Murderkill River Watershed Pollution Control Strategy

A Watershed-Based Strategy to Implement Total Maximum Daily Loads in Delaware

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Prepared for the Murderkill River Tributary Action Team
By the Watershed Assessment and Management Section
http://de.gov/pollutioncontrolstrategy

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MURDERKILL RIVER WATERSHED POLLUTION CONTROL STRATEGY

Introduction and Background

The Murderkill River Watershed is located in the southeastern portion of Kent County, Delaware and has a drainage area of 106 square miles (Figure 1). The Murderkill River flows eastward for approximately 20 miles from its headwaters, west of Felton, to its confluence with the Delaware Bay at Bowers Beach. The lower portion of the Murderkill River is tidal from its mouth at the Delaware Bay to the Rt. 113 Bridge at Frederica. Several free flowing tributaries, such as Browns Branch, Double Run, and Hudson Branch, enter the Murderkill River at various points. In addition, the watershed includes many lakes and ponds, such as McColley Pond on the Browns Branch, Killens Pond and Courseys Pond on the Murderkill River, McGinnis Pond on the Hudson Branch, and Andrews Lake on the Spring Creek Branch. Municipalities that are found in the watershed include Bowers Beach, Felton, Frederica, Harrington, and Viola.

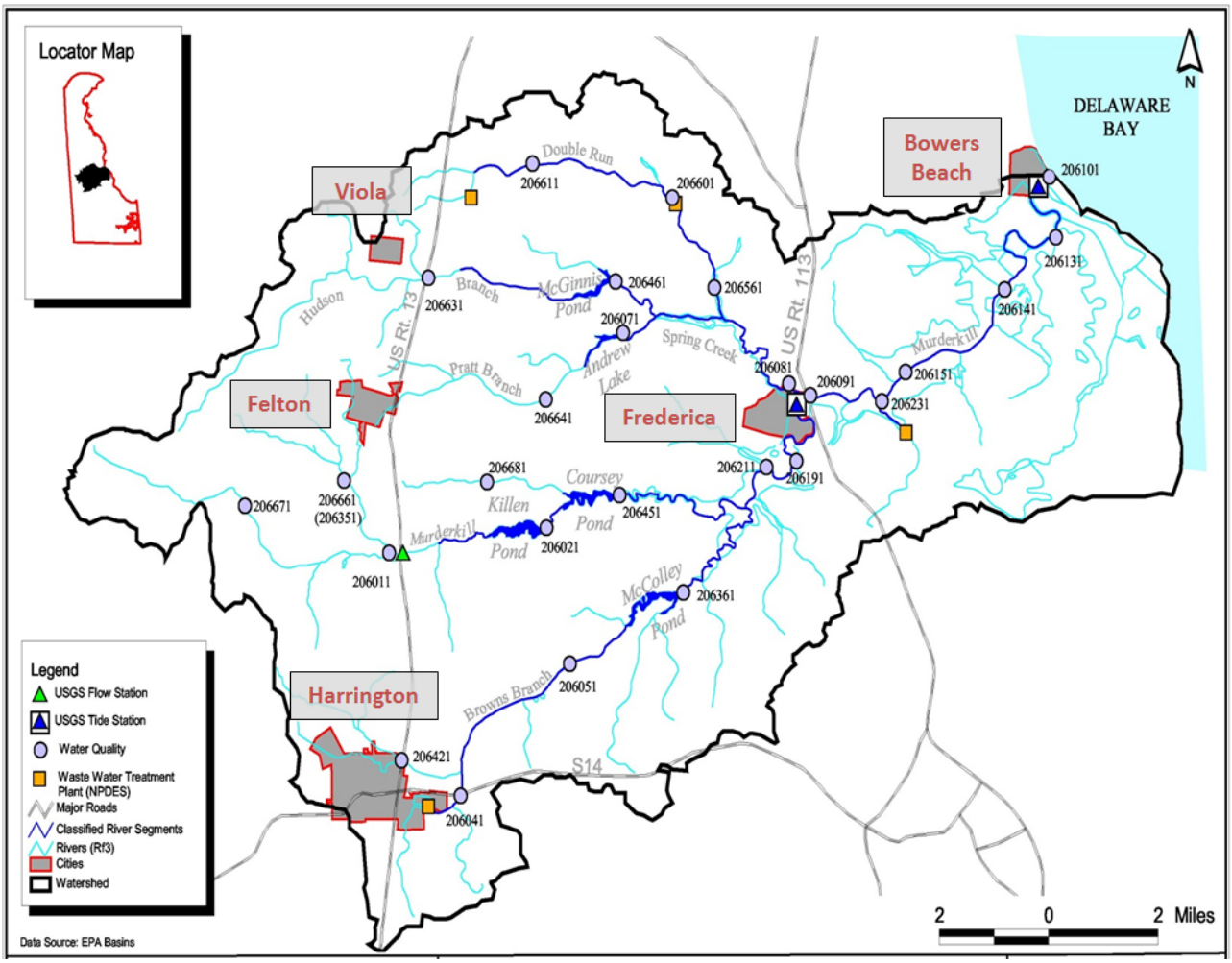

Figure 1 - Map of Murderkill Watershed with sampling stations identified

Land Use

Figure 2 portrays the 2007 land use within the watershed. The map shows that about 56% of the watershed is agriculture, 16% is urban/built up, 11% is forest, 17% is wetlands (fresh and tidal), and about 2% is water. Based upon the 2007 land use data, this watershed has lost 4% of its agricultural land from 1997 to accommodate a 3.7 % increase in urban lands as seen in Table 1.

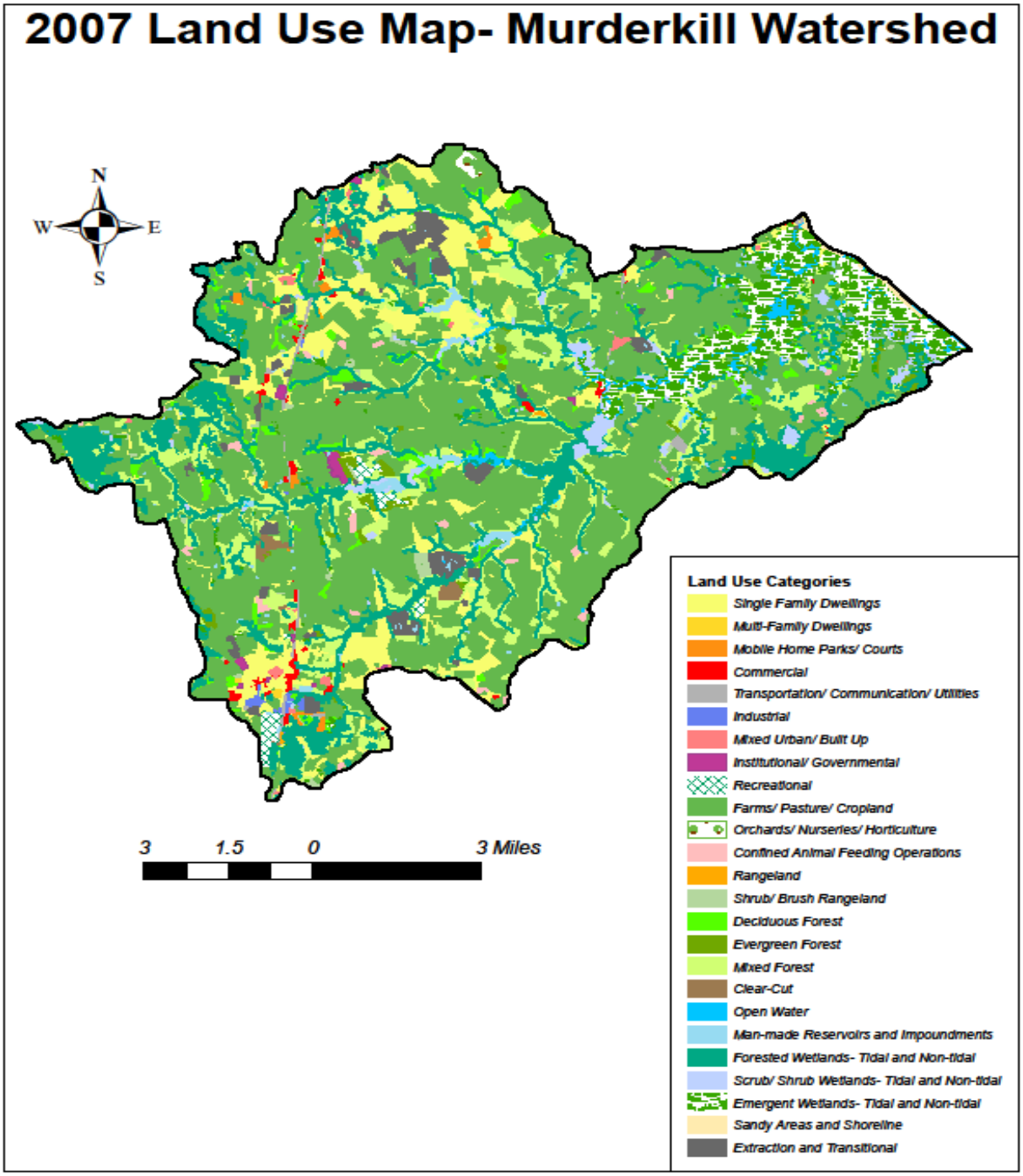

Figure 2 - 2007 Landuse for the Murderkill Watershed

Table 1 - Land use change as percentage from 1997 to 2007 within the Murderkill Watershed			
Land Use	1997	2007	Change
Agriculture	56.28	51.84	-4.44
Barren/Open	1.07	2.03	+0.96
Urban	12.51	16.25	+3.74
Forest Land	11.6	10.99	-0.61
Water	1.49	1.90	+0.41
Wetlands	17.05	16.98	-0.07%

Water Quality

Delaware's Department of Natural Resources and Environmental Control (DNREC) has done intensive water quality monitoring in the Murderkill River Watershed, finding that several of Murderkill's tributaries and ponds are impaired due to low dissolved oxygen and high nutrient levels. The alarmingly low concentrations of dissolved oxygen are harmful to fish, shellfish, and other aquatic life. Also, abnormally high levels of nutrients, such as nitrogen and phosphorus can cause uninhabitable conditions for aquatic organisms. Nutrient over-enrichment has brought the aquatic environment many problems, including frequent phytoplankton blooms, decreased water clarity, deficient dissolved oxygen, altered composition and diversity of native species, and possible human health effects.

Oxygen is essential to the survival of aerobic organisms. Hypoxia, an environment experiencing high oxygen depletion, and the more extreme anoxia, an environment with complete oxygen depletion, are harmful to fish, shellfish, and other aquatic life. Field and laboratory studies have shown that low dissolved oxygen is detrimental to the survival and growth of juvenile and adult fish, and negatively impacts larval recruitment.

Hypoxic and anoxic environments occur following high inflows of pollutants and nutrients. Oxygen consuming pollutants discharged from point and nonpoint sources use dissolved oxygen for biochemical reactions, reducing the overall oxygen content of the water. Nutrient over-enrichment impacts dissolved oxygen concentrations because algae generates oxygen in the presence of sunlight (photosynthesis process) but consumes dissolved oxygen at night and on cloudy days (respiration process). During algal blooms, which are exacerbated by nutrient over-enrichment, depletion of the dissolved oxygen during nighttime or on cloudy days can be very severe and result in harm to water quality, killing the aquatic life.

Concentrations of nutrients, nitrogen and phosphorous, in the Murderkill River are generally high and exceed the State's target levels of 1.0-3.0 mg/l for total nitrogen and 0.1-0.2 mg/l for total phosphorous. The maximum concentration of total nitrogen in the watershed has been as high as 19.66 mg/l at Station 206041 (Browns Branch at Rt. 14 Bridge). The maximum concentration has exceeded 2.4 mg/l of total phosphorus at several stations in the tidal portions of the Murderkill River. Concentration profiles of total nitrogen and total phosphorous at several stations along Browns Branch and Murderkill River are shown in Figures 3 and 4, respectively.

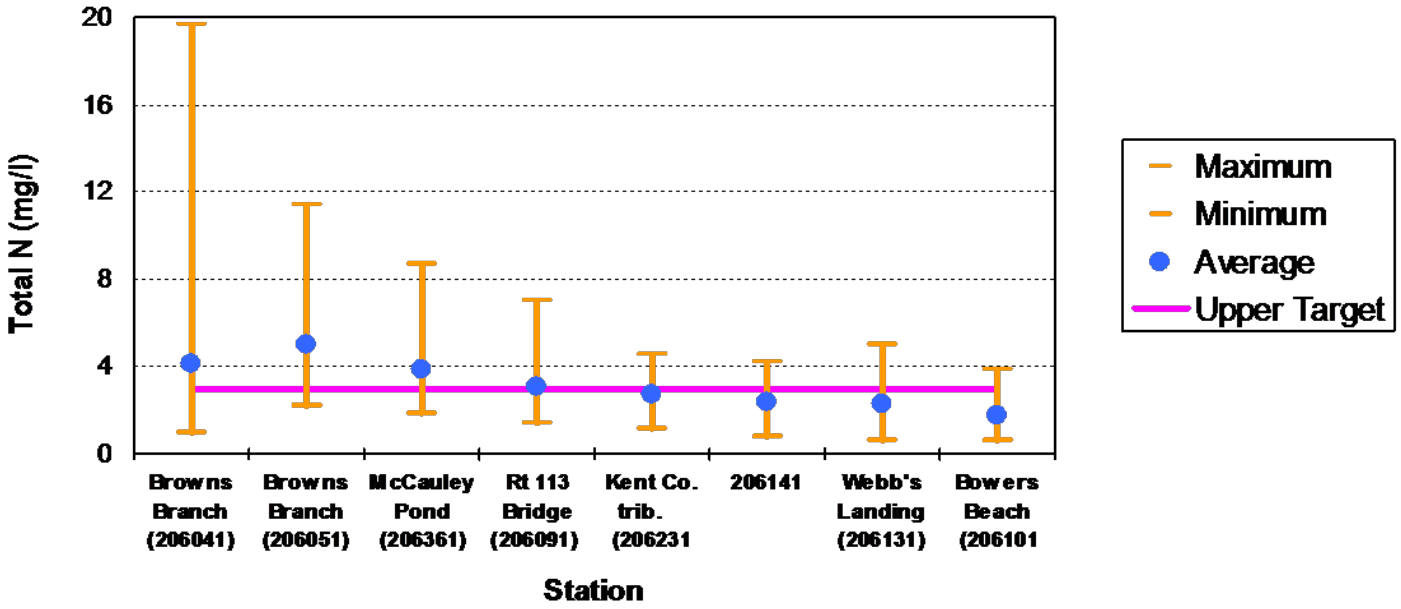

Figure 3 - Total N levels throughout Murderkill Watershed monitoring stations

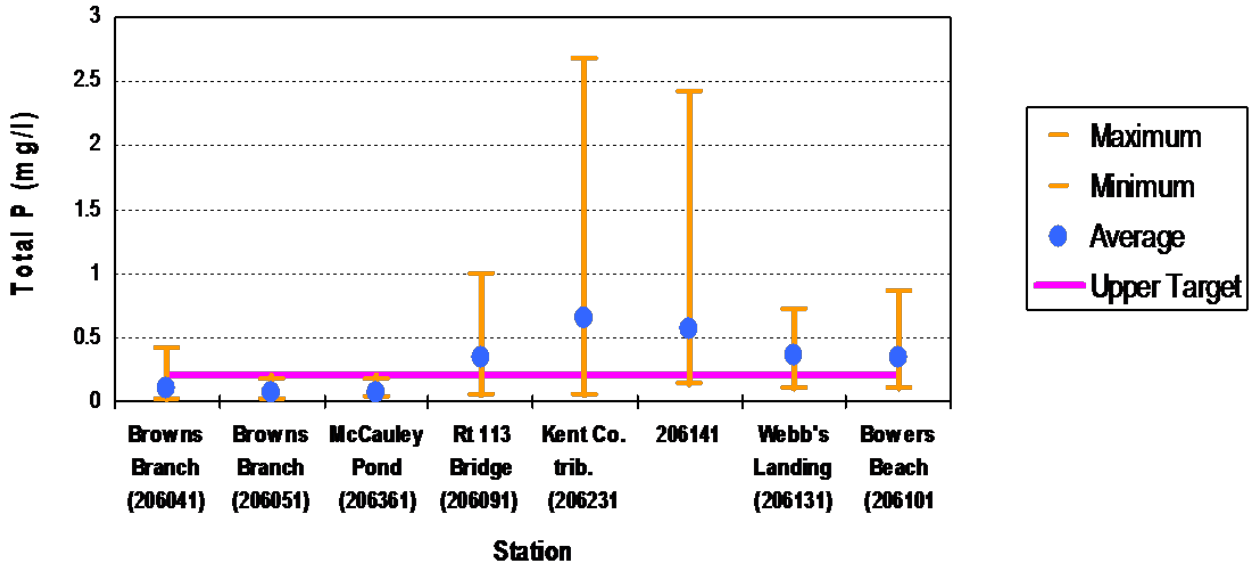

Figure 4 - Total P levels throughout Murderkill Watershed monitoring stations

Murderkill River Total Maximum Daily Load (TMDL)

The 2001 Murderkill River TMDL was established based on the results of water quality analyses using a water quality model, WASP (Water Analysis Simulation Program), of the tributaries and ponds of the Murderkill River. The WASP modeling framework was developed and is supported by the United States Environmental Protection Agency (US EPA). The Murderkill River WASP Model was developed and calibrated using extensive water quality and hydrologic data. Based on the results of modeling analyses, it was determined that point and nonpoint sources of nutrients and oxygen consuming compounds (BOD) need to be reduced in order to meet the State of Delaware's Water Quality Standard and nutrient targets. The State's Water Quality Standard for dissolved oxygen is 5.5 mg/l for fresh water segments and 5.0 mg/l for marine waters, and the State's upper target value for total nitrogen (TN) is 3.0 mg/l and for total phosphorous (TP) is 0.2 mg/l.

Figure 5 - Murderkill Watershed with nutrient impaired stream segments indicated in red

Following adoption of the Murderkill River TMDL Regulation in December 2001, Kent County Levy Court, which owns and operates the Kent County Regional Wastewater Treatment Facility, appealed the TMDL Regulation for the lower Murderkill River to the State Environmental Appeal Board and State Superior Court. Kent County Levy Court, in its appeal of the TMDL Regulation, presented data showing that the Murderkill River WASP Model underestimated physical dimensions (width, depth, cross-sectional area) of the lower Murderkill River. In addition, the County believed that the model underestimated tidal currents in the lower Murderkill River. Because of the above two factors, the County believed that the model underestimated discharge flows, hence underestimated assimilative capacity of the lower Murderkill River. In order to address Kent County Levy Court's concerns, the Department

agreed to collect additional field data and if necessary, modify the Murderkill River WASP Model. In subsequent negotiation between the Department and the County, it was agreed that the Department would:

1. Conduct limited site-specific monitoring and data collection to improve the 2001 model and revise the TMDL if warranted, and
2. Starting in 2007, conduct a comprehensive monitoring and modeling effort to quantify the impact of tidal marshes on water quality of tidal portions of the Murderkill River, develop site-specific water quality criteria with regard to dissolved oxygen and nutrients for tidal Murderkill River, and revise the 2001 TMDL if warranted.

The activities identified in step 1 above were completed in 2005 and a revised TMDL was adopted for the tidal Murderkill River in 2005 (Table 2). The comprehensive monitoring and modeling identified in step 2 above was also completed.

HydroQual, who initially developed the 2001 Murderkill River TMDL, is taking the numerous findings of the monitoring and modeling effort by various scientists and determining any potential impact that the tidal marshes might have on the developed TMDL for Murderkill River. HydroQual has developed a new model which includes the impact of tidal marshes on water quality within the Murderkill Watershed and by early fall of 2012 will have a predictive model for TMDL development.

Table 2 - Murderkill Watershed Nutrient Loads based upon land use and landuse load rates (See Appendix D)

Nutrients	Urban	Agricultural	Wetland	Forests	Other
TN (lbs/day)	456.4	2426.4	0	29.0	42.6
TP (lbs/day)	14.6	58.2	0	2.67	2.7

Pollution Control Strategy

The attainment of TMDLs within the State will be achieved through development and implementation of a Pollution Control Strategy (PCSs). The purpose of PCS is to initiate actions that will reduce the nutrient loads to impaired water bodies that do not meet Delaware's water quality standards. The proposed PCS will be accomplished by optimizing Best Management Practices (BMPs) for nutrient removal at existing point sources facilities and by developing and implementing pollution control strategies for nonpoint sources.

The Delaware Pollution Control Strategy (PCS) process places great importance on public participation. The team process enables citizens to get involved in sorting out the difficult issues, wrestling with the trade-offs, and developing ways to reduce pollution and improve the health of the environment. In this way, the strategies have greater support in the communities they impact.

A Tributary Action Team (TAT) holds the responsibility of preparing recommendations to include in the PCS. A TAT is comprised of a group of local stakeholders with varying interests in the watershed. The team, led by a facilitator, defines the issues specific to the watershed in multiple ways so that all people within the community understand the water quality problems and the connection to what occurs on land and the resulting water quality problems. After

defining the problems, the team frames the potential solutions in various ways to make the solutions understandable and the goals achievable for multiple stakeholders. The team decides which approaches will be most effective in its watershed, based on extensive study, comments at citizen forums, advice from experts, and discussions at public team meetings. In this way, the community defines a strategy that it is willing to implement.

To guide the writing of the actions within this Pollution Control Strategy, the Murderkill Tributary Action Team adhered to the following guidelines:

- All levels of government need to communicate and coordinate with each others' programs and collaborate on mutually beneficial activities in order to improve the water quality of the Murderkill River. Appropriate fees and penalties need to be assigned to activities that impact water quality.
- Water pollution management measures need to be flexible so that they can change with the advances in science and technology.
- People need to have access to information and technology that will prevent pollution in order to be better stewards of the land and waters. Financial incentives will be used to promote best management practices.
- Equitable division of the clean up responsibility must be achieved.
- Complete a fair, comprehensive vision for future land use to clean up our surface and ground waters.

The Tributary Action Team's PCS recommendations have been incorporated into this Pollution Control Strategy. The Pollution Control was modified to meet the elements of a Watershed Plan in compliance with the a) through i) criteria as established by EPA. The Murderkill River Watershed Plan is developed utilizing information found with the following documents:

- Murderkill River Pollution Control Strategy – by the Department of Natural Resources and Environmental Control
- State of Delaware - 2010 Combined Watershed Assessment Report (305(b)) and Determination for the Clean Water Act Section 303(d) List of Waters Needing TMDLs
- Technical Analysis for Amendment of the 2001 Murderkill River TMDLs (Amended 2005)
- Delaware's Surface Water Quality Monitoring Plan, 2007

Although changes have been made, this Strategy is substantially based on the recommendations offered by the Team (Appendix B). The strategies are presented in order of importance based on their ability to meet water quality goals set forth by the TMDL. Each of the specific recommended actions is followed by a brief explanation of why the action was included, whether nutrient load reductions for the action have been prescribed, and if any additional commentary is needed for clarity.

Order of importance was based on two major criteria. First, more stringent reductions are needed for phosphorus than for nitrogen; and second, phosphorus enters the watershed from

point sources to a greater extent than it does through nonpoint sources. These criteria led to actions that are recommended to be implemented to achieve adequate water quality in a hierarchical, prioritized structure. This structure places all the recommended actions in context with each other and makes a complex subject easier to understand.

The strategies consider a variety of factors in addition to environmental science in order to accommodate the wide range of stakeholders within the Murderkill watershed. These factors include but are not limited to: location within the watershed; proximity to water resources; site specific physical characteristics; subdivision, project, and system size; future activities planned by other agencies/entities; and best available technologies. These regulations also consider the issues associated with those living on fixed incomes, people with serious illnesses, people facing financial hardship, and owners of small parcels of land.

Progress To Date

Seven years have passed since the 2005 revision to the 2001 TMDL for the Murderkill River was promulgated using pollution levels from 1997. The TMDL revision resulted from conducting limited site-specific monitoring and data collection to improve the 2001 model. The revision of the Murderkill TMDL was promulgated in 2005.

Since 1997, population and pressures from development have increased throughout the watershed. However, stormwater and wastewater regulations have improved, and farmers have increased their use of best management practices (BMPs). Increased use of BMPs in all sectors reduces nutrient loading and contributes to progress towards achieving water quality standards.

Estimated water quality improvements resulting from the installation of best management practices after the TMDL baseline was calculated and the subsequent nutrient reductions from those BMPs are presented in the following sections. Scientists researched the nutrient load reduction efficiencies associated with these practices in order to estimate pollution reductions. Appendix D documents those calculations and Appendix E estimates the associated costs.

Point Sources

There were four municipal wastewater treatment plants and one business operating a seasonal vegetable washing facility that were considered point sources. Two small point sources (Canterbury Crossing Mobile Home Park and Southwood Acres Mobile Home Park) have been eliminated, and Harrington wastewater will now be treated by Kent County wastewater treatment facility as the Harrington treatment facility has shut down. The vegetable facility terminated surface water discharges to the Murderkill River in 2000. In addition, Kent County has purchased some land for a spray irrigation facility near Frederica. Because of these changes, fewer nutrients are entering the Murderkill River.

Total Progress to Date:

> Estimated Nutrient Reductions: 1.0 lb/day TP; 146.3 lbs/day TN (data is from the facilities' permits)

Agriculture

Since the baseline period (1997), the agricultural community has reduced a significant amount of nonpoint source nitrogen and phosphorus, leading the efforts to curtail nonpoint source loadings. From the baseline to 2011, multiple BMPs have been implemented and the Delaware Nutrient Management Act was passed. As of January 2007, all farms that apply nutrients to 10 acres or more are required to have Nutrient Management Plans (NMPs). Subsequent Farm Bills have also led to increased funding levels of cost-share programs for BMPs that protect the environment, especially water quality.

New regulations concerning Concentrated Animal Feeding Operations (CAFOs) in Delaware were made effective on November 11, 2011 Poultry farmers and livestock operations in the State that are identified as CAFOs will need to apply for a CAFO permit within 90 days after the effective date of these regulations. To apply for the permit, farmers and other livestock operators must send a signed Notice of Intent (NOI) and a copy of their most recent nutrient management plan (NMP) or animal waste management plan (AWMP) to the Delaware Department of Agriculture (DDA). As result of the CAFO regulations, new stormwater best management practices must be placed on any new chicken houses or other structural practices.

Table 3 - Implemented Agricultural Best Management Practices (BMP) as of the end of 2011.

	Acres	**TN reduced (lb/day)**	**TP reduced (lb/day)**
Cover Crops (annual)	4848.3	213.19	0.05
Shallow water areas for wildlife (CP9*)	54.40	3.70	0.06
Wildlife Habitat (CP4D*)	128.7	5.3	0.07
Grassed Filter Strips (CP21*)	181.4	18.9	0.42
Wetland restoration (CP23*)	1835.1	119.84	2.22
Riparian Buffers (CP22*)	1.0	0.14	0.003
Wildlife planting(CP4D*)	47.3	6.0	0.12
Hardwood Plantings	403.3	56.35	1.21
Nutrient Management Plans	35,426.0	325.1	15.67
Manure Relocation (annual) tons	449.0	8.2	0.5
Phytase	2,772.6	0	1.10

*Conservation Reserve Enhancement Codes

Total Progress to Date:

Estimated Nutrient Reductions: 756.7lbs/day TN; 21.78 lbs/day TP

Estimated Progress to Date Implementation Cost: $14,612,248 (Does not include the costs of manure relocation and phytase)

Open Space

The Tributary Action Team has made some voluntary recommendations for open space. In the Murderkill watershed there are 3390.2 acres of public lands approximately 58% of the public lands are nontidal. Waterways within public ownership fared much better than those in privately owned lands. Within public lands, 21 miles (81 percent) are adequately buffered along both stream banks, 4 miles (15 percent) have deficient buffers along either one or both of the stream banks, and only 1 mile (4 percent) had no forested buffer along either stream bank.

Total Progress to Date:

Estimated Nutrient Reductions: lbs/day TP unknown; lbs/day TN unknown

Onsite Wastewater

Current septic system pump outs and conversion of onsite wastewater systems to central sewer systems, while not extensive, have helped to decrease the nutrient pollution entering the Murderkill watershed. Estimated averages of 100 septic systems and 14 holding tanks in the watershed are currently being pumped out a year, while 240 properties in the watershed have been converted from septic systems to central sewer systems.

Total Progress to Date:

Estimated Nutrient Reductions: 14.06 lbs/day TN; 1.42 lbs/day TP

Estimated Progress to Date Implementation Cost: $5,129,880

Stormwater

In June 1990, the Delaware Legislature passed the Sediment and Stormwater Law to help correct the State's water quality and quantity problems. Implementation was initiated in July of 1991, and addressed sediment control during construction and post-construction, stormwater quantity, and water quality control. Since this implementation, many BMPs for stormwater have been implemented and more are constructed each year. The Sediment and Stormwater Regulations are currently being revised to promote the use of stormwater management techniques that are more efficient at reducing nutrient loading, heightening awareness of green technology BMPs, and promoting stormwater management practices based on low impact development and conservation design.

Table 4 - Total Stormwater BMPs Implemented as of end of 2011

BMP	Acres treated	TN Reduced (lb/day)	TP Reduced (lb/day)
Dry Pond	466.5	0.96	0.06
Wet Pond	2,263	27.8	1.49
Biofiltration	168.7	3.47	0.16
Infiltration Practice	311.4	6.40	0.26

Total Progress to Date:

Estimated Nutrient Reductions: 38.72 lbs/day TN; 1.99 lbs/day TP

Estimated Progress to Date Implementation Cost: $34,941,894

Bacteria reductions

Bacteria survival is dependent on soil moisture, temperature, pH, availability of nutrients and antagonistic organisms. Under ideal conditions, the bacteria is retained near the soil surface long enough for infiltration of water into unsaturated soil to occur, resulting in bacteria die off within the first two feet. Under less than ideal conditions, best management practices (BMPs) are the most effective and practical means of preventing or reducing bacteria from entering surface waters.

BMPs reduce bacteria levels in many different ways. Non-structural BMPs are practices that mainly control bacteria at the source; a few examples of these are proper cleanup of pet waste, managing livestock manure, and routine septic inspections and pump-outs. Septic tanks should be inspected every three years and pumped as needed, usually every three years or when the tank is about 1/3 filled. By maintaining your septic system regularly, it is less likely to fail and contaminate surface or ground water. It also extends the longevity of your septic system, saving money for costly repairs or replacements.

Structural BMPs usually involve building a structure and may have a higher cost associated with it. Examples include buffers, constructed wetlands, sand filters, infiltration trenches, low impact development, and stream fencing. Dense vegetative buffers facilitate conventional bacteria removal through detention, filtration by vegetation, and infiltration into soil.

Other methods of bacteria removal include the use of chemicals, such as chlorine, or the use of ultraviolet lights. These methods can be costly and require considerable oversight. These Pollution Control Strategies will result in reduction in bacteria numbers.

Table 5 - Illustrates typical bacterial reductions from commonly used BMPs

BMP	Land Area Needed	Cost	Total Nitrogen % Reduction	Total Phosphorus % Reduction	Suspended Solids % Reduction	Bacteria Reduction %
Buffer Strips	Low	Medium	20 - 60	20 – 60	20 - 80	43-57
Constructed Wetlands	N/A	N/A	20	45	60	78-90
Sand Filters	N/A	N/A	47	41	57	36-83
Dry Detention Pond	High	High	15	25	70	
Infiltration Trenches	Low	Medium	45 - 70	50 – 75	75 - 99	
Wet Ponds* *if properly managed	Medium	High	20	45	55-94	44-99
Biofiltration	N/A	N/A	25	34		>99
Bioswales	Low	Medium	25	34	70	
Storm water wetlands	N/A	N/A	30	49	N/A	78-90

The Murderkill bacteria TMDL requires a 40% reduction in bacteria numbers. The State of Delaware Surface Water Quality Standards, as amended July 11, 2004, provides specific numeric criteria for bacteria for the waters of the Christina Basin. The water quality standard for enterococcus bacteria in the Christina Basin is as follows for primary contact recreation for fresh waters:

- Single-sample value is 185 enterococcus colonies per 100 ml.
- The geometric mean of representative samples should not exceed 100 colonies per 100 ml.

The geometric mean enterococcus bacteria levels in the Murderkill River are discussed in more detail below.

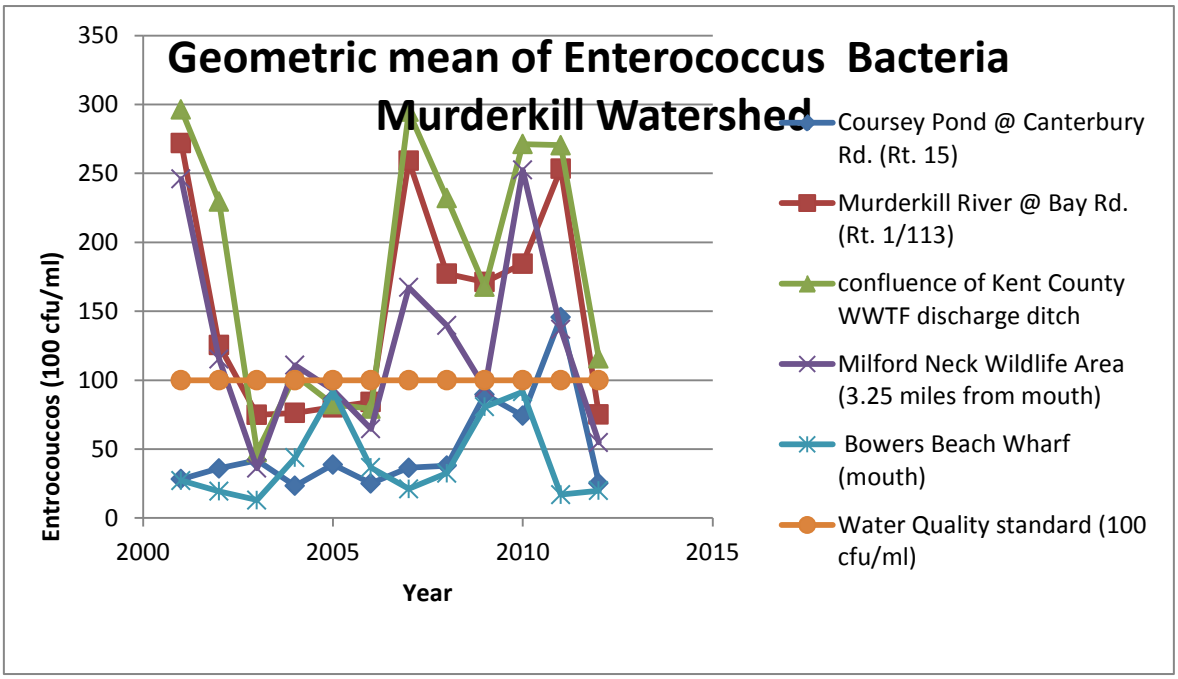

Figure 6 - The yearly geometric mean of Entrococcus Bacteria in Browns Branch of the Murderkill River.

The levels of enterococcus bacteria in Brown Branch of the Murderkill River show no apparent trend as was observed in Double Run Branch and the main stem of the Murderkill River above Coursey Pond. The levels continue to fluctuate in the Browns Branch as well as, Double Run Branch and the main stem of the Murderkill River above Coursey Pond. Figure 6 shows the geometric mean enterococcus bacteria levels in the River from 2001 to 2012.

Implementing these Pollution Control Strategies will result in continued reduction in bacteria numbers. Only monitoring of the surface-water will clearly demonstrate the effectiveness of the installed BMPS in reducing bacteria numbers.

Additional Progress Items

The Murderkill Tributary Action Team has enjoyed success on several other fronts, improving the water quality of the Murderkill River, its tributaries, and its ponds. Accomplishments of the Team include:

- Kent County is pursuing the following projects:

* Double Run Wetlands Restoration and Nutrient Reduction Project - The creation of a two (2) acre wetland within the upper reaches of the Murderkill basin and conversion of a stormwater management pond to bio filtration;

* Greater Meadowbrook Acres Area – An on- site septic elimination project for well over 200 private systems;

* Land Conservation Loan Program Project - The purchase of 255 acres of prime conservation land along the Murderkill River. Restoration of 91 acres, currently in cropland, to their natural habitat under a Habitat Restoration Agreement with the Division of Fish & Wildlife. In additional, the project will protect a riparian forest buffer of 164.4 acres from ever being developed and/or destroyed.

- Award of a Nonpoint Source 319 Program grant to repair failing septic systems in the Walnut Shade area of the watershed;
- Award of a DNREC Coastal Program's grant to extend a pilot program started in the Inland Bays to the Murderkill that provided funding for an individual onsite wastewater treatment and disposal system inspection and pump out compliance program.
- Assistance to a farm located in the headwaters of the Murderkill River near McColley's Pond to become the beneficiary of a cost-share program
- Administered by the Kent County Conservation District for the installation of farm improvements and BMPs. The farm had cattle and donkeys which had unobstructed access to two streams that define the property boundaries. The BMP and farm improvement project involved the installation of fencing to remove direct livestock access to the streams that enter McColley's Pond, the addition of water troughs to provide water for the cattle in place of the streams, and the creation of a manure storage shed. These improvements eliminated direct fecal deposition (bacteria and pathogens) and minimized runoff (sediment and nutrients) to the streams.
- Development of a build-out map of the watershed, with help from a consultant, to prioritize areas for installation of agriculture BMPs and to identify potential areas for stormwater retrofit projects.

The Murderkill River Watershed was designated as a Critical Environmental Area by the Nutrient Management Commission. The large amount of agricultural land in the watershed made it important to prioritize and recognize the watershed so that maximize assistance could reach farmers to address their nutrient management. In 2003, the Team requested Secretary Hughes to submit a letter to the Nutrient Management Commission requesting the Critical Area designation. In September 2003, the Department recommended that the Nutrient Management Commission designate the Murderkill Watershed as a "Critical Watershed." The declaration targets the watershed for increased cost share funds when they are available.

Overall Nutrient Load Reduction Progress

All sectors to date have taken steps to improve water quality through the implementation of laws, regulations, and voluntary BMPs. Analysis using a basic land use loading rate model shows that, to date, nonpoint sources of Total Nitrogen and Total Phosphorus have been reduced by 88% and 61% respectively from the TMDL baseline levels. There is still a need for further reductions in

areas that are currently lacking, such as wastewater and stormwater to reach TMDL required levels. The total strategy implementation reductions and costs are discussed in more detail in the section entitled, “Analysis for TMDL Achievement and Costs”.

Authority

The authority to create a Strategy comes from the Delaware Code, Title VII, Chapter 60. The General Assembly found multiple reasons why regulation of natural resources was needed, including recognizing that “the regulation of the development and utilization of the land, water, underwater and air resources of the State is essential to protect beneficial uses and to assure adequate resources for the future” (7 Del. Code §6001 (a)).

The related policies and purposes are also broad in their coverage (§6001 (b, c)). Section 6010 (a) states that the “Secretary may adopt, amend, modify or repeal rules or regulations, or plans, after public hearing, to effectuate the policy and purposes of this chapter.” Thus, control of pollution and protection of resources are legitimate regulatory goals.

Article 8 of the TMDL for the Murderkill River Regulation requires the development and execution of an implementation plan. Additionally, the State Water Quality Standards state that all “human induced nonpoint sources, subject to control through the use of best management practices or otherwise, shall be required to remove nutrients to the extent necessary to prevent excessive growth of photosynthetic organisms.” The TMDL has determined that level, and this Strategy outlines the actions for achieving that level of water quality.

POLLUTION CONTROL STRATEGY RECOMMENDATIONS

Broad Purpose

The broad purpose of this strategy is to return the impaired waters of the Murderkill River Watershed to a condition permitting use of the waterways as required by the Clean Water Act (33 USC §1251 et seq. (1972)) so it can be removed from the 303(d) list.

Specific Goals

More specific goals of this strategy include limiting pollutants to levels at or below the Total Maximum Daily Load (TMDL) values specified in the regulation as follows in Table 6:

Table 6 - Pollutant Sources in the Murderkill River Watershed as of 2005 revised TMDL

Nutrient Allocation for Sources[5]		Flow (mgd)	Total Nitrogen (lbs/d)	Total Phosphorous (lbs/d)	CBOD5 (lbs/d)
Load Allocation for Nonpoint Sources		-	560	96	-
Load Allocation for City of Harrington Wastewater Facility[6 & 7]	During No discharge	0	0	0	0
	During seasonal discharge	0.75	140	0.75	37.5
Load Allocation for the Kent County Wastewater Facility		15	751	62.5	1001
Load Allocation for the Canterbury Crossing Mobile Home Park Wastewater Treatment Facility		0.05	4.3	0.2	9.6
TMDL (When Harrington not discharging)		-	1315.3	158.7	1010.6
TMDL (When Harrington discharging)		-	1455.3	159.45	1048.1

Based on 2007 land use data, reductions required would be 919.90 lbs TN/day reduced and 41.08 lbs TP/day reduced.

[5] The figures listed in this table are limits proposed in the 2005 TMDL amendments.
[6] The City of Harrington wastewater treatment facility point source discharge is in the process of connecting to Kent County Treatment Plant.
[7] Harrington NPDES permit effective January 2010.

Strategy Prioritization

The recommendations are organized according to pollutant loads and the strategies that will have the highest nutrient reductions. Since the phosphorus reductions were more burdensome than the nitrogen reductions called for by the TMDL, the Team attempted to prioritize the recommendations by the strategy that would have the most impact at reducing phosphorus within the watershed. The Team believes this hierarchical, prioritized structure will lead to the ultimate goal of achieving adequate water quality within the watershed. In addition, this structure helped greatly improve the ability of the Team to understand this complicated subject by placing the recommended actions in context with each other.

Nutrient Reducing Recommendations

The following prioritized strategies are listed in bold. Under each strategy is the basis for the recommendation.

Nutrient Reducing Recommendation 1 – Kent County Wastewater Treatment Facility

> The Kent County Wastewater Treatment Facility should upgrade its operations to the most appropriate technologies for decreasing the amount of nutrients in the effluent, and seek to apply all effluent by land over and above the current permitted average daily flows to decrease the concentration of the contaminants discharged into the Murderkill River.

Implementation Goal: Upgrade the Kent County Wastewater Treatment Facility.

Basis for Recommendation: There were four point source discharges in the Murderkill River Watershed:

- Canterbury Crossing Mobile Home Park Treatment Facility
- Kent County Wastewater Treatment Plant
- Southwood Acres Mobile Home Park Treatment Facility
- City of Harrington Wastewater Treatment Plant

The Kent County Wastewater Treatment Plant (Figure 7) accounts for a majority of the total amount of phosphorous in the waterways of the watershed.

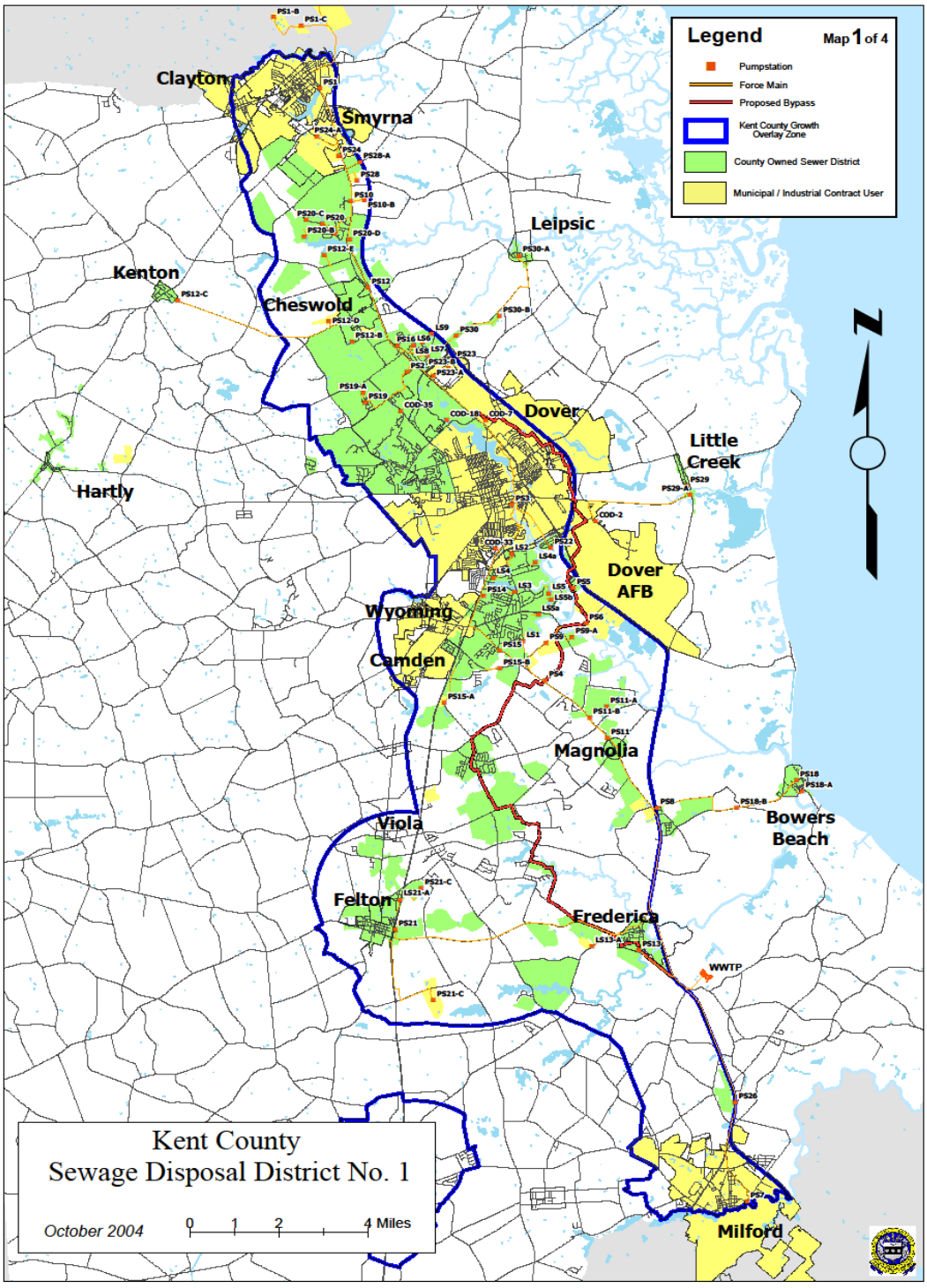

Figure 7 - Kent County Sewage Disposal District No. 1

The baseline total discharge for phosphorus into the Murderkill River from point sources was given as 274 pounds per day (in 1997) to be reduced to 62.5 pounds per day. The Kent County Regional Wastewater and Treatment Facility will be responsible for most of that load reduction. The facility receives wastewater from all over Kent County and part of southern New Castle County. The sewage collection system for the facility is old and has significant inflow and

infiltration during wet periods after significant storm events. Consequently, the treatment plant must handle large volumes of water before the treated wastewater is discharged into the Murderkill River. Kent County Regional Wastewater Treatment Facility received an award from EPA in October 2007 for Outstanding Operations and Maintenance Practices at Wastewater Treatment Facilities**.**

Kent County should encourage the reduction of inflow and infiltration throughout the wastewater collection system. Dover has finished its inflow and infiltration study, and has eliminated some stormwater from entering the wastewater collection system. Milford has also finished its inflow and infiltration study. Additionally, a mechanism needs to be established to compensate the Murderkill Watershed for the increased water quality burden from assimilating the nutrient load from all over Kent County and southern New Castle County. In any case, the Kent County Facility bears a significant task in treating wastewater load from the entire County while meeting the local watershed TMDL mandate.

After the daily loads are reduced to the values called for in the TMDL regulation, the Kent County Facility will account for over 98 percent of the phosphorus reductions from point sources and 39.4 percent of the phosphorus reductions from all sources. Of the 159.45 pounds per day of phosphorous allowed under the amended TMDL, the Kent County Wastewater Treatment facility would be allowed to discharge 62.5 pounds per day. Thus, the Kent County Regional Wastewater Treatment Facility would be contributing 98 percent of the point source phosphorus and 52 percent of point source nitrogen load to the Murderkill River. In addition, because of the TMDL regulation for the Murderkill River Watershed, greater reductions of phosphorus will come from the point sources than from the nonpoint sources, so the other point sources must also be addressed.

Less wastewater being discharged into the Murderkill River would mean that fewer pounds per day of phosphorus will be entering the river. In addition, if spray irrigation is used, it's been shown to reduce phosphorus and nitrogen loads to groundwater by 90%. Spray irrigation will also promote groundwater recharge because currently the treatment facility discharges all of its wastewater into the Murderkill River and tributaries with no opportunity for groundwater recharge.

Implementation Schedule: Upgrades have been completed as of December 2010. These upgrades eliminated the use of chlorine and sulfur dioxide to reduce bacteria in the discharge wastewater. The plant now uses ultraviolet light to eliminate bacteria.
Expected Nutrient Reduction: 3.75 lbs/day/mgd of total phosphorus and 45 lbs/day/mgd total nitrogen when diverted to spray irrigation assuming no stream discharge.

Cost: Wastewater treatment costs Kent County $0.037 per gallon and the facility handles 13,000,000 gallons per day.

Potential Funding Sources: Sewer fees from customers of Kent County Wastewater Treatment Facility.

Action Needed: The upgrades to the Kent County Treatment Facility have already been finished.

Nutrient Reducing Recommendation 2 – Harrington Sewage Treatment Plant

Support Harrington's Sewage Treatment Plant conversion to a spray irrigation facility on nearby farm ground.

Implementation Goal: Eliminate Harrington Sewage Treatment Plant surface water discharge from Browns Branch, a tributary of the Murderkill River

Basis for Recommendation: The amended TMDL allowed Harrington's Sewage Treatment Plant to spray irrigate most of its wastewater but could still discharge a portion of the load into Browns Branch when it is too wet to spray irrigate. Based on an analysis initiated by the City of Harrington and conducted by the City's engineer, Davis, Bowen and Friedel, Inc., the average daily amounts of total nitrogen (72.8 lb/day) from the effluent discharges of 2008 are lower than its NPDES permitted limit, but for total phosphorus (0.8 lb/day) is higher than the permitted limit. The City of Harrington has applied to DNREC's Financial Assistance Branch for a loan to construct a pumping station, and a transmission to connect the City's Treatment Plant to the Kent County Treatment Plant. This project was completed in December 2010.

Kent County has traded farmland they own with West Farms, and are in negotiation for another parcel near the Frederica Facility. The County's intent is to use this land for a possible wastewater spray irrigation site. The total acreage they have available for land application of wastewater is approximately 1000 acres. They plan to use this area if they cannot meet load limits in their permit, or if they need assistance to accommodate their growth. As of March 2012, the County has not initiated a permit for the site as a wastewater spray irrigation facility.

Implementation Schedule: Completed as of December 2010

Expected Reduction: 0.8 lbs/day of Total Phosphorus and 140 lbs/day of Total Nitrogen with an increase in capacity to 0.426 mgd

Nutrient Reducing Recommendation Effectiveness Criteria: Will be measured by the pounds of phosphorus and nitrogen eliminated from entering streams in the Murderkill watershed.

Cost: Engineering and construction cost for the wastewater transmission line from Harrington to Kent County Treatment Plant is approximately $7,000,000.

Potential Funding Sources: Sewer fees from customers of Kent County Wastewater Treatment Facility, United Sates Department of Agriculture, Delaware's Clean Water Advisory Council.

Action Needed: No action is needed.

Nutrient Reducing Recommendation 3 – Mitigate Canterbury Crossing Mobile Home Park and Southwood Acres

Mitigate Canterbury Crossing Mobile Home Park and Southwood Acres point source nutrient loads by utilizing best management practices to reduce nutrients coming from the communities and minimize their respective discharges.

Implementation Goal: Eliminate stream discharges of wastewater for Canterbury Crossing and Southwood Acres Mobile Home Parks.

Basis of Recommendation: The Team did not want to recommend the expenditure of a large amount of resources in ameliorating these two point discharges. Instead, the Team preferred that their loads be reduced by installing best management practices within each development, reducing loads. Their combined load proposed by the amended TMDL only amounts to 0.3 pounds of phosphorus per day and 6.3 pounds per day for total nitrogen. Even if this discharge were completely eliminated, the benefit to the Murderkill River would be slight. However, the Team did endorse their elimination which was completed by Canterbury Crossing Mobile Home Park in March 2009. In addition, Kent County has already eliminated 240 septic systems in the Walnut Shade area east of Woodside, and plans to eventually eliminate another 260 systems in the area over the next several years.

The Team believes that the installation of best management practices within these developments would lead to a decrease in load to the Murderkill at a more inexpensive cost than the cost of eliminating the point source discharges.

Implementation Schedule: To be completed by July 2012.

Expected Reduction: 0.2 lbs/day of total phosphorus and 4.3 lbs/day of total nitrogen

Nutrient Reducing Recommendation Effectiveness Criteria: Will be measured by the pounds of phosphorus and nitrogen eliminated from entering streams in the Murderkill watershed.

Cost: The elimination of septic systems in Walnut Shade was part of a "South Central" project in Kent County which eliminated most of the septic systems in the Meadowbrook subdivision, Woodville and Terry Drives. The "South Central" project cost $13 million with the County paying approximately 15% of the cost. The vast majority of that $13 million was spent in the Meadowbrook, Woodville and Terry Drive sewer projects. Canterbury Crossing was paid for exclusively by the developer and the Department has no knowledge of the cost. Southwood Acres has not been connected to the county wastewater facility.

Potential Funding Sources: Funds will come from developer.

Action Needed: No action is needed.

Nutrient Reducing Recommendation 4 – Nutrient Management Plans

> Encourage farmers to comply with the Nutrient Management Act (NMA) and to actively participate in establishing nutrient reducing best management practices (BMPs) on their farms.

Implementation Goal: All farms in the Murderkill watershed will have nutrient management plans, as applicable.

Basis of Recommendation: As of 2007, all lands over 10 acres that have nutrients applied must be in compliance with Nutrient Management Act. The Nutrient Management Act requires all

farms over 10 acres or with 8 animal units to establish a nutrient management plan, which includes the use of fertilizers and the fate of manure. Assessing the impact of this requirement will help quantify the efficiency and reduction of nitrogen and phosphorus.

Since the baseline period (1997), the agricultural community has reduced a significant amount of nonpoint source nutrient loading, leading the efforts to curtail nonpoint source nutrient loading. From 1997 to 2008, multiple Best Management Practices (BMPs) have been implemented, and the Delaware Nutrient Management Act was passed. The 2002 Farm Bill has led to unprecedented funding levels of cost-share programs for BMPs that protect the environment, especially water quality, and with the 2008 Farm Bill, additional BMPs were constructed to further improve water quality within the watershed.

In the Murderkill, like many watersheds, polluted runoff from cropland, manure-disposal sites, and concentrated animal-feeding operations (CAFOs) are some of the important sources of phosphorus to surface waters. As of 2003, there were 29 poultry operations, which produce approximately 2,490,684 birds annually, 2 dairies, 8 beef cattle operations, 13 equine and 4 goat operations in the Murderkill Watershed. Potential nutrient inputs are related to manure, runoff, erosion, and atmospheric deposition of nutrients. In 2007, 51.85% of the Murderkill Watershed was used for agriculture, which equates to approximately 35,426 acres. Therefore, the agricultural activity is the second leading source, after the Kent County wastewater treatment plant, of phosphorus entering the waterways. In addition, these sources contribute a significant loading of nonpoint source nitrogen.

There are 35,426 acres of crops in the watershed that require nutrients in order to produce an economic yield. Crops produced in the watershed can include soybeans, potatoes, barley, wheat, corn, and vegetables. Nutrient inputs include fertilizer and manure application, which if applied improperly may contribute to nutrient over-enrichment in streams and tributaries in the Murderkill Watershed.

The Delaware Conservation Partnership (DCP) conducted a survey in July 2007, after the deadline requiring all eligible farm operations to have a plan, to evaluate nutrient management planning in the state. The DCP consists of the Delaware Conservation Districts, the Natural Resources Conservation Service, and the Delaware Department of Natural Resources and Environmental Control, and strives to work together to meet the needs of Delaware farmers by providing cost-share programs, educational opportunities, and nutrient management planning services. The survey was designed to inform those programs by identifying gaps in information and education and opportunities to spend cost-share dollars more effectively. In short, the purpose of the project was to make nutrient management work better for farmers in Delaware.

The surveys were sent out to everyone who has been certified by the Nutrient Management Program - 2,034 people in all. The Delaware Conservation Partnership received 698 responses - about a 34% response rate. The following shows the breakdown of responses among different sizes of farms:

1-10 Acres- 9%	100-499 Acres- 25%
11-99 Acres- 29%	500+ Acres- 20%

Animals Only- 10%

The survey indicated that fertilizer application rates have most severely decreased among farmers who till at least 500 acres, while manure applications have most dramatically decreased among farmers who till between 11 and 99 acres. The Partnership determined that Sussex farmers had the highest reduction rate of N and P fertilizer applications, Kent farmers had the lowest rate of N applications, and New Castle farmers had the lowest rate of P applications.

An Agricultural Workgroup was established to gather the best available science on nonpoint source pollution prevention and compare efficiencies based on the DCP survey to other estimates of nutrient management planning effectiveness. The Workgroup operated off the basic assumption that if fewer nutrients are being applied to the land, fewer nutrients will be lost to Delaware's water bodies. From this premise, the Workgroup determined nutrient efficiencies for various agricultural best management practices including the effectiveness of nutrient management planning as seen in Table 7.

Table 7 - Percent changes in fertilizer and manure application rates by county as a result of the 2002 Nutrient Management Law (data from 2007 DCP Survey)

County	Acres in farms	Change in nitrogen fertilizer applications	Change in phosphorus fertilizer applications	Change in manure application
Kent	173,808	13.4	26.9	5.4
New Castle	66,981	16.0	20.1	13.6
Sussex	269,464	18.5	37.1	24.2
Statewide weighted average	510,253	16.7	31.0	19.9

Initially, the Workgroup looked at the impact of nutrient management planning (NMP) in the Inland Bays and Nanticoke watersheds from a study by McGowan and Milliken (1992). This study listed the reductions associated with various management practices observed over a three year period, with a total of 103,736 lbs TN reduced by 2,328 acres under nutrient management planning. To determine a general NMP TN reduction, the Workgroup removed the reductions and acreage associated with manure allowance and cover crops from further calculations; the reductions for both of these items are determined separately and all NMPs will not include manure relocation. This subtraction gave a total of 1,224 acres of nutrient management planning, and a load reduction of 70,136 lbs of TN, resulting in a reduction rate of 57.3 lbs/acre per 3-year planning cycle. McGowan and Milliken (1992) reported that the TN application rate prior to the introduction of NMPs was 280 lbs/acre per 3-year planning cycle, so NMPs produced a 20.5% reduction in TN. This estimate falls in the lower range reported by the State of Maryland (MDNR, 1996), which was 20-39% for nitrogen. The corresponding phosphorus range reported by the Maryland DNR was 9-30%.

In the Murderkill watershed, one representative farm within the watershed volunteered to allow the Workgroup to analyze the nutrient data they routinely gather. This particular farm tracks nutrient application rates to each crop field within a database that goes back to 1999, prior to the passing of the Nutrient Management Act. The data was separated into two groups, pre-Nutrient Management Plans (NMPs) (1999-2002) and post-NMPs (2003-2004), and entered into Statgraphics Software for statistical analysis. It was determined that there was a statistically significant difference between the mean application rates at the 95% confidence level for nitrogen. The average nitrogen application rate decreased by 12.4% from the pre-NMP level and this value will be taken as the NMP reduction efficiency; unfortunately, no reduction could be calculated for phosphorus from this data.

At the request of the NMC, Sims et al. (2008) conducted extensive nutrient mass balance calculations for the State for the years 1996 through 2006. They calculated both input/output and management–oriented mass balances for nitrogen and phosphorus. The Sims et al. (2008) approach included calculations for manure relocation and estimates of biological fixation of nitrogen by leguminous crop and clearly demonstrated that fewer nutrients are being applied to Delaware's cropland.

The DNREC Watershed Assessment Section (WAS) has worked with the NMC and the University of Delaware Cooperative Extension to determine the impact of the Nutrient Management Act on the amount of nutrients applied to Delaware's agricultural fields. Using an input-output type analysis using fertilizer sales data and crop yields, WAS determined that on a state-wide basis, 47% less nitrogen and 62% less phosphorus has been applied to Delaware's cropland. Both the WAS and Sims et al. (2008) approach produced similar results.

The DCP values, which are based on the reductions in nutrient applications actually reported by Delaware farmers, fall within the range of efficiencies determined by the numerous other methods and data sets discussed above. As a result, DNREC proposed to use the DCP efficiencies to estimate the reduction in nutrient application rates resulting from the promulgation of the Nutrient Management Law.

Implementation Schedule: Farms are checked for compliance of Nutrient Management Act December of each year since 2007.

Expected Reduction: The Chesapeake Bay Program (2009) has aggressively established nitrogen and phosphorus reductions associated with various urban and agricultural best management practices including nutrient management planning. The Program applies a 13% reduction to nitrogen and a 27% reduction to phosphorus for every acre of cropland that has a nutrient management plan. Those nutrient reductions were applied to every acreage of cropland in the Murderkill watershed.

Total Phosphorus 15.2.4 lbs/day and 325.1 lbs/day of Total Nitrogen

Nutrient Reducing Recommendation Effectiveness Criteria: Effectiveness will be measured by number of enforcement actions undertaken for failure to comply with NMA within the watershed.

Cost: DNREC's Nonpoint Source Program estimated a cost up to $93,900.

Because Nutrient Management Plans reduce excess cropland nutrients, it is strongly recommended that the Nutrient Management Commission ensure full compliance of the Nutrient Management Act. The cost to develop a nutrient management plan decreases as the acreage in the plan increases. A three year plan for an operation with less than 500 acres costs $5.70, with 501-1,000 acres cost $4.50, with 1,001-2,000 acres cost $3.90, and with more than 2,000 acres cost $3.30 (DNMC, 2004). The average of these values is $4.35/acre every three years, which when annualized is $1.45/acre/year. Farmers can be reimbursed the entire cost for developing a nutrient management plan from the Delaware Nutrient Management Commission.

Potential Funding Sources: Delaware Nutrient Management Commission, State of Delaware Cost Share, DNREC Watershed Assessment Section, and/or NPS Program 319 Funding

Action Needed: DNREC and Delaware Department of Agriculture should assess the impact of nutrient management planning as required by the Nutrient Management Law. Both Departments as well as the Delaware Nutrient Management Commission are actively quantifying the effect of nutrient management on water quality.

Nutrient Reducing Recommendation 5 – Agriculture Best Management Practices

> Establish and prioritize nutrient reducing best management practices (BMPs) in order of efficiency and cost effectiveness. Assess the array of drainage systems and BMPs on agriculture lands in use along the drainage systems within the watershed and identify any areas for possible improvement.

Implementation Goal: Train Kent Conservation District staff to use the existing targeting tool to prioritize agriculture BMPs for nutrient reduction and cost effectiveness.

Basis of Recommendation: The establishment of best management practices on agricultural land will address nutrient inputs from all facets of agriculture operations, including the use of manure from animal operations and fertilizers for crops. The environmental and quality of life benefits of agriculture should be recognized as a way to encourage and enforce BMP implementation. Encourage the use of buffers on agricultural lands where best nitrogen and phosphorous uptake is likely. By targeting areas for BMP implementation geographically, more effective and efficient nutrient reductions can likely be expected.

Specific BMPs that are used in the Murderkill Watershed have many beneficial nutrient reducing capabilities as follows:

- **Cover crops** protect soil when row crops are not being grown. This practice helps retain nitrogen in the soil for the next crop, reducing fertilizer costs to the farmer.
- **Grassed filter strips and grassed buffers** trap sediments in surface runoff and take up excess nutrients.
- **Ponds** capture nutrient losses from upland or cropped acreage.

- **Riparian forested buffers** reduce nutrient losses from upland acres and reduce sediment bound phosphorous from entering waterways.
- **Wetland restoration** reduces nutrient loss from upland acres.
- **Field border plantings** trap sediment in surface runoff and take up excess nutrients.
- **Manure relocation** removes significant amounts of excess manure, consequently removing excess nutrients.

The Kent Conservation District developed a Geographic Information System database of farm fields to improve their ability to coordinate and effectively manage agricultural NPS pollutant reductions. The spatial database will facilitate a more efficient:

- Consolidation of information from the numerous agricultural agencies that develop and administer BMP and conservation practices.
- Approach to highlighting the geographic location of all existing BMP and conservation practice locations in a designated watershed.
- Utilization of watershed planning tools capable of targeting and ranking farm field properties for various BMP and conservation practice implementation.

This Geographic Information System database was developed to identify and target farm field sites for potential enrollment in various state and federal agricultural voluntary cost-share programs that address nutrient nonpoint source pollutant loading. The targeting of farm fields was applied to those Murderkill River subwatershed areas not prioritized for land use conversion from agriculture to urban/residential (Center for Watershed Protection, *Prioritization of Murderkill Subwatersheds*, 2005). The following list of subwatershed areas was included in the farm field targeting effort: Double Run, Beaverdam Branch, Swamp Creek, Browns Branch, Upper Murderkill River, Middle Murderkill River, Lower Murderkill River, McColley Pond, and Spring Creek.

This Tool will allow the District and its state and federal partner agencies to maximize the limited implementation funds and planning resources earmarked for potential agricultural NPS loading sources within the Murderkill.

The farm field GIS database was utilized to conduct a desktop assessment of potential nutrient loading sources and to assist with the future prioritization of agricultural BMP and conservation practices implemented in the specified subwatershed areas of the Murderkill River. Agricultural BMP and conservation practices addressing three nutrient loading pathways were reviewed: nutrient (nitrogen) loading from cropland in high groundwater recharge areas; nutrient (nitrogen and particulate phosphorous) loading into stream areas lacking appropriate riparian buffering; and nutrient (nitrogen and phosphorous) loading from farm animal waste sources. A number of farm fields were prioritized for potential voluntary enrollment in the existing state and federal agricultural cost-share programs. This prioritization provides the District and their state and federal agency partners with an ability to initiate a proactive approach to farm field enrollment in available agricultural BMP and conservation practice cost-share programs.

Implementation Schedule: District staff to be trained by December 2012.

Expected Reduction: As of March 2012, agricultural best management practices on the ground in the Murderkill River Watershed have reduced phosphorus loads by 21.78 lbs per day or 53 percent of the way towards the total phosphorus load goal 756.70 lbs per day of total nitrogen or 82 percent of the way towards the nitrogen TMDL reduction load goal.

Table 8 - Murderkill Watershed Nutrient Reductions from Agricultural BMPs end of 2011			
	Acres	***TN reduced (lb/day)***	***TP reduced (lb/day)***
Cover Crops (annual)	4848.3	213.2	0.39
Shallow water areas for wildlife (CP9)	28.7	1.0	0.00
Wildlife Habitat (CP4D)	128.7	5.3	0.07
Grassed Filter Strips (CP21)	178.3	18.9	0.41
Wetland restoration (CP21)	1835.1	119.8	2.22
Wildlife planting(CP4D)	47.3	6.0	0.12
Hardwood Plantings	403.3	56.35	1.21
Nutrient Management Plans (annually)	35,426	325.1	15.67

Nutrient Reducing Recommendation Effectiveness Criteria: Effectiveness will be measured by the number of acres of BMP install within the watershed.

Cost: Training of District staff will be done by DNREC staff**.** The costs of implementing BMPs have been estimated using data gathered by United States Department of Agriculture (USDA), Natural Resource and Conservation Service (NRCS) at the county and state level. Recently, changes in the state cost share program have required a Pollution Control Strategy for watershed residents to receive funding. Thus, the state cost share information found in Table 9 is based on a PCS approved for the Murderkill watershed. These are estimates, as costs for specific project may vary.

Table 9 - Agricultural BMP Costs				
	Installation Cost / Acre	**Lifespan (years)**	**Total Maintenance Costs over**	**Total Cost/ Acre**

			Lifespan	
Cover Crops	$49.33	1	$5	$54.33
Ponds	$3,758.50	10	$5	$3,808.50
Grassed Waterways	$16,404.24	10	$5	$16,454.24
Filter Strips/Wildlife Habitat	$495.24	10	$5	$545.24
Forest Buffers	$495.24	15	$5	$570.24
Riparian Buffers	$502.00	15	$5	$577.00
Wetland Restoration	$4,374.50	15	$5	$4,449.50
Field Border	$495.24	10	$5	$545.24
Critical Area Planting	$7,229.24	10	$5	$7,279.24
Conservation Tillage	$17.33	4	$5	$37.33

Potential Funding Sources: United States Department of Agriculture Natural Resource Conservation Service, Farm Service Agency, Kent Conservation District, DNREC Watershed Assessment, DNREC NPS Program 319 Funding, United States Fish and Wildlife Service, DNREC Ecological Restoration Program, Delaware Department of Agriculture Nutrient Management Commission

Action Needed: The Tool has been completed but needs to be implemented.

Nutrient Reducing Recommendation 6 – Stream Monitoring

Ongoing in-stream monitoring must be done in order to quantify the amount of nutrients in the waterways of the Murderkill Watershed.

Implementation Goal: On a routine basis, monitor surface water quality of Murderkill River through DNREC's GAMN stations.

Basis for Recommendation: Monitoring plans help determine the effectiveness of watershed projects that aim to improve TMDLs and overall water quality. As a result, it is important to institute tracking and monitoring systems to measure improvements in sub-watershed indicators over time. These systems include the internal tracking of restoration projects in each sub-watershed, as well as monitoring of stream indicators at sentinel monitoring stations. Performance monitoring of individual restoration projects can be tracked to improve the design of future restoration practices. Information gathered from a tracking system is then used to revise or improve the restoration plan over a multi-year cycle.

Undoubtedly over time, the Murderkill Watershed will experience significant changes in land use. Monitoring plans for water quality improvement should take in to account the possibility of build out and the associated impacts. As a result, the following monitoring approaches are recommended:

Project Monitoring (Milestone Monitoring): As warranted, small scale (reach or smaller) project monitoring should be conducted to illustrate benefits of individual restoration efforts. Project managers will want to invest in both in-stream and non-stream monitoring of individual restoration projects to assist in measuring project success. Such monitoring can be relatively simple (observing the success of a reforestation project or measuring public awareness through surveys) or extremely complex and expensive (measuring the pollutant reduction of a storm water retrofit or the biological response to a comprehensive stream restoration project). On an annual basis, information derived from the baseline and project monitoring should be complied into a report.

The annual report should summarize current biological and physical conditions in the watershed; the number, type, and extent of projects taken; and the Murderkill success to date of the plan in improving watershed conditions. Reporting on an annual basis will allow for mid-course corrections and adjustments to be made based on the monitoring data.

Sentinel Station Monitoring: Sentinel monitoring stations are fixed, long-term monitoring stations which are established to measure trends in key indicators over many years. DNRECs Water Quality Monitoring stations (GAMN) contain the history of data necessary to detect trends in water quality that would be beneficial to determine project success in removing targeted pollutants. These are the stations which TMDL data was used for calibration. A list of existing GAMN stations can be found in Table 10 below.

Table 10 - Murderkill Watershed General Monitoring Network (GAMN) Stations

Location	Site ID	Sampling frequency
Murderkill River @ confluence of Black Swamp Creek at Rt. 13	206011	12 times, Annually
Browns Branch @ Milford - Harrington Hwy. (Rt. 14)	206041	12 times, Annually
Murderkill River @ Bay Rd. (Rt. 1/113)	206091	12 times, Annually
Murderkill River @ Bowers Beach Wharf (mouth)	206101	12 times, Annually
Murderkill River near levee @ Milford Neck Wildlife Area (3.25 miles from mouth)	206141	12 times, Annually
Murderkill River @ confluence of Kent County WWTF discharge ditch	206231	12 times, Annually
McColley Pond @ Canterbury Rd. (Rt. 15)	206361	12 times, Annually
Coursey Pond @ Canterbury Rd. (Rt. 15)	206451	12 times, Annually
McGinnis Pond @ McGinnis Pond Rd. (rd. 378)	206461	12 times, Annually
Double Run @ Barretts Chapel Rd. (rd. 371)	206561	12 times, Annually

If future funding allows, it is recommended to expand the GAMN station locations to include routine sampling of those station currently only monitored on an as needed basis. This would allow for data continuity and ease of collection. In addition, if additional point sources are discovered or added, downstream sampling sites should be added. Additionally, as warranted on a project specific basis, increased sampling will occur to measure and document BMP efficiency.

Illicit Discharge Monitoring: Illicit discharge detection and investigation are critical elements of watershed restoration and planning especially when there are obvious indicators of illicit discharges. Illicit discharges are often a significant source of pollution in a watershed that occurs repeatedly in association with specific polluting behaviors. The GAMN station locations are areas where illicit discharges can be detected. Additionally, volunteer stream assessments, which could be conducted yearly, could identify potential illicit discharges.

Implementation Schedule: DNREC evaluates its monitoring plan yearly to maximize monitoring dollars with sampling needs**.**

Expected Reduction: An efficiency and reduction value cannot be assigned to this recommendation. Monitoring does not have a direct reduction.

Cost: Each year the State spends $1,000,000 on sampling and monitoring.

Potential Funding Sources: DNREC receives state funding and EPA funds for its surface water monitoring program.

Action Needed: The Department has an ongoing trend study that uses its routine water quality monitoring stations to access current water quality. The study has been completed for the years 2006 and 2010.

Nutrient Reducing Recommendation 7 – Septic Elimination

> Optimize and prioritize areas where individual, large, and community wastewater treatment and disposal systems can be eliminated by connecting to Kent County Wastewater Treatment Plant.

Implementation Goal: Eliminate failing septic systems by connecting them to the Kent County Wastewater Treatment Plant.

Basis for Recommendation: In Delaware surface and groundwater are directly connected. Thus, impacts on groundwater will impact the quality of the surface water. In the summer months, surface water flow is primarily groundwater seepage into the stream. Thus, nutrients from functioning onsite wastewater treatment and disposal systems reach the surface water through groundwater contamination. An individual onsite wastewater treatment and disposal system may contribute as much as 5.8 lbs per year of phosphorus and 22 pounds per year of nitrogen to the groundwater. As of 2010, approximately 7,565 septic tanks were identified in the Murderkill Watershed. In 1997, which is the baseline year for the TMDL, there were 5,238 individual septic tanks in the watershed. In 2010, the potential contribution of phosphorus from septic systems could reach up to 15.2 lbs per day, while 219.4 lbs per day of nitrogen will enter groundwater and ultimately end up in the surface water.

Kent County has aimed to install a connection to a central sewer for the Walnut Shade Road and Peachtree Run near Woodside, Delaware, where 500 residences use onsite wastewater treatment and disposal systems, many of which are old and malfunctioning. Kent County has also included Woodville and Terry Drives, areas where most of the homes are served by environmentally

ineffective and outdated cesspools. System failures pose the greatest threat to human health and water quality.

Implementation Schedule: This proposed sewer district will be connecting to the Kent County Wastewater Treatment Facility within the next 3-5 years.

Expected Reduction: It has been estimated that 8 lbs/day of TP and 30 lbs/day of TN can be reduced by implementing this recommendation.

Nutrient Reducing Recommendation Effectiveness Criteria: Effectiveness will be measured by the number of systems connected to Kent County Plant.

Cost: See cost for Nutrient Reducing Recommendation 3. The cost of these systems will be paid by the land owner. Cost-share funds may be found to assist those of middle-income and below. At present, State Revolving Fund (SRF) money and Septic Rehabilitation Loan Program funds may be used to provide low interest loans to property owners that need to replace a failing system.

Potential Funding Sources: See funding sources for Nutrient Reducing Recommendation 3.
Action Needed: DNREC should assist the county by identifying areas that have a large number of failing old wastewater treatment and disposal systems due to system age and undersized disposal areas.

Nutrient Reducing Recommendation 8 – Inspection and Pump Out of Septic Systems

> Promote compliance with regular inspections and pump outs of individual onsite wastewater treatment and disposal systems (OSWDS).
>
> Require the onsite wastewater treatment and disposal system be inspected and pumped out upon house sales to verify the system was maintained and is operational.

Implementation Goal: Have all systems within the watershed inspected once every three years.

Basis of Recommendation: Currently, septic permits require that the systems be pumped out every three years, or when the system contains at least 30 percent solids. The Department's Groundwater Discharges Section in the Division of Water has the authority to implement this recommendation through a revision of the Regulations Governing the Design, Installation, and Operation of On-site Wastewater Treatment and Disposal Systems.

Additionally, the Department has the authority to regulate OSWDS. On July 11, 2003 the Governor signed House Bill 150 into law, which authorizes the Department to establish a license for persons who inspect systems and other OWTDS, and sets an annual license fee for septic system designers, installers, site evaluators, liquid waste haulers, inspectors and percolation testers, similar to other license fees charged by the Department. On January 1, 2006, DNREC developed and implemented the Class H license for a septic system inspector. Following the inspection, the inspector provides the homeowner/resident with educational materials and receipt of pump out.

The watershed currently has 7,565 OSWD systems within its boundaries. If all systems are pumped once every three years, as required by state regulations, then 2,522 systems are pumped annually. The soils in the watershed are mostly well drained, so the actual TP reduction will likely be significantly less. Each system pumped out would reduce TP and TN surface and/or groundwater load by 1.40 lbs/system/year and 3.62 lbs/system/year respectively.

Implementation Schedule: Have routine inspections occurring by July 2013.

Expected Reduction: 1.49 lbs/day of total phosphorus and 3.6 lbs/day of total nitrogen for 2,522 systems

Nutrient Reducing Recommendation Effectiveness Criteria: Effectiveness will be measured by the number of pumped out within the watershed.

Cost: DNREC's Small Systems Branch (personal communication, 2006) revealed that the installation of best available technologies (BATs) to existing small (<2,500 gallon per day (gpd)) OWTDSs for advanced nitrogen removal would cost between $3500 and $6000 per system with an average of $4,750. These technologies require a service contract by a certified service provider with an estimated annual cost that ranges from $150 to $300, with an average cost of $225/system/year. In addition, the systems will still require pump-outs, which cost $64/system/year (DNREC small System Branch, personal communication, 2007), and will need periodic mechanical parts repaired, estimated to cost $50/system/year and the electric cost of running the system is likely to also cost about $50/system/year (DNREC Financial Assistance Branch, personal communication, 2007). Costs are not currently available for the retrofit of larger systems.

Potential Funding Sources: The cost of these systems will be paid by the land owner. Cost-share funds may be found to assist those of middle-income and below. At present, State Revolving Fund (SRF) money and Septic Rehabilitation Loan Program funds may be used to provide low interest loans to property owners that need to replace a failing system.

Action Needed: With the promulgation of the new proposed Regulations Governing the Design, Installation, and Operation of On-site Wastewater Treatment and Disposal System Regulations by the end of 2012, the Department believes that Nutrient Reducing Recommendation 8 for inspections of individual onsite wastewater treatment and disposal systems (OSWDS) will occur at the time of sale and at least once every three years. If the new OSWDS regulations are not promulgated as anticipated, the Department will promulgate the necessary regulations for this recommendation.

Nutrient Reducing Recommendation 9 — Cesspools and Seepage Pits

> Systematically eliminate cesspools and seepage pits as the properties are transferred from one owner to another.

Implementation Goal: Eliminate all cesspools and seepage pits in watershed.

Basis for Recommendation: The DNREC Watershed Assessment Section estimates that there are at least 30 cesspools and/or seepage pits in the Murderkill Watershed, however that estimation may be low. Any remaining cesspools would likely be with old farmsteads and very old mobile home parks.

Due to the cost of these systems, the Financial Assistance Branch which administers the Septic Rehabilitation Loan Program provides a source of low interest financing for repairing or replacing failing septic systems or cesspools with systems that will function in an environmentally sound and cost effective manner. Eligibility is open to property owners with on-site wastewater disposal systems that need rehabilitation in order to meet regulatory requirements. In addition, the property owners must meet program income guidelines and must demonstrate the ability to repay the loan. Financing is available at an interest rate of 3 or 6 percent depending on income and can be repaid over 20 years with no prepayment penalty. Loans range from $1,000 to $25,000 for individual systems with maximum loans of $250,000 for community or mobile home park systems. Eligible costs include:

- Site evaluation fees
- Septic system design fees
- Permit fees
- Construction costs

A new Septic Extended Funding Option (SEFO) has been established for homeowners who do not qualify for the Septic Rehabilitation Loan Program. SEFO can be used when the current program cannot provide all the funds necessary to assist an applicant. All SEFO loans are interest-free and secured by a due-on-transfer mortgage lien that stipulates full loan repayment when the property is sold or transferred. To receive funding, loan recipients must sign a mortgage lien and loan note. No monthly payments are required and SEFO loans will be forgiven after 20 years, the useful life of the septic system.

Implementation Schedule: To be completed by July 2015.

Expected Reduction: 0.6 lbs/day of total phosphorus and 0.16 lbs/day of total nitrogen can be reduced if 30 cesspools are removed.

Nutrient Reducing Recommendation Effectiveness Criteria: Effectiveness will be measured by the number of cesspools and seepage pits eliminated within the watershed.

Cost: The cost depends on the number of systems that need replacement and the types of systems that would be permitted in their place.

Potential Funding Source: The cost of these systems will be paid primarily by the property owner. Cost-share funds may be found to assist those of middle-income and below. At present, State Revolving Fund (SRF) money and Septic Rehabilitation Loan Program funds may be used to provide low interest loans to property owners that need to replace a failing system.

Action Needed: With the promulgation of the new proposed Regulations Governing the Design, Installation, and Operation of On-site Wastewater Treatment and Disposal Systems regulations in 2012, the Department believes that Nutrient Reducing Recommendation 9, which details the systematic elimination of cesspools and seepage pits as the properties are transferred from one owner to another. If the new OWTDS regulations are not promulgated as anticipated, the Department will work to promulgate the necessary regulations to implement this recommendation separately.

Nutrient Reducing Recommendation 10 – Wastewater Education

> Provide new homeowners with onsite wastewater disposal system educational materials on how the systems function and the steps that are necessary for maintenance at the time they close on their homes.

Implementation Goal: The owners of a new onsite wastewater disposal system permit will receive a maintenance manual.

Basis of Recommendation: New homebuyers may not understand the functioning of their system or the impacts a failing system could have on the environment. Therefore, by providing education materials, the homeowner may prevent long-term problems and may save money as well.

Implementation Schedule: As of July 2012, all owners of a new onsite wastewater disposal system permit will receive a maintenance manual.

Nutrient Reducing Recommendation Effectiveness Criteria: Effectiveness will be measured by the number homeowners receiving educational materials on septic systems within the watershed.

Cost: $5,000 for 10,000 copies of “Simply Septics”.

Potential Funding Sources: To be paid by permitting fees or by grant funding.

Action Needed: The Department needs funds to publish and update onsite wastewater disposal systems educational materials. The Small System Branch has produced “Simply Septics” which educates a homeowner about their septic system, which needs to be reprinted and updated.

Nutrient Reducing Recommendation 11 – Alternative Wastewater Systems

> Provide education about alternative, enhanced, nutrient reducing onsite wastewater treatment and disposal systems and develop a fund to offset the cost of these systems within the watershed.

Implementation Goal: Require all new, reducing, onsite wastewater treatment and disposal systems meet TMDL nitrogen reductions**.**

Basis for Recommendation: In response to the TMDL, Kent County requires that new, individual residential, large, or community onsite sewage treatment and disposal systems sited in a watershed with an established Total Maximum Daily Load (TMDL) shall be designed and installed with nutrient reducing device that will meet required TMDL reductions or they shall use the best available technologies in order to achieve the required nutrient reduction targets set for the particular watershed (See Chapter 187, Subdivision and Land Development (Adopted June 24, 2003).

Due to the cost of these systems, the Financial Assistance Branch which administers the Septic Rehabilitation Loan Program provides a source of low interest financing for repairing or replacing failing septic systems or cesspools with systems that will function in an environmentally sound and cost effective manner. Eligibility is open to property owners with on-site wastewater disposal systems that need rehabilitation in order to meet regulatory requirements. In addition, the property owners must meet program income guidelines and must demonstrate the ability to repay the loan. Financing is available at an interest rate of 3 or 6 percent depending on income and can be repaid over 20 years with no prepayment penalty. Loans range from $1,000 to $25,000 for individual systems with maximum loans of $250,000 for community or mobile home park systems. Eligible costs include:

- Site evaluation fees
- Septic system design fees
- Permit fees
- Construction costs

Implementation Schedule: An existing Kent County ordinance already requires that all new onsite wastewater treatment and disposal systems meet TMDL nitrogen reductions**.**

Expected Reduction: For small individual septic systems, performance based septic systems could reduce nitrogen content of the wastewater by 50%. However, this will only apply to new homes.

Nutrient Reducing Recommendation Effectiveness Criteria: Effectiveness will be measured by the number of system installed with nutrient reducing technologies installed within the watershed.

Cost: DNREC's Small Systems Branch (personal communication, 2006) revealed that the installation of best available technologies (BATs) to existing small (<2,500 gallon per day (gpd)) OWTDSs for advanced nitrogen removal would cost between $3,500 and $6,000 per system with an average of $4,750. These technologies require a service contract by a certified service provider with an estimated annual cost that ranges from $150 to $300, with an average cost of $225/system/year. In addition, the systems will still require pump-outs, which cost $64/system/year (DNREC small System Branch, personal communication, 2007), and will need periodic mechanical parts repaired, estimated to cost $50/system/year and the electric cost of running the system is likely to also cost about $50/system/year (DNREC Financial Assistance

Branch, personal communication, 2007). Costs are not currently available for the retrofit of larger systems.

Potential Funding Source: The cost of these systems will be paid by the land owner. Cost-share funds may be found to assist those of middle-income and below. At present, State Revolving Fund (SRF) money and Septic Rehabilitation Loan Program funds may be used to provide low interest loans to property owners that need to replace a failing system.

Nutrient Reducing Recommendation 12 – Sediment and Stormwater Plans

> Design and implement all permanent sediment and stormwater management plans to include design criteria to further reduce nutrient contributions by the percentage required by the TMDL to the ground and surface waters to the maximum extent practicable.

Implementation Goal: Develop sediment and stormwater regulations that require nutrient reductions as required by the TMDL for stormwater management plans.

Basis of Recommendation: Since 1991, stormwater runoff from new development has been regulated under the Delaware Sediment & Stormwater Regulations, administered by the Division of Watershed Stewardship. As stormwater moves over land, it picks up natural and human-made pollutants from lawns, streets, parking lots, and industrial and commercial facilities, eventually depositing them into the waters of the Murderkill. Stormwater management is the primary way to control nonpoint source pollution from developed areas. A variety of methods can be used to control and treat runoff from lawns, homes, parking lots, roads, and commercial and industrial facilities. Some of these methods reduce nutrient loading from stormwater more than others. When possible, these methods should be preferred. However, there may be instances where the pollutant of most concern on the site would not be reduced sufficiently by the most effective nutrient removal technique. In these cases, the method used should be the best at treating the removal of the pollutant of most concern. Reducing stormwater impacts within the Murderkill will require all stakeholders to implement innovative management techniques.

As a result of the PCS for the Indian River, Indian River Bay, Rehoboth Bay, and Little Assawoman Bay Watersheds, several options were developed to control nutrient loadings in stormwater runoff from new development. These are generally divided into two categories: Performance-Based approaches and Standards-Based approaches. The Performance-Based approaches require that the designer perform calculations to verify that the nutrient reduction goals for a given project have been satisfied. The first goal should always be to apply Green Technology BMPs in accordance with the Delaware Sediment & Stormwater Regulations. These BMPs are intended to recharge stormwater runoff and decrease pollutant loadings. A series of calculations based on the proposed BMP selection is then performed to determine whether the pollutant loadings have been reduced enough to meet target levels. The process also recognizes the concept of the "irreducible concentration." That is, the current technology is only capable of reducing pollutant concentrations to a certain level. Once that level is reached, it is considered to have met the current Best Available Technology (BAT). If the irreducible concentration has not been met, the designer must employ a "treatment train" approach by adding BMPs in series and going through an iterative process to determine whether the required reductions have been met or the irreducible concentration has been reached. These approaches

are based on preserving specific natural features of a site and preclude having to perform load reduction calculations to verify compliance.

Additionally, the report "Governor Minner's Task Force on Surface Water Management" (2005) recommends including nutrient reduction as an aspect of sediment and stormwater law. As part of recommendations 10 A and B, it is suggested that State Sediment and Stormwater Regulations and plans be updated to include requirements for stormwater recharge, runoff volumes, land use cover conditions, turbidity limits, adequate conveyance, and pollutant loads. The Sediment and Stormwater Regulations are currently under revision and will be modified to better address volume management by increasing emphasis on recharge and infiltration of stormwater, where it is technically and environmentally feasible. In addition, regulations should include design criteria to reduce nutrient contributions through practices such as comparing post development conditions with and without stormwater quality controls, using treatment trains of stormwater controls, and/or reducing impervious cover.

These revised regulations are expected to be promulgated in 2012. The Department will use the interim period between the promulgation date and effective date for education and outreach efforts to train the various Delegated Agency staff and regulated community. The revised regulations will apply to new development and redevelopment projects and will include requirements for both construction site and post-construction stormwater management State-wide. A technical document containing technical standards for new development and re-development projects will be developed in conjunction with the proposed revisions to the Sediment and Stormwater Regulations.

The emphasis under the proposed revisions for both stormwater quality and stormwater quantity management will be runoff reduction techniques that encourage infiltration and recharge of stormwater runoff. This method will both decrease pollutant loads and mitigate the hydrologic impacts to receiving waters often associated with land development. All projects developed under the revised Sediment and Stormwater Regulations will be required to meet the TMDL for that particular watershed.

Implementation Schedule: Regulations to be promulgated in 2012.

Expected Reduction: This action will only impact new construction and reductions will depend on what stormwater practices are implemented.

Nutrient Reducing Recommendation Effectiveness Criteria: Effectiveness will be measured by the number of systems installed that are compliant with new stormwater regulations within the watershed.

Cost: Approximately $200,000 for consulting services for regulation development.

Potential Funding Sources: Cost is first absorbed by the developer of the project, and then passed on to the new property owner.

Action Needed: Promulgated regulations.

Nutrient Reducing Recommendation 13 -- Buffers

Require vegetated buffers of adequate and proper widths sufficient to reduce or eliminate nonpoint source pollution for lots abutting all waters of the state.

Implementation Goal: Require 100 foot riparian buffers from top of bank of streams.

Basis of Recommendation: Based upon the GIS analysis conducted for this recommendation, forty-three percent of the waterways within the Murderkill River Watershed are not adequately protected by forested riparian buffers which are capable of reducing excess loading amounts of nutrients and sediment. Buffers help to filter nutrients and slow overland stormwater flow. Kent County has promulgated several ordinances related to development and buffers, including an ordinance requiring 100-foot setbacks from tidal and blue line streams and a 50-foot setback from shoreline or top of bank of steep slopes, of any stream, creek or drainage ditch as seen in Table 11.

The current County setbacks, specified distances from designated points, are not required to be vegetated, except in certain TMDL watersheds. The Murderkill Tributary Action Team (TAT) feels these ordinances may not be strong enough as written to adequately protect the waters of the Murderkill River. Based upon the Tributary Action Team's recommendations, DNREC is proposing to strengthen and supplement County requirements with the expectation that these measures will protect and improve water quality and the quality of life for the residents in the watershed.

Table 11 - Kent County Ordinance (187-78) required setbacks from water bodies

Waterbody type	Distance in feet	Requirements	Planting required
Tidal	100 from shoreline (as defined by mean high-water line)	No Buildings, structures, paved surfaces, except stairs, ramps, patios, or docks less than 200 square feet	No
Non-tidal freshwater body, lake, pond or "blue –line stream"	same as above	Same as above	No
Any non-blue line stream, creek or ditch	50 from shoreline or top of bank	Same as above	No
Any TMDL promulgated basin	100 from center line of stream	Requires preservation or reestablishment of riparian buffer	Maybe required

The TAT recommended that buffers be required for the following: stormwater and drainage conveyances, grassed waterways, intermittent streams, and tidal and freshwater wetlands. Those buffer widths shall be measured from shoreline or top of bank. In addition, buffers should be free of any encumbrances including onsite wastewater treatment and disposal systems, fences, portable buildings, kennels, livestock paddocks and decks.

From the above recommendations, DNREC performed GIS analyses using ESRI's ArcGIS software on the 2007 National Hydrologic Data Set from U.S. Geological Survey (USGS) and Delaware Statewide Wetlands Mapping Project state wetlands maps (SWMP). Using these tools, a comparison of the current and proposed setback and buffer protection measures for all waterbody types, including TMDL and non-TMDL waters, identifies vulnerable areas that require additional protection.

In the first GIS analysis, perennial and intermittent streams were delineated using the Hydrologic Data Set and 100 and 50 foot setbacks were applied according to the existing Kent County ordinance for TMDL and non-TMDL waters. For this analysis, the outer limits of the delineated streams were used to approximate the mean high water line, shoreline, and/or top of bank that are used in non-TMDL watersheds. The resulting map (Figure 8) shows the approximate area protected by the existing setbacks outlined in County ordinance §187-78.

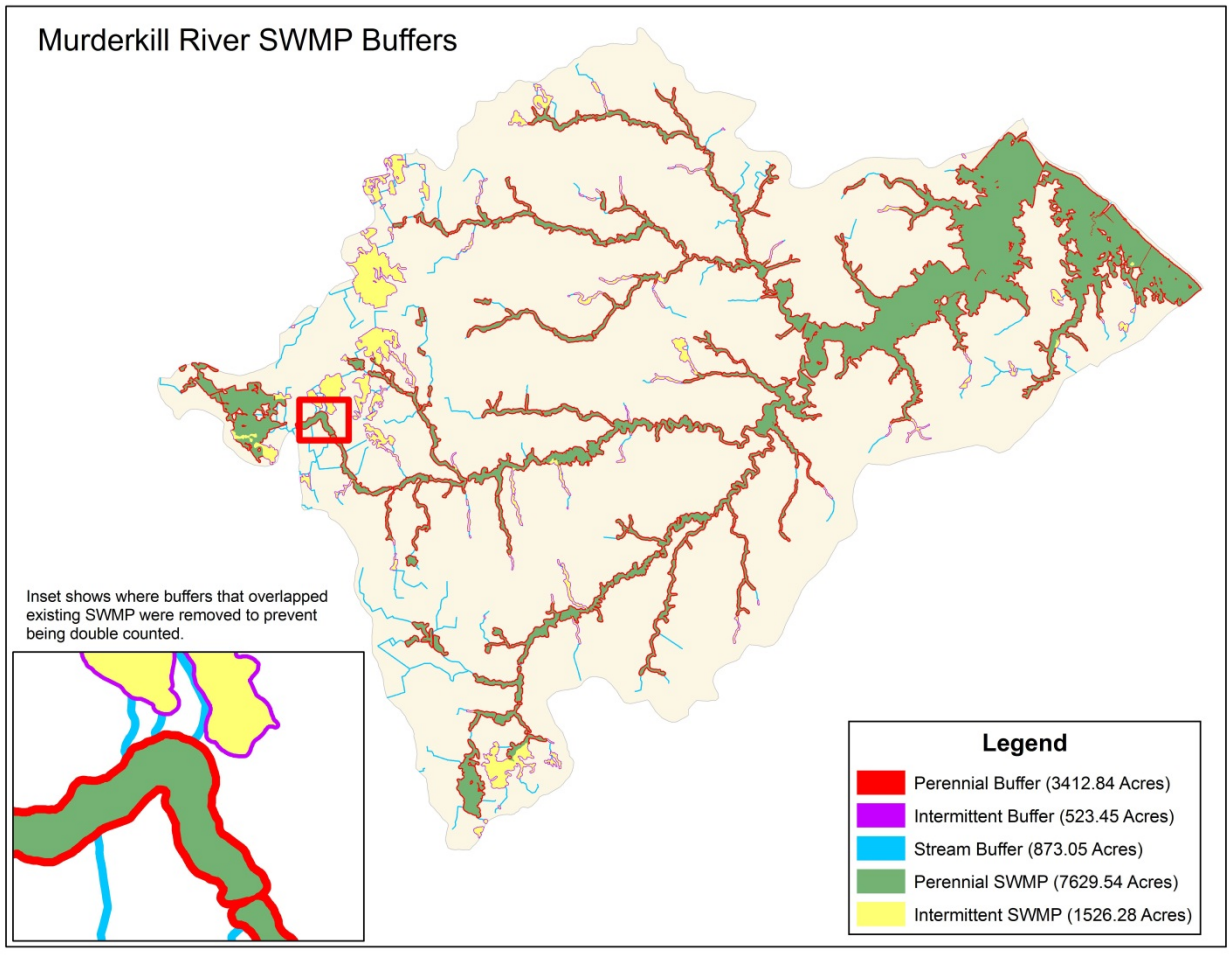

Figure 8 - Buffers needed in the Murderkill

Furthermore, the Kent County ordinance for TMDL watersheds was applied through another GIS analysis, where 100 foot buffers were mapped from the center line of the tidal waters and perennial streams and 50 foot buffer from intermittent streams (non-blue line streams and ditches). The U.S. Geological Survey (USGS) no longer identifies waterbodies as blue-line and non-blue line streams. Now, the USGS maps watercourses using a new mapping scheme that

identifies streams and ditches as perennial or intermittent streams and those terms are incorporated into the remainder of this proposal.

The following GIS analysis applied buffers from the edge of the wetland associated with the perennial and intermittent streams instead of the center line of stream as it currently stands in the ordinance. A 100 foot buffer was applied to perennial streams from top of bank (i.e. edge of wetland) and 50 feet from top of bank of intermittent streams to mimic the Kent County setback requirements (187-78) for non-TMDL watersheds. Acreage of the buffers from each GIS analysis provides a comparison between the current and proposed riparian buffering schemes in Table 12.

Table 12 - Acreage included in setback by means of Kent County Ordinance §187-78 or protected by §187-77*

Setback	Distance in feet	Type	Acreage included in required County setback 187-78	Additional acres protected by wetlands ordinance 187-77*	Total acres protected resulting from current County ordinances 187-77, 187-78
Any TMDL promulgated watershed	100 from center line of stream	Perennial	3511	4118**	7629
Any TMDL promulgated watershed	100 from center line of stream	Intermittent	1526	0	1526
Non-TMDL watershed	100 from shore line or mean-high line	Perennial fresh and/or tidal waters	3413	7630**	11043
Non-TMDL watershed	50 from shore or top of bank	intermittent stream or ditch	1396	1527**	2923

** As per ordinance § 187-77, Kent County does not allow subdivision, filling, developing or clearing of vegetation in wetlands unless granted permission by a regulating agency.*

*** In the Murderkill watershed additional acres protected are applied equally for either TMDL or Non-TMDL waters.*

GIS analysis showed that applying the non-TMDL waters setback to all perennial and intermittent streams within the Murderkill watershed allows an additional 4,811 acres of potential buffer to surround the water. The setback includes vegetation, making it a riparian buffer, further improving the water quality benefits of the entire watershed. Again, DNREC believes that the current TMDL setback ordinance for watersheds does not provide adequate water quality protection for the streams. In most cases, streams are bordered by wetlands, which have no buffer protection from the adjacent uplands. Upland sources are a primary contributor of nutrients and bacteria found in these waters. It must be noted, this scenario assumes that all lands adjacent to perennial and intermittent streams have the potential to be developed, but this would most likely not occur in the Murderkill watershed under current County zoning ordinances.

Research has shown that each acre of buffer established with grass, shrubs and/or trees removes excess nutrients and bacteria from 2 acres of the surrounding area. If the County ordinance for non-TMDL waters was applied to TMDL waters in the Murderkill watershed, so that the setback was applied at the mean high tide line for tidal waters and the top of bank for non-tidal waters, an additional 4,811 acres of buffer would protect the water quality in these waterways. Currently, the TMDL waters setback protects 9,155 acres, however if the non-TMDL waters setback was applied as stated above, the total acreage in buffer protection would increase to 13,956 acres. In the latter scenario, 1 acre of buffer protection would provide water quality benefits to approximately 3 acres of land.

The proposed recommendation would offer protection for a portion of existing forested riparian buffer currently at-risk of being developed and allow inadequate buffers to reestablish in order to fully provide water quality treatment benefits. Developers should be required to protect existing and/or provide new buffers if necessary as community open space, however, the responsibility for buffer maintenance will fall to civic and homeowners associations or maintenance corporations, not individual homeowners. Buffers should be planted and designed to require minimal maintenance. In addition, buffers should be planted with native species in an effort to ease maintenance, reduce erosion and increase nutrient uptake capabilities. The developer must also guarantee all trees planted in the development remain living for the first year or offer replacement plants as individuals are lost.

From the two GIS analyses and Tributary Action Team recommendations, DNREC proposes that a 100 foot vegetated buffer be applied to all perennial streams from either top of bank or the mean high-tide line based on tidal properties and 50 feet from top of bank for intermittent streams within the Murderkill Watershed. This would mimic Kent County's current ordinance 187-78 for non-TMDL waters, except the setback (buffer) would need to be planted in native vegetation. From GIS analyses, DNREC believes that requiring a 100 foot buffer from the top of bank for perennial streams and tidal waters and 50 feet from intermittent streams, that no additional land would be removed from development opportunities since the County ordinance already requires this identical setback on non-TMDL watersheds, but are not required to be planted. DNREC believes that Kent County wanted to give TMDL waters a higher level of protection than non-TMDL waters by requiring 100 setbacks from center line of streams and maintaining or re-establishing riparian buffers. As applied, however, the County's TMDL ordinance is less protective than its non-TMDL setback requirements. See appendix for planting recommendations.

Implementation Schedule: December 2012.

Expected Reduction: For each acre of 100 foot wide buffer installed, 0.004 lbs per day of total phosphorus and 0.18 lbs per day of total nitrogen could be reduced.

Nutrient Reducing Recommendation Effectiveness Criteria: Will be measured by the number acres of riparian buffer established and the number of communities within the Murderkill watershed that have riparian buffer ordinances.

Cost: One acre of riparian buffer costs $570 to implement.

Potential Funding Sources: Developers should be required to protect existing and/or provide new buffers if necessary as community open space: however, the responsibility for buffer maintenance will fall to civic and homeowners associations or maintenance corporations, not individual homeowners. Buffers should be planted and designed to require zero or minimal maintenance. The developer must also guarantee all trees planted in the development for the first year.

Action Needed: The Department will work with Kent County and other municipalities within the watershed to develop buffer regulations that would be consistent with existing ordinances.

Nutrient Reducing Recommendation 14 – Deficient Buffers

> Determine the location and acreage of buffers in the watershed and identify areas for improvement, i.e. stream miles with and without buffers.
>
> Establish riparian buffers on all public lands, including retrofits. Fifty percent of appropriate public lands should have buffers installed within 5 years, and within 10 years all public lands should have buffers as appropriate.

Implementation Goal: Establish riparian buffers on public lands.

Basis of Recommendation: Stream reaches within the Murderkill Watershed that either lack forested riparian buffers, or have only narrow forested riparian buffers were identified using ESRI's ArcGIS software. The analysis included the use of multiple layers of data including 1997 forest cover data from the Delaware Natural Heritage Program, hydrograph data from the U.S. Geological Survey (USGS), 2002 wetlands maps from the Delaware Statewide Wetlands Mapping Project (SWMP), and public lands data from DNREC's 2004 Outdoor Resources Inventory (ORI). Since the forest cover data was somewhat outdated, 2002 aerial photos were also used to help update some of the forest cover data as needed.

GIS software was used to identify 100 foot wide buffer areas around rivers, streams, and ditches, and 50 foot buffer areas around freshwater wetlands. Tidal wetland areas were considered unsuitable for the establishment of forested buffers and were removed from the analysis. All tidal tributaries, and tidal portions of the river were included in the analysis. Buffers around tidal areas were considered adequate if the wetlands extended at least 100 feet from the edge of the water. For all non-tidal areas, buffers were considered adequate if the entire designated buffer areas consisted of forests. Stream sections within the watershed were categorized into three groups according to the status of the adjacent forested riparian buffers. The three categories included: 1) adequate forested buffers along both stream banks, 2) deficient forested buffers along either one or both stream banks, or 3) no forested buffers along either stream bank. Since the establishment of additional forested riparian buffers has a greater likelihood of being implemented on public lands than on privately owned lands, the analysis was broken out for both publicly owned and private lands.

Within the Murderkill Watershed there are approximately 230 miles of waterways excluding ponds and reservoirs. The analysis found that out of 230 miles of rivers, streams, and tax ditches, only 130 miles (57 percent) are adequately buffered along both stream banks. Sixty-

seven miles (29 percent) have deficient buffers along either one or both of the stream banks, and 33 miles (14 percent) have no stream buffers along either stream bank.

Within the Murderkill watershed only 26 miles (11 percent) of rivers, streams, and tax ditches flow through publicly owned lands. Waterways within public ownership fared much better than those in privately owned lands. Within public lands, 21 miles (81 percent) are adequately buffered along both stream banks, 4 miles (15 percent) have deficient buffers along either one or both of the stream banks, and only 1 mile (4 percent) had no forested buffer along either stream bank.

Overall, within the Murderkill watershed most of the tidal portions of the watershed and the main stem of the river are adequately buffered. The areas in most need of attention are the agricultural ditches, many of which have no forested riparian buffers. The analysis also emphasizes the importance of working in cooperation with private landowners, since a majority of the waterways flow through privately owned lands. Overall, 43 percent of the waterways within the Murderkill River Watershed are not adequately protected by forested riparian buffers that are capable of reducing the loading of excess nutrients and sediment.

Implementation Schedule: Have 50 percent of appropriate public lands with adequate riparian buffers within 5 years.

Expected Reduction: See Recommendation 13 for expected reductions.

Nutrient Reducing Recommendation Effectiveness Criteria: Will be measured by the number acres of riparian buffer established on public lands within the Murderkill watershed.

Cost: One acre of riparian buffer costs $570 to implement.

Potential Funding Source: The costs of implementing BMPs have been estimated using data gathered by United States Department of Agriculture (USDA), Natural Resource and Conservation Service (NRCS) at the county and state level. Recently, changes in the state cost share program have required a Pollution Control Strategy for watershed residents to receive funding. Thus, the state cost share information found in Table 9 is based on a PCS approved for the Murderkill watershed. These are estimates, as costs for specific project may vary.

Action Needed: The Division of Watershed Stewardship will work with the other state agencies that have property that have deficient buffers along either one or both of the stream banks to determine if the areas can be buffered and will try to obtain funding to accomplish this goal.

Nutrient Reducing Recommendation 15 – Buffer Vegetation

> Support research to identify vegetation that will give the most nitrogen and phosphorus reduction for planting along maintenance right of ways for ditches and in buffers.

Implementation Goal: Use the latest research information to maximize nutrient reduction capability of buffers.

Basis of Recommendation: Riparian buffers effectively trap the sediments, nutrients, and bacteria in the surface and ground waters flowing from uplands, and thus, improve the quality of receiving waters. Several studies have examined the effectiveness of buffers at removing sediment from surface runoff, with the general agreement being that as buffer width increases, sediment removal increases (Castelle et al., 1994; Wenger, 1999; Dosskey, 2001). An experiment in the North Carolina Coastal Plain, though, found that although the studied buffer trapped as much as 90% of the sediment eroded from an agricultural field, almost 50% of that sediment traveled more than 300 feet into the buffer (Cooper et al., 1987 as cited in Wenger, 1999). This suggests that wide buffers are necessary for long term sediment sequestration. Sediment can be trapped by forested or grassy vegetation. The deep root structures of trees stabilize soils and promote further sedimentation. Grassed buffers, on the other hand, are effective at minimizing runoff velocity and trapping sediment by maintaining sheet flow through the riparian zone, but they can become covered in high sedimentation environments, which rapidly decrease their efficiency (Wenger, 1999; Dosskey, 2001).

Once nutrients like phosphorus and nitrogen enter riparian buffer zones they either become trapped in the soils, taken up by vegetation, or transformed by other processes. Phosphorus is often found bound to sediment and is mobilized in surface runoff. Thus, particulate P can be effectively removed through the trapping of sediment in wide buffers as described above (Wenger, 1999). Nitrogen, on the other hand, is primarily transported in the dissolved form and is taken up by vegetation or permanently removed from the system through denitrification, a process through which microbial organisms in the soils and streambed reduce nitrate-N to nitrogen gas. Denitrification is likely the more significant mechanism of nitrate-N removal (Peterjohn and Correll, 1984), however, several factors influence where the greatest amount of denitrification will occur. Denitrification rates are often greatest when the ground water table is near the surface and when carbon and nitrate-N are in good supply (Wenger, 1999; Lowrance, 1992). Thus, these zones of high denitrification can be highly spatially variable and in order to capture as many zones as possible, and hence remove as much nitrate-N as possible, buffer width should be maximized. A width of at least 100 feet has been suggested as an optimal buffer width for this purpose (Wenger, 1999). Grass and forest buffers are both effective at removing N and P from surface waters, however forests are more efficient at removing N from ground waters (Osborn and Kovacic, 1993 as cited in Wenger, 1999).

Implementation Schedule: Continue researching types of vegetation that will be best in a nutrient reducing buffer through 2012.

Expected Reduction: See Recommendation 13

Nutrient Reducing Recommendation Effectiveness Criteria: Will be measured by the number acres of riparian buffer established with appropriate vegetation

Cost: The only cost associated with this recommendation would be staff cost for research.

Action Needed: From existing studies, develop planting recommendations in order to maximize nutrient reductions.

Nutrient Reducing Recommendation 16 – Open Space Management

Require management of open space, as defined by county and municipal ordinances, for nutrient reductions.

Implementation Goal: Encourage the planting of open space in native vegetation and require compliance of Nutrient Management Act for parcels greater than 10 acres. Prevent nutrient application in open spaces unless recommended by a soil test or nutrient management plan.

Basis of Recommendation: Open space can have many valuable functions and should include natural areas; however, wetland restoration areas and buffers should be included as open space. Open space should be developed with appropriate native vegetation and protected though easements. In impaired watersheds, it makes sense that water quality protection should be important when developers design open space. Maintenance of these spaces is important for water quality benefits. While it is logical that inclusion of open space in a developed area will help to reduce nutrient loads, it is difficult to assign a specific load reduction to this recommendation.

DNREC's Delaware Coastal Programs in late 2005 produced *Community Spaces, Natural Places* which is a guide to restoration, management and maintenance of community open spaces. The guide provides communities and landowners with a basic understanding of low cost natural habitat options for community open space and was designed to provide practical approaches for open space management, challenges and opportunities of mobilizing a community open space as well as low cost natural habitat options for open space.

Implementation Schedule: As development projects are reviewed, encourage use of native vegetation.

Expected Reduction: For each acre of open space converted from agricultural land to open space, 0.0001 lbs/day of total phosphorus and from 0.054 to 0.041 lbs/ day of total nitrogen could be reduced.

Nutrient Reducing Recommendation Effectiveness Criteria: Will be measured by the number acres of open space with nutrient management plans within the Murderkill watershed.

Cost: In 2003, three Northern Illinois landscapers estimated installation and maintenance costs for turf-grass and native landscapes. All three concluded that turf grass is more expensive than native landscaping. Variations in conditions from site to site can create exceptions to this scenario.

Table 13 - First-Year Installation Costs Per Acre (Natural Landscaping for Public Officials: A Sourcebook. Chicago: Northeastern Illinois Planning Commission, 2004)

Landscape Treatment	Low-End Estimate	High-End Estimate

Turf Grass	$5,550	$6,471
Native Landscaping	$1,600	$ 1,788

Potential Funding Source: Cost is first absorbed by the developer of the project, and then passed on to the new property owner.

Action Needed: The Department will work with the Kent County and municipalities to implement a program that will encourage homeowners associations only apply nutrients to open space unless prescribed by a nutrient management plan. The Department also requests communities to follow the *Helping the Environment Starts in Your Back Yard* and developed by the Department's Coastal Program to restore, manage and maintain open space.

Nutrient Reducing Recommendation 17 – Stormwater BMPs

> Monitor existing and new stormwater BMPs, quantifying the return on investment for different practices, locating and identifying structures, quantifying the types and amount of different pollutants, and identifying the most effective and cost efficient practices.

Implementation Goal: Implement the new proposed Delaware Sediment and Stormwater Regulations**.**

Basis of Recommendation: DNREC and the Delaware Department of Transportation (DelDOT) are involved in projects monitoring the effectiveness of various stormwater practices. DelDOT has been investigating the performance of four different types of inlet protection devices in urbanized areas of northern Delaware. They are evaluating and comparing the performance of these inserts with respect to their ability to remove sediment and hydrocarbons from stormwater runoff, as well as their maintenance requirements in different applications. Monitoring will continue year-round over a two- to three-year period, in order to incorporate data from varying seasonal and rainfall conditions. These projects combined with the literature will provide nutrient reduction efficiencies for various practices in the future.

Kent County Conservation District has initiated assessing all stormwater BMPs installed in Kent County, identifying priority areas for stormwater retrofits, and evaluating the effectiveness of BMPs already constructed.

Implementation Schedule: Promulgate regulations by end of December 2012.

Expected Reduction: Depending on the type of green technology BMP that is installed, nutrients could be reduced by 40-70%.

Cost: Approximately $200,000 for consulting services for regulation development.

Potential Funding Source: Funded through State general funds.

Action Needed: With the promulgation of the new proposed Sediment and Stormwater Regulations by the end of 2012, the Department believes that this recommendation will be met. If the new regulations are not promulgated as anticipated, the Department will promulgate

stormwater regulations for the Murderkill watershed that meet this recommendation and the required TMDL reduction.

Nutrient Reducing Recommendation 18 – Stormwater Retrofits

Identify areas in the watershed where stormwater retrofits would be effective in reducing nutrients from entering into surface waters.

Implementation Goal: Use existing stormwater BMP database to identify retrofit areas.

Basis for Recommendation: Land developed prior to 1990 did not have any stormwater requirements. Kent Conservation District has delegated authority from DNREC to run the stormwater program in Kent County and is in the process of identifying priority areas for stormwater retrofits.

Implementation Schedule: Create a list of potential retrofit areas in 2012.

Expected Reduction: Nutrient reductions will depend on the specific systems selected for upgrade and the acreages involved. Table 14 shows the pollutant removal efficiencies of some of the most common stormwater BMPs.

Nutrient Reducing Recommendation Effectiveness Criteria: Effectiveness will be measured by the number of systems installed that are compliant with new stormwater regulations within the watershed.

Table 14 - Qualitative Pollutant Removal Efficiencies

Relative Pollutant Removal Capabilities for Storm Water Treatment Practices

	TSS	***TP***	***TN***	***Metals***	***Bacteria***	***Oil & Grease***
Dry Detention Ponds	○	○	○	○	○	○
Wet Ponds	●	●	◉	●	●	●
Stormwater Wetlands	●	●	◉	◉	●	●
Filtering Practices	●	●	●	●	○	●
Infiltration Practices	●	●	●	●	●	**Don't Use**
Water Quality Swales	●	◉	●	●	○	◉

● **High Removal** ◉ **Medium Removal** ○ **Low Removal**

Source: CWP, 2005

Cost: The Watershed implementation plans generated for the St. Jones and Broadkill watershed cost $175,000 for each watershed.

Potential Funding Source: State and federal grants

Action Needed: The Department will work with Kent Conservation District to identify areas that are suitable for stormwater retrofits.

Nutrient Reducing Recommendation 19 – Separation of Flows

All Municipalities in the county must separate their stormwater flow from their wastewater flows according to the Kent County Sanitary Code.

Implementation Goal: Reduce inflow and infiltration into the Kent County sewer system.

Basis of Recommendation: Based upon information given to the Team by Kent County, flow to the county wastewater treatment plant may double during rain events and nutrient loads may increase from more runoff. Cost estimates have been developed from Dover's experiences in flow separation. It is estimated that Dover residents are paying at least $100,000 a year to Kent County the just to treat rainwater that has infiltrated into Dover's collection system. In the fall of 2006, Dover contracted with Video Pipe Services of Beltsville, Maryland to determine areas where the sewer collection system needs repairs in order to eliminate infiltration. From the information collected from this action, the City of Dover estimated that over 700,000 gals of rain water was eliminated from infiltrating and inflowing during wet periods into their collection system. This estimated inflow resulted from 27 homes in old Dover.

Implementation Schedule: Completed In Harrington

Expected Reduction: A reduction of 2.9 lbs/day of P and 35 lbs/day of N from rain water inflowing from 27 homes.

Nutrient Reducing Recommendation Effectiveness Criteria: Effectiveness will be measured by the number of home that have had their downspouting disconnected from wastewater collection system within the watershed.

Cost: The City of Harrington estimated that $400,000 is needed to fix leaky sewer pipes that are letting rainwater into the town's sewer system.

Potential Funding Source: Sewer fees from customers of Kent County Wastewater Treatment Facility and City of Harrington.

Action Needed: The Department will request information on Dover's study to develop information on the benefits of reducing infiltration into County's collection system.

Nutrient Reducing Recommendation 20 – Stormwater Utility

Implement a stormwater utility within the watershed.

Implementation Goal: Institute a stormwater utility in Kent County and within the Murderkill watershed.

Basis of Recommendation: Former Governor Minner's Task Force on Surface Water Management quantified the statewide financial need for stormwater management. "The Finance Subcommittee identified stormwater capital requirements of $207.3 million over the next five years and projected annual maintenance requirements of $13.73 million" (DNREC, 2005). The Task Force further recommended that a stormwater utility operating at the county or local level should be formed as a funding vehicle for the purpose of providing a simplified and comprehensive approach to drainage and flooding problems. A stormwater utility is an approach

that can generate a stable source of funding for stormwater management within the region. The funds are made available by collecting user fees. Stormwater utility fees are generally set by the amount of impervious cover on each resident's property. The higher the impervious cover, the higher the fee. GIS mapping will be utilized to measure impervious surface generated by residential and commercial development, and the utility fee will be charged based on the property's Equivalent Runoff Unit (ERU).

The Delaware Sediment and Stormwater Regulations serve as an enabling structure for the local ordinances needed in order to set up the utility. For example, the City of Wilmington has established a stormwater utility for residential and commercial customers in the municipality where all properties pay a stormwater charge based on their impervious cover.

Implementation Schedule: DNREC has worked with Kent County and the Kent Conservation District, the implementation is progressing slowly and will depend on County actions.

Expected Reduction: Nutrient reductions cannot be assigned to this recommendation as it is a mechanism for funding practices, not for implementing a practice.

Nutrient Reducing Recommendation Effectiveness Criteria: Effectiveness will be measured whether a stormwater utility is developed within the watershed.

Cost: DNREC, Kent County and Kent Conservation District requested a level of service analysis and investigation of the stormwater service district for Kent County that was conducted. URS, Inc. received the contract for the analysis, which cost $75,000.

Potential Funding Source: Kent County

Action Needed: The Department will assist the County or any other municipality who may be interested in implementation of a stormwater utility in their jurisdiction.

Nutrient Reducing Recommendation 21—Stormwater Education

> Improve watershed residents' knowledge of stormwater best management practices by establishing guidelines that correlate to national and state curriculum standards with an emphasis on the benefits of stormwater management.

Implementation Goal: Develop an education program for stormwater management throughout the watershed.

Basis of Recommendation: Since 1991, stormwater runoff from new development is regulated under the Delaware Sediment & Stormwater Regulations, administered by the Division of Watershed Stewardship. As stormwater moves over land, it picks up natural and human-made pollutants from lawns, streets, parking lots, and industrial and commercial facilities, eventually depositing them into the waters of the Murderkill. Stormwater management is the primary way to control nonpoint source pollution from developed areas. A variety of methods can be used to control and treat runoff from lawns, homes, parking lots, roads, and commercial and industrial facilities. Some of these methods reduce nutrient loading from stormwater more than others.

Reducing stormwater impacts within the Murderkill will require all stakeholders to implement innovative management techniques.

Implementation Schedule: Develop or institute a stormwater education plan by 2013 after the new Sediment and Stormwater regulations are in place.

Expected Reduction: Nutrient reductions cannot be assigned to this recommendation, as it is a mechanism for education.

Nutrient Reducing Recommendation Effectiveness Criteria: Effectiveness will be measured by the homeowners that received stormwater management education

Cost: Unknown at this time and is a function of program developed.

Potential Funding Source: State and/or Federal grants.

Action Needed: The Department will continue its education efforts for stormwater management and will assist Kent County and municipalities with their education efforts.

Nutrient Reducing Recommendation 22 – Lawn Care

> Quantify the amount of nutrients lawn care is contributing to waterways through the use of surveys or other methods, as appropriate.

Implementation Goal: Initiate Delaware Liveable Lawns to the Murderkill watershed.

Basis for Recommendation: It was apparent from data that the non-farm fertilizer tonnage has grown significantly from 1995 to 2009 as seen in Figure 9. Correspondingly, there has been an 8 percent increase in urban acreage over this time period, suggesting that fertilizer applications to other land uses, such as residential lawns, is increasing. Sims et al. (2007) reported that from 2000 to 2006, 50%, 30%, and 20% of the non-farm N fertilizer and 44%, 32%, and 24% of the non-farm P fertilizer was used in New Castle, Kent and Sussex County, respectively. There was a 162.5% increase in non-farm tonnage sold within Delaware when compared to before 2002 and the Delaware Nutrient Management Law.

In Delaware, 58 percent of homeowner turf acres were fertilized. Of these, the average nitrogen application rate to home lawns falls within the range recommended by the University of Delaware Soil Test Procedure (UDSTP) and phosphorus application rates fall below the range specified by UDSTP. Also in this study, researchers found that professional landscape services used significantly less fertilizer than homeowners.

The Delaware Livable Lawns Program is administered by the Delaware Nursery & Landscape Association (DNLA), a leader in Delaware's $745 million Green Industry. The DNLA is a non-profit trade organization serving Delaware's horticultural related businesses and the companies that supply them. The DNLA's mission is to advance the common interests of its members and to promote the use, and enhance the quality, of the products and skills of the green industry. The DNLA also works in cooperation with the Delaware Department of Agriculture and Delaware

Cooperative Extension to shape legislative and administrative policies and procedures on matters that are of interest to Delaware's Green Industry.

Figure 9 - Growth in non-farm fertilizer usage in Delaware from 1994 through 2009

The Delaware Livable Lawns Program Advisory Group was developed through a cooperative effort of:

- Delaware Department of Transportation
- Delaware Department of Natural Resources & Environmental Control
- Appoquinimink River Association
- Delaware Department of Agriculture Nutrient Management Commission
- New Castle Conservation District
- US Department of Agriculture Natural Resources Conservation Service
- University of Delaware Institute for Public Administration Water Resources Agency
- University of Delaware Cooperative Extension

- Delaware Grounds Management Association
- Delaware Nursery & Landscape Association

Implementation Schedule: Program started in January 2011.

Nutrient Reducing Recommendation Effectiveness Criteria: Effectiveness will be measured by the number of homeowners enrolled in Delaware Livable Lawns or Smartyards programs within the watershed.

Expected Reduction: Unknown

Cost: Cost of program is $40,000 for the first year and $25,000 each year there after.

Potential Funding Source: Program was funded through DelDOT initially. The Department will work with partners including the County and local governments to apply for grants for this work.

Action Needed: The Department will work with the Delaware Nursery and Landscape Association and the Delaware Nutrient Management Commission with other partners including the County and local governments to accomplish this recommendation.

Nutrient Reducing Recommendation 23 – Fertilizer Education

Identify lawn care companies and other fertilizer applicators within the watershed.

Require lawn care fertilizer applicators to log nutrients applied to individual properties to help to track the amount of nutrients being applied within the watershed.

Require lawn care companies to incorporate soil tests into lawn service, prior to applying fertilizers.

Implementation Goal: See Recommendation 22.

Basis of Recommendation: The Delaware Nutrient Management Commission (DNMC) is the controlling authority for fertilizer application on parcels of land greater or equal to 10 acres within the State. The Nutrient Management Law requires nutrient applicators of 10 acres or more to be certified. Requiring applicators to log the amount of nutrients they are applying will help to track the amount of nutrients being applied to individual non-agricultural properties. The DMNC has also recognized that significant contributions of nitrogen and phosphorous come from land parcels less than 10 acres in size. In response to this knowledge, the DNMC has produced a brochure on proper lawn maintenance. These brochures have been placed in most retail outlets that sell fertilizer in the watershed. In addition, an advertisement was broadcast on local television station reminding people about proper lawn nutrient application and urging people to get a soil test done prior to applying fertilizer.

Lawn care companies must be in compliance with the Nutrient Management Act requirement for turf management. Requiring soil tests by lawn service companies would ensure only the necessary amount of nutrients are being applied to lawns.

Voluntary programs have already been implemented in the watershed through Smartyards. Smartyards is a unique component of the Delaware Nature Society's Backyard Habitat program, through which participants discover how to provide an oasis for local birds, butterflies, and other wildlife while helping to ensure the health of our streams and rivers. At no cost to participants, Smartyards provides official certification for properties where owners meet the four criteria necessary for wildlife habitat: food, cover, water, and places for wildlife to raise young. Certified habitats may range from those meeting the minimum requirements, such as a small urban balcony or rooftop, to extensive naturalized areas that meet a variety of wildlife needs. By adopting practices beneficial to wildlife such as planting native species, limiting use of chemical fertilizers and pesticides, reducing the size of lawn areas, and better maintaining small areas of forest or wetlands if located in backyards, participants help to improve local water quality. Smartyards provide habitat for a greater diversity of wildlife species, prevent the pollution of runoff from urban and suburban yards, and reduce the quantity of runoff more than traditional turf grass landscapes. Participants begin to make the connection that the wildlife in their yards is a part of the natural environment of their community, which includes the Murderkill River and its streams and tributaries.

Another program that the Department has become a founding partner of is Delaware Livable Lawns. The Livable Lawns Program certifies lawn care companies that follow environmentally-friendly practices in fertilizer application while educating homeowners. While many homeowners may be unaware of how, when, and how much fertilizer to apply, professional lawn care staff have the expertise to fertilize lawns correctly. Certified Livable Lawns companies go a step beyond the current regulations that govern fertilizer use by following environmentally-friendly practices resulting in healthy lawns and healthy water. In addition, the Livable Lawns program is beginning a residential education portion to educate homeowners as to their responsibility when it comes to fertilizer application and how what they do on their lawns can affect us all.

Implementation Schedule: Implement the Livable Lawns program in the Murderkill watershed in 2012.

Expected Reduction: Implementation of Smartyard landscaping can reduce 0.11 lb of N and 0.04 lb of P per acre. A post-campaign survey, conducted by the Chesapeake Bay Program, showed that of the respondents who could recall fertilizer education ads, 35% of them were less likely to fertilize in the spring and even more, 39% were not planning on fertilizing at all. Furthermore, there was a 15% increase of people who were planning on not fertilizing at all after the campaign then there were before it. While we cannot put an actual reduction to this recommendation, it is expected that nutrient reduction will occur as a result of implementation.

Nutrient Reducing Recommendation Effectiveness Criteria: See recommendation 2.

Cost: Cost of program is $40,000 for the first year and $25,000 each year thereafter.

Potential Funding Source: The Department will work with partners including the County and local governments to apply for grants for this work.

Action Needed: The Department will work with the Delaware Nursery and Landscape Association and the Delaware Nutrient Management Commission with other partners including the County and local governments to accomplish this recommendation.

Nutrient Reducing Recommendation 24 – Impervious Cover

> Require effective impervious cover to be limited to conserve water quality and protect existing wetlands. Local ordinances should be modified and implemented to restrict effective impervious surfaces, and impervious cover calculations should include streets and sidewalks.

Implementation Goal: Implementation of new proposed Sediment and Stormwater regulations in 2012.

Basis for Recommendation: In 1992, watershed impervious cover was estimated to be 4% which increased to 5% by 2007 and is expected continue to increase based upon current County Code. Kent County Code presently allows 20 percent of each lot to be covered by impervious surfaces; however this allotment does not include streets or other impervious areas outside the lot boundary in the calculation.

Recent research has revealed a strong relationship between impervious cover and various indicators of stream quality. When porous land cover is converted to impervious cover, a greater fraction of annual rainfall is converted to surface runoff, and a smaller volume recharges the groundwater. This increased surface runoff volume causes higher peak flows that erode stream channels and lower baseflow, which ultimately results in in-stream habitat degradation. In addition, surface runoff carries a suite of pollutants that can degrade water quality. Stream research generally indicates that at about 10% impervious cover, sensitive stream elements are lost from the system. A second threshold appears to exist at around 25-30% impervious cover, where most indicators of stream quality consistently shift to a poor condition. The Center for Watershed Protection has developed the following stream classification (Table 15) based on the relationship between impervious cover and stream health.

Table 15 - Impervious Cover Classification	
Classification	***Description***
Sensitive (≤10% IC)	Typically high quality streams (though rurally-impacted watersheds will have low impervious cover) Generally have stable channels, excellent habitat structure, good to excellent water quality, diverse communities of both fish and aquatic insects Do not see frequent flooding and other hydrological changes associated with urbanization
Impacted (11%-25% IC)	Show clear signs of degradation due to watershed urbanization Greater storm flows begin to alter the stream geometry Both erosion and channel widening are clearly evident Stream banks become unstable, and physical habitat in the stream declines noticeably Stream water quality shifts into the fair/good category during storms and dry weather Stream biodiversity declines to fair levels, fewer sensitive fish and aquatic insects
Non-supporting (11%-25% IC)	Streams essentially conduits for conveying stormwater flows Stream channel becomes highly unstable, and many reaches experience severe widening, down-cutting and streambank erosion Pool and riffle structure diminished or eliminated, and the stream substrate can no longer provide habitat for aquatic insects, or spawning areas for fish Water quality often rated fair to poor, and water contact recreation not possible Subwatersheds generally display increases in nutrient loads to downstream receiving waters, even if effective urban stormwater treatment practices are installed and maintained. Biological quality is generally considered poor, dominated by pollution tolerant species

Source: CWP, 2005

With the potential for future growth to affect the water quality of the rivers, streams, and ponds of the Murderkill Watershed, regulations need to include impervious cover limits for new subdivisions and major land disturbing activities.

The new State Sediment and Stormwater Regulations is expected to limit some of the negative effects of effective impervious cover by virtue of the requirement that stormwater must be infiltrated rather discharged through a conveyance system. If infiltration is not possible on the site, the stormwater treatment on site must have several best management practices designed to reduce the stormwater nutrient and bacteria load. As for existing property that will be redeveloped, unless new construction will be undertaken on the property, no reduction of effective impervious cover will result. The exact nature that impervious cover will be dealt with through the revised regulations will be unveiled in 2012.

The Department recommends that effective impervious cover be reduced on redeveloped properties. Effective impervious cover is the portion of the total amount impervious cover that is directly connected to the storm drain system. Impervious cover that drains to vegetated areas where stormwater can infiltrate, or be filtered and stored, is not considered part of the effective impervious cover.

Implementation Schedule: The regulations should be implemented by the end of December of 2012.

Expected Reduction: By limiting effective impervious cover as lands are developed, the impacts on water quality will be reduced. A specific numeric reduction is not currently available.

Nutrient Reducing Recommendation Effectiveness Criteria: Effectiveness will be measured by the number of systems installed that are compliant with new stormwater regulations within the watershed.

Cost: This recommendation would only apply for new proposed development so it is not possible to calculate implementation costs at this time. In a study funded by DNREC (1997), the Brandywine Conservancy demonstrated that by reducing road and driveway widths and minimizing the disturbance boundary in developments in Kent County, the developer could reduce impervious cover 24% and at the same time reduce development costs by 39%.

Potential Funding Source: Costs would be incurred by the developer.

Action Needed: With the promulgation of the new proposed Sediment and Stormwater Regulations by the end of 2012, the Department believes that this recommendation to establish watershed-wide limit for effective impervious coverage will be met. The Department will work with Kent County or any municipality to develop effective impervious cover reduction controls through ordinances on redeveloped properties.

Nutrient Reducing Recommendation 25 – Homeowner Education Plan

> Develop a comprehensive education plan for the urban/suburban landowner, homeowner's associations, local garden clubs, school districts and other educational facilities on the issues of water quality and urban nutrients.

Implementation Goal: Use watershed coordinators to implement a comprehensive homeowner education program in 2012.

Basis of Recommendation: The Murderkill Tributary Action Team has identified residential activities as an important origin for nutrients in the Murderkill Watershed and has made several recommendations to address this issue. Residential behavior is a difficult source to regulate, thus the Team's recommendations focus on providing education and outreach activities to change residential behavior and increase environmental awareness.

DNREC's Sediment and Stormwater Program developed and completed a handbook for homeowners associations that can be used to learn how to maintain their stormwater plan. DNREC, as well as the agencies with delegated authority from the Sediment and Stormwater Program, are working with homeowners in forwarding this concept. The Kent and Sussex County Conservation Districts with cooperation from DNREC's Sediment and Stormwater Program and NEMO has held workshops for homeowners associations and residents in Kent and Sussex Counties.

The comprehensive homeowner education plan should consist of the following parts:

1. Identify values which are affecting residential activities and target those that will affect behavior change.
2. Encourage educational facilities with turf athletic facilities where nutrients are applied to develop nutrient management plan for their facility.
3. Develop an advertising strategy that promotes the use of soil tests to the urban/suburban homeowner.
4. Work with the University of Delaware to revise their soil test results sheet for homeowners to make it easier to be understood and provide specific fertilizer application recommendations based upon existing fertilizer blends found within the State.
5. Education of fertilizer retailers such that retailers will pass out educational materials with purchase of fertilizer and will have available soil testing materials at their location.
6. Educate homeowners and homeowner associations on stormwater BMPs that can be used around the home to reduce impact on water quality.
7. Integrate education into various (State and local) permitting processes.
8. Create public information campaigns based upon goal of behavior change.
9. Support a demonstration project/workshop for homeowners on application of fertilizers and composting methods.
10. Support and encourage the use of water conservation measures like those below by individuals to help reduce the amount of nutrients leaving individual properties.
    - Gray water recycling (use of gray water around the home on plants and gardens, etc).
    - Rain collection systems such as rain barrels and rain gardens.
    - Directing stormwater runoff from roofs and impervious surfaces onto grassy areas.
    - The use of water saving devices in and around the home. The overall reduction of water usage in households and on lawns.
11. Work with the Delaware Nutrient Management Commission and the Master Gardeners to provide education and programs for homeowner's on lawn and garden best management practices such as:
    - Proper mowing practices.
    - Leaving lawn clippings on the lawn.
    - Leaving a buffer along stream edge.
    - Reduce lawn size.
    - Water conservation measures and stormwater BMPs for the lawn and garden.

- Encourage use of native species and noninvasive species.
- Discourage ideas that lawns need chemicals to be green.
- Proper use of lawn and garden chemicals (including natural fertilizers and compost).
- Use of compost rather than chemicals as a means of reducing synthetic chemical fertilizers.

Implementation Schedule: A Watershed Coordinator has been hired for Kent County and many educational programs such as Rain Gardens for the Bays is being implemented within the watershed.

Expected Reduction: Nutrient reductions cannot be assigned to this recommendation as it is a mechanism for education.

Cost: Unknown at this time and is a function of program developed.

Potential Funding Source: To be determined.

Action Needed: The Department will continue to work with Kent county and municipalities on providing educational outreach.

ANALYSIS FOR TMDL ACHIEVEMENT AND COST

Promulgation of this Pollution Control Strategy and full implementation of its elements should lead to the achievement of the TMDLs for Total Nitrogen (TN) and Total Phosphorus (TP). Because of the lag time between seeing improvements in ground and surface water quality, estimated to be up to 30 years, improved water quality conditions will not be realized immediately. The Department will continue to monitor water quality as will many citizen volunteers. The Department is committed to revisit this Pollution Control Strategy in 10 years to ensure that water quality is improving with implementation of the regulations and voluntary practices called for within this document.

Analysis using a basic land use loading rate model shows that, to date, nonpoint sources of TP and TN have been reduced by 61 % and 88 %, respectively (See Figures 8 and 9) but when the reductions from implementing the proposed PCS are included 100% of the required TMDL reductions will be achieved. Voluntary programs for installation of agricultural best management practices have been extremely successful as well as the County and local governments' efforts to protect open space and riparian buffers. Implementation of the Delaware Sediment and Stormwater Law has also lead to decreases in nutrient loading. The required nitrogen reduction can easily be achieved by slightly increasing the acreage of cover crops and the placement of riparian buffers on public lands within the watershed. The additional 8.35 pounds of phosphorus reductions needed to achieve the required TMDL phosphorus reductions will come from the septic system upgrades and by converting dry ponds in older subdivisions into infiltration basins which are more effective in reducing phosphorus than dry ponds. By connecting failing septic systems to the Kent County wastewater treatment facility, approximately a pound of phosphorus will be eliminated from the watershed.

Table 16 - Best Management Practices Goals for Achieving the Murderkill Watershed TMDL Reductions			
Best Management Practice	Acres Required	Total Nitrogen Reduced (lbs/day)	Total Phosphorus reduced (lbs/day)
Agriculture			
Cover Crops	6027	51.85	0.1
Grass buffers and filter strips on public and private lands	1594.7	147.14	3.28
Forested buffers on public and private lands	1817.6	197.448	4.23
Wetland Restoration	472.4	34.27	0.73
Total proposed reduction		**430.75**	**8.35**

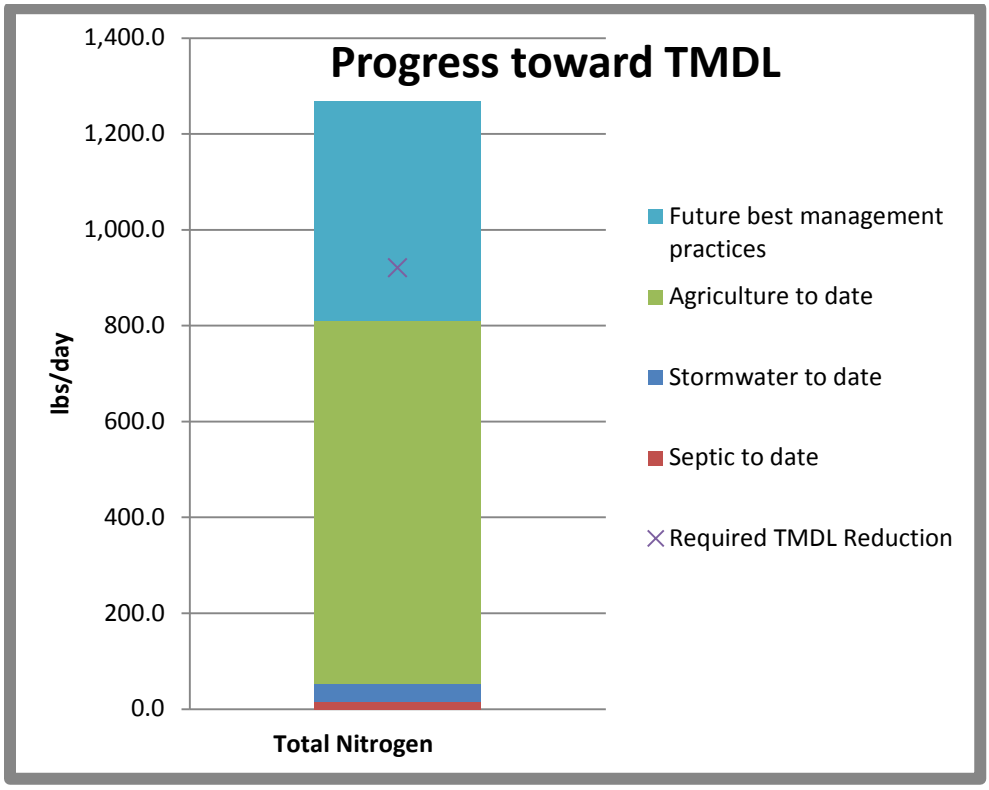

Figure 10 - Nitrogen TMDL Progress

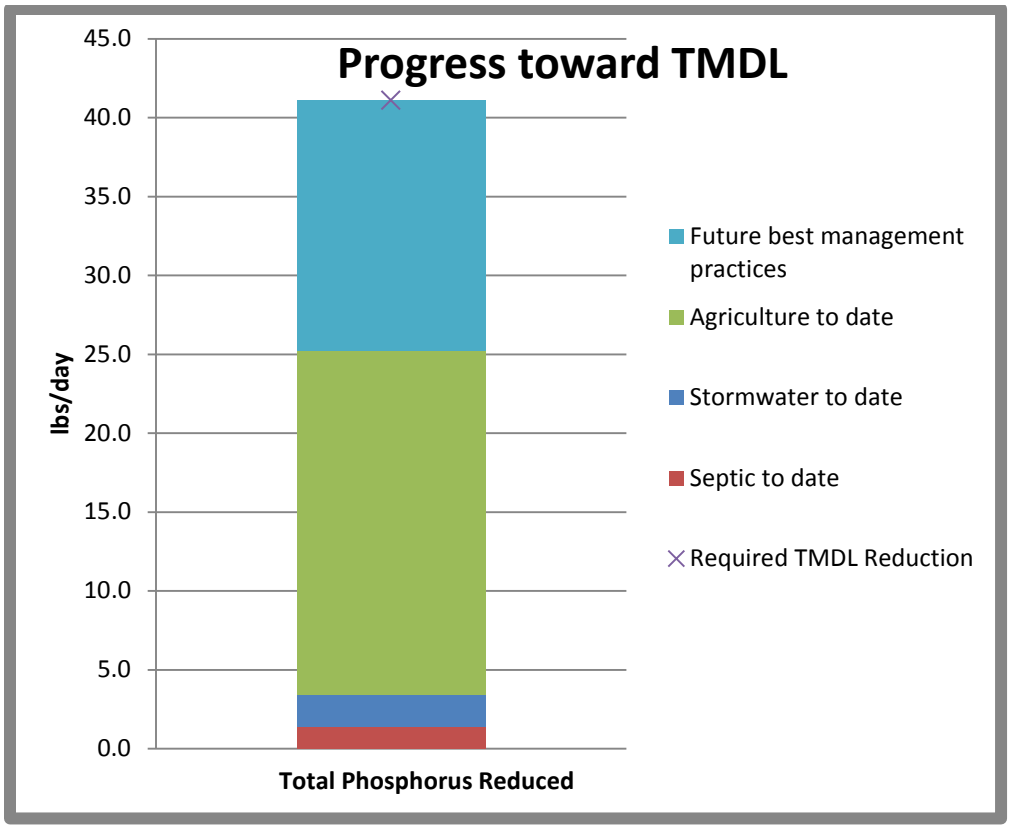

Figure 11 - Phosphorus TMDL Progress

While current implemented practices have done a lot to reach the required reductions, it is important to note that there are practices that are still necessary to keep the watershed healthy and meeting its TMDL. The most important area for future implementation is wastewater. This includes requiring existing septic tanks to be pumped out at time of property transfer and preferably once every three years, continuing to connect existing septic tanks to sewer systems and implementing technologies that will allow systems to meet performance standards to remove nutrients. In addition, realizing that development is still occurring throughout the watershed and stormwater best management practices are required, future BMP implementation must move away from practices that only deal with water quantity, but also provide significant water quality benefits. Also, the strategy is based on the maintenance of agricultural practices currently in place as well as the continued push towards open space and riparian buffer preservation. Adding these future practices help the Murderkill waters to reach their TMDL reductions as seen in Figures 10 and 11.

Overall, this strategy costs close to $92,500,000 including capital expenditures plus annual operation and maintenance costs of various best management practices. Of this strategy total, about $33,500,000 has already been paid for the installation of current practices. Figure 11 shows the total strategy costs for each category of BMP including current and future practices.

Every effort has been made to make the Strategy fair and equitable. It impacts everyone in the watershed given that all activities contribute to nutrient loading. And, it attempts to take cost into consideration through promoting the least expensive actions and cost-share for those actions that are more expensive. The Department intends to review the Strategy in 10 years and update it if further actions are needed to improve water quality.

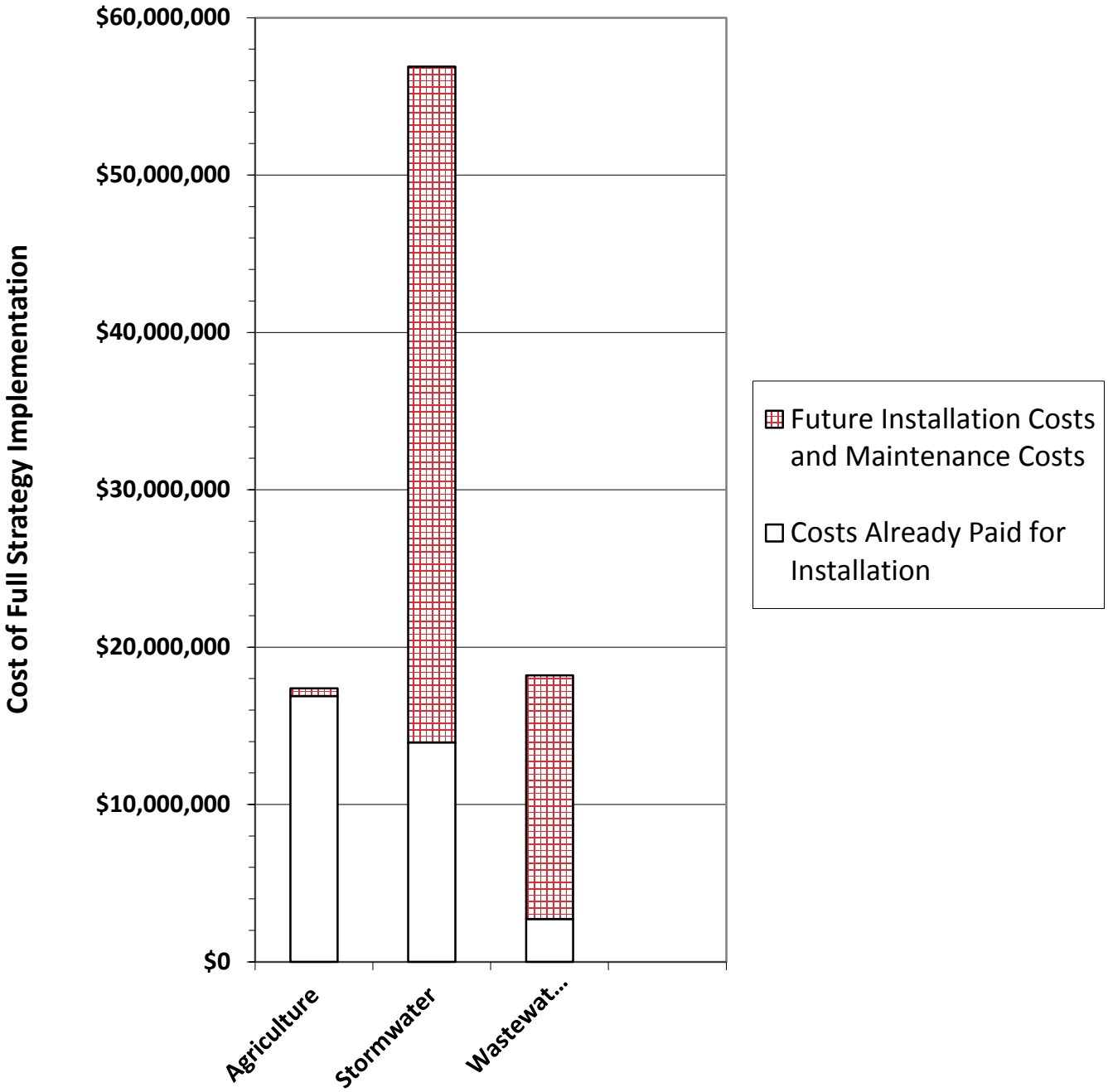

Figure 12 - Total Strategy Implementation Costs

IMPLEMENTATION PROGRAMS

Pollution of the Murderkill did not happen over a short period of time, nor did it only happen due to the actions of a few people. Implementing the Pollution Control Strategy will necessitate participation from a broad variety of programs, agencies, nonprofit, and community organizations. These programs will provide technical, financial, and administrative assistance in the effort to clean up these waters.

Coastal Nonpoint Program – 6217

The Coastal Nonpoint Program was established by Congress in 1990 under section 6217 of the Coastal Zone Act Reauthorization Amendments (CZARA) to ensure that coastal states have the tools needed to address polluted runoff. A consistent set of management measures was established for states to use in controlling polluted runoff. Management measures are designed to prevent polluted runoff resulting from a variety of sources. The program includes enforceable policies and mechanisms to ensure implementation of the measures. The Delaware Coastal Nonpoint Program is administered in the State of Delaware by the Delaware Coastal Programs in the Department of Natural Resources and Environmental Control. Delaware's Coastal Nonpoint Program is a networked program with implementation responsibilities distributed throughout the State. The Delaware Coastal Programs receives an annual award used to aid in the implementation of management measures, program initiatives and the funding of grants for projects designed to preserve and protect Delaware's waterways from the degradation of nonpoint source pollution. Through cooperative efforts will both government agencies and local organizations, numerous projects have been designed and funded to help address issues concerning nonpoint source pollution in Delaware.

The Delaware Forest Service

The Delaware Forest Service is a section of the Delaware Department of Agriculture and is charged to improve and enhance the state rural and urban forest resources. Delaware's Forest Service staff, through the Urban and Community Forestry Program, provides technical, educational and financial assistance to cities, towns, communities, developers and local governments to develop a community forestry management plans and resource evaluation studies. Foresters also review new planned subdivisions in order to conserve forest resources. Additionally, the program provides annual grant assistance to a variety of partners to provide both tree planting and tree care activities. Also, the professional foresters help private and public landowners to improve their forest resources through a variety of services. This technical assistance encompasses a wide range of forest management activities including reforestation, timber stand improvements, timber harvesting and forest management plan development.

DNREC -- Groundwater Discharges Section

Located within the Division of Water, the Groundwater Discharges Section is responsible for overseeing all aspects of the siting, design and installation of on-site wastewater treatment and disposal systems. This is a three step process which includes the site evaluation, the design/permit application and the construction/installation of the system. The Small Systems Permitting Branch reviews and approves site evaluations, permit applications and conducts inspections of system installations. Experimental/alternative technologies and advanced treatment units are approved and permitted for use by the Large Systems Permitting Branch. The Section is also responsible for the permitting of underground injection wells, large spray irrigation wastewater systems, and other means associated with land application wastewater treatment. The Section also issues waste transporter permits and licenses to designers, percolation testers, site evaluators and system installers.

DNREC – Nonpoint Source Program

The Delaware Nonpoint Source Program (NPS) administers a competitive grant made possible through Section 319 of the Clean Water Act. It is housed under the Division of Watershed Stewardship within the Department of Natural Resources and Environmental Control. The grant provides funding for projects designed to reduce nonpoint source pollution in Delaware. NPS pollution may be defined as any pollution that originates from a diffuse source (such as an open field or road) and is transported to surface or ground waters through leaching or runoff. Reduction of NPS pollution, but most frequently involve agriculture, silviculture, construction, marinas and septic systems. Proposals are reviewed and evaluated, and those which are determined to meet specific requirements are eligible for funding. All projects must include matching funding from a non-Federal source totaling at least 40 percent of the overall project cost. In addition to funding projects that achieve reductions in NPS pollution, the Delaware NPS Program is committed to addressing the issue through educational programs, publications and partnerships with other organizations working to reduce NPS pollution in Delaware.

DNREC-Sediment and Stormwater Program

The Sediment and Stormwater Program is managed by the Division of Watershed Stewardship in the Department of Natural Resources and Environmental Control. Delaware's stormwater management program requires sediment control during construction and post-construction, stormwater quantity and water quality control. This program functions from the time construction begins through a project's lifespan. It requires construction and development projects to obtain sediment control and stormwater plan approval, be inspected during construction, and a post-construction inspection of permanent stormwater facilities and education and training. The program's initial emphasis is to prevent existing flooding or water quality from worsening and limit further degradation until more comprehensive, watershed approaches (as detailed in State legislation and regulations) are adopted.

Revised stormwater management regulations are expected to be promulgated in the first quarter of 2012, with an effective date sometime around the third quarter of 2012. The Department will use the interim period between the promulgation date and effective date for education and outreach efforts to train the various Delegated Agency staff and regulated community. The revised regulations will apply to new development and redevelopment projects and will include requirements for both construction site and post-construction stormwater management State-wide. A technical document containing technical standards for new development and re-development projects will be developed in conjunction with the proposed revisions to the Sediment and Stormwater Regulations.

The emphasis under the proposed revisions for both stormwater quality and stormwater quantity management will be on runoff reduction techniques that encourage infiltration and recharge of stormwater runoff. This method will both decrease pollutant loads and mitigate the hydrologic impacts to receiving waters often associated with land development. All projects developed under the revised Sediment and Stormwater Regulations will be required to meet the TMDL for that particular watershed.

DNREC - Surface Water Discharges Program

The Surface Water Discharges Program is delegated to the Division of Water in the Department of Natural Resources and Environmental Control. Program administrators are responsible for eliminating pollutant discharges into State surface waters by issuing regulatory permits under the National Pollutant Discharge Elimination System (NPDES). An NPDES permit legally sanctions the discharge of substances that may become pollutants. However, the NPDES permit is designed to limit the discharge of those substances so that there will be no adverse effect on the quality of the receiving waters or interference with the designated uses of those waters. The health of a water body is measured by its attainment of designated uses. If potential pollutants in a NPDES discharge are reduced to levels that allow receiving waters to meet applicable designated uses, then, in effect, the pollutant discharge has been eliminated.

Municipal sewage treatment or industrial plants that discharge wastewater to surface waters of Delaware are issued permits specifying discharge limitations, monitoring requirements and other terms and conditions that must be met to be allowed to discharge. In addition to wastewater, wastewater facilities often generate a waste sludge solid that is also an NPDES discharge under federal and State regulations. The NPDES General Permit for "stormwater discharges associated with industrial activities," a single permitting regulation with requirements that apply to a group of similar dischargers is also issued to industrial sites that discharge only stormwater.

DNREC – Water Supply Section – Groundwater Protection Branch

This program is responsible for providing technical review of permit applications for non-hazardous waste sites (i.e. large septic, wastewater spray irrigation, sludge application) and for water well permit applications where wells are located near problem sites. Staff hydrologists conduct investigations based on public complaints of groundwater quality, often associated with domestic water wells.

The Source Water Protection Program (SWPP) has been delegated to DNREC and is managed by the Water Supply Section, Groundwater Protection Branch of the Division of Water. This program was created from the 1996 Amendments from the Safe Drinking Water Act. The SWPP is responsible for determining the locations of water supplies used for public drinking water. The program is also responsible for mapping the wellhead protection areas (those areas around a well or group of wells from which a source obtains within those delineated areas, and determining the susceptibility of the drinking water source to contamination. The SWPP is required to make this information available to the public and does so through the program's website: www.wr.udel.edu/swaphome/index.html.

Through the Source Water Protection Law of 2001, the SWPP was charged with the development of a guidance manual for the protection of source water areas. This manual was development to give the counties and those municipalities containing 2000 or more persons) ideas on methods that could be used to protect those areas by 2007.

Local Governments

County and local governments have the authority to enact ordinances to further the goals of this Pollution Control Strategy. They are all required to complete Comprehensive Plans and address

how they intend on assisting in the implementation of the TMDLs. Many of these entities have ordinances that require buffers, open space and maximum impervious coverage – ordinances that work towards achieving water quality standards. Local governments within the TMDL watershed include: Kent County, Town of Felton, Town of Frederica, Town of Harrington, Town of Magnolia and the Town of Viola.
Kent County Planning Office and public works were very involved in the pollution control; strategy development process.

Nutrient Management Commission

The Delaware Nutrient Management Program was established as a result of the Delaware Nutrient Management Law. The Delaware Nutrient Management Commission (DNMC) was established to direct the program and develop regulations pertaining to nutrient management, waste management for Animal Feeding Operations (AFOs) and National Pollutant Discharge Elimination System (NPDES) permits for concentrated animal feeding operations (CAFOs). The DNMC manages activities involving the generation and application of nutrients in order to help maintain and improve the quality of Delaware's ground and surface waters to help meet or exceed federally mandated water quality standards in the interest of the overall public welfare. All persons who operate an animal feeding operation in excess of 8 animal units (1 AU = 1,000 pounds) and/or control/manage property in excess of 10 acres where nutrients are applied must develop and implement a nutrient management or animal waste plan. The DNMC provides cost assistance programs, certifications and investigation of complaints.

Office of State Planning Coordination

The mission of the Office of State Planning Coordination (OSPC) is "the continuous improvement of the coordination and effectiveness of land use decisions made by state, county and municipal governments while building and maintaining a high quality of life in the State of Delaware." Under the new PLUS (preliminary land use service) process, the OSPC will bring together State agencies and developers early in the development process in order to try to identify and mitigate potential impacts. The OSPC also supports the Governor's "Livable Delaware" initiative and has published *Better Models for Development in Delaware* that includes many best management practices which will be needed in order to achieve the TMDL.

Soil and Water Conservation Districts

County Conservation Districts were created by State law and are administer through Delaware Natural Resources and Environmental Control. They operate the State Conservation Cost Share Program which provides funds for installation of agricultural management practices, promote the State Revolving Loan Fund Program for poultry producers (low-interest loans to implement best management practices) and are the delegated agencies for the Sediment and Stormwater Management Program carrying out plan review and field inspections in their respective counties. Watersheds prioritized by Delaware's Nonpoint Source (Section 319) Pollution Program can be targeted by these activities.

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Appendix A - Total Maximum Daily Load

7408 TMDLs for Nutrients for the Murderkill River Watershed

1.0 Introduction and Background

1.1 Intensive water quality monitoring performed by Delaware Department of Natural Resources and Environmental Control (DNREC) has shown that the waters of the Murderkill River and several of its tributaries and ponds are impaired as the result of low dissolved oxygen and high nutrients. Low concentrations of dissolved oxygen are harmful to fish, shellfish, and other aquatic life. With regard to nutrients (nitrogen and phosphorus), although they are essential elements for both plants and animals, their presence in excessive amounts causes undesirable conditions. Symptoms of nutrient overenrichment include frequent phytoplankton blooms, decreased water clarity, dissolved oxygen deficiency, alteration of composition and diversity of economically important native species of plants and animals, and possible human health effects.

1.2 A reduction in the amount of nutrients and oxygen consuming pollutants reaching the waters of the Murderkill River and its tributaries and ponds is necessary to reverse these undesirable impacts. These pollutants and nutrients enter the waters of the Murderkill River from point sources and nonpoint sources. Point sources are end-of-pipe discharges from municipal or industrial wastewater treatment plants. Nonpoint sources include runoff from agricultural and urban areas, septic tank effluent, and ground water discharges.

1.3 Section 303(d) of the Federal Clean Water Act (CWA) requires states to develop a list (303(d) List) of waterbodies for which existing pollution control activities are not sufficient to attain applicable water quality criteria and to develop Total Maximum Daily Loads (TMDLs) for pollutants of concern. A TMDL sets a limit on the amount of a pollutant that can be discharged into a waterbody and still protect water quality. TMDLs are composed of three components, including Waste Load Allocations (WLAs) for point source discharges, Load Allocations (LAs) for nonpoint sources, and a Margin of Safety (MOS) to account for uncertainties and future growth.

1.4 DNREC listed the Murderkill River and several of its tributaries and ponds on the Delaware's 1996, 1998, and 2000 303(d) Lists and proposes the following Total Maximum Daily Load regulation for nitrogen, phosphorous, and Carbonaceous Biochemical Oxygen Demand (CBOD).

2.0 Total Maximum Daily Loads (TMDLs) Regulation for the Murderkill River Watershed, Delaware

Article 1. The total nitrogen waste load from the Kent County Facility and Canterbury Crossing Mobile Home Park shall be limited to 755.3 pounds per day. The waste load allocation for the Kent County Facility will be 751 pounds per day and for Canterbury Crossing Mobile Home Park will be 4.3 pounds per day.

Article 2. The total phosphorus waste load from the Kent County Facility and Canterbury Crossing Mobile Home Park shall be limited to 62.7 pounds per day. The waste load allocation

for the Kent County Facility will be 62.5 pounds per day and for Canterbury Crossing Mobile Home Park will be 0.2 pounds per day.

Article 3. The CBOD5 (5-day Carbonaceous Biochemical Oxygen Demand) waste load from the Kent County Facility and Canterbury Crossing Mobile Home Park shall be limited to 1010.6 pounds per day. The waste load allocation for Kent County Facility will be 1001 pounds per day and for Canterbury Crossing Mobile Home Park will be 9.6 pounds per day.

Article 4. Treated wastewater from the City of Harrington wastewater treatment facility shall be used for spray irrigation. However, during the winter season, as well as during wet weather periods, when spray irrigation of treated wastewater is not practical, the effluent may be discharged into Browns Branch. During periods of surface discharge, the maximum discharge flow rate shall not exceed 750,000 gallons per day and daily waste loads shall not exceed 140 pounds per day for total nitrogen, 0.75 pounds per day for total phosphorus, and 37.5 pounds per day for CBOD5. Furthermore, the total annual waste load discharged from the City of Harrington wastewater treatment facility to the surface waters of Browns Branch shall not exceed 9125 pounds per year for total nitrogen, 55 pounds per year for total phosphorus, and 3000 pounds per year for CBOD5.

Article 5. The nonpoint source nitrogen load in the entire watershed shall be reduced by 30 percent (from the 1997 base-line). This shall result in a yearly-average total nitrogen load of 560 pounds per day.

Article 6. The nonpoint source phosphorus load in the entire watershed shall be reduced by 50 percent (from the 1997 base-line). This shall result in a yearly-average total phosphorous load of 96 pounds per day.

Article 7. Based upon hydrodynamic and water quality model runs and assuming implementation of reductions identified by Articles 1 through 6, DNREC has determined that, with an adequate margin of safety, water quality standards and nutrient targets will be met in the Murderkill River and its tributaries and ponds.

Article 8. Implementation of this TMDL Regulation shall be achieved through development and implementation of a Pollution Control Strategy. The Strategy will be developed by DNREC in concert with the Murderkill River Tributary Action Team, other stakeholders, and the public.

8 DE Reg. 1722 (6/1/05)

Appendix B - Murderkill Tributary Action Team Recommendations

TO: Secretary John Hughes, DNREC
FR: Murderkill Tributary Action Team
RE: MURDERKILL RIVER WATERSHED POLLUTION CONTROL STRATEGY RECOMMENDATIONS
DATE: March 2005

The Murderkill Tributary Action Team was formed in April of 2001 in order to recommend a Pollution Control Strategy to the Department of Natural Resources and Environmental Control. This Strategy, attached, outlines the actions needed to implement the Total Maximum Daily Load (TMDL) of nutrients for the Murderkill River and its tributaries.

Section 303(d) of the Federal Clean Water Act (CWA) requires states to develop a list of water bodies for which existing pollution control activities are not sufficient to attain applicable water quality criteria and to develop Total Maximum Daily Loads (TMDL) for pollutants of concern. The TMDL Regulation for the Murderkill was promulgated in 2001, setting goals for a 30% reduction in nonpoint source nitrogen loading and a 50% reduction in phosphorus loading to the River and its tributaries. The TMDL also reduced nutrient discharges from the point sources in the watershed.

Specifically, Articles I through V of the TMDL Regulation identified the pollutants and their sources and the number of pounds of each pollutant the River and its tributaries could include and still meet the water quality criteria established in the CWA. Article VI states if the requirements in the first six articles are met, then water quality will be sufficient. The final article requires accomplishment of the first six articles through the implementation of a "Pollution Control Strategy" developed by DNREC in concert with the Department's Whole Basin Management Program, the Murderkill River Tributary Action Team, and other affected parties.

The Murderkill River Tributary Action Team ("Team") studied water pollution in the watershed and discovered there were several pollutants, numerous sources, and many possible remedies. As a result of their study, the Team concluded the most effective plan would be one favoring remedies that had the greatest impact on pollution . The team then reviewed data from DNREC to determine the most pertinent data for pollutants and their sources as depicted in Table 1.

Table 1 - Proposed Amended 2005 TMDLs for the Murderkill Watershed				
	Baseline[1][2] lb/day	**TMDL requirement[3] lb/day**	**Percent change**	**Change Lb/day**
Total Nitrogen (N)	1471	1338	-9	-133
N from point sources	796	778	-2	-18
N from nonpoint sources	675	560	-17	-115
Total Phosphorus (P)	416	158	-62	-258
P from point sources	274	62	-77	-212
P from nonpoint sources	142	96	-32	-46

The data in Table 1 suggests two conclusions: First, more stringent reductions in phosphorus are needed than nitrogen reductions; and second, phosphorus enters the watershed from point sources to a far greater extent than it does through nonpoint sources. These conclusions led to actions the Team recommends be implemented to achieve an adequate water quality in a hierarchical, prioritized structure. This structure places all the recommended action in context with each other and makes a complex subject easier to understand.

A drawback to this approach is that some significant elements may be low in the hierarchy while others will even be outside of it entirely. For example, even if point source pollution were eliminated, agricultural run-off would remain a major source of phosphorus and nitrogen. Sediment that washes into waterways would still affect water quality. Septic systems and other kinds of onsite waste treatment could still have serious effects. Even pet and waterfowl droppings can ruin a waterway. Some necessary elements of a good Pollution Control Strategy, such as education, cannot even be placed in the hierarchy with pollutants and sources. There are many behaviors, events, conditions, and interrelations that make water pollution a difficult problem. In order for our plan to work it must take into account as many of these factors that we are aware of and we can reasonably afford to address.

The attached recommendations for addressing nutrient pollution in the Murderkill River Watershed are presented in priority of importance of actions required to meet water quality goals set forth by the TMDL. The specific recommended actions are followed by a brief explanation of why the action was included, whether nutrient load reductions for the action have been prescribed, and any additional commentary needed to be added for clarity. In some of the strategies, a Departmental perspective was added for the Teams edification and to indicate the knowledge base the Team used to forward this particular strategy to you. If you have any questions, please feel free to contact the Team through your own Watershed Assessment Section.

Thank you for your kind attention to the Team's Strategy. Together, your Department and the Team can work together design a plan that will reduce pollutants in our watershed and serve our community. As you will see when you read the last enclosure, the Team has met with great

[1] The "baseline" for the pollutants nitrogen and phosphorus and CBOD5 compounds is the number of pounds of each deposited in the watershed per day in 1997.
[2] Tables 2.3 and 3.1 in the *Technical Analysis for the Murderkill River TMDLs*. December 2001. Delaware Department of Natural Resources and Environmental Control. Division of Water Resources.
[3] Table 1 in *Draft Technical Analysis for Amendment of the 2001 Murderkill River TMDLs*. August 2004. Delaware Department of Natural Resources and Environmental Control. Division of Water Resources.

success to date, but much more remains to be done. We look forward to working with your Department in the future to complete the work the Team began four years ago.

Sincerely,

Murderkill Tributary Action Team

MURDERKILL RIVER WATERSHED TRIBUTARY ACTION TEAM POLLUTION CONTROL STRATEGY RECOMMENDATIONS

1 BROAD PURPOSE

Return the impaired waters of the Murderkill Watershed to a condition permitting use of the waterways as required by the Clean Water Act (CWA) so they can be removed from the 303d list.

2 SPECIFIC GOALS

Limit pollutants to levels at or below the Total Maximum Daily Load (TMDL) values specified in the regulation, i.e., an overall reduction of phosphorus in the waterways by 62%, or 258 pounds per day (from 416 to 1583 lbs per day), and a reduction in nitrogen of 9%, or 133 pounds per day (from 1471 to 1338 lbs per day).

3 STRATEGY PRIORIZATION

The strategies are organized according to pollutant loads and the nutrient reduction strategies that will reduce the most nutrients. Since the phosphorus reductions were more onerous than the nitrogen reductions called for by the TMDL, the Team attempted to prioritize the recommendations by the strategy that would have the most impact at reducing phosphorus within the watershed. The Team believes this hierarchical, prioritized structure will lead to the ultimate goal of achieving adequate water quality within the watershed. In addition this structure helped greatly improve the ability of the Team to understand this complicated subject because it places all the recommended actions in context with each other.

4 NUTRIENT REDUCING STATEGIES

The following prioritized strategies are listed in bold. Under each strategy is the basis for the recommendations. In cases where the Team was given data regarding the actual nutrient reductions that could be anticipated from the strategy, that information is given as well.

Nutrient Reducing Strategy 1

> The Kent County Waste Water Treatment Facility should (will?) investigate the possibility of utilizing spray irrigation for a significant portion of their wastewater load.

Basis for Recommendation: There are four point source discharges in the Murderkill River Watershed:

- Canterbury Crossing Mobile Home Park treatment facility,
- Southwood Acres Mobile Home Park treatment facility,
- City of Harrington Wastewater Treatment Plant,
- And the Kent County Waste Water Treatment Plant.

Phosphorus: The Kent County Waste Water Treatment Plant was found to account for 63.8 percent[4] of the total amount of phosphorous in the waterways of the watershed in 1997.

Table 2 - Point Sources in the Murderkill River Watershed (Proposed)				
Nutrient Allocation for Point Sources[5]	**Flow (mgd)**	**Total Nitrogen (lbs/d)**	**Total Phosphorous (lbs/d)**	**CBOD5 (lbs/d)**
City of Harrington[6]	.75	25	.15	8.2
Kent County Facility	15	751	62.5	1001
Canterbury Crossing Mobile Home Park	0.05	4.3	0.2	9.6
South wood Acres Mobile Home Park	0.024	2.0	0.1	4.5

The baseline total discharge for phosphorus into the Murderkill River from point sources was given as 274 pounds per day (in 1997) to be reduced to 62.8 pounds per day. The Kent County facility will be responsible for most of the load reduction. The facility receives wastewater from all over Kent County and part of southern New Castle County. The sewerage collection system for the facility is old and has significant inflow and infiltration during wet periods after significant storm events[7]. Consequently, the treatment plant must handle large volumes of water before the treated wastewater is discharged into the Murderkill River. Kent County should encourage the reduction of Inflow and Infiltration throughout the wastewater collection system. Additionally, a mechanism needs to be established to compensate the Murderkill Watershed for the increased water quality burden from assimilating the nutrient load from all over Kent County. In any case, the Kent County Facility bears a significant task in treating wastewater load from the entire County and at the same time meeting the local watershed TMDL mandate.

After the daily loads are reduced to the values called for in the TMDL regulation, the Kent County facility will account for over 96 percent of the phosphorus from point sources and 20.3 percent of the phosphorus from all sources. Of the 123.3 pounds per day of phosphorous allowed under the amended TMDL, the Kent County Wastewater Treatment facility would be allowed to discharge 25 pounds per day. Thus, the Kent County Waste Water Treatment Facility would be contributing 96 percent of the point source phosphorus and 68.7 percent of point source nitrogen load to the Murderkill River. In addition, because the TMDL regulation calls for greater reductions of phosphorus from point sources than nonpoint sources, consequently the other point sources must also be addressed.

[4] Table 3.1 in *Technical Analysis for the Murderkill River TMDLs*. December 2001. Department of Natural Resources and Environmental Control.
[5] The figures listed in this table are limits proposed in the 2005 TMDL amendments.
[6] The City of Harrington wastewater treatment facility point source discharge is in the process of converting to spray irrigation since the original TMDL was written.
[7] Personnel Communication Kent County Treatment Plant, 2003

Less wastewater being discharged into the Murderkill River would mean that, fewer pounds per day of phosphorus or other nutrients will be entering the River. Spray irrigation has been shown to reduce phosphorus and nitrogen load to groundwater by 90% and ultimately into the surface waters. If spray irrigation is not utilized, growth in the County could be stymied due to the lack of the facility's ability to handle any more wastewater i.e. nutrients, from the proposed growth. Reduction of the nutrient load by diverting some of the wastewater flow to spray irrigation would ultimately allow for more growth within the County. Spray irrigation will also promote groundwater recharge where as the treatment facility discharges all of its wastewater into the Murderkill River and tributaries with no opportunity for groundwater recharge.

EXPECTED REDUCTION: 44 lbs/day assuming that you have 15mgd flow and current performance of plant with no stream discharge

Ancillary reduction of N: 300 lbs/day assuming that you have 15mgd flow and current performance of plant with no stream discharge

Nutrient Reducing Strategy 2

The Kent County Wastewater Treatment Facility should upgrade to the best available technologies for decreasing the amount of nutrients in the effluent and, therefore, decrease the pounds per day of these contaminants discharged into the Murderkill River.

Basis for Recommendation: Strategy 2 would be costly; consequently the team recommends that the County produce a Financial Impact Study before undertaking it. Potential funding sources could include, such things as bond sales, Federal and/or State grants, low interest capitalization loans, increased impact fees, increased user fees, utilization of a portion of county tax revenues, etc.

Department's Perspective: In Nutrient Reducing Strategy 1 the Team recommended the utilization of spray irrigation for the Kent County Wastewater Treatment Facility; however, Strategy 2 may not be beneficial for the utilization of spray irrigation within the watershed. Wastewater that is treated to high a level may not provide adequate nutrients for the vegetative growth within the spray field and additional fertilization may be needed to meet nutrient needs of plants for growth which may not achieve the TMDL.

Nutrient Reducing Strategy 3

Support Harrington's Sewage Treatment Plant (STP) conversion to a spray irrigation facility on near by farm ground.

Basis for Recommendation: The proposed amended TMDL calls for the Harrington Waste Water Treatment Facility to totally eliminate any direct discharge into the Murderkill River; however, Harrington Waste Water Treatment Facility wants to spray irrigate most of its wastewater but still be allowed to discharge a portion of the load into Browns Branch when it is too wet to spray irrigate. The amended waste load allocation for the Kent County Facility is established based on the assumption that surface discharge from the City of Harrington STP will be eliminated in the near future. This provided additional assimilative capacity for the Kent County Facility. However, if because of practical and/or logistical considerations, Harrington STP facility could not spray its treated wastewater during certain periods and discharges into the

surface waters, the waste load allocation for the Kent County Facility should be reduced by the amount of nutrient loads being discharged to the surface waters by the Harrington facility

Department's Perspective: Article 4 of the proposed amended TMDL presented to The City of Harrington and Kent County." Treated wastewater from the City of Harrington wastewater treatment facility shall be used for spray irrigation. However, during the winter season, as well as during wet weather periods, when spray irrigation of treated wastewater is not practical, the effluent may be discharged into Browns Branch. During periods of surface discharge, the maximum discharge flow rate shall not exceed 750,000 gallons per day and daily waste loads shall not exceed 140 pounds per day for total nitrogen, 0.75 pounds per day for total phosphorus, and 37.5 pounds per day for CBOD5. Furthermore, the total annual waste load discharged from the City of Harrington wastewater treatment facility to the surface waters of Browns Branch shall not exceed 9125 pounds per year for total nitrogen, 55 pounds per year for total phosphorus, and 3000 pounds per year for CBOD5."

EXPECTED REDUCTION: 0.15 lbs/day of TP

Ancillary reduction of N: 25 lbs/day

Nutrient Reducing Strategy 4

Mitigate Canterbury Crossing and Southwood Acres point source nutrient loads by utilizing best management practices to reduce nonpoint source nutrients coming from the communities and minimize their respective discharges.

Basis of Recommendation: The Team does not recommend the expenditure of a large amount of resources in ameliorating their respective discharge; instead their loads should be reduced by installing best management practices within each development that will reduce their nonpoint source load. Their combined load proposed amended TMDL only amounts to 0.3 pounds of phosphorus per day and 6.3 pound for total nitrogen. Even if this discharge were completely eliminated, the benefit to the Murderkill River would be slight. The Team believes that the installation of best management practices within these developments would lead to decrease load to the Murderkill at much cheaper cost than the cost of eliminating them.

Department's Perspective: Canterbury Crossing Mobile Home Park plans to connect to the Kent County Facility when the Walnut Shade Sewer project moves forward (see attached map of proposed sewer district).

EXPECTED REDUCTION: 0.2 lbs/day of TP

Ancillary reduction of N: 4.3 lbs/day

Nutrient Reducing Strategy 5

Designate the Murderkill River Watershed as a Critical Environmental Area in order to enhance the potential to receive available cost-share and grant funds.

Basis for Recommendation: Because of the amount of agricultural land in the watershed it is important to prioritize and recognize the watershed in order to maximize assistance for farmers

to address nutrient management. In 2003, the Team requested Secretary Hughes to submit a letter to the Nutrient Management Commission requesting the Critical Area designation. In September 2003, the Department recommended that the Nutrient Management Commission (Commission) designate the Murderkill Watershed as a "Critical Watershed." The declaration targets the watershed for increased cost share funds, when available.

EXPECTED REDUCTION: Reduction achieved will be a function of the acreage and type of new agricultural best management practices constructed with the watershed.

Nutrient Reducing Strategy 6

Encourage farmers to comply with the Nutrient Management Act (NMA) and to actively participate in establishing nutrient reducing best management practices (BMPs) on their farms.

The Department and Delaware Department of Agriculture should assess the impact of nutrient management planning as required by the Nutrient Management Law.

Basis of Recommendation: As of 2007 all lands (over 10 acres) that have nutrients applied must be in compliance with NMA. The NMA requires all farms over 10 acres or with 8 animal units to establish a nutrient management plan, which includes the use of fertilizers and the fate of manure. Assessing the impact of this requirement will quantify the efficiency and reduction of nitrogen and phosphorus.

Since the baseline period (1997), the agriculture community has reduced a significant amount of nonpoint source nutrient loading, leading the efforts to curtail nonpoint source nutrient loading. From the 1997 to 2003, multiple Best Management Practices (BMPs) have been implemented, and the Delaware NMA was passed. As of February 2003, 6116 acres of cropland already has had nutrient management plans developed and by 2007, all farms that apply nutrients to ten acres or more will be required to have Nutrient Management Plans (NMPs). The 2002 Farm Bill has led to unprecedented funding levels of cost-share programs for BMPs that protect the environment, especially water quality.

In many watersheds polluted runoff from cropland, manure-disposal sites, and concentrated animal-feeding operations (CAFOs) are some of the important sources of phosphorus to surface waters. As of 2002, there were 29 poultry operations, which produce approximately 2,490,684 birds annually, 2 dairies, 8 beef cattle operations, 13 equine and 4 goat operations in the Murderkill Watershed[8]. Potential nutrient inputs are related to manure, runoff, erosion, and atmospheric deposition of nutrients. In 2002, 55% of the Murderkill Watershed was used for agriculture, which equates to approximately 37,393[9] acres. In 1997, agricultural land use accounted for 58%[10] of the total land area in the watershed; therefore, it is likely that agricultural activity is the second leading source, after the Kent County treatment plant, of phosphorus entering the waterways. In addition, these sources have an ancillary significant loading of nonpoint source nitrogen.

[8] Glenn Gladders, Nonpoint Source 319 Program, DNREC. 2004. Personal Communication.
[9] 2002 Landuse data
[10] 1997 Landuse data

There are 37,393 acres of crops in the watershed.[11] Crops require nutrients in order to produce an economic yield. Crops produced in the watershed may include soybeans, potatoes, barley, wheat, corn, and vegetables. Nutrient inputs include fertilizer and manure application, which if applied improperly may contribute to nutrient over-enrichment in streams and tributaries in the Murderkill Watershed.

The Pollution Control Strategy Workgroup has not been able to assigned nutrient reduction from nutrient management planning due the baseline period (6/6/97 to 9/30/98) being so close to when NMA was enacted (2002). The nutrient management plans from the baseline period used for comparison were essential the same as nutrient management plans required by the NMA.

> EXPECTED REDUCTION: Reduction achieved will be a function of the acreage and type of new agricultural best management practices constructed within the watershed.

Nutrient Reducing Strategy 7

> Establish and prioritize nutrient reducing best management practices (BMPs) in order of efficiency and cost effectiveness.
>
> Assess the array of drainage systems and BMPs on agriculture lands in use along the drainage systems within the watershed in order to identify any areas for possible improvement.

Basis of Recommendation: The establishment of best management practices on agricultural land will address nutrient inputs from all facets of agriculture operations, including the use of manure from animal operations and fertilizers for crops. Voluntary use should be recommended first. Identify areas where BMPs can be implemented. The environmental and quality of life benefits of agriculture should be recognized as a way to encourage and enforce BMP implementation. Encourage use of buffers on agricultural lands where best nitrogen and phosphorous uptake is likely. By targeting areas for BMP implementation geographically, more effective and efficient nutrient reductions can likely be expected.

Department's Perspective: An Agricultural Pollution Control Strategy Workgroup was convened to gather the best available science for nonpoint source pollution prevention from agricultural sources for the Inland Bays. The Workgroup met since April 2002 to gather the best available data on nutrient efficiencies for various agricultural best management practices. Their recommendations and calculations are based on averages over several years from different studies and are dependent on weather conditions, soil type, crop production intensity, excess manure generation, topography and other site-specific conditions. In addition, the workgroup recognized that a lag time likely exists between practice implementation and benefit observation, which cannot currently be estimated since all nutrient fate and transport processes are not well understood at this time. The PCS Workgroup has identified efficiency values for BMPs in the Murderkill Watershed.

[11] Glenn Gladders, Nonpoint Source 319 Program, DNREC. 2004. Personal Communication.

EXPECTED REDUCTION: As of February 2003, agricultural best management practices on the ground in the Murderkill River Watershed have reduced phosphorus loads by 1.38 lbs per day or 1.44 percent of the way towards the P load goal.

Ancillary reduction of N: 71.87 lbs per day of nitrogen or 12.8 percent of the way towards the nitrogen load goal

Nutrient Reducing Strategy 8

Ongoing in-stream monitoring must be done in order to quantify the amount of nutrients in the waterways of the Murderkill Watershed.

Basis for Recommendation: This monitoring will identify areas of high nutrient influx allowing for installation of BMPs to reduce the nutrient load or initiate some mitigation strategy to reduce the high nutrient influx.

The Division of Water Resource's Watershed Assessment Section monitors 14 surface water stations for water quality quarterly in the Murderkill. We recognize that any additional sampling will require more funds which may not be available due to already mandated sampling expenditures.

EXPECTED REDUCTION: An efficiency and reduction value cannot be assigned to this recommendation. Monitoring does not have a direct reduction.

Ancillary reduction of N: none Ancillary.

Nutrient Reducing Strategy 9

Optimize and prioritize areas where individual, large and community wastewater treatment and disposal systems can be eliminated by connecting to Kent County Waste Water Treatment Plant.

Basis for Recommendation: In Delaware, surface and ground water are directly connected. Consequently, impacts on groundwater will impact the quality of the surface water. In the summer, surface water flow is primarily groundwater seepage into the stream. Nutrients from onsite wastewater treatment and disposal systems will reach the surface water through the groundwater. An individual onsite wastewater treatment and disposal system may contribute 5.8 lbs per year of phosphorus and 22 pounds per year of nitrogen to the groundwater. As of 2001, approximately 6402[12] septic tanks were identified in the Murderkill Watershed. In 1997, which is the baseline year for the TMDL, there were 5238 individual septic tanks in the watershed. Therefore in 2001, the potential contribution of phosphorus from septic systems may be up to 12.1 lbs per day and 376.8 lbs per day of nitrogen to the groundwater and ultimately surface water.

Kent County has targeted Walnut Shade area, where 500 residences are served with onsite wastewater treatment and disposal systems, for connection to central sewer. Many of these systems are old and are malfunctioning. Kent County has also included Woodville and Terry

[12] J. (Jennings) Volk

Drives, an area where most of the homes are served by environmentally ineffective and outdated cesspools, in this expansion. This area was included because system failures pose the greatest threat to human health and water quality. This proposed sewer district will be connecting to Kent County Treatment Facility within the next 3-5 years.

EXPECTED REDUCTION: 8 lbs/day of TP

Ancillary reduction of N: 30 lbs/day

Nutrient Reducing Strategy 10

Promote compliance with regular inspections and pump outs of individual onsite wastewater treatment and disposal systems (OSWDS).

Require when a house is sold that the onsite wastewater treatment and disposal system is inspection and pump-out, if necessary, to verify the system was maintained and is operational at the time of inspection.

Basis of Recommendation: Currently septic permits require that the systems be pumped out every three years or when the system contains 30 percent or more of solids. The County and/or Department should institute a program that enforces the inspection and pump out requirement for onsite septic systems. Homeowner's should be notified of this requirement in their tax bills the year their system is due. The County and State should use computer software to track the occurrence of inspections and cooperate to ensure compliance with regulations. Additionally, the state should implement a pilot onsite septic inspection and compliance program for the Murderkill Watershed. The program should assist residents who have not had their septic pumped in the previous two years to have their system pumped and inspected. The State and County should subsidize the cost of inspection and pump out. Following the inspection, the inspector should provide the homeowner/resident with educational materials and receipt of pump out.

By requiring this before closing, new property owners will be educated on their system and gain a better understanding of maintenance and operation requirements, thus reducing long term or future problems with the system. Section 8.0000 of the *"Regulations Governing the Design, Installation and Operation of On-site Wastewater Disposal and Treatment Systems"* dictates owner responsibility for maintaining and operating on-site wastewater treatment and disposal system.

The watershed currently has 6402 OSWD systems within its boundaries. If all systems are pumped once every three years, as required by state regulations,[14] then 2134 systems would be pumped annually. The soils in the watershed are mostly well drained: the actual TP reduction will likely be significantly less. Each system pumped out would reduce TP and TN surface and/or groundwater load by 0.8 lbs/system/year and 2.0, respectively.)

Department's Perspective: On July 11, 2003, the Governor signed House Bill 150 into law which amended Title 7, Chapter 60 of the Delaware Code relating to the Department of Natural

[14] Regulations Governing the Design, Installation and Operation of On-Site Wastewater Treatment and Disposal Systems, adopted March 11, 2002.

Resources and Environmental Control. This legislation authorizes the Department to establish a license for persons who inspect septic systems (Class "H") and other on-site wastewater treatment systems, and sets an annual license fee for septic system designers, installers, site evaluators, liquid waste haulers, inspectors and percolation testers, similar to other license fees charged by the Department. The Class H license authorizes the inspection, investigation, data collection and certification/non-certification of on-site wastewater treatment and disposal systems[13]. The Regulations were updated to include an inspector's license in early 2004. At this point, limited State funds preclude the staff from conducting more than 10 system inspections per week. Currently, a pilot inspection and compliance program has been developed and is being implemented in the Inland Bay Watershed. However, the State does not have specific requirements for onsite wastewater treatment and disposal systems to be inspected and pumped out prior to property transfer. Some bank lenders may require prior to closing once the program is funded, it can be implemented.

EXPECTED REDUCTION: 4.9 lbs/day of TP for 2134 systems

Ancillary reduction of N: 12.3 lbs/day

Nutrient Reducing Strategy 11

Systematically eliminate cesspools and seepage pits as the compliance program and resulting inspections program are instituted and as properties are transferred from one owner to another.

Basis for Recommendation: The DNREC Watershed Assessment Section estimates that there are at least 30 cesspools[15] and/or seepage pits in the Murderkill Watershed, however that estimation may be low. Any existing system would likely be Ancillary with old farmsteads and very old mobile home parks (See Nutrient reducing Strategy 10).

EXPECTED REDUCTION: Unknown

Ancillary reduction of N: Unknown

Nutrient Reducing Strategy 12

Provide new homeowners with onsite wastewater disposal systems educational materials on how the systems function and the steps that are necessary for maintenance at the time they close on their homes.

Basis of Recommendation: New homebuyers may not understand the functioning of their system or the impacts a failing system could have on the environment. Therefore, by providing education materials, the homeowner may prevent long-term problems and may save money as well.

[13] Onsite Regulations

[15] This number was determined by using a GIS and old aerial photographs to assess large parcels over 10 acres within the Murderkill Watershed with the assumption that large parcels were farmsteads and had a dwelling unit and cesspool.

EXPECTED REDUCTION: Unknown

Ancillary reduction of N: Unknown

Nutrient Reducing Strategy 13

Provide education about alternative enhanced nutrient reducing onsite wastewater treatment and disposal systems and develop a fund to offset the cost of these systems within the watershed.

Basis for Recommendation: In response to the TMDL, Kent County requires that: Individual residential, large or community onsite sewage treatment and disposal systems sited in a watershed with an established Total Maximum Daily Load (TMDL) shall be designed and installed in accordance with the nutrient load reductions prescribed by the TMDL or they shall use the best available technologies in order to achieve the required nutrient reduction targets set for the particular watershed. (See Chapter 187, Subdivision and Land Development (Adopted June 24, 2003)).

Due to the cost of these systems the Financial Assistance Branch administers low interest loans for on-site wastewater systems for persons of low to moderately low incomes from the State Revolving Fund.

EXPECTED REDUCTION: This action will only impact new construction

Ancillary reduction of N: This action will only impact new construction

Nutrient Reducing Strategy 14

Design and implement all permanent sediment and stormwater management plans to include design criteria to further reduce nutrient contributions by the percentage required by the TMDL to the ground and surface waters to the maximum extent practicable.

Basis of Recommendation: Since 1991, stormwater runoff ancillary with new development is regulated under the Delaware Sediment & Stormwater Regulations, administered by the Division of Soil & Water Conservation. As stormwater moves over land, it picks up natural and human-made pollutants from lawns, streets, parking lots and industrial and commercial facilities, eventually depositing them into the waters of the Murderkill. Stormwater management is the primary way to control nonpoint source pollution from developed areas. A variety of methods can be used to control and treat runoff from lawns, homes, parking lots, roads and commercial and industrial facilities. Some of these methods reduce nutrient loading from stormwater more than others. When possible, these methods should be preferred. However, there may be instances where the pollutant of most concern on the site would not be reduced sufficiently by the most effective nutrient removal technique. In these cases, the method used should be the best at treating the removal of the pollutant of most concern. Reducing stormwater impacts within the Murderkill will require action by all stakeholders and will required innovative management techniques.

The water quality goal under the current regulations is 80 percent removal of the average annual load of total suspended solids (TSS). The Department may require acceptable stormwater

quality practices if a receiving water body has been identified as impaired, or designated with a specific pollutant reduction target necessary to meet State of Delaware water quality regulations.[16] Stormwater runoff for specific industries or point sources is managed through the National Pollutant Discharge Elimination System (NPDES) program, administered by the Surface Water Discharges Section within DNREC's Division of Water Resources.

EXPECTED REDUCTION: This action will only impact new construction

Ancillary reduction of N: This action will only impact new construction

Nutrient Reducing Strategy 15

Require vegetated buffers of adequate and proper widths sufficient to reduce or eliminate nonpoint source pollution for lots abutting tidal water and perennial streams.

Basis of Recommendation: Buffers help to filter nutrients and slow overland stormwater flow. Kent County has issued several ordinances related to development and buffers, including an ordinance requiring 100-foot setbacks from blue line streams and tax ditches and a 25-foot buffer/setback for wetlands. However, the County setbacks are not required to be vegetated. The Murderkill Tributary Action Team feels these ordinances may not be strong enough as written to adequately protect the waters of the Murderkill River Watershed. Recommendations are being made to strengthen and supplement County and State requirements with the expectation that these measures will protect and improve water quality and the quality of life for the residents in the watershed. Buffers should be required on, but not limited to the following: stormwater and drainage conveyances, grassed waterways, ponds, catch basins, intermittent streams, tidal and freshwater wetlands, and tile wells and based on individual site conditions. In addition buffer should be free of any encumbrances including onsite wastewater treatment and disposal systems.

Developers should be required to protect existing and/or provide new buffers if necessary as community open space: however, the responsibility for buffer maintenance will fall to civic and homeowners associations or maintenance corporations, not individual homeowners. Buffers should be planted and designed to require zero or minimal maintenance. The developer must also guarantee all trees planted in the development for the first year.

EXPECTED REDUCTION: For each acre of 100 feet buffer installed 0.003 lbs day of TP could be reduced.

Ancillary reduction of N: For each acre of 100 feet buffer installed 0.14 lbs day of TN could be reduced.

Nutrient Reducing Strategy 16a

Determine the location and acreage of buffers in the watershed and identify areas for improvement, i.e. stream miles with and without buffers.

[16] Randy Greer, Sediment and Stormwater Program. August 11, 2004. Personal Communication.

Nutrient Reducing Strategy 16b

> Establish riparian buffers on all public lands, including retrofits. Fifty percent of appropriate public lands should have buffers installed within 5 years, and within 10 years all public lands should have buffers as appropriate.

Basis of Recommendation: Stream reaches within the Murderkill Watershed that either lack forested riparian buffers, or have only narrow forested riparian buffers were identified using ESRI's ArcGIS software. The analysis included the use of multiple layers of data including 1997 forest cover data from the Delaware Natural Heritage Program, hydrography data from the U.S. Geological Survey (USGS), 2002 wetlands maps from the Delaware Statewide Wetlands Mapping Project (SWMP), and public lands data from DNREC's 2004 Outdoor Resources Inventory (ORI). Since the forest cover data was somewhat outdated, 2002 aerial photos were also used to help update some of the forest cover data as needed.

The GIS software was used to identify 100 foot buffer areas around rivers, streams, and tax ditches, and 50 foot buffer areas around freshwater wetlands. Tidal wetland areas were considered unsuitable for the establishment of forested buffers and were removed from the analysis. Tidal portions of the river and any tidal tributaries were included in the analysis. Buffers around tidal areas were considered adequate if the wetlands extended at least 100 feet from the edge of the water. For all non-tidal areas, buffers were considered adequate if the entire designated buffer areas consisted of forests. Stream sections within the watershed were categorized into three groups according to the status of the adjacent forested riparian buffers. The three categories included: 1) adequate forested buffers along both stream banks, 2) deficient forested buffers along either one or both stream banks, or 3) no forested buffers along either stream bank. Since the establishment of additional forested riparian buffers has a greater likelihood of being implemented on public lands than on privately owned lands the analysis was broken out for both publicly owned and private lands.

Within the Murderkill Watershed there are approximately 230 miles of waterways excluding ponds and reservoirs. The analysis found that out of 230 miles of rivers, streams, and tax ditches, only 130 miles (57 percent) are adequately buffered along both stream banks. Sixty-seven miles (29 percent) have deficient buffers along either one or both of the stream banks, and 33 miles (14 percent) have no stream buffers along either stream bank.

Within the Murderkill watershed only 26 miles (11 percent) of rivers, streams, and tax ditches flow through publicly owned lands. Waterways within public ownership fared much better than those in privately owned lands. Within public lands, 21 miles (81 percent) are adequately buffered along both stream banks, 4 miles (15 percent) have deficient buffers along either one or both of the stream banks, and only 1 mile (4 percent) had no forested buffer along either stream bank.

Overall within the Murderkill watershed most of the tidal portions of the watershed and the main stem of the river are adequately buffered. The areas in most need of attention are the agricultural tax ditches, many of which have no forested riparian buffers. The analysis also emphasizes the importance of working in cooperation with private landowners, since a majority of the waterways flow through privately owned lands. Overall, 43 percent of the waterways within the

Murderkill River Watershed are not adequately protected by forested riparian buffers that are capable of reducing the loading of excess nutrients and sediment.

> EXPECTED REDUCTION: For each acre of 100 feet buffer installed 0.003 lbs day of TP could be reduced.
>
> Ancillary reduction of N: For each acre of 100 feet buffer installed 0.14 lbs day of TN could be reduced.

Nutrient Reducing Strategy 17

> (Support research to) identify vegetation that will give the most nitrogen and phosphorus reduction for planting along maintenance right of ways for tax ditches and in buffers.

Basis of Recommendation: Riparian buffers effectively trap the sediments, nutrients, and bacteria in the surface and ground waters flowing from uplands and thus improve the quality of receiving waters. Several studies have examined the effectiveness of buffers at removing sediment from surface runoff, with the general agreement being that as buffer width increases, sediment removal increases (Castelle et al., 1994; Wenger, 1999; Dosskey, 2001). An experiment in the North Carolina Coastal Plain, though, found that although the studied buffer trapped as much as 90% of the sediment eroded from an agricultural field, almost 50% of that sediment traveled more than 300 feet into the buffer (Cooper et al., 1987 as cited in Wenger, 1999). This suggests that wide buffers are necessary for long term sediment sequestration. Sediment can be trapped by forested or grassy vegetation. The deep root structures of trees stabilize soils and promote further sedimentation. Grassed buffers, on the other hand, are effective at minimizing runoff velocity and trapping sediment by maintaining sheet flow through the riparian zone, but they can become covered in high sedimentation environments, which rapidly decrease their efficiency (Wenger, 1999; Dosskey, 2001).

Once nutrients like phosphorus and nitrogen enter riparian buffer zones they either become trapped in the soils, taken up by vegetation, or transformed by other processes. Phosphorus is often found bound to sediment and is mobilized in surface runoff. Thus, particulate P can be effectively removed though the trapping of sediment in wide buffers as described above (Wenger, 1999). Nitrogen, on the other hand, is primarily transported in the dissolved form and is taken up by vegetation or permanently removed from the system through denitrification, a process through which microbial organisms in the soils and streambed reduce nitrate-N to nitrogen gas. Denitrification is likely the more significant mechanism of nitrate-N removal (Peterjohn and Correll, 1984), however, several factors influence where the greatest amount of denitrification will occur. Denitrification rates are often greatest when the ground water table is near the surface and when carbon and nitrate-N are in good supply (Wenger, 1999; Lowrance, 1992). Thus, these zones of high denitrification can be highly spatially variable and in order to capture as many zones as possible, and hence remove as much nitrate-N as possible, buffer width should be maximized. A width of at least 100 feet has been suggested as an optimal buffer width for this purpose (Wenger, 1999). Grass and forest buffers are both effective at removing N and P from surface waters, however forests are more efficient at removing N from ground waters (Osborn and Kovacic, 1993 as cited in Wenger, 1999).

EXPECTED REDUCTION: Unknown

Ancillary reduction of N: Unknown

Nutrient Reducing Strategy 18

Manage open space for nutrients.

Basis of Recommendation: Open space can have many valuable functions and should include natural areas; however, wetland restoration areas and buffers should be included as open space. Open space should be developed with appropriate native vegetation and protected though easements. In impaired watersheds, it makes sense that water quality protection should be important when developers design open space. Maintenance of these spaces is important for water quality benefits. It is logical that inclusion of open space in a developed area will help to reduce nutrient loads; it is difficult to assign a specific load reduction to this recommendation.

EXPECTED REDUCTION: For each acre of open space 0.003 lbs day of TP could be reduced.

Ancillary reduction of N: For each acre of open space 0.14 lbs day of TN could be reduced.

Nutrient Reducing Strategy 19

Monitor existing and new stormwater BMPs, quantifying the return on investment for different practices, locating and identifying structures, quantifying the types and amount of different pollutants, and identifying the most effective and cost effective practices.

Basis of Recommendation: The Department and Delaware Department of Transportation (DelDOT) are involved in projects monitoring the effectiveness of various stormwater strategies. DelDOT has been investigating the performance of four different types of inlet protection devices in urbanized areas of northern Delaware. They are evaluating and comparing the performance of these inserts with respect to their ability to remove sediment and hydrocarbons from stormwater runoff, as well as their maintenance requirements in different applications. Monitoring will continue year-round over a two- to three-year period, in order to incorporate data from varying seasonal and rainfall conditions. These projects combined with the literature will provide nutrient reduction efficiencies for various practices in the future. Our current knowledge of these elements is listed below and believes that adequate research is being conducted on new and existing BMPs that the literature will provide adequate information on these BMPs.

Kent County Conservation District is in the process of assessing all stormwater BMPs installed in Kent County, identifying priority areas for stormwater retrofits and evaluating the effectiveness of BMPs already constructed.

Biofiltration/bioswales must be at least 200 ft long for TN reduction and 100 ft. swales are more effective in reducing TP (45 percent) as compared to 200 ft. swales (29 percent).

EXPECTED REDUCTIONS:

Table 4.1 - Storm water best available technology (BMPs)		
	BMP Efficiency as Percent for TN	**BMP Efficiency as Percent for TP**
Wet ponds	12	55
Dry pond (extended detention)	15	25
Infiltration (swale, infiltration basin/trench)	65	70
Biofiltration*	25	29
Sandfilter	47	41

Nutrient Reducing Strategy 20

Identify areas in the watershed where stormwater retrofits would be effective in reducing nutrients from entering into surface waters.

Basis for Recommendation: Land developed prior to 1990 did not have any stormwater requirements. Kent County Conservation District has delegated authority from DNREC to run the stormwater program in Kent County and is in the process of identifying priority areas for stormwater retrofits.

EXPECTED REDUCTION: Nutrient reductions will depend on the specific systems selected for upgrade and the acreages involved. See the table above for BMP efficiencies.

Nutrient Reducing Strategy 21

Municipalities must separate their stormwater flow from their wastewater flows according to the Kent County Sanitary Code.

Basis of Recommendation: Based upon information given to the Team by Kent County, flow to the county wastewater treatment plant may double during rain events and nutrient loads may increase from more runoff.

EXPECTED REDUCTION: UNKNOWN

Ancillary reduction of N: UNKNOWN

Nutrient Reducing Strategy 22

Implement a storm water utility within the watershed

Basis of Recommendation: Stormwater best management practices have maintenance requirements and operational expenses. Most community management associations do not have

the knowledge or the financial means to operate and manage their stormwater structures. The Sediment and Stormwater regulations serve as an enabling structure for the local ordinances needed in order to set up the utility. The Sediment and Stormwater program has held several workshops to generate interest in the formation of a utility. Stormwater utilities are designed to become a funding mechanism for stormwater retrofits and maintenance.

EXPECTED REDUCTION: Nutrient reductions cannot be assigned to this recommendation as it is a mechanism for funding practices, not for implementing practice.

Nutrient Reducing Strategy 23

Improve landowner knowledge of stormwater best management practices by establishing guidelines that correlate to national and state curriculum standards with an emphasis on the benefits of stormwater management.

Basis of Recommendation: DNREC could convene a joint working group from Kent County Conservation District, Kent County Land Use and Planning Office, the Nutrient Management Commission, DelDOT, municipalities, EPA and any other relevant agencies to share information and create appropriate methods to integrate stormwater management practices and education.

EXPECTED REDUCTION: UNKNOWN

Ancillary reduction of N: UNKNOWN

Nutrient Reducing Strategy 24

Quantify the amount of nutrients lawn care is contributing to waterways through the use of surveys or other methods as appropriate.

Basis for Recommendation: Nutrient contributions from lawn care are assumed to be high, however it is very difficult to quantify. In Delaware, 58 percent of homeowner turf acres were fertilized[18]. Of these the average nitrogen application rate to home-lawns falls within the range recommended by the University of Delaware Soil Test Procedure (UDSTP) and phosphorus application rates fall below the range specified by UDSTP[19]. Also in this study, researchers found that professional landscape services used significantly less fertilizer than homeowners.

EXPECTED REDUCTION: UNKNOWN

Ancillary reduction of N: UNKNOWN

Nutrient Reducing Strategy 25

Identify lawn care companies and other fertilizer applicators within the watershed.

[18] Avenue, 1994
[19] Sims and Gartley, 1996

Requiring fertilizer applicators to log nutrients applied to individual properties will help to track the amount of nutrients being applied within the watershed.

Require lawn care companies to incorporate soil tests into lawn service, prior to applying fertilizers.

Basis of Recommendation: The Delaware Nutrient Management Commission (DNMC) is the controlling authority for fertilizer application on parcels of land greater or equal to 10 acres within the State. The Nutrient Management law requires nutrient applicators to be certified. Requiring applicators to log the amount of nutrients they are applying will help to track the amount of nutrients being applied to individual non-agricultural properties. The DMNC has also recognized that significant contributions of nitrogen and phosphorous come from land parcels less than 10 acres in size. In response to this knowledge, the DNMC has produced a brochure on proper lawn maintenance. These brochures have been placed in most retail outlets that sell fertilizer in the watershed. In addition, an advertisement was broadcast on local television station reminding people about proper lawn nutrient application and urging people to get a soil test done prior to applying fertilizer.

Lawn care companies must comply with Nutrient Management Act requirement for turf management by 2007. The Team suggests a compliance timeline similar to that being required for the agriculture community. Requiring soil test by lawn service companies would ensure only the necessary amount of nutrients are being applied to lawns.

EXPECTED REDUCTION: Unknown

Ancillary reduction of N: Unknown

Nutrient Reducing Strategy 26

Require impervious cover to be limited to no more than 15% of the watershed to conserve water quality. Local ordinances should be implemented to assist in restricting impervious surfaces and impervious cover calculations should include streets and sidewalks.

Basis for Recommendation: As impervious cover increases in a watershed, water quality decreases. Limiting impervious cover reduces the amount of runoff that can enter the river and its tributaries. Research has consistently shown that once a threshold of imperviousness is crossed in a given watershed, water quality and stream habitat cannot be maintained at the predevelopment level. The consensus among many independent researchers is that watershed imperviousness should not exceed 10 percent in environmentally sensitive watersheds. As research has uncovered the link between increases impervious cover and deteriorating water quality, businesses have developed pervious paving products that can replace impervious methods.

Kent County Code presently allows 20 percent of each lot to be covered by impervious surfaces; however this allotment does not include streets or other impervious areas outside the lot boundary in the calculation. Consequently, subdivisions have over 20 percent impervious cover. Commercial lots could 100 percent impervious cover. In 1984 (?), impervious cover within the

Murderkill Watershed was estimated to be around 0.5 percent and in 2002 data is estimated to have increased to 8.1 percent.

EXPECTED REDUCTION: Although there have been links between percent impervious cover and watershed health, nutrient loading rates for phosphorus and nitrogen have not been established for percent imperviousness, however logic tells us that by reducing runoff, we will reduce nutrient loads in the river, ponds and tributaries. We do not have the ability to connect a numeric reduction with coverage limits.

Ancillary reduction of N: Unknown

Nutrient Reducing Strategy 27

Protect existing wetlands from impacts of impervious area through conservation site design and low impact development.

Basis of Recommendation: Regulations should include the concept and practice of low impact development. There are several ways to approach changing regulations and ordinances to promote low impact development (LID). Livable Delaware Advisory Council has completed "*Better Models for Development in Delaware*" which promotes ideas for creating more livable and prosperous communities. The Sea Grant Marine Advisory Service will be promoting an education program for municipal leaders "NEMO" which educate leaders for various aspects of promoting better development.

EXPECTED REDUCTION: UNKNOWN

Ancillary reduction of N: UNKNOWN

Nutrient Reducing Strategy 28

Develop a comprehensive education plan for the urban/suburban landowner, homeowner's associations, local garden clubs, school districts and other educational facilities on the issues of water quality and urban nutrients.

The plan should:

1. Identify values which are affecting residential activities and target those that will effect behavior change
2. Encourage educational facilities with turf athletic facilities where nutrients are applied to develop nutrient management plan for their facility. (The DNMA requires licenses for facilities personnel applying nutrient fertilizers to educational facility.)
3. Develop an advertising strategy that promotes the use of soil tests to the urban/suburban homeowner.
4. Work the University of Delaware to revise their soil test results sheet for homeowners to make it easier to be understood and provide specific fertilizer application recommendations based upon existing fertilizer blends found within the State.

5. Education of fertilizer retailers such that retailers will pass out educational materials with purchase of fertilizer and will have available soil testing materials at their location
6. Educate homeowners and homeowner associations on stormwater BMPs that can be used around the home to reduce impact on water quality
7. Integrate education into various (State and local) permitting processes and public information campaigns should be based upon goal of behavior change
8. Support a demonstration project/workshop for homeowners on application of fertilizers and composting methods.
9. Support and encourage the use of water conservation measures by individuals to help reduce the amount of nutrients leaving individual properties. Use of these measures will help in the effort to reduce the amount of nutrients ending up in the Murderkill River.
    - Gray water recycling (use of gray water around the home on plants and gardens, etc),
    - Rain collection systems such as rain barrels and rain gardens,
    - Directing stormwater runoff from roofs and impervious surfaces onto grassy areas,
    - The use of water saving devices in and around the home, in addition to
    - The overall reduction of water usage in households and on lawns
10. Work with the Delaware Nutrient Management Commission and the Master Gardeners to provide education and programs for homeowner's on lawn and garden best management practices such as:
    - Proper mowing practices,
    - Leaving lawn clippings on the lawn;
    - Encourage proper lawn care maintenance-leave a buffer along stream edge;
    - Reduce lawn size;
    - Water conservation measures and stormwater BMPs for the lawn and garden;
    - Encourage use of native species and noninvasive species;
    - Discourage ideas that lawns need chemicals to be green;
    - Proper use of lawn and garden chemicals (including natural fertilizers and compost);
    - Use of compost rather than chemicals as a means of reducing synthetic chemical fertilizers.

Basis for Recommendation: Based on 2002 land use data, a significant portion of Murderkill Watershed is urban (14.1 percent) and much of it is turf. Over 73,000 acres of residential turf exists in Delaware and 58 percent of it is fertilized, usually with little forethought. The

Murderkill Tributary Action Team has identified residential activities as an important origin for nutrients in the Murderkill Watershed and thus has made several recommendations to address this issue. Residential behavior is a difficult source to regulate, thus the Team's recommendations focus on providing education and outreach activities to change residential behavior and increase environmental awareness.

DNREC's Sediment and Stormwater program developed and completed a handbook for homeowners associations that can be used to learn how to maintain their stormwater plan. DNREC, as well as the agencies with delegated authority from the Sediment and Stormwater program, are working with homeowners in forwarding this concept. The Kent and Sussex County Conservation Districts with cooperation from DNREC's Sediment and Stormwater Program and NEMO has held workshops for homeowners associations and residents in Kent and Sussex Counties.

EXPECTED REDUCTION: Unknown

Ancillary reduction of N: Unknown

5 PROGRESS TO DATE

The Murderkill Tributary Action Team has enjoyed success on several fronts, thus improving the water quality of the Murderkill River, its tributaries and ponds. Highlights follow:

- A Nonpoint Source 319 Program grant to repair failing septic systems in the Walnut Shade area of the Murderkill Watershed eventually the tanks will be replaced with sewer.
- Funding for an individual onsite wastewater treatment and disposal system inspection and pump out compliance program. Funding was made available by extending a pilot program started in the Inland Bays to the Murderkill.
- Received funding for FY05 from the Nonpoint Source 319 Program to implement a Smartyards program in the watershed in partnership with the Delaware Nature Society as an outreach and educational opportunity to promote residential behavior change. Smartyards is a component of the Backyard Wildlife Habitats program conducted in partnership with the National Wildlife Federation, the Delaware Department of Natural Resources and Environmental Control, the University of Delaware - Water Resources Agency, the Gateway Garden Center, and Wild Birds Unlimited. The program provides official certification for properties where owners meet the four criteria necessary for wildlife habitat: food, cover, water, and places for wildlife to raise young. By adopting practices beneficial to wildlife such as planting native species and limiting the use of chemical fertilizers and pesticides, participants help to improve local water quality by reducing their reliance on products that contribute to the nonpoint source pollution.
- A farm located in the headwaters of the Murderkill River near McColley's Pond was the beneficiary of a cost-share program administered by the Kent County Conservation District for the installation of farm improvements and BMPs. The farm has cattle and donkeys which have unobstructed access to two streams that define the property boundaries. The BMP and farm improvement project involved the installation of fencing to remove direct livestock access to the streams that enter McColley's Pond, the addition of water troughs to provide water for the cattle in place of the streams, and manure

storage shed. These improvements and BMPs eliminate direct fecal deposition (bacteria and pathogens) and minimize un-off (sediment and nutrients) to the streams.

- DNREC is working with a consultant to develop a build-out map of the watershed, prioritize areas for installation of agriculture BMPs, and identify potential areas for stormwater retrofit projects.
- The agriculture community in the Murderkill Watershed has already gone a long way to help reduce nutrients in the watershed. Table shows the number of acres in the watershed currently being treated by BMPs.

Table 5.1 - Agricultural Best Management Practices (BMPS) Utilized in the Murderkill Watershed as of Feb. 2003

BMP	Number of BMPs installed or Acres	Nutrient Reduction (lbs/day)	
		TN	TP
Performance Basis			
Nutrient Management Plans	6166		NA
Farmstead BMPs			
Animal Waste Storage	6		
Animal Mortality disposal	5		
Calibration of application equipment			
Nutrient Loading Basis			
Animal Nutrition Management (phytase)	2,490,684	NA	0.72
Nutrient Management relocation	0	0	0
Soil, plant, manure analysis (PSNT)			
Phosphorus Site Index			
Nutrient credits (legumes)			
Nutrient Loss Basis			
Nutrient source characteristics			
Nutrient timing, application method			
Conservation tillage (acres)	770		
CREP and CRP			
Grassed waterways	0.0	0.0	0.0
Filter strips	195	0.0	0.0
Riparian buffers	5.8	0.81	0.02
Grass buffers			
Forest buffers	82	11.34	0.29
Ponds	54	1.92	0.0
Wetlands	61	8.52	0.18
Wildlife Habitat	148	6.08	0.08
Cover crops (acres)	1,062	43.20	0.09
Water control structures	0	0	NA
Stream Fencing			
Total Agriculture Reduction		**71.87**	**1.38**
TMDL		**560**	**96**
Percentage toward TMDL		**12.8%**	**1.44%**

DNREC and DELDOT are involved in projects to monitor the effectiveness of various stormwater strategies. These projects, combined with the literature, will provide nutrient reduction efficiencies for various practices in the future. The Kent County Conservation District and the Division of Soil and Water Conservation have compiled a list of Stormwater BMPs installed (1996-2002) for the Nonpoint Source 319 Program. Table 5.2 shows the number of acres in the watershed currently being treated by stormwater BMPs and the Ancillary nutrient reductions.

Table 5.2 - Stormwater BMPs on the Ground in the Murderkill Watershed as of 2002

BMP	Number of BMPs	Acres Treated	TN (lb/day)	TP (lb/day)
Wet ponds	29	21	0.38	0.64
Dry ponds	14	5.8	0.06	0.04
Infiltration systems	3	0.5	0.00	0.00
Biofiltration/bioswales*	8			
Total Stormwater reductions			0.44	0.68

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Appendix C - Public Talk –Real Choices

Introduction

Public Talk – Real Choices: A Model for Public Engagement in Creating Pollution Control Strategies

Bill McGowan[1], Joe Farrell[2], Ed Lewandowski[3], Kathy Bunting-Howarth[4], Lyle Jones[5]

Public issues are complex, 'wicked' problems. Poverty, education, land-use, environment and others are issues not easily resolved. Delaware for example is a national leader in welfare reform, education reform, land use legislation and the environment but those close to these issues know the reforms are stalled locally and nationally. Why? We believe a lack of public engagement in creating public policy is a fundamental reason. We have become a technocratic society, resulting in the public abdicating it's role as participants in creating public policy to a bureaucracy. It is generally accepted by both parties, the public and bureaucracy, that the public does "not have the capacity" to work through complex issues. It is incumbent on those who work with the public to create a better way to engage the public in creating sustainable public policy.

A Common Model for Public Engagement

One model found frequently when public agencies need public input is the "workshop" model. The model begins with a selection of a small group of people, a citizens advisory committee or "blue ribbon" panel. The group, usually with the help of the public agency, goes through an education process, writes a report, and delivers it to the agency. The agency holds "tell and sell" workshops, followed by public hearings and possible promulgation of regulation. The model more often than not fails to give the public a significant chance to participate in policy formation, resulting in disillusionment, and failed policy. Both the public and public agencies need and deserve a better way to work together that produces sustainable decisions.

A Preliminary Approach

Losing Ground: What Will We Do About Delaware's Changing Landscape? A series of issue forums or public conversations, throughout the state in 1996, introduced deliberative dialogue to 340 Delawareans. Deliberative Dialogue is a conversation in which people, the public, weigh the cost and consequences of their thinking and make choices based on their deliberations. It was the first time for many where in a public meeting citizens had the opportunity to both listen and talk to each other in an environment conducive to learning. It was not a public hearing where comments are taken for the record or workshop with information presented by experts. Comments after the forums indicated citizens would come out and discuss issues of importance, people want a way to engage issues personally, and will engage each other in questioning and

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learning. The results of *Losing Ground* appear to indicate the public wants a better model to engage public issues. It is from the conversations heard from citizens that participated in *Losing Ground* that the model *Public Talk – Real Choices* emerged.

Why Develop Another Model?

Two major citizen efforts assisted by DNREC, the Inland Bays Monitoring Committee and the Citizens Advisory Committee of the National Estuary Program, produced action plans for restoration of the Inland Bays. The plans are very similar to each other, in fact a matrix of the two plans attempts to avoid duplication of effort (CCMP, 1995). Citizens spent over nine years of work between the two plans. Both plans emerged from a visioning model asking the questions "What do we want the Bays to look like?" and "How can we get there?" The action plans are broad recommendations that lack specific suggestions for implementation. There remains a tremendous amount of frustration from citizens who have engaged in one or the other or both of the Bay protection efforts (Citizen Advisory Committee Minutes, 1997) and the public agency, DNREC, whose mission is to preserve and protect the natural resources of Delaware. Both parties want the same thing, healthy bays, and still there is no solution or commitment.

A Caveat

There is a difference between then and now and that is TMDL's are regulations. Both the Inland Bays Monitoring Committee and the National Estuary Program were voluntary. The regulatory community can argue TMDL's are promulgated regulation that demand action through pollution control strategies. That is true to a point. The State met the requirement of the settlement by establishing the TMDL's for the watershed. The pollution control strategies are self-imposed requirements. Without significant public engagement in creating strategies that potentially impact all residents in the watershed, the strategies will die in the political arena. By taking time on the front end, and working through a truly public process, the State stands to gain more in the end product of a sustainable public policy.

The Model: Public Talk – Real Choices

The purpose of *Public Talk – Real Choices* is to move formulation and creation of a major public policy decision from a public agency to the public for dialogue and deliberation. *Public Talk – Real Choices* builds on what happened in *Losing Ground* forums. Using deliberative dialogue as the core, *Public Talk* goes further by engaging the public in learning about the issue, weighing the costs and consequences of what is important through dialogue with each other, and coming to public judgment. The model consists of six steps; Organization of Work Team, Education, Issue Framing, Evaluation of the Issue Framework, Public Forums/Choice Work, Recommendations.

Model Components

Organization - is a structural component that brings the public agency and public, the work team, into agreement as to what needs to be accomplished. Without preliminary understanding and agreement by both parties, the effort will fail. **Education -** further enhances this arrangement by building upon the knowledge of the process shared in the organizational discussions and then adding information necessary to frame the issue. A good portion of technical information will come from the public agency e.g. the Inland Bays Whole Basin Assessment Report.

Issue framing - is the critical piece necessary for public engagement. Issue framing lays out in an organized fashion for public consumption three or four choices. The framework must be unbiased, represent the under girding values embedded in policy choices and articulate the basic costs and consequences of the choices. It should represent the voices of all impacted by the issue.

The framework sets the stage for our conflicting motives – those things we consider valuable and that pull us in different directions when we have to decide how to act. The issues need to be stated in ways that compel the public to make their views known.

Evaluation of the Framework - This piece gives insight into how successfully the teams framed the issue. The use internal deliberation, focus groups, etc. enhances the success of the framework. For successful public deliberation all voices need to heard within the framework. The choices must be neutral and offer a positive approach for issue resolution.

Public deliberation **-** is the cornerstone of *Public Talk – Real Choices*. A significant representation of the public must deliberate the issue. This occurs through successful planning and selection of venues for forums. The forums must result in some form of common ground for action.

Recommendations - The work teams sift through and analyses the public voice they heard from the forums. From this public voice the work team develops the pollution control strategies.

Why This Model?

National Issues Forums - National Issues forums are "town meetings" that bring people together to deliberate "wicked problems," problems that won't go away, with the help of moderator. The medical analogy of a broken arm versus diabetes describes wicked problems. The broken arm can be set and heals. Diabetes requires life -changing alterations. Participants use an issue book that offers three to four choices for resolution. Within the choices are basic values, cost and consequences of the choice. With the help of a moderator the public works through the choices, by looking at four things: What is valuable? What are the costs and consequences of the choice? Where is the tension? Where is there common ground for action? Participants must consider "It's not what I want to do but what we ought to do."

Why Are These Models Effective?

The Harwood Group in a report *Meaningful Chaos- How People Form Relationships with Public Concerns,* found nine factors necessary for public engagement.

Connections – People tend to enlarge rather than narrow their views of public concerns, making connections among ideas and topics that society tends to fragment.

Personal Context – People relate to concerns that "fit" with their personal context, moving beyond self-interest to what is meaningful

Coherence – People want to hear the whole story. They want to understand what it means.

Room for Ambivalence – People do not immediately see black and white. They want a gray area to question, discuss, test ideas, and become comfortable with their opinions.

Emotion – Too many processes try to remove emotion from decisionmaking. Emotions are necessary to sustain relationships with public concerns.

Authenticity – People and information must "ring true".

Sense of Possibilities – People really want something to happen and they might play a role in it.

Catalysts – Everyday people, not just experts and elite, are critical in helping people form relationships with public issues.

Mediating Institutions – Places where people come together to talk and act on public concerns. (Harwood, 1993)

National Issues Forums and *Public Talk – Real Choices* adhere to these tenets.

The Facilitator Team

Public Talk – Real Choices uses a neutral, third party facilitator. By using a neutral, third party as the facilitator, the facilitator becomes an advocate for the process (Kaner, 1996). Third party facilitation avoids the perception of bias that can occur when the facilitator is personally associated with the issue.

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Appendix D - BMP Nutrient Reduction calculations

BMP NUTRIENT REDUCTION CALCULATIONS

Calculating the Required Total Maximum Daily Load Reductions Based on Land-use

The Total Maximum Daily Load (TMDL) for receiving waters in the Murderkill calls for a 30% reduction in total nitrogen (TN) and a 50% reduction in total phosphorus (TP) (EPA, 2005). The baseline period for this TMDL was established from 1992 land use data used to determine the acreages of each of the following land uses: Urban, Agricultural, Forest, Wetland, Water, and Other, which includes land uses like rangeland and barren land. The results are tabulated below (Table 1).

Table 1 - 1997 Murderkill Watershed Land-use Acreages

Urban	Agricultural	Forest	Wetland	Water	Other	Total acreage
8,539	38,411	7,918	3,769	11,638	1017	67, 226

In order to calculate nutrient loads from non-point pollution sources, the land use acreages from Table 1 were combined with the land use loading rates in Table 2, which were determined based on results of research conducted by experts in the Murderkill Watershed to produce daily nutrient loads according to land use, as displayed in Table 3.

Table 2 - Land-use Loading Rates

	TN (lbs/acre/yr)	TP (lbs/acre/yr)	Source
Developed	15.0	0.48	Ritter and Levan (1992) average of high and low density
Agriculture	25.0	0.60	Ritter and Levan (1992)
Grasslands	10.0	0.40	Ritter and Levan (1992)
Forests	5.0	0.25	Ritter and Levan (1992)
Wetlands	0.0	0.00	Ritter and Levan (1992)
Water	12.0	0.75	Ritter and Levan (1992)
Other	10.0	0.40	Ritter and Levan (1992)

Table 3 - 1997 Murderkill Watershed Land-use Based Loads							
	Urban	Agricultural	Forest	Wetland	Water	Other	Total
TN (lbs/day)	350.9	2630.9	108.5	0.00	33.44	19.2	3116.0
TP (lbs/day)	11.23	63.14	5.42	0.00	2.09	0.78	50.58

I. Baseline load calculation for land-use type by reduction area:

Using the land use loading rates listed in Table 2, the nutrient loads coming from non-point sources during the baseline period are determined using the equation below. It should be noted that the grassland loading rate was used to determine the loads from the "Other" land use category.

Nutrient load Lbs/yr & lbs/day (Table 3)	=	Acreage of specific land-use (Table 1)	X	Loading rate for specific land-use (lbs/acre/yr) (Table 2)

EX: TN load for urban land use:

TN load	=	3,156 acres	X	15 lbs TN/acre/yr	=	**47,340 lbs TN/yr or 129.70 lbs TN/day**

II. Required TMDL reduction on a land-use basis:

The annual and daily nutrient load reductions needed from non-point sources to achieve the reductions outlined in the TMDL are calculated using the following equation. For the Murderkill Watershed, the TN load needs to be reduced by 934.8 lbs/day and the TP load by 40.29 lbs/day. In order to achieve these reductions, the best management practices (BMPs) discussed in the Pollution Control Strategy must be implemented.

Required TMDL reduction (lb/day)	=	Baseline load (lb/day)	X	Percent reduction

EX: TN TMDL required load reduction:

Required TMDL reduction (lb/day)	=	3116.0 lbs TN/day	X	30%	=	**934.8 lbs TN/day**

Onsite Wastewater Disposal System (OWTDS) BMP Calculations

In order to determine the nutrient loading by OWTDS to groundwater, local watershed data and knowledge has been utilized.

Twelve OWTDS existing near Red Mill Pond in Lewes, Delaware were monitored in 1993 (DNREC, 1994). The average total phosphorus concentration of the effluent from these systems was 15.7 mg/L, while the total kjeldahl nitrogen (TKN) concentration was 58.5 mg/L and the nitrate/nitrite concentration was 0.8 mg/L. The total nitrogen concentration of the average effluent from this study was summed to equal 59.3 mg/L. Conversations with professionals in this industry have suggested that 50.0 mg/L is a more appropriate value of TN concentrations in on-site effluent and this value has been used in subsequent calculations.

Small systems, which are typical individual household systems, have flows less than 2,500 gpd. The average design flow for individual residential OWTDS is 221 gpd.

The nutrient load to the watershed from drain fields can be established by determining the product of the above concentrations and respective flow rates.

Robertson and Hartman (1999) found that 85% of the total phosphorous in the effluent will be retained in the vadose zone or the unsaturated soil above the water table, most of which is within 12 inches of the drain field (Gold and Sims, 2000). Initial calculations presented by the Department, also based on the Red Mill Pond study, assumed that 87% of TP and 52% of TN is assimilated in the soils once the effluent leaves the septic tank.

The final loading rates from OWTDS to groundwater can be determined using the following equations:

Small systems (<2,500 gpd):

[Conc. (mg/l) x (lb/453,592 mg)] x [(221 gal/system/day) x (3.7854 l/gal)] x (1-soil assimilative capacity)

Thus, the OWTDS nutrient loading rates to groundwater in the Murderkill Watershed are:

- 0.052 lbs TN/system/day and 0.004 lbs TP/system/day for individual small systems less than 2,500 gpd

I. Connecting OWTDS to Sewer Districts

Since 1992, 11 OWTDS (septic) systems are reported to have been removed from the Murderkill watershed by connecting homes and businesses to sewer districts (Kent County Wastewater Treatment Facility). These systems have been connected to sewer districts that dispose of their waste at spray irrigation facilities.

Reductions for systems that are connected to plants that use spray irrigation receive a 90% efficiency since nutrients remain in the ecosystem (DNREC Groundwater Discharges Section,

personal communication, 2003). The nutrient load reductions are calculated using the following equation.

Nutrient load reduction (lbs/day)	=	OWTDS loading rate (lbs/system/day)	X	# of eliminated OWTDS	X	Reduction efficiency

EX: TN reduction due to OWTDS connection:

TN load reduction (lbs/day)	=	0.052 lbs TN/system/ day	X	11 eliminated OWTDS	X	90%	=	**0.52 lbs TN/day**

II. Holding Tank Inspection and Compliance Program

On average, holding tanks have a 2,800 gallon capacity. Metcalf and Eddy (1991) reported that holding tanks typically hold 2,596 gallons of effluent and 204 gallons of septage (solids). Recent observations from the compliance program indicate volumes of 2,464 gallons of effluent and 336 gallons of septage volume. The average effluent concentrations previously discussed (50.0 mg TN/L and 15.7 mg TP/L) have been used to determine the effluent loads from holding tanks. The nutrient load contribution from septage in holding tanks will be determined using the nutrient concentrations in septage from holding tanks (600 mg TN/L and 250 mg TP/L), as reported in Wastewater Engineering, Third Edition (Metcalf and Eddy, 1991). The nutrients removed per holding tank pump-out are shown in Table 5, calculated using the above concentrations.

Table 5 - Nutrient Reductions from a Holding Tank Pump-Out

	Total N (lbs/tank/pump-out)	Total P (lbs/tank/pump-out)
Holding Tank Effluent	1.03	0.32
Holding Tank Septage	1.68	0.70
Total	2.71	1.02

Effluent:
Nutrients Removed (lbs/tank/pump-out) =
Conc. (mglL) x (lb/453,592 mg) x (2,464 gal/tank) x (3.7854 l/gal)
Septage*:*
Nutrients Removed (lbs/tank/pump-out) =
Conc. (mglL) x (lb/453,592 mg) x (336 gal/tank) x (3.7854 l/gal)

There are 14 holding tanks currently in the Murderkill Watershed. Each time a holding tank is pumped, 2.71 lbs TN and 1.02 lbs of TP do not enter the Murderkill.

Initially, the Department assumed that tanks are pumped-out 16 times per year. The Small Systems Branch, Groundwater Discharges Section of the Division of Water Resources determined this number to be high. Records from the Holding Tank Compliance program indicate that on average, holding tanks are pumped-out about 12 times per year, or once a month

(DNREC Groundwater Discharges Section, personal communication, 2001). Thus, this latter figure was used for subsequent calculations to determine the annual load reduction using the equation below.

Nutrient load reduction (lbs/yr)	=	Reduction rate (lbs/tank/pump-out)	X	12 pump-outs year	X	# of tanks

EX: TN reduction due to Holding Tank Pump Out:

TN load reduction (lbs/day)	=	2.71 lbs TN/tank/pump-out	X	12 pump-outs year	X	1 tank	=	**32.52 lbs TN/yr or 0.09 lbs TN/day**

III. OWTDS Pump-outs

Using a GIS, an analysis was conducted that determined as of March 2009, there were 7,565 OWTDS in the Murderkill Watershed.

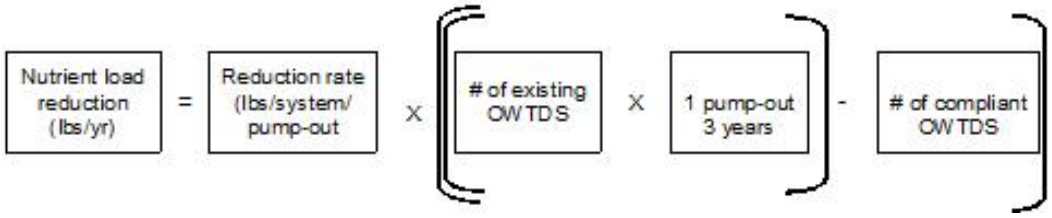
Waste haulers usually deliver waste to the nearest wastewater treatment plant. According to information from the Wilmington Treatment Facility, 53 tanks were pumped from the Murderkill Watershed in 2001. In addition, it was estimated that 47 tanks from the Murderkill Watershed were pumped from the Kent County Treatment Facility in 2001 because they could not give exact information on the number of systems pumped. This equals 100 tanks being pumped out a year in the Murderkill Watershed based on a 1,000 gallon tank capacity. By assuming that after three years, a septic tank will contain 750 gallons of effluent and 250 gallons of septage (volumes based on local inspector-hauler observations), and using the concentrations of effluent and septage given above, the effluent load reductions per system achieved by a pump-out program are shown below in Table 6.

Table 6 - Nutrient Reductions from an OWTDS Pump-Out

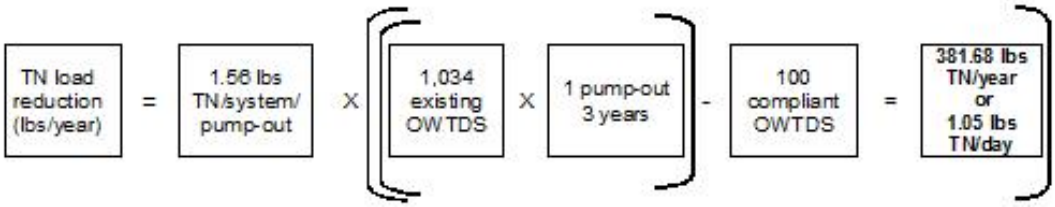
	Total N (lbs/system/pump-out)	Total P (lbs/system/pump-out)
OWTDS Effluent	0.31	0.10
OWTDS Septage	1.25	0.52
Total	1.56	0.62

Effluent:
Nutrients Removed (lbs/system/pump-out) =
Conc. (mg/l) x (lb/453,592 mg) x (750 gal/system) x (3.7854 l/gal)
Septage:
Nutrients Removed (lbs/system/pump-out) =
Conc. (mg/l) x (lb/453,592 mg) x (250 gal/system) x (3.7854 l/gal)

The load reduction in the water column achieved by this practice can be calculated using the following equation.



EX: TN reduction due to OWTDS pump-out program:



IV. OWTDS Performance Standards

Wastewater pretreatment technologies exist to remove nitrogen, phosphorus, or both from wastewater prior to soil dispersal of the effluent. A consultant hired by the Department evaluated the performance efficiencies of these technologies then recommended performance standards for OWTDS in Delaware and several levels of performance efficiencies for nitrogen and phosphorus (The On-Site Wastewater Corporation, draft written communication, 2003).

A recommendation in the Murderkill Pollution Control Strategy surrounding small septic systems requires new and replacement subdivisions in areas outside of sewer districts to be equipped with systems that can reach standards such as "Performance Standard Nitrogen 3" (PSN3) to reduce nutrients. Technologies that can achieve PSN3 will produce a 50% reduction of effluent TN concentration when compared to the TN influent concentration. The nutrient load reduction can be determined using the following equation.

Nutrient load reduction (lbs/day)	=	OWTDS loading rate (lbs/system/day	X	# of existing OWTDS in program	X	Reduction efficiency

EX: TN reduction due to upgrading to alternative systems:

TN load reduction (lbs/day)	=	0.052lbs TN/system/ day	X	1,034 OWTDS	X	50%	=	**27.1 lbs TN/day**

Stormwater BMP Calculations

I. Stormwater BMPs

Several types of structures that treat stormwater runoff are used throughout the Murderkill Watershed. The efficiencies associated with common stormwater BMPs are listed in Table 7. In order to calculate the load reduction to the receiving water body, the calculation outlined below is used. The nitrogen urban loading rate is 15 lbs/acre/yr, while the phosphorus loading rate is 0.5 lb/acre/yr (Ritter and Levan, 1992).

Table 7 - Stormwater BMP Reduction Efficiencies (Chesapeake Bay Program, 2009)

BMP	TN (%)	TP (%)
Wet ponds	30	50
Dry pond (extended detention)	5	10
Infiltration (swale, infiltration basin/trench)	50	70
Biofiltration	50	70
Filtering Practice (bioretention)	50	70

Nutrient load reduction (lbs/day)	=	Total drainage area treated by structures (acres)	X	Urban loading rate (lbs/acre/yr)	X	Reduction efficiency

EX: TN reduction due to wet ponds:

TN load reduction (lbs/day)	=	5,861.43 acres treated on average	X	15 lbs TN/acre/yr	X	30%	=	**26,376 lbs TN/yr or 72 lbs TN/day**

II. Potential Future Stormwater Retrofit Projects:

It is anticipated that an additional 789.6acres of urban area in the Murderkill watershed will be retrofitted in the future. It is difficult to project, however, the exact number and type of treatment structures that will be used. The majority of stormwater practices currently in use in the watershed are wet and dry ponds, while infiltration, biofiltration, and filtration structures together are less likely to be used. It is unlikely that these same proportions will be used in future retrofit projects since the construction of ponds will require a considerable amount of space and it may be unfeasible to create these structures in areas that are already developed. Because of this, it has been assumed that future retrofits will be more equitable with equal implementation of ponds and other practices.

The load reductions achieved from the stormwater BMPs currently on the ground have been summed into two categories, “Ponds” and “Other.” These values were divided by the total area treated in each category to calculate nutrient reduction rates. For “Ponds,” the reduction rates are

1.84 lbs TN/acre/yr and 0.25 lbs TP acre/yr, while the reduction rates for "Other" are 5.69 lbs TN/acre/yr and 0.20 lbs TP acre/yr.

The potential future loading reduction to the stream as a result of retrofitting 789.6 acres of urban lands can thus be determined using the equation below.

Nutrient load reduction (lbs/day)	=	Reduction rate (lbs/acre/yr)	X	Acres of retrofit	X	Future percent use of practice

EX: TN reduction from future stormwater ponds:

TN load reduction (lbs/day)	=	1.84 acres TN/acre/yr	X	789.6 acres	X	10%	=	**2,904 lbs TN/yr or 7.95 lbs TN/day**

Open Space Calculations

Grassed Open Space

Grassed open space is treated as a land use change from agricultural cropland to grassed open space. Thus, the acres that undergo change will receive a lower loading rate. The loading reduction is calculated as follows.

EX: TN reduction due to open space provisions in the UDC:

Riparian Buffer

It is assumed that for every one acre of land where riparian buffers are employed, that two upland urban acres are treated. This approach is similar to the practice employed by the Chesapeake Bay Program (CBP, 1998). The efficiencies for nutrient load reductions are an average of the range presented by J.T. Sims and J.L. Campagnini (written communication, 2002). Thus, the agreed efficiencies are as follows:

Forested buffers: TN-- 62% and TP-- 62%

For these BMPs, the actual acre of the practice will be treated as a land use conversion and the reduction efficiencies will be applied to two acres of affected upland for each acre of practice.

EX: TN reduction due to riparian buffer requirements:

Agriculture BMP Calculations

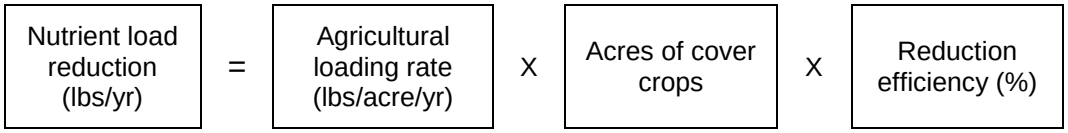
The following calculations are provided as a result of the Agricultural Pollution Control Strategy Workgroup's efforts in gathering the best available science for nonpoint source pollution prevention from agricultural sources. The workgroup began meeting in April 2002 to gather the best available data on nutrient efficiencies for various agricultural best management practices. These recommendations and calculations are based on averages over several years from different studies and are dependent on weather conditions, soil type, crop production intensity, excess manure generation, topography and other site specific conditions. In addition, a lag time likely exists between practice implementation and benefit observation, which can not currently be estimated since all nutrient fate and transport processes are not well understood at this time.

I. Cover Crops

Nitrogen reduction efficiencies for cover crops were calculated using a weighted average method for each year. The data used in this calculation came from ranges of cover crop TN efficiencies for several plant species presented by J.T Sims and J.L. Campagnini (written communication, 2002). The Workgroup chose a single efficiency, often an average of the range, for the commonly used species in Delaware (Table 8). The United States Department of Agriculture, National Resource Conservation Service provided information on each cover crop planted in the 2008-2009 season in the Murderkill Watershed (shown in bold). This information was used to calculate a weighted average efficiency of the crops planted, determined to be 54.9% for the 2008-2009 season. It should be noted that with this approach, the efficiency will change from year to year, depending on the acreage of each cover crop species planted. For TP, the Workgroup referred to the best professional judgment presented by Sims and Campagnini, which was "less than 5%," and will be considered for these purposes as 4.9%. The nutrient load reduction is calculated with the equation shown below.

Table 8 - Cover Crop Efficiencies for TN

Cover Crop Species	Work Group BMP Efficiency (%)
Barley	70
Hairy Vetch	6
Annual Rye	65
Cereal Rye	54.5
Oats	55
Wheat	55



EX: TN reduction due to 3,144.80 acres of cover crops:

TN load reduction (lbs/day)	=	25 lbs TN/acre/yr	X	3,144.80 acres	X	54.9%	=	**43,162 lbs TN/yr or 118.25 lbs TN/day**

II. Ponds, Grassed Waterways, Grassed Filter Strips, Wildlife Habitat

The Conservation Reserve Program (CRP) practices are treated as a land use change from agricultural cropland to grassed waterways or grassed filter strips, or wildlife habitat. Thus, the acres that undergo change will receive a lower loading rate. Since the Conservation Reserve Enhancement Program (CREP) was implemented, any new grass filter strips created will be treated as a CREP practice and will receive a reduction calculated by the method described later. The loading reduction is calculated as follows.

Nutrient load reduction (lbs/yr)	=	[Agricultural loading rate (lbs/acre/yr)	-	Grass loading Rate (lbs/acre/yr)]	X	Acres of CRP practices

EX: TN reduction due to 1,413.80 acres of wildlife habitat:

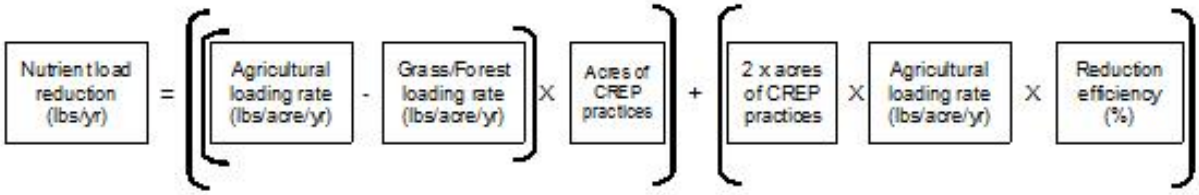
TN load reduction (lbs/yr)	=	[25 lbs TN/acre/yr	-	10 lbs TN/acre/yr]	X	1,413.80 Acres	=	**21,207 lbs TN/yr or 58.10 lbs TN/day**

III. Filter Strips, Forest Buffers, Riparian Buffers, Wetlands

The Conservation Reserve Enhancement Program (CREP) practices (CP21-grass filter strips) are assumed to act as grassed buffers. CREP practices (CP22-riparian buffer, CP23-wetland restoration and CP3A-hardwood trees) are all assumed to act as forested buffers. The Workgroup assumed that for every one acre of land where these practices are employed, that two upland acres are treated. This approach is similar to the practice employed by the Chesapeake Bay Program (CBP, 1998). The efficiencies for nutrient load reductions are an average of the range presented by J.T. Sims and J.L. Campagnini (written communication, 2002). Thus, the agreed efficiencies are as follows:

Grassed buffers: TN-- 46% and TP-- 54%
Forested buffers: TN-- 62% and TP-- 62%

For these BMPs, the actual acre of the practice will be treated as a land use conversion and the reduction efficiencies will be applied to two acres of affected upland for each acre of practice.



EX: TN reduction due to 30.8 acres of CREP filter strips:

IV. Field Border

Nutrient reductions from field borders are treated as Conservation Reserve Program (CRP) practices. These practices are treated as a land use change from agricultural cropland to grassland habitat. Thus, the acres that undergo change will receive a lower loading rate. It is important to note that field borders are measured in feet and must be converted to acres.

EX: TN reduction due to 18,299 ft of wildlife habitat:

Critical Area Planting

Critical area planting is a BMP that controls soil erosion and results in phosphorus reductions since phosphorus adsorbs to soils. The critical area planting practice is considered a hot spot BMP and is applied to areas in fields where soils are severely eroding. Soil loss is based upon NRCS values. The critical area planting practice decreases soil erosion from these highly erodible areas from 10 tons per acre per year to 0.5 tons per acre per year, or a soil loss reduction of 9.5 tons per acre per year. To calculate the reduction from this practice, the acreage of the practice is multiplied by the soil loss reduction value, the amount of readily desorbed phosphorus (0.23 mg P/kg soil) (Sims et al. 1994), and conversion factors.

TP load reduction (lbs/yr)	=	Acres	X	Reduction in soil loss (9.5 tons/ac/yr)	X	Readily desorbed phosphorus (0.23 mg P/kg soil)	X	Conversion factors

EX: TP reduction due to 35.80 acres of critical area planting:

TP load reduction (lbs/yr)	=	35.8 acres	X	9.5 tons/ ac/yr	X	0.23 mg P/kg soil	X	2000 lbs/ ton	X	kg 10^6/mg	=	**0.16 lb TP/yr or 0.004 lb TP/day**

VI. Conservation Tillage

Conservation tillage is a BMP that controls soil erosion by modifying tillage practices on a farm field which reduces sediment and hence phosphorus losses from the tilled field. Soil loss is again based upon NRCS values. Conservation tillage practice can lower soil erosion to 1.5 tons per acre per year from approximately 4.1 tons per acre per year for conventional tillage, or a soil loss reduction of 2.6 tons per acre per year. To calculate the reduction from this practice, the acreage of the practice is multiplied by the soil loss reduction value, the amount of readily desorbed phosphorus (0.23 mg P/kg soil) (Sims et al. 1994), and conversion factors.

TP load reduction (lbs/yr)	=	Acres	X	Reduction in soil loss (2.6 tons/ac/yr)	X	Readily desorbed phosphorus (0.23 mg P/kg soil)	X	Conversion factors

EX: TP reduction due to 4,182.20 acres of conservation tillage:

TP load reduction (lbs/yr)	=	4,182.20 acres	X	2.6 tons ac/yr	X	0.23 mg P/kg soil	X	2000 lbs/ ton	X	kg 10^6/mg	=	**5 lb TP/yr or 0.01 lb TP/day**

VII. Nutrient Management Plans

To reduce agriculture's impact on water quality, Delaware legislated a nutrient management program in 2002 to oversee nutrient applications within the State. In 2003, 20% of farmers applying nutrients to 10 acres or more or those who manage 8 or more animal units within the state were required by the Nutrient Management Act to create and submit a nutrient management plan (NMP) to the Nutrient Management Commission (NMC). Each year between 2004 and 2007, another 20% of eligible farmers were required to have NMPs, with 100% implementation by January 1, 2007. These plans are routinely updated and modified to meet the nutrient needs of the future cropping rotations and practices.

The Delaware Conservation Partnership (DCP) conducted a survey in July 2007, after the deadline requiring all eligible farm operations to have a plan, to evaluate nutrient management planning in the state. The DCP consists of the Delaware Conservation Districts, the Natural Resources Conservation Service, and the Delaware Department of Natural Resources and Environmental Control, and strives to work together to meet the needs of Delaware Farmers by providing cost-share programs, educational opportunities, and nutrient management planning services. The survey was designed to inform those programs by identifying gaps in information and education and opportunities to spend cost-share dollars more effectively. In short, the purpose of the project was to make nutrient management work better for farmers in Delaware.

The surveys were sent out to everyone who has been certified by the Nutrient Management Program- 2,034 people in all. The Delaware Conservation Partnership received 698 responses- about a 34% response rate. The following is the breakdown of responses among different sizes of farms:

1-10 acre farms – 9% response rate

11-99 acre farms – 29% response rate

100-499 acre farms – 25% response rate

500 + acre farms – 20% response rate

Animal only farms – 10% response rate

Responses varied only slightly among different farm sizes and types, with the exception of whether or not nutrient management provided an economic benefit to their farm. Larger farms and those whose plans were written by a private consultant were most likely to agree that nutrient management provides an economic benefit to their operation. Small farms, animal operations and those whose plan was written by someone on staff were least likely to agree.

The surveys indicated that fertilizer application rates have decreased the most among farmers who till at least 500 acres, while manure applications have decreased most among farmers who till between 11 and 99 acres. When fertilizer application rates are evaluated by county, Sussex farmers reduced the rate of N and P applications the most, Kent reduced N applications the least, whereas New Castle deceased P applications the least.

Table 5 - Change in Fertilizer and Manure Application Rates Due to 2002 Nutrient Management Law

County	***Farm Acres***	***% Change in nitrogen fertilizer applications***	***% Change in phosphorus fertilizer applications***	***% Change in manure application***
Kent	173,808	13.4	26.9	5.4
New Castle	66,981	16.0	20.1	13.6
Sussex	269,464	18.5	37.1	24.2
Weighted Average		16.4	31.4	19.9

The efficiencies based on the DCP survey can be compared to other estimates of nutrient management planning effectiveness. An Agricultural Workgroup was established to gather the best available science on nonpoint source pollution prevention for agricultural sources. The Workgroup operated off the basic assumption that if fewer nutrients are being applied to the land, fewer nutrients will be lost to Delaware's water bodies. From this premise, the Workgroup determined nutrient efficiencies for various agricultural best management practices including the effectiveness of nutrient management planning.

Initially, the Workgroup addressed the impact of nutrient management planning (NMP) in the Inland Bays and Nanticoke watersheds from a study by McGowan and Milliken (1992). This study listed the reductions associated with various management practices observed over a three year period, with a total of 103,736 lbs TN reduced by 2,328 acres under nutrient management planning. To determine a general NMP TN reduction, the Workgroup decided that the reductions and acreage associated with manure allowance and cover crops should be removed from further calculations since reductions for both of these items are determined separately and all NMPs will not include manure relocation. This subtraction gave a total of 1,224 acres of nutrient management planning and a load reduction of 70,136 lbs of TN, resulting in a reduction rate of 57.3 lbs/acre per 3-year planning cycle. McGowan and Milliken (1992) reported that the TN application rate prior to the introduction of NMPs was 280 lbs/acre per 3-year planning cycle, so NMPs produced a 20.5% reduction in TN. This estimate falls in the lower range reported by the State of Maryland (MDNR, 1996), which was 20-39% for nitrogen. The corresponding phosphorus range reported by the Maryland DNR was 9-30%. However, due to the absence of a report similar to the McGowan and Milliken study in Delaware for P, there is not enough information available to determine an appropriate reduction efficiency to apply to NMPs for phosphorus in these two watersheds.

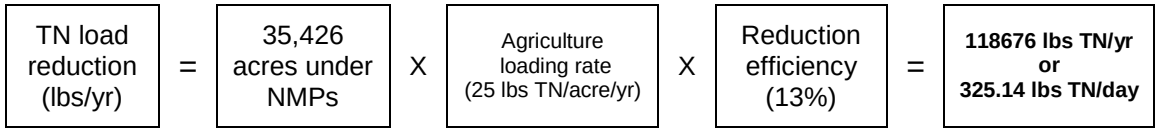
In the Murderkill watershed, one representative farm within the watershed volunteered to allow the Workgroup to analyze the nutrient data they routinely gather. This particular farm tracks nutrient application rates to each crop field within a database that goes back to 1999, prior to the passing of the Nutrient Management Act. The data were separated into two groups, pre-Nutrient Management Plans (NMPs) (1999-2002) and post-NMPs (2003-2004), and entered into Statgraphics Software for statistical analysis. It was determined that there was a statistically significant difference between the mean application rates at the 95% confidence level for nitrogen. The average nitrogen application rate decreased by 12.4% from the pre-NMP level and this value will be taken as the NMP reduction efficiency; unfortunately, no reduction could be calculated for phosphorus from this data.

At the request of the NMC, Sims et al. (2008) conducted extensive nutrient mass balance calculations for the State for the years 1996 through 2006. They calculated both input/output and management–oriented mass balances for nitrogen and phosphorus. The Sims et al. (2008) approach included calculations for manure relocation and estimates of biological fixation of nitrogen by leguminous crop and clearly demonstrated that fewer nutrients are being applied to Delaware's cropland.

DNREC Watershed Assessment Section (WAS) has worked with the NMC and the University of Delaware Cooperative Extension to determine the impact of the Nutrient Management Act on the amount of nutrients applied to Delaware's agricultural fields. Using an input-output type analysis using fertilizer sales data and crop yields, WAS determined that on a state-wide basis, 47% less nitrogen and 62% less phosphorus has been applied to Delaware's cropland. Both the WAS and Sims et al. (2008) approach produced similar results.

The DCP values, which are based on the reductions in nutrient applications actually reported by Delaware farmers, fall within the range of efficiencies determined by the numerous other methods and data sets discussed above. As a result, DNREC proposes to use the DCP efficiencies to estimate the reduction in nutrient application rates resulting from the promulgation of the Nutrient Management Law.

There were 35,425.86 acres of nutrient management planning in the Murderkill Watershed in 2008. The Chesapeake Bay Program (2009) has aggressively establish nitrogen and phosphorus reductions associated with various urban and agricultural best management practices including nutrient management planning. The Program applies a 13% reduction to nitrogen and a 27% reduction to phosphorus for every acre of cropland that has a nutrient management plan. Those nutrient reductions were applied to every acre of cropland in the Murderkill watershed. Using the Bay program reductions TN and TP efficiencies and the agricultural loading rate reported earlier, the annual and daily load reductions due to these acres can be calculated as follows.



Appendix E – BMP cost calculations

This document describes the cost-effectiveness of urban and agricultural best management practices (BMPs) that reduce nutrients. Although the costs for Total Phosphorus (TP) removal appear high, they may be thought of as ancillary benefits of Total Nitrogen (TN) removal. In addition, they show the relative cost effectiveness of TP removal by each practice.

On-Site Wastewater Treatment and Disposal System (OWTDS) BMP Cost Calculations

Connecting OWTDS to Sewer Districts

According to DNREC's Financial Assistance Branch (personal communication, 2007), the average cost of constructing a sewer system is $8,500 per equivalent dwelling unit (EDU). In the future, this cost is expected to increase to $10,000/EDU. The debt service, or cost of financing these systems, at roughly an average 2% rate is currently $1,867/EDU and will be $2,194/EDU for future septic eliminations and sewer connections. Additionally, system owners must pay for the final septic system pump-out, crushing and filling the tank, and the connection costs associated with building the lateral line running from the building to the right of way. These three expenditures together run approximately $1,000/EDU. Finally, operation and maintenance (O&M), including repair fees, of roughly $200 per EDU per year will also be added to these values for an average 20 year lifespan of a connection (DNREC Financial Assistance Branch, personal communication, 2007) (Table 1).

Table 1 - OWTDS Elimination Costs

	Past Conversions	Future Conversions
Construction of sewer system	$8,500/EDU	$10,000/EDU
Debt service	$1,867/EDU	$2,194/EDU
Additional expenditures	$1,000/EDU	$1,000/EDU
Operation and Maintenance (over 20 year lifespan)	$4,000/EDU	$4,000/EDU
TOTAL	$15,367/EDU	$17,194/EDU

Holding Tank Inspection and Compliance Program

The cost of pumping-out a 2,800 gallon holding tank averages around $250 per system per pump-out (DNREC Small Systems Branch, personal communication, 2007). As a result of the holding tank inspection and compliance program, they have been shown to be pumped-out roughly 12 times a year. This information reveals that the owner of a single holding tank will spend $3,000 each year. In addition to this cost, there is an annual inspection fee of $60 per system (DNREC Small Systems Branch, personal communication, 2007), so that the total expenditure for holding tank inspection and compliance is $3,060/system/year and over a 20 year lifespan the cost is $61,200/system.

OWTDS Pump-outs

The cost of pumping-out OWTDS ranges from $185-200 per system, with an average cost of $192.50 per system (DNREC Small Systems Branch, personal communication, 2007). It is proposed that septic systems be pumped once every three years and inspected during that time period as well. These proposed inspections will be performed by licensed inspectors at an estimated cost that ranges from $200 to $400 with an average cost of $300 at the time of pump-out (DNREC Small Systems Branch, personal communication, 2007). The total cost of the OWTDS inspection and compliance program will cost the system owner $164.17/system/year and over a 20 year lifespan this equals $3,283.33/system.

OWTDS Performance Standards

Licensed installers and members of DNREC's Small Systems Branch (personal communication, 2007) revealed that the installation of best available technologies (BATs) to existing small (<2,500 gallon per day (gpd)) OWTDSs for advanced nitrogen removal would cost between $3,500 and $6,000 per system with an average installation of $4,750. These technologies are believed to last for approximately 20 years. These technologies require a service contract by a certified service provider with an estimated annual cost that ranges from $150 to $300, with an average cost of $225/system/year. In addition, the systems will still require pump-outs, which costs $64/system/year (DNREC Small Systems Branch, personal communication, 2007), and they will need periodic mechanical parts repaired, estimated to cost $50/system/year and the electrical cost of running the systems is likely to also cost about $50/system/year (DNREC Financial Assistance Branch, personal communication, 2007). Taking all of this into account, the total cost of this strategy is $12,530/system.

Stormwater BMP Cost Calculations

Wet and Dry Ponds

Typical costs for retention basins were retrieved from Chapter 6.0, "Costs and Benefits of Storm Water BMPs," of an EPA on-line document (EPA, 1999). In this document, it states that a retention basin treating a 50-acre residential site in 1999 costs about $100,000, such that the cost per unit area was $2,000/acre. All values reported in the document need to be divided by an adjustment factor to account for regional differences. Delaware falls in Region 2, which has a 0.90 adjustment factor (EPA, 1999). Thus, retention basins in Delaware in 1999 cost approximately $2,222.22/acre. Using the average annual federal inflation rate for the time period of 1913-2007 (3.42%), the capital cost of Delaware retention basins in 2009 is $2,982/acre. To this value, the annual operation and maintenance costs over a 25 year lifespan must be added. Operation and maintenance costs for retention basins can range from 3-6% of the construction costs (EPA, 1999). We have used an average value of 4.5% which is $134.19 and applied this to the regionally adjusted construction cost over the 25 year lifespan. The total cost for this strategy is $6,336.75/acre.

Infiltration Structures

The 1999 construction costs of infiltration trenches and infiltration basins treating 5-acre commercial sites were averaged to represent the range of infiltration structures utilized as

stormwater BMPs throughout Delaware. These costs were $45,000 for trenches and $15,000 for basins (EPA, 1999), which equates to $9,000/acre and $3,000/acre, respectively, and averages $6,000/acre. Once adjusted for the regional variability in cost (0.90 factor), and inflated to 2009, this value becomes $8,946.67/acre treated by infiltration structures. Annual O&M costs for infiltration structures range anywhere from 1-20% of the construction cost (EPA, 1999), and average 10.5%. This produces an annual O&M cost of $939.40/acre/yr which when calculated over a 25 year lifespan and added to construction costs equals $32,431.68/acre.

Filtering Practices

Cost data for filtering practices was obtained from a publication of the Environmental and Water Resources Institute of the American Society of Civil Engineers (ASCE, 2001). Since filtering practices treat runoff from pavement and impervious areas, the construction cost was reported for the early 1990s as $10,117.36 per impervious acre. The 2009 cost can be estimated using the average federal inflation rate and the early 1990s values to be $17,008.41/acre. The O&M costs typically range from 11-13% of the construction costs (EPA, 1999), which on average, is $2,041.01/acre/year. Calculating the O&M costs over a 25 year lifespan and adding to construction costs provides a total cost of $68,033.64/acre.

Biofiltration

The EPA on-line document reported that the construction costs for biofiltration devices in 1999 were $60,000 for a 5-acre commercial site (EPA, 1999), which equates to $12,000/acre. This value must also be divided by the 0.90 adjustment factor to account for regional cost differences, which yields $13,333.33/acre, and then adjusted to the 2009 value, $17,893.33/acre. The annual O&M costs range from 5-7% of the construction cost (EPA, 1999). When using 6% as the average, annual O&M costs $1,073.60/acre/year and are further calculated over a 25 year lifespan. Thus, total costs for biofiltration equals $44,733.33/acre.

Table 2 - Stormwater BMP Costs

	Wet and Dry Ponds	Infiltration Structures	Filtering Practices	Biofiltration
Construction/acre	$2,982.00	$8,946.67	$17,008.41	$17,893.33
O&M (% of Construction)	4.5%	10.5%	12%	6%
Annual O&M per acre over a 25 year lifespan	$3,354.75	$23,485.00	$51,025.25	$26,840.00
Total Cost/acre	$6,336.75	$32,431.67	$68,033.66	$44,733.33