TOTAL MAXIMUM DAILY LOAD (TMDL) ANALYSIS

FOR

INDIAN RIVER, INDIAN RIVER BAY, AND REHOBOTH BAY, DELAWARE

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EXECUTIVE SUMMARY

Section 303(d) of the Clean Water Act (CWA), as amended by the Water Quality Act of 1987, requires States to identify and list those waters within their boundaries that are water quality limited (303(d) List), to prioritize them, and to develop Total Maximum Daily Loads (TMDLs) for pollutants of concern. A water quality limited water is a waterbody in which water quality does not meet applicable water quality standards, or is not expected to meet applicable standards, even after application of technology-based effluent limitations for Publicly Owned Treatment Works (POTW) and other point sources. A TMDL sets a limit on the amount of a specific pollutant that can be discharged into a waterbody and still protect water quality. TMDLs have three elements: Waste Load Allocations (WLAs) for point sources, Load Allocations (LAs) for nonpoint sources, and a Margin of Safety (MOS).

Intensive water quality monitoring performed by the State of Delaware, the federal government, various university and private researchers, and citizen monitoring groups has shown that the Indian River, Indian River Bay, and Rehoboth Bay are highly enriched with the nutrients nitrogen and phosphorous. As the result, Department of Natural Resources and Environmental Control (DNREC) has included these waters on the State's 1996 and 1998 303(d) Lists and has established Total Maximum Daily Loads for nitrogen and phosphorous. These TMDLs are based on analyzing the effects of various pollution reduction scenarios while using a comprehensive and state-of-the-art hydrodynamic and water quality model (the Inland Bays Model). The Inland Bays Model was developed through a cooperative agreement between DNREC and the US Army Corps of Engineers - Waterway Experiment Station, Vicksburg, Mississippi with significant financial support from the U.S. Environmental Protection Agency.

The Total Maximum Daily Loads for the Indian River (segment DE140-004), Indian River Bay (segments DE140-E01 and DE140-E02) and Rehoboth Bay(segment DE280-E01) requires that:

1. All point source discharges to the Indian River, Indian River Bay, Rehoboth Bay, and their tributaries should be eliminated systematically.

2. The nonpoint source nitrogen loads from five tributaries in the upper Indian River should be reduced by 85 percent (from the base-line period of 1988 through 1990). These tributaries include Swan Creek, Iron Branch, Pepper Creek, Vines Creek, and Millsboro Pond. This will result in reducing nitrogen loads from these tributaries during a normal rainfall year from 1285 kilograms per day (2833 pounds per day) to 193 kilograms per day (425 pounds per day).

3. The nonpoint source phosphorous loads from these five tributaries in the upper Indian River should be reduced by 65 percent (from the base-line period of 1988 through 1990). This will result in reducing phosphorous loads from these tributaries during a normal rainfall year from 38 kilograms per day (84 pounds per day) to 13 kilograms per day (29 pounds per day).

4. The nonpoint source nitrogen loads from all remaining tributaries to the Indian River, Indian River Bay, and Rehoboth Bay should be reduced by 40 percent (from the base-line period of 1988 through 1990). This will result in reducing nitrogen loads from these tributaries during a normal rainfall year from 732 kilograms per day (1614 pounds per day) to 439 kilograms per day (968 pounds per day).

5. The nonpoint source phosphorous loads from all remaining tributaries to the Indian River, Indian River Bay, and Rehoboth Bay should be reduced by 40 percent (from the base-line period of 1988 through 1990). This will result in reducing phosphorous loads from these tributaries during a normal rainfall year from 36 kilograms per day (79 pounds per day) to 22 kilograms per day (49 pounds per day).

6. The atmospheric nitrogen deposition rate should be reduced by 20 percent (from the base-line period of 1988 through 1990). This will result in reducing the atmospheric nitrogen deposition rate from 765 kilograms per day (1687 pounds per day) to 612 kilograms per day (1349 pounds per day).

The result of hydrodynamic and water quality model runs has shown that through implementation of the above requirements, all water quality standards and targets in the Indian River, Indian River Bay, and Rehoboth Bay will be achieved with an adequate margin of safety.

Implementation of this proposed TMDL will be achieved through development and implementation of a Pollution Control Strategy (PCS). The PCS will be developed by DNREC in concert with the Department’s ongoing Whole Basin Management Program and the affected public.

SECTION 1

INTRODUCTION and BACKGROUND

Indian River, Indian River Bay, and Rehoboth Bay are part of Delaware's Inland Bays and are located in the southeastern part of the State, in Sussex County (Figure 1.1). Fresh water enters the bays through ground water discharge, overland runoff, and from tributaries. Salt water enters the bays mainly through the Indian River Inlet. Lewes and Rehoboth Canal at the northern end, and Assawoman Canal at the southern end of the bays provide additional sources of salt water to the bays.

DESIGNATED USES

Section 10 of the State of Delaware Surface Water Quality Standards, as amended, designates the following specific uses for the waters of the Indian River, Indian River Bay, and Rehoboth Bay (1):

a. Fish, Aquatic Life, and Wildlife
b. Primary Contact Recreation
c. Secondary Contact Recreation
d. Industrial Water Supply
e. ERES Waters (Waters of Exceptional Recreational or Ecological Significance)
f. Harvestable Shellfish Waters

Note: Only parts of the Indian River, Indian River Bay, and Rehoboth Bay are designated as ERES or harvestable shellfish waters.

Figure 1.1 Delaware Inland Bays Sub-basin

This map is prepared for the DNREC Whole Basin Initiative.
The information in this map is subject to change or modification
at any time. Use of the information by others is at their own risk,
and the DNREC in no way guarantees or warrants the accuracy
and/or completeness of the information. The information
depicted is provided for general and approximate graphical
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APPLICABLE WATER QUALITY STANDARDS

The following sections of the State of Delaware Water Quality Standards provide specific narrative and numeric criteria concerning the waters of the Inland Bays (1):

1. Section 3. This Section of the State Water Quality Standards provides general guidelines regarding the Department's Antidegradation policies.
2. Section 7. This Section of the Standards provides specific narrative and numeric criteria for controlling nutrient overenrichment in waters of the State.
3. Section 9. This Section provides specific narrative and numeric criteria for toxic substances.
4. Section 11. This Section of the Standards provides specific water quality criteria for surface waters of the State.

Based on the above Sections, the following is a summary of some pertinent water quality standards which are applicable to the waters of Indian River, Indian River Bay, and Rehoboth Bay:

a. *Dissolved Oxygen (D.O.):*

  - 5.0 mg/l daily average (from June through September)
  - 4.0 mg/l minimum

b. *Nutrients (Phosphorous and Nitrogen) during submerged aquatic vegetation growth season (March 1 through October 31):*

  - 0.01 mg/l Dissolved Inorganic Phosphorous (DIP)
  - 0.14 mg/l Dissolved Inorganic Nitrogen (DIN)

c. *Total Suspended Solids (TSS) during submerged aquatic vegetation growth season (March 1 through October 31):*

  - 20 mg/l

d. *Enterococcus Bacteria:*

  - 10 colonies / 100 ml

e. Temperature:

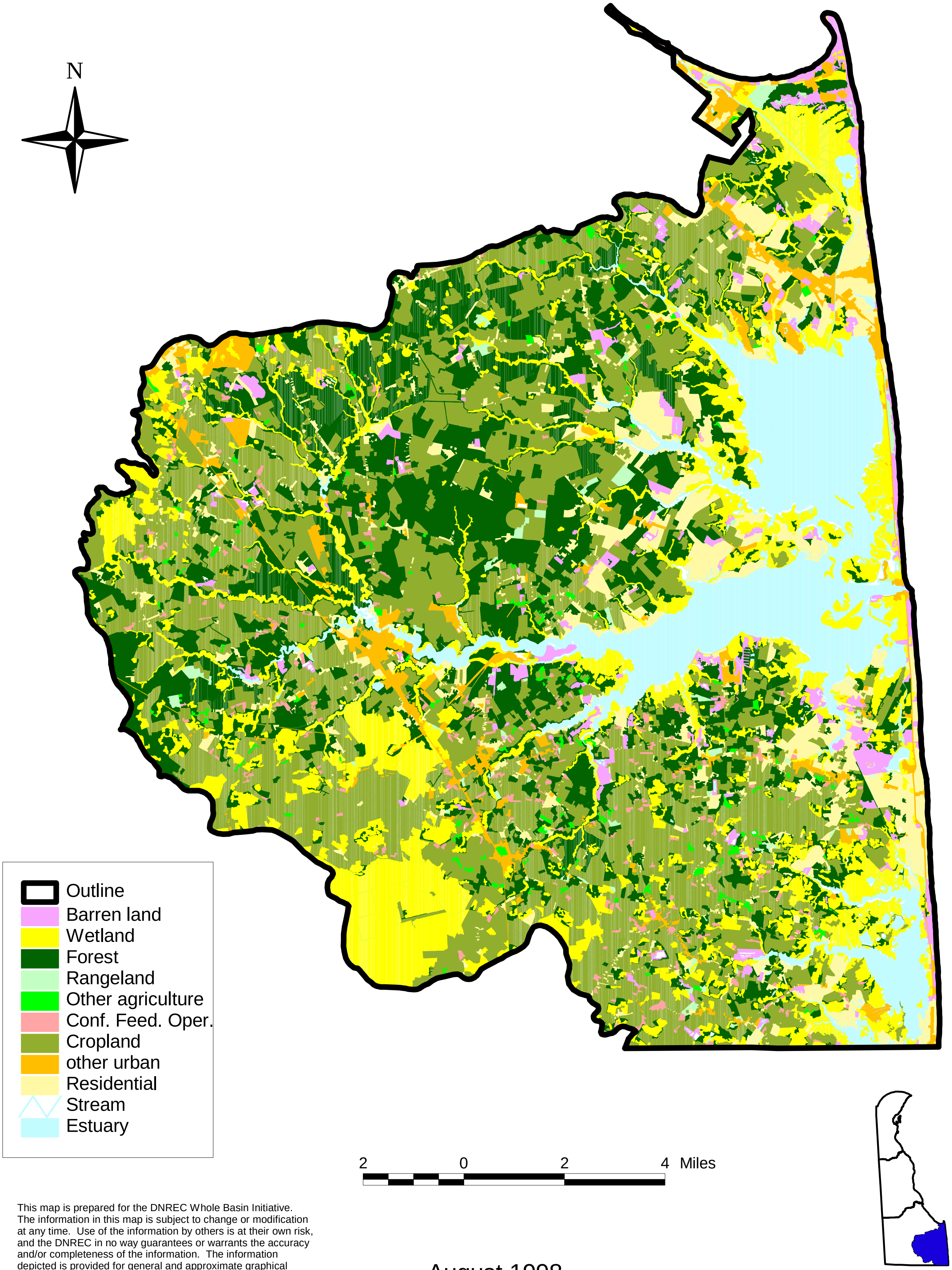
- 86 degree Fahrenheit, maximum daily
- 84 degree Fahrenheit, mean daily
- Maximum increase above natural condition: 4 degree Fahrenheit

In addition to the above narrative and numeric criteria, Section 11.5 of the State Water Quality Standards provides general policies and criteria for Waters of Exceptional Recreational or Ecological Significance (ERES Waters). The Section requires that ERES Waters, which are considered as special natural assets of the State, shall be accorded a level of protection in excess of that provided for most other waters of the State. Furthermore, it calls for restoring ERES Waters, to the maximum extent practicable, to their natural condition by adopting pollution control strategies which will take appropriate action to cause systematic control, reduction, or elimination of existing pollution sources.

LAND USE

Figure 1.2 shows major land uses in the Inland Bays sub-basin based on the 1992 land use survey. The results of this land use survey is also summarized in a pie chart shown in Figure 1.3. As can be seen from Figures 1.2 and 1.3, agriculture (cropland) and wooded lands are major land uses in the Inland Bays Sub-basin. The percentage of land use for these two categories are 37% and 22.4%, respectively. Other major land uses in the sub-basin include: urban (11.1%), range/barren land (3.4%), wetland (14.4%) and water (11.7%).

Figure 1.2 1992 Land Use



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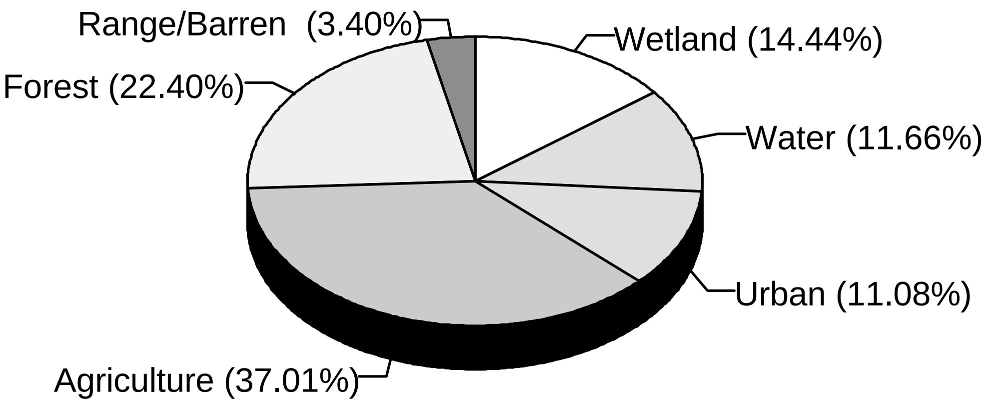

Figure 1.3 Summary of Land Use Activities in the Inland Bays Sub-basin

WATER QUALITY CONDITIONS OF THE INLAND BAYS

Intensive water quality monitoring and assessment studies performed by the State of Delaware, the federal government, various university and private researchers, and citizen monitoring groups has shown that waters of the Indian River, Indian River Bay, and Rehoboth Bay are highly enriched with the nutrients nitrogen and phosphorous. Although nutrients are essential elements for both plants and animals, their presence in excessive amounts cause undesirable conditions and significant negative impacts to fish and other aquatic life. Symptoms of nutrient enrichment in the Inland Bays have include excessive macroalgae growth (sea lettuce and other species), phytoplankton blooms (some potentially toxic), large daily swings in dissolved oxygen levels, loss of Submerged Aquatic Vegetation (SAV), and fish kills. These symptoms threaten the future of the Inland Bays - a very significant natural, ecological, and recreational resources of the State - and may result in adverse impacts to the local and State economies through reduced tourism, a decline in property values, and lost revenues. Hence, excessive nutrients pose a significant threat to the health and well being of people, other animals, and plants living within the watershed.

Nutrient overenrichment was ranked as the top environmental problem of the Inland Bays during a comprehensive water quality assessment conducted for the U.S. Environmental Protection Agency's (EPA's) National Estuary Program (NEP) (2). The study concluded that habitat loss is the other major environmental concern in the Inland Bays. Based on this findings, which was supported by other studies, nutrient load reduction was considered as a major goal for the Inland Bays Comprehensive Conservation and Management Plan (CCMP) which was adopted in 1995 (4).

Nutrient overenrichment and violation of water quality standards are also evident from Figures 1.4 through 1.9, which provide summaries of several water quality parameters at selected monitoring stations in the Indian River, Indian River Bay, and Rehoboth Bay. These data were collected during a three-year period from 1995 through 1977. Summary statistics as well as water quality standards and targets are shown in these figures (5).

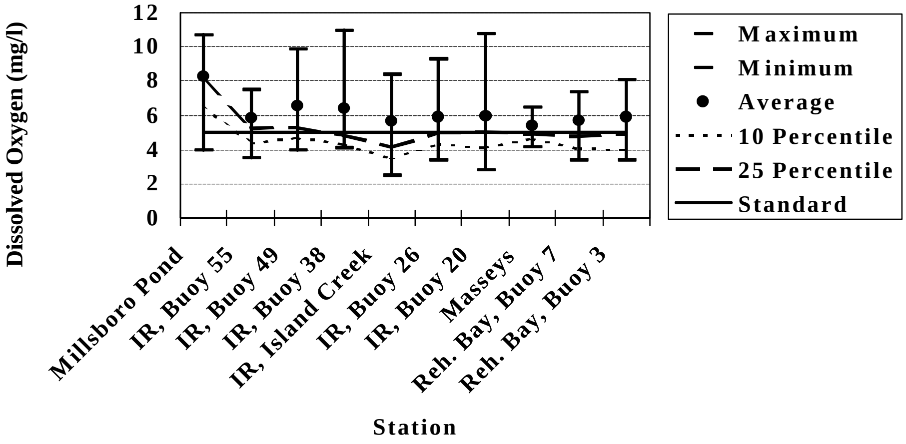

Figure 1.4 Dissolved Oxygen Concentrations in the Inland Bays (1995 - 1997 Period)

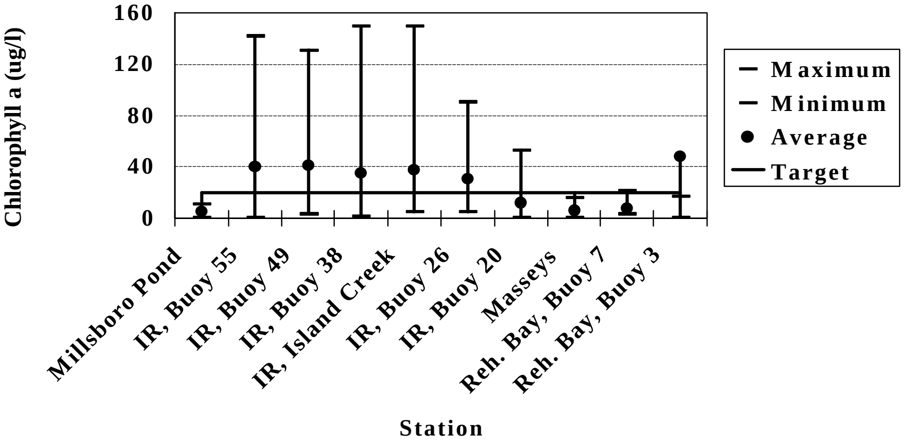

Figure 1.5 Chlorophyl a Concentrations in the Inland Bays (1995 - 1997 Period)

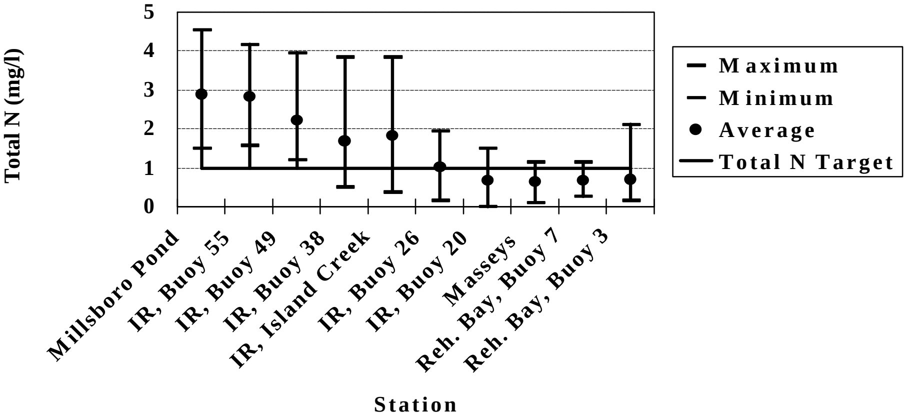

Figure 1.6 Total Nitrogen Concentrations in the Inland Bays (1995 - 1997 Period)

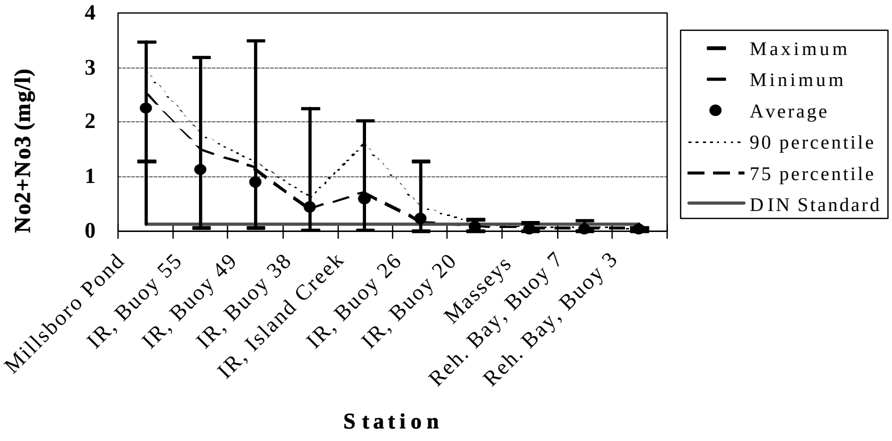

Figure 1.7 Nitrite + Nitrate Concentrations in the Inland Bays (1995 - 1997 Period)

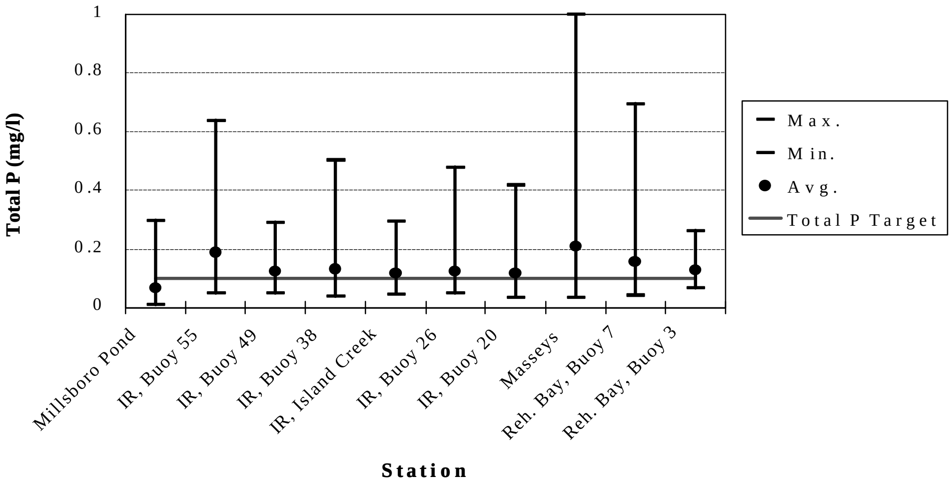

Figure 1.8 Total Phosphorous Concentrations in the Inland Bays (1995 - 1997 Period)

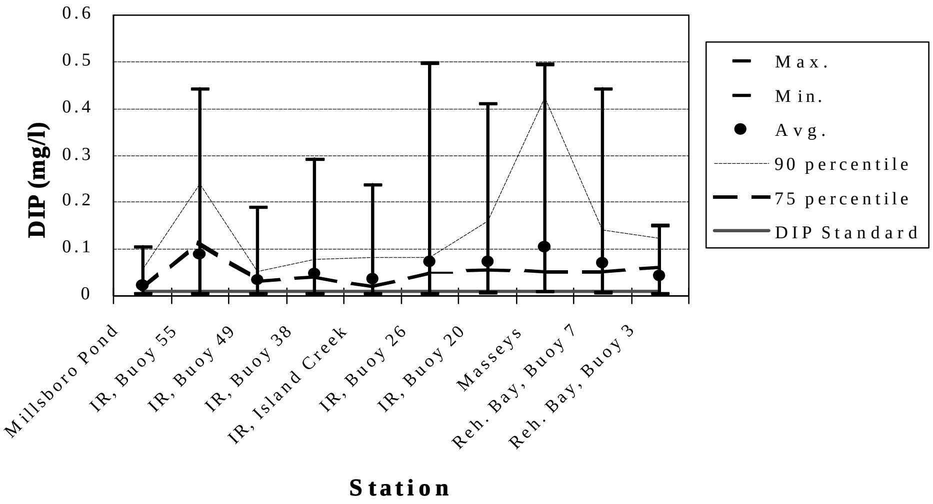

Figure 1.9 Dissolved Inorganic P Concentrations in the Inland Bays (1995 - 1997 Period)

Furthermore, nutrient overenrichment and violation of water quality standards are documented by the State's 1996 and 1998 Watershed Assessment Reports (Clean Water Act Section 305(b) Reports) (6,7). The 305(b) Reports are prepared by the State on April 1 of every even numbered year and provide comprehensive assessments of water quality conditions of all waters of the State. In addition, these reports summarize the level of designated use support for all waters of the State. Figures 1.10 and 1.11 show the results of designated use support analyses for the Indian River Bay portion of the Inland Bays as reported by the State's 1996 and 1998 305(b) Reports. These two figures indicate that aquatic life use and the ERES Water use are not supported in the Indian River Bay. Furthermore, the primary contact recreation use and shellfish harvesting use are partially supported in these waters. The primary pollutants and/or stressors causing violation of water quality standards are high concentrations of nutrients, low levels of dissolved oxygen, and high levels of bacteria.

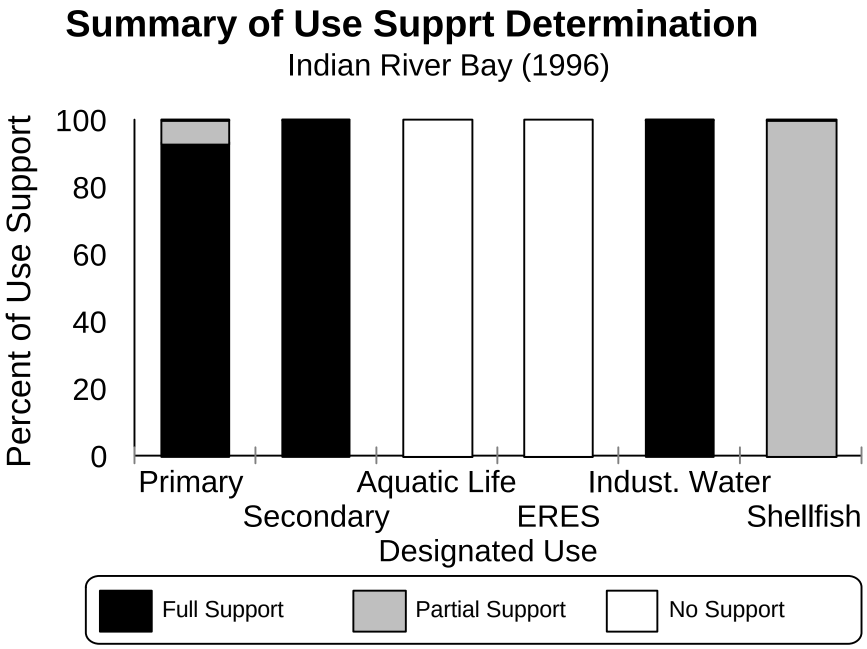

Figure 1.10 Designated Use Support for the Indian River Bay, Delaware (1996)

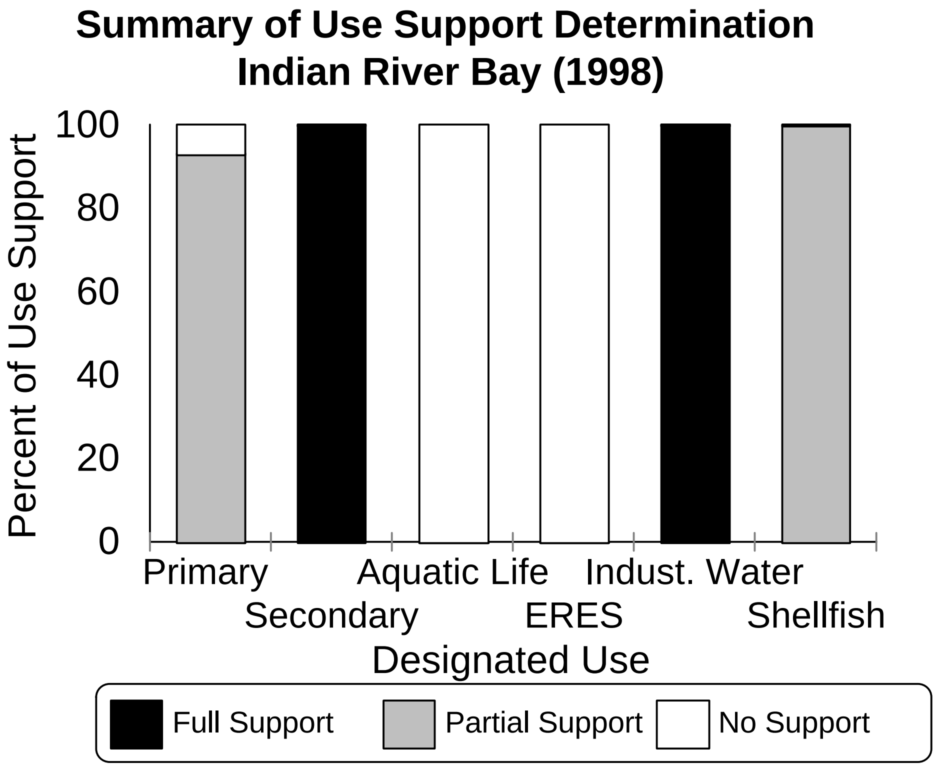

Figure 1.11 Designated Use Support for the Indian River Bay, Delaware (1998)

The use support determinations, as summarized in Figures 1.10 and 1.11, are based on the following criteria:

a. A waterbody is considered fully supporting its designated uses when at least 90 percent of the observations meet applicable water quality standards.

b. A waterbody is considered partially supporting its designated uses when between 75 to 90 percent of the observations meet applicable water quality standards.

c. A waterbody is considered to not support its designated uses when less than 75 percent of the observations meet applicable water quality standards.

Since waters of the Indian River, Indian River Bay, and Rehoboth Bay are not fully supporting their designated uses, they have been placed on the State's 1996 and 1998 303(d)

Lists (8, 9). The proposed nitrogen and phosphorous TMDLs for these waters, as detailed in this report, need to be established in order to achieve all applicable water quality standards and targets.

POLLUTANTS OF CONCERN

Excessive nutrients, i.e., nitrogen and phosphorus, are "pollutants of concern" for the Indian River, Indian River Bay, and Rehoboth Bay and cause violations of water quality standards. The sources of nutrient loads to the bays include point source discharges from municipal and industrial wastewater treatment plants, surface runoff from agricultural, urban, and other land use activities in the sub-basin, atmospheric deposition, groundwater discharge, and contributions from nutrient-rich coastal waters (3).

DEVELOPMENT OF THE INLAND BAYS HYDRODYNAMIC AND WATER QUALITY MODEL

To develop a comprehensive and scientifically defensible management tool that could be used for establishing Total Maximum Daily Loads for the Inland Bays, the Delaware Department of Natural Resources and Environmental Control (DNREC) initiated development of a hydrodynamic and water quality model of the bays. The model was developed and was calibrated through cooperative agreements with the U.S. Army Corps of Engineers, Waterway Experiment Station, Vicksburg, Mississippi, with financial support from the US EPA's Inland Bays National Estuary Program. The model was calibrated using water quality and hydrodynamic data collected by DNREC, the U.S. Geological Survey (USGS), US Army Corps of Engineers, University of Delaware researchers, citizen monitors, and others.

The Inland Bays Model is considered a state-of-the-art assessment and modeling tool which has been used extensively by DNREC to conduct a wide variety of water quality analyses and evaluations. This modeling tool has been used to establish the total maximum daily loads for nitrogen and phosphorous for the Indian River, Indian River Bay, and Rehoboth Bay.

SCOPE AND OBJECTIVES OF THE TMDL ANALYSIS

The Delaware Department of Natural Resources and Environmental Control has established total maximum daily loads for nitrogen and phosphorous for the Indian River, Indian River Bay, and Rehoboth Bay. These segments and their EPA's Water Body System (WBS) identification numbers are shown in Figure 1.12. The established TMDLs are based on the results of various load reduction scenario runs which were conducted using the Inland Bays Model as a predictive tool. The proposed TMDLs are designed to achieve applicable water quality standards and targets for dissolved oxygen, total nitrogen, total phosphorous, dissolved inorganic nitrogen, dissolved inorganic phosphorous, and chlorophyl a.

Section 2 of this report provides a brief review of the Inland Bays Model development and calibration. The results of scenario runs and development of the TMDLs for nitrogen and phosphorous are discussed in Section 3.

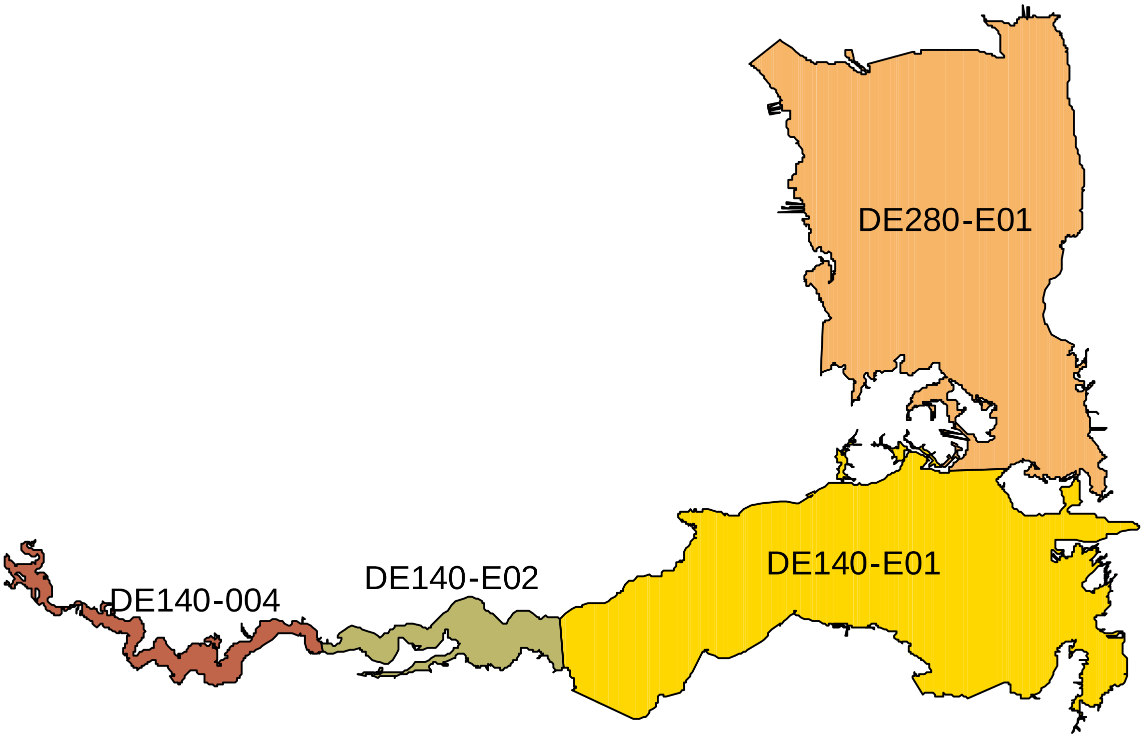

Figure 1.12 The Four Water Body Segments Included in the TMDL Analysis

SECTION 2

THE HYDRODYNAMIC AND WATER QUALITY MODEL OF THE INDIAN RIVER, INDIAN RIVER BAY, AND REHOBOTH BAY

Development of the nitrogen and phosphorous total maximum daily loads for the Indian River, Indian River Bay, and Rehoboth Bay is based on the results of various load reduction scenarios using a hydrodynamic and water quality model - the Inland Bays Model. This model is made of two main components; a hydrodynamic model (CH3D), and a water quality model (CE-QUAL-ICM) (Figure 2.1). The Inland Bays Model was developed and calibrated using intensive water quality and quantity data collected by the State, federal government, and by University of Delaware researchers.

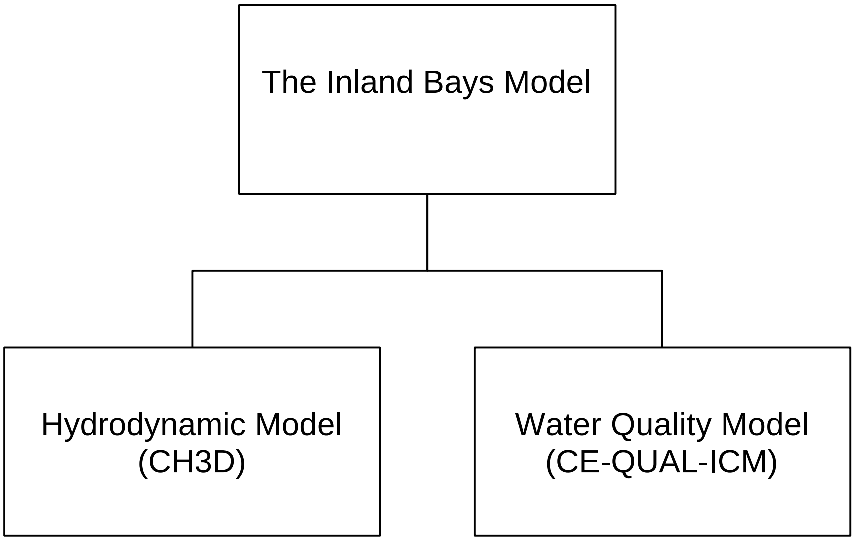

Figure 2.1 Components of the Inland Bays Model

Following is a brief description of the components of the Inland Bays Model. A detailed discussion of the model development, model calibration, and data requirements are provided in a U.S. Army Corps of Engineers' report entitled "Hydrodynamic and Eutrophication Model Study of Indian River and Rehoboth Bay, Delaware, Technical Report EL-94-5, May 1194." (3).

THE INLAND BAYS HYDRODYNAMIC MODEL (CH3D)

The CH3D (Curvilinear Hydrodynamics in Three Dimensions) Model is used as the hydrodynamic model for Delaware's Inland Bays. A key feature of the CH3D Model is its ability to represent waterbodies with irregular coastal boundaries. The original CH3D modeling framework was developed in the mid '80s and was applied to the Chesapeake Bay. Since then, the CH3D Model has been applied to several other complex estuarine systems including the Inland Bays and San Francisco Bay.

The Model calculates time-variable flows and surface elevations for the entire estuarine system using classical equations of momentum and continuity (Navier-Stockes equations) formulated for a Cartesian coordinate system. These equations are as follows:

a. Momentum Equation (for x direction):

$$\frac{\partial u}{\partial t} + \frac{\partial}{\partial x}\left[\frac{UU}{H}\right] + \frac{\partial}{\partial y}\left[\frac{UV}{H}\right] + gH\frac{\partial S}{\partial x}$$

$$- fV - \frac{\text{é}_{sx}}{\text{ñ}} + \frac{\text{é}_{Bx}}{\text{ñ}} + A_H\left[\frac{\partial^2 U}{\partial x^2} + \frac{\partial^2 U}{\partial x^2}\right] + \frac{1}{\text{ñ}}\frac{\partial p}{\partial x} = 0$$

B. Continuity Equation:

$$\frac{\partial S}{\partial t} + \frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0$$

where,

x, y, t = *independent space and time variables*
U, V = *unit flow rate components in the x- and y- direction, respectively*
H = *total water depth* $(h + S)$
S = *water surface displacement measured relative to an arbitrary datum*
h = *static water depth measured from the same datum*
g = *gravitational acceleration*
f = *Coriolis parameter*
$\hat{o}_{sx}, \hat{o}_{sy}$ = *surface shear stress in the x- and y- direction, respectively*
$\hat{o}_{Bx}, \hat{o}_{By}$ = *bottom shear stress in the x- and y- direction, respectively*
$\tilde{n}$ = *water density (assumed to be constant)*
A_H = *generalized dispersion coefficient*
p = *pressure*

To develop a hydrodynamic computer model for an estuarine system, the waterbody is generally divided into a number of small segments (cells). Then, for each cell and at each time step, equations of momentum and continuity are solved simultaneously to obtain a time series of the volume of water and its velocity in each cell. These results are saved in an output file and used as an input to the water quality model.

The Inland Bays hydrodynamic model is made up of more than 2,000 cells. The size of each cell is about 100 to 200 feet wide and about 400 feet long (Figure 2.2). The time step to run the Inland Bays hydrodynamic model is 30 seconds. Principal input data for the model are: tidal oscillations at the ocean boundary, fresh water flows entering the bays from tributaries, wind speed, and wind direction. The CH3D Model for the Inland Bays was calibrated using observed field data for tidal elevations and tidal currents at several monitoring locations in the bays during a three-year base-line period (1988 through 1990). Figure 2.3 shows a snapshot of tidal velocity and direction in various cells of the Inland Bays as generated by the Inland Bays Model.

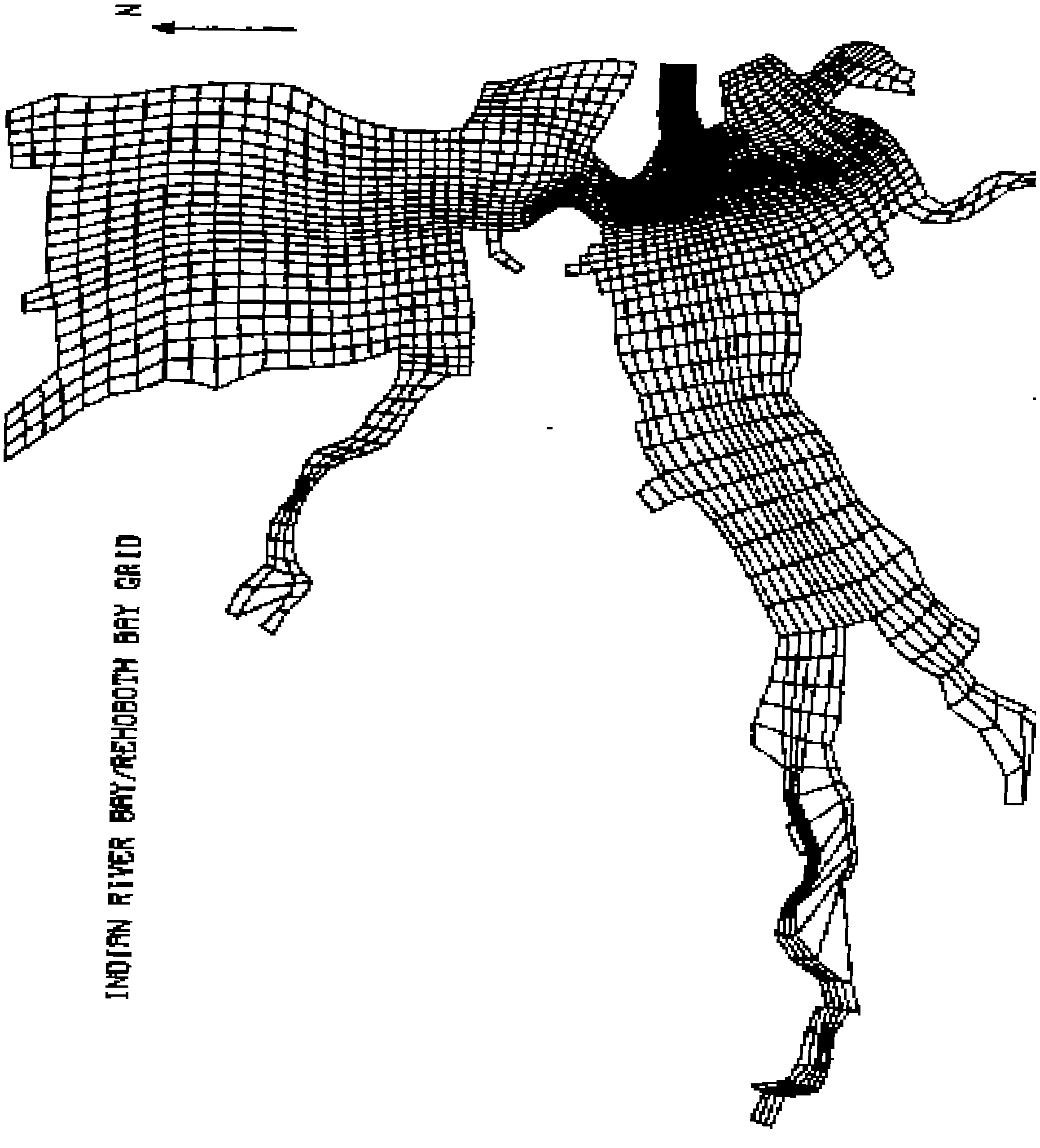

Figure 2.2 The Inland Bays Hydrodynamic Model Segmentation

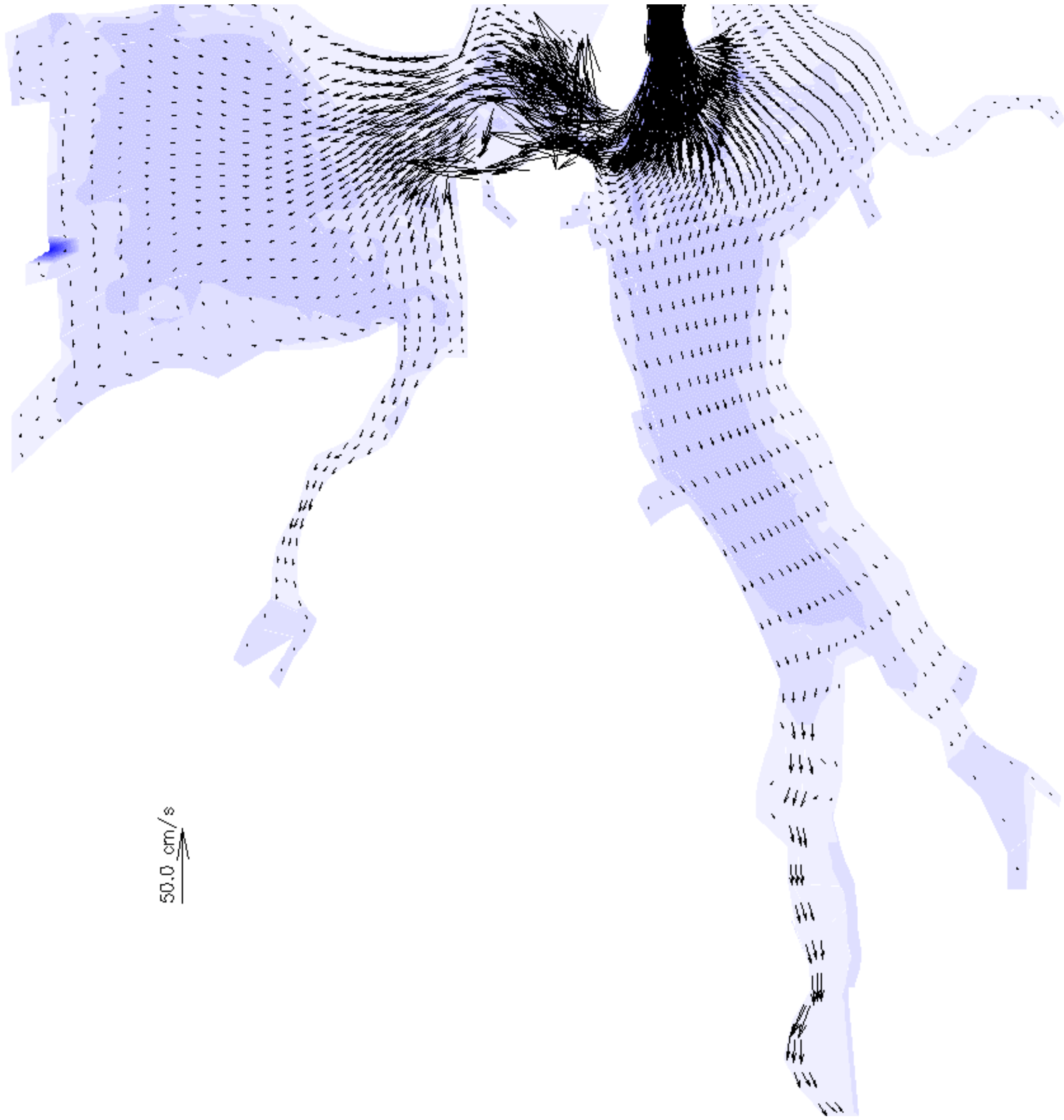

Figure 2.3 A Snapshot of Tidal Velocity and Direction in the Inland Bays

Following a successful development and calibration of the hydrodynamic model, model outputs were saved in a file to be used as inputs to the water quality model.

INLAND BAYS WATER QUALITY MODEL (CE-QUAL-ICM)

The CE-QUAL-ICM Model was used as the water quality component of the Inland Bays Model. This model was originally developed to study eutrophication problems of the Chesapeake Bay. The CE-QUAL-ICM model solves the equation of conservation of mass for a control volume to calculate time series of concentrations of various water quality parameters. Control volumes in the water quality model correspond to one or more cells on the hydrodynamic model grid. The number of water quality control volumes (cells) in the Inland Bays water quality model is 281 (Figure 2.4).

For the Inland Bays, the following two-dimensional, vertically integrated form of the conservation of mass equation is employed:

$$\frac{\delta V_i C_i}{\delta t} = \sum_{j=1}^{n} Q_j C_j^* + \sum_{j=1}^{n} A_j D_j \frac{\delta C}{\delta x_j} + \sum S_i$$

Where,

V_i = *volume of ith control volume* (m^3)

C_i = *concentration in ith control volume* ($gm\ m^{-3}$)

Q_j = *volumetric flow across flow face j of ith control volume* ($m^3\ sec^{-1}$)

C_i* = *concentration in flow across flow face j* ($gm\ m^{-3}$)

A_j = *Area of flow face j* (m^3)

D_j = *Diffusion coefficient at flow face j* ($m^2\ sec^{-1}$)

n = *number of flow faces attended to ith control volume*

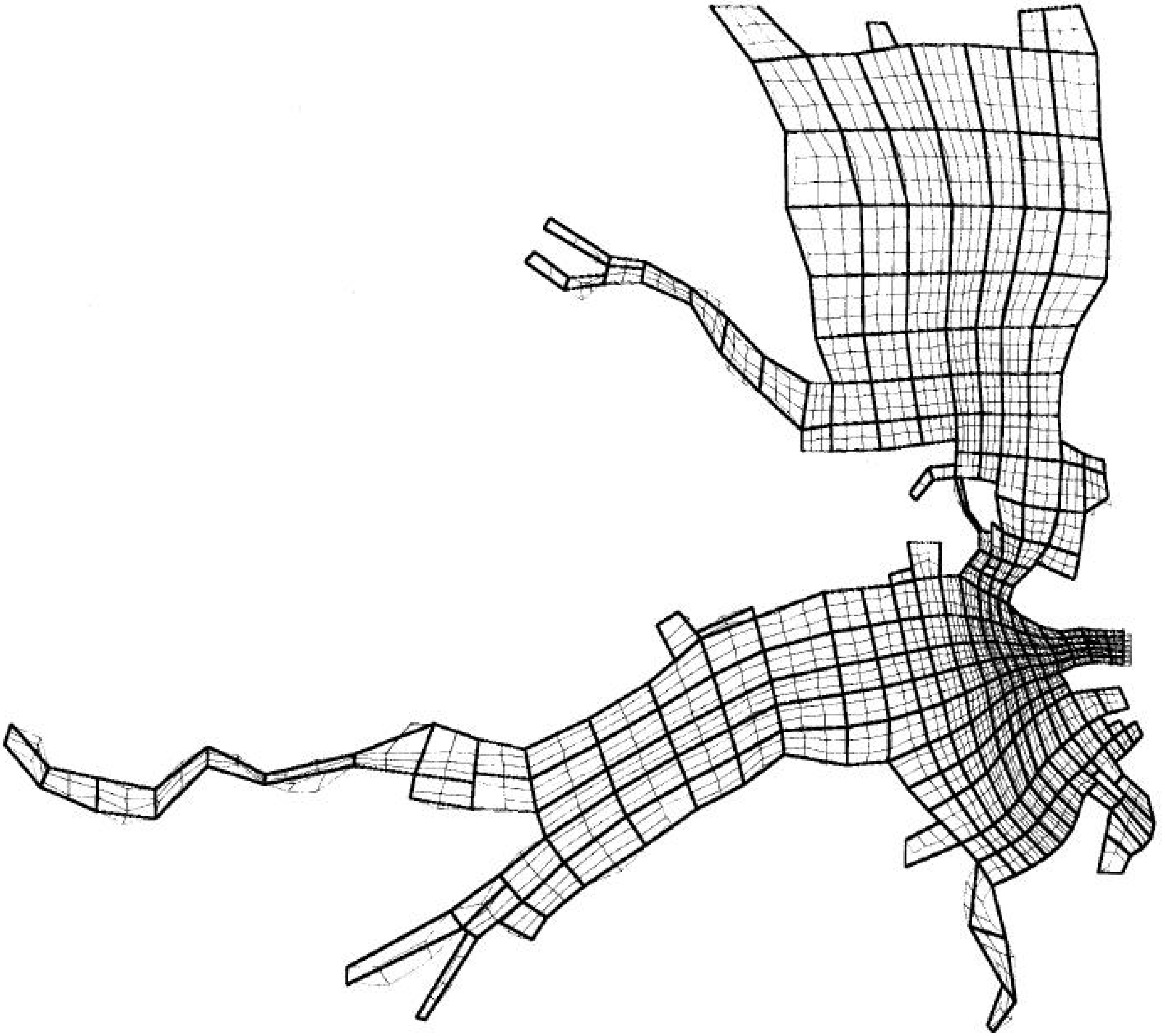

Figure 2.4 Water Quality Model Segmentation

Figure 2.4 water quality model segmentation

S_i = *external loads and kinetic sources and sinks in ith control volume* ($gm\ sec^{-1}$)
t, x = *temporal and spatial coordinates*

The version of the CE-QUAL-ICM Model which is applied to the Inland Bays simulates the following 16 water quality parameters (3):

1. Temperature
2. Salinity
3. Algae (as represented by Chlorophyll a)
4. Dissolved organic carbon
5. Labile particulate organic carbon
6. Refractory particulate organic carbon
7. Ammonia
8. Nitrite+nitrate nitrogen
9. Dissolved organic nitrogen
10. Labile particulate organic nitrogen
11. Refractory particulate organic nitrogen
12. Total phosphorous
13. Dissolved organic phosphorous
14. Labile particulate organic phosphorous
15. Refractory particulate organic phosphorus
16. Dissolved oxygen

The principal input data for the water quality model include the hydrodynamic model output, point source pollution and nutrients loads, nonpoint source loads, algal growth kinetics rates, settling velocities for particulate compounds, and meteorological conditions. The magnitude of point source loads, nonpoint source loads, and atmospheric deposition of nitrogen in the Inland Bays Sub-basin during base-line period (1988 through 1990) is discussed below.

POINT SOURCE DISCHARGES

During the base-line period (1988 through 1990), thirteen municipal and industrial wastewater treatment plants were discharging to the waters of the Inland Bays and its tributaries (Figure 2.5). Discharge of pollutants to the waters of the State is regulated through the Department's administration of the National Pollution Discharge Elimination System (NPDES) Permits Program. Section 402 of the Clean Water Act requires each discharger to apply and obtain an NPDES Discharge Permit prior to initiation of its discharge. An NPDES Permit is issued for a five-year period and regulates the quality and quantity of pollutants that can be discharged into the surface waters of the State. It also establishes the requirements for effluent monitoring and reporting. Table 2.1 lists point source discharges in the Inland Bays Sub-basin, their discharge permit numbers, the receiving streams, and the nitrogen and phosphorous loads during the base-line period (1988 through 1990).

Since 1990, three facilities in the Inland Bays Sub-basin have eliminated their surface discharge. These facilities are: Frankford Elementary School, Colonial East Mobile Home Park, and Delaware State Housing Authority.

Figure 2.5 Point Source Discharges in the Inland Bays Sub-basin

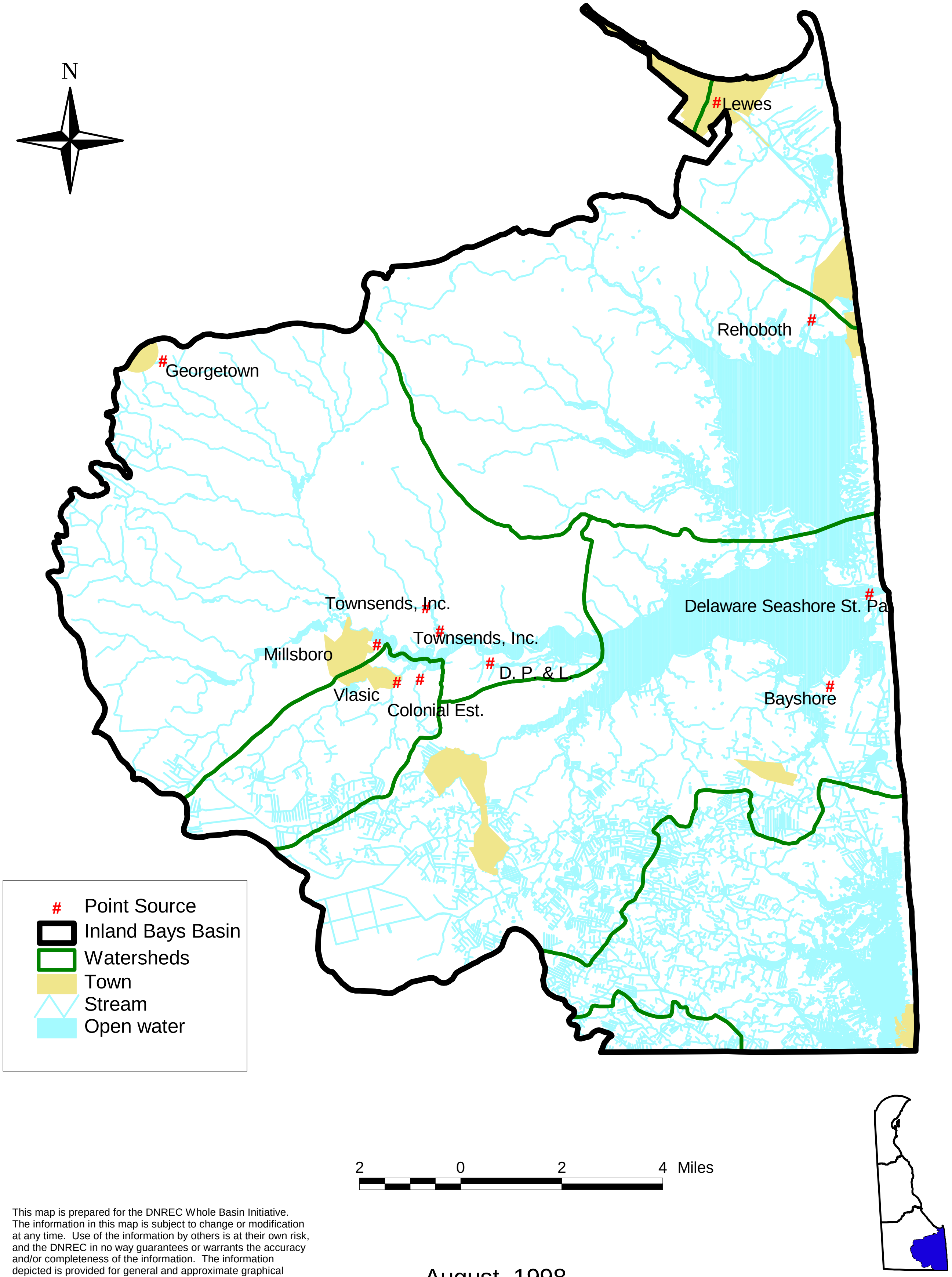

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Table 2.1 Point Source Discharges in the Inland Bays Sub-basin
(during base-line period 1988 - 1990)

Facility Name	NPDES No.	Receiving Stream	Total Nitrogen Load (kg/d)	Total Phosphorous Load (kg/d)
Delaware Seashore State Park	DE0021857	Indian River Inlet	1.37	0.30
Delmarva Power and Light	DE0050580	Island Creek	0.53	1.68
Frankford Elementary School	DE 0050237	Tributary of Vines Creek	0.27	0.05
Town of Millsboro	DE0050164	Tiger Branch	11.87	2.84
Townsends, Inc.	DE0050164	Swan Creek	145.23	0.52
Vlasic Food, Inc.	DE0000736	Iron Branch	4.79	0.14
Colonial East Mobile Home Park	DE0050709	L&R Canal	1.14	0.18
Rehoboth Beach	DE0020028	L&R Canal	25.76	16.43
Delaware State Housing Authority	DE0050903	L&R Canal	0.94	0.16
Bayshore Mobile Home Park	DE0050750	White Creek	0.26	0.06
Colonial Estates	DE0020061	Indian River	0.90	0.17
Georgetown	DE0020257	Eli Walls Ditch (Stockley Branch)	34.37	0.48
Lewes	DE002151	L&R Canal	32.29	7.77
Total Load			259.72	30.78

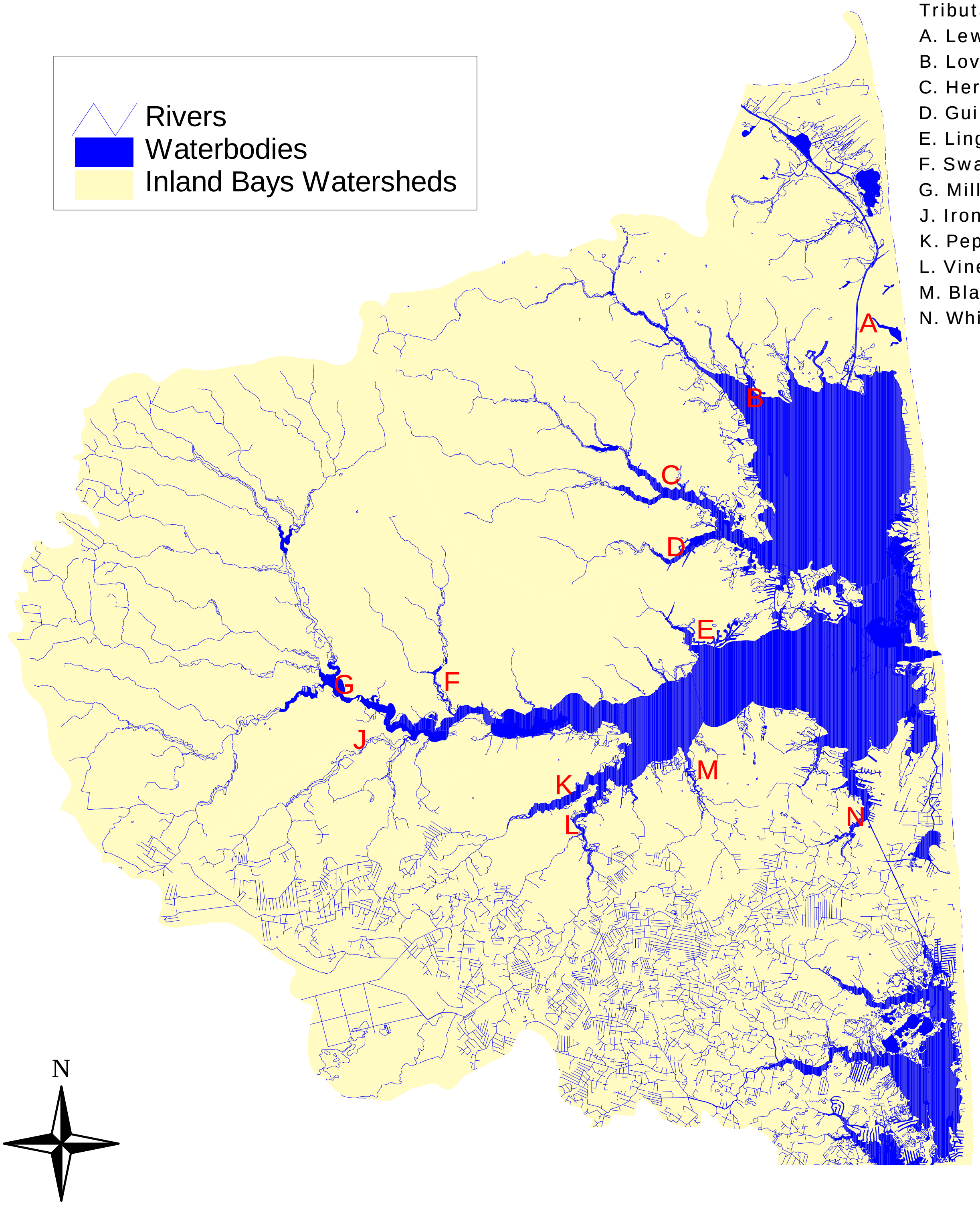
NONPOINT SOURCES OF POLLUTION

Pollutants loads not associated with discrete discharges are categorized as "nonpoint (diffused) sources". In contrast to continuous discharge from treatment plants, loading from nonpoint sources is typically intermittent and is mainly driven by storm events. Depending on the type of land use and physiographic characteristics of a watershed, nonpoint source pollution may account for a significant portion of the total load within the watershed.

The Inland Bays sub-basin consists of 12 major tributaries. Locations of these tributaries are shown in Figure 2.6; the size of their drainage area is listed in Table 2.2. The estimated average nitrogen and phosphorous loads contributed by these tributaries during the base-line period (1988 through 1990) are shown in Figure 2.7. These loadings are calculated by multiplying nutrient concentrations at each tributary by its flow rates. Tributary flow rates are estimated by establishing runoff rates for the watershed using stream flow data at two USGS gaging stations in the sub-basin. These two gages included Stockley Branch gaging station located at Stockley, Delaware (USGS-01484500), and Millsboro Pond Outlet gaging station located at Millsboro, Delaware (USGS-01484525).

The daily stream flow as well as the long-term average and the yearly-average flows for the years 1988, 1989, and 1990 for the Stockley Branch gaging station are shown in Figure 2.8. As it can be seen from this Figure, the long-term daily average flow at this station is 6.82 cubic feet per second (cfs). The yearly average daily flow for the years 1988, 1989, and 1990 are 3.81 cfs, 10.05 cfs, and 5.94 cfs, respectively. Considering these flow rates, 1988 is considered to represent a typical dry year; while 1989 and 1990 are considered to represent a wet and a normal year, respectively.

Figure 2.6 Tributary Flows to the Inland Bays



Tributaries
A. Lewes-Rehoboth Canal
B. Love Creek
C. Herring Creek
D. Guinea Creek
E. Lingo Creek
F. Swan Creek
G. Millsboro Branch
J. Iron Branch
K. Pepper Creek
L. Vines Creek
M. Blackwater Creek
N. White Creek

Table 2.2 Major Tributaries of the Inland Bays Sub-basin

Tributary Code	**Tributary Name**	**Drainage Area**		
		Hectare	**Acres**	**Square Miles**
A	Lewes-Rehoboth Canal	3785	9353.11	14.61
B	Love Creek	5682	14040.79	21.94
C	Herring Creek	6397	15807.63	24.70
D	Guinea Creek	3547	8764.99	13.70
E	Lingo Creek	1801	4450.45	6.95
F	Swan Creek	5527	13657.77	21.34
G	Millsboro Pond	14339	35433.10	55.36
J	Iron Branch	5997	14819.19	23.15
K	Pepper Creek	4154	10264.95	16.04
L	Vines Creek	4027	9951.12	15.55
M	Blackwater Creek	3549	8769.93	13.70
N	White Creek	3385	8364.67	13.07

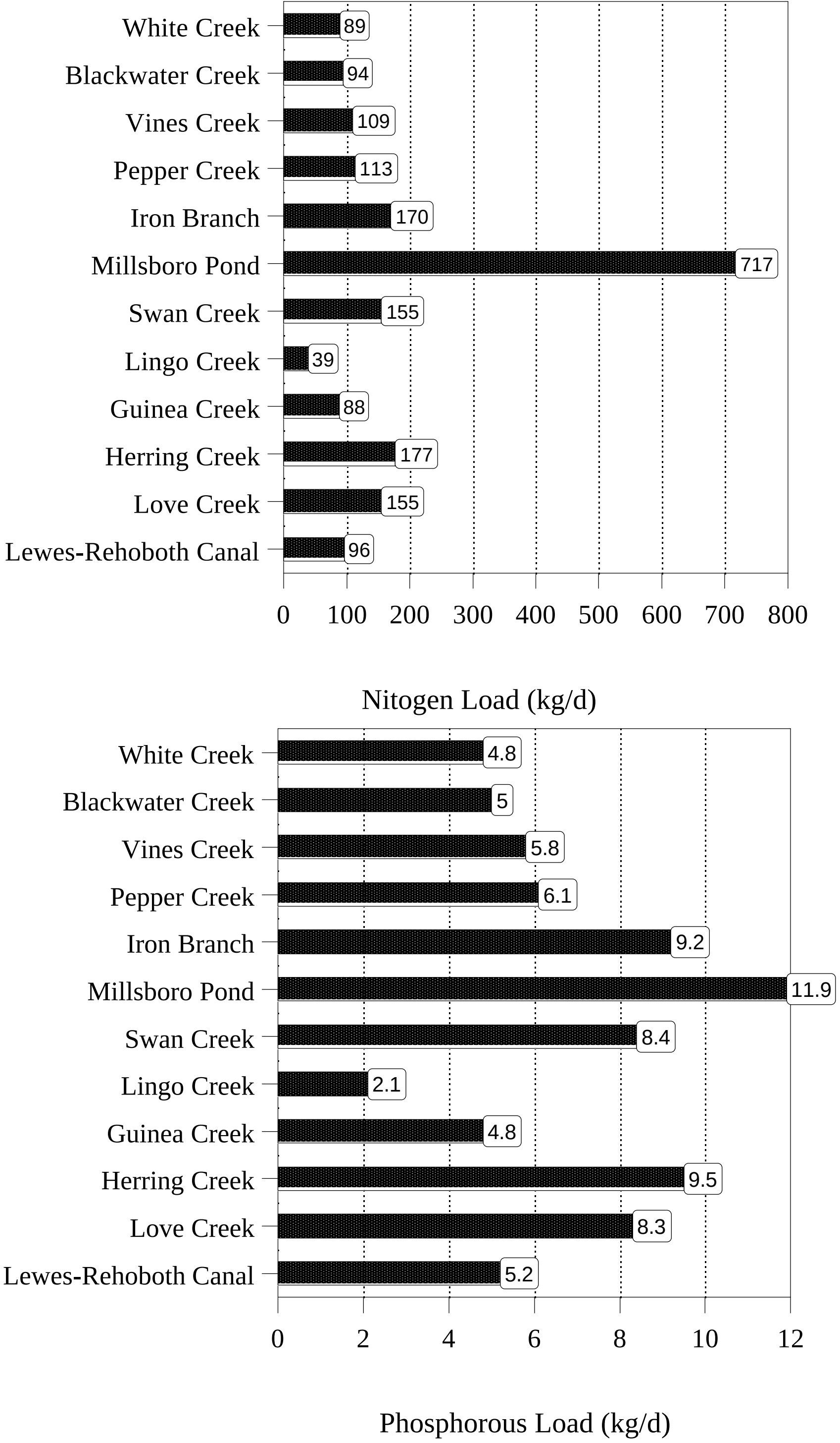


Figure 2.7 Phosphorous and Nitrogen Loads From Tributaries in the Inland Bays Sub-Basin (during base-line period, 1988-1990)

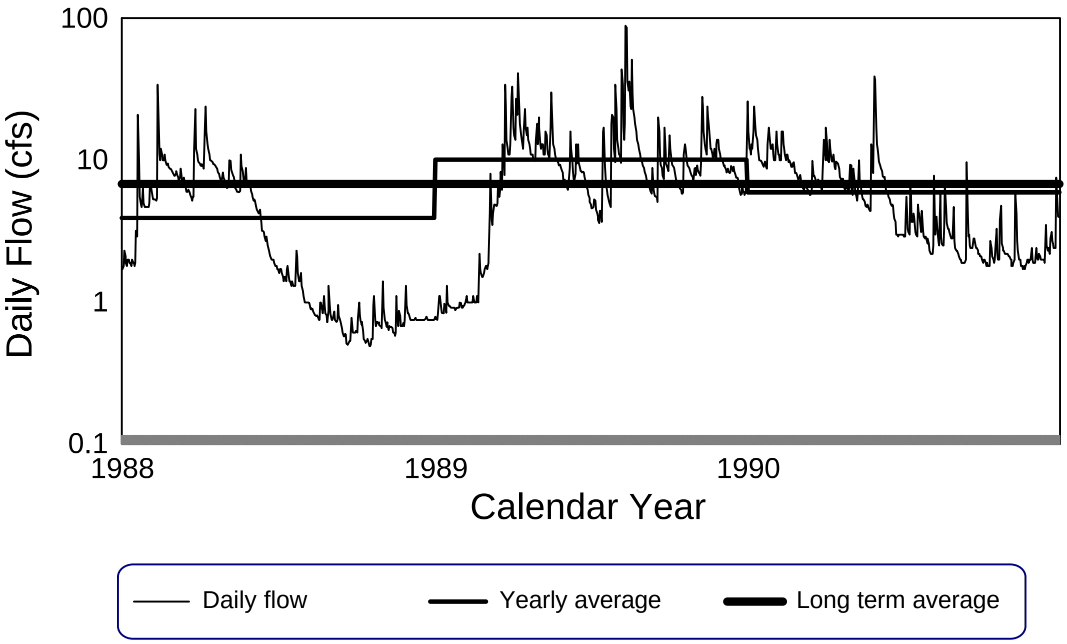


Figure 2.8 Stream Flow at Stockley Branch Gaging Station, Stockley (USGS-01484500) (during base-line period, 1988 - 1990)

ATMOSPHERIC DEPOSITION LOADS

An estimate of the atmospheric nitrogen load for the Inland Bays Sub-basin was based on the results of monitoring data collected by the University of Delaware's Graduate College of Marine Studies at Cape Henlopen State Park, Lewes, Delaware. Data collected at this site indicated that the mean ammonium load in rainfall is 2.6 kilograms of nitrogen per hectare per year (kg N hectare^{-1} year^{-1}) and the mean nitrate load is 14.1 kg N hectare^{-1} year^{-1}. The organic load of nitrogen at this site was estimated to be 15% of the inorganic nitrogen load. Also, it was assumed that dryfall nitrogen loads are equal to wetfall. Atmospheric loads were applied uniformly to surface waters of the Indian River, Indian River Bay, and Rehoboth Bay. This resulted in a daily nitrogen load of 765 kilograms per day (kg day^{-1}).

The monitoring data at the Cape Henlopen State Park did not detect any atmospheric load of phosphorous. Therefore, no atmospheric phosphorous load was considered for the Inland Bays Sub-basin.

WATER QUALITY MODEL OUTPUTS

The CE-QUAL-ICM Model for the Inland Bays was successfully calibrated for a three-year period (1988 through 1990) spanning the conditions of a dry year, wet year, and an average year. The master input file for the water quality model is provided in Appendix A and snapshots of concentration distributions of chlorophyll a, total nitrogen, and total phosphorous as predicted by the Inland Bays Model are shown in Figures 2.9 through 2.11.

In an effort to simplify the evaluation and assessment of model results, the entire Inland Bays was divided into eleven segments (regions). These eleven regions of the bays are shown in Figure 2.12 and consist of five regions in the upper Indian River, five regions in the Rehoboth Bay, and a single region that covers the entire Indian River Bay. The five regions of the upper Indian River include Indian River Zone 1 (IR zone1), Indian River Zone 2 (IR Zone2), Indian River Zone 3 (IR Zone3), Indian River Zone 4 (IR Zone4), and Indian River Zone 5 (IR Zone5). The five regions of the Rehoboth Bay include Rehoboth Bay Zone 1 (RB Zone1), Rehoboth Bay Zone 2 (RB Zone2), Rehoboth Bay Zone 3 (RB Zone3), Rehoboth Bay Zone 4 (RB Zone4), and Rehoboth Bay Zone 5 (RB Zone5). The Indian River Bay segment is labeled as “IR Bay.” Considering these eleven regions, summer-average concentrations of various water quality parameters for each region are calculated and are shown in Figures 2.13 through 2.15. For this analysis, the summer season is considered to be from the month of June through August.

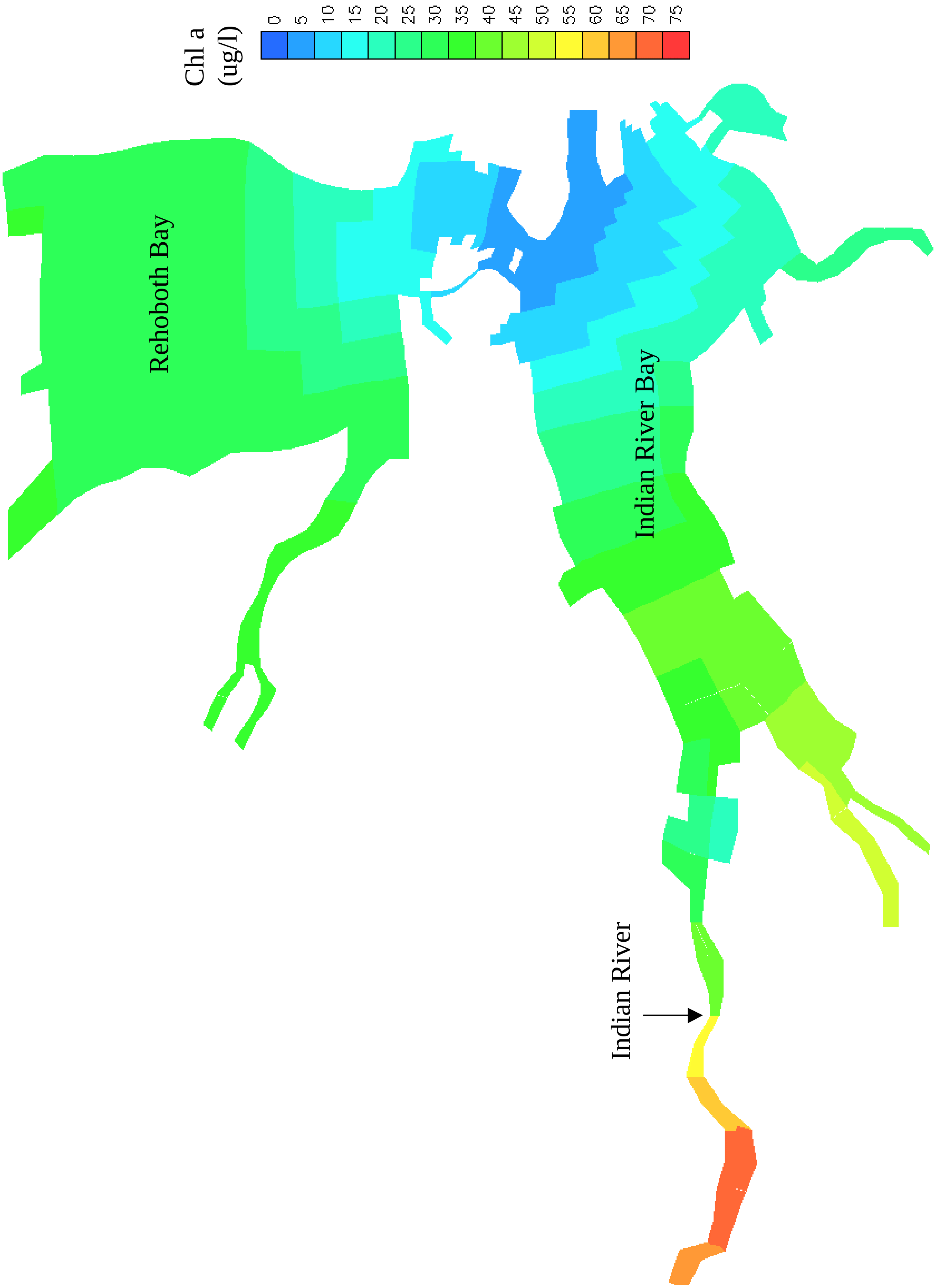


Figure 2.9 Chlorophyll a Distribution in the Inland Bays (August, 1988)

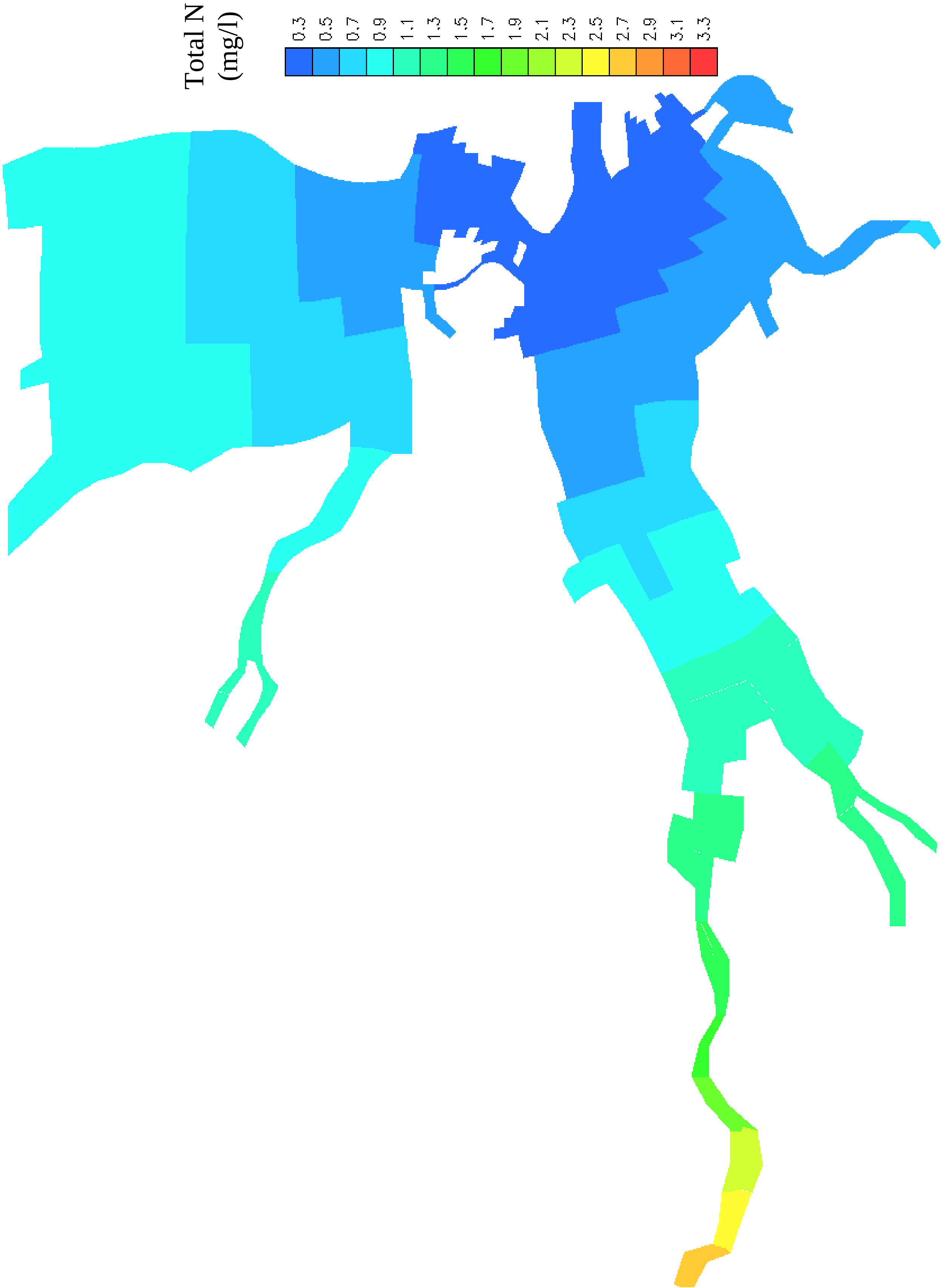


Figure 2.10 Total Nitrogen Concentration Distribution in the Inland Bays (August, 1988)

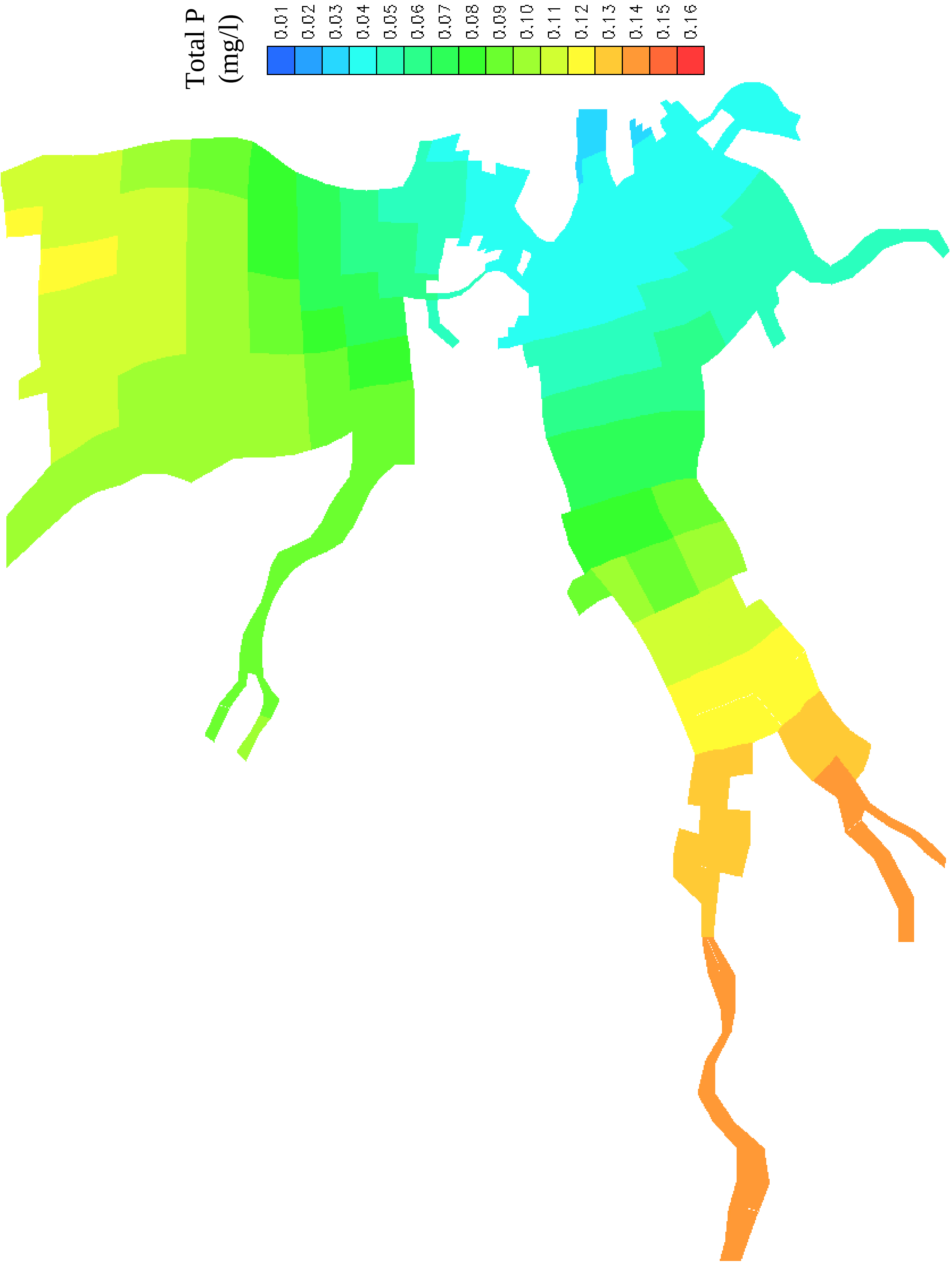


Figure 2.11 Total Phosphorous Concentration Distribution in the Inland Bays (August, 1988)

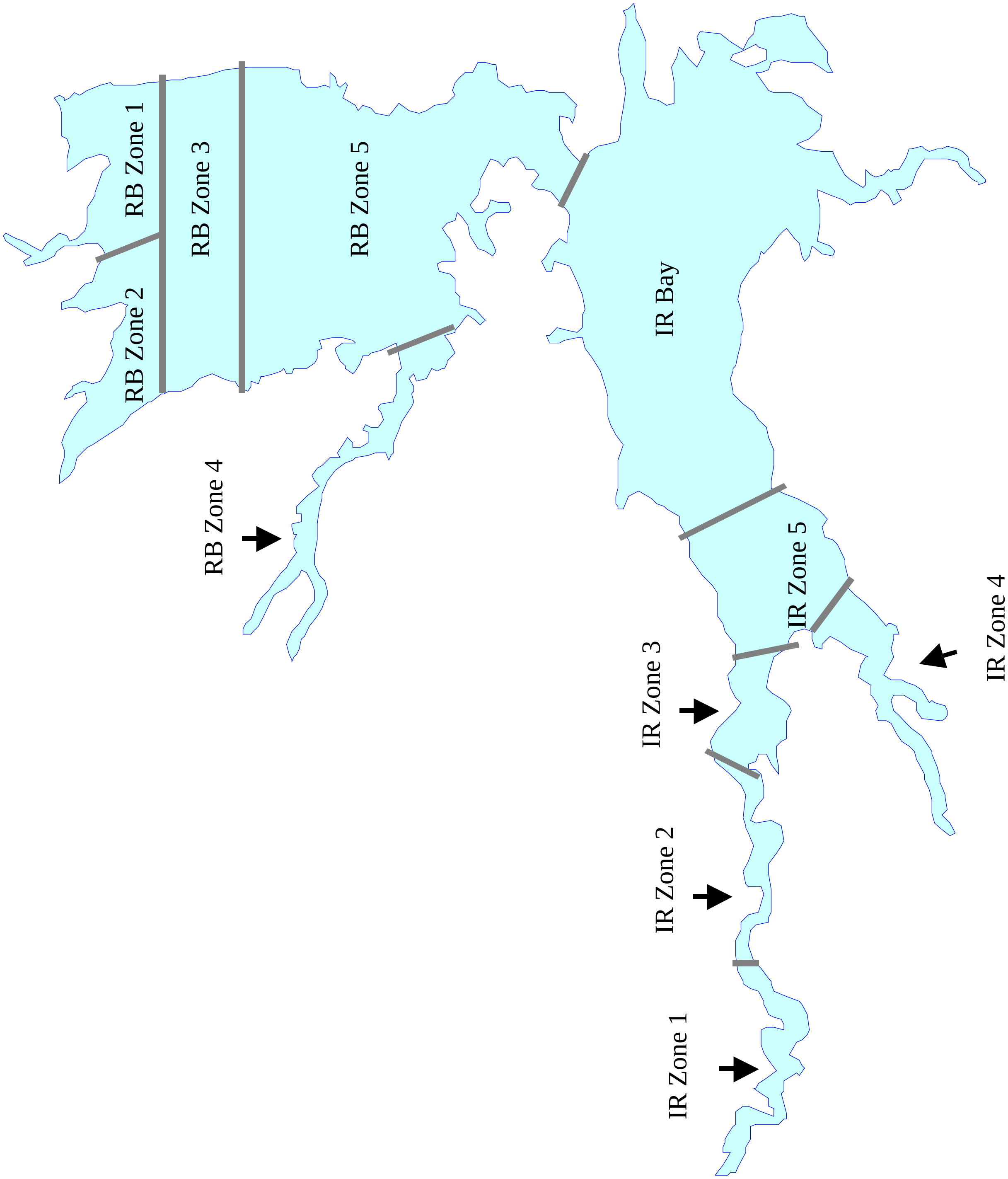


Figure 2.12 Segments of the Indian River, Indian River Bay, and Rehoboth Bay

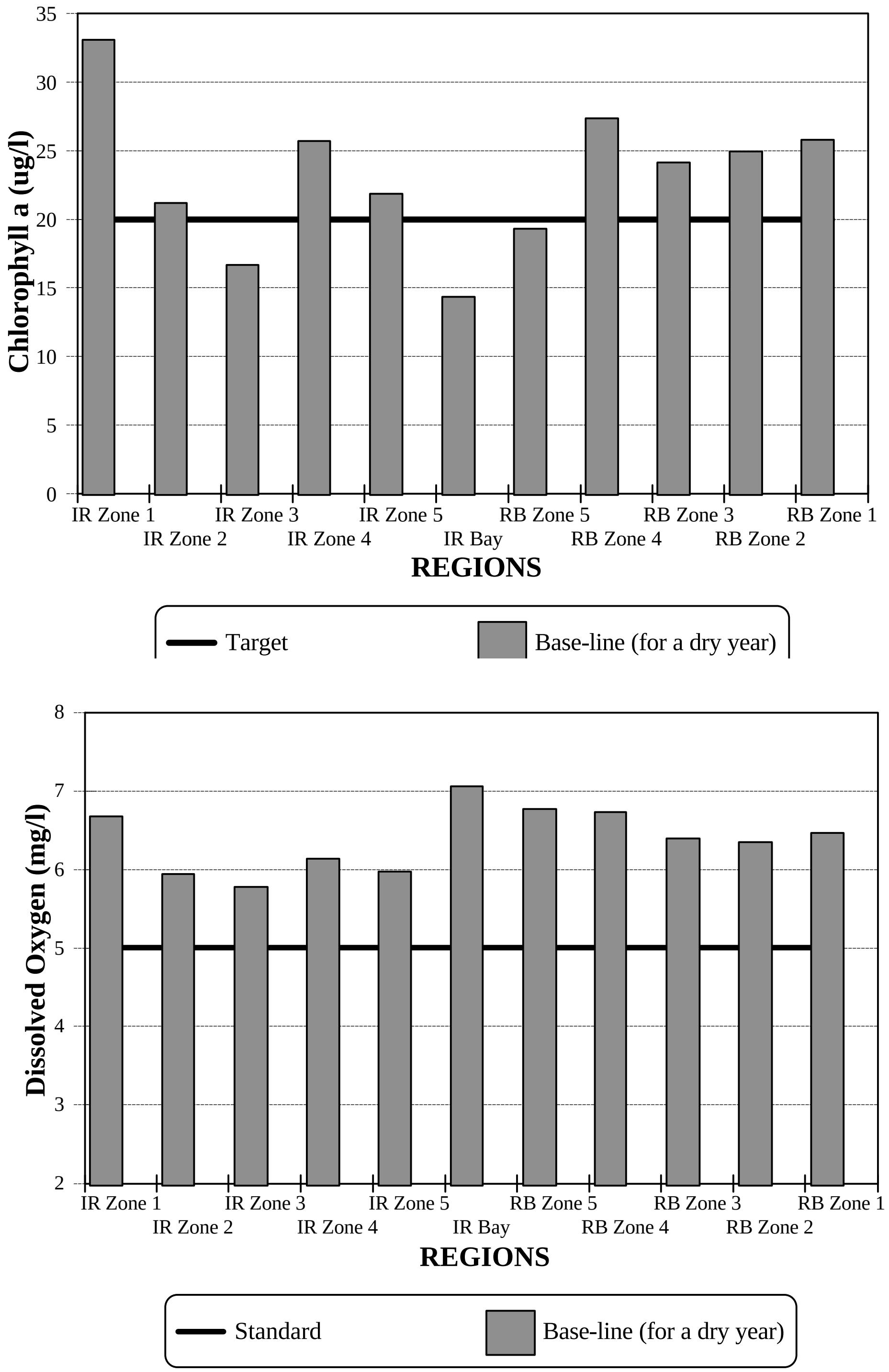


Figure 2.13 Concentration of Chlorophyll a and Dissolved Oxygen in Various Regions of the Inland Bays

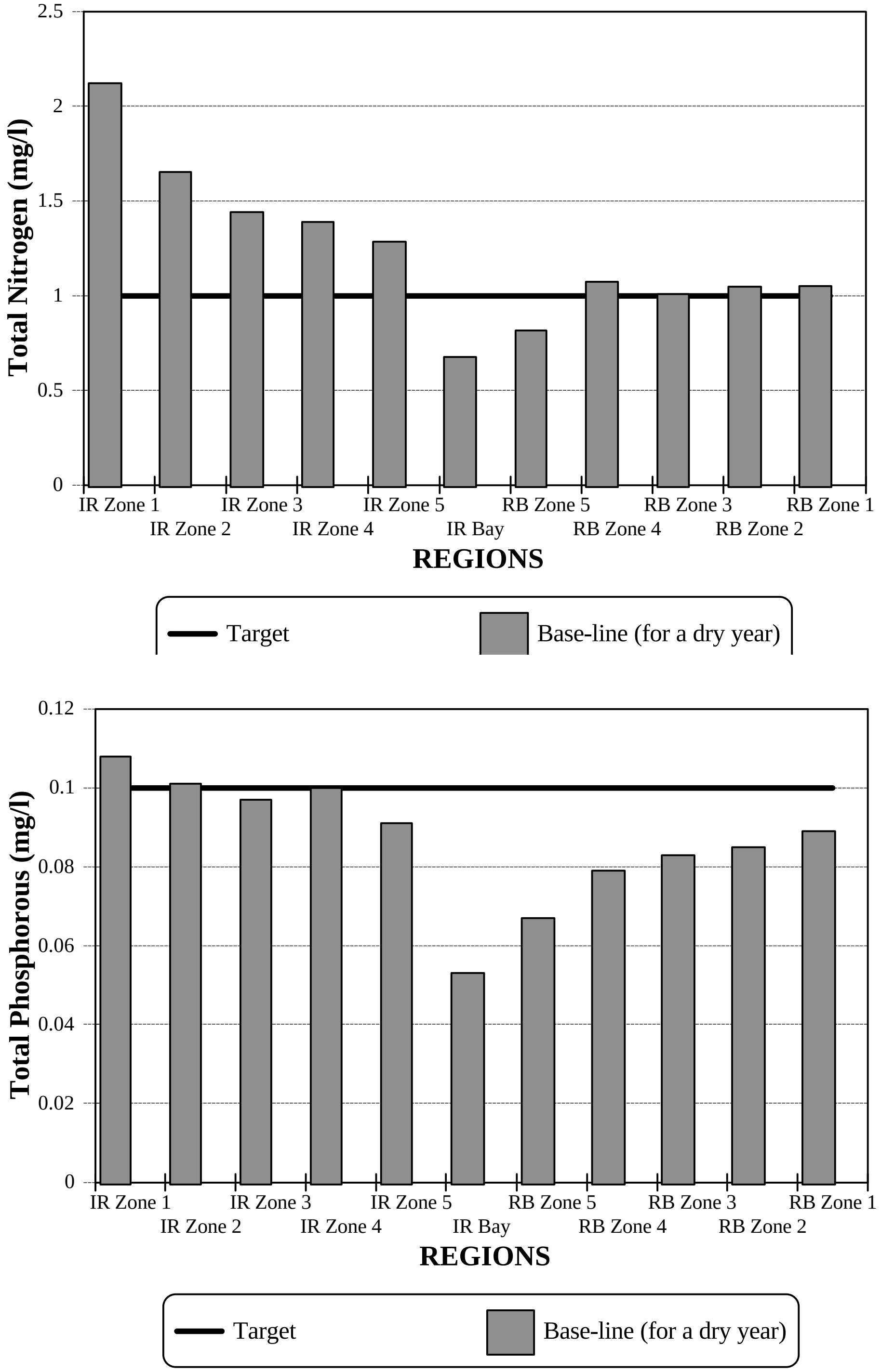


Figure 2.14 Concentration of Total Nitrogen and Total Phosphorous in Various Regions of the Inland Bays

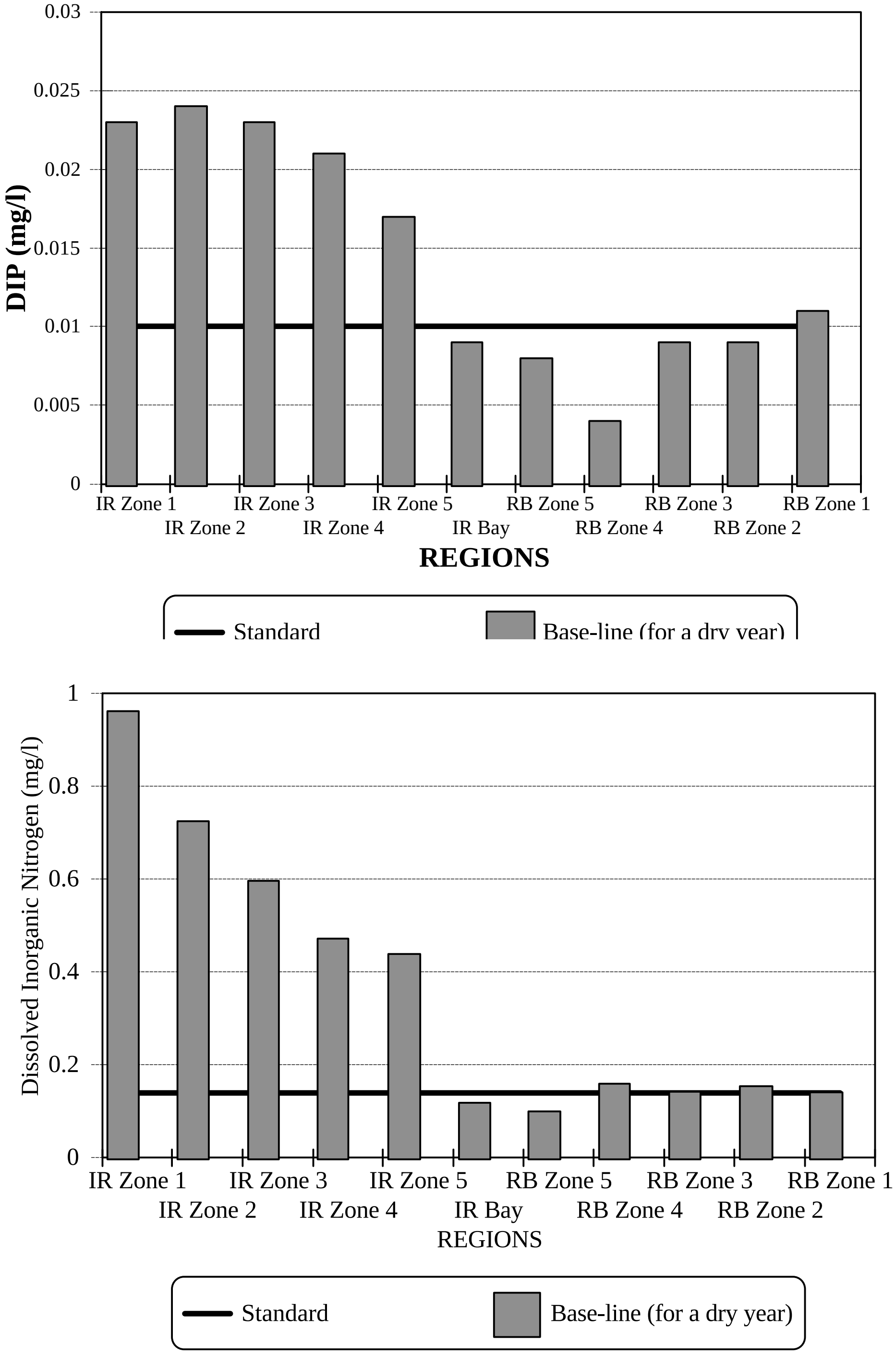


Figure 2.15 Concentration of Dissolved Inorganic Nitrogen and Dissolved Inorganic Phosphorous in Various Regions of the Inland Bays

THE USE OF INLAND BAYS HYDRODYNAMIC AND WATER QUALITY MODEL FOR DEVELOPING TOTAL MAXIMUM DAILY LOADS FOR NITROGEN AND PHOSPHOROUS

Following a successful development and calibration of the Inland Bays Hydrodynamic and Water Quality Model, the model was transferred to the Watershed Assessment Section, DNREC, which has been used extensively as a valuable assessment and management tool for evaluating water quality conditions of the Inland Bays and projecting water quality conditions under various point and nonpoint source loading scenarios.

Since portions of the Indian River, Indian River Bay, and Rehoboth Bay are not meeting applicable water quality standards and targets, the calibrated Inland Bays Model is used to test the effectiveness of various load reduction scenarios. A summary of load reduction scenarios considered for this analysis and their effects on Inland Bays water quality is presented in Section 3.

SECTION 3

DEVELOPMENT OF TOTAL MAXIMUM DAILY LOADS FOR NITROGEN AND PHOSPHOROUS FOR THE INDIAN RIVER, INDIAN RIVER BAY, AND REHOBOTH BAY

Figures 1.4 through 1.9 presented in Section 1 of this report show that several water quality standards and targets are not being met in parts of the Indian River, Indian River Bay, and Rehoboth Bay. The Inland Bays Model projection of summer-average concentration of various parameters as shown in Figures 2.13 through 2.15 confirm this observation. The major pollutants and stressors causing violation of water quality standards are high nutrients and low dissolved oxygen.

In order to determine the magnitude of pollutant load reductions necessary to attain all water quality standards and targets in the Inland Bays, many load reduction scenarios are evaluated. These scenarios considered various percentage of phosphorous and nitrogen load reductions from point sources, from nonpoint sources, and from the atmosphere. Then, using the calibrated hydrodynamic and water quality model as the assessment tool, concentration of various parameters during a normal year, a dry year, and a wet year were projected and were compared with the State water quality standards and targets. The hydrologic condition of the year 1988 was considered to represent a dry year, 1989 a wet year, and 1990 a normal year. A complete list of various scenarios considered during this analysis is provided in Appendix B. In the following, two of these scenarios are presented in detail.

A. **Scenario 34.** This scenario was considered to project water quality condition of the Inland Bays as the result of implementing easily achievable load reduction measures for point and nonpoint sources. The load reduction measures considered in this scenario included:

a. Four major point sources in the sub-basin implement biological nutrient removal

(BNR) technology for treating their wastewater. These four facilities included Rehoboth Sewage Treatment Plant (STP), Lewes STP, Georgetown STP, and Millsboro STP.

b. Loads from the remaining sewage treatment plants in the sub-basin are capped at their base-line period load (1988 through 1990).

c. Nonpoint source nitrogen loads in the sub-basin are reduced by 30 percent

d. Nonpoint source phosphorous loads in the sub-basin are reduced by 70 percent.

Summer average concentration of various water quality parameters in all regions of the Inland Bays as projected by the Inland Bays Hydrodynamic and Water Quality Model are shown in Figures 3.1 through 3.3. Figure 3.1 shows that the state dissolved oxygen standard of 5.0 mg/l daily average is being achieved in all regions of the Inland Bays. Furthermore, the model predicts that the water quality targets of 1.0 mg/l for total nitrogen, 0.1 mg/l for total phosphorous, and 20 ug/l for chlorophyll a being achieved in large portions of the Inland Bays. However, Figure 3.2 indicates that water quality standards with regard to dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorous (DIP) would be violated in several regions of the Indian River and Rehoboth Bay. This indicates that, although the magnitude of nutrient load reductions suggested by this scenario is substantial, it is not sufficient to achieve all applicable water quality standards and targets in the Inland Bays.

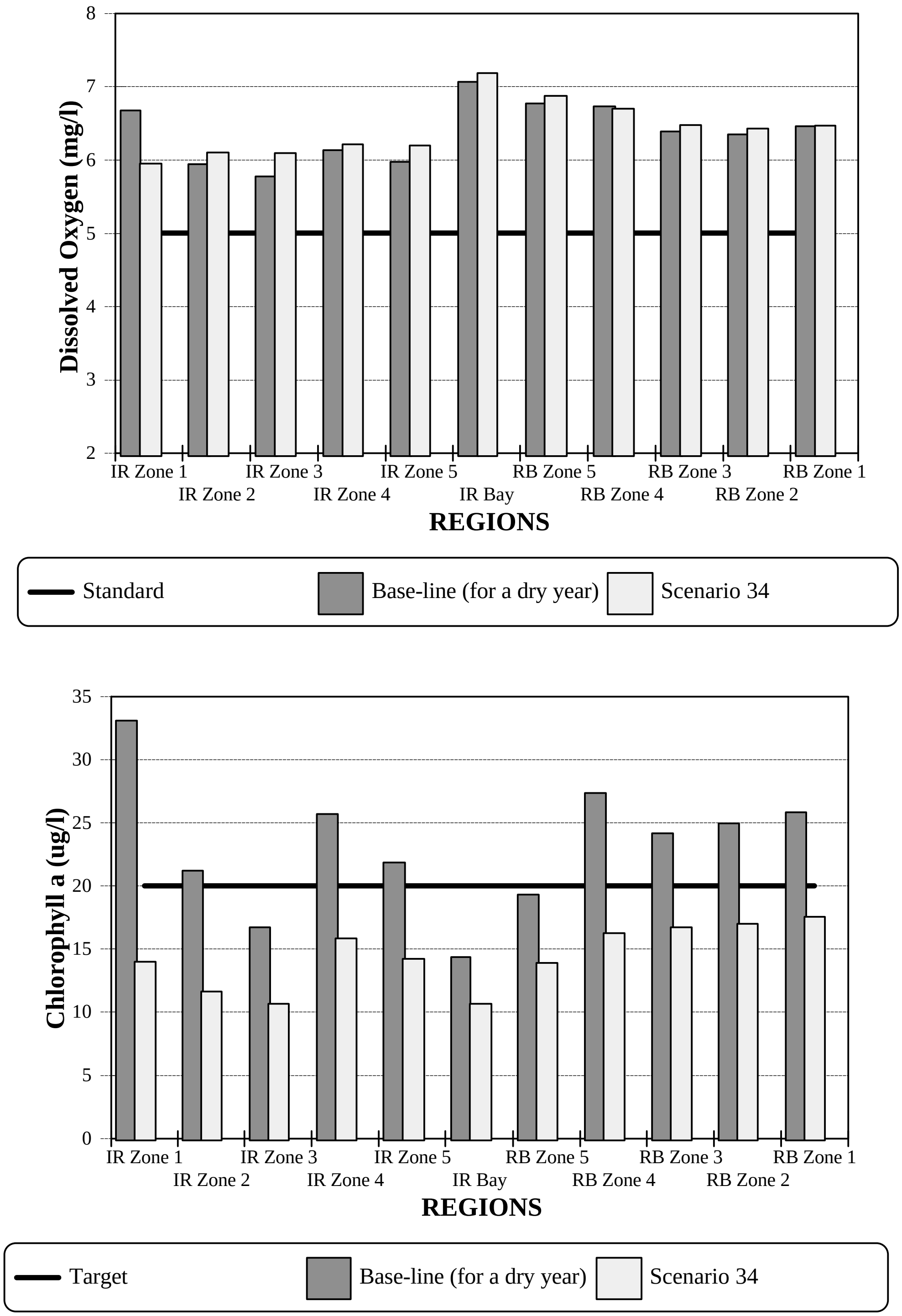


Figure 3.1 Dissolved Oxygen and Chlorophyll a Concentrations in Various Regions of the Inland Bays Under Scenario 34

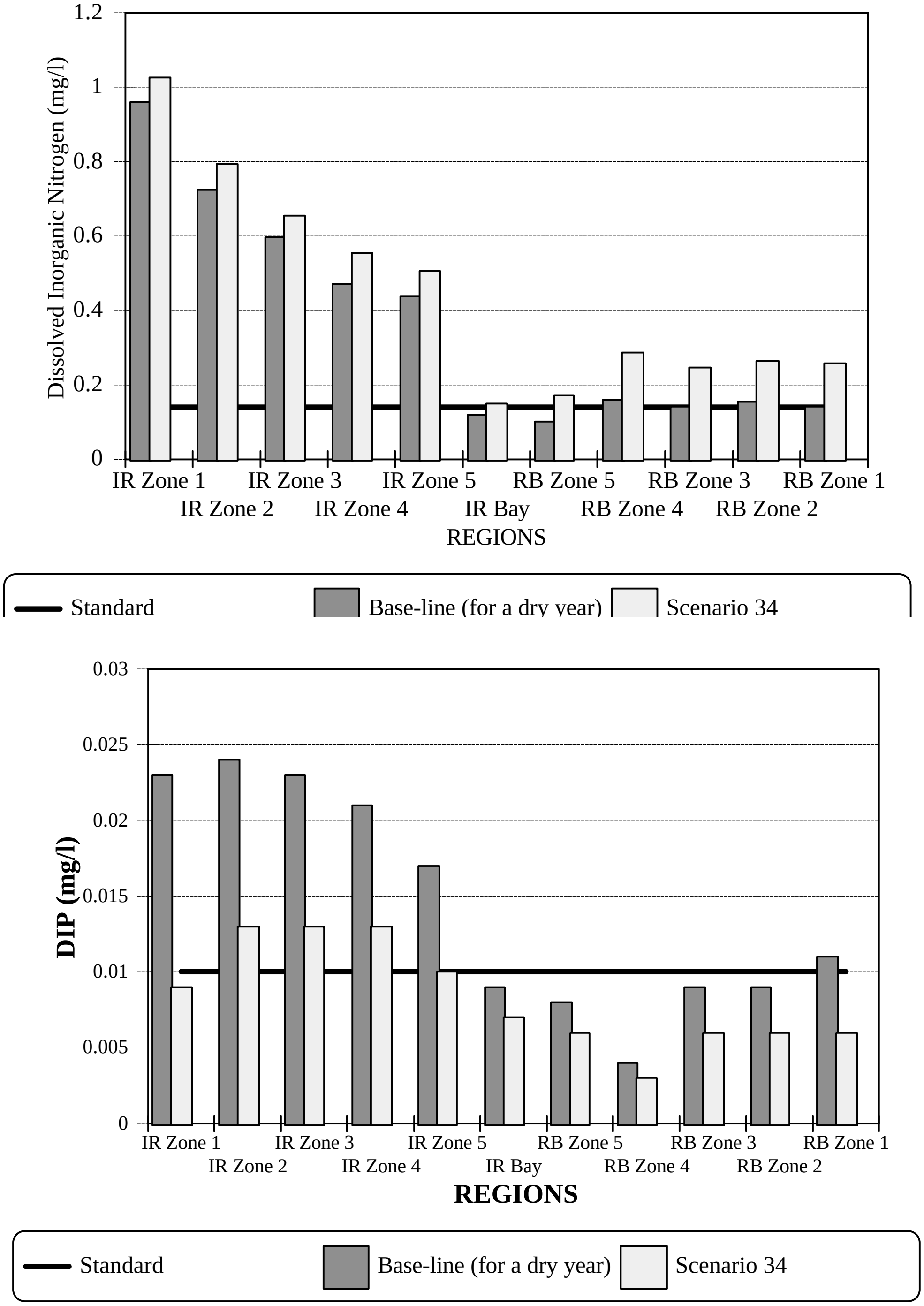


Figure 3.2 Dissolved Inorganic Nitrogen and Dissolved Inorganic Phosphorous Concentrations in Various Regions of the Inland Bays Under Scenario 34

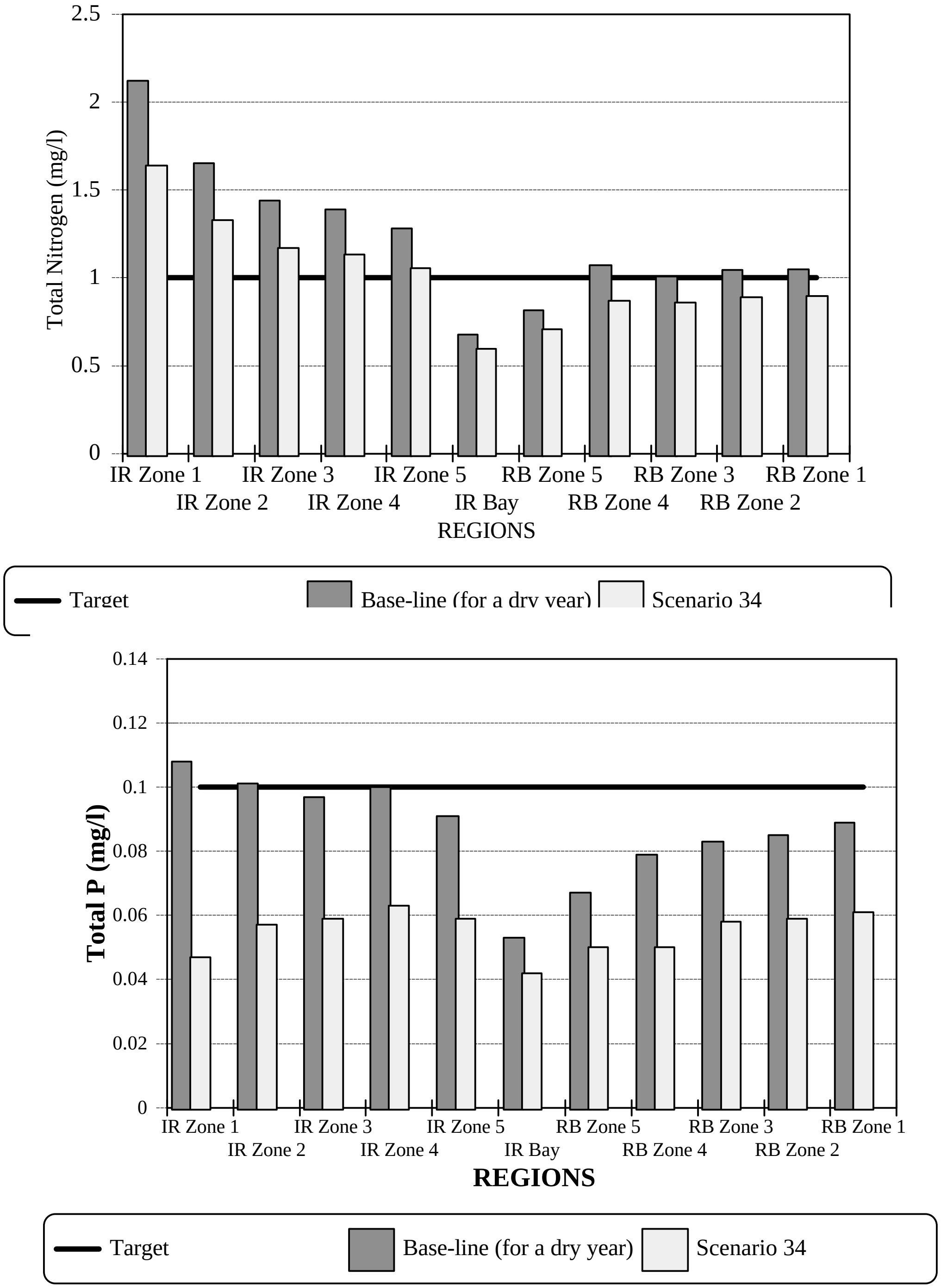


Figure 3.3 Total Nitrogen and Total Phosphorous Concentrations in Various Regions of the Inland Bays Under Scenario 34

B. **Scenario 69.** After considering many other load reduction scenarios that did not result in meeting all applicable water quality standards and targets in all regions of the Indian River, Indian River Bay, and Rehoboth Bay, this scenario was considered. For this scenario, it is assumed that:

a. All point sources of nutrients are eliminated,

b. The nonpoint source nitrogen loads from five tributaries in the upper Indian River are reduced by 85 percent (from the base-line period of 1988 through 1990). These tributaries include Swan Creek, Iron Branch, Pepper Creek, Vines Creek, and Millsboro Pond,

c. The nonpoint source phosphorous loads from these five tributaries in the upper Indian River are reduced by 65 percent (from the base-line period of 1988 through 1990),

d. The nonpoint source nitrogen loads from all remaining tributaries to the Indian River, Indian River Bay, and Rehoboth Bay are reduced by 40 percent (from the base-line period of 1988 through 1990),

e. The nonpoint source phosphorous loads from all remaining tributaries to the Indian River, Indian River Bay, and Rehoboth Bay are reduced by 40 percent (from the base-line period of 1988 through 1990), and

f. The atmospheric nitrogen deposition rate is reduced by 20 percent (from the base-line period of 1988 through 1990).

Water quality condition under this scenario, as projected by the Inland Bays Hydrodynamic and Water Quality Model, are shown in Figures 3.4 through 3.6. These figures show that all water quality standards and targets including dissolved oxygen, dissolved inorganic nitrogen, and dissolved inorganic phosphorous are achieved in all regions of the Inland Bays. Furthermore, the projected concentrations are better than the standards and targets, hence, providing sufficient margins of safety.

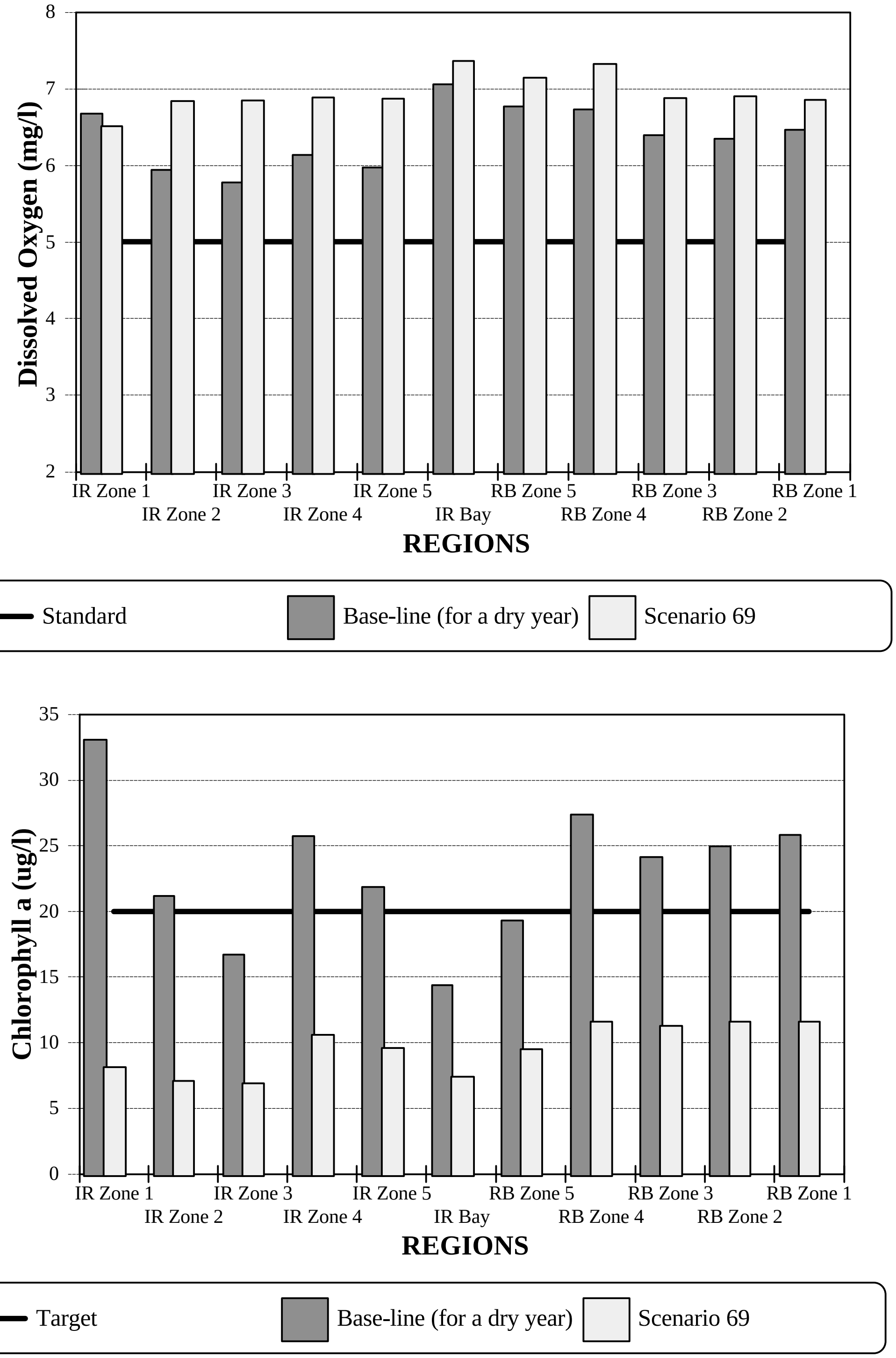
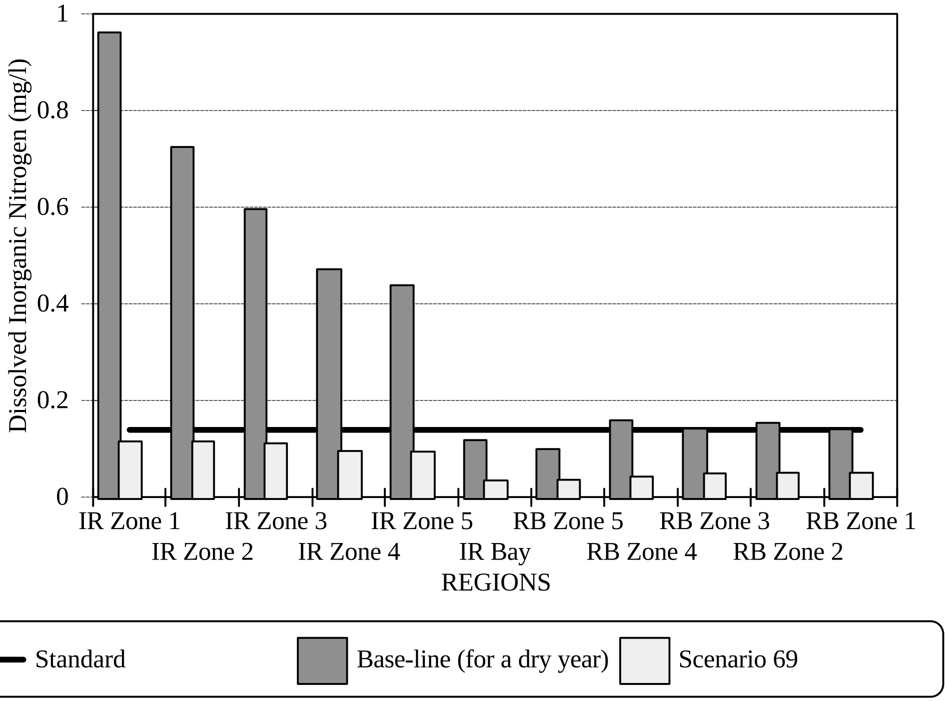


Figure 3.4 Dissolved Oxygen and Chlorophyll a Concentrations in Various Regions of the Inland Bays Under Scenario 69



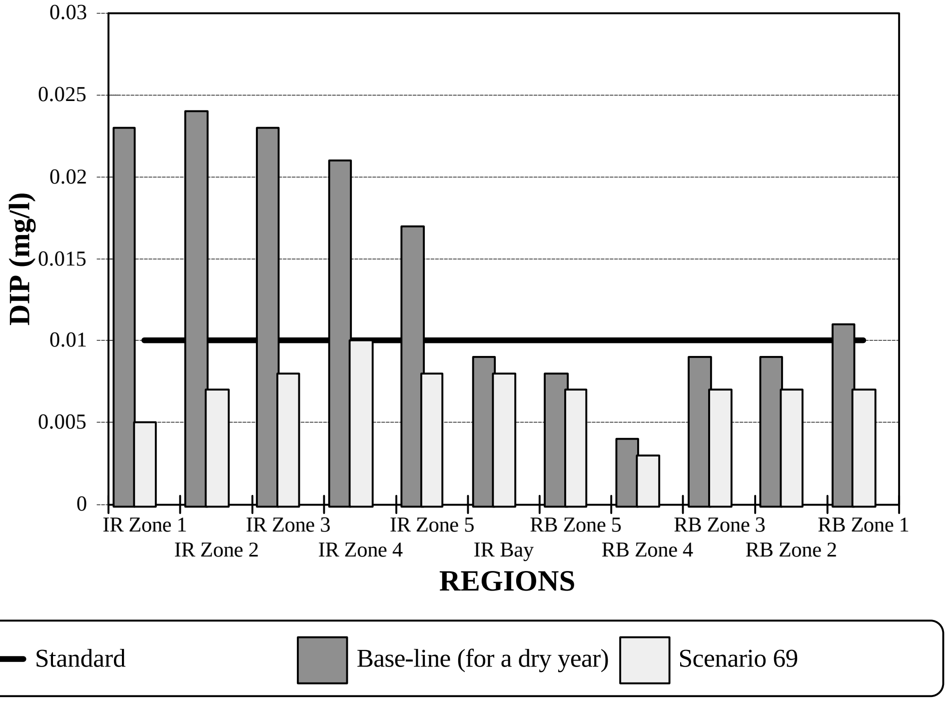


Figure 3.5 Dissolved Inorganic Nitrogen and Dissolved Inorganic Phosphorous Concentrations in Various Regions of the Inland Bays Under Scenario 69

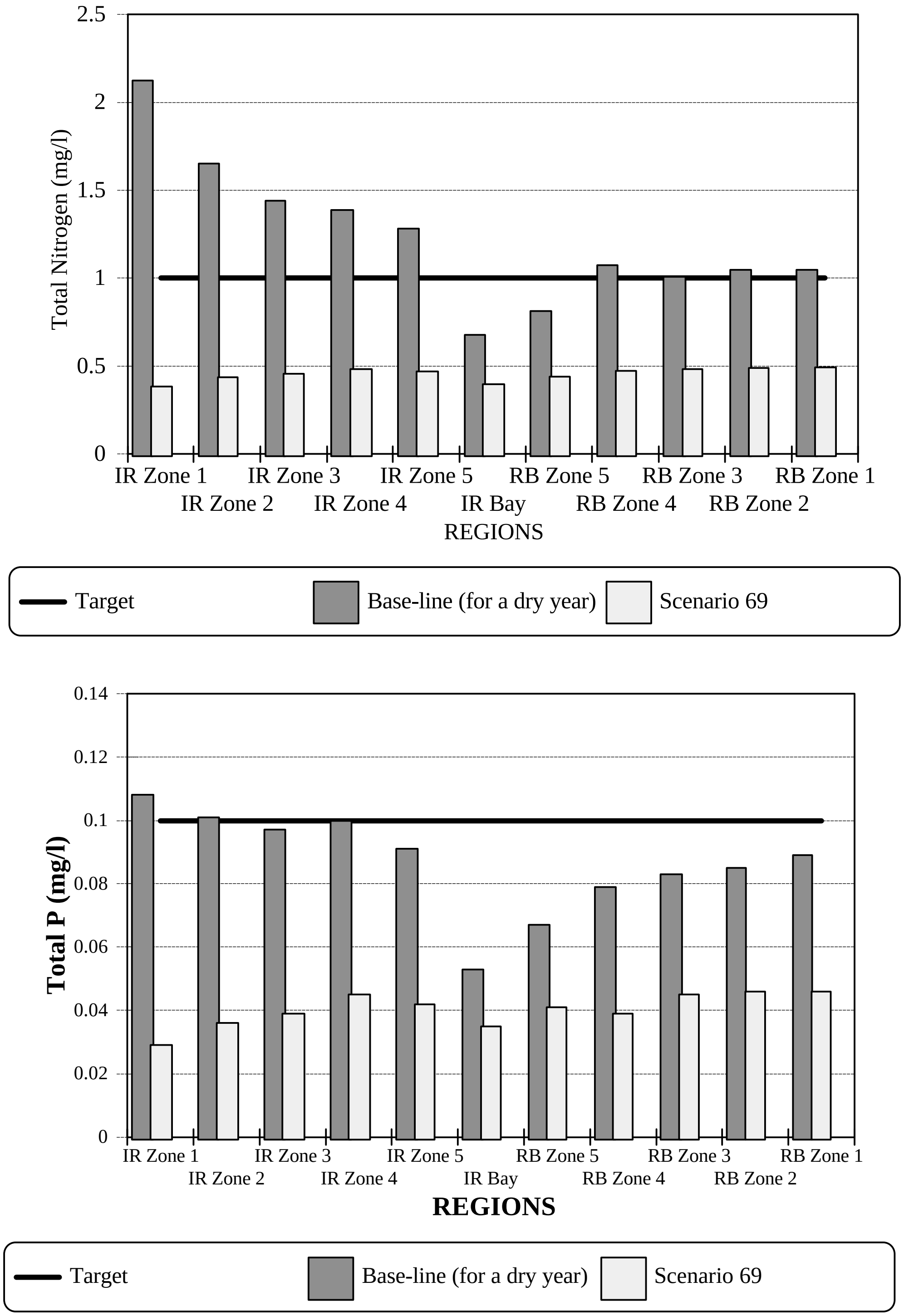


Figure 3.6 Total Nitrogen and Total Phosphorous Concentrations in Various Regions of the Inland Bays Under Scenario 69

SELECTION OF THE TMDL LOADING CONDITION

A review of the summer-average concentration of various water quality parameters in the Indian River, Indian River Bay, and Rehoboth Bay under different load reduction scenarios indicates that scenario 69 is one of the least restrictive load reduction scenarios that would result in meeting all applicable water quality standards and targets in the Inland Bays (see Figures 3.4 through 3.6). Furthermore, this scenario divides the responsibility of nutrient load reductions among various sources equitably. All other scenarios would require higher degrees of load reductions from pollutant sources, or assign the burden of load reductions on a specific source unfairly. Therefore, scenario 69 is selected as the basis for establishing the total maximum daily loads for the Indian River, Indian River Bay, and Rehoboth Bay. The established TMDL includes a Waste Load Allocation (WLA) for point sources, a Load Allocation (LA) for nonpoint sources, and a margin of safety (MOS).

WASTE LOAD ALLOCATION FOR POINT SOURCE DISCHARGES

Under scenario 69, it is considered that all point source discharges in the Inland Bays Sub-basin are eliminated systematically. This results in a waste load allocation of zero pounds for nitrogen and for phosphorous (Table 3.1).

LOAD ALLOCATION FOR NONPOINT SOURCES

With regard to nonpoint source loads, scenario 69 considers that nitrogen and phosphorous loads from various tributaries of the Inland Bays are reduced by 40 percent to 85 percent (from the base-line period of 1988 through 1990). Considering these load reductions, the nitrogen load allocation for the entire sub-basin during a typical normal rainfall year will be 632 kg/d (1393 lbs/d). The corresponding phosphorous load allocation for the entire sub-basin during a normal rainfall year will be 35 kg/d (78 lbs/d) (Table 3.1).

To allocate nitrogen and phosphorous loads among major nonpoint source categories in the Inland Bays sub-basin, Table 3.2 is presented which indicates that agriculture, unsewered

TABLE 3.1 Nitrogen and Phosphorous Load Reductions

Source	Base Line (1988 - 1990)		TMDL (for a normal rainfall year)	
	Nitrogen Load (lbs/d)	Phosphorous Load (lbs/d)	Nitrogen Load (lbs/d)	Phosphorous Load (lbs/d)
Point Sources	537	68	0	0
Nonpoint sources	4447	163	1393	78
Atmospheric Deposition	1687	0	1349	0

urban areas, and septic systems are major sources of nonpoint source pollution and are targeted for equal percentage load reductions at this time. Further refinement of these percentage load reductions will be accomplished through development of a pollution control strategy for the Indian River, Indian River Bay, and Rehoboth Bay.

To achieve the nonpoint source load reductions as required under this TMDL, appropriate best managements practices must be implemented in all land use activities within the Inland Bays sub-basin. Some of possible BMPs that may be considered are:

1. ***For Agricultural Activities:***
    a. Nutrient management
    b. Conservation tillage
    c. Contour farming
    d. Contour cover crop

Table 3.2 Preliminary Load Allocation Among Major Categories of Nonpoint Source Load

Nonpoint Source Category	Nitrogen		Phosphorous	
	Load allocation (kg/d)	Percentage reduction (%)	Load allocation (kg/d)	Percentage reduction (%)
Agriculture	1393	40 - 85	78	40-65
Unsewered urban				
Septic tanks				
Others				

- e. Cover crops
- f. Crop rotation
- g. Animal waste management
- h. Integrated pest management

2. ***For Construction Activities:***
   - a. Runoff detention / retention
   - b. Nonvegetative soil stabilization
   - c. Disturbed area limits

3. ***Urban Areas:***
   - a. Runoff detention / retention
   - b. Flood storage
   - c. Street cleaning

4. *Multicategory:*

a. Buffer strips
b. Detention /retention basins
c. Grassed waterway
d. Sediment traps
e. Vegetative stabilization / mulching
f. Streamside management zones

Within Delaware Department of Natural Resources and Environmental Control, the Nonpoint Source Program within the Division of Soil and Water Conservation is responsible for development and implementation of best management practices in the state. It is envisioned that after development and implementation of BMPs, the effectiveness of best management practices in reducing nonpoint source loads of nutrients will be monitored closely to ensure compliance with the established Load Allocations for the sub-basin.

LOAD ALLOCATION FOR ATMOSPHERIC NITROGEN DEPOSITION

The atmospheric nitrogen load during the base-line period is calculated to be 765 kg/d (1687 lbs/d). Scenario 69 considers that the atmospheric deposition of nitrogen is reduced by 20 percent. This level of reduction is believed to be achievable as the result of implementation of the requirements of the Clean Air Act (CAA) Amendments of 1990. Considering this reduction, the load allocation for atmospheric nitrogen deposition in the Inland Bays will be 612 kg/d (1349 lbs/d) (Table 3.1).

TOTAL MAXIMUM DAILY LOAD FOR TOTAL SUSPENDED SOLIDS

Section 7 of the State of Delaware Surface Water Quality Standard (1) establishes a numeric criteria of 20 mg/l for total suspended solids in tidal portions of the Indian River, Indian River Bay, and Rehoboth Bay. This criterion is being established to attain and promote growth of submerged aquatic vegetation in the Inland Bays and is applicable during growing season (approximately March 1 through October 31). State of Delaware's 1996 and 1998 Clean Water Act Section 303(d) Lists indicate that TSS criteria is being exceeded in upper reaches of the Indian River (segment DE140-004), hence, it is necessary to establish a total suspended solids TMDL for this segment of the Inland Bays.

High levels of total suspended solids in upper reaches of the Indian River are caused by discharges from point sources; transport of suspended solids and sediments by tributaries; resuspension of bottom sediments caused by tidal actions, boating, and other recreational activities in the area; and by high concentrations of microscopic phytoplankton (algae bloom). It is believed that among the above factors, high concentration of algae has the most significant impact in causing violation of water quality standards with regard to total suspended solids in this region.

Since the current version of the Inland Bays Hydrodynamic and Water Quality Model does not simulate suspended solids, DNREC has developed an empirical relationship between concentration of total suspended solids and algae (as represented by chlorophyll a) in upper reaches of the Indian River. This empirical relationship is developed by retrieving growing season TSS and chlorophyll a data for four monitoring stations in upper Indian River. The data was retrieved for the period of 1989 through 1997. The four monitoring stations considered for this analysis included STORET station 306191 (Buoy 55), STORET station 306181 (Buoy 49), STORET station 306171 (Buoy 45), and STORET station 306161 (Buoy 38). Scatter plot of TSS vs. Chl_a at these four stations is shown in Figure 3.7 and summery statistics for TSS and Chl_a at each monitoring station is shown in Table 3.3

Table 3.3 Summary Statistics for TSS and Chl_a in Upper Indian River During Growing Season (1989 through1997)

Monitoring Station	TSS (mg/l)				Chl_a (ug/l)			
	Mean	Min.	Max.	S.D.	Mean	Min.	Max.	S.D.
306161	31.9	1	89	20.7	54.7	1	349	73
306171	39.7	13	106.7	25.5	96	1	935	197
306181	34	8	92	22.8	92	1	918	174
306191	47	5	158	40	152	1	905	250

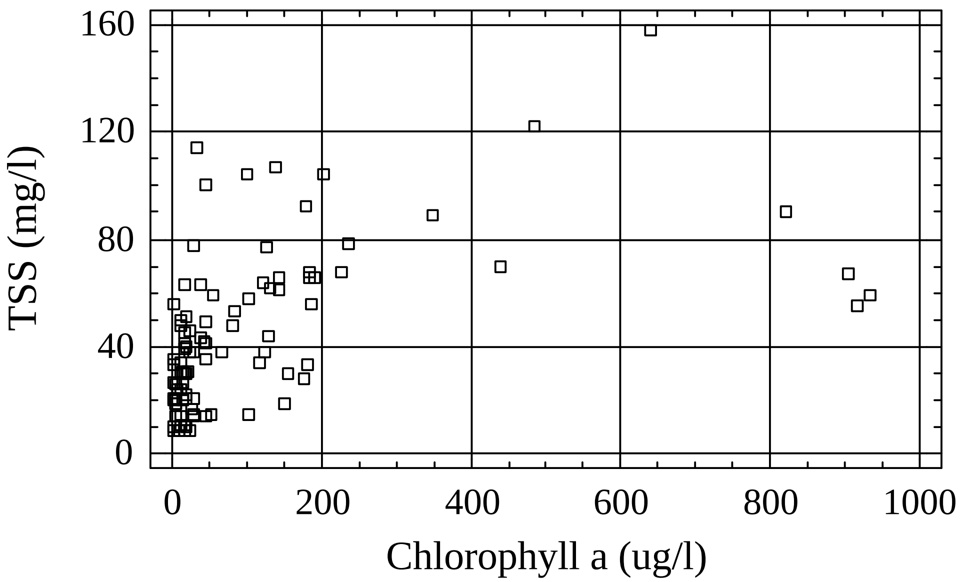


Figure 3.7 Scatter plot of total suspended solids vs. chlorophyll a during growing season in Upper Indian River (1989 through 1997)

A review of the data shown in Figure 3.7 indicates that extremely high chlorophyll a concentrations (in excess of 400 ug/l) are not representative of the average conditions in the area and should be considered as outliers. Removing these outliers from the data set and performing regression analysis using several different models, indicated that a statistically significant relationship between Chl_a and TSS ($p < 0.01$) can be established by considering a square root x model. The equation between chl_a and TSS using the square root x model is:

$$TSS = 13.59 + 3.638 \ * \sqrt{Chl\_a}$$

The correlation coefficient for the above equation is 0.750796, indicating a moderately strong relationship between TSS and Chl_a variables. Figures 3.8 show the fitted model for the mean value (solid line) and 95% confidence levels around the mean (dashed lines).

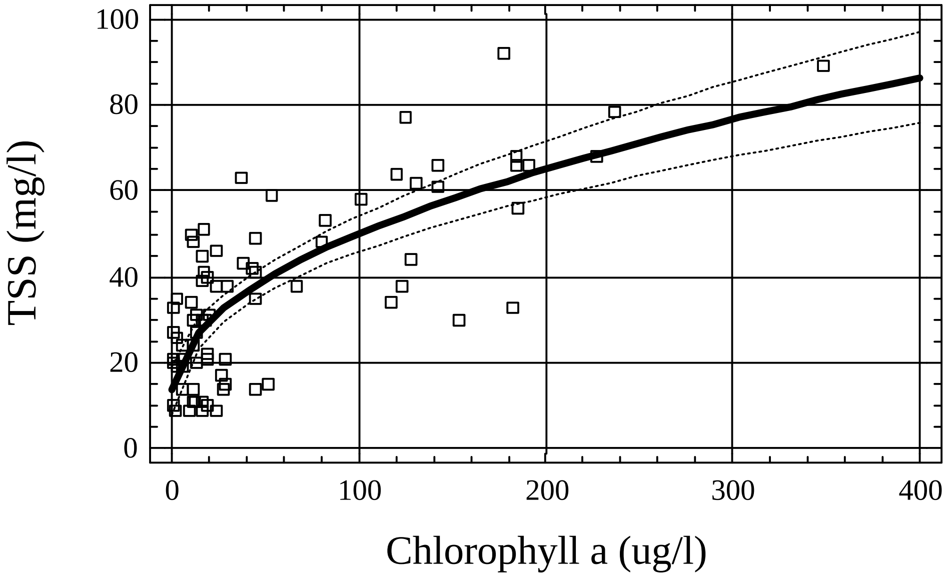


Figure 3.8 Fitted model for TSS vs. Chlorophyll a in upper Indian River during growing season

Considering the above relationship between chlorophyll a and TSS and using Figure 3.8, it can be shown that in order to achieve an average TSS concentration of 20 mg/l, chl_a concentration in upper Indian River must be between 1 and 9 ug/l (considering 95% confidence limit). Since the predicted chlorophyll a concentration in IR Zone I of the Indian River for scenario 69 is about 8.0 ug/l, it can be concluded that improving water quality condition of the Inland Bays and reducing chlorophyll a concentration would result in meeting the total suspended solids criteria in upper Indian River during the growing season.

CONSIDERATION OF A MARGIN OF SAFETY

Section 303(d)(1)(c) of the Clean Water Act requires States to develop a total maximum daily loads for pollutants of concern for their water quality limited waters. Furthermore, it requires that the established TMDLs include a margin of safety to take into account any uncertainty or any simplified assumptions made during the evaluation process. Consideration of a margin of safety insures that water quality standards will be met despite the uncertainty that may exist as a result of the variability of field data or assumptions made during the analysis.

A review of the summer-average concentration of dissolved oxygen, chlorophyll a, total nitrogen, total phosphorous, dissolved inorganic nitrogen, and dissolved inorganic phosphorous in the Inland Bays under scenario 69 (Figures 3.4 through 3.6) indicates that all applicable water quality standards and targets are achieved. With regard to dissolved oxygen, projected summer average DO concentration in various regions of the Inland Bays range from 6.5 mg/l to 7.4 mg/l. Considering that the DO standard is 5.0 mg/l, it can said that at least, a 30 percent margin of safety exists with regard to dissolved oxygen.

With regard to dissolved inorganic nitrogen, projected summer average concentration in various regions of the Inland Bays range from 0.034 to 0.116 mg/l. Considering that dissolved inorganic nitrogen standard for the Inland Bays is 0.14 mg/l, it can be concluded that at least a 17 percent margin of safety exists with regard to dissolved inorganic nitrogen. Similarly, concentration of dissolved inorganic phosphorous in various regions of the Inland Bays range from 0.003 to 0.010 mg/l. Since the dissolved inorganic phosphorous standard for the Inland Bays is 0.01 mg/l, it can be concluded that a reasonable margin of safety exists wit regard to dissolved inorganic phosphorous.

AUTHORITY AND RESPONSIBILITY FOR TMDL DEVELOPMENT

Authority to develop a total maximum daily load is provided by Chapter 60, Title 7, of the Delaware Code and Section 303(d) of the Federal Clean Water Act, 33 U.S.C. 1251 et. seq., as amended. Section 402 of the Federal Clean Water Act, 33 U.S.C. 1251 et. seq., as amended and Chapter 60, Title 7, of the Delaware Code provide the authority for issuance of Discharge Permits. Sections 7 and 11.5 of the State of Delaware Surface Water Quality Standards provide the regulatory basis for establishing nutrient controls from point and human-induced nonpoint sources in the Inland Bays.

POLLUTION CONTROL STRATEGY

The Delaware Department of Natural Resources and Environmental Control is proposing to implement the requirements of the proposed total maximum daily loads for nitrogen and phosphorous through development of a Pollution Control Strategy (PCS). A PCS for the Indian River, Indian River Bay, and Rehoboth Bay will be established through Department’s Whole Basin Management Program in concert with the affected public.

REFERENCES

1. State of Delaware Surface Water Quality Standards, as amended February 26, 1993, Department of Natural Resources and Environmental Control, Division of Water Resources.
2. Roy F. Weston, "Characterization Study of the Inland Bays, Delaware Inland Bays Estuary Program", 1993.
3. Carl A. Cerco, et. al, "Hydrodynamic and Eutrophication Model Study of Indian River-Rehoboth Bay, Delaware", Draft Report, June 1993.
4. Final Draft, Comprehensive Conservation and Management Plan for Delaware's Inland Bays, Delaware Inland Bays Estuary Program, October 1993.
5. DNREC's internal water quality data base and U.S. EPA's STORET National Data Base..

f. State of Delaware 1996 Watershed Assessment Report (305(b)), Department of Natural Resources and Environmental Control (April 1, 1996).

g. State of Delaware 1998 Watershed Assessment Report (305(b)), Department of Natural Resources and Environmental Control (April 1, 1998).

h. Final Determination, State of Delaware 1996 Clean Water Act Section 303(d) List of Waters Needing TMDLs.

i. Final Determination, State of Delaware 1998 Clean Water Act Section 303(d) List of Waters Needing TMDLs.

Appendix

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  Control file for WQM: INDIAN RIVER: July 31 1992


TITLE C .......3/10/95...............TITLE...................................
* run 50 *** FC analysis for Bay Shore MH * segment 10 ** 60 day simulation*
*** constituent 2 (salt) is used as surrogate for FC ****
*** discharge into segment 34 of the WQM with a load of 6.022E+10 FC/d
Algal light effect = 16.  Settling = 0.1 m/day.
***** REAL HYDRO 88, 89, and 90  ******. Combined CC and BWB versions.
SAV off.  Monthly, regional light extinction.  HDIFF=12.  January 20, 1993

GEOM DEFINE   NB     NSB     NQF    NHQF   NSHQF      NL
             281     281     500     500     500       1

TIME CON  TMSTRT   TMEND
             0.0   365.0 366.0

# DLT       NDLT
               1

DLT DAY     DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD
             0.0

DLT VAL   DLTVAL  DLTVAL  DLTVAL  DLTVAL  DLTVAL  DLTVAL  DLTVAL  DLTVAL  DLTVAL
            30.0

DLT MAX   DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX
         10800.0

DLT FTN   DLTFTN  DLTFTN  DLTFTN  DLTFTN  DLTFTN  DLTFTN  DLTFTN  DLTFTN  DLTFTN
            0.95

HM DLT    AHMDLT   HMEND
          3600.0   365.0

SNAPSHOT    SNPC    NSNP
              ON       1

SNAP DAY    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD    SNPD
             0.0

SNAP FRQ    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF    SNPF
            91.2   365.0    30.0

PLOT        PLTC   QPLTC   SPLTC    NPLT
             OFF      ON      ON       1

PLOT DAY    PLTD    PLTD    PLTD    PLTD    PLTD    PLTD    PLTD    PLTD    PLTD
             0.0

PLOT FREQ   PLTF    PLTF    PLTF    PLTF    PLTF    PLTF    PLTF    PLTF    PLTF
             1.0

AV PLOT    APLTC    NAPL
              ON       1

AVPLT DAY  APLTD   APLTD   APLTD   APLTD   APLTD   APLTD   APLTD   APLTD   APLTD
              0.

AVPLT FREQ  APLF    APLF    APLF    APLF    APLF    APLF    APLF    APLF    APLF
             1.0   91.24    1.00    2.07      5.
```

```
TRAN FLUX   TFLC    NTFL
              ON       1

FLUX DAY    TFLD    TFLD    TFLD    TFLD    TFLD    TFLD    TFLD    TFLD    TFLD
              0.

FLUX FREQ   TFLF    TFLF    TFLF    TFLF    TFLF    TFLF    TFLF    TFLF    TFLF
           30.41

KIN FLUX    KFLC    NKFL   NKFLB  NKFLBB
             OFF       1       8       8

FLUX DAY    KFLD    KFLD    KFLD    KFLD    KFLD    KFLD    KFLD    KFLD    KFLD
              0.

FLUX FREQ   KFLF    KFLF    KFLF    KFLF    KFLF    KFLF    KFLF    KFLF    KFLF
            91.2

WQM BOX     KFLB    KFLB    KFLB    KFLB    KFLB    KFLB    KFLB    KFLB    KFLB
              34     143     158     163     203     220     252     275     281

SED BOX    KFLBB   KFLBB   KFLBB   KFLBB   KFLBB   KFLBB   KFLBB   KFLBB   KFLBB
              34     143     158     163     203     220     252     275     281

OXY PLOT    OPLC    NOPL   NOINT
             OFF      12       8

OXY INT     OINT    OINT    OINT    OINT    OINT    OINT    OINT    OINT    OINT
            -1.0     1.0     2.0     3.0     4.0     5.0     8.0    16.0

OXY DAY     OPLD    OPLD    OPLD    OPLD    OPLD    OPLD    OPLD    OPLD    OPLD
             60.    150.    270.    365.    425.    515.    635.    730.    790.
            880.   1000.   1090.

OXY FREQ    OPLF    OPLF    OPLF    OPLF    OPLF    OPLF    OPLF    OPLF    OPLF
            200.    200.    200.    200.    200.    200.    200.    200.    200.
            200.    200.    200.    200.

MASS BAL    MBLC    NMBL
              ON       1

MBL DAY     MBLD    MBLD    MBLD    MBLD    MBLD    MBLD    MBLD    MBLD    MBLD
             0.0

MBL FREQ    MBLF    MBLF    MBLF    MBLF    MBLF    MBLF    MBLF    MBLF    MBLF
           30.41   30.43

DIAGNSTCS   DIAC    NDIA
              ON       1

DIA DAY     DIAD    DIAD    DIAD    DIAD    DIAD    DIAD    DIAD    DIAD    DIAD
               0.

DIA FREQ    DIAF    DIAF    DIAF    DIAF    DIAF    DIAF    DIAF    DIAF    DIAF
           30.41

RESTART     RSOC    NRSO    RSIC
             OFF       1     OFF

RST DAY     RSOD    RSOD    RSOD    RSOD    RSOD    RSOD    RSOD    RSOD    RSOD
           364.0
```

```
HYD MODEL   HYDC
        DEPTH_AV

HYD SOLTN    SLC   CONSC      TH
        QUICKEST    MASS     1.0

CONTROLS    SEDC   AUTOC     VBC    BFOC    STLC    ICIC
             OFF      ON      ON      ON      ON      ON

DEAD SEA     FLC   XYDFC    ZDFC
              ON      ON     OFF

HDIFF       XYDF  ZDFMUL  ZDFMAX
           12.00     1.0     0.1

CST INPUT    BCC     PSC    NPSC     MDC     BFC    ATMC    SAVC
              ON      ON      ON     OFF      ON      ON     OFF

NUTR RED  REDPSC  REDPSN  REDPSP  REDNPC  REDNPN  REDNPP  REDCBC  REDCBN  REDCBP
             1.0     1.0     1.0     1.0     0.7     0.3     1.0     1.0     1.0

BOUNDARY   BNDCC
            STEP

BOUNDARY   BNDSC   BNDSC   BNDSC   BNDSC   BNDSC   BNDSC   BNDSC   BNDSC   BNDSC
          UPWIND  UPWIND  UPWIND  UPWIND  UPWIND  UPWIND  UPWIND  UPWIND  UPWIND
          UPWIND  UPWIND  UPWIND  UPWIND  UPWIND  UPWIND  UPWIND  UPWIND  UPWIND
          UPWIND  UPWIND  UPWIND  UPWIND

ACT CST      ACC     ACC     ACC     ACC     ACC     ACC     ACC     ACC     ACC
              ON      ON      ON     OFF     OFF      ON      ON      ON      ON
              ON      ON      ON      ON      ON      ON      ON      ON      ON
              ON      ON     OFF     OFF

HALF SAT 1 KHONT   KHNNT    KHNC    KHPC    KHRC    KHND    KHPD    KHRD    KHSD
             1.0     1.0   0.010   0.001     0.5   0.010   0.001     0.5    0.03

HALF SAT 2  KHNG    KHPG    KHRG  KHOCOD  KHODOC   KHNDN
           0.010   0.001     0.5     0.5     0.5     0.1

RATIOS      AOCR    AONT    ANCC    ANCD    ASCD    ANCG    ANDC
            2.67    4.33   0.167   0.167   0.400   0.167   0.933

P TO C    PCPRM1  PCPRM2  PCPRM3
            60.0     0.0     0.0

FRACTN N 1  FNIC    FNDC    FNLC    FNRC    FNID    FNDD    FNLD    FNRD    FNIG
            0.00    1.00    0.00    0.00    0.00    1.00    0.00    0.00    0.20

FRACTN N 2  FNDG    FNLG    FNRG    FNIP    FNDP    FNLP    FNRP
            0.80    0.00    0.00    0.00    0.00   0.700   0.300

FRACTN P 1  FPIC    FPDC    FPLC    FPRC    FPID    FPDD    FPLD    FPRD    FPIG
            0.00    1.00    0.00    0.00    0.00    1.00    0.00    0.00    0.20

FRACTN P 2  FPDG    FPLG    FPRG    FPIP    FPDP    FPLP    FPRP
            0.80    0.00    0.00    0.00    0.00   0.700   0.300

FRACTN C    FCDC    FCDD    FCDG    FDOP    FCDP    FCLP    FCRP
             0.0     0.0     0.0     0.0    0.00   0.700   0.300

MNRL/HYDRL   KDC     KLC     KRC     KND     KLN     KRN     KDP     KLP     KRP
```

```
           0.100   0.075   0.005   0.100   0.075   0.005    0.10   0.075   0.005

MNRL/HYDRL  KSUA    KCOD
            0.03    10.0

REF T RESP   TRC     TRD     TRG   TRCOD   TRMNL   TRHDR   TRSUA
            20.0    20.0    20.0    23.0    20.0    20.0    20.0

TEMP EFF    KTBC    KTBD    KTBG   KTCOD   KTMNL   KTHDR   KTSUA
           0.069   0.069   0.069   0.041   0.069   0.069   0.092

ALGAL EFF KDCALG  KLCALG  KRCALG  KDNALG  KLNALG  KRNALG  KDPALG  KLPALG  KRPALG
             0.0     0.0     0.0     0.0     0.0     0.0     0.2     0.0     0.0

SUBOPT T   KTNT1   KTGC1   KTGD1   KTGG1
            0.09   0.005   0.004   0.012

SUPOPT T   KTNT2   KTGC2   KTGD2   KTGG2
            0.09   0.004   0.006   0.012

MAX T       TMNT     TMC     TMD     TMG
            30.0    27.5    20.0    25.0

PREDATION   NPRD
               1

PRED DAY    PRDD    PRDD    PRDD    PRDD    PRDD    PRDD    PRDD    PRDD    PRDD
             0.0   152.0   365.0   517.0   730.0   882.0

PRED VAL  PRDVAL  PRDVAL  PRDVAL  PRDVAL  PRDVAL  PRDVAL  PRDVAL  PRDVAL  PRDVAL
             1.0     0.0     1.0     0.0     1.0     0.0

MACROBEN    MBGM      FR     UCM     UDM     UGM
             0.0     1.0     0.0     0.0     0.0

LIGHT 1    DOPTC   DOPTD   DOPTG   FCYAN   KECHL
             0.5     0.5     0.5     1.0    16.0

LIGHT 2       I0   ISMIN    I0WT    I1WT    I2WT
           110.0    40.0     0.7     0.2     0.1

METALS    KDOTAM  TAMDMX  BENTAM   KTBMF   KHBMF
             1.0   0.015    0.00     0.2     0.5

SORPTION  KADPO4   KADSA
             0.0     0.0

CAR/CHL    CCHLC   CCHLD   CCHLG
            60.0    60.0    60.0

MISC       NTMAX      DL       R    FSAP   SCTOX   AANOX
           0.100     1.0     0.4     0.3     1.0     0.5

# FILES    NHYDF   NTVDF
               2       2

MAP FILE................................MAPFN...................................
        map.inp

GEO FILE................................GEOFN...................................
        geo.inp
```

```
ICI FILE................................ICIFN...................................
        wqm_ici_FC.nosed

RSI FILE................................RSIFN...................................
        wqm_rso.npt

AGR FILE................................AGRFN...................................
        wqm_agr.indr

STL FILE................................STLFN...................................
        wqm_stl.indr

HYD FILE................................HYDFN...................................
        FIN_88HYD.BIN
        FIN_88HYD.BIN

MET FILE................................METFN...................................
        wqm_met.88
        wqm_met.88

PTS FILE................................PTSFN...................................
        pslds88_FC2.indr
        pslds88_FC2.indr

NPS FILE................................NPSFN...................................
        npslds88.indr
        npslds88.indr

ATM FILE................................ATMFN...................................
        wqm_atm.indr
        wqm_atm.indr

SAV FILE................................SAVFN...................................
        wqm_sav.indr
        wqm_sav.indr

EXT FILE................................EXTFN...................................
        wqm_kei.comb
        wqm_kei.comb

CBC FILE................................CBCFN...................................
        wqm_cbc_FC.88
        wqm_cbc_FC.88

BFI FILE................................BFIFN...................................
        wqm_bfi.final
        wqm_bfi.final

SNP FILE................................SNPFN...................................
        wqm_snp.opt

RSO FILE................................RSOFN...................................
        wqm_rso.opt

PLT FILE................................PLTFN...................................
        wqm_plt.opt

APL FILE................................APLFN...................................
        wqm_apl.opt

DIA FILE................................DIAFN...................................
        wqm_dia.opt
```

```
TFL FILE................................TFLFN...................................
        wqm_tfl.opt

KFL FILE................................KFLFN...................................
        wqm_kfl.opt

OPL FILE................................OPLFN...................................
        wqm_opl.opt

MBL FILE................................MBLFN...................................
        wqm_mbl.opt

BFO FILE................................BFOFN...................................
        wqm_bfo.opt
```

```
1988 Point-Source Loads
'Final DP&L Loads, December 16, 1992'

           NPSLN   NPSLN   NPSLN   NPSLN   NPSLN   NPSLN   NPSLN   NPSLN   NPSLN
               0       0       0       0       0       0      12      12      12
              12      12      12      12      12      12      12      12      12
               0       0       0       0

    TEMP   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


    SALT   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


    FEMN   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


    CYAN   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


    DIAT   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


    GREN   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


     DOC   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
              89     135      90     157     160     158     275     275     275
              10     159     135

    LPOC   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
              89     135      90     157     160     158     275     275     275
              10     159     135

    RPOC   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
              89     135      90     157     160     158     275     275     275
              10     159     135

     NH4   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
              89     135      90     157     160     158     275     275     275
              10     159     135
```

```
     NO3   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
              89     135      90     157     160     158     275     275     275
              10     159     135

     DON   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
              89     135      90     157     160     158     275     275     275
              10     159     135

    LPON   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
              89     135      90     157     160     158     275     275     275
              10     159     135

    RPON   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
              89     135      90     157     160     158     275     275     275
              10     159     135

     PO4   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
              89     135      90     157     160     158     275     275     275
              10     159     135

     DOP   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
              89     135      90     157     160     158     275     275     275
              10     159     135

    LPOP   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
              89     135      90     157     160     158     275     275     275
              10     159     135

    RPOP   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
              89     135      90     157     160     158     275     275     275
              10     159     135

     COD   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


      DO   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


    PSIL   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


    DSIL   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


 PS LOAD    JDAY  KG/DAY  KG/DAY  KG/DAY  KG/DAY  KG/DAY  KG/DAY  KG/DAY  KG/DAY
    TEMP     0.0     0.0
    SALT     0.0     0.0
    FEMN     0.0     0.0
    CYAN     0.0     0.0
    DIAT     0.0     0.0
    GREN     0.0     0.0
     DOC     0.0     0.5     0.0     0.1    15.8   125.6    13.9     0.9    31.5
                     0.5     0.2     0.6     0.3
    LPOC     0.0     0.1     0.0     0.0     3.0    23.5     2.6     0.2     5.9
                     0.1     0.0     0.1     0.1
    RPOC     0.0     0.0     0.0     0.0     1.0     7.8     0.9     0.1     2.0
                     0.0     0.0     0.0     0.0
     NH4     0.0     0.3     0.0     0.1     7.8     8.7     0.1     0.6     2.1
                     0.0     0.1     0.3     0.0
     NO3     0.0     0.6    30.8     0.1     2.8   190.1     3.0     0.4     1.4
                     1.0     0.2     0.4     0.3
     DON     0.0     0.0   -24.6     0.0     1.4    34.9     1.0     0.0     8.4
```

```
                     0.0     0.0     0.0     0.0
    LPON     0.0     0.0    -3.1     0.0     0.2     4.4     0.1     0.0     1.1
                     0.0     0.0     0.0     0.0
    RPON     0.0     0.0    -3.1     0.0     0.2     4.4     0.1     0.0     1.1
                     0.0     0.0     0.0     0.0
     PO4     0.0     0.1     3.2     0.0     2.6     0.9     0.1     0.1     7.6
                     0.1     0.0     0.1     0.0
     DOP     0.0     0.0     0.0     0.0     0.1     0.0     0.0     0.0     0.5
                     0.0     0.0     0.0     0.0
    LPOP     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPOP     0.0     0.0     0.0     0.0     0.2     0.0     0.0     0.0     0.8
                     0.0     0.0     0.0     0.0
     COD     0.0     0.0
      DO     0.0     0.0
    PSIL     0.0     0.0
    DSIL     0.0     0.0
    TEMP    30.4     0.0
    SALT    30.4     0.0
    FEMN    30.4     0.0
    CYAN    30.4     0.0
    DIAT    30.4     0.0
    GREN    30.4     0.0
     DOC    30.4     2.1     0.0     0.1    15.1   121.2    14.1     0.7    30.0
                     0.4     0.2     0.6     0.3
    LPOC    30.4     0.4     0.0     0.0     2.8    22.7     2.6     0.1     5.6
                     0.1     0.0     0.1     0.1
    RPOC    30.4     0.1     0.0     0.0     0.9     7.6     0.9     0.0     1.9
                     0.0     0.0     0.0     0.0
     NH4    30.4     1.1     0.0     0.1     7.5     8.4     0.1     0.4     2.0
                     0.0     0.1     0.3     0.0
     NO3    30.4     2.6    30.8     0.2     2.7   183.5     3.0     0.3     1.3
                     0.9     0.2     0.4     0.3
     DON    30.4     0.0   -24.6     0.0     1.3    33.7     1.0     0.0     8.0
                     0.0     0.0     0.0     0.0
    LPON    30.4     0.0    -3.1     0.0     0.2     4.2     0.1     0.0     1.0
                     0.0     0.0     0.0     0.0
    RPON    30.4     0.0    -3.1     0.0     0.2     4.2     0.1     0.0     1.0
                     0.0     0.0     0.0     0.0
     PO4    30.4     0.6     3.1     0.0     2.5     0.8     0.1     0.1     7.2
                     0.1     0.0     0.1     0.0
     DOP    30.4     0.0     0.0     0.0     0.1     0.0     0.0     0.0     0.5
                     0.0     0.0     0.0     0.0
    LPOP    30.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPOP    30.4     0.1     0.0     0.0     0.2     0.0     0.0     0.0     0.8
                     0.0     0.0     0.0     0.0
     COD    30.4     0.0
      DO    30.4     0.0
    PSIL    30.4     0.0
    DSIL    30.4     0.0
    TEMP    60.9     0.0
    SALT    60.9     0.0
    FEMN    60.9     0.0
    CYAN    60.9     0.0
    DIAT    60.9     0.0
    GREN    60.9     0.0
     DOC    60.9     1.0     0.0     0.2    15.1   119.6    14.7     0.7    36.0
                     0.4     0.2     0.6     0.4
    LPOC    60.9     0.2     0.0     0.0     2.8    22.4     2.8     0.1     6.8
                     0.1     0.0     0.1     0.1
    RPOC    60.9     0.1     0.0     0.0     0.9     7.5     0.9     0.0     2.3
```

```
                     0.0     0.0     0.0     0.0
     NH4    60.9     0.5     0.0     0.1     7.5     8.3     0.1     0.5     2.4
                     0.0     0.1     0.3     0.0
     NO3    60.9     1.2    30.8     0.2     2.7   181.0     3.2     0.3     1.6
                     0.7     0.2     0.4     0.5
     DON    60.9     0.0   -24.6     0.0     1.3    33.2     1.1     0.0     9.6
                     0.0     0.0     0.0     0.1
    LPON    60.9     0.0    -3.1     0.0     0.2     4.2     0.1     0.0     1.2
                     0.0     0.0     0.0     0.0
    RPON    60.9     0.0    -3.1     0.0     0.2     4.2     0.1     0.0     1.2
                     0.0     0.0     0.0     0.0
     PO4    60.9     0.3     3.3     0.1     2.5     0.8     0.1     0.1     8.7
                     0.1     0.0     0.1     0.0
     DOP    60.9     0.0     0.0     0.0     0.1     0.0     0.0     0.0     0.6
                     0.0     0.0     0.0     0.0
    LPOP    60.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPOP    60.9     0.0     0.0     0.0     0.2     0.0     0.0     0.0     0.9
                     0.0     0.0     0.0     0.0
     COD    60.9     0.0
      DO    60.9     0.0
    PSIL    60.9     0.0
    DSIL    60.9     0.0
    TEMP    91.3     0.0
    SALT    91.3     0.0
    FEMN    91.3     0.0
    CYAN    91.3     0.0
    DIAT    91.3     0.0
    GREN    91.3     0.0
     DOC    91.3     0.3     0.0     0.1    12.1    60.6    11.0     0.8    49.1
                     0.6     0.2     0.7     0.3
    LPOC    91.3     0.1     0.0     0.0     2.3    11.4     2.1     0.1     9.2
                     0.1     0.0     0.1     0.1
    RPOC    91.3     0.0     0.0     0.0     0.8     3.8     0.7     0.0     3.1
                     0.0     0.0     0.0     0.0
     NH4    91.3     0.1     0.0     0.1     6.0     4.2     0.0     0.5     3.2
                     0.0     0.1     0.4     0.0
     NO3    91.3     0.3    30.8     0.2     2.2    91.7     2.4     0.4     2.1
                     1.2     0.2     0.5     0.3
     DON    91.3     0.0   -24.6     0.0     1.1    16.8     0.8     0.0    13.1
                     0.0     0.0     0.0     0.0
    LPON    91.3     0.0    -3.1     0.0     0.1     2.1     0.1     0.0     1.6
                     0.0     0.0     0.0     0.0
    RPON    91.3     0.0    -3.1     0.0     0.1     2.1     0.1     0.0     1.6
                     0.0     0.0     0.0     0.0
     PO4    91.3     0.1     3.2     0.1     2.0     0.4     0.0     0.1    11.8
                     0.2     0.0     0.1     0.0
     DOP    91.3     0.0     0.0     0.0     0.1     0.0     0.0     0.0     0.8
                     0.0     0.0     0.0     0.0
    LPOP    91.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPOP    91.3     0.0     0.0     0.0     0.2     0.0     0.0     0.0     1.2
                     0.0     0.0     0.0     0.0
     COD    91.3     0.0
      DO    91.3     0.0
    PSIL    91.3     0.0
    DSIL    91.3     0.0
    TEMP   121.7     0.0
    SALT   121.7     0.0
    FEMN   121.7     0.0
    CYAN   121.7     0.0
    DIAT   121.7     0.0
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GREN   121.7     0.0
 DOC   121.7     0.9     0.0     0.1    13.6    65.5    17.3     1.0    55.1
                 0.6     0.2     0.6     0.5
LPOC   121.7     0.2     0.0     0.0     2.6    12.3     3.2     0.2    10.3
                 0.1     0.0     0.1     0.1
RPOC   121.7     0.1     0.0     0.0     0.9     4.1     1.1     0.1     3.4
                 0.0     0.0     0.0     0.0
 NH4   121.7     0.4     0.0     0.1     6.7     4.5     0.1     0.7     3.6
                 0.0     0.1     0.3     0.0
 NO3   121.7     1.0    30.8     0.2     2.5    99.2     3.7     0.5     2.4
                 1.2     0.2     0.4     0.5
 DON   121.7     0.0   -24.6     0.0     1.2    18.2     1.2     0.0    14.7
                 0.0     0.0     0.0     0.1
LPON   121.7     0.0    -3.1     0.0     0.2     2.3     0.2     0.0     1.8
                 0.0     0.0     0.0     0.0
RPON   121.7     0.0    -3.1     0.0     0.2     2.3     0.2     0.0     1.8
                 0.0     0.0     0.0     0.0
 PO4   121.7     0.2     1.5     0.0     2.3     0.5     0.1     0.2    13.2
                 0.2     0.0     0.1     0.0
 DOP   121.7     0.0     0.0     0.0     0.1     0.0     0.0     0.0     0.9
                 0.0     0.0     0.0     0.0
LPOP   121.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPOP   121.7     0.0     0.0     0.0     0.2     0.0     0.0     0.0     1.4
                 0.0     0.0     0.0     0.0
 COD   121.7     0.0
  DO   121.7     0.0
PSIL   121.7     0.0
DSIL   121.7     0.0
TEMP   152.1     0.0
SALT   152.1     0.0
FEMN   152.1     0.0
CYAN   152.1     0.0
DIAT   152.1     0.0
GREN   152.1     0.0
 DOC   152.1     1.1     0.0     0.0    16.0    68.2    16.8     1.1    83.7
                 0.8     0.2     0.5     0.5
LPOC   152.1     0.2     0.0     0.0     3.0    12.8     3.2     0.2    15.7
                 0.1     0.0     0.1     0.1
RPOC   152.1     0.1     0.0     0.0     1.0     4.3     1.1     0.1     5.2
                 0.0     0.0     0.0     0.0
 NH4   152.1     0.5     0.0     0.0     7.9     4.7     0.1     0.7     5.5
                 0.1     0.1     0.3     0.0
 NO3   152.1     1.3    30.8     0.1     2.9   103.3     3.6     0.5     3.6
                 1.5     0.2     0.4     0.5
 DON   152.1     0.0   -24.6     0.0     1.4    19.0     1.2     0.0    22.4
                 0.0     0.0     0.0     0.1
LPON   152.1     0.0    -3.1     0.0     0.2     2.4     0.2     0.0     2.8
                 0.0     0.0     0.0     0.0
RPON   152.1     0.0    -3.1     0.0     0.2     2.4     0.2     0.0     2.8
                 0.0     0.0     0.0     0.0
 PO4   152.1     0.3     3.2     0.0     2.7     0.5     0.1     0.2    20.1
                 0.2     0.0     0.1     0.0
 DOP   152.1     0.0     0.0     0.0     0.1     0.0     0.0     0.0     1.4
                 0.0     0.0     0.0     0.0
LPOP   152.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPOP   152.1     0.0     0.0     0.0     0.2     0.0     0.0     0.0     2.1
                 0.0     0.0     0.0     0.0
 COD   152.1     0.0
  DO   152.1     0.0
PSIL   152.1     0.0
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DSIL   152.1     0.0
TEMP   182.6     0.0
SALT   182.6     0.0
FEMN   182.6     0.0
CYAN   182.6     0.0
DIAT   182.6     0.0
GREN   182.6     0.0
 DOC   182.6     2.3     0.0     0.0    16.9    66.6    19.0     1.5   111.4
                 0.9     0.2     0.6     0.6
LPOC   182.6     0.4     0.0     0.0     3.2    12.5     3.6     0.3    20.9
                 0.2     0.0     0.1     0.1
RPOC   182.6     0.1     0.0     0.0     1.1     4.2     1.2     0.1     7.0
                 0.1     0.0     0.0     0.0
 NH4   182.6     1.1     0.0     0.0     8.3     4.6     0.1     1.0     7.3
                 0.1     0.1     0.3     0.0
 NO3   182.6     2.8    63.8     0.0     3.1   100.8     4.1     0.7     4.8
                 1.8     0.2     0.4     0.6
 DON   182.6     0.0   -51.0     0.0     1.5    18.5     1.4     0.0    29.8
                 0.0     0.0     0.0     0.1
LPON   182.6     0.0    -6.4     0.0     0.2     2.3     0.2     0.0     3.7
                 0.0     0.0     0.0     0.0
RPON   182.6     0.0    -6.4     0.0     0.2     2.3     0.2     0.0     3.7
                 0.0     0.0     0.0     0.0
 PO4   182.6     0.6     3.3     0.0     2.8     0.5     0.1     0.2    26.8
                 0.3     0.0     0.1     0.1
 DOP   182.6     0.0     0.0     0.0     0.1     0.0     0.0     0.0     1.9
                 0.0     0.0     0.0     0.0
LPOP   182.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPOP   182.6     0.1     0.0     0.0     0.2     0.0     0.1     0.0     2.8
                 0.0     0.0     0.0     0.0
 COD   182.6     0.0
  DO   182.6     0.0
PSIL   182.6     0.0
DSIL   182.6     0.0
TEMP   213.0     0.0
SALT   213.0     0.0
FEMN   213.0     0.0
CYAN   213.0     0.0
DIAT   213.0     0.0
GREN   213.0     0.0
 DOC   213.0     2.0     0.0     0.0    16.3    63.3    19.4     1.5   110.6
                 0.8     0.2     0.6     0.5
LPOC   213.0     0.4     0.0     0.0     3.1    11.9     3.6     0.3    20.7
                 0.2     0.0     0.1     0.1
RPOC   213.0     0.1     0.0     0.0     1.0     4.0     1.2     0.1     6.9
                 0.1     0.0     0.0     0.0
 NH4   213.0     1.0     0.0     0.0     8.0     4.4     0.1     1.0     7.3
                 0.1     0.1     0.3     0.0
 NO3   213.0     2.4    63.8     0.0     2.9    95.9     4.2     0.7     4.8
                 1.7     0.2     0.4     0.6
 DON   213.0     0.0   -51.0     0.0     1.5    17.6     1.4     0.0    29.6
                 0.0     0.0     0.0     0.1
LPON   213.0     0.0    -6.4     0.0     0.2     2.2     0.2     0.0     3.7
                 0.0     0.0     0.0     0.0
RPON   213.0     0.0    -6.4     0.0     0.2     2.2     0.2     0.0     3.7
                 0.0     0.0     0.0     0.0
 PO4   213.0     0.5     3.3     0.0     2.7     0.4     0.1     0.2    26.6
                 0.2     0.0     0.1     0.0
 DOP   213.0     0.0     0.0     0.0     0.1     0.0     0.0     0.0     1.9
                 0.0     0.0     0.0     0.0
LPOP   213.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
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                 0.0     0.0     0.0     0.0
RPOP   213.0     0.0     0.0     0.0     0.2     0.0     0.1     0.0     2.8
                 0.0     0.0     0.0     0.0
 COD   213.0     0.0
  DO   213.0     0.0
PSIL   213.0     0.0
DSIL   213.0     0.0
TEMP   243.4     0.0
SALT   243.4     0.0
FEMN   243.4     0.0
CYAN   243.4     0.0
DIAT   243.4     0.0
GREN   243.4     0.0
 DOC   243.4     1.0     0.0     0.2    15.1    54.6    18.5     1.3    63.3
                 0.3     0.2     0.6     0.4
LPOC   243.4     0.2     0.0     0.0     2.8    10.2     3.5     0.2    11.9
                 0.1     0.0     0.1     0.1
RPOC   243.4     0.1     0.0     0.0     0.9     3.4     1.2     0.1     4.0
                 0.0     0.0     0.0     0.0
 NH4   243.4     0.5     0.0     0.1     7.5     3.8     0.1     0.8     4.2
                 0.0     0.1     0.3     0.0
 NO3   243.4     1.2    63.8     0.2     2.7    82.7     4.0     0.6     2.7
                 0.7     0.2     0.4     0.5
 DON   243.4     0.0   -51.0     0.0     1.3    15.2     1.3     0.0    16.9
                 0.0     0.0     0.0     0.1
LPON   243.4     0.0    -6.4     0.0     0.2     1.9     0.2     0.0     2.1
                 0.0     0.0     0.0     0.0
RPON   243.4     0.0    -6.4     0.0     0.2     1.9     0.2     0.0     2.1
                 0.0     0.0     0.0     0.0
 PO4   243.4     0.3     2.5     0.1     2.5     0.4     0.1     0.2    15.2
                 0.1     0.0     0.1     0.0
 DOP   243.4     0.0     0.0     0.0     0.1     0.0     0.0     0.0     1.1
                 0.0     0.0     0.0     0.0
LPOP   243.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPOP   243.4     0.0     0.0     0.0     0.2     0.0     0.1     0.0     1.6
                 0.0     0.0     0.0     0.0
 COD   243.4     0.0
  DO   243.4     0.0
PSIL   243.4     0.0
DSIL   243.4     0.0
TEMP   273.9     0.0
SALT   273.9     0.0
FEMN   273.9     0.0
CYAN   273.9     0.0
DIAT   273.9     0.0
GREN   273.9     0.0
 DOC   273.9     0.7     0.0     0.2    15.1    65.5    18.0     0.9    50.1
                 0.6     0.2     0.7     0.4
LPOC   273.9     0.1     0.0     0.0     2.8    12.3     3.4     0.2     9.4
                 0.1     0.0     0.1     0.1
RPOC   273.9     0.0     0.0     0.0     0.9     4.1     1.1     0.1     3.1
                 0.0     0.0     0.0     0.0
 NH4   273.9     0.3     0.0     0.1     7.5     4.5     0.1     0.6     3.3
                 0.0     0.1     0.4     0.0
 NO3   273.9     0.8    66.0     0.3     2.7    99.2     3.9     0.4     2.2
                 1.2     0.2     0.5     0.4
 DON   273.9     0.0   -52.8     0.0     1.3    18.2     1.3     0.0    13.4
                 0.0     0.0     0.0     0.0
LPON   273.9     0.0    -6.6     0.0     0.2     2.3     0.2     0.0     1.7
                 0.0     0.0     0.0     0.0
RPON   273.9     0.0    -6.6     0.0     0.2     2.3     0.2     0.0     1.7
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                   0.0     0.0     0.0     0.0
   PO4   273.9     0.2     0.3     0.1     2.5     0.5     0.1     0.1    12.0
                   0.2     0.0     0.1     0.0
   DOP   273.9     0.0     0.0     0.0     0.1     0.0     0.0     0.0     0.8
                   0.0     0.0     0.0     0.0
  LPOP   273.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                   0.0     0.0     0.0     0.0
  RPOP   273.9     0.0     0.0     0.0     0.2     0.0     0.0     0.0     1.3
                   0.0     0.0     0.0     0.0
   COD   273.9     0.0
    DO   273.9     0.0
  PSIL   273.9     0.0
  DSIL   273.9     0.0
  TEMP   304.3     0.0
  SALT   304.3     0.0
  FEMN   304.3     0.0
  CYAN   304.3     0.0
  DIAT   304.3     0.0
  GREN   304.3     0.0
   DOC   304.3     0.7     0.0     0.1    15.1    71.0    13.5     0.7    40.6
                   0.5     0.2     0.4     0.4
  LPOC   304.3     0.1     0.0     0.0     2.8    13.3     2.5     0.1     7.6
                   0.1     0.0     0.1     0.1
  RPOC   304.3     0.0     0.0     0.0     0.9     4.4     0.8     0.0     2.5
                   0.0     0.0     0.0     0.0
   NH4   304.3     0.3     0.0     0.1     7.5     4.9     0.1     0.5     2.7
                   0.0     0.1     0.2     0.0
   NO3   304.3     0.8    49.7     0.2     2.7   107.4     2.9     0.3     1.7
                   1.1     0.2     0.3     0.5
   DON   304.3     0.0   -39.8     0.0     1.3    19.7     1.0     0.0    10.9
                   0.0     0.0     0.0     0.1
  LPON   304.3     0.0    -5.0     0.0     0.2     2.5     0.1     0.0     1.4
                   0.0     0.0     0.0     0.0
  RPON   304.3     0.0    -5.0     0.0     0.2     2.5     0.1     0.0     1.4
                   0.0     0.0     0.0     0.0
   PO4   304.3     0.2     3.1     0.1     2.5     0.5     0.1     0.1     9.8
                   0.2     0.0     0.1     0.0
   DOP   304.3     0.0     0.0     0.0     0.1     0.0     0.0     0.0     0.7
                   0.0     0.0     0.0     0.0
  LPOP   304.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                   0.0     0.0     0.0     0.0
  RPOP   304.3     0.0     0.0     0.0     0.2     0.0     0.0     0.0     1.0
                   0.0     0.0     0.0     0.0
   COD   304.3     0.0
    DO   304.3     0.0
  PSIL   304.3     0.0
  DSIL   304.3     0.0
  TEMP   334.7     0.0
  SALT   334.7     0.0
  FEMN   334.7     0.0
  CYAN   334.7     0.0
  DIAT   334.7     0.0
  GREN   334.7     0.0
   DOC   334.7     0.7     0.0     0.1    15.1   120.1     9.1     0.8    32.4
                   0.5     0.2     0.5     0.4
  LPOC   334.7     0.1     0.0     0.0     2.8    22.5     1.7     0.1     6.1
                   0.1     0.0     0.1     0.1
  RPOC   334.7     0.0     0.0     0.0     0.9     7.5     0.6     0.0     2.0
                   0.0     0.0     0.0     0.0
   NH4   334.7     0.3     0.0     0.1     7.5     8.3     0.0     0.5     2.1
                   0.0     0.1     0.3     0.0
   NO3   334.7     0.8    26.4     0.2     2.7   181.8     2.0     0.4     1.4
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                     1.0     0.2     0.4     0.4
     DON   334.7     0.0   -21.1     0.0     1.3    33.4     0.7     0.0     8.7
                     0.0     0.0     0.0     0.0
    LPON   334.7     0.0    -2.6     0.0     0.2     4.2     0.1     0.0     1.1
                     0.0     0.0     0.0     0.0
    RPON   334.7     0.0    -2.6     0.0     0.2     4.2     0.1     0.0     1.1
                     0.0     0.0     0.0     0.0
     PO4   334.7     0.2     3.0     0.0     2.5     0.8     0.0     0.1     7.8
                     0.1     0.0     0.1     0.0
     DOP   334.7     0.0     0.0     0.0     0.1     0.0     0.0     0.0     0.5
                     0.0     0.0     0.0     0.0
    LPOP   334.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPOP   334.7     0.0     0.0     0.0     0.2     0.0     0.0     0.0     0.8
                     0.0     0.0     0.0     0.0
     COD   334.7     0.0
      DO   334.7     0.0
    PSIL   334.7     0.0
    DSIL   334.7     0.0
Distributed Loads, groundwater eliminated, 1988.
Locations corrected.  January 5, 1993

           NPSLN   NPSLN   NPSLN   NPSLN   NPSLN   NPSLN   NPSLN   NPSLN   NPSLN
               0       0       0       0       0       0      12      12      12
              12      12      12      12      12      12      12      12      12
               0       0       0       0

    TEMP   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


    SALT   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


    FEMN   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


    CYAN   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


    DIAT   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


    GREN   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


     DOC   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
             275     278     228     233     187     160     158      92      90
              71       7     157

    LPOC   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
             275     278     228     233     187     160     158      92      90
              71       7     157

    RPOC   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
             275     278     228     233     187     160     158      92      90
              71       7     157

     NH4   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
             275     278     228     233     187     160     158      92      90
              71       7     157

     NO3   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
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             275     278     228     233     187     160     158      92      90
              71       7     157

     DON   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
             275     278     228     233     187     160     158      92      90
              71       7     157

    LPON   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
             275     278     228     233     187     160     158      92      90
              71       7     157

    RPON   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
             275     278     228     233     187     160     158      92      90
              71       7     157

     PO4   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
             275     278     228     233     187     160     158      92      90
              71       7     157

     DOP   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
             275     278     228     233     187     160     158      92      90
              71       7     157

    LPOP   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
             275     278     228     233     187     160     158      92      90
              71       7     157

    RPOP   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB
             275     278     228     233     187     160     158      92      90
              71       7     157

     COD   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


      DO   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


    PSIL   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


    DSIL   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB   NPSLB


NPS LOAD    JDAY  KG/DAY  KG/DAY  KG/DAY  KG/DAY  KG/DAY  KG/DAY  KG/DAY  KG/DAY
    TEMP     0.0     0.0
    SALT     0.0     0.0
    FEMN     0.0     0.0
    CYAN     0.0     0.0
    DIAT     0.0     0.0
    GREN     0.0     0.0
     DOC     0.0   154.4   249.5   285.3   142.4    63.6   250.4   273.9   181.5
                   175.2   151.2   143.0   778.9
    LPOC     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPOC     0.0    38.6    62.4    71.3    35.6    15.9    62.6    68.5    45.4
                    43.8    37.8    35.7   194.7
     NH4     0.0     2.1     3.5     4.0     2.0     0.9     3.5     3.8     2.5
                     2.4     2.1     2.0    10.8
     NO3     0.0    63.9   103.2   118.1    59.0    26.3   103.6   113.4    75.1
                    72.5    62.6    59.2   332.1
     DON     0.0    10.0    16.2    18.5     9.3     4.1    16.3    17.8    11.8
                    11.4     9.8     9.3    45.4
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    LPON     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPON     0.0     6.7    10.8    12.4     6.2     2.8    10.8    11.9     7.9
                     7.6     6.6     6.2    30.3
     PO4     0.0     2.4     3.8     4.4     2.2     1.0     3.8     4.2     2.8
                     2.7     2.3     2.2     3.2
     DOP     0.0     0.1     0.1     0.1     0.1     0.0     0.1     0.1     0.1
                     0.1     0.1     0.1     0.2
    LPOP     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPOP     0.0     0.6     0.9     1.1     0.5     0.2     0.9     1.0     0.7
                     0.7     0.6     0.5     1.9
     COD     0.0     0.0
      DO     0.0     0.0
    PSIL     0.0     0.0
    DSIL     0.0     0.0
    TEMP    30.4     0.0
    SALT    30.4     0.0
    FEMN    30.4     0.0
    CYAN    30.4     0.0
    DIAT    30.4     0.0
    GREN    30.4     0.0
     DOC    30.4   369.5   597.1   682.9   341.0   152.3   599.3   655.7   434.6
                   419.3   362.0   342.3  1721.7
    LPOC    30.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPOC    30.4    92.4   149.3   170.7    85.2    38.1   149.8   163.9   108.6
                   104.8    90.5    85.6   430.4
     NH4    30.4     5.1     8.3     9.5     4.7     2.1     8.3     9.1     6.0
                     5.8     5.0     4.8    23.9
     NO3    30.4   132.4   214.0   244.7   122.2    54.6   214.8   235.0   155.7
                   150.3   129.7   122.7   724.6
     DON    30.4    24.0    38.8    44.4    22.2     9.9    39.0    42.6    28.2
                    27.3    23.5    22.2   100.4
    LPON    30.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPON    30.4    16.0    25.9    29.6    14.8     6.6    26.0    28.4    18.8
                    18.2    15.7    14.8    67.0
     PO4    30.4     5.6     9.1    10.4     5.2     2.3     9.2    10.0     6.6
                     6.4     5.5     5.2     7.2
     DOP    30.4     0.2     0.2     0.3     0.1     0.1     0.2     0.3     0.2
                     0.2     0.2     0.1     0.5
    LPOP    30.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPOP    30.4     1.4     2.2     2.6     1.3     0.6     2.2     2.5     1.6
                     1.6     1.4     1.3     4.3
     COD    30.4     0.0
      DO    30.4     0.0
    PSIL    30.4     0.0
    DSIL    30.4     0.0
    TEMP    60.9     0.0
    SALT    60.9     0.0
    FEMN    60.9     0.0
    CYAN    60.9     0.0
    DIAT    60.9     0.0
    GREN    60.9     0.0
     DOC    60.9   322.3   520.9   595.7   297.4   132.8   522.8   572.0   379.1
                   365.8   315.8   298.6  1517.3
    LPOC    60.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPOC    60.9    80.6   130.2   148.9    74.4    33.2   130.7   143.0    94.8
                    91.4    78.9    74.6   379.3
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     NH4    60.9     4.5     7.2     8.3     4.1     1.8     7.3     7.9     5.3
                     5.1     4.4     4.1    21.1
     NO3    60.9   118.6   191.7   219.3   109.5    48.9   192.4   210.5   139.5
                   134.6   116.2   109.9   560.6
     DON    60.9    21.0    33.9    38.7    19.3     8.6    34.0    37.2    24.6
                    23.8    20.5    19.4    88.5
    LPON    60.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPON    60.9    14.0    22.6    25.8    12.9     5.8    22.7    24.8    16.4
                    15.9    13.7    12.9    59.0
     PO4    60.9     4.9     8.0     9.1     4.5     2.0     8.0     8.7     5.8
                     5.6     4.8     4.6     6.3
     DOP    60.9     0.1     0.2     0.2     0.1     0.1     0.2     0.2     0.2
                     0.2     0.1     0.1     0.4
    LPOP    60.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPOP    60.9     1.2     2.0     2.2     1.1     0.5     2.0     2.1     1.4
                     1.4     1.2     1.1     3.8
     COD    60.9     0.0
      DO    60.9     0.0
    PSIL    60.9     0.0
    DSIL    60.9     0.0
    TEMP    91.3     0.0
    SALT    91.3     0.0
    FEMN    91.3     0.0
    CYAN    91.3     0.0
    DIAT    91.3     0.0
    GREN    91.3     0.0
     DOC    91.3   403.9   652.7   746.5   372.7   166.4   655.1   716.7   475.0
                   458.4   395.7   374.2  1899.7
    LPOC    91.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPOC    91.3   101.0   163.2   186.6    93.2    41.6   163.8   179.2   118.8
                   114.6    98.9    93.5   474.9
     NH4    91.3     5.6     9.1    10.4     5.2     2.3     9.1    10.0     6.6
                     6.4     5.5     5.2    26.4
     NO3    91.3   114.4   184.9   211.5   105.6    47.2   185.6   203.1   134.6
                   129.9   112.1   106.0   588.4
     DON    91.3    26.3    42.4    48.5    24.2    10.8    42.6    46.6    30.9
                    29.8    25.7    24.3   110.8
    LPON    91.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPON    91.3    17.5    28.3    32.3    16.2     7.2    28.4    31.1    20.6
                    19.9    17.1    16.2    73.9
     PO4    91.3     6.2    10.0    11.4     5.7     2.5    10.0    10.9     7.3
                     7.0     6.0     5.7     7.9
     DOP    91.3     0.2     0.3     0.3     0.2     0.1     0.3     0.3     0.2
                     0.2     0.2     0.2     0.5
    LPOP    91.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                     0.0     0.0     0.0     0.0
    RPOP    91.3     1.5     2.4     2.8     1.4     0.6     2.5     2.7     1.8
                     1.7     1.5     1.4     4.7
     COD    91.3     0.0
      DO    91.3     0.0
    PSIL    91.3     0.0
    DSIL    91.3     0.0
    TEMP   121.7     0.0
    SALT   121.7     0.0
    FEMN   121.7     0.0
    CYAN   121.7     0.0
    DIAT   121.7     0.0
    GREN   121.7     0.0
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     DOC     121.7     292.8     473.1     541.0     270.1     120.6     474.8     519.4     344.3
                       332.2     286.8     271.2    1845.1
    LPOC     121.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
                         0.0       0.0       0.0       0.0
    RPOC     121.7      73.2     118.3     135.3      67.5      30.2     118.7     129.9      86.1
                        83.0      71.7      67.8     461.3
     NH4     121.7       4.1       6.6       7.5       3.8       1.7       6.6       7.2       4.8
                         4.6       4.0       3.8      25.6
     NO3     121.7      65.9     106.4     121.7      60.8      27.1     106.8     116.9      77.5
                        74.7      64.5      61.0     627.8
     DON     121.7      19.0      30.7      35.2      17.6       7.8      30.9      33.8      22.4
                        21.6      18.6      17.6     107.6
    LPON     121.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
                         0.0       0.0       0.0       0.0
    RPON     121.7      12.7      20.5      23.4      11.7       5.2      20.6      22.5      14.9
                        14.4      12.4      11.8      71.8
     PO4     121.7       4.5       7.2       8.3       4.1       1.8       7.3       7.9       5.3
                         5.1       4.4       4.1       7.7
     DOP     121.7       0.1       0.2       0.2       0.1       0.1       0.2       0.2       0.1
                         0.1       0.1       0.1       0.5
    LPOP     121.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
                         0.0       0.0       0.0       0.0
    RPOP     121.7       1.1       1.8       2.0       1.0       0.5       1.8       1.9       1.3
                         1.2       1.1       1.0       4.6
     COD     121.7       0.0
      DO     121.7       0.0
    PSIL     121.7       0.0
    DSIL     121.7       0.0
    TEMP     152.1       0.0
    SALT     152.1       0.0
    FEMN     152.1       0.0
    CYAN     152.1       0.0
    DIAT     152.1       0.0
    GREN     152.1       0.0
     DOC     152.1     132.8     214.6     245.4     122.5      54.7     215.3     235.6     156.1
                       150.7     130.1     123.0     835.3
    LPOC     152.1       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
                         0.0       0.0       0.0       0.0
    RPOC     152.1      33.2      53.6      61.3      30.6      13.7      53.8      58.9      39.0
                        37.7      32.5      30.7     208.8
     NH4     152.1       1.8       3.0       3.4       1.7       0.8       3.0       3.3       2.2
                         2.1       1.8       1.7      11.6
     NO3     152.1      15.9      25.6      29.3      14.6       6.5      25.7      28.1      18.7
                        18.0      15.5      14.7     247.1
     DON     152.1       8.6      13.9      15.9       8.0       3.6      14.0      15.3      10.1
                         9.8       8.5       8.0      48.7
    LPON     152.1       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
                         0.0       0.0       0.0       0.0
    RPON     152.1       5.8       9.3      10.6       5.3       2.4       9.3      10.2       6.8
                         6.5       5.6       5.3      32.5
     PO4     152.1       2.0       3.3       3.7       1.9       0.8       3.3       3.6       2.4
                         2.3       2.0       1.9       3.5
     DOP     152.1       0.1       0.1       0.1       0.1       0.0       0.1       0.1       0.1
                         0.1       0.1       0.1       0.2
    LPOP     152.1       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
                         0.0       0.0       0.0       0.0
    RPOP     152.1       0.5       0.8       0.9       0.5       0.2       0.8       0.9       0.6
                         0.6       0.5       0.5       2.1
     COD     152.1       0.0
      DO     152.1       0.0
    PSIL     152.1       0.0
    DSIL     152.1       0.0
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TEMP   182.6     0.0
SALT   182.6     0.0
FEMN   182.6     0.0
CYAN   182.6     0.0
DIAT   182.6     0.0
GREN   182.6     0.0
 DOC   182.6    60.8    98.2   112.3    56.1    25.0    98.6   107.9    71.5
                69.0    59.5    56.3   733.1
LPOC   182.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPOC   182.6    15.2    24.6    28.1    14.0     6.3    24.6    27.0    17.9
                17.2    14.9    14.1   183.3
 NH4   182.6     0.8     1.4     1.6     0.8     0.3     1.4     1.5     1.0
                 1.0     0.8     0.8    10.2
 NO3   182.6     1.9     3.1     3.6     1.8     0.8     3.1     3.4     2.3
                 2.2     1.9     1.8   137.5
 DON   182.6     4.0     6.4     7.3     3.6     1.6     6.4     7.0     4.6
                 4.5     3.9     3.7    42.8
LPON   182.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPON   182.6     2.6     4.3     4.9     2.4     1.1     4.3     4.7     3.1
                 3.0     2.6     2.4    28.5
 PO4   182.6     0.9     1.5     1.7     0.9     0.4     1.5     1.6     1.1
                 1.1     0.9     0.9     3.1
 DOP   182.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.2
LPOP   182.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPOP   182.6     0.2     0.4     0.4     0.2     0.1     0.4     0.4     0.3
                 0.3     0.2     0.2     1.8
 COD   182.6     0.0
  DO   182.6     0.0
PSIL   182.6     0.0
DSIL   182.6     0.0
TEMP   213.0     0.0
SALT   213.0     0.0
FEMN   213.0     0.0
CYAN   213.0     0.0
DIAT   213.0     0.0
GREN   213.0     0.0
 DOC   213.0    36.4    58.8    67.3    33.6    15.0    59.0    64.6    42.8
                41.3    35.6    33.7   507.5
LPOC   213.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPOC   213.0     9.1    14.7    16.8     8.4     3.7    14.8    16.1    10.7
                10.3     8.9     8.4   126.9
 NH4   213.0     0.5     0.8     0.9     0.5     0.2     0.8     0.9     0.6
                 0.6     0.5     0.5     7.0
 NO3   213.0     5.7     9.2    10.6     5.3     2.4     9.3    10.1     6.7
                 6.5     5.6     5.3    69.1
 DON   213.0     2.4     3.8     4.4     2.2     1.0     3.8     4.2     2.8
                 2.7     2.3     2.2    29.6
LPON   213.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPON   213.0     1.6     2.5     2.9     1.5     0.6     2.6     2.8     1.9
                 1.8     1.5     1.5    19.7
 PO4   213.0     0.6     0.9     1.0     0.5     0.2     0.9     1.0     0.7
                 0.6     0.5     0.5     2.1
 DOP   213.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.1
LPOP   213.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
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RPOP   213.0     0.1     0.2     0.3     0.1     0.1     0.2     0.2     0.2
                 0.2     0.1     0.1     1.3
 COD   213.0     0.0
  DO   213.0     0.0
PSIL   213.0     0.0
DSIL   213.0     0.0
TEMP   243.4     0.0
SALT   243.4     0.0
FEMN   243.4     0.0
CYAN   243.4     0.0
DIAT   243.4     0.0
GREN   243.4     0.0
 DOC   243.4    26.8    43.3    49.5    24.7    11.0    43.5    47.5    31.5
                30.4    26.2    24.8   419.4
LPOC   243.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPOC   243.4     6.7    10.8    12.4     6.2     2.8    10.9    11.9     7.9
                 7.6     6.6     6.2   104.9
 NH4   243.4     0.4     0.6     0.7     0.3     0.2     0.6     0.7     0.4
                 0.4     0.4     0.3     5.8
 NO3   243.4     6.3    10.2    11.6     5.8     2.6    10.2    11.2     7.4
                 7.1     6.2     5.8    99.0
 DON   243.4     1.7     2.8     3.2     1.6     0.7     2.8     3.1     2.0
                 2.0     1.7     1.6    24.5
LPON   243.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPON   243.4     1.2     1.9     2.1     1.1     0.5     1.9     2.1     1.4
                 1.3     1.1     1.1    16.3
 PO4   243.4     0.4     0.7     0.8     0.4     0.2     0.7     0.7     0.5
                 0.5     0.4     0.4     1.7
 DOP   243.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.1
LPOP   243.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPOP   243.4     0.1     0.2     0.2     0.1     0.0     0.2     0.2     0.1
                 0.1     0.1     0.1     1.0
 COD   243.4     0.0
  DO   243.4     0.0
PSIL   243.4     0.0
DSIL   243.4     0.0
TEMP   273.9     0.0
SALT   273.9     0.0
FEMN   273.9     0.0
CYAN   273.9     0.0
DIAT   273.9     0.0
GREN   273.9     0.0
 DOC   273.9    26.8    43.3    49.5    24.7    11.0    43.5    47.5    31.5
                30.4    26.2    24.8   419.4
LPOC   273.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPOC   273.9     6.7    10.8    12.4     6.2     2.8    10.9    11.9     7.9
                 7.6     6.6     6.2   104.9
 NH4   273.9     0.4     0.6     0.7     0.3     0.2     0.6     0.7     0.4
                 0.4     0.4     0.3     5.8
 NO3   273.9     1.5     2.3     2.7     1.3     0.6     2.4     2.6     1.7
                 1.6     1.4     1.3   102.5
 DON   273.9     1.7     2.8     3.2     1.6     0.7     2.8     3.1     2.0
                 2.0     1.7     1.6    24.5
LPON   273.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPON   273.9     1.2     1.9     2.1     1.1     0.5     1.9     2.1     1.4
                 1.3     1.1     1.1    16.3
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 PO4   273.9     0.4     0.7     0.8     0.4     0.2     0.7     0.7     0.5
                 0.5     0.4     0.4     1.7
 DOP   273.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.1
LPOP   273.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPOP   273.9     0.1     0.2     0.2     0.1     0.0     0.2     0.2     0.1
                 0.1     0.1     0.1     1.0
 COD   273.9     0.0
  DO   273.9     0.0
PSIL   273.9     0.0
DSIL   273.9     0.0
TEMP   304.3     0.0
SALT   304.3     0.0
FEMN   304.3     0.0
CYAN   304.3     0.0
DIAT   304.3     0.0
GREN   304.3     0.0
 DOC   304.3    30.8    49.8    56.9    28.4    12.7    49.9    54.6    36.2
                34.9    30.2    28.5   606.2
LPOC   304.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPOC   304.3     7.7    12.4    14.2     7.1     3.2    12.5    13.7     9.1
                 8.7     7.5     7.1   151.6
 NH4   304.3     0.4     0.7     0.8     0.4     0.2     0.7     0.8     0.5
                 0.5     0.4     0.4     8.4
 NO3   304.3     4.3     6.9     7.9     3.9     1.8     6.9     7.6     5.0
                 4.9     4.2     4.0   148.2
 DON   304.3     2.0     3.2     3.7     1.8     0.8     3.2     3.6     2.4
                 2.3     2.0     1.9    35.4
LPON   304.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPON   304.3     1.3     2.2     2.5     1.2     0.5     2.2     2.4     1.6
                 1.5     1.3     1.2    23.6
 PO4   304.3     0.5     0.8     0.9     0.4     0.2     0.8     0.8     0.6
                 0.5     0.5     0.4     2.5
 DOP   304.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.2
LPOP   304.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPOP   304.3     0.1     0.2     0.2     0.1     0.0     0.2     0.2     0.1
                 0.1     0.1     0.1     1.5
 COD   304.3     0.0
  DO   304.3     0.0
PSIL   304.3     0.0
DSIL   304.3     0.0
TEMP   334.7     0.0
SALT   334.7     0.0
FEMN   334.7     0.0
CYAN   334.7     0.0
DIAT   334.7     0.0
GREN   334.7     0.0
 DOC   334.7    30.4    49.1    56.2    28.0    12.5    49.3    53.9    35.7
                34.5    29.8    28.2   784.2
LPOC   334.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                 0.0     0.0     0.0     0.0
RPOC   334.7     7.6    12.3    14.0     7.0     3.1    12.3    13.5     8.9
                 8.6     7.4     7.0   196.1
 NH4   334.7     0.4     0.7     0.8     0.4     0.2     0.7     0.7     0.5
                 0.5     0.4     0.4    10.9
 NO3   334.7    10.3    16.6    19.0     9.5     4.2    16.6    18.2    12.1
                11.6    10.0     9.5   272.3
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   DON   334.7     2.0     3.2     3.7     1.8     0.8     3.2     3.5     2.3
                   2.2     1.9     1.8    45.7
  LPON   334.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                   0.0     0.0     0.0     0.0
  RPON   334.7     1.3     2.1     2.4     1.2     0.5     2.1     2.3     1.5
                   1.5     1.3     1.2    30.5
   PO4   334.7     0.5     0.8     0.9     0.4     0.2     0.8     0.8     0.5
                   0.5     0.5     0.4     3.3
   DOP   334.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                   0.0     0.0     0.0     0.2
  LPOP   334.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
                   0.0     0.0     0.0     0.0
  RPOP   334.7     0.1     0.2     0.2     0.1     0.0     0.2     0.2     0.1
                   0.1     0.1     0.1     2.0
   COD   334.7     0.0
    DO   334.7     0.0
  PSIL   334.7     0.0
  DSIL   334.7     0.0
```

Appendix B. Various Scenarios Considered for the Inland Bays Model

Scenario	**Description**
Original	Base-line (1988-1990) Condition
One	This scenario was considered to investigate the sensitivity of the model with regard to maximum algal growth rate and D.O. molecular diffusion coefficient
Two	50% reduction of point and nonpoint source nitrogen loads + 50% reduction of point and nonpoint source phosphorous loads (using the original sediment flux rates)
Three	100% reduction of nitrogen loads from point and nonpoint sources + 100% reduction of phosphorous loads from point and nonpoint sources (using the original sediment flux rates)
Four	100% reduction of nitrogen loads from point sources (using the original sediment flux rates)
Five	100% reduction of phosphorous loads from point sources (using the original sediment flux rates)
Six	100% reduction of nitrogen loads from nonpoint sources (using the original sediment flux rates)
Seven	100% reduction of phosphorous loads from nonpoint sources (using the original sediment flux rates)
Eight	Same as scenario Four (100% reduction of nitrogen loads from point sources) except the simulation was run for a 3-year period (using the original sediment flux rates)
Nine	Same as scenario Two (50% reduction of nitrogen loads from point and nonpoint sources + 50% reduction of phosphorous loads from point and nonpoint sources) except simulation was performed for the hydrologic condition of a normal year (1990) (using the original sediment flux rates)
Ten	50% reduction of nitrogen loads from point sources + 50% reduction of phosphorous loads from point sources (using the original sediment flux rates)
From here, a revised version of sediment nutrient flux rates, as supplied by the US Army Corps of Engineers, was used for the model.	
11	100% reduction of nitrogen loads from point and nonpoint sources + 100% reduction of phosphorous loads from point and nonpoint sources

Appendix B. Various Scenarios Considered for the Inland Bays Model, Continued

Scenario	Description
12	100% reduction of nitrogen loads from point sources + 100% reduction of phosphorous loads from point sources
13	50% reduction of nitrogen loads from point sources + 100% reduction of phosphorous loads from point sources
14	100% reduction of nitrogen loads from point sources
15	100% reduction of phosphorous loads from point sources
16	100% reduction of nitrogen loads from nonpoint sources
17	100% reduction of phosphorous loads from nonpoint sources
18	50% reduction of nitrogen loads from point and nonpoint sources + 50% reduction of phosphorous loads from point and nonpoint sources
19	50% reduction of nitrogen loads from point sources, nonpoint sources, and boundary condition + 50% reduction of phosphorous loads from point sources, nonpoint sources, and boundary conditions. For this scenario, the original sediment nutrient flux rates was used.
20	50% reduction of nitrogen loads from point and nonpoint sources + 50% reduction of phosphorous loads from point and nonpoint sources + 50% reduction of carbon loads from point and nonpoint sources. For this scenario, the original sediment nutrient flux rates were used.
21	Same as the base-line condition except when Sewage Treatment Plants are discharging according to their NPDES permitted loads
22	Same as scenario 21 except when loads from point sources discharges are considered to monthly-average instead of yearly-average
23	Same as scenario 22 except when nitrogen load for Rehoboth STP is considered to be equal to the facility's revised permitted load
24	NPDES permitted flow and Biological Nutrient Removal (BNR) for Rehoboth and Millsboro STPs. Nutrient loads from other treatment plants are considered to be the same as the base-line period (1988-1990).
25	Same as scenario 24 except no summer discharge from Rehoboth and Millsboro STPs.

Appendix B. Various Scenarios Considered for the Inland Bays Model, Continued

Scenario	Description
26	Same as Scenario 24 expect when it is considered that additional 30% reduction of nitrogen load + 70% reduction of phosphorous loads is achieved from all nonpoint sources. The possibility of 30/70 Nitrogen /Phosphorous nonpoint source reduction was based on the results of application of AGNPS Model to a typical watershed in the Inland Bays.
27	Current NPDES loads from treatment plants + 30% reduction of nitrogen load and 70% reduction of phosphorous loads from nonpoint sources + zero discharge from Rehoboth, Millsboro, and Townsend STPs.
28	Same as scenario 27 except when it is assumed that NO3 loads from tributaries entering IR Zone1 are reduced by 50%.
29	BNR treatment for Rehoboth and Millsboro STPs + the same nutrient loads from other STPs in the sub-basin as their base-line period + 30% reduction of nitrogen loads from nonpoint sources + 70% reduction of phosphorous loads from nonpoint sources
30	Same as scenario 29 except with no NO3 discharge from Townsends STP
31	Same as scenario 29 except when loads from Lewes STP are added to the model
32	Same as scenario 29 except when it is assumed that thermal discharge from DP&L power plant is discontinued
From here, a new version of sediment nutrient flux rates as supplied by the US Army Corps of Engineers (based on proportional reduction assumption) was used for the model.	
33	Same as scenario 11 (100% reduction of nitrogen loads from point and nonpoint sources + 100% reduction of phosphorous loads from point and nonpoint sources) except using the latest sediment flux rates (corresponding to proportional reduction assumption).
34	Same as Scenario 29 (BNR treatment for Rehoboth and Millsboro + nutrient loads from other STPs the same as their base-line period + 30% reduction of nitrogen loads from nonpoint sources + 70% reduction of phosphorous loads from nonpoint sources) except considering the latest sediment flux rates (corresponding to proportional reduction assumption)
35	Same as scenario 12 (100% reduction of nitrogen loads from point sources + 100% reduction of phosphorous loads from point sources) except considering the latest sediment flux rates (corresponding to proportional reduction assumption)
36	Same as scenario 13 (50% reduction of nitrogen loads from point sources + 100% reduction of phosphorous loads from point sources) except considering the latest sediment flux rates (corresponding to proportional reduction assumption)

Appendix B. Various Scenarios Considered for the Inland Bays Model, Continued

Scenario	Description
37	Same as Scenario 34 except with zero discharge from Rehoboth STP
38	Same as Scenario 34 except with 20% reduction in atmospheric nitrogen deposit rates.
39	Fecal Coliform analysis
40	Same as Scenario 34 except no reduction from nonpoint source loads
41	Same as Original except when it is considered that daily Total Phosphorous Load from Millsboro Sewage Treatment Plant is equal to 0.85 kg/d (which is the same as the current plant performance). For this scenario, it is assumed that sediment flux rates reflect improved conditions.
42	Same as Scenario 41 (Original with TP=0.85kg/d from Millsboro) except using the original sediment flux rates.
43	Same as Scenario 42 (original with TP=0.85kg/d from Millsboro and original flux rates) except when the discharge flow from Millsboro STP is increased to 566,000 gpd and discharge from Colonial Estate STP is terminated
44	Same as Scenario 34 except when discharge flow from Millsboro STP is increased to 566,000 gpd while utilizing BNR technology for the plant. For this scenario, it is assumed that discharge from Colonial Estate STP is terminated
45	Same as Scenario 43 (Original condition with current the current TP concentration from Millsboro STP) except when discharge flow from this facility is increased to 1.0 mgd
46	Same as Scenario 40 except with lower sediment flux rates
47	Same as Original except when nonpoint source load entering Cell 157 of the Water Quality Model (Millsboro Pond) is reduced equal to 100% of load from Georgetown STP
48	Same as Scenario 34 except when the nonpoint source load entering Cell 157 of the model is equal to the load of scenario 47.
49	Same as Scenario 48 except when the current point source load from Georgetown STP is entering Cell 157.
50	Bacteria analysis to evaluate the impact of discharge from Bayshore Mobile Home Park on shellfish waters

Appendix B. Various Scenarios Considered for the Inland Bays Model, Continued

Scenario	Description
51	Evaluation of the impact of thermal discharge from DP&L power plant when considering ÄT=10 C. For this scenario, it was assumed that algae do not die when they go through the power plant's cooling tanks. This scenario did not produce reasonable results, hence, was discarded.
52	Same as scenario 32 (using wqm_dpl code) with the assumption that ÄT was increased from 4 C to 10 C. This scenario produced a reasonable temperature distribution. However, Chl-a around DP&L outfall still is lower than the surrounding areas.
53	After consultation with the USACOE (personal communication with Dr. Barry Bunch), the file wqm_dpl_10b.f was created with ÄT=10 C from DP&L power plant and no dissociation of algae passing through power plants cooling tanks. The point source loads file was changed and was saved as psld88_dpl.indr.
54	Same code as Scenario 53 (wqm_dpl_10b.f) except with ÄT= 0 C from DP&L power plant.
55	Same as base-line (original) except when it is considered that thermal discharge from DP&L Power Plant is eliminated
56	VOID
57	Same as Scenario 34 except when it is assumed that traditional nonpoint source Best Management Practices (BMPs) can only reduce the nitrogen loads by 20 percent and the phosphorous load by 50%. Furthermore, it is assumed that BMP implementation occurs only in 50% of the watershed.
58	Zero point source load + 40% reduction of nonpoint source nitrogen load + 60% reduction of nonpoint source phosphorous load. Furthermore, it is assumed that BMP implementation is occurring in 100% of the watershed.
59	Same as Scenario 58 except when it is considered that nutrient loads from tributaries of the upper Indian River is reduced by another 50%
60	Same as Scenario 58 except that when it is considered that nutrient loads from tributaries of the upper Indian River is reduced by another 85%.
61	Same as Scenario 57 (BNR + 20N-50P reduction from 50% of the lands) except using sediment nutrient flux rates as suggested by proportional rates (as in USACOE memo of Oct. 6, 1993).

Appendix B. Various Scenarios Considered for the Inland Bays Model, Continued

Scenario	Description
61-a	Same as Scenario 61 except when atmospheric nitrogen deposition rates are reduced by 20%. This scenario is considered to reflect the improvements as the result of 1990 Clean Air Act Amendments
62	Same as scenario 58 (no PS+40N-60P reduction from all NPS) except with sediment nutrient flux rates as provided by the USACOE memo of 10/6/93
63	60% reduction of nonpoint source nitrogen loads from tributaries in the upper Indian River + 50% reduction of nonpoint source phosphorous loads from tributaries in the upper Indian River + 50% reduction of nonpoint source nitrogen loads from the remaining tributaries to the Inland Bays + 50% reduction of nonpoint source phosphorous load from the remaining tributaries to the Inland Bays + zero discharge from point sources + lower air deposition rates for nitrogen.
64	Zero point source load + 70% reduction of nonpoint source nitrogen loads from tributaries in the Upper Indian River + 60% reduction of nonpoint source phosphorous loads from tributaries in the upper Indian River + 40% reduction of nonpoint source nitrogen loads from the remaining tributaries to the Inland Bays + 40% reduction of nonpoint source phosphorous load from the remaining tributaries in the Inland Bays + low air deposition rate for nitrogen. For this scenario, it was assumed that the sediment nutrient flux rates are the same as for scenario 63
65	Zero point source load + 80% reduction of nonpoint source nitrogen loads from tributaries in the Upper Indian River + 70% reduction of nonpoint source phosphorous loads from tributaries in the upper Indian River + 40% reduction of nonpoint source nitrogen loads from the remaining tributaries to the Inland Bays + 40% reduction of nonpoint source phosphorous load from the remaining tributaries in the Inland Bays + low air deposition rate for nitrogen.
66	Zero point source load + 85% reduction of nonpoint source nitrogen loads from tributaries in the Upper Indian River + 65% reduction of nonpoint source phosphorous loads from tributaries in the upper Indian River + 40% reduction of nonpoint source nitrogen loads from the remaining tributaries to the Inland Bays + 40% reduction of nonpoint source phosphorous load from the remaining tributaries in the Inland Bays + 20% reduction of atmospheric nitrogen deposition rates.

Appendix B. Various Scenarios Considered for the Inland Bays Model, Continued

Scenario	Description
66-a	Zero point source load + 85% reduction of nonpoint source nitrogen loads from tributaries in the Upper Indian River + 65% reduction of nonpoint source phosphorous loads from tributaries in the upper Indian River + 40% reduction of nonpoint source nitrogen loads from the remaining tributaries to the Inland Bays + 40% reduction of nonpoint source phosphorous load from the remaining tributaries in the Inland Bays + 40% reduction of atmospheric nitrogen deposition rates.
67	Same as Scenario 66-a except when the model was run for a 3-year period.
68	Same as Scenario 66 except when the sediment NH3 flux rate was considered to be 20% lower
69	Same as Scenario 68 except when it was considered that the sediment NH3 flux rate is 10% lower (to account for the fact that nitrogen deposition rate is being applied only to the water surface and not to the entire watershed)
70	Same as Scenario 66 except when the atmospheric nitrogen deposition rate was reduced by only 12% (to account for improvements as the result of CAA Amendments only and not considering the improvements as the result of OTC recommendations) and 6% reduction for NH3 sediment flux rates
71	Same as Scenario 69 except when considering seasonal discharge from the Rehoboth STP. For this scenario it is assumed that summer (May - September) flow is 3.4 mgd and winter (October - April) flow is 1.5 mgd. Furthermore, it is assumed that the effluent concentration of Total N is 3.0 mg/l and concentration of Total P is 0.5 mg/l.
72	Same as Scenario 34 with the exception that it is assumed that atmospheric nitrogen deposition rate will be reduced by 20%.
73	This scenario considers that the only nutrient load input to the Inland Bays is from the Rehoboth STP. Furthermore, it assumes that the load from Rehoboth is ten times higher than the plant’s load during 1988. For this scenario, all other sources including point sources, nonpoint sources, and atmospheric deposition rate is set to zero.
74	Same as Scenario 47 with the exception that it assumes that the annual load from the Georgetown STP is 4670 lbs of total nitrogen and 146 lbs of total phosphorous. Furthermore, it assumes that the above load is being discharged during a 100-day period (from December through March).
75	Same as Scenario 71 except that the nutrient loads from the Rehoboth STP is increased by a factor of two.

Appendix B. Various Scenarios Considered for the Inland Bays Model, Continued