Tar River TMDL
1994
Tar-Pamlico River
Basinwide Water Quality Management Plan

6.4 MANAGEMENT STRATEGIES FOR NUTRIENTS

The Tar River basin has exceeded its assimilative capacity for nutrients. Due to its hydraulic conditions, the estuary from Washington downstream to the Pungo River is experiencing degradation from excessive nutrient loadings. Algal blooms are common in the middle reaches of the estuary, and winter blooms regularly occur. Lack of dissolved oxygen near the bottom of the sound (hypoxia) has been responsible for the die-off of bottom dwelling (benthic) organisms. This condition occurs during periods of water layer stratification (no mixing of waters between the top and bottom layers) and warm temperatures. To address this problem, and based on the results of extensive computer modeling of nutrient loadings and their impacts on the estuary, a 30% reduction in TN and existing TP loading at Washington are recommended for the Tar-Pamlico River Basin. These loading targets correspond to 1,361,000 kg/yr of TN and 180,000 kg/yr of TP at Washington.

Control of nutrients is necessary to limit algal growth potential, to assure protection of the instream chlorophyll *a* standard, and to avoid development of nuisance conditions in the state's waterways including anoxic conditions in bottom waters and fish kills. To meet this goal further reductions in both point and nonpoint source loadings of TP and TN will be necessary. Point source controls typically involve NPDES permit limits on total phosphorus (TP) and total nitrogen (TN). Nonpoint controls of nutrients generally include best management practices (BMPs) to control nutrient loading from areas such as agricultural land, forests, and urban centers.

6.4.1 Existing Nutrient Control Strategies

Designation of the Tar-Pamlico Basin as Nutrient Sensitive Waters (NSW)
The Environmental Management Commission (EMC) declared the Tar-Pamlico River basin as nutrient sensitive waters (NSW) in September 1989. The NSW policy stated that new discharges greater than 0.05 MGD (50,000 gallons per day) and expanding dischargers to flows greater than 0.5 MGD (500,000 gallons per day) would receive total phosphorus (TP) limits of 2 mg/l. New discharges greater than 0.1 MGD and expanding discharges to flows greater than 0.5 MGD would also receive a summer total nitrogen (TN) limit of 4 mg/l and a winter TN limit of 8 mg/l. Nutrient budget work in the basin indicated that nonpoint sources contributed the majority of the total nitrogen to the basin's waters and a considerable amount of the total phosphorus, particularly when Texas Gulf was eliminated from the analysis. More information on the original nutrient budget is outlined in section 3.2.2.

Point/Nonpoint Source Nutrient Reduction Trading Plan
Due to the large component of nonpoint source loading, an innovative method of implementing the strategy was devised which allowed dischargers to provide funding for nonpoint source controls in place of expensive facility upgrades at their respective plants. The EMC approved an NSW Implementation Strategy agreement in December 1989 which was subsequently revised in February 1992 (see Appendix V). The purpose of this agreement was to formalize and clarify the details of the first phase (Phase I) of the NSW Strategy (1990 - 1994). An association of discharges, the Tar-Pamlico Basin Association (the Association), was formed. This group agreed to fund the creation of an estuarine water quality model which would aid the Division in developing nutrient reduction goals. In exchange, expanding discharges which belonged to the Association would have their individual NPDES nutrient limits waived. Association members were also required to conduct engineering evaluations of their wastewater treatment plants (WWTPs) and implement minor operational and capital improvements to reduce nutrient loading. Extensive effluent monitoring for TP and TN was also required of all Association members.

The effluent nutrient monitoring was to be used to judge compliance with nutrient reduction goals laid out in the Implementation Strategy. The Implementation Strategy projected flows for the Association members to be 30.555 MGD by the end of Phase I of the NSW strategy (i.e., by end of 1994). Assuming that no nutrient reductions would be made at any of the Association facilities, it was estimated that the total nutrient load from Association facilities would be 625,000 kg/yr by the end of 1994. The NSW strategy for the basin recommended point source nutrient reductions of 200,000 kg/yr. Thus nutrient goals were established for the Association for each year ending with a goal of 425,000 kg in 1994, a reduction of 200,000 kg from the projected 625,000 kg. Any year that the Association did not meet its goal, payments of $56 for every kilogram above the goal were to be paid into a nutrient-reduction trading fund. The allowable nutrient loading for each year is summarized below:

Calendar Year	Allowable Nutrient Load (kg)
1991	525,000
1992	500,000
1993	475,000
1994	425,000

For 1991, 1992 and 1993, the Association met its nutrient goals with the following calculated loads:

Year	Total Nitrogen (kg)	Total Phosphorus (kg)	Total Nutrients (kg)	Total Effluent Flow (MGD)
1991	396,916	64,478	461,394	24.88
1992	386,208	50,170	436,378	26.85
1993	371,336	45,881	417,217	28.57

The data indicate that the Association members had improved their nutrient treatment since loading decreased between the three years while total monthly average flow for the facilities had increased from 24.88 MGD in 1991 to 28.57 MGD in 1993. In addition to meeting their Phase I reduction goals, the Association was able to obtain 1.2 million dollars for nonpoint source controls and development of a nutrient model, discussed below.

6.4.2 Nutrient Modeling in the Tar-Pamlico River Estuary

The Association contracted with HydroQual, Inc. to perform the estuary modeling. HydroQual developed a two dimensional, laterally averaged hydrodynamic water quality model to predict the impacts of nutrient loading in the estuary. The model extends from Greenville to Pamlico Point, a distance of approximately 60 miles. Figure 6.3 illustrates the model segmentation below Washington. Further information on the HydroQual model can be found in the draft modeling report (Gallagher et al, 1994).

Nutrient Assimilative Capacity Exceeded in the Tar-Pamlico Estuary
DEM ran the model under the 1991 calibration conditions as well as under various nutrient reduction scenarios and plotted the results for a site located near Washington in order to evaluate possible management strategies. The Washington site was chosen since modeling results indicated that this was where the greatest number of chlorophyll *a* and DO violations occurred, and the magnitude of the violations was the greatest. Thus, it is the critical portion of the river. Under 1991 loading conditions, the model indicates that the chlorophyll *a* standard was violated approximately 18% of the time at Washington. In addition, chlorophyll *a* concentrations as high as 70 ug/l were predicted at that site (Figure 6.4). The reader should note that these predictions are daily averages and are averaged across the river. Therefore specific areas within a model segment or given times of day may indicate better or worse water quality than that predicted. Dissolved oxygen concentrations on the bottom were also plotted for the site at Washington (Figures 6.5 and 6.6). The results indicate that DO concentrations as low as 0.5 mg/l can occur at Washington for prolonged periods. Again, since the model was laterally averaged, there may be areas within the segment where anoxic conditions occur or where low DO concentrations occur more frequently than noted on the frequency diagram. In addition, dynamic plots of DO showed predicted prolonged anoxic conditions in the bottom and middle layers of certain portions of the estuary.

The nutrient inputs were then cut by varying amounts to determine what loading was necessary to protect water quality standards. The model was run for a five year period to allow improvements in the sediment concentrations to be reflected in the water column quality. The results indicate that a 45% reduction in total nitrogen is needed to maintain the chlorophyll *a* standard of 40 ug/l (Figure 6.4) at Washington. This 45% reduction also results in a significant increase in bottom water DO and prevents extended anoxic conditions as well as decreases the frequency of supersaturation conditions (Figure 6.5). Dynamic plots indicate that the extent of low oxygen bottom waters is over a shorter stretch of estuary and does not go as far up into the water column as was noted in the calibration run.

6.4.3 Recommended Nutrient Reduction Goals for Nitrogen and Phosphorus

It is difficult to determine what would be an acceptable level of water quality in the basin. Even if the basin was not developed, it is likely that blooms would occasionally occur naturally. In addition, a 45% reduction in nitrogen loading may not be feasible given current BMP methods and point source treatment technologies. There is also model error and uncertainty in predictions which could result in costly treatments which are not needed to meet water quality standards. The reader should also note that the model was calibrated under relatively high nutrient loading conditions. The modeling results must be evaluated within the context of the model calibration. The further a given nutrient loading scenario is from calibration conditions, the greater the uncertainty is for obtaining an accurate prediction of the water quality impacts of such loading. At present, interpretation of modeling suggest that algal and DO concentrations in the estuary will respond significantly to reductions in the nitrogen loading. A 45% TN reduction is predicted to result in no chlorophyll-a violations. However, the model cannot be considered fully reliable for conditions so different from existing conditions. To improve confidence in the

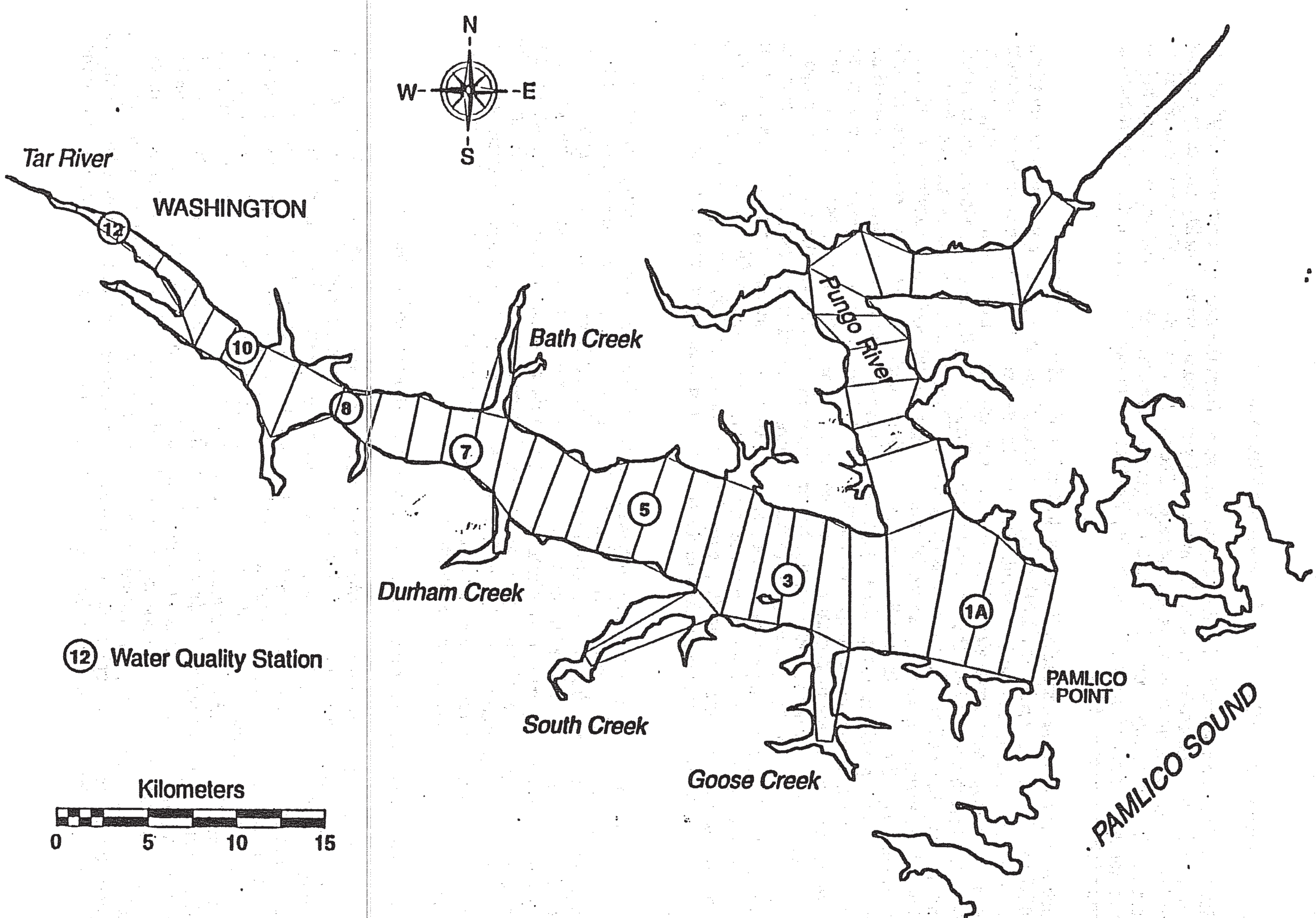

Figure 6.3 HydroQual, Inc. Nutrient Model Segmentation Below Washington

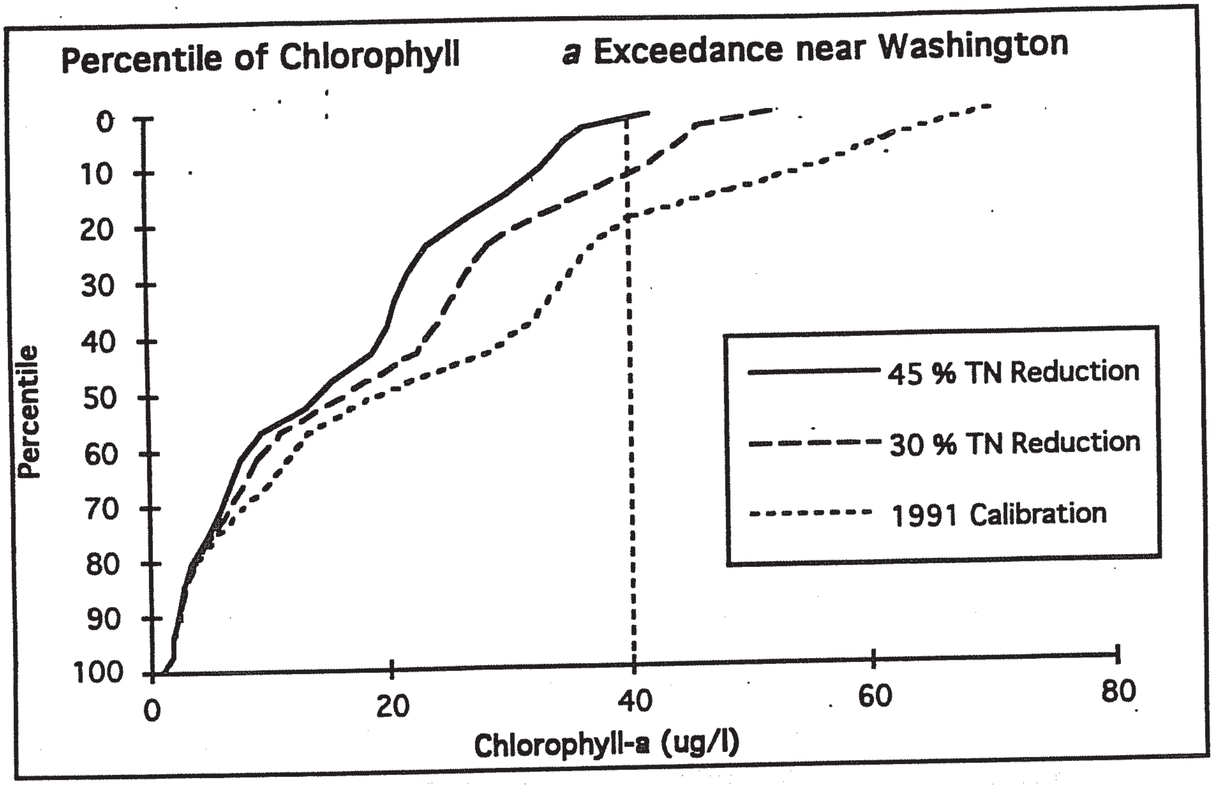

Figure 6.4 Percentile of Chlorophyll *a* Exceedances of the 40 ug/l Standard at Washington Based HydroQual Model

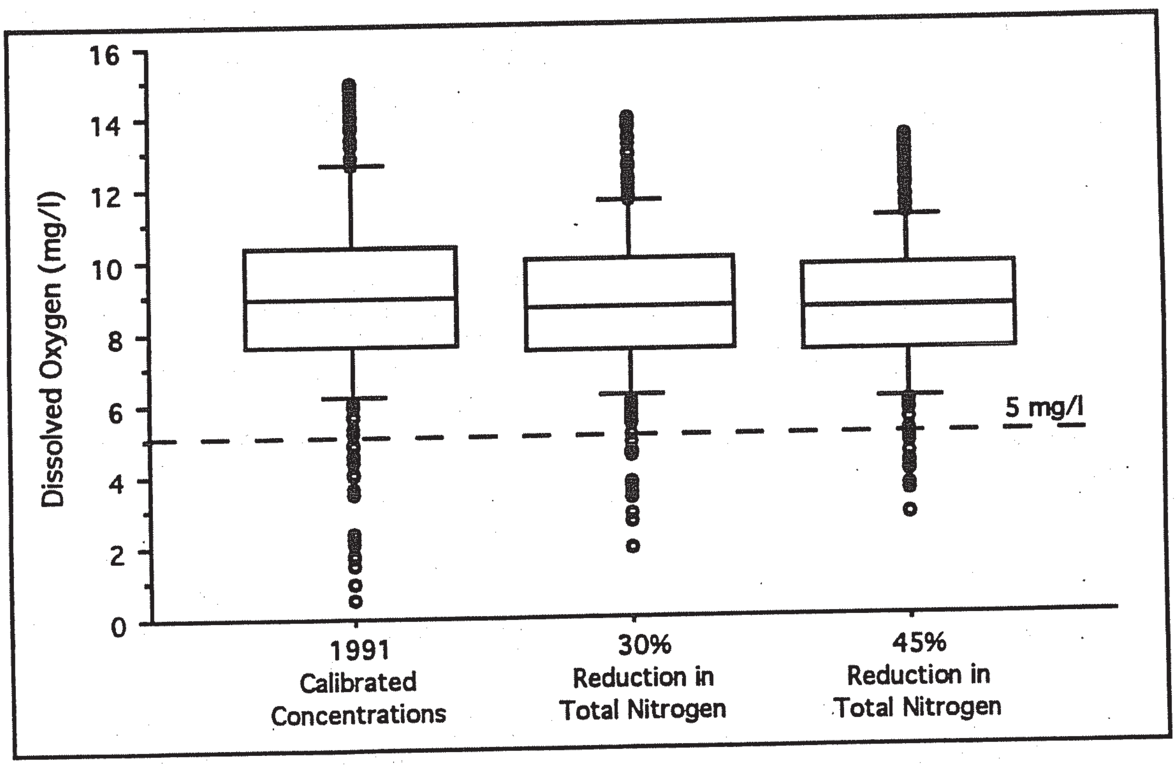

Figure 6.5 Predicted Dissolved Oxygen (DO) Concentrations for Calibrated and Nutrient Reduction Scenarios for Bottom Waters at Washington

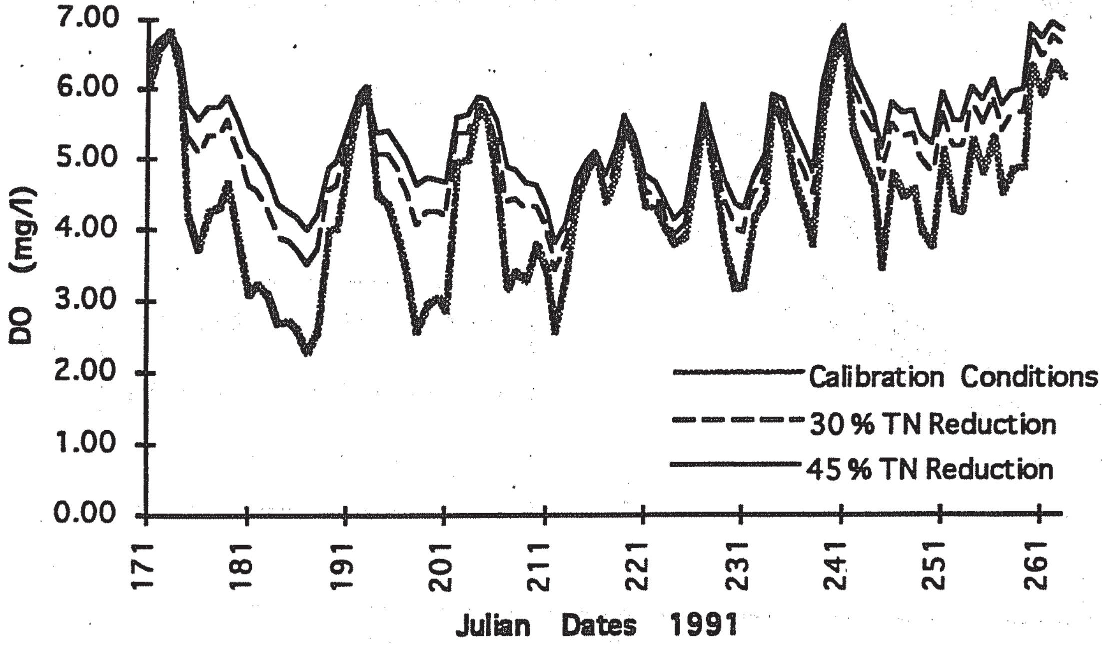

Figure 6.6 Predicted Summer Dissolved Oxygen Concentrations for Calibrated and Nutrient Reduction Scenarios for Station 3 (Days 171 through 261 in 1991)

modeling results, the model must be recalibrated to reflect changing conditions as nutrient loading is reduced. Given the uncertainty inherent to a predictive model, an interim target will be established while model calibration will continue. The interim goal for TN reduction is 30% from 1991 conditions. This level of reduction was selected because it resulted in most of the predicted change in chlorophyll-a and DO that was observed under TN reduction scenarios applied to the model (Figures 6.4-6.6). It is likely that a further TN reduction will be required, but a more exact target cannot be established until the model is calibrated to lower nutrient loading conditions. This 30% reduction is an interim goal. The final target of no violations remains the ultimate goal for the Tar-Pamlico estuary.

The model indicates that the middle estuary does not respond significantly to phosphorus reductions. This is probably because more saline estuarine waters tend to be nitrogen limited. However, it is important to consider the upper and lower bounds of the study area, where phosphorus is more likely to be limiting on a seasonal basis. Phosphorus levels may become more important in the future after significant nitrogen reductions cause a commensurate shift in ratios of nitrogen to phosphorus. However, the proposed targets, if achieved, would result in TN:TP ratios within a desired range. Another important consideration associated with elevated concentrations in either or both nutrients in this estuary is the loss of important submerged aquatic vegetation (SAV). While it is extremely difficult to model and predict recovery of SAV and their effect on nutrient dynamics, it would not be prudent to support additional increases in a phosphorus rich estuary. Finally, there are initial indications that certain life stages of the toxic dinoflagellate may be stimulated by nutrients, particularly phosphorus. Accordingly, the recommended strategy is no additional increase in load of total phosphorus into the estuary.

<u>Therefore a 30% reduction in TN and existing TP loading at Washington are the recommended TMDLs for the Tar-Pamlico River Basin. These loading targets correspond to 1,361,000 kg/yr of TN and 180,000 kg/yr of TP at Washington.</u>

It should be noted that the estuary model as currently calibrated does not allow examination of the impacts of nutrient controls in the estuary portion of the watershed. The flow calibration in the lower estuary was weak, and there would be much uncertainty involved in an analysis which examined nutrient controls below Washington. Therefore, the numeric TMDL strategies have been set at Washington. However, nutrient controls should be implemented in this lower portion of the basin in order to reduce direct loading to the estuary.

Point/Nonpoint Source Reduction Targets for Nitrogen
A 30% reduction goal provides a TN target load at Washington of 1.361 million kg/yr or a TN load reduction of 583,000 kg/yr for both point and nonpoint sources. It is estimated that approximately 8% of the TN load at Washington is from point sources based on use of the export coefficient model described in section 3.2.2 of Chapter 3. The remaining 92% is from nonpoint sources. The targeted TN loads for point and nonpoint sources at Washington are therefore as follows:

Point sources: 8% X 583,000 = 46,640 kg/yr
Nonpoint sources: 92% X 583,000 = 536,360 kg/yr

6.4.4 Nonpoint Source Control Strategies for Meeting Nutrient Goals

In order to achieve the needed TN reduction in nonpoint source nutrient loading, DEM has made a commitment to convene and coordinate meetings with appropriate groups and agencies to establish a coordinated and focused plan to achieve the required nonpoint source nutrient reductions. This additional strategy that will provide further details of how such reductions are to achieved by nonpoint sources and the accounting of such actions is to be established by September, 1995. DEM's commitment is included in the Tar-Pamlico NSW Implementation Strategy: Phase II. The Phase II strategy can be found in Appendix IV.

Feasibility of Meeting Nonpoint TN Source Reduction Target
It is not reasonable to expect that the loading targets at Washington can be met during the next basin cycle. The export coefficient nutrient loading described in Chapter 3 indicated that point sources contribute approximately 8% of the total nitrogen in the basin upstream from the estuary (subbasins 01 through 06). Therefore, in order to meet the loading targets, additional nonpoint source controls will need to be implemented. Since DEM does not have good information on where current BMPs are located, what types of BMPs are in place, and the cost and effectiveness of BMPs in North Carolina, it will not be possible to fully evaluate the time frame and the best strategies to meet these targets until better information relating to BMPs is known. However, to evaluate the feasibility of being able to meet the loading targets, the export coefficient model described in Chapter 3 was slightly modified.

To estimate nutrient loading in chapter 3, the median export coefficient values were used. It was assumed that effective BMPs would result in lower export coefficients, and the low nitrogen coefficients listed in Table 3.1 were input to the model for agricultural landuse in subbasins 01 through 06. The change was made for agriculture only since much of the land in the Tar-Pamlico River Basin is agricultural. In addition, changing only agriculture will result in a more conservative estimate of loading reduction than if all land use coefficients were changed. The changes were only made for subbasins 01 to 06 since the loading targets were set at Washington, and changes in subbasins 07 to 08 will not result in lower loading at Washington. The results indicated that if the relative change in the median and low nitrogen export coefficients is similar to what will happen when BMPs are fully implemented, the nitrogen loading will be reduced by 33% above Washington. Actual changes in predicted loading have not been noted, due to the uncertainty in the model. This uncertainty results from inadequacies in the land use data (all agriculture was lumped together) and in assumptions which were made in applying the model (export coefficients based on literature values rather than measured values). The reader should also note that the export coefficient model does not account for any assimilation of a given pound of nitrogen before it reaches the estuary, and therefore these results should be interpreted carefully. Given the assumptions listed above, the results indicate that it is possible to meet the loading targets by implementing BMPs.

Priority Management Areas for Nonpoint Source Nutrient Reductions

Agencies other than DEM have jurisdiction over many of the nonpoint source programs. In order to give them guidance in prioritizing areas in need of BMPs, a list of streams with high areal loadings is given below. This list should also be used by DEM to prioritize waterbodies for 319 project moneys as they become available to the state. This prioritized list is as follows:

- Chicod Creek
- Swift Creek
- Conetoe Creek
- Cokey Swamp Creek
- Tranters Creek
- Tar River Estuary

This prioritized listing was based on the results of the nutrient loading models described in Chapter 3. Each of these streams was predicted to have fairly high nutrient loading or areal nutrient loading. In addition, each of the streams with the exception of Swift Creek is listed on the state's 303(d) list with nonpoint sources being the cause of the degradation (see Table 6.1). Swift Creek was given highest priority even though it is not considered degraded since it harbors endangered species populations which are threatened by high nutrient and sediment loads. The estuary was also listed as a priority area since more of the nutrient loading in the lower basins will be transported to the estuary rather than from the upper basins where they will have time to be assimilated. Other areas can be prioritized through the use of Table 6.1 and the nutrient loading model results described in chapter 3. Other modeled streams that are impaired include: the Upper Tar River, Lower Tar River, Stony Creek and Fishing Creek.

Strategies to Reduce Nutrient Loading from Agriculture

- <u>Nutrient Management Plans Recommended for Agricultural Lands</u>

  In addition to the strategies listed above, the mass balance model described in chapter 3 indicated that on average, 40% of the nitrogen applied as fertilizer is lost to the environment. Research should be done to see if this number can be reduced. In addition, as part of the Coastal Zone Act Reauthorization Amendments (CZARA), all farms in the defined coastal area will have to develop nutrient management plans which evaluate the nutrients needed for their crops and identify timing and application methods to achieve realistic crop yields and reduce losses to the environment. For any areas not defined as being in the coastal area through CZARA, the agricultural agencies may want to consider nutrient management planning as a cost effective method to reduce nutrient loading. Information assimilated through the Chesapeake Bay program indicates that nutrient management is one of the least costly methods to reduce nutrient loading and when combined with other BMP practices is very effective at reducing nutrients (Chesapeake Bay Program, 1988).

  In North Carolina, the NC Cooperative Extension Service (NCCES) is in the process of offering Nutrient Management Training. Specialists from the Departments of Soil Science and Biological and Agricultural Engineering at North Carolina State University have developed a nutrient management training program for county extension agents to teach them the concepts behind nutrient management planning and how to write plans. The program is voluntary; no agent is required to take the training or to write plans. However, it is recommended that agents from all counties in the Tar-Pamlico River basin and other watersheds or basins that are classified as nutrient sensitive waters receive this training.

Each three-day training session includes lectures, discussions, case-study development, along with presentations and an exam. Participants receive a comprehensive notebook containing plan development materials and additional resources. The training builds on individuals' current knowledge basis, tying in concepts of nutrient cycling, nutrient movement and plant use of nutrients, including fertilizers and organic nutrient sources.

An exam at the end of the training is meant to test agents' knowledge and competency in writing nutrient management plans. Agents who pass the test are certified by the Cooperative Extension Service to write nutrient management plans on behalf of the organization. More than 60 agents have been certified in three training sessions given in the mountains, Piedmont and Coastal Plain. The results of this training will become more significant in the future, especially in the areas included under the (CZARA), where, as noted above, total nutrient management planning for all agricultural operations will be required.

The Cooperative Extension Service, in conjunction with the Natural Resources Conservation Service, will conduct a modified version of the training to NRCS and District employees. This version of the training will emphasize fertilizer nutrient sources since most NRCS and District employees have considerable experience in developing animal waste management plans.

- <u>Develop an Agricultural Nonpoint Source BMP Database</u>
  During the next five years, DEM should continue to work with the nonpoint source agencies to develop a good database on the type, location and effectiveness of BMPs. Of special note is a new data management system soon to be used by the USDA-Natural Resources Conservation Service to track all of its field office activities including those that are water quality oriented. This new system is called Field Office Computer System or FOCS.

  FOCS trainers training has been under way since May 1994. These trainer's will be returning to their areas to provide training to the local NRCS staff on the operation of the new FOCS system. It will take at least six months to implement the FOCS systems in all of the local area offices. The major task element here being the conversion of existing data from the old computer data management system to the compatible form in the new FOCS environment. All of the data in FOCS will be available by new 14 digit Hydrologic Unit (HU) codes and county locations.

- <u>Promote Voluntary BMP Installation</u>
  <u>Through Education and Use of State and Federal Cost Share Programs</u>
  A concerted effort to educate the nonpoint source contributors on the importance of reducing nutrient loading to encourage further voluntary participation in the BMP programs should occur.

  One such program is the ASCS Water Quality Incentive Projects (WQIP). Established by FACTA, the goal of WQIP is to achieve the source reduction of nonpoint source agricultural pollutants in an environmentally and economically sound manner. WQIP utilizes an ecosystem approach in dealing with the resource issues. Agricultural producers will be provided with the financial, educational, and technical assistance required to make changes in management systems to: a) restore or enhance impaired water resources where agricultural nonpoint source pollution has detrimental effect, and/or b) prevent future impairments. Farmers may receive up to three years of funding (up to $3,500 per year) depending on whether Long Term Agreement (LTA) is signed. The national ASCS target is to enroll 10 million acres by 1995.

In 1992, 32 farms and 18 producers, accounting for 5400 acres in Beaufort County signed contracts and received WQIP funds. Most of the allocated funds were utilized in development of total nutrient management plans for these farms. These plans were written by local cooperative extension agents or by consultants who submitted them to NRCS for approval. The farms in Beaufort Co. received an average of $8.90/ acre in contracts which extend through 1995.

At the state level, the NC Agricultural Cost Share Program (ACSP), administered by the NC Division of Soil and Water Conservation, provides cost share funds to farmers to install BMPs. Under the ACSP in the Tar-Pamlico basin:

- Contracts totaling $4,519,060.26 have been signed.
- A total of 131,127.2 acres have been treated.
- A total of 75 animal waste systems have been installed.
- A total of 443 water control structures have been built.

- <u>Costs for Additional Agricultural</u>
<u>NPS Controls to Meet the Recommended Nitrogen Reduction Goal</u>
The total load of total nitrogen (TN) from point and nonpoint sources in subbasins 01 through 06 is 4,982,340 kg/year based on the coefficient method data summarized in Table 3.2 in Chapter 3. Runoff from agricultural activities is estimated to contribute approximately 65% of this load compared to 24% for dischargers that are members of the Association. However, in order to account for fate and transport losses and for equity purposes, the agricultural load is estimated to be 50% of the total compared to 9% for the Association of dischargers (a net reduction of 15%). The TN reduction requirement for point and nonpoint sources from 1991 loadings is 583,000 kg/yr at Washington. Therefore, load reductions from agriculture should be approximately 291,500 kg/yr (583,000 x .50).

The Research Triangle Institute conducted a study on the cost-effectiveness of agricultural BMPs in reducing nutrient loading. An approximate cost of $29/kg was determined for overall agricultural nutrient reductions (somewhat higher for animal waste operations and somewhat lower for nutrient management on cropland). Using this figure, the total cost for a 30% reduction in TN from agriculture from 1991 is estimated to be $8,453,500. It is recommended that funding of the North Carolina Agricultural Cost Share Program for Nonpoint Source Pollution Control be increased.

<u>Voluntary implementation of nutrient BMPs is preferred over mandatory controls.</u> To make this happen, there needs to be a concerted effort to educate the nonpoint source contributors on the importance of reducing nutrient loading, to encourage further voluntary participation in the BMP programs, and <u>to provide them with cost-effective options</u>. Education may be conducted through the NC Cooperative Extension Service, Soil and Water Conservation Districts, Farm Bureau, NC Department of Agriculture and others. Cost share opportunities are offered through the USDA Agricultural Stabilization and Conservation Service and the NC Agricultural Cost Share Program. DEM will need assess the need for mandatory nonpoint source control measures during updating of the basin plan in 1999.

Support Development of Cost Effective Measures and New Technologies for Nonpoint Sources
DEM should also work with the agencies to obtain better information on BMP cost/effectiveness to supplement the research that Research Triangle Institute is performing. A portion of 319 funds and cost share moneys should be used to perform site specific monitoring before and after BMPs are implemented. This will provide data specific to the North Carolina coastal plain to help develop cost effective nutrient management strategies.

Wetlands Protection and Nutrient Reductions
Protection and/or restoration of wetlands may prove to be a cost-effective tool in controlling nutrients. Numerous authors have studied the effectiveness of riparian wetland forests for nutrient retention and transformation (see section 5.3.8). The location of riparian wetlands allows them the opportunity to receive nutrients from the surrounding landscape as well as through overbank flooding. In addition to the storage of nutrients in wetland vegetation, the microbial and chemical processes within wetland soils may function to completely remove nutrients from the system.

Headwater riparian wetlands are the most important wetlands in terms of sediment and associated nutrient and toxicant retention. Since small stream comprise most of the total stream length within a watershed, these areas intercept the greatest proportion of eroded sediments and associated substances before these pollutant reach waters downstream. One study found that approximately 80% of the sediments entering a stream were retained in headwater wetlands.

In the Tar-Pamlico River Basin, there is a project being funded under the Clean Water Act (CWA) Section 319 (h) Nonpoint Source Program to restore an Atlantic White Cedar wetland at Pocosin Lakes National Wildlife Refuge. This project is intended to restore Atlantic white cedar wetlands to 640 acres of prior converted wetlands with peaty soils to achieve nonpoint source reductions of nitrogen and mercury to surface waters which drain into the Pungo River. The hydrology of the area will be restored through the placement of a single large flashboard riser. Extensive measurements of ground elevations have been made by the U.S. Natural Resources Conservation Service to determine where the riser should be placed to achieve the desired restoration. The sites selected for planting have been extensively degraded by heavy grazing of cattle to the point that natural regeneration of the plant community is not occurring.

6.4.5 Point Source Nutrient Reduction Strategy

The Division finalized Phase II of the Tar-Pamlico Basin NSW Implementation Strategy. This is in followup to Phase I which ends this year. The Phase II agreement outlines loading targets for point source facilities and other actions the dischargers will take to reduce nutrient loading in the basin. It includes reduction strategies for both dischargers that are members of the Tar-Pamlico Basin Association and non-association dischargers. It also includes a commitment by DEM to work with the appropriate nonpoint source agencies to develop a plan by September, 1995 to meet the nutrient reduction goals outlined in the preceding section. The Phase II strategy is included in Appendix IV (pages *A-IV*-11 through *A-IV*-32).

6.4.6 Future Monitoring and Research Needs

Performance Monitoring Needed to Evaluate Nutrient Reductions Strategies
A monitoring plan should be developed during the next year which will allow DEM to evaluate this management strategy. As part of the monitoring, a gaging station should be located Tarboro and Grimesland, and monthly ambient data including the nutrient series should be measured. This will give DEM more accurate loading downstream estimates. DEM should also consider setting up gages to obtain better flow data in the estuary as this will allow the model

hydrodynamics to be recalibrated so the model can be used to evaluate nutrient control strategies in the lower portion of the basin. In addition, extensive monitoring should continue throughout the estuary. East Carolina University has been collecting data in the Pamlico River for many years, and continuation of these studies should be encouraged. In addition, as part of the Albemarle-Pamlico (A/P) Estuarine Study, the Washington Regional Office had an extra monitoring staff position to provide sampling data in the A/P study area. The funding for this position will be halted soon, and DEM or the Association should consider finding alternative funds to keep the position open. An alternative would be to set up a monitoring network that would be funded by the Association and would replace NPDES instream monitoring requirements. Data obtained through this monitoring will be used to document nutrient reductions, evaluate changes in estuary quality, and improve the modeling analysis and loading targets.

Further Studies on Fate and Transport of Nutrients Recommended
Finally, a long term goal should be to develop methods to perform fate and transport modeling to examine how nutrients are assimilated instream. Current models available in the Tar-Pamlico Basin do not allow one to determine what percentage of nutrients which run off into a stream in the upper portion of the watershed actually is transported to the estuary. Fate and transport modeling is extremely data intensive and is not practical to perform on a large basin at this time. However, it is feasible to do this type of modeling on a small watershed if data are available. If future monitoring indicates severe nutrient problems on a smaller watershed, it may be cost effective to perform studies to develop a fate and transport model. In addition, people are beginning to develop simpler models which examine nutrient transport which will not require as much data. Finally, if estuary data indicate that problems are still prevalent in the estuary after loading targets are met, it may be prudent to develop a more sophisticated modeling tool.

6.4.7 Near-term Watershed-scale Nutrient Control Strategies for Subbasins Within the Tar-Pamlico River Basin

In addition to the NSW strategy, other strategies are necessary in localized areas. While the NSW designation was designed to protect the basin as a whole on an annual basis, some localized areas are impacted by a constant discharge. These areas are outlined below. No localized nutrient related problems have been identified in subbasins 03, 04, 06, and 08.

Subbasin 01
This subbasin is characterized by large amounts of agricultural land (143,000 acres or 34% of land area). Erosion rates for this region are above average, and there are high rates of fertilizer application. These characteristics can cause eutrophication under the right hydrologic conditions. Phytoplankton data have indicated that there are eutrophic conditions in Lake Devin, Lake Royale, and Hart Pond.

Lake Devin is a small water supply reservoir for the Town of Oxford, and is primarily forested with some agricultural land use. Lake Devin is located on Hatchers Run in the Fishing Creek basin. Fishing Creek Watershed, a PL-566 watershed protection project, was completed in 1994. Measures installed through the project will address some of the nonpoint nutrient problems, and DEM should continue to monitor the subbasin for improvements.

Lake Royale is a privately owned lake on Cypress Creek, and there are no permitted dischargers in the watershed. There has been a history of sanitary problems at Lake Royale since the early 1980's. In addition, there are a number of hog operations upstream which may be contributing to the problem. As part of the animal waste management operations adopted in December 1992 (15A NCAC 2H .0217), many of these hog operations will have to register with the state (see section 5.3.2). This listing will help DEM determine the source of some of the problems and indicate specific areas in need of BMP development.

Hart Pond, in Granville County, had a large algal bloom reported in 1990. Several thousand caged catfish died. It is likely that anoxic conditions caused by deteriorating algal mats and algal respiration contributed to the fish kill. DEM should explore the sources of this nutrient problem.

Subbasin 02

Subbasin 02 is characterized by large areas of agricultural land (187,000 acres; 61% of land). Elevated concentrations of nitrogen have been detected on Swift Creek near Hilliardston during biological studies in 1992. Heavy growths of macrophytes have also been noted at this location. Nonpoint sources of pollution appear to be the source, and DEM should work with the agricultural agencies to address the problem. Modeling by RTI shows high areal nutrient and sediment loads (Chapter 3). This stream provides habitat for a large number of threatened and endangered mussel species. and should be given a high priority for BMP implementation.

Elevated chlorophyll *a* values have been noted within the Tar River Reservoir, a water supply for the City of Rocky Mount. Although biovolume estimates have not indicated bloom conditions, DEM should continue to monitor this lake to ensure that conditions do not worsen.

Subbasin 05

The Chicod Creek subbasin is primarily agricultural. In the past decade a dramatic increase in the number of confined animal operations has occurred. As a result, nutrient loading in this watershed has become a major concern. Data collected through NAWQA have shown instream concentrations of TP as high as 3 mg/l and NH_3 as high as 25 mg/l, and modeling by RTI shows high predicted areal loads of TN (see Chapter 3). In order to reduce nutrient loading, the Association arranged for federal funds from the Environmental Protection Agency (EPA) under section 104(b)(3) of the Clean Water Act to be provided to the Division of Soil and Water to implement best management practices (BMPs). In addition, DEM has begun an intensive survey of the watershed in which nutrients are collected daily at the USGS gaging station on Chicod Creek at SR 1760. Turbidity, TSS, fecal coliform, pH, conductivity, DO, hardness, and metals are sampled bimonthly in the creek. Benthic and fish tissue data are also being collected in the basin. These data are being collected to demonstrate present conditions in Chicod Creek and to document changes in nutrient loading and water quality resulting from the BMPs.

Subbasin 07

Kennedy Creek is tidally influenced and has little freshwater inflow. Since there is little flushing in the creek and winds often push waters upstream, phytoplankton populations proliferate. Algal blooms have been reported in the creek in 1987, 1988, and 1991. The City of Washington currently discharges into the creek, but it has been told that no expansions will be allowed, and the City is trying to remove its discharge. If the discharge is not removed, stringent nutrient limits will be applied to the NPDES permit in the future. It is recommended that no new discharges be permitted in the creek.