Total Maximum Daily Loads of
Nitrogen and Phosphorus for
Corsica River

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List of Abbreviations

7Q10	7-day consecutive lowest flow expected to occur every 10 years, also known as the "design stream flow"
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous Oxygen Demand
CEAM	Center for Exposure Assessment Modeling
CWA	Clean Water Act
DMR	Discharge Monitoring Report
EPA	Environmental Protection Agency
EUTRO5	Eutrophication Module of WASP5
FA	Future Allocation
CREM	Corsica River Eutrophication Model
LA	Load Allocation
MDA	Maryland Department of Agriculture
MDE	Maryland Department of the Environment
MOS	Margin of Safety
NBOD	Nitrogenous Biochemical Oxygen Demand
NH3	Ammonia
NO23	Nitrate + Nitrite
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
ON	Organic Nitrogen
OP	Organic Phosphorus
PO4	Ortho-Phosphate or Inorganic Phosphorus
SOD	Sediment Oxygen demand
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WASP5	Water Quality Analysis Simulation Program 5
WLA	Waste Load Allocation
WQLS	Water Quality Limited Segment
WWTP	Wastewater Treatment Plant

PREFACE

Section 303(d) of the federal Clean Water Act directs States to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards. For each WQLS, the State is to establish a Total Maximum Daily Load (TMDL) of the specified substance that the water can receive without violating water quality standards.

The Corsica River was identified on the State's 1996 list of WQLSs as impaired by nutrients (nitrogen and phosphorus). This report documents the proposed establishment of two TMDLs for the Corsica River: one for nitrogen and one for phosphorus.

Once the TMDLs are approved by the United States Environmental Protection Agency (EPA) the approved TMDLs will be documented through the State's Continuing Planning Process. In the future, the established TMDLs will support point and nonpoint source measures needed to restore water quality in the Corsica River.

EXECUTIVE SUMMARY

This document establishes Total Maximum Daily Loads (TMDLs) for nitrogen and phosphorus in the Corsica River. The Corsica River is a tributary of the Chester River, and is part of the Upper Eastern Shore Tributary Strategy Basin. The river is impaired by the nutrients, nitrogen and phosphorus, which cause excessive algal blooms and can cause exceedances of the dissolved oxygen standard.

The water quality goal of these TMDLs is to reduce high chlorophyll-a concentrations (a surrogate for algal blooms), and maintain dissolved oxygen standards at levels where the designated uses for the Corsica River will be met. The TMDL was determined using the WASP5 water quality model. Total loading caps for nitrogen and phosphorus entering the Corsica River are established for both low flow conditions and for annual loads.

As part of the TMDL process, the model was used to investigate seasonal variations and to establish margins of safety that are environmentally conservative. Load allocations are determined for distributing allowable loads between point and nonpoint sources. The estimated annual nonpoint source loads for the TMDLs are based on land uses projected to the year 2000. The annual point source load allocations are based on projected maximum design flows at the existing point source, assuming biological nitrogen removal and chemical phosphorus removal at the Centreville Wastewater Treatment Plant. The low flow nonpoint source loads for the TMDLs are established as the estimated base flow concentration times the base flow. The low flow point source allocation is based on projected maximum design flows at the Centreville Wastewater Treatment Plant, assuming summer performance of biological nitrogen removal and chemical phosphorus removal.

The low flow TMDL for nitrogen is **1379** lbs/month, and the low flow TMDL for phosphorus is **202** lbs/month. These TMDLs apply during the period May 1 – October 31, and will be implemented through NPDES permits. The annual TMDL for nitrogen is **287,670** lbs/yr, and the annual TMDL for phosphorus load is **22,244** lbs/yr.

Three factors provide assurance that these TMDLs will be implemented. First, for the low flow TMDL, which is driven primarily by point source loads, NPDES permits will play a major role in assuring implementation. Second, for the average annual TMDLs, which involve more significant nonpoint source considerations, Maryland has several well-established programs that will be drawn upon, including the Tributary Strategies developed in accordance with the Chesapeake Bay Agreement. Finally, Maryland has adopted a watershed cycling strategy, which will assure accountability that routine future monitoring and TMDL evaluations are conducted.

1.0 INTRODUCTION

The federal Clean Water Act Section 303(d)(1)(C) and federal regulation 40CFR§130.7(c)(1) direct each State to develop a Total Maximum Daily Load (TMDL) for each impaired water on the Section 303(d) list, taking into account seasonal variations and a margin of safety (MOS) to account for uncertainty. A TMDL reflects the total pollutant loading of the impairing substance a waterbody can receive and still meet water quality standards. The Corsica River was first identified on the 1996 303(d) list submitted to EPA by the Maryland Department of the Environment**.** It was listed as being impaired by nutrients. This document establishes TMDLs for the nutrients nitrogen and phosphorus in the Corsica River.

The Corsica River was identified as being impaired by nutrients due to signs of eutrophication. Eutrophication is the overenrichment of aquatic systems by excessive inputs of nitrogen and phosphorus**,** and was evidenced in the Corsica River by high chlorophyll-a levels. Land development as well as the addition of point source discharges can increase the rate of eutrophication to problematic levels. Highly eutrophic waters will characteristically have fewer species present, and particularly high concentrations of algae. Due to the algae**,** dissolved oxygen levels are likely to fluctuate between day and night, which can cause fish kills. The estuarine portion of the Corsica River below Earl Cove is classified as a Use II water and all free flowing tributaries are classified as Use I waters according to the Code of Maryland Regulations 26.08.02. High concentrations of algae and wide fluctuations in dissolved oxygen can interfere with the designated uses for the Corsica River, and therefore cause a violation of the water quality standards of the State. For these reasons, this document will address high levels of nitrogen and phosphorus, to control chlorophyll-a concentrations (a surrogate for algal blooms) and to maintain dissolved oxygen standards.

2.0 SETTING AND WATERQUALITY DESCRIPTION

2.1 General Setting and Source Assessment

The Corsica River, a tributary of the Chester River, is located in Queen Anne’s County, Maryland. The Corsica River is approximately 6 miles in length (refer Figure 1). The watershed of the Corsica River has an area of approximately 25,000 acres or 40 square miles. The predominant land use in the watershed is shown in Figure 2. The predominant land use, based on 1994 Maryland Office of Planning information, is agricultural (15,600 acres or 62%), forest (6,700 acres or 27%), urban (1,400 acres or 5%), and open water (1,400 acres or 6%). The estimated land use for these categories is graphically represented in Figure 3. The upper free-flowing portion of the Corsica River traverses primarily agricultural lands, with some forested areas. The Town of Centreville, county seat of Queen Anne’s County, is located at the head of tide. The lower, tidal portion enters the Chester River near Town Point in the oligohaline salinity zone. Much of the shoreline of the Corsica River’s tidal portion is classified as agricultural, with scattered forested areas and coastal shallow fresh marsh. Depths of the river range from 1-2 feet in the headwaters to greater than 15 feet in the tidal zone prior to the river’s confluence with the Chester River.

Corsica River Drainage Basin

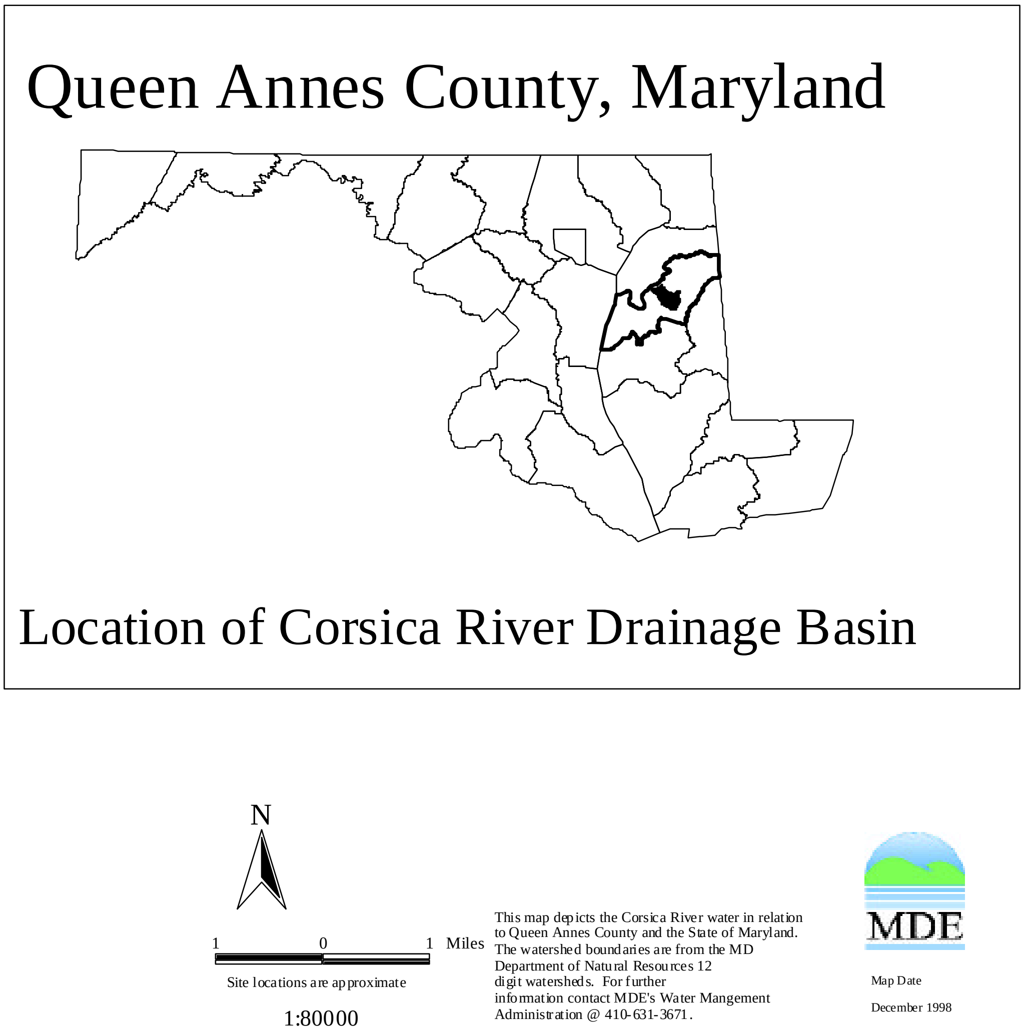

Figure 1: Location Map of the Corsica River Drainage Basin within Maryland

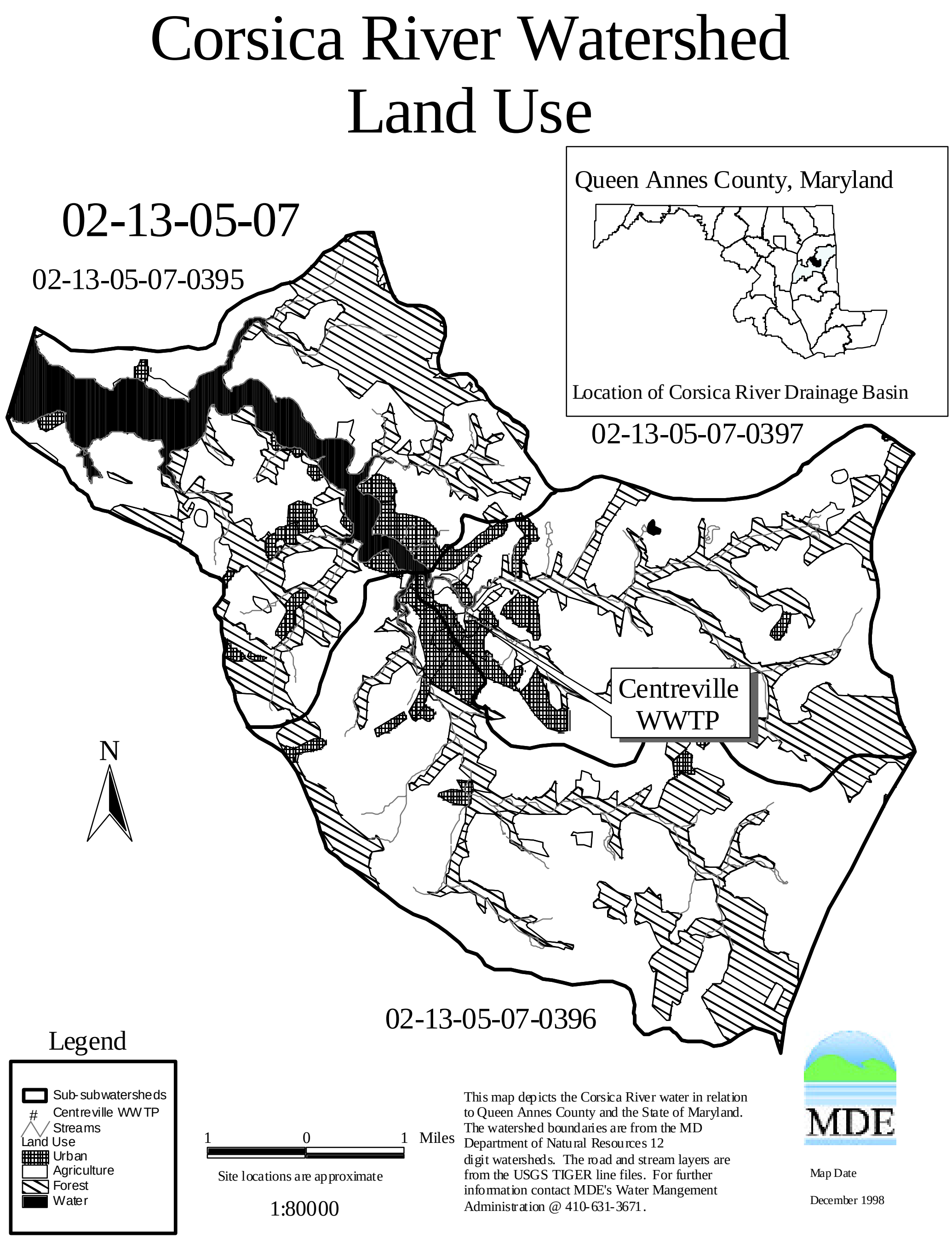

Figure 2: Predominant Land Use in the Corsica River Drainage Basin

The average depth of the river is given as 6.2 feet (Cronin and Pritchard, 1975). For location map of the Corsica River Drainage Basin within Maryland refer Figure 1.

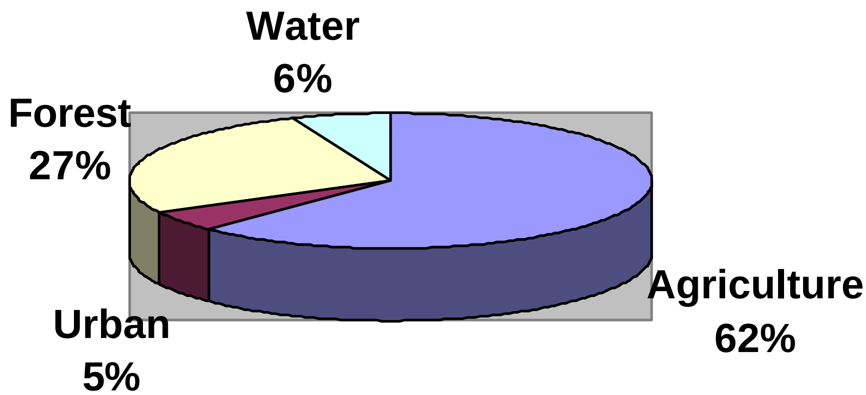

Figure 3: Estimated Land Use in the Corsica River Drainage Basin

The tidal portion of the Corsica River is *a slow flowing system* located in the Coastal Plain Province. The drainage basin is generally flat, and the soils are typically classified as Sassafrass and other loams (Soil survey, Queen Anne's County, Maryland, USDA). The net change in water height due to tidal action averages ~1.7 feet (Beatty, 1997).

In the Corsica River watershed the total nutrient load coming from nonpoint sources is a total nitrogen load of 268,211 lb/yr, and a total phosphorus load of 19,380 lb/yr. The existing nonpoint source loads were determined using a land use loading coefficient approach. The Corsica River Basin was digitized and overlaid onto a land use map using ARC/INFO GIS. The land use map was based on 1994 Maryland Office of Planning data. Next, the total nonpoint source load was calculated summing all of the individual land use areas multiplied by the corresponding land use loading coefficients. The loading rates were based on the results of the Chesapeake Bay Model (U.S. EPA, 1991), which was a continuous simulation model. The Chesapeake Bay Program nutrient loading rates account for atmospheric deposition, loads from septic tanks, and loads coming from urban development, agriculture, and forest land.

The point source loads came from the discharge monitoring reports (DMRs) stored in MDE's point source database. The year 1997 was used because this is the most recent year for which point source data is presently available. For both nutrients, nonpoint sources are the single greatest load, with agriculture the dominant source for both nitrogen (86 % of the total load and 90 % of the nonpoint source) and phosphorus (84 % of the total load and 95 % of the nonpoint source load). The Centreville Wastewater Treatment Plant (WWTP), with an annual average flow of 0.312 million gallons per day (mgd) in 1997 and a design capacity of 0.375 mgd is the only point source. The Centreville WWTP contributes 4% of the total nitrogen load and 11% of the total phosphorus load. Nitrogen and phosphorus point and nonpoint source loadings are shown in Figure 4.

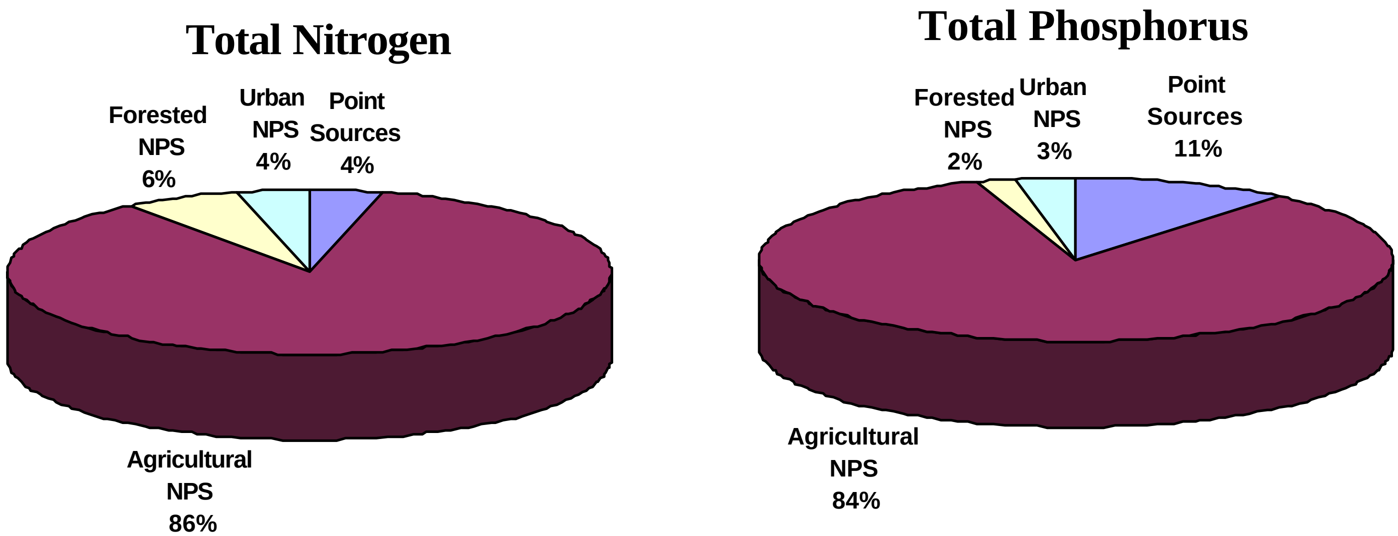

Figure 4: Nitrogen and Phosphorus Point and Nonpoint Source Loadings

2.2 WATER QUALITY CHARACTERIZATION

The water quality of four physical parameters, chlorophyll-a, inorganic phosphorus, total nitrogen, and dissolved oxygen, were examined to determine the extent of the impairment in the Corsica River. Two water quality surveys were conducted in the Corsica River watershed in the summer of 1997. For complete details of water quality data refer to Appendix A. Figure 5 identifies the locations of the water chemistry sites sampled during each survey. The summer represents critical conditions for the Corsica River. This is because there is less water flowing in the channel, higher concentrations of nutrients, and the water temperatures are usually warmer creating good conditions for algal growth. The water quality data from 1997 was used because it was comprehensive. Previous intensive surveys conducted in 1992 and 1993 concentrated on the headwaters areas near the current Centreville Wastewater Treatment Plant discharge point, and extended down only to the Watson Road Bridge (Station COR0056 on Figure 5). This location is not far enough downstream in the Corsica River to be useful for determining a TMDL for the entire Corsica River basin.

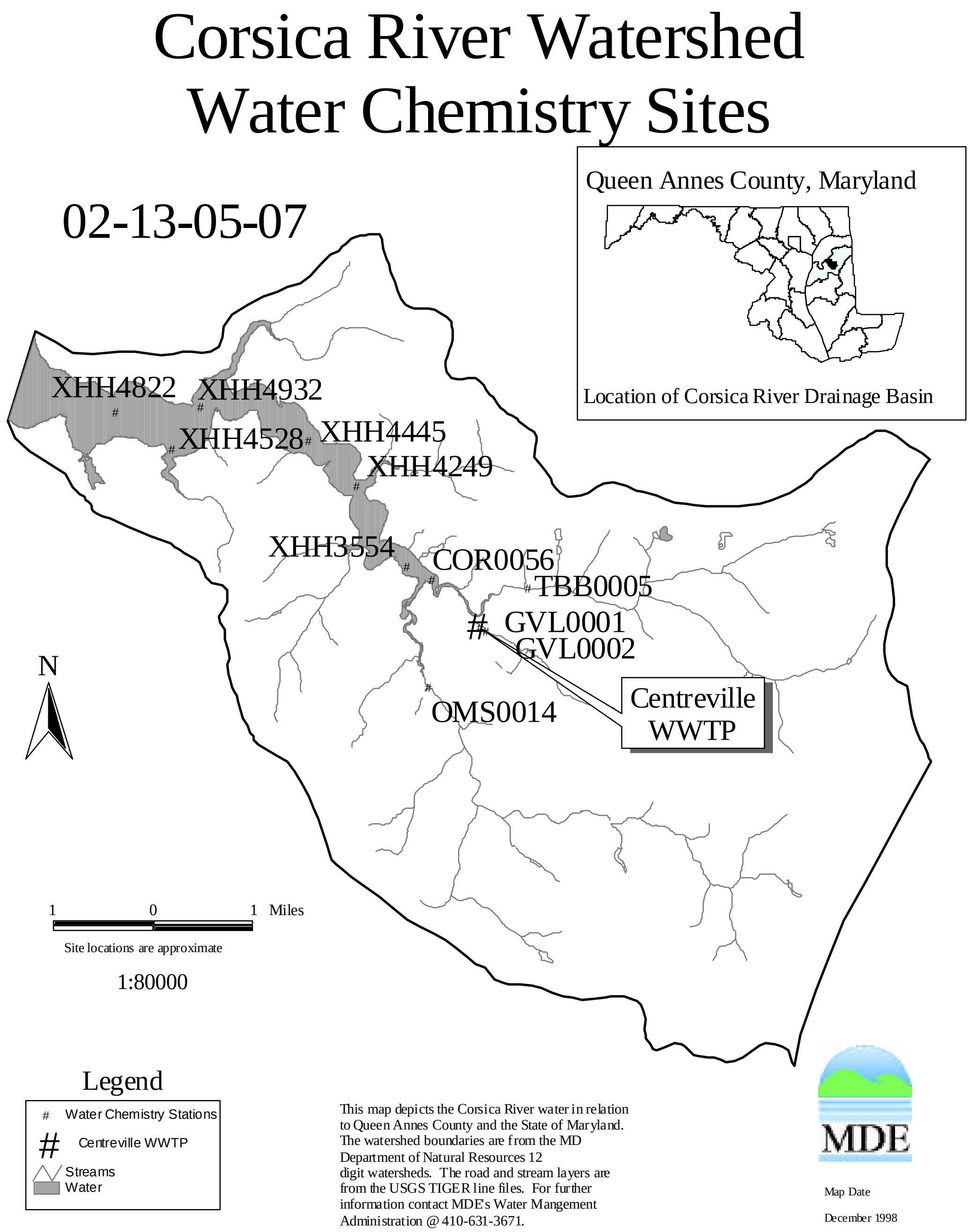

Figure 5: Location of Water Quality Stations sampled in summer of 1997

Figure 6 presents a longitudinal profile of chlorophyll-a data sampled in summer months during the 1997 field surveys. The sampling region covers the entire tidal portion of the Corsica River from Town Point near its confluence with the Chester main stem (Station XHH4822). As the data indicates, ambient chlorophyll-a concentrations range from ~17 µg/l at Station XHH4822, to ~26 µg/l at Station XHH4445, to a maximum value of 146 µg/l at COR0056 (Watson Road Bridge).

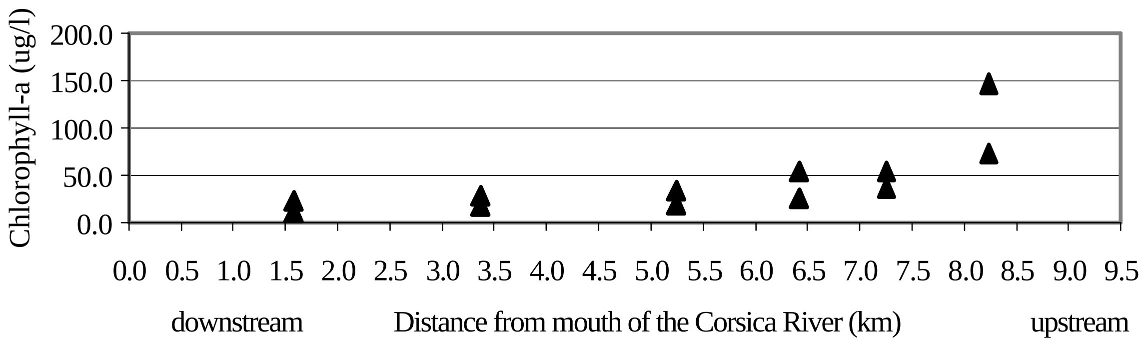

Figure 6: Longitudinal Profile of Chlorophyll-a Data of the Corsica River-- Summer 1997

Table 1: Location of Water Quality Stations

Water Quality Stations	Kilometers from Mouth of Corsica River
GVL0002	8.871
COR0056	8.236
XHH3454	7.256
XHH4249	6.418
XHH4445	5.242
XHH4932	3.366
XHH4822	1.581

Figure 7 presents a longitudinal profile of inorganic phosphorus as indicated by dissolved levels measured in samples collected in 1997. In the tidal portion of the Corsica River (below station COR0056), Inorganic phosphorus levels are generally less than 0.15 mg/l.

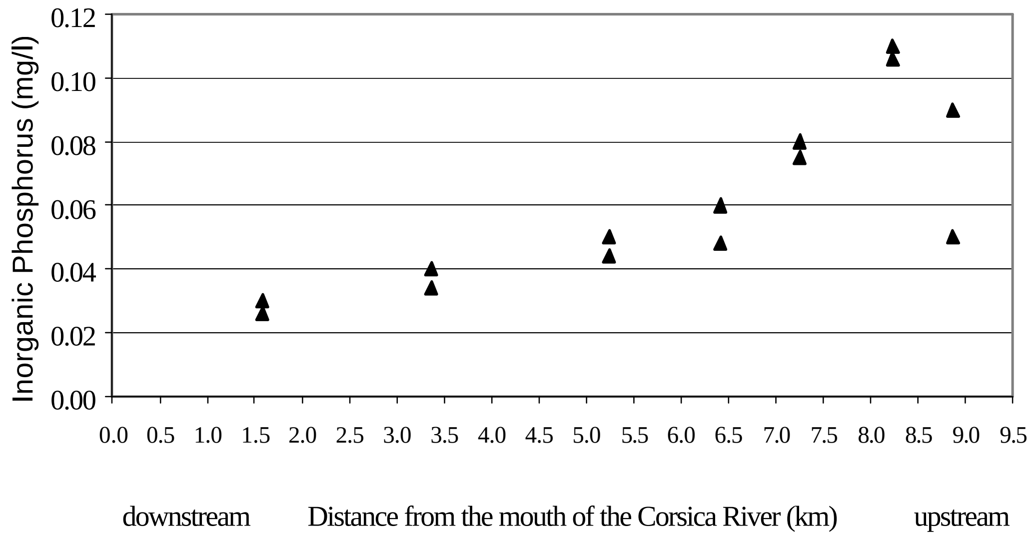

Figure 7: Longitudinal Profile of Inorganic Phosphorus Data of the Corsica River-Summer 1997

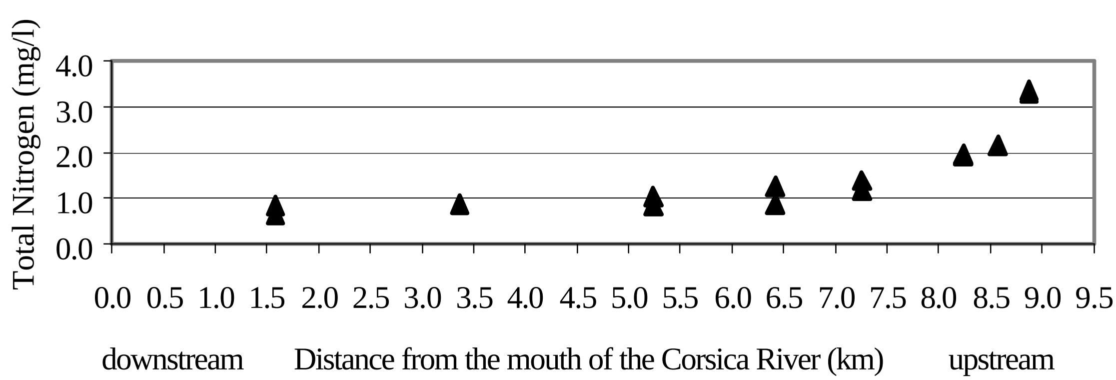

Figure 8: Longitudinal Profile of Total Nitrogen Data of the Corsica River-Summer 1997

The total nitrogen levels along the longitudinal profile are depicted in Figure 8. The higher values of total nitrogen in the upper reaches of the Corsica River indicate a possible localized impact on nutrient levels due to the Centreville WWTP.

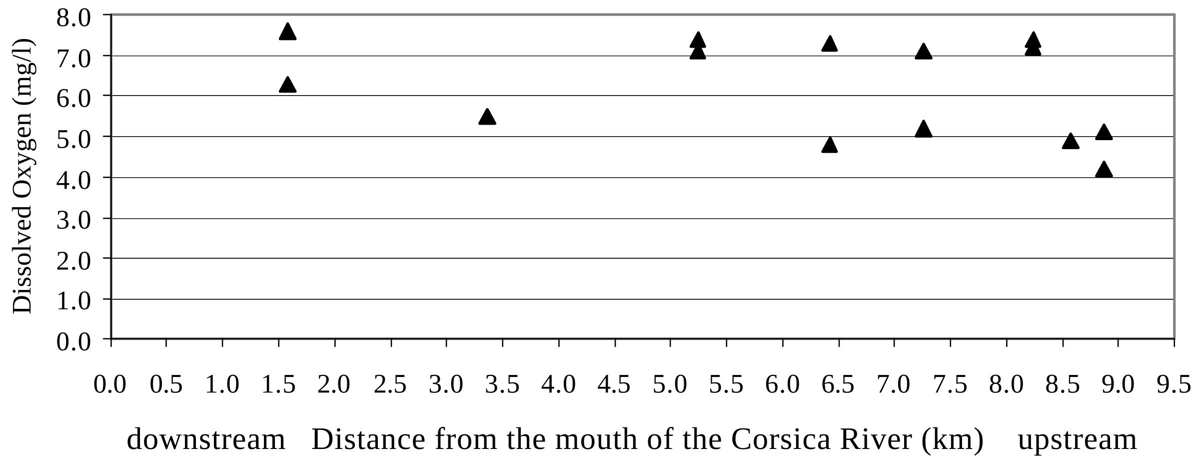

Figure 9: Longitudinal Profile of Dissolved Oxygen Data of the Corsica River-Summer 1997

Dissolved oxygen concentrations along the longitudinal profile are depicted in Figure 9. All values are typically above the minimum water quality criteria of 5.0 mg/l in the lower portion of the Corsica River. The values are below the minimum water quality criteria in the upper reaches of the Corsica River due to the localized impact of the Centrville WWTP.

2.3 WATER QUALITY IMPAIRMENT

The upper reaches of the Corsica River are impaired by an overenrichment of nutrients. Nitrogen and phosphorus loadings from both point and nonpoint sources have resulted in persistent seasonal algal blooms, observed and documented by MDE, in the reach from the Watson Road Bridge on upstream to the tidal boundary, as indicated in Figure 6. Mean summer concentrations of chlorophyll-a in that region typically fall above 70 µg/l, with nuisance algal bloom levels periodically reaching 146 µg/l.

3.0 TARGETED WATER QUALITY GOAL

The objective of the TMDLs for nitrogen and phosphorus for the Corsica River is to reduce nutrient inputs to a level that will ensure the maintenance of the dissolved oxygen standards and reduce frequency and magnitude of algal blooms. Specifically, the TMDLs for nitrogen and phosphorus for the Corsica River are intended to:

1. Assure that a minimum dissolved oxygen of 5 mg/l is maintained throughout the Corsica River system, and,

2. Reduce peak chlorophyll-a levels (a surrogate for algal blooms) to below 50 µg/l. [(1)]

The dissolved oxygen goal is based on specific numeric criteria for Use I & II waters set forth in the Code of Maryland Regulations 28.08.02. The chlorophyll-a water quality goal is based on the designated use of the Corsica River, and guidelines set forth by Thomann and Mueller (1987) and by the EPA *Technical Guidance Manual for Developing Total Maximum Daily Loads, Book 2, Part* (1997).

4.0 TOTAL MAXIMUM DAILY LOADS AND ALLOCATION

4.1 Overview

This section describes how the nutrient TMDLs and loading allocations were developed for the Corsica River watershed. The first section describes the modeling framework for simulating nutrient loads, hydrology, and water quality responses. The second and third sections summarize the scenarios that were explored using the model. The assessment investigates water quality responses assuming different stream flow and nutrient loading conditions. The fourth and fifth sections present the modeling results in terms of TMDLs, and allocate the TMDLs between point sources and nonpoint sources. The sixth section explains the rationale for the margin of safety and a remaining future allocation. Finally, the pieces of the equation are combined in a summary accounting of the TMDLs for seasonal low flow conditions and for annual loads.

4.2 Analysis Framework

The computational framework chosen for the TMDL of Corsica River was WASP5. This water quality simulation program provides a generalized framework for modeling contaminant fate and transport in surface waters and is based on the finite-segment approach (Di Toro *et al.*, 1983). To date, WASP5 has been employed in many modeling applications and has been used in a wide range of applications by regulatory agencies, consulting firms, and others.

(1) MDE establishes permit limits based on maintaining chlorophyll-a concentrations below a maximum level of 100µg/l, with an ideal goal of less than 50µg/l.

WASP5 [(2)] is supported and distributed by U.S. EPA's Center for Exposure Assessment Modeling (CEAM) in Athens, GA (Ambrose *et al.*, 1988). WASP5 is supplied with two kinetic sub-models, EUTRO5 and TOXI5, to simulate two of the major problems: conventional pollution (involving dissolved oxygen, biochemical oxygen demand, nutrients, and eutrophication) and toxic pollution (involving organic chemicals, metals, and sediment). EUTRO5 is the component of WASP5 that is applicable to modeling eutrophication, incorporating eight water quality constituents in the water column and sediment bed. TOXI5 is the component of WASP5 that is applicable for calibrating the dispersion by simulating the dye concentrations.

TOXI5 was used to calibrate the exchange coefficients using the dye study data of summer 1997. The calibrated coefficients ranged from 2.5 m^2/s near the outfall to 12.5 m^2/s at the confluence of Chester River. The calibrated exchange coefficients were used for the calibration and validation model runs of the Corsica River Eutrophication Model (CREM).

The spatial domain of the Corsica River Eutrophication Model (CREM) for calibration and validation extends from the Gravel Run and Three Bridges Branch confluence to the confluence of Corsica River and Chester River for about 8.8 kilometers along the main stem of the Corsica River. Following a review of the bathymetry for the Corsica River, the model was divided into 16 segments. Figure 10 shows the model segmentation and the location of the WWTP. Complete details of input data for calibration, validation, and model run scenarios 1 through 5 are included in Appendix A. Calibrated exchange coefficients were used for these model runs.

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(2) The WASP model calculates the daily average dissolved oxygen concentrations in the stream. This is not necessarily protective of water quality when one considers the effects of diurnal dissolved oxygen variation due to photosynthesis and respiration of algae. The photosynthetic process centers about the chlorophyll containing algae, which utilize radiant energy from the sun to convert water and carbon dioxide into glucose, and release oxygen. Because the photosynthetic process is dependent on solar radiant energy, the production of oxygen proceeds only during daylight hours. Concurrently with this production, however, the algae require oxygen for respiration, which can be considered to proceed continuously. Minimum values of dissolved oxygen usually occur in the early morning predawn when the algae have been without light for the longest period of time. Maximum values of dissolved oxygen usually occur in the early afternoon. The diurnal range of dissolved oxygen (maximum minus minimum) may be large when excessive algae is present.

The diurnal dissolved oxygen variation due to photosynthesis and respiration can be estimated based on the amount of chlorophyll-a in the water. The WASP Model incorporates this variation by using an oxygen balance equation. The results of model runs for both low and average flow conditions produce a dissolved oxygen concentration well above the standard of 5 mg/l. Therefore, the nutrient loads used for these model runs are protective of both the chlorophyll-a standard and the dissolved oxygen standard (refer output results in Appendix A).

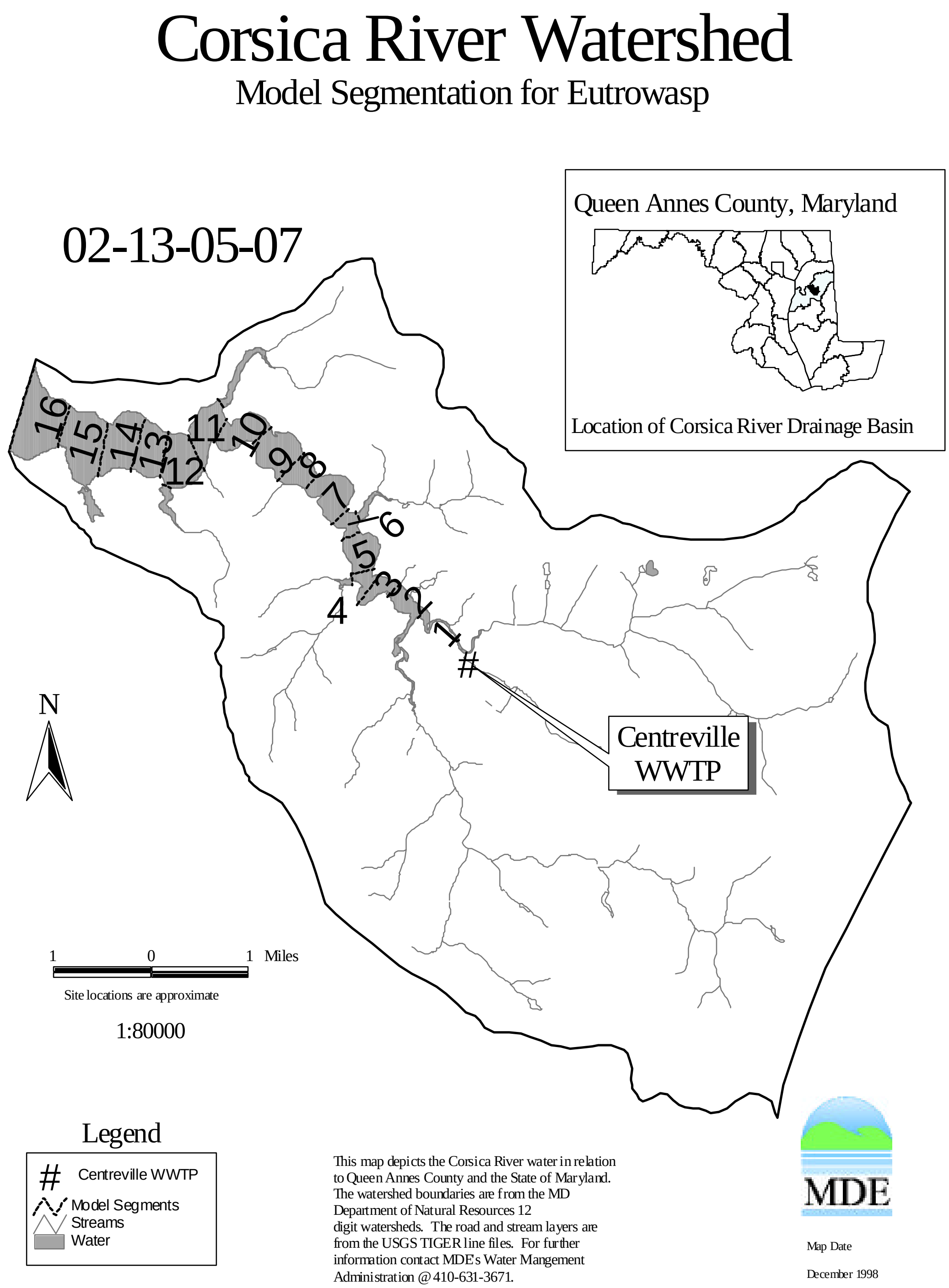
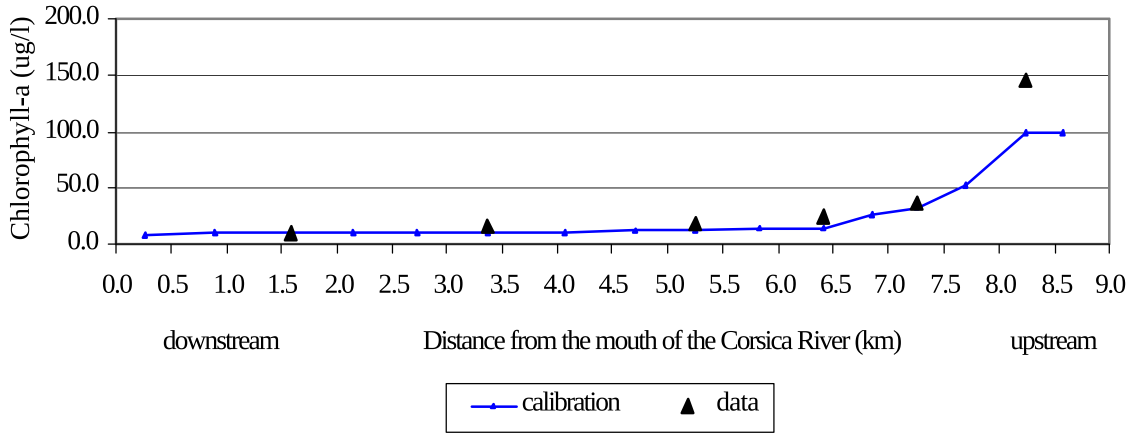


Figure 10: Water Quality Segmentation used for Corsica River Eutrophication Model (CREM)

The CREM was calibrated using the water quality monitoring data collected during July 1997. The results of this calibration for chlorophyll-a and dissolved oxygen are shown in Figure 11 and the complete details are presented in Appendix A. As can be seen the calibration and validation of the model captured the peak chlorophyll-a concentrations, and did well in capturing the trend in the dissolved oxygen concentrations.



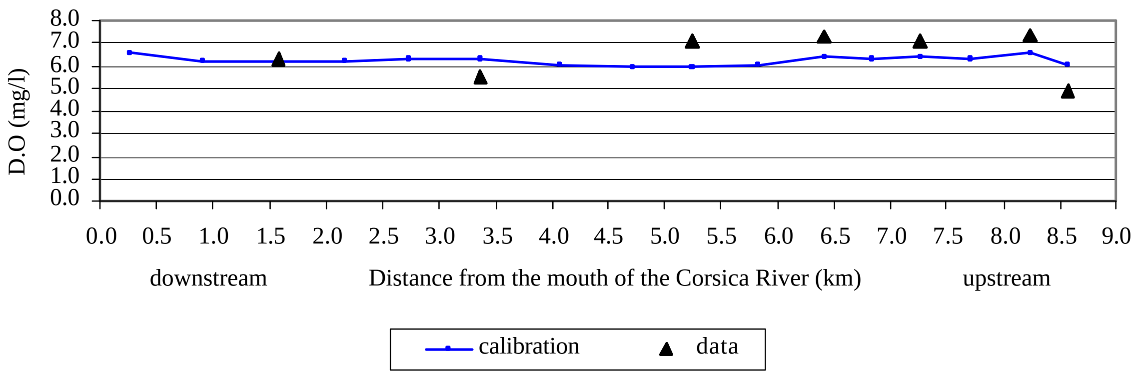


Figure 11: Results of the Calibration of CREM for Chlorophyll-a and Dissolved Oxygen

The CREM was validated using the water quality monitoring data collected during August 1997. The results of this validation for chlorophyll-a and dissolved oxygen are shown in Figure 12 and the complete details are presented in Appendix A. As can be seen the calibration and validation of the model captured the peak chlorophyll-a concentrations, and did well in capturing the trend in the dissolved oxygen concentrations.

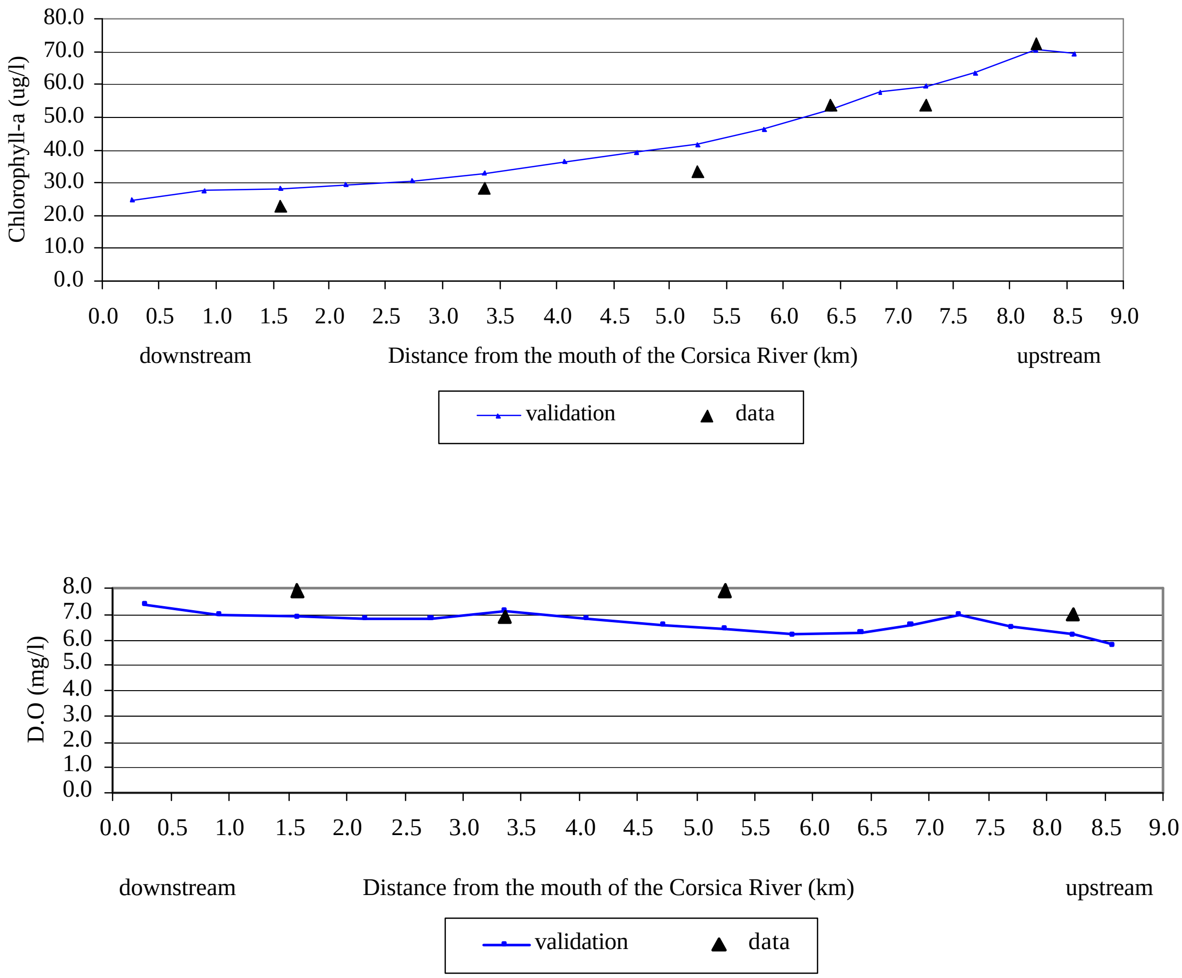


Figure 12: Results of the Validation of CREM for Chlorophyll-a and Dissolved Oxygen

4.3 Scenarios Description

The Eutro5 model was applied to several different nutrient loading scenarios under various stream flow conditions to project the water quality response of the system. By modeling various stream flows, the scenarios simulate seasonal conditions, which are a necessary element of the TMDL development process. Point and nonpoint source nutrient loads were established to achieve the water quality goal of maintaining a dissolved oxygen concentration of 5.0 mg/l and reducing chlorophyll-a concentrations to 50 ug/l.

Scenario 1, 7Q10 Base Conditions 1

The calibrated and validated model runs show the significant impact of the Centreville WWTP at the current level of treatment. Accordingly, the first model run was made to estimate the impact of the current WWTP discharging at the current location under 7Q10, the 7-day consecutive lowest flow expected to occur every 10 years, stream flow condition. The USGS gage at Morgan Creek (01493500) was used to estimate 7Q10 flow because it is located nearby and assumed to have similar drainage area size. A tributary flow of 0.45 cfs (0.0127 m^3/s) was used as total flow in the basin. The first model run indicated that the plant will violate the stream dissolved oxygen water quality criteria. The point source loads for Centreville WWTP represent the design flow multiplied by the corresponding concentration of current level of treatment. Nonpoint source loads were simulated as 7Q10 flow nutrient concentrations. The complete details are presented in Appendix A.

Scenario 2, 7Q10 Base Conditions 2

Model Run 2 was made to estimate the impact of current secondary level treatment, when the WWTP is discharging, downstream of Watson Road Bridge, under 7Q10 flow conditions. The Town of Centreville has been notified that, due to severe eutrophication problem immediately below the current outfall location, the discharge point must be moved downstream of the Watson Road Bridge. A tributary flow of 0.45 cfs (0.0127 m^3/s) was used as total flow in the basin. The results of this model run projected a violation of the stream dissolved oxygen standard. Point source loads for Centreville WWTP represent the design flow multiplied by the corresponding concentration of secondary level treatment. Nonpoint source loads were simulated as 7Q10 flow nutrient concentrations. The complete details are presented in Appendix A.

Scenario 3, 7Q10 Final Conditions

Model Run 3 was made to estimate the impact of BNR at the Centreville WWTP when discharging downstream of Watson Road Bridge under 7Q10 flow conditions. A tributary flow of 0.45 cfs (0.0127 m^3/s) was used as total flow in the basin. The results of this model run projected no violations of the stream dissolved oxygen standard. The results also projected significant reduction in algae growth. The point source loads for Centreville WWTP represent the design flow multiplied by the corresponding projected concentration of BNR treatment. Nonpoint source loads were simulated as 7Q10 flow nutrient concentrations plus a 3% margin of safety (MOS). This model run establishes **the final condition** for TMDL projections during low flow conditions. The complete details are presented in Appendix A

Scenario 4 , 1997 Low Flow Conditions

Model Run 4 represented conditions for 1997 low stream flow. A tributary flow of 6.5 cfs (0.1840 m^3/s) was used as total flow in the basin. This flow was estimated using 1997 field surveys flow rate and corresponding contributing drainage areas. Nonpoint source loads were simulated as 1997 summer base flow nutrient concentrations plus a 3% margin of safety (MOS). Model Run 4 was made to estimate the impact of BNR at the WWTP when discharging at the downstream location under these flow conditions. The results of this model run projected no violation of stream water quality standards (refer Appendix A). This model run does not project the 7Q10 low flow conditions. Accordingly, scenario 3 is selected as the final condition for the low flow TMDL. The complete details are presented in Appendix A.

Scenario 5, Average Flow Final Conditions

Model Run 5 represented conditions for average flow stream flow. The nonpoint source loads are based on the year 2000 loading rates. These loading rates were based on the results of the Chesapeake Bay Model (U.S. EPA, 1991), and account for loads from both atmospheric depositions and septic tanks**.** In addition, a 3% MOS was applied to the nonpoint source loads. Model Run 5 was made to estimate the impact of BNR at the WWTP when discharging downstream from its original location under these flow conditions. Tributary flow of 32 cfs (0.9056 m^3/s) was used as total flow in the basin. Results of this model run projected no violation of stream water quality standards (refer Appendix A). However, with the higher flushing, the increase in concentration of nutrients was noted in the stream segments. The point source loads for Centreville WWTP, represent the design flow multiplied by the corresponding projected nitrogen and phosphorus concentrations including BNR treatment**.** Accordingly, scenario 5 is selected as the **final condition** for the annual TMDL. The complete details are presented in Appendix A

It can be expected that BNR will operate more efficiently during summer months (i.e. June, July, and August). The average total nitrogen discharge during summer months over several years for nine sewage treatment plants (Ballenger Creek, Bowie, Broadneck, Chesapeake Beach, Easton, Maryland City, MCI, Patuxent, and Perryville) operating with various types of BNR was calculated from their respective DMRs. The values ranged from 1.89 to 6.16 mg/l TN. With this information, the summer average BNR value for TN for Centreville Plant was assumed at about 8 mg/l for TMDL estimation plus a MOS of 2 mg/l.

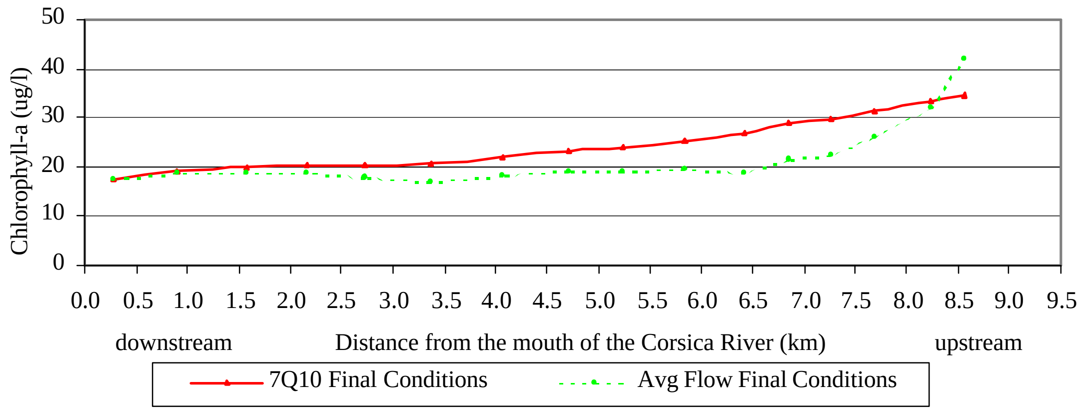
The loads used in all the model scenario runs are shown in Table 2.

Table 2: Point and Nonpoint Source Loads used in the model Scenario Runs

Model Senario	**Point Source**			**Nonpoint Source**			**MOS**	
	Flow mgd	Nitrogen lbs/day	Phosphorus lbs/day	Flow cfs	Nitrogen lbs/day	Phosphorus lbs/day	Nitrogen lbs/day	Phosphorus lbs/day
1	0.375	49	6.3	0.45	11	0.50	0.33	0.15
2	0.375	49	6.32	0.45	11	0.50	0.33	0.15
3	0.375	25.0	4.7	0.45	14	0.43	6.70	1.60
4	0.375	25.0	4.7	6.5	278	9.5	14.6	1.89
5	0.375	25.0	4.7	31.5	735	53	28.2	3.16

4.4 Model Run Scenarios Results

The results of the third scenario indicate that under summer low flow conditions, the water quality target for dissolved oxygen and chlorophyll-a is satisfied at all locations along the main stem of the Corsica River. The fifth scenario shows that water quality standards for both chlorophyll-a and dissolved oxygen are achieved along the entire length of the Corsica River during average flow conditions. The results from scenario 3 and 5 also showed that water quality is protected for the full length of the Corsica River.The results from these two scenarios show that the water quality of the system is significantly improved, compared to the calibration. The results from these two scenarios for chlorophyll-a and dissolved oxygen can be seen in Figure 13. These two scenarios provide the justification for the TMDL presented below. For complete output results for all the scenarios and their detailed explanation see Appendix A.



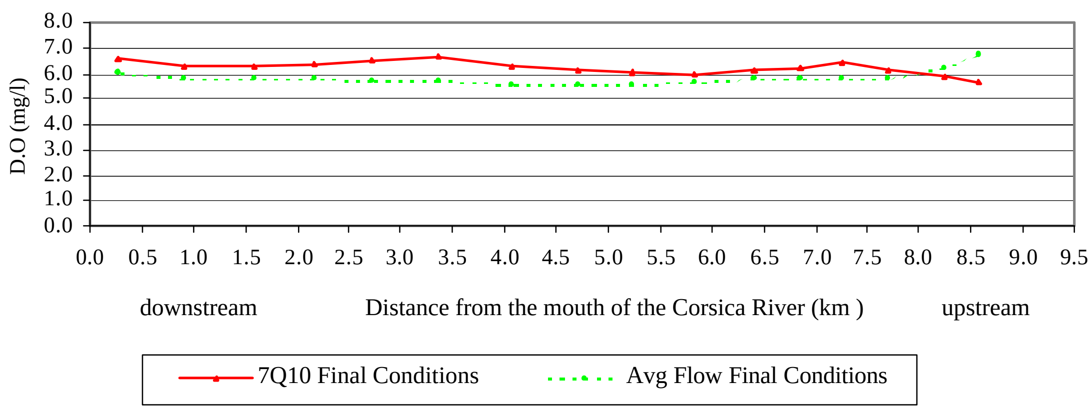


Figure 13: Model Results for the Final Conditions Scenarios for Chlorophyll-a and Dissolved oxygen

4.5 TMDL Loading Caps

The critical season for excessive algal growth in the Corsica River is during low flow conditions in the summer. During this period the stream is poorly flushed, resulting in slow moving, warm water, which is susceptible to excessive algal growth. The model results for 7Q10 (design stream flow) conditions (scenario 3) indicate that, under critical summer conditions, the desired water quality goals are achieved. The summer critical condition TMDLs are stated in monthly terms to be consistent with the monthly concentration limits stated in NPDES permits also low flow conditions occur for shorter periods of time. For the summer months, May 1 through October 31, the following TMDLs apply.(2)

NITROGEN TMDL	**1379 *lbs/month***
PHOSPHORUS TMDL	**202 *lbs/month***

In addition, during average and high flows, the stream is sufficiently flushed to avoid water quality problems near the WWTP outfall. However, the Department recognizes that nutrient laden sediments deposited during higher flow periods pose a potential concern that cannot be accurately quantified at the present time. The specific concern, based on limited information, is that the nutrient laden sediments that settle at the head of the Corsica River, might be causing excessive sediment oxygen demand. This statement was substantiated by considering higher values of SOD in the upstream segments of the model during sensitivity analysis. During average flow conditions, the increased nonpoint source nutrient loads can also cause excessive algal growth. In response, the Department is also establishing annual TMDLs based on the average annual flow. The resultant annual TMDLs for nitrogen and phosphorus are:

NITROGEN TMDL	**287,670 *lbs/yr***
PHOSPHORUS TMDL	**22,244 *lbs/yr***

These loads are protective of water quality during average stream flow conditions due to the flushing effects noted in average flow model run (Model Run 5). In order to understand how the TMDLs are protective of water quality standards during low flow conditions one must consider the *concentration* of nitrogen. As the discharge flow from the Centreville WWTP increases from about 0.312 mgd to .375 mgd, and BNR is implemented, the discharge concentration will decrease from about 18 mg/l to an annual average of 8 mg/l, or lower in the summer when the BNR process is more efficient. Thus, although the flow increases, the in-stream nitrogen concentration during summer low flow is reduced. This, in concert with the phosphorus reductions, results in the water quality improvements.

4.6 Load Allocations Between Point Sources and Nonpoint Sources

The allocations described in this section demonstrate how the subject TMDLs can be implemented to achieve water quality standards in the Corsica River. Specifically, these allocations show, that the sum of nutrient loadings to Corsica River from the existing and anticipated point sources and anticipated land uses can be maintained safely within the TMDLs established here.

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(2)This TMDL assumes that the Centreville WWTP discharge point is moved downstream at least as far as the Watson Road Bridge. The TMDL will then protect the Corsica River basin. If the Centreville WWTP discharge point were to be kept at its current location near the head of tide on Gravel Run, there would be localized water quality impairments near the outfall even if the TMDL were to be implemented. MDE can consider an option that will protect water quality of Corsica River if the discharge point remains at the current location as a seasonal surface discharge for winter months of December through March only with both Biological Nitrogen Removal (BNR) & Chemical Phosphorus Removal (CPR) at the current location and spray irrigation for other eight months of the year. This option will be even more protective of the Corsica River basin

The Clean Water Act and EPA regulations provide for flexibility in implementation of TMDLs, as long as the overall load is not exceeded. In the present case, individual waste load allocations (WLAs), i.e., effluent limitations for the point sources, will be established through NPDES permits, which will be issued, reissued, or modified as appropriate on a watershed-wide basis. Load allocations (LAs) to nonpoint sources set forth in this section represent best estimates of what loading rates will be in the year 2000 in light of existing land use and land use trends. They are not intended to impose restrictions on land use or require a reduction in loading from nonpoint sources below actual year 2000 loading rates. MDE expressly reserves the right to allocate these TMDLs among different sources and land use categories in any manner that is reasonably calculated to achieve water quality standards.

This section describes possible allocations for both the low flow and average annual cases. Note that the point source load allocations described in this section combine the current Waste Load Allocations (WLA) with the Future Allocations (FA)(Tables 3 and 5). That is, the unused parts of the allocations are not separated from the current estimated loads; however, they are identified separately in the following section on "Margins of Safety and Future Allocations," and in "Summary of Total Maximum Daily Loads."

The load allocations described in this section are for both the low flow and average annual flow cases. The critical summer low flow point source load allocations are Waste Load Allocations (WLA) with the Future Allocations (FA) for nitrogen and phosphorus.

Because the TMDL sets limits on nitrogen, and because of the way the model simulated nitrogen, it is not necessary to also include a TMDL for nitrogenous oxygen demand (NBOD) to protect the dissolved oxygen standards in the river. It was also deemed unnecessary to include a TMDL for Carbonaceous Oxygen Demand (CBOD), because the NPDES permit reflects limits that are protective of dissolved oxygen standards on the river.

Low Flow Allocations

The nonpoint source load allocations (LA) for nitrogen and phosphorus for the summer low flow critical conditions are represented as 7Q10 loads. These loads were simulated as 7Q10 flow nutrient concentrations from the observed water quality data. The background or natural pollutant contribution is included in the nonpoint source loads. To be clear, the nonpoint source loads assumed in the model account for both "natural" and human-induced components. Ideally one would separate the two, but in these cases adequate data was not available to do so. All significant nonpoint sources are addressed by this allocation and are described further in the technical memorandum entitled *Significant Nutrient Nonpoint Sources in the Corsica River Watershed.*

Point source load allocations for the summer low flow critical conditions made up the balance of the total allowable load. This point source load allocation was adopted from results of model scenario 3. All significant point sources are addressed by this allocation and are described further in the technical memorandum entitled *Significant Nutrient Point Sources in the Corsica River Watershed*. The nonpoint source and point source nitrogen and phosphorus allocations for summer critical low flow conditions are shown in Table 3.

Table 3**: Point Source and Nonpoint Source Summer Low Flow Load Allocations**

	Total Nitrogen *(lb/month)*	**Total Phosphorus *(lb/month)***
Nonpoint Source	**427**	**13**
Point Source	**625**	**117**

Annual Allocations

The annual nonpoint source nitrogen and phosphorus load allocations are represented as estimated year 2000 loads. The background concentrations are included in the nonpoint source loads. As was discussed in the "Scenario Descriptions" section of this document the year 2000 loads were based on loading rates from the Chesapeake Bay Model (US EPA, 1991).

Point source load allocations for the annual flow conditions made up the balance of the total allowable load. This point source load allocation was adopted from the results of model scenario 5. All significant point sources are addressed by this allocation and are described further in the technical memorandum entitled *Significant Nutrient Point Sources in the Corsica River Watershed*. Table4 shows the load allocations to point and nonpoint sources respectively, for nitrogen and phosphorus for the annual TMDL

Table 4: **Point Source and Nonpoint Source Annual Load Allocations**

	Total Nitrogen *(lb/yr)*	**Total Phosphorus *(lb/yr)***
Nonpoint Source	**268,211**	**19,380**
Point Source	**7,598**	**1,424**

4.7 Future Allocations and Margins of Safety

Future allocations represent surplus assimilative loading capacity that is either currently available, or projected to be available due to planned implementation of environmental controls. The future allocations for point sources for nitrogen and phosphorus have been computed as the difference between the estimated loads from the one WWTP at its current flow and anticipated future effluent limits and the loads at the WWTP's full design capacity accounting for anticipated future BNR and CPR at the Centreville WWTP. The current loads at the WWTPs were calculated by multiplying 1997 monthly average flow by the anticipated future concentrations.

A margin of safety (MOS) is required as part of a TMDL in recognition of the fact that there are many uncertainties in scientific and technical understanding of water quality in natural systems. Specifically, knowledge is incomplete regarding the exact nature and magnitude of pollutant loads from various sources and the specific impacts of those pollutants on the chemical and biological quality of complex, natural water bodies. The MOS is intended to account for such uncertainties in a manner that is conservative from the standpoint of environmental protection.

Based on EPA guidance, the MOS can be achieved through one of two approaches (EPA, April 1991). One approach is to reserve a portion of the loading capacity as a separate term in the TMDL (i.e., TMDL = WLA + LA + MOS). The second approach is to incorporate the MOS as part of the design conditions for the WLA and the LA computations.

For these two TMDLs, MDE has adopted margins of safety that combine these two approaches. Following the first approach, the load allocated to the MOS was computed as 3% of the average year 2000 annual nonpoint source loads for nitrogen and phosphorus for the annual TMDL. Similarly, a 5% MOS was included in computing the low flow TMDLs. For the Centreville WWTP, concentrations of 10 mg/l TN and 2.0 mg/l TP were used for low and average flow conditions. Typical BNR facility effluent averages 8 mg/l TN year round and below that in the summer, and 1.5 mg/l TP year round. The assumed 10 mg/l TN and 2.0 mg/l TP incorporate a MOS of 2 mg/l TN and 0.5 mg/l TP year round. These explicit nitrogen and phosphorus margins of safety are summarized in Table 5 and Table.6.

Table 5: Summer Critical Low Flow Margins of Safety and Future Allocations

Category	**Total Nitrogen *(lb/month)***	**Total Phosphorus *(lb/month)***
Margins of Safety	209	48
Future Allocations	118	24
Total	327	72

Table 6: Annual Margins of Safety and Future Allocations

Category	**Total Nitrogen *(lb/yr)***	**Total Phosphorus *(lb/yr)***
Margins of Safety	10,327	1,152
Future Allocations	1,534	288
Total	11,861	1,440

In addition to these explicit set-aside MOSs, additional safety factors are built into the TMDL development process. First, Maryland Tributary Strategy for nutrient reduction provides a framework for nonpoint source controls in the basin, yet the LA for nonpoint sources assumes no nutrient reductions. Next, in addition that the results of the model scenario for the critical low flow case indicate a chlorophyll-a concentration that is below 50 μg/l. Further, the 50 μg/l chlorophyll-a target is itself somewhat conservative. In the absence of other factors, a generally acceptable range of peak chlorophyll-a concentrations is between 50 and 100 μg/l. For the present TMDLs, MDE has elected to use the more conservative peak concentrations of 50 μg/l. Finally, under low stream flow conditions, the nonpoint source contribution is a fairly stable concentration associated with the stream's base flow. Thus, the margin of safety depends most on the point source contribution, the control of it is much more certain than nonpoint sources. Hence, another implicit safety factor will be provided by the NPDES permits, which are conservatively based on low flow conditions

4.8 Summary of Total Maximum Daily Loads

The critical low flow TMDLs, applicable from May through October for Corsica River, equated with illustrative allocations, are:

For Nitrogen (lb/month):

TMDL	**=**	**LA**	**+**	**WLA**	**+**	**MOS**	**+**	**FA**
1379	=	427		625		209		118

For Phosphorus (lb/month):

TMDL	**=**	**LA**	**+**	**WLA**	**+**	**MOS**	**+**	**FA**
202	=	13		117		48		24

The annual TMDLs for Corsica River, equated with illustrative allocations, are:

For Nitrogen (lb/year):

TMDL	**=**	**LA**	**+**	**WLA**	**+**	**MOS**	**+**	**FA**
287,670	=	268,211		7,598		10,327		1,534

For Phosphorus (lb/year):

TMDL	**=**	**LA**	**+**	**WLA**	**+**	**MOS**	**+**	**FA**
22,244	=	19,380		1,424		1,152		288

Where

TMDL= Total Maximum Daily Load
LA = Load Allocation (Nonpoint Source)
WLA = Waste Load Allocation (Point Source)
MOS =Margin of Safety
FA = Future Allocation

Average Daily Loads:

On average, the annual TMDLs will result in loads of approximately **788 lbs/day** of nitrogen and **61 lbs/day** of phosphorus. And, on average the summer critical low flow TMDLs will result in loads of approximately **46 lbs/day** of nitrogen and **7 lbs/day** of phosphorus.

5.0 ASSURANCE OF IMPLEMENTATION

This section provides the basis for reasonable assurances that the nitrogen and phosphorus TMDLs will be achieved and maintained. For both TMDLs, and especially the annual TMDLs which involve more significant non-point source considerations, MDE has several well established programs that will be drawn upon: the Water Quality Improvement Act of 1998 (WQIA), and the EPA- sponsored Clean Water Action Plan of 1998 (CWAP), and the State's Chesapeake Bay Agreement's Tributary Strategies for Nutrient Reduction. Also, Maryland has adopted procedures to assure that future evaluations are conducted for all TMDLs that are established.

Maryland's WQIA requires that comprehensive and enforceable nutrient management plans be developed, approved and implemented for all agricultural lands throughout Maryland. This act specifically requires that these nutrient management plans be developed and implemented by 2004. Maryland's CWAP has been developed in a coordinated manner with the State's 303 (d) process. All category I watersheds identified in Maryland's Unified Watershed Assessment process are totally coincident with the impaired waters list for 1996 and 1998 approved by EPA. The State has given a high-priority for funding assessment and restoration activities to these watersheds.

The implementation of point source nutrient controls will be executed through the use of NPDES permits. The NPDES permit for the Centreville WWTP, which is the only plant discharging to the Corsica River, will require implementation of Biological Nutrient Removal (BNR) and Chemical Phosphorus Removal (CPR). The NPDES permits for Centreville and the other point sources in the Corsica River will have compliance provisions, which provide a reasonable assurance of implementation.

In 1983, the states of Maryland, Pennsylvania, and Virginia, the District of Columbia, the Chesapeake Bay commission, and the U.S. EPA joined in a partnership to restore the Chesapeake Bay. In 1987, through the Chesapeake Bay Agreement, Maryland made a commitment to reduce nutrient loads to the Chesapeake Bay. In 1992, the Bay Agreement was amended to include the development and implementation of plans to achieve these nutrient reduction goals. Maryland's resultant Tributary Strategies for Nutrient Reduction provide a framework that will support the implementation of nonpoint source controls in the Lower Chester Tributary Strategy Basin, which includes the Corsica River watershed. Maryland is in the forefront of implementing quantifiable nonpoint source controls through the Tributary Strategy efforts. In addition, Maryland is refining its State Nonpoint Source Management Plan, required under Section 319 of the Clean Water Act, through which the Tributary Strategy and other nonpoint source control efforts can be integrated. This will help to assure that nutrient control activities are targeted to areas in which nutrient TMDLs have been established.

Finally, Maryland has recently adopted a five-year watershed cycling strategy to manage its waters. Pursuant to this strategy, the State is divided into five regions, and management activities will cycle through those regions over a five-year period. The cycle begins with intensive monitoring, followed by computer modeling, TMDL development, implementation activities, and follow-up evaluation. The choice of a five-year cycle is motivated by the five-year federal NPDES permit cycle. This continuing cycle ensures that, within five years of establishing a TMDL, intensive follow-up monitoring will be performed. Thus, the watershed cycling strategy establishes a TMDL evaluation process that assures accountability.

REFERENCES

Ambrose, Robert B., Tim A. Wool, John P. Connolly, Robert W. Schanz. "WASP4, a hydrodynamic and water quality model: Model theory, user's manual, and programmer's guide." Environmental Research Laboratory, Office of Research and Development, EPA 600/3-87/039, Athens, GA. 1988.

Di Toro, D.M., J.J. Fitzpatrick, and R.V. Thomann "Documentation for Water Quality Analysis Simulation Program (WASP) and Model Verification Program (MVP)." EPA/600/3-81-044. 1983.

Maryland Department of the Environment, Maryland Point Source Database, January, 1998.

Maryland Department of the Environment, "Tributary Strategy Loading Calculations Spreadsheets," 1995.

Maryland Department of the Environment, Maryland Department of Natural Resources, Maryland Department of Agriculture, Maryland Office of State Planning, Maryland's Governor's Office, University of Maryland, "Maryland's Tributary Strategies for Nutrient Reduction: A Statewide Summary," March, 1995.

Maryland Department of the Environment, Maryland Department of Natural Resources, Maryland Department of Agriculture, Maryland Office of State Planning, Maryland's Governor's Office, University of Maryland, "Tributary Strategy for Nutrient Reduction in Upper Eastern Chesapeake Bay Watershed," March, 1995.

State of Maryland, "Technical Appendix for Maryland's Tributary Strategies," March 12, 1996. National Atmospheric Deposition Program (IR-7) National Trends Network. (1989) NAPD/NTN Coordination Office, Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO.

Thomann, Robert V., John A. Mueller "Principles of Surface Water Quality Modeling and Control, " HarperCollins Publisher Inc., New York, 1987.

Thomann R. V., and J. J. Fitzpatrick, "Calibration and Verification of a Mathematical Model of the Eutrophication of the Potomac Estuary," HydroQual, Inc. Final Report Prepared for the D.C. Department of Environmental Services, 1982.

U.S. EPA, "Technical Guidance Manual for Developing Total Maximum Daily Loads, Book 2: Streams and Rivers, Part 1: Biochemical Oxygen Demand /Dissolved Oxygen and Nutrients / Eutrophication," Office of Water, Washington D.C, March 1997.

U.S. EPA Chesapeake Bay Program, "Chesapeake Bay Program Watershead Model Application to calculate Bay Nutrient Loadings: Final Findings and Recommendations," and Appendices, May, 1991.