Appendix A

Development of the Level-of-Effort Scenarios

Listed in this appendix are the assumptions and methods employed in determining four best management BMP (including point source technologies) implementation levels for the three tiers and 'everything, everywhere, by everybody' (E3) scenarios. The scenarios were developed by the Chesapeake Bay Program's Nutrient Subcommittee Workgroups to provide reference points for load reductions of nutrients and sediment that could be associated with increasing levels of BMP implementation for both point and nonpoint sources in the Chesapeake Bay watershed. The Use Attainability Analysis (UAA) workgroup was provided with examples of the types of BMPs and implementation levels to develop a defensible costing tool. These four scenarios range from Tier 1, which represents the current level of implementation throughout the watershed plus regulatory requirements implemented through the year 2010, up to a limit of technology scenario referred to as the E3 scenario. Tier 2 and Tier 3 represent intermediate levels of implementation between Tier 1 and the E3 scenario. Each tier has associated with it a given nitrogen, phosphorus and sediment load reduction effected by the different technologies assigned to the tier. The nutrient and sediment sources were divided into the following categories for tier development:

- point sources
- nonpoint source agriculture
- nonpoint source urban
- nonpoint source forests
- onsite treatment systems
- atmospheric deposition

The Chesapeake Bay Program partners have acknowledged that the E3 scenario goes beyond what is physically possible in some cases, and that the feasibility of implementing certain reduction measures at Tier 3 are also questionable. These tiers are a broad brush estimate of technological reduction measures that could be implemented at the bay watershed level without regard to physical limitations. Certainly, there will be local circumstances and conditions that make implementation of these tiers as defined unreasonable. It will be up to the individual jurisdictions to tailor reduction programs that fit their specific capabilities and needs. The series of ranging scenarios were simulated using the Chesapeake Bay Program's Phase 4.3 Watershed Model, and the resultant loads for nitrogen, phosphorus, and sediment were used as inputs to the Chesapeake Bay Water Quality Model. Evaluation of dissolved oxygen, water clarity and chlorophyll *a* concentrations from the Water Quality Model, in turn, provided a sense of the response of key water quality parameters to the various loading levels. For the tiered and the E3 scenario scenarios, the BMP implementation levels, the resultant modeled loads, and the measured responses in tidal water quality are all informational. They are not intended to prescribe control measures the jurisdictions must implement to meet *Chesapeake 2000* nutrient and sediment cap load allocations.

All above and below fall line nitrogen, phosphorus, and sediment loads are included in the loadings for each tier. Shoreline erosion control sediment reductions at 2000 progress levels are assumed for all tiers.

The costs for specific management practices developed by the UAA Workgroup could be used by Chesapeake Bay basin jurisdictions for their individual UAAs. The Water Quality Steering Committee of the Chesapeake Bay Program believed it would be useful to provide data to the jurisdictions to promote coordination and consistency across all jurisdictions. It is a jurisdiction's prerogative to use the basinwide cost analyses in developing their UAA.

Implementation levels in all of the tiers and the E3 scenario are not the most cost effective. More cost-effective combinations of BMPs will be evaluated by jurisdictions and their tributary strategy watershed teams as their strategies are developed. In addition, levels of BMP implementation for the E3 scenario are theoretical since, generally, the scenario does not account for physical limitations or participation levels in its design.

The tier and the E3 scenario BMP implementation levels were mostly deliberated and set by the 'source' workgroups of the Chesapeake Bay Program's Nutrient Subcommittee. These workgroups are made up of representatives of Chesapeake Bay-watershed jurisdictions and Chesapeake Bay Program Office personnel. The specific workgroups that decided BMP implementation levels include the Agricultural Nutrient Reduction Workgroup, the Forestry Workgroup, the Point Source Workgroup, and the Urban Stormwater Workgroup. The Tributary Strategy Workgroup and Nutrient Subcommittee finalized the E3 scenario definitions after review and further deliberation.

To conform to *Chesapeake 2000* goals, all of the scenarios were based on 2010 projections of landuses, animals, point source flows, and septic systems as well as 2007/2010 or 2020 air emission controls. Landuses and animal populations in the Chesapeake Bay Program Watershed Model are developed from an array of national, regional, and state databases as described in *Chesapeake Bay Watershed Model Land Use and Model Linkages to the Airshed and Estuarine Models* (Chesapeake Bay Program, 2000). The modeled landuses include the following categories:

- forest
- conventional-tilled (high-till)
- conservation-tilled (low-till)
- hay
- pasture
- manure acres (model accounting of runoff from animal feeding operations)
- pervious urban
- impervious urban
- mixed open.

The 2010 agricultural landuses were projected from 1982, 1987, 1992, and 1997 Agricultural Census information by county according to methods chosen by individual states. Projected animal populations,

to estimate manure applications, were based on county Agricultural Census trends and information from state environmental and agricultural agencies.

Implementation of Low Impact Development (LID) or Environmental Site Design (ESD) in the tiered scenarios was used to reflect urban pollutant load reductions that go above and beyond conventional storm water management practices. The tiered scenarios reflect an ongoing shift from conventional storm water management to the more innovative LID/ESD practices that address both storm water quantity (replicating pre-development hydrology) and quality (reducing pollutant loads). The LID/ESD approach encourages practices that promote groundwater recharge, stream channel protection, flood protection, and improved water quality. The pollutant removal efficiencies for LID/ESD were developed by the Urban Storm Water Workgroup, based on national and watershed studies and expert professional judgement. The workgroup evaluated pollutant removal efficiencies for over 50 best management practices from sources such as the American Society of Civil Engineers Best Management Practices national database, the Center for Watershed Protection's National Pollutant Removal Performance Database for Stormwater Treatment Practices, the 2000 Maryland Stormwater Design Manual, the Virginia Stormwater Handbook, and Prince George's County's Low Impact Development Design Strategies manual. Maintenance costs of ESD/LID approaches were based on data primarily from Maryland (which promotes ESD) and Prince George's County (which promotes LID). There are several jurisdictions that are actively promoting ESD (Maryland state storm water regulations) and LID (Prince George's County, District of Columbia, various municipalities in Virginia).

The 2010 urban landuses were mostly projected from methods involving human population changes as determined by the U.S. Census Bureau for 1990 and 2000, and by individual state agencies for 2010. The population changes were related to 1990 high-resolution satellite imagery of the Chesapeake Bay watershed, which is the primary source of urban and forest acreages. In the case of Maryland, urban growth from 2000 to 2010 was determined by Maryland Department of Natural Resources and the Maryland Department of Planning.

For all jurisdictions except Maryland and Virginia, 2010 forest and mixed open landuses were determined by proportioning the net change between 2010 and 1990 agricultural and urban land to 1990 mixed open and 1990 forest. Maryland and Virginia forest acreage changes followed methodologies or data submitted by these states.

Each agricultural BMP in the tier scenarios is associated with research that identifies the expected level of nutrient reduction. In many cases this could be viewed as the best reduction one can expect from a BMP given optimal growing conditions and expected annual maintenance. However, the yield reserve BMP is slightly different. This BMP is not based solely on hydrologic conditions, but includes the known response of a particular crop to nutrient availability. There is an additional amount or cushion within universally recommended nutrient application rates to insure optimal yield under ideal growing conditions. Real world observations have shown that optimal growing conditions occur infrequently, and ‘average’ hydrologic conditions may result in substantially less than optimal yield. By combining this management practice with an insurance plan to protect against yield loss in suboptimal growth years, potential nitrogen leaching and phosphorus runoff are reduced while providing plant nutrient

requirements seven or eight years out of every ten. The insurance program protects producers in those two to three years of yield loss. Since this is the reduction of a direct input based on plant response curves and not an estimate of nutrient reduction efficiency, the potential benefits from a yield reserve program can be fully modeled. Since yield is a function of rainfall and nutrient availability, the benefits of this type of program can be seen best in years with less than average rainfall when yields fall, yet spring application rates were high.

Estimates of the number of septic systems in the watershed in 2010 were derived from human population projections and people per septic system ratios from the 1990 U.S. Census Bureau survey.

Point sources were divided into categories which include 1) significant municipal wastewater treatment facilities—generally discharging flows greater than or equal to 0.5 million gallon per day, 2) significant industrial facilities—discharging nutrient loads of greater than or equivalent to municipal facilities with flows greater than or equal to 0.5 million gallon per day, and 3) non-significant municipal wastewater treatment facilities—discharging flows less than 0.5 million gallon per day, and limited to facilities in Maryland and Virginia due to availability of data.

Point source nitrogen and phosphorus loads from significant and non-significant municipal wastewater treatment facilities were determined using flows projected for the year 2010 for POTWs located in all jurisdictions of the Chesapeake Bay Watershed. These future flows were developed either from population projections or information obtained directly from the municipal facility operators. The tier and E3 scenario flows for industrial dischargers remained at 2000 levels because industrial flows are not necessarily subject to growth due to population.

Technologies in municipal facilities varied among the tiers depending on the nutrient concentrations to be achieved under each tier description. The technologies include extended aeration processes and denitrification zones, chemical additions, additional clarification tanks, deep bed denitrification filters, and micro-filtration. For industrial dischargers, site-specific information on reductions by facility was obtained via phone contacts or site visits.

Estimation of atmospheric deposition to the Chesapeake Bay watershed for all tier and E3 scenarios employed deposition data from the Regional Acid Deposition Model (RADM) which also provides deposition estimates representing current conditions used for Progress model runs. All of the air scenarios involve nitrogen oxide emissions reductions made by roughly 37 states (the deposition modeling domain). Air scenarios in Tiers 1 and 2 describe existing Clean Air Act regulations that have passed; the Tier 3 and E3 air scenarios describe additional voluntary control measures.

Table A-1 provides a brief overview of the reduction measures in the tiers organized by nutrient source. Table A-2 shows the implementation levels of the BMPs in the tier scenarios in terms of landuse acres, or their appropriate unit of measurement (Figures A-1 through A-3). The text that follows provides a more detailed overview of the reduction measures per source, organized by tier scenario.

In the listing of BMP levels in Table A-2, there are cases where implementation levels may be lower in a higher tier, or may be lower for the 2010 scenarios, when compared to 2000 progress. It is important to note that landuses change from 2000 to 2010 were based on trends specified by individual jurisdictions with concurrence from the Chesapeake Bay Program Nutrient Subcommittee's Tributary Strategy Workgroup. Also, landuses change through the 2010 tiers and the E3 scenario depending on degrees of BMP implementation (i.e., riparian buffers, wetland restoration, land retirement, carbon sequestration for agricultural land). In other words, as landuses change, less land may be available to apply BMPs in a higher level-of-effort scenario. Overall however, nutrient and sediment reductions will increase through the tiers to the E3 scenario as the combined impact of nonpoint source BMPs increases. Note that riparian buffer information is presented both in terms of acres and 1-side stream miles.

Table A-1. Descriptions of the source reduction measures by tier scenario.

Nutrient Reduction Activity	Tier 1	Tier 2	Tier 3	E3
Cropland Conversions to Forest or Hayland				
Buffers-pasture to forest	Continue current level of implementation using average rate of 1997-2000. Note: Includes fencing	Increase level of implementation up to a total of 20% of the remaining stream reaches in pasture. Note: Includes fencing	Increase level of implementation up to a total of 30% of the remaining stream reaches in pasture. Note: Includes fencing	Both sides of all stream reaches within pasture receive 100 foot forest buffers and fencing.
Buffers-cropland to forest	Continue current level of implementation using average rate of 1997-2000.	Increase level of implementation up to a total of 20% of the remaining stream reaches in cropland.	Increase level of implementation up to a total of 30% of the remaining stream reaches in cropland.	Both sides of all stream reaches within cropland receive forest buffers.
Buffers-cropland to grass	Continue current level of implementation using average rate of 1997-2000.	25% of remaining stream reaches within cropland.	50% of remaining stream reaches within cropland.	
Buffers-hayland to forest	Continue current level of implementation using average rate of 1997-2000.	25% of remaining stream reaches within hayland over Tier 1.	50% of remaining stream reaches within hayland over Tier 1.	Both sides of all stream reaches within hayland receive forest buffers.
Wetland Reserve (cropland to forest)	Continue current level of implementation using average rate of 1997-2000.	Increase level of implementation up to a total of 33% of the remaining goal.	Increase level of implementation up to a total of 66% of the remaining goal.	Wetland Reserve equals 25,000 acres in signatory states (based on *Chesapeake 2000* goal).

Table A-1. Descriptions of the source reduction measures by tier scenario.

Nutrient Reduction Activity	Tier 1	Tier 2	Tier 3	E3
CRP/CREP (cropland to mixed open)	Continue current level of implementation using average rate of 1997-2000.	CRP-CREP-Wetland Reserve-buffers (combined) comprise 10% of cropland within each county.	CRP-CREP-Wetland Reserve-buffers (combined) comprise 15% of cropland within each county.	CRP-CREP-Wetland Reserve buffers (combined) comprise 25% of cropland within each county.
Carbon Sequestration & Bioenergy			Applied to 15% of remaining The E3 scenario cropland after land conversion programs applied.	Applied to 25% of remaining cropland after land conversion programs applied.
Agriculture NPS				
Conservation Tillage	Continue current level of implementation using average rate of 1997-2000.	Applied to 30% of remaining cropland beyond Tier 1.	Applied to 60% of remaining cropland beyond Tier 1.	Conservation tillage on 100% of cropland.
Farm Plans	Continue current level of implementation using average rate of 1997-2000.	Applied to 30% of remaining agricultural land (crop, hay, pasture) beyond Tier 1.	Applied to 70% of remaining agricultural land (crop, hay, pasture) beyond Tier 1.	Applied to 100% of agricultural land (crop, hay, pasture).
Cover Crops	Continue current level of implementation using average rate of 1997-2000.	Applied to 40% of remaining cropland beyond Tier 1.	Applied to 75% of remaining cropland beyond Tier 1.	Applied to 100% of cropland
Nutrient Management Planning	MD & DE: 100% cropland and hayland under nutrient management. Other basin states: Continue current level of implementation using average rate of 1997-2000.	MD & DE: 100% cropland and hayland under nutrient management. Other basin states: Applied to 30% of remaining cropland and hayland beyond Tier 1.	MD & DE: 100% cropland and hayland under nutrient management. Other basin states: Applied to 30% of remaining cropland and hayland beyond Tier 2.	Applied to 100% of cropland and hayland.

Table A-1. Descriptions of the source reduction measures by tier scenario.

Nutrient Reduction Activity	Tier 1	Tier 2	Tier 3	E3
Yield Reserve			Applied to 30% of the cropland and hayland under nutrient management. Replaces nutrient application component of nutrient management plan.	Applied to 100% of cropland and hayland. Replaces nutrient application component of nutrient management plan.
Excess Nutrients	Assume alternative use for excess manure.	Assume alternative use for excess manure.	Assume alternative use for excess manure.	Assume alternative use for excess manure.
Agriculture Waste Systems	Continue current level of implementation using average rate of 1997-2000.	Applied to 25% of remaining confined animal units beyond Tier 1 (combines storage system and barnyard runoff controls).	Applied to 60% of remaining confined animal units beyond Tier 1 (combines storage system and barnyard runoff controls).	Applied to 100% of confined animal units (combines storage system and barnyard runoff controls).
Stream Protection without fencing	Continue current level of implementation using average rate of 1997-2000.	Applied to 10% of remaining stream reaches within pasture land beyond Tier 1.	Applied to 25% of remaining stream reaches within pasture land beyond Tier 1.	N/A (see buffers-forest-pasture)
Stream Protection with fencing	Continue current level of implementation using average rate of 1997-2000.	Applied to 15% of remaining stream reaches within pasture land beyond Tier 1.	Applied to 75% of remaining stream reaches within pasture land beyond Tier 1.	N/A (see buffers-forest-pasture)
Grazing Land Protection	Continue current level of implementation using average rate of 1997-2000.	Applied to 25% of remaining pasture land beyond Tier 1.	Applied to 50% of remaining pasture land beyond Tier 1.	Applied to 100% of pasture land.
Urban NPS				
Urban Land Conversion (PA, MD, VA and DC only)	Full 2000-2010 urban land conversion based on 2010 population.	2000-2010 urban conversion -reduced 10% (acres 'returned' as 65% forest, 20% mixed open, 15% agriculture)	2000-2010 urban conversion -reduced 20% (acres 'returned' as 65% forest, 20% mixed open, 15% agriculture)	2000-2010 urban conversion - reduced 30% (acres 'returned' as 100% forest).

Table A-1. Descriptions of the source reduction measures by tier scenario.

Nutrient Reduction Activity	Tier 1	Tier 2	Tier 3	E3
Stormwater management & LID - New Development (2001-2010)	66% of new development has stormwater management. (TN=35, TP=45, TSS=80)	75% of new development has stormwater management. 25% of new development employs environmental site design and low-impact development techniques. Efficiencies represent a 75%/25% weighted average reduction. (TN=40, TP=55, TSS=85)	50% of new development has stormwater management. 50% of new development employs environmental site design and low-impact development techniques. Efficiencies represent a 50%/50% weighted average reduction. (TN=45, TP=57, TSS=87)	100% of new development employs environmental site design and low-impact development techniques (TN=50, TP=60, TSS=90).
Stormwater management-Recent Development (1986-2000)	60% of recent development has stormwater management. (TN=27, TP=40,TSS=65)	60% of recent development has stormwater management. (TN=27, TP=40,TSS=65)	60% of recent development has stormwater management. (TN=27, TP=40,TSS=65)	
Retrofits - Recent (1986-2000) & Old (pre 1986) Development	0.8% of recent and old (pre 1986) development is retrofitted (TN=20, TP=30,TSS=65)	5% of recent and old (pre 1986) development is retrofitted (TN=20, TP=30,TSS=65)	20% of recent and old (pre 1986) development is retrofitted (TN=20, TP=30,TSS=65)	100% of recent and old (pre 1986) development is retrofitted (TN=40, TP=40, TSS=80).
Urban Nutrient Management	Continue to implement BMP at average annual rate through 2010, using average of 1997-2000. (TN=17%, TP=22%)	40% of urban pervious and mixed open lands are under nutrient management. (TN=17%, TP=22%)	75% of urban pervious and mixed open lands are under nutrient management. (TN=17%, TP=22%)	No fertilizer is applied to urban pervious or mixed open land.

Table A-1. Descriptions of the source reduction measures by tier scenario.

Nutrient Reduction Activity	Tier 1	Tier 2	Tier 3	E3
Buffers-Grass (existing)	All urban stream reaches are assumed to have either grass or tree buffers. Where urban disturbance has altered a stream reach beyond repair/restoration, it is not included as a potential buffer area.	Reduce grass buffers by 10% below Tier 1 level. (conversion to forest buffers)	Reduce grass buffers by 30% below Tier 1 level. (conversion to forest buffers)	
Buffers- Grass to Forest		Increase forest buffer acreage by the same amount of 'reduced' grass buffer acreage.	Increase forest buffer acreage by the same amount of 'reduced' grass buffer acreage.	50 foot forest buffer on both sides of stream reaches in urban pervious areas. No credit given on upstream effects, land conservation only.
Buffers- Mixed Open to Forest	Continue current level of implementation using average rate of 1997-2000.	Increase forest buffer acreage by the same amount as forest buffers on urban pervious.	Increase forest buffer acreage by the same amount as forest buffers on urban pervious.	100 foot forest buffer on mixed open. No credit given on upstream effects, land conservation only.
Onsite Treatment Systems				
New Systems (post 2000)	Maintain current concentration/load per system.	10% of new treatment systems will meet an edge of drainage field concentration for nitrogen of 10 mg/L TN per system. Remaining systems meet existing concentration/load levels.	100% of new treatment systems will meet an edge of drainage field concentration for nitrogen of 10 mg/L TN per system.	100% of new treatment systems will meet an edge of drainage field concentration of nitrogen of 10 mg/L TN per system.

Table A-1. Descriptions of the source reduction measures by tier scenario.

Nutrient Reduction Activity	Tier 1	Tier 2	Tier 3	E3
Existing Systems (pre-2001)	Maintain current concentration/load per system.	Maintain current concentration/load per system.	1% of existing (per year) treatment systems will meet an edge of drainage field concentration for nitrogen of 10 mg/L TN per system. (1% represents failed systems and opportunities for upgrades.) Remaining systems maintain existing concentrations/ loads.	100% of existing treatment systems will meet an edge of drainage field concentration of nitrogen of 10 mg/L TN per system.
Point Sources				
Municipal Wastewater Treatment (Significant Facilities as of 2000)	Existing NRT and those planned to go to NRT by 2010: 2010 flow at 8.0 mg/l TN and 2000 concentrations for TP. For all remaining facilities without NRT existing or planned: 2000 TN & TP. For certain VA facilities in lower VA tributaries TP=1.5 mg/l	Reach and maintain 8.0 mg/l TN and 1.0 mg/l TP concentrations at 2010 flows at all facilities. (Phosphorus concentration is 1.0 mg/l or permit limit, whichever is lower).	Reach and maintain 5.0 mg/l TN and 0.5 mg/l TP concentrations at 2010 flows at all facilities. (Phosphorus concentration is 0.5 mg/l or permit limit, whichever is lower.)	Reach and maintain 3.0 mg/l TN and 0.10 mg/l TP concentrations at 2010 flows at all facilities. (Phosphorus concentration is 0.1 mg/l or permit limit, whichever is lower).
Industrial Wastewater Treatment (Significant Facilities as of 2000)	Maintain current levels.	Generally a 50% reduction from Tier 1 (2000 concentrations) or permit conditions if less	Generally an 80% reduction from Tier 1 (2000 concentrations) or permit conditions if less	TN = 3.0; TP = 0.1 or permit conditions if less
Municipal Wastewater Treatment (Non-significant Facilities as of 2000)	Maintain current TN/TP concentrations with 2010 flows.	Maintain current TN/TP concentrations with 2010 flows.	Maintain current TN/TP concentrations with 2010 flows.	Maintain 8.0 mg/L nitrogen and 2.0 mg/L phosphorus concentrations or 2000 concentrations if less with 2010 flows.

Table A-1. Descriptions of the source reduction measures by tier scenario.

Nutrient Reduction Activity	Tier 1	Tier 2	Tier 3	E3
CSO Control (DC)	43% reduction in CSOs.	43% reduction in CSOs.	43% reduction in CSOs.	Zero discharge from DC CSOs.
Forest NPS				
Forest Harvest BMPs	Forestry BMPs are properly installed on 80% of all harvested lands.	Forestry BMPs are properly installed on 90% of all harvested lands.	Forestry BMPs are properly installed on 100% of all harvested lands with no measurable increase in nutrient and sediment discharge.	Forestry BMPs are properly installed on 100% of all harvested lands with no measurable increase in nutrient and sediment discharge.
Air Emissions				
Air Controls (NO_x only)	2007/2010 Base with NOx SIP.	2020 CAA with Tier 2 and heavy duty diesel regulations.	2020 CAA with aggressive utility controls.	2020 CAA aggressive utility controls and industry-point and mobile controls.

Table A-2. 2000 Progess, 2010 tiers, and 2010 E3 scenario BMP implementation levels.

BMP	Unit of Measure	Applicable Landuse	2000 Progress	2010 Tier 1	2010 Tier 2	2010 Tier 3	2010 E3
Agricultural BMPs							
Conservation Tillage	Acres	Low-Till	1,994,745	1,962,824	2,340,908	2,300,093	2,312,209
Riparian Forest Buffers	Acres	Row Crop, Hay	9,054	30,588	133,772	206,663	494,450
Riparian Forest Buffers	1-side stream miles, 100 foot width	Row Crop, Hay	747	2,524	11,036	17,050	40,792
Wetland Restoration	Acres	Row Crop, Hay	1,277	2,862	10,260	17,659	25,282
Land Retirement	Acres	Row Crop, Hay	87,488	128,510	500,452	742,695	1,090,540
Grass Buffers	Acres	Row Crop	4,294	15,036	71,985	113,800	0
Tree Planting	Acres	Row Crop, Pasture	8,568	4,142	0	0	0
Riparian Forest Buffers	Acres	Pasture	0	0	46,732	63,851	184,081
Riparian Forest Buffers	1-side stream miles, 100 foot width	Pasture	0	0	3,855	5,268	15,187
Carbon Sequestration/ Bio-Energy	Acres	Row Crop	0	0	0	509,431	770,736
Standard Nutrient Management Plan Implementation	Acres	Row Crop, Hay	2,283,426	3,023,742	3,850,244	2,967,870	0
Yield Reserve Implementation	Acres	Row Crop, Hay	0	0	0	1,271,944	4,830,817
Total Nutrient Management Plan Implementation	Acres	Row Crop, Hay	2,283,426	3,023,742	3,850,244	4,239,814	4,830,817
Farm Plans	Acres	Agriculture	3,666,165	5,075,549	5,860,003	6,854,953	7,202,280

BMP	Unit of Measure	Applicable Landuse	2000 Progress	2010 Tier 1	2010 Tier 2	2010 Tier 3	2010 E3
Cover Crops	Acres	Row Crop	220,134	152,766	1,544,635	2,203,196	2,312,209
Stream Protection With Fencing	Acres	Pasture	40,744	69,257	171,739	580,365	712,302
Stream Protection Without Fencing	Acres	Pasture	26,166	27,979	83,584	63,583	0
Grazing Land Protection	Acres	Pasture	134,327	304,868	853,863	1,394,909	2,371,463
Animal Waste Management	Acres	Manure Acres	4,886	6,425	6,953	7,692	8,537
Animal Waste Management	Animal Units	Manure Acres	708,498	931,677	1,008,208	1,115,351	1,237,801
Manure Excess	Wet Tons As Excreted	N/A	1,270,139	1,927,899	2,145,277	1,870,085	8,856,825
Urban and Mixed Open BMPs							
Abandoned Mine Reclamation	Acres	Urban/Exposed	6,062	0	0	0	0
Urban Growth Reduction	Acres	Urban	38,787	0	26,096	52,192	78,288
Riparian Forest Buffers	Acres	Pervious Urban	0	364	9,808	28,522	93,643
Riparian Forest Buffers	1-side stream miles, 50-foot width	Pervious Urban	0	60	1,618	4,706	15,451
Grass Buffers	Acres	Pervious Urban	0	95,022	84,997	65,702	0
Stormwater Management on New Development	Acres	Urban	0	153,157	207,705	183,440	159,560
SWM on Recent Development	Acres	Urban	165,040	374,357	373,817	373,236	0
SWM On Recent and Old Development	Acres	Urban	0	29,959	187,185	748,488	3,740,806

BMP	Unit of Measure	Applicable Landuse	2000 Progress	2010 Tier 1	2010 Tier 2	2010 Tier 3	2010 E3
Total Stormwater Management	Acres	Urban	165,040	557,474	768,707	1,305,164	3,900,366
Erosion and Sediment Control	Acres	Urban	25,911	0	0	0	0
Urban Nutrient Management	Acres	Pervious Urban	6,608	28,630	1,055,077	1,964,784	2,601,733
Tree Planting	Acres	Mixed Open	22,596	44,280	0	0	0
Riparian Forest Buffers	Acres	Mixed Open	0	0	54,702	73,757	413,922
Riparian Forest Buffers	1-side stream miles, 100-ft. width	Mixed Open	0	0	4,513	6,085	34,149
Mixed Open Nutrient Management	Acres	Mixed Open	0	60,791	1,997,497	3,870,252	4,950,621
Forestry BMPs							
Forest Harvesting Practices	Acres	Forest	67,448	0	0	0	0
Septic BMPs							
Septic Connections	Systems	Septic	31,514	31,514	31,514	31,514	31,514
Septic Pumping	Systems	Septic	2,954	N/A	N/A	N/A	N/A
Septic Denitrification	Systems	Septic	312	312	N/A	N/A	N/A
Denitrification/Pumping on New & Existing Systems	Systems	Septic	N/A	N/A	8,305	93,014	1,357,026

2010 TIER 1 SCENARIO

2010 Tier 1 BMP implementation levels were generally determined by continuing current levels of effort and cost-share in the Chesapeake Bay watershed. In addition, expected regulatory measures, jurisdictional programs, and construction schedules between 2000 and 2010 were included.

2010 Tier 1 Scenario Nonpoint Source BMPs

For most nonpoint source BMPs, implementation rates between 1997 and 2000 were continued to the year 2010 with limits that levels could not exceed the available or the E3 scenario land area to apply the BMPs to. The scale of the calculations was a county-segment, or the intersection of a county political boundary and a model hydrologic segment. This is the same scale that most jurisdictions report BMP implementation levels to the Chesapeake Bay Program Office.

Every effort was made to include BMPs submitted by the jurisdictions for progress model runs into Tier 1. Since historic BMP data was not available from New York, Delaware, and West Virginia, 2010 Tier 1 projections were determined from watershed-wide implementation rates in the states which employ and track the practice.

2010 Tier 1 BMPs were extrapolated from recent implementation rates by the landuse types submitted by the states for each BMP. For example, if a jurisdiction submits data for nutrient management on crop, 2010 Tier 1 crop was projected and then split among high-till, low-till, and hay according to relative percentages. If a jurisdiction submits data as nutrient management on high-till, low-till, and hay individually, projections were done for each of these landuse categories.

The 2010 Tier 1 scenario does not include tree planting on tilled land, forest conservation, and forest harvesting practices as these BMPs are not part of the tier and E3 scenarios. For forest harvesting practices and erosion and sediment control, the model simulation does not account for additional loads from disturbed forest and construction areas, respectively. For forest conservation, planting above what is removed during development is accounted for in the 2010 urban and forest projections. Tree planting on agricultural land was included in Tier 1 for pasture as forest buffers since this BMP is also part of the tier and E3 scenarios and pasture tree planting and pasture buffers are treated the same in the model.

2010 Tier 1 Scenario Agricultural BMPs

- Tier 1 Conservation tillage
  - Continue 1997–2000 implementation rates of conservation-tillage.
  - Low-till acres cannot be below 2000 levels or greater than 75 percent of the available cropland by county-segment.
  - Landuse conversion of high-till to low-till.
- Tier 1 Riparian forest buffers on agriculture

  - Continue 1997–2000 implementation rates of riparian forest buffers on cropland and hay to the year 2010.
  - Continue 1997–2000 implementation rates of tree planting on pasture to the year 2010.
  - Tier 1 implementation levels cannot exceed the available or E3 scenario land area to apply the BMP to.
  - The E3 scenario assumes 100-foot forest buffers on un-buffered stream miles (each side) associated with crop, hay, and pasture.
  - Landuse conversion of crop, hay, and pasture to forest.
  - For every acre of crop and hay converted, two upland acres of crop and hay receive a reduction of 57 percent (TN), 70 percent (TP), and 70 percent (SED).
  - There is no upland benefit associated with forest buffers on pasture.
- Tier 1 Wetland restoration
  - Continue 1997–2000 implementation rates of wetland restoration on cropland and hay to the year 2010.
  - Landuse conversion of crop and hay to forest.
- Tier 1 Agricultural land retirement
  - Continue 1997–2000 implementation rates of cropland and hay retirement to the year 2010.
  - The sum of the acreage in Tier 1 riparian forest buffers, wetland restoration, and land retirement cannot exceed 25 percent of the total crop and hay in a county-segment.
  - Landuse conversions of crop and hay to mixed open.
- Tier 1 Riparian grass buffers on cropland
  - Continue 1997–2000 implementation rates of riparian grass buffers on cropland to the year 2010 with limits that levels cannot exceed the available or the E3 scenario land area to apply the BMPs to.
  - The E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - The E3 scenario assumes 100-foot buffers on un-buffered stream miles (each side) associated with agricultural land.
  - Landuse conversions of crop to mixed open.
  - For every acre of cropland converted, two upland acres of crop receive a reduction of 43 percent (TN), 53 percent (TP), and 53 percent (SED).
- Tier 1 Nutrient Management Plan Implementation
  - Continue 1997–2000 rates of nutrient management plan implementation on crop and hay to the year 2010 in all jurisdictions except MD and DE where all crop and hay acres are fully implementing nutrient management plans.
  - Nutrient management plan implementation levels cannot exceed the available land area to apply the BMPs to.
  - Under nutrient management plans, crop and hay acres do not receive more than 130 percent of their TN and TP need.
- Tier 1 Manure excess
  - Excess nutrients resulting from the differences between manure generated and conforming to nutrient management rules and losses in agricultural land are reported.

  - It is assumed that all of the excess manure has alternative uses that do not affect loads to the Chesapeake Bay tidal waters.
- Tier 1 Animal waste management/runoff control
  - Continue 1997–2000 implementation rates of animal waste management on 'manure acres' to the year 2010 with limits that levels cannot exceed the available area to apply the BMPs to.
  - Manure acres are the model's accounting of runoff from animal feeding operations based on the number of animal units.
  - The BMP combines storage systems and barnyard runoff controls and reduction factors of 75 percent (TN and TP) are applied to protected manure acres.
- Tier 1 Farm Plans (non-nutrient management)
  - Continue 1997–2000 rates of Farm Plan implementation on agricultural land (crop, hay, and pasture) to the year 2010 with limits that levels cannot exceed the available land area to apply the BMPs to.
  - Nutrient and sediment reduction factors for Farm Plans on high-till are 10 percent (TN) and 40 percent (TP and SED). Low-till and hay reduction factors are 4 percent (TN) and 8 percent (TP and SED) while the reduction factors for Farm Plans on pasture are 20 percent (TN) and 14 percent (TP and SED).
- Tier 1 Cover crops
  - Since cover crop acreage varies annually or is not cumulative, cover crop implementation is determined as the average of 1997–2000 implementation acreage (or years in that period where data exists from the jurisdictions) with limits that levels cannot exceed the available land area to apply the BMPs to.
  - BMP reduction factors of 35 percent (TN) and 15 percent (TP and SED) are applied to cover crop acres.
- Tier 1 Streambank protection with fencing
  - Continue 1997–2000 implementation rates of streambank protection with fencing on pasture to the year 2010 with limits that levels cannot exceed the available of the E3 scenario land area to apply the BMPs to.
  - The E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - The E3 scenario assumes for every stream mile protected, 51 upland acres of pasture receive a reduction benefit.
  - BMP reduction factors of 75 percent for TN, TP, and SED are applied to pasture acres protected.
- Tier 1 Streambank protection without fencing
  - Continue 1997–2000 implementation rates of streambank protection without fencing on pasture to the year 2010 with limits that levels cannot exceed the available pasture land area to apply the BMPs to.
  - BMP reduction factors of 40 percent for TN, TP, and SED are applied to pasture acres protected.
- Tier 1 Grazing land protection

  - Continue 1997–2000 implementation rates of rotational grazing on pasture to the year 2010 with limits that levels cannot exceed the available land area to apply the BMPs to.
  - BMP reduction factors of 50 percent (TN) and 25 percent (TP) are applied to protected pasture acres.

2010 Tier 1 Urban and Mixed Open BMPs

- Tier 1 Stormwater Management on new development
  - Stormwater Management applied to 66 percent of new development between 2000 and 2010.
  - Stormwater Management practices are designed to reduce TN by 35 percent, TP by 45 percent, and SED by 80 percent.
- Tier 1 Stormwater Management on recent development
  - 60 percent of recent development (1986–2000) is has Stormwater Management that are designed to reduce nutrients and sediment in stormwater runoff by 27 percent (TN), 40 percent (TP), and 65 percent (SED).
- Tier 1 Stormwater retrofits on old and recent development
  - 0.8 percent of pre-1986 urban land and 1986–2000 recent development is retrofitted with a suite of practices that reduce nutrients and sediment in runoff by 20 percent (TN), 30 percent (TP), and 65 percent (SED).
- Tier 1 Riparian forest and grass buffers on urban
  - It is assumed that all urban stream reaches have either forest or grass riparian buffers except where urban disturbance has altered a stream reach beyond repair/restoration (i.e., impervious surface).
  - 50-foot buffers on all un-buffered stream miles (each side) associated with pervious urban.
  - Landuse conversion of pervious urban to mixed open (grass buffers) or forest (forest buffers).
  - There is no upland benefit associated with forest and grass buffers on urban.
- Tier 1 Riparian forest buffers on mixed open
  - Continue 1997–2000 implementation rates of tree planting on mixed open to the year 2010 with limits that levels can not exceed the available or the E3 scenario land area to apply the BMPs to.
  - 100-foot forest buffers on all un-buffered stream miles (each side) associated with mixed open.
  - Landuse conversion of mixed open to forest.
  - There is no upland benefit associated with forest buffers on mixed open.
- Tier 1 Nutrient management on urban and mixed open
  - Continue 1997–2000 implementation rates of nutrient management on pervious urban and mixed open to the year 2010 with limits that levels cannot exceed the available land area to apply the BMPs to.
  - BMP reduction factors of 17 percent (TN) and 22 percent (TP) are applied to acres under nutrient management.

2010 Tier 1 Forest Harvest BMPs

- It is assumed that forestry BMPs designed to minimize the environmental impacts from timber harvesting, such as road building and cutting/thinning operations, are properly installed on all harvested lands with no measurable increase in nutrient and sediment discharge.
- The assumption is based on maintaining the state of forest loads as measured during the calibration of the Chesapeake Bay Watershed Model.

2010 Tier 1 Septic BMPs

- Current edge-of-septic-field concentrations and flows per system are maintained.
- The number of systems varies according to population projections from 2000 to 2010.
- Septic BMPs incorporate submissions from the Chesapeake Bay-basin jurisdictions of the current number of systems employing denitrification technologies (50 percent TN reduction) and those with regular maintenance through pumping (5 percent TN reduction).

2010 Tier 1 Point Source BMPs

- Tier 1 Significant municipal wastewater treatment facilities
  - Nitrogen – POTWs with existing nutrient-removal technologies (NRT) and those planned to go to NRT by 2010 are at 2010 projected flows and 8 mg TN/L effluent concentrations (annual average). All remaining significant facilities are at 2010 projected flows and 2000 TN effluent concentrations.
  - Phosphorus – 2010 projected flows and 2000 TP/L effluent concentrations except those targeted in VA which are at 1.5 mg TP/L (annual average).
- Tier 1 Significant industrial dischargers
  - 2000 flows and maintain current (2000) levels of effluent concentrations for TN and TP or the permit limit, whichever is less.
- Tier 1 Non-significant municipal wastewater treatment facilities
  - 2000 TN and TP effluent concentrations applied to 2010 projected flows.

2010 Tier 1 Combined Sewer Overflow BMPs

- There is a 43 percent reduction in the current discharge from DC combined sewer overflows, the only CSO loads among all jurisdictions for which the Chesapeake Bay Program has nutrient load data specifically quantified in the model simulation.
- The reduction from 2000 loads is what is expected by the District to be achieved by 2010.

2010 Tier 1 Atmospheric Deposition BMPs

Tier 1 atmospheric deposition assumes implementation of the 1990 Clean Air Act projected for the year 2010 with nitrogen oxide emissions regulations for ground-level ozone and acid rain that have

passed. Estimated changes in deposition for the Tier 1 scenario includes the following controls on nitrogen oxide emissions:

- 2007 non-utility (industrial) point source and area source emissions.
- 2007 mobile source emissions with 'Tier II' tail pipe standards on light duty vehicles.
- 2010 utility emissions with Title IV (Acid Rain Program) fully implemented and 20-state NOx SIP call reductions at 0.15 lbs/MMbtu during the May to September ozone season only.

The impacts of Tier 1 emissions and deposition to the Chesapeake Bay watershed's land area and non-tidal waters are part of the reported nutrient loads from the individual landuse source categories (i.e., agriculture, urban, mixed open, forest, and non-tidal surface waters). The reported Watershed Model loads, however, usually do not include contributions from atmospheric deposition to tidal waters although the water quality responses, as measured by the Estuary Model, account for this source at levels prescribed by Tier 1.

2010 Tier 1 Shoreline Erosion BMPs

- Tier 1 shoreline erosion controls include structural and non-structural practices at 2000 levels.

The impacts of Tier 1 shoreline erosion controls are not included in the reported Watershed Model loads although the water quality responses, as measured by the Estuary Model, account for this source at BMP levels prescribed by Tier 1.

2010 TIER 2 SCENARIO

2010 Tier 2 BMP implementation levels for nonpoint sources were generally determined by increasing levels above Tier 1 by a percentage of the difference between the Tier 1 and the E3 scenario levels for each BMP. These percentages were mostly recommended by individual source workgroups under the Chesapeake Bay Program Nutrient Subcommittee, and were applied watershed-wide by county-segments, or the intersections of county political boundaries and the Watershed Model's hydrologic segmentation.

For Tier 2 point source municipal facilities, technologies to achieve 8 mg TN/L include extended aeration processes and denitrification zones, along with chemical addition to achieve a phosphorus discharge of 1.0 mg/l where facilities are not already achieving these levels.

In the design of the Tier 2 scenario, considerations of the costs of BMP implementation, participation levels, and physical limitations are very limited. Tier 2 BMP levels are considered technically possible, and are listed below for each of the major source categories.

2010 Tier 2 Scenario Agricultural BMPs

- Tier 2 Conservation tillage
  - Applied to 'Tier 1' levels plus 30 percent of the of the available crop acres between 'Tier 1' and the 'E3' scenario levels.
  - Tier 1 and the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - Landuse conversion of high-till to low-till.
- Tier 2 Riparian forest buffers on agriculture
  - Applied to 'Tier 1' levels plus 20 percent of the of the available stream reaches in cropland and pasture and 25 percent of the remaining stream reaches in hay between 'Tier 1' and 'the E3 scenario' levels.
  - Tier 1 and the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - The E3 scenario assumes 100-foot forest buffers on un-buffered stream miles (each side) associated with crop, hay, and pasture.
  - Tier 1 forest buffers on pasture are rooted in agricultural tree planting from jurisdictional BMP reporting.
  - Landuse conversions of crop, hay, and pasture to forest.
  - For every acre of crop and hay converted, two upland acres of crop and hay receive a reduction of 57 percent (TN), 70 percent (TP), and 70 percent (SED).
  - There is no upland benefit associated with forest buffers on pasture.
- Tier 2 Wetland restoration
  - Applied to 'Tier 1' levels plus 33 percent of the of the available crop and hay acres in PA, MD, and VA between 'Tier 1' and the 'E3' scenario levels.

  - Tier 1 and the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - Landuse conversion of crop and hay to forest.
- Tier 2 Agricultural land retirement
  - The remainder of 10 percent of the total crop and hay acres and those acres converted through forest buffers and wetland restoration is retired to a grass condition.
  - Landuse conversions of crop and hay to mixed open.
- Tier 2 Riparian grass buffers on cropland
  - Applied to 'Tier 1' levels plus 25 percent of the of the available stream reaches in cropland between 'Tier 1' and the 'E3' scenario levels and after forest buffer planting.
  - Tier 1 and the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - The E3 scenario assumes 100-foot buffers on un-buffered stream miles (each side) associated with agricultural land.
  - Landuse conversions of crop to mixed open.
  - For every acre of cropland converted, two upland acres of crop receive a reduction of 43 percent (TN), 53 percent (TP), and 53 percent (SED).
- Tier 2 Nutrient Management Plan Implementation
  - Applied to 'Tier 1' levels plus 30 percent of the of the available crop and hay acres between 'Tier 1' and 'the E3 scenario' levels in PA, VA, NY, and WV.
  - All crop and hay acres in MD and DE are fully implementing nutrient management plans.
  - Tier 1 and the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - Under nutrient management plans, crop and hay acres do not receive more than 130 percent of their TN and TP need.
- Tier 2 Manure excess
  - Excess nutrients resulting from the differences between manure generated and conforming to nutrient management rules and losses in agricultural land are reported.
  - It is assumed that all of the excess manure has alternative uses that do not affect loads to the Chesapeake Bay tidal waters.
- Tier 2 Animal waste management/runoff control
  - Applied to 'Tier 1' levels plus 25 percent of the of the available manure acres between 'Tier 1' and 'the E3 scenario' levels.
  - Tier 1 ands the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - BMP reduction factors of 75 percent (TN and TP) are applied to protected manure acres.
- Tier 2 Farm Plans (non-nutrient management)
  - Applied to 'Tier 1' levels plus 30 percent of the of the available agricultural acres (crop, hay, and pasture) between 'Tier 1' and 'the E3 scenario' levels.
  - Tier 1 and the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - Nutrient and sediment reduction factors for Farm Plans on high-till are 10 percent (TN) and 40 percent (TP and SED). Low-till and hay reduction factors are 4 percent (TN) and 8

percent (TP and SED) while the reduction factors for Farm Plans on pasture are 20 percent (TN) and 14 percent (TP and SED).

- Tier 2 Cover crops
  - Applied to ‘Tier 1' levels plus 40 percent of the of the available cropland between ‘Tier 1' and the ‘E3' scenario levels.
  - Tier 1 and the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - BMP reduction factors of 35 percent (TN) and 15 percent (TP and SED) are applied to cover crop acres.
- Tier 2 Streambank protection with fencing
  - Applied to ‘Tier 1' levels plus 15 percent of the of the available pasture land that can be protected between ‘Tier 1' and the ‘E3' scenario levels.
  - Tier 1 ands the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - BMP reduction factors of 75 percent for TN, TP, and SED are applied to pasture acres protected.
- Tier 2 Streambank protection without fencing
  - Applied to ‘Tier 1' levels plus 10 percent of the available pasture land area to apply the BMPs to accounting for the acres protected by fencing.
  - Tier 1 levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes and streambank protection with fencing.
  - BMP reduction factors of 40 percent for TN, TP, and SED are applied to pasture acres protected.
- Tier 2 Grazing land protection
  - Applied to ‘Tier 1' levels plus 25 percent of the available pasture land between ‘Tier 1' and ‘the E3 scenario’ levels.
  - Tier 1 ands the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - BMP reduction factors of 50 percent (TN) and 25 percent (TP) are applied to protected pasture acres.

2010 Tier 2 Urban and Mixed Open BMPs

- Tier 2 Reduction in 2000–2010 urban growth
  - 10 percent of the projected pervious and impervious urban growth in PA, MD, VA, and DC between 2000 and 2010 is not developed.
  - It is assumed that 65 percent of the reduction in projected urban growth is retained in forest, 20 percent in mixed open, and 15 percent in agriculture.
  - Landuse conversions of pervious and impervious urban to forest, mixed open, and agriculture (crop, hay, and pasture).
- Tier 2 Stormwater Management and environmental site design/low-impact development on new development
  - Stormwater Management applied to 75% of new development between 2000 and 2010.

  - Environmental site design/low-impact development practices applied to 25% of new development between 2000 and 2010.
  - Efficiencies of Stormwater Management and environmental site design and low-impact development practices represent a 75%/25% weighted average reduction of 40% for TN, 55% for TP, and 85% for TSS.
- Tier 2 Stormwater Management on recent development
  - 60 percent of recent development (1986–2000) has Stormwater Management practices that are designed to reduce nutrients and sediment in stormwater runoff by 27 percent (TN), 40 percent (TP), and 65 percent (SED).
- Tier 2 Stormwater retrofits on old and recent development
  - 5 percent of pre-1986 urban land and 1986–2000 recent development has stormwater management practices that reduce nutrients and sediment in runoff by 20 percent (TN), 30 percent (TP), and 65 percent (SED).
- Tier 2 Riparian grass buffers on urban lands
  - Urban grass buffer acreage is reduced 10 percent below ‘Tier 1' levels and is converted to urban forest buffers.
  - Tier 1 levels are revised following the same methodology but account for previously applied BMPs that involve landuse changes.
  - The assumption is maintained that all urban stream reaches have 50-foot riparian buffers in either forest or grass except where urban disturbance has altered a stream reach beyond repair/restoration (i.e., impervious surface).
  - There is no upland benefit associated with grass buffers on urban.
- Tier 2 Riparian forest buffers on urban lands
  - Urban forest buffer acreage is increased by the same amount as the reduction in urban grass buffers.
  - The assumption is maintained that all urban stream reaches have 50-foot riparian buffers in either forest or grass except where urban disturbance has altered a stream reach beyond repair/restoration (i.e., impervious surface).
  - There is no upland benefit associated with forest buffers on urban.
- Tier 2 Riparian forest buffers on mixed open lands
  - Mixed open forest buffer acreage is increased from ‘Tier 1' levels by the same amount as the increase in urban forest buffers between ‘Tier 1' and Tier 2.
  - Tier 1 levels are revised following the same methodology but account for previously applied BMPs that involve landuse changes.
  - Landuse conversion of mixed open to forest.
  - There is no upland benefit associated with forest buffers on mixed open.
- Tier 2 Nutrient management on urban and mixed open lands
  - It is assumed that 40 percent of pervious urban and 40 percent of mixed open land are under nutrient management.
  - BMP reduction factors of 17 percent (TN) and 22 percent (TP) are applied to acres under nutrient management.

2010 Tier 2 Forest Harvest BMPs

- It is assumed that forestry BMPs designed to minimize the environmental impacts from timber harvesting, such as road building and cutting/thinning operations, are properly installed on all harvested lands with no measurable increase in nutrient and sediment discharge.
- The assumption is based on maintaining the state of forest loads as measured during the calibration of the Chesapeake Bay Watershed Model.

2010 Tier 2 Septic BMPs

- 10 percent of new treatment systems between 2000 and 2010 employ denitrification technologies and are maintained through regular pumping to meet an edge of septic field TN concentration of 10 mg/l or 2.3 lbs TN per person-year.
- Remaining new and existing systems are at current edge of septic field concentrations and flows per system.
- Septic BMPs incorporate submissions from the Chesapeake Bay-basin jurisdictions of the current number of systems employing denitrification technologies (50 percent TN reduction) and those with regular maintenance through pumping (5 percent TN reduction).

2010 Tier 2 Point Source BMPs

- Tier 2 Significant municipal wastewater treatment facilities
  - Nitrogen – All significant POTWs are at 2010 projected flows and reach and maintain effluent concentrations of 8 mg TN/L (annual average) including those facilities that planned to go to NRT by 2010.
  - Phosphorus – POTWs are at 2010 projected flows and reach and maintain effluent concentrations of 1.0 mg TP/L (annual average) or the permit limit, whichever is less.
- Tier 2 Significant industrial dischargers
  - 2000 flows and generally maintain effluent concentrations that are 50 percent less that those in Tier 1 or the permit limit, whichever is less.
- Tier 2 Non-significant municipal wastewater treatment facilities
  - 2000 TN and TP effluent concentrations applied to 2010 projected flows.

2010 Tier 2 Combined Sewer Overflow BMPs

- There is a 43 percent reduction in the current discharge from District of Columbia combined sewer overflows, the only CSO loads among all jurisdictions for which the Chesapeake Bay Program has nutrient load data specifically quantified in the model simulation.
- The reduction from 2000 loads is what is expected by the District of Columbia to be achieved by 2010.

2010 Tier 2 Atmospheric Deposition BMPs

Atmospheric deposition under Tier 2 reflects implementation of the 1990 Clean Air Act projected for the year 2020 with nitrogen oxide emissions regulations described in Tier 1 plus heavy duty diesel regulations that have passed. Estimated changes in deposition for the Tier 2 scenario reflects the following controls on nitrogen oxide emissions:

- 2020 non-utility (industrial) point source and area source emissions with no additional controls than Tier 1.
- 2020 mobile source emissions with the effect of the Tier II tail pipe standards on light duty vehicles being felt, and the implementation of the heavy duty diesel standards to further reduce NO_x emissions.
- 2020 utility emissions with Title IV (Acid Rain Program) fully implemented and 20-state NO_x SIP call reductions at 0.15 lbs/MMbtu during the May to September ozone season only—Same as Tier 1 controls.

The impacts of emissions and deposition to the Chesapeake Bay watershed's land area and non-tidal waters under Tier 2 are part of the reported nutrient loads from the individual landuse source categories (i.e., agriculture, urban, mixed open, forest, and non-tidal surface waters). The reported Watershed Model loads, however, usually do not include contributions from atmospheric deposition to tidal waters although the water quality responses, as measured by the Estuary Model, account for this source at levels prescribed by Tier 2.

2010 Tier 2 Shoreline Erosion BMPs

- Tier 2 shoreline erosion controls include structural and non-structural practices at 2000 levels.

The impacts of Tier 2 shoreline erosion controls are not included in the reported Watershed Model loads although the water quality responses, as measured by the Estuary Model, account for this source at BMP levels prescribed by Tier 2.

2010 TIER 3 SCENARIO

The 2010 Tier 3 BMP implementation levels for nonpoint sources were generally determined by increasing levels above the Tier 1 scenario by a percentage of the difference between the Tier 1 and the E3 scenario levels, with the percentages being higher than those used in the Tier 2 scenario. As with the Tier 2 scenario, the levels of nonpoint source control were applied watershed-wide by county-segments, or the intersections of county political boundaries and the Watershed Model's hydrologic segmentation.

For Tier 3 municipal point source facilities, technologies to achieve 5 mg TN/L include extended aeration processes beyond those in the Tier 2 scenario, a secondary anoxic zone plus methanol addition, additional clarification tanks, and additional chemicals to achieve a phosphorus discharge of 0.5 mg TP/L.

In the Tier 3 scenario, considerations of the costs of BMP implementation, participation levels, and physical limitations are very limited. Tier 3 BMP levels, considered technically possible, are listed below for each of the major source categories.

2010 Tier 3 Agricultural BMPs

- Tier 3 Conservation tillage
  - Applied to 'Tier 1' levels plus 60 percent of the of the available crop acres between 'Tier 1' and the 'E3' scenario levels.
  - Tier 1 and the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - Landuse conversion of high-till to low-till.
- Tier 3 Riparian forest buffers on agriculture
  - Applied to 'Tier 1' levels plus 30 percent of the of the available stream reaches in cropland and pasture and 50 percent of the remaining stream reaches in hay between 'Tier 1' and the 'E3' scenario levels.
  - Tier 1 and the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - The E3 scenario assumes 100-foot forest buffers on un-buffered stream miles (each side) associated with crop, hay, and pasture.
  - Tier 1 forest buffers on pasture are rooted in agricultural tree planting from jurisdictional BMP reporting.
  - Landuse conversions of crop, hay, and pasture to forest.
  - For every acre of crop and hay converted, two upland acres of crop and hay receive a reduction of 57 percent (TN), 70 percent (TP), and 70 percent (SED).
  - There is no upland benefit associated with forest buffers on pasture.
- Tier 3 Wetland restoration
  - Applied to 'Tier 1' levels plus 66 percent of the of the available crop and hay acres in PA, MD, and VA between 'Tier 1' and the 'E3' scenario levels.

  - Tier 1 and the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - Landuse conversion of crop and hay to forest.
- Tier 3 Agricultural land retirement
  - The remainder of 15 percent of the total crop and hay acres and those acres converted through forest buffers and wetland restoration is retired to a grass condition.
  - Landuse conversions of crop and hay to mixed open.
- Tier 3 Carbon sequestration/bio-energy
  - 15 percent of crop acres (after BMP landuse conversions) are replaced with long-term grasses that serve as a carbon bank and could be converted to energy through combustion.
  - Landuse conversion of low-till to hay.
- Tier 3 Riparian grass buffers on cropland
  - Applied to ‘Tier 1' levels plus 50 percent of the of the available stream reaches in cropland between ‘Tier 1' and the ‘E3' scenario levels and after forest buffer planting.
  - Tier 1 and the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - The E3 scenario assumes 100-foot buffers on un-buffered stream miles (each side) associated with agricultural land.
  - Landuse conversions of crop to mixed open.
  - For every acre of cropland converted, two upland acres of crop receive a reduction of 43 percent (TN), 53 percent (TP), and 53 percent (SED).
- Tier 3 Nutrient Management Plan Implementation (standard and yield reserve program)
  - Nutrient management is applied to ‘Tier 2' levels plus 30 percent of the of the available crop and hay acres between ‘Tier 2' and the ‘E3' scenario levels in PA, VA, NY, and WV.
  - Tier 2 and the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - All crop and hay acres in MD and DE are fully implementing nutrient management plans.
  - Of the crop and hay acres available for nutrient management, 30 percent conforms to a yield reserve program where the land receives 25 percent less TN and TP than standard nutrient management applications - Do not receive more than 98 percent of TN and TP need.
  - Yield reserve program assumes farmer insurance for yield losses.
  - The remaining 70 percent of land available for nutrient management follows standard rules where crop and hay acres do not receive more than 130 percent of their TN and TP need.
- Tier 3 Manure excess
  - Excess nutrients resulting from the differences between manure generated and conforming to nutrient management rules and losses in agricultural land are reported.
  - It is assumed that all of the excess manure has alternative uses that do not affect loads to the Chesapeake Bay tidal waters.
- Tier 3 Animal waste management/runoff control
  - Applied to ‘Tier 1' levels plus 60 percent of the of the available manure acres between ‘Tier 1' and the ‘E3' scenario levels.
  - Tier 1 ands the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - BMP reduction factors of 75 percent (TN and TP) are applied to protected manure acres.

- Tier 3 Farm Plans (non-nutrient management)
  - Applied to ‘Tier 1' levels plus 70 percent of the of the available agricultural acres (crop, hay, and pasture) between ‘Tier 1' and the ‘E3' scenario levels.
  - Tier 1 and the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - Nutrient and sediment reduction factors for Farm Plans on high-till are 10 percent (TN) and 40 percent (TP and SED). Low-till and hay reduction factors are 4 percent (TN) and 8 percent (TP and SED) while the reduction factors for Farm Plans on pasture are 20 percent (TN) and 14 percent (TP and SED).
- Tier 3 Cover crops
  - Applied to ‘Tier 1' levels plus 75 percent of the of the available cropland between ‘Tier 1' and the ‘E3' scenario levels.
  - Tier 1 and the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - BMP reduction factors of 35 percent (TN) and 15 percent (TP and SED) are applied to cover crop acres.
- Tier 3 Streambank protection with fencing
  - Applied to ‘Tier 1' levels plus 75 percent of the of the available pasture land that can be protected between ‘Tier 1' and the ‘E3' scenario levels.
  - Tier 1 ands the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - BMP reduction factors of 75 percent for TN, TP, and SED are applied to pasture acres protected.
- Tier 3 Streambank protection without fencing
  - Applied to ‘Tier 1' levels plus 25 percent of the available pasture land area to apply the BMPs to accounting for the acres protected by fencing.
  - Tier 1 levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes and streambank protection with fencing.
  - BMP reduction factors of 40 percent for TN, TP, and SED are applied to pasture acres protected.
- Tier 3 Grazing land protection
  - Applied to ‘Tier 1' levels plus 50 percent of the of the available pasture land between ‘Tier 1' and the ‘E3' scenario levels.
  - Tier 1 ands the E3 scenario levels are revised following the same methodologies but account for previously applied BMPs that involve landuse changes.
  - BMP reduction factors of 50 percent (TN) and 25 percent (TP) are applied to protected pasture acres.

2010 Tier 3 Urban and Mixed Open BMPs

- Tier 3 Reduction in 2000–2010 urban growth
  - 20 percent of the projected pervious and impervious urban growth in PA, MD, VA, and DC between 2000 and 2010 is not developed.

  - It is assumed that 65 percent of the reduction in projected urban growth is retained in forest, 20 percent in mixed open, and 15 percent in agriculture.
  - Landuse conversions of pervious and impervious urban to forest, mixed open, and agriculture (crop, hay, and pasture).
- Tier 3 Stormwater Management and environmental site design/low-impact development on new development
  - Stormwater Management applied to 50 percent of new development between 2000 and 2010.
  - Environmental site design/low-impact development practices applied to 50 percent of new development between 2000 and 2010.
  - Efficiencies of Stormwater Management and environmental site design and low-impact development practices represent a 50%/50% weighted average reduction of 45% for TN, 57% for TP, and 87% for TSS.
- Tier 3 Stormwater Management on recent development
  - 60 percent of recent development (1986–2000) has Stormwater Management practices that are designed to reduce nutrients and sediment in stormwater runoff by 27 percent (TN), 40 percent (TP), and 65 percent (SED).
- Tier 3 Stormwater retrofits on old and recent development
  - 20 percent of pre-1986 urban land and 1986–2000 recent development has stormwater management practices that reduce nutrients and sediment in runoff by 20 percent (TN), 30 percent (TP), and 65 percent (SED).
- Tier 3 Riparian grass buffers on urban lands
  - Urban grass buffer acreage is reduced 30 percent below ‘Tier 1' levels and is converted to urban forest buffers.
  - Tier 1 levels are revised following the same methodology but account for previously applied BMPs that involve landuse changes.
  - The assumption is maintained that all urban stream reaches have 50-foot riparian buffers in either forest or grass except where urban disturbance has altered a stream reach beyond repair/restoration (i.e., impervious surface).
  - There is no upland benefit associated with grass buffers on urban.
- Tier 3 Riparian forest buffers on urban lands
  - Urban forest buffer acreage is increased by the same amount as the reduction in urban grass buffers.
  - The assumption is maintained that all urban stream reaches have 50-foot riparian buffers in either forest or grass except where urban disturbance has altered a stream reach beyond repair/restoration (i.e., impervious surface).
  - There is no upland benefit associated with forest buffers on urban.
- Tier 3 Riparian forest buffers on mixed open lands
  - Mixed open forest buffer acreage is increased from ‘Tier 1' levels by the same amount as the increase in urban forest buffers between ‘Tier 1' and Tier 3.
  - Tier 1 levels are revised following the same methodology but account for previously applied BMPs that involve landuse changes.
  - Landuse conversion of mixed open to forest.
  - There is no upland benefit associated with forest buffers on mixed open.

- Tier 3 Nutrient management on urban and mixed open lands
  - It is assumed that 75 percent of pervious urban and 75 percent of mixed open land are under nutrient management.
  - BMP reduction factors of 17 percent (TN) and 22 percent (TP) are applied to acres under nutrient management.

2010 Tier 3 Forest Harvest BMPs

- It is assumed that forestry BMPs designed to minimize the environmental impacts from timber harvesting, such as road building and cutting/thinning operations, are properly installed on all harvested lands with no measurable increase in nutrient and sediment discharge.
- The assumption is based on maintaining the state of forest loads as measured during the calibration of the Chesapeake Bay Watershed Model.

2010 Tier 3 Septic BMPs

- 100 percent of new treatment systems between 2000 and 2010 and 1 percent of existing systems employ denitrification technologies and are maintained through regular pumping to meet an edge-of-septic-field TN concentration of 10 mg/L or 2.3 lbs TN per person-year.
- The 1 percent of existing systems represents failed systems and opportunities for upgrades.
- The remaining existing systems are at current edge of septic field concentrations and flows per system.
- Septic BMPs incorporate submissions from the Chesapeake Bay-basin jurisdictions of the current number of systems employing denitrification technologies (50 percent TN reduction) and those with regular maintenance through pumping (5 percent TN reduction).

2010 Tier 3 Point Source BMPs

- Tier 3 Significant municipal wastewater treatment facilities
  - Nitrogen – All significant POTWs are at 2010 projected flows and reach and maintain effluent concentrations of 5 mg TN/L (annual average) including those facilities that planned to go to NRT by 2010.
  - Phosphorus – POTWs are at 2010 projected flows and reach and maintain effluent concentrations of 0.5 mg TP/L (annual average) or the permit limit, whichever is less.
- Tier 3 Significant industrial dischargers
  - 2000 flows and generally maintain effluent concentrations that are 80 percent less that those in Tier 1 or the permit limit, whichever is less.
- Tier 3 Non-significant municipal wastewater treatment facilities
  - 2000 TN and TP effluent concentrations applied to 2010 projected flows.

2010 Tier 3 Combined Sewer Overflow BMPs

- There is a 43 percent reduction in the current discharge from District of Columbia combined sewer overflows, the only CSO loads among all jurisdictions for which the Chesapeake Bay Program has nutrient load data specifically quantified in the model simulation.
- The reduction from 2000 loads is what is expected by the District of Columbia to be achieved by 2010.

2010 Tier 3 Atmospheric Deposition BMPs

Atmospheric deposition under the Tier 3 scenario reflects existing regulatory nitrogen oxide emissions controls under the 1990 Clean Air Act, as well as more aggressive but voluntary emissions controls on the utility sector, projected for the year 2020. Estimated changes in deposition for the Tier 3 scenario reflect the following controls on nitrogen oxide emissions:

- 2020 non-utility (industrial) point source and area source emissions with no additional controls than Tiers 1 and 2.
- 2020 mobile source emissions with the effect of the Tier II tail pipe standards on light duty vehicles being felt, and the implementation of the heavy duty diesel standards to further reduce NO_x emissions. Same as Tier 2 controls.
- 2020 utility emissions with major (90 percent) reductions in SO_2 and aggressive 20-state NO_x SIP call reductions through utilities going to 0.10 lbs/MMbtu for the entire year—no longer just seasonal.

The impacts of emissions and deposition to the Chesapeake Bay watershed's land area and non-tidal waters under the Tier 3 scenario are part of the reported nutrient loads from the individual landuse source categories (i.e., agriculture, urban, mixed open, forest, and non-tidal surface waters). The reported loads, however, usually do not include contributions from atmospheric deposition to tidal waters although the water quality responses, as measured by the Water Quality Model, account for this source at levels prescribed by the Tier 3 scenario.

2010 Tier 3 Shoreline Erosion BMPs

- Tier 3 shoreline erosion controls include structural and non-structural practices at 2000 levels.

The impacts of Tier 3 shoreline erosion controls are not included in the reported Watershed Model loads although the water quality responses, as measured by the Water Quality Model, account for this source at BMP levels prescribed by the Tier 3 scenario.

2010 E3 SCENARIO

BMP implementation levels in the tier scenarios were bounded by for the E3 scenario. The E3 scenario was specifically designed to take out most of the subjectivity surrounding what can or cannot be achieved in control measures. The E3 scenario BMP implementation levels were, in part, based on earlier work of the Chesapeake Bay Program partners when a 'limit-of-technology' condition was assessed by the Tributary Strategy Workgroup. However, the E3 scenario is less subjective than the limit-of-technology scenario in terms of maximum implementation levels. The BMP levels in the E3 scenario are theoretical: there are no cost and few physical limitations to implementing BMPs for point and nonpoint sources. In addition, the E3 scenario includes new BMP technologies and programs that are not currently part of jurisdictional pollutant control strategies.

For most nonpoint source BMPs, the workgroups assumed that the load from every available acre of the relevant land area was being controlled by a full suite of existing or innovative practices. In addition, management programs convert landuses from those with high-yielding nutrient and sediment loads to those with lower. For point sources in the E3 scenario, municipal wastewater treatment facilities reach and maintain effluent concentrations of 3 mg TN/L, and at least 0.1 mg TP/L, through technologies such as deep bed denitrification filters and micro-filtration.

The E3 scenario scenario implementation levels and their associated reductions in nutrients and sediment were developed without consideration of site specific physical constraints, costs, or even plausible BMP program participation levels. The Chesapeake Bay Program partners acknowledge that if these factors are considered, several aspects of the E3 scenario could not be achieved. On the other hand, there are some control measures in the E3 scenario that physically could be more aggressive. The E3 scenario conditions for these BMPs were established because a theoretical maximum implementation level would have been entirely subjective.

BMP implementation levels for the E3 scenario are described in detail below for the major source categories—agriculture, urban and mixed open, point sources, septic, and atmospheric deposition.

Physical Limitations to the E3 Scenario

In all appropriate circumstances, BMP implementation levels in the E3 scenario were applied to all relevant landuse areas or current limits-of-technology. In many cases and to remove the subjectivity in determining human-caused conditions that cannot be remedied, there were no physical limitations to employing the practices or programs.

For many BMPs, the E3 scenario implementation levels could not be physically achieved. For example, space may not be available for 50-foot riparian buffers in urban areas, or certain developed lands may not allow for retrofitting with practices that attain pollutant reduction efficiencies used in the E3 scenario. As other examples, certain crop types cannot be conservation-tilled, and it may be physically impossible to completely eliminate runoff from animal feeding operations.

It is also unlikely that every homeowner and farmer would efficiently apply fertilizers so that only the needs of the vegetation are met and that water-front property owners would plant 50-foot buffers even if it were physically possible. As a whole, 'feasible' participation levels are not built into the E3 scenario. All of the above-mentioned instances are examples of where the E3 scenario may overestimate reductions.

Underestimations of Load Reductions under the E3 Scenario

Contrarily, there are assumptions in the E3 scenario where BMP implementation levels could physically be even higher than those currently defined in the E3 scenario. For example, it is physically possible that more than 25,000 acres of cropland and hay in Chesapeake Bay watershed could be restored to wetlands. This limit on wetland acres restored in the E3 scenario in Pennsylvania, Maryland and Virginia was used to reflect the *Chesapeake 2000* goal since a theoretical maximum implementation level for wetlands restoration would be entirely subjective.

As an other example, 25 percent of cropland was replaced with long-term grasses that serve as a carbon bank and could be converted to energy through combustion. Benefits of a carbon sequestration program, in terms of lower pollutant loads, would increase as more agricultural land is converted. Conversion of more than 25 percent of cropland is physically possible. In addition, the 30 percent reduction in urban sprawl over a decade could be physically set at a higher level. This rate was employed in the E3 scenario to adhere to a *Chesapeake 2000* goal.

The E3 scenario only includes shoreline erosion controls at current levels for lack of a 'maximum' limit that would not be entirely subjective. It has been demonstrated through modeling efforts that additional controls of shoreline erosion can significantly improve tidal water quality. In general, much opportunity exists for reducing sediment and nutrient loads from eroding shorelines that would not be reflected in the E3 scenario water quality model results.

If greater BMP implementation levels than those designated in the E3 scenario could be physically achieved for any BMPs, pollutant loadings would decrease and the there would be corresponding improved responses in water quality. For the most part, however, the E3 scenario does not include real physical limitations to BMP implementation or participation levels.

2010 E3 Agricultural BMPs

- The E3 scenario conservation tillage
  - All cropland (high-till and low-till) is conservation-tilled
  - Landuse conversion of high-till to low-till.
- The E3 scenario riparian forest buffers on agriculture
  - 100-foot forest buffers on all un-buffered stream miles (each side) associated with crop, hay, and pasture.
  - Landuse conversion of low-till, hay, and pasture to forest.
  - For every acre of low-till and hay converted, two upland acres of low-till and hay receive a reduction of 57 percent (TN), 70 percent (TP), and 70 percent (SED).

  - There is no upland benefit associated with forest buffers on pasture.
- The E3 scenario wetland restoration
  - In accordance with the *Chesapeake 2000* agreement, 25,000 acres of crop and hay in PA, MD, and VA are converted to and simulated as forest.
  - The 25,000 acre restoration goal is allocated among these states as follows to conform to agreements subsequent to *Chesapeake 2000*: PA = 4,250 acres, MD = 15,000 acres, and VA = 5,750 acres.
- The E3 scenario agricultural land retirement
  - The remainder of 25 percent of the total crop and hay acres and those acres converted through forest buffers and wetland restoration is retired to a grass condition.
  - Landuse conversions of low-till and hay to mixed open.
- The E3 scenario carbon sequestration/bio-energy
  - 25 percent of crop acres (after BMP landuse conversions) are replaced with long-term grasses that serve as a carbon bank and could be converted to energy through combustion.
  - Landuse conversion of low-till to hay.
- The E3 scenario yield reserve program
  - All crop and hay acres (after BMP landuse conversions) receive 25 percent less TN and TP than normal nutrient management applications - Do not receive more than 98 percent of TN and TP need.
  - Yield reserve program assumes farmer insurance for yield losses.
- The E3 scenario manure excess
  - Excess nutrients resulting from the differences between manure generated and conforming to yield reserve (nutrient management) rules and losses in agricultural land are reported.
  - It is assumed that all of the excess manure has alternative uses that do not affect loads to the Chesapeake Bay tidal waters.
- The E3 scenario animal waste management/runoff control
  - There is no runoff from manure in animal feeding operations.
  - Modeled landuse acres that account for runoff from animal feeding operations are converted to pasture.
  - Landuse conversion of manure acres to pasture.
- The E3 scenario Farm Plans (non-nutrient management)
  - Farm Plans are fully implemented on all agricultural land (crop, hay, and pasture).
  - Nutrient and sediment reduction factors for Farm Plans on low-till and hay are 4 percent (TN) and 8 percent (TP and SED). Pasture reduction factors are 20 percent (TN) and 14 percent (TP and SED).
- The E3 scenario cover crops
  - All crop landuses have cover crops.
  - BMP reduction factors of 35 percent (TN) and 15 percent (TP and SED) are applied to all low-till.
- The E3 scenario streambank protection with fencing
  - Streambank protection with fencing on all unprotected stream miles (each side) associated with pasture.
  - For every stream mile protected, 51 upland acres of pasture receive a reduction of 75 percent for TN, TP and SED.

- The E3 scenario grazing land protection
  - All pasture land is protected through rotational grazing.
  - BMP reduction factors of 50 percent (TN) and 25 percent (TP) are applied.

2010 E3 Scenario Urban and Mixed Open BMPs

- The E3 scenario reduction in 2000–2010 urban growth
  - 30 percent of the projected pervious and impervious urban growth in PA, MD, VA, and DC between 2000 and 2010 remains in forest to conform to the *Chesapeake 2000* agreement.
  - It is assumed that the reduction in projected urban growth in PA, MD, VA, and DC over the decade is retained or planted in forest.
  - Landuse conversions of pervious and impervious urban to forest.
- The E3 scenario environmental site design/low-impact development on new development
  - Environmental site design/low-impact development practices applied to all urban growth between 2000 and 2010.
  - Environmental site design and low-impact development practices are designed to reduce TN by 50 percent, TP by 60 percent, and SED by 90 percent.
- The E3 scenario stormwater retrofits on existing urban
  - All pre-2001 urban areas are retrofitted with a suite of practices to reduce nutrients and sediment in stormwater runoff by 40 percent (TN), 40 percent (TP), and 80 percent (SED).
- The E3 scenario riparian forest buffers on urban
  - 50-foot forest buffers on all un-buffered stream miles (each side) associated with pervious urban.
  - Landuse conversion of pervious urban to forest.
  - There is no upland benefit associated with forest buffers on urban.
- The E3 scenario riparian forest buffers on mixed open
  - 100-foot forest buffers on all un-buffered stream miles (each side) associated with mixed open.
  - Landuse conversion of mixed open to forest.
  - There is no upland benefit associated with forest buffers on mixed open.
- The E3 scenario nutrient management on urban and mixed open
  - All pervious urban and mixed open acres do not receive nutrient applications from chemical fertilizers.

2010 E3 Scenario Forest Harvest BMPs

- It is assumed that forestry BMPs designed to minimize the environmental impacts from timber harvesting, such as road building and cutting/thinning operations, are properly installed on all harvested lands with no measurable increase in nutrient and sediment discharge.
- The assumption is based on maintaining the state of forest loads as measured during the calibration of the Chesapeake Bay Program Watershed Model.

2010 E3 Scenario Septic BMPs

- All septic systems employ denitrification technologies and are maintained through regular pumping to meet an edge-of-septic-field TN concentration of 10 mg/L or 2.3 lbs TN per person-year.

2010 E3 Scenario Point Source BMPs

- The E3 scenario significant municipal wastewater treatment facilities
  - Nitrogen –POTWs are at 2010 projected flows and reach and maintain effluent concentrations of 3 mg TN/L (annual average).
  - Phosphorus –POTWs are at 2010 projected flows and reach and maintain effluent concentrations of 0.1 mg TP/L (annual average).
- The E3 scenario significant industrial dischargers
  - Nitrogen – 2000 flows and effluent concentrations of 3.0 mg TN/L (annual average) or the permit limit, whichever is less.
  - Phosphorus – 2000 flows and effluent concentrations of 0.1 mg TP/L (annual average) or the permit limit, whichever is less.
- The E3 scenario non-significant municipal wastewater treatment facilities
  - Nitrogen – POTWs are at 2010 projected flows and reach and maintain effluent concentrations of 8 mg TN/L (annual average).
  - Phosphorus –POTWs are at 2010 projected flows and reach and maintain effluent concentrations of 2.0 mg TP/L (annual average) or 2000 concentrations, whichever is less.

2010 E3 Scenario Combined Sewer Overflow BMPs

- There is no discharge from DC combined sewer overflows, the only CSO loads among all jurisdictions for which the Chesapeake Bay Program has nutrient load data specifically quantified in the model simulation.

2010 E3 Scenario Atmospheric Deposition BMPs

Levels of atmospheric deposition in the E3 scenario reflect existing regulatory nitrogen oxide emissions controls under the 1990 Clean Air Act, as well as more aggressive but voluntary emissions controls on the utility, industrial, and mobile source sectors, projected for the year 2020. Estimated changes in deposition for the E3 scenario reflects the following controls on nitrogen oxide emissions:

- 2020 non-utility (industrial) point source emissions cut almost in half for both SO_2 and NO_x.
- 2020 area source emissions that are the same as the Tier 1-3 scenarios.
- 2020 mobile source emissions assuming super ultra-low emissions for light duty vehicles and heavy duty diesel standards to further reduce NO_x emission beyond Tier 2 and Tier 3.
- 2020 utility emissions with major (90 percent) reductions in SO_2 and aggressive 20-state NO_x SIP call reductions through utilities going to 0.10 lbs/MMbtu for the entire year—same as Tier 3 controls.

The impacts of emissions and deposition to the Chesapeake Bay watershed's land area and non-tidal waters under the E3 scenario are part of the reported nutrient loads from the individual landuse source categories (i.e., agriculture, urban, mixed open, forest, and non-tidal surface waters). The reported Watershed Model loads, however, usually do not include contributions from atmospheric deposition to tidal waters although the water quality responses, as measured by the Estuary Model, account for this source at levels prescribed by the E3 scenario.

2010 E3 Scenario Shoreline Erosion BMPs

- The E3 scenario shoreline erosion controls include structural and non-structural practices at 2000 levels.

The impacts of the E3 scenario shoreline erosion controls are not included in the reported Watershed Model loads although the water quality responses, as measured by the Estuary Model, account for this source at BMP levels prescribed by the E3 scenario.

BAY-WIDE LOADS FOR 2000, TIERS 1 TO 3, AND E3 Scenario

Figures A-1 through A-3 depict modeled Chesapeake Bay-wide nutrient and sediment loads delivered to the Chesapeake Bay and its tidal tributaries by major source category for each of the tier scenarios as well as the E3 scenario. As references, the estimated loads for the year 2000 are also portrayed.

The delivered loads are a yearly average of loads simulated over a 10-year period (1985–1994). This convention removes considerations of the effects of variable precipitation levels or flows on loads. Also, nutrient loads are reported in units of million pounds per year while sediment fluxes are in million tons per year.

Load reductions through the tiers to the E3 scenario show the impact of most point and nonpoint source BMPs in the scenarios as described previously in this Appendix. Atmospheric deposition to the Chesapeake Bay watershed's land area and non-tidal waters are part of the reported loads, but the loads do not include contributions from atmospheric deposition to tidal waters. In addition, the reported loads do not reflect shoreline erosion controls employed in the scenarios. The water quality responses as measured by the Watershed Model, however, account for both atmospheric deposition to tidal waters and shoreline erosion at levels prescribed by the tier and E3 scenarios.

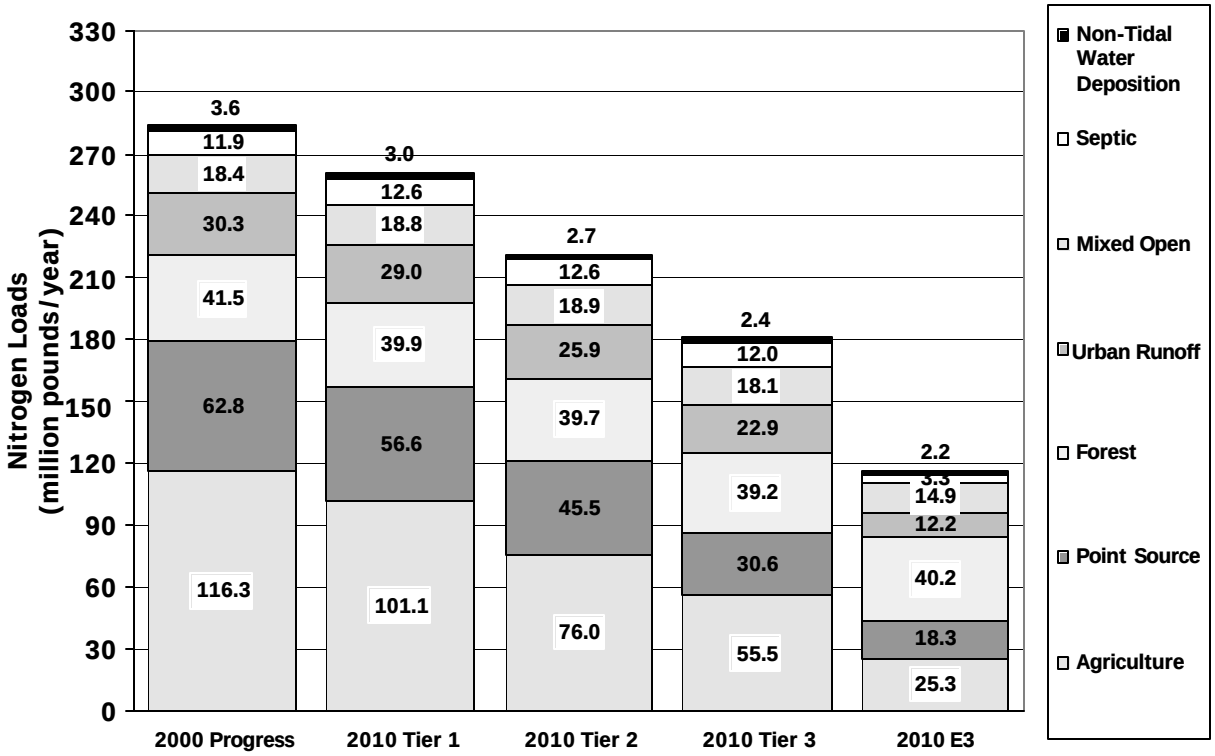

Figure A-1. Nitrogen loads delivered to the Chesapeake Bay and its tidal tributaries by source.

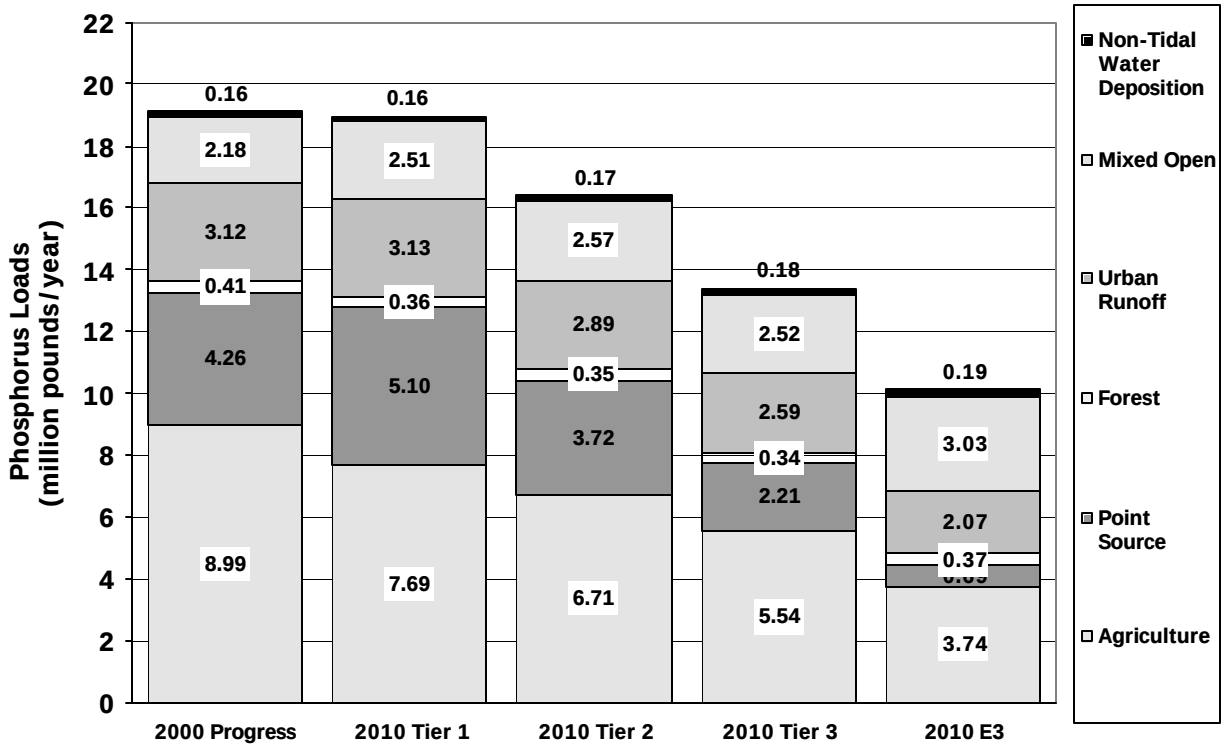

Figure A-2. Phosphorus loads delivered to the Chesapeake Bay and its tidal tributaries by source.

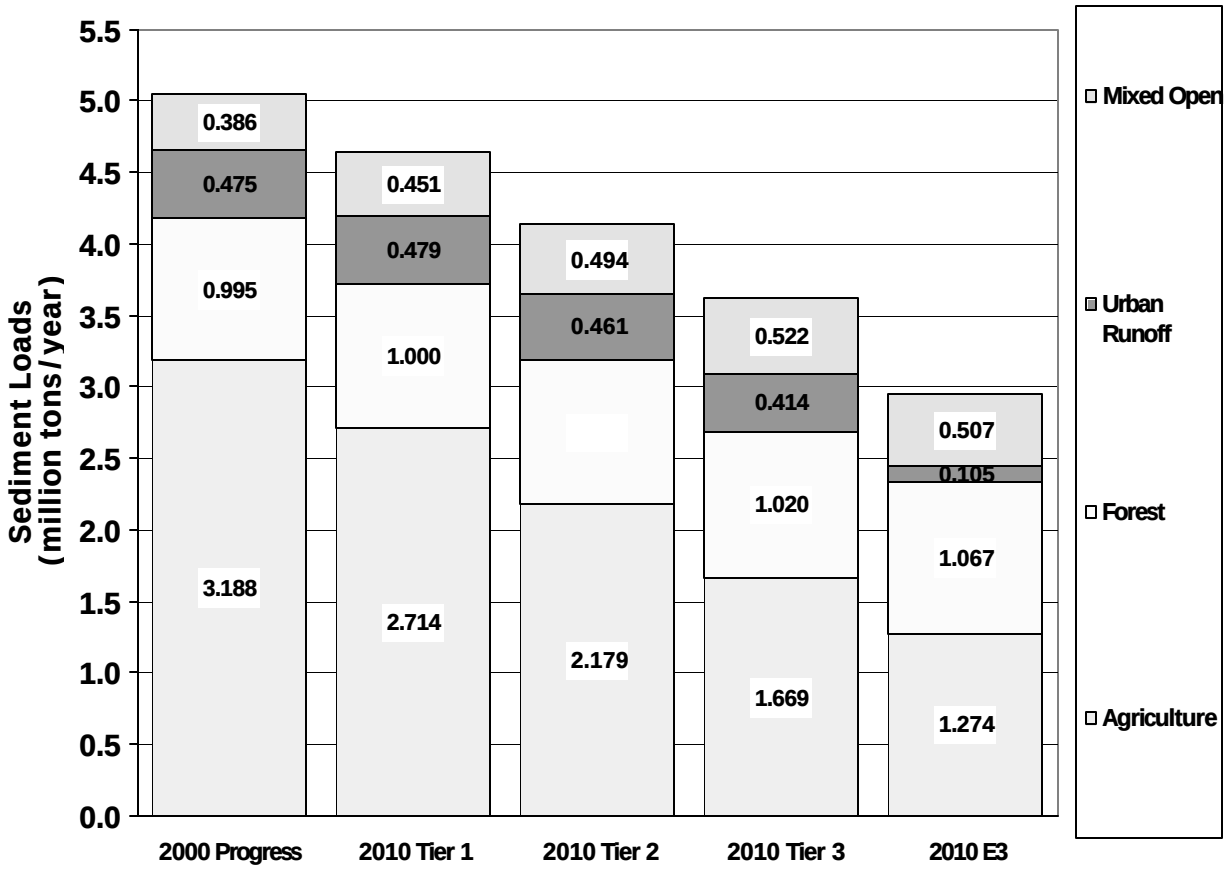

Figure A-3. Sediment loads delivered to the Chesapeake Bay and its tidal tributaries by source.

It is important to note that landuses and animal populations change considerably between 2000 Progess and the tier and E3 scenarios, which are based on projected 2010 landuses and populations. Therefore, nutrient applications to agricultural land change considerably over the decade. Also, the number of septic systems and the flows from municipal wastewater treatment facilities shift dramatically from 2000 to 2010 based on an increasing population. For example, point source phosphorous loads increase from 2000 to 2010 Tier 1 because of increases in POTW flows which, unlike nitrogen, are not offset by technologies to reduce this nutrient in effluents.

In addition to changes between 2000 and 2010 tier and E3 scenarios, it is imperative to consider landuse changes among the tier and E3 scenarios due to increasing non-point source BMP implementation levels. For example, sediment loads from forested land increase through the tier to E3 scenarios because the land area increases as, for example, more and more riparian buffers are planted on agricultural and urban land. In addition, increases in loads from mixed open land is attributable to greater acreage in this category as, for example, agricultural land is retired.

INFLUENCE OF EMISSION CONTROLS AND ATMOSPHERIC DEPOSITION ON LOADS

The impacts of emission controls and the resultant lower atmospheric deposition to the Chesapeake Bay watershed's land area and non-tidal waters are part of the reported nutrient loads from the individual landuse source categories in the tier and E3 scenarios (i.e., agriculture, urban, mixed open, forest, and non-tidal surface waters). As mentioned previously, the reported loads however, usually do not include contributions from atmospheric deposition to tidal waters although the model simulated tidal Bay water quality responses account for this source.

To estimate the effects of only the tier and E3 scenarios air emission controls—without the influences of other point and non-point source BMPs—the following histogram (Figure A-4) show changes in atmospheric deposition of nitrogen to the watershed's land area and non-tidal waters, and the response in delivered loads. In these model simulations, all land uses, fertilizer applications, point sources, septic loads, and BMP implementation levels were held constant at 2000 conditions; only atmospheric deposition varied.

What these scenarios say is that "If projected emission and deposition reductions associated with the tiers and E3 scenarios were realized today (2000), loads to the Chesapeake Bay and its tidal tributaries are estimated to be the following." As references, Tier 1 and Tier 2 scenario loads delivered from the watershed are shown in the graphics.

As can be seen in Figure A-4, atmospheric deposition to the watershed progressively declines from 2000 through the tier to E3 scenarios as more emission controls are included in the model simulation. But note how the loads from the watershed's land area and non-tidal waters respond to these progressive emission and deposition reductions, but to a much smaller degree.

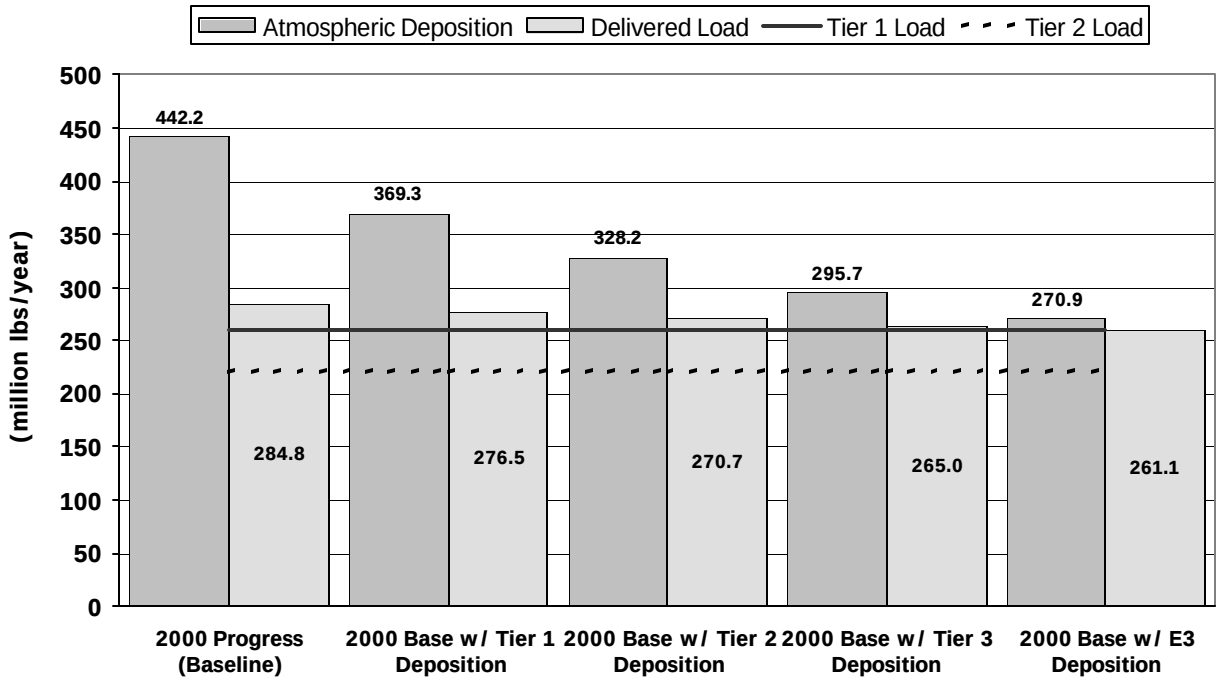

Figure A-4. Nitrogen deposits versus delivered loads.

The most significant reason for the dampened response is that the Chesapeake Bay watershed is about 57 percent forested—or 57 percent of atmospheric nitrogen deposits on forests—and among landuses, forests have the greatest potential to uptake nitrogen. Generally, forests in the Chesapeake Bay basin are not nitrogen-saturated—whereby they leak nitrogen to sub-surface or ground water.

The largest single source of nitrogen loads to the Chesapeake Bay is agriculture where nitrogen-based commercial fertilizers and animal manure applied to agricultural land are currently eight times the input of nitrogen to agricultural land from atmospheric deposition.

It is the impacts of emission controls on loads that are important in evaluating water quality responses, the development of a cost estimating tool, and the establishment of tributary strategies—rather than the contribution to loads from atmospheric deposition. Understanding the loading responses to changes in deposition better addresses to what degree the loads can be controlled. The proportion of the loads attributed to atmospheric deposition changes dramatically from 2000 through the tiers and E3 scenarios because of both variable emission controls and changes in landuses that the atmospheric nitrogen is deposited to.

In the most dramatic case, deposition of nitrogen to the watershed decreases 171 million pounds/year from the 2000 Progress to 2010 E3 Scenarios. If this reduction in deposition were realized today, (i.e., deposition was to 2000 landuses with all other present conditions), nitrogen loads to the Chesapeake Bay would decrease 21 million pounds/year or would be at levels associated with the Tier 1 scenario.

It is important to note that the E3 scenario levels of emission controls are considered to be the current limits of technology with aggressive controls on all major sources - utilities, mobile, and industrial - and follow the format of defining the E3 scenario BMPs. It is not important that these emission controls would be voluntary, as opposed to regulatory, as the E3 scenario implementation levels for almost all other point and nonpoint source BMPs did not consider physical limitations, participation rates, and costs. In other words, the tier scenarios are not intended to establish what can and cannot be done through management actions - either regulatory or voluntary - as this is the responsibility of Chesapeake Bay watershed jurisdictions. However, the air scenarios involve actions taken by 37 states not just the Chesapeake Bay watershed states.