AfG Work Group Background Memo: Pollutants, Sources, Loads and Scale (2-14-13)

This paper addresses three pollutants -- nitrogen, phosphorus and sediment. It discusses the pollutants, states how the Bay Total Maximum Daily Load (TMDL) limits them, and recounts how the Maryland Watershed Implementation Plan (WIP) is structured to reach those limits. It describes how one can calculate the amount of each pollutant that reaches the Bay from different land uses in different locations. It also addresses some questions of scale: Bay watershed, watersheds of major rivers in the Bay watershed, and watersheds of the larger of the minor rivers in the Bay watershed. This background will help the AfG Work Group understand the issues involved in deciding whether the offset requirement should apply to all of these pollutants or if the policy can be simplified by omitting one of them without compromising the TMDL.

This paper is not about trading, baselines for credit generation, protecting local water quality, or any of the other issues the Work Group will be addressing later.

Nutrient Pollution[1]

The nutrients

Nutrients are substances that all living organisms need for growth and reproduction. Two major nutrients, nitrogen and phosphorus, occur naturally in water, soil, and air. Nutrients are present in animal and human waste and chemical fertilizers. Organic material such as leaves and grass clippings also contain nutrients.

How nutrients enter the Bay

Nutrients can find their way to the Bay from anywhere within the 64,000 square mile watershed. All streams, rivers and storm drains in the watershed eventually lead to the Chesapeake. The activities of over 17 million people in the watershed have overwhelmed the Bay with excess nutrients. Nutrients come from a wide range of sources, which include sewage treatment plants, onsite sewage disposal systems, industry, agricultural fields, lawns, and even the atmosphere. Nutrient inputs are divided into two general categories, point sources and nonpoint sources.

Point sources

Sewage treatment plants, industries, and factories are the major point sources. These facilities discharge wastewater containing nutrients directly into a waterway. Each facility is regulated by a permit that limits the amount of nutrients that can be legally discharged.

Nonpoint sources

Nonpoint source nutrients are usually carried to a waterway by rainwater runoff but are also present in groundwater. Rain picks up nutrients from the land and travels either directly overland to a waterway or soaks into groundwater, which eventually feeds into streams. Farm fertilizers and animal manure comprise a portion of nonpoint source

[1] This section is adapted from http://www.fws.gov/chesapeakebay/nutrient.html.

nutrients. Other nonpoint sources originate from the urban environment and include lawn fertilizers, septic tanks and organic material.

Algal blooms and impacts

Excess nutrients cause algae populations to grow rapidly, or "bloom." An overabundance of algae contributes to two problems in the Bay: reduction in sunlight and reduction in dissolved oxygen. Algae occur as tiny single-celled plants called phytoplankton or as larger seaweeds which look like leafy "slime" growing on rocks and jetties. Phytoplankton blooms turn the water brown or blue-green and prevent essential sunlight from reaching rooted underwater plants known as submerged aquatic vegetation (SAV). Excess nutrients also cause algae to grow directly on the leaves of SAV, further limiting essential sunlight. Without this sunlight, the plants die. Many shellfish, fish, and waterfowl depend on SAV as their primary habitat and food source.

The second problem created by widespread algal blooms occurs when the algae die, sink to the bottom, and decay. During the decay process, bacteria consume large amounts of dissolved oxygen from the water. This causes extremely low levels of dissolved oxygen in large areas of the Bay. Because warm water holds less oxygen than cool water, this problem worsens in the summer. With out oxygen, many organisms perish.

The nutrient-related decline of submerged aquatic vegetation has eliminated essential habitat for many fish, shellfish, and other aquatic life. SAV is a rich nursery ground, providing food and habitat for fish and shellfish.

The low oxygen conditions created by excess nutrients have severely impacted life in the Bay. Since 1960, there has been a substantial increase in the amount of Bay bottom with dangerously low levels of dissolved oxygen. Bottom-dwelling, or benthic, organisms including worms, clams, oysters, crabs, and many smaller invertebrates are an essential link in the food web. With the decline of these benthic organisms, the entire Chesapeake ecosystem is altered.

Nutrient Limitation

Like all plants, phytoplankton (algae) need light and nutrients (*e.g.* nitrogen, phosphorus, carbon) to grow. Light and nutrients are the “resources” for phytoplankton growth. If light is not blocked by suspended materials suspended in the water, phytoplankton will continue to reproduce and grow as long as there are nutrients in the water. (Nutrients are added from both non-point and point sources, as well as regenerated from the Bay sediments under certain conditions such as anoxia). However, unless the nutrients are available in adequate amounts relative to each other (generally a ratio of nitrogen to phosphorus of 16:1), phytoplankton growth is “nutrient limited” by one or the other nutrient. That is, if the phytoplankton are using all the phosphorus that is available in their environment, but there is more nitrogen than they can use, adding more nitrogen will not increase algal growth. If both nutrients are added in enough excess (regardless of the relative proportion of them), phytoplankton will not be “limited” even when they are growing as fast as they can, and the system is “nutrient saturated.”

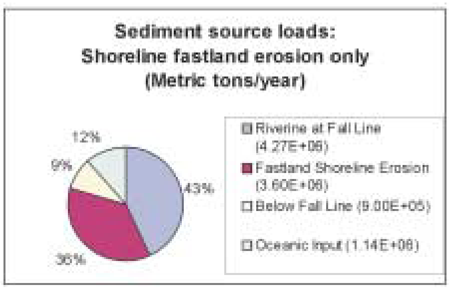
In the Bay, nutrient limitation is complex and can vary by location and season. For this reason, controlling excess algal growth in the Bay and its subestuaries will require basin-specific management practices for both N and P reductions in influent waters.

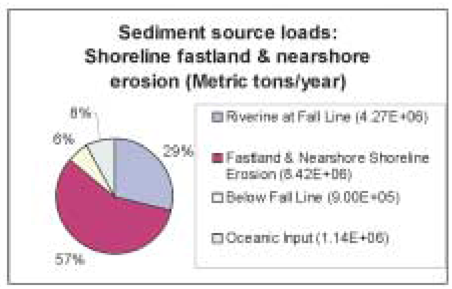
It is a general consensus that non-tidal streams, lakes and reservoirs are phosphorus limited. Therefore algal growth is limited by the amount of phosphorus entering the water body.

Sediment Pollution[2]

Makeup of sediment
Sediment is made up of loose particles of sand, silt and clay. Fine-grained sediment is made up of clay and silt; coarse-grained sediment is made up of sand and gravel. Sediment is associated with and transports other contaminants, such as phosphorus.

How sediments enter the Bay
The primary sources of sediment into the main bay are input from the main rivers in the watershed, input from smaller tributaries and streams, erosion from shorelines and coastal marshes, and internal production through bottom erosion and re-suspension. It is estimated that more than half of the sediment entering the Bay is from erosion.





Watershed sources of sediment
Sediment sources in the Chesapeake Bay watershed include agricultural areas, forests, roads, urban areas, construction sites, gullies and ditches, mines, and streambeds and banks. Management strategies to reduce sediment inputs differ depending on whether the sediment is eroded from upland areas or from streambeds and banks. Therefore, it is important to identify the location of the sediment source in the watershed as a first step in designing management strategies.

Several generalities about sediment movement and sources can be made. For rivers on the western shore, watershed inputs are the primary source of sediment delivered to tidal fresh regions of tributaries. As in the main stem, there is an Estuarine Turbidity Maximum[3] (ETM) zone upstream in the larger tributaries. For regions of western shore tributaries downstream of the ETM zone, and in most Eastern Shore rivers, coastal plain

[2] Adapted from *A Summary Report of Sediment Processes in Chesapeake Bay and Watershed,* USGS (2003), http://pa.water.usgs.gov/reports/wrir03-4123.pdf.

[3] An ETM is a region where fine-grained particulate material is "trapped," deposited, and sometimes resuspended and redeposited.

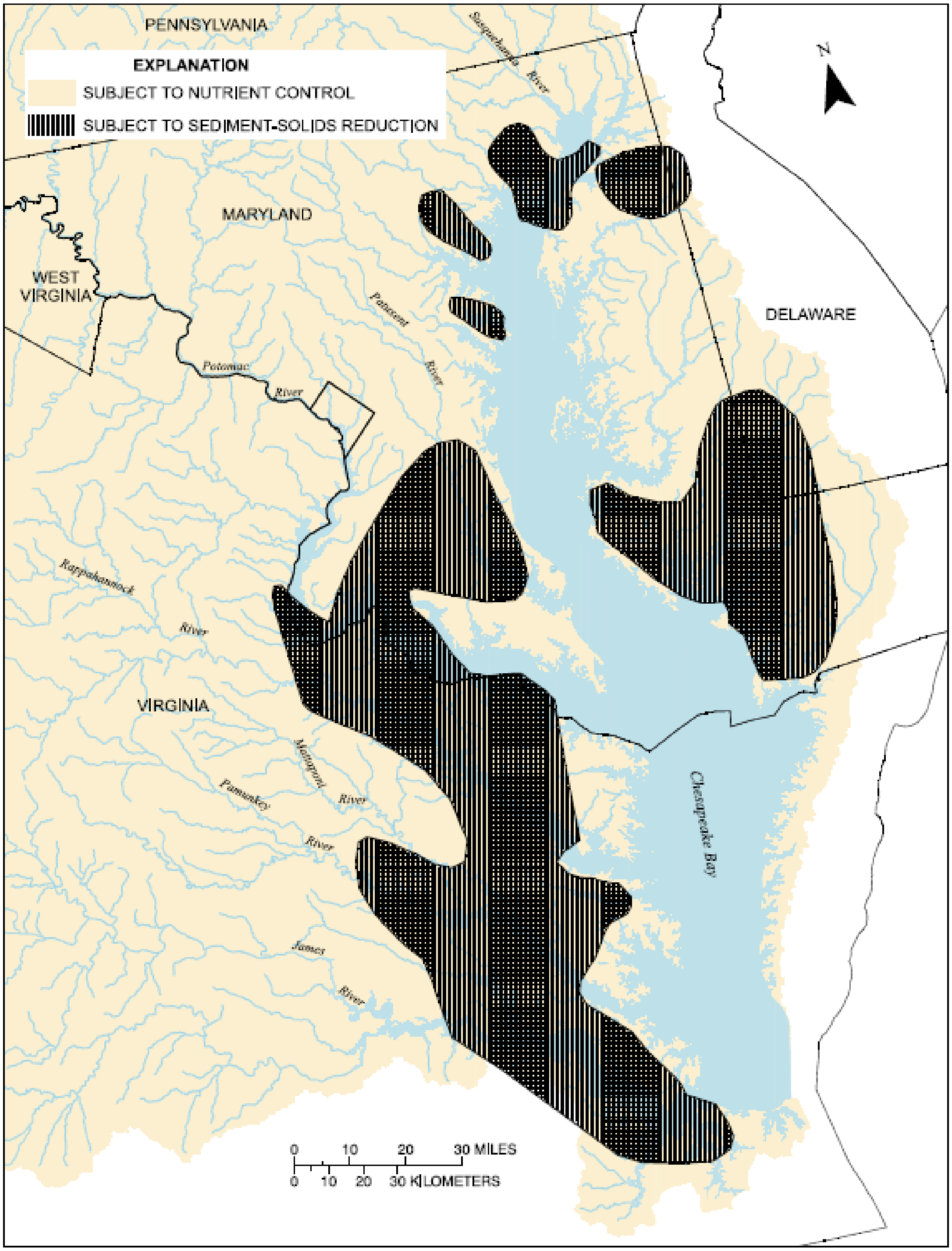
tributaries and shorelines are more important sources of sediment. In the most northern part of the main stem of bay, the Susquehanna River is a predominant source of sediment influx, however, most of that is trapped by the ETM zone in the northern Bay. In the central bay, the majority of sediment influx comes from shoreline erosion or is produced internally by biological processes. In the southern bay, shoreline erosion and influx from the ocean is the dominant source.

Impacts to Aquatic Life

Excessive sediment has an adverse effect on the health of the Bay and the streams in the bay watershed, on submerged aquatic vegetation, and on living resources in the estuary; it results in degraded water quality, loss of habitat, and population declines in biological communities. Sediment can reduce water clarity and increase light attenuation so much that light penetration falls below the thresholds needed to support healthy SAV. SAV beds constitute an important biological resource in estuaries.

Sensitivity to nutrients and sediment

Modeling results indicate that certain areas of the Bay are more sensitive to nutrient reductions while others are sensitive to sediment reductions. The figure presented bellow illustrates that the Bay proper is predominately more sensitive to nutrient management, as are most of the estuarine areas located in Maryland.



Estuarine areas that benefit more from sediment controls (shaded area) than from nutrient controls (areas shown in yellow) in the watershed and tidal tributaries. From Cerco, C.F., et al., 2002, *Tributary refinements to the Chesapeake Bay Model*, U.S. Army Corps of Engineers, http://el.erdc.usace.army.mil/elpubs/pdf/tr02-4.pdf.

The Bay TMDL and Maryland's WIP

The United States Environmental Protection Agency (EPA), in coordination with the Bay watershed jurisdictions of Maryland, Virginia, Pennsylvania, Delaware, West Virginia, New York, and the District of Columbia (DC), developed and, on December 29, 2010, established a Total Daily Maximum Load – a nutrient and sediment pollution diet for the Bay; that is, amounts that the Bay could receive and still meet water quality standards and remain healthy.

EPA established overall allocations for nitrogen, phosphorus and sediment for Maryland and the other Bay states. Maryland set targets to reach its allocations for nitrogen, phosphorus and sediment for each of the 5 major basins: the Eastern Shore, the Patuxent River basin, the Potomac River basin, the Susquehanna River basin and the Western Shore. Maryland set individual source sector targets for nitrogen and phosphorus, but not for sediment.[4]

Although the statewide nitrogen and phosphorus reductions called for in the WIP more than meet the statewide Final (2025) Targets, and assure the water quality goals are met, the results are uneven regionally. In several of the major basins, nitrogen targets are not met and phosphorus targets are overachieved. This is one reason that the earlier AfG program did not propose to require offsets for phosphorus. EPA has communicated to Maryland that it would prefer that both nitrogen and phosphorus be offset.

The Interim (2017) and Final (2025) Target strategies for phosphorus are expected to reduce sediment by millions of pounds per year more than the target. For this reason, Maryland did not assign sediment targets for source sectors, and the earlier AfG program did not propose that sediment be offset.

How much nitrogen, phosphorus and sediment get to the Bay

EOS Loading Factors – Land Use

Estimates of the amount of nitrogen, phosphorus and sediment that reach the nearest surface water (Edge-of-Stream or EOS) for different types of land use, before the implementation of practices to reduce the loading (No Action), have been established. They are expressed as pounds of the pollutant per acre per year. The factors for forest, impervious urban, and pervious urban are listed in tables in Appendix 1 for the five major basins and for the 12 "major minor" basins.

The way the loading factors were derived in the Bay watershed model leads to the anomaly that some lands that are close together, but in different watersheds, sometimes have dramatically different loading factors. This is apparent in the differences between the Potomac and Patuxent major basins. The differences are not eliminated by going to smaller watersheds. It was for this reason, and in an attempt to make the offset program simpler to understand and administer, that MDE originally suggested that statewide average loading factors be used to calculate post-development load.

EOS Loading Factors – Septic Systems

The Chesapeake Bay Program Model uses the figure 8.82 pounds of nitrogen per year per person as the generation rate. An average household surveyed in the 2010 Census has 2.63 persons. An average household therefore sends 23.2 lb of nitrogen per year into the

[4] EPA set a sector goal for sediment for the agricultural sector.

septic system. Conventional systems do not remove nitrogen; MDE-approved Best Available Technology systems remove between 55% and 76% of the nitrogen before discharging it to the system drain field. The full data can be found here . The phosphorus and sediment that may enter the drain field do not reach surface water.

How much of the nitrogen leaving the drain field reaches Edge-of-Stream depends on how close the septic system is to the Bay or other surface water. Maryland estimates that this value varies from 30% to 80% for three zones, and that a weighted average of all systems in the State is 42.5%.

Maryland Septic Systems
(Source: MAST)

SepticZone		Systems	Delivery
Critical Area		48,140	80%
Within 1000 ft of a perennial stream		157,063	50%
Outside of the Critical Area, not within 1000 ft of a perennial stream		237,655	30%
	Total	*442,858*	**42.5%**

↑
Weighted Delivery

In its initial AfG proposal for calculating the post-development load, MDE suggested using the single value of 42.5% reaching EOS statewide for simplicity. It would be possible to use the appropriate zone factor.

Delivery Ratios

Not all of the substances that reach the nearest stream reach the Bay. Delivery ratios apply discount factors to account for attenuation (*i.e.*, the rate at which nutrients are reduced through natural processes, such as hydrolysis, oxidation, and biodegradation, on their way through tributaries to the mainstem of the water body). For nitrogen, these ratios range from about 0.1 to 1; the statewide average delivery ratio for nitrogen is 0.762 (calculated using the 2010 progress loads and only considering the following land uses/sources: impervious, pervious, septic, and municipal wastewater).

The full file from the Chesapeake Bay Program, with delivery rates for total nitrogen, total phosphorus and sediment can be viewed and downloaded here: Delivery rates.

Calculating the Load

The product of multiplying the loading rate for a particular land use by the acres of that use by the delivery ratio yields the pounds of nitrogen, phosphorus or sediment that will arrive at, or be delivered to, the mainstem of the Bay from a particular parcel. The loads that account for this transport loss are called "delivered loads."

Direct Deposition

Nitrogen oxides (NOx) in the air are deposited onto the land and water. Economic and population growth results in an increase in vehicle miles traveled (VMT) and, consequently, NOx emissions. This new NOx load is not accounted for in the stormwater loading factor.

In its original AfG proposal, Maryland calculated the new nitrogen loading to the Bay that would be associated with VMT from new development. See Appendix 2. It was estimated that approximately 5% of the new NOx generated in Maryland would be deposited in Maryland. Data are available for VMT and NOx emissions from Census tracts of varying densities. Census tracts with populations of greater than 10,000 persons per square mile have markedly lower VMT than less densely populated census tracts. Using these numbers resulted in the original proposal of 0.5 pounds of nitrogen per household in census tract areas with density of greater than 10,000 persons per square mile, and 1.0 pounds of nitrogen per household for all other census tracts.

Modeling NOx emissions from development would be expensive and time consuming. It is beyond the ability of Maryland to develop at this time.

Best Management Practices (BMPs)

Not all BMPs remove all three pollutants, or remove them with equal effectiveness. The Chesapeake Bay Program has established efficiency rates for various BMPs. These are listed in Appendix 3. In Maryland's WIP, the management practices applied generally reduce sediment more effectively than nutrients. Additionally, the majority of stormwater management practices reduce significantly more sediment then nutrients. For example, it is estimated that Environmental Site Design to the Maximum Extent Practicable reduces approximately 90% of sediment from a no BMP scenario where nitrogen would be reduced by 50%.

Another way of looking at the efficiency of stormwater BMPs is to evaluate separately BMPs that *treat* runoff as opposed to *reduce* runoff. In October, 2012, the Water Quality Goal Implementation Team of the Chesapeake Bay Program accepted reports that developed protocols for evaluating new stormwater performance standards and urban stormwater retrofit projects. The new stormwater performance standard document identifies the BMPs as either Runoff Reduction (RR) or Stormwater Treatment (ST). The classifications can be found in Appendix 4. The document then provides graphs to determine the removal efficiency of each, depending on the amount of runoff treated and the degree of runoff reduction it provides. The graphs can be found in Appendix 5.

This method offers one possible alternative approach to MDE's original AfG proposal of assuming a 50% reduction of nitrogen for Maryland's stormwater requirements for new development, Environmental Site Design to the Maximum Extent Practicable.

Appendix 1: Edge-of-Stream Loading Factors

Major Basin Scale

Forest, Edge-of-stream Unit Load

MajorBasin	TN (lb/ac/yr, EOS)	TP (lb/ac/yr, EOS)
Eastern Shore of Chesapeake Bay	1.75	0.05
Patuxent River Basin	2.19	0.06
Potomac River Basin	4.61	0.12
Susquehanna River Basin	4.40	0.07
Western Shore of Chesapeake Bay	2.48	0.05
Statewide Average	**3.08**	**0.08**

Impervious Urban, Edge-of-stream Unit Load, No Action (No BMP) Scenario

MajorBasin	TN (lb/ac/yr, EOS)	TP (lb/ac/yr, EOS)
Eastern Shore of Chesapeake Bay	10.76	1.06
Patuxent River Basin	11.58	1.54
Potomac River Basin	20.10	2.17
Susquehanna River Basin	20.21	1.51
Western Shore of Chesapeake Bay	13.39	1.52
Statewide Average	**15.34**	**1.70**

Pervious Urban, Edge-of-stream Unit Load, No Action (No BMP) Scenario

MajorBasin	TN (lb/ac/yr, EOS)	TP (lb/ac/yr, EOS)
Eastern Shore of Chesapeake Bay	7.59	0.32
Patuxent River Basin	7.65	0.37
Potomac River Basin	13.81	0.53
Susquehanna River Basin	13.79	0.36
Western Shore of Chesapeake Bay	10.12	0.40
Statewide Average	**10.78**	**0.43**

Major-Minor Basin Scale

Forest, Edge-of-stream Unit Load

MajorBasin	TN (lb/ac/yr, EOS)	TP (lb/ac/yr, EOS)
Potomac Upper	5.81	0.16
Potomac Middle	6.16	0.14
Potomac Lower	1.85	0.06
Patuxent Upper	3.06	0.07
Patuxent Lower	1.77	0.05
Western Shore Lower	1.73	0.05
Western Shore Middle	2.84	0.06
Western Shore Upper	2.64	0.05
Susquehanna Lower	4.40	0.07
Eastern Shore Upper	2.04	0.05
Eastern Shore Middle	1.61	0.05
Eastern Shore Lower	1.68	0.04
Statewide Average	**3.08**	**0.08**

Impervious Urban, Edge-of-stream Unit Load, No Action (No BMP) Scenario

MajorBasin	TN (lb/ac/yr, EOS)	TP (lb/ac/yr, EOS)
Potomac Upper	24.82	2.41
Potomac Middle	29.23	2.89
Potomac Lower	11.94	1.56
Patuxent Upper	14.63	1.67
Patuxent Lower	8.60	1.42
Western Shore Lower	9.53	1.50
Western Shore Middle	13.74	1.52
Western Shore Upper	15.02	1.54
Susquehanna Lower	20.21	1.51
Eastern Shore Upper	10.90	1.05
Eastern Shore Middle	9.75	1.05
Eastern Shore Lower	11.12	1.08
Statewide Average	**15.34**	**1.70**

Pervious Urban, Edge-of-stream Unit Load, No Action (No BMP) Scenario

MajorBasin	TN (lb/ac/yr, EOS)	TP (lb/ac/yr, EOS)
Potomac Upper	18.46	0.55
Potomac Middle	19.39	0.70
Potomac Lower	7.34	0.37
Patuxent Upper	9.91	0.41
Patuxent Lower	5.31	0.34
Western Shore Lower	7.93	0.52
Western Shore Middle	10.17	0.38
Western Shore Upper	11.13	0.36
Susquehanna Lower	13.79	0.36
Eastern Shore Upper	7.35	0.27
Eastern Shore Middle	8.39	0.39
Eastern Shore Lower	7.35	0.34
Statewide Average	**10.78**	**0.43**

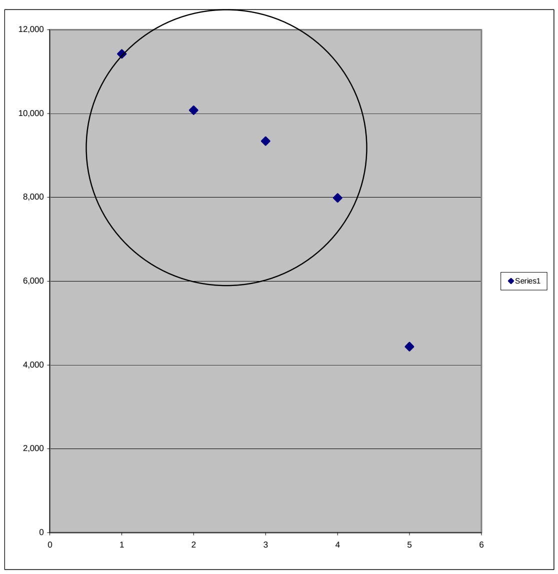
Appendix 2

Table 3. NOx Emissions from Different Land Use Development Patterns

Census Tract Density Range (people per square mile)	Land Use Type	2005 Vehicle Miles Traveled per Capita (VMT per capita)[1]	NOx emissions (lbs/year per capita)[2]	% of MD population represented by the census tract density range (estimate)	2005 MD population	2005 MD population within the density range (estimate)	2005 MD VMT for density range	NOx emissions (lbs/yr)	NOx emissions (metric tons/yr)
0-499	Rural	11,422	9.65	0.14	5,572,400	780,136	8,910,713,392	7,529,834	3415.47546
500-1,999	Low-density suburban; small towns/villages	10,083	8.52	0.22	5,572,400	1,225,928	12,361,032,024	10,445,463	4737.98222
2,000-3,999	Moderate-density suburban; still auto-oriented	9,345	7.90	0.20	5,572,400	1,114,480	10,414,815,600	8,800,848	3991.99768
4,000-9,999	Urban or high-density suburban	7,986	6.75	0.25	5,572,400	1,393,100	11,125,296,600	9,401,227	4264.32496
10,000+	High-density urban	4,437	3.75	0.18	5,572,400	1,003,032	4,450,452,984	3,760,773	1705.85814

1. VMT per capita for different land use types (and % of population represented by different census tract densities) from Moving Cooler. An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions. 2009. Cambridge Systematics. See Appendix B, pp. B-17 and B-20

2. VMT to NOx emission calculation from "Simplified methodology to estimate PM2.5 emissions and NOx emissions as PM2.5 precursor emissions reduction benefits", memo from Anant Choudhary, Transportation Engineer to MWCOG Travel Management Subcommittee", March 21, 2006. Modified slightly to show results in terms of lbs. instead of tons.



Per capita
3.75 Nox
2.63 persons/HH

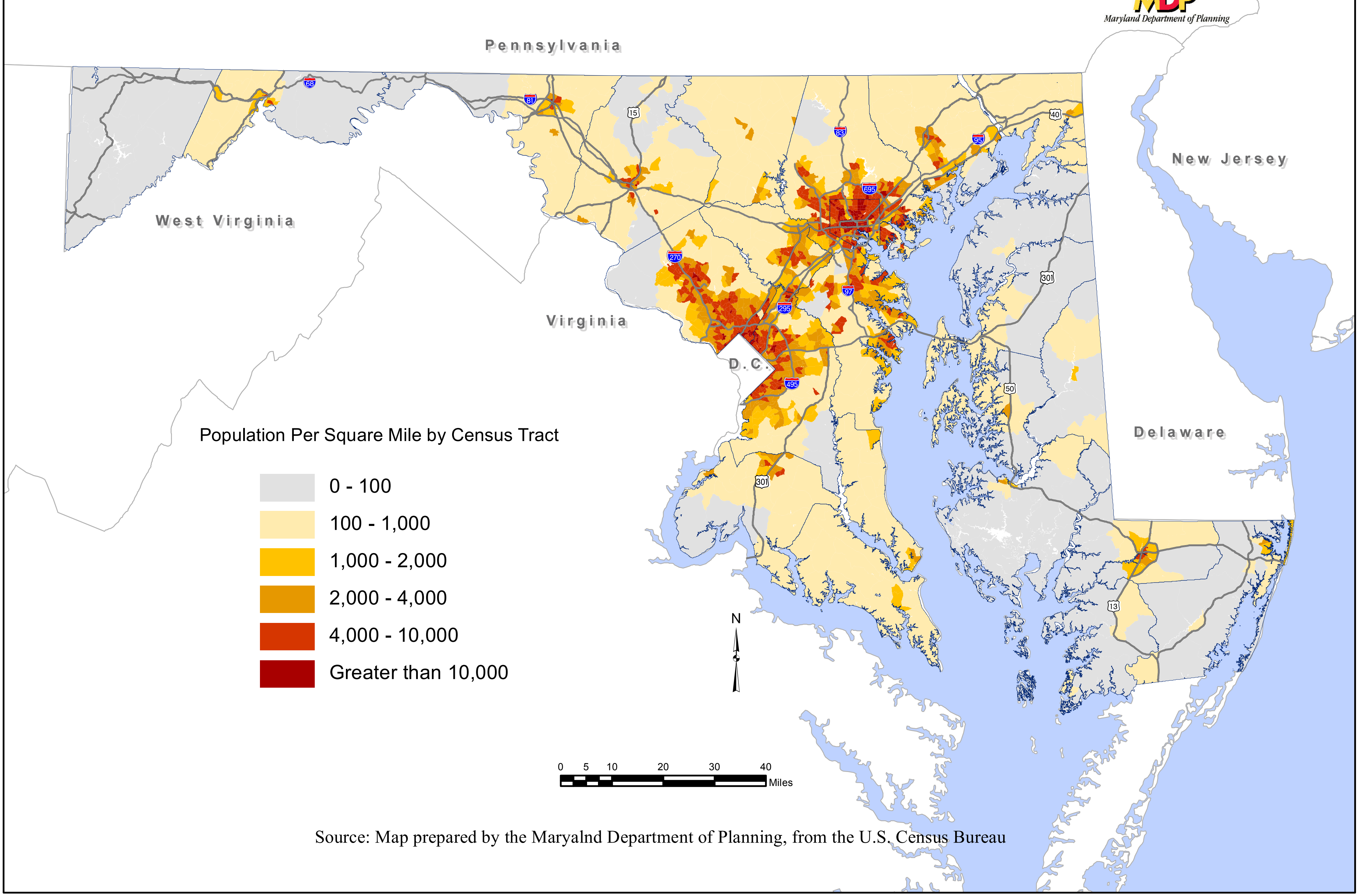
Nox emitted
9.86 /HH

5% Deposited
0.05 in MD
NOx emissions/HH in high
0.5 density

Median/cap not in high
8.21 density
2.63 persons/HH
NOx
21.59 emitted/HH

5% deposited
0.05 in MD
NOx emissions/HH in high
1 density

Maryland Population Density by Census Tract, 2010



Source: Map prepared by the Maryalnd Department of Planning, from the U.S. Census Bureau

Appendix 3: BMP Removal Efficiencies

The following table shows urban BMP efficiencies for various soil types (A, B, C, and D) with or without under drains (w/ UD and w/o UD). Forest buffers, forest conservation, impervious surface reduction, and tree planting are modeled as a land use change rather than as a percentage reduction from a static land use. A reduction efficiency percentage is not readily available for these BMPs and will depend on location.

Approved CBP BMP Efficiency Rates (Mass Load Reduction as % reduction)

BMP	TN Efficiency	TP Efficiency
Wet Ponds and Constructed Wetlands	20	45
Dry Detention Ponds	5	10
Dry Extended Detention Ponds	20	20
Infiltration	80 (85)	85
Filtering Practices (Sand Filters)	40	60
Bioretention		
C & D w/UD	25	45
A & B w/ UD	70	75
A & B w/o UD	80	85
Permeable Pavement		
C & D w/UD	10 (20)	20
A & B w/ UD	45 (50)	50
A & B w/o UD	75 (80)	80
Grass Channels		
C & D w/o UD	10	10
A & B w/o UD	45	45
Bioswale (aka dry swale)	70	75

Numbers in parentheses reflect a design variation

Source:
Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards, Table B-5
http://www.chesapeakebay.net/channel_files/18149/092812_performance_standards_memo.pdf

BMP	TN Efficiency	TP Efficiency
Forest Buffers (upland efficiency)	25	50
Urban Stream Restoration	0.02lb/ft	0.003lb/ft

Source:
Non-Point Source Best Management Practices and Efficiencies currently used in Scenario Builder
http://archive.chesapeakebay.net/pubs/NPS_BMP_Table1.8.pdf

Appendix 4: Classification of BMPs[5]

Table 4 Classification of BMPs based on Runoff reduction capability

Runoff Reduction (RR) Practices	*Stormwater Treatment (ST) Practices*
Non-Structural Practices	
Landscape Restoration/Reforestation	Constructed Wetlands
Riparian Buffer Restoration	Filtering Practices (aka Constructed Filters, Sand Filters, Stormwater Filtering Systems)
Rooftop Disconnection (aka Simple Disconnection to Amended Soils, to a Conservation Area, to a Pervious Area, Non-Rooftop Disconnection)	Proprietary Practices (aka Manufactured BMPs)
Sheetflow to Filter/Open Space* (aka Sheetflow to Conservation Area, Vegetated Filter Strip)	Wet Ponds (aka Retention Basin)
Non-Structural BMPs, PA 2006 BMP Manual, Chapter 5	Wet Swale
Practices	
All ESD practices in MD 2007	
Bioretention or Rain Garden (Standard or Enhanced)	
Dry Swale	
Expanded Tree Pits	
Grass Channels (w/ Soil Amendments, aka Bioswale, Vegetated Swale)	
Green Roof (aka Vegetated Roof)	
Green Streets	
Infiltration (aka Infiltration Basin, Infiltration Bed, Infiltration Trench, Dry Well/Seepage Pit, Landscape Infiltration)	
Permeable Pavement (aka Porous Pavement)	
Rainwater Harvesting (aka Capture and Re-use)	
*May include a berm or a level spreader (Footnotes omitted)	

[5] Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards, http://chesapeakestormwater.net/wp-content/uploads/downloads/2012/10/Final-CBP-Approved-Expert-Panel-Report-on-Stormwater-Performance-Standards-LONG.pd

Appendix 5: Curves[6]

Figure 1, below, illustrates the way of using the curves: one first defines the runoff volume captured by the project (on the x-axis), and then determines whether the practice is classified as having runoff reduction (RR) or stormwater treatment (ST) capability. (See Appendix 4.) One then goes upward to intersect with the appropriate curve, and moves to the left to find the corresponding removal rate on the y-axis. In this example, capturing 0.5 inches of rainfall per impervious acre, using practices that reduce runoff, removes about 52% of the phosphorus compared to land that has no BMPs.

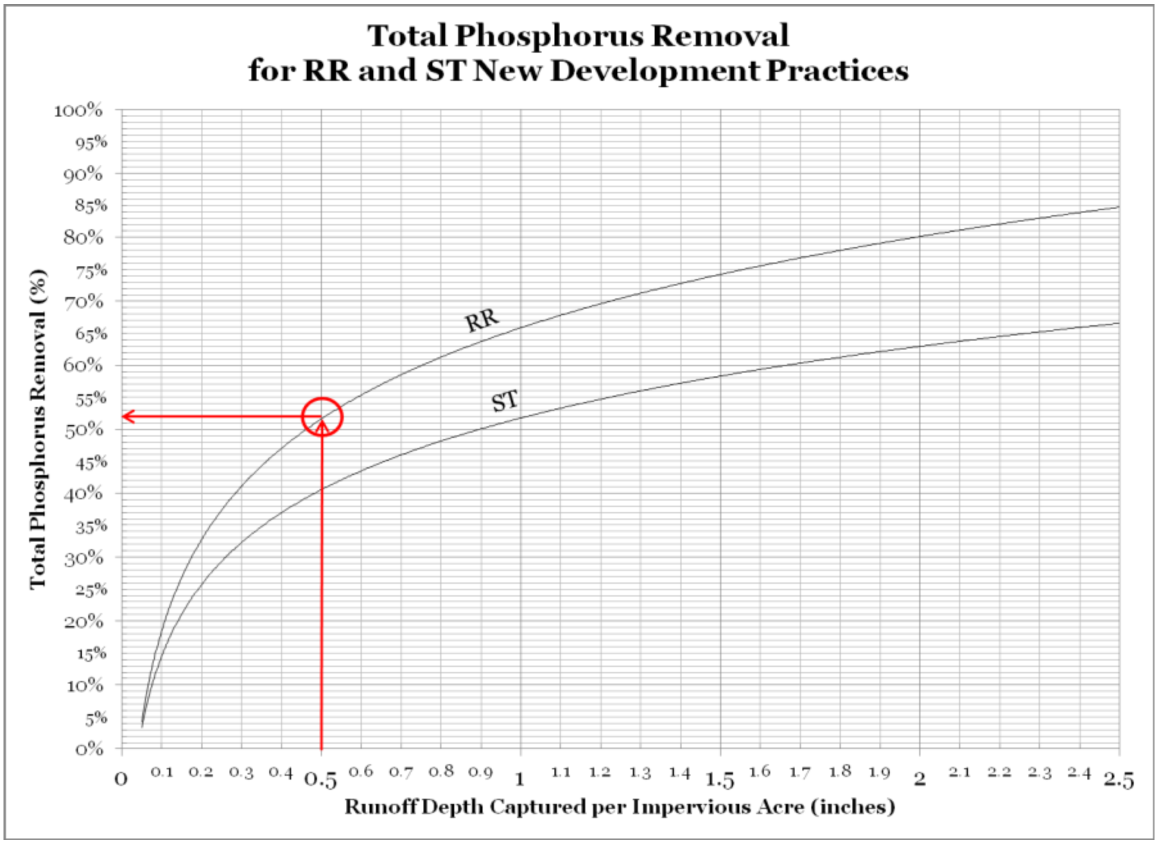


Figure 1. New BMP Removal Rate Adjustor Curve for Total Phosphorus

[6] Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards, http://chesapeakestormwater.net/wp-content/uploads/downloads/2012/10/Final-CBP-Approved-Expert-Panel-Report-on-Stormwater-Performance-Standards-LONG.pd

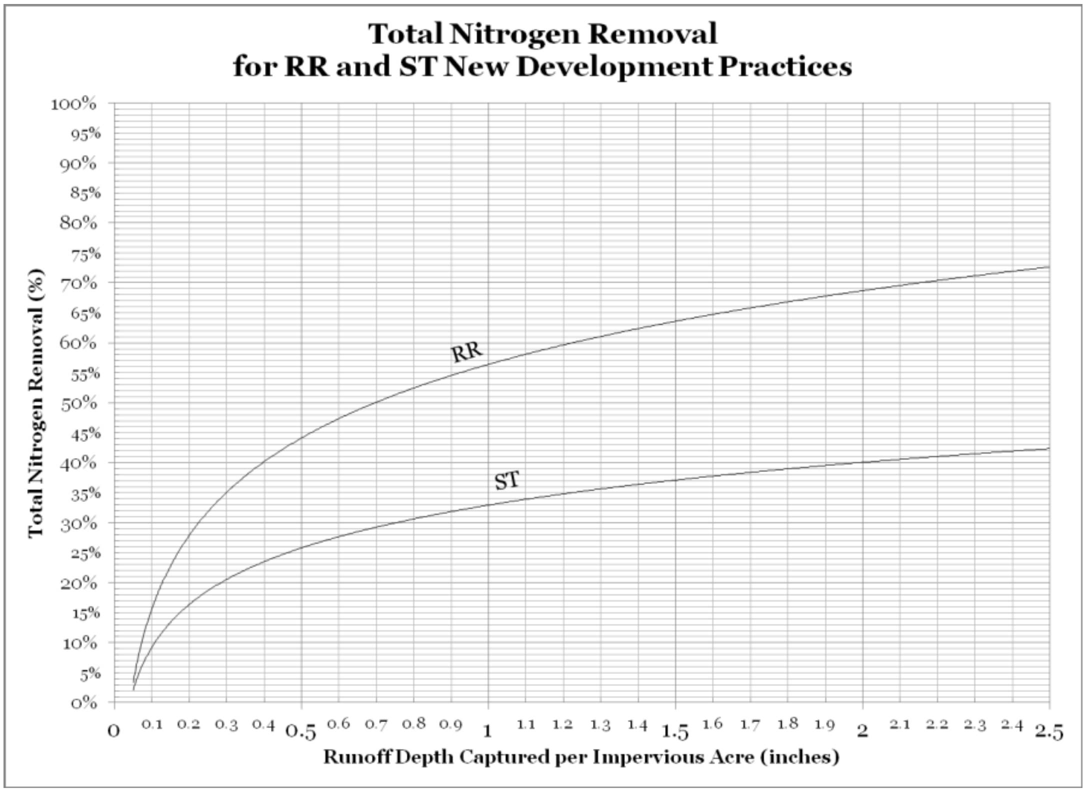


Figure 2. New BMP Removal Rate Adjustor Curve for Total Nitrogen

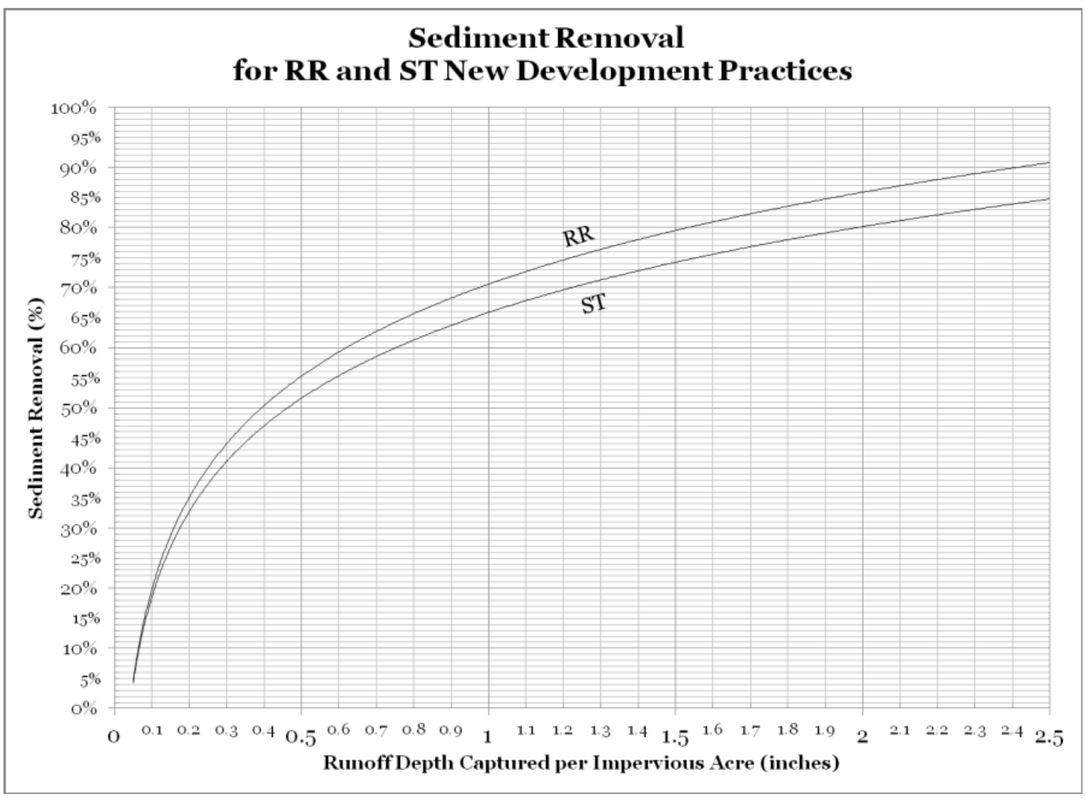


Figure 3. New BMP Removal Rate Adjustor Curve for Sediment