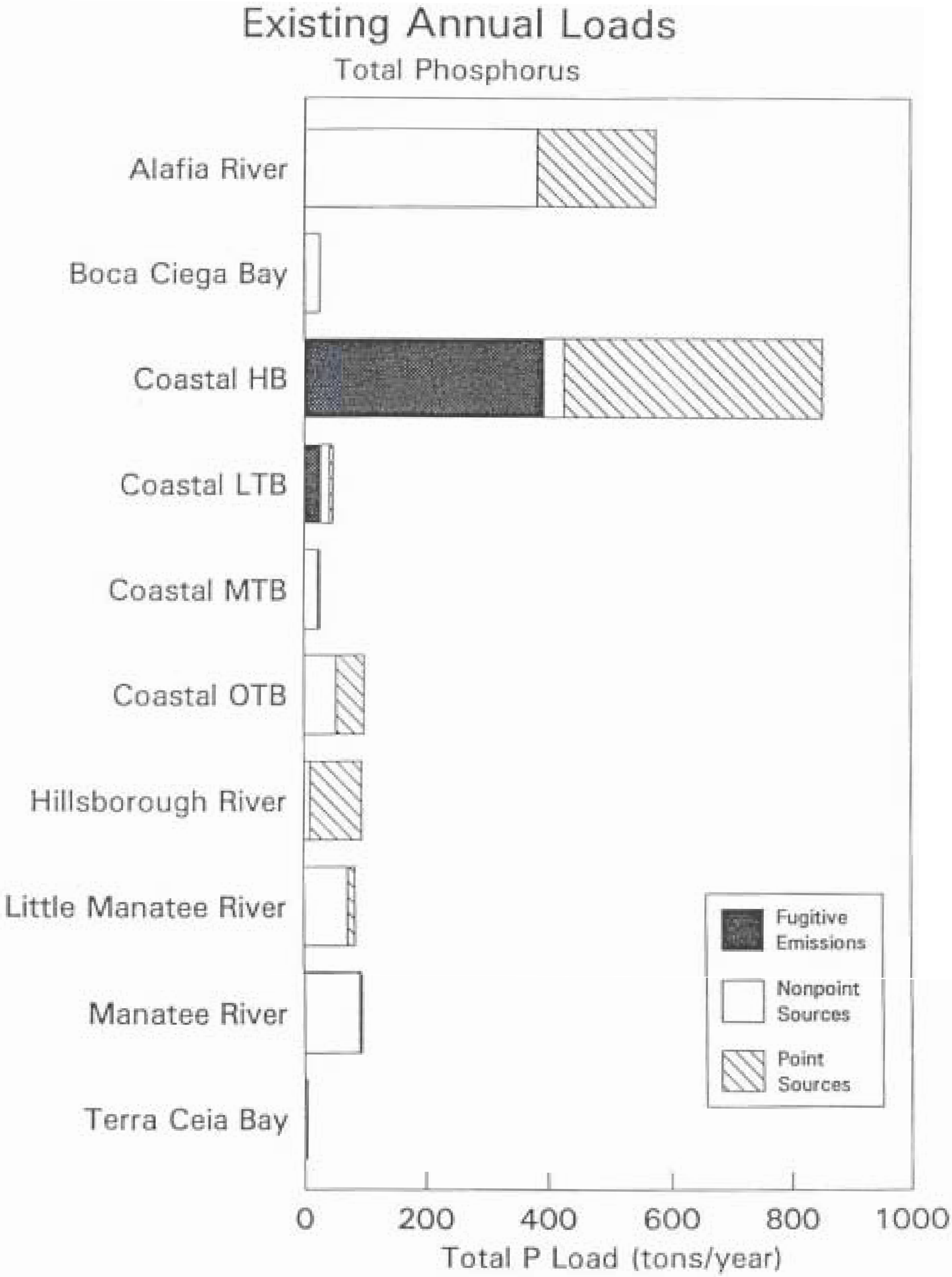


Figure 5-6 Existing annual loads of TP by major drainage basin

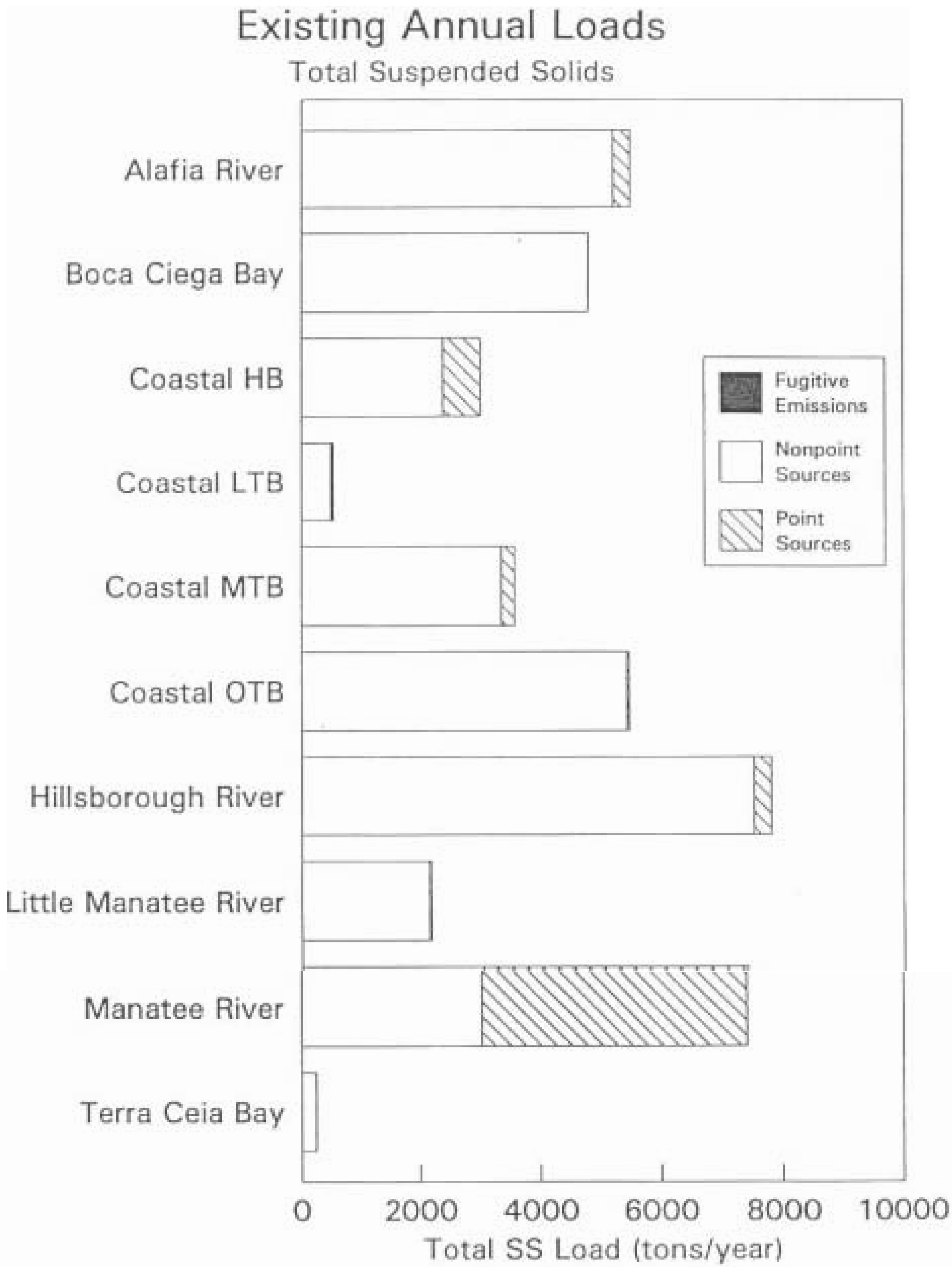


Figure 5-7 Existing annual loads of TSS by major drainage basin

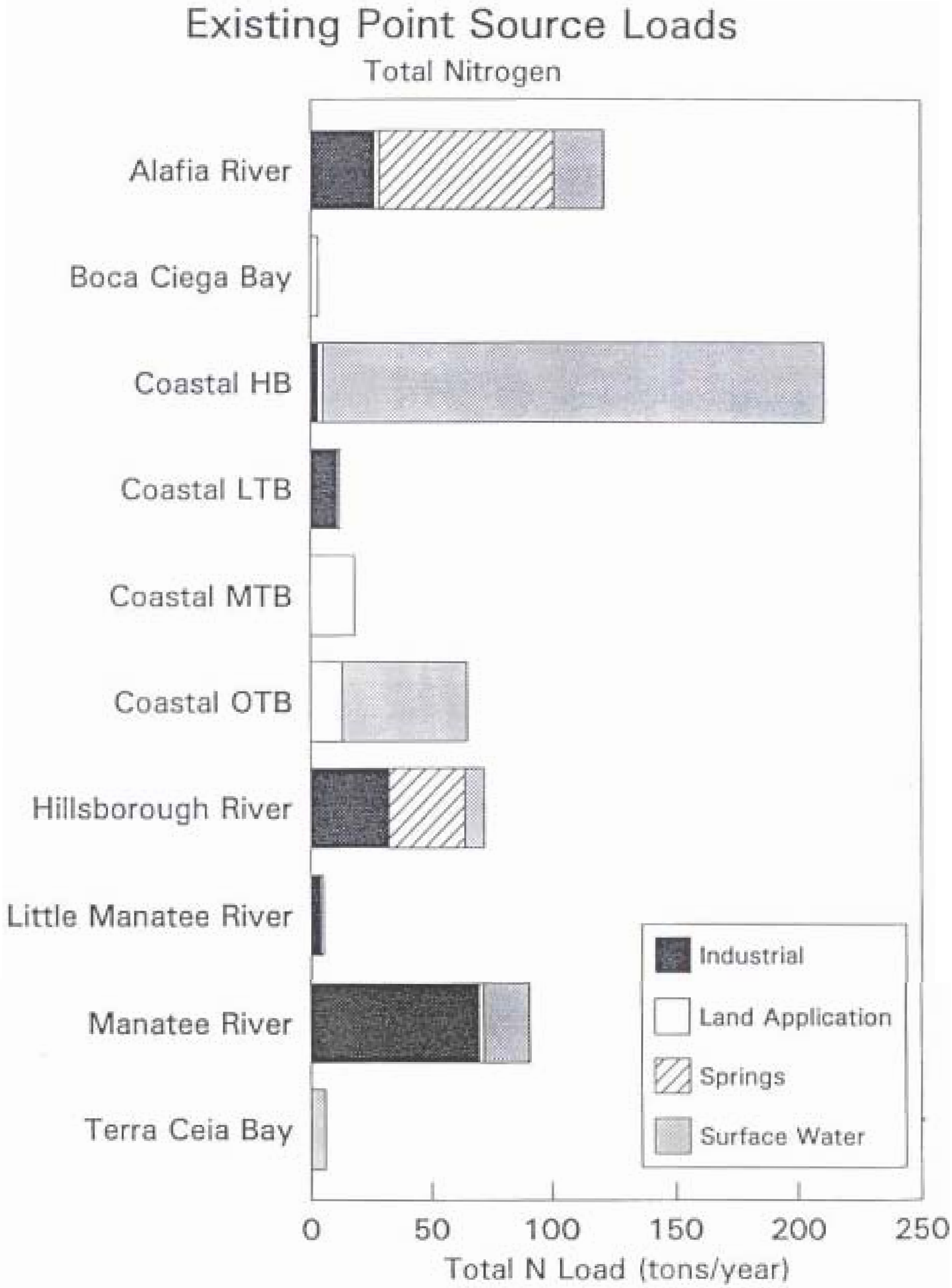


Figure 5-8 Existing point source loads of TN by major drainage basin

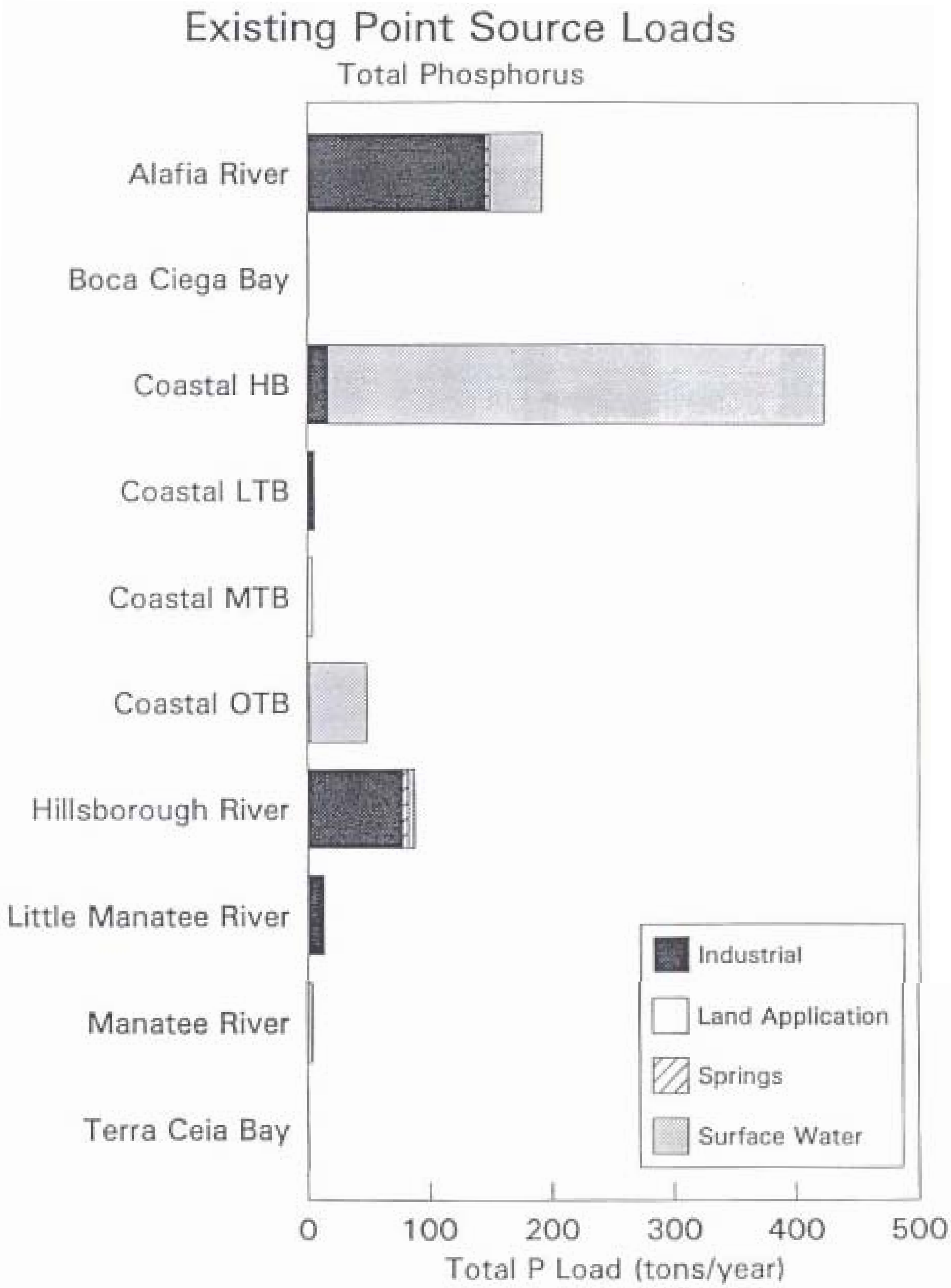


Figure 5-9 Existing point source loads of TP by major drainage basin

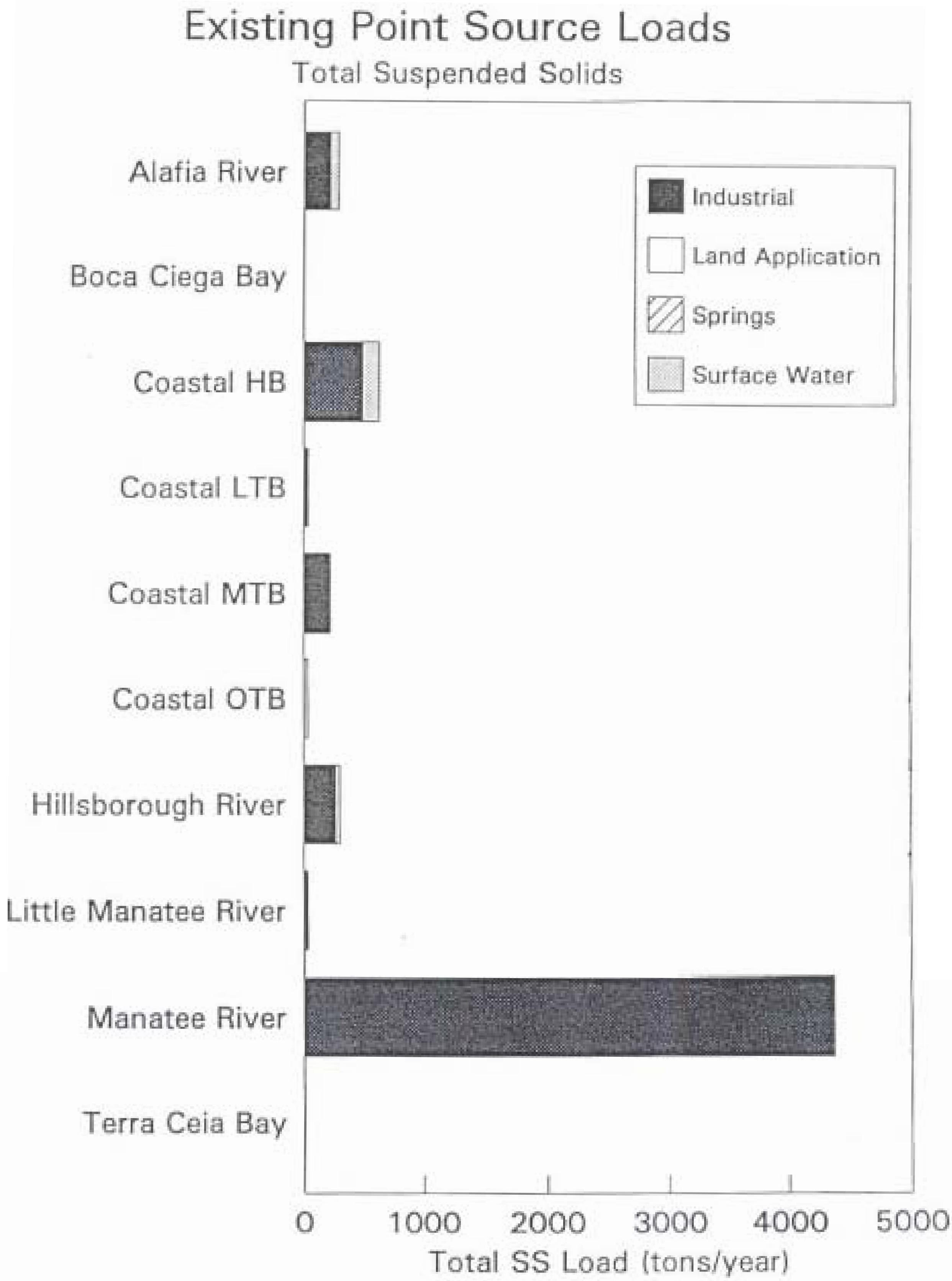


Figure 5-10 Existing point source loads of TSS by major drainage basin

a relatively minor source overall. Industrial point sources are relatively important contributors to the TN point source loads from the Manatee River, Alafia River, Coastal Lower Tampa Bay, and Hillsborough River drainage basins, and make up about 25% (almost 200 tons/year) of the total point source load to the bay.

The surface water discharge component is the most important source of the domestic point source loads of TP, accounting for an estimated 500 tons/year (65% of point source loads), or about 25% of the total TP load from the ten major drainage basins (Figure 5-9). Most of this TP load component originates in the Coastal Hillsborough Bay, Alafia River and Coastal Old Tampa Bay drainage basins. Little of the total TP point source load can be attributed to land-applied effluent - only about 1%. Industrial sources of TP are relatively important contributors to the total TP point source loads from the Alafia River, Hillsborough River, Little Manatee River, and Coastal Lower Tampa Bay drainage basins.

Industrial point sources are by far the major contributors to the total TSS point source loads for the major drainage basins (Figure 5-10). Surface water discharges also contribute to the point source loads of TSS in the Coastal Hillsborough Bay, Alafia River, and Coastal Old Tampa Bay drainage basins.

- Nonpoint Source Loads

As with point source loads, the relative contributions to the nonpoint source loads of TN, TP, and TSS from each of the major drainage basins can be further examined by reviewing these loads alone. In this case, the relative contributions to the total nonpoint source loads by land use type can be estimated. Figures 5-11 through 5-13 present the TN, TP, and TSS nonpoint source loads from each of the ten major drainage basins by land use type. For sake of ease of presentation, the land use types are aggregated into the following categories: urban, agriculture, pasture/rangeland, undeveloped (forest, water and wetland), and mining. The FLUCCS land use/cover codes aggregated into these land use types are defined above in Section 2 and in Appendix 1.

The contributions from the urban, agriculture, and pasture/rangeland land use types clearly account for the majority of the nonpoint source TN loads from most of the major drainage basins (Figure 5-11), contributing a majority of the nonpoint source TN loads. The Hillsborough River, Alafia River, Little Manatee River, and Manatee River basins have the largest relative contributions from undeveloped land (forest/water/wetland). These estimate loadings do not imply that individual land cover types generate all of the nonpoint source loads attributed to them here. Internal processes (such as in wetlands) can be responsible for transformation of nitrogen inputs from inorganic to organic forms, irrespective of the total N import/export relationships. Also, atmospheric deposition in the watershed contributes to nonpoint source loadings.

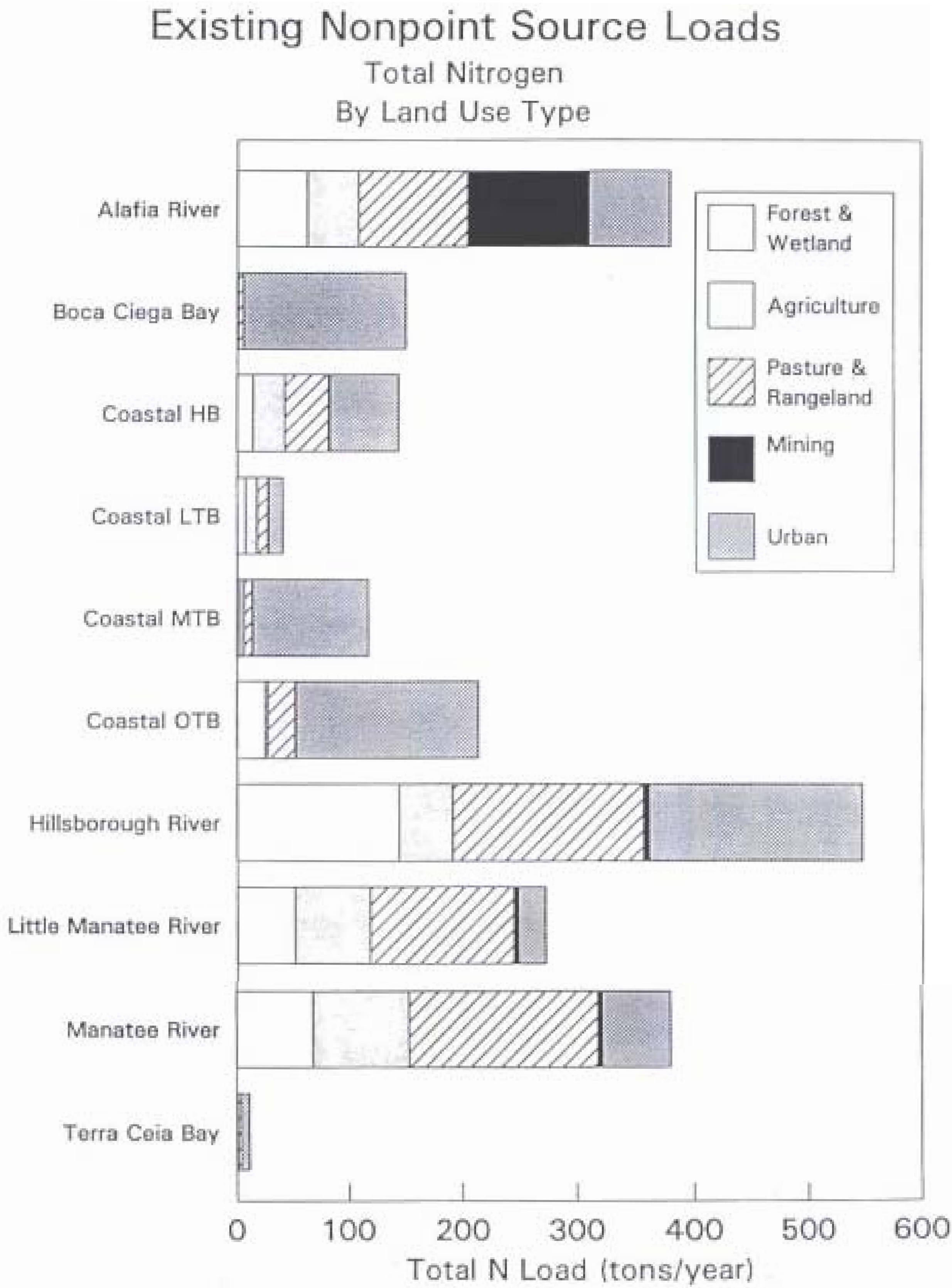


Figure 5-11 Existing nonpoint source loads of TN by major drainage basin

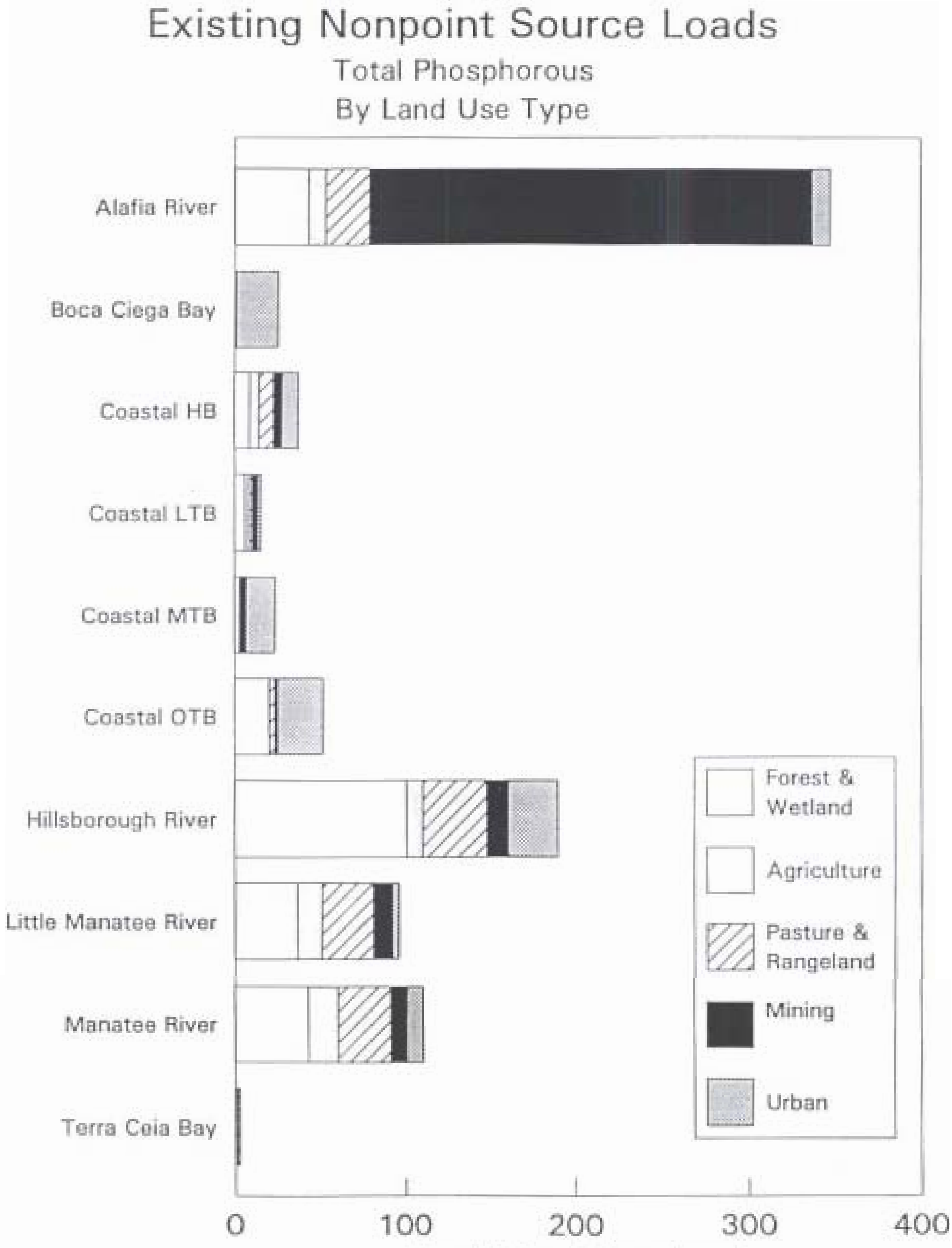


Figure 5-12 Existing nonpoint source loads of TP by major drainage basin

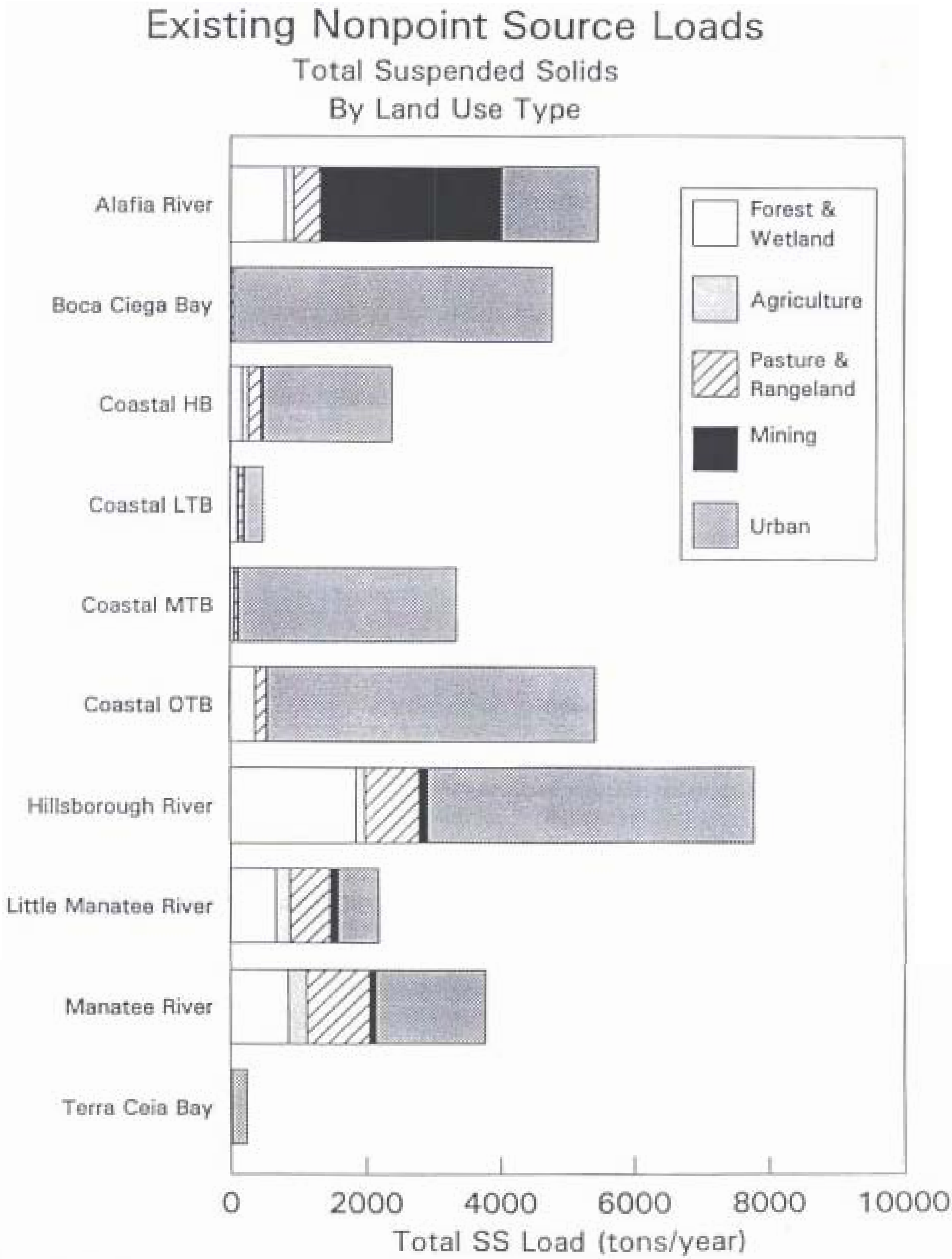


Figure 5-13 Existing nonpoint source loads of TSS by major drainage basin

The contribution from the agriculture and pasture/rangeland land use type to the nonpoint source loads of TP from the Alafia River, Hillsborough River, Little Manatee River, and Manatee River drainage basins is very important (Figure 5-12). Nonpoint source loads of TP from the urban land use type are most important in the coastal areas (Boca Ciega Bay, Coastal Middle Tampa Bay, and Coastal Old Tampa Bay drainage basins). As with TN, the TP nonpoint source loads from the wetland/water land cover type in the Hillsborough River, Little Manatee River, and Manatee River basins are also somewhat important. Mining in the Alafia River basin contributes the highest proportion, and the largest single land use load, for a drainage area - over half the total nonpoint source load for that basin.

The contribution from the urban land use type to the nonpoint source loads of TSS from the Boca Ciega Bay, Coastal Hillsborough Bay, Coastal Middle Tampa Bay, Coastal Old Tampa Bay, Coastal Lower Tampa Bay, and Hillsborough River drainage basins is very important (Figure 5-13). The agriculture and pasture/rangeland land use type contributes most significantly to the TSS nonpoint source loads from three of the major river basins - the Hillsborough River, Little Manatee River, and Manatee River basins.

The nonpoint source loads from the ten major drainage basins can also be expressed as a "basin yield" or load per unit area. This is derived by dividing the total nonpoint source load for a drainage area by the land area of the drainage area. Figures 5-14 through 5-16 present the nonpoint source load per unit area for TN, TP, and TSS, respectively for the ten major drainage basins of the Tampa Bay watershed.

The load per unit area of TN from most of the major drainage basins is similar, ranging from 2 to 4 lbs/acre/year (Figure 5-14). The Boca Ciega Bay, Little Manatee River, Alafia River, and Manatee River basins had the highest TN load per unit area. The coastal basins had lower basin yields, ranging from 1-2.5 lbs/acre/year.

The load per unit area of TP from the Alafia River basin is estimated to be in excess of 3 lbs/acre/year, much greater than the loads per unit area for the other major drainage basins (Figure 5-15). Typically, these loads per unit area were approximately 0.5-1 lbs/acre/year.

The load per unit area of TSS was also generally similar among most of the major drainage basins, ranging from 30 to 50 lbs/acre/year (Figure 5-16). The largest TSS load per unit area was from the Boca Ciega Bay basin where the estimated TSS load per unit area is nearly 130 lbs/acre/year. The next highest load per unit area for TSS was from the Coastal Middle Tampa Bay basin, and equalled approximately 60 lbs/acre/year.

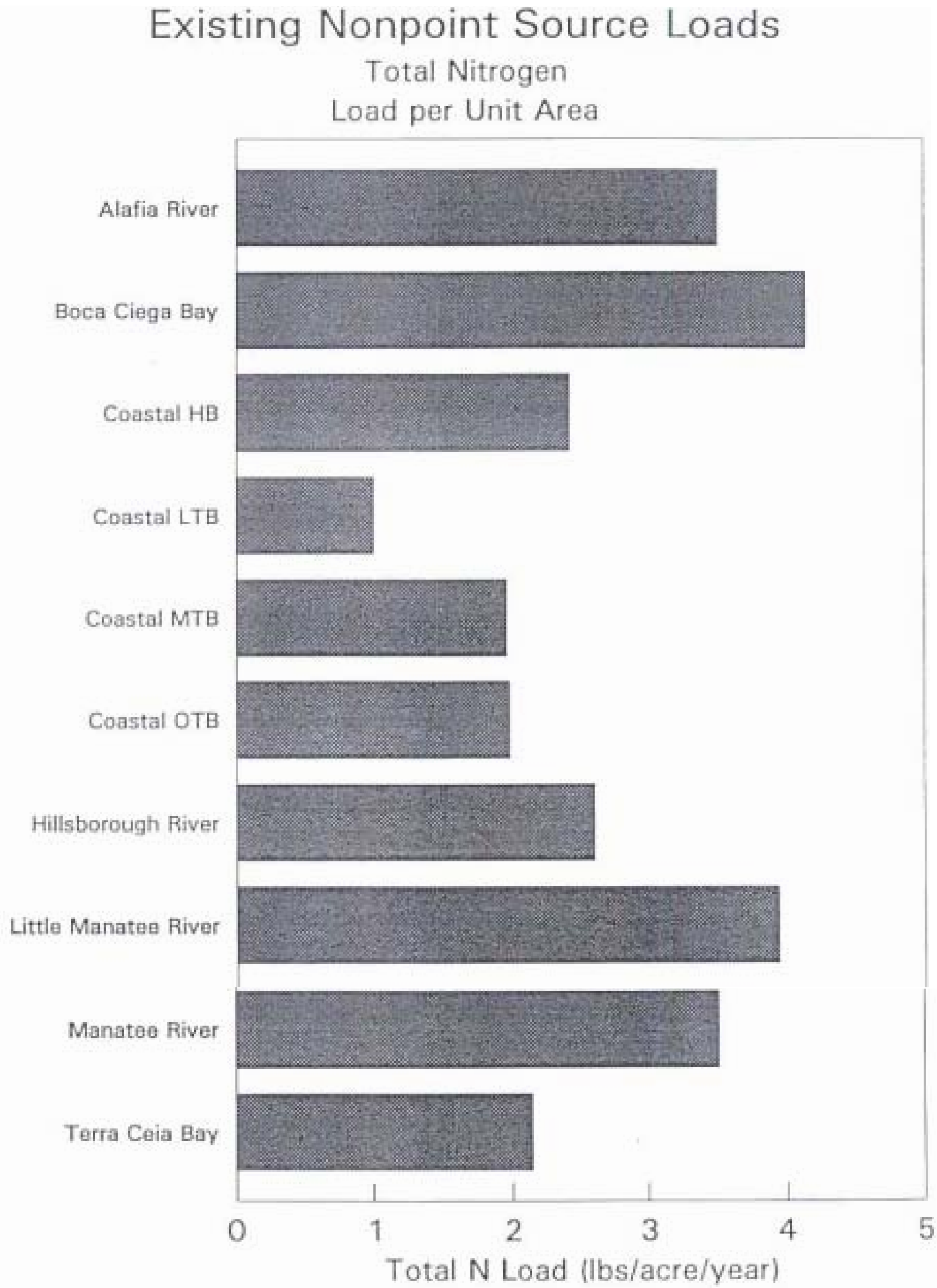


Figure 5-14 Existing nonpoint source loads of TN per unit area by major basin

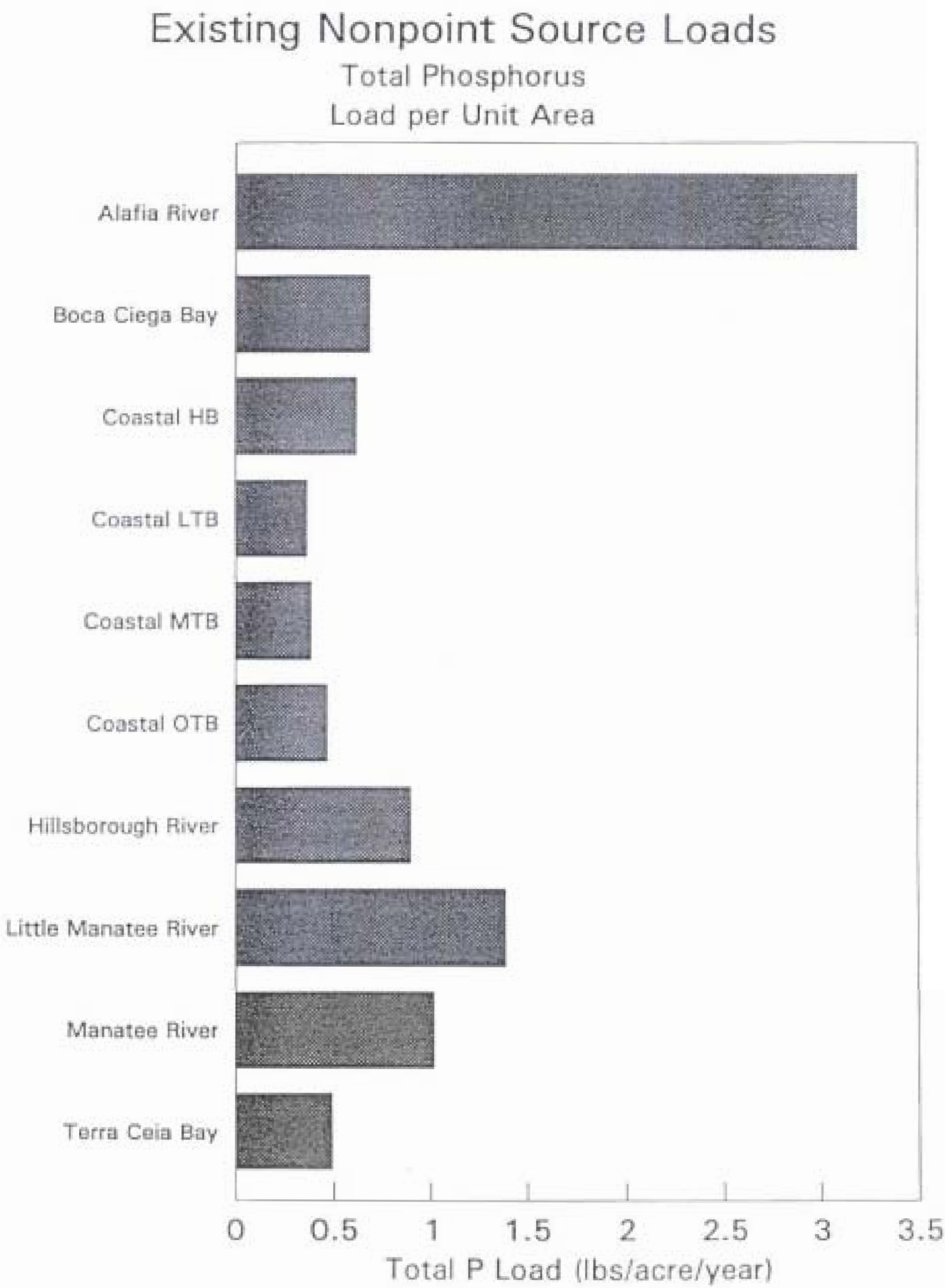


Figure 5-15 Existing nonpoint source loads of TP per unit area by major basin

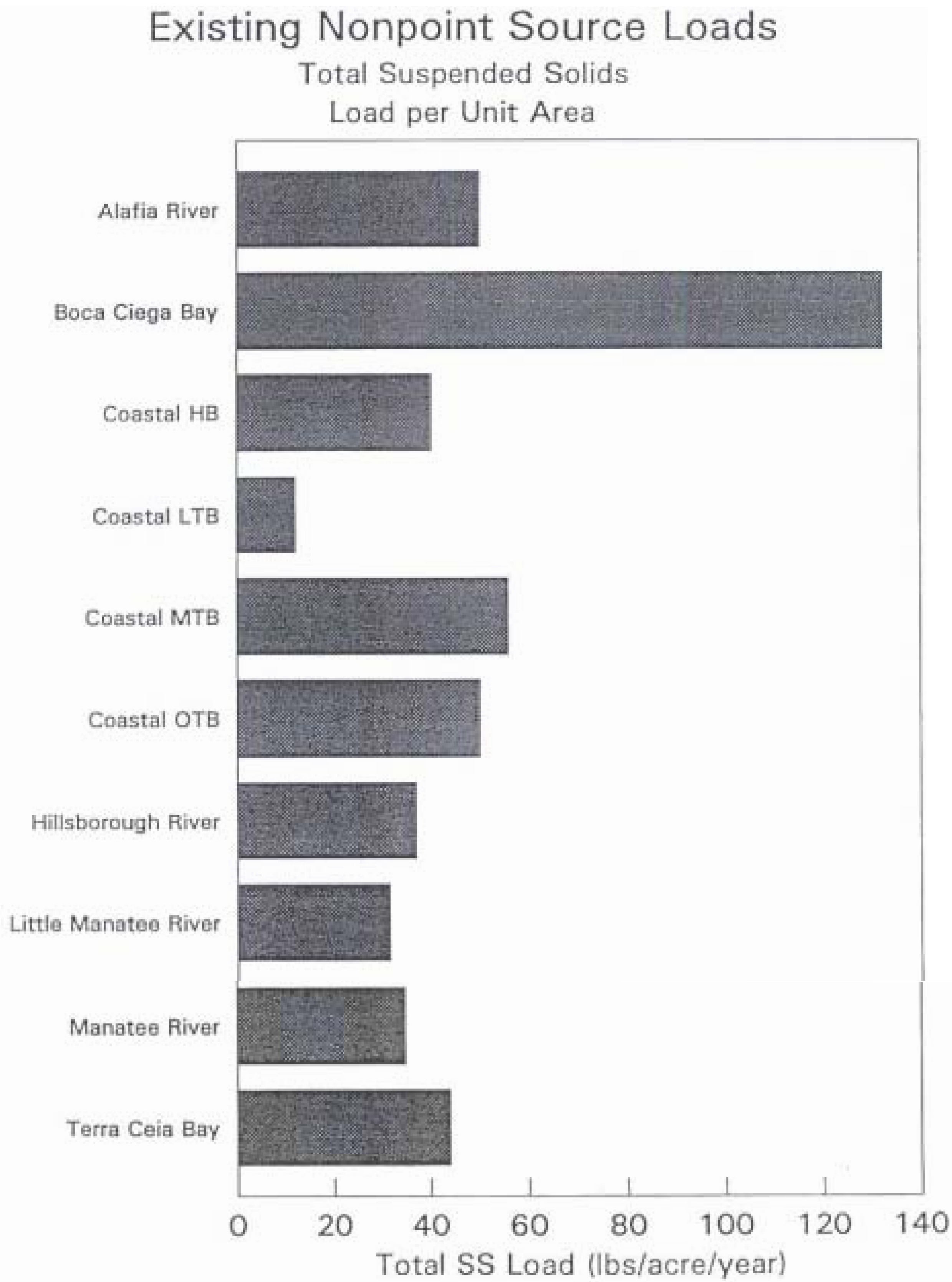


Figure 5-16 Existing nonpoint source loads of TSS per unit area by major basin

5.2 Benchmark Loads

The estimated pollutant loads for the benchmark period (ca. 1938-40) were completed as described in Section 4. Figures 5-17 through 5-19 present the benchmark annual loads by bay segment for TN, TP, and TSS, respectively. Estimated loads by source, including nonpoint source, point source, atmospheric deposition, groundwater, and fugitive emissions, are shown. Hillsborough Bay had the highest estimated benchmark TN load - about 800 tons/year.

The major contributions to benchmark TN loads for all bay segments were from nonpoint sources and atmospheric deposition (Figure 5-17). The estimated point source TN loads to Hillsborough Bay were also significant, and were estimated to contribute a little over 20% (180 tons/year) of the total benchmark TN load to that segment. No TN load resulted from fugitive emissions during the benchmark period, because nitrogen was not a component of fertilizer until the late 1940's.

The largest contributors of benchmark TP loads were estimated to be atmospheric deposition and point sources. As has been estimated for existing conditions, fugitive emissions were a relatively important source of TP loading to Hillsborough Bay and Middle Tampa Bay during the benchmark period (Figure 5-18). The relative contribution of benchmark nonpoint source TP loading was generally lower than for TN loads. Atmospheric deposition, point sources, and fugitive emissions all contributed major fractions of benchmark TP loads.

The major contribution to the TSS loads to all bay segments in the benchmark period was from nonpoint sources (Figure 5-19). Point source loads are the only other source, and contribute only an estimated 5% of the total benchmark TSS load.

5.3 Comparison of Benchmark and Existing Loads

The estimated loads to each bay segment for benchmark and existing conditions can be compared to estimate increases in pollutant loading to Tampa Bay during the past 50 years. Figures 5-20 through 5-22 present the comparison of TN, TP, and TSS loads under benchmark and existing conditions, respectively. Overall, benchmark TN, TP, and TSS loads were estimated to be approximately 50%, 35%, and 25% of existing conditions loads, respectively.

In all bay segments except Terra Ceia Bay, the TN load under existing conditions is considerably greater than that estimated for benchmark conditions (Figure 5-20). The greatest relative differences are estimated for Hillsborough Bay, Boca Ciega Bay, and Middle Tampa Bay. On a bay-wide basis, existing TN loading are estimated to exceed benchmark loads by about 2,000 tons/year. Of that amount, the absolute difference in both estimated TN loads under benchmark and existing conditions is clearly greatest

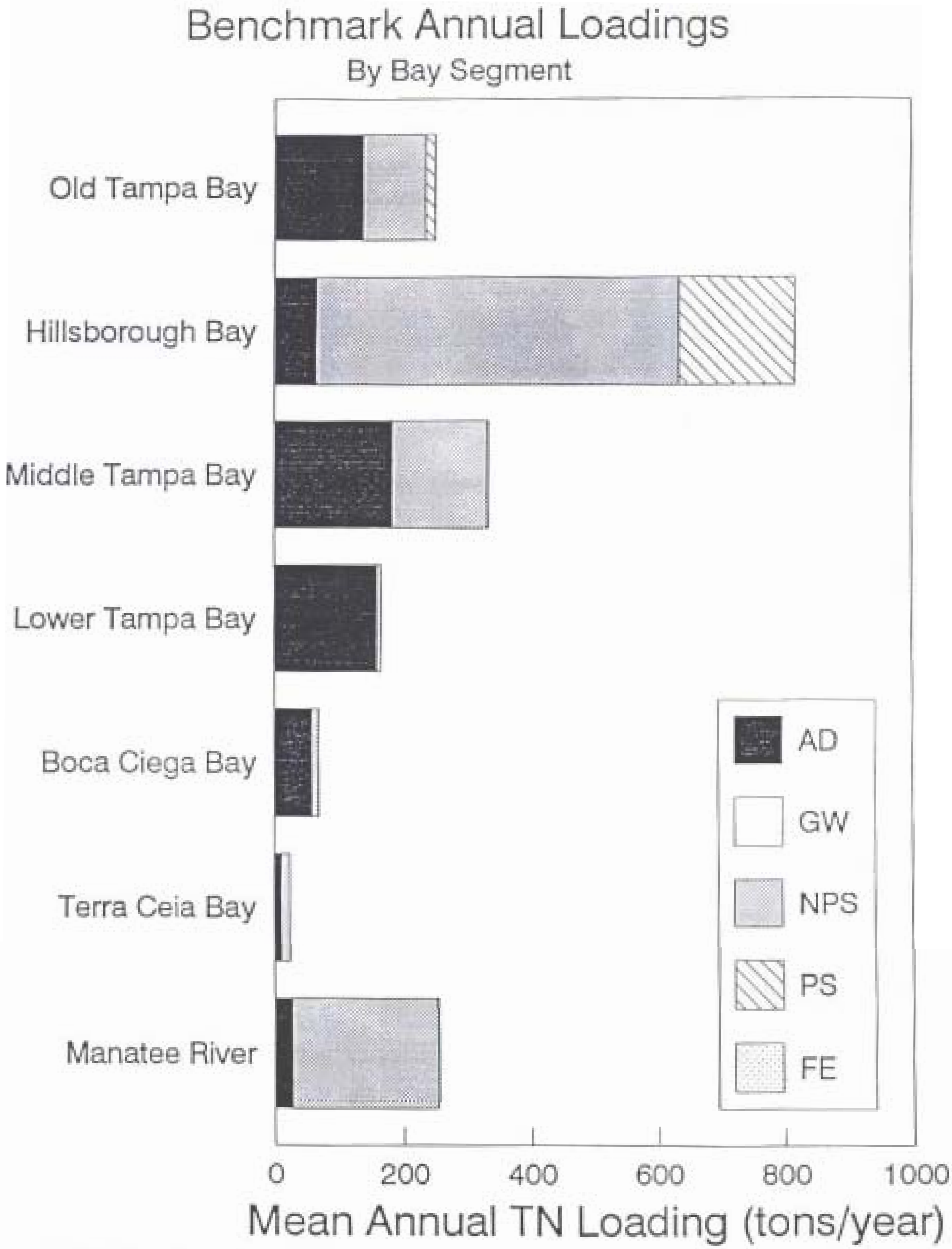


Figure 5-17 Benchmark annual loads of TN by bay segment

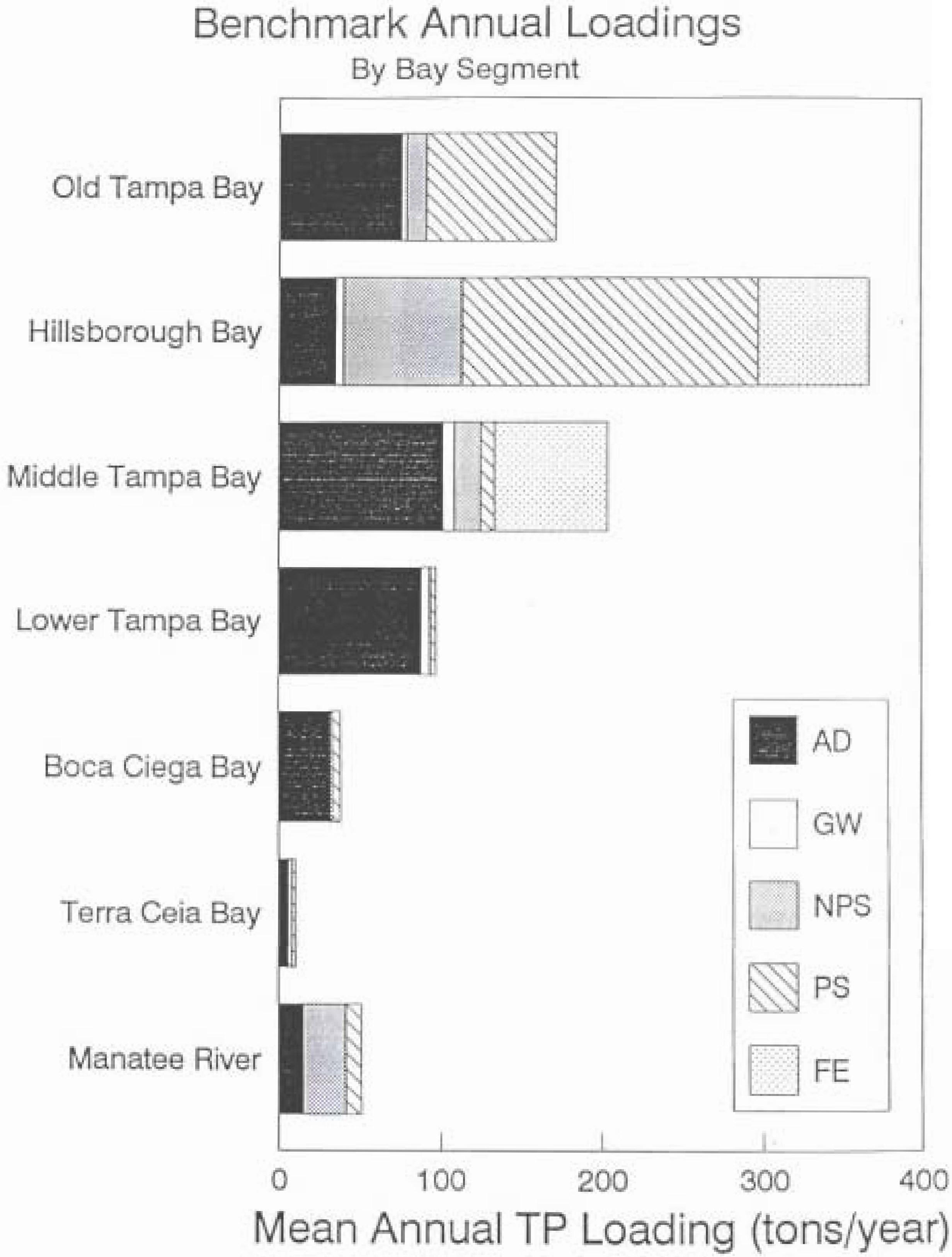


Figure 5-18 Benchmark annual loads of TP by bay segment

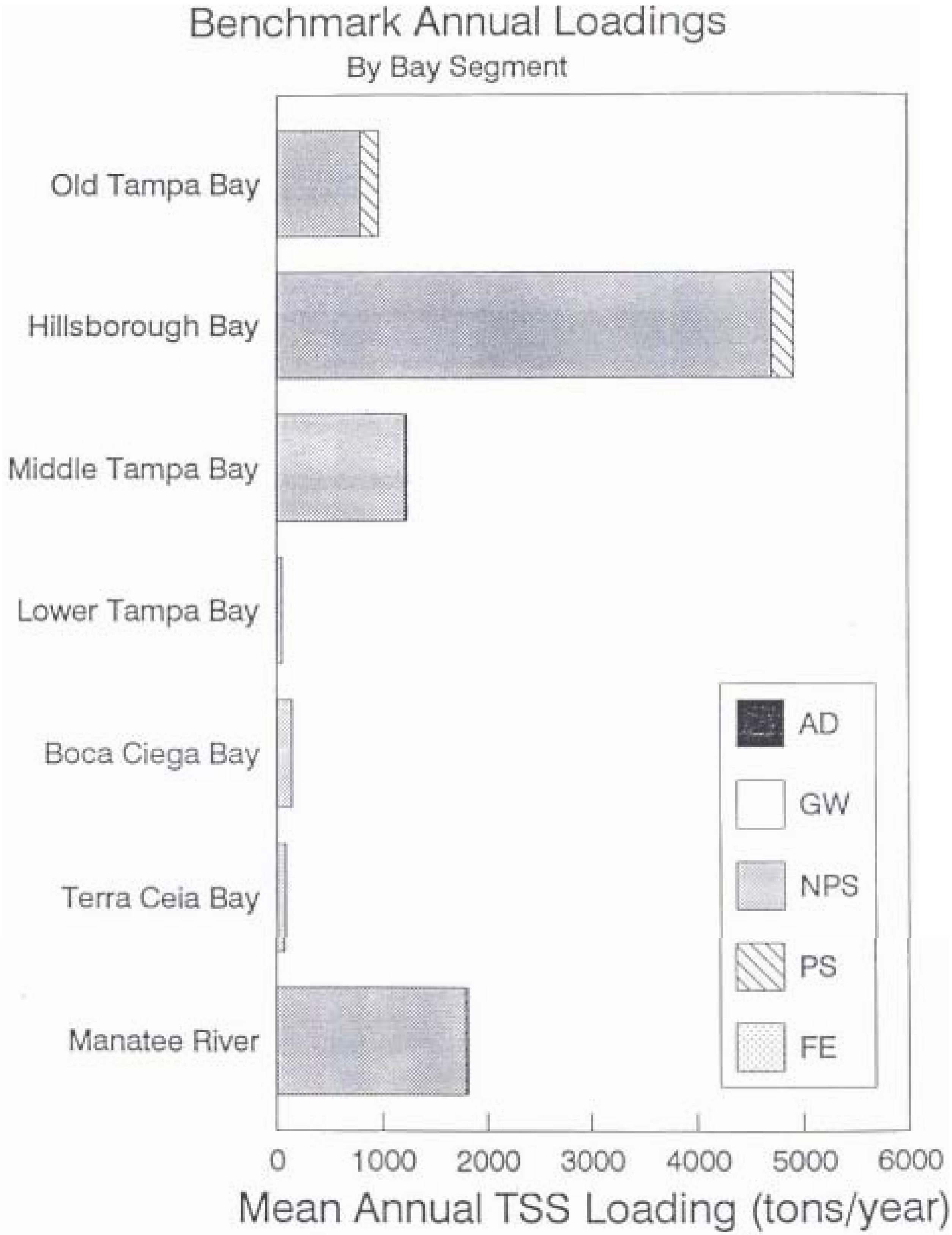


Figure 5-19 Benchmark annual loads of TSS by bay segment

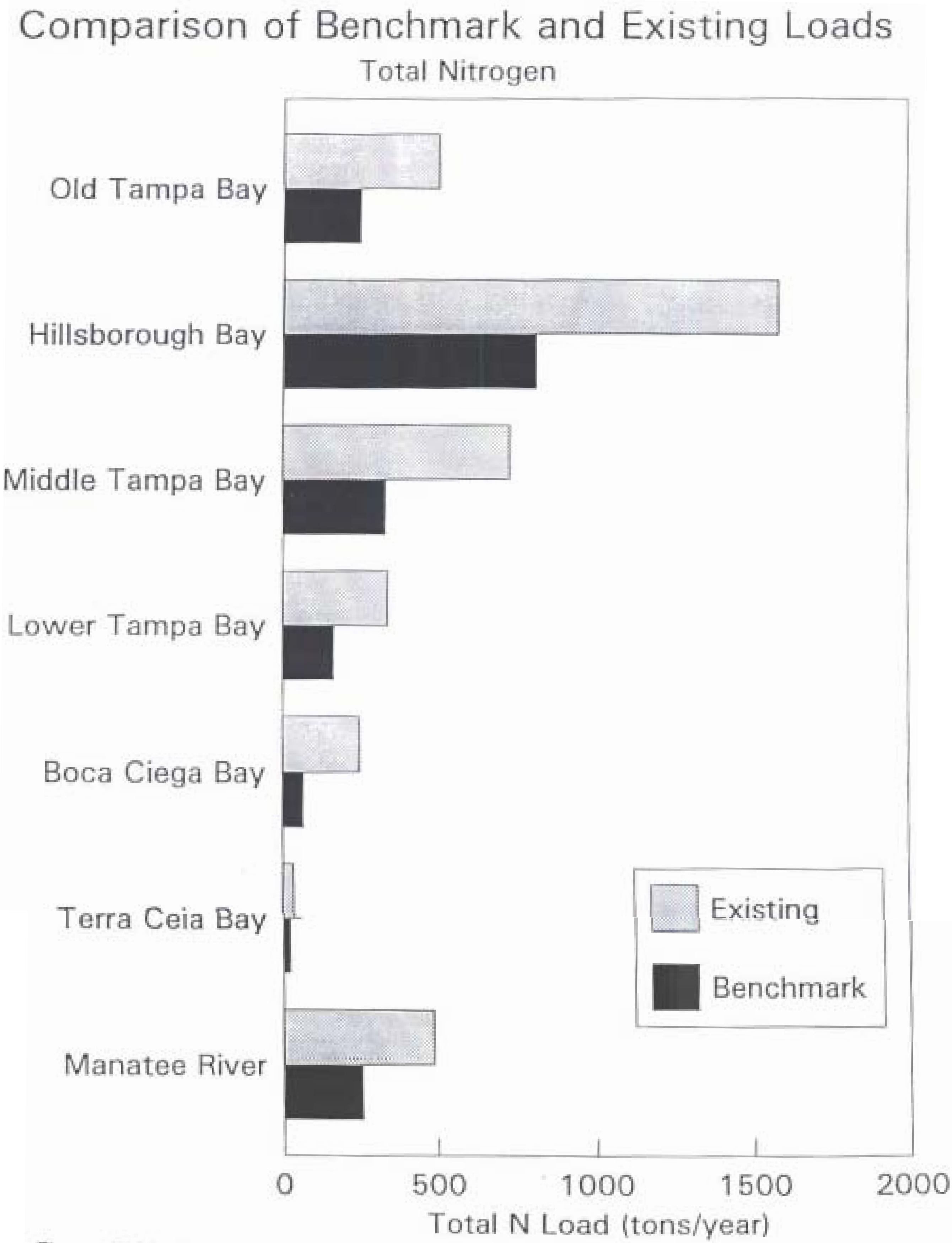
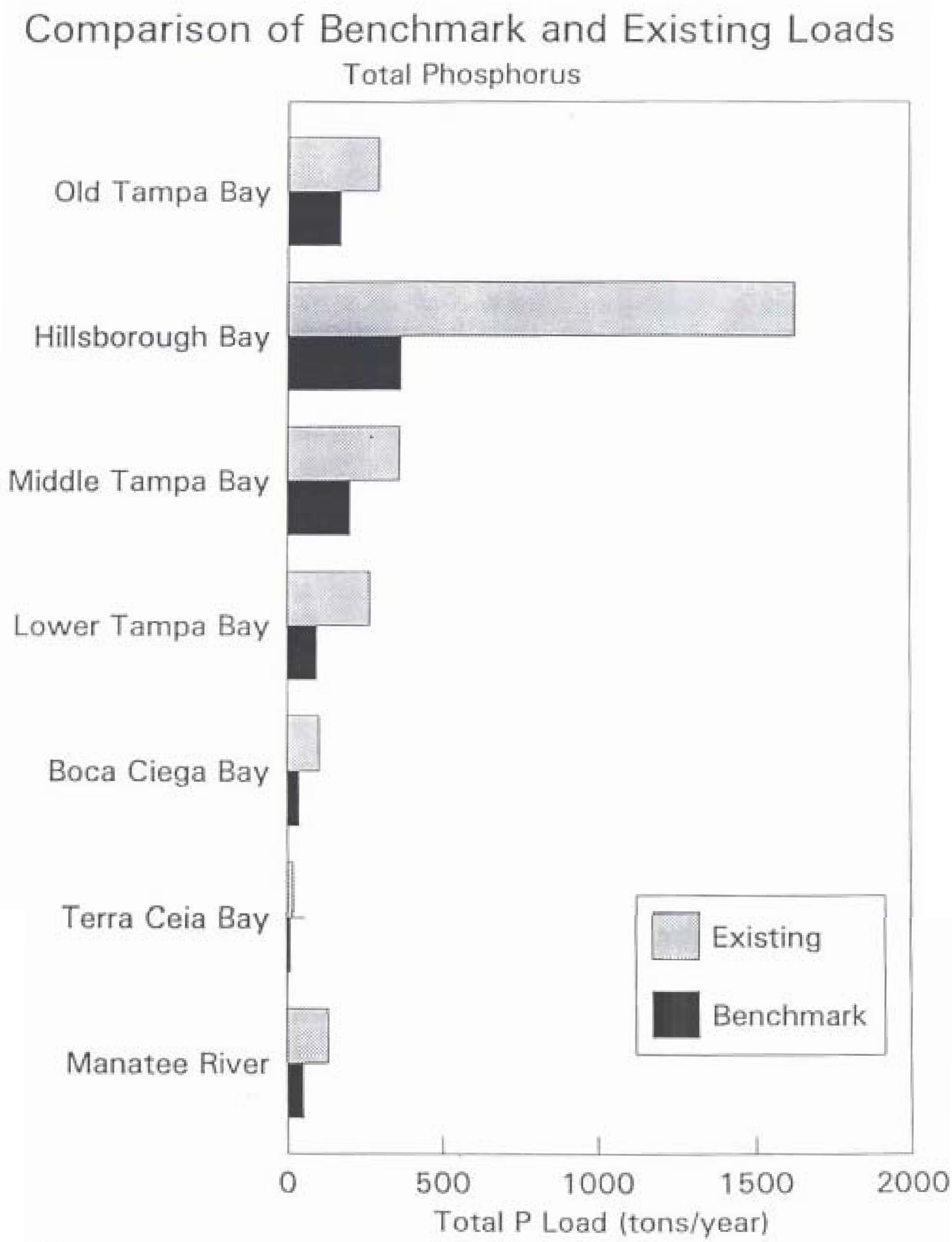
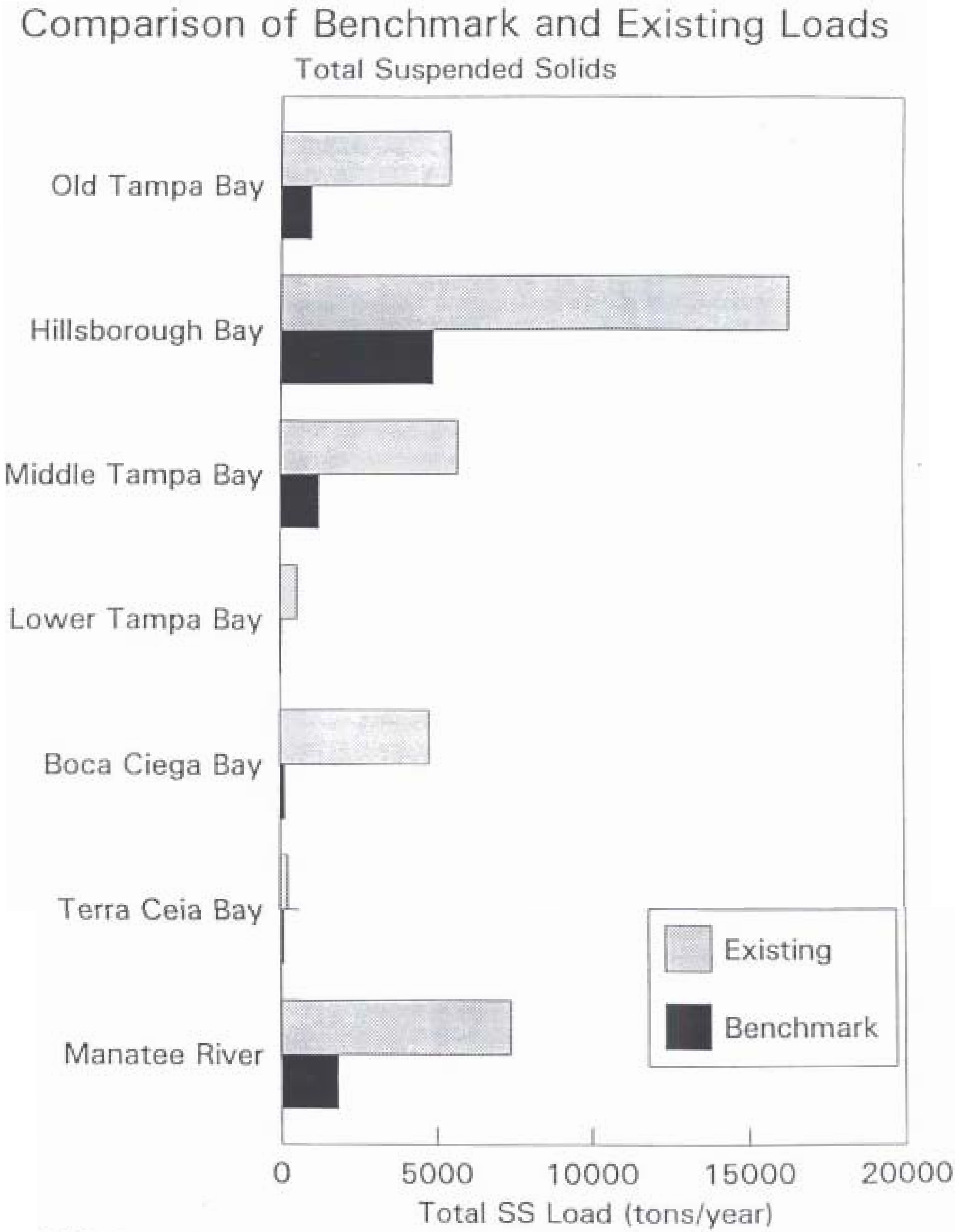


Figure 5-20 Comparison of benchmark and existing TN loads by bay segment



5-21 Comparison of benchmark and existing TP loads by bay segment



5-22 Comparison of benchmark and existing TSS loads by bay segment

(780 tons/year and 400 tons/year, respectively), for Hillsborough Bay and Middle Tampa Bay. There is less difference between the TP load estimates for these two time periods for Old Tampa Bay, Middle Tampa Bay, Boca Ciega Bay, and Terra Ceia Bay. With the exception of Terra Ceia Bay and the Manatee River, the TSS loads to all bay segments under existing conditions are estimated to be appreciably greater (more than twice as large) than under the benchmark conditions.

A comparison of loadings under the two conditions can be further examined by comparing the loads by source for existing conditions to the total estimated loads under the benchmark conditions (Figures 5-23 through 5-25). This approach to loading comparisons for these two conditions is very interesting, especially with regard to potential management strategies that would be necessary if it were desired to reduce pollutant loads to near levels similar to those estimated under benchmark conditions. For example, Figure 5-23 presents the comparison of the benchmark TN loads to each bay segment to the TN loads by source under existing conditions. It is clear from this comparison that current TN loads from atmospheric deposition alone generally equal or exceed the estimated TN loads under the benchmark conditions for several bay segments. This is also true for nonpoint source loads of TN to Hillsborough Bay, Middle Tampa Bay, Boca Ciega Bay and the Manatee River. The estimated current TP loads from atmospheric deposition and nonpoint sources also exceed the total estimated TP loads for several segments under the benchmark conditions (Figure 5-24). Similar results can be seen for TSS loads in Figure 5-25.

5.4 Data Uncertainties, Project Reviews, and Recommendations for Future Study

As discussed above, the pollutant loads generated by this project have been useful for several related projects. The existing pollutant loads have been used in the TBNEP statistical model which relates TN and TP loads to chlorophyll *a* concentrations and light attenuation in Tampa Bay. The results from that model address estimates of the loads of nutrients and suspended solids that can enter Tampa Bay and still allow recolonization of seagrasses in areas that historically had supported seagrass beds.

The loads estimated in this project are also being used in another related project (*SWIM Box Model for Tampa Bay) in which a box model attempts to relate pollutant* loadings to chlorophyll *a* levels in the bay. The nonpoint source load estimates are also being used in a TBNEP project which is attempting a "reality check" by estimating the potential pollutant load reduction levels that can be afforded by best management practices in the Tampa Bay watershed. The pollutant load estimates will also be used in the next year to develop strategies and agreements for pollutant load reductions as part of the Tampa Bay Comprehensive Conservation and Management Plan. Because of the many uses of the data resulting from this investigation, it is important to understand the level of confidence that may be attributed to data used to make the

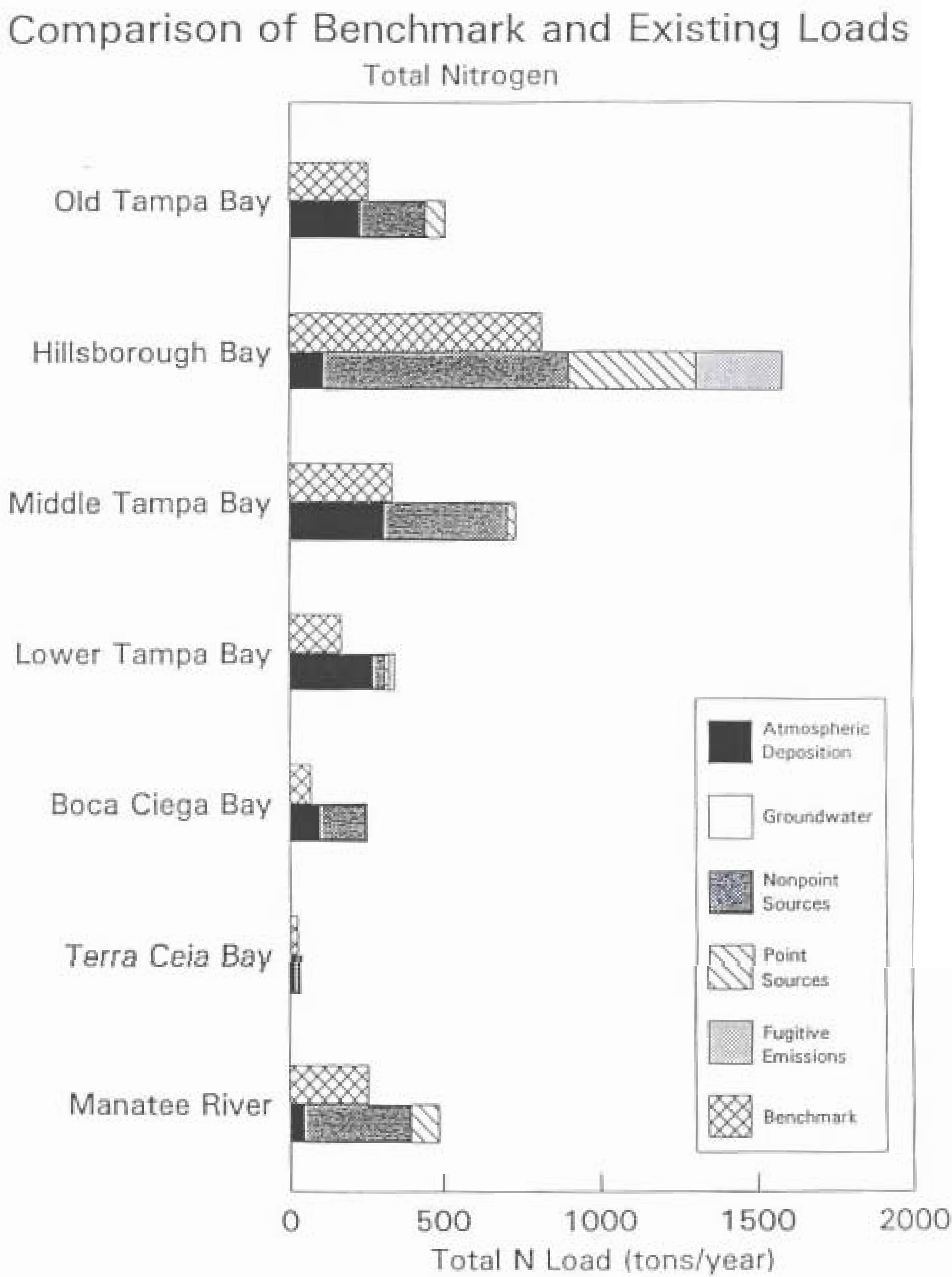


Figure 5-23 Comparison of benchmark and existing TN loads by source and bay segment

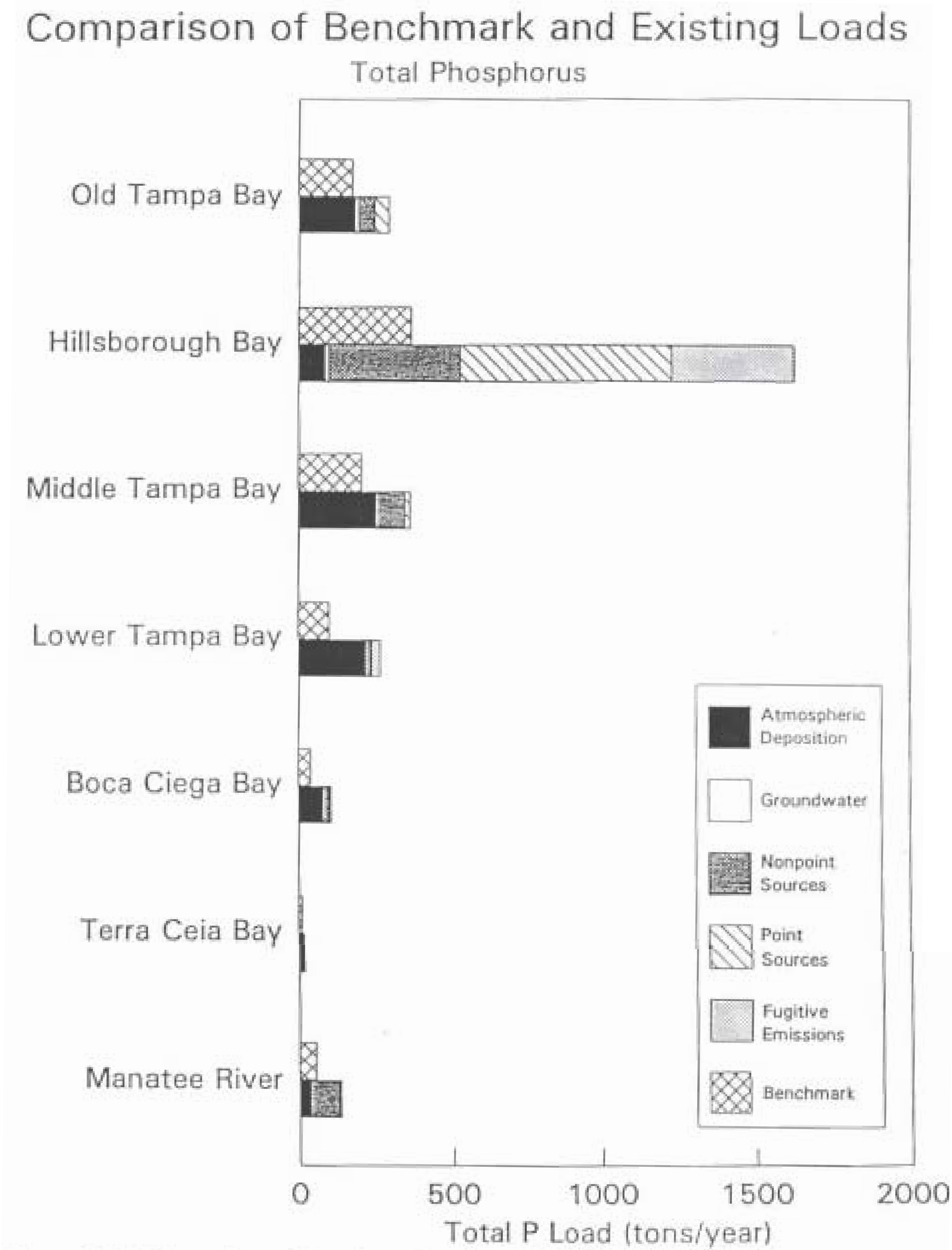


Figure 5-24 Comparison of benchmark and existing TP loads by source and bay segment

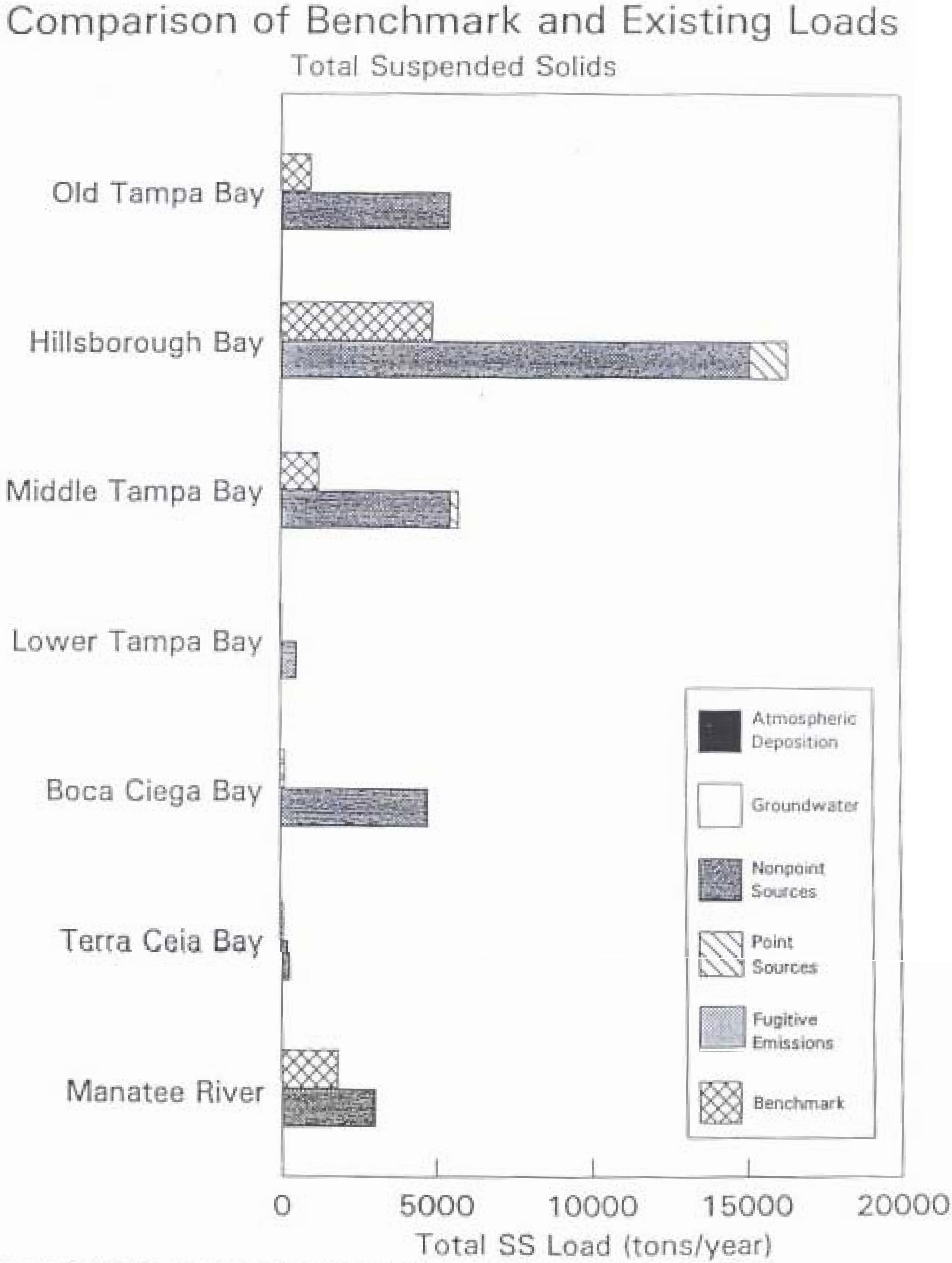


Figure 5-25 Comparison of benchmark and existing TSS loads by source and bay segment

loading estimates, the review process that was completed subsequent to the finalization of this report, and the recommended actions that should be undertaken to improve the certainty of these results. These items are all addressed below.

5.4.1 Data Uncertainties

Numerous sources of information were used to ensure that these estimates of TN, TP, and TSS loadings to TB are as accurate as possible. An extensive review and revision process was completed to allow input from numerous individuals and groups in the public and private sector. However, questions remain about the relative importance of loadings from many of the pollutant sources. This section describes some of these uncertainties, some of which may be addressed for future work to allow a higher degree of confidence in subsequent loading estimates in the Tampa Bay, and other, watersheds. Major loading sources that were included in this analysis are discussed below, with an general appraisal of the completeness and accuracy of the data that were available for use in making the loading estimates.

1) Nonpoint Sources

- Watershed characteristics - generally good data for physical features such as watershed and subbasin boundaries and soils series delineation. Some discrepancies were identified, but much good information exists.

- Hydrologic monitoring data - excellent continuous long-term stream flow data exist from much of the watershed. USGS, SWFWMD and others have long-term monitoring networks in the watershed. Much of the continuous flow data is collected at 15-minute intervals, and are commonly summarized to daily values. Estimates of flows using these data are considered very accurate, and have the higher level of certainty for any parameter used in this analysis.

- Water quality monitoring data - An excellent network of monitoring sites exists. USGS, SWFWMD and local government agencies (EPCHC, PCDEM, MCEAC) have sampling programs within the watershed. One weakness of all these programs is that samples are generally taken on a monthly basis. Although this does provide good data for spatial and long term temporal trends, one grab sample per month does not provide sufficient information to allow modeling estimates to be developed on a short term basis, such as for storm events.

  Also, these periodic samples are generally not taken with regard to stream flow or antecedent rainfall conditions. From a predictive stand point, it is much preferable to have measured water quality data over a wide range of conditions, rather than only from low or moderate flow situations.

Because water quality sampling in the TB watershed is done on a monthly, quarterly or even annual basis, estimates of surface water quality cannot be made with the same confidence as stream flow. It is noted that the cost of monitoring program is very high, and that the desire for more complete data must be balanced with the realities of monetary constraints.

Also, it must be stressed that the monitoring programs in the Tampa Bay watershed are excellent for tracking temporal trends, and provide more consistent long term data than almost any region in the state or country. Therefore, estimates of pollutant loadings made for Tampa Bay should be regarded as very good, especially with respect to loading estimates made for other areas without such complete data.

- <u>Ungaged streamflow and water quality</u> - for portions of the watershed that are not monitored for stream flow or water quality, estimates of loadings must be made using models and literature values of land use-specific water quality concentrations. Ungaged surface runoff/stream flow and pollutant loadings are usually modeled using land use-specific runoff coefficients and water quality concentration factors. Although these factors are based on measured data, this methodology requires wide generalizations to be made about watershed characteristics. Additionally, synthesizing and interpreting data from a variety of field sampling studies is very difficult. Sampling techniques may vary greatly, often preventing a direct comparison of data gathered from a variety of studies. Also, it is very difficult to find and instrument a site suitable for collecting water quality data from a catchment with a single land use.

  However, regionally-specific values for many of these numbers have been developed based on local field sampling programs, so the uncertainty associated with using land use based values is somewhat less for the Tampa Bay region than many other areas. Despite this local work, much uncertainty does exist when using this approach to estimating pollutant loads. The site-specific nature of many land uses prevents an accurate appraisal of their contribution to the nonpoint loadings for a basin. Runoff coefficients and water quality concentrations for land uses and land covers with the most diverse character, such as mining, wetlands and agriculture, generally yield results with the highest uncertainty.

  Additionally, many of the monitoring studies were completed several years ago. Because of changing conditions within many watersheds, such as increasing atmospheric deposition, increased treatment of surface runoff, etc., (as well as changing analytical techniques for measuring water quality constituents), field data older than five or ten years may not be representative of current conditions.

- Land use-specific loading estimates - To estimate nutrient loading to a water body, chemical concentrations are typically measured or estimated from a variety of sources including nonpoint and point sources, atmospheric deposition, groundwater, and others as described in this report. However, it is important to remember that these "sources" are in some cases merely pathways for the conveyance of nutrients to the water body, and that the total nitrogen (TN) and total phosphorus (TP) loadings attributed to these pathways may in fact originate from other ultimate sources. The most commonly recognized true sources of imported TN and TP for a typical watershed include atmospheric deposition, fertilizer application, and the generation of animal waste (Fisher et al., 1988). Although the importance of these factors is now commonly recognized, it is difficult or impossible, at this time, to separate the ultimate sources of the materials that are measured or estimated and attributed to a particular component of the total load.

  This phenomenon is evident when examining stormwater runoff quality for a number of land uses. Stormwater from highly urbanized areas commonly exhibits relatively high concentrations of TN and TP. By examining the potential sources of these materials, it can be concluded that nitrogen and phosphorus must typically be imported to the system from sources and pathways such as atmospheric deposition, fertilizer application (for landscaping), or animal waste (a minor component in an urban setting). Similarly, the TN and TP concentrations in stormwater runoff from agricultural land may be only partially attributable to fertilizer application and animal waste. Therefore, to control and manage nutrient and other loadings the true sources, as well as the more obvious pathways, for the delivery of these materials should be evaluated. Because the relative importance of many true sources and processes is currently poorly understood, research efforts would be wisely spent to examine these issues in greater detail.

2) Point Sources

- Monthly operating reports - MOR records for domestic facilities are generally complete and submitted to FDEP in a timely manner. Using these records for estimating loads is made easier because of the uniform requirements for monthly reports of flow and chemistry. Because domestic facilities all receive wastewater with similar water quality characteristics, the same parameters are sampled at many sites.

  Industrial MOR records are much less complete and consistent. This is mainly a result of different monitoring requirements for different types of industrial facilities. Because plants may treat widely varying process waters, the chemicals required for monitoring may vary significantly between sites. Also, it is sometimes not required to submit monthly MOR for an industrial facility. A uniform requirement for monitoring parameters and monthly submittals would greatly enhance the confidence in MOR data when used for loading estimates.

3) Atmospheric Deposition

- Dryfall data - Rainfall chemistry has been widely monitored and is relatively well-documented with respect to nutrient content on a regional basis. However, it has proven very difficult to quantify the contribution of dryfall (dust fall) to total atmospheric deposition. The ranges of percent contribution vary quite significantly (Section 3), and should be subject to continuing study to more accurately determine the magnitude of this loading source. Additionally, the fraction of upland atmospheric deposition that reaches surface water bodies is not well known. This is subject to numerous factors, and is difficult to estimate. It would prove very useful to resource managers to develop a method of estimating the amount of nonpoint source loading that is attributable to atmospheric deposition.

5.4.2 Project Reviews

The approaches taken in this project to estimating pollutant loads for existing, "worst case", future, and benchmark conditions have been subject to an intense review process. Initially, the Modeling TAC subcommittee reviewed the hydrologic components of the loading model in meetings held in February and March, 1993. A later subcommittee review meeting was held in April to review the loading estimates and the approach to be taken to estimate pollutant loads under benchmark conditions. A draft report of the results was circulated by TBNEP in late May, prior to a series of seminars presented to federal, state, and local government agency staff, as well as to the Management and Policy committees in June, 1993.

Several additional workshops and review meetings were held during the summer of 1993. Revisions, additions, and other input from these reviews was incorporated into the model. Additionally, data uncertainties were recognized and documented. This report is the result of input from those individuals and groups listed in the acknowledgements, as well as numerous others.

5.4.3 Recommendations for Future Study

Recommendations for methods to improve the existing loading estimates have been made by a number of individuals and groups during the review process. Many of the suggestions made during that process have already been incorporated into this report. Some of the recommendations for future refinement of the Tampa Bay loading estimates include:

- Estimate loadings for organic and inorganic nitrogen species in addition to total nitrogen.
- Provide further examination of reclaimed water (land-applied effluent) loading estimates from several systems.
- Provide estimates of loads from septic tanks.
- Incorporate nutrient exchange with bottom sediments and exchange between bay segments and the bay and Gulf of Mexico into the loading estimates.
- Estimate influence of reservoirs and in-stream retention areas on nutrient loading to the bay or tributaries.
- Improve estimates of nonpoint source loadings from agricultural land and wetlands with respect to the ultimate source of pollutants that are measured in runoff from those areas.
- Estimate atmospheric loading contribution to nonpoint source loads in the watershed.
- Improve estimates of nitrous oxide emissions.
- Revise fugitive emission loadings to reflect recent improvements in pollution control measures.

These and other comments and recommendations should be considered in the process of refining the pollutant loading estimates.

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APPENDICES

APPENDIX 1

AGGREGATED FLORIDA LAND USE, COVER AND FORM CLASSIFICATION SYSTEM CATEGORIES

URBAN LAND USE CATEGORIES

COASTAL LAND USE CODE	FLUCCS CODE
1 - Low Density Residential	1100
2 - Medium Density Residential	1200
3 - High Density Residential	1300
4 - Commercial	1400
5 - Industrial	1500
7 - Institutional, Transportation, Utilities	1700 8100 8200 8300

AGRICULTURE LAND USE CATEGORIES

COASTAL LAND USE CODE	FLUCCS CODE
6 - Mining	1600
11 - Groves	2200 2210 2220 2230
12 - Feedlots	2300
13 - Nursery	2400
14 - Row and Field Crops	2100 2140 2150 2440

UPLAND FORESTED LAND USE CATEGORIES

COASTAL LAND USE CODE	FLUCCS CODE
8 - Range Lands	1480 1800 1900 2420 2600 3100 3200 3300
9 - Barren Lands	7100 7200 7300 7400
10 - Pasture	2110 2120 2130
15 - Upland Forests	4100 4110 4120 4200 4300 4340 4400

WATER AND WETLANDS LAND USE CATEGORIES

COASTAL LAND USE CODE	FLUCCS CODE
16 - Freshwater	2500 2540 2550 5100 5200 5210 5220 5230 5240 5300 5310 5320 5330 5340 5500 5600 6440 6450
17 - Saltwater	5400 9113 9116 9121
18 - Forested Freshwater Wetlands	6100 6110 6150 6200 6210 6240 6300
19 - Saltwater Wetlands	6120 6420
20 - Non-forested Freshwater Wetlands	6400 6410 6411 6430 6530
21 - Tidal Flats	6500 6510, 6520

APPENDIX 2

EXISTING CONDITIONS LAND USE-SPECIFIC SEASONAL RUNOFF COEFFICIENTS

Season Land Use-Specific Runoff Coefficients

Coastal Land Use Classification and Land Use Type	Hydrologic Soil Group	Dry Season Runoff Coeff.	Wet Season Runoff Coeff.
1) Single Family Residential	A	0.15	0.25
	B	0.18	0.28
	C	0.21	0.31
	D	0.24	0.34
2) Medium Density Residential	A	0.25	0.35
	B	0.30	0.40
	C	0.35	0.45
	D	0.40	0.50
3) Multifamily Residential	A	0.35	0.50
	B	0.42	0.57
	C	0.50	0.65
	D	0.58	0.75
4) Commercial	A	0.70	0.79
	B	0.74	0.83
	C	0.78	0.97
	D	0.82	0.91
5) Industrial	A	0.65	0.75
	B	0.70	0.80
	C	0.75	0.85
	D	0.80	0.90

Season Land Use-Specific Runoff Coefficients (cont)

Land Use	Hydrologic Soil Group	Dry Season Runoff C.	Wet Season Runoff C.
6) Mining	A	0.20	0.20
	B	0.30	0.30
	C	0.40	0.40
	D	0.50	0.50
7) Institutional, Transportation Utilities	A	0.40	0.50
	B	0.45	0.55
	C	0.50	0.60
	D	0.55	0.65
8) Range Lands	A	0.10	0.18
	B	0.14	0.22
	C	0.18	0.26
	D	0.22	0.30
9) Barren Lands	A	0.45	0.55
	B	0.50	0.60
	C	0.55	0.65
	D	0.60	0.70
10) Agricultural - Pasture	A	0.10	0.18
	B	0.14	0.22
	C	0.18	0.26
	D	0.22	0.30

Season Land Use-Specific Runoff Coefficients (cont)

Land Use	Hydrologic Soil Group	Dry Season Runoff C.	Wet Season Runoff C.
11) Agricultural - Groves	A	0.20	0.26
	B	0.23	0.29
	C	0.26	0.32
	D	0.29	0.33
12) Agricultural - Feedlots	A	0.35	0.45
	B	0.40	0.50
	C	0.45	0.55
	D	0.50	0.60
13) Agricultural - Nursery	A	0.20	0.30
	B	0.25	0.35
	C	0.30	0.40
	D	0.35	0.45
14) Agricultural - Row and Field Crops	A	0.20	0.30
	B	0.25	0.35
	C	0.30	0.40
	D	0.35	0.45
15) Upland Forested	A	0.10	0.15
	B	0.13	0.18
	C	0.16	0.21
	D	0.19	0.24

Season Land Use-Specific Runoff Coefficients (cont)

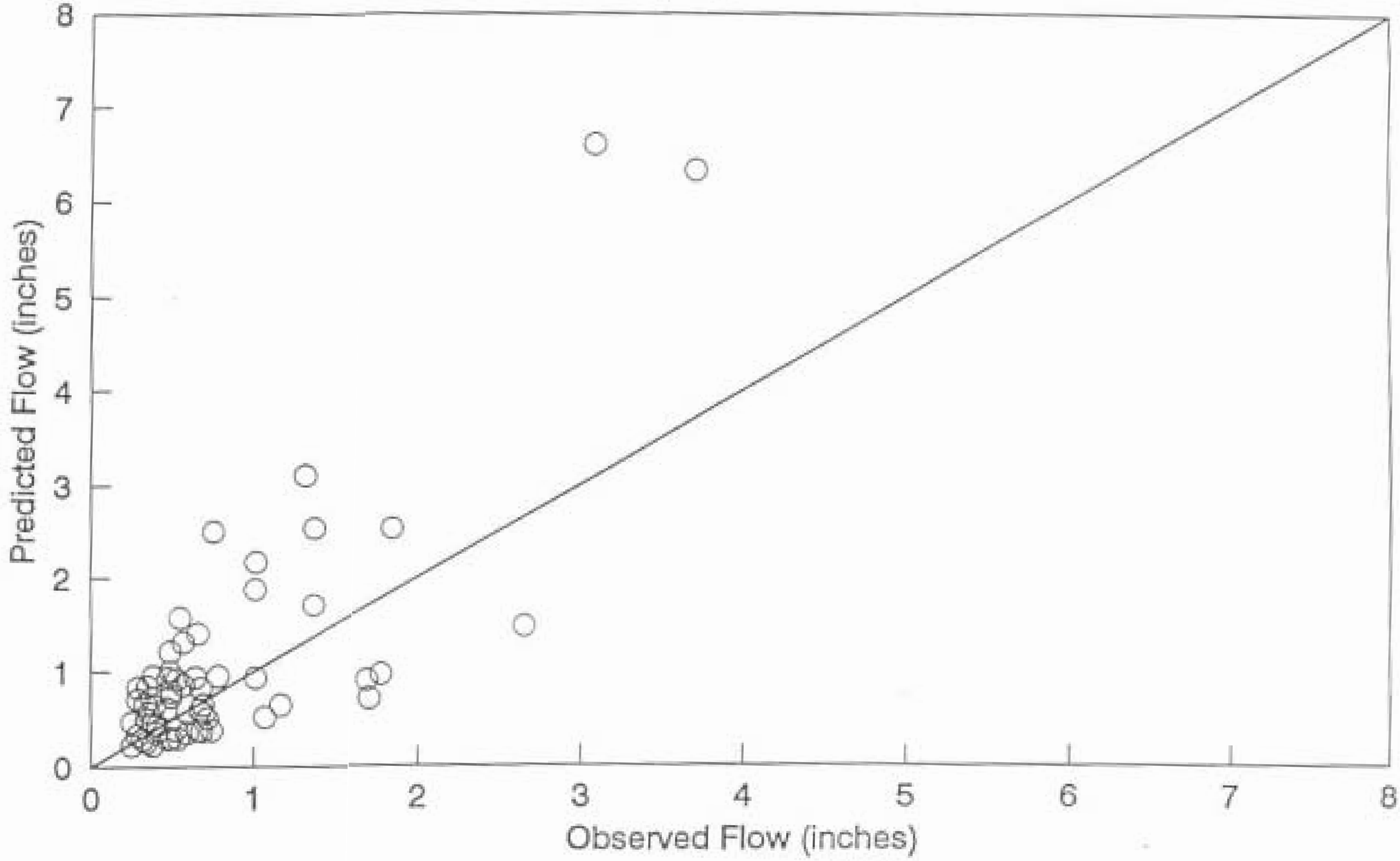
Land Use	Hydrologic Soil Group	Dry Season Runoff C.	Wet Season Runoff C.
16) Freshwater - Open Water	A	0.80	0.90
	B	0.80	0.90
	C	0.80	0.90
	D	0.80	0.90
17) Saltwater - Open Water	A	1.0	1.0
	B	1.0	1.0
	C	1.0	1.0
	D	1.0	1.0
18) Forested Freshwater Wetlands	A	0.50	.60
	B	0.55	0.65
	C	0.60	0.70
	D	0.65	0.75
19) Saltwater Wetlands	A	0.95	0.95
	B	0.95	0.95
	C	0.95	0.95
	D	0.95	0.95
20) Non-forested Freshwater Wetlands	A	0.45	0.55
	B	0.50	0.60
	C	0.55	0.65
	D	0.60	0.70
21) Tidal Flats	A	1.0	1.0
	B	1.0	1.0
	C	1.0	1.0
	D	1.0	1.0

APPENDIX 3

EMPIRICAL HYDROLOGIC MODEL VALIDATION PLOTS

TAMPA BAY HYDROLOGIC MODEL

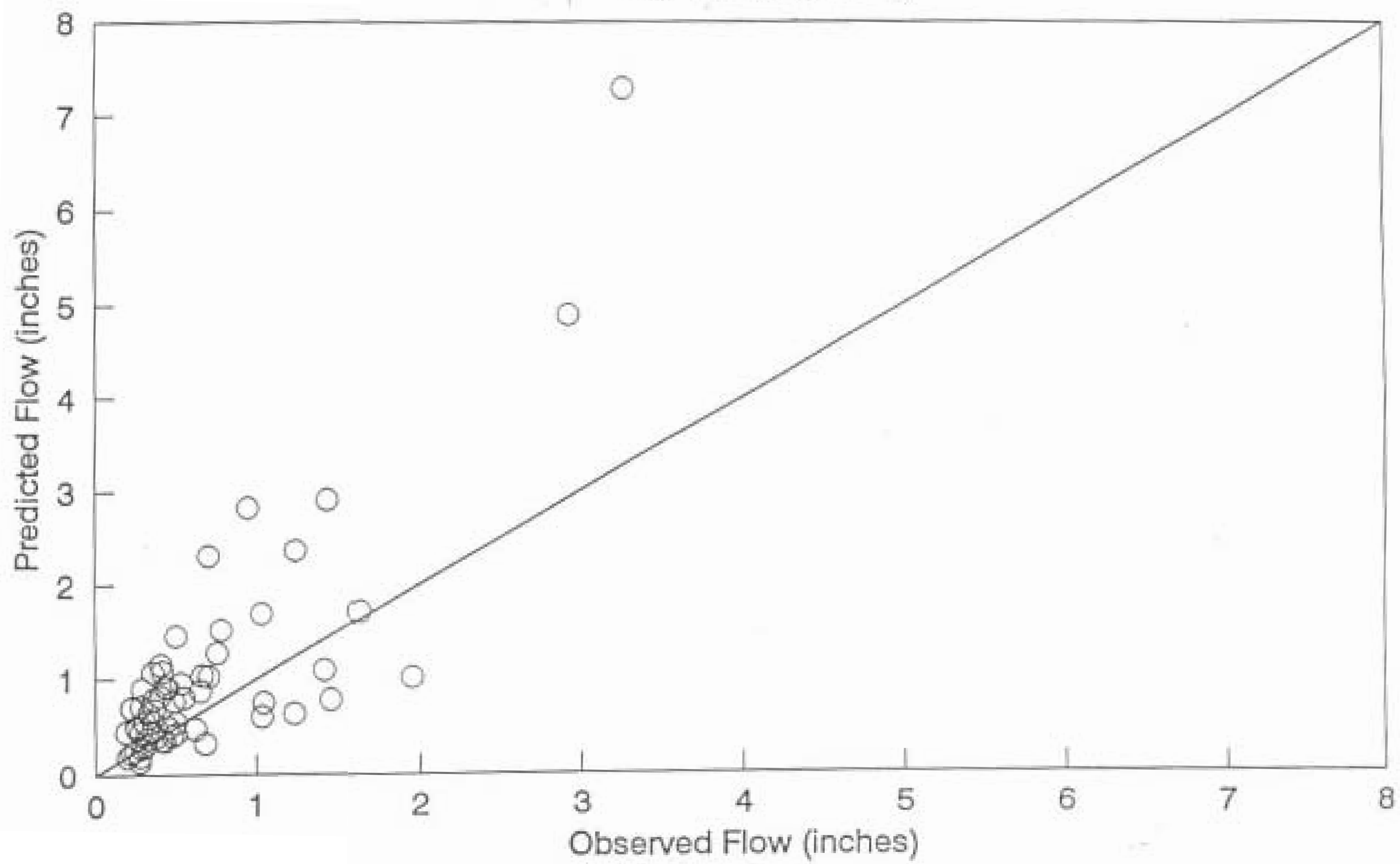
Predicted vs. Observed Flow
Alafia River (Gage 02301000)

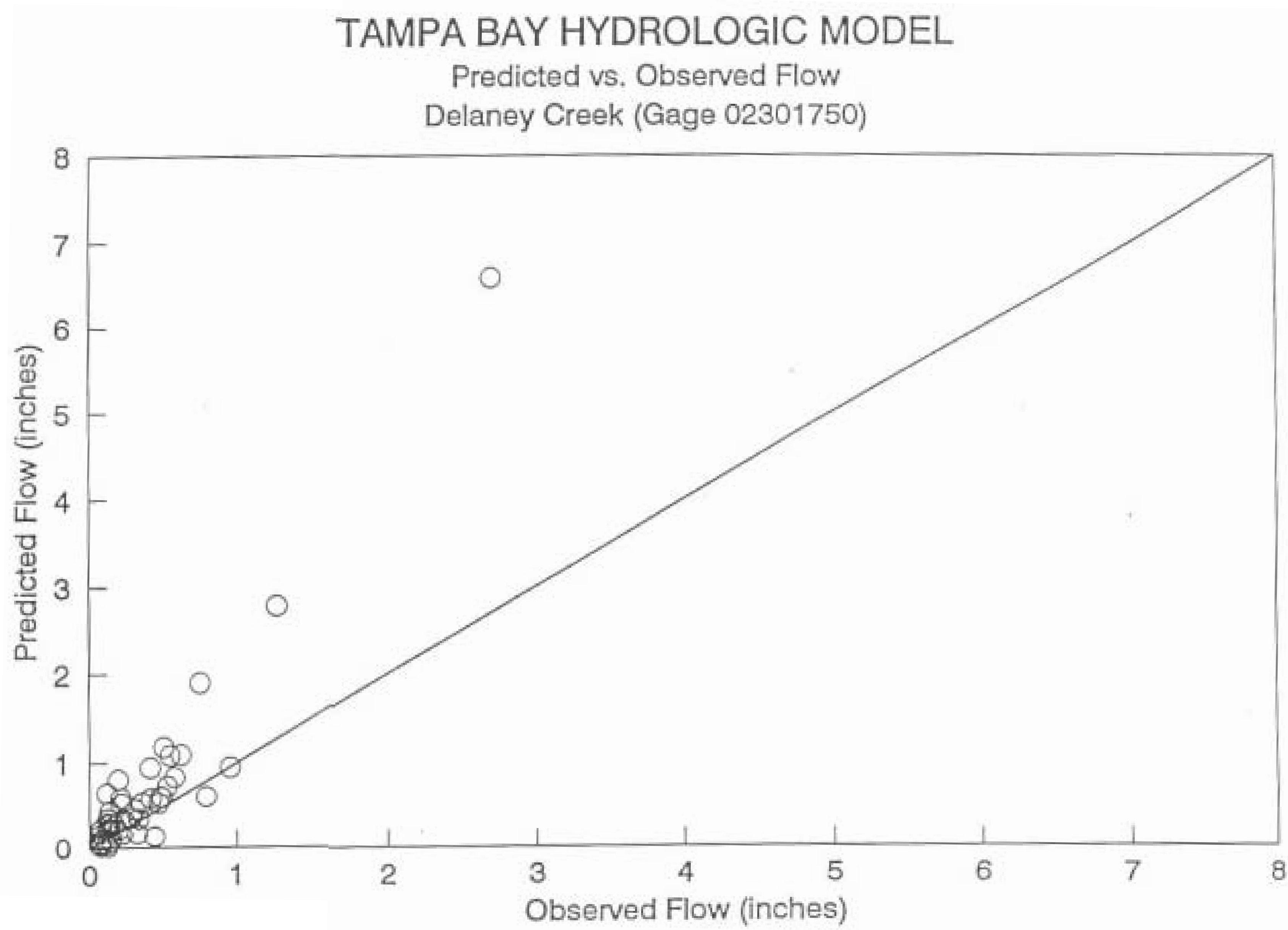


TAMPA BAY HYDROLOGIC MODEL

Predicted vs. Observed Flow

Alafia River (Gage 02301500)

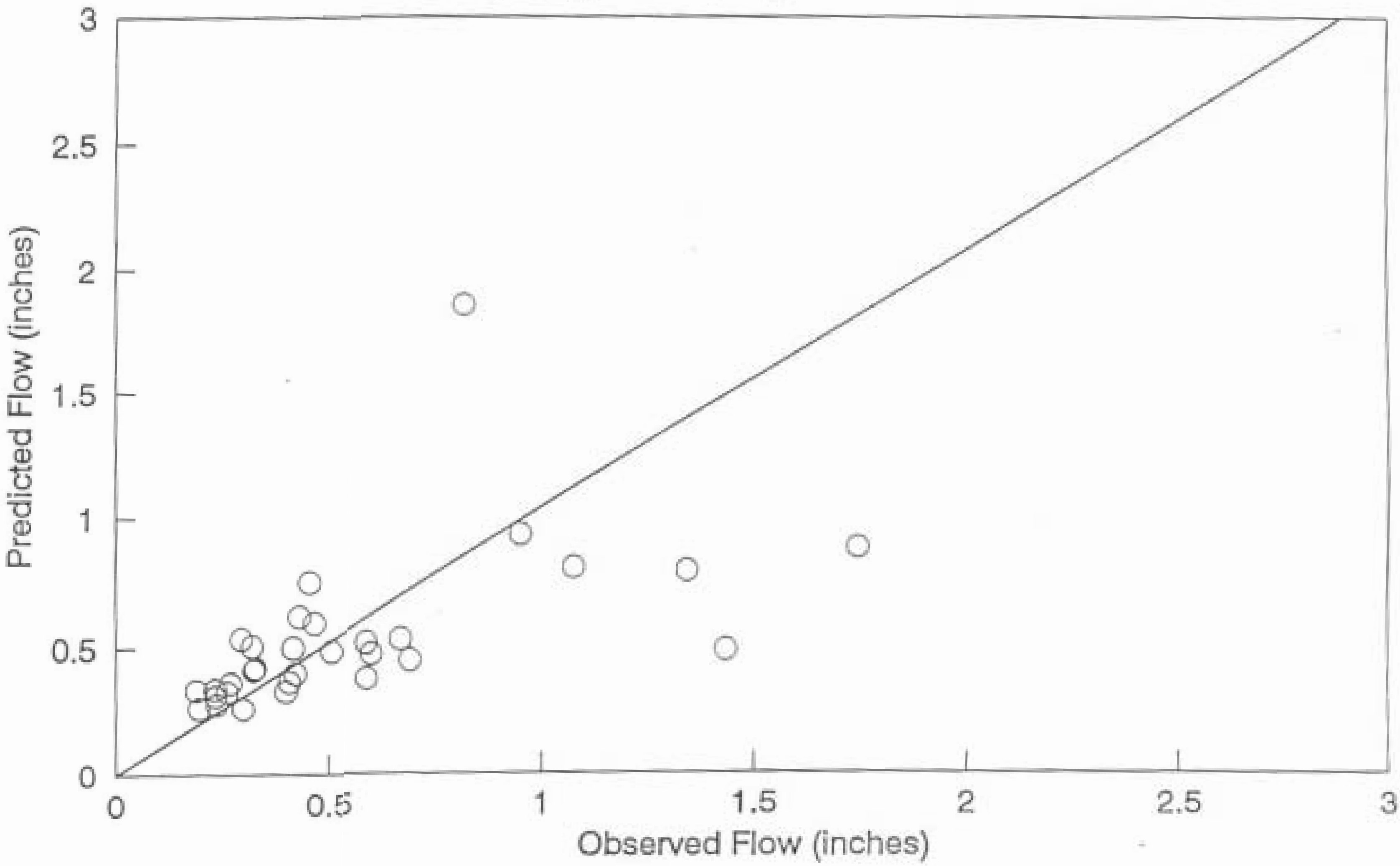


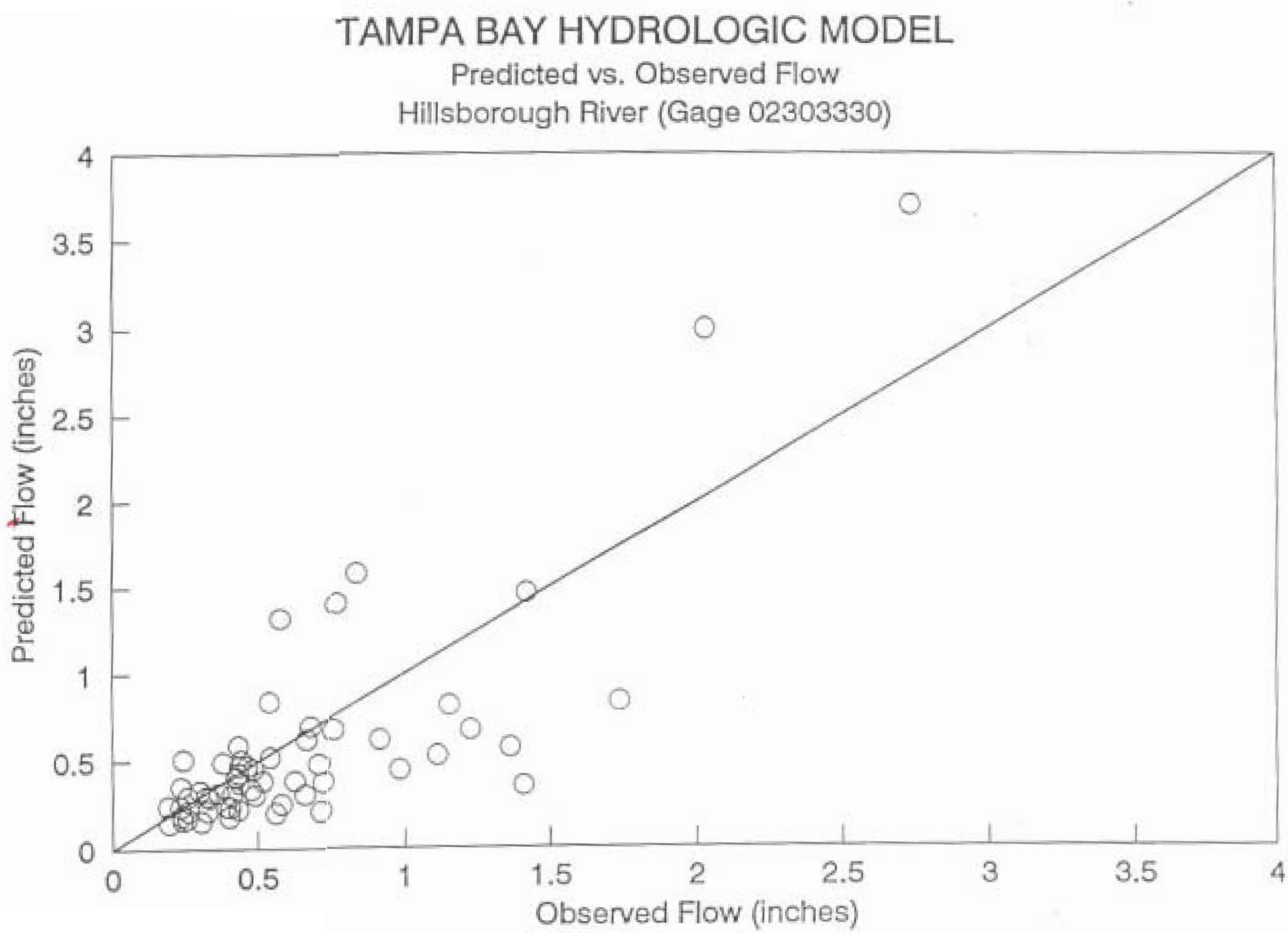

TAMPA BAY HYDROLOGIC MODEL
Predicted vs. Observed Flow
Delaney Creek (Gage 02301750)
Predicted Flow (inches)
Observed Flow (inches)
0
1
2
3
4
5
6
7
8

TAMPA BAY HYDROLOGIC MODEL

Predicted vs. Observed Flow

Hillsborough River (Gage 02303000)

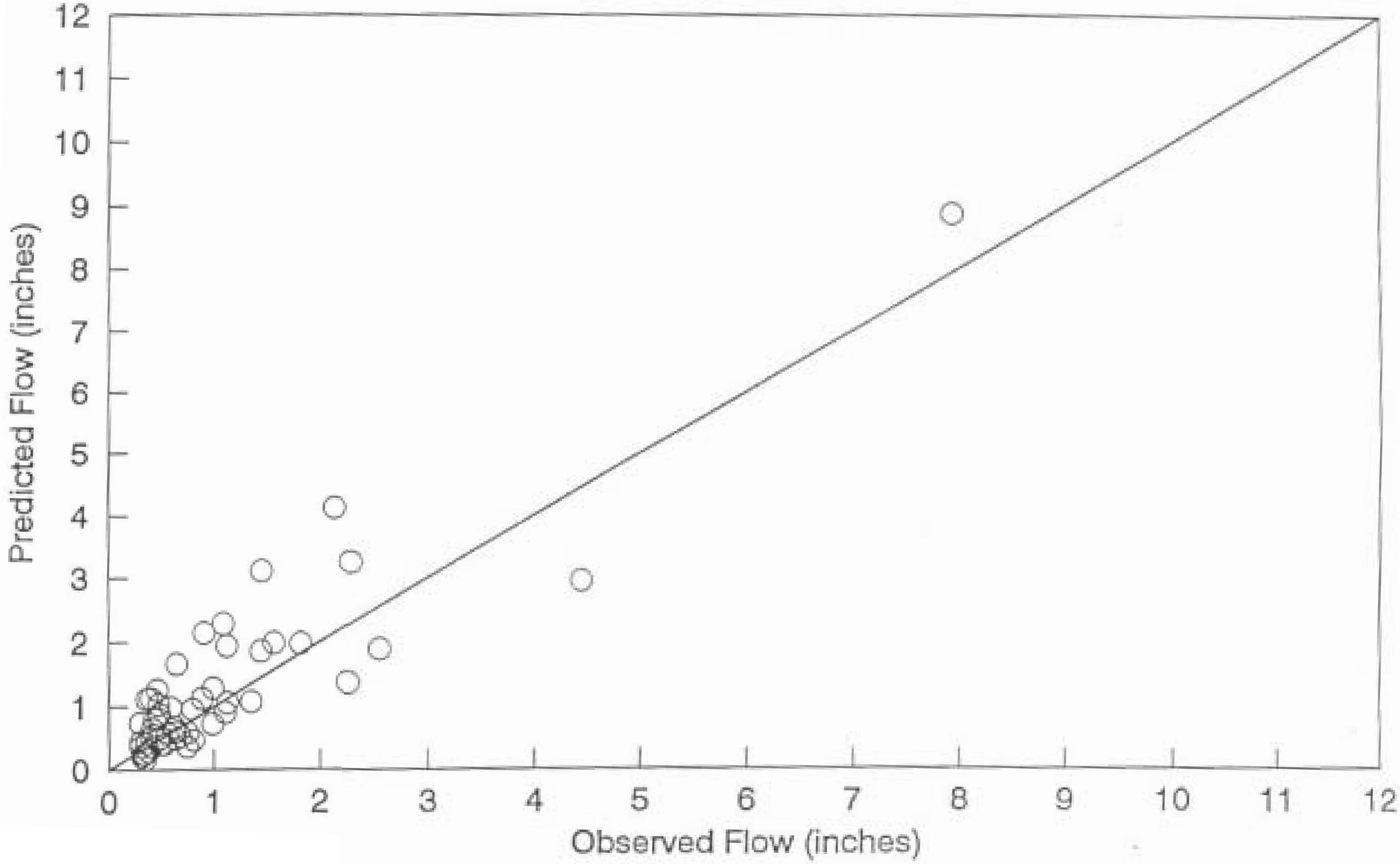



TAMPA BAY HYDROLOGIC MODEL
Predicted vs. Observed Flow
Hillsborough River (Gage 02303330)
Predicted Flow (inches)
Observed Flow (inches)
0
0.5
1
1.5
2
2.5
3
3.5
4

TAMPA BAY HYDROLOGIC MODEL

Predicted vs. Observed Flow

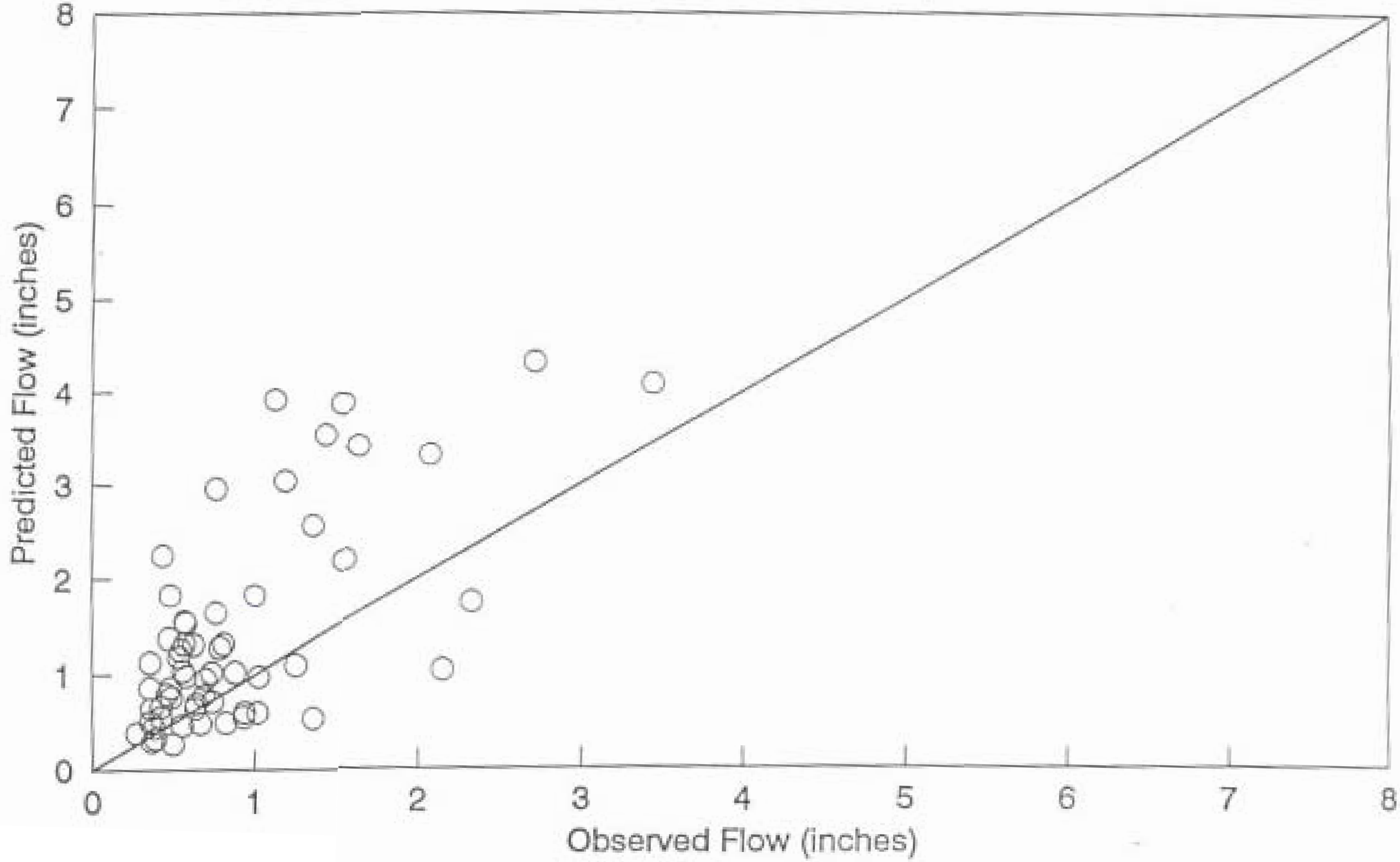
Little Manatee River (Gage 02300500)



TAMPA BAY HYDROLOGIC MODEL

Predicted vs. Observed Flow

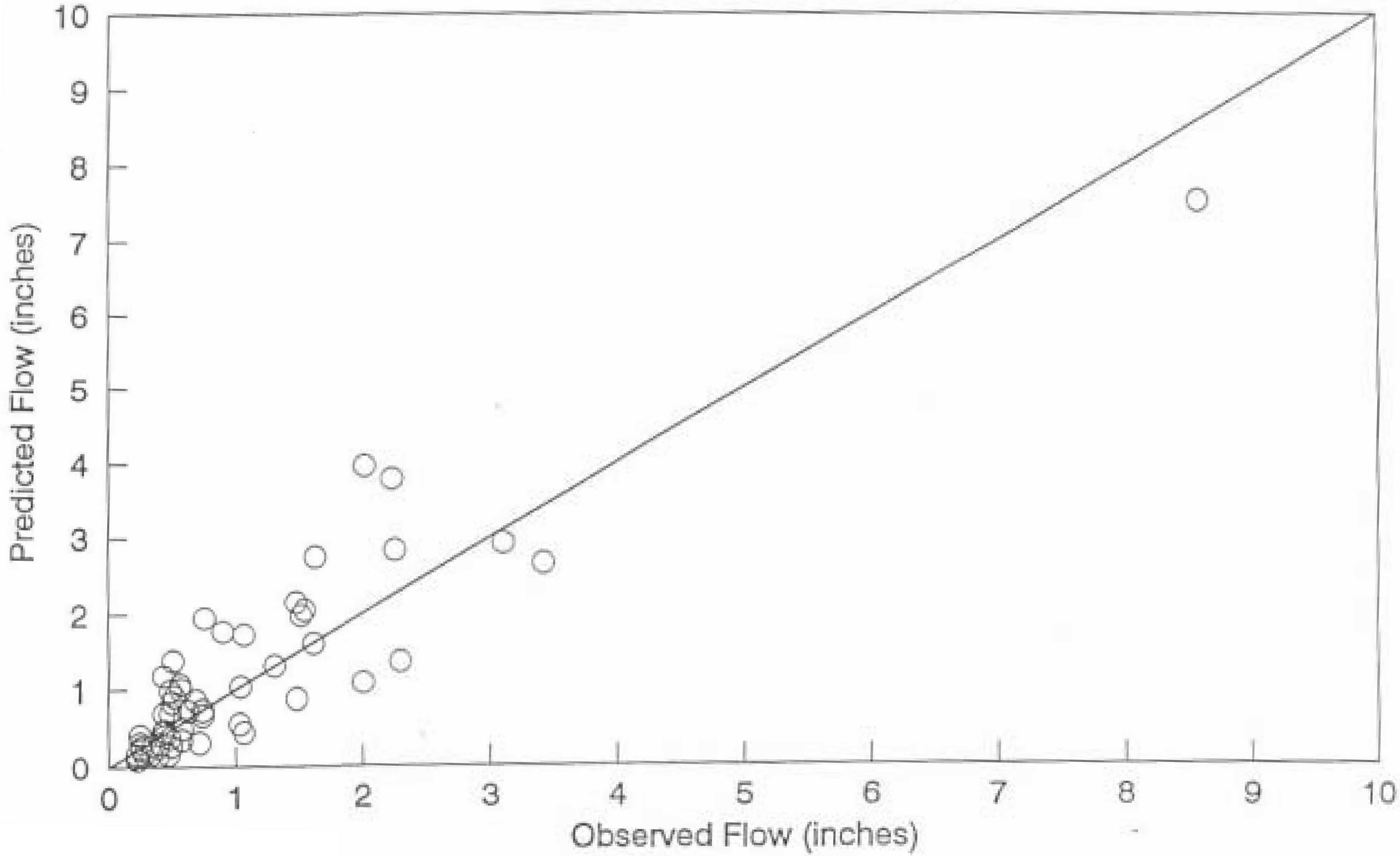
Bullfrog Creek (Gage 02300700)



TAMPA BAY HYDROLOGIC MODEL

Predicted vs. Observed Flow

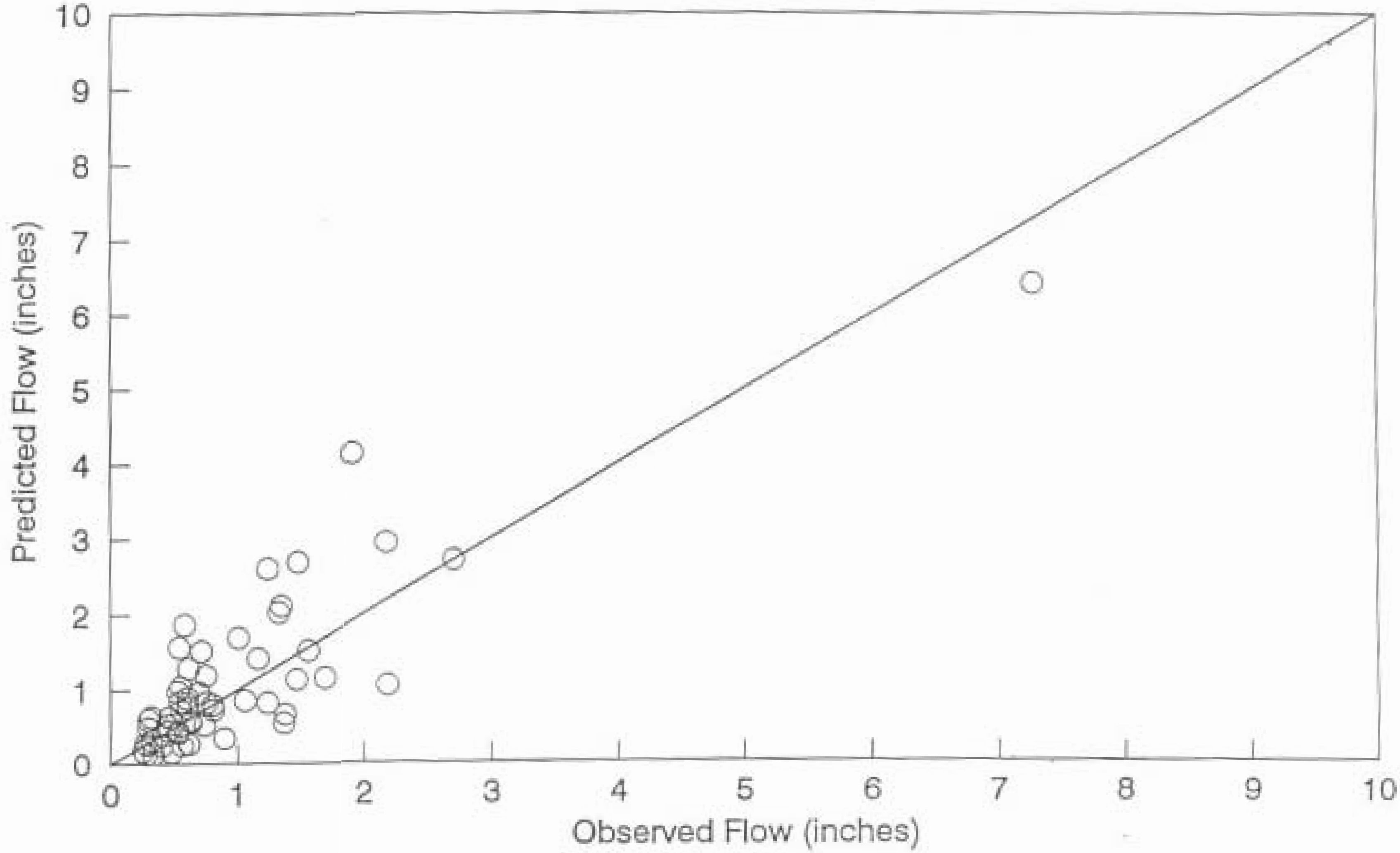
Sweetwater Creek (Gage 02306647)



TAMPA BAY HYDROLOGIC MODEL

Predicted vs. Observed Flow

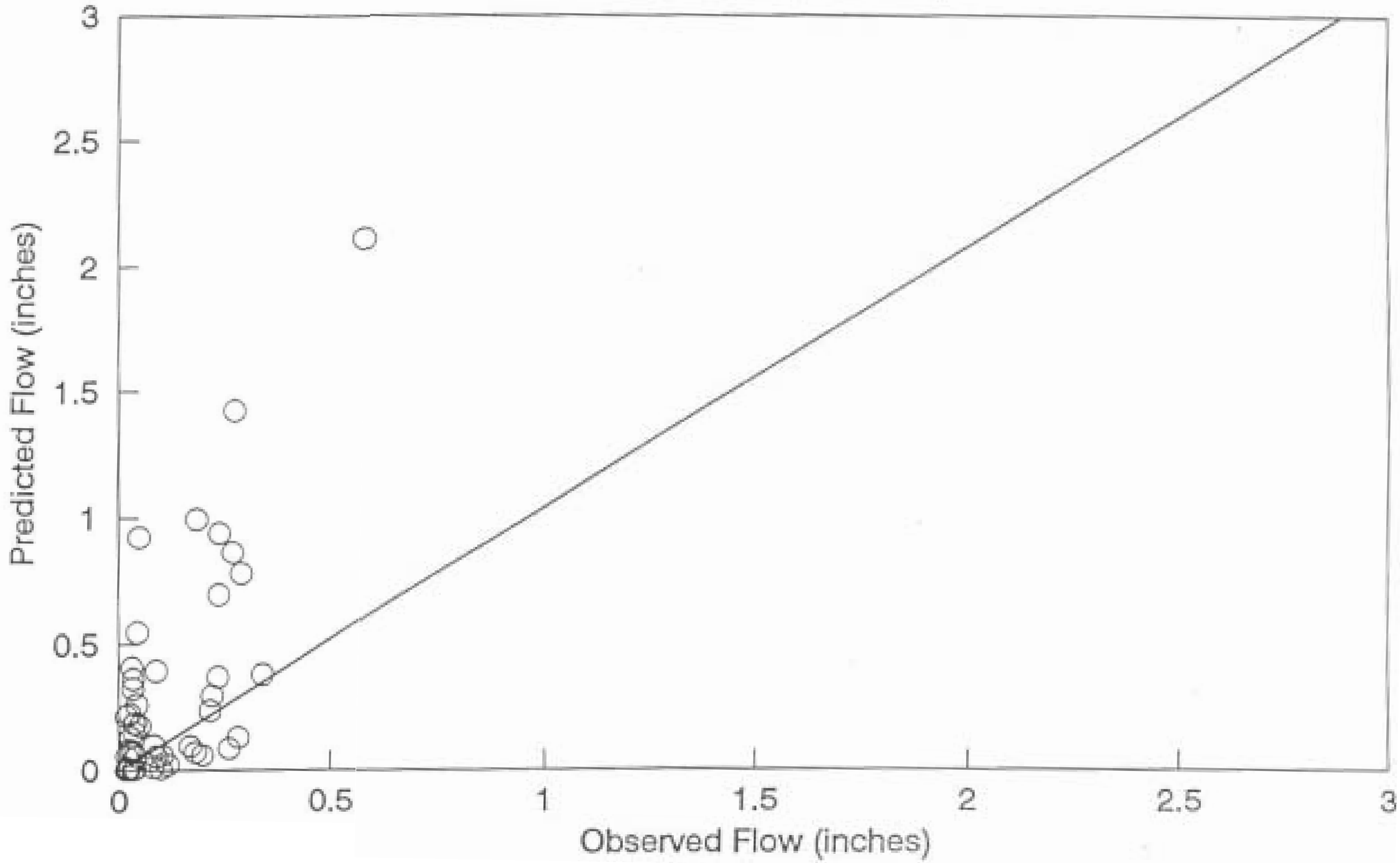
Rocky Creek (Gage 02307000)



TAMPA BAY HYDROLOGIC MODEL

Predicted vs. Observed Flow

Brooker Creek (Gage 02307359)



APPENDIX 4

EXISTING CONDITIONS LAND USE-SPECIFIC WATER QUALITY CONCENTRATIONS

URBAN LAND USES					
Land Use Classification			Land Use-Specific Water Quality Concentrations		
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)
1 (LDR)	Low Density Single Family Residential (SFR)	(1)	2.31	0.40	33.0
		(1)	2.14	0.32	28.0
		(1)	0.605	0.073	7.2
		(1)	1.18	0.307	3.5
		(1)	3.0	0.45	-
		(1)	2.2	0.25	-
		(4)	1.87	0.39	-
		min	0.605	0.073	3.5
		mean	1.9	0.313	17.93
		max	3.0	0.45	33.0
2 (MDR)	Medium Density SFR (See notes)	min	0.81	0.053	8.9
		mean	2.05	0.38	35.8
		max	3.84	0.59	64.3
3 (HDR)	Multifamily Residential	(1)	1.61	0.33	53.0
		(1)	2.57	0.45	36.8
		(1)	4.68	0.72	95.6
		(1)	1.91	0.73	-
		(1)	1.02	0.033	67.6
		(1)	1.91	0.51	14.3
		(4)	1.65	0.33	-
		min	1.02	0.33	14.3
		mean	2.19	0.443	53.46
		max	4.68	0.33	95.6

URBAN LAND USES					
Land Use Classification			Land Use-Specific Water Quality Concentrations		
(Data combined for CLUCCS code 4)	Low Intensity Commercial	(1)	1.19	0.15	22.0
		(1)	1.1	0.10	45.0
		(1)	0.89	0.16	146.0
	High Intensity Commercial	(1)	2.81	0.31	94.3
		(1)	3.53	0.82	-
		(1)	2.15	0.15	-
4	Combined Commercial (See notes)		1.52	0.12	58.0
			1.96	0.23	70.0
			2.36	0.49	120.0
5	Industrial	(1)	1.42	0.19	71.8
		(1)	2.53	0.42	108.0
		(1)	1.42	0.31	102.0
		(4)	1.18	0.15	-
6	Mining	(4)	1.18	0.15	-
7	Institutional	(4)	1.18	0.15	-

AGRICULTURAL LAND USES					
Land Use Classification			Land Use-Specific Water Quality Concentrations		
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)
10	Pasture	(1) (1) (2) (3) (4) (5)	2.37 2.48 2.0 3.0 1.02 5.1	0.697 0.27 0.3 0.25 0.16 3.2	- 8.6 - - - -
11	Grove	(7)	2.31	0.10	-
11,13	Grove, Nursery	(4)	0.92	0.41	-
12	Feed Lot	(3) (3) (5)	29.3 3.74 26.0	5.1 1.13 5.1	- - -
14	Field Crop	(2) (3) (4)	2.5 2.5 3.75	0.25 2.5 1.13	-
Mixed Agricultural					
10,11	Citrus + Pasture	(1) (1) (1) (1) (1)	1.57 1.33 2.58 2.68 3.26	0.09 0.09 0.046 0.562 0.24	- 4.6 180 - 28.0
11,14	Citrus + Row Crops	(6)	1.78	0.3	5.6

(See following page for summarized agricultural water quality concentrations.)

SUMMARIZED AGRICULTURAL LAND USE DATA					
Land Use Classification			Land Use-Specific Water Quality Concentrations		
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)
8	Range	min mean max	0.90 1.24 1.47	0.02 0.01 0.21	4.8 11.0 17.3
10	Pasture	min mean max	1.0 2.66 5.1	0.16 0.081 3.2	8.6 8.6 8.6
11	Grove	min mean max	0.92 1.67 2.31	0.10 0.27 0.41	5.0 5.3 5.6
12	Feed Lot	min mean max	3.74 19.7 29.3	1.13 3.8 5.1	50(e)
13	Nursery (See notes)	mean	1.67(e)	0.27(e)	5.3(e)
14	Row Crop (See notes)	mean	2.91	0.54	10

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WATER/WETLAND AND FOREST/UNDEVELOPED LAND USES					
Land Use Classification			Land Use-Specific Water Quality Concentrations		
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)
8	Open Space/ Non-forested	(1) (1) (1) (4)	1.38 0.90 1.47 1.02	0.07 0.02 0.07 0.16	17.3 4.8 - -
15	Upland Forest	(2) (3) (4)	0.1 0.2 1.02	0.007 0.007 0.16	- - -
16,17	Open Water	(1) (1) (1)	0.79 0.73 2.22	0.17 0.04 -	- 0.00 6.2
18,20	Freshwater Wetland	(1) (1) (1) (1) (4)	2.26 1.02 1.24 1.88 0.79	0.09 0.16 0.018 0.33 0.17	13.4 - 4.6 12.7 -
17	Saltwater		NA	NA	NA
19	Saltwater Wetlands		NA	NA	NA
21	Tidal Flats		NA	NA	NA

Notes:

- Concentrations for CLUCCS code 2 (MDR) are an average of CLUCCS codes 1 (LDR) and 3 (HDR).
- Concentrations for CLUCCS code 4 (Commercial) are an average of reported values for "low intensity" and "high intensity" commercial.
- Estimated (e) agricultural values were based on similar land uses data when no land use specific data were identified.
- Row crop data were often reported with other agricultural uses.

loadco.tab

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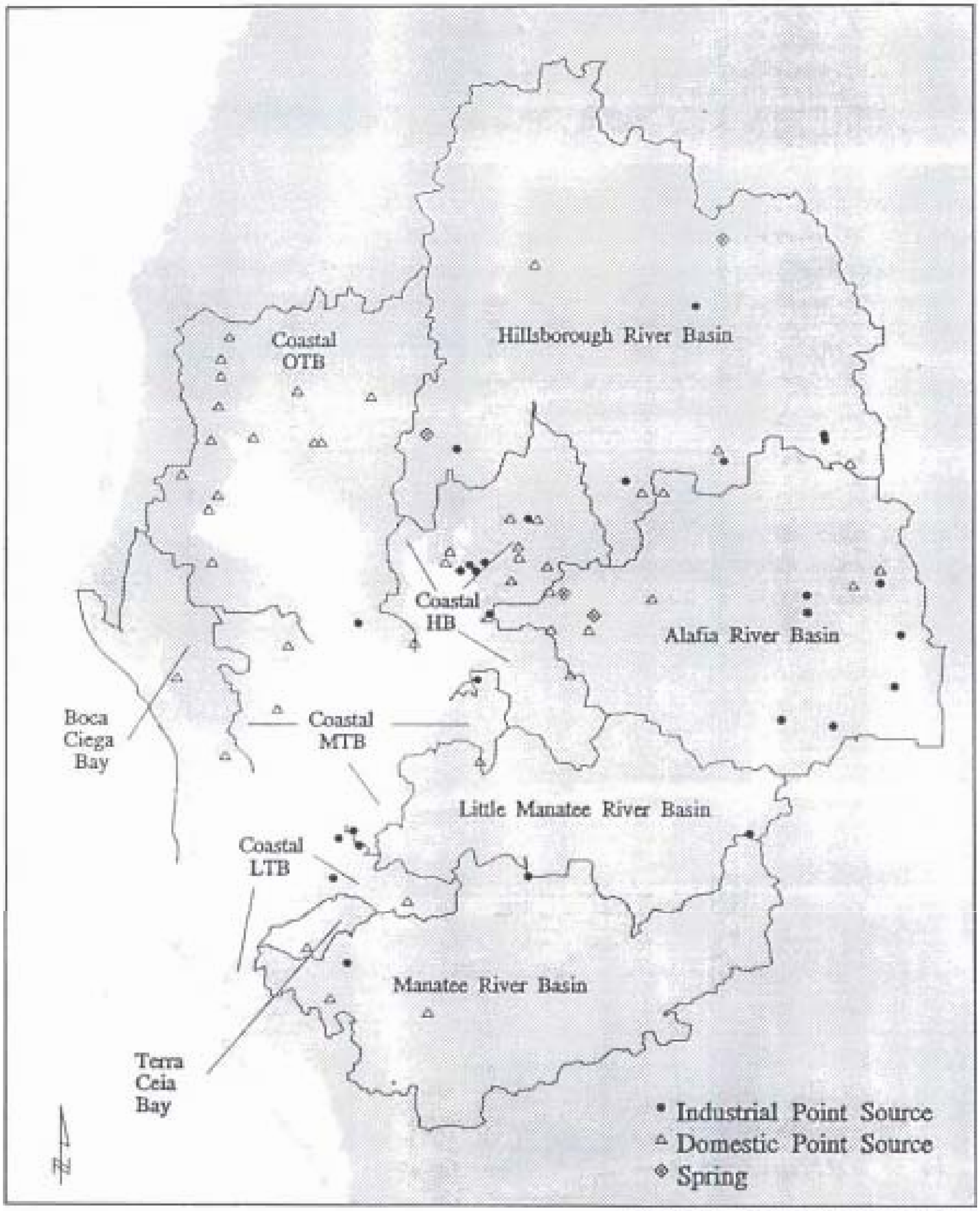
(7) Allhands, M. 1993. Water Quality Data for Gator Slough Groves. Agricultural Management Services. Punta Gorda, Florida.

APPENDIX 5

POINT SOURCE INVENTORY

POINT SOURCE DISCHARGES



Map Prepared by Coastal Environmental, Inc.

Domestic Point Sources

FACILITY	FACILITY ID	BAY SEGMENT	DRAINAGE BASIN
Boyette Springs Subdivision	11	2	Alafia River
Northwest Regional Water Reclamation	112	1	Coastal Old Tampa Bay
Pebble Creek Village	118	2	Hillsborough Bay
Plant City	121	2	Hillsborough Bay
Progress Village	124	2	Coastal Hillsborough Bay
Rice Creek	128	2	Alafia River
River Oaks AWT	129	1	Coastal Old Tampa Bay
Riverhills Country Club	133	2	Alafia River
Seaboard Utilities Corp.	143	2	Coastal Hillsborough Bay
South Hillsborough Regional	149a	3	Little Manatee River
South Hillsborough Regional	149b	3	Coastal Middle Tampa Bay
Summerfield Subregional	157	2	Coastal Hillsborough Bay
Valrico Subregional	176	2	Alafia River
Dale Mabry	50	2	Coastal Hillsborough Bay
Falkenburg Road	59	2	Coastal Hillsborough Bay
Hookers Point	82	2	Coastal Hillsborough Bay
Bloomington Hills	9	2	Alafia River

MacDill AFB	98	3	Coastal Middle Tampa Bay
North County Regional	MC009	4	Coastal Lower Tampa Bay
Manatee County Southeast Subregional	MC011	7	Manatee River
City of Palmetto	MC077	6	Terra Ceia Bay
Bradenton	MC757	7	Manatee River
Pine Ridge	PC004	1	Coastal Old Tampa Bay
City of St. Petersburg, Northwest	PC156	5	Boca Ciega Bay
City of St. Petersburg, Albert Whitted	PC157	3	Coastal Middle Tampa Bay
City of St. Petersburg, Southwest	PC158	5	Boca Ciega Bay
City of St. Petersburg, Northeast	PC159	3	Coastal Middle Tampa Bay
City of Oldsmar	PC520	1	Coastal Old Tampa Bay
City of Clearwater, East	PC691	1	Coastal Old Tampa Bay
On Top of the World	PC749	1	Coastal Old Tampa Bay
City of Largo	PC750	1	Coastal Old Tampa Bay
Eastlake Woodlands	PC888	1	Coastal Old Tampa Bay
City of Clearwater, Northeast	PC963	1	Coastal Old Tampa Bay
Meadowlands	PK051	2	Hillsborough Bay
City of Mulberry	PK246	2	Alafia River

City of Lakeland, Artificial Wetlands	PK852	2	Alafia River

Industrial Point Sources

BAY SEGMENT	DRAINAGE BASIN	FACILITY ID	FACILITY NAME
1	Coastal Old Tampa Bay	4029P20103	SHELL OIL CO PORT TAMPA PLANT
2	Alafia River	4029P20002	MOBIL MINING BIG FOUR MINE
2	Alafia River	4029P20038	CARGILL INC.
2	Alafia River	4053P20049	ESTECH SILVER CITY MINE
2	Alafia River	4053P20061	FARMLAND HYDRO L.P. GREEN BAY PLANT
2	Alafia River	4053P20095	MOBIL MINING NICHOLS PREP PLANT
2	Alafia River	4053P20098	MOBIL MINING - NICHOLS MINE
2	Alafia River	4053P20111	MULBERRY PHOSPHATES INC.
2	Alafia River	4053P20138	IMC FERTILIZER HAYNESWORTH MINE
2	Coastal Hillsborough Bay	4029P20045	IMC FERTILIZER PORT SUTTON TERMINAL
2	Coastal Hillsborough Bay	4029P20048	TRADEMARK NITROGEN
2	Coastal Hillsborough Bay	4029P20054	NITRAM INC.
2	Coastal Hillsborough Bay	4029P20069	SEMINOLE FERTILIZER-AMMONIA TERMINAL
2	Coastal Hillsborough Bay	4029P20086	TECO GANNON
2	Hillsborough River	4029M20028	TAMPA CITY OF WATERWORKS
2	Hillsborough River	4029P20023	CF INDUSTRIES-PLANT CITY CHEM. PLANT
2	Hillsborough River	4029P20030	CRYSTALS INTERNATIONAL INC.
2	Hillsborough River	4029P20081	FLORIDA SNO-MAN INC.
2	Hillsborough River	4053P20092	ERLY JUICE INC.
2	Hillsborough River	4053P20113	CSX TRANSPORTATION WINSTON YARD
3	Coastal Middle Tampa Bay	4029P20085	TECO BIG BEND
3	Coastal Middle Tampa Bay	4041S20024	FDNR STOCK ENHANCEMENT FACILITY
3	Little Manatee River	4041P20020	IMC FERTILIZER FOUR CORNERS MINE
4	Coastal Lower Tampa Bay	4041P20000	NU-GULF INDUSTRIES ROCK TERMINAL
4	Coastal Lower Tampa Bay	4041P20001	PINEY POINT PHOSPHATES INC.
4	Coastal Lower Tampa Bay	4041P20014	COASTAL FUELS MARKETING INC.
7	Manatee River	4041P20006	FLORIDA POWER & LIGHT
7	Manatee River	4041P20011	TROPICANA PRODUCTS INC.

APPENDIX 6

ANALYSIS OF CITY OF ST. PETERSBURG REUSE MONITORING WELL DATA

1) Background

The determination of transport and assimilation rates of chemicals in the natural environment, including groundwater, is the subject of widespread research. However, the behavior of many chemicals, in particular nitrogen and phosphorus, appear to vary greatly with site-specific characteristics. Therefore, it is sometimes difficult to predict these phenomena based on data collected under a variety of site conditions.

Because primary production in Tampa Bay is widely believed to be limited by nitrogen, it was desired to determine the most technically-defensible estimates of nitrogen loading rates from all potentially important sources. Land application of treated wastewater is a common method of effluent disposal in the Tampa Bay watershed. The practice of spray application of effluent (reuse water) for landscape irrigation provides many benefits, such as introducing vital nutrients to vegetation, and greatly reducing the use of potable water for irrigation purposes. However, because eutrophication can occur if excess nutrients reach an estuarine system such as Tampa Bay, it is very important to obtain as accurate an estimate as possible of the retention and delivery rates of nitrogen that enters the environment through reuse. The following discussion summarizes an analysis of local groundwater monitoring data that were used to aid in this process (see Section 3.B.1). The City of St. Petersburg has been instrumental in obtaining and providing these local groundwater monitoring data.

2) City of St. Petersburg Reuse Monitor Well System

The City of St. Petersburg Public Utilities Department maintains and samples groundwater from a network of shallow monitor wells located at selected reuse application sites (see location map). Results of the sampling data were obtained and analyzed to estimate potential impacts to groundwater quality from the application of reuse water. Two sets of data exist. The earlier monitor wells (numbered 770 - 778) were constructed to screened depths of 19 to 21 feet below land surface. These wells were sampled from April, 1979 to February, 1992. In 1992 new wells (numbered (770A, 772A, 775A, and 777A) were constructed to much shallower depths, and their screens intersect the water table surface, These shallower wells *have been sampled from April of 1992 to present.*

These wells are constructed within or adjacent to areas receiving secondary treated effluent from St.Petersburg municipal wastewater treatment plants. As discussed below, some of the well sites are thought to be influenced by other sources of nutrients, such as supplemental landscape fertilization. Groundwater quality data from the wells were examined to determine what, if any, impacts the reuse water had on local groundwater quality. Chemicals of interest include ammonia (NH_3), nitrate (NO_3), and chloride (Cl). Ammonia is the most prevalent nitrogen species in St. Petersburg's reuse water, and is not otherwise commonly found in high concentrations in an urban setting. Nitrate is also present in effluent, but is also a common form of nitrogen found in fertilizer. Chloride is used as a conservative tracer to indicate the presence and strength of effluent present. Cl concentrations in the effluent averages about 400 mg/L, and background groundwater concentrations are 50 mg/L or less. The location of the monitor wells discussed below is shown and described following this text. Graphs showing results of monitoring data also follows.

3) Analysis of NH_3, NO_3 and Cl concentrations in deeper discontinued wells:

Well #771

Total Kjeldahl Nitrogen (TKN) ranges from 0.50 to 3.0 mg/L during first two years (1979 - 1981) with an average of approximately 0.8. No TKN data were collected after 1981. Highest TKN value may be due to lab error, as all wells showed a peak at the same time.

Background (well 776) NH_3 ranged from 0.2 to 0.5 mg/L. Background nitrite appears negligible (generally less than 0.01 mg/L). Effects of effluent first were first picked up in samples in 1986, seven years after sampling began, as evidenced by a rise in CL from a background of about 30 mg/L to 400mg/L. After 1986, NH_3 increased to an average of about 1.8 mg/L, with a peak concentration of 2.8 mg/L. Nitrate remained low.

Conclusion: NH_3 was not reduced to background before reaching the water table at this site. Seven year delay for impacts to reach the monitor well may be a result of the deep sampling.

Well #773

Cl concentrations did not show a significant increase until 1990, ten years after sampling began. No clear trend in NH_3 concentration is evident, but may be slightly increased over a background of 0.5 mg/L. No NH_3 data exist for 1990 and beyond. No change was observed in NO_3 which remains negligible small.

Well # 774

NH_3 and NO_3 was greater than 150 mg/L for first two (2) years (1979-1989) of monitoring. This site is near an old landfill. Cl is highly variable, and ranges from near zero to 1700 mg/L. The variability reduces after 1985 when a declining trend begins. Cl concentration gradually falls from 1600 to about 700 between 1985-1992.

NH_3 and NO_3 concentrations fell to about 40 mg/L in 1988 and 1989, down from a pre-1981 average of about 150 mg/l.

Conclusion: Effluent from the spray operation apparently diluted high Cl and NO_3 in leachate from the old landfill. This well is of no value for reporting impact of spray irrigation but does raise a flag regarding potential landfill impacts.

Well #776

This is a control well, with no reuse of other identified nitrogen source nearby. NH_3 concentrations averaged about 0.6 mg/L for first two (2) years of monitoring (1979-1981). Sampling was discontinued from 1981-1986. NH_3 appeared to be at about the same level when sampling resumed in 1987. NO_3 showed low concentrations (less than 0.1 mg/L) at all times.

No discernable change in Cl was observed between 1979 and 1992, although Cl did rise from below 10 mg/L to above 20 mg/L from 1986 - 1992. Low concentrations indicate little reuse exist at the site, or that dilution is active.

Conclusion: This site appears to be a valid control.

Well #778

Cl concentrations were very low (less than 15 mg/L) in first two (2) years of monitoring (1979 - 1981). Sampling was discontinued during 1981 -1985. Cl concentrations increased to an average of about 250 mg/L (ranging from 100 to 400) between 1985 and 1992.

NH_3 averaged about 0.6 mg/L during 1979 - 1981. Samples taken from 1987 - 1990 show higher NH_3 concentrations, averaging about 1.0 mg/L, with high values over 1.5 mg/L. The coincident rise in Cl and NH_3 concentrations suggest that effluent has impacted water quality at this site.

Well #770

Cl concentrations are low (less than 20mg/L) for first two (2) years (1979 - 1981) with one peak near 100 mg/L. Cl begins a gradually increasing trend in 1988 and climbing to peak of 500 in 1991.

NH_3 concentrations range from 0.7 to 1.4 from 1979 - 1981. Monitoring of NH_3 was discontinued at #770 in 1982. NO_3 had a spike in 1979 of 0.65 mg/L, but was negligible at all other times.

Conclusions: No conclusions can be made regarding potential impacts of spray irrigation because of lack of NH_3 data.

Well #772

No discernable influence of reuse water. NH_3, Cl and NO_3 all remained low from April 1979 to 1992.

Well #775

Cl concentrations were low (less than 50mg/L) from 1979 until 1990, and sharply rose, peaking at about 400 mg/L in 1991 and dropping back to 175 mg/l by 1992.

NH_3 concentrations were low (approximately 0.3 mg/L) for 1979 - 1981. No NH_3 measurements were made after that date. NO_3 was low through 1990, and then rose to 1.75 mg/L in August, 1991 before dropping to 0.7 in February, 1992.

Conclusions:

Strong influence of reuse water was evident in early 1991, followed in about six months by high NO_3 peak, by far the largest of any noticed in deeper wells.

Well #777

Cl was low for the period 1979 through 1980. Sampling of Cl was discontinued until 1985 by which time the Cl concentration was up to an average of about 250 mg/L, and as high as 600 mg/L in August 1986.

NH_3 average was about 0.3 - 0.4 for first two (2) years (1979 - 1980). No information thereafter. NO_3 was very low throughout.

Conclusions:

Reuse water reaches this well (high Cl) but impact of NH_3 cannot be determined due to lack of data after October, 1980.

4) Analysis of NH_3, NO_3 and Cl concentrations in new, shallower wells:

Well #770A

CL averaging 80-100 mg/L over the last two years (1992-1993). No background from this well to compare, but at the deeper well, background was 15 to 20 mg/l. Cl had peaked at about 500 mg/L at the deeper well just before it was discontinued.

The low chloride concentration at the shallow well compared to the levels detected at the deeper wells suggests a high degree of dilution in the last several years or a substantial reduction in Cl in the applied effluent.

Well #772A

This well may be impacted by other nitrogen sources according to St. Petersburg. The Cl concentration rose from 200 to 300 mg/L since April, 1992 during which time

NH_3 oscillated around 2 mg/l. The fact that the ratio of NH_3 to Cl is quite variable suggesting factors other than simple dilation of the effluent are influencing these concentrations. NO_3 has remained very low except for one value of 0.3 corresponding to drop in NH_3 of 0.5.

Well #775A:

St. Petersburg believes that fertilizer application to a landscaped area adjacent to the well has influenced the water quality. NO_3 averages 2.3 mg/l and peaked at 4.5 mg/l. NH_3 average 0.03 with a peak at 0.08.

CL has averaged about 225 mg/l at the new well but peaked around 400 in the deeper well.

Possible explanations:

1) Fertilizer application results in high NO_3. Low NH_3 suggests no significant reuse water impact.

2) Applied fertilizer contains NH_3 and NO_3, and reuse water is high in NH_3. Soil nitrifying bacteria may have converted all nitrogen in the fertilizer and the reuse water to NO_3.

Problem with that hypothesis: Why hasn't the conversion of NH_3 to NO_3 occurred at the other shallow sites and the deeper sites? High levels of NH_3 have not been measured at any of the other site (except the ones presumably receiving fertilizer loads.

3) High NO_3 levels in the reuse water. This is not likely, as all operating reports for municipal plants show very high ration of NH_3 to NO_3.

Well #777A:

Same conclusions and questions apply here as to #772.

Further Notes on #775:

The high NO_3 measured at #775 (deeper well) in 1991 and 1992 (4 values of 0.6 and above) were probably accurate values. The fact that they peaked almost in phase with the Cl concentration suggests that they were following a similar diffusion pattern. The NO_3 concentrations lag the Cl by about four months but is very similar.

5) Estimation of background nitrogen concentrations

St. Petersburg reuse monitor well data

WELL	Nitrogen concentrations NH3	NO_3	DIN	COMMENTS
#771	0.66	0.04	0.70	Based on St. Petersburg monitoring results 4/79 - 8/80
#773	0.27	0.03	0.30	Same
#778	0.58	0.04	0.62	Based on St. Petersburg data 4/79 - 8/80
#770	1.14	0.05	1.19	Same
#772	0.39	0.01	0.40	Same
#775	0.24	0.01	0.25	Same
#777	0.46	0.01	0.47	Same
AVE	0.53	0.03	0.56	

Other monitoring data of nitrogen concentrations in unimpacted shallow groundwater

WELL	BACKGROUND NH_3	NO_3	DIN	COMMENTS
USGS (Reichenhaugh) #CB-1 & CB-2	1.70	0.00	1.70	From St. Petersburg reuse test site. Average of 6 samples prior to irrigation with effluent. Sampling depth 5-20 ft.
SWFWMD - various reports	0.0	0.001 to 0.1	0.001 to 0.1	From unimpacted sites in Tampa Bay watershed. Summary of SWFWMD monitoring data - see cited literature.

Assume: Organic nitrogen is not included in the computation of background and potentially impacted concentrations. This may underestimate the impact of reuse water, because although there is virtually no organic nitrogen in the effluent, some portion of the NH_3 may be converted to organic nitrogen in the biologically active layers of soil. Ammonia and nitrate are combined as dissolved inorganic nitrogen (DIN).

Estimated average background DIN for St. Petersburg water table is:

$$((7 \times 0.56) + (2 \times 1.7))/9 = 0.81 \text{ mg/L}$$

where:
- 7 St. Petersburg wells average 0.56 mg/L
- 2 USGS wells averaged 1.7 mg/L at reuse test site
- to be conservative, watershed-wide unimpacted well data not used.

Monitoring data of nitrogen concentrations in impacted shallow groundwater

WELL	Nitrogen concentrations NH_3	NO_3	DIN	COMMENT
771	2.00	0.00	2.00	Ave. of three samples during period with high Cl concentration
778	1.50	0.03	1.53	Average of most recent samples
772A	1.90	0.04	1.94	This site may be influenced by other sources.
AVE	1.80	0.02	1.82	

ASSUMPTION: Well #770 was not included in the estimate since low Cl concentrations suggest that the well was not apparently showing the full influence of reclaimed water. Average Cl levels were only 100 mg/L or less. Cl would be expected to be higher (300 - 400 mg/L) if reuse water had full influence on samples. If NH_3 (DIN) levels were increased in proportion to that required to raise the Cl concentration to "full impact" (300/100, or a factor of 3), the DIN concentration for that well would be 0.62 x 3 = 1.86 mg/L, or virtually the same as the average for the other wells.

6) Estimation of percent nitrogen removal

Using the results from City of St. Petersburg monitor wells and USGS test wells, the application of reclaimed water is estimated to raise groundwater inorganic nitrogen (DIN) concentrations by about:

$$1.82 - 0.81 = 1.01 \text{ mg/L.}$$

where:

- background DIN concentration is 0.81 mg/L
- impacted DIN concentration is 1.82 mg/L

Concentration of ammonia and nitrate-nitrogen in secondary treated effluent from municipal plants averaged 17.2 mg/L for the period 1985 - 1991 (from FDEP files of domestic wastewater monthly operating records). The fraction of nitrogen remaining in groundwater resulting from spray application of reuse water is:

$$1.01/17.2 = 0.059, \text{ or about } 6\%$$

where:

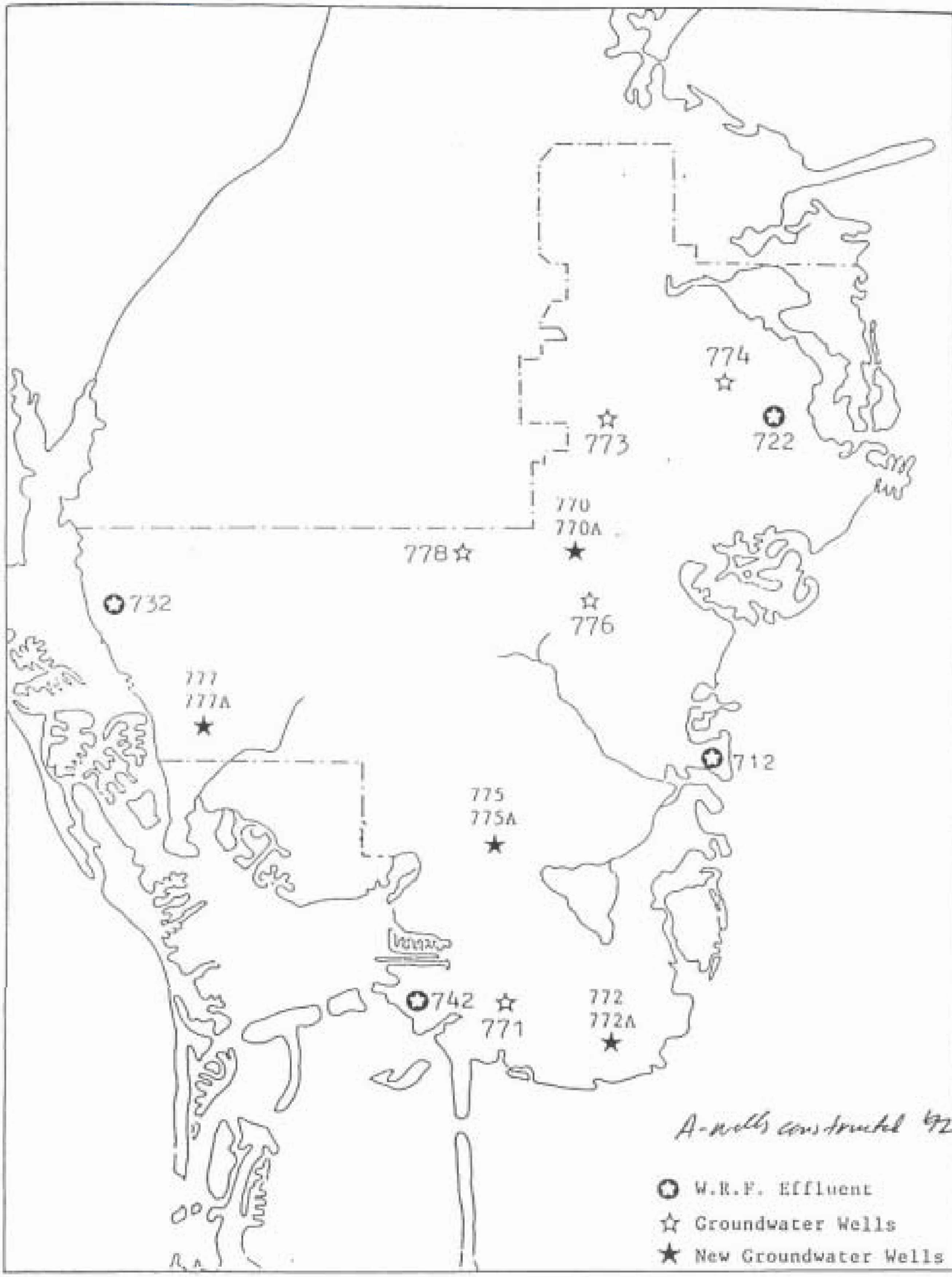
- concentration increase in groundwater DIN attributed to reuse water is 1.01 mg/L
- effluent TN concentration ($NH_3 + NO_3$) is 17.2 mg/L

Therefore, the removal rate of nitrogen from the effluent is approximately:

$$(1-0.06) \times 100 = 94\%$$

The 94% (rounded to the nearest 5%, or 95%) removal rate is applied to the total volume of effluent, with no further reduction in load based on flow reductions.

St. Pete reuse monitoring wells



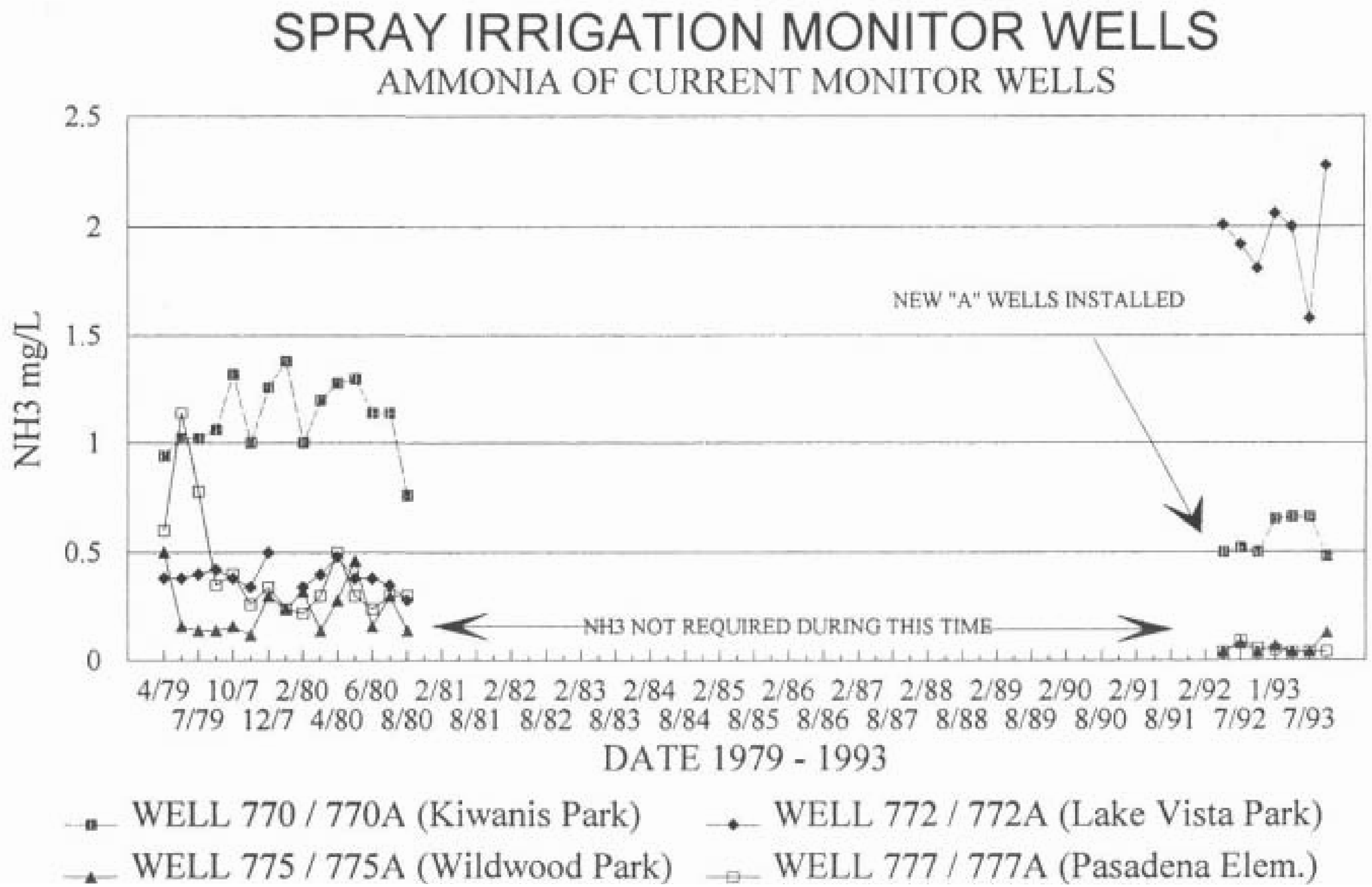
GROUNDWATER MONITORING SYSTEM

SPRAY IRRIGATION WELLS

Well #	Total Well Depth	Aerial #	Location Description
770	19.0 ft.	H-22 (5-78)	(Control Well) on the southside of 40th Avenue North and east of 19th Street.
771	21.0 ft.	I-27 (5-78)	On the southside of 54th Avenue South between Cordova Way and Caesar Way.
772	21.0 ft.	G-31 (5-78)	60th Avenue South and 16th Street. Location in Lake Vista Park at Northeast Corner of main building.
773	20.5 ft.	H-30 (5-78)	Just south of 58th Avenue North on west side of 16th Street (N.E. High School).
774	20.5 ft.	D-34 (5-78)	Mangrove Bay golf Course. Take 62nd Avenue N.E. to road which runs along the west boundary to Busch Field. Located on west side of road a short distance north of Busch Field (after bend in road).
775	20.5 ft.	I-7 (5-78)	East of 27th Street on south boundary of Wildwood Park (between 12th Avenue and Langdon Avenue South).
776	19.5 ft.	G-16 (5-78)	28th Avenue North and 11th Street. (In Park southeast of center). (Control well)
777	19.5 ft.	R-2 (5-78)	South of 2nd Avenue North on east side of 72nd Street (Pasadena Elementary School).
778	20.0 ft.	K-22 (5-78)	On North side of 38th Avenue North and west of 35th Street.

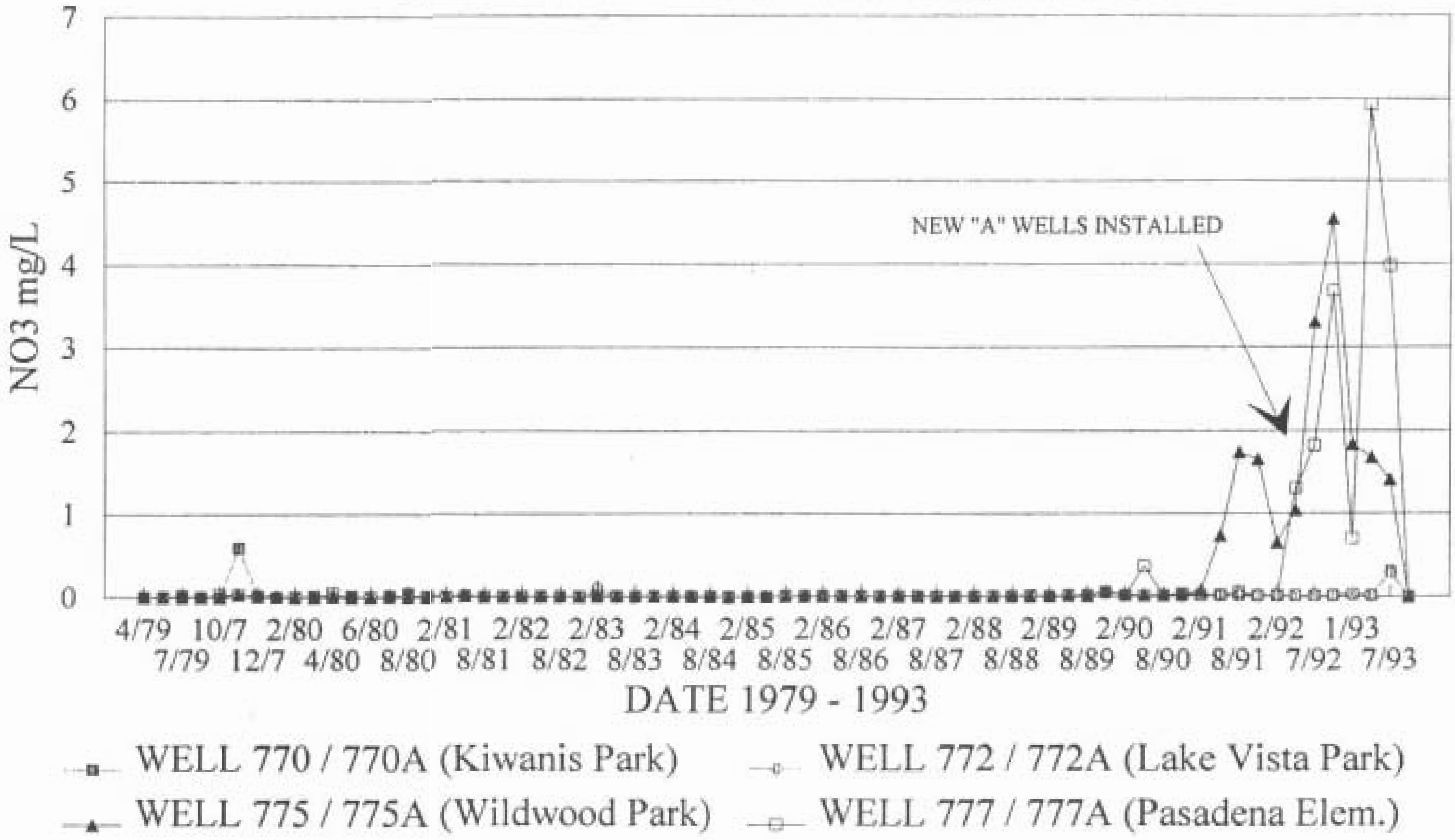
NEW SPRAY IRRIGATION MONITOR WELL LOCATIONS

WELL #	LOCATION
770A	Kiwanis Park - East of old well 770 along parkway by picnic area.
772A	Lake Vista - Move north northeast about 100-150 feet from old 772 well over by sprinkler controls.
775A	Wildwood Park - Just east of old 775 well along sidewalk.
777A	Pasadena Elementary School - Move north about 100 feet along parkway from old 777 well.


SPRAY IRRIGATION MONITOR WELLS
AMMONIA OF CURRENT MONITOR WELLS
NH3 mg/L
2.5
2
1.5
1
0.5
0
NEW "A" WELLS INSTALLED
NH3 NOT REQUIRED DURING THIS TIME
4/79 10/7 2/80 6/80 2/81 2/82 2/83 2/84 2/85 2/86 2/87 2/88 2/89 2/90 2/91 2/92 1/93
7/79 12/7 4/80 8/80 8/81 8/82 8/83 8/84 8/85 8/86 8/87 8/88 8/89 8/90 8/91 7/92 7/93
DATE 1979 - 1993
WELL 770 / 770A (Kiwanis Park)
WELL 772 / 772A (Lake Vista Park)
WELL 775 / 775A (Wildwood Park)
WELL 777 / 777A (Pasadena Elem.)

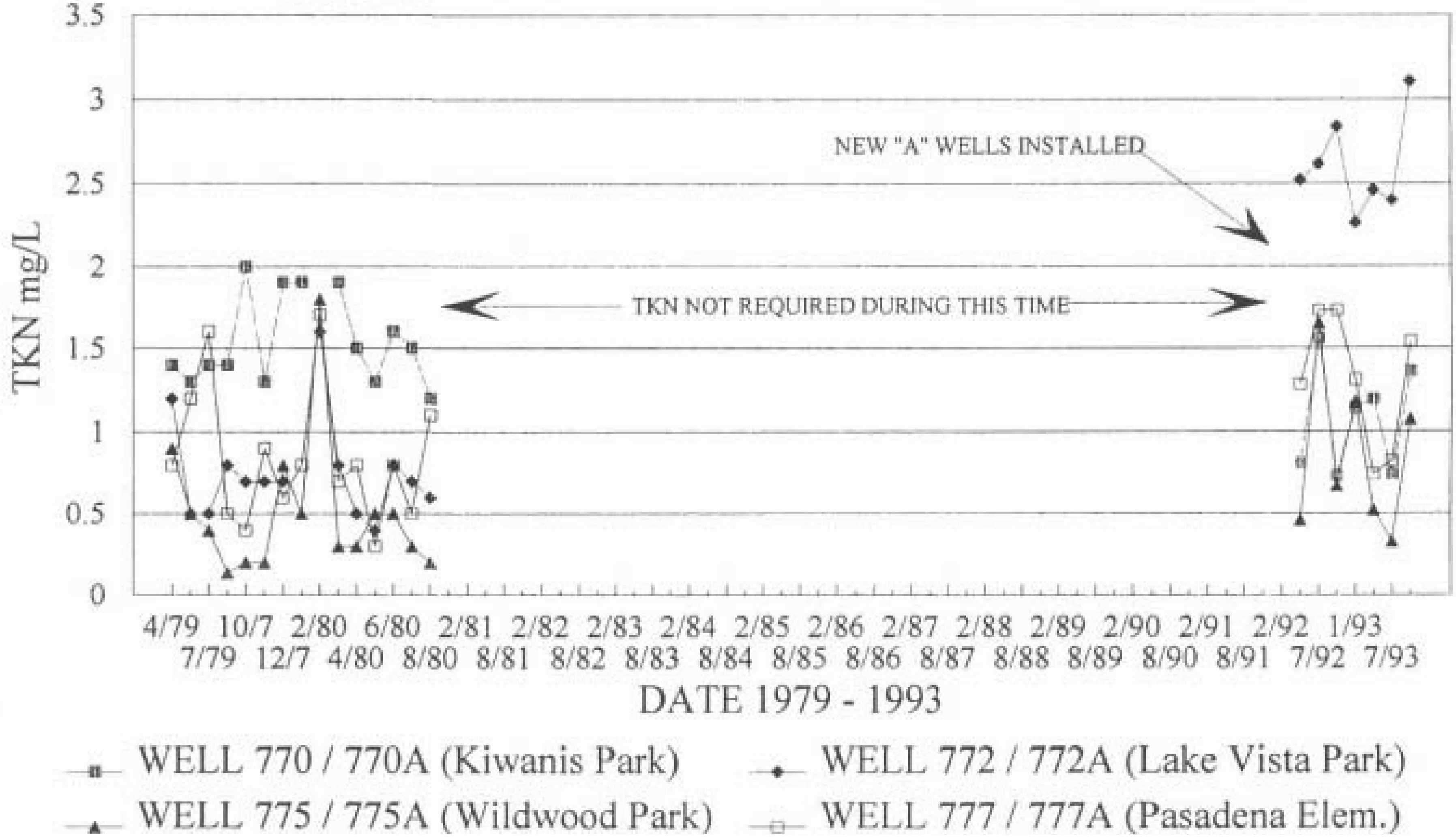
SPRAY IRRIGATION MONITOR WELLS

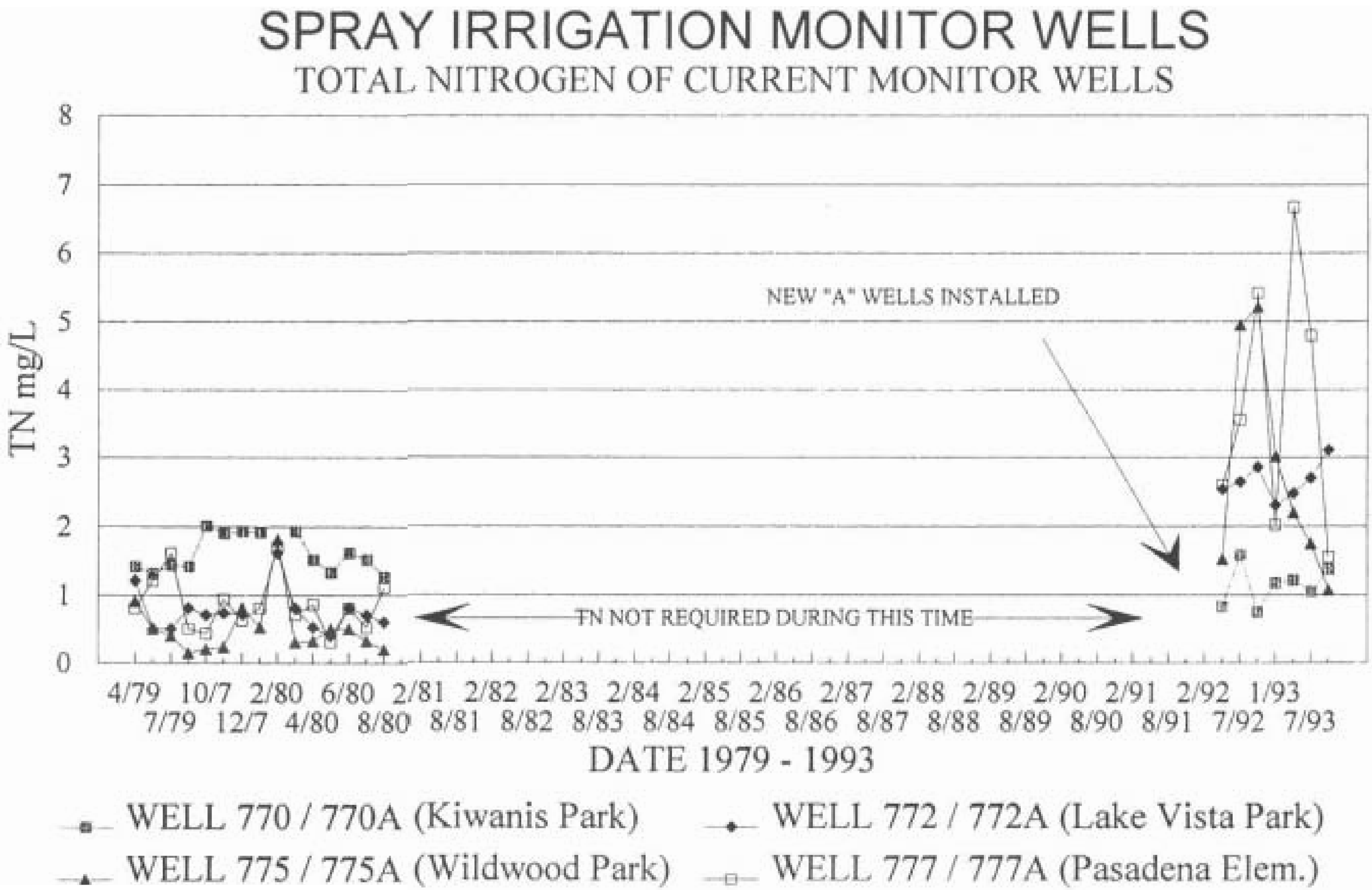
NITRATE OF CURRENT MONITOR WELLS

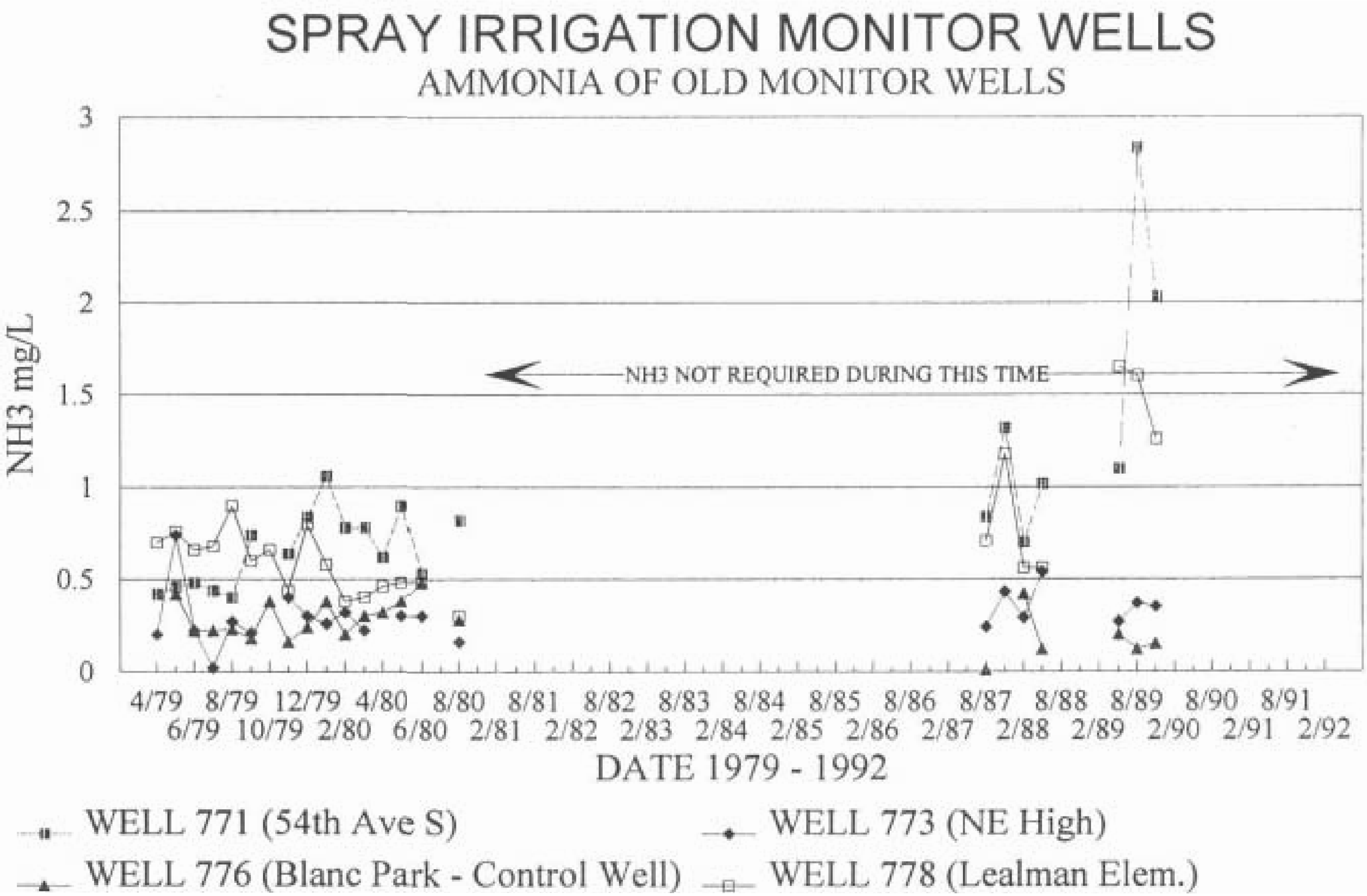


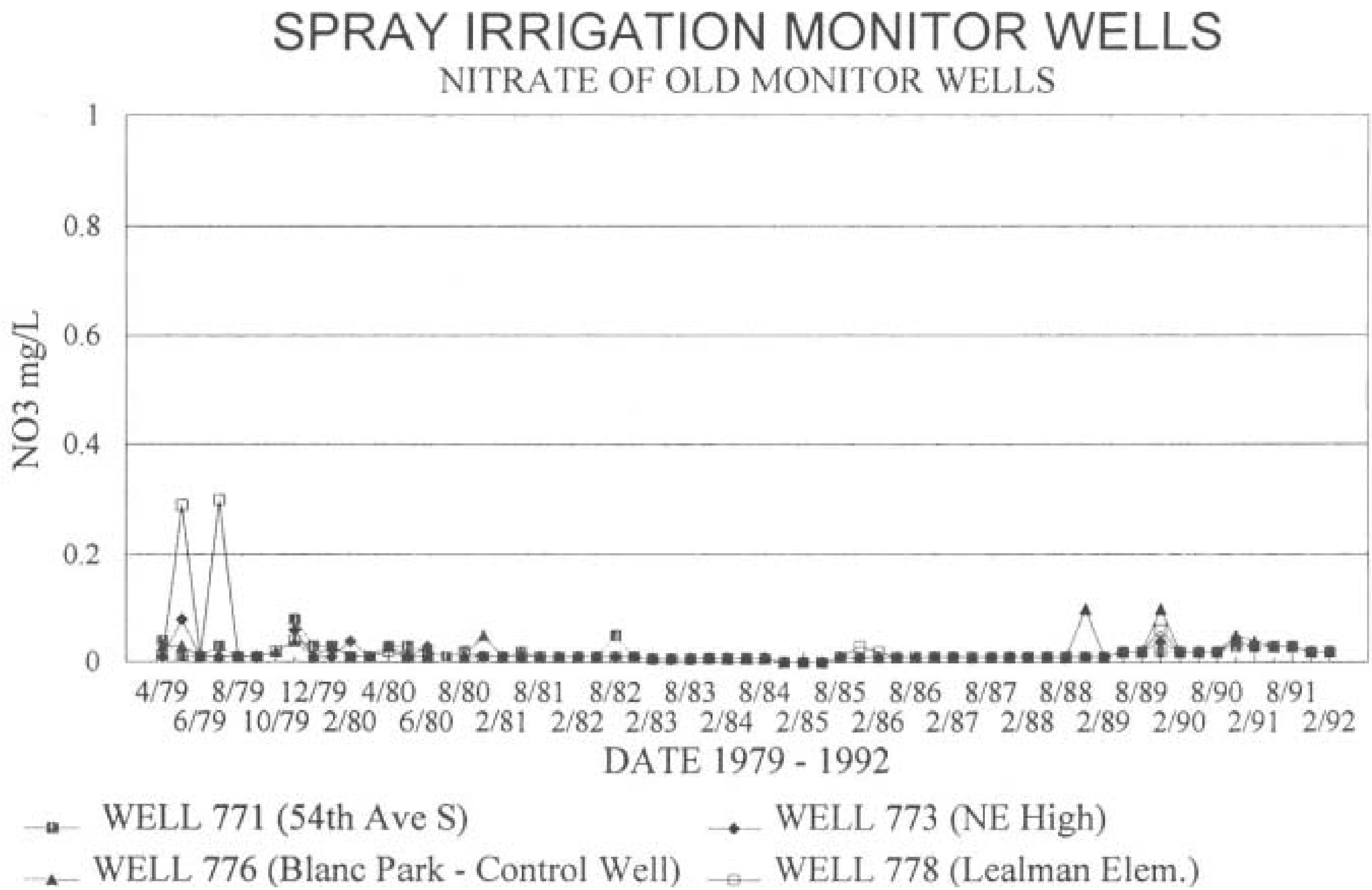
SPRAY IRRIGATION MONITOR WELLS

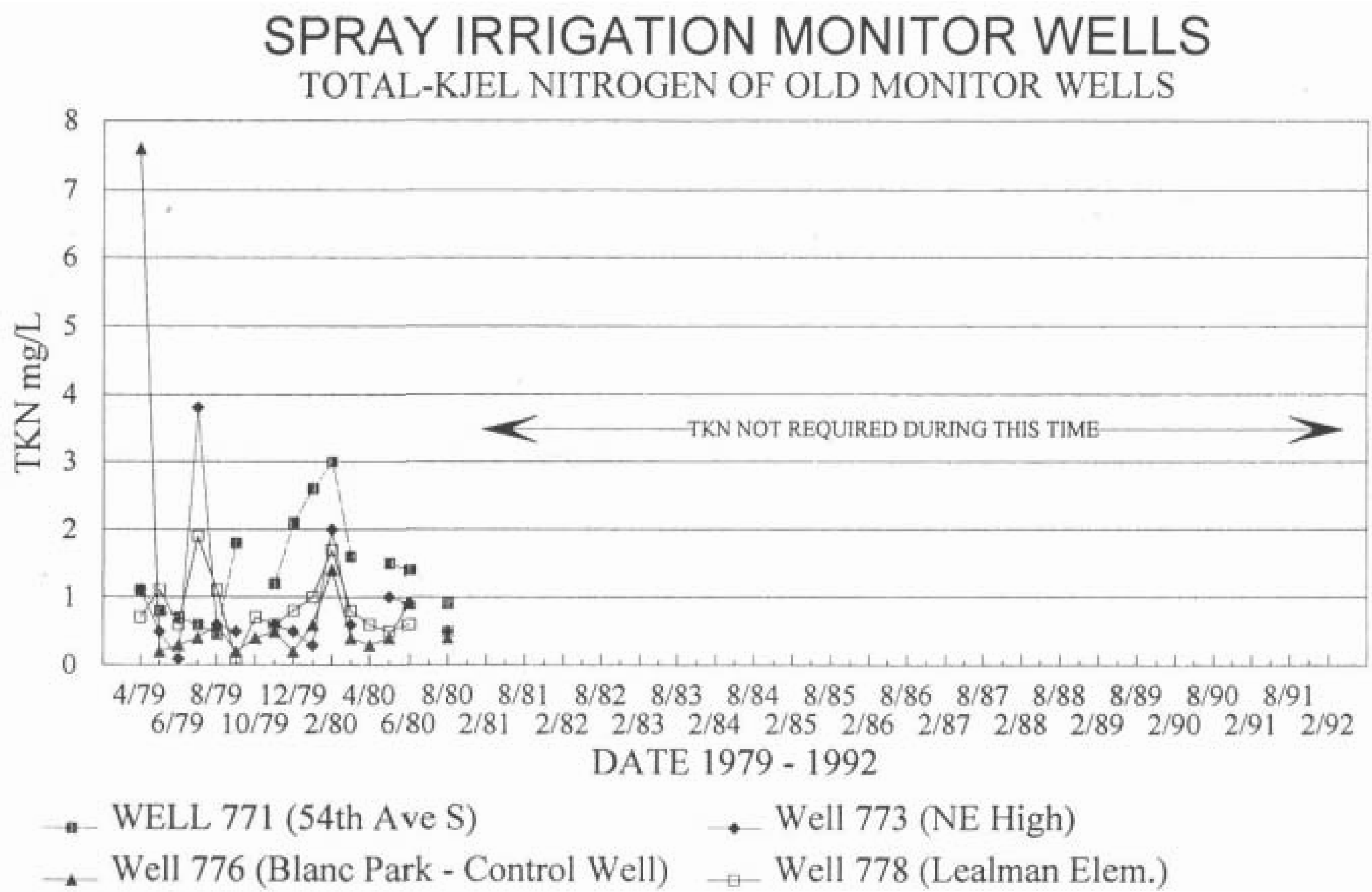
TOTAL KJEL-NITROGEN OF CURRENT MONITOR WELLS




SPRAY IRRIGATION MONITOR WELLS
TOTAL NITROGEN OF CURRENT MONITOR WELLS
TN mg/L
0
1
2
3
4
5
6
7
8
NEW "A" WELLS INSTALLED
TN NOT REQUIRED DURING THIS TIME
4/79 10/7 2/80 6/80 2/81 2/82 2/83 2/84 2/85 2/86 2/87 2/88 2/89 2/90 2/91 2/92 1/93
7/79 12/7 4/80 8/80 8/81 8/82 8/83 8/84 8/85 8/86 8/87 8/88 8/89 8/90 8/91 7/92 7/93
DATE 1979 - 1993
WELL 770 / 770A (Kiwanis Park)
WELL 772 / 772A (Lake Vista Park)
WELL 775 / 775A (Wildwood Park)
WELL 777 / 777A (Pasadena Elem.)

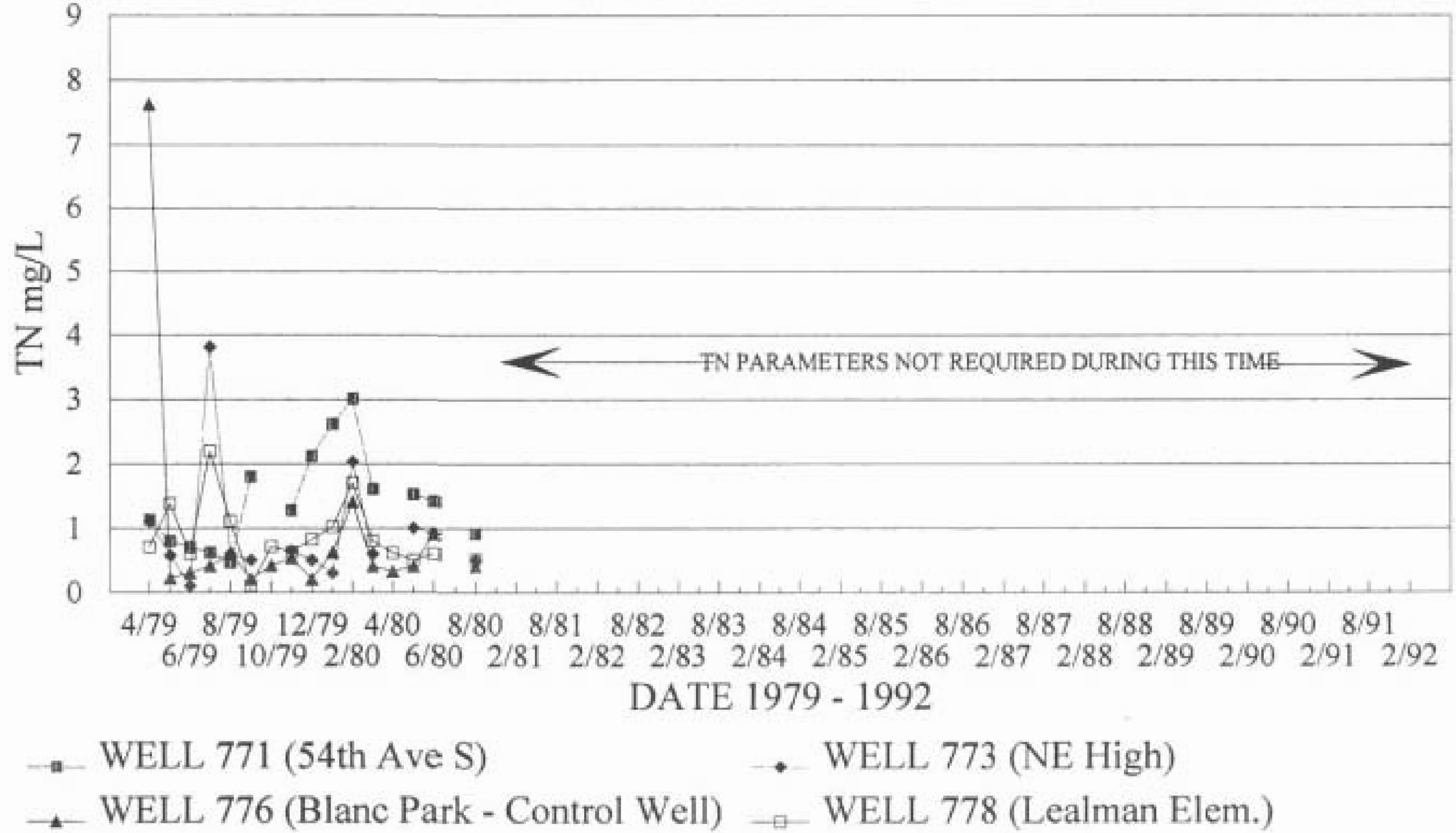

SPRAY IRRIGATION MONITOR WELLS
AMMONIA OF OLD MONITOR WELLS
NH3 mg/L
3
2.5
2
1.5
1
0.5
0
NH3 NOT REQUIRED DURING THIS TIME
4/79 8/79 12/79 4/80 8/80 8/81 8/82 8/83 8/84 8/85 8/86 8/87 8/88 8/89 8/90 8/91
6/79 10/79 2/80 6/80 2/81 2/82 2/83 2/84 2/85 2/86 2/87 2/88 2/89 2/90 2/91 2/92
DATE 1979 - 1992
WELL 771 (54th Ave S)
WELL 773 (NE High)
WELL 776 (Blanc Park - Control Well)
WELL 778 (Lealman Elem.)


SPRAY IRRIGATION MONITOR WELLS
NITRATE OF OLD MONITOR WELLS
NO3 mg/L
1
0.8
0.6
0.4
0.2
0
4/79 8/79 12/79 4/80 8/80 8/81 8/82 8/83 8/84 8/85 8/86 8/87 8/88 8/89 8/90 8/91
6/79 10/79 2/80 6/80 2/81 2/82 2/83 2/84 2/85 2/86 2/87 2/88 2/89 2/90 2/91 2/92
DATE 1979 - 1992
WELL 771 (54th Ave S)
WELL 773 (NE High)
WELL 776 (Blanc Park - Control Well)
WELL 778 (Lealman Elem.)


SPRAY IRRIGATION MONITOR WELLS
TOTAL-KJEL NITROGEN OF OLD MONITOR WELLS
TKN mg/L
0
1
2
3
4
5
6
7
8
TKN NOT REQUIRED DURING THIS TIME
4/79 8/79 12/79 4/80 8/80 8/81 8/82 8/83 8/84 8/85 8/86 8/87 8/88 8/89 8/90 8/91
6/79 10/79 2/80 6/80 2/81 2/82 2/83 2/84 2/85 2/86 2/87 2/88 2/89 2/90 2/91 2/92
DATE 1979 - 1992
WELL 771 (54th Ave S)
Well 773 (NE High)
Well 776 (Blanc Park - Control Well)
Well 778 (Lealman Elem.)

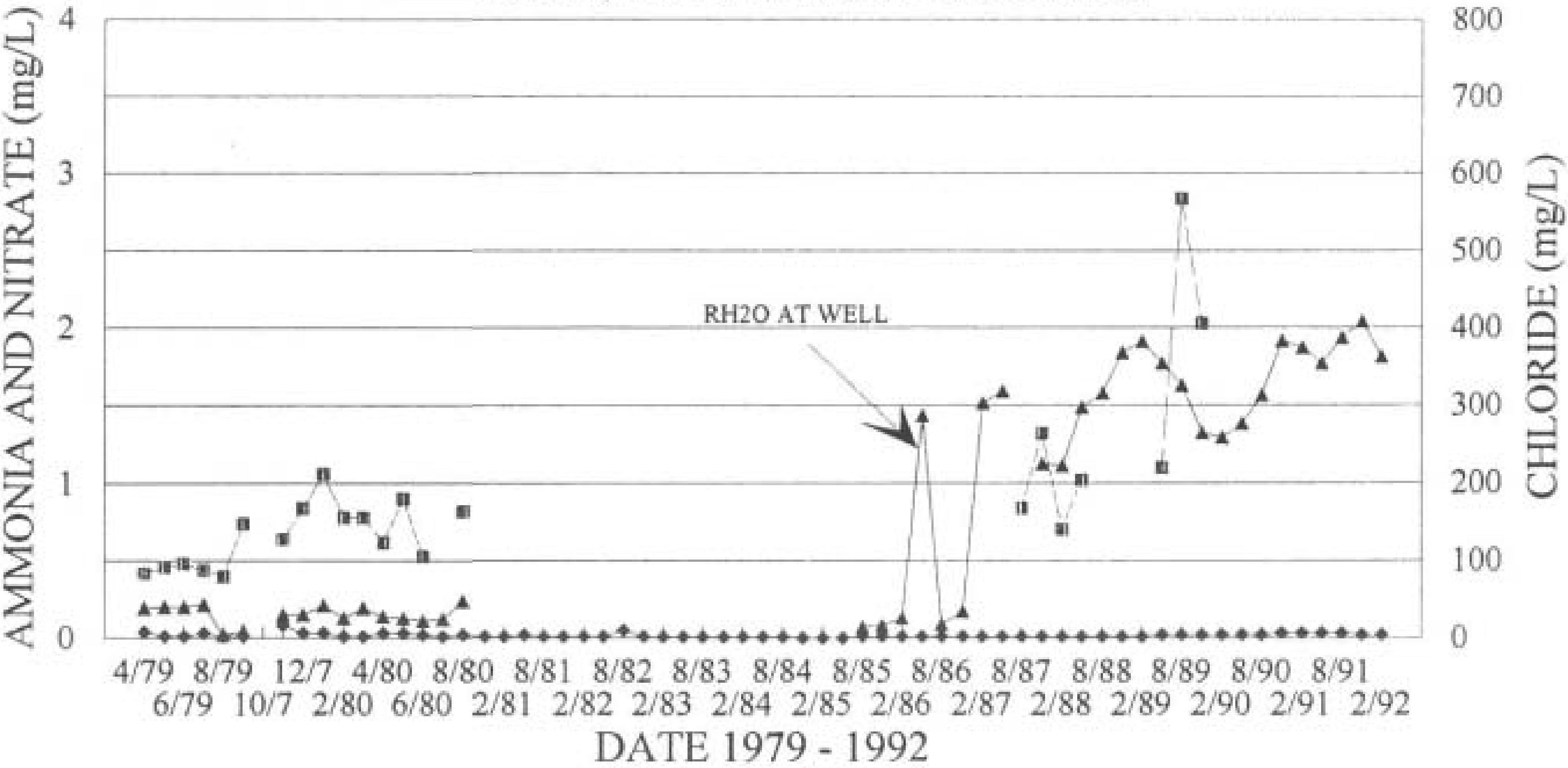
SPRAY IRRIGATION MONITOR WELLS

TOTAL NITROGEN OF OLD MONITOR WELLS

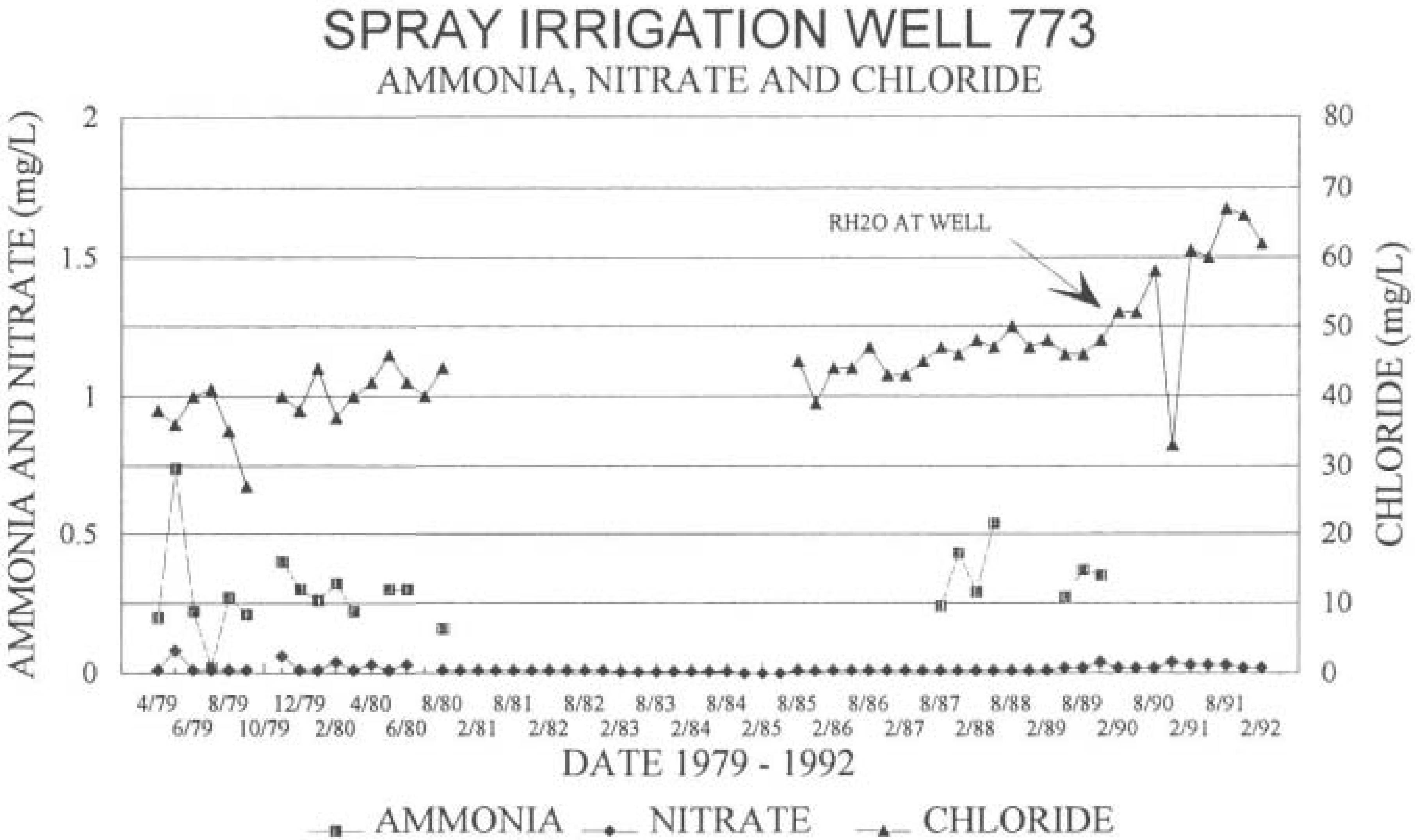


SPRAY IRRIGATION WELL 771

AMMONIA, NITRATE AND CHLORIDE



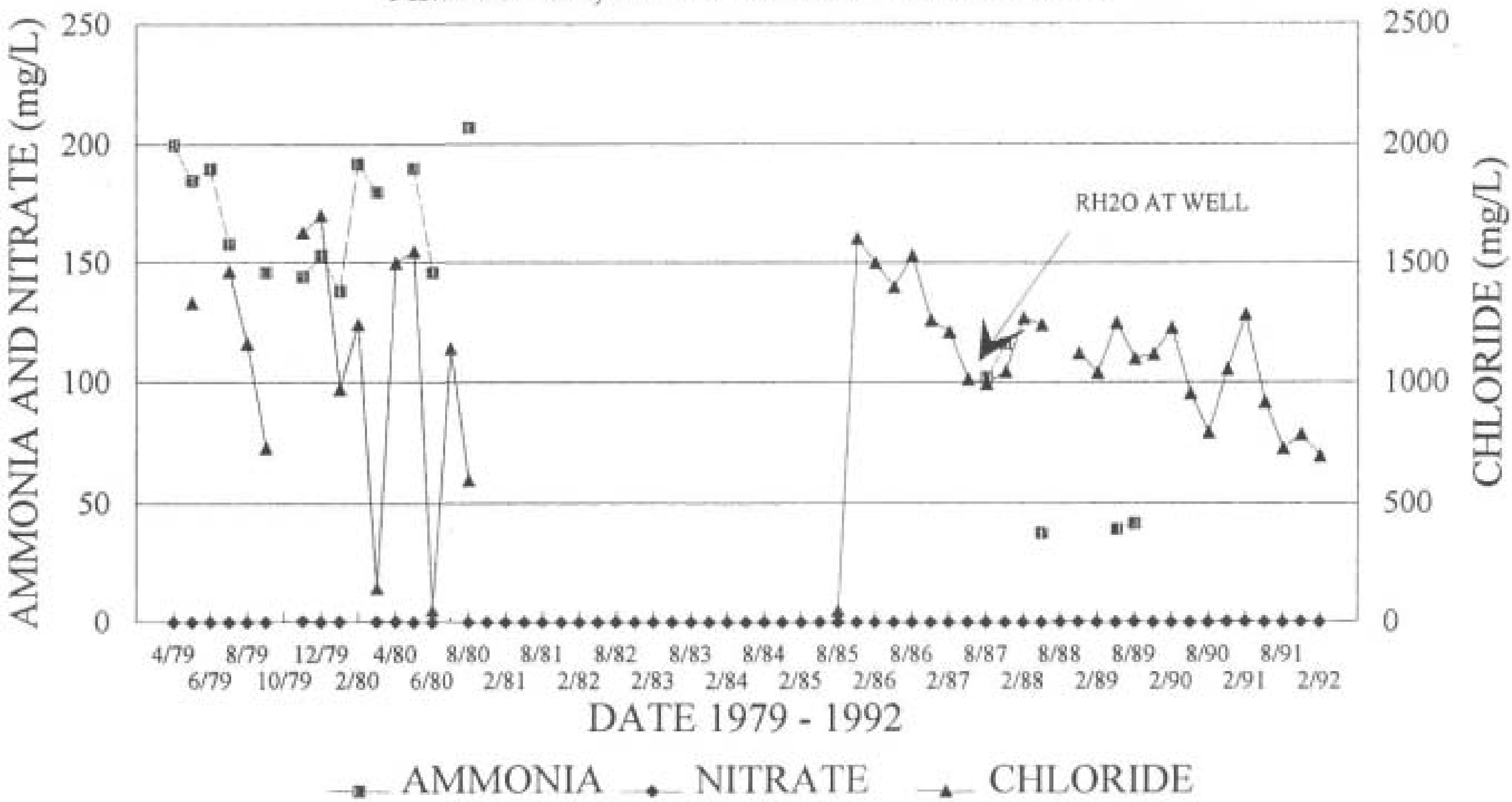
LOCATION: 54TH AVE SO PARKWAY
WELL ABANDONED 4/92



LOCATION: NORTHEAST HIGH SCHOOL
WELL ABANDONED 4/92

SPRAY IRRIGATION WELL 774

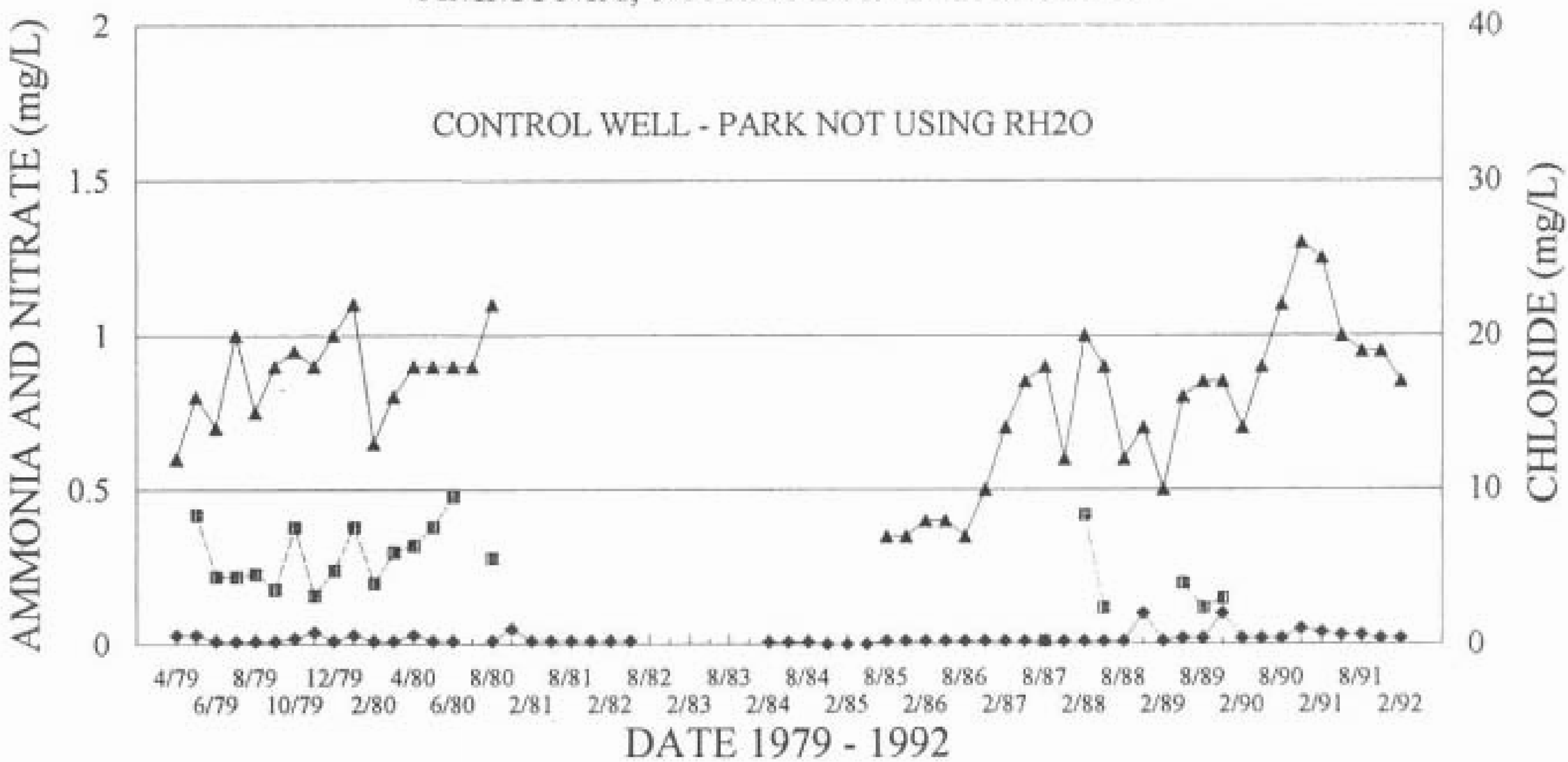
AMMONIA, NITRATE AND CHLORIDE



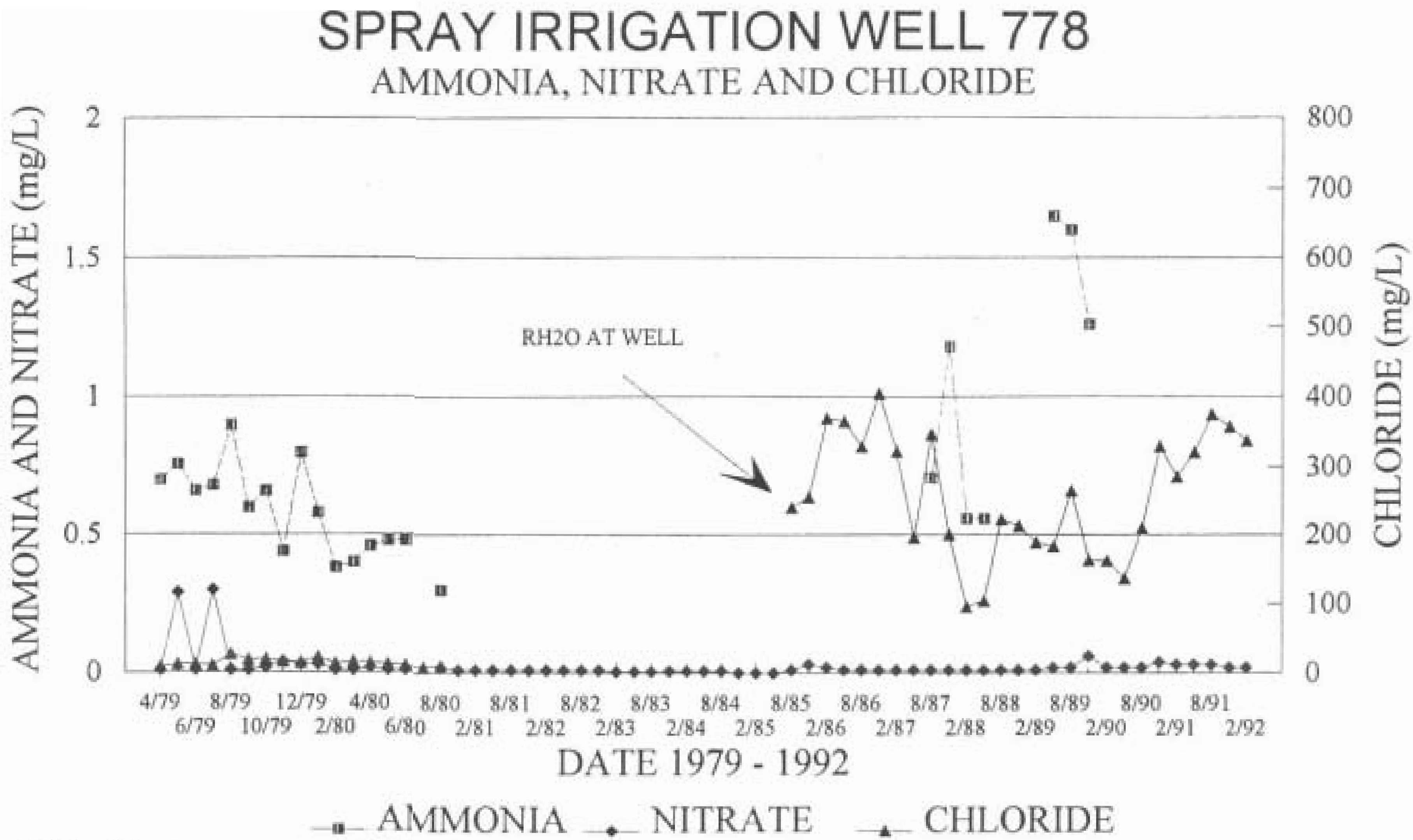
LOCATION: MANGROVE BAY GOLF COURSE
WELL ABANDONED 4/92

SPRAY IRRIGATION WELL 776

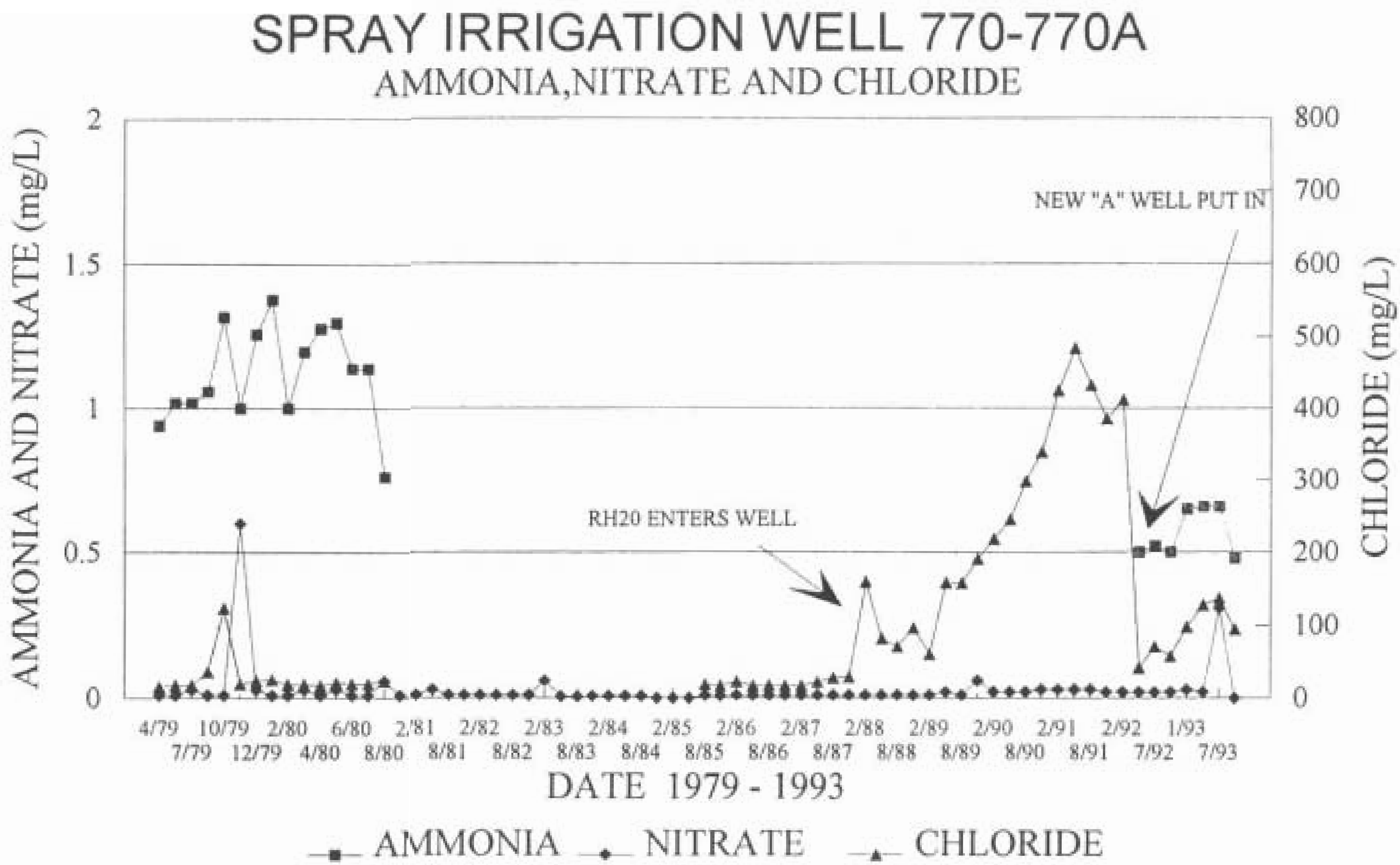
AMMONIA, NITRATE AND CHLORIDE



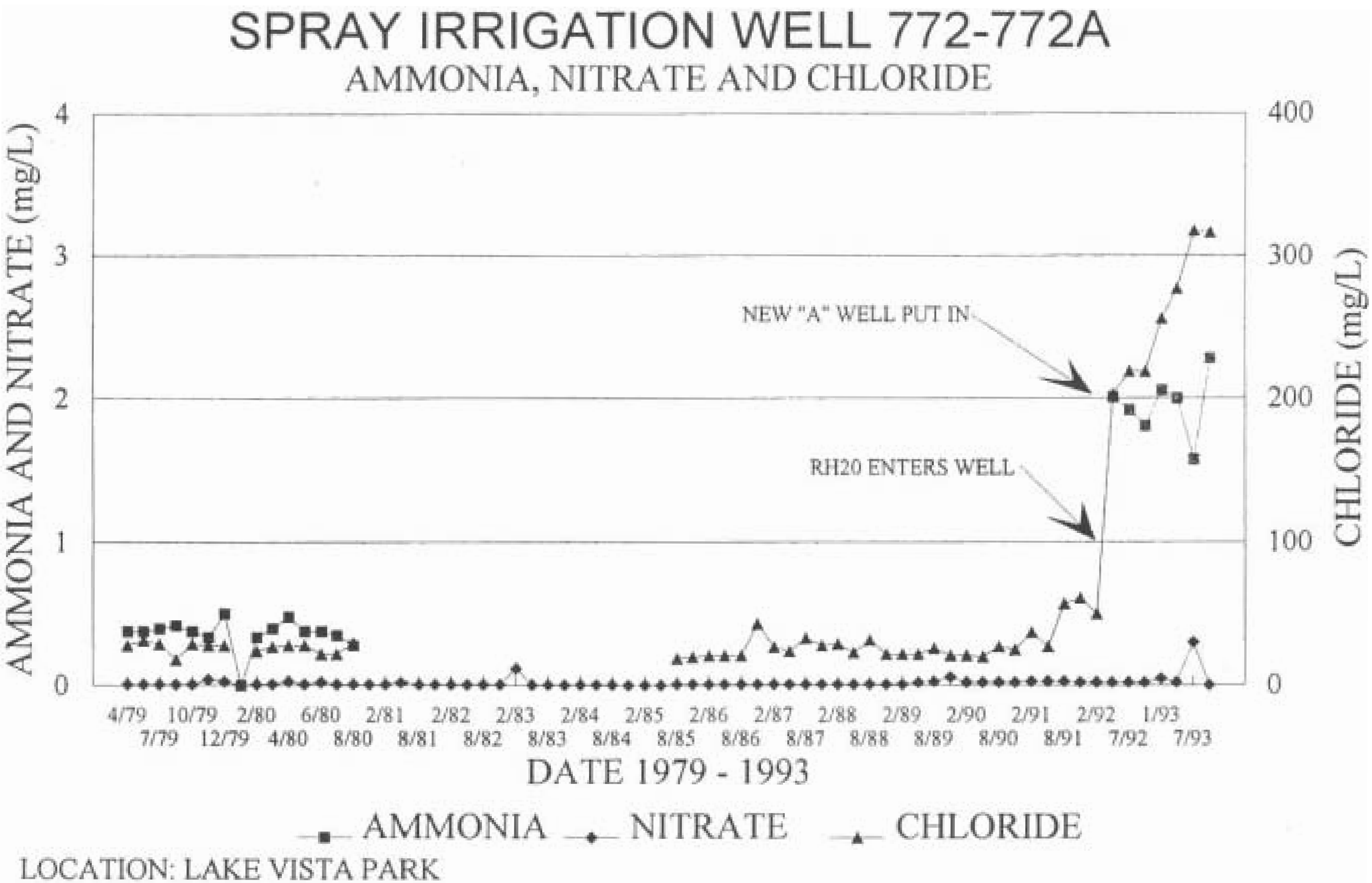
LOCATION: BLANC PARK - "CONTROL WELL"
WELL ABANDONED 4/92

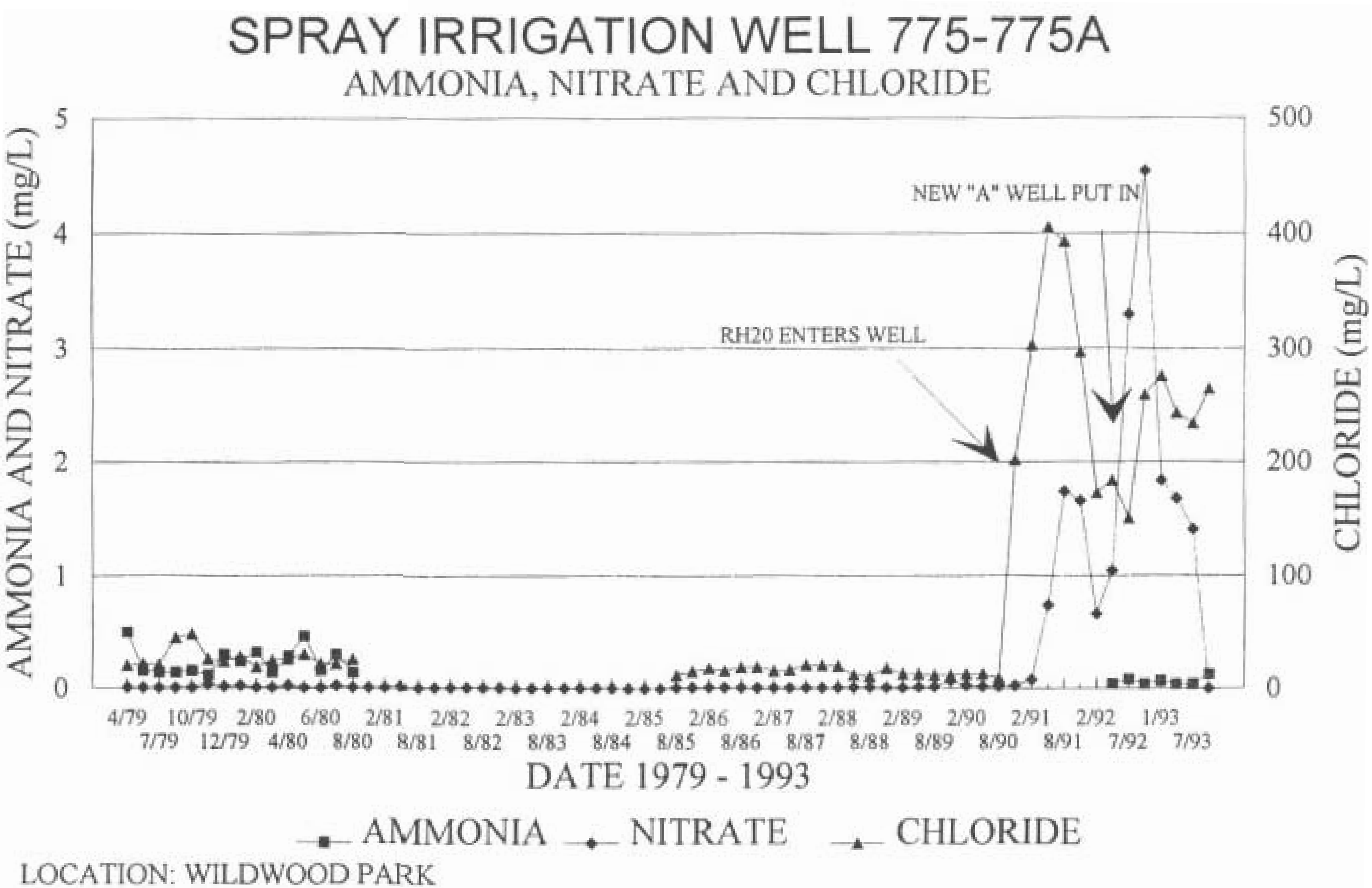


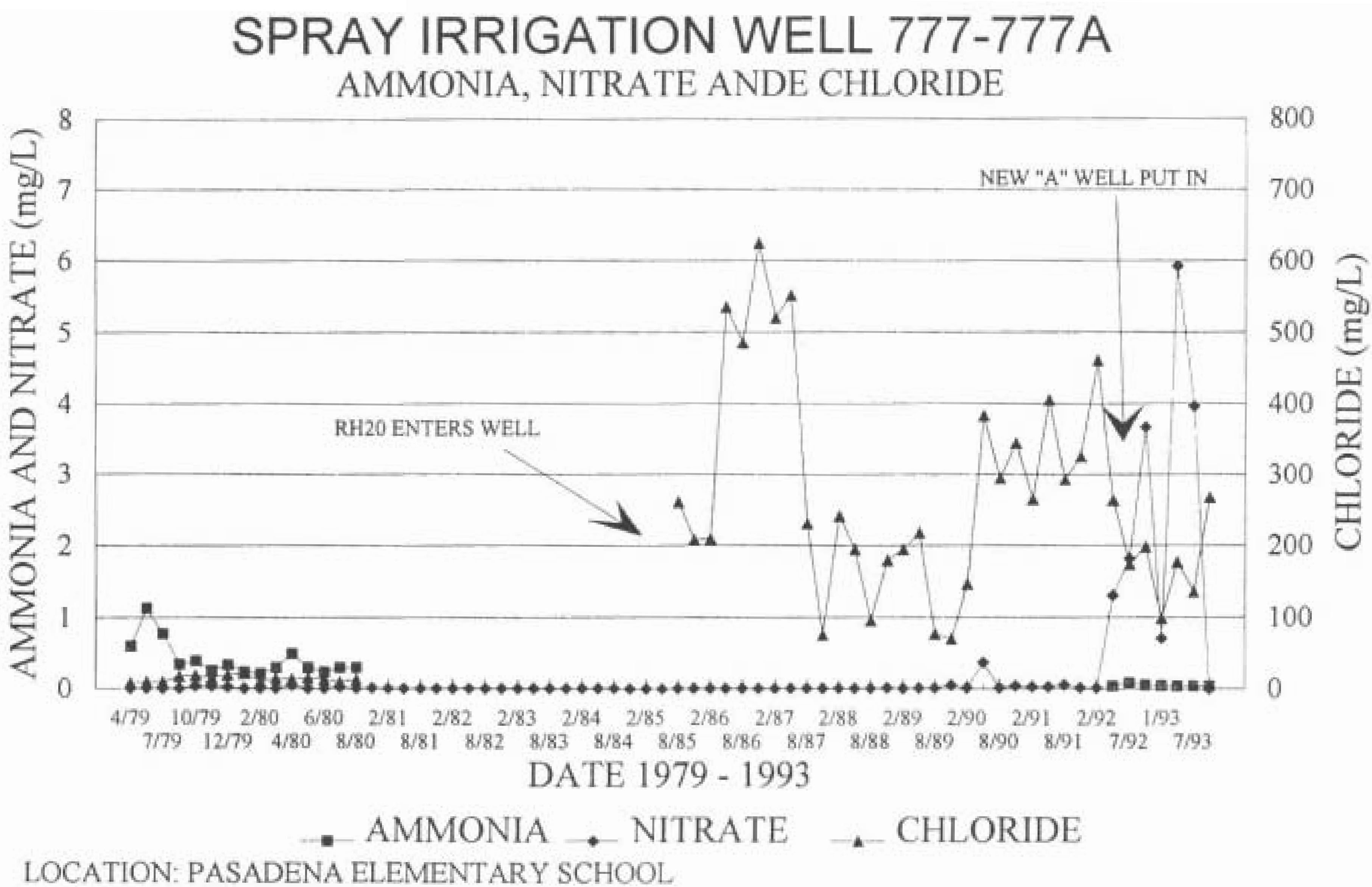
LOCATION: LEALMAN ELEMENTRY SCHOOL
WELL ABANDONED 4/92



LOCATION: KIWANIS PARK


SPRAY IRRIGATION WELL 772-772A
AMMONIA, NITRATE AND CHLORIDE
AMMONIA AND NITRATE (mg/L)
4
3
2
1
0
CHLORIDE (mg/L)
400
300
200
100
0
NEW "A" WELL PUT IN
RH20 ENTERS WELL
4/79 10/79 2/80 6/80 2/81 2/82 2/83 2/84 2/85 2/86 2/87 2/88 2/89 2/90 2/91 2/92 1/93
7/79 12/79 4/80 8/80 8/81 8/82 8/83 8/84 8/85 8/86 8/87 8/88 8/89 8/90 8/91 7/92 7/93
DATE 1979 - 1993
AMMONIA
NITRATE
CHLORIDE
LOCATION: LAKE VISTA PARK


SPRAY IRRIGATION WELL 775-775A
AMMONIA, NITRATE AND CHLORIDE
AMMONIA AND NITRATE (mg/L)
CHLORIDE (mg/L)
0
1
2
3
4
5
0
100
200
300
400
500
NEW "A" WELL PUT IN
RH20 ENTERS WELL
4/79 10/79 2/80 6/80 2/81 2/82 2/83 2/84 2/85 2/86 2/87 2/88 2/89 2/90 2/91 2/92 1/93
7/79 12/79 4/80 8/80 8/81 8/82 8/83 8/84 8/85 8/86 8/87 8/88 8/89 8/90 8/91 7/92 7/93
DATE 1979 - 1993
AMMONIA
NITRATE
CHLORIDE
LOCATION: WILDWOOD PARK



SPRAY IRRIGATION WELL 777-777A
AMMONIA, NITRATE ANDE CHLORIDE
AMMONIA AND NITRATE (mg/L)
CHLORIDE (mg/L)
0
1
2
3
4
5
6
7
8
0
100
200
300
400
500
600
700
800
RH20 ENTERS WELL
NEW "A" WELL PUT IN
4/79 10/79 2/80 6/80 2/81 2/82 2/83 2/84 2/85 2/86 2/87 2/88 2/89 2/90 2/91 2/92 1/93
7/79 12/79 4/80 8/80 8/81 8/82 8/83 8/84 8/85 8/86 8/87 8/88 8/89 8/90 8/91 7/92 7/93
DATE 1979 - 1993
AMMONIA
NITRATE
CHLORIDE
LOCATION: PASADENA ELEMENTARY SCHOOL

APPENDIX 7

EXISTING CONDITIONS GROUNDWATER FLOW AND NUTRIENT LOADINGS

3/10/93
Rev.6/29/93
(add Man. Riv.)
Rev. 11/18/93
(new WQ data)

Groundwater and Nutrient Inflow to Tampa Bay

- flows from (1) Hutchinson,(1983) and (2) Brooks et al,(1992)
- water quality from (3) DeHaven et al,(1991)

Bay Segment	Aquifer	Wet Season Flow (mgd) (1) 9/78	(2) 9/85	(2) 9/90	x bar	Nitrate Load (kg/mo)	Phos. Load (kg/mo)	(3) Nitrate Conc. (mg/l)	(3) Phos. Conc. (mg/l)	Water Load (m3/mo.)
Old TB										
	Fla	35	38	35	36.0	53.82	621.00	0.013	0.15	
	Int	0	0	0	0.0	0.00	0.00	0	0	
	WT	0.1	0.1	0.1	0.1	0.41	1.84	0.036	0.16	
	total	35.1	38.1	35.1	36.1	54.23	622.84			4167960
Hill.Bay										
	Fla	63	29	35	42.3	58.42	973.67	0.012	0.2	
	Int	0	1.4	1.6	1.5	20.70	44.85	0.12	0.26	
	WT	0.07	0.07	0.07	0.1	0.49	2.82	0.061	0.35	
	total	63.07	30.47	36.67	43.9	79.61	1021.33			5068901
MTB										
	Fla	14	10	12	12.0	34.50	276.00	0.025	0.2	
	Int	0	1.8	3.6	2.7	37.26	80.73	0.12	0.26	
	WT	0.1	0.1	0.1	0.1	0.26	4.14	0.023	0.36	
	total	14.1	11.9	15.7	14.8	72.02	360.87			1708748
LTB										
	Fla	5	6	5	5.3	15.33	92.00	0.025	0.15	
	Int	0	1.65	6.8	4.2	58.30	97.18	0.12	0.2	
	WT	0.1	0.1	0.1	0.1	0.26	2.88	0.023	0.25	
	total	5.1	7.75	11.9	9.7	73.90	192.05			1115112
BCB										
	Fla	0	2	2	1.3	0.15	15.33	0.001	0.1	
	Int	0	0	0	0.0	0.00	0.00	0	0	
	WT	0.05	0.05	0.05	0.1	0.23	1.15	0.04	0.2	
	total	0.05	2.05	2.05	1.4	0.38	16.48			159714
TCB										
	Fla	0	0.5	0.5	0.3	0.50	3.83	0.013	0.1	
	Int	0	0.15	0.15	0.2	2.07	4.49	0.12	0.26	
	WT	0.007	0.007	0.007	0.0	0.04	0.20	0.053	0.25	
	total	0.007	0.657	0.657	0.5	2.61	8.52			56612
Man. River										
	Fla	0	2.5	2.5	1.7	2.49	19.17	0.013	0.1	
	Int	0	0.55	0.55	0.6	7.59	16.45	0.12	0.26	
	WT	0.02	0.02	0.02	0.0	0.12	0.58	0.053	0.25	
	total	0.02	3.07	3.07	2.2	10.20	36.19			258236
Wet Season Totals									Q(total) (m3/mo.)	12535284
	Fla	117	85.5	89.5	97.33	162.73	1981.83			
	Int	0	5	12.15	8.575	118.34	227.24			
	WT	0.427	0.427	0.427	0.427	1.71	13.02			
	total	117.43	90.93	102.08	103.5	282.77	2222.10			

Conversion: (mg/l)*(mgd)*(30.5d/mo)*(10e6gal/1mgal)*(kg/10e6mg)*(3.79liter/gal)=kg/mo
:(mg/l)*(mgd)*(115)=kg/mo

Bay Seg.	Aquifer	Dry Season Flow (mgd) (1) 5/78	(2) 5/86	(2) 5/91	x bar	Nitrate Load (kg/mo)	Phos. Load (kg/mo)	Nitrate Conc. (mg/l)	Phos. Conc. (mg/l)	Water Load (m3/mo.)
Old TB										
	Fla	34	43	44	40.3	60.30	695.75	0.013	0.15	
	Int		0	0	0.0	0.00	0.00	0.12	0.26	
	WT	0.05	0.05	0.05	0.1	0.30	2.07	0.053	0.36	
	total	34.05	43.05	44.05	40.4	60.60	697.82			4662496
Hill.Bay										
	Fla	45	16	31	30.7	45.85	705.33	0.013	0.2	
	Int		0.8	1.2	1.0	13.80	29.90	0.12	0.26	
	WT	0.05	0.05	0.05	0.1	0.30	2.07	0.053	0.36	
	total	45.05	16.85	32.25	31.7	59.95	737.30			3661878
MTB										
	Fla	3	8	2	4.3	6.48	99.67	0.013	0.2	
	Int		1.3	2.4	1.9	25.53	55.32	0.12	0.26	
	WT	0.05	0.05	0.05	0.1	0.30	2.07	0.053	0.36	
	total	3.05	9.35	4.45	6.2	32.31	157.05			719675
LTB										
	Fla	2	9	5	5.3	7.97	92.00	0.013	0.15	
	Int		0.5	4.4	2.5	33.81	73.26	0.12	0.26	
	WT	0.05	0.05	0.05	0.1	0.30	2.07	0.053	0.36	
	total	2.05	9.55	9.45	7.8	42.09	167.33			904405
BCB										
	Fla		2	1	1.5	2.24	17.25	0.013	0.1	
	Int		0	0	0.0	0.00	0.00	0.12	0.26	
	WT	0.02	0.02	0.02	0.0	0.12	0.83	0.053	0.36	
	total	0.02	2.02	1.02	1.52	2.36	18.08			175493
TCB										
	Fla		0.5	0.5	0.5	0.75	11.50	0.013	0.2	
	Int		0.25	0.5	0.4	5.18	11.21	0.12	0.26	
	WT	0.005	0.005	0.005	0.0	0.03	0.21	0.053	0.36	
	total	0.005	0.755	1.005	0.88	5.95	22.92			101601
Man. River										
	Fla	0	2	2	1.3	1.99	15.33	0.013	0.1	
	Int	0	0.35	0.75	0.6	7.59	16.45	0.12	0.26	
	WT	0.02	0.02	0.02	0.0	0.12	0.58	0.053	0.25	
	total	0.02	2.37	2.77	1.9	9.71	32.35			219751
Totals								0.013	0.2	
	Fla	84	80.5	85.5	84	123.59	1621.50	0.12	0.26	
	Int	0	3.2	9.25	6.225	78.32	169.68	0.053	0.36	
	WT	0.245	0.245	0.245	0.245	1.37	9.32			28287
	total	84.245	83.945	94.995	87.7	203.27	1800.50		Q(total) (m3/mo.)	10473587

Conversion: (mg/l)*(mgd)*(30.5d/mo)*(10e6gal/1mgal)*(kg/10e6mg)*(3.79liter/gal)=kg/mo

APPENDIX 8

BENCHMARK LAND USE-SPECIFIC WATER QUALITY CONCENTRATIONS

HISTORICAL NONPOINT SOURCE

LAND USE-SPECIFIC WATER QUALITY CONCENTRATIONS

1) URBAN

	Residential	Commercial	Industrial	Estimated Area-weighted Average
(w/ estimated relative area coverage)	0.7	0.2	0.1	
TN				
Min.	0.41	0.76	0.59	0.50
Mean	1.02	0.61	0.82	0.92
Max.	1.91	1.18	1.26	1.70
TP				
Min.	0.025	0.06	0.08	0.04
Mean	0.19	0.14	0.14	0.18
Max.	0.29	0.44	0.21	0.31
TSS				
Mean	36	42	94	43

2) AGRICULTURAL

	Grove	Nursery Feed lot	Row & Field Crop	Estimated Area-weighted Average
(w/ estimated relative area coverage)	0.3	0.05	0.65	
TN				
Min.	0.75	2.70	1.00	1.01
Mean	1.00	15.0	1.16	1.80
Max.	1.50	21.0	1.50	2.48
TP				
Min.	0.075	0.85	0.10	0.13
Mean	0.10	2.80	0.27	0.35
Max.	0.3	3.80	1.06	0.97
TSS				
Mean	5	50	10	10.5

3) UNDEVELOPED ("FOREST")

	(w/ estimated relative area coverage)				
	0.4	0.125	0.4	0.075	Estimated
	Range	Pasture	Open space/ non-forested	Upland forest	Area-weighted Average
TN					
Min.	0.68	0.50	0.90	0.10	0.70
Mean	0.93	1.30	1.21	0.50	1.06
Max.	1.10	2.50	1.47	1.02	1.38
TP					
Min.	0.008	0.02	0.08	0.007	0.022
Mean	0.016	0.09	0.40	0.05	0.096
Max.0.16	0.16	0.21	1.50	0.16	0.35
TSS					
Mean	8.2	11	5	2	8.5

4) OPEN WATER/WETLAND

	(Assume no load) 0.50 Open water	0.50 FW wetland	Estimated Area-weighted Average
TN			
Min.		0.79	0.40
Mean	0	1.43	0.72
Max.		2.26	1.13
TP			
Min.		0.09	0.05
Mean	0	0.19	0.10
Max.		0.33	0.16
TSS			
Min.		4.6	2.3
Mean	0	10.23	5.12
Max.		13.4	6.7

APPENDIX 9

BENCHMARK WASTEWATER TREATMENT PLANTS

Historical WWTP Information
(compiled by Andy Squires)

Dave Pickard, Plant Manager, City of Tampa AWT Plant (Hookers Point), Interviewed at AWT Plant, 3-30-93

Hookers Point primary plant went on-line about 1950-51. An Imhoff Tank, located near 22nd Street and McKay Bay, may have been in use prior to that time.

The "rule of thumb" flow expected from a typical domestic population is 100 gallons per person. Hookers Point was primary from 1951 through December 1977. During that time frame, the percent TKN and TP removed was very small. Expected TN and TP influent concentrations for a domestic WWTP is generally around 30mg/l and 8-10mg/l, respectively. Due to recent changes in detergents low in phosphates, influent TP levels are presently around 4 mg/l. Ten years ago it was twice as high.

Around 1967-68, the Breweries went on-line an affected TN (TKN) influent significantly. The Breweries discharge very high concentrations of TN in their effluent which then becomes part of the COT plant influent.

In Section 8, page 15, of the Hagan report, they found that about 7000 lbs TKN was going out into the bay. Dave suggested that this may be same that was going into the plant.

Records of building permits for Davis Island may give indication as to how sewage was treated prior to 1950.

Dave also suggested calling Cliff Courson (former plant manager of Drew Park WWTP in mid to late 1940's, 685-7254). He has good knowledge of domestic wastewater practices prior to 1950. Ralph Metcalf and his father may also prove to be good sources of information.

Cliff Courson, currently retired, but former manager of Drew Park WWTP, phone conversation 3-30-93.

Mr. Courson operated the first WWTP in Florida at Drew Park (current site of TIA) about 1948 through 1951.

Tampa's primary plant (Hookers Point) was constructed in 1950-51, on-line by 1951. Prior to that time an Imhoff tank located just off 22nd Street near McKay Bay was in use, but Mr. Courson did not know the population it served.

Prior to 1950, the COT dumped much of their sewage directly into the bay or river without any treatment whatsoever. He specifically recalls a discharge site near Marabell's Fish Company (current location of Convention Center) in downtown Tampa. In general, industrial and commercial entities dumped directly into surface waters without treatment, while single residences typically had septic tank systems.

Dave Shulmister (sp?), City of St. Petersburg, manager of all WWTPs, phone conversation on 3-31-93.

1893-1894 - First sanitary sewer system (gravity sewer) covered 100 acres.

1925 - sewer system served 1200 acres.
1925 - Albert Whitted was put on-line and performed screening and chlorination. Its service area included N to 9th Av N, S to 7th Av S, and W to 16th St., and E to the bay.
1931 - Plant expanded, but exact nature unknown.
1953 - Service area extended N to 54 Av N & 16th St.
1954 - A 14 million dollar bond issued resulted in Plant expansion.
1956 - Two primary plants went on-line: 1) NE (2mgd capacity), and 2) NW (4mgd capacity).
1957 - SW plant went on-line (6mgd)
1968 - Albert Whitted expanded to 20mgd capacity and upgraded to secondary treatment (contact stabilization).
1976-77 - SW expanded to advanced secondary.
1977 - SW plant started reclaimed water discharge, and deep well injection.
1979 - NE plant to adv. secondary (16mgd)
1980 - NE started reclaimed discharge
1980 - SW stops all surface water discharges to Boca Ciega Bay.
1982 - NW on-line, 20 mgd adv. secondary.
1984 - NW stops all discharges to Boca Ciega Bay.
1988 - Albert Whitted stopped all discharge to Tampa Bay.

Old STP records may be at Central Records, but they may have cleaned those files out in 1988 or 1989.

Tim Forgue (893-7377), the Chief operator at Albert Whitted, may have some old records on plant flows and concentrations. Also Fred Krafa (892-5693), Central Lab supervisor, may know if any old records are available at the lab.

Typical St. Pete TP influent at present is 4 mg/l TP and 20-30 TN. TP effluent is about 3.5-4.0 mg/l TP.

Old population information may be obtained at Planning (893-7153).

Bill Washburn, FDER Tampa, Manatee Co. Domestic WWTP coordinator, phone conversation on 3-29-93.

Information on STPs out of service in archives and difficult at best to obtain. The old plants operated by County public utilities no longer exists. They consisted of several small package plants.

Current Co. plants include:

- North - new plant
- Southeast - new plant
- Southwest - relatively old

Port Manatee had 3 plants serving County at one time.
City of Palmetto - old plant at current plant site.
City of Bradenton - old plant at current plant site.

Ed Snipes, FDER Tampa, Pinellas Co. Domestic WWTP coordinator, phone conversation on 3-29-93.

Status of WWTP is described in document published in mid 60's (perhaps he is referring to Hagan report) by HRS, Wayne Wyatt, Pinellas Co. Health Dept.

To get handle on historical WWTPs, check EPA records and perhaps 201 Plans.

Bill Dunn, of the Pinellas County Sewer System, may have working knowledge of pre-development WWTP situation in County (462-4721).

Bill Dunn, Pinellas Co. Sewer, phone conversation on 3-29-93.

STPs in general not constructed until 1950's, with the following exceptions:

- Clearwater - Marshall Street STP in 1930's
- St. Pete - Albert Whitted in 1920's
- Largo - Centralized Septic Tank system in 1920's
- Safety Hbr - Septic Tank serving small area of City (pre 1940's

Major population centers in 20's-30's were in St. Pete & Clearwater.

Pinellas County's first plant was South Cross Bayou in 1961-62.

Municipal plant history:

St. Pete	- plants in 1950's
Pinellas Park	- STP came on-line in 1960's, but has been abandoned since early 1970's.
Long Key Sewer District	- served southwestern Pinellas beach communities in late 1950's.
Treasure Is.	- small plants in 1950's
Madeira Beach	- STPs in 1950's
Largo	- STPs in 1950's
Clearwater	- STP's 1950's
Dunedin	- STP's 1950's
Oldsmar	- STP in late 50's or early 60's.
Tarpon Springs	- STP in 50's

In general, several small package plants operated prior to the 1950's.

Ralph Metcalf, Director, COT Dept. of Sanitary Sewers phone conversation 3-31-93.

Ralph concurred with my summary of what Cliff Courson's described, but suggested I call his farther, Ralph Metcalf Senior (831-2591).

Ralph Metcalf (Senior, 831-2591), phone conversation on 4-7-93, Former Head of the Wastewater Treatment Division for the State Board of Health in Jacksonville (1940's) and sold wastewater treatment plant equipment for the private sector from the early 50's through the 1970's. During his tenure at the Bd. of Health, he traveled around the state in order to promote the implementation of primary wastewater treatment plants.

Prior to the 1950's, only a small percentage of the population in most areas (certainly less than 20%) was on any type of primary treatment system. The most common system was primary treatment by an Imhoff tank (or some facsimile thereof) which provided both settling and digestion in the same structure. These tanks typically served small subdivisions and were purchased by the developers. Mr. Metcalf recalls an Imhoff tank near Bay-to-Bay and Manhattan, and near Gandy and Dale Mabry, both of which were purchased by the developers of the subdivision being served. The majority of residential households were served by separate septic tanks. In urban areas, including the City of Tampa, commercial and industrial buildings were usually outfitted to discharge raw sewage directly to the nearest surface water, due to lack of space for septic tanks operation.

Starting from the 1950's and continuing through to the 1970's, increasingly larger percentages of the population were served by a regional sanitary sewer system. However, from the 1950's into the 1960's, many subdivision developers provided their own wastewater treatment in the form of Imhoff tank type systems. Some of these Imhoff tanks were modified with trickling filters, and thus, were considered to achieve secondary treatment capabilities.

APPENDIX 10

BENCHMARK DOMESTIC LOADING ESTIMATIONS

Benchmark (circa 1940) Domestic Waste Loading
Tampa Bay Watershed

Bay Segment	Parameter Name	(A) 1940 Populatio	(B) Flow per Capita (gal/d)	(C) Net Flow (Less ET Recharge Loss) (gal/d)	(D) Effluent Quality (mg/L)	(E) In-ground Reduction High %	Low %	(F) Total Benchmark Domestic Load Low (kg/yr)	High (kg/yr)
Old TB									
	TN	98702	50	37.5	40	0.525	0.225	97156	158518
	TP	98702	50	37.5	6	0.713	0.525	8805	14573
	TSS	98702	50	37.5	50	0.713	0.375	73378	159796
	Qtotal	98702	4935100	3701325				3701325	
Hills	TN	128706	50	30	40	0.525	0.225	101352	165364
	TP	128706	50	30	6	0.713	0.525	9186	15203
	TSS	128706	50	30	50	0.713	0.375	76547	166697
	Qtotal	128706	6435300	3861180				3861180	
Middle TB									
	TN	11201	50	35	40	0.525	0.225	10291	16790
	TP	11201	50	35	6	0.713	0.525	933	1544
	TSS	11201	50	35	50	0.713	0.375	7772	16925
	Qtotal	11201	560050	336030				336030	
Lower TB									
	TN	3991	50	35	40	0.525	0.225	3667	5982
	TP	3991	50	35	6	0.713	0.525	332	550
	TSS	3991	50	35	50	0.713	0.375	2769	6031
	Qtotal	3991	199550	119730				119730	
Boca Ciega									
	TN	5581	50	40	40	0.525	0.225	5860	9561
	TP	5581	50	40	6	0.713	0.525	531	879
	TSS	5581	50	40	50	0.713	0.375	4426	9638
	Qtotal	5581	279050	167430				167430	
Terra Ceia									
	TN	2500	50	40	40	0.525	0.225	2625	4283
	TP	2500	50	40	6	0.713	0.525	238	394
	TSS	2500	50	40	50	0.713	0.375	1982	4317
	Qtotal	2500	125000	75000				75000	
Manatee River									
	TN	12722	50	35	40	0.525	0.225	11688	19070
	TP	12722	50	35	6	0.713	0.525	1059	1753
	TSS	12722	50	35	50	0.713	0.375	8827	19223
	Qtotal	12722	636100	381660				381660	
TOTAL									
	TN	(kg/yr)						232638	379567
	TP	(kg/yr)						21084	34896
	TSS	(kg/yr)						175703	382628
	Qtotal	(gal/yr)						8642355	
	Qtotal	(gal/mo)						720196	
	Populatio	(people)						263403	

(A) 1940 population from Florida Statistical Abstracts, 1967.
(B) 1940 domestic waste stream of 50 gpd/cap is less than current rate of 75-100.
(C) ET+Recharge varies from 0.2 - 0.4 oif total 1940 domestic waste by bay segment drainage ar
(D) 1940 TP concentrations in domestic effluent are less than typical current values.
(E) Assume no WWTP, 75% on-site facilities, 25% have direct discharge.
(E) In ground reduction efficiencies are: TN(30-70%), TP(70-95%), TSS(50-95%). Reduction acts on effluent leaving drain field, final concentration is in water table plume.
(F) kg/yr=(gal/day)*(mg/L)*(3.785L/gal)*(kg/10E6mg)*(365day/yr)*(1-treatment efficiency)

APPENDIX 11

BENCHMARK GROUNDWATER FLOW AND NUTRIENT LOADINGS

Historical Groundwater and Nutrient Inflow to Tampa Bay

-based on (1) (Hutchinson, 1983) and (2) (Brooks et al, 1992)

Bay Segment	Aquifer	Wet Season Flow (mgd) (1) 9/78	(2) 9/85	(2) 9/90	x bar	Nitrate Load (kg/mo)	Phos. Load (kg/mo)	Nitrate Conc. (mg/l)	Phos. Conc. (mg/l)
Old TB									
	Fla	35	38	35	36.0	8.28	207.00	0.002	0.05
	Int	0	0	0	0.0	0.00	0.00	0.001	0.26
	WT	0.1	0.1	0.1	0.1	0.78	2.30	0.068	0.2
	total	35.1	38.1	35.1	36.1	9.06	209.30		
Hill.Bay									
19.5	Fla	63	29	35	61.8	14.22	355.54	0.002	0.05
	Int	0	1.4	1.6	1.5	0.17	44.85	0.001	0.26
	WT	0.05	0.05	0.05	0.1	0.01	0.69	0.0013	0.12
	total	63.05	30.45	36.65	63.4	14.40	401.08		
MTB									
74.5	Fla	14	10	12	86.5	19.90	497.38	0.002	0.05
	Int	0	1.8	3.6	2.7	0.31	80.73	0.001	0.26
	WT	0.1	0.1	0.1	0.1	0.15	0.81	0.013	0.07
	total	14.1	11.9	15.7	89.3	20.36	578.91		
LTB									
41.5	Fla	5	6	5	46.8	10.77	269.29	0.002	0.05
	Int	0	1.65	6.8	4.2	0.49	126.33	0.001	0.26
	WT	0.1	0.1	0.1	0.1	0.15	0.12	0.013	0.01
	total	5.1	7.75	11.9	51.2	11.41	395.73		
BCB									
2	Fla	0	2	2	3.3	0.77	19.17	0.002	0.05
	Int	0	0	0	0.0	0.00	0.00	0.001	0.26
	WT	0.01	0.01	0.01	0.0	0.00	0.01	0.002	0.01
	total	0.01	2.01	2.01	3.3	0.77	19.18		
TCB									
2	Fla	0	0	0	2.0	0.46	11.50	0.002	0.05
	Int	0	0.35	0.5	0.4	0.05	12.71	0.001	0.26
	WT	0.002	0.002	0.002	0.0	0.00	0.00	0.002	0.01
	total	0.002	0.352	0.502	2.4	0.51	24.21		
Wet Season Totals									
	Fla	117	85	89	236.50	54.40	1359.88		
	Int	0	5.2	12.5	8.85	1.02	264.62		
	WT	0.362	0.362	0.362	0.362	1.09	3.92		
	total	117.36	90.56	101.86	103.3	56.50	1628.41		

Conversion: (mg/l)*(mgd)*(30.5d/mo)*(10e6gal/1mgal)*(kg/10e6mg)*(3.79liter/gal)=kg/mo
:(mg/l)*(mgd)*(115)=kg/mo

Bay Seg.	Aquifer	Historical Dry Season Flow (mgd) (1) 5/78	(2) 5/86	(2) 5/91	x bar	Nitrate Load (kg/mo)	Phos. Load (kg/mo)	Nitrate Conc. (mg/l)	Phos. Conc. (mg/l)
Old TB									
	Fla	34	43	44	40.3	9.28	231.92	0.002	0.05
	Int		0	0	0.0	0.00	0.00	0.001	0.26
	WT	0.05	0.05	0.05	0.1	0.39	1.15	0.068	0.2
	total	34.05	43.05	44.05	40.4	9.67	233.07		
Hill.Bay									
19.5	Fla	45	16	31	50.2	11.54	288.46	0.002	0.05
	Int		0.8	1.2	1.0	0.12	29.90	0.001	0.26
	WT	0.05	0.05	0.05	0.1	0.01	0.69	0.0013	0.12
	total	45.05	16.85	32.25	51.2	11.66	319.05		
MTB									
74.5	Fla	3	8	2	78.8	18.13	453.29	0.002	0.05
	Int		1.3	2.4	1.9	0.21	55.32	0.001	0.26
	WT	0.05	0.05	0.05	0.1	0.07	0.40	0.013	0.07
	total	3.05	9.35	4.45	80.7	18.42	509.01		
LTB									
41.5	Fla	2	9	5	46.8	10.77	269.29	0.002	0.05
	Int		0.5	4.4	2.5	0.28	73.26	0.001	0.26
	WT	0.05	0.05	0.05	0.1	0.07	0.06	0.013	0.01
	total	2.05	9.55	9.45	49.3	11.13	342.60		
BCB									
2	Fla		2	1	3.0	0.69	17.25	0.002	0.05
	Int		0	0	0.0	0.00	0.00	0.001	0.26
	WT	0.005	0.005	0.005	0.0	0.00	0.01	0.002	0.01
	total	0.005	2.005	1.005	0.5	0.69	17.26		
TCB									
2	Fla		1	1	2.7	0.61	15.33	0.002	0.05
	Int		0.25	0.5	0.4	0.04	11.21	0.001	0.26
	WT	0.001	0.001	0.001	0.0	0.00	0.00	0.002	0.01
	total	0.001	1.251	9	0.5	0.66	26.55		
Dry Season Totals									
	Fla	84	79	84	221.83	51.02	1275.54		
	Int	0	2.85	8.5	5.675	0.65	169.68		
	WT	0.206	0.206	0.206	0.206	0.55	2.31		
	total	84.206	82.056	92.706	222.2	52.22	1447.53		
						52.22	1447.53		

Conversion: (mg/l)*(mgd)*(30.5d/mo)*(10e6gal/1mgal)*(kg/10e6mg)*(3.79liter/gal)=kg/mo

APPENDIX 12

TABULAR SUMMARY OF LOADING ESTIMATES FOR EXISTING CONDITIONS

TOTAL LOADS BY BAY SEGMENT

OLD TAMPA BAY								
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Atmospheric Deposition			225	184	0	44.1%	62.4%	0.0%
Point Sources			65	48	34	12.7%	16.3%	0.6%
	Domestic		65	48	33	12.7%	16.3%	0.6%
		Land Application	13	2	4	2.5%	0.7%	0.1%
		Surface Water	52	46	29	10.2%	15.6%	0.5%
	Industrial		< 1	< 1	1	<0.1%	<0.1%	<0.1%
	Springs		< 1	< 1	< 1	<0.1%	<0.1%	<0.1%
Fugitive Emissions			0	0	0	0.0%	0.0%	0.0%
Groundwater			1	9	< 1	0.2%	3.1%	<0.1%
Nonpoint Sources			219	54	5430	42.9%	18.3%	99.4%

HILLSBOROUGH BAY								
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Atmospheric Deposition			108	87	0	6.8%	5.3%	0.0%
Point Sources			405	705	1204	25.6%	43.3%	7.4%
	Domestic		238	457	245	15.0%	28.1%	1.5%
		Land Application	4	1	1	0.3%	0.1%	<0.1%
		Surface Water	234	456	244	14.8%	28.0%	1.5%
	Industrial		61	241	957	3.8%	14.8%	5.9%
	Springs		106	7	2	6.7%	0.4%	<0.1%
Fugitive Emissions			272	396	< 1	17.2%	24.3%	<0.1%
Groundwater			1	11	< 1	0.1%	0.7%	<0.1%
Nonpoint Sources			799	428	15102	50.4%	26.3%	92.6%

MIDDLE TAMPA BAY								
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Atmospheric Deposition			306	248	0	41.7%	68.1%	0.0%
Point Sources			24	17	251	3.3%	4.7%	4.4%
	Domestic		19	3	2	2.6%	0.8%	<0.1%
		Land Application	19	3	2	2.6%	0.8%	<0.1%
		Surface Water	<1	<1	<1	<0.1%	<0.1%	<0.1%
	Industrial		5	14	249	0.7%	3.8%	4.3%
	Springs		0	0	0	0.0%	0.0%	0.0%
Fugitive Emissions			0	0	0	0.0%	0.0%	0.0%
Groundwater			1	3	<1	0.1%	0.8%	<0.1%
Nonpoint Sources			403	96	5497	54.9%	26.4%	95.6%

LOWER TAMPA BAY								
SOURCES	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Atmospheric Deposition			269	215	0	78.7%	80.8%	0.0%
Point Sources			12	6	37	3.5%	2.3%	7.0%
	Domestic		1	< 1	< 1	0.3%	<0.1%	<0.1%
		Land Application	1	< 1	< 1	0.3%	<0.1%	<0.1%
		Surface Water	< 1	< 1	< 1	<0.1%	<0.1%	<0.1%
	Industrial		11	6	37	3.2%	2.3%	7.0%
	Springs		0	0	0	0.0%	0.0%	0.0%
Fugitive Emissions			19	28	< 1	5.6%	10.5%	<0.1%
Groundwater			1	2	< 1	0.3%	0.8%	<0.1%
Nonpoint Sources			41	15	490	12.0%	5.6%	93.0%

BOCA CIEGA BAY

SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Atmospheric Deposition			96	78	0	38.6%	75.0%	0.0%
Point Sources			3	1	<1	1.2%	1.0%	<0.1%
	Domestic		3	1	<1	1.2%	1.0%	<0.1%
		Land Application	3	1	<1	1.2%	1.0%	<0.1%
		Surface Water	<1	<1	<1	<0.1%	<0.1%	<0.1%
	Industrial		<1	<1	<1	<0.1%	<0.1%	<0.1%
	Springs		0	0	0	0.0%	0.0%	0.0%
Fugitive Emissions			0	0	0	0.0%	0.0%	0.0%
Groundwater			<1	<1	<1	<0.1%	<0.1%	<0.1%
Nonpoint Sources			150	25	4766	60.2%	24.0%	100.0%

TERRA CEIA BAY								
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Atmospheric Deposition			18	14	0	50.0%	77.8%	0.0%
Point Sources			6	1	5	16.7%	5.6%	2.1%
	Domestic		6	1	5	16.7%	5.6%	2.1%
		Land Application	< 1	< 1	< 1	<0.1%	<0.1%	<0.1%
		Surface Water	6	1	5	16.7%	5.6%	2.1%
	Industrial		< 1	< 1	< 1	<0.1%	<0.1%	<0.1%
	Springs		0	0	0	0.0%	0.0%	0.0%
Fugitive Emissions			0	0	0	0.0%	0.0%	0.0%
Groundwater			< 1	< 1	< 1	<0.1%	<0.1%	<0.1%
Nonpoint Sources			12	3	237	33.3%	16.7%	97.9%

MANATEE RIVER								
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Atmospheric Deposition			46	36	0	9.4%	27.3%	0.0%
Point Sources			91	4	4367	18.6%	3.0%	59.0%
	Domestic		21	4	18	4.3%	3.0%	0.2%
		Land Application	2	< 1	< 1	0.4%	<0.1%	<0.1%
		Surface Water	19	4	18	3.9%	3.0%	0.2%
	Industrial		70	< 1	4349	14.3%	<0.1%	58.8%
	Springs		0	0	0	0.0%	0.0%	0.0%
Fugitive Emissions			0	0	0	0.0%	0.0%	0.0%
Groundwater			< 1	< 1	< 1	<0.1%	<0.1%	<0.1%
Nonpoint Sources			351	92	3031	71.9%	69.7%	41.0%

POINT SOURCE AND NONPOINT SOURCE LOADS
BY BAY SEGMENT

COASTAL OLD TAMPA BAY								
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Point Sources			65	48	34	22.9%	47.1%	0.6%
	Domestic		65	48	33	22.9%	47.1%	0.6%
		Land Application	13	2	4	4.6%	2.0%	0.1%
		Surface Water	52	46	29	18.3%	45.1%	0.5%
	Industrial		0	0	0	0.0%	0.0%	0.0%
	Springs		0	0	0	0.0%	0.0%	0.0%
Nonpoint Sources			219	54	5430	77.1%	52.9%	99.4%

HILLSBOROUGH RIVER								
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Point Sources			72	87	293	23.3%	88.8%	3.8%
	Domestic		8	5	34	2.6%	5.1%	0.4%
		Land Application	0	0	0	0.0%	0.0%	0.0%
		Surface Water	8	5	34	2.6%	5.1%	0.4%
	Industrial		32	78	259	10.4%	79.6%	3.3%
	Springs		32	4	0	10.4%	4.1%	0.0%
Nonpoint Sources			237	11	7511	76.7%	11.2%	96.2%

			COASTAL HILLSBOROUGH BAY					
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Point Sources			211	424	626	61.3%	93.0%	20.8%
	Domestic		208	407	142	60.5%	89.3%	4.7%
		Land Application	2	0	1	0.6%	0.0%	0.0%
		Surface Water	206	407	141	59.9%	89.3%	4.7%
	Industrial		3	17	484	0.9%	3.7%	16.1%
	Springs		0	0	0	0.0%	0.0%	0.0%
Nonpoint Sources			133	32	2383	38.7%	7.0%	79.2%

ALAFIA RIVER								
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Point Sources			121	192	285	22.0%	33.3%	5.2%
	Domestic		22	44	69	4.0%	7.6%	1.3%
		Land Application	2	0	0	0.4%	0.0%	0.0%
		Surface Water	20	44	69	3.6%	7.6%	1.3%
	Industrial		26	145	215	4.7%	25.2%	3.9%
	Springs		73	3	1	13.3%	0.5%	0.0%
Nonpoint Sources			429	384	5208	78.0%	66.7%	94.8%

LITTLE MANATEE RIVER								
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Point Sources			5	13	33	1.7%	15.1%	1.5%
	Domestic		1	0	0	0.0%	0.0%	0.0%
		Land Application	1	0	0	0.3%	0.0%	0.0%
		Surface Water	0	0	0	0.0%	0.0%	0.0%
	Industrial		4	13	33	1.4%	15.1%	1.5%
	Springs		0	0	0	0.0%	0.0%	0.0%
Nonpoint Sources			286	73	2147	98.3%	84.9%	98.5%

COASTAL MIDDLE TAMPA BAY								
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Point Sources			18	4	218	13.2%	14.8%	6.1%
	Domestic		18	3	2	13.3%	11.1%	0.1%
		Land Application	18	3	2	13.3%	11.1%	0.1%
		Surface Water	0	0	0	0.0%	0.0%	0.0%
	Industrial		0	1	216	0.0%	3.7%	6.1%
	Springs		0	0	0	0.0%	0.0%	0.0%
Nonpoint Sources			117	23	3350	86.7%	85.2%	93.9%

			COASTAL LOWER TAMPA BAY					
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Point Sources			12	6	37	22.6%	28.6%	7.0%
	Domestic		1	0	0	1.9%	0.0%	0.0%
		Land Application	1	0	0	1.9%	0.0%	0.0%
		Surface Water	0	0	0	0.0%	0.0%	0.0%
	Industrial		0	0	0	0.0%	0.0%	0.0%
	Springs		73	3	1	13.3%	0.5%	0.0%
Nonpoint Sources			41	15	490	77.4%	71.4%	93.0%

BOCA CIEGA BAY								
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Point Sources			3	1	0	2.0%	3.8%	0.0%
	Domestic		3	1	0	2.0%	3.8%	0.0%
		Land Application	3	1	0	2.0%	3.8%	0.0%
		Surface Water	0	0	0	0.0%	0.0%	0.0%
	Industrial		0	0	0	0.0%	0.0%	0.0%
	Springs		0	0	0	0.0%	0.0%	0.0%
Nonpoint Sources			150	25	4786	98.0%	96.2%	100.0%

TERRA CEIA BAY								
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Point Sources			6	1	5	33.3%	25.0%	2.1%
	Domestic		6	1	5	33.3%	25.0%	2.1%
		Land Application	0	0	0	0.0%	0.0%	0.0%
		Surface Water	6	1	5	33.3%	25.0%	2.1%
	Industrial		0	0	0	0.0%	0.0%	0.0%
	Springs		0	0	0	0.0%	0.0%	0.0%
Nonpoint Sources			12	3	237	66.7%	75.0%	97.9%

MANATEE RIVER								
SOURCE	CATEGORY	SUBCATEGORY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Point Sources			91	4	4367	20.6%	4.2%	59.0%
	Domestic		21	4	18	4.8%	4.2%	0.2%
		Land Application	2	0	0	0.5%	0.0%	0.0%
		Surface Water	19	4	18	4.3%	4.2%	0.2%
	Industrial		0	0	4349	15.8%	0.0%	58.8%
	Springs		0	0	0	0.0%	0.0%	0.0%
Nonpoint Sources			351	92	3031	79.4%	95.8%	41.0%

POINT SOURCE AND NONPONT SOURCE LOADS

BY MAJOR BASIN

COASTAL OLD TAMPA BAY									
CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		78282	163	28	4902	37.2%	76.3%	54.7%	90.3%
	Residential	53134	109	19	2829	25.3%	50.9%	36.3%	52.1%
	Commercial	8471	27	4	1141	4.0%	12.6%	7.5%	21.0%
	Industrial	4460	11	2	657	2.1%	5.4%	3.7%	12.1%
	Mining	432	1	2	18	0.2%	0.3%	3.4%	0.3%
	Institutional	11786	15	2	256	5.6%	7.1%	3.8%	4.7%
AGRICULTURAL		32036	26	4	167	15.2%	12.3%	6.9%	3.1%
	Range	20695	15	0	129	9.8%	6.8%	0.2%	2.4%
	Pasture	8499	9	3	29	4.0%	4.3%	5.4%	0.5%
	Feedlots	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Groves	2375	2	1	6	1.1%	1.0%	1.0%	0.1%
	Nursery	444	0	0	2	0.2%	0.1%	0.2%	0.0%
	Row Crops	24	0	0	0	0.0%	0.0%	0.0%	0.0%
UNDEVELOPED		99842	24	20	358	47.5%	11.4%	38.4%	6.6%
	Upland Forest	11552	2	0	23	5.5%	1.0%	0.5%	0.4%
	Open Water	66620	0	0	0	31.7%	0.0%	0.0%	0.0%
	Wetlands	21670	22	19	334	10.3%	10.5%	37.8%	6.2%

COASTAL HILLSBOROUGH BAY									
CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		41107	63	14	1933	35.5%	44.6%	39.1%	81.6%
	Residential	21199	30	5	688	18.3%	20.9%	13.6%	29.1%
	Commercial	7047	18	3	760	6.1%	12.6%	7.0%	32.1%
	Industrial	2664	5	1	286	2.3%	3.5%	2.2%	12.1%
	Mining	1812	2	5	51	1.6%	1.4%	13.3%	2.1%
	Institutional	8384	9	1	148	7.2%	6.1%	3.0%	6.2%
AGRICULTURAL		33179	66	14	272	28.7%	46.5%	38.1%	11.5%
	Range	12543	10	0	92	10.8%	7.3%	0.2%	3.9%
	Pasture	14962	27	8	88	12.9%	19.2%	22.6%	3.7%
	Feedlots	301	5	1	12	0.3%	3.4%	2.6%	0.5%
	Groves	2043	4	1	13	1.8%	3.1%	2.9%	0.6%
	Nursery	284	0	0	2	0.2%	0.2%	0.3%	0.1%
	Row Crops	3047	19	3	64	2.6%	13.2%	9.4%	2.7%
UNDEVELOPED		41508	13	8	164	35.8%	8.9%	22.8%	6.9%
	Upland Forest	7953	2	0	24	6.9%	1.5%	0.8%	1.0%
	Open Water	28295	0	0	0	24.4%	0.0%	0.0%	0.0%
	Wetlands	5261	10	8	140	4.5%	7.4%	22.1%	5.9%

HILLSBOROUGH RIVER									
CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		97097	191	42	5007	23.2%	35.0%	22.3%	64.5%
	Residential	72059	126	21	2577	17.2%	23.1%	11.0%	33.2%
	Commercial	9525	36	5	1520	2.3%	6.6%	2.7%	19.6%
	Industrial	2946	9	2	537	0.7%	1.7%	0.8%	6.9%
	Mining	2946	5	13	135	0.7%	1.0%	6.8%	1.7%
	Institutional	9621	14	2	238	2.3%	2.6%	0.9%	3.1%
AGRICULTURAL		173821	213	47	929	41.5%	39.2%	24.9%	12.0%
	Range	60566	45	0	400	14.4%	8.3%	0.2%	5.2%
	Pasture	94319	121	37	393	22.5%	22.3%	19.5%	5.1%
	Feedlots	970	23	4	57	0.2%	4.1%	2.3%	0.7%
	Groves	12115	13	3	39	2.9%	2.4%	1.7%	0.5%
	Nursery	1566	1	1	6	0.4%	0.2%	0.3%	0.1%
	Row Crops	4286	10	2	34	1.0%	1.8%	1.0%	0.4%
UNDEVELOPED		148390	141	100	1823	35.4%	25.8%	52.9%	23.5%
	Upland Forest	42506	10	1	110	10.1%	1.8%	0.7%	1.4%
	Open Water	11963	0	0	0	2.9%	0.0%	0.0%	0.0%
	Wetlands	93921	131	99	1712	22.4%	24.1%	52.2%	22.1%

ALAFIA RIVER									
CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		73642	177	270	4150	33.9%	46.6%	77.6%	76.0%
	Residential	27276	51	8	783	12.6%	13.6%	2.3%	14.3%
	Commercial	1385	7	1	279	0.6%	1.7%	0.3%	5.1%
	Industrial	1045	5	1	285	0.5%	1.3%	0.2%	5.2%
	Mining	40862	108	259	2701	18.8%	28.5%	74.5%	49.4%
	Institutional	3074	6	1	103	1.4%	1.6%	0.2%	1.9%
AGRICULTURAL		81914	142	35	518	37.7%	37.4%	10.1%	9.5%
	Range	14306	13	0	116	6.6%	3.4%	0.0%	2.1%
	Pasture	50888	82	25	266	23.4%	21.7%	7.2%	4.9%
	Feedlots	643	16	3	40	0.3%	4.2%	0.9%	0.7%
	Groves	13025	22	5	63	6.0%	5.7%	1.5%	1.2%
	Nursery	580	1	0	3	0.3%	0.2%	0.1%	0.1%
	Row Crops	2472	9	2	29	1.1%	2.2%	0.5%	0.5%
UNDEVELOPED		61723	61	43	795	28.4%	16.0%	12.3%	14.5%
	Upland Forest	26378	6	1	74	12.1%	1.7%	0.2%	1.4%
	Open Water	5103	0	0	0	2.3%	0.0%	0.0%	0.0%
	Wetlands	30242	54	42	721	13.9%	14.3%	12.0%	13.2%

COASTAL MIDDLE TAMPA BAY									
CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		25608	104	19	3249	22.4%	88.8%	82.7%	97.0%
	Residential	15424	70	12	2084	13.5%	60.3%	52.9%	62.2%
	Commercial	2570	17	2	723	2.3%	14.6%	10.5%	21.6%
	Industrial	764	4	1	223	0.7%	3.3%	2.7%	6.7%
	Mining	1238	1	2	25	1.1%	0.9%	10.4%	0.8%
	Institutional	5612	11	1	193	4.9%	9.8%	6.2%	5.8%
AGRICULTURAL		12389	10	2	54	10.9%	8.8%	7.2%	1.6%
	Range	4072	4	0	32	3.6%	3.1%	0.1%	1.0%
	Pasture	4757	3	1	10	4.2%	2.6%	4.0%	0.3%
	Feedlots	6	0	0	0	0.0%	0.1%	0.1%	0.0%
	Groves	768	0	0	1	0.7%	0.4%	0.4%	0.0%
	Nursery	163	0	0	1	0.1%	0.1%	0.2%	0.0%
	Row Crops	2624	3	1	10	2.3%	2.5%	2.4%	0.3%
UNDEVELOPED		76142	3	2	46	66.7%	2.4%	10.1%	1.4%
	Upland Forest	2288	1	0	7	2.0%	0.5%	0.3%	0.2%
	Open Water	71260	0	0	0	62.4%	0.0%	0.0%	0.0%
	Wetlands	2594	2	2	39	2.3%	1.9%	9.8%	1.2%

LITTLE MANATEE RIVER									
CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		9925	29	16	715	7.2%	10.5%	16.4%	32.8%
	Residential	6308	17	3	364	4.6%	6.1%	2.9%	16.7%
	Commercial	620	4	1	159	0.5%	1.4%	0.6%	7.3%
	Industrial	113	0	0	22	0.1%	0.1%	0.1%	1.0%
	Mining	1591	5	12	124	1.2%	1.8%	12.4%	5.7%
	Institutional	1294	3	0	45	0.9%	1.0%	0.4%	2.1%
AGRICULTURAL		89057	193	44	786	64.7%	70.9%	45.7%	36.1%
	Range	20976	29	0	254	15.2%	10.5%	0.2%	11.7%
	Pasture	43979	98	30	316	32.0%	35.9%	31.0%	14.5%
	Feedlots	70	2	0	6	0.1%	0.9%	0.5%	0.3%
	Groves	12810	25	6	73	9.3%	9.1%	6.2%	3.3%
	Nursery	327	0	0	2	0.2%	0.1%	0.2%	0.1%
	Row Crops	10895	39	7	135	7.9%	14.4%	7.6%	6.2%
UNDEVELOPED		38583	51	36	676	28.0%	18.7%	37.9%	31.1%
	Upland Forest	14549	5	1	61	10.6%	2.0%	0.7%	2.8%
	Open Water	3745	0	0	0	2.7%	0.0%	0.0%	0.0%
	Wetlands	20289	46	36	616	14.7%	16.7%	37.2%	28.3%

COASTAL LOWER TAMPA BAY

CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		4307	14	5	306	5.4%	33.9%	34.0%	62.6%
	Residential	2096	7	1	135	2.6%	16.9%	7.4%	27.6%
	Commercial	166	1	0	48	0.2%	2.8%	1.1%	9.8%
	Industrial	67	0	0	21	0.1%	0.9%	0.4%	4.2%
	Mining	449	1	3	34	0.6%	3.4%	21.7%	7.0%
	Institutional	1529	4	1	69	1.9%	10.0%	3.4%	14.0%
AGRICULTURAL		9503	19	4	80	11.9%	47.7%	27.5%	16.3%
	Range	2326	3	0	29	2.9%	8.0%	0.2%	5.9%
	Pasture	2626	6	2	19	3.3%	14.1%	11.5%	3.8%
	Feedlots	10	0	0	1	0.0%	0.9%	0.5%	0.2%
	Groves	3724	7	2	21	4.7%	18.0%	11.6%	4.4%
	Nursery	170	0	0	1	0.2%	0.5%	0.6%	0.2%
	Row Crops	647	3	0	9	0.8%	6.2%	3.1%	1.8%
UNDEVELOPED		65730	7	6	103	82.6%	18.4%	38.6%	21.1%
	Upland Forest	669	0	0	3	0.8%	0.7%	0.2%	0.6%
	Open Water	61828	0	0	0	77.7%	0.0%	0.0%	0.0%
	Wetlands	3233	7	6	100	4.1%	17.7%	38.3%	20.5%

BOCA CIEGA BAY									
CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		41036	144	24	4730	57.8%	96.5%	96.5%	98.9%
	Residential	29702	102	18	3013	41.8%	68.3%	71.8%	63.0%
	Commercial	5045	25	4	1078	7.1%	17.0%	14.6%	22.5%
	Industrial	2137	9	1	503	3.0%	5.9%	5.7%	10.5%
	Mining	16	0	0	1	0.0%	0.0%	0.3%	0.0%
	Institutional	4136	8	1	135	5.8%	5.3%	4.1%	2.8%
AGRICULTURAL		4483	4	0	37	6.3%	2.8%	0.3%	0.8%
	Range	4365	4	0	36	6.1%	2.7%	0.1%	0.8%
	Pasture	18	0	0	0	0.0%	0.0%	0.0%	0.0%
	Feedlots	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Groves	24	0	0	0	0.0%	0.0%	0.0%	0.0%
	Nursery	76	0	0	0	0.1%	0.0%	0.1%	0.0%
	Row Crops	0	0	0	0	0.0%	0.0%	0.0%	0.0%
UNDEVELOPED		25513	1	1	18	35.9%	0.7%	3.2%	0.4%
	Upland Forest	1432	0	0	5	2.0%	0.3%	0.2%	0.1%
	Open Water	23510	0	0	0	33.1%	0.0%	0.0%	0.0%
	Wetlands	571	1	1	13	0.8%	0.4%	3.0%	0.3%

TERRA CEIA BAY									
CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		2681	7	1	209	26.4%	64.1%	45.7%	88.1%
	Residential	2053	5	1	133	20.2%	46.2%	34.7%	56.1%
	Commercial	288	1	0	58	2.8%	11.8%	7.4%	24.5%
	Industrial	39	0	0	9	0.4%	1.3%	0.9%	3.6%
	Mining	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Institutional	301	1	0	9	3.0%	4.8%	2.7%	4.0%
AGRICULTURAL		2392	3	1	15	23.5%	27.5%	27.1%	6.2%
	Range	756	1	0	7	7.4%	6.6%	0.2%	2.8%
	Pasture	1094	2	1	6	10.8%	14.7%	19.6%	2.3%
	Feedlots	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Groves	409	1	0	2	4.0%	4.9%	5.1%	0.7%
	Nursery	106	0	0	1	1.0%	0.8%	1.6%	0.2%
	Row Crops	27	0	0	0	0.3%	0.6%	0.5%	0.1%
UNDEVELOPED		5085	1	1	14	50.1%	8.4%	27.2%	5.7%
	Upland Forest	432	0	0	1	4.3%	1.1%	0.6%	0.6%
	Open Water	4099	0	0	0	40.4%	0.0%	0.0%	0.0%
	Wetlands	554	1	1	12	5.5%	7.3%	26.5%	5.1%

MANATEE RIVER									
CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		25678	62	20	1741	12.0%	16.4%	17.8%	46.1%
	Residential	17728	41	7	1017	8.3%	10.8%	6.3%	26.9%
	Commercial	2111	8	1	356	1.0%	2.2%	1.1%	9.4%
	Industrial	882	3	0	159	0.4%	0.7%	0.4%	4.2%
	Mining	1715	4	10	106	0.8%	1.1%	9.2%	2.8%
	Institutional	3242	6	1	103	1.5%	1.6%	0.7%	2.7%
AGRICULTURAL		116902	251	48	1177	54.4%	66.0%	43.6%	31.2%
	Range	42950	65	1	580	20.0%	17.2%	0.5%	15.4%
	Pasture	47552	100	30	324	22.1%	26.3%	27.6%	8.6%
	Feedlots	577	14	3	35	0.3%	3.7%	2.4%	0.9%
	Groves	9913	20	5	58	4.6%	5.2%	4.3%	1.5%
	Nursery	484	0	0	2	0.2%	0.1%	0.1%	0.1%
	Row Crops	15426	52	10	177	7.2%	13.6%	8.7%	4.7%
UNDEVELOPED		72251	67	43	859	33.6%	17.6%	38.6%	22.8%
	Upland Forest	32756	13	2	153	15.2%	3.5%	1.6%	4.0%
	Open Water	14021	0	0	0	6.5%	0.0%	0.0%	0.0%
	Wetlands	25474	53	41	706	11.9%	14.0%	37.0%	18.7%

NONPOINT SOURCE LOADS BY BAY SEGMENT

OLD TAMPA BAY

CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		78282	163	28	4902	37.2%	76.3%	54.7%	90.3%
	Residential	53134	109	19	2829	25.3%	50.9%	36.3%	52.1%
	Commercial	8471	27	4	1141	4.0%	12.6%	7.5%	21.0%
	Industrial	4460	11	2	657	2.1%	5.4%	3.7%	12.1%
	Mining	432	1	2	18	0.2%	0.3%	3.4%	0.3%
	Institutional	11786	15	2	256	5.6%	7.1%	3.6%	4.7%
AGRICULTURAL		32036	26	4	167	15.2%	12.3%	6.9%	3.1%
	Range	20695	15	0	129	9.8%	6.8%	0.2%	2.4%
	Pasture	8499	9	3	29	4.0%	4.3%	5.4%	0.5%
	Feedlots	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Groves	2375	2	1	6	1.1%	1.0%	1.0%	0.1%
	Nursery	444	0	0	2	0.2%	0.1%	0.2%	0.0%
	Row Crops	24	0	0	0	0.0%	0.0%	0.0%	0.0%
UNDEVELOPED		99842	24	20	358	47.5%	11.4%	38.4%	6.6%
	Upland Forest	11552	2	0	23	5.5%	1.0%	0.5%	0.4%
	Open Water	66620	0	0	0	31.7%	0.0%	0.0%	0.0%
	Wetlands	21670	22	19	334	10.3%	10.5%	37.8%	6.2%

HILLSBOROUGH BAY									
CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		211846	431	327	11090	28.2%	40.4%	56.8%	71.1%
	Residential	120534	207	34	4048	16.0%	19.4%	5.9%	26.0%
	Commercial	17957	60	9	2559	2.4%	5.6%	1.5%	16.4%
	Industrial	6656	19	3	1107	0.9%	1.8%	0.5%	7.1%
	Mining	45621	115	277	2887	6.1%	10.8%	48.2%	18.5%
	Institutional	21079	29	4	489	2.8%	2.7%	0.6%	3.1%
AGRICULTURAL		288914	421	97	1719	38.4%	39.5%	16.8%	11.0%
	Range	87414	69	1	608	11.6%	6.4%	0.1%	3.9%
	Pasture	160169	231	70	747	21.3%	21.7%	12.2%	4.8%
	Feedlots	1914	43	8	110	0.3%	4.1%	1.5%	0.7%
	Groves	27182	39	9	116	3.6%	3.7%	1.7%	0.7%
	Nursery	2430	2	1	11	0.3%	0.2%	0.2%	0.1%
	Row Crops	9804	37	7	128	1.3%	3.5%	1.2%	0.8%
UNDEVELOPED		251622	214	151	2782	33.4%	20.1%	26.4%	17.8%
	Upland Forest	76838	18	2	209	10.2%	1.7%	0.4%	1.3%
	Open Water	45361	0	0	0	6.0%	0.0%	0.0%	0.0%
	Wetlands	129423	196	149	2573	17.2%	18.4%	25.9%	16.5%

MIDDLE TAMPA BAY									
CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		35533	132	35	3964	14.1%	34.0%	29.3%	71.7%
	Residential	21732	87	15	2448	8.6%	22.4%	12.7%	44.3%
	Commercial	3190	21	3	882	1.3%	5.3%	2.5%	16.0%
	Industrial	877	4	1	245	0.3%	1.1%	0.6%	4.4%
	Mining	2829	6	14	150	1.1%	1.5%	12.0%	2.7%
	Institutional	6905	14	2	238	2.7%	3.6%	1.5%	4.3%
AGRICULTURAL		101446	204	46	841	40.3%	52.3%	38.2%	15.2%
	Range	25048	32	0	287	10.0%	8.3%	0.2%	5.2%
	Pasture	48735	101	31	326	19.4%	25.9%	25.7%	5.9%
	Feedlots	76	2	0	6	0.0%	0.6%	0.4%	0.1%
	Groves	13577	25	6	74	5.4%	6.5%	5.1%	1.3%
	Nursery	490	0	0	2	0.2%	0.1%	0.2%	0.0%
	Row Crops	13519	42	8	145	5.4%	10.9%	6.6%	2.6%
UNDEVELOPED		114725	54	39	723	45.6%	13.8%	32.5%	13.1%
	Upland Forest	16837	6	1	68	6.7%	1.5%	0.7%	1.2%
	Open Water	75005	0	0	0	29.8%	0.0%	0.0%	0.0%
	Wetlands	22883	48	38	655	9.1%	12.2%	31.8%	11.8%

LOWER TAMPA BAY									
CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		4307	14	5	306	5.4%	33.9%	34.0%	62.6%
	Residential	2096	7	1	135	2.6%	16.9%	7.4%	27.6%
	Commercial	166	1	0	48	0.2%	2.8%	1.1%	9.8%
	Industrial	67	0	0	21	0.1%	0.9%	0.4%	4.2%
	Mining	449	1	3	34	0.6%	3.4%	21.7%	7.0%
	Institutional	1529	4	1	69	1.9%	10.0%	3.4%	14.0%
AGRICULTURAL		9503	19	4	80	11.9%	47.7%	27.5%	16.3%
	Range	2326	3	0	29	2.9%	8.0%	0.2%	5.9%
	Pasture	2626	6	2	19	3.3%	14.1%	11.5%	3.8%
	Feedlots	10	0	0	1	0.0%	0.9%	0.5%	0.2%
	Groves	3724	7	2	21	4.7%	18.0%	11.6%	4.4%
	Nursery	170	0	0	1	0.2%	0.5%	0.6%	0.2%
	Row Crops	647	3	0	9	0.8%	6.2%	3.1%	1.8%
UNDEVELOPED		65730	7	6	103	82.6%	18.4%	38.6%	21.1%
	Upland Forest	669	0	0	3	0.8%	0.7%	0.2%	0.6%
	Open Water	61828	0	0	0	77.7%	0.0%	0.0%	0.0%
	Wetlands	3233	7	6	100	4.1%	17.7%	38.3%	20.5%

BOCA CIEGA BAY									
CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		41036	144	24	4730	57.8%	96.5%	96.5%	98.9%
	Residential	29702	102	18	3013	41.8%	68.3%	71.8%	63.0%
	Commercial	5045	25	4	1078	7.1%	17.0%	14.6%	22.5%
	Industrial	2137	9	1	503	3.0%	5.9%	5.7%	10.5%
	Mining	16	0	0	1	0.0%	0.0%	0.3%	0.0%
	Institutional	4136	8	1	135	5.8%	5.3%	4.1%	2.8%
AGRICULTURAL		4483	4	0	37	6.3%	2.8%	0.3%	0.8%
	Range	4365	4	0	36	6.1%	2.7%	0.1%	0.8%
	Pasture	18	0	0	0	0.0%	0.0%	0.0%	0.0%
	Feedlots	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Groves	24	0	0	0	0.0%	0.0%	0.0%	0.0%
	Nursery	76	0	0	0	0.1%	0.0%	0.1%	0.0%
	Row Crops	0	0	0	0	0.0%	0.0%	0.0%	0.0%
UNDEVELOPED		25513	1	1	18	35.9%	0.7%	3.2%	0.4%
	Upland Forest	1432	0	0	5	2.0%	0.3%	0.2%	0.1%
	Open Water	23510	0	0	0	33.1%	0.0%	0.0%	0.0%
	Wetlands	571	1	1	13	0.8%	0.4%	3.0%	0.3%

TERRA CEIA BAY

CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		2681	7	1	209	26.4%	64.1%	45.7%	88.1%
	Residential	2053	5	1	133	20.2%	46.2%	34.7%	56.1%
	Commercial	288	1	0	58	2.8%	11.8%	7.4%	24.5%
	Industrial	39	0	0	9	0.4%	1.3%	0.9%	3.6%
	Mining	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Institutional	301	1	0	9	3.0%	4.8%	2.7%	4.0%
AGRICULTURAL		2392	3	1	15	23.5%	27.5%	27.1%	6.2%
	Range	756	1	0	7	7.4%	6.6%	0.2%	2.8%
	Pasture	1094	2	1	6	10.8%	14.7%	19.6%	2.3%
	Feedlots	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Groves	409	1	0	2	4.0%	4.9%	5.1%	0.7%
	Nursery	106	0	0	1	1.0%	0.8%	1.6%	0.2%
	Row Crops	27	0	0	0	0.3%	0.6%	0.5%	0.1%
UNDEVELOPED		5085	1	1	14	50.1%	8.4%	27.2%	5.7%
	Upland Forest	432	0	0	1	4.3%	1.1%	0.6%	0.6%
	Open Water	4099	0	0	0	40.4%	0.0%	0.0%	0.0%
	Wetlands	554	1	1	12	5.5%	7.3%	26.5%	5.1%

MANATEE RIVER									
CATEGORY	SUBCATEGORY	Area (acres)	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% Area	% TN Load	% TP Load	% TSS Load
URBAN		25678	62	20	1741	12.0%	16.4%	17.8%	46.1%
	Residential	17728	41	7	1017	8.3%	10.8%	6.3%	26.9%
	Commercial	2111	8	1	356	1.0%	2.2%	1.1%	9.4%
	Industrial	882	3	0	159	0.4%	0.7%	0.4%	4.2%
	Mining	1715	4	10	106	0.8%	1.1%	9.2%	2.8%
	Institutional	3242	6	1	103	1.5%	1.6%	0.7%	2.7%
AGRICULTURAL		116902	251	48	1177	54.4%	66.0%	43.6%	31.2%
	Range	42950	65	1	580	20.0%	17.2%	0.5%	15.4%
	Pasture	47552	100	30	324	22.1%	26.3%	27.6%	8.6%
	Feedlots	577	14	3	35	0.3%	3.7%	2.4%	0.9%
	Groves	9913	20	5	58	4.6%	5.2%	4.3%	1.5%
	Nursery	484	0	0	2	0.2%	0.1%	0.1%	0.1%
	Row Crops	15426	52	10	177	7.2%	13.6%	8.7%	4.7%
UNDEVELOPED		72251	67	43	859	33.6%	17.6%	38.6%	22.8%
	Upland Forest	32756	13	2	153	15.2%	3.5%	1.6%	4.0%
	Open Water	14021	0	0	0	6.5%	0.0%	0.0%	0.0%
	Wetlands	25474	53	41	706	11.9%	14.0%	37.0%	18.7%

DOMESTIC POINT SOURCE LOADS BY

BAY SEGMENT AND MAJOR BASIN

Note:

- "LA" denotes land application of effluent by spray irrigation or percolation ponds.
- "SW" denotes surface water discharge of effluent.

SEGMENT	BASIN	Facility	LA TN Load (tons/year)	LA TP Load (tons/year)	LA TSS Load (tons/year)	SW TN Load (tons/year)	SW TP Load (tons/year)	SW TSS Load (tons/year)
Old Tampa Bay			13.1	1.6	4.1	52.3	45.6	29.3
	Coastal Old Tampa Bay		13.1	1.6	4.1	52.3	45.6	29.3
		City of St. Petersburg (4 plants)	3.8	0.7	0.4	0.0	0.0	0.0
		City of Clearwater, East	0.0	0.0	0.0	12.3	18.6	8.0
		City of Clearwater, Northeast	0.0	0.0	0.0	14.3	18.6	12.9
		City of Largo	4.1	0.7	3.5	0.0	0.0	0.0
		City of Oldsmar	0.1	0.0	0.0	2.4	1.2	2.1
		Eastlake Woodlands	0.6	0.0	0.0	0.0	0.0	0.0
		Northwest Regional Water Reclamation	0.0	0.0	0.0	5.8	2.5	1.2
		On Top of the World	1.5	0.1	0.1	0.0	0.0	0.0
		Pine Ridge	0.4	0.1	0.0	0.0	0.0	0.0
		River Oaks AWT	0.0	0.0	0.0	17.6	4.6	5.0
		Tarpon Lake Village	1.0	0.0	0.0	0.0	0.0	0.0
		Tarpon Woods	1.7	0.1	0.0	0.0	0.0	0.0
Hillsbororough Bay			4.0	0.6	0.9	225.5	450.7	210.3
	Alafia River		1.9	0.1	0.2	19.5	43.5	69.4
		Bloomington Hills	0.1	0.0	0.0	0.0	0.0	0.0
		Boyette Springs Subdivision	0.3	0.0	0.1	0.0	0.0	0.0
		City of Lakeland, Artificial Wetland	0.0	0.0	0.0	16.7	42.6	67.6
		City of Mulberry	0.0	0.0	0.0	1.7	0.6	1.5
		Rice Creek	0.4	0.0	0.1	0.0	0.0	0.0
		Riverhills Country Club	0.0	0.0	0.0	0.0	0.0	0.0
		Valrico Subregional	1.2	0.1	0.1	1.2	0.3	0.3
	Coastal Hillsborough Bay		1.9	0.4	0.6	206.0	407.2	140.9
		Dale Mabry	1.0	0.0	0.1	11.0	2.1	5.3
		Falkenburg Road	0.1	0.0	0.0	3.4	1.0	0.9
		Hookers Point	0.0	0.0	0.0	191.4	403.9	134.6

		Progress Village	0.2	0.1	0.0	0.0	0.0	0.0
		Seaboard Utilities Corp.	0.5	0.3	0.5	0.0	0.0	0.0
		Sterling Ranch	0.0	0.0	0.0	0.2	0.2	0.1
		Summerfield Subregional	0.2	0.0	0.0	0.0	0.0	0.0
	Hillsborough River		0.0	0.0	0.0	8.4	5.0	34.0
		Meadowlands	0.0	0.0	0.0	0.2	0.0	0.2
		Pebble Creek Village	0.0	0.0	0.0	0.8	0.9	0.1
		Plant City	0.0	0.0	0.0	7.4	4.1	33.7
Middle Tampa Bay			19.1	3.3	2.0	0.0	0.0	0.0
	Coastal Middle Tampa Bay		17.7	3.1	2.0	0.0	0.0	0.0
		City of St. Petersburg (4 plants)	16.7	2.9	1.9	0.0	0.0	0.0
		MacDill AFB	0.9	0.2	0.1	0.0	0.0	0.0
		South Hillsborough Regional	0.1	0.0	0.0	0.0	0.0	0.0
	Little Manatee River		1.4	0.2	0.0	0.0	0.0	0.0
		South Hillsborough Regional	1.4	0.2	0.0	0.0	0.0	0.0
Lower Tampa Bay			0.9	0.2	0.1	0.0	0.0	0.0
	Coastal Lower Tampa Bay		0.9	0.2	0.1	0.0	0.0	0.0
		North County Regional	0.9	0.2	0.1	0.0	0.0	0.0
Boca Ciega Bay			3.1	0.5	0.3	0.0	0.0	0.0
	Boca Ciega Bay		3.1	0.5	0.3	0.0	0.0	0.0
		City of St. Petersburg (4 plants)	3.1	0.5	0.3	0.0	0.0	0.0
Terra Ceia Bay			0.0	0.0	0.0	6.5	1.0	4.8
	Terra Ceia Bay		0.0	0.0	0.0	6.5	1.0	4.8
		City of Palmetto	0.0	0.0	0.0	6.5	1.0	4.8
Manatee River			1.6	0.0	0.1	19.0	4.2	17.9
	Manatee River		1.6	0.0	0.1	19.0	4.2	17.9
		Bradenton	0.0	0.0	0.0	19.0	4.2	17.9
		Manatee County Southeast Subregional	1.6	0.0	0.1	0.0	0.0	0.0

SEGMENT	BASIN	Facility	% LA TN Load	% LA TP Load	% LA TSS Load	% SW TN Load	% SW TP Load	% SW TSS Load
Old Tampa Bay			20.0%	3.5%	12.2%	99.6%	99.9%	99.6%
	Coastal Old Tampa Bay		20.0%	3.5%	12.2%	99.6%	99.9%	99.6%
		City of St. Petersburg (4 plants)	5.8%	1.4%	1.3%	0.0%	0.0%	0.0%
		City of Clearwater, East	0.0%	0.0%	0.0%	23.4%	40.9%	27.3%
		City of Clearwater, Northeast	0.0%	0.0%	0.0%	27.2%	40.8%	43.9%
		City of Largo	6.3%	1.6%	10.4%	0.0%	0.0%	0.0%
		City of Oldsmar	0.1%	0.0%	0.0%	4.6%	2.6%	7.3%
		Eastlake Woodlands	0.9%	0.1%	0.1%	0.0%	0.0%	0.0%
		Northwest Regional Water Reclamation	0.0%	0.0%	0.0%	11.0%	5.5%	4.2%
		On Top of the World	2.2%	0.1%	0.2%	0.0%	0.0%	0.0%
		Pine Ridge	0.5%	0.1%	0.1%	0.0%	0.0%	0.0%
		River Oaks AWT	0.0%	0.0%	0.0%	33.5%	10.1%	16.9%
		Tarpon Lake Village	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%
		Tarpon Woods	2.5%	0.2%	0.1%	0.0%	0.0%	0.0%
Hillsborough Bay			1.7%	0.1%	0.4%	100.0%	100.0%	100.0%
	Alafia River		0.8%	0.0%	0.1%	8.7%	9.7%	33.0%
		Bloomington Hills	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Boyette Springs Subdivision	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
		City of Lakeland, Artificial Wetland	0.0%	0.0%	0.0%	7.4%	9.5%	32.2%
		City of Mulberry	0.0%	0.0%	0.0%	0.7%	0.1%	0.7%
		Rice Creek	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%
		Riverhills Country Club	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Valrico Subregional	0.5%	0.0%	0.0%	0.5%	0.1%	0.1%
	Coastal Hillsborough Bay		0.8%	0.1%	0.3%	91.3%	90.3%	67.0%
		Dale Mabry	0.4%	0.0%	0.0%	4.9%	0.5%	2.5%
		Falkenburg Road	0.0%	0.0%	0.0%	1.5%	0.2%	0.5%
		Hookers Point	0.0%	0.0%	0.0%	84.9%	89.6%	64.0%

		Progress Village	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
		Seaboard Utilities Corp.	0.2%	0.1%	0.3%	0.0%	0.0%	0.0%
		Sterling Ranch	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%
		Summerfield Subregional	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
	Hillsborough River		0.0%	0.0%	0.0%	3.7%	1.1%	16.1%
		Meadowlands	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%
		Pebble Creek Village	0.0%	0.0%	0.0%	0.3%	0.2%	0.0%
		Plant City	0.0%	0.0%	0.0%	3.3%	0.9%	16.0%
Middle Tampa Bay			100.0%	100.0%	100.0%	0.0%	0.0%	0.0%
	Coastal Middle Tampa Bay		92.5%	93.7%	98.9%	0.0%	0.0%	0.0%
		City of St. Petersburg (4 plants)	87.3%	87.4%	94.5%	0.0%	0.0%	0.0%
		MacDill AFB	4.6%	5.9%	4.4%	0.0%	0.0%	0.0%
		South Hillsborough Regional	0.5%	0.4%	0.0%	0.0%	0.0%	0.0%
	Little Manatee River		7.5%	6.3%	1.1%	0.0%	0.0%	0.0%
		South Hillsborough Regional	7.5%	6.3%	1.1%	0.0%	0.0%	0.0%
Lower Tampa Bay			100.0%	100.0%	100.0%	0.0%	0.0%	0.0%
	Coastal Lower Tampa Bay		100.0%	100.0%	100.0%	0.0%	0.0%	0.0%
		North County Regional	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%
Boca Ciega Bay			100.0%	100.0%	100.0%	0.0%	0.0%	0.0%
	Boca Ciega Bay		100.0%	100.0%	100.0%	0.0%	0.0%	0.0%
		City of St. Petersburg (4 plants)	100.0%	100.0%	100.0%	0.0%	0.0%	0.0%
Terra Ceia Bay			0.0%	0.0%	0.0%	100.0%	100.0%	100.0%
	Terra Ceia Bay		0.0%	0.0%	0.0%	100.0%	100.0%	100.0%
		City of Palmetto	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%
Manatee River			7.7%	0.8%	0.5%	99.6%	99.8%	100.0%
	Manatee River		7.7%	0.8%	0.5%	99.6%	99.8%	100.0%
		Bradenton	0.0%	0.0%	0.0%	99.6%	99.8%	100.0%
		Manatee County Southeast Subregional	7.7%	0.8%	0.5%	0.0%	0.0%	0.0%

INDUSTRIAL POINT SOURCE LOADS BY
BAY SEGMENT AND MAJOR BASIN

BAY SEGMENT	MAJOR DRAINAGE BASIN	FACILITY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
Old Tampa Bay			0.0	0.0	0.5	0.0%	0.0%	100.0%
	Coastal Old Tampa Bay		0.0	0.0	0.5	0.0%	0.0%	100.0%
		Shell Oil Co, Port Tampa Plant	0.0	0.0	0.5	0.0%	0.0%	100.0%
Hillsborough Bay			60.6	240.7	956.9			
	Alafia River		26.1	145.5	214.6	43.1%	60.4%	22.4%
		Mobil Mining Big Four Mine	0.0	10.3	36.1	0.0%	4.3%	3.8%
		Mobil Mining Nichols Mine	0.2	0.2	0.5	0.3%	0.1%	0.1%
		Cargill Inc.	1.8	9.4	18.0	3.0%	3.9%	1.9%
		Mobil Mining Nichols Prep Plant	1.3	2.3	3.5	2.1%	1.0%	0.4%
		IMC Fertilizer Haynesworth Mine	0.2	0.2	0.5	0.3%	0.1%	0.1%
		Estech Silver City Mine	18.1	62.6	152.8	29.9%	26.0%	16.0%
		Mulberry Phosphates Inc.	1.7	7.4	3.3	2.8%	3.1%	0.3%
		Farmland Hydro L.P. Green Bay Plant	2.8	53.1	0.0	4.6%	22.1%	0.0%
	Coastal Hillsborough Bay		2.6	17.4	483.5	4.4%	7.2%	50.5%
		Seminole Fertilizer Ammonia Terminal	0.3	6.2	14.8	0.5%	2.6%	1.5%
		Trademark Nitrogen	0.9	0.0	0.3	1.4%	0.0%	0.0%
		Nitram Inc.	1.5	0.3	1.4	2.5%	0.1%	0.1%
		TECO Gannon	0.0	0.0	47.0	0.0%	0.0%	4.9%
		IMC Fertilizer Port Sutton Terminal	0.0	10.9	420.0	0.0%	4.5%	43.9%
	Hillsborough River		31.8	77.8	258.7	52.5%	32.3%	27.0%
		Crystals International, Inc.	19.9	0.0	0.0	32.8%	0.0%	0.0%

BAY SEGMENT	MAJOR DRAINAGE BASIN	FACILITY	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	% TN Load	% TP Load	% TSS Load
		Florida Sno-Man Inc.	8.4	69.4	22.0	13.8%	28.8%	2.3%
		CSX Transportation Winston Yard	1.1	0.4	2.4	1.8%	0.2%	0.3%
		Ery Juice Inc.	0.8	1.1	21.3	1.4%	0.5%	2.2%
		CF Industries Plant City Chemical Plant	0.5	6.9	193.1	0.9%	2.9%	20.2%
		Tampa City Waterworks	1.2	0.0	19.9	1.9%	0.0%	2.1%
Middle Tampa Bay			4.5	13.9	248.7			
	Coastal Middle Tampa Bay		0.2	1.1	215.7	4.2%	7.9%	86.7%
		TECO Big Bend	0.0	0.0	16.1	0.0%	0.0%	6.5%
		FDNR Stock Enhancement Facility	0.2	1.1	199.7	4.2%	7.9%	80.3%
	Little Manatee River		4.3	12.8	33.0	95.8%	92.1%	13.3%
		IMC Fertilizer Four Corners Mine	4.3	12.8	33.0	95.8%	92.1%	13.3%
Lower Tampa Bay			11.4	5.6	37.4			
	Coastal Lower Tampa Bay		11.4	5.6	37.4	100.0%	100.0%	100.0%
		Coastal Fuels Marketing Inc.	0.0	0.0	31.5	0.0%	0.0%	84.3%
		Nu-Gulf Industries Rock Terminal	10.1	1.5	0.9	88.6%	27.4%	2.3%
		Piney Point Phosphates Inc.	1.3	4.1	5.0	11.4%	72.6%	13.3%
Manatee River			70.0	0.0	4348.5			
	Manatee River		70.0	0.0	4348.5	100.0%	100.0%	100.0%
		Florida Power & Light	14.4	0.0	0.2	20.5%	100.0%	0.0%
		Tropicana Products Inc.	55.7	0.0	4348.3	79.5%	0.0%	100.0%

DOMESTIC, INDUSTRIAL AND SPRINGS POINT SOURCE LOADS BY YEAR (1985-1991)

Tampa Bay National Estuary Program
Tampa Bay Hydrologic & Pollutant Loading Model
Domestic Point Sources
Loadings Data

Facility	Year	LA TN load (tons/year)	LA TP load (tons/year)	LA TSS load (tons/year)	SW TN load (tons/year)	SW TP load (tons/year)	SW TSS load (tons/year)
Bloomington Hills	1985	0.0	0.0	0.0	0.0	0.0	0.0
Bloomington Hills	1986	0.0	0.0	0.0	0.0	0.0	0.0
Bloomington Hills	1987	0.0	0.0	0.0	0.0	0.0	0.0
Bloomington Hills	1988	0.0	0.0	0.0	0.0	0.0	0.0
Bloomington Hills	1989	0.0	0.0	0.0	0.0	0.0	0.0
Bloomington Hills	1990	0.0	0.0	0.0	0.0	0.0	0.0
Bloomington Hills	1991	0.1	0.0	0.0	0.0	0.0	0.0
Boyette Springs Subdivision	1985	0.0	0.0	0.0	0.0	0.0	0.0
Boyette Springs Subdivision	1986	0.0	0.0	0.0	0.0	0.0	0.0
Boyette Springs Subdivision	1987	0.0	0.0	0.0	0.0	0.0	0.0
Boyette Springs Subdivision	1988	0.0	0.0	0.0	0.0	0.0	0.0
Boyette Springs Subdivision	1989	0.3	0.0	0.0	0.0	0.0	0.0
Boyette Springs Subdivision	1990	0.3	0.0	0.1	0.0	0.0	0.0
Boyette Springs Subdivision	1991	0.3	0.0	0.1	0.0	0.0	0.0
Bradenton	1985	0.0	0.0	0.0	19.0	4.2	17.9
Bradenton	1986	0.0	0.0	0.0	19.0	4.2	17.9
Bradenton	1987	0.0	0.0	0.0	19.0	4.2	17.9
Bradenton	1988	0.0	0.0	0.0	19.0	4.2	17.9
Bradenton	1989	0.0	0.0	0.0	19.0	4.2	17.9
Bradenton	1990	0.0	0.0	0.0	19.0	4.2	17.9
Bradenton	1991	0.0	0.0	0.0	19.0	4.2	17.9
City of Clearwater, East	1985	0.0	0.0	0.0	12.3	18.6	8.0
City of Clearwater, East	1986	0.0	0.0	0.0	12.3	18.6	8.0
City of Clearwater, East	1987	0.0	0.0	0.0	12.3	18.6	8.0
City of Clearwater, East	1988	0.0	0.0	0.0	12.3	18.6	8.0
City of Clearwater, East	1989	0.0	0.0	0.0	12.3	18.6	8.0
City of Clearwater, East	1990	0.0	0.0	0.0	12.3	18.6	8.0
City of Clearwater, East	1991	0.0	0.0	0.0	12.3	18.6	8.0
City of Clearwater, Northeast	1985	0.0	0.0	0.0	14.3	18.6	12.9
City of Clearwater, Northeast	1986	0.0	0.0	0.0	14.3	18.6	12.9
City of Clearwater, Northeast	1987	0.0	0.0	0.0	14.3	18.6	12.9
City of Clearwater, Northeast	1988	0.0	0.0	0.0	14.3	18.6	12.9
City of Clearwater, Northeast	1989	0.0	0.0	0.0	14.3	18.6	12.9
City of Clearwater, Northeast	1990	0.0	0.0	0.0	14.3	18.6	12.9
City of Clearwater, Northeast	1991	0.0	0.0	0.0	14.3	18.6	12.9
City of Lakeland, Artificial Wetlands	1985	0.0	0.0	0.0	16.7	42.6	67.6
City of Lakeland, Artificial Wetlands	1986	0.0	0.0	0.0	16.7	42.6	67.6
City of Lakeland, Artificial Wetlands	1987	0.0	0.0	0.0	16.7	42.6	67.6
City of Lakeland, Artificial Wetlands	1988	0.0	0.0	0.0	16.7	42.6	67.6
City of Lakeland, Artificial Wetlands	1989	0.0	0.0	0.0	16.7	42.6	67.6
City of Lakeland, Artificial Wetlands	1990	0.0	0.0	0.0	16.7	42.6	67.6
City of Lakeland, Artificial Wetlands	1991	0.0	0.0	0.0	16.7	42.6	67.6
City of Largo	1985	4.1	0.7	3.5	0.0	0.0	0.0
City of Largo	1986	4.1	0.7	3.5	0.0	0.0	0.0
City of Largo	1987	4.1	0.7	3.5	0.0	0.0	0.0

Tampa Bay National Estuary Program
Tampa Bay Hydrologic & Pollutant Loading Model
Domestic Point Sources
Loadings Data

Facility	Year	LA TN load (tons/year)	LA TP load (tons/year)	LA TSS load (tons/year)	SW TN load (tons/year)	SW TP load (tons/year)	SW TSS load (tons/year)
City of Largo	1988	4.1	0.7	3.5	0.0	0.0	0.0
City of Largo	1989	4.1	0.7	3.5	0.0	0.0	0.0
City of Largo	1990	4.1	0.7	3.5	0.0	0.0	0.0
City of Largo	1991	4.1	0.7	3.5	0.0	0.0	0.0
City of Mulberry	1985	0.0	0.0	0.0	1.7	0.6	1.5
City of Mulberry	1986	0.0	0.0	0.0	1.7	0.6	1.5
City of Mulberry	1987	0.0	0.0	0.0	1.7	0.6	1.5
City of Mulberry	1988	0.0	0.0	0.0	1.7	0.6	1.5
City of Mulberry	1989	0.0	0.0	0.0	1.7	0.6	1.5
City of Mulberry	1990	0.0	0.0	0.0	1.7	0.6	1.5
City of Mulberry	1991	0.0	0.0	0.0	1.7	0.6	1.5
City of Oldsmar	1985	0.1	0.0	0.0	2.4	1.2	2.1
City of Oldsmar	1986	0.1	0.0	0.0	2.4	1.2	2.1
City of Oldsmar	1988	0.2	0.0	0.0	4.9	2.4	4.3
City of Oldsmar	1989	0.1	0.0	0.0	2.4	1.2	2.1
City of Oldsmar	1990	0.1	0.0	0.0	2.4	1.2	2.1
City of Oldsmar	1991	0.1	0.0	0.0	2.4	1.2	2.1
City of Palmetto	1985	0.0	0.0	0.0	6.5	1.0	4.8
City of Palmetto	1986	0.0	0.0	0.0	6.5	1.0	4.8
City of Palmetto	1987	0.0	0.0	0.0	6.5	1.0	4.8
City of Palmetto	1988	0.0	0.0	0.0	6.5	1.0	4.8
City of Palmetto	1989	0.0	0.0	0.0	6.5	1.0	4.8
City of Palmetto	1990	0.0	0.0	0.0	6.5	1.0	4.8
City of Palmetto	1991	0.0	0.0	0.0	6.5	1.0	4.8
City of St. Petersburg, Albert Whitted	1985	5.1	0.7	0.4	0.0	0.0	0.0
City of St. Petersburg, Albert Whitted	1986	5.1	0.7	0.4	0.0	0.0	0.0
City of St. Petersburg, Albert Whitted	1987	5.1	0.7	0.4	0.0	0.0	0.0
City of St. Petersburg, Albert Whitted	1988	5.1	0.7	0.4	0.0	0.0	0.0
City of St. Petersburg, Albert Whitted	1989	5.1	0.7	0.4	0.0	0.0	0.0
City of St. Petersburg, Albert Whitted	1990	5.1	0.7	0.4	0.0	0.0	0.0
City of St. Petersburg, Albert Whitted	1991	5.1	0.7	0.4	0.0	0.0	0.0
City of St. Petersburg, Northeast	1985	5.1	0.9	0.4	0.0	0.0	0.0
City of St. Petersburg, Northeast	1986	5.1	0.9	0.4	0.0	0.0	0.0
City of St. Petersburg, Northeast	1987	5.1	0.9	0.4	0.0	0.0	0.0
City of St. Petersburg, Northeast	1988	5.1	0.9	0.4	0.0	0.0	0.0
City of St. Petersburg, Northeast	1989	5.1	0.9	0.4	0.0	0.0	0.0
City of St. Petersburg, Northeast	1990	5.1	0.9	0.4	0.0	0.0	0.0
City of St. Petersburg, Northeast	1991	5.1	0.9	0.4	0.0	0.0	0.0
City of St. Petersburg, Northwest	1985	2.5	0.5	0.3	0.0	0.0	0.0
City of St. Petersburg, Northwest	1986	2.5	0.5	0.3	0.0	0.0	0.0
City of St. Petersburg, Northwest	1987	2.5	0.5	0.3	0.0	0.0	0.0
City of St. Petersburg, Northwest	1988	2.5	0.5	0.3	0.0	0.0	0.0
City of St. Petersburg, Northwest	1989	2.5	0.5	0.3	0.0	0.0	0.0
City of St. Petersburg, Northwest	1990	2.5	0.5	0.3	0.0	0.0	0.0
City of St. Petersburg, Northwest	1991	2.5	0.5	0.3	0.0	0.0	0.0
City of St. Petersburg, Southwest	1985	11.0	1.9	1.5	0.0	0.0	0.0
City of St. Petersburg, Southwest	1986	11.0	1.9	1.5	0.0	0.0	0.0
City of St. Petersburg, Southwest	1987	11.0	1.9	1.5	0.0	0.0	0.0
City of St. Petersburg, Southwest	1988	11.0	1.9	1.5	0.0	0.0	0.0
City of St. Petersburg, Southwest	1989	11.0	1.9	1.5	0.0	0.0	0.0
City of St. Petersburg, Southwest	1990	11.0	1.9	1.5	0.0	0.0	0.0
City of St. Petersburg, Southwest	1991	11.0	1.9	1.5	0.0	0.0	0.0

Tampa Bay National Estuary Program
Tampa Bay Hydrologic & Pollutant Loading Model
Domestic Point Sources
Loadings Data

Facility	Year	LA TN load (tons/year)	LA TP load (tons/year)	LA TSS load (tons/year)	SW TN load (tons/year)	SW TP load (tons/year)	SW TSS load (tons/year)
Dale Mabry	1985	2.6	0.4	0.3	47.0	42.3	49.2
Dale Mabry	1986	2.6	0.4	0.3	47.0	42.3	49.2
Dale Mabry	1987	2.6	0.4	0.3	47.0	42.3	49.2
Dale Mabry	1988	2.6	0.4	0.3	47.0	42.3	49.2
Dale Mabry	1989	1.5	0.0	0.1	20.1	2.8	9.9
Dale Mabry	1990	1.1	0.0	0.1	17.2	2.8	12.3
Dale Mabry	1991	1.0	0.0	0.1	11.0	2.1	5.3
Eastlake Woodlands	1985	0.6	0.0	0.0	0.0	0.0	0.0
Eastlake Woodlands	1986	0.6	0.0	0.0	0.0	0.0	0.0
Eastlake Woodlands	1987	0.6	0.0	0.0	0.0	0.0	0.0
Eastlake Woodlands	1988	0.6	0.0	0.0	0.0	0.0	0.0
Eastlake Woodlands	1989	0.6	0.0	0.0	0.0	0.0	0.0
Eastlake Woodlands	1990	0.6	0.0	0.0	0.0	0.0	0.0
Eastlake Woodlands	1991	0.6	0.0	0.0	0.0	0.0	0.0
Falkenburg Road	1985	2.9	0.1	0.1	12.7	3.0	3.9
Falkenburg Road	1986	2.9	0.1	0.1	12.7	3.0	3.9
Falkenburg Road	1987	2.9	0.1	0.1	12.7	3.0	3.9
Falkenburg Road	1988	2.9	0.1	0.1	12.7	3.0	3.9
Falkenburg Road	1989	0.5	0.1	0.1	1.8	2.8	1.3
Falkenburg Road	1990	0.1	0.0	0.0	5.3	1.9	2.8
Falkenburg Road	1991	0.1	0.0	0.0	3.4	1.0	0.9
Hookers Point	1985	0.0	0.0	0.0	283.7	479.3	262.8
Hookers Point	1986	0.0	0.0	0.0	283.7	479.3	262.8
Hookers Point	1987	0.0	0.0	0.0	283.7	479.3	262.8
Hookers Point	1988	0.0	0.0	0.0	283.7	479.3	262.8
Hookers Point	1989	0.0	0.0	0.0	250.8	462.2	134.4
Hookers Point	1990	0.0	0.0	0.0	208.0	418.8	155.7
Hookers Point	1991	0.0	0.0	0.0	191.4	403.9	134.6
MacDill AFB	1985	0.8	0.2	0.1	0.0	0.0	0.0
MacDill AFB	1986	0.8	0.2	0.1	0.0	0.0	0.0
MacDill AFB	1987	0.8	0.2	0.1	0.0	0.0	0.0
MacDill AFB	1988	0.8	0.2	0.1	0.0	0.0	0.0
MacDill AFB	1989	0.5	0.2	0.1	0.0	0.0	0.0
MacDill AFB	1990	0.7	0.2	0.1	0.0	0.0	0.0
MacDill AFB	1991	0.9	0.2	0.1	0.0	0.0	0.0
Manatee County Southeast Subregional	1985	1.6	0.0	0.1	0.0	0.0	0.0
Manatee County Southeast Subregional	1986	1.6	0.0	0.1	0.0	0.0	0.0
Manatee County Southeast Subregional	1987	1.6	0.0	0.1	0.0	0.0	0.0
Manatee County Southeast Subregional	1988	1.6	0.0	0.1	0.0	0.0	0.0
Manatee County Southeast Subregional	1989	1.6	0.0	0.1	0.0	0.0	0.0
Manatee County Southeast Subregional	1990	1.6	0.0	0.1	0.0	0.0	0.0
Manatee County Southeast Subregional	1991	1.6	0.0	0.1	0.0	0.0	0.0
Meadowlands	1985	0.0	0.0	0.0	0.2	0.0	0.2
Meadowlands	1986	0.0	0.0	0.0	0.2	0.0	0.2
Meadowlands	1987	0.0	0.0	0.0	0.2	0.0	0.2
Meadowlands	1988	0.0	0.0	0.0	0.2	0.0	0.2
Meadowlands	1989	0.0	0.0	0.0	0.2	0.0	0.2
Meadowlands	1990	0.0	0.0	0.0	0.2	0.0	0.2
Meadowlands	1991	0.0	0.0	0.0	0.2	0.0	0.2
North County Regional	1985	0.9	0.2	0.1	0.0	0.0	0.0
North County Regional	1986	0.9	0.2	0.1	0.0	0.0	0.0
North County Regional	1987	0.9	0.2	0.1	0.0	0.0	0.0

Tampa Bay National Estuary Program
Tampa Bay Hydrologic & Pollutant Loading Model
Domestic Point Sources
Loadings Data

Facility	Year	LA TN load (tons/year)	LA TP load (tons/year)	LA TSS load (tons/year)	SW TN load (tons/year)	SW TP load (tons/year)	SW TSS load (tons/year)
North County Regional	1988	0.9	0.2	0.1	0.0	0.0	0.0
North County Regional	1989	0.9	0.2	0.1	0.0	0.0	0.0
North County Regional	1990	0.9	0.2	0.1	0.0	0.0	0.0
North County Regional	1991	0.9	0.2	0.1	0.0	0.0	0.0
Northwest Regional Water Reclamation	1985	0.0	0.0	0.0	5.8	2.5	1.2
Northwest Regional Water Reclamation	1986	0.0	0.0	0.0	5.8	2.5	1.2
Northwest Regional Water Reclamation	1987	0.0	0.0	0.0	5.8	2.5	1.2
Northwest Regional Water Reclamation	1988	0.0	0.0	0.0	5.8	2.5	1.2
Northwest Regional Water Reclamation	1989	0.0	0.0	0.0	5.8	2.5	1.2
Northwest Regional Water Reclamation	1990	0.0	0.0	0.0	5.8	2.5	1.2
Northwest Regional Water Reclamation	1991	0.0	0.0	0.0	5.8	2.5	1.2
On Top of the World	1985	1.5	0.1	0.1	0.0	0.0	0.0
On Top of the World	1986	1.5	0.1	0.1	0.0	0.0	0.0
On Top of the World	1987	1.5	0.1	0.1	0.0	0.0	0.0
On Top of the World	1988	1.5	0.1	0.1	0.0	0.0	0.0
On Top of the World	1989	1.5	0.1	0.1	0.0	0.0	0.0
On Top of the World	1990	1.5	0.1	0.1	0.0	0.0	0.0
On Top of the World	1991	1.5	0.1	0.1	0.0	0.0	0.0
Pebble Creek Village	1985	0.0	0.0	0.0	0.3	0.5	0.3
Pebble Creek Village	1986	0.0	0.0	0.0	0.3	0.5	0.3
Pebble Creek Village	1987	0.0	0.0	0.0	0.3	0.5	0.3
Pebble Creek Village	1988	0.0	0.0	0.0	0.3	0.5	0.3
Pebble Creek Village	1989	0.0	0.0	0.0	0.3	0.6	0.2
Pebble Creek Village	1990	0.0	0.0	0.0	0.4	0.7	0.3
Pebble Creek Village	1991	0.0	0.0	0.0	0.8	0.9	0.1
Pine Ridge	1985	0.4	0.1	0.0	0.0	0.0	0.0
Pine Ridge	1986	0.4	0.1	0.0	0.0	0.0	0.0
Pine Ridge	1987	0.4	0.1	0.0	0.0	0.0	0.0
Pine Ridge	1988	0.4	0.1	0.0	0.0	0.0	0.0
Pine Ridge	1989	0.4	0.1	0.0	0.0	0.0	0.0
Pine Ridge	1990	0.4	0.1	0.0	0.0	0.0	0.0
Pine Ridge	1991	0.4	0.1	0.0	0.0	0.0	0.0
Plant City	1985	0.0	0.0	0.0	9.0	19.5	15.9
Plant City	1986	0.0	0.0	0.0	9.0	19.5	15.9
Plant City	1987	0.0	0.0	0.0	9.0	19.5	15.9
Plant City	1988	0.0	0.0	0.0	9.0	19.5	15.9
Plant City	1989	0.0	0.0	0.0	11.6	16.8	19.0
Plant City	1990	0.0	0.0	0.0	11.4	7.5	24.7
Plant City	1991	0.0	0.0	0.0	7.4	4.1	33.7
Progress Village	1985	0.4	0.1	0.0	0.0	0.0	0.0
Progress Village	1986	0.4	0.1	0.0	0.0	0.0	0.0
Progress Village	1987	0.4	0.1	0.0	0.0	0.0	0.0
Progress Village	1988	0.4	0.1	0.0	0.0	0.0	0.0
Progress Village	1989	0.1	0.1	0.0	0.0	0.0	0.0
Progress Village	1990	0.2	0.1	0.0	0.0	0.0	0.0
Progress Village	1991	0.2	0.1	0.0	0.0	0.0	0.0
Rice Creek	1985	0.3	0.0	0.0	0.0	0.0	0.0
Rice Creek	1986	0.3	0.0	0.0	0.0	0.0	0.0
Rice Creek	1987	0.3	0.0	0.0	0.0	0.0	0.0
Rice Creek	1988	0.3	0.0	0.0	0.0	0.0	0.0
Rice Creek	1989	0.8	0.0	0.1	0.0	0.0	0.0
Rice Creek	1990	0.3	0.1	0.1	0.0	0.0	0.0

Tampa Bay National Estuary Program
Tampa Bay Hydrologic & Pollutant Loading Model
Domestic Point Sources
Loadings Data

Facility	Year	LA TN load (tons/year)	LA TP load (tons/year)	LA TSS load (tons/year)	SW TN load (tons/year)	SW TP load (tons/year)	SW TSS load (tons/year)
Rice Creek	1991	0.4	0.0	0.1	0.0	0.0	0.0
River Oaks AWT	1985	0.0	0.0	0.0	26.1	3.5	13.5
River Oaks AWT	1986	0.0	0.0	0.0	26.1	3.5	13.5
River Oaks AWT	1987	0.0	0.0	0.0	26.1	3.5	13.5
River Oaks AWT	1988	0.0	0.0	0.0	26.1	3.5	13.5
River Oaks AWT	1989	0.0	0.0	0.0	12.7	2.2	12.0
River Oaks AWT	1990	0.0	0.0	0.0	10.2	2.8	9.9
River Oaks AWT	1991	0.0	0.0	0.0	17.6	4.6	5.0
Riverhills Country Club	1985	0.0	0.0	0.0	0.0	0.0	0.0
Riverhills Country Club	1986	0.0	0.0	0.0	0.0	0.0	0.0
Riverhills Country Club	1987	0.0	0.0	0.0	0.0	0.0	0.0
Riverhills Country Club	1988	0.0	0.0	0.0	0.0	0.0	0.0
Riverhills Country Club	1989	0.0	0.0	0.0	0.0	0.0	0.0
Riverhills Country Club	1990	0.0	0.0	0.0	0.0	0.0	0.0
Riverhills Country Club	1991	0.0	0.0	0.0	0.0	0.0	0.0
Seaboard Utilities Corp.	1985	0.6	0.2	0.8	0.0	0.0	0.0
Seaboard Utilities Corp.	1986	0.6	0.2	0.8	0.0	0.0	0.0
Seaboard Utilities Corp.	1987	0.6	0.2	0.8	0.0	0.0	0.0
Seaboard Utilities Corp.	1988	0.6	0.2	0.8	0.0	0.0	0.0
Seaboard Utilities Corp.	1989	0.6	0.2	0.8	0.0	0.0	0.0
Seaboard Utilities Corp.	1990	0.6	0.2	0.8	0.0	0.0	0.0
Seaboard Utilities Corp.	1991	0.5	0.3	0.5	0.0	0.0	0.0
South Hillsborough Regional	1985	0.7	0.1	0.0	0.0	0.0	0.0
South Hillsborough Regional	1986	0.7	0.1	0.0	0.0	0.0	0.0
South Hillsborough Regional	1987	0.7	0.1	0.0	0.0	0.0	0.0
South Hillsborough Regional	1988	0.7	0.1	0.0	0.0	0.0	0.0
South Hillsborough Regional	1989	0.3	0.1	0.0	0.0	0.0	0.0
South Hillsborough Regional	1990	0.4	0.1	0.0	0.0	0.0	0.0
South Hillsborough Regional	1991	1.5	0.2	0.0	0.0	0.0	0.0
Sterling Ranch	1985	0.1	0.0	0.0	0.0	0.0	0.0
Sterling Ranch	1986	0.1	0.0	0.0	0.0	0.0	0.0
Sterling Ranch	1987	0.1	0.0	0.0	0.0	0.0	0.0
Sterling Ranch	1988	0.1	0.0	0.0	0.0	0.0	0.0
Sterling Ranch	1989	0.1	0.0	0.0	0.0	0.0	0.0
Sterling Ranch	1990	0.1	0.0	0.0	0.0	0.0	0.0
Sterling Ranch	1991	0.0	0.0	0.0	0.2	0.2	0.1
Summerfield Subregional	1985	0.2	0.0	0.0	0.0	0.0	0.0
Summerfield Subregional	1986	0.2	0.0	0.0	0.0	0.0	0.0
Summerfield Subregional	1987	0.2	0.0	0.0	0.0	0.0	0.0
Summerfield Subregional	1988	0.2	0.0	0.0	0.0	0.0	0.0
Summerfield Subregional	1989	0.3	0.0	0.0	0.0	0.0	0.0
Summerfield Subregional	1990	0.2	0.0	0.0	0.0	0.0	0.0
Summerfield Subregional	1991	0.2	0.0	0.0	0.0	0.0	0.0
Tarpon Lake Village	.	.	.	.	.	.	.
Tarpon Woods	1985	1.7	0.1	0.0	0.0	0.0	0.0
Tarpon Woods	1986	1.7	0.1	0.0	0.0	0.0	0.0
Tarpon Woods	1987	1.7	0.1	0.0	0.0	0.0	0.0
Tarpon Woods	1988	1.7	0.1	0.0	0.0	0.0	0.0
Tarpon Woods	1989	1.7	0.1	0.0	0.0	0.0	0.0
Tarpon Woods	1990	1.7	0.1	0.0	0.0	0.0	0.0
Tarpon Woods	1991	1.7	0.1	0.0	0.0	0.0	0.0
Valrico Subregional	1985	1.1	0.1	0.1	0.0	0.0	0.0

Tampa Bay National Estuary Program
Tampa Bay Hydrologic & Pollutant Loading Model
Domestic Point Sources
Loadings Data

Facility	Year	LA TN load (tons/year)	LA TP load (tons/year)	LA TSS load (tons/year)	SW TN load (tons/year)	SW TP load (tons/year)	SW TSS load (tons/year)
Valrico Subregional	1986	1.1	0.1	0.1	0.0	0.0	0.0
Valrico Subregional	1987	1.1	0.1	0.1	0.0	0.0	0.0
Valrico Subregional	1988	1.1	0.1	0.1	0.0	0.0	0.0
Valrico Subregional	1989	1.1	0.1	0.1	0.0	0.0	0.0
Valrico Subregional	1990	1.1	0.1	0.1	0.0	0.0	0.0
Valrico Subregional	1991	1.2	0.1	0.1	1.2	0.3	0.3

Tampa Bay National Estuary Program
Tampa Bay Hydrologic & Pollutant Loading Model
Industrial Point Sources
Loadings Data

Bay Segment	Major Drainage Basin	Facility	Facility Number	Year	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)
2	Hillsborough R.	TAMPA CITY OF WATERWORKS	4029M20028	1985	1.6	<0.1	29.5
2	Hillsborough R.	TAMPA CITY OF WATERWORKS	4029M20028	1986	1.0	<0.1	17.0
2	Hillsborough R.	TAMPA CITY OF WATERWORKS	4029M20028	1987	1.1	<0.1	16.3
2	Hillsborough R.	TAMPA CITY OF WATERWORKS	4029M20028	1988	0.9	<0.1	16.9
2	Hillsborough R.	TAMPA CITY OF WATERWORKS	4029M20028	1989	1.1	<0.1	19.9
2	Hillsborough R.	TAMPA CITY OF WATERWORKS	4029M20028	1990	1.1	<0.1	19.9
2	Hillsborough R.	TAMPA CITY OF WATERWORKS	4029M20028	1991	1.1	<0.1	19.9
2	Alafia R.	MOBIL MINING BIG FOUR MINE	4029P20002	1985	0.1	4.5	31.2
2	Alafia R.	MOBIL MINING BIG FOUR MINE	4029P20002	1986	0.1	4.5	31.2
2	Alafia R.	MOBIL MINING BIG FOUR MINE	4029P20002	1987	0.3	2.9	36.6
2	Alafia R.	MOBIL MINING BIG FOUR MINE	4029P20002	1988	0.2	1.6	25.6
2	Alafia R.	MOBIL MINING BIG FOUR MINE	4029P20002	1989	0.1	3.2	26.5
2	Alafia R.	MOBIL MINING BIG FOUR MINE	4029P20002	1990	0.1	4.5	31.2
2	Alafia R.	MOBIL MINING BIG FOUR MINE	4029P20002	1991	<0.1	10.3	36.1
2	Hillsborough R.	CF INDUSTRIES-PLANT CITY CHEMICAL PLANT	4029P20023	1985	0.5	6.9	193.1
2	Hillsborough R.	CF INDUSTRIES-PLANT CITY CHEMICAL PLANT	4029P20023	1986	0.3	5.6	163.8
2	Hillsborough R.	CF INDUSTRIES-PLANT CITY CHEMICAL PLANT	4029P20023	1987	0.3	6.6	193.6
2	Hillsborough R.	CF INDUSTRIES-PLANT CITY CHEMICAL PLANT	4029P20023	1988	1.0	9.7	249.7
2	Hillsborough R.	CF INDUSTRIES-PLANT CITY CHEMICAL PLANT	4029P20023	1989	0.5	6.6	160.2
2	Hillsborough R.	CF INDUSTRIES-PLANT CITY CHEMICAL PLANT	4029P20023	1990	0.5	6.0	198.2
2	Hillsborough R.	CF INDUSTRIES-PLANT CITY CHEMICAL PLANT	4029P20023	1991	0.5	6.9	193.1
2	Hillsborough R.	CRYSTALS INTERNATIONAL, INC.	4029P20030	1985	11.5	<0.1	<0.1
2	Hillsborough R.	CRYSTALS INTERNATIONAL, INC.	4029P20030	1986	10.2	<0.1	<0.1
2	Hillsborough R.	CRYSTALS INTERNATIONAL, INC.	4029P20030	1987	9.8	<0.1	<0.1
2	Hillsborough R.	CRYSTALS INTERNATIONAL, INC.	4029P20030	1988	8.4	<0.1	<0.1
2	Hillsborough R.	CRYSTALS INTERNATIONAL, INC.	4029P20030	1989	9.6	<0.1	<0.1
2	Hillsborough R.	CRYSTALS INTERNATIONAL, INC.	4029P20030	1990	11.5	<0.1	<0.1
2	Hillsborough R.	CRYSTALS INTERNATIONAL, INC.	4029P20030	1991	19.9	<0.1	<0.1
2	Alafia R.	CARGILL INC.	4029P20038	1985	9.1	13.2	32.0
2	Alafia R.	CARGILL INC.	4029P20038	1986	9.1	13.2	32.0
2	Alafia R.	CARGILL INC.	4029P20038	1987	6.1	8.8	21.3
2	Alafia R.	CARGILL INC.	4029P20038	1988	21.5	17.7	36.4
2	Alafia R.	CARGILL INC.	4029P20038	1989	13.7	23.0	55.3
2	Alafia R.	CARGILL INC.	4029P20038	1990	2.4	7.2	28.9
2	Alafia R.	CARGILL INC.	4029P20038	1991	1.8	9.4	18.0
2	Coastal HB	IMC FERTILIZER PORT SUTTON TERMINAL	4029P20045	1985	<0.1	16.4	335.9
2	Coastal HB	IMC FERTILIZER PORT SUTTON TERMINAL	4029P20045	1986	<0.1	16.4	335.9
2	Coastal HB	IMC FERTILIZER PORT SUTTON TERMINAL	4029P20045	1987	<0.1	12.7	199.9
2	Coastal HB	IMC FERTILIZER PORT SUTTON TERMINAL	4029P20045	1988	<0.1	20.9	268.7
2	Coastal HB	IMC FERTILIZER PORT SUTTON TERMINAL	4029P20045	1989	<0.1	18.5	353.0
2	Coastal HB	IMC FERTILIZER PORT SUTTON TERMINAL	4029P20045	1990	<0.1	19.1	437.8
2	Coastal HB	IMC FERTILIZER PORT SUTTON TERMINAL	4029P20045	1991	<0.1	10.9	420.0
2	Coastal HB	TRADEMARK NITROGEN	4029P20048	1985	1.3	<0.1	0.3
2	Coastal HB	TRADEMARK NITROGEN	4029P20048	1986	1.3	<0.1	0.3
2	Coastal HB	TRADEMARK NITROGEN	4029P20048	1987	1.3	<0.1	0.3
2	Coastal HB	TRADEMARK NITROGEN	4029P20048	1988	1.3	<0.1	0.3
2	Coastal HB	TRADEMARK NITROGEN	4029P20048	1989	2.1	<0.1	0.6
2	Coastal HB	TRADEMARK NITROGEN	4029P20048	1990	0.7	<0.1	0.1
2	Coastal HB	TRADEMARK NITROGEN	4029P20048	1991	0.9	<0.1	0.3
2	Coastal HB	NITRAM INC.	4029P20054	1985	2.3	0.4	2.5
2	Coastal HB	NITRAM INC.	4029P20054	1986	2.3	0.4	2.5

Tampa Bay National Estuary Program
Tampa Bay Hydrologic & Pollutant Loading Model
Industrial Point Sources
Loadings Data

Bay Segment	Major Drainage Basin	Facility	Facility Number	Year	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)
2	Coastal HB	NITRAM INC.	4029P20054	1987	2.3	0.4	2.5
2	Coastal HB	NITRAM INC.	4029P20054	1988	2.3	0.4	2.5
2	Coastal HB	NITRAM INC.	4029P20054	1989	2.3	0.4	2.5
2	Coastal HB	NITRAM INC.	4029P20054	1990	3.1	0.5	3.7
2	Coastal HB	NITRAM INC.	4029P20054	1991	1.5	0.3	1.4
2	Coastal HB	SEMINOLE FERTILIZER-AMMONIA TERMINAL	4029P20069	1985	0.6	4.1	9.8
2	Coastal HB	SEMINOLE FERTILIZER-AMMONIA TERMINAL	4029P20069	1986	0.6	4.1	9.8
2	Coastal HB	SEMINOLE FERTILIZER-AMMONIA TERMINAL	4029P20069	1987	1.3	4.1	9.8
2	Coastal HB	SEMINOLE FERTILIZER-AMMONIA TERMINAL	4029P20069	1988	0.6	4.1	9.8
2	Coastal HB	SEMINOLE FERTILIZER-AMMONIA TERMINAL	4029P20069	1989	0.2	2.2	5.1
2	Coastal HB	SEMINOLE FERTILIZER-AMMONIA TERMINAL	4029P20069	1990	0.5	4.1	9.7
2	Coastal HB	SEMINOLE FERTILIZER-AMMONIA TERMINAL	4029P20069	1991	0.3	6.2	14.8
2	Hillsborough R.	FLORIDA SNO-MAN INC.	4029P20081	1985	11.8	51.3	17.3
2	Hillsborough R.	FLORIDA SNO-MAN INC.	4029P20081	1986	14.1	48.7	13.0
2	Hillsborough R.	FLORIDA SNO-MAN INC.	4029P20081	1987	16.9	49.9	7.6
2	Hillsborough R.	FLORIDA SNO-MAN INC.	4029P20081	1988	12.1	44.4	6.5
2	Hillsborough R.	FLORIDA SNO-MAN INC.	4029P20081	1989	1.3	43.8	12.0
2	Hillsborough R.	FLORIDA SNO-MAN INC.	4029P20081	1990	4.2	44.5	43.7
2	Hillsborough R.	FLORIDA SNO-MAN INC.	4029P20081	1991	8.4	69.4	22.0
3	Coastal MTB	TECO BIG BEND	4029P20085	1985	<0.1	<0.1	15.9
3	Coastal MTB	TECO BIG BEND	4029P20085	1986	<0.1	<0.1	15.9
3	Coastal MTB	TECO BIG BEND	4029P20085	1987	<0.1	<0.1	15.2
3	Coastal MTB	TECO BIG BEND	4029P20085	1988	<0.1	<0.1	15.6
3	Coastal MTB	TECO BIG BEND	4029P20085	1989	<0.1	<0.1	14.8
3	Coastal MTB	TECO BIG BEND	4029P20085	1990	<0.1	<0.1	17.6
3	Coastal MTB	TECO BIG BEND	4029P20085	1991	<0.1	<0.1	16.0
2	Coastal HB	TECO GANNON	4029P20086	1985	<0.1	<0.1	38.9
2	Coastal HB	TECO GANNON	4029P20086	1986	<0.1	<0.1	38.9
2	Coastal HB	TECO GANNON	4029P20086	1987	<0.1	<0.1	22.7
2	Coastal HB	TECO GANNON	4029P20086	1988	<0.1	<0.1	38.7
2	Coastal HB	TECO GANNON	4029P20086	1989	<0.1	<0.1	54.5
2	Coastal HB	TECO GANNON	4029P20086	1990	<0.1	<0.1	31.7
2	Coastal HB	TECO GANNON	4029P20086	1991	<0.1	<0.1	47.0
1	Coastal OTB	SHELL OIL CO. PORT TAMPA PLANT	4029P20103	1985	<0.1	<0.1	0.5
1	Coastal OTB	SHELL OIL CO. PORT TAMPA PLANT	4029P20103	1986	<0.1	<0.1	0.5
1	Coastal OTB	SHELL OIL CO. PORT TAMPA PLANT	4029P20103	1987	<0.1	<0.1	0.5
1	Coastal OTB	SHELL OIL CO. PORT TAMPA PLANT	4029P20103	1988	<0.1	<0.1	0.8
1	Coastal OTB	SHELL OIL CO. PORT TAMPA PLANT	4029P20103	1989	<0.1	<0.1	0.4
1	Coastal OTB	SHELL OIL CO. PORT TAMPA PLANT	4029P20103	1990	<0.1	<0.1	0.4
1	Coastal OTB	SHELL OIL CO. PORT TAMPA PLANT	4029P20103	1991	<0.1	<0.1	0.5
4	Coastal LTB	NJ-GULF INDUSTRIES ROCK TERMINAL	4041P20000	1985	10.1	1.1	1.2
4	Coastal LTB	NJ-GULF INDUSTRIES ROCK TERMINAL	4041P20000	1986	10.1	1.1	1.2
4	Coastal LTB	NJ-GULF INDUSTRIES ROCK TERMINAL	4041P20000	1987	10.1	1.1	1.2
4	Coastal LTB	NJ-GULF INDUSTRIES ROCK TERMINAL	4041P20000	1988	10.1	0.9	1.0
4	Coastal LTB	NJ-GULF INDUSTRIES ROCK TERMINAL	4041P20000	1989	10.1	1.0	1.7
4	Coastal LTB	NJ-GULF INDUSTRIES ROCK TERMINAL	4041P20000	1990	10.1	1.0	1.2
4	Coastal LTB	NJ-GULF INDUSTRIES ROCK TERMINAL	4041P20000	1991	10.1	1.5	0.9
4	Coastal LTB	PINEY POINT PHOSPHATES INC.	4041P20001	1985	2.9	12.7	20.3
4	Coastal LTB	PINEY POINT PHOSPHATES INC.	4041P20001	1986	2.9	12.7	20.3
4	Coastal LTB	PINEY POINT PHOSPHATES INC.	4041P20001	1987	2.2	9.5	15.6
4	Coastal LTB	PINEY POINT PHOSPHATES INC.	4041P20001	1988	4.7	39.5	36.2
4	Coastal LTB	PINEY POINT PHOSPHATES INC.	4041P20001	1989	3.1	3.0	32.1

Tampa Bay National Estuary Program
Tampa Bay Hydrologic & Pollutant Loading Model
Industrial Point Sources
Loadings Data

Bay Segment	Major Drainage Basin	Facility	Facility Number	Year	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)
4	Coastal LTB	PINEY POINT PHOSPHATES INC.	4041P20001	1990	3.2	7.4	12.4
4	Coastal LTB	PINEY POINT PHOSPHATES INC.	4041P20001	1991	1.3	4.1	5.0
7	Manatee R.	FLORIDA POWER & LIGHT	4041P20006	1985	20.4	<0.1	0.2
7	Manatee R.	FLORIDA POWER & LIGHT	4041P20006	1986	20.4	<0.1	0.2
7	Manatee R.	FLORIDA POWER & LIGHT	4041P20006	1987	13.9	<0.1	0.2
7	Manatee R.	FLORIDA POWER & LIGHT	4041P20006	1988	29.4	<0.1	0.2
7	Manatee R.	FLORIDA POWER & LIGHT	4041P20006	1989	27.1	<0.1	0.2
7	Manatee R.	FLORIDA POWER & LIGHT	4041P20006	1990	17.3	<0.1	0.2
7	Manatee R.	FLORIDA POWER & LIGHT	4041P20006	1991	14.4	<0.1	0.2
7	Manatee R.	TROPICANA PRODUCTS INC.	4041P20011	1985	22.4	<0.1	2649.4
7	Manatee R.	TROPICANA PRODUCTS INC.	4041P20011	1986	22.4	<0.1	2649.4
7	Manatee R.	TROPICANA PRODUCTS INC.	4041P20011	1987	3.7	<0.1	455.1
7	Manatee R.	TROPICANA PRODUCTS INC.	4041P20011	1988	10.2	<0.1	1661.3
7	Manatee R.	TROPICANA PRODUCTS INC.	4041P20011	1989	9.7	<0.1	2381.7
7	Manatee R.	TROPICANA PRODUCTS INC.	4041P20011	1990	32.7	<0.1	4400.6
7	Manatee R.	TROPICANA PRODUCTS INC.	4041P20011	1991	55.7	<0.1	4348.3
4	Coastal LTB	COASTAL FUELS MARKETING INC.	4041P20014	1985	<0.1	<0.1	31.5
4	Coastal LTB	COASTAL FUELS MARKETING INC.	4041P20014	1986	<0.1	<0.1	31.5
4	Coastal LTB	COASTAL FUELS MARKETING INC.	4041P20014	1987	<0.1	<0.1	31.5
4	Coastal LTB	COASTAL FUELS MARKETING INC.	4041P20014	1988	<0.1	<0.1	35.8
4	Coastal LTB	COASTAL FUELS MARKETING INC.	4041P20014	1989	<0.1	<0.1	27.3
4	Coastal LTB	COASTAL FUELS MARKETING INC.	4041P20014	1990	<0.1	<0.1	31.5
4	Coastal LTB	COASTAL FUELS MARKETING INC.	4041P20014	1991	<0.1	<0.1	31.5
3	L. Manatee R.	IMC FERTILIZER FOUR CORNERS MINE	4041P20020	1985	3.5	8.2	24.1
3	L. Manatee R.	IMC FERTILIZER FOUR CORNERS MINE	4041P20020	1986	3.8	8.9	26.3
3	L. Manatee R.	IMC FERTILIZER FOUR CORNERS MINE	4041P20020	1987	3.8	8.9	26.3
3	L. Manatee R.	IMC FERTILIZER FOUR CORNERS MINE	4041P20020	1988	3.4	8.2	28.0
3	L. Manatee R.	IMC FERTILIZER FOUR CORNERS MINE	4041P20020	1989	4.3	3.9	18.3
3	L. Manatee R.	IMC FERTILIZER FOUR CORNERS MINE	4041P20020	1990	3.2	10.9	26.0
3	L. Manatee R.	IMC FERTILIZER FOUR CORNERS MINE	4041P20020	1991	4.3	12.8	33.0
3	Coastal MTB	FDNR STOCK ENHANCEMENT Facility	4041S20024	1985	0.2	1.2	162.4
3	Coastal MTB	FDNR STOCK ENHANCEMENT Facility	4041S20024	1986	0.2	1.2	162.4
3	Coastal MTB	FDNR STOCK ENHANCEMENT Facility	4041S20024	1987	0.2	1.2	162.4
3	Coastal MTB	FDNR STOCK ENHANCEMENT Facility	4041S20024	1988	0.2	1.3	158.1
3	Coastal MTB	FDNR STOCK ENHANCEMENT Facility	4041S20024	1989	0.2	1.3	124.7
3	Coastal MTB	FDNR STOCK ENHANCEMENT Facility	4041S20024	1990	0.2	1.3	167.1
3	Coastal MTB	FDNR STOCK ENHANCEMENT Facility	4041S20024	1991	0.2	1.1	199.7
2	Alafia R.	ESTECH SILVER CITY MINE	4053P20049	1985	23.4	81.9	196.6
2	Alafia R.	ESTECH SILVER CITY MINE	4053P20049	1986	23.4	81.9	196.6
2	Alafia R.	ESTECH SILVER CITY MINE	4053P20049	1987	22.5	76.0	187.4
2	Alafia R.	ESTECH SILVER CITY MINE	4053P20049	1988	40.5	156.3	360.6
2	Alafia R.	ESTECH SILVER CITY MINE	4053P20049	1989	22.6	68.0	177.9
2	Alafia R.	ESTECH SILVER CITY MINE	4053P20049	1990	13.0	46.7	104.4
2	Alafia R.	ESTECH SILVER CITY MINE	4053P20049	1991	18.1	62.6	152.8
2	Alafia R.	FARMLAND HYDRO L.P. GREEN BAY PLANT	4053P20061	1985	1.5	53.6	<0.1
2	Alafia R.	FARMLAND HYDRO L.P. GREEN BAY PLANT	4053P20061	1986	1.5	47.1	<0.1
2	Alafia R.	FARMLAND HYDRO L.P. GREEN BAY PLANT	4053P20061	1987	1.5	66.5	<0.1
2	Alafia R.	FARMLAND HYDRO L.P. GREEN BAY PLANT	4053P20061	1988	0.5	45.9	<0.1
2	Alafia R.	FARMLAND HYDRO L.P. GREEN BAY PLANT	4053P20061	1989	1.2	60.2	<0.1
2	Alafia R.	FARMLAND HYDRO L.P. GREEN BAY PLANT	4053P20061	1990	1.8	48.5	<0.1
2	Alafia R.	FARMLAND HYDRO L.P. GREEN BAY PLANT	4053P20061	1991	2.8	53.1	<0.1
2	Hillsborough R.	ERLY JUICE INC.	4053P20092	1985	0.5	1.5	165.2

Tampa Bay National Estuary Program
Tampa Bay Hydrologic & Pollutant Loading Model
Industrial Point Sources
Loadings Data

Bay Segment	Major Drainage Basin	Facility	Facility Number	Year	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)
2	Hillsborough R.	ERLY JUICE INC.	4053P20092	1986	0.7	1.2	87.0
2	Hillsborough R.	ERLY JUICE INC.	4053P20092	1987	0.7	1.3	118.9
2	Hillsborough R.	ERLY JUICE INC.	4053P20092	1988	0.7	1.1	98.8
2	Hillsborough R.	ERLY JUICE INC.	4053P20092	1989	0.6	1.1	116.1
2	Hillsborough R.	ERLY JUICE INC.	4053P20092	1990	1.0	1.2	42.5
2	Hillsborough R.	ERLY JUICE INC.	4053P20092	1991	0.8	1.1	21.3
2	Alafia R.	MOBIL MINING NICHOLS PREP PLANT	4053P20095	1985	1.2	2.1	3.3
2	Alafia R.	MOBIL MINING NICHOLS PREP PLANT	4053P20095	1986	1.2	2.1	3.3
2	Alafia R.	MOBIL MINING NICHOLS PREP PLANT	4053P20095	1987	1.2	1.4	3.3
2	Alafia R.	MOBIL MINING NICHOLS PREP PLANT	4053P20095	1988	1.3	2.7	4.0
2	Alafia R.	MOBIL MINING NICHOLS PREP PLANT	4053P20095	1989	1.0	1.9	2.8
2	Alafia R.	MOBIL MINING NICHOLS PREP PLANT	4053P20095	1990	1.1	2.1	3.0
2	Alafia R.	MOBIL MINING NICHOLS PREP PLANT	4053P20095	1991	1.3	2.3	3.5
2	Alafia R.	MOBIL MINING - NICHOLS MINE	4053P20098	1985	0.2	0.2	0.5
2	Alafia R.	MOBIL MINING - NICHOLS MINE	4053P20098	1986	0.2	0.2	0.5
2	Alafia R.	MOBIL MINING - NICHOLS MINE	4053P20098	1987	0.2	0.2	0.5
2	Alafia R.	MOBIL MINING - NICHOLS MINE	4053P20098	1988	0.2	0.2	0.5
2	Alafia R.	MOBIL MINING - NICHOLS MINE	4053P20098	1989	0.2	0.2	0.5
2	Alafia R.	MOBIL MINING - NICHOLS MINE	4053P20098	1990	0.2	0.2	0.5
2	Alafia R.	MOBIL MINING - NICHOLS MINE	4053P20098	1991	0.2	0.2	0.5
2	Alafia R.	MULBERRY PHOSPHATES INC.	4053P20111	1985	2.4	19.9	6.0
2	Alafia R.	MULBERRY PHOSPHATES INC.	4053P20111	1986	2.4	19.9	6.0
2	Alafia R.	MULBERRY PHOSPHATES INC.	4053P20111	1987	2.4	19.9	6.0
2	Alafia R.	MULBERRY PHOSPHATES INC.	4053P20111	1988	2.4	19.9	6.0
2	Alafia R.	MULBERRY PHOSPHATES INC.	4053P20111	1989	2.9	28.4	7.4
2	Alafia R.	MULBERRY PHOSPHATES INC.	4053P20111	1990	2.5	23.7	7.4
2	Alafia R.	MULBERRY PHOSPHATES INC.	4053P20111	1991	1.7	7.4	3.3
2	Hillsborough R.	CSX TRANSPORTATION WINSTON YARD	4053P20113	1985	0.7	1.0	1.6
2	Hillsborough R.	CSX TRANSPORTATION WINSTON YARD	4053P20113	1986	0.7	1.0	1.6
2	Hillsborough R.	CSX TRANSPORTATION WINSTON YARD	4053P20113	1987	0.4	1.1	1.0
2	Hillsborough R.	CSX TRANSPORTATION WINSTON YARD	4053P20113	1988	0.3	0.6	1.3
2	Hillsborough R.	CSX TRANSPORTATION WINSTON YARD	4053P20113	1989	0.8	1.2	1.7
2	Hillsborough R.	CSX TRANSPORTATION WINSTON YARD	4053P20113	1990	0.9	1.6	1.6
2	Hillsborough R.	CSX TRANSPORTATION WINSTON YARD	4053P20113	1991	1.1	0.4	2.4
2	Alafia R.	IMC FERTILIZER HAYNESWORTH MINE	4053P20138	1985	0.2	0.2	0.5
2	Alafia R.	IMC FERTILIZER HAYNESWORTH MINE	4053P20138	1986	0.2	0.2	0.5
2	Alafia R.	IMC FERTILIZER HAYNESWORTH MINE	4053P20138	1987	0.2	0.2	0.5
2	Alafia R.	IMC FERTILIZER HAYNESWORTH MINE	4053P20138	1988	0.2	0.2	0.5
2	Alafia R.	IMC FERTILIZER HAYNESWORTH MINE	4053P20138	1989	0.2	0.2	0.5
2	Alafia R.	IMC FERTILIZER HAYNESWORTH MINE	4053P20138	1990	0.2	0.2	0.5
2	Alafia R.	IMC FERTILIZER HAYNESWORTH MINE	4053P20138	1991	0.2	0.2	0.5

Tampa Bay National Estuary Program
Tampa Bay Hydrologic & Pollutant Loading Model
Springs Loading

Segment	Year	TN Load (tons/year)	TP Load (tons/year)
2	1985	90.65	5.88
2	1986	113.00	7.47
2	1987	128.95	7.80
2	1988	109.41	6.91
2	1989	93.62	6.56
2	1990	104.81	6.34
2	1991	99.06	5.60

APPENDIX 13

ESTIMATED NUTRIENT AND SUSPENDED SOLIDS LOADING TO TAMPA BAY FOR "WORST CASE" CONDITIONS

TABLE OF CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

Nutrient loading estimates for the Tampa Bay watershed were made for the mid-1970's period, as a "worst case" condition. This time period is thought to represent the period of maximum nutrient loading to Tampa Bay, and subsequently, overall water quality was at perhaps its lowest level, on a bay-wide basis. Urbanization was at relatively high levels, but several water quality improvement programs now in practice had not yet been implemented. During this period, major publically-owned domestic wastewater treatment facilities discharged large volumes of poorly treated effluent directly to the bay, and numerous privately-operated small treatment plants operated without adequate oversight and treatment of sewage. Stormwater runoff generated by new development was not managed until the passage of the Henderson Act. In addition, the phosphate industry was very active, but without the environmental controls currently in place. Several activities occurred shortly after that period that resulted in reduced nutrient loadings and improved bay water quality:

- major improvements were made upgrading the level of treatment provided by several large domestic wastewater treatment plants (such as the City of Tampa's Hookers Point facility),
- many of the small wastewater treatment plants (package plants) were taken out of use,
- enhanced phosphate mining regulations for surface water quality improvement were implemented,
- surface water management permitting programs to improve nonpoint source water quality were developed,
- effluent treatment and discharge facilities for several significant industrial point sources were improved, and
- the phosphate industry experienced a general decline in activities.

It was desired to document the estimated total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS) loadings to Tampa Bay for the mid-1970's period to compare, in a relative sense, the reduction in loadings that has occurred during the past 15 to 20 years. This analysis was not intended to develop loading estimates with the level of accuracy and detail as for existing condition loads. Rather, it was desired to make a general estimate of these loads from the mid-1970's to allow a "first order" comparison to be made between this time period and existing conditions. Sources of information reviewed included various reports on Tampa Bay including studies conducted by state agencies, private firms and summary proceedings.

The objective of this investigation was to identify and evaluate existing summary information of TN, TP, and TSS loading estimates for Tampa Bay as a whole, and for bay segments, for the mid-1970's period. Existing documents with summaries of point and nonpoint source loadings were examined for technical merit and accuracy. The best existing summaries of TN, TP, and TSS loadings were synthesized to develop an overall estimate of these loads during the mid-1970's.

In the literature cited, data were presented in various formats including information from individual point sources, summarized loadings from all point sources to a bay segment, or estimates combining point and nonpoint sources. Loading estimates were obtained via different methods such as the summarization of previous information or actual field studies. Loading estimates were presented in numerous formats including daily, weekly, monthly, wet/dry season or annually. Because of the variations in data presentation and the fact that each publication focused on different objectives, few direct comparisons could be made.

2.0 METHODS

Although this investigation required the evaluation of several existing loading model studies, it was not within this scope of work to develop new estimates of point and nonpoint loadings for the mid-1970's. Additionally, flow and quality data for individual point source facilities were not obtained from the FDEP permit files. Rather, existing documents with estimates of TN, TP, and TSS loadings were reviewed and summarized to develop a best estimate of point and nonpoint contributions to nutrient loadings to Tampa Bay based on previous work. Several documents that addressed aspects of point and/or nonpoint nutrient loading to Tampa Bay for the mid-1970's were reviewed, including:

- Surface Flows to Tampa Bay: Quantity and Quality Aspects (Dooris and Dooris, 1985)
- Nonpoint Assessment for the Wilson-Grizzle Area (FDER, 1982)
- Tributary Streamflows and Pollutant Loadings Delivered to Tampa Bay (Hartigan and Hanson-Walton, 1984)
- Long-Term Trends of Nitrogen Loading, Water Quality and Biological Indicators in Hillsborough Bay, Florida (Johansson, 1991)
- Point Source Discharge in the Tampa Bay Area (Moon, 1985)
- Central Florida Phosphate Industry Areawide Impact Assessment Program Volume V: Water (Texas Instruments, 1978)
- Waste Load Allocation for Tampa Bay Tributaries (Yousef, 1976)
- Nonpoint Source Effects (Wanielista, 1976)

Several of these references were not appropriate for use for a variety of reasons, including incomplete coverage, inadequate documentation of methods, suspect methods or results, or other factors. However, data from the documents that were believed to be most accurate and representative were summarized and compared, as described below. The following discussion describes the synthesis of these data and methods that were used to develop estimates of TN, TP, and TSS loads.

2.1 Nonpoint Sources

Initially, existing literature values were used to develop estimates of "worst case" TN, TP, and TSS loading. Several studies previously estimated these nutrient inputs for the mid to late 1970's, including those listed above. Of those reports, "Nonpoint Assessment for the Wilson-Grizzle Area" (FDER, 1982) provided the only available consistent, basin-wide estimate of nonpoint source TN and TP loads, and was closely scrutinized. This investigation used a land use coverage for 1975, projected to 1980 conditions. Using a delineation for the Tampa Bay watershed that included 33 subbasins, TN and TP loadings were estimated on an average annual basis for the seven bay segments.

Despite the consistent coverage of nonpoint source loadings, no detailed discussion of methods was included in the FDER (1982) report. However, the development of the nonpoint source loadings used in this study are described in the report "Wasteloads and Wasteload Allocation for Priority and Non-Priority Areas of the Tampa Bay Region" (ESE, 1977). Several potential shortcomings of that nonpoint source analysis are pointed out in the 1982 FDER report, and should be noted. These include incompatibility of the land use data used by ESE with other existing land use classifications, use of 1975 land use data to project 1980 land use, and the categorization of mining lands into one of three generalized rural land use classifications. The quality of input data as well as the predictive capabilities of the models used (USEPA model SWMM-Level 1 and EPARRB-Model B), is also questioned in the FDER (1982) report.

Another potential weakness in the ESE (1977) report includes the approach that was used, which was to model nutrient loads from the entire watershed, instead of using measured streamflow and water quality concentration data where available. In addition, modeling nonpoint source loads in the mid 1970's was hampered by the relative scarcity of land use specific water quality data for stormwater runoff.

Because of these weaknesses, the nonpoint source loads presented in the FDER (1982) report were not thought to be of sufficient accuracy to be used for compare to existing conditions loadings as developed for this report. Additionally, nonpoint source TN and TP loads as estimated by FDER (1982) were compared to existing condition loads. Both TN and TP nonpoint source loads from FDER (1982) were about 2.0 times existing loads, and were substantially higher than loads for test basins that were estimated using measured data. These comparisons suggest that the nonpoint source loadings from FDER (1982) are unrealistically high, and were not used.

During the past fifteen years, advances in nonpoint source modeling, stormwater characterization, and land use mapping capabilities have reduced many of these uncertainties. However, it was beyond the purpose of this investigation to attempt to refine the mid-1970's nonpoint source loadings, based on current knowledge. Because none of the identified nonpoint source loading estimates appeared to be sufficiently accurate, it was necessary to determine an alternative method of estimating nonpoint TN, TP, and TSS loads to Tampa Bay for the mid-1970's period. The following steps were used to develop a suitable estimate:

1) It was assumed that, on a watershed-wide basis, 20% of the urban land that is shown on the 1990 GIS land use coverage (used for the existing condition analysis) that now receives stormwater treatment had no treatment during the mid-1970's. This represents urban land that existed in the mid-1970's that had no form of stormwater treatment, either intentional or inadvertent (e.g. from drainage ponds or overland flow).

2) It was assumed that treatment efficiencies for stormwater facilities was 50% removal for TN, TP, and TSS. This assumption is based on using treatment efficiency rates that are similar to, but slightly lower than treatment efficiencies for modern, well-functioning stormwater BMP's.

3) Therefore, 20% of the 1990 urban land area was assigned an increased loading rate for the mid-1970's period, based on a 50% treatment efficiency.

It is recognized that land use development patterns vary significantly in different portions of the watershed, and that stormwater facilities' treatment efficiencies vary based on design and parameter. However, this methodology was determined to be an adequate means of estimating nonpoint source loadings for the mid-1970's period in lieu of acceptable existing data. Moreover, the primary focus on this loading scenario was to document the level of reduction of point source loads to Tampa Bay. The nonpoint source loadings shown in Section 3 reflect these assumptions.

2.2 Point Sources

2.2.1 Domestic and Industrial Facilities

TN, TP, and TSS loads from domestic and industrial point sources were obtained from three main information sources. The primary source of information was the document entitled "Nonpoint Assessment for the Wilson-Grizzle Area" (FDER, 1982). This report summarizes domestic and industrial point source discharges of TN and TP to Tampa Bay with adequate spatial resolution. These data were originally obtained from a review of FDER monthly operating records of facilities with surface water discharges to Tampa Bay and adjacent waters.

The FDER (1982) assessment report partitions the Tampa Bay watershed into 33 subbasins, which are assigned to four major study areas - Old Tampa Bay, Hillsborough Bay, Tampa Bay (which includes the areas tributary to Middle Tampa Bay, Lower Tampa Bay, and the Manatee River), and Boca Ciega Bay. The subbasins in the report were generally delineated matching existing conditions major basin boundaries, and thus allowed the assignment of point source loads to the respective bay segments. However, in some cases it was necessary to make assumptions about splitting subbasin loads between two adjacent bay segments. For example, some point source loads in the eastern Pinellas County peninsula had to be partitioned between Old Tampa Bay and Middle Tampa Bay (Figure 1).

Using the data provided, point source loads were assigned to the seven current bay segments. Although the loading data were from 1980 - several years after the target period of the mid 1970's - it was assumed that they would be adequate to represent point source loadings during that time, with a few exceptions, as described below. One major exception was the City of Tampa's Hookers Point facility. This wastewater treatment plant was converted to a higher level of treatment (advanced secondary - AWT) in 1978, so loadings from 1980 would not reflect the conditions during the mid 1970's. In addition, some of the other point sources, specifically industrial facilities in the phosphate industry, had made improvements to their discharge systems by 1980.

To obtain point source data for the "pre-improvement" condition at these facilities, a second reference document was used. The "Central Florida Phosphate Industry Areawide Impact Assessment Program, Volume V: Water" (Texas Instruments, 1978) was originally published to support an evaluation of cumulative impacts from phosphate industry activities in the Tampa Bay and Charlotte Harbor watersheds.

These drainage areas include the Alafia River and Peace River basins, which have historically supported the most intensive levels of phosphate mining and processing activities. Average daily point source loads for TN, TP, and TSS, based on 1976 FDER records, are listed for individual facilities in all portions of the Tampa Bay watershed except Pinellas County. Because it was desired to obtain the most consistent, watershed-wide loading estimates, these data were not used as the primary source of loadings, but were used to supplement the information obtained from the Wilson-Grizzle evaluation. Data obtained from this reference includes TN, TP, and TSS average daily loads for major dischargers in the Hillsborough Bay drainage area, which includes Hookers Point and almost all the phosphate industry facilities in the watershed. Additionally, "worst case" TSS loads for point source facilities in the watershed were not available from any other source, and were obtained from this document.

The third reference used to estimate surface discharge point source loads was the document "Tributary Streamflows and Pollutant Loadings Delivered to Tampa Bay" (Hartigan and Hanson-Walton, 1984). This report provides a description of data to be used for input to the University of South Florida (USF) Tampa Bay Model, which was designated by FDER as the primary planning tool for the FDER Tampa Bay Wasteload Allocation Study. Individual domestic and industrial facilities are listed with mean flow (mgd), and TN and TP concentrations obtained from FDER data for 1982-3. Although these data were also from several years after the period of interest, in some

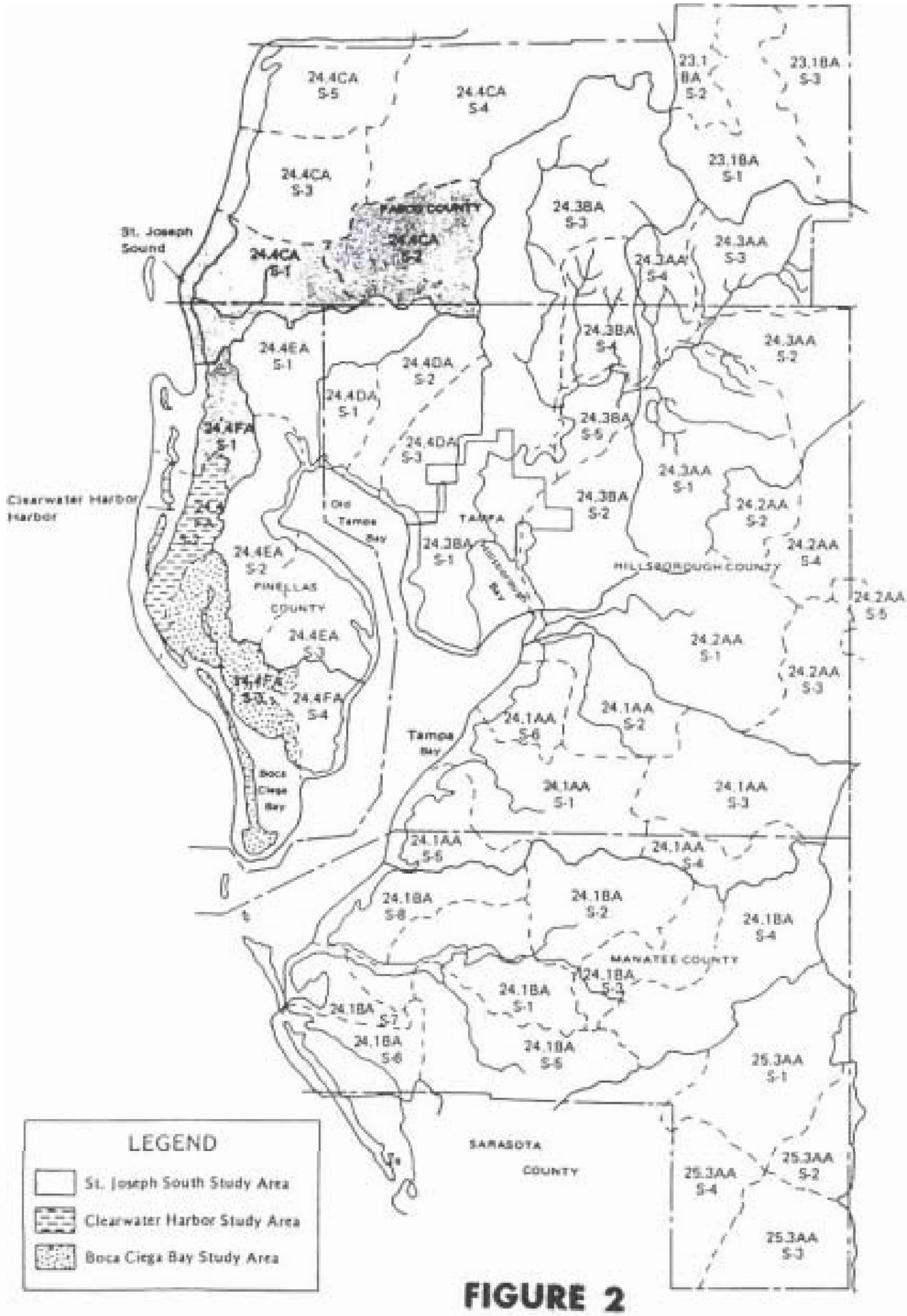


FIGURE 2
SURVEY AREA I BOUNDARY

SOURCE: Tampa Bay Regional Planning Council, Wasteloads and Wasteload Allocations For Priority and Non-Priority Areas of the Tampa Bay Region. September 1977.

Figure 1 Survey Area Boundaries (FDER, 1982) cases they are the best available data and therefore were subsequently used. For example, this data set is the only available source of TN and TP concentrations for the phosphate fertilizer facility at Port Manatee (AMAX at the time). This plant had recorded average discharges of almost one million gallons per day with an average TN concentration of 145 mg/L, making it one of the major sources of nitrogen input to Middle Tampa Bay.

It is suspected that the true extent of point source loadings during the mid 1970's may be underestimated, based only on reported data. Permit requirements for reporting of operating data, and enforcement of those requirements, were much less stringent during that period than currently. Additionally, there was little effort to monitor conditions at point source facilities beyond permit requirements, with the exception of a few facilities, such as the City of Tampa's Hookers Point Wastewater Treatment Plant and the City of St. Petersburg's effluent reuse sites. Since that time, more comprehensive monitoring requirements and enforcement have become routine, greatly improving the completeness of point source loading data.

2.2.2 Springs

Nutrient loads from springs vary as a function of flow and concentration. Measured flow and water quality data were obtained for the period 1985 - 1991 for the existing conditions loading analysis. Spring discharge rates will vary somewhat based on rainfall and nearby groundwater pumping, and water quality of the discharge will reflect various sources of nutrients in the watershed (such as fertilizer and effluent land application).

Flows from springs in the Tampa Bay watershed have not exhibited significant changes between the late 1970's and 1990. Combined flows from Crystal, Sulphur, and Lithia springs have changed less than 10% (from approximately 132 cfs to 126 cfs) during that period (USGS, 1991 and 1992; Rosenau et al., 1977). Sampling data from Lithia Springs suggest that nitrate+nitrite-N (NO_2+NO_3-N) concentrations were approximately 1.3 mg/L in the early 1970's (Jones, 1993). Similarly, NO_2+NO_3-N concentrations in Crystal Springs discharges were reported to be about 1.2 during the *same period (Rosenau et al., 1977).*

Taking an average NO_2+NO_3-N concentration of 1.25 mg/L and combined spring flow for the two ungaged springs (Lithia and Sulphur) of approximately 84 cfs (54 mgd) for the mid 1970's, the TN load to Tampa Bay (all to Hillsborough Bay) was estimated to be about 103 tons/year. The current (1985-91) spring loading for Lithia and Sulphur springs is approximately 106 tons/year (from Appendix 12). Because spring TN loading estimates for the two periods varied by only 3% it was assumed that existing conditions average nutrient and solids loadings from springs would be appropriate for the mid-1970's loading analysis.

2.3 Fugitive Losses of Fertilizer

Fugitive emission loadings of nitrogen and phosphorus result from spillage and dust releases of phosphate rock and fertilizer products shipped from the loading terminals at East Bay, in upper Hillsborough Bay. Because fugitive emissions were not widely recognized as a significant source of nutrient loadings during the mid 1970's, no measured data from this period exist. This load can be expressed as a percent of product shipped, and is thought to be a significant source of nutrients to the upper bay. Estimates of fugitive emissions in Hillsborough Bay for the periods 1966-67 and 1987-90 have been made by Johansson (1991) based on a 0.05% loss rate of fertilizer product shipped. These values - 120 tons/year for 1967-69 and 770 tons/year for 1987-90 - were averaged to estimate a fugitive loss rate for the mid-1970's period for Hillsborough Bay of 450 tons/year.

Port Manatee shipped almost 200,000 tons/year of phosphate rock and fertilizer products during the period 1975-76 (Highland, 1993). Based on an estimated ratio of nitrogen-containing fertilizer products to total fertilizer material shipments of 40% (Highland, 1993) and the 0.05% loss rate, a fugitive loss rate of 39 tons/year was estimated for Lower Tampa Bay.

2.4 Atmospheric Deposition

Data from the National Atmospheric Deposition Program (NADP) and National Urban Runoff Program (NURP) were used to estimate atmospheric deposition of nitrogen and phosphorus for existing conditions. Neither of these programs were in existence in the time period of worst case loadings (mid-1970's). In addition, there was a general lack of measured precipitation chemistry data, and the characteristics of this nutrient source, especially dryfall, were much less understood than currently. Therefore, it was necessary to identify either 1) precipitation chemistry data collected from that period, or 2) a trend analysis to relate either emissions or deposition from that period to existing conditions levels.

No representative, reliable precipitation chemistry data from the mid-1970's were identified. However, the document "National Air Pollutant Emission Trends, 1900-1992" (EPA, 1993) contains a trend analysis for NO_x emissions from 1900 to 1992. Based on this report, nation-wide NO_x emissions increased steadily from the turn of the century until the early 1970's, and have remained at about the same levels since then. This finding is also documented in other nation-wide trend analysis reports (USEPA, 1991; U.S. Congress Office of Technology Assessment, 1984).

The assumption was made that 1) changes in NO_x emissions are proportional to total atmospheric deposition, and that 2) the national trend is representative of conditions in the Tampa Bay watershed. These assumptions were made because of the lack of regional data, and because atmospheric deposition is thought to be much more responsive to large scale transport processes, and not local conditions. Based on these factors, atmospheric deposition for the mid-1970's scenario was made equal to existing conditions levels.

2.5 Groundwater

Groundwater nutrient loads are a function of flow rate and concentration. Groundwater flows were estimated and measured nutrient concentrations were obtained for the existing conditions analysis. No data were identified that suggested that nutrient loading from groundwater was significantly different from existing conditions, and that would justify changing either flows or concentrations for future conditions. Monitoring data at some locations, such as springs, shows an increase in spring discharge concentrations of nitrogen (Jones, 1993). However, it must be noted that springs are geologically unusual, and, in the Tampa Bay watershed, are usually located in areas where the geology allows significant surface water infiltration into the ground. The geology of most of the watershed is such that the potential for surface water infiltration to groundwater is much less. In addition, groundwater loading of nutrients is estimated to be less than one-tenth of one percent of the total bay-wide TN loading for mid-1970's conditions. Therefore, it was assumed that existing condition groundwater loads would be appropriate, and were used for this analysis.

3.0 RESULTS

3.1 Bay-wide Loadings

Estimated bay-wide loadings of TN, TP,and TSS are shown in Figures 2, 3, and 4. Comparisons of estimated current (1985-91) to mid-1970's loadings are shown in Figures 5, 6, and 7. On a bay-wide basis, "worst case" (ie. mid-1970's) total nitrogen (TN) loading was estimated to be approximately 9,900 tons/year from all sources (Figure 2). In contrast, current (1985 - 1991) TN loads are estimated to be about 3,900 tons/year, a significant reduction. Similarly, mid-1970's TP loads are estimated to be approximately 4,000 tons/year, while current conditions loads are approximately 2,800 tons/year (Figure 3), and mid-1970's TSS loads are about 73,700 tons/year, to current conditions loads of approximately 40,500 tons/year (Figure 4). This represents a relative reduction from worst case conditions in bay-wide TN, TP, and TSS loadings of approximately 60%, 30%, and 45%, respectively. These load reductions are thought to be mainly the result of reduced point source loadings and lower fugitive emission loadings from phosphate handling facilities.

Point sources were estimated to contribute ten times (6,000 tons/year) the existing conditions TN load (600 tons/year) to Tampa Bay during the mid-1970's (Figure 5). Loadings from both domestic and industrial point sources were higher, based on the available data. However, it is believed that the point source loads, while much higher than for existing conditions, may have been underestimated in the cited literature for the mid-1970's period. This would be primarily a result of monitoring and reporting techniques and requirements, which were much less stringent than for subsequent time periods. Nonpoint source loadings were also estimated to be higher during that period, based on available information.

Fugitive emission TN loadings were also estimated to be higher during the mid-1970's (500 tons/year), than the existing conditions estimate of 300 tons/year. These external loads enter the bay at the East Bay (Hillsborough Bay) and Port Manatee (Lower Tampa Bay) phosphate shipping terminals. It should be noted that the data for the existing condition period covers the years 1985 - 1991. Significant reductions to several phosphate handling and loading facilities have occurred since 1991, most notably the IMC-Agrico Port Sutton facility, and additional reductions to this source are anticipated during the next several years.

Atmospheric deposition was assumed to be the same for both time periods (Section 2.4. Spring discharges and groundwater loadings are much smaller than other major sources of TN loading that were evaluated. Although these inputs can be expected to change with time, the expected variation in these loads is not significant with respect to the other sources (Section 2.5). Therefore, these loads were set to equal existing conditions for this analysis.

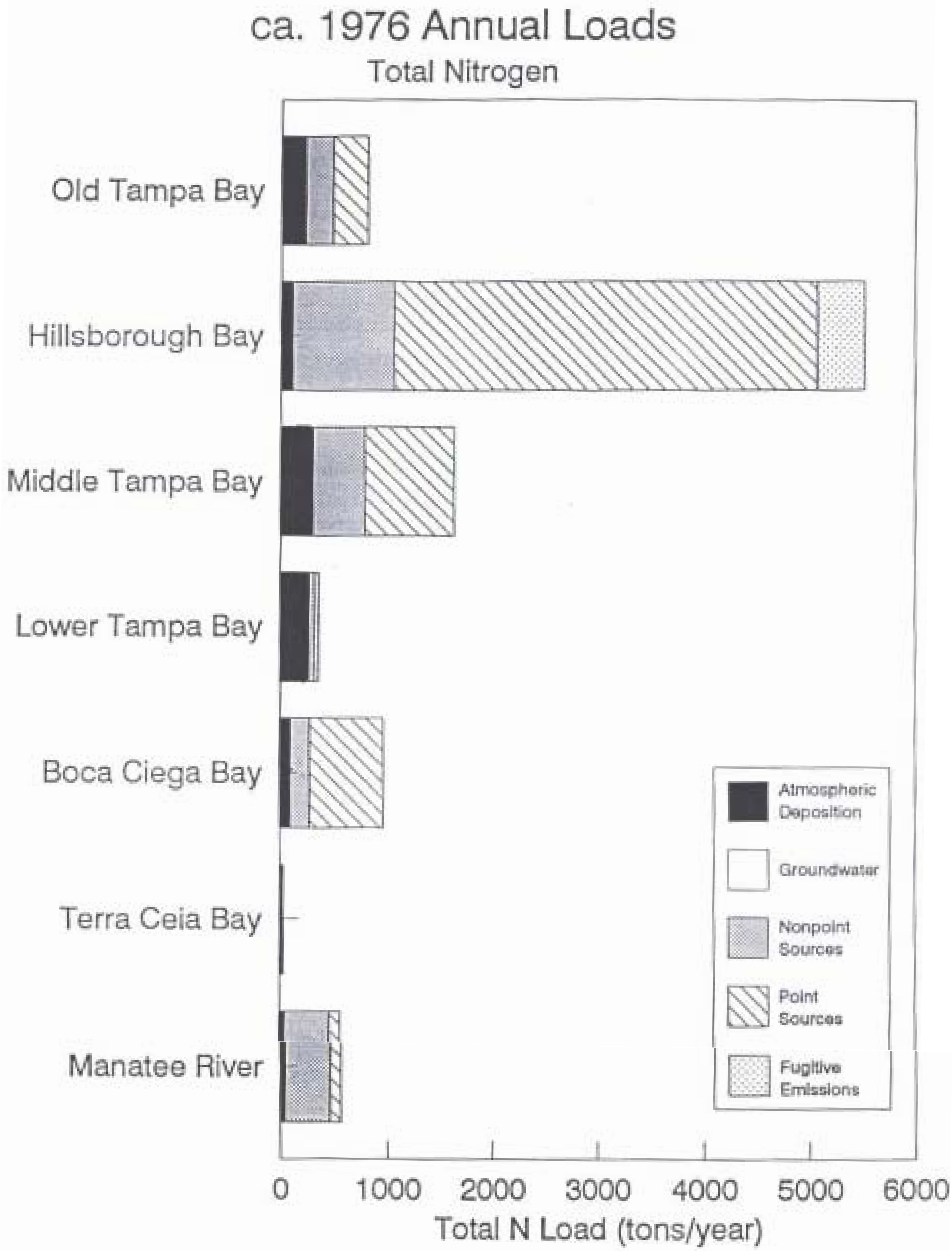


Figure 2 Circa 1976 Annual Loads - Total Nitrogen

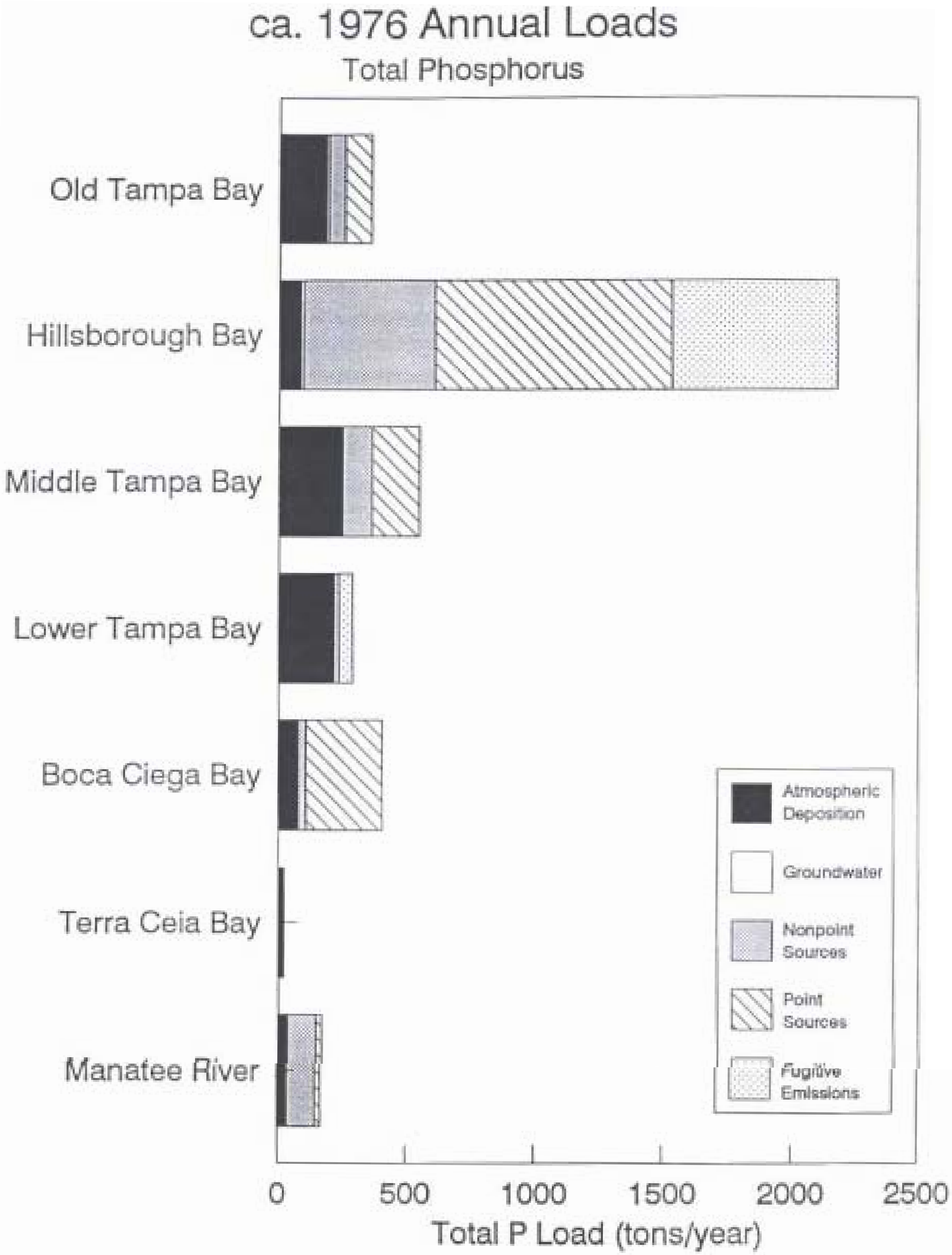


Figure 3 Circa 1976 Annual Loads - Total Phosphorus

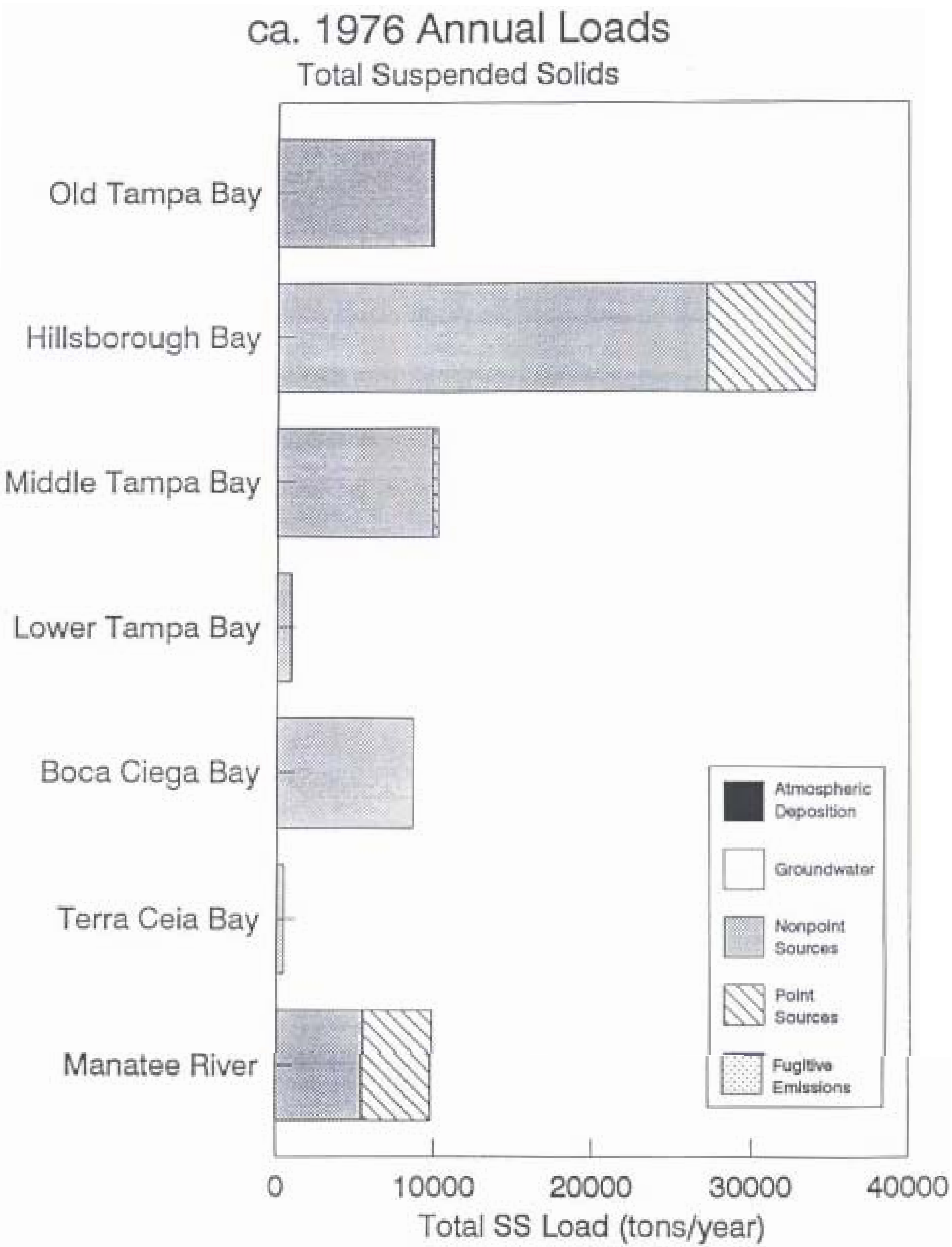


Figure 4 Circa 1976 Annual Loads - Total Suspended Solids

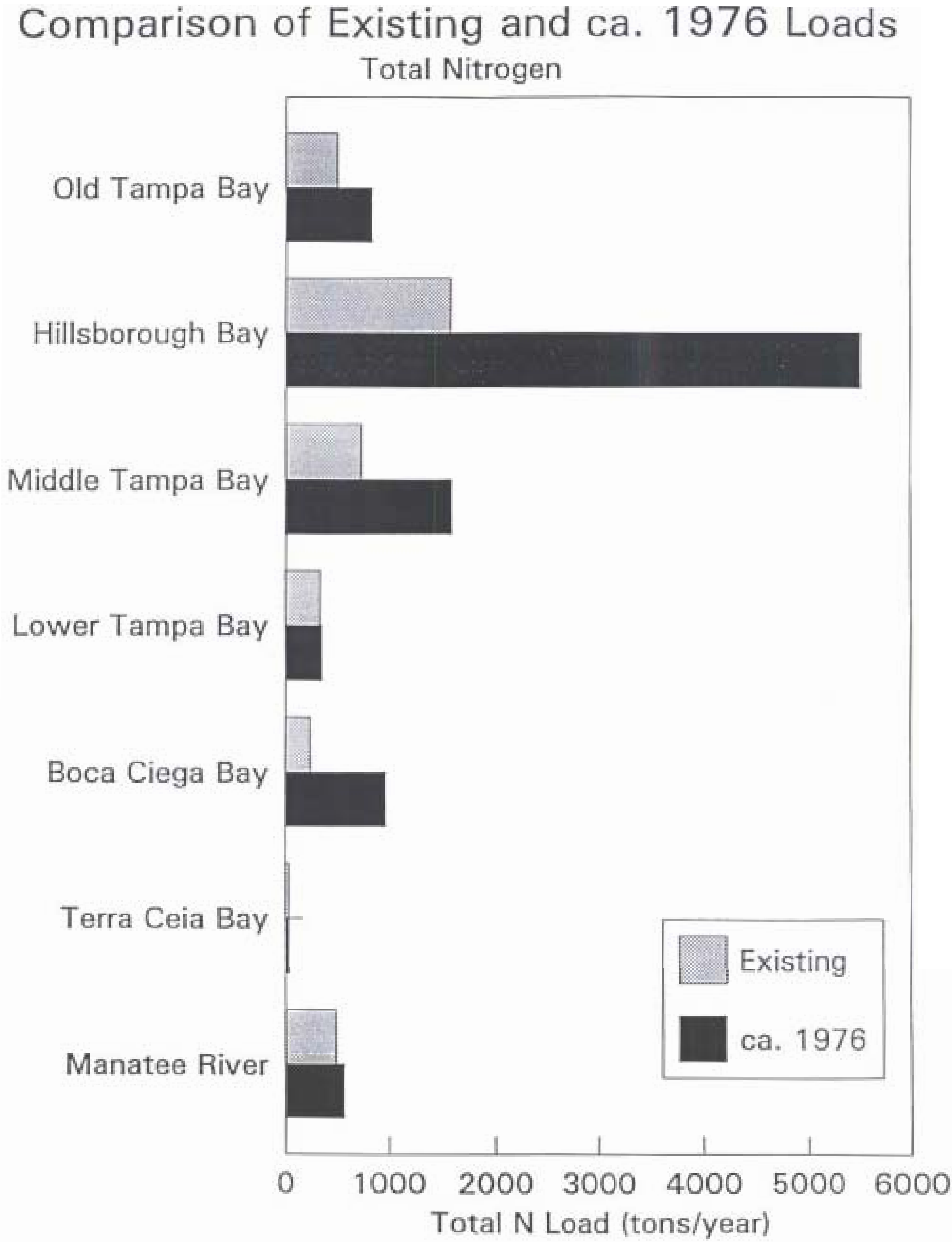


Figure 5 Comparison of Existing and circa 1976 Loads - Total Nitrogen

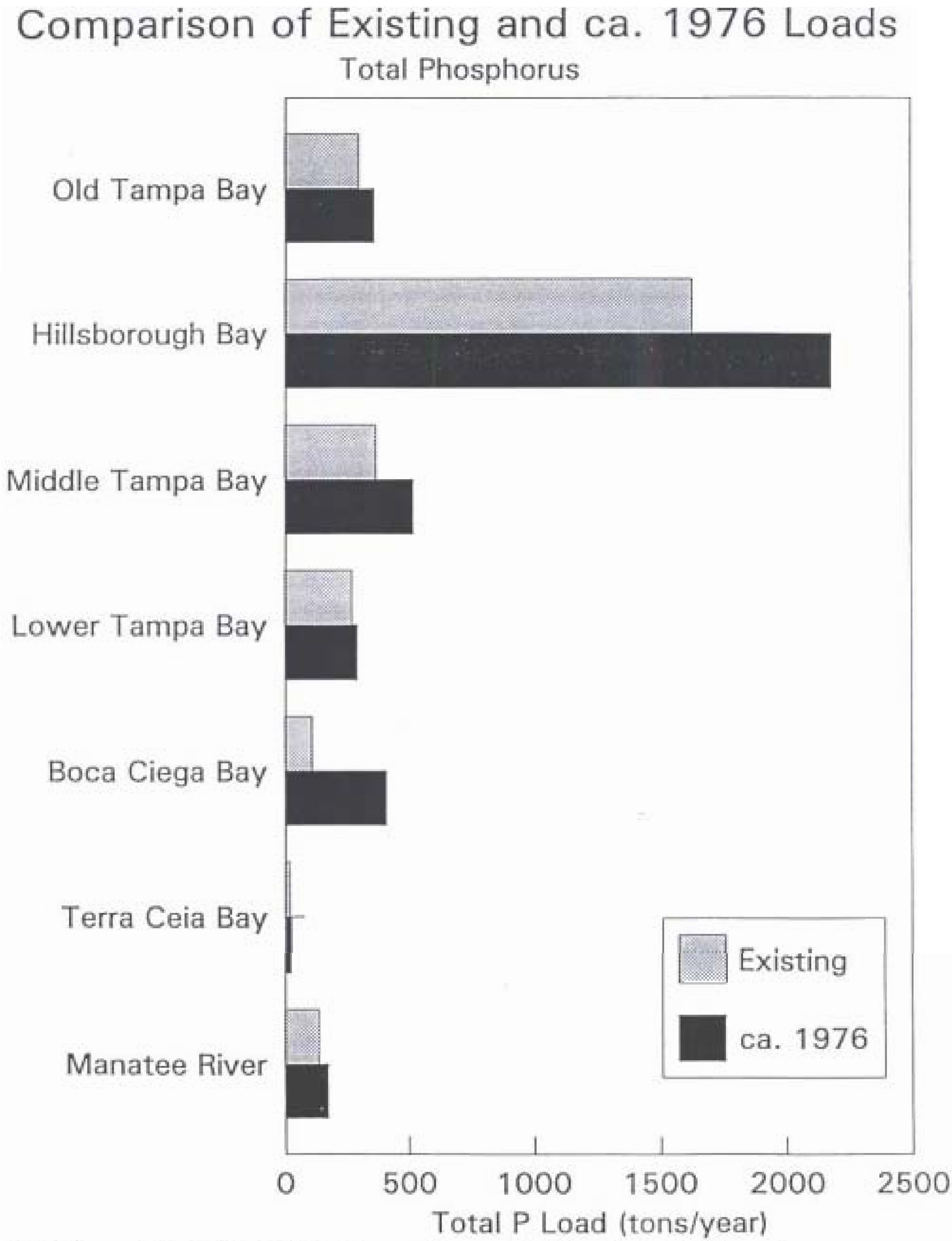


Figure 6 Comparison of Existing and circa 1976 Loads - Total Phosphorus

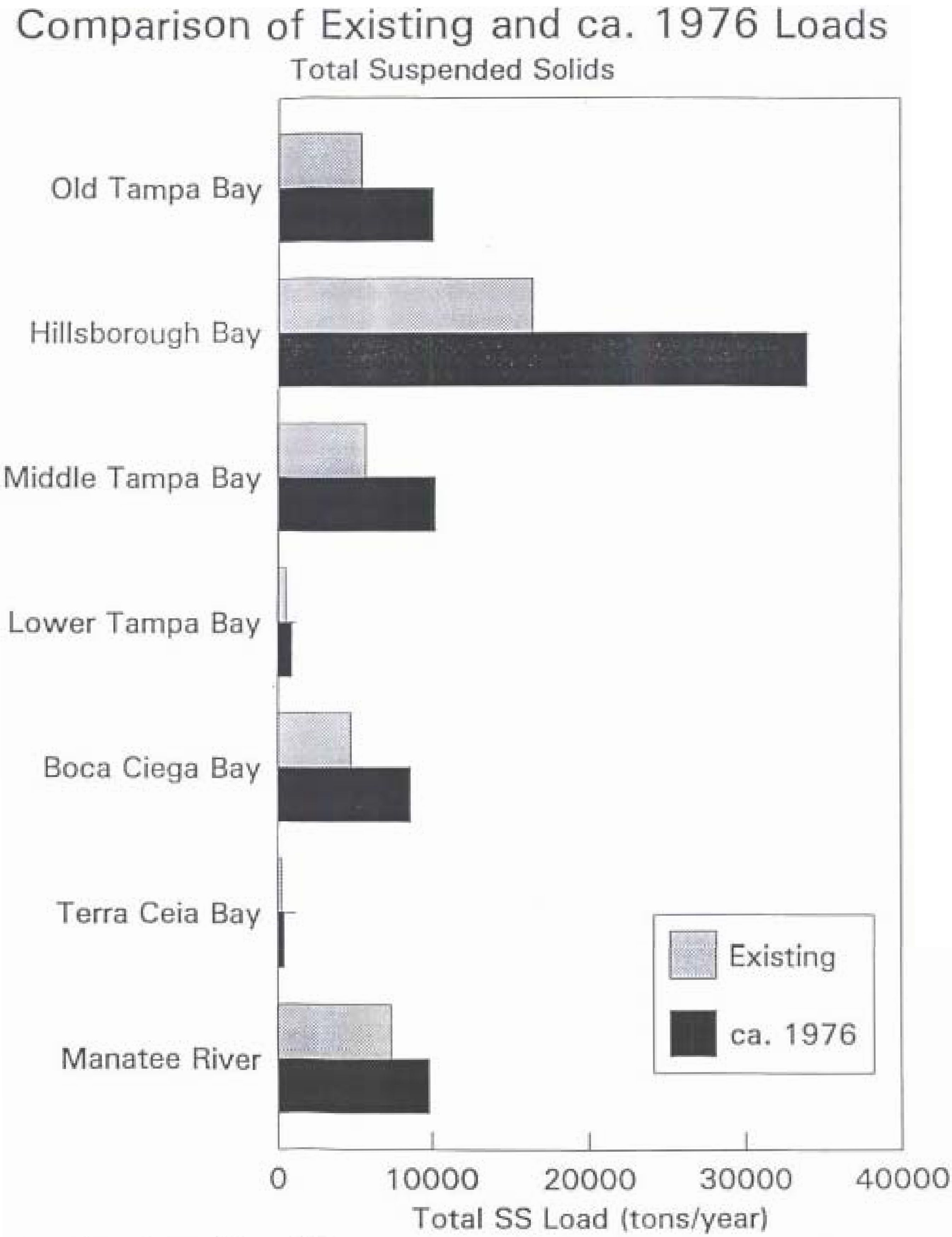


Figure 7 Comparison of Existing and circa 1976 Loads - Total Suspended Solids

Trends in estimated TP loadings were similar to those for TN (Figure 6). Estimated loadings from point sources, nonpoint sources, and fugitive emissions all were higher across the watershed during the worst case period. Of these, point source loadings changed the most, with mid-1970's TP loads estimated to be about twice existing conditions (1,500 tons/year to 800 tons/year).

Estimated TSS loads were also significantly higher for the mid-1970's estimates than for existing conditions (Figure 7). Bay-wide nonpoint source TSS loads for the mid-1970's (62,000 tons/year) were estimated to be almost twice current loads (34,600 tons/year). Similarly, point source TSS loads were estimated to be about two times higher for the mid-1970's estimates (11,600 tons/year) than for existing conditions (5,900 tons/year).

3.2 Bay Segment Loadings

TN loads to Old Tampa Bay are about 40% lower (about 320 tons/year difference) currently than during the mid-1970's. TP loads are about 13% lower currently, and TSS loads are estimated to be about 46% lower currently. These lower bay segment loadings are primarily attributable to reduced point source loads resulting from improved treatment levels at domestic wastewater treatment plants.

Hillsborough Bay received the highest TN loading of any bay segment during the mid-1970's. Hillsborough Bay alone received approximately 60% of the total bay-wide TN load. The greatest change in the magnitude of bay segment nitrogen loads also occurred in Hillsborough Bay, where external TN inputs have been reduced since the mid-1970's from an estimated 5,500 tons/year to about 1,500 tons/year. TN load reductions of this magnitude have also been documented by Johansson (1991). Of the major sources of TN, fugitive emissions are now lower by almost 180 tons/year and nonpoint source loadings are lower by about 150 tons/year. Mid-1970's point source loads (4010 tons/year) were estimated to be 90% higher than current loads (404 tons/ year), which represents an absolute reduction in TN of approximately 3,600 tons/year.

The greatest relative reduction in phosphorus loads also occurred in Hillsborough Bay (25%), a difference of approximately 550 tons annually. Fugitive emissions have been reduced an estimated 250 tons/year, nonpoint sources are slightly lower, and TP loads are now more than 200 tons/year less than during the mid-1970's.

Hillsborough Bay also experienced the greatest reduction in TSS load reduction to Tampa Bay. TSS loads are now less than half of the mid-1970's levels. TSS load reduction to this segment (approximately 17,600 tons/year), is about half of the total TSS load reduction for the entire bay between the mid-1970's and existing conditions. Much of this load reduction (about 12,000 tons/year) is attributed to nonpoint source loads. It is possible that the cited loading estimates for the mid-1970's overestimated nonpoint source loads (Section 2.1), and the comparison between periods therefore may not be strictly valid.

Middle Tampa Bay has experienced a large relative reduction in TN loadings, with mid-1970's loadings reported at approximately 1,630 tons/year and current loadings at 730 tons/year - a 55% decrease. Point sources contributed about half (800 tons/year) of the total nitrogen load to Middle Tampa Bay in the mid-1970's, mainly from surface discharge of domestic wastewater and phosphate facilities. However, as a result of wastewater reuse programs and improvements to industrial permitting, that contribution is now under 5% (less than 25 tons/year). TP also has been significantly reduced, and TSS loads are now about 44% lower than during the mid-1970's.

TN loads to Lower Tampa Bay are estimated to have experienced virtually no change. TP loads are now slightly lower, and TSS loads are estimated to be approximately 45% lower. During the mid-1970's, Lower Tampa Bay received approximately 7% of the TN load, about 13% of the TP load, and less than 3% of the TSS load of Hillsborough Bay.

Boca Ciega Bay has had its TN load reduced from an estimated 970 tons/year during the mid-1970's to almost 250 tons/year (a reduction of almost 75%). Although the relative reduction in TN loading for Boca Ciega Bay is greater than Hillsborough Bay's, Hillsborough Bay accounts for a much greater absolute reduction in tonnage of nitrogen - almost 4,000 tons/year versus about 500 tons/year for Boca Ciega Bay.

TN, TP, and TSS loads to Terra Ceia Bay were all estimated to have been higher during the mid-1970's. TN and TP loads show little change between the two periods (36 versus 37 tons/year, and 18 versus 23 tons/year, respectively). TSS loading for mid-1970's conditions (450 tons/year) was almost double existing conditions (250 tons/year).

The Manatee River bay segment is also estimated to have experienced reductions in TN, TP, and TSS loads since the mid-1970's. TN loads are estimated to have been *reduced by about 80 tons/year, TP loads are estimated to be approximately* 35 tons/year less currently than during that time period, and TSS loads are approximated to be about 2,500 tons/year less under existing conditions.

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APPENDIX 14

ESTIMATED NUTRIENT AND SUSPENDED SOLIDS LOADING

TO TAMPA BAY FOR FUTURE CONDITIONS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The final nutrient loading scenario described in this report is an estimate of TN, TP, and TSS loads for future conditions. These loading estimates are intended to be used as input data for the SWFWMD SWIM box model (WASP), to evaluate the bay's response to increased levels of nutrient and suspended solids inputs. These estimates of the relative increases in loadings to the bay will be used to estimate Tampa Bay's assimilative capacity with respect to nitrogen and phosphorus.

The time period for this analysis is circa 2010, and was chosen mainly because that period is a typical planning horizon for growth management and infrastructure demands for water and wastewater flow projections, future land use scenarios, and population estimates. All major potential nutrient and solids loading sources were addressed.

It is estimated that the population of the Tampa Bay watershed will grow from a current level of about 1.7 million residents to over 2.2 million by the year 2010 (University of Florida, 1993). This growth will result in additional urban development, wastewater facilities, roadways, industrial activity and other factors than have the potential to increase TN,TP, and TSS loadings to the bay. However, water use, stormwater, and other environmental regulations, water reuse measures, and other resource conservation actions may partially offset the potential increase in loads to the bay. The following describes methods that were used to make estimates of TN, TP, and TSS loadings to the bay. The methods and assumptions used to make these loading estimates attempt to account for both the increased urbanization, and the management and regulatory activities that are intended to partially mitigate the resultant higher nutrient and solids loadings to Tampa Bay.

2.0 METHODS

2.1 Nonpoint Sources

Future conditions nonpoint source loads were estimated using techniques similar to those used to calculate existing condition nonpoint source loadings, described in Sections 2 and 3 of the main report. GIS coverages for land use and subbasin boundaries, monthly precipitation values and land use-specific runoff coefficients and water quality values were used. Using long-term average precipitation conditions, average monthly values for one calendar year of future condition nonpoint source loadings of TN, TP, and TSS were estimated for each of the ten major subbasins in the Tampa Bay watershed. The nonpoint source loading from the entire watershed was modeled, as described below.

Land use - An ARC INFO GIS coverage of future conditions land use for Hillsborough County, Pinellas County, Manatee County, and Pasco County was obtained from Tampa Bay Regional Planning Council (TBRPC). Future land use for the portion of Polk County within the Tampa Bay watershed was obtained from the Polk County Planning Department, and incorporated into the regional map for a complete coverage of the watershed.

The future land use map is a conceptual planning tool. It depicts areas that are most appropriate for future development, and are most likely to be developed. The TBRPC future conditions land use map, (developed with reference to the year 2010) does not show what land use planners expect to be the actual extent of development in the year 2010. Rather, it shows the most intensive land use that is deemed appropriate for areas of the planning area, if developed by that time. Therefore, the future land use map may be thought of as a "buildout" condition land use scenario.

The future land use map is not intended to show a detailed delineation of land uses at the same scale, and was not produced at the same level of detail, as the existing conditions land use map. Subsequently, if the TBRPC future land use map were used *- as is - in place of the existing land use map (which is based on aerial photography* and is very detailed), much inaccuracy would be introduced into the nonpoint source modeling. Therefore, a methodology was developed to revise the more detailed existing land use map to reflect future conditions. This procedure included the following steps:

1) Some existing land uses were expected to remain the same for future conditions, irrespective of the future land use map delineations. For example, it was assumed that environmental permitting would result in the preservation of most areas within the land use classifications of freshwater (lakes, rivers,

etc.), freshwater wetlands, and saltwater wetlands. Therefore, areas within these land use categories remained unchanged from existing conditions.

2) The remaining land use categories were reviewed to determine the relative intensity of development for each, and the per-acre nitrogen loading that each land use category would generate. Estimates of land use-specific nitrogen loadings were based on the methods used for the existing condition analysis. The land uses were then ranked according to the per-acre nitrogen load, the highest loading being ranked first. Land use-specific loadings are a function of runoff coefficient and measured water quality concentrations. Runoff coefficients and land use-specific water quality concentrations are shown in Appendices 2 and 4.

3) The existing conditions land use map was electronically merged with the future conditions land use map.

4) These procedures were then followed:

- If the future land use map showed a land use with a higher per-acre nitrogen yield that the existing land use map, the land use was changed to the future condition (with the exceptions listed above).

- If the future land use map showed a land use with the same or lower per-acre nitrogen loading than the existing land use map, that land use remained the same as existing conditions.

The result of this mapping technique was that, subsequent to comparing existing and future land uses for the watershed, the land use condition with the higher nitrogen load was used, and land uses with lower nitrogen loads were changed (with the exceptions listed above).

5) The resultant land use coverage was used for the future condition nutrient loading analysis. This coverage included all wetlands delineated on the existing land use map, and either the existing or future land uses, depending on which land use of the existing/future map overlay had the highest per-acre nitrogen loading yield. Several sources of uncertainty limit the predictive value of this analysis, including the uncertainty of future land use growth rates and land development patterns and the unknown future condition of certain land use types, such as mined lands.

Major basin boundaries - The current SWFWMD GIS subbasin boundary coverage for the Tampa Bay watershed, described in Section 2 of this report, was used for this portion of the data base. No alterations were made to this coverage. TN, TP, and

TSS loadings were completed for each of the ten major drainage areas within the Tampa Bay watershed.

Precipitation - Long-term National Weather Service rainfall data for the watershed was used to develop average monthly rainfall for the watershed. The monthly values were used to generate monthly streamflow and nonpoint source load estimates using the same techniques that were employed to generate existing conditions nonpoint source loads. Estimates of TN, TP, and TSS nonpoint source loads were generated for the ten major Tampa Bay watershed basins. Because current and historical rainfall trends may vary in the future, estimates of nonpoint source loads based on existing rainfall records may ultimately prove to be inaccurate.

Nonpoint source loads and treatment efficiency coefficients - Nonpoint source loads of TN, TP, and TSS were developed for future conditions land uses, following these procedures:

- The existing conditions runoff coefficients and water quality concentrations, described in Section 2 of this report and summarized in Appendices 2 and 4, were used to develop initial loadings for the future conditions land uses.

- Loadings were adjusted on a land use-specific basis to account for stormwater treatment of runoff from new urban development. Based on the land use transformations described above, nonpoint source loads from new urban land (land which was not categorized as urban for existing conditions, but is shown as urban on the future land use map), were reduced by a factor representing average stormwater best management practices (BMP) treatment efficiencies. Treatment efficiencies were adapted from the SWIM Tampa Bay Urban Stormwater Analysis and Improvement Study (Dames & Moore, 1991), and are representative of average treatment efficiencies for a variety of BMPs. The treatment efficiencies are shown in Table 1.

Table 1 Stormwater best management practices treatment efficiencies

Parameter	Pollutant Removal Rate (%)
Total Nitrogen	30
Total Phosphorus	50
Total Suspended Solids	80

These stormwater treatment efficiencies were applied to some of the land uses that occur in the future land use coverage, described above. No treatment was allotted to existing urban land uses that occurred on the final future land use coverage, because this development may or may not have pre-dated requirements for stormwater management (1984). Existing condition urban land uses were not analyzed to determine the relative proportion that had been developed with stormwater treatment. Likewise, no treatment was given to freshwater or wetland areas. The only areas that were afforded water quality treatment were those lands with lower nitrogen loadings that changed to higher nitrogen loadings on the final future land use coverage. This included such conditions as agricultural lands that changed to urban, or urban lands that changed to other urban land with higher nitrogen loading.

It should be noted that existing conditions land use-specific water quality concentrations have been used for the future conditions nonpoint source loadings. These values may vary substantially for future conditions, and are subject to changes in development patterns, permitting requirements, or stormwater treatment facility efficiencies. Additionally, that portion of atmospheric deposition that is delivered to the watershed has been included in the nonpoint source portion of the total loading estimates. If, as is assumed for atmospheric deposition that is delivered directly to the bay, deposition rates increase over the next decades, then the existing runoff water quality concentrations may underestimate future conditions. These factors introduce a relatively high level of uncertainty in the nonpoint source loading estimates for future conditions.

2.2 Point Sources

2.2.1 Domestic Point Sources

The existing conditions domestic point source loading data base was revised to reflect probable future conditions, as shown in Table 2. Revisions included:

- changing the flow rates at individual plants to reflect projected future conditions,
- changing loading estimates from individual plants to reflect changes to treatment levels or effluent disposal methods,
- removal of all flows and loads from small plants planned to be taken out of service during the next twenty years, and
- addition of flows and loads from planned new plants.

Table 2 Projected status of domestic point sources circa 2010 (Page 1/3)

Facility Name	Future Conditions Status and Information Source
Dale Mabry Regional	Flows revised per Hillsborough County Planning and Development Management (HCPDM) (SD, LA)
Pebble Creek Village	Flows revised per HCPDM (SD)
Plant City	Flows revised per City of Plant City Dept. of Public Works (IR)
Valrico Subregional	Flows revised per HCPDM (LA)
Bloomingdale Hills	No flow, connect to regional plant (HCDPM)
Boyette Springs	No flow, connect to regional plant (HCDPM)
Faulkenburg	Flows revised per (HCDPM) (50% IR, 50% LA)
City of Tampa Hookers Point	Flows revised per City of Tampa Dept. Sanitary Sewers (SD)
MacDill AFB	No flow, connect to Hookers Point (HCDPM)
Hills. Co. NW Regional	Flows revised per HCPDM (LA, SD)
Progress Village	No flow, connect to regional plant (HCDPM)
Rice Creek	No flow, connect to regional plant (HCDPM)
River Oaks	Revised flow per HCPDM (SD, LA)
River Hills Country Club	No flow, connect to regional plant (HCDPM)
Seaboard Utilities	No flow, connect to regional plant (HCDPM)
Summerfield Regional	Flows revised per HCDPM) (LA)
South Hills. Co. Regional	Flows revised per (HCDPM) (LA, IR)
City of Palmetto	Flows revised per City of Palmetto Utilities Dept. (LA)
Manatee County North Regional	Flows revised per 1990 master plan (Manatee County Public Works Dept. - MCPWD) (LA)
Manatee County SE Regional	Flows revised per 1990 master plan (MCPWD) (LA)

Table 2 (continued) Projected status of domestic point sources circa 2010 (Page 2/3)

Facility Name	Future Conditions Status and Information Source
City of Bradenton	Flows revised per plant staff - City of Bradenton Public Works Dept.(SD, LA)
City of Mulberry	No flow - hookup to Lakeland WWTP (FDEP)
Meadowlands	No flow - hookup to Lakeland WWTP (FDEP)
City of Lakeland	Flows revised per FDEP (LA, SD)
City of Oldsmar	Flows revised per City of Oldsmar Public Works Dept. (LA)
City of Largo	No change (City of Largo Public Works Dept.)
City of Clearwater NE	Flows revised per City of Clearwater Public Works Dept. (SD)
City of Clearwater East	Flows revised per City of Clearwater Public Works Dept. (SD)
Top of the World	No change per City of Clearwater Public Works Dept. (LA)
City of St. Petersburg SW	Flows revised per City of St. Petersburg Public Utilities Dept. (LA)
City of St. Petersburg NE	Flows revised per City of St. Petersburg Public Utilities Dept. (LA)
City of St. Petersburg Albert Whitted	Flows revised per City of St. Petersburg Public Utilities Dept. (LA)
City of St. Petersburg NW	Flows revised per City of St. Petersburg Public Utilities Dept. (LA)
Pine Ridge	No flow, connect to regional plant, per Pinellas County Sewer System Dept.
Tarpon Woods	No flow, connect to regional plant, per Pinellas County Sewer System Dept.
Tarpon Lake Village	No flow, connect to regional plant, per Pinellas County Sewer System Dept.

Table 2 (continued) Projected status of domestic point sources circa 2010 (Page 3/3)

Facility Name	Future Conditions Status and Information Source
Eastlake Woodlands	No flow, connect to regional plant, per Pinellas County Sewer System Dept.
South Cross Bayou	Flows revised, per Pinellas County Sewer System Dept. (75% LA, 25% SD)

NOTES: SD = surface water discharge
IR = industrial reuse
LA = land application (spray irrigation/reuse or percolation pond)

Flow rates were adjusted using data provided by local governments' utilities planning departments, as shown in Table 2. Flow rates under future conditions were estimated based on projected population growth in the local jurisdictions and per capita water use volumes, and were taken from wastewater master plans and comprehensive plans. The planning horizon for this information is most often the year 2010, so the estimates obtained from the local agencies were used without revision.

Although no major treatment plants are scheduled to undergo significant improvements to current treatment methods, several plants are scheduled to convert their effluent disposal systems to include water reuse capabilities. This could have several implications with respect to the water balance, water quality, and flushing rates in some bay segments, including:

- Reuse of highly treated effluent will reduce the demand on potable water for such uses as landscape irrigation and industrial process water.
- Application of the effluent on landscaped areas will enhance nutrient uptake and reduce nutrient loading to the bay from these sources.

Local utilities planners have scheduled several small private or public treatment plants to be taken out of service over the next two decades, and the service areas of larger plants to be expanded to serve these areas. Hillsborough County and Pinellas County in particular are taking aggressive actions to upgrade sewer service by connecting areas currently served by small package plants to regional plant systems. Because the larger plants generally have better quality effluent and are planning to implement reuse options, this will have the overall effect of reducing nutrient loading to the bay, despite larger plant flows. Not all projected population growth in the watershed can be accommodated by existing treatment plants. Hillsborough County has a new regional plant scheduled for construction during the near future. This plant has been included in planning estimates of flows and service area, and is included in the future condition point source loading estimates. It should be noted that potential changes in future operation levels and demands for service may significantly alter the estimates of future TN, TP, and TSS loadings.

2.2.2 Industrial Point Sources

Projected future condition industrial flows are less readily available than domestic point source data. Because industrial activity and resultant plant flows are driven by a variety of factors, it is not possible to accurately predict future flows from many facilities. However, projections of future levels of activity for some industries are available, and some major industrial plants have very recently completed, are currently completing, or plan to make significant changes to wastewater treatment levels or effluent disposal methods. Based on interviews with industry and regulatory personnel, some changes were made to industrial flows and loadings.

Several industrial facilities that had permitted discharges during the 1985 - 1991 period either now have no discharge, or will have no direct discharge by 2010. This may be a result of several conditions, such as sending effluent discharges to a regional sewer plant, converting the effluent discharge to land application or reuse, or the facility ceasing operations. Based on discussions with FDEP, the following industrial facilities, all within the Hillsborough River watershed, were assigned zero discharge for the future conditions analysis:

- CF Industries - Plant City Chemical Plant
- Crystals International, Inc.
- Florida Sno-man, Inc.
- Erly Juice, Inc.
- CSX Transportation Winston Yard.

The Nitram chemical plant in the Coastal Hillsborough basin is preparing its application for the renewal of its state discharge permit by 1995. Discussions with FDEP staff reveal that under currently negotiated conditions, permit compliance will require that Nitram limit its average daily discharge to 25 pounds of TN per day. Therefore, this limit was used for the future TN loading from this individual industrial facility.

The Tropicana plant in Bradenton is another major industrial facility in the watershed. This plant has long been a source of high TSS and nutrient loadings to the Manatee River. Under an agreement with FDEP, the plant will limit its discharges to 50 pounds of TN per day during the plant's active months (June through November), as established in the Water Quality Based Effluent Limitation (WQBEL) Study for the

Manatee River (DeGrove, 1986). In addition, Tropicana has recently completed construction of an on-site process water treatment plant, and now provides secondary treatment to all industrial effluent prior to off-site discharge. Two quarterly samples taken since the plant began operation have been reported to FDEP, and both are within the 50 pound per day limit for TN, so this value is assumed to be a valid future condition TN load for Tropicana. For the months other than those addressed by the new permit conditions, average existing conditions effluent discharges are used to represent future conditions.

The phosphate industry is a major industrial source of nutrient and solids loadings to Tampa Bay. Discussions with Florida Phosphate Council staff (1994) indicate that industry analysts project very modest growth (one to two percent per year) over the next ten to fifteen years. Although some growth is forecast, it is anticipated that enhanced compliance with state and local regulatory requirements will offset any increases in industry activity in terms of TN, TP, and TSS loadings. Therefore, permitted discharges from all phosphate facilities were held at current levels for the future conditions analysis.

2.2.3 Springs

Nutrient loads from springs vary as a function of flow and concentration. Measured flow and water quality data were obtained for the period 1985 - 1991 for the current conditions loading analysis. Spring discharge rates vary based on rainfall and nearby groundwater pumping, and the water quality of these discharges will reflect various sources of nutrients in the watershed (such as fertilizer and effluent land application). Although resource managers recognize the potential for higher nutrient loads from springs based on increased pollutant inputs from septic tank effluent, fertilizer, and other sources (Jones and Upchurch, 1993), no data were identified to allow future TN,TP, and TSS loadings from springs to be predicted. Therefore, it was assumed that average monthly nutrient and solids loadings from springs would be used for the future conditions analysis.

2.3 Fugitive Losses of Fertilizer

A significant source of nutrient loadings associated with the phosphate industry is fugitive emissions - the unregulated loss of phosphate rock and fertilizer products resulting from the handling and transportation of these materials. Within the past two years, a few of the phosphate loading dock facilities (most notably, IMC-Agrico) have completed major improvements to stormwater management and dust suppression systems and general facility upkeep that have greatly reduced the amount of nutrients entering the bay from these sources. Historical losses of fertilizer products have been estimated to range from 0.05% to 0.02% of product shipped (Cardinale and Dunn, 1991; Johansson, 1991; Morrison and Eckenrod, 1994). However, fugitive losses from two phosphate processing and handling facilities (IMC-Agrico) which have substantially reduced these releases is estimated to be, as of 1993, about 0.002-percent of product shipped - equivalent to a ten-fold reduction in nutrient loading to Tampa Bay from these facilities (IMC-Agrico, 1994).

Local and state agencies are currently working with the industry to achieve similar reductions in fugitive emissions at all loading facilities. Based on the above analysis, the future condition loading estimates for fugitive emissions sets the loss rate for the two IMC-Agrico facilities at the current rate (0.002-percent). Because the other five loading facilities, unlike the two IMC-Agrico sites, do not have the land available to retain entire stormwater volumes, it is anticipated that reaching the 0.002-percent loss rate may not be feasible. However, because of commitments by the companies involved to reduce fugitive losses at these sites, a future loss rate of 0.004-percent was assumed to be appropriate for the future loading analysis. Sources of uncertainty with these loading estimates include projecting the relative level of activity of the phosphate industry in the future, and the difficulty in characterizing this source of nutrient loads.

2.4 Atmospheric Deposition

Atmospheric deposition can change based on rainfall patterns, and the rate of emissions of material into the atmosphere. If it is assumed that average rainfall will occur, then projected increases in atmospheric emissions can be used to estimate future conditions. Recent research by the Environmental Defense Fund (Fisher, 1988) suggests that atmospheric nitrate emission, which originates mainly from power plants (stationary sources) and motor vehicles (mobile sources), will continue to increase in the future. Emission rates for the southeast region of the United States are projected to increase from a 1989 level of 0.42 million tons/year to 0.63 million tons/year in the year 2010, a 50-percent increase. This projected increase was assumed to apply for all forms of atmospheric deposition of nutrients, and the future condition atmospheric deposition loads of TN and TP were estimated by multiplying existing condition loads by 1.5. Because estimates of future conditions loadings are based on historical and current conditions, changes in economic and environmental conditions may greatly alter these projections.

2.5 Groundwater

Like springs, described above, groundwater nutrient loads are a function of flow rate and concentration. Groundwater flows were estimated and measured nutrient concentrations were obtained for the existing conditions analysis. No methodologies were identified that would justify changing either flows or concentrations for future conditions. Therefore, it was assumed that existing condition groundwater loads would be appropriate, and were used for the future conditions analysis.

3.0 RESULTS

The results discussed below are based on available data and interviews with public and private organizations' staff. It should be noted that additional refinements, that were not included in the scope of work for this project, are possible. These refinements include a more detailed evaluation of future land use conditions, a verification of future industrial point source discharges, and possibly other improvements to existing data sources.

The loadings discussed below are sound general estimates of the projected relative increases in TN, TP, and TSS loadings to Tampa Bay. By completing the above refinements to these future loading estimates, an additional level of certainty could be assigned to the absolute magnitude of the estimates.

3.1 Bay-wide Loadings

On a bay-wide basis, TN loadings for future conditions (circa 2010) were estimated at approximately 5,800 tons per year from all sources (Figure 1), a significant increase over the existing conditions (1985-1991) TN load of 3,900 tons/year. Bay-wide existing and future TP loadings were estimated to be approximately 2,800 and 3,400 tons/year, respectively (Figure 2). Existing conditions TSS loads totalled about 40,500 tons/year, while future conditions were estimated at 74,000 tons/year (Figure 3). This represents estimated relative changes in TN, TP, and TSS loads to Tampa Bay of approximately 45%, 20%, and 80%, respectively, between existing and future conditions.

Contributing to these changes are nonpoint source loads, which were estimated at levels almost 70% higher for future conditions, atmospheric deposition (50% higher), and point source loads (40% higher). Fugitive emissions were approximately 90% lower, based on projected improvements to phosphate loading facilities. On an absolute scale, the major contributors to the projected increases in TN loadings are nonpoint sources (estimated at a 1,300 tons/year increase), atmospheric deposition (500 tons/year increase), and point sources (over 200 tons/year increase). Fugitive emissions totalled less than 5 tons/year TN, down significantly from almost 300 tons/year for the existing conditions load.

Bay-wide nonpoint source TN loading for future conditions was estimated to be the most significant contributor of future nonpoint TN loads in terms of absolute magnitude (Figure 4). This is a function of land use changing from agriculture to urban, based on the TBRPC future land use map, with the resultant higher per-acre loads. The actual change in nonpoint source loads for future conditions may vary from these estimates if development does not attain the future conditions shown on the future land use map obtained from TBRPC, or if stormwater treatment facilities vary from literature values for treatment efficiencies.

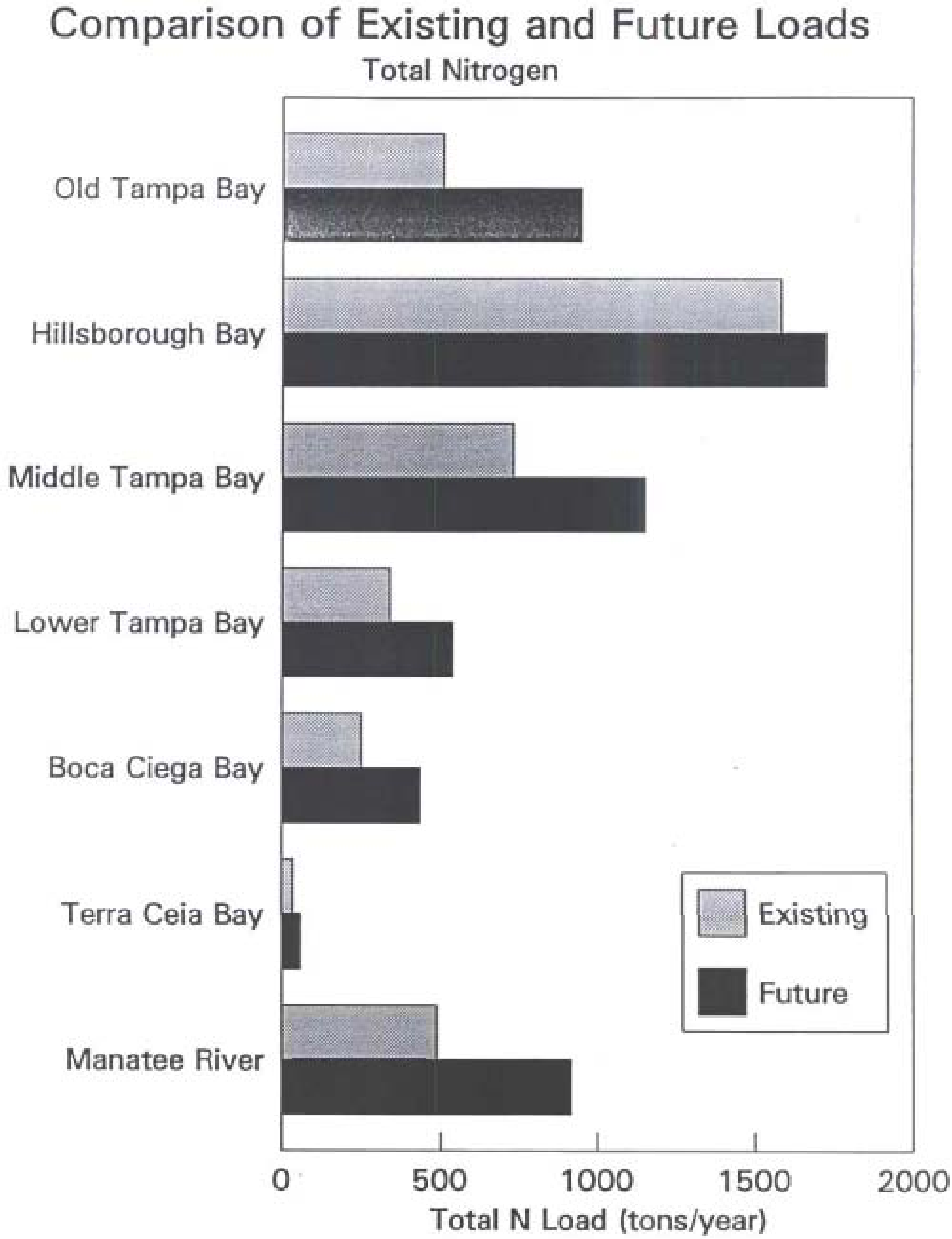

Figure 1 Comparison of Existing and Future Loads - Total Nitrogen

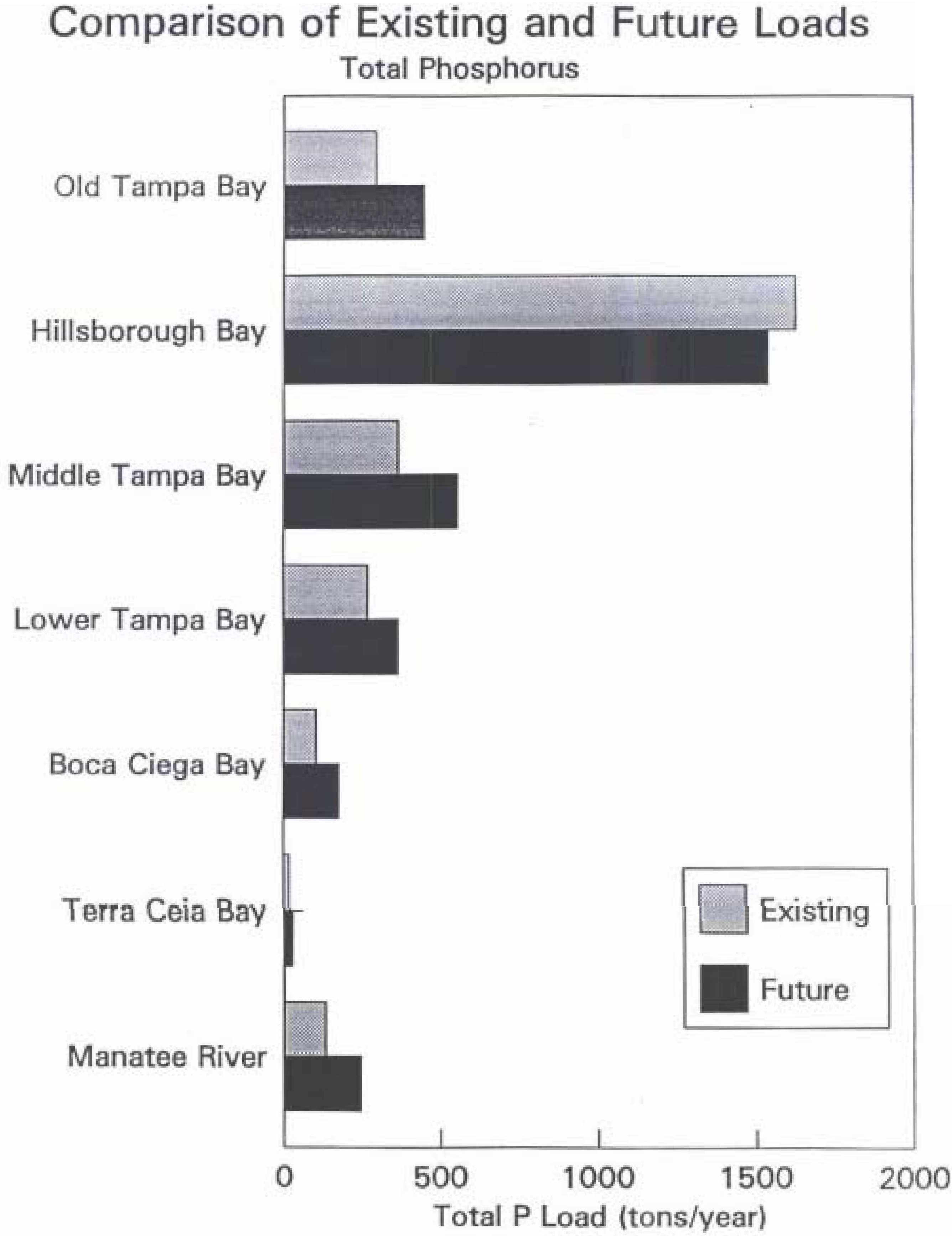

Figure 2 Comparison of Existing and Future Loads - Total Phosphorus

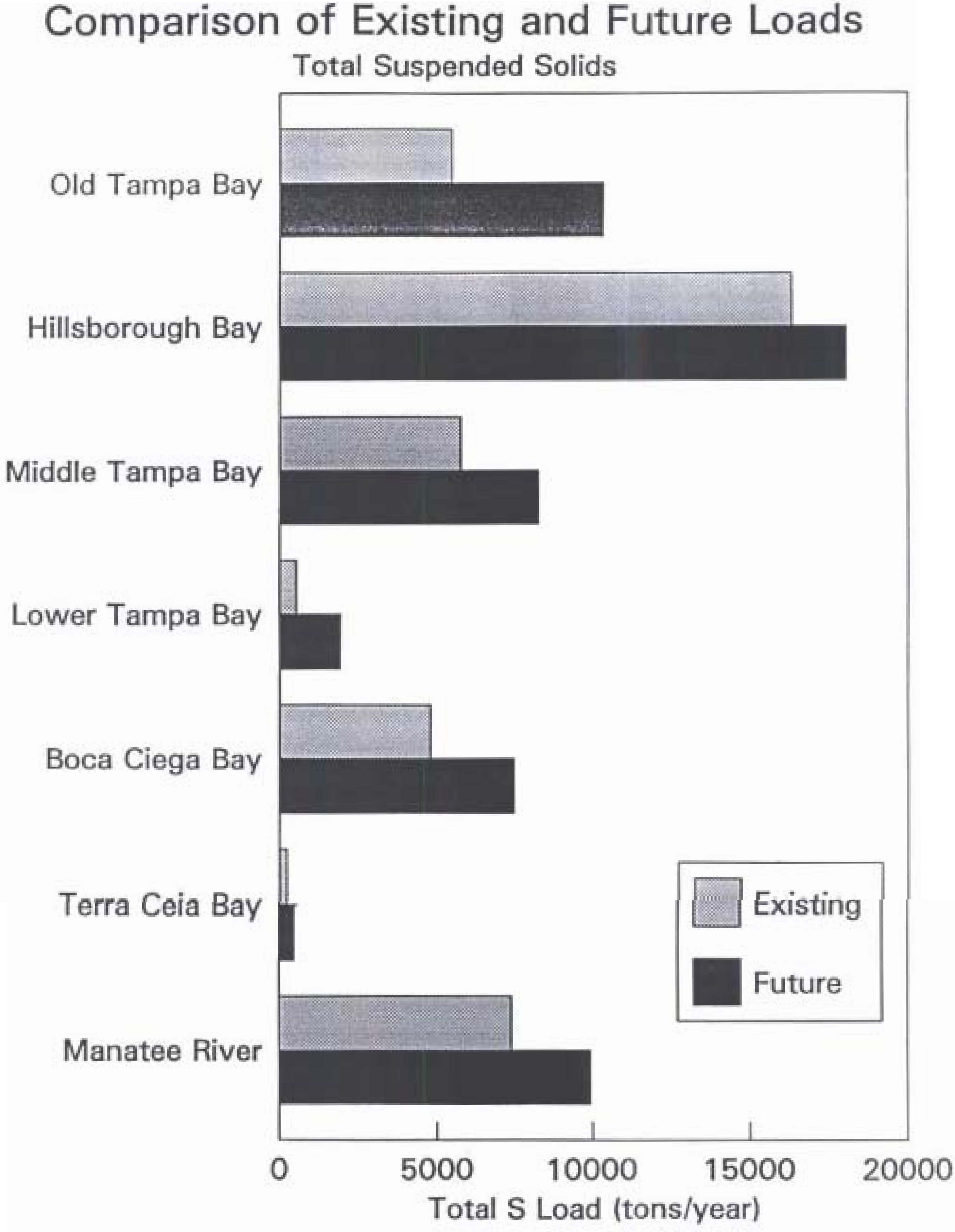

Figure 3 Comparison of Existing and Future Loads - Total Suspended Solids

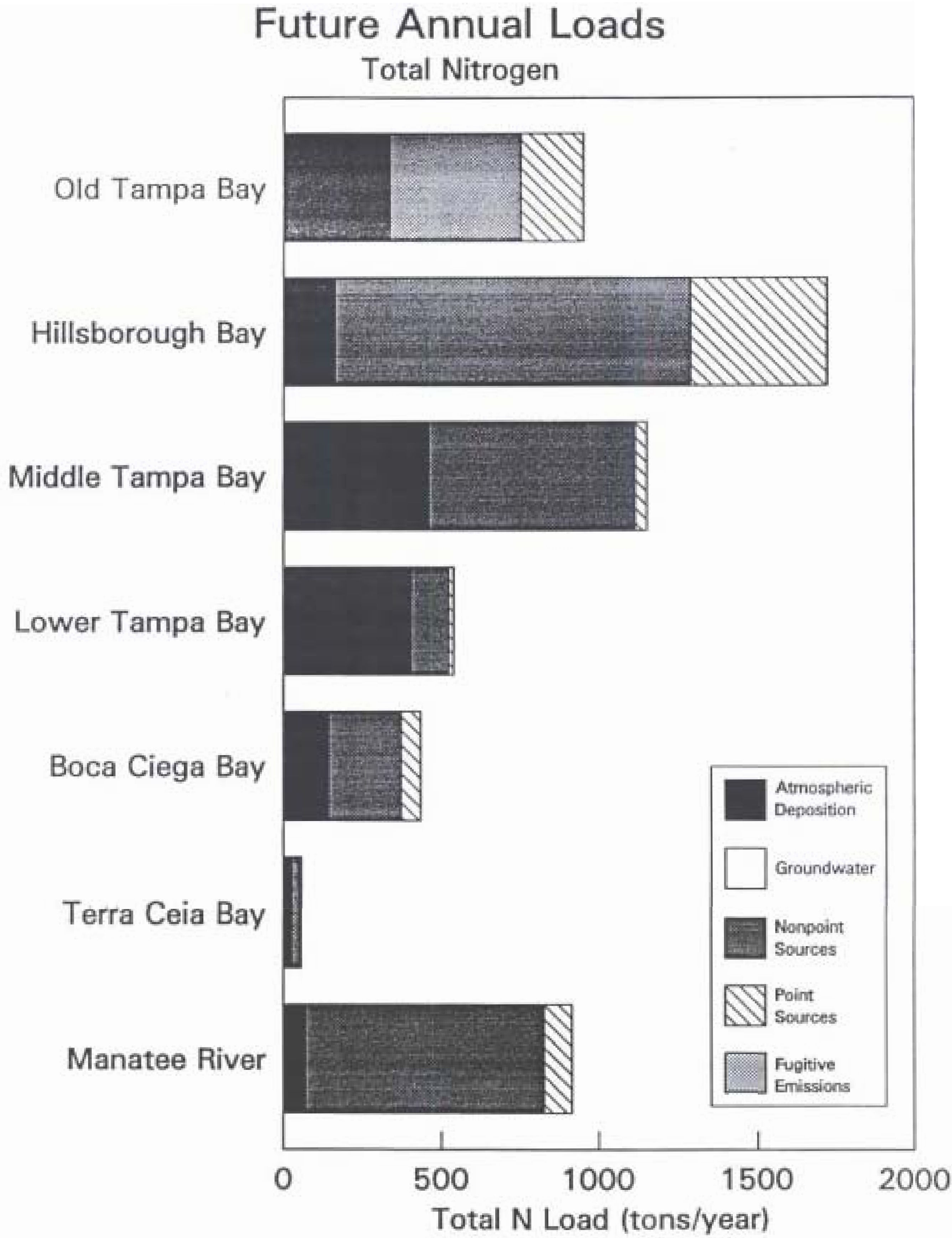

Figure 4 Future Annual Loads - Total Nitrogen

Future bay-wide TP loads displayed similar trends (Figure 5). Atmospheric deposition increased from about 900 tons/year to about 1,300 tons/year for future conditions. Nonpoint sources were also higher, with estimated contributions changing from about 700 tons/year for existing conditions to over 900 tons/year for future conditions. Point sources were estimated to contribute a larger TP load bay-wide, changing from about 800 tons/year for existing conditions to 1,100 tons/year for future conditions. These changed loads represent increases to the major sources of 50% for atmospheric deposition, 30% for nonpoint sources, and 40% for point sources. The future point source loads do not account for any change in the Hookers Point wastewater treatment plant's effluent disposal methods. If some degree of reuse is instituted, point source loadings to the bay will decrease.

Future conditions TSS loads (74,000 tons/year) are about 80% higher than existing conditions loads (40,500 tons/year) on a bay-wide basis (Figure 6). Nonpoint source TSS loads are estimated to change from about 34,600 tons/year for existing conditions to 74,000 tons/year for future conditions. This is attributed to urbanization and subsequent higher per-acre TSS loads. The balance of the TSS load (12,000 tons/year for future conditions and 6,000 tons/year for existing conditions) is from point sources.

3.2 Bay Segment Loadings

Future TN loads to Old Tampa Bay were estimated to be about 85% (440 tons/year) higher than for existing conditions, and TP loads were 50% higher (150 tons/year). Both these increases are a result of higher point source, nonpoint source, and atmospheric deposition contributions. Future TSS loads were also estimated to be higher for future conditions (9,900 tons/year) than for existing conditions (5,500 tons/year), resulting primarily from nonpoint source loading from new urban land.

TN loads to Hillsborough Bay were estimated to be slightly higher for future conditions (1,700 tons/year) than for existing conditions (1,600 tons/year), primarily a result of higher nonpoint source loads and lower fugitive emission loads. Point source loads increased less than 10%, and atmospheric deposition was estimated to be 50% higher. TP loads to Hillsborough Bay were estimated to be slightly lower for future conditions (1,500 tons/year) than for existing conditions (1,600 tons/year), also a result of increases in nonpoint and point sources being offset by lower fugitive emissions. TSS loads were estimated to change from approximately 16,000 tons/year for existing conditions to 18,000 tons/year for future conditions.

Point sources were assumed to be a significant source of TN, TP, and TSS loading to Hillsborough Bay under future conditions. However, although there are now no definite plans to institute capabilities for effluent reuse at Hookers Point wastewater treatment plant, that disposal option is very possible. If reuse were implemented,

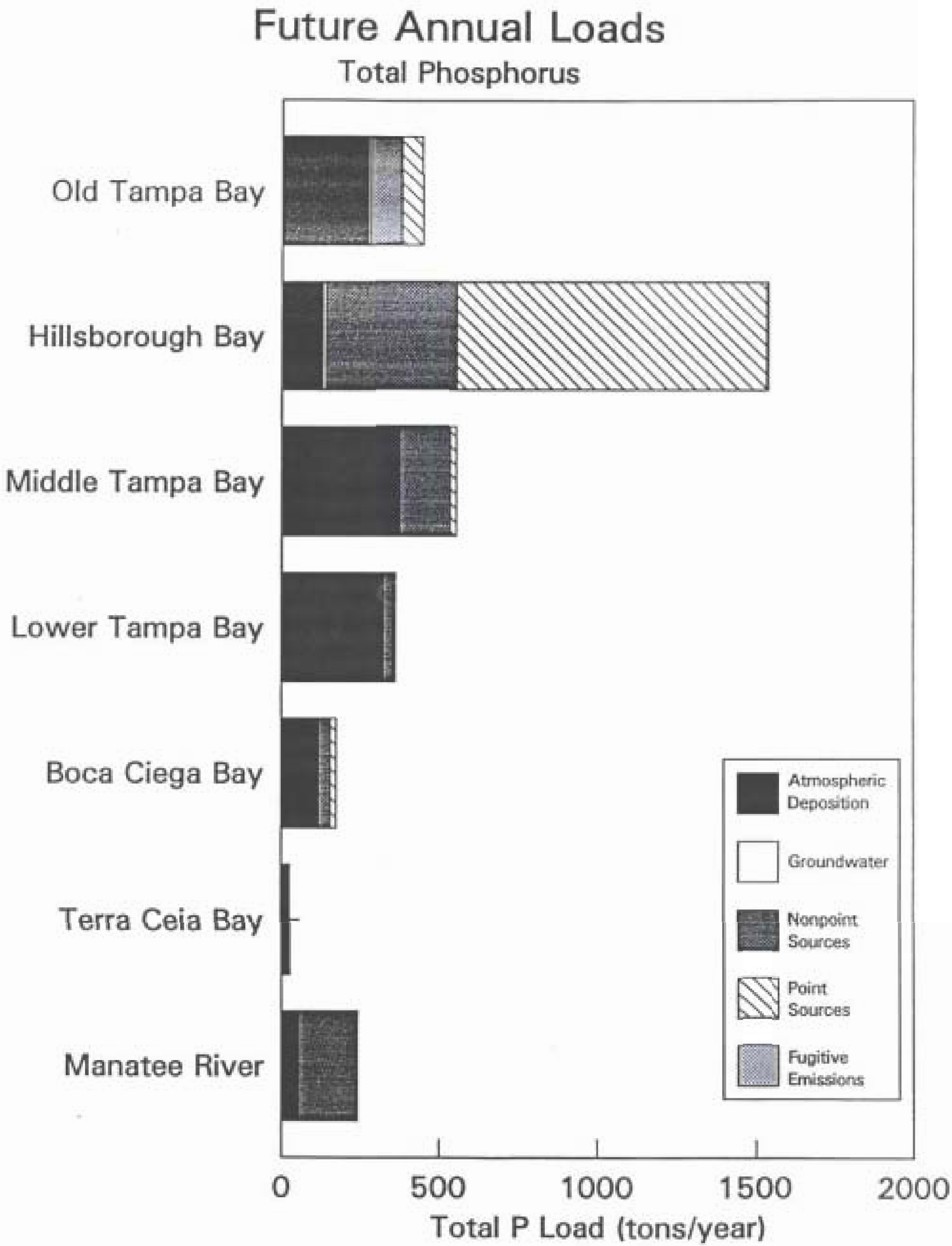

Figure 5 Future Annual Loads - Total Phosphorus

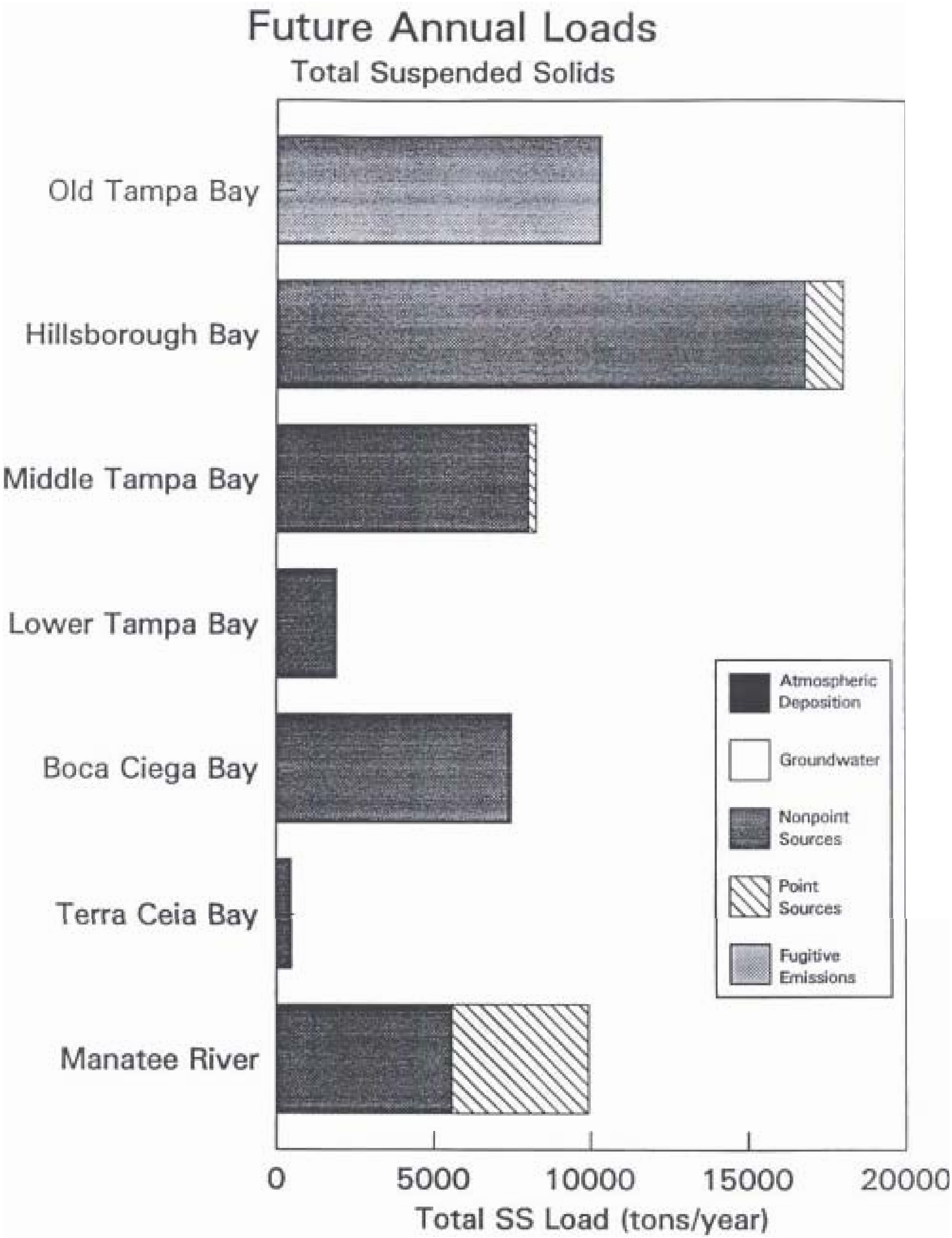

Figure 6 Future Annual Loads - Total Suspended Solids

point source inputs of TN, TP, and TSS would all be lower in Hillsborough Bay. Middle Tampa Bay had a 55% change in TN loads, estimated at about 700 tons/year for existing and about 1,200 tons/year for future conditions. All the major sources were estimated to increase - nonpoint source by 60%, atmospheric deposition by 50%, and point sources by 55%. TP loads to Middle Tampa Bay also increased, from about 350 to 550 tons/year. All major sources including nonpoint, point, and atmospheric deposition, increased by at least 50%. Of these sources, nonpoint sources contributed the largest magnitude of additional loading, about 250 tons/year.

Lower Tampa Bay also showed increases in all three parameters. TN loads were estimated to be about 350 tons/year for existing conditions, and about 550 tons/year for future loadings (55% higher). Future TP loads were estimated to be approximately 350 tons/year, up from about 250 tons/year for existing conditions (40% higher), and future TSS loads were estimated at 1,900 tons/year, versus almost 550 tons/year for existing conditions (250% higher). All major external sources were estimated to have higher TSS loadings in this bay segment under future conditions. Nonpoint sources contributed the highest additional load of TSS - about 2,600 tons/year over existing conditions.

TN and TP loads to Boca Ciega Bay are estimated to be higher for future conditions (450 and 200 tons/year, respectively) than for existing conditions (250 and 100 tons/year, respectively). Atmospheric deposition, point source, and nonpoint source contributions are all estimated to be higher for future conditions for both nutrients. TSS loads were estimated to be higher for future conditions (7,500 tons/year) than for existing conditions (4,800 tons/year), resulting primarily from higher nonpoint source loads.

TN, TP, and TSS loads to Terra Ceia Bay were all estimated to be higher for future conditions than for existing conditions. TN and TP loads show moderate change between the future and existing periods (60 versus 35 tons/year, and 30 versus 20 tons/year, respectively). TSS loading for future conditions was almost double (450 tons/year) existing conditions (250 tons/year).

TN, TP, and TSS loads to the Manatee River were all estimated to be higher for future conditions than for existing conditions, resulting primarily from larger nonpoint source and atmospheric deposition loading. Point source loads were estimated to be lower for the future conditions, a result of domestic point sources reusing effluent and industrial point sources improving process water treatment capabilities. TN loading was estimated to be about 500 tons/year for existing conditions, and 900 tons/year for future conditions. TP loads were estimated to be about 150 tons/year for existing conditions, and about 250 tons/year for future conditions. TSS loads exhibited significant change, with existing loads of 7,400 tons/year and approximately 10,000 tons/year for future conditions, mainly from nonpoint source inputs.

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APPENDIX 15

SUMMARY OF REPORTED CHEMICAL SPILLS OF NITROGEN AND PHOSPHORUS IN TAMPA BAY, 1985-1991

TABLE OF CONTENTS

ATTACHMENTS

LIST OF TABLES

LIST OF FIGURES

1.0 PROJECT OBJECTIVES

The purpose of this study was to estimate nitrogen and phosphorus loadings originating from industrial chemical spills that may have affected the nutrient balance of Tampa Bay during the period 1985 - 1991. This was accomplished by obtaining and analyzing existing documentation in order to determine the quantity, location, type and frequency of major chemical spills. The information reviewed included data on spills of effluent, industrial products or by-products, and other materials containing the pollutants of concern. The chemical characteristics, volume, timing and location of the spills were determined based on the availability of documented information. Various data sources including local, state and federal agencies' files, data bases, and staff, and local newspaper reports were reviewed for relevant information.

The information obtained from this work will be used to supplement existing estimates of nutrient loads for Tampa Bay, as detailed in the report "Current and Benchmark Loadings of Total Nitrogen, Total Phosphorus, and Total Suspended Solids to Tampa Bay, Florida" (Coastal Environmental, Inc. 1993, draft). The final loading estimates will be used as input to the Southwest Florida Water Management District SWIM box model, and data for the Tampa Bay National Estuary Program statistical model. Both these modeling efforts will characterize the response of water quality in Tampa Bay to changes in nutrient loadings.

Acknowledgement is due many groups who supplied information for this inventory, especially the Environmental Protection Commission of Hillsborough County (EPCHC), the Southwest District office of the Florida Department of Environmental Protection (FDEP), the U.S. Coast Guard Marine Safety Office in Tampa (USCG-MSO), the *St. Petersburg Times*, and the Florida Institute of Phosphate Research.

2.0 Methods

To obtain the most complete data on spills in Tampa Bay, a variety of information sources were queried. This section describes the process that was completed to obtain or review the data sources that were used to develop the inventory of spills, and the data gaps and inconsistencies that were identified.

2.1. Project Approach

The purpose of this inventory was to summarize nitrogen and phosphorus inputs from industrial chemical spills that may have affected the nutrient balance of Tampa Bay segments, or the bay as a whole. Because of the large water volumes of the bay segments, it was assumed that only large spill events would influence ambient nutrient concentrations. The first step in the inventory process was to review existing listings and inventories of spill events, and to identify all potentially important spills above a certain threshold. A minimum criterion of 20,000 gallons of spilled material was used to identify potentially significant spills. A spill volume of 20,000 gallons of 70-percent ammonium nitrate, for example, contains approximately 64,000 kilograms (kg), or about 70 tons, of nitrogen.

Once the largest and potentially most significant spills were identified, detailed information was obtained from agency files (USCG, EPCHC, and FDEP), newspaper reports, agency staff and other local experts to determine the spill material composition and concentration, location and timing (gradual or catastrophic), receiving water, recovery efforts, etc. This allowed a refinement of the estimated volume/mass of material actually entering the bay. This was especially important for spills occurring on land adjacent to the bay, and not in the open water.

Water quality data for Tampa Bay, collected monthly by EPCHC, was used as an indicator of excessive amounts of nitrogen or phosphorus in the bay. Using EPCHC water quality data and estimates of bay segment volumes, approximate monthly nutrient masses in the bay were calculated. The nutrient masses were *calculated on a volume-weighted basis. Monthly EPCHC water quality* concentrations for total nitrogen (TN) and total phosphorus (TP) were averaged for each bay segment, and multiplied by the average water volume of that bay segment to yield a nutrient mass for each bay segment. The segments were then summed to give an estimate of bay-wide nutrient mass.

These time series were examined for unusual periods of elevated nitrogen or phosphorus mass within the 1985 - 1991 time period. Figures 1 and 2 illustrate the calculated mass of total nitrogen and total phosphorus in Tampa Bay. After

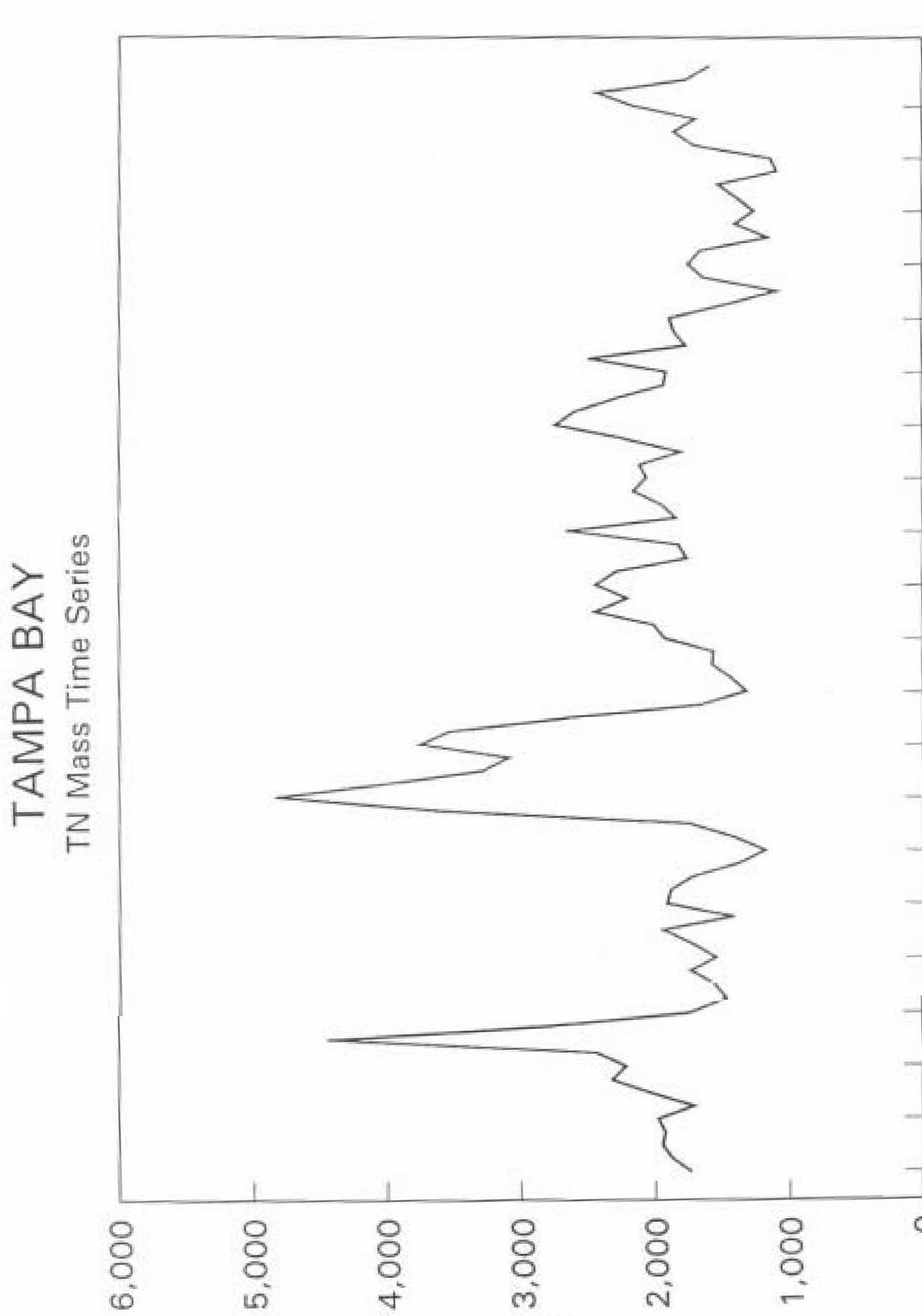

Figure 1 Tampa Bay Total Nitrogen Mass Time Series

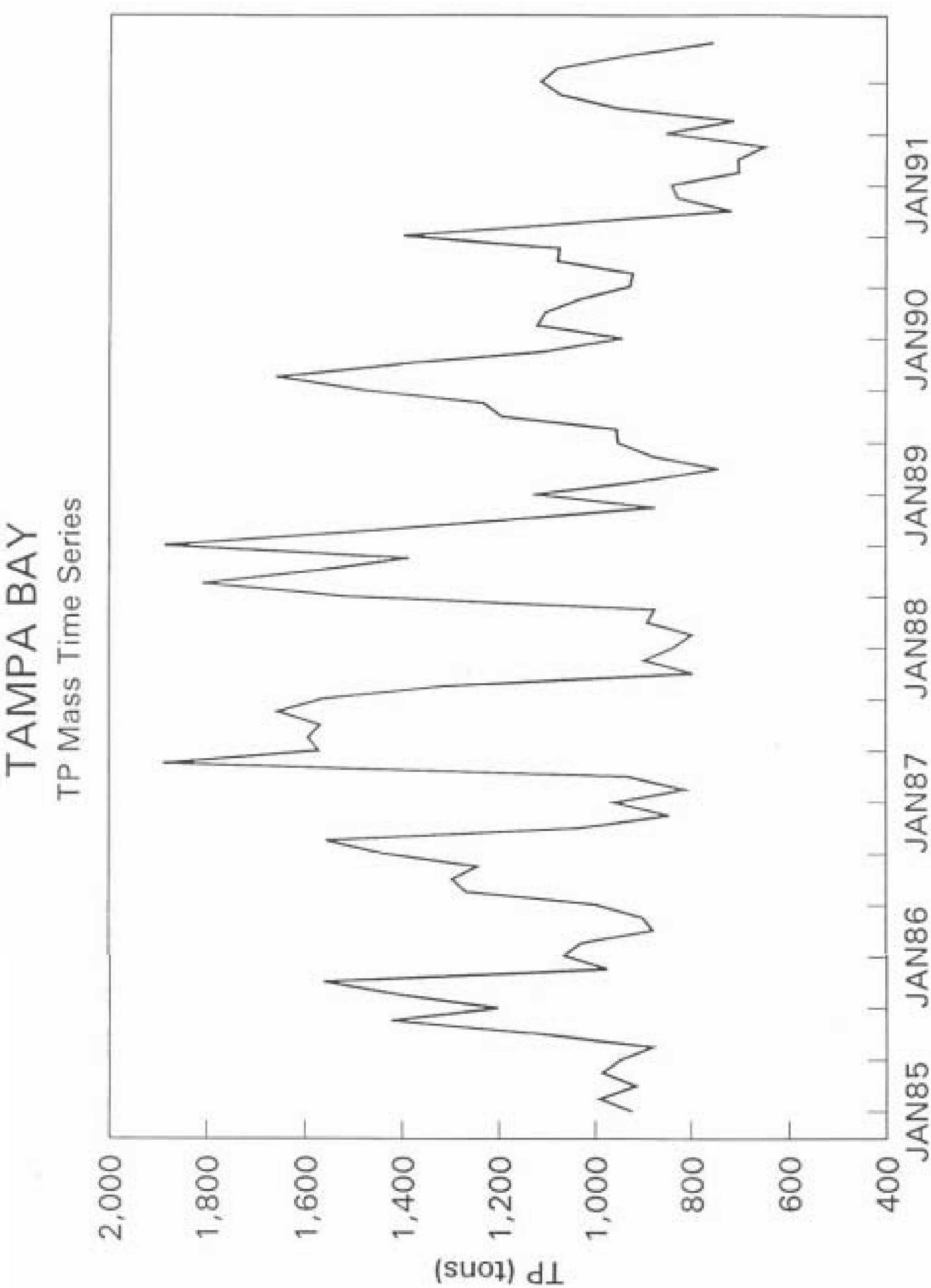

Figure 2 Tampa Bay Total Phosphorus Mass Time Series

the initial review of reported spills, the identified incidents were reviewed with respect to the time series of nutrient mass. Time periods showing large increases in mass, without concurrent sudden inputs were further examined for possible caused for the rapid temporary increases in nutrient mass within the bay.

2.2. Data Sources and Information Obtained

Documentation of spills were obtained from various sources. Some sources were used for an overall review of incidents, and some data sources were examined in detail for specific information regarding individual events. Electronic data bases, paper files, and local individuals were all used as sources of information for this work. The agencies and organizations discussed below include the majority of those contacted, and all of the sources that had useful information.

U.S. Coast Guard

Information was obtained through the United States Coast Guard (USCG) - Marine Safety Office (MSO) in Tampa. Various data bases are maintained by this branch, as they are the prime contact and lead for incidents occurring on or near Tampa Bay. Their data base includes information on spills (all materials), incident date, location, USCG case number, waterbody affected, source of spill, quantity, cleanup responsibility and category of incident (e.g.: major or minor spill, etc.). Printouts obtained through MSO included *The Investigation Activity Status at Port*, *The Marine Pollution Port Log*, and *The Marine Casualty Port Log*. These reports include information on spills, groundings, casualties, boat collisions, fires, and sinkings. The comprehensive printout listing all incidents logged at Tampa MSO over the past ten years included over 4,000 cases. However, this listing did not contain detailed information on all cases (eg. quantity or location). A more complete USCG compilation of information from spill incidents on Tampa Bay was available from USCG MSO Headquarters in Washington, D.C. Coastal requested this data base, but received it from a local source (see below). This more detailed USCG data base included files from the documents *Pollution Substances Spilled* and the *Pollution Incident Reports*. Information provided included case number, spill material, potential amount of spill (container size), amount spilled on land and in water, location and receiving water, and amount recovered.

St. Petersburg Times

On October 11, 1993, the *St. Petersburg Times* published a report entitled "Danger on the Bay". This article was the product of research conducted by Mr. Bob Port, Mr. Chuck Murphy and Ms. Alicia Calwell, and was based upon a summary of

USCG MSO Headquarters (Washington, D.C.) data base records, as well as other information sources. The article provided a chronology of major incidents on Tampa Bay since 1970, including ship collisions, gas releases, petroleum spills and other hazardous material incidents. Discussions with the article authors and a review of the database used for the research yielded much good information.

The USCG data base that the *St.Petersburg Times* had used in its research was a more detailed version of the above referenced data bases that were available from the local MSO. Coastal had requested this data base from the MSO headquarters in Washington, D.C. through the Freedom of Information Act. However, it was anticipated that obtaining these data would take several weeks, if not months. In an attempt to expedite obtaining the USCG data base, Coastal requested and received a copy of this data base as the *St. Petersburg Times* had received it.

Records from the data base were sorted by Coastal to identify spills of nitrogen or phosphorus over 20,000 gallons that occurred only within and adjacent to Tampa Bay. Because the quantity of spilled material was reported in various ways (e.g.: gallons, barrels, pounds, tons, etc.), conversions were made to isolate those incidents over 20,000 gallons. From this information, ten (10) cases were identified to be potentially significant. Case records of these incidents were requested and obtained from MSO-Tampa. After review of the case specifics, seven cases were deleted due to material, type of incident or location. The case specifics were then requested and received from MSO-Tampa.

Florida Department of Environmental Protection (FDEP)

The Southwest District of FDEP was contacted for information on spills. Files of spill events are documented in the Domestic Wastewater, Industrial Wastewater, Hazardous Material Section, and Enforcement Division, depending on the nature of the spill. Chronological accounts of spill events are available for review. However, only written records exist, and must be manually searched to determine spill material, quantity and location. FDEP log books and files are recorded by facility and chronologically back to the mid 1980's. The reports have location of spills, material (if known), correspondence, legal proceedings and referrals to other agencies. These files were examined for detailed information on specific incidents that were identified by searching computerized data bases.

Environmental Protection Commission of Hillsborough County

EPCHC samples numerous sites both in the bay and its tributaries for water quality on a monthly basis. The data obtained are summarized in a bi-annual report. Water quality data is reported in these documents, as is a description of possible causes for identified trends in parameter concentrations. General descriptions of nutrient concentration trends in Hillsborough Bay and Delaney Creek, and discussions with EPCHC staff led to a further investigation of EPCHC files. This agency's enforcement section investigates reported incidents, and documents water quality and other environmental violations. Detailed information about several documented major spills in Hillsborough County were obtained from a review of these data.

Florida Marine Patrol

Mr. Chris Rosbock of the Florida Marine Patrol reported that they respond to petroleum, ammonia and chlorine spills. All incidents that they investigate are documented by FDEP or USCG.

Hillsborough County and City of Tampa Fire Departments

Inquires to the Hillsborough County and City of Tampa Fire Department Hazardous Material Response Teams confirmed that the best record of spill information would be obtained through the USCG and FDEP. The Hazardous Material Response Team has computer records for the last two years, but the data cannot be sorted by spill material.

FDEP Office of Coastal Protection

Ms. Debra Preble of the Office of Coastal Protection (OCP) (Tallahassee) said they have individual case files, but no data base. These case files would have to be individually sorted by jurisdiction and then further reviewed to identify those involved with nitrogen or phosphorus. Because of the statewide focus of this data source and the abundance of locally-available material, no attempt was made to review the OPC files.

FDEP Hazardous Material Management Division

Mr. Jerry Weinrich of the FDEP Hazardous Material Management Division in Tallahassee maintains a database that can be searched by water body. Information regarding Tampa Bay and the tributaries was requested, received and reviewed. Twenty incidents were reported, however, very little supporting information was provided. All the reported incidents were also documented in the USCG data base that was received by Coastal.

Florida Department of Community Affairs

Ms. Eve Rainey of the Department of Community Affairs (DCA) in Tallahassee stated that they have a daily record of events, however these are not sorted by jurisdiction. The entire state-wide data base would have to be reviewed, investigating each event separately to determine contents, quantity and location of spill. A computerized record of hazardous material spills for the last two years does exist, but is not indexed by location. Again, because of the locally available information, these data were not reviewed.

3.0 Results

The purpose of this study was to estimate nitrogen and phosphorus loadings originating from industrial chemical spills that may have affected the nutrient balance of Tampa Bay during the period 1985 - 1991. The chemicals of interest for this analysis include nitrogen and phosphorus containing compounds. Materials of this composition for which spills were reported include ammonium nitrate (AN) and phosphoric acid. All spill incidents of relevant material and significant volume were attributed to industrial sources. No domestic waste spills of sufficient magnitude and concentration were documented. Table 1 presents the results of the inventory investigation. These incidents include all reported spills with a volume of 20,000 gallons or greater, of material with significant nitrogen or phosphorus content, that occurred in or adjacent to Tampa Bay during the period 1985 - 1991.

To calculate the reported nutrient load to the bay resulting from these spills, it was necessary to convert the spill volume to pounds of nitrogen and phosphorus. This was done by determining the percent of nitrogen and phosphorus in each spill material, and converting the resultant amount to a weight. First, the chemical composition of ammonium nitrate (NH_4NO_3) and phosphoric acid (H_3PO_4) was determined. The molecular weight of each element in the material was used to calculate the % weight of nitrogen and phosphorus for each compound (Table 2).

According to staff at the Florida Institute of Phosphate Research, the normal commercial strength, or concentration, of phosphorus in phosphoric acid is 54-percent. The commercial strength of AN in the 1985 and 1987 spills was reported in agency files as 83-percent and 70-percent, respectively. The specific gravity of phosphoric acid and ammonium nitrate is 1.75 and 1.2, respectively. Using these data, the net release of nitrogen and phosphorus, as reported in agency records, was computed. The weight of nitrogen and phosphorus in the spills was determined by the following calculation:

$$(V) \times (WT_{H2O}) \times (SG) \times (WT_{P/N}) \times (1\ kg/2.2\ lb) = kg\ N\ or\ P$$

where: V = *volume of discharged material (gallons)*

WT_{H2O} = *weight of water (8.342 lb/gallon)*

SG = *specific gravity of material*

$WT_{P/N}$ = *amount of N or P in material ("strength" x % molecular weight)*

TABLE 1

REPORTED AND POTENTIAL MAJOR SPILLS OF NITROGEN AND PHOSPHORUS CONTAINING COMPOUNDS IN TAMPA BAY - 1985 THROUGH 1991

DATE	RECEIVING WATER	MATERIAL	REPORTED SPILL VOLUME (Gal)	REPORTED RECOVERED VOLUME (Gal)	REPORTED NET RELEASE	
					Gal	kg N or P
9/6/85	Hillsborough Bay	Ammonium Nitrate (?%)	Unreported	Unreported	--	--
1/15/87	Hillsborough Bay	Ammonium Nitrate (83%)	100,000	100,00	0	0
2/23/87	Hillsborough Bay	Ammonium Nitrate (70%)	700,000	695,000	5,000	5,574 N
5/2/88	Hillsborough Bay	Phosphoric Acid (54%)	40,000	0	40,000	45,271 P
5/16/89	Hillsborough Bay	Phosphoric Acid (54%)	168,389	56,840	111,549	126,248 P

TABLE 2

PERCENT WEIGHT BY CHEMICAL

Chemical	Nitrogen	Phosphorus
Ammonium nitrate	35%	--
Phosphoric acid	--	31.6%

4.0 Discussion

Several trends were noted in EPCHC Tampa Bay water quality data for TN and TP. Water quality concentrations and nutrient masses were examined on a bay-wide basis, as well as for Hillsborough Bay and Middle Tampa Bay. Time series of concentration and mass were developed to compare normal seasonal and inter-annual variability with extreme changes which could indicate a sudden input of anthropomorphic origin, such as a chemical spill.

4.1. Nitrogen Loadings

With two exceptions, the mass of nitrogen in Tampa Bay during the study period (1985 - 1991) generally remained within a range of a factor of less than two, from 1.25 to 2.25 million kilograms (kg) (1375 to 2475 tons). However, two peaks of TN are apparent from Figure 1. The first began in September 1985, and peaks in November, reached approximately 4.0 million kg (4400 tons). The second began in February, 1987, and reaches a peak of approximately 4.5 million kg (4950 tons) in May.

Based on information received from the sources discussed above, there were spills of nitrogen-rich material (with varying degrees of documentation) in the general time frame of both these anomalies. These incidents occurred at the Nitram, Inc. chemical plant adjacent to Delaney Creek, which is tributary to Hillsborough Bay. Nitram, Inc. stores fertilizer components and products on-site, including ammonium nitrate (AN), typically at 50% or greater commercial strength. Two large documented spills at Nitram, Inc. (January 15, 1987 and February 23, 1987) involved 83% and 70% AN.

The EPCHC issued a Notice of Alleged Violation (NOAV) to Nitram, Inc. for an alleged spill incident on September 6, 1985. This is the same period as the beginning of the 1985 increase in TN mass. The volume or specific type of material was not documented, but a fish kill in Delaney Creek was observed (EPCHC, 1985). *The mass of TN in Tampa Bay as a whole during the month after* this incident increased approximately 1.7 million kg (1870 tons). For the referenced spill to account for this increase, over 530,000 gallons of 70% AN would have had to be released to Delaney Creek. Although this is a very large amount, the facility does have holding tanks with over a million gallons capacity.

The second major TN increase in Tampa Bay began in February, 1987, and peaked in May. The increase in TN mass in the bay during this period was approximately 2.5 to 3.0 million kg (2750 to 3300 tons). Two large AN spills occurred at Nitram, Inc. during this period. On January 15, 1987, about 100,000 gallons of

83% AN was reported spilled over the course of several hours from a split welded seam on a holding tank. Nitram, Inc. reported that all of the product had been retained on-site in earthen berms and holding ponds, and that there had been no off-site discharge of product.

On February 23, 1987, a catastrophic failure of a holding tank with a 1.4 million gallon capacity caused the release of 700,000 gallons of 73% AN onto the ground. During the next few hours, containment dikes were constructed, but off-site discharge was reported. Although the amount of recovered product was not documented for some time, the USCG data base records that all but 5,000 gallons of AN were retained on-site. The 5,000 gallons would account for only about 5,574 kg (6.1 tons) of nitrogen, which is insignificant with respect to the observed TN increase during the following months. The total release of AN onto the Nitram site from these two spills (800,000 gallons), equates to approximately 2.5 million kg (2750 tons) nitrogen. This amount is approximately equivalent to the increase in bay-wide nitrogen during the two following months.

In an effort to further verify the reported information, USCG staff were contacted. The USCG data base is the only source to report a net volume of material released for the February 23, 1987 spill. According to discussions with Petty Officer Tom Partiss, USCG - Marine Safety Office in Tampa, the results reported in the case files are from investigations by Coast Guard personnel. The reported volumes of potential spill, actual spill and recovered volume are generated by the investigating officer, not the responsible party. The volumes are estimated from daily record logs, amount of material recovered by the cleanup firm and measurements of remaining material.

Therefore, no documented information exists in data bases or files that were reviewed that would verify that the released volumes of AN were significantly greater than reported. However, no other large source of nitrogen was identified as entering the bay during this time period. In addition, a review of EPCHC monitoring sites from within Hillsborough Bay and Middle Tampa Bay clearly shows a plume of elevated nitrogen concentrations between January and May of 1985 and February and May of 1985. The high concentrations are first noted in Hillsborough Bay stations, and spread to Middle Tampa Bay sites during subsequent months. These data very strongly suggest that some sudden massive nitrogen inputs from a point source in the vicinity of middle Hillsborough Bay did occur during January 1985 and February 1987.

This is also evident in Figures 3 and 4. For Figure 3, TN concentrations for all EPCHC water quality sampling sites in Hillsborough Bay were averaged, and plotted with a similar time series for Middle Tampa Bay. A lag in the rise in TN concentrations between Hillsborough Bay and Middle Tampa Bay is clear in early 1987, which strongly suggests that TN increases in Middle Tampa Bay originated

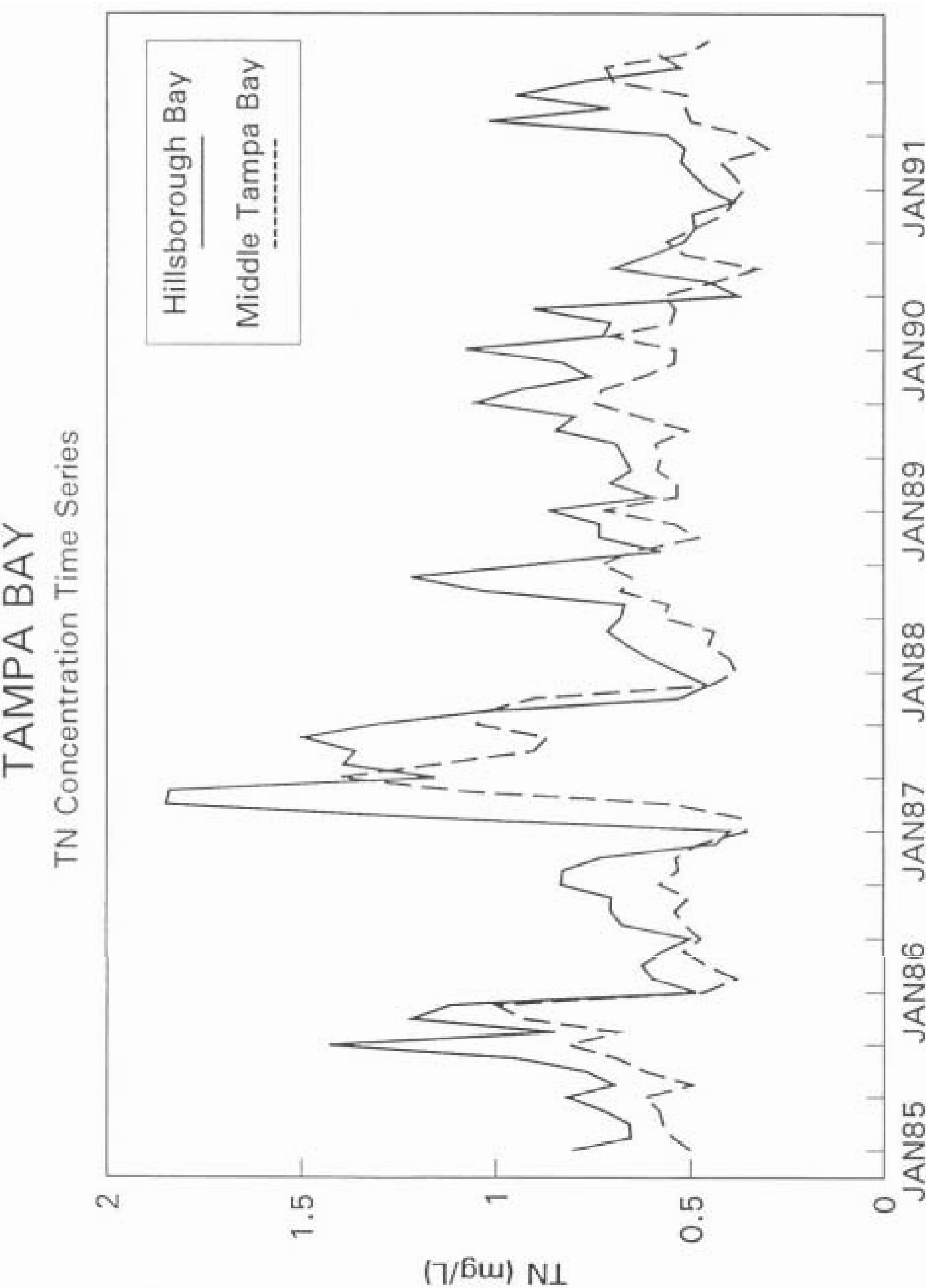

Figure 3 Hillsborough Bay and Middle Tampa Bay Total Nitrogen Concentration Times Series

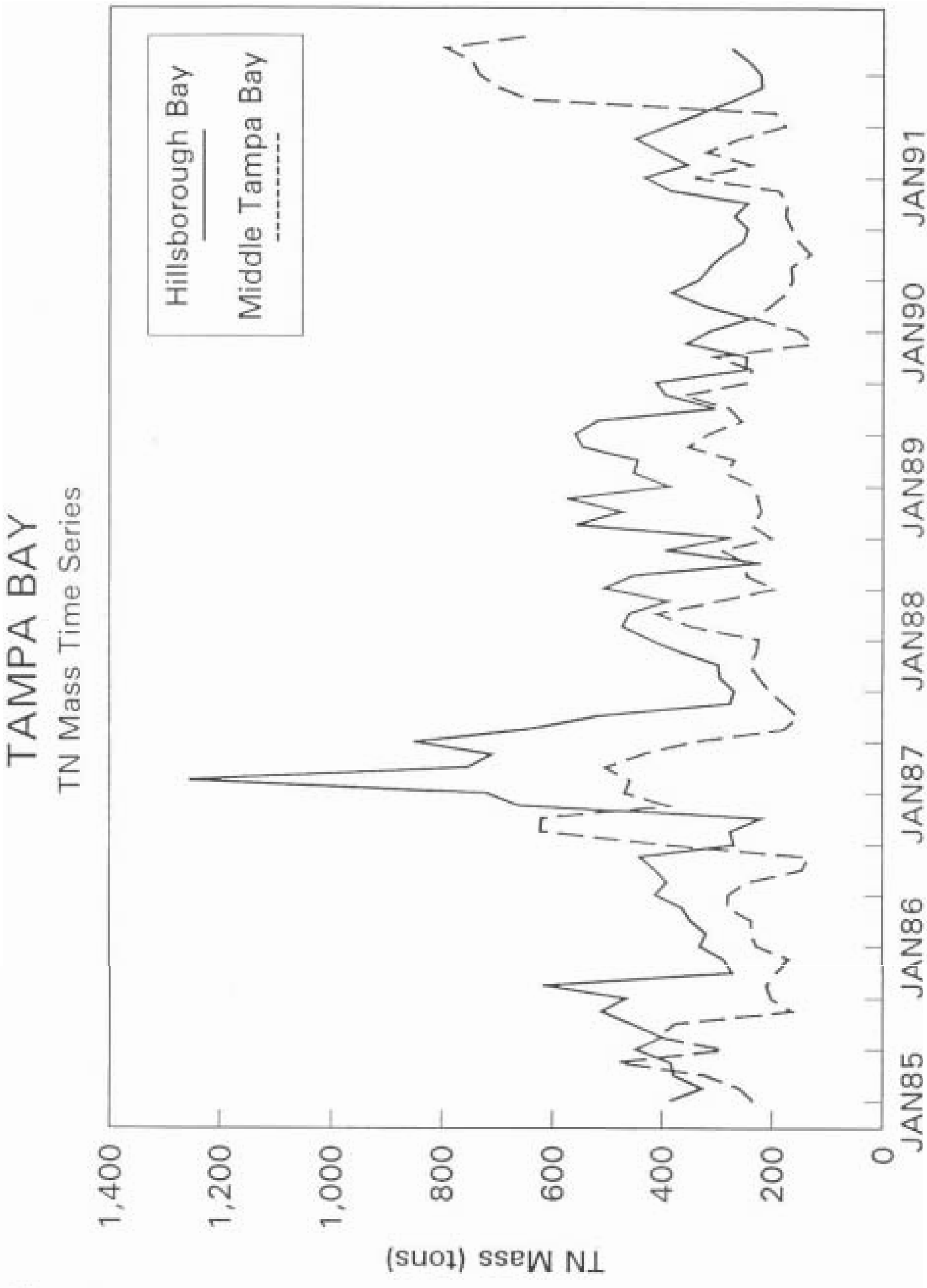

Figure 4 Hillsborough Bay and Middle Tampa Bay Total Nitrogen Mass Times Series

in Hillsborough Bay. However, this lag is not so marked for the rise in concentration during mid to late 1985, but a small lag can be seen during the fall of the concentrations in late 1985. Similar trends can be discerned in Figure 4, which shows TN mass in Hillsborough Bay and Middle Tampa Bay.

Therefore, based on the potential for large amounts of nitrogen to have entered the bay from the reported spills, the lack of certain information about the volume of these spills, the observed sharp rise in nitrogen mass in Tampa Bay immediately following these spills, and the lag in concentration rise between Hillsborough Bay and Middle Tampa Bay, it is strongly suspected that the three spills referenced in Table 1 contributed more nitrogen to Tampa Bay than is firmly documented. It is therefore recommended that potential nutrient loadings from these incidents be used as input to supplement estimates of nitrogen loading to Tampa Bay. Based on the size of the increases in nitrogen in the bay, the recommended increase in total nitrogen loading from these spills for the respective months is shown in Table 3.

TABLE 3

ESTIMATED SPILL CONTRIBUTIONS
TO TOTAL NITROGEN LOADS TO TAMPA BAY

MONTH/YEAR	RECEIVING WATER	KILOGRAMS TOTAL NITROGEN	TONS TOTAL NITROGEN
September 1985	Hillsborough Bay	1,500,000	1650
January 1987	Hillsborough Bay	320,000	350
February 1987	Hillsborough Bay	2,230,000	2450

4.2. Phosphorus Loadings

Figure 2 presents the time series of in-bay total phosphorus (TP) mass for the period 1985 - 1991. This graph shows a broad intra-annual variability, with peaks occurring on an annual basis during the summer months. During the study period, the total Tampa Bay phosphorus mass generally ranged from annual lows in the range of 600,000 to 900,000 kg (660 to 990 tons) to annual highs of 1.1 to 1.7 million kg (1210 to 1870 tons). The highest annual peaks occurred in 1987 and 1988, but these are not exceptionally higher than for preceding or following years.

This is also evident in Figures 5 and 6. For Figure 5, TP concentrations for all EPCHC water quality sampling sites in Hillsborough Bay were averaged and the time series was plotted with a similar plot for Middle Tampa Bay. A lag in the rise in TP concentrations between Hillsborough Bay and Middle Tampa Bay is clear in early 1987, which strongly suggests that increases in TP in Middle Tampa Bay originated in Hillsborough Bay. This lag is also obvious during the rise in concentration during early 1988. Similar trends can be discerned in Figure 6, which shows TP mass in Hillsborough Bay and Middle Tampa Bay.

The results of the spill inventory reveal two major phosphoric acid spills during the 1985 to 1991 period. These spills occurred at the Gardinier phosphate plant (now Cargill), and at the GATX terminal, both on Hillsborough Bay. The first, on May 2, 1988, resulted in a net off-site discharge of approximately 40,000 gallons of phosphoric acid (45,271 kg, or 50 tons, of phosphorus). The second, on May 15, 1989, discharged approximately 111,550 gallons of phosphoric acid (126,248 kg, or 139 tons, of phosphorus). However, the highest annual peak observed occurred during 1987. No spills of phosphoric material were documented for that time frame. It should be noted, however, that all the annual peaks are within the same general range, with no outstanding spikes, as shown on the nitrogen mass time series. Based on these data, it is recommended that loading estimates of total phosphorus loading to Tampa Bay be increased by the amounts shown in Table 4, attributable to two spills.

TABLE 4

ESTIMATED SPILL CONTRIBUTIONS
TO TOTAL PHOSPHORUS LOADS TO TAMPA BAY

MONTH/YEAR	RECEIVING WATER	KILOGRAMS TOTAL PHOSPHORUS	TONS TOTAL PHOSPHORUS
May 1988	Hillsborough Bay	143,335	158
May 1989	Hillsborough Bay	399,721	440

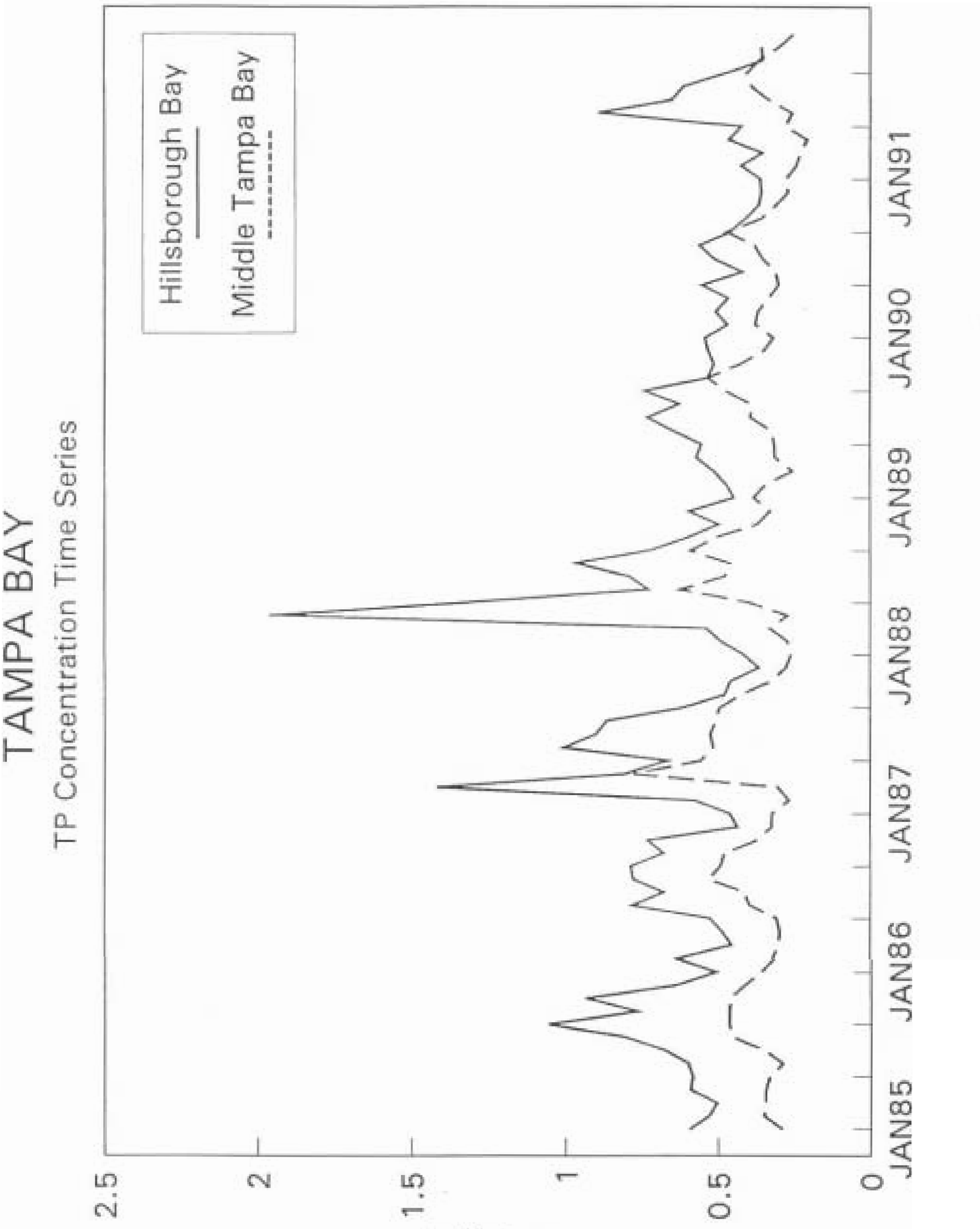

Figure 5 Hillsborough Bay and Middle Tampa Bay Total Phosphorus Concentration Times Series

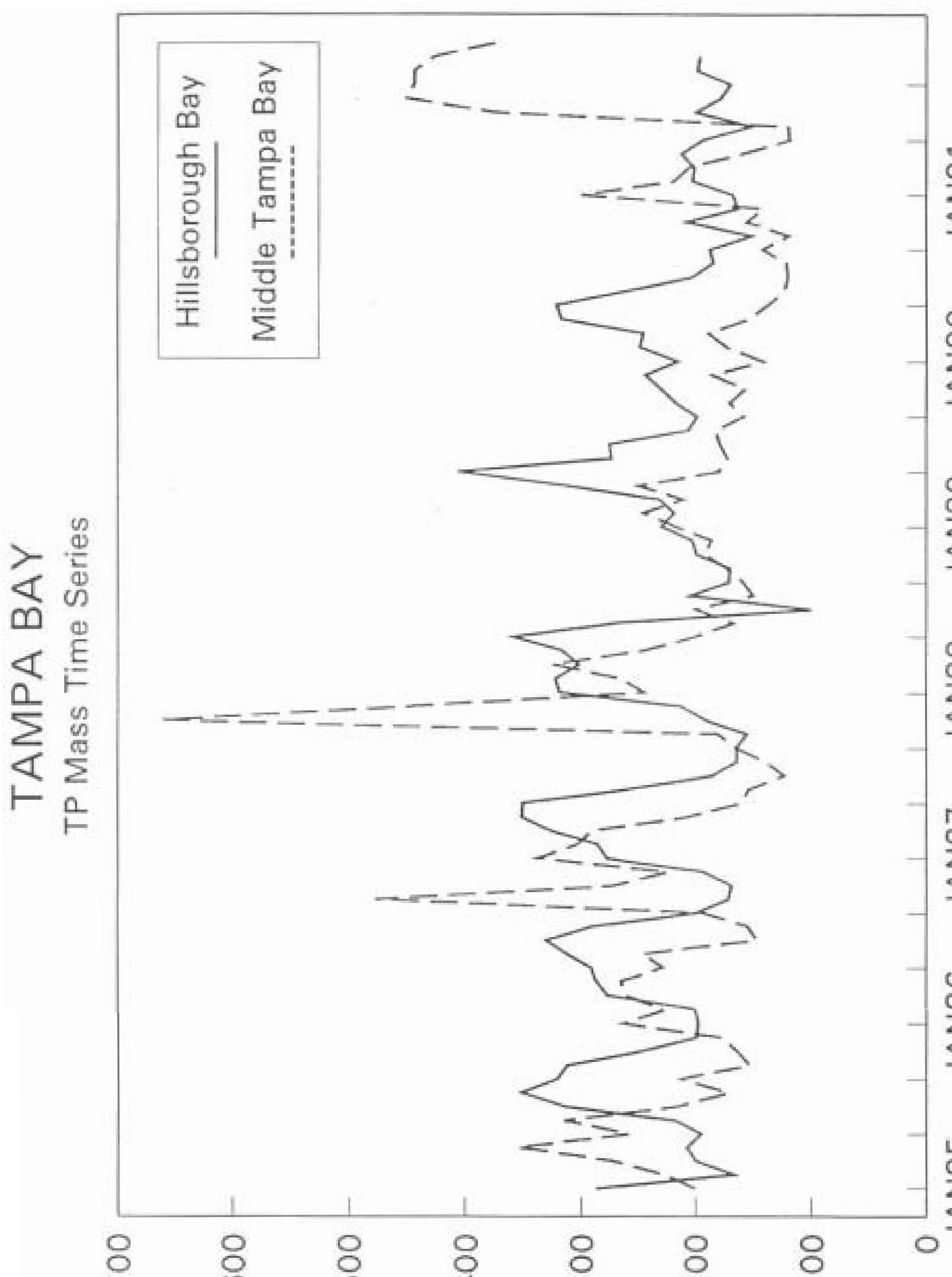

Figure 6 Hillsborough Bay and Middle Tampa Bay Total Phosphorus Mass Times Series

ATTACHMENTS

Attachment 1

Chronology of Spill Reports and Water Quality Sampling at Nitram, Inc.

Attachment 2

U.S. Coast Guard Spill Data Base

Summary of PSST Records
MPCASE Records

ATTACHMENT 1

Chronology of Spill Reports and Water Quality Sampling at Nitram, Inc.

Chronology of Reported Spills and Water Quality Sampling Results at Nitram, Inc. - 1985 through 1990
(Source: FDEP and EPCHC case files)

DATE	COMMENT
7/3/84	Monitoring data from NPDES reports of surface discharge records. NH_4 = 13.2 mg/L NO_3 = 107.2 mg/L.
5/85 through 1/88	On-site monitor well samples show ammonia concentrations ranging from 1,142 to 16,000 mg/L and nitrate concentrations averaging approximately 2,000 mg/L.
8/12/85	Faulty truck value results in spill of 18 tons (3600 gallons) of 60% AN.
9/6/85	Unauthorized discharge at outfall #001. Material and volume not documented. EPCHC issues Notice of Alleged Violation for observed fish kills in Delaney Creek.
2/6/86	Nitram reports spill with off-site discharge. No volume or material source is documented.
2/20/86	Overflow of chill water tank results in off-site discharge of undetermined amount. Fish kill in Delaney Creek reported.
1/15/87	Storage tank seam split - 100,000 gallons of 83% AN spilled. Nitram reports all material contained on-site.

1/16/87	The day after the spill, EPCHC samples discharge at Nitram outfall #003. $TN = 668.2$ mg/L $NH_4 = 348.5$ mg/L $NO_{2+3} = 347.9$ mg/L
2/23/87	Storage tank ruptured - 700,000 gallons of 70% AN spilled. Amount of off-site release undetermined at the time, later estimated at 5,000 gallons.
2/23/87 - 2/24/87	EPCHC samples water quality in Delaney Creek five hours after, one day after, and three days after 2/23 spill (see data below).
3/7/87 - 3/29/87	FDER measures stormwater runoff discharging from Nitram property. TN values range from 236 to 937 mg/L. Groundwater is also sampled. Nitrate concentrations in three on-site monitor wells near storage facilities range from 110 to 16,000 mg/L.

EPCHC water quality monitoring data from Delaney Creek after 2/23/87 spill.

			(mg/L)	
Date	Site	TN	NH_4	NO_{2+3}
2/23/87	Nitram west ditch	41,618	36,776	24,509
2/23/87	Delaney/54th St.	2,942	2,670	1,295
2/23/87	Delaney/U.S. 41	64	145	39
2/23/87	Delaney/Richmond	2.1	2.0	2.7
2/24/87	Nitram west ditch	30,228	41,839	17,341
2/24/87	Delaney/54th St.	85	80	49
2/24/87	Delaney/U.S. 41	142	201	93
2/24/87	Delaney/Richmond	194	249	112
2/26/87	Delaney/54th St.	3.9	1.7	1.2
2/26/87	Delaney/U.S. 41	66	31	240

ATTACHMENT 2

U.S. Coast Guard Spill Data Base

Summary of PSST Records
MPCASE Records

The attached summarizes results of the various queries performed on the USCG - Office of Marine Protection database. The printouts include spill data on all Tampa Bay cases, a query of the main database for spills over 20,000 gallons, a summary page defining codes, and information on case particulars.

PSST Records with PRIT records having same MCASE code

MPCASE	CHRIS_CD	UNITS_ME	TYPE	SPDT_RPD	SUPPLEME	POTENTIA	OUTSPILL	OUTQTYRE	INSPILLE	INQTYREC	UNIT	OSC	SPDT
MP87001265	ANR	GALLONS	C	2/23/1987	1	700000	0	0	700000	695000	TAMMS	USCG	2/23/1987
MP87002084	MWS	GALLONS	C	3/31/1987	1	150000	95000	0	5000	0	TAMMS	USCG	3/31/1987
MP88002759	PAC	GALLONS	C	5/02/1988	1	80000	0	0	40000	0	TAMMS	USCG	5/02/1988
MP88006300	OTD	BARRELS	P	9/05/1988	1	23400	0	0	165220	0	TAMMS	USCG	9/05/1988
MP89003693	PAC	GALLONS	C	5/16/1989	1	398440	131206	56840	37183	0	TAMMS	USCG	5/16/1989
MP89003922	SFA	BARRELS	C	5/24/1989	1	24804	43450	8	0	0	TAMMS	USCG	5/24/1989
MP89007109	SFA	TONS-2K	C	8/21/1989	1	5000	8550000	4275	0	0	TAMMS	EPA	8/21/1989
MP89008128	ODS	GALLONS	P	9/20/1989	2	0	42000	41900	0	0	TAMMS	USCG	9/20/1989
MP89011124	***	GALLONS	U	12/13/1989	1	0	0	0	500000	500000	TAMMS	USCG	12/13/1989
MP91003649	***	TONS-2K	U	4/06/1991	1	0	0	0	20000	0	TAMMS	USCG	4/06/1991

MPCASE	CITY	STATE	REGION	WATER	MCCASE	RPDT	STATUS	CLDT	SPTIME	LAT_DIR	LATITUDE	LONG_DIR
MP87001265	TAMPA	FL		GCX		2/23/1987	CD	3/02/1987	1300	N	27550	W
MP87002084	CLEARWATER	FL		AIBT		3/31/1987	CD	4/03/1987	1510	N	27550	W
MP88002759	GIBSONTON	FL		AIBT		5/04/1988	DI	8/05/1988	0001	N	27500	W
MP88006300	TAMPA	FL	4	GZX		9/09/1988	DI	10/25/1988		N	29 00	W
MP89003693	TAMPA	FL	4	AIBT		5/16/1989	CD	7/19/1989	2200	N	27540	W
MP89003922	TAMPA	FL	4	AIBT		5/24/1989	CD	6/20/1989	0800	N	27540	W
MP89007109	PALMETTO	FL	4	GCX		8/21/1989	CD	8/28/1989	1620	N	27382	W
MP89008128	TAMPA	FL	4	AIBT		9/20/1989	CD	9/26/1989	0700	N	27540	W
MP89011124	CRYSTAL RIVER	FL	4	GCX		12/13/1989	NC	12/14/1989	1800	N	28540	W
MP91003649	CLEARWATER	FL	4	GCX		4/06/1991	DI	4/26/1991		N	27550	W

MPCASE	LONGITUD	REMPARTY	VAL_IND	CTF_IND	PRO_NUM	PRO_TYP	KNOWN_DT	RPTIME	NUMNONCG	RPTDBY	SUBJECT
MP87001265	82260	RPF	X				E	1300	1	INDIVIDUAL	CHEMICAL SPILL
MP87002084	82420	RPF	X				E	1520	1	INDIVIDUAL	HAZ WASTE SPILL
MP88002759	82250	RPF	X				U	0730	3	COMM. SOURCE	PHOSPHORIC ACID SPILL
MP88006300	87 00	NON	X				U	0815		RESP PARTY	EXXON B. 503
MP89003693	82260	RPF	X				K	2324	7	RESP PARTY	PHOS ACID SPILL/GATX
MP89003922	82240	RPF	X				E	0800	1	RESP PARTY	SULFURIC ACID
MP89007109	82315	RPF	X				K	1645	3	USCG	MAJOR- SULFURIC ACID SPILL
MP89008128	82260	RPF	X				K	0710	2	USCG	POTENTIAL MEDIUM OIL SPILL
MP89011124	82360	NON	X				K	1910	1	USCG	CRYSTAL RIVER POWER PLANT
MP91003649	82420	NON	X				U	1319		INDIVIDUAL	RED TIDE- CLEARWATER

MPCASE	NRC	NRCCASE	NUM_VES	NUMNONVE	RI_MILE	AUTHCEIL	TTL_COST	FUNDSEXP	NUM_CG	BPRIT	BPSST3
MP87001265	N		0	1	0	0	0	0	1	1	1
MP87002084	N		0	1	0	0	0	0	1	1	1
MP88002759	Y	05658	0	1	0	0	0	0	1	1	1
MP88006300	N		1	0	0	0	0	0	1	1	1
MP89003693	Y	7522	0	1	0	0	0	0	1	1	1
MP89003922	BOL	Y	0	1	0	0	0	0	1	1	1
MP89007109	Y	14678	0	1	0	0	0	0	1	1	1
MP89008128	Y		0	1	0	0	0	0	1	1	1
MP89011124	Y	22298	0	1	0	0	0	0	1	1	1
MP91003649	N		1	0	0	0	0	0	1	1	1

MPIR MARINE POLLUTION INCIDENT REPORT 30NOV9:

CASE NUMBER../ MP8700[redacted] PORT/ TAMMS OSC AGENCY/ USCG EPA REGION..../
DATE CLOSED../ 02MAR87 VALIDATED(X)/ X CTF/ INV/ HUDKI NOTIFY../

SUBJECT....../ CHEMICAL SPILL
REPORTED BY../ INDIVIDUAL NAME/ JULIE GROSS TEL/ 813-985-7402
DATE REPORTED/ 23FEB87 TIME REPORTED/ 1300 NRC NOTIFICATION? (Y/N)/ N
DATE OF SPILL/ 23FEB87 E TIME OF SPILL/ 1300 NRC CASE REF/
REF. CASE..../ ——— REF. SUBJECT./

---INCIDENT LOCATION---

BODY OF WATER/ GULF OF MEXICO-COASTAL
RIVER MILE.../ . (OR) LATITUDE...../ N 27-55.0
LONGITUDE..../ W 82-26.0
CITY........./ TAMPA STATE......../ FL
CLEAN UP ACT./ CLEAN-UP PERF REMOVAL PARTY/ RESP PARTY

---FEDERAL COST INFORMATION---

PROJECT NUMBER./ PROJECT TYPE/
AUTH CEILING($)/ FUNDS EXPENDED($)/ TOT COST($)/

---GENERAL CASE DESCRIPTION---

---SUPPLEMENTAL DETAILS REPORTED---

KEY	TYPE	NUMBER
1	VESSEL SOURCES...........(MPVS)	
2	NON-VESSEL SOURCES.......(MPNS)	1
3	CG UNIT RESPONSE REPORTS (MPRC)	1
4	NON-CG RESPONSE REPORTS (MPRN)	1
5	TEXT SUPPLEMENT..........(MPTS)	

MPNS MARINE POLLUTION NON-VESSEL SOURCE SUPPLEMENT 30NOV9

CASE/ MP87001265

--- NON-VESSEL SOURCE INVOLVED --- VERIFICATION(V/K)/

SOURCE NAME..../ NITRAM, INC. LOCAL SOURCE ID/ TAMMS4000

IDENTIFICATION./ 5321 HARTFORD STREET,TAMPA, FL. 33601

OWNERSHIP CLASS/ COMMERCIAL TYPE/ LAND FACILITY,NON MAR USE/ PROD. MAN. FA

OPERATION/ NO OPERATION IN PROGRESS

CAUSE...: PRIMARY/ STRUCTURAL FAILURE SECONDARY/ TANK RUPTURE,LEAK

CONTRIBUTING FACT/ NEC UNKNOWN

--- POLLUTING SUBSTANCES AND QUANTITIES INVOLVED ---

CHRIS CODE	TOTAL POTENTIAL	OUT OF WATER SPILLED	OUT OF WATER RECOVERED	IN WATER SPILLED	IN WATER RECOVERED	UNITS
ANR	Ammonium-nitrate-solution (greater than 45% and less th					
	700000			700000	695000	GALLONS

MPIR

MARINE POLLUTION INCIDENT REPORT

CASE NUMBER../ MP88002759 PORT/ TAMMS OSC AGENCY/ USCG EPA REGION..../
DATE CLOSED../ 05AUG88 VALIDATED(X)/ X CTF/ INV/ TAMMS NOTIFY../

SUBJECT....../ ~~PHOSPHORIC ACID SPILL~~

REPORTED BY../ COMM. SOURCE NAME/ RADIO TEL/
DATE REPORTED/ 04MAY88 TIME REPORTED/ 0730 NRC NOTIFICATION? (Y/N)/ Y
DATE OF SPILL/ 02MAY88 U TIME OF SPILL/ 0001 NRC CASE REF/ 05658
REF. CASE..../ REF. SUBJECT./

---INCIDENT LOCATION---

BODY OF WATER/ TAMPA BAY
RIVER MILE.../ . (OR) LATITUDE...../ N 27-50.0
LONGITUDE..../ W 82-25.0
CITY........./ GIBSONTON STATE......../ FL
CLEAN UP ACT./ DISSIPATED REMOVAL PARTY/ RESP PARTY

---FEDERAL COST INFORMATION---

PROJECT NUMBER./ PROJECT TYPE/
AUTH CEILING($)/ FUNDS EXPENDED($)/ TOT COST($)/

---GENERAL CASE DESCRIPTION---

---SUPPLEMENTAL DETAILS REPORTED---

KEY	TYPE	NUMBER
1	VESSEL SOURCES...........(MPVS)	
2	NON-VESSEL SOURCES.......(MPNS)	1
3	CG UNIT RESPONSE REPORTS (MPRC)	1
4	NON-CG RESPONSE REPORTS (MPRN)	3
5	TEXT SUPPLEMENT..........(MPTS)	

MPNS MARINE POLLUTION NON-VESSEL SOURCE SUPPLEMENT 30

CASE/ MP88002759

--- NON-VESSEL SOURCE INVOLVED --- VERIFICATION(V/

SOURCE NAME..../ GARDINIER, INC. LOCAL SOURCE ID/ TAMMS(

IDENTIFICATION./ P.O. BOX 3269, TAMPA, FL. 33601

OWNERSHIP CLASS/ COMMERCIAL TYPE/ DESG. WATERFRONT FAC USE/ PROCESSIN(

OPERATION/ INDUSTRIAL OR MFG PROCESS

CAUSE...: PRIMARY/ KNOWN CAUSE, NEC SECONDARY/ TANK OVERFLOW

CONTRIBUTING FACT/ IMP VALVE OPS UNKNOWN

--- POLLUTING SUBSTANCES AND QUANTITIES INVOLVED ---

CHRIS CODE	TOTAL POTENTIAL	--- OUT OF WATER --- SPILLED	RECOVERED	----- IN WATER ----- SPILLED	RECOVERED	UNI
PAC	Phosphoric acid					
	80000			40000	0	GALL

MPIR MARINE POLLUTION INCIDENT REPORT 30NO

CASE NUMBER../ MP89009693 PORT/ TAMMS OSC AGENCY/ USCG EPA REGION..../ 4
DATE CLOSED../ 19JUL89 VALIDATED(X)/ X CTF/ INV/ WAUGH NOTIFY../

SUBJECT....../ PHOS ACID SPILL/GATX
REPORTED BY../ RESP PARTY NAME/ GATX-ELAINE MACINSKI TEL/ 813-248-214
DATE REPORTED/ 16MAY89 TIME REPORTED/ 2324 NRC NOTIFICATION? (Y/N)/ Y
DATE OF SPILL/ 16MAY89 K TIME OF SPILL/ 2200 NRC CASE REF/ 7522
REF. CASE..../ REF. SUBJECT./

---INCIDENT LOCATION---

BODY OF WATER/ TAMPA BAY
RIVER MILE.../ . (OR) LATITUDE...../ N 27-54.0
LONGITUDE..../ W 82-26.0
CITY........./ TAMPA STATE......../ FL
CLEAN UP ACT./ CLEAN-UP PERF REMOVAL PARTY/ RESP PARTY

---FEDERAL COST INFORMATION---

PROJECT NUMBER./ PROJECT TYPE/
AUTH CEILING($)/ FUNDS EXPENDED($)/ TOT COST($)/

---GENERAL CASE DESCRIPTION---

PHOSPHORIC ACID RELEASED INTO TAMPA BAY. GATX TANK WITH THE CAPACITY OF 10,000 BBLS RUPTURED.

---SUPPLEMENTAL DETAILS REPORTED---

KEY	TYPE	NUMBER
1	VESSEL SOURCES...........(MPVS)	
2	NON-VESSEL SOURCES.......(MPNS)	1
3	CG UNIT RESPONSE REPORTS (MPRC)	1
4	NON-CG RESPONSE REPORTS (MPRN)	7
5	TEXT SUPPLEMENT..........(MPTS)	

MPNS MARINE POLLUTION NON-VESSEL SOURCE SUPPLEMENT 30N(

CASE/ MP89008698[redacted]

--- NON-VESSEL SOURCE INVOLVED --- VERIFICATION(V/K

SOURCE NAME..../ GATX TERMINALS CORPORATIONS LOCAL SOURCE ID/ TAMMS1(
IDENTIFICATION./ RESULTED WHEN THE PHOS ACID TANK LINING FAILED AND EVENTUAl
DETERIORATED THE TANK WALL.
OWNERSHIP CLASS/ COMMERCIAL TYPE/ DESG. WATERFRONT FAC USE/ STORAGE FA(
OPERATION/ NO OPERATION IN PROGRESS
CAUSE...: PRIMARY/ STRUCTURAL FAILURE SECONDARY/ TANK RUPTURE,LE
CONTRIBUTING FACT/ IMP MAINTENANCE MATERIAL DEFECT

--- POLLUTING SUBSTANCES AND QUANTITIES INVOLVED ---

CHRIS	TOTAL	--- OUT OF WATER ---		----- IN WATER -----		
CODE	POTENTIAL	SPILLED	RECOVERED	SPILLED	RECOVERED	UNIT:
PAC	Phosphoric acid					
	398440	131206	56840	32183	0	GALLO

POLLUTION REPORT TABLE (prit)

DATA KEY	ELEMENT NAME	COLUMN NAME	DATA TYPE	LENGTH	PURPOSE/USE
PRI001	MP Case	mpcase	C	10	Marine Pollution Case Number. Primary join path to cases supplements (not implemented) and violation products.
PRI002	Unit	unit	C	5	MSIS port code (parent units only).
PRI005	On Scene Coord Agency	osc	C	4	On Scene Coordinator for incident - see table 30.
PRI006	Occurance Date	spdt	D	8	Spill date.
PRI007	City Nearest OCC	city	C	25	City spilled occurred in.
PRI008	State of OCC	state	C	2	State spill occurred in.
PRI009	EPA Region	region	C	2	EPA region spill occurred in - see table 27.
PRI010	Waterbody Affected	water	C	6	Water body affected - see table 56.
PRI014	Casualty Ref	mccase	C	10	Marine Casualty Incident Report case number associated with spill case (if any).
PRI016	Date Case Reported	rptd	D	8	Date spill reported.
PRI019	Clean-up Status	status	C	1	Case status - see table 6.
PRI021	Num of Vessels Inv	num_ves	I	1	Number of vessels associated with spill case.
PRI023	Num NonVes SRC Inv	num_nonves	I	2	Number of non-vessels (facilities) associated with case.

POLLUTION REPORT TABLE (prit) (CONT'D)

DATA KEY	ELEMENT NAME	COLUMN NAME	DATA TYPE	LENGTH	PURPOSE/USE
PRI025	Date Case Closed	cldt	D	8	Case closed date.
PRI027	Time of Spill	sptime	C	4	Time spill occurred (if known).
PRI029	River Mile	ri_mile	I	2	River mile spill occurred at (if applicable).
PRI031	Latitude Direction	lat_dir	C	1	Direction where spill occurred.
PRI031	Spill Latitude	latitude	C	6	Latitude where spill occurred.
PRI035	Longitude Direction	long_dir	C	1	Direction where spill occurred.
PRI035	Spill Longitude	longitude	C	7	Longitude where spill occurred.
PRI039	Spill Removal Party	rem_party	C	3	Party that conducted removal operations - see table 18.
PRI040	Inv Rep Validated	val_ind	C	1	Case validated indicator ("X" or NULL).
PRI041	Report Close to File	ctf	C	1	"X" - Case closed to file.
PRI042	Project No	pro_num	C	10	Federal project number (if any).
PRI043	Project Type	pro_typ	C	6	Project type.
PRI044	M Spill Date Know/Est	known_dt	C	1	Spill date/time known.
PRI045	Auth Ceiling Cost	auth_ceil	M	8	Authorized ceiling (Federal projects).

POLLUTION REPORT TABLE (prit) (CONT'D)

DATA KEY	ELEMENT NAME	COLUMN NAME	DATA TYPE	LENGTH	PURPOSE/USE
PRI046	Total Cost of Spill	ttl_cost	M	8	Total cost of spill cleanup.
PRI047	Funds Expended	funds_exp	M	8	Pollution fund expenditures.
PRI048	No. OPFAC Res Rep	num_cg	I	1	Number of CG response reports (supplements filed).
PRI049	Time Spill Reported	rptime	C	4	Time spill reported.
PRI052	No. NONCG Res Rep.	num_noncg	I	2	Number of non-CG response reports (supplements filed).
PRI061	Reported by	rptdby	C	12	Spill reported by.
PRI062	Subject	subject	C	26	Cause of spill.
PRI063	NRC Notification	nrc	C	1	NRC notified unit (Y/N/NULL).
PRI064	NRC Ref Case	nrccase	C	12	NRC case number (if any).
	Latitude	num_lat	F	8	For use in conjunction with Natural Language.
	Longitude	num_long	F	8	For use in conjunction with Natural Language.

POLLUTION SUBSTANCE SPILLED TABLE (psst)

DATA KEY	ELEMENT NAME	COLUMN NAME	DATA TYPE	LENGTH	PURPOSE/USE
PSS001	MPCASE	mpcase	C	10	Marine Pollution Case Number. Primary join path to case supplements and violation products.
PSS002	Supplement ID	supplement_id	C	4	Each supplement associated with a case is uniquely identified by this element.
PSS003	Substance CHRIS Code	chris_code	C	3	CHEM ID Code (based on CHRIS Code).
PSS004	Total Potential Qty	potential_qty	I	4	Quantity in gallons of potential substance spilled.
PSS005	Out of Wtr Qty Spilled	out_of_water_spilled	I	4	Quantity in gallons of spill out of water.
PSS006	Out of Wtr Qty Rec.	out_of_water_qty_rec	I	4	Quantity in gallons of spill recovered out of water.
PSS007	In Water Qty Spilled	in_water_qty_spilled	I	4	Quantity in gallons of spill in the water.
PSS008	In Water Qty Rec.	in_water_qty_rec	I	4	Quantity in gallons of spill recovered in the water.
PSS009	Units of Measure	units_measure	C	7	Units of measure.
PSS010	Substance Name	substance_name	C	55	Substance spilled name.
	Substance Type	type	C	1	Single character indicating type of substance: C = Chemical P = Petroleum based products O = Other oil products G = Garbage U = Unknown M = Multiple substances N = Natural substances
	Spill Date	spdt	D		Date of Spill (from prit)

MSO TAMPA SPILL STATS ABBREVIATIONS

SUBJECT LINE ABBR S

CATEGORY

~~LOW LETTER OF WARNING~~

N = NON-VIOLATION
P = POTENTIAL
V = VIOLATION
F = FPO
H = HAZ MAT
M = MARPOL V
E = SPILL THAT OCCURS WITHIN EPA JURISDICTION
C = CERCLA
~~LW = Letter of Warning~~

WATERBODY

CR = CRYSTAL RIVER
WIR = WITHLACOOCHEE RIVER
TS = TARPON SPRINGS AREA
CLRH = CLEARWATER HARBOR/PASS
BCBN = BOCA CIEGA BAY NORTH
BCBS = BOCA CIEGA BAY SOUTH
SB = SARASOTA BAY
VEN = VENICE AREA
CH = CHAROLETTE HARBOR
PIS = PINE ISLAND SOUND
SBY = SAN CARLOS BAY
CALR = CALOOSAHATCHEE RIVER
FMB = FT. MYERS BEACH AREA
MI = MARCO ISLAND AREA
GMLX<12 = GOM < 12NM
GMX>12 = GOM > 12NM
ONW = OTH NAVIGABLE WATERWAY

PORT = PORT OF TAMPA
PS = PORT SUTTON
HBY = HILLSBOROUGH BAY
TBY = TAMPA BAY
OTBY = OLD TAMPA BAY
WI = WEEDON ISLAND
BYBH = BAYBORO HARBOR
BB = BIG BEND
STP = ST. PETERSBURG
PM = PORT MANATEE
AR = ALAFIA RIVER
LMR = LITTLE MANATEE RIVER
MR = MANATEE RIVER
MP = MATLACHA PASS
ICW = INTRACOASTAL WATERWAY
NW = NON WATERWAY

SOURCE

MYS = MYSTERY SPILL
T/B = TANK BARGE
F/V = COMMERCIAL FISHING VESSEL
P/C = PLEASURE CRAFT
M/V = U.S. MOTOR VESSEL
FM/V = FOREIGN MOTOR VESSEL
ONS = ON SHORE FACILITY
ONP = ON SHORE PIPELINE
OFP = OFF-SHORE PIPELINE
OTH = OTHER/MISC ITEMS

QUANTITY

P = POUNDS
G = GALLONS
B = BARRELS
K = THOUSAND (i.e., 24KG = 24,000 GALLONS)
M = MILLION (i.e., 3.9MG = 3,900,000 GALLONS)

S = STATE CLEANUP
L = LOCAL AGENCY (FIRE D'

CLEANUP ACTION

R = RESPONSIBLE PARTY CLEANUP
J = RESPONSIBLE PARTY CLEANUP / COAST GUARD OPENS FUND TO RECOUP MONITOR COSTS
C = COAST GUARD SUPERVISOR OF CLEANUP
N = NO CLEANUP

I.E.: N BCBN MYS 2G N ! V PORT FM/V GEMINY 25G R
F 07-3028 PM MYS 15B C ! V/F 3028 PS P/C LUCK LDY 20G C