Nutrient Sensitive Water Strategy

OVERVIEW

Nutrients (nitrogen and phosphorus), which occur in fertilizers, human and animal wastes and air pollution, can promote algal blooms. These blooms, in turn, can deplete the water column of oxygen causing fish kills. Recurring nutrient-related problems have been documented in the Pamlico River estuary through the latter half of the 20th century. Control of nutrients is necessary to limit algal growth potential, to assure protection of the instream chlorophyll *a* standard, and to avoid anoxic conditions and fish kills in the state's waterways. A large portion of the estuarine eutrophication problems have been linked to an overabundance of nutrients from agricultural and urban runoff, wastewater treatment plant discharges and atmospheric deposition.

The entire basin was classified as nutrient sensitive waters (NSW) by the North Carolina Environmental Management Commission (EMC) in 1989. As a result, a NSW strategy was developed to help assess progress towards meeting instream nutrient loading goals of a 30% reduction in total nitrogen (TN) loading and no increase in total phosphorus (TP) loading from the 1991 baseline. The strategy is to be implemented by WWTP dischargers, municipal stormwater programs and agriculture. Each of these programs report to DWQ annually on their progress of meeting nutrient loading goals. Despite the fact that the targeted point and nonpoint pollution sources have been able to meet their nutrient reductions, total nitrogen and total phosphorous concentrations do not show a downward trend and loads have not fallen below the 1991 baseline load goals.

While individual implementation dates varied, all of the rules were fully implemented by 2006. This chapter provides a summary of the nutrient strategy implementation progress followed by an evaluation of the strategy which identifies additional opportunities and research needs to address nutrient loading to the Pamlico River Estuary. For the complete NSW rules, visit http://portal.ncdenr.org/web/wq/ps/nps/tarpamns. It is important to note that at this time, DWQ is not reassessing the Total Maximum Daily Load (TMDL) or suggesting that the current NSW rules be modified.

The 2010 water quality assessment of the Pamlico River Estuary indicates ~28,923 acres are Impaired because they failed to meet chlorophyll *a* water quality standards (over 10% of the samples taken within a five year data window exceeded the chlorophyll *a* standard of 40 µg/L). This impairment extends from the mouth of the Pamlico River near the city of Washington to Huddy Creek (south shore) and Saint Claire Creek (north shore). This estuary impairment essentially represents the same area of Impairment as described in the 1994 Basinwide Plan and is covered by the estuarine response modeling and TMDL strategies described in the 1994 Basin Plan. The water quality assessments discussed in the 1999 and 2004 Basinwide Plans showed the impaired area retreating to the area just below where Chocowinity Bay and the Pamlico River merge (~3,430 acres). Water quality assessment of the estuary occurs every two years and it is likely the assessments will fluctuate as data included will represent different climate conditions that influence algal distribution within the estuary.

Trends in Nutrient Loading to the Pamlico River Estuary

Pamlico River Estuary TMDL

A Total Maximum Daily Load (TMDL) is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that load among the various sources of that pollutant. Pollutant sources are characterized as either point sources or nonpoint sources. In 1995, the EPA approved the estuarine response modeling reported in the 1994 Basinwide Plan as the TMDL for nutrients in the Pamlico River Estuary.

Due to a combination of hydrologic conditions and nutrient inputs from upstream, the estuary from Washington downstream to Saint Claire Creek has and continues to experience excessive algal activity. Estuary response modeling was conducted to determine appropriate nutrient reduction goals, described in detail in the **1994 Basinwide Plan**. DWQ applied 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 model was calibrated under relatively high nutrient loading conditions, but also represented the typical estuary impairment conditions, where chlorophyll a violations occurred 18% of the time. However, 1991 was a much dryer than average year; 1991 mean annual flow measured at the USGS Tarboro gauging station was 1,249 cfs, whereas the average annual flow from 1897-2009 was 2,226 cfs. In wetter years, both nutrient loading and estuary response will differ from dry-year results. Therefore, the modeling results were evaluated within the context of the model calibration.

The model recommendations include an instream reduction goal of 30% for total nitrogen (TN) (1,361,000 kg/yr target) and maintenance of existing total phosphorus (TP) loading (180,000 kg/yr) at Washington. The model indicated that point sources contribute only 5% of the total nitrogen in the entire basin and approximately 8% of the total nitrogen in the basin upstream from the estuary. Nonpoint sources therefore account for 92% of the TN loading. Based on the overall annual TN reduction goal of 583,000 kg/yr at Washington from all sources, annual point and nonpoint source reduction goals at Washington are as follows:

Point Sources = 46,640 kg/yr (583,000 kg/yr x .08)
Nonpoint Sources = 536,350 kg/yr (583,000 kg/yr x .92)

Reductions in nutrient inputs may take time to detect in measured loading, due to year-to-year variability in precipitation and flow. Based on the results of recent trend analysis (see trend analysis summary below) in the basin, it is evident that it will take more time to discern a 30 percent decrease in load to the estuary. The Pamlico River Estuary will continue to be monitored to determine if the chlorophyll *a* criterion is met and the Tar-Pamlico River will continue to be monitored to determine if the 30 percent TN load reduction and no increase in TP load from the 1991 level is being achieved. This information will help direct adaptive management in TMDL compliance activities.

Trend Analysis

Introduction

The DWQ's Modeling and TMDL Unit performed a trend analysis of annual nutrient loads and concentrations focused on data from the ambient monitoring station O6500000, between 1991–2008, to evaluate progress towards meeting TMDL reduction goals. This station is located at Grimesland, which is approximately 7-miles upstream of Washington. Currently, there is enough data to perform statistical analysis of daily load. DWQ does not recommend performing trend analysis on annual load because the effects of flow could lead to confounding results.

The purpose of any statistical trend testing is to determine whether a set of data that arise from a particular probability distribution represent a detectable increase or decrease over time (or space). There are a wide variety of trend testing techniques, all of which have certain assumptions that must be met for the analysis to be valid. The result of false assumptions may be that interpretations are incorrect or unnecessarily inconclusive.

Detecting trends in a water quality data series is not as simple as drawing a line of best fit and measuring the slope. There are likely to be multiple factors contributing to variation in water quality over time, many of which can hide or exaggerate trend components in the data. Changes in water quality brought about by human activity will usually be superimposed on natural sources of variation such as flow and season. Identification and separation of these components is one of the most important tasks in trend testing.

Methods

Daily load was calculated as measured concentration multiplied by average daily flow and converted to units of kilograms per day. For the 1991-2008 time frame, there are 186 data points, with an average of 10.3 sampling events per year. Trend analysis was performed for TN, TP, Total Kjeldahl Nitrogen (TKN), ammonia (NH_3), and nitrite+nitrate (NO_2+NO_3). TN was not directly measured, but was calculated as NO_2+NO_3 plus TKN. Due to the lack of a stream gage at Grimesland, flow data were generated by multiplying flow from the closest upstream gage, which is approximately 13 miles upstream at Greenville (USGS 02084000), by a drainage area (DA) ratio of 1.07 (Grimesland DA divided by Greenville DA).

The WQStat Plus model was used to evaluate trends in TP, TN, TKN, NH_3, and NO_2+NO_3 in the Tar River. The model is a multi-faceted computer program, which is capable of computing flow-adjusted concentration and the nonparametric Seasonal Kendall test.

For water quality constituents that are closely related to flow, an apparent trend in quality could be caused by a change in flow. By flow adjusting concentrations before trend analysis, one is able to determine the magnitude and statistical significance of trends that are not explained by flow. The WQStat Plus model removes the concentration variation related to stream flow with flow-adjusted data by assuming a log-log relationship between water quality and flow:

$$\log \text{concentration} = b(\log \text{flow}) + a$$

WQStat Plus uses linear regression to estimate the slope (b) and intercept (a) of the line above. The resulting equation is used to predict concentration at each sampling point. Then, from each water quality observation, the corresponding prediction is subtracted, producing a series of residuals. To each residual, the mean of the original log concentration series is added, producing a flow-adjusted series of log concentrations.

Many water quality constituents are also influenced by season. The Seasonal Kendall test accounts for seasonality by computing the Mann-Kendall test on each of the user-specified seasons separately, and then combining the results (Helsel and Hirsch, 2002). For this analysis, seasons are defined as monthly. So, for monthly “seasons,” January data are compared only with January, February only with February, etc.

The Seasonal Kendall test was applied to test a null hypothesis that there was no trend in measured nutrient concentrations or daily load. The alternative hypothesis is that there is a trend. For this analysis, upward trend (positive slope) indicates degradation of water quality, whereas downward trend (negative slope) indicates improvement of water quality. The hypothesis was tested at 95% confidence level.

Trend Analysis Results

Flow-Adjusted Concentration

The results of the Seasonal Kendall test for flow-adjusted concentrations of TP, TN, TKN, NH_3, and NO_2+NO_3 are provided in Table 6-1. The results indicate that there were statistically significant trends for NH_3, NO_2+NO_3, and TKN. There was no statistically significant trend for TN or TP. TKN showed an increasing trend in concentration, while both NH_3 and NO_2+NO_3 showed decreasing trends.

Trend slope (seasonal sen trend slope) represents the median rate of change in flow-adjusted concentrations and is shown in Table 6-1 for each statistically significant parameter. For example, the statistically significant upward slope of TKN suggests that the average increase in median TKN concentration per year was 0.01 mg/L during the study period, representing a 32% increase in median TKN concentration over the 18 years of the study period. Conversely, there was a 28% decrease in NO_2+NO_3 concentrations.

TABLE 6-1. RESULTS OF SEASONAL KENDALL TREND ANALYSIS FOR FLOW-ADJUSTED CONSTITUENTS

PARAMETERS	SEASONAL SEN TREND SLOPE (MG/L PER YEAR)	SIGNIFICANT TREND AT 95%	1991 MEDIAN	AVG. % CHANGE IN MEDIAN FROM 1991 - 2008
TP (mg/L)	x	No	0.16	x
TN (mg/L)	x	No	1.27	x
TKN (mg/L)	0.01	Yes	0.50	32%
NH_3 (mg/L)	-0.002	Yes	0.07	-45%
NO_2+NO_3 (mg/L)	-0.01	Yes	0.77	-28%
X= slope was not significant and therefore not reported				

Daily Load

The results of the Seasonal Kendall test for daily loads of TP, TN, TKN, NH_3, and NO_2+NO_3 are provided in Table 6-2. Daily average flow was also trend tested to check for bias. The results indicate that there were statistically significant decreasing trends in NH_3 and NO_2+NO_3 daily loads. There was no statistically significant trend for TKN, TN, or TP. As shown in Table 6-2, there was a statistically significant decreasing trend for flow. Therefore, even though there is a statistically significant decreasing trend for NH_3 and NO_2+NO_3 flow adjusted concentrations (Table 6-1), it is possible that the decreasing trends for NH_3 and NO_2+NO_3 loads are also partially explained by the decreasing trend in flow. Trend slope (seasonal sen trend slope) represents the median rate of change in daily load and is shown in Table 6-2 for each statistically significant parameter.

TABLE 6-2. RESULTS OF SEASONAL KENDALL LOAD TREND ANALYSIS

PARAMETERS	SEASONAL SEN TREND SLOPE (KG/D/YEAR)	SIGNIFICANT TREND AT 95%
TP (kg/day)	x	No
TN (kg/day)	x	No
TKN (kg/day)	x	No
NH_3 (kg/day)	-8.84	Yes
NO_2 + NO_3 (kg/day)	-44.37	Yes
	cfs per year	
Flow (cfs)	-20	Yes
X= slope was not significant and therefore not reported		

Annual Load

As mentioned above, there are not enough years to do statistical trend analysis of annual load. As an alternative, the U.S. Army Corps of Engineers' FLUX program was used to estimate annual loads of TP and TN for 1991-2008 and plotted as a time series.

The TP annual load time series is provided in Figure 6-1. Annual total precipitation is also provided for comparison. As shown in Figure 6-1, 2007 and 2008 are the only years with total TP loads less than the 1991 baseline load. It should be noted that both years were impacted by drought conditions. The annual load of TP is closely related to the amount of precipitation. This implies that the total load is being driven more by the amount of precipitation, which drives flow, than by nutrient concentrations.

FIGURE 6-1. TIME SERIES OF ANNUAL LOAD OF TP (KG/YEAR) WITH TOTAL ANNUAL PRECIPITATION PROVIDED FOR COMPARISON

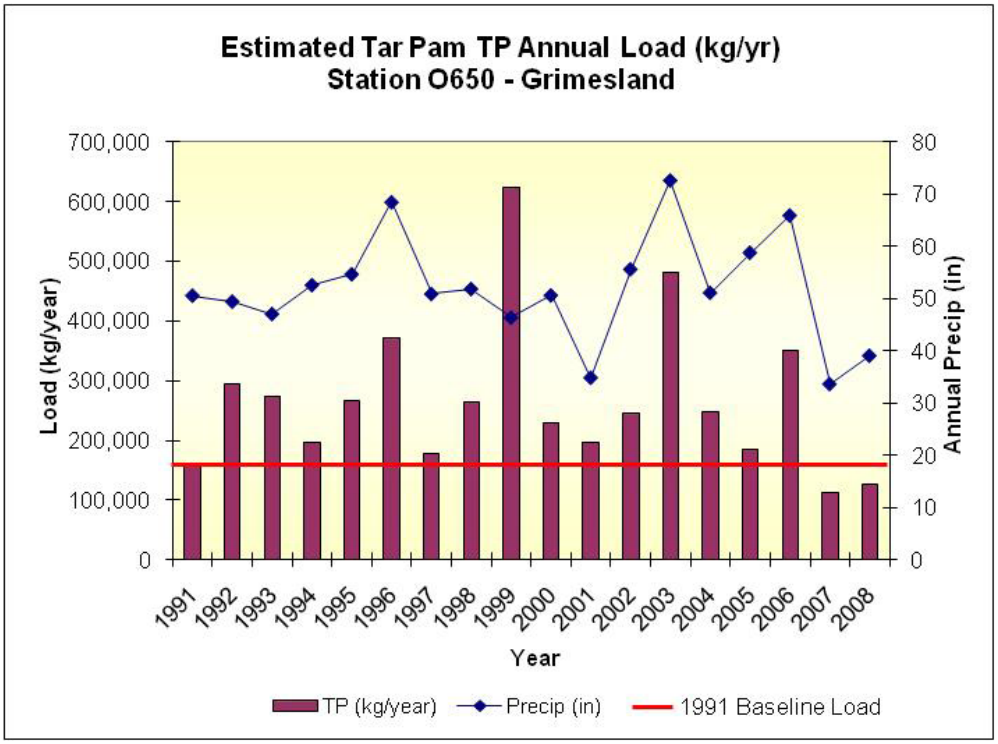
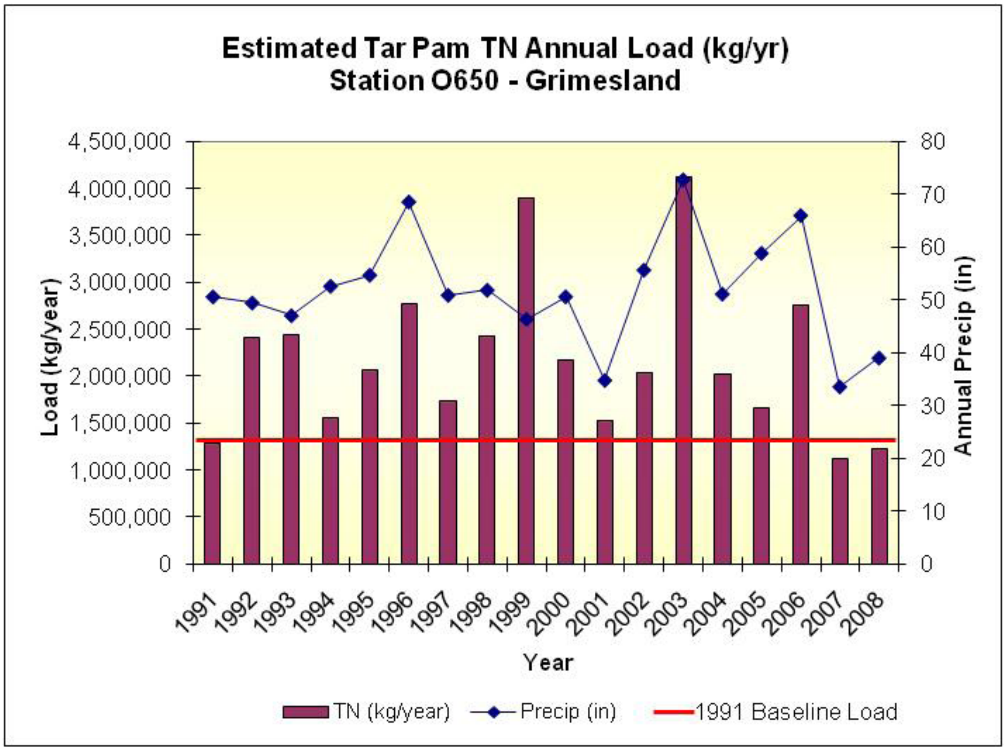


FIGURE 6-2. TIME SERIES OF ANNUAL LOAD OF TN (KG/YEAR) WITH TOTAL ANNUAL PRECIPITATION PROVIDED FOR COMPARISON



The TN annual load time series is provided below in Figure 6-2. As with TP, the only years with estimated total TN loads less than the 1991 baseline load are 2007 and 2008. This is more likely due to the drought conditions than due to decreases in nutrient concentrations.

Conclusion
Trend analyses of TP, TN, TKN, NH_3, and NO_2+NO_3 concentrations and estimated daily loads were performed for the Tar River at Station O650000. The WQStat Plus model was used to test a null hypothesis that no trends in nutrient concentrations or daily loads exist at the 95% confidence level. The results are summarized below in Table 6-3.

Table 6-3. Summary of Trend Analysis Results for concentrations and daily loads

1991-2008		
Constituent	Concentration	Daily Load
TP	No trend	No trend
TN	No trend	No trend
NH_3	Decreasing	Decreasing
NO_2+NO_3	Decreasing	Decreasing
TKN	Increasing	No trend
Flow	-----	Decreasing

The results of the trend analyses indicate that, from 1991 through 2008, concentrations of TP and TN show no trend in the Tar River at Station O650000.

Further analyses of the nitrogen series indicates that the increasing trend in TKN concentrations cancels out the decreasing trends observed for NO_2+NO_3 concentrations, resulting in no trend for TN. TKN is comprised of NH_3 and organic nitrogen. Because there was a decreasing trend observed for NH_3, the increase in TKN is likely explained by an increase in organic nitrogen.

Trend Analysis Discussion & Next Steps
Based on the trend analyses the TN 30% loading reduction goal has not been reached and the TP load has exceeded the 1991 maintenance level. There is also no decrease in TN or TP concentrations trends. Reevaluation of the TMDL is justified when the 30% TN instream load reduction has been achieved and chlorophyll *a* standards are still not being met.

Even though significant efforts have been taken by point sources and the agricultural community to reduce their collective nutrient loading, the implementation of the NSW strategy has thus far not resulted in meeting water quality standards in the Pamlico River Estuary. The decrease in annual loads of TP and TN below the baseline levels as shown in Figures 6-1 and 6-2, during the drought years of 2007-2008, suggest recent nutrient loading to the estuary is likely a result of nonpoint source contributions. The NSW strategy accounts for aspects of agriculture and stormwater nonpoint source contributions however, it is recognized that some nonpoint sources may have not been accounted for or are exceeding the original source contributions. Specifically, looking at the different forms of nitrogen, organic nitrogen has increased and thus warrants identifying sources and reducing inputs of organic nitrogen throughout the basin.

By expanding the analysis outside of the TMDL compliance point and focusing on specific watersheds with dominant land use types, staff may be able to better gauge the effectiveness and progress of strategy implementation. For this reason it will be necessary to conduct additional trend analyses on tributaries within the basin that represent predominately agriculture and urban watersheds respectively. While we believe that further analyses of existing data and additional years of data collection will provide greater certainty as to the effect of the strategy on the estuary, we also recognize other basin factors (e.g., groundwater, atmospheric deposition, nutrient recycling) may contribute to the results seen in these analyses and conditions in the estuary.

NSW Strategy Program Reviews

The goal of a 30 percent reduction in TN loading and no increase in TP loading from 1991 conditions at Washington and the goal of meeting chlorophyll *a* water quality standards within the Pamlico River Estuary have not been achieved to date. However, the efforts to reduce nitrogen from several sources have been very successful and additional reductions are likely needed in areas that were not completely covered by the initial set of management rules. Identifying additional nonpoint source pollution sources and potential reduction measures is a priority to reduce TP & TN loads beyond the >30% reduction already achieved by a majority of dischargers and agriculture. The estuary is a complex and dynamic system and due to the decades of chronic overloading of nutrients and the likelihood of nutrient recycling, it may be some time before current reductions in nutrient loading will reflect in improved water quality.

Point to Nonpoint Source Nutrient Trading Program:

The Tar-Pamlico NSW includes three phases to address both point and nonpoint source pollution contributions to the estuary. A detailed description of the phases are available on the DWQ Nonpoint Source website: **http://portal.ncdenr.org/web/wq/ps/nps/tarpamlico**.

Phase I

The strategy's first phase, which ran from 1990 through 1994, produced an innovative point source/nonpoint source trading program that allows point sources, such as wastewater treatment plants and industry, to achieve reductions in nutrient loading in more cost-effective ways. The Tar-Pamlico Basin Association (TPBA) made up of 14 point source dischargers, was established and they received collective annual end-of-pipe nitrogen and phosphorus loading caps. The TPBA members did not exceed their cap, but were given 4,608 kg nitrogen credit for financially supporting agricultural BMPs. The credits were predetermined to offset discharger nutrient exceedances with funds to be used for agricultural BMPs.

Phase II

The second phase, which ran through 2004, established nutrient goals of a 30% reduction in nitrogen loading from 1991 levels and holding phosphorus loading to 1991 levels based on estuarine conditions. Phase II required new point source nutrient caps and required nonpoint sources to contribute to estuary goals. It established a set of nonpoint source rules addressing agriculture, urban stormwater, fertilizer management across all land uses, and riparian buffer protection. The Phase II Agreement established requirements for existing and expanding domestic and industrial non-association dischargers and all new facilities that enter the basin.

Phase III

Phase III was approved by the EMC on April 14, 2005 and it spans an additional ten years through December 31, 2014. The Phase III Agreement updates TPBA membership and related nutrient caps. During the first two years, the parties agreed to actions to improve the offset rate, resolve related temporal issues, and revisit alternative offset options. It also establishes 10-year estuary performance objectives and alternative management options. Non-association dischargers are to maintain permit limits required in Phase II. The Agreement further provides that the TPBA may accrue and bank nitrogen credits by funding nonpoint source nutrient reduction measures (e.g., agricultural BMPs) and that it may purchase credits or apply banked credits in anticipation of future cap exceedances. The TPBA has consistently and reliably kept its nutrient loadings beneath the caps without relying on banked credits.

The parties in the Agreement identified actions to be taken by the conclusion of Phase III and addressed in Phase IV, these include:

1. Evaluate the NC Agricultural Cost Share Program to determine if it continues to provide the most efficient method of implementing the pollution credits trading program. This evaluation should consider the effect of delays in BMP implementation relative to nutrient cap exceedance and how such delays may impact the allowable point source nutrient budget.

2. Evaluate the trading offset credit cost calculation method to ensure the offset rate reflects all actual costs incurred in program development and implementation and reflects the costs of the type of agricultural BMPs implemented through this program.
3. Conduct a water quality trend analysis, including evaluation of TN losses occurring during transport to the estuary. This analysis will inform the parties regarding the need for changes in acceptable loads and the relative impacts of point and non-point contributions.

Phase IV

Individual discharger permit limits will be incorporated in 2014 during the fourth phase of the Agreement. Also, based on the Pamlico Estuary's response to nutrient management efforts, additional nutrient reduction options may be considered.

Tar-Pamlico Basin Association Facilities Loading Requirements

The TPBA dischargers (Table 6-4) account for 98.7% of the known effluent flow to the basin. As part of Phase I the TPBA members agreed to optimize their nutrient reduction performance with the goal of each facility attaining TP of 2 mg/L and TN of 4 mg/L in the summer and 8 mg/L in the winter. A collective nutrient cap was established for years 1991-1994 (Table 6-5). The cap was reevaluated for years 1995-2004 after model results suggested the 30% TN cumulative point and nonpoint source reduction and no increase in TP from baseline 1991 levels (Table 6-6). For Phase III, the TPBA's end-of-pipe nitrogen cap is 404,274 kg TN and the final phosphorus cap of 73,060 kg TP (Table 6-7). Cap values are adjusted for any change in TPBA membership.

Since the Tar-Pamlico strategy's inception, the EPA has praised the strategy for its innovative and integrative approach to nutrient management and has touted it repeatedly as a model for others to use. However, guidance released by the EPA's Office of Water Management in 2007 re-iterates that federal NPDES regulations (40 C.F.R. 122.44(d)(1)) and Section 301(b)(1)(C) of the federal Clean Water Act require that NPDES permits include any applicable limitations established in or based upon an approved TMDL. The Tar-Pamlico permits have not included nutrient limits, because the Agreement specified the TPBA's caps and, until recently, the EPA Region 4 office had accepted that approach. In light of the 2007 guidance, Region 4 has modified its position on the matter and is requiring that the members' permits include the group nutrient limits at this time and individual limits in 2014.

In order to establish individual nutrient limits by 2014, the DWQ must conduct additional technical studies (e.g., determine delivery rates for each discharger, develop individual N and P allocations) and work with the TPBA to complete major revisions to the Tar-Pamlico strategy and the Agreement. It is also likely that the DWQ must adopt rules to provide for the operation of the TPBA under a group NPDES permit.

Table 6-4. Tar-Pamlico Basin Association Discharge Members

Permit	Owner	Facility	Permitted Flow (MGD)	Subbasin HUC	Receiving Stream
NC0042269	Town of Bunn	Bunn WWTP	0.15	3020101	Crooked Creek
NC0020061	Town of Spring Hope	Spring Hope WWTP	0.4	3020101	Tar River
NC0020231	Town of Louisburg	Louisburg WWTP	1.37	3020101	Tar River
NC0069311	Franklin County	Franklin County WWTP	3	3020101	Cedar Creek
NC0025054	City of Oxford	Oxford WWTP	3.5	3020101	Fishing Creek
NC0030317	City of Rocky Mount	Tar River Regional WWTP	21	3020101	Tar River
NC0023337	Town of Scotland Neck	Scotland Neck WWTP	0.675	3020102	Canal Creek
NC0025402	Town of Enfield	Enfield WWTP	1	3020102	Fishing Creek
NC0020834	Town of Warrenton	Warrenton WWTP	2	3020102	Fishing Creek
NC0020435	Town of Pinetops	Pinetops WWTP	0.3	3020103	Town Creek
NC0026042	Town of Robersonville	Robersonville WWTP	1.8	3020103	Flat Swamp

Permit	Owner	Facility	Permitted Flow (MGD)	Subbasin HUC	Receiving Stream
NC0020605	Town of Tarboro	Tarboro WWTP	5	3020103	Tar River
NC0023931	Greenville Utilities Commission	GUC WWTP	17.5	3020103	Tar River
NC0026492	Town of Belhaven	Belhaven WWTP	1	3020104	Battalina Creek
NC0020648	City of Washington	Washington WWTP	3.65	3020104	Tar River
		Total Permitted Flow = 62.35			

Table 6-5. Phase I TPBA Nutrient Caps and Reported Loads

Combined N+P	1991[1]	1992[1]	1993[1]	1994[1]
Loading Cap [a] (kg/yr)	525,000	500,000	475,000	425,000
Actual Load (kg/yr)	total= 461,394 TN= 396,916 TP =64,478	total= 436,128 TN= 386,014 TP= 50,113	total= 417,217 TN=371,336 TP= 45,881	total= 371,200 TN=319,181 TP= 52,019
% of Cap	88	87	88	87
Average Daily Flow (MGD)	24.88	26.86	28.46	26.65

Table 6-6. Phase II TPBA Nutrient Caps and Reported Loads

Separate N & P	1995[2]	1996[2]	1997[2]	1998[2]	1999[2]	2000[2]	2001[3]	2002[4]	2003[4]	2004[4]
Loading Cap [a] (kg/yr)	N: 405,256 P: 69,744	N: 405,256 P: 69,744	N: 405,256 P: 69,744	N: 405,256 P: 69,744	N: 405,256 P: 69,744	N: 405,256 P: 69,744	N: 421,972 P: 73,060	N: 426,782 P: 73,694	N: 426,782 P: 73,694	N: 426,782 P: 73,694
Actual Load (kg/yr)	N: 372,582 P: 37,360	N: 354,219 P: 43,266	N: 320,670 P: 36,532	N: 344,781 P: 36,864	N: 309,476 P: 32,052	N: 297,988 P: 30,277	N: 279,958 P: 32,730	N: 279,330 P: 34,076	N: 309,724 P: 30,856	N: 256,791 P: 33,566
% of Cap	N: 92 P: 54	N: 87 P: 62	N: 79 P: 52	N: 85 P: 53	N: 76 P: 46	N: 74 P: 43	N: 66 P: 45	N: 65 P: 46	N: 72 P: 42	N: 60 P: 45
Average Daily Flow (MGD)	31.03	33.57	29.84	33.31	33.39	32.74	30.21	30.54	36.86	29.56

Table 6-7. Phase III TPBA Nutrient Caps and Reported Loads

Separate N & P	2005[5]	2006	2007	2008
Loading Cap [a] (kg/yr)	N: 404,274 P: 73,060	N: 404,274 P: 73,060	N: 404,274 P: 73,060	N: 404,274 P: 73,060
Actual Load (kg/yr)	N: 242,020 P: 39,267	N: 232,568 P: 46,995	N: 246,465 P: 50,077	N: 253,818 P: 43,821
% of Cap	N: 60 P: 54	N: 58 P: 64	N: 61 P: 69	N: 63 P: 60
Average Daily Flow (MGD)	29.21	32.85	27.05	27.39

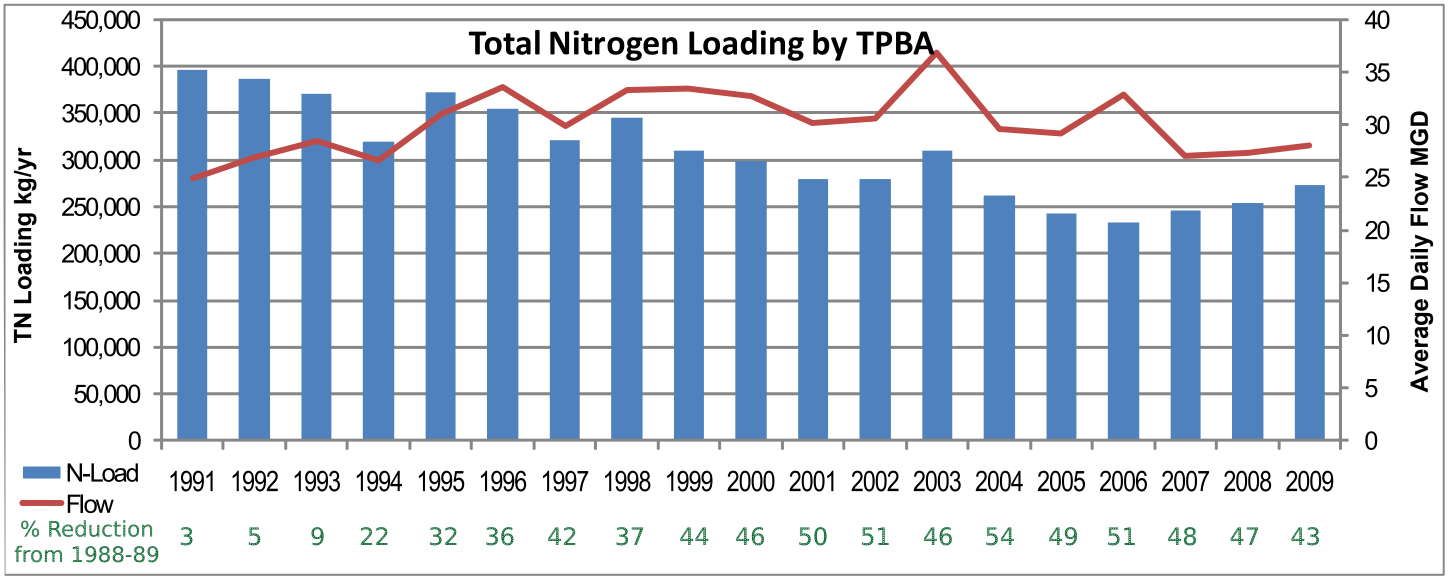
Loads were estimated by NC Division of Water Quality as the sum of calendar-year monthly load values for each facility, which are based on minimum biweekly nutrient concentrations and daily mass flows.

[a] Cap values and changes result from the following:

- [1] Phase I – Original 12-member Association
- [2] Phase II through 2000 – 14-member Association.
- [3] Robersonville added in 2001, making a 15-member Association.
- [4] Scotland Neck added in 2002, making a 16-member Association.
- [5] National Spinning Removed in 2005, making a 15 member Association in Phase III

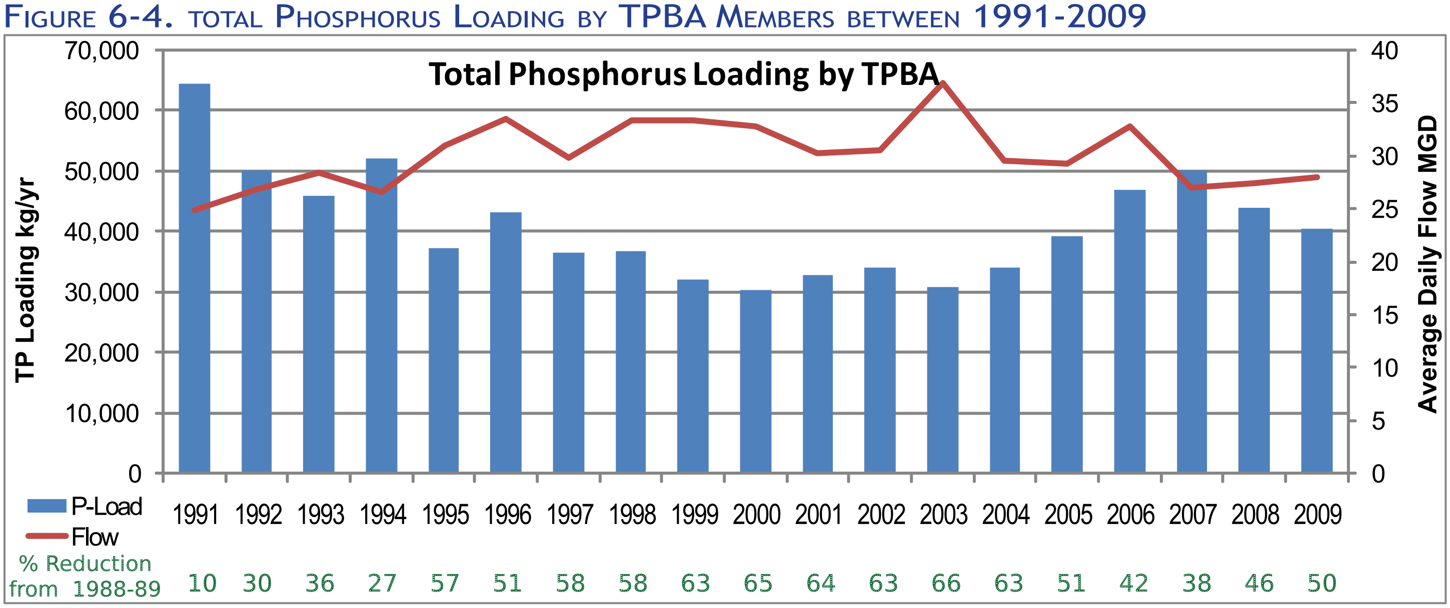
The TPBA has consistently and reliably kept its nutrient loadings beneath the caps without relying on banked credits. Relaxation of these caps in future amendments to this Agreement would only be contemplated if monitoring and modeling results suggest all water quality standards and goals are being met and that assimilative capacity is available to the TPBA while maintaining a margin of safety, all consistent with the TMDL. The dischargers TN loads and MGD average daily flow are seen in Figure 6-3. The percent reduction in TN loads from 1988-89 (pre-reduction) load levels are listed in green below the years; these percents have been adjusted appropriately for the number of TPBA members active for the particular year.

Figure 6-3. Total Nitrogen Loading by TPBA Members between 1991-2009.



The reductions in TP since 1991 are shown in Figure 6-4 in correlation to the discharges average daily flow levels. The percent reduction in TP loads from 1988-89 (pre-reduction) load levels are listed in green below the years; these percents have been adjusted appropriately for the number of TPBA members active for the particular year.

Figure 6-4. total Phosphorus Loading by TPBA Members between 1991-2009



Non-Association Discharge Facilities Loading Requirements

The non-association dischargers account for less than 2% of the effluent flow within the basin (Table 6-8). The Phase II Agreement established requirements for existing and expanding domestic and industrial dischargers and all new facilities to enter the basin. Those requirements are maintained in Phase III. Existing domestic facilities permitted at or above flows of 0.5 million gallons per day (MGD) have received 6 mg/L TN and 1 mg/L TP effluent concentration limits in all NPDES permit renewals beginning in Phase II, while existing industrial dischargers have received Best Available Technology (BAT) limits.

Phase II Agreement requirements for expanding and new facilities were codified as rules 15A NCAC 2B .0229 and .0237, which were effective April 1, 1997. No changes are recommended to these requirements under Phase III. Any future changes would require rule amendment. Domestic and industrial dischargers expanding to 0.5 MGD or greater and all new dischargers are required to offset all new nutrient loads at 110 percent of the rate established. Payment for the life of the permit is required at issuance or renewal. In addition, domestic and industrial dischargers expanding to at least 0.5 MGD are faced with 6 mg/L TN and 1 mg/L TP effluent concentration limits and BAT limits respectively, while new dischargers of any kind receive 1 mg/L TP effluent concentration limits if they exceed 0.05 MGD permitted flow, and additionally 6 mg/L TN effluent concentration limits if they exceed 0.5 MGD permitted flow.

Table 6-8. Tar-Pamlico Basin Non-Association Dischargers

Permit	Owner	Facility	Permitted Flow (MGD)	Subbasin HUC	Receiving Stream
Non-Association Domestic Less than 0.05 MGD					
NC0050415	Edgecombe County Schools	Phillips Middle School	0.010	03020101	Moccasin Creek
NC0050431	Edgecombe County Schools	North Edgecombe H S	0.02	03020101	Swift Creek
NC0037885	Nash/Rocky Mount Schools	Southern Nash Junior H S	0.015	03020101	Tar River
NC0047279	C&J Bradshaw LLC	Heritage Meadows WWTP	0.010	03020101	North Fork Tar River
NC0029131	Kittrell Job Corps Center	Kittrell Job Corps Center	0.025	03020101	Long Creek
NC0048631	Interstate Property Mgmt Inc	Long Creek Court WWTP	0.007	03020101	Long Creek
NC0038580	Halifax County Schools	Eastman M School WWTP	0.0048	03020102	Little Fishing Creek
NC0038610	Halifax County Schools	Pittman El School WWTP	0.0096	03020102	Burnt Coat Swamp
NC0038644	Halifax County Schools	Dawson El School WWTP	0.0073	03020102	Deep Creek
NC0037231	Martin County Schools	Bear Grass El Sc WWTP	0.005	03020103	Turkey Swamp
NC0036919	Town of Pantego	Pantego WWTP	0.006	03020104	Pantego Creek
NC0040584	Pantego Rest Home	Pantego Rest Home	0.004	03020104	Pantego Creek
		Total Permitted Flow =	0.1237		
Non-Association Domestic 0.05 to 0.5 MGD					
NC0042510	Total EnvSolutions Inc	Lake Royale WWTP	0.080	03020101	Cypress Creek
NC0025691	Town of Littleton	Littleton WWTP	0.28	03020102	Butterwood Creek
NC0050661	Town of Macclesfield	Macclesfield WWTP	0.175	03020103	Bynums Mill Creek
NC0021521	Town of Aurora	Aurora WWTP	0.12	03020104	South Creek
NC0069426	Dowry Creek Community Assc.	Dowry Creek	0.05	03020104	Pungo River

Permit	Owner	Facility	Permitted Flow (MGD)	Subbasin HUC	Receiving Stream
		Total Permitted Flow =	0.705		
Non-Association Domestic 0.5 MGD or Greater					
None					
Non-Association Industrial Discharging Nutrients					
NC0003255	PCS Phosphate Company Inc	PCS Phosphate Co- Aurora	No Limit	03020104	Pamlico River
		Total Permitted Flow = 0.83			

Nonpoint Source Controls

The Phase II Agreement called for a nonpoint source strategy, which was approved by the Commission in December 1995. The Commission then received annual reports on the progress of implementation under this voluntary plan. The implementation of this strategy is to help meet the instream TN reduction target of 766,228 kg/yr. After two years of implementation, the Commission found that progress was insufficient and initiated rulemaking for nonpoint sources. Modeled after rules implemented in the adjacent Neuse River Basin in 1998, a set of rules addressing agriculture, urban stormwater, riparian buffer protection and fertilizer management went into effect during 2000 and 2001.

Agriculture Rule

Effective September 2001, the **Tar-Pamlico Agricultural Nutrient Control Strategy Rule** and **Law** provides for a collective strategy for farmers to meet nutrient reductions required by the TMDL. Farmers in the basin are to implement land management practices that achieve certain nutrient reduction goals. The goals are a 30 percent reduction in nitrogen loading from 1991 levels within five to eight years of the rule's implementation, and control of phosphorus levels at or below 1991 levels within four years of the approval of a phosphorus accounting methodology. The main agriculture rule details the process and options for achieving the nutrient goals. Implementation relies on cooperation between a Basin Oversight Committee and Local Advisory Committees. The Basin Oversight Committee has representatives from governmental, environmental, farming and scientific communities. It developed a tracking and accounting methodology to gauge progress toward the nutrient goals based on implementation of various nutrient-reducing management practices. The Soil and Water Conservation Commission approved standard practices in 2002 based on the recommendations of a Technical Review Committee and consultation with farming commodity groups. Each Local Advisory Committee, comprised of farmers and local agriculture agency representatives, developed a local strategy and submit annual reports quantifying progress toward the nutrient goals to the Basin Oversight Committee. Farmers, who are involved in the commercial production of crops or horticultural products, or whose livestock or poultry holdings exceed specified numbers, are subject to the rule and are required to register with their local committee. More information about the Agriculture rules are available on the DWQ Non-Point Source Unit's website: **http://portal.ncdenr.org/web/wq/ps/nps/tarpamagrule**.

Implementation Results

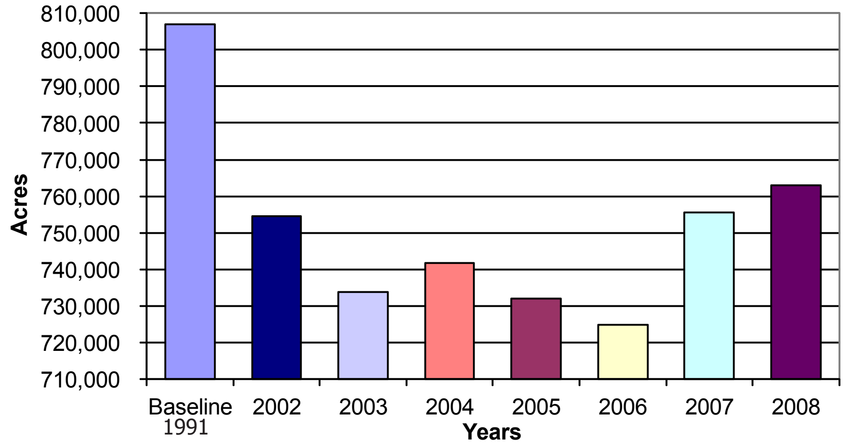
Currently there are five full time Soil and Water Conservation District (SWCD) technicians that work with local farmers on designing BMPs to reduce nutrient runoff from their agricultural operations. These technicians work with Local Advisory Committees (LACs) to coordinate nitrogen and phosphorous management information for the Basin Oversight Committee (BOC) annual reports. Fertilizer information used in these reports are based on best professional judgement and BMPs implemented are often only accounted for if funded through the NC Agricultural Cost Share Program.

In addition to the BOC annual accounting reports, a 319 grant was awarded to NCSU to do an agriculture sample analysis of fertilizer and BMP usage within the basin. The sample analysis conclusions indicate farmers are implementing agricultural practices that minimize their environmental impact. A majority of farmers were found to use a fertilizer plan for a particular crop and did not compensate for soil test results. However, this did not result in an excess of fertilization, except in the application of phosphorus. The reduction of phosphorus fertilizer application is recommended for over 2/3 of the fields. The survey data found that information collected by the LACs tended to over report fertilizer rates, while conservation tillage was under reported. Buffers were found along most stream/field interfaces in the upper portion of the basin while water control structures were more commonly used in coastal areas where topography is suitable. (Osmond et al., 2006). The full report is available here: [Delineating Agriculture in the Tar-Pamlico River Basin].

The following nitrogen and phosphorus reduction information is summarized from the Basin Oversight Committee Annual Progress Report for Crop Year 2008. The information was collected by the SWCD technicians and summarized to meet annual reporting requirements. This report is available from the Division of Soil and Water Conservation website: http://www.enr.state.nc.us/dswc/pages/Tar_Annual_Report_CY2008_Final.pdf

It is estimated that approximately 9,800 acres have been permanently lost to development and more than 31,000 acres have been converted to grass or trees since 1991. Figure 6-4 shows the fluctuation of cropland acres with the 1991 croplands comprising 807,053 acres and over an 11% decrease in 2006.

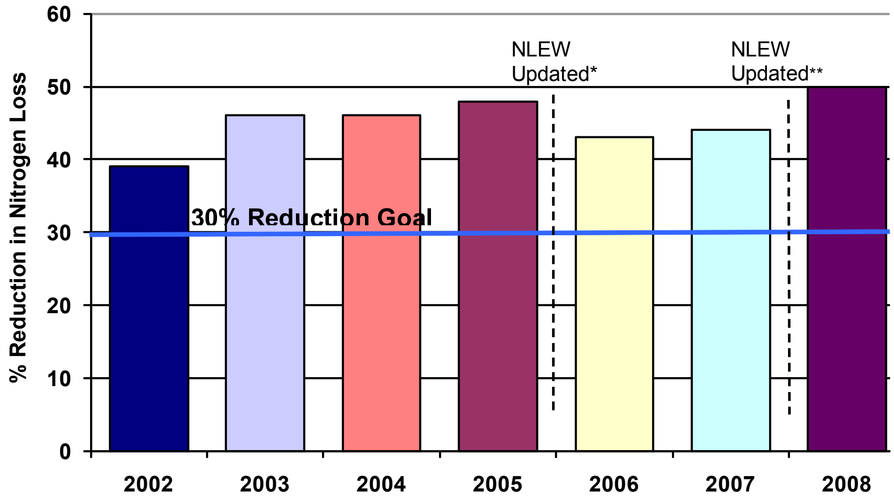
Figure 6-4. Changes in Cropland Acreage



Nitrogen Reductions

All fourteen LACs submitted their first annual report in November 2003, which collectively estimated a 34% reduction in nitrogen, and 10 of 14 LACs individually exceeded the 30%. Collective reductions have gradually increased in succeeding years, and by 2007 only one LAC was shy of the 30% individually. In 2008, all LACs exceeded the 30% nitrogen loss reduction goal. Figure 6-5 shows the percent nitrogen reduction since the implementation of the agriculture rule.

Figure 6-5. Collective Nitrogen Loss Reduction Percent 2002 to 2008



* Between 2005 & 2006 NLEW was updated to incorporate revised soil management units and buffer nitrogen reduction efficiencies were reduced.

** Between 2007 & 2008 NLEW was updated to incorporate revised soil management units and correct some realistic yield errors.

Nitrogen reductions are estimated using the Nitrogen Loss Estimation Worksheet (NLEW); the calculations represent county-wide nitrogen loss from cropland agriculture. NLEW captures application of both inorganic and animal waste sources of fertilizer to cropland. It does not capture the effects of managed livestock on nitrogen movement, including pastured, confined, and non-commercial livestock. NLEW is an "edge-of-management unit" accounting tool; it estimates changes in nitrogen loss from croplands, but does not estimate changes in nitrogen loading to surface waters. Table 6-9 shows the percentage of nitrogen loss reductions through the combination of fertilization rate decreases, cropping shifts, BMP implementation and cropland attenuation.

Table 6-9. Factors Influence on Nitrogen Reduction by Percentage on Agricultural Lands

	2005	2006	2007	2008
BMP implementation	10%	8%	10%	10%
Fertilization Management	21%	20%	20%	21%
Cropping shifts	10%	7%	8%	10%
Reduction in cropland due to idle land	*%	4%	3%	4%
Reduction in cropland due to cropland conversion	*%	3%	2%	4%
Reduction in cropland due to development	*%	1%	1%	1%
TOTAL	**48%**	**43%**	**44%**	**50%**

*Not calculated prior to 2006.

Agriculture Phosphorus Reductions

Phosphorus Technical Advisory Committee (PTAC) developed recommendations for qualitative tracking of relative changes in land use management that either increase or decrease the risk of phosphorus loss from agricultural lands in the basin on an annual basis. The phosphorus predicted loss or gain is shown for several land management practices in Table 6-10. Most parameters indicate less risk of phosphorus loss than in the baseline. Contributing to the reduced risk of phosphorus loss is the increase of nutrient reducing BMPs in the basin. As indicated in the table below, the acres affected in the basin by vegetated buffers and water control structures have steadily increased. It should also be noted that the median phosphorus soil test number reported for the basin fluctuates each year due to the nature of how the data are collected and compiled. The BOC has reviewed the data and determined there has not been an increase risk of phosphorus loss.

Table 6-10. Agriculture Land Use Phosphorus Changes

Parameter	Units	1991 Baseline	2005	2006	2007	2008	1991-08 % Change	2008 P Loss Risk +/-
Agricultural land	Acres	807,026	732,139	724,778	755,489	763,066	-5.4%	-
Cropland conversion (to grass & trees)	Acres	660	22,369	23,083	20,754	31,110	4712%	-
CRP / WRP (cumulative)	Acres	19,241	25,921	30,768	34,614	38,375	199%	-
Conservation tillage	Acres	41,415	362,102	362,102	66,079	31,421	24%	-
Vegetated buffers (cumulative)	Acres	50,836	193,867	195,673	210,488	214,043	421%	-
Water control structures (cumulative)	Acres Affected	52,984	75,980	75,641	79,167	80,418	152%	-
Scavenger crop	Acres	13,272	80,604	97,405	120,565	109,741	827%	-
Animal waste P	lbs of P/yr	13,597,734	14,064,368	14,728,831	14,626,960	NA		+
Soil test P median	mg/kg	83	85	85	89	89	107%	+

Stormwater Rule

The stormwater rule which became effective in April 2001, required six municipalities and five counties in the Tar-Pamlico Basin to develop and implement stormwater programs within two and a half years. The municipalities are: Greenville, Henderson, Oxford, Rocky Mount, Tarboro, and Washington. The counties are: Beaufort, Edgecombe, Franklin, Nash, and Pitt. These local governments were identified based on their potential nutrient contributions to the Pamlico River Estuary. The EMC may add other local governments as appropriate in the future through rule-making. Local programs are to include the permitting of new development to reduce nitrogen runoff by 30 percent compared to pre-development loading conditions, and to keep phosphorus inputs from increasing from 1991 levels. The local programs must also identify and remove illicit discharges, educate developers, businesses, and homeowners, and make efforts toward treating runoff from existing developed areas. More information about the stormwater rules are available on the DWQ Non-Point Source Unit's website: http://portal.ncdenr.org/web/wq/ps/nps/tarpamstorm.

New Development Nutrient Offset

Under the requirements of the rule, the nutrient export goal for new development projects is limited to a total nitrogen export of 4 lbs/acre/yr and 0.4 lbs/acre/yr of total phosphorus with limits on peak flows to not exceed the predevelopment conditions for the 1-year 24-hour storm. The lbs/ac/yr export target represents the 30% reduction goal applied to new development. It represents a 30% reduction from the average pre-development loading conditions. The nitrogen export goal is achieved through a combination of site design and the use of on-site best management practices (BMPs). Developers also have the option to offset the nutrient export offsite by making offset payments to a private party with available offset credits or by making payments to the North Carolina Ecosystem Enhancement Program (NCEEP) nutrient offset program. If the nitrogen export for a planned project site is calculated to be greater than 6.0 lbs/ac/yr or 10.0 lbs/ac/yr for residential or commercial development respectively, the developer must first implement onsite BMPs or take part in an approved regional or jurisdiction-wide stormwater strategy to lower the nitrogen export to at least those levels before being allowed to "buy down" the remainder of their nitrogen export to the lbs/ac/yr target through either a private party with approved nutrient offset credits or the NCEEP nutrient offset program.

Implementation Results

By 2006, each of the six local governments subject to the Tar-Pam Stormwater Rule adopted and implemented their local permitting programs requiring new development projects to control stormwater runoff. The City of Washington was the last municipality to adopt a local stormwater ordinance in April 2006. The other municipalities implemented their stormwater programs in 2004 and began reporting to DWQ in 2005. As of April 2010, EEP has received 94 nutrient offset payments totalling over $1.2 milllion for new development projects to offset ~50,630 lbs of nitrogen and ~3,542 lbs of phosphorus from the Tar-Pamlico River Basin.

A number of public education programs have been implemented in the various communities, as required under the rule. All of the local governments under the rule are supporting partners of the Clean Water Education Partnership (CWEP) which is a cooperative effort between local governments, state agencies, and nonprofit organizations to educate the general public about water quality in the Tar-Pamlico, Neuse, and Cape Fear River Basins. The education and outreach programs conducted include workshops, development of web sites, newsletters, brochures, storm drain stenciling, participation at school programs such as science fairs, field days, development of environmental fact sheets, and implementation of demonstration projects for stormwater control. Several communities have also partnered with other agencies such as the NC Cooperative Extension Service and local Soil and Water Conservation Districts to aid in the development of their public education and outreach programs.

All of the local governments subject to the Tar-Pamlico Stormwater Rule have also developed ordinances and programs that, in addition to requiring the nutrient export goal be met, establish local authority for the removal of illegal discharges. This includes establishing a 24-hour hotline the public can use to report an illegal discharge. Each local program is also responsible for maintaining a database that tracks illicit discharge detection and removal activities, and a number of local governments have noted in their annual reports to DWQ that this element of the stormwater program has resulted in the removal of several illicit dischargers to date.

Each reporting year, local governments also identify a pre-set number of viable stormwater retrofit sites for existing developments in their jurisdictional areas. These sites are made available to groups that may have funding to implement retrofit activities for nitrogen reduction. In addition to identifying retrofit sites, a few local governments have reported activities completed or underway that have worked to reduce existing nitrogen loading. One example of such an effort is the development of local programs to buy out properties in floodplain areas and restore these areas to natural conditions for water quality improvements.

Buffer Rule- Protection and Maintenance of Existing Forested Riparian Areas

A set of three buffer rules were adopted. The main rule, called the buffer protection rule, requires that existing vegetated riparian buffers in the basin be protected and maintained on both sides of intermittent and perennial streams, lakes, ponds, and estuarine waters. This rule does not establish new buffers unless the existing use in the buffer area changes. The footprints of existing uses such as agriculture, buildings, commercial and other facilities, maintained lawns, utility lines, and on-site wastewater systems are exempt. A total of 50 feet of riparian area is required on each side of waterbodies. Within this 50 feet, the first 30 feet referred to as Zone 1 is to remain undisturbed with the exception of certain activities; the outer 20 feet referred to as Zone 2 must be vegetated, but certain additional uses are allowed. Specific activities are identified in the rule as “exempt”, “allowable”, “allowable with mitigation” or “prohibited”. Examples of “exempt” activities include driveway and utility crossings of certain sizes through Zone 1, and grading and revegetation in Zone 2. “Allowable” and “allowable with mitigation” activities require review by Division staff and include activities such as new ponds in drainage ways and water crossings. The other two buffer rules are the buffer mitigation rule and the buffer program delegation rule. The mitigation rule defines the process applicants would follow to gain approval for activities that are identified in the buffer protection rule as “allowable with mitigation”. It also outlines acceptable mitigation measures. The delegation rule lays out the criteria and process for local governments to obtain authority to implement the buffer rules within their jurisdictions. More information about the Buffer rules are available at: http://portal.ncdenr.org/web/wq/swp/ws/401/riparianbuffers.

Implementation Results

Since implementation of the Tar-Pamlico buffer rule there have been a total of 36 general major variances and 59 minor variances. A major variance request pertains to activities that are proposed to impact any portion of Zone 1 or any portions of Zone 1 and Zone 2 of the riparian buffer. A minor variance request pertains to activities that are proposed only to impact any portion of Zone 2 of the riparian buffer.

Buffers are not necessarily part of permitted activity that DWQ tracks through a permit number and DWQ has limited ability to monitor for buffer compliance. DWQ often relies on notification from other agencies or citizen reports and therefore, the true number of buffer impacts that exist in NC are difficult to determine. Most site visits that determine the presence of buffer impacts are reported in a DWQ Notice of Violation. There is always the potential for a buffer impact to result in an enforcement case. DWQ began tracking buffer enforcement cases in 2005. Records indicate that from 2006 through July 2009 there were nine enforcement cases. Of these nine enforcement cases, approximately $81,000 in civil penalties were assessed. Also, during this time, 92 buffer violations that were reported resulted in approximately 176,965 ft^2 of impacted buffers. It is important to recognize that not all NOVs reported the length of buffer impacts; therefore, the total length of impacted buffers within these years is difficult to determine. DWQ intends to improve the database currently used for tracking buffer compliance to include the length of buffer impacted at each site visit, a description of the type of buffer impact, and impacted buffer location information. These improvements to the database will hopefully allow DWQ to be better measure the success of the buffer rules on reducing nutrient loading.

Delegation of local authority for implementing the buffer rule was granted to Pitt County in 2006 and their ordinance became effective January 1, 2007.

Nutrient Management Rule

The nutrient management rule requires people who apply fertilizer in the basin, except residential landowners who apply fertilizer to their own property, to either take state-sponsored nutrient management training or have a nutrient management plan in place for the lands to which they apply fertilizer. The rule applies to fertilizer applicators, people who own or manage fertilized lands, and consultants who provide nutrient management advice. More information about the Nutrient Management rules are available on the DWQ Non-Point Source website: **http://portal.ncdenr.org/web/wq/ps/nps/tarpamnutrman**.

Implementation Results

Over the winter of 2005 and 2006, 1,969 fertilizer applicators in the Tar-Pamlico River Basin were trained in nutrient management. Training courses were held in 14 counties and applicators attended a 4 hour training and certification program. Trainings are given on an as needed basis. The effectiveness of this program is not known, however expanding this program to include education materials for homeowners is an opportunity to reduce nutrients especially as agricultural land is converted to residential. Recently, in several states, new lawn fertilizer ordinances regulating nitrogen and phosphorus application rates have been adopted at county and municipal levels.

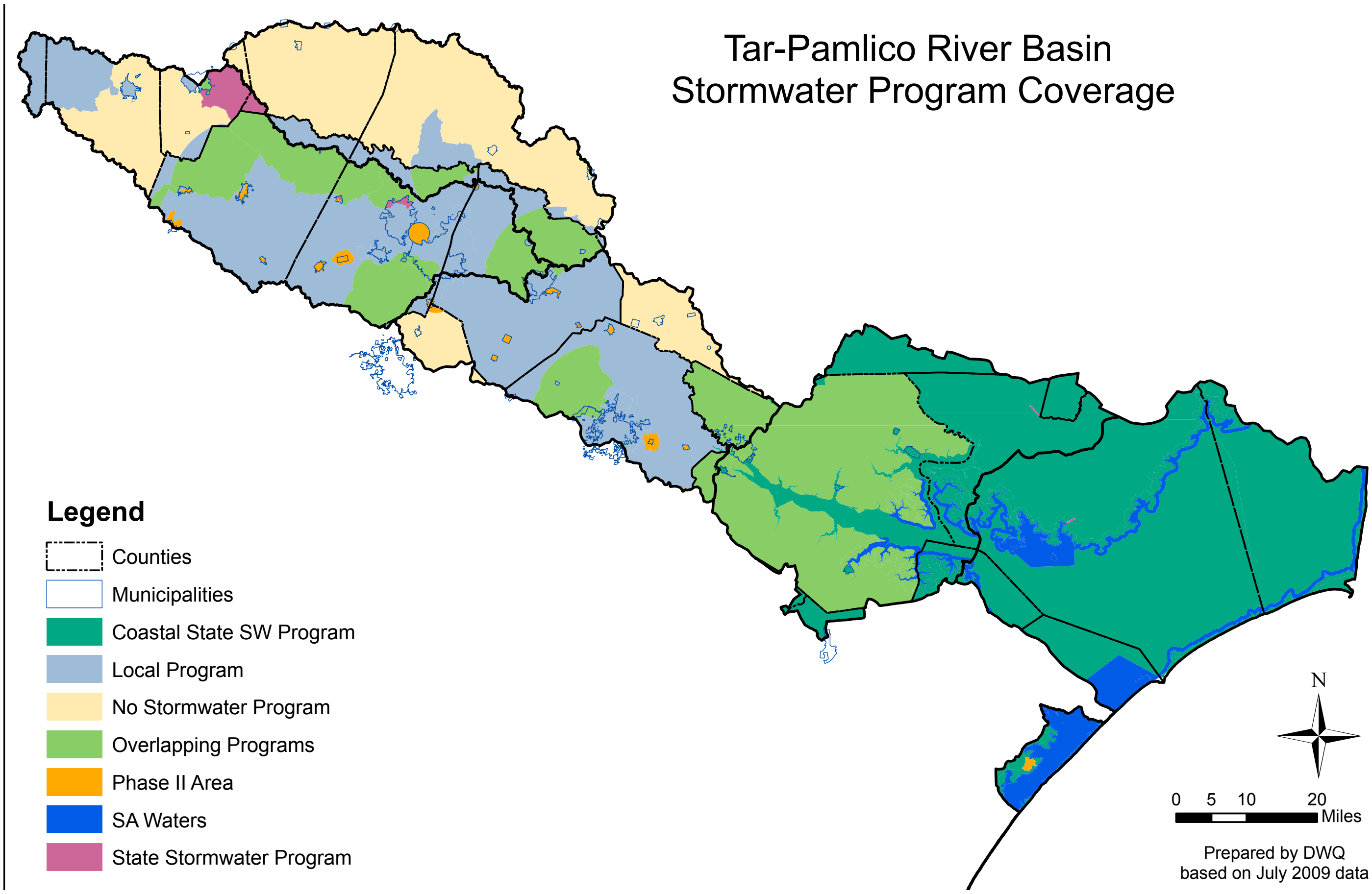
Strategy Analysis and Opportunities for Additional Nutrient Reductions

New Development Stormwater Rule

The Tar-Pamlico stormwater rule establishes a nutrient export goal of 4.0 lbs/ac/yr of TN and 0.4 lbs/ac/yr of TP for new residential and commercial development projects within the planning and zoning jurisdictions of six of the largest and fastest-growing local municipalities and five counties within the basin. Each of these local governments has successfully implemented its stormwater program since 2006 and continues to achieve the nutrient export target through a combination of onsite BMPs and off site nutrient offsets. DWQ has begun to assess the extent to which the stormwater rule does not address new development activities in the basin. A key factor in this assessment is determining the impact of increases in population and the corresponding growth in residential and commercial development activities in municipalities and counties that are currently not subject to the stormwater rule.

Approximately 55% of the basin is covered by either Phase II or the NSW stormwater rules, 1% is covered by solely ORW or Water Supply Watershed stormwater regulations, 19% by Coastal stormwater rules and 23% of the basin has no stormwater program. Nutrient stormwater controls are in place for only 54% of the basin. Figure 6-5 shows how the stormwater programs are distributed throughout the basin, more detailed maps are found within the subbasin chapters.

Figure 6-5. Stormwater Programs in the Tar-Pamlico River Basin



The requirements of Phase II stormwater regulations and the Tar-Pamlico NSW Stormwater Rule do share some similarities; both include provisions for implementing illicit discharge detection and elimination programs, public outreach and education, and some type post construction stormwater controls. However, there are additional protective measures provided for in the NSW Stormwater Rules that specifically address nutrients that are not present in the Phase II regulations. While Phase II stormwater regulations do not currently address nutrients, DWQ could consider including nutrient requirements under Phase II programs when existing permits are renewed or future Phase II designations are made. Table 6-11 details the population growth of the municipalities with a population greater than 500 as of July 2008 and their corresponding stormwater program, if applicable.

Table 6-11. Stormwater Programs in Municipalities with Populations* >500

	April	July	Growth		NPDES Phase II	NSW Stormwater Rules	Coastal Stormwater Rules	State Stormwater Program	Water Supply Watershed Stormwater Requirements
Municipality	2000	2008	Amount	%					
Greenville	61,209	81,092	19,883	328	local	X			X
Rocky Mount	55,977	59,228	3,251	6	local	X			X
Princeville	940	2,368	1,428	152	post				
Oxford	8,338	9,426	1,088	13		X			
Franklinton	1,745	2,497	752	43	local/post				X
Washington	9,619	10,216	597	6		X	X		
Youngsville	651	1,211	560	86	post				
Louisburg	3,111	3,608	497	16	local/post			X	X
Nashville	4,417	4,841	424	10	local				X
Red Oak	2,723	2,991	268	10	local			X	
Sharpsburg	2,421	2,612	191	8	post				
Henderson	16,095	16,273	178	1	local	X			
Warrenton	811	922	111	14					
Dortches	809	873	64	8	post				
Bethel	1,760	1,809	49	3	post				
Spring Hope	1,261	1,307	46	4	local/post				
Fountain	533	578	45	8	post				
Aurora	583	565	-18	-3			X		
Belhaven	1,968	1,945	-23	-1			X		
Littleton	692	668	-24	-3					
Norlina	1,107	1,082	-25	-2					
Chocowinity	733	706	-27	-4			X		
Elm City	1,412	1,373	-39	-3					
Whitakers	799	758	-41	-5	post				
Enfield	2,370	2,250	-120	-5					
Pinetops	1,419	1,277	-142	-10	post				
Robersonville	1,731	1,589	-142	-8					
Scotland Neck	2,362	2,195	-167	-7					
Tarboro	11,138	10,383	-755	-7	local	X			

local= local program satisfies Phase II requirements

post=subject to Phase II post construction

*NC Office of State Budget and Management http://www.osbm.state.nc.us/

Table 6-12 lists county population and growth rates. Counties shaded are subject to the Tar-Pamlico NSW Stormwater Rules in the unincorporated areas of the county.

Table 6-12. County Population Estimates*.

County	April 2000 Estimate	July 2008 Estimate	Growth Amount	Growth Percent	Projected 2020 Population
BEAUFORT	44,958	46,590	1,632	3.6	49,100
CARTERET	59,386	63,520	4,134	7	65,589
DARE	29,967	33,955	3,988	13.3	31,248
EDGECOMBE	55,606	51,800	-3,806	-6.8	51,223
FRANKLIN	47,260	57,923	10,663	22.6	70,900
GRANVILLE	48,498	56,250	7,752	16	63,644
HALIFAX	57,374	55,217	-2,157	-3.8	54,222
HYDE	5,826	5,516	-310	-5.3	5,066
MARTIN	25,546	23,870	-1,676	-6.6	22,792
NASH	87,385	93,981	6,596	7.5	108,955
PAMLICO	12,934	12,892	-42	-0.3	12,786
PERSON	35,623	37,510	1,887	5.3	38,576
PITT	133,719	155,570	21,851	16.3	200,135
VANCE	42,952	43,502	550	1.3	43,919
WARREN	19,972	19,918	-54	-0.3	19,765
WILSON	73,811	78,917	5,106	6.9	92,253
*NC Office of State Budget and Management http://www.osbm.state.nc.us/					

DWQ also recognizes that greater oversight of local stormwater programs by the state should provide more assurance of full implementation of the rule as well as provide better data to assess the effectiveness of the rule and its various components. One method being considered by staff is conducting periodic audits of each individual stormwater program. The audits would serve to help identify improvements needed in both implementation and reporting.

In addition to the rule's geographic coverage limitations, it does not set a quantitative reduction target for nitrogen loading from existing developed lands. According to land cover data collected by the National Resources Inventory (NRI), as of 1997 approximately 7% of the entire basin is considered developed. Since the current nutrient strategy addresses stormwater from new development starting in 2006, the stormwater runoff from these ~200,000 acres, plus any lands developed between 1997 and 2006, and any land developed after 2006 on which a vested development right was established, has not been subject to the rule. The great majority of these lands are not being treated to achieve nutrient reductions. Treating nutrient runoff from existing development through stormwater retrofit BMPs and other load reducing measures, both structural and management oriented, represents a real opportunity to further reduce existing nutrient loads to the basin from this significant source. A rule to address nutrient contributions from stormwater runoff from existing development could provide municipalities opportunities to receive nutrient reduction through practices such as removing existing impervious cover, buffer restoration, street sweeping, and removal of illicit discharges, in addition to structural retrofits.

There are also potential low cost opportunities to address existing sources of nutrients in runoff from existing development. Existing sources include nutrients from pet waste and over fertilization of turf and landscape areas. Controls could be incorporated into local stormwater programs and ordinances to address these two sources of nutrients. Educational opportunities should be incorporated into established local stormwater programs' public education and outreach requirement. Some local governments in North Carolina already implement pet waste ordinances. Local governments in other parts of the country are beginning to place limitations on home fertilizer use with success as well. One example is the Minnesota phosphorus fertilizer law

(18C.60, MN Statutes 2006) which prohibits use of phosphorus lawn fertilizer unless new turf is being established or a soil or tissue test shows need for phosphorus fertilization.

Agriculture Rule

The progress achieved by the agriculture sector in implementing the Tar-Pamlico Agriculture Rule is well documented in the Annual Agricultural Progress Reports submitted to the EMC every fall since 2003. As of 2002, the agriculture sector exceeded its collective 30% nutrient reduction goal and in 2008 reported a 50% reduction in estimated nitrogen loss to the basin through a combination of BMP implementation, crop shifts, fertilization rate reductions, and loss of overall cropland acres. During implementation, improvements have been made to the accounting of these reductions as more research and data becomes available concerning the effectiveness of agriculture BMPs. Opportunities remain for further improvement to the accounting process and fuller accounting of contributing agricultural sources.

DWQ staff will continue to consult with university researchers and Division of Soil and Water Conservation staff as more data becomes available concerning the efficiencies of agricultural BMPs and how this information can be used to further refine the nutrient reduction credits applied under the current program. In addition to revisiting BMP efficiencies, DWQ plans to continue collaborating with an interagency workgroup started in 2007 to identify methods to better track land use changes. Specifically, staff will be working to develop a “whole basin” land accounting strategy that will work to ensure that accounting for land that goes out of agriculture does not result in double counting of nutrient reductions.

The agricultural Basin Oversight Committee (BOC) was established to oversee the required agricultural nutrient reductions in the Tar-Pamlico basin in response to the NSW strategy. The Agricultural Nutrient Control Strategy (15A NCAC 02B. 0256) describes the role and expectations of the BOC and the Local Advisory Committees (LACs). The BOC develops and approves an annual report based on information provided by the LACs, summarizing local nitrogen and phosphorus loadings and estimated nutrient reductions based on implemented BMPs in the watershed. According to the rule, the accounting methodology shall provide for quantification of changes in nutrient loading due to changes in agricultural land use, modifications in agricultural activity, or changes in atmospheric nitrogen loading to the extent allowed by advances in technical understanding (15A NCAC 02B. 0256. (f)(3)(E)) and this should be done with sufficient detail to allow for compliance monitoring at the farm level. However, the approved accounting methodology supports aggregated county-wide nutrient accounting in the annual reports. Given the requirements of the agricultural rule, it is recommended that the BOC incorporate in their annual accounting estimates adjusted N rates from ammonia deposition and second year N availability contributions, when the data are available.

One potential limitation of the agriculture rule involves pastured livestock nitrogen contributions. Nutrient loading from pasture-based livestock operations has not been well characterized generally, including in NC, and the accounting tool used for rule compliance does not include the ability to quantify the effects of livestock management on nitrogen loading. Additional research is still needed to better quantify the nutrient benefits of various pasture management practices like fencing out livestock, pasture renovation and restoring riparian buffers. Encouraging the use pasture BMPs could represent an opportunity to achieve additional nutrient reductions.

In addition to better potential nutrient loading from pastures, staff also recognizes the need to better understand the role that artificial drainage, such as subsurface tile drains, plays in contributing nutrient loads to the basin. The interception of shallow ground water beneath agricultural fields through tile drains to ditches can increase nitrogen loading into receiving streams by allowing the runoff to bypass BMP treatment. Quantifying the extent of the drains has proven challenging because tile drain maps are either outdated or nonexistent. Additional research is needed to determine the location and geographic extent of tile drains along with mitigation options. Better management of tile drains represents an opportunity for improvement that could result in additional nutrient load reductions. Identification of functioning drainage districts and the types of activities being used to maintain drainage within agricultural lands is also needed to help describe conditions near DWQ monitoring sites.

There is also a need to better understand the potential magnitude of nutrient loading from animal housing, holding, waste storage facilities and sprayfields used by confined animal feeding operations (CAFOs), such as dairies, hog farms, and poultry operations. Subsurface seepage from waste lagoons and ammonia emissions from CAFOs are also not captured under the NSW agriculture rule, but are to some degree addressed under other state rules and programs addressing animal operations. The location of hog and cattle CAFOs are known due to the fact that an NPDES permit is required by DWQ. While their direct nutrient contribution is not currently well understood, knowing that these sources exist in the watershed can help water quality managers to better understand the available water quality data and make better regulatory recommendations and decisions.

Due to a hog farm moratorium put in place in 1997 and a new law passed in 2007 prohibiting the construction of new hog waste lagoons and spray fields as the primary method of waste management (SB 1465), nutrient contributions from hog operations have remained fairly constant over the last several years. However, the continued growth in the poultry industry in the coastal plain of NC is adding to the current nutrient loading from non-point sources. Most poultry operations produce a dry litter by-product which is not regulated. The locations of poultry operations and the disposal of their waste is not known to environmental regulators due to the fact that there are no permitting requirements, making it very difficult to get a complete picture of the possible non-point sources contributions within a specific watershed. This makes managing and protecting water quality more challenging.

The 2007 USDA census data indicates in 2007 there were 7,370,874 chickens in the Tar-Pamlico basin. The number of chickens has likely increased by at least another 3,000,000 totaling over 10,000,000 chickens due to the Rose Acres egg farm continuing to stock their facility. This would result in an increase of at least 35% since 2002. The data that is currently available for the Rose Acres Farm indicates that poultry operations are likely having an impact on the water quality in the Tar-Pamlico River Basin and other coastal basins. It is estimated that 40% of the nitrogen entering the Albemarle-Pamlico Sound originate from atmospheric sources (DENR-DAQ, 1999; Costanza et al., 2008). Due to the prevailing wind direction, the highest nitrogen depositional rates from CAFOs are in the Neuse and Tar-Pamlico watersheds (Costanza et al., 2008). This is likely to increase overtime with the continued growth of the poultry industry in coastal North Carolina.

Point Source Rule

Even though the point sources are meeting their yearly cumulative cap limits, efforts should be focused on achieving Best Available Technology levels within their facilities. The 2014 permit renewal process will include individual permit limits.

Nutrient Contributions from Land Application Sources of Waste

Indirect nutrient loads from point sources and agriculture through groundwater is likely a significant source of nutrient loading to the Pamlico River Estuary. There is a limited amount of research available that quantifies changes and the amount of nutrient contributions from groundwater to surface waters in the basin. Initial research indicates that land application of treated wastewater, biosolids from municipal wastewater treatment systems, and animal waste from confined animal feeding operations (CAFOs) are all considered likely sources of nutrients found in groundwater in the Tar-Pamlico River Basin.

The predominant wastewater treatment systems used at swine CAFOs are lagoons and sprayfields, in which waste is flushed from confined animal housing units into large waste lagoons and then periodically sprayed onto agricultural fields. Similarly, municipal wastewater treatment plants commonly land apply the sludge that is a by-product of the treatment process to agriculture fields as a means of disposal. In both cases the nitrogen contained in the land-applied products will either be assimilated by crops, volatilize into the atmosphere, run off into adjacent streams, or infiltrate into the groundwater system and eventually discharge into streams in the basin (Paerl et al., 2002).

Point sources

As the demand for wastewater treatment increases with population growth, the dischargers will still have to comply with the nutrient reduction goals. DWQ requires new and expanding NPDES permit applicants to consider non-discharge alternatives such as spray irrigation, rapid infiltration basins and drip irrigation systems. Land application of treated wastewater is likely to increase as a means of complying with this rule. Evaluation of the extent that land application may be yielding a net increase in nutrient loading is needed. A better understanding of land application program compliance and compliance criteria is also needed to quantify nutrient loading.

High-rate infiltration

High-rate infiltration systems are a variation of land application systems that have become a growing practice in the coastal plain. These systems are being proposed to address wastewater needs of some new developments where receiving waters would not accommodate direct discharge of treated wastewater and no POTW is available. The new nutrient load from these systems is not captured by the point source rule or other strategy accounting mechanisms. Concerns have been raised about the system's use of landscape features to treat effluent prior to entering the surface waters. Nutrient contributions to surface waters from these systems have not been well quantified.

Biosolids

Residuals, biosolids or treated sludge are by-products of the wastewater treatment process. After pathogen reduction, vector attraction reductions and metal limits are met, these residuals are disposed in a manner to protect public health and the environment. Disposal sites include land fills, dedicated and non-dedicated residual disposal sites, agricultural land for crops not for human consumption, and distribution to the public for home use. When applied to the land, steps must be taken to assure that residuals are applied at or below agronomic rates based on the soil and crop types present at the disposal site. Class B residuals are monitored by DWQ and are applied to fields at agronomic rates. Class A residuals are not monitored by DWQ but can also contribute nitrogen and phosphorus loading within the basin which are not currently accounted for. Additional research would be necessary to determine if organic nitrogen from biosolids is contributing to the basinwide increase in organic nitrogen.

A recent example of how nutrient loading to groundwater can occur from land application of biosolids is the situation at Novozymes in Franklin County. The facility has nitrate-nitrogen groundwater standard exceedances and is likely discharging off-site into local surface waters. The current leaching from the site is a result of past applications >10 years ago and has not been quantified. Novozymes has initiated a groundwater treatment system to address contaminated groundwater. Novozymes' wastewater, now low in nitrogen, is applied to approximately 900 acres of sprayfields. They also have a Class A equivalent biosolids permit for spent biomass (another source of N) from their industry process. These systems provide primary treatment of the wastewater along with some means of disinfection and then they dispose of the treated wastewater on irrigation fields.

While most regulations require that land application not exceed realistic yield-based agronomic rates, studies have shown that nitrate concentrations are higher in groundwater under crop fields sprayed with animal wastes than in groundwater beneath crop fields fertilized with commercial fertilizers (Spruill, 2004). Ideally, nutrient application should be based on crop needs and, for a given crop, there should be no difference in nitrogen loss between nutrient types applied. Given that the use of land application is expected to continue, and in light of the projected increase in human population in the Tar-Pamlico Basin, the continued use of this waste disposal method from such high volume sources highlights the importance of seeking a better understanding of the relative impacts of these practices on nutrient loading to surface waters.

Export of land-applied nutrients to surface waters, whether originating from municipal, commercial, or animal facility is enhanced when the field in question has artificial drainage systems like tile drains. The NLEW accounting tool used for agriculture rule compliance does not capture the effects of drain tiles nor does it reflect the research findings cited above regarding nitrogen concentrations under waste-applied fields.

While not part of the Tar-Pamlico NSW agriculture rule, there are other state rules that regulate land application. These include the 15A NCAC 2T rules, which specify requirements for systems that treat, store and dispose of wastes that are not discharged to surface waters of the state. These rules went into effect in 2006 and replaced the ".0200" or non-discharge rules. While these regulations do not contain nutrient reduction requirements and were not developed to specifically address the 30% nitrogen reduction goal, the rules do require management practices that could help reduce nutrient inputs in the Tar-Pamlico Basin from land application operations.

In addition, in 2007 the NC General Assembly incorporated the findings of the Smithfield Agreement into Senate Bill 1465 (Session Law 2007, Section 523). Senate Bill 1465 prohibits permitting of a new or expanding swine management system utilizing an anaerobic lagoon and sprayfield as the swine farm's primary method of treatment. Senate Bill 1465 also charged the Environmental Management Commission (EMC) to adopt rules to make the performance standards permanent thus allowing for the construction of innovative swine waste management systems for either new farms or for expansion of existing farms. The swine waste management system performance standards are to:

- Eliminate swine waste discharge to surface water and groundwater through direct discharge, seepage or runoff,
- Substantially eliminate atmospheric emission of ammonia,
- Substantially eliminate odor detectable beyond the swine farm property boundaries,
- Substantially eliminate disease-transmitting vectors and pathogens, and
- Substantially eliminate nutrient and heavy metals in soils and groundwater.

In 2007, a petition filed by several environmental groups requested monitoring requirements for general permits for animal feeding operations to ensure compliance with non-discharge effluent limitations. This petition for rulemaking resulted in a public stakeholder process that generated draft rules requiring CAFO facilities to develop monitoring plans that would serve to track the performance of the permitted system, verify that the system is protective of surface water standards and document water quality parameter concentrations in adjacent surface waters and compliance with permit discharge limitations. As of summer 2010 these rules are still draft and it is likely that DWQ and US Geological Services (USGS) will coordinate to do monitoring at swine CAFOs over a two year period. Although, this monitoring is not directly related to the 30% nitrogen reduction goal, the information collected will provide valuable information that will be useful in identifying high priority areas of nutrient inputs from animal waste land application sites.

Nutrient Contributions from Onsite Wastewater Systems

In addition to land application of waste as a potential nutrient source, initial evidence suggests that residential on-site wastewater systems may be a source of nutrients in the basin. A study conducted by researchers at the NCSU Department of Soil Science provided potential nitrogen loading numbers generated by households in the basin that use onsite wastewater systems. It estimates that approximately 49% of households in the Tar-Pamlico River Basin use onsite systems, and the cumulative nitrogen load generated by these systems is 1.76 million lb N/yr (Pradham, 2007). While the study is somewhat limited in that it used 1990 Census data, were this magnitude of loading delivered directly to streams it would rival that delivered to the Pamlico estuary by all other sources combined. Of course these disposal systems rely on nitrogen removal through landscape processes, primarily denitrification and plant uptake. These processes are believed to remove the vast majority of nitrogen generated by onsite systems before it reaches surface waters. However, such landscape processes are variable in nature, and a question requiring additional study is quantifying the extent to which such ground absorption systems may increase N loading to streams as compared to centralized collection of wastewater, and under what landscape conditions. A second question, which is discussed in the following section, involves understanding the temporal pattern of nitrogen movement through groundwater to surface water toward better understanding the relationship between population increases and nitrogen delivery to streams.

One study that begins to answer this question is an unpublished study conducted through a joint effort between the North Carolina Division of Public Health and the United States Geological Survey (USGS) compared the effects of onsite and offsite wastewater treatment on the occurrence of nitrogen in the Upper Neuse River Basin. It concluded that onsite systems contribute slightly more nitrogen to the nutrient load in recharging surface water than the load contributions from similar residences served instead by municipal sewer systems (Grimes & Ferrell, 2005). In light of these findings it is evident that additional research in this area is needed to better quantify the role on-site wastewater treatment systems play in contributing nitrogen to the Tar-Pamlico River Basin.

Nutrient Loading from Groundwater

An area of growing interest involves improving our understanding of the role of groundwater in nutrient loading to the estuary. Harden and Spruill (2008) reported that in North Carolina's Coastal Plain, shallow groundwater contributes at least 40 percent of the average annual stream flows. They have found that nutrient delivery to surface waters via groundwater can be influenced by various environmental, hydrogeological and geochemical factors.

The denitrification processes was shown to be the most significant factor responsible for decreasing groundwater nitrate concentrations. Additional factors influencing the groundwater nitrate concentrations included soil drainage, presence or absence of riparian buffers, evapotranspiration, fertilizer use, groundwater recharge rates and residence times, aquifer properties, subsurface tile drainage, sources and amount of organic matter and hyporheic processes (Harden and Spruill, 2008). They also reported that in the NC Coastal Plain, the nitrate reducing capacity of the buffer and hyporheic zones combined, substantially lowered the amount of groundwater nitrate discharged to streams from agricultural settings. However, the beneficial effects from these denitrification zones was greatly diminished by the presence of subsurface tile drainage that allows groundwater to bypass these natural streamside buffers and organic carbon-rich streambed (Harden and Spruill, 2008).

While there are no specific studies for the Tar-Pamlico River Basin, a study published by USGS in 2008, estimates groundwater nitrogen flux into the Neuse River Estuary and reported nutrient fluxes from groundwater to the estuary account for 6% of the nitrogen inputs derived from all sources and approximately 8% of the nitrogen annual inputs from surface-water inflow to the Neuse River Estuary (Spruill and Bratton, 2008).

In 1997, Spruill presented results from the U.S. Geological Survey's National Water Quality Assessment study indicating that groundwater was also a significant source of phosphorus loading in Coastal Plain streams of the Albemarle-Pamlico drainage basin. He reported that the concentrations of phosphorus were significantly higher in discharging groundwater (median = 0.23 mg/L) than in surface water (median = 0.07 mg/L) and that shallow groundwater typically had lower concentrations (median = ≤ 0.01 mg/L) than deeper groundwater (median = 0.2-0.3 mg/L) (Spruill, 1997).

The nitrogen and phosphorus loads delivered by groundwater were not identified as part of the Tar-Pamlico TMDL, nor assigned a reduction requirement. This was in part because quantitative knowledge was limited at the time on either direct groundwater flux into the estuary or the makeup of groundwater's contribution to loading into basin streams. In addition, from a management standpoint DWQ views groundwater primarily as a pathway rather than a source, and currently we look to manage inputs to this pathway rather than considering treatment of groundwater itself. Over sufficient time, the groundwater nitrogen flux should respond to reductions in landscape inputs. Research is increasingly showing that deeper groundwater flow paths may take on the order of decades to express themselves as surface discharges. This raises several questions including:

- Can we characterize the temporal pattern of groundwater nitrogen delivery to streams?
- Can we reliably monitor changes to both stream and estuary nitrogen inputs over time?
- To what extent have the Tar-Pamlico nutrient rules and other regulations resulted in reductions to landscape N and P inputs?

To begin answering these questions, we recognize that the set of landscape activities that add nitrogen to groundwater are primarily the variety of human and animal waste disposal and crop fertilization activities mentioned in sections above. An additional contribution is the overlay of atmospheric deposition of nitrogen across the landscape, as described in the following section. Much of these groundwater additions occur under the practice of agriculture. The agriculture rule focuses on surface water and does not require reduction of groundwater N inputs by 30%. Certain practices used to meet the agriculture rule, primarily decreasing N fertilization rates, should decrease groundwater N concentrations. Applying the 30% goal to N application would be problematic since the business of growing crops relies on certain application rates, and crops have inherent N use efficiencies that result in the loss of a fraction of that N, often on the order of half, to groundwater. But we believe that actions taken by producers to comply with the Tar-Pamlico agriculture rule should yield decreases in cropland N contributions to groundwater. Similarly, as detailed in the previous section, other regulations should result in decreased groundwater N inputs. The state CAFO regulations initiated in the mid-1990's have yielded significant decreases in waste N land application rates. Changes to residuals application included in the 2T rules should yield similar reductions to application rates for this activity.

The other questions will require us to pursue knowledge improvements by seeking additional monitoring and research into groundwater-to-surface water N dynamics. It will be important to assess the magnitude of contributions through this pathway over years and decades.

Nutrient Loading from Atmospheric Deposition

Atmospheric deposition of nitrogen oxides (NO_x) and ammonia (NH_3) is a significant source of nitrogen input into North Carolina's coastal nutrient sensitive estuaries and sounds (Whitall and Paerl, 2001; Whitall et al., 2003; Costanza et al., 2008). However due to lack of available data at the time, contributions through atmospheric deposition were vastly underestimated in developing the Tar-Pamlico TMDL, nor was it assigned a reduction requirement. Much like groundwater contributions, this was in part because quantitative knowledge was limited at the time on the magnitude of either direct deposition to the surface of the estuary or its contribution to N loading to basin streams. From a management standpoint, atmospheric deposition was viewed primarily as a pathway rather than a source, and currently we look to manage inputs to this pathway rather than considering treatment of atmospheric nitrogen itself. Over sufficient time, atmospheric N deposition rates should respond to reductions by emissions sources. As with groundwater, this raises several questions including:

- To what extent are air quality regulations resulting in reductions to atmospheric N emissions?

- Can we characterize the relationship between reductions in N emissions and reductions in N deposition?
- Can we reliably monitor changes to nitrogen deposition over time?

While the scientific understanding of atmospheric deposition continues to evolve, some general observations can be made about atmospheric deposition as a source of nitrogen input into North Carolina's estuaries. Atmospheric inputs can be divided into two main types:

Direct: those that fall directly into the estuary and

Indirect: those that are deposited on various land surfaces throughout the basin, some portion of which is transported into streams and eventually delivered to the estuary.

As the population grows in the airshed of the Tar-Pamlico River Basin, an increase in NO_x emissions from increased fossil fuel combustion is likely to occur. Ammonia also contributes to atmospheric nitrogen. The majority of atmospheric ammonia in the coastal plan volatilizes from confined animal operations, but sewage treatment plants and fertilizers applied to the land also contribute small amounts (Whitall et al., 2003; Walker et al., 2004). In North Carolina, animal agriculture is responsible for over 90 percent of all ammonia emissions; in turn, ammonia comprises more than 40 percent of the total estimated nitrogen emissions from all sources (Aneja et al., 1998).

In April 1989, the Division of Environmental Management, Water Quality Section reported that 18 percent of the nitrogen budget originated from atmospheric sources (DEM, 1989). The 1994 Tar-Pamlico River Basin Plan noted atmospheric deposition was one of the main cultural sources of nutrients in the estuary along with agricultural runoff, wastewater treatment plants and forestry.

While there are no recent studies indicating the overall amount of atmospheric deposition of nitrogen to the entire Tar-Pamlico River Basin, there are studies that suggest that up to 40 percent of the nitrogen entering the Albemarle-Pamlico Sound comes from atmospheric sources (DENR-DAQ, 1999; Costanza et al., 2008). A recent study on the potential geographic distribution of atmospheric nitrogen deposition from CAFOs in NC reported that due to the high number of CAFO lagoons in the coastal plain and the prevailing southwest wind direction for 10 months of the year, the highest nitrogen depositional rates from CAFOs are in Neuse and Tar-Pamlico watersheds (Costanza et al., 2008). They also reported that between 24 and 47 percent of the Sound receives 50 percent of the atmospheric deposition from these CAFO lagoons (Costanza et al., 2008).

Studies have been conducted to assess the direct and indirect contribution from wet atmospheric N deposition to the Neuse River Basin. The results of one such study completed in 2003 indicates that atmospheric contributions of nitrogen vary seasonally and spatially within the watershed but that overall it accounts for approximately 24% of the total nitrogen load to the Neuse River Estuary, and these contributions have risen over the last twenty years (Whitall et al., 2003). It is likely that these results are similar for the Pamlico River Estuary.

While some of the land-based portion of this loading is addressed through stormwater rules and adjustments to crop fertilization rates, attaining the 30% reduction in nitrogen load to the Pamlico River Estuary may be challenging without first quantifying atmospheric contributions to the watershed more accurately, and eventually seeking appropriate management measures on all significant emission sources.

There is very little data available on the concentrations of dry nitrogen deposition. As with wet deposition, dry deposition rates are expected to vary across the basin depending on the proximity to the source. Initial research by the NC DAQ and EPA suggest that the amount of nitrogen contributed to an area from dry deposition is likely to be at least comparable to if not greater than that contributed through wet deposition.

Emissions from concentrated animal operations comprise the great majority of atmospheric ammonia emissions (Aneja et al., 1998). Currently, these outputs are not directly regulated. However, one recent improvement addresses new and expanding operations. In 2007, the NC legislature enacted a new law (SB 1465) requiring animal waste systems that serve new and expanding swine farms to meet or exceed five performance standards. One of the standards requires such farms to "substantially eliminate atmospheric emission of ammonia." This performance standard specifically requires that "ammonia emissions from the swine farm must not exceed an annual average of 0.9 kg NH_3 /wk/1,000 kg of steady state live weight" (15A NCAC 02T .1307 (2) (C)). This new regulation may be expected to substantially cap NH_3 emissions from swine farms at current levels. However, it does not require reductions from existing operations, nor does it apply to other types of CAFOs, such as cattle and poultry operations. Thus NH_3 emissions from existing CAFOs remain the largest unregulated source of atmospheric nitrogen emissions.

Additional research and monitoring is needed to obtain a complete understanding of the magnitude and variability of all atmospheric nitrogen inputs into the Pamlico River Estuary. Due to the dynamic nature of the airshed, it is also necessary to develop a better understanding of the relationship between emission levels and deposition rates of atmospheric nitrogen. DWQ is working with DAQ staff to identify research opportunities. One such opportunity comes from DAQ modeling work using Community Multi-scale Air Quality modeling system (CMAQ) to conduct emissions modeling. The CMAQ modeling system simulates various chemical and physical processes that are thought to be important for understanding atmospheric trace gas transformations and distributions. The modeling system contains three types of modeling components: a meteorological modeling system for the description of atmospheric states and motions, emission models for man-made and natural emissions that are injected into the atmosphere, and a chemistry-transport modeling system for simulation of the chemical transformation and fate. It is possible that the use of an add-on tool to this model in the future may make it possible to use the output of this model to develop estimates of projected atmospheric nitrogen deposition rates.

Phosphorus Reductions

Phosphorus loading to the estuary decreased significantly as a result of two events. Effective January 1, 1988, the NC General Assembly adopted a statewide phosphate detergent ban, which resulted in significant drops in stream phosphorus concentrations statewide, however this ban does not include dishwasher detergent. Also, in the fall of 1992, PCS Phosphate, located on the Pamlico River estuary in Aurora, began a wastewater recycling program that reduced its phosphorus discharge by about 97 percent. Opportunities to further reduce phosphorus loading include eliminating phosphorus in lawn fertilizers and automatic dishwasher detergent. Several other states have taken this easy step to reduce eutrophication including New York State's recent **law amendment** to limit the amount of phosphorus in dishwashing detergent and limit the use of lawn fertilizer's containing phosphorus.

Estuary Dynamics

Climatic variability also plays an important role in the mobilization, processing, and delivery of nutrients and subsequent chlorophyll *a* response in the Pamlico River Estuary. Conditions in Pamlico River and Sound are more influenced by wind driven tides than the lunar cycle, where climate conditions such as hurricanes and drought impact both nutrient loading and cycling within the estuary. Estuary improvement is a generally complex nature of estuary dynamics; more specifically the potential for continual release of stored nutrients in sediments while water column nutrient concentrations decrease. Water residence time varies between 10 days and 2 months, with an average of 24 days in the Pamlico (Stanley, 1992). However, little is known about the residence time and recycling of nutrients within the estuary. A study is needed to gauge the extent to which purging of estuary sediments may be expected to delay improvements in estuary productivity response.

Summary & Necessary Actions

Full implementation of the nutrient reduction strategy has been a measured process and was finally reached in 2006. Point sources continually have met their targeted nutrient loading caps from the early 1990's. The agriculture community has reduced their estimated nitrogen loss from cropland and pastureland by an average 45%, since 2002. Almost 2,000 fertilizer applicators have received nutrient management training and the six local governments covered under the stepped Stormwater Rule have all adopted and implemented local stormwater programs to limit nitrogen and phosphorus inputs from stormwater runoff resulting from new development. Despite this successful implementation, the goal of a 30 percent reduction in instream nitrogen loading and no net increase in phosphorus loading since 1991 does not appear to have been met, and the Pamlico River Estuary remains impaired.

The estuary is a very complex and dynamic system. Climatic variability plays an important role in the mobilization, processing, and delivery of nutrients to the Pamlico estuary. The estuarine water quality response is affected by climatic events and this variability obscures clear trends in nutrient loading and the estuary's response to these loads, despite efforts to reduce point and non-point source loads. It is important to note that the water quality is assessed every two years in the estuary; each assessment represents data from a specific 5-year data window. The 2008 Impairment data includes data from 2002-2006 and the 2010 data window includes data collected during 2004-2008. Therefore, both of these assessments capture point source and agriculture reductions but likely did not capture reductions made from stormwater improvements. Due to the decades of chronic overloading, the time lag required for nonpoint source input reductions to be fully expressed, and the likelihood of nutrient cycling within the estuary, it may be some time before current reductions in nutrient loading will reflect in improved water quality, and before a definitive assessment of the effect of the strategy on the estuary can be made.

DWQ staff have begun an evaluation of the limitations of the current strategies and identified opportunities for developing a better understanding of the nutrient dynamics for both the Tar-Pamlico and Neuse River systems. While we believe that further analysis of existing data and additional years of data collection will provide greater certainty as to the effect of the strategies on the estuaries, we also recognize the existing strategies limitations and other basin factors that contribute to estuarine conditions. Listed below are the more overarching recommendations and research needs identified in this chapter which will be pursued during this next basin plan cycle.

Source Assessment and Trends

- Coordinate efforts with the Division of Air Quality to assess atmospheric nitrogen contributions to the watershed and develop recommendations on better ongoing characterization of atmospheric nitrogen deposition and emission source regulatory considerations.
    - Specifically address better characterization of the contribution of ammonia emissions from CAFO operations.

- Work with Division of Soil and Water Conservation and Basin Oversight Committee to achieve the following:
    - Identify additional opportunities to offset new or increased sources of nutrients from agricultural operations.
    - Increase the focus on local nutrient control strategies that specify the numbers and types of all agricultural operations within their areas, numbers of BMPs that will be implemented by enrolled operations and acres to be affected by those BMPs, estimated nitrogen and phosphorus reductions and schedule for BMP implementation and efficacy. (In accordance to the Agricultural Nutrient Control Strategy Rule 15A NCAC 02B .0256).

- Continue to work with the US Fish and Wildlife Service to evaluate the impact of the Rose Acres egg-laying operation on the Pocosin Lakes National Wildlife Refuge and the surrounding aquatic ecosystem. Develop recommendations on how to reduce the impacts from this and other poultry operations.

- Continue follow-up actions on hybrid striped bass farms and other fish farms in the lower Basin to improve their effluent quality and better quantify their impact to the Estuary. If warranted, include their nutrient contributions in the Basin's accounting of progress towards meeting nutrient reduction goals.

- Identify the need for additional monitoring locations and parameters to better characterize basin nutrient sources and relative contributions.

- Develop a more detailed analysis of current and historic data in order to better quantify the status of nutrient loading to the estuary; conduct additional trend and loading analysis upstream of the Pamlico River Estuary focusing on smaller watersheds with dominant land use types. This will allow staff to better gauge the effectiveness and progress of strategy implementation.

- Develop a fate and transport model. Required in order to develop individual NPDES nutrient limits per agreement with the USEPA by 2014.

- Utilize the CAFO monitoring plan rulemaking data once it becomes available to help identify sources.

- Assess Tar-Pamlico Buffer compliance.

Stormwater Needs

- Develop a full assessment and recommendations on stormwater programmatic coverage gaps and need to meet nutrient strategy goals on new development activities. Include recommendations on most appropriate regulatory approach.
  - Assessment of stormwater Phase II and Tar-Pamlico Stormwater permitting programs. Make recommendations on how to strengthen the current program to be more environmentally protective. Need to address hydrologic, sediment and nutrient issues.
  - Audit local stormwater programs for effectiveness and work with local governments to strengthen their implementation.

- Evaluate the magnitude of nitrogen loading in runoff from existing development areas and develop recommendations on the need to address this source under the strategy.

- Review stormwater and sediment and erosion control compliance activities; assess need for additional staff for inspection and enforcement needs.

Identified Research Needs

- Develop monitoring to better characterize the nature, magnitude and trends in atmospheric and groundwater derived nutrient contributions to the Tar-Pamlico River Estuary.

- Assess nutrient residence time in the estuary.

- Characterize the location, geographic extent and functionality of tile drains under agricultural fields.

- Quantify the potential magnitude of nutrient loading from spray fields, directly from animal housing and holding, and waste storage facilities on CAFOs.

- Characterize the geographic extent and quantify the potential magnitude of nutrient loading from dry litter poultry facilities, animal housing and waste storage.

•Characterize the potential for groundwater contamination and transport of nutrients from biosolids and wastewater land application fields to the surface waters of the Tar-Pamlico Basin.

•Quantify the nitrogen contributions from conventional on-site wastewater treatment systems to surface waters of the Tar-Pamlico Basin.

•Better quantification of BMP effectiveness (agricultural and stormwater BMPs); improve accounting tools.

•Characterize nutrient loading from various pasture management practices which leads to a better understanding of pasture's nutrient contributions and the value of different management options.

•Explore additional nutrient offset option to be included in the NSW Point/Nonpoint Phase IV Agreement.

•Identify the local Drainage Districts and understand their current role in controlling water flow and drainage issues. Work with the Districts to develop recommendations on how to protect water quality in these areas.

Voluntary Opportunities

•Require stormwater best management practices for existing and new development.

•Develop, strengthen and enforce riparian buffer ordinances.

•Develop and enforce local erosion control ordinances.

•Implement pet waste and residential fertilizer reduction ordinances.

•Work with local resource agencies to install appropriate BMPs in order to reduce the contribution of nutrient, sediment, bacteria and toxicants as well as addresses stormwater volume and velocity issues.

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