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EPA

TMDL CASE STUDY

Tar-Pamlico Basin, North Carolina

Key Feature:	A trading program between municipal dischargers and agriculture as an innovative, cost-effective tool to meet nutrient reduction goals
Project Name:	Tar-Pamlico Nutrient Trading Program
Location:	USEPA Region IV/North Carolina
Scope/Size:	Watershed area 11,650 km^2
Land Type:	Piedmont and Coastal Plain
Type of Activity:	Agriculture, urban
Pollutant:	Nitrogen, phosphorus
TMDL Development:	No
Data Sources:	State
Data Mechanisms:	Hydrodynamic estuarine model, Generalized Watershed Loading Functions (GWLF)
Monitoring Plan:	Yes
Control Measures:	WWTP operational improvements, agricultural BMPs

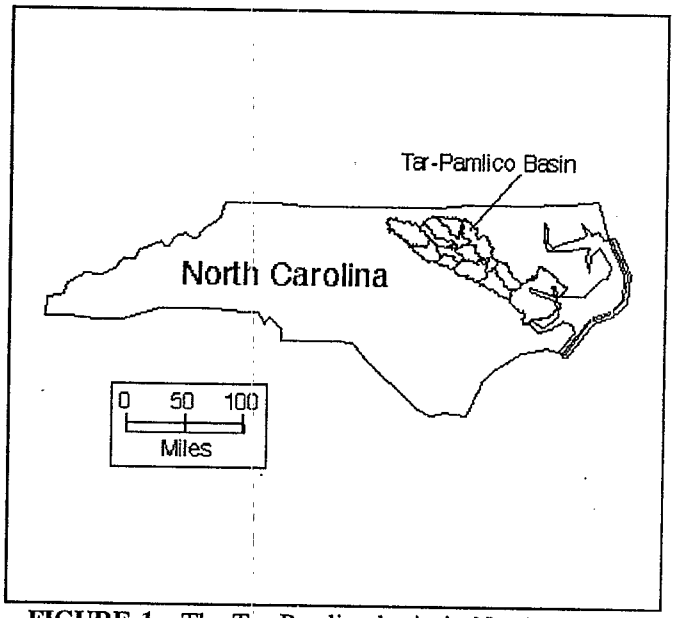

FIGURE 1. The Tar-Pamlico basin in North Carolina

Summary: In recent years, low dissolved oxygen levels, sporadic fish kills, loss of submerged vegetation, and other water quality problems have plagued North Carolina's Tar-Pamlico basin. Studies have linked many of these problems to increased nitrogen and phosphorus loading to the system. In 1989, the North Carolina Environmental Management Commission (EMC) designated the Tar-Pamlico basin as a Nutrient Sensitive Water. The classification, based on years of detailed nutrient loading studies, required the development and implementation of a strategy to manage both point and nonpoint nutrient sources to meet water quality goals.

The North Carolina Division of Environmental Management (NCDEM) responded by developing stricter nitrogen and phosphorus effluent standards for dischargers in the basin. However, dischargers were concerned about the high capital costs that might be required to achieve the nutrient reduction goals. Consequently, a coalition of dischargers, working in cooperation with the Environmental Defense Fund, the Pamlico-Tar River Foundation, and NCDEM, proposed a nutrient trading framework through which dischargers can pay for the development and implementation of agricultural best management practices (BMPs) to achieve all or part of the total nutrient reduction goals. The EMC approved the program in December 1989, and the implementation phase (Phase 1) is currently under way. As a condition of EMC's approval, the discharger coalition agreed to fund the development of an estuarine model. The model will be used as a tool to evaluate specific nutrient reduction strategies for the basin. This information will then be used to revise effluent nutrient standards for Phase 2 of the project. The nutrient trading program is proving to be a popular solution, largely because it achieves the state's nutrient reduction goals and addresses nonpoint loadings while also reducing the economic burden to municipal dischargers.

Contact: David Harding, North Carolina Department of Environment, Health, and Natural Resources, Division of Environmental Management, PO Box 29535, Raleigh, NC 27626-0535, phone (919) 733-5083

BACKGROUND

The Resource

North Carolina's Tar-Pamlico basin encompasses 11,650 km^2 and portions of 17 counties. Its waters are a highly valued natural resource that supports commercial and recreational fisheries, recreational boating, swimming, and many other beneficial uses. The basin also serves as the primary source of drinking water for eight cities and towns in central and eastern North Carolina, including Rocky Mount and Greenville (NCDEM, 1987).

The Tar River constitutes the upper portion of the basin, flowing for roughly 140 miles through the North Carolina piedmont and across the coastal plain (Figure 2). The Tar gradually widens to form the Pamlico River just east of Washington, North Carolina. The Pamlico River becomes the Pamlico Estuary and flows approximately 35 miles before entering Pamlico Sound on the North Carolina coast. The Sound is protected by an extensive barrier island system with only a few small inlets connecting to the Atlantic Ocean (NCDEM, 1989).

Agriculture and forest are the dominant land uses in the Tar-Pamlico basin. While forest in the upper half of the basin is largely undisturbed, a large portion in the lower coastal plain is managed for logging. Thirty-seven percent of the basin is devoted to agriculture, which is predominantly row crop cultivation and intensive livestock operations. Five of the state's 10 leading hog-producing counties, as well as the leading chicken-producing county, are in the basin (Harding, 1990). As of 1989, there were approximately 875 hog, chicken, dairy, and turkey operations. Many of these have expanded beyond their original capacities or are using outdated waste management facilities. Table 1 summarizes population data for hogs, cows, and chickens in the Tar-Pamlico basin.

Increasing fertilizer use, expanding livestock operations, and a growing human population have been affecting the waters of the Tar-Pamlico basin for more than three decades. In recent years, the effects have included diseased fish, sporadic fish kills, increased sediment and nutrient loads, phytoplankton blooms, and low dissolved oxygen (DO) levels. High nutrient loads have been associated with dinoflagellate blooms in the estuary. These blooms produce large amounts of organic carbon, which can lead to oxygen depletion in bottom waters; in fact, DO concentrations as low as 0.5 mg/L have been recorded and associated with fish kills. The state's DO standard for most of the basin is 5 mg/L. In 1986, 10 percent of all chlorophyll-*a* samples taken in the Pamlico Estuary exceeded the state standard of 40 μg/L (Steel, 1991). Losses of submerged aquatic vegetation have also impaired the economically valuable commercial fisheries in the Pamlico River Estuary (NCDEM, 1987).

Programmatic Issues

Declining water quality has sparked substantial concern and activity on the part of the state government and environmental organizations such as the Environmental Defense Fund and the Pamlico-Tar River Foundation. Several large research projects, including the Albemarle-Pamlico Estuarine Study, have studied the effects of nutrients, sediment, and toxic loads on waters in the basin. North Carolina's 1992 305(b) report states that 59 percent of the stream miles in the Tar-Pamlico basin are supporting their designated uses, 25 percent are partially supporting, and 7 percent are not supporting. The report identifies agricultural runoff as the major source of impairment.

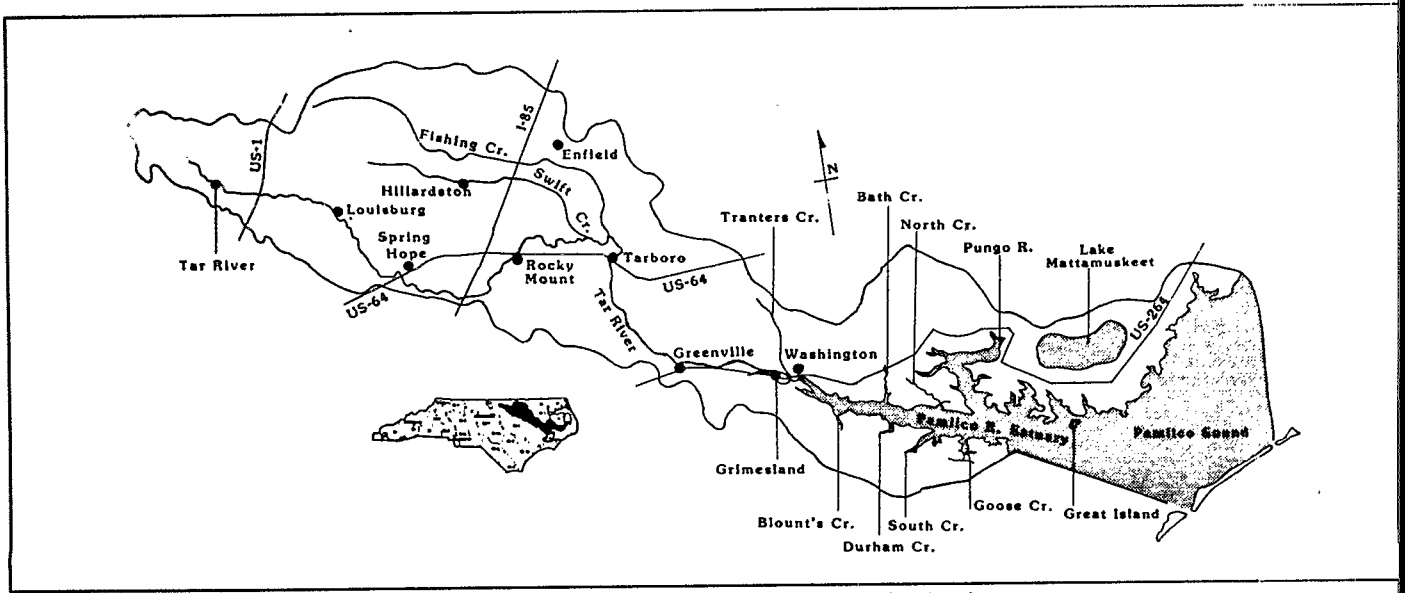

FIGURE 2. Schematic of the Tar-Pamlico Basin

TABLE 1. 1990 Livestock Data for the Tar-Pamlico Basin (NCDA, 1990)

Animal	Total Number	Number/km^2
Chickens	3,937,240	350.2
Hogs	295,725	26.3
Beef cattle	14,479	1.28
Milk cows	1,838	0.167

Six waterbodies in the Tar-Pamlico basin are on the state's 1992 303(d) list (R. Swanek, North Carolina Division of Environmental Management, personal communication, August 9, 1993). The state is currently conducting several allocation studies that would qualify as TMDLs under section 303(d). Under North Carolina's new basinwide planning process, each major basin in the state comes up for review on a 5-year cycle. North Carolina plans to match the development of formal TMDLs with the basinwide planning cycle. The final basinwide plan for the Tar-Pamlico is due in August 1994. The nutrient load reductions and allocation strategy on which the Tar-Pamlico Nutrient Trading Program is based will probably be submitted as a formal TMDL after the basin plan is complete.

ASSESSING AND CHARACTERIZING THE PROBLEM

Nitrogen and phosphorus loading to the Tar and Pamlico Rivers are the primary cause of degraded water quality in the Pamlico River Estuary. Nitrogen and phosphorus are critical nutrients for algal growth and, in sufficient quantities, support algal blooms that consume DO as they decay (NCDEM, 1989).

A nutrient source budget (i.e., an accounting of the magnitude of all nutrient sources in the watershed) was prepared for the Tar-Pamlico basin in 1986. However, two major events that have a significant impact on present and future phosphorus budgets have occurred since the budget calculations. First, the North Carolina General Assembly enacted a ban on the sale of phosphate detergents. Then, a new NPDES permit was issued to Texasgulf Industries, Inc., a phosphate mining operation whose total phosphorus loads accounted for 50 percent of the phosphorus budget for the entire basin. After revising the budget for expected changes due to the phosphate ban and the Texasgulf permit, the North Carolina Division of Environmental Management (NCDEM) estimated that approximately 66 percent of the total phosphorus in the basin comes from nonpoint sources. Approximately 25 percent comes from WWTPs, and the remaining 9 percent comes from Texasgulf Industries, Inc. Eighty-three percent of the total nitrogen in the basin comes from nonpoint sources, primarily agricultural runoff and, to a lesser extent, urban runoff and atmospheric deposition (NCDEM, 1989). Most researchers agree that nitrogen is the limiting factor for plant growth in the estuarine portion of the Tar-Pamlico basin (NCDEM, 1987). The revised 1988 nutrient budgets for the basin (after the phosphorus ban and the Texasgulf permit implementation) are summarized in Figure 3.

MANAGING POLLUTANT LOADS

The Initial Nutrient Control Strategy

In April 1989 North Carolina's Environmental Management Commission designated the Tar-Pamlico basin as a Nutrient Sensitive Water (NSW). Under provisions of state law, this designation requires the development and implementation of a management strategy for both point and nonpoint nutrient sources.

The development of a comprehensive strategy for the Tar-Pamlico was complicated because the phosphate ban and the new Texasgulf permit were enacted after the nutrient budgets had been calculated. NCDEM was uncertain about how much these changes would improve water quality; however, because of continuing development, they could not afford to wait until all the necessary information had been obtained through research. Consequently, the state proposed an interim strategy that required mandatory limits on nitrogen and phosphorus for new and expanding dischargers in the basin. The aim of the strategy was to halt point source increases until a scientifically defensible nutrient reduction plan could be designed and implemented. The NSW strategy specified effluent concentration limits of 2 mg/L for total phosphorus throughout the year, 4 mg/L for total nitrogen in the summer, and 8 mg/L for total nitrogen in the winter.

Dischargers in the basin responded to the state's initial strategy with concerns regarding the high costs of new facility construction to meet the nutrient control goals. The dischargers soon formed a coalition, the Tar-Pamlico Basin Association, and began negotiations with the state, the Environmental Defense Fund (NCEDF), and the Pamlico-Tar River Foundation. In 1989, the Association proposed a new strategy that allows for "nutrient trading" between point source dischargers and agricultural operations while meeting the overall nutrient reduction goal.

An Alternative Allocation Strategy—Nutrient Trading

Under the nutrient trading proposal, the Association contributes funding for agricultural best management practices (BMPs) in order to achieve all or part of the total nutrient reduction goals established for the member

facilities. The underlying premise is that nutrient reductions via BMPs can sometimes be more cost-effective (on a per kilogram removal basis) than capital outlays for new treatment facilities. The Association estimates that controlling one unit of nonpoint source loads with BMPs costs one-tenth as much as controlling the same load from a wastewater treatment plant (M. Green, Tar-Pamlico Basin Association, personal communication, July 30, 1993).

The nutrient trading proposal was approved by the North Carolina Environmental Management Commission in December 1989. The program sets up an overall reduction goal and then allows nutrient sources to find the most cost-effective way to allocate allowable loads. Polluters have the flexibility to trade reduction credits among themselves or to pay to control pollution at other sources, such as pig or chicken farms, as long as the total nutrient limit for the basin is not exceeded (NCEDF, 1993).

Determining Initial Load Reductions

NCDEM projected the 1994 flow for all the municipal Association members at 30.55 million gallons per day (mgd). Assuming no nutrient reductions from pre-strategy conditions, NCDEM estimated that total nutrient loading in 1994 would reach 625,000 kg/yr. Under the original NSW proposal, which required mandatory phosphorus and nitrogen limits for point sources, projected loadings for 1994 would decrease to an estimated 425,000 kg/yr, a reduction of 200,000 kg/yr. Subsequently, NCDEM, the Association, NCEDF, and the Pamlico-Tar River Foundation together established 200,000 kg/yr as the reduction goal for Phase 1 of the Nutrient Trading Program. Of this, 180,000 kg/yr is for nitrogen and 20,000 kg/yr is for phosphorus (NCDEM, 1992). The program was a popular solution because it fulfilled the state's NSW reduction goals, addressed nonpoint source concerns, and reduced the economic burden to municipal dischargers.

Determining Control Costs

The estimated cost of achieving the 200,000 kg/yr nutrient reduction goal using agricultural BMPs alone was $11.8 million—$10 million on the ground and $1.8 million in administration (Harding, 1990). These values were determined by multiplying the reductions by a factor of $56 per kg per year, the estimated cost for removing 1 kg of nutrient per year using BMPs. The rate was drawn from BMP funding experience in the adjoining Chowan River basin. The calculation of the cost factor included a margin of safety by multiplying by a factor of 3 for cropland BMPs and by a factor of 2 for animal BMPs (NCDEM, 1992).

IMPLEMENTING THE NUTRIENT TRADING PROGRAM

Phase 1

Implementation of the Nutrient Trading Program is being divided into phases. Phase 1 of the program will last 5

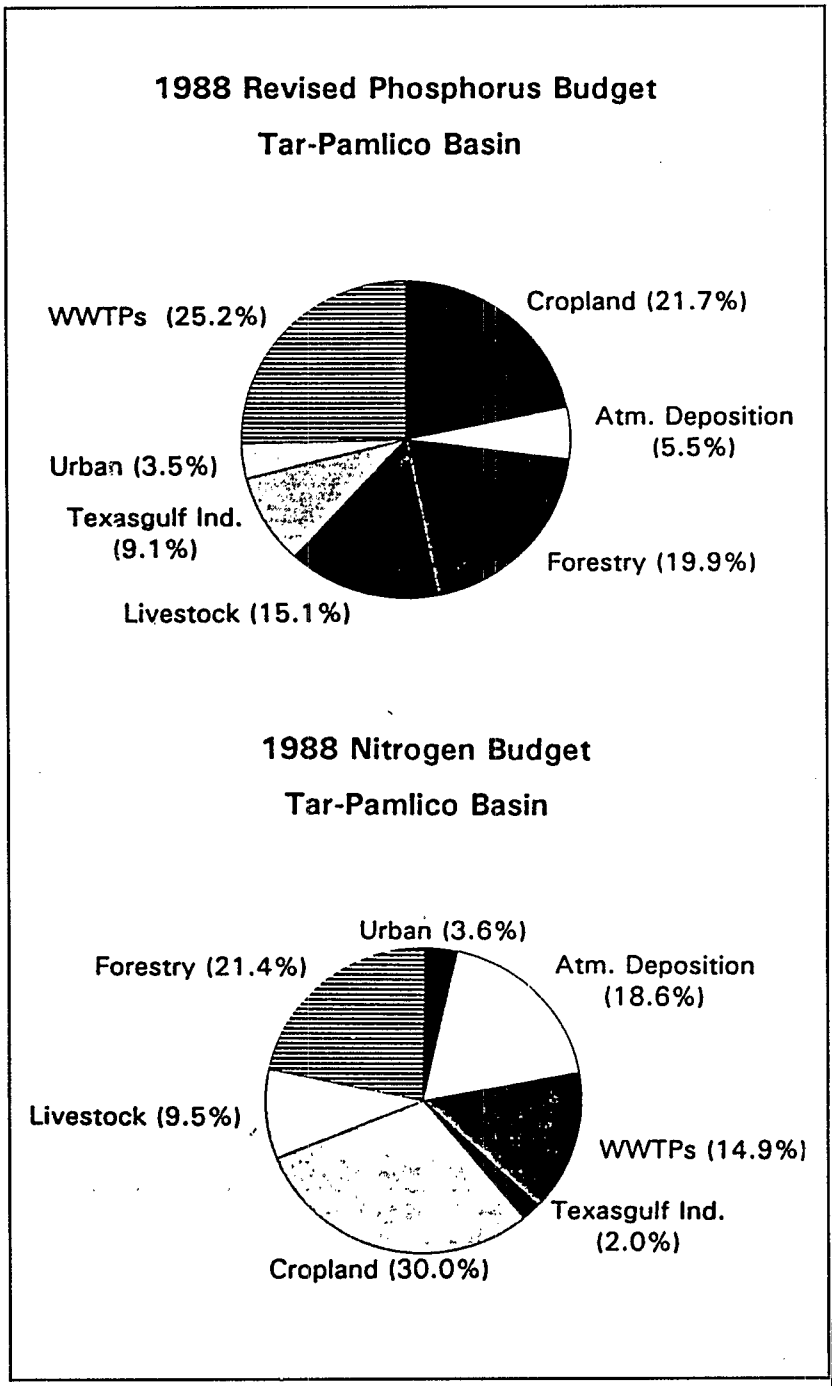

FIGURE 3. The 1988 nitrogen and phosphorus source budgets for the Tar-Pamlico Basin (NCDEM, 1989)

years, during which time the trading approach will be refined and evaluated. As part of Phase 1, NCDEM requires that the Association meet the following conditions to maintain the nutrient trading option:

- *Develop an estuarine model*

  The Association is funding the development of an estuarine model to assess the relative importance of different nitrogen and phosphorus sources (i.e., wastewater dischargers, nonpoint, sediment, and atmosphere) to algal growth and oxygen stress. This three-dimensional model combines both hydrodynamic and water quality components to simulate DO depletion, algal growth, concentrations of soluble and particulate nutrients, and several other parameters of concern. Recommendations for Phase 2 nutrient goals will be based on the results of this model.

- *Evaluate existing wastewater treatment plants*

  The Association hired a consultant to comprehensively analyze the 12 participating municipal plants and to determine the changes needed to ensure that they are operating at the highest level of efficiency. The municipalities will implement the operational and minor capital improvements recommended by the consultant, attempting to achieve the original NSW effluent goals of 2 mg/L total phosphorus, 4 mg/L total nitrogen in summer, and 8 mg/L total nitrogen in winter.

- *Fund the design and administration of the Nutrient Trading Program*

  The Association will provide $150,000 over a 2- year period to fund additional personnel in the North Carolina Division of Soil and Water Conservation (NCDSWC). These funds will be used to design and establish the nutrient trading system, including targeting and documenting BMP implementation.

Ten of the 21 major municipal dischargers (design flow >0.1 mgd) in the Tar-Pamlico basin have joined the Association. Two smaller municipal dischargers are also members. One industrial discharger is a member of the Association; however, its membership includes an exemption from weekly monitoring provisions. Membership in the Association is voluntary, but if dischargers choose not to participate in the nutrient trading program they will be subject to the NSW nitrogen and phosphorus limits as previously discussed.

The Association has obtained an EPA grant to fund the development of a nutrient management decision support system. The system will use geographic information system (GIS) technology to track monitoring information, point source loads, and BMP implementation data. The system will also incorporate a watershed nutrient and sediment loading model based on the Generalized Watershed Loading Functions (GWLF) (Haith et al., 1992). The model will function as a tool to assist in targeting subbasins for BMP implementation. GWLF includes routines for calculating point source loads, as well as dissolved- and solid-phase nonpoint source loads from rural, urban, and septic sources (RTI, 1992).

Under the Tar-Pamlico Nutrient Trading Program, dischargers are free to trade reduction debits and credits among themselves, as long as the loading standards for the basin are met. This allows Association members to maximize the cost-effectiveness of their operations. However, the state will continue to use individualized permitting and enforcement to control any localized impacts that may occur. Nutrient trading avoids the inefficiencies and costs associated with prescribing controls for each discharger.

The opportunity to develop and implement the Nutrient Trading Program was made possible by the state's use of the Basinwide Planning Process. Under Basinwide Planning, a basin is viewed as the basic unit for water quality management, allowing the State to evaluate and address the primary causes of pollution in a basin, as opposed to constantly traveling throughout the state to "put out fires."

Funding BMP Implementation and Maintenance

The Association payments go to the North Carolina Division of Soil and Water Conservation, which then distributes the monies to the local soil and water conservation districts. The conservation districts distribute the funds to BMP projects via the North Carolina Agricultural BMP Cost Share Program. At the District level, a ranking process is used to allocate cost-share funds to agricultural operations according to the severity of nutrient control problems. NCDEM has set up a schedule for determining allowable nutrient loads and payments during Phase 1 (Table 2). If the total loads for the participating dischargers exceed the allowable load for that year, the Association will pay an amount equal to $56 times the excess loading (kg).

The results of the WWTP engineering evaluations indicate that a majority of the required nutrient reductions can be achieved through operational changes and minor capital improvements. Consequently, the actual level of BMP funding is likely to be substantially less than $11.8 million, which was estimated assuming all nutrient reductions would be achieved via BMPs.

To ensure the operation of the Nutrient Trading Program and the availability of funds, the Association has agreed

TABLE 2. Schedule of Nutrient Loads and Payments (NCDEM, 1992; P. Blount, City of Rocky Mount, North Carolina, personal communication, August 10, 1993)

Calendar Year	Allowable Nutrient Load (kg)	Actual Nutrient Load (kg)	Payment for Exceeding Allowable Load ($)	Minimum Payment[a] ($)	Report Results	Payment Due
1991	525,000	455,685	0.00	150,000	March 1, 1992	September 30, 1992
1992	500,000	422,962	0.00	250,000	March 1, 1993	September 30, 1993
1993	475,000	n/a	n/a	100,000	March 1, 1994	September 30, 1994
1994	425,000	n/a	n/a	n/a	March 1, 1995	September 30, 1995

[a] to ensure the operation of the Nutrient Trading Program

to make yearly minimum payments to the trading fund (Table 2). These funds are in addition to the $150,000 administrative payments and will be used to fund BMP implementation. For 1991 and 1992, the Association's total loading was less than the maximum allowable load. Consequently, the Association has paid the minimum each year. When calculating loading payments for a given year, the Association will receive credit for minimum payments made in prior years. All BMP credits will have a useful life of 10 years unless otherwise specified.

Currently, NCDEM is conducting a pilot BMP project on Chicod Creek, a coastal plain tributary to the Tar River. Chicod Creek has been identified by the state as severely impacted due to runoff from animal operations. The purpose of the project is to quantify the effectiveness of various animal waste management BMPs. The project is funded by EPA appropriations obtained through the efforts of the Association. The results of this study will provide important information on how BMP monies can be effectively targeted in other portions of the Coastal Plain.

Monitoring

Since July 1991, Association facilities have been performing weekly effluent monitoring for total phosphorus, total nitrogen, and flow. The Association reports monitoring data to NCDEM annually. NCDEM has developed a set of guidelines for estimating flow and concentration if this information is not provided.

Phase 2

Phase 2 of the Tar-Pamlico Nutrient Trading Program will be initiated in January 1995. At that time, the estuarine model will be complete and will be used to determine nutrient reduction goals for the whole basin. Essentially, Phase 2 will refine the simple loading calculations that were conducted to set goals for the initial phase of the project. Details of this phase will be determined primarily by the success of Phase 1 and the results of the estuarine model.

NCEDF has proposed wetlands restoration as a key strategy in Phase 2 of the program; however, details regarding implementation of this strategy have not yet been defined. Over the past 30 years, an estimated 50 percent of the Pamlico's wetlands have been destroyed. Wetlands control excessive nutrients by trapping pollutant-laden sediment, blocking erosion, lowering flood peaks, trapping nutrients in vegetation, and burying nutrients in soil. On Chicod Creek, in addition to NCDEM's efforts, NCEDF is developing high-resolution maps to pinpoint degraded wetlands and areas of major nonpoint source pollution. This information will be used to set priorities for restoring former wetlands based on their potential for reducing pollution (NCEDF, 1993).

CONSIDERATIONS

The Tar-Pamlico Nutrient Trading Program has largely been the subject of praise from the state, dischargers, and environmental groups. By addressing nonpoint sources, the state and environmental groups have gained a reduction program that is more comprehensive than the original NSW strategy. Dischargers are benefitting from the increased flexibility and cost-effectiveness of the trading approach. However, Phase 2 will be met with a number of challenges, including tracking compliance, determining accountability, and making sure that load reductions are actually achieved. The trading program is designed so that once a discharger makes a trading payment to the state for BMPs, its responsibility for that share of pollutant reduction ends for that year. The $56 per kilogram per year trading factor is also a subject of continued debate. The technical basis for the value is poorly documented and must be further validated. In addition, the plan does not include provisions for escalating the factor due to inflation or other factors (Woods, 1991). The Association has applied for a USDA grant to study BMP effectiveness to address these

challenges in Phase 2 (M. Green, Tar-Pamlico Basin Association, personal communication, July 30, 1993).

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This case study was prepared by Research Triangle Institute, Research Triangle Park, NC, in conjunction with USEPA, Office of Office of Wetlands, Oceans, and Watersheds, Watershed Management Section. To obtain copies, contact your EPA Regional 303(d)/TMDL Coordinator.