CORE ENVIRONMENTAL SITE DESIGN PRINCIPLES

For the implementation of the Maryland Stormwater Management Act of 2007

Endorsed by the Stormwater Consortium

1000 Friends of Maryland * Alliance for Sustainable Communities * Anacostia Watershed Citizens Advisory Committee * Anacostia Watershed Society * Assateague Coastal Trust, Assateague Coastkeeper * Audubon Naturalist Society * Baltimore Harbor Waterkeeper * Cecil Land Use Alliance * Chesapeake Bay Foundation * Chesapeake Environmental Protection Association * Chesapeake Stormwater Network * Chesapeake Sustainable Business Alliance * Clean Water Action * Coalition for Smarter Growth * Deer Creek Watershed Association * Environment Maryland Research & Policy Center * Friends of Harford * Friends of Lower Beaverdam Creek * Green Building Institute * Herring Run Watershed Association * Jones Falls Watershed Association * Lower Western Shore Tributary Team * Magothy River Association * Maryland Aquatic Resources Coalition * Krista McKim of McKim Environmental Consulting, LLC * MD League of Conservation Voters * Mid-Atlantic Council of Trout Unlimited * Natural Resources Defense Council * Octoraro Watershed Association * Patapsco River Conservation Association * Patuxent Riverkeeper * Potomac Conservancy * Potomac River Association * Port Tobacco Conservancy * Savage River Association * Severn Riverkeeper * Sierra Club, Maryland Chapter * South Arundel Citizens for Responsible Management (SACRED) * South River Federation * South Riverkeeper * Sportsmens Chapter of Izaak Walton League of America * St Mary's River Watershed Association * Waterkeeper Alliance * West/Rhode Riverkeeper

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I. Why Stormwater Runoff is an Urgent Problem

Low density sprawl development continues to occur throughout the Bay watershed. For example, between 1990 and 2000, Bay population climbed by 8%, but impervious cover climbed by 41%, and turf cover increased by nearly 80%. The rate of land conversion has accelerated since 2000, and it is now estimated that nearly 1% of the entire Bay watershed is being developed each year. Between now and the year 2030, Maryland's population is expected to climb by nearly 17%, which will further increase pavement and turf cover across the State **(1).**

The continuing wave of land development constitutes a major threat to the quality of Maryland streams and the health of the Chesapeake Bay. Consider the following:

- The stream habitat and biological diversity of 10,000 stream miles in the Bay watershed has been degraded by past development, and hundreds more stream miles are at risk from future development **(2).** Urban stormwater runoff has been directly linked to major stream degradation.
- Research has shown major ecological impacts to fish and benthos in small estuaries and coastal creeks in the Bay, with as little as ten percent land development in their watersheds **(2).**
- Urban land constitutes the fastest growing nutrient load source in the Bay watershed. In 1985, developed land produced less than 5% of the nutrient load to the Bay. In 2005, the total nitrogen and total phosphorus load produced by developed land climbed to 19 and 30% of the total load delivered to the Bay, respectively **(2).**
- Developed lands currently produce nearly 20% of the annual sediment load to the Bay, primarily due to urban streambank erosion and construction site runoff **(2).**
- Bacteria levels in urban stormwater runoff routinely exceed water quality standards, and cause closure of streams, beaches and shellfish harvesting areas after significant rains throughout much of the watershed **(3).**
- Pesticides have been detected in 95% of urban streams and fish tissues sampled, and stormwater runoff from urban lands has created a distinct pollution signature in the sediment layer of the Bay estuaries, a mix of metals, PCBs and hydrocarbons **(3).**

II. What Exactly is Environmental Site Design?

The goal of environmental site design (ESD) is to mimic natural systems as rain travels from the roof to the stream through combined application of a series of practices throughout the entire development site. The objective of ESD is to replicate forest hydrology and water quality following land development. ESD practices are considered at the earliest stage of site design, implemented during construction and sustained in the future as a low maintenance natural system. Each ESD practice incrementally reduces the volume of stormwater on its way to the stream, thereby reducing the amount of conventional stormwater infrastructure required. Although the feasibility of individual ESD practices must be assessed for each site, research and experience in Maryland and elsewhere indicates that ESD practices as a group perform better, are more cost effective, have lower maintenance burdens, and are more protective during extreme storms than conventional stormwater practices **(4).** For a residential “green-field” setting, ESD involves a combination of practices implemented from the roof to the stream, as shown in Table 1.

Table 1: From the Roof to the Stream: ESD in a Residential Context

What it Is	What it Replaces	How it Works
Early ESD Site Assessment	Doing SWM design after site layout	Map and plan submitted at earliest stage of development review showing environmental, drainage and soil features **(5)**
Maximize Forest Canopy	Mass clearing	Preservation of priority forests and reforestation of turf areas to intercept rainfall (**6)**
Conserve Soils and Contours	Mass grading and soil compaction	Construction practices to conserve soil structure and only disturb a small site footprint **(6)**
Minimize Impervious Cover	Large streets, lots & cul-de-sacs	Narrower streets, permeable driveways, clustering lots and others reduce site IC **(7)**
Utilize Rooftop Runoff	Direct connected roof leaders	A series of practices to capture, disconnect, store, infiltrate or re-use rooftop runoff **(8)**
Front Yard Bioretention	Positive drainage from roof to road	Grading front yard to treat roof, lawn and driveway runoff using shallow bioretention **(9)**
Dry Swales	Curb/gutter and storm drain pipes	Shallow, well-drained bioretention swales located in the street right of way (**10)**
Linear Wetlands	Large detention ponds	Long, multi-cell, forested wetlands located in the stormwater conveyance system **(11)**
Stream Buffer Management	Un-managed stream buffers	Active reforestation of buffer and restoration of degraded streams **(12)**
Note. ESD Practices are applied in a series, although all of the above may not be needed at a given residential site. Alternative ESD practices and credits may also be used. This “roof to the stream” approach works best for residential development less than 40% IC		

The same basic “roof to stream approach” also works for more intensely developed commercial, ultra-urban and redevelopment projects, although the precise combination of ESD practices is different and somewhat more flexible (see Table 2). For example, ESD may involve building watershed restoration practices to enhance water quality in existing urbanized watersheds. In this manner, ESD practices are consistent with smart growth and urban redevelopment projects and enhance the benefits they provide.

Table 2: Modification of ESD Practices for Commercial Areas and Urban Watersheds	
ESD Prescription in Commercial Areas	**ESD Prescription for Urban Areas (13)**
• Pollution prevention practices • Green rooftops • Cisterns • Foundation planters • Smaller, green parking lots • Permeable pavers • Bioretention in landscaping setbacks • Sand filters for hotspots • Dry swales • Landscaping practices • Stormwater hotspot management and enforcement	• Restoring natural area remnants • Pollution prevention practices • Compost-amended soils • Impervious cover removal • Permeable pavers • Green roofs and cisterns • Foundation planters • Expanded tree pits • Street bioretention • Underground filters • Stormwater retrofits • Reforestation/restoration of stream corridor
The exact combination of ESD practices used depends on site and subwatershed conditions	

III. How ESD Has Evolved in Maryland

Maryland has been a national leader in stormwater management over the last two decades, although it is now recognized that a more aggressive approach is urgently needed to protect our streams from the impacts of expected future land development in the State. Research and experience has also proven that widespread use of ESD practices is an effective and economical way to mitigate the many impacts of land development. Regrettably, progress in adopting ESD practices has been slow over the last decade. In response, the State legislature passed the Stormwater Management Act of 2007 (HB 786); a summary of the key provisions of this landmark legislation is provided in Table 3.

A Consortium of watershed, environmental and advocacy groups in Maryland representing watersheds in the Chesapeake Bay, the Atlantic Coastal Bays, and the Ohio River Basin in Garrett County have worked for six months to develop an effective strategy to implement the Act. To this end, the Consortium have worked together to craft a core list of principles to effectively implement the intent of the Act (see Table 4). The recurring theme among the principles is to create more accountability at the site, local and state level to increase the speed by which ESD practices are applied at development sites.

While the principles will require a major shift in how land is developed, the Consortium believes the principles are scientifically sound, cost-effective and workable on the ground. Further, the Consortium contends that the range of ESD practices offered are feasible for the wide variation in soils, geology, terrain, vegetation, hydrology and development intensity encountered across the State **(15).**

Table 3: The Stormwater Management Act of 2007 at a Glance (14)
The 2007 Maryland Stormwater Act defines Environmental Site Design as: 1) Using small-scale stormwater management practices 2) Nonstructural techniques 3) Better site planning In order to mimic natural hydrological runoff characteristics and minimize the impact of land development on water resources. The Act further defines ESD as: 1) Optimizing the conservation of natural features 2) Minimizing the use of impervious surfaces 3) Slowing down runoff to maintain discharge timing and to increase infiltration and evapotranspiration 4) Using other nonstructural practices or innovative stormwater management techniques approved by the Department. The Act directs MDE, in consultation with DNR and stormwater stakeholders, to revise regulations and manual to: • Implement ESD to the maximum extent practicable (MEP) • Include both new development and redevelopment • Maintain 100% of average annual predevelopment groundwater recharge volume for the site • Review and modify, if necessary, local planning, zoning or public works ordinances to remove impediments to ESD implementation. • Requires developers demonstrate that a) ESD has been implemented to the MEP; b) Standard BMPs have been used only where absolutely necessary.

The Consortium recognizes that implementation of the Act must be integrated with and strengthen related State stormwater regulations, such as the construction general permit, industrial stormwater permits, the Erosion and Sediment Control Act, and the issuance or renewals of municipal Phase 1 and Phase 2 NPDES stormwater permits. Lastly, the Consortium fully understands that the implementation of ESD practices at the site level needs to be fully integrated and consistent with other protection and restoration requirements and recommendations contained within local and/or State watershed plans (**16**).

Over the last three months, the Consortium has solicited and received extensive feedback from more than 250 scientists, engineers, planners, citizens, public works officials and developers directly and during a series of three workshops. Based on this feedback, the Consortium has systematically revised the core principles to ensure they represent the most workable and cost-effective approach to protect aquatic resources in the State. The Consortium encourages Maryland stormwater stakeholders to embrace these core principles, work with MDE to incorporate them into new regulations, model ordinances, manuals and/or permits, and become early ESD adopters in their own community.

Table 4: Core ESD Principles at a Glance	
Site Analysis and Design	
1	Increase Onsite Runoff Reduction Volumes
2	Require a Unified Early ESD Map
3	Establish Nutrient- Based Stormwater Loading Criteria
4	Apply ESD Techniques to Redevelopment
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13	Implement ESD Training, Certification and Enforcement

IV. Core Principles Relating to Site Assessment and Design

Principle 1: Increase Onsite Runoff Reduction Volumes. The regulations and the manual should define an operational runoff reduction volume to ensure that sites mimic predevelopment hydrology and recharge, as specified in the Act. The current sizing criteria should be modified to require runoff reduction of the full difference between the predevelopment and post development one-year, 24 hour runoff volume. The means of computing the runoff reduction volume, and the sequential approach for achieving it through runoff prevention, impervious cover minimization, runoff reduction and conventional stormwater treatment at individual sites are detailed in Note **17**. Runoff reduction means reducing the annual runoff volume from a site through a combination of infiltration, evaporation, water reuse, extended filtration or evapotranspiration (**18**).

More stringent recharge and runoff reduction requirements are needed to drive designers and plan reviewers to maximize use of ESD practices, and reduce reliance on large detention ponds. While the 2000 regulations instituted a modest recharge requirement, it is not sufficient to meet hydrological objectives for runoff reduction, and provides few incentives to maximize the role of natural vegetation and intact soils to absorb and attenuate stormwater. The Consortium understands that the shift from the current sizing criteria to the runoff reduction approach will require improved engineering models to account for and verify the progressive reductions in runoff volume that are achieved by individual ESD practices used in a series. Several existing models have been developed for this purpose in other states that need to be adapted for Maryland conditions. The manual will need to reference the modified computational procedure to document compliance with the proposed runoff reduction requirements, outline minimum site soil testing requirements and present minimum specifications for vegetation and soil protection and recovery. Since recharge and infiltration techniques can be challenging at some urban redevelopment projects, the expanded definition of runoff reduction provides greater flexibility to achieve compliance at difficult sites.

Principle 2: Require a Unified Early ESD Map. The regulations should require a unified ESD map and plan at time of earliest development plan concept design to ensure ESD practices are incorporated into initial site layout.

ESD works best when it is considered early in the design process and is fully integrated with site design and protected environmental features. The basic idea is to integrate all state and local environmental development regulations into a single ESD package (e.g., stormwater, erosion and sediment control, forest conservation, buffers) and add new site mapping requirements to delineate recharge areas and zero order streams. The goal is to ensure every site planning, resource protection and environmental site design opportunity is fully considered from the beginning of the site design process. The unified map would be submitted at the earliest stage of local development approval. The ESD plan and map would be publicly available throughout the design review process, and any amendments or changes would constitute a special exception. The regulations, ordinance and manual should outline the specific minimum features to be shown on the plan and map, including:

- Mapping of the existing topography, drainage features and stream network (including zero-order streams)
- Site footprint including impervious cover, turf cover and forest cover
- On-site soil testing to identify priority infiltration, recharge and soil conservation areas
- Designation of whether the site is located in a special watershed or receiving water, or is designated as a stormwater hotspot **(19)**
- Location of any stream, shoreline or wetland buffers, wetlands, steep slopes, forest conservation areas and proposed reforestation areas
- Initial nutrient load reduction computations for the ESD treatment train used at the site
- Integration of any recommendations or requirements from a locally developed watershed protection or restoration plan

Local plan reviewers would conduct a coordinated review of both the stormwater and erosion and sediment control concept plans at this early stage of development review. The updated manual should include a sample ESD plan and several site design examples that show how the various elements of ESD can be integrated to comply with regulations.

Principle 3: Establish Nutrient- Based Stormwater Loading Criteria. The stormwater regulations, ordinance and manual should contain specific and numeric performance criteria to assure the aggregate nutrient load delivered to the Chesapeake Bay, Atlantic Coastal Bays and other waters of the State from urban development is actually reduced over time. The regulations should establish a post-development phosphorus load limit of 0.25 lb/acre/yr for low and moderate density residential development and a 2.5 lbs/acre/year limit on total nitrogen load for all other forms of development.

The current manual does not contain accountability mechanisms to ensure development projects really meet watershed objectives to protect the Chesapeake Bay, the Atlantic Coastal Bays and other State waters **(20).** Stormwater science has evolved enough in recent years so that numeric stringent performance standards can be defended and achieved.

The site-based nutrient load requirement effectively does four things. First, it directly links performance at individual development sites to water quality objectives for the Chesapeake Bay, the Atlantic Coastal Bays, and other State waters. Second, the nutrient load requirement is so stringent that it cannot be met unless a maximum effort is made to incorporate ESD at most sites. Third, it sets forth a defensible and scientific standard for the performance of ESD and stormwater practices, which until now has been lacking **(21).** Lastly, it meets the intent of HB 786 to "minimize pollutants in stormwater runoff" and to encourage "watershed-wide analysis to prevent undesirable downstream effects of increased runoff." What it does <u>not</u> do is impose stormwater nutrient monitoring requirements on individual development sites.

Operationally, developers would have to compute their excess nutrient load after development, demonstrate how ESD practices would reduce these loads and demonstrate compliance with an on-site stormwater treatment train. The computational method for determining nutrient removal rates would be outlined in the stormwater manual, and would be reviewed and verified by the local stormwater plan reviewer.

A stormwater phosphorus load reduction requirement has been in place in the MD Critical Area for nearly a decade **(22).** The proposed new requirement would apply statewide, and is similar to proposed nutrient stormwater regulations under consideration in the Commonwealth of Virginia. The updated manual should contain a simple and verifiable computational system for nutrient reduction to document compliance at every development site. Such a system is being developed in Virginia which could be quickly implemented in Maryland with minor modifications.

Principle 4: Environmental Site Design Applies to Redevelopment. The new regulations should apply the same runoff reduction volume and ESD site assessment methods that apply to development to redevelopment projects (**23**).

Many ESD practices exist that can be applied to a diverse range of redevelopment conditions. The manual should provide technical guidance, design examples and case studies to assist the design community to choose the most cost-effective and appropriate combination of ESD practices for redevelopment projects. In addition, MDE should identify grant opportunities and other incentives to demonstrate effective use of ESD practices at redevelopment projects. In the rare event that a designer can demonstrate that compliance with the on-site runoff reduction requirement is not physically feasible in whole or in part for an individual site, developers should be required to pay a corresponding fee-in-lieu to finance equivalent runoff reduction, stormwater treatment or restoration elsewhere in the same watershed (**24**).

Development forecasts for the next two decades indicate that as much as ten percent of existing developed land will be redeveloped in the State of Maryland. This represents an outstanding opportunity to improve the quality of streams already degraded by past development, and achieve actual pollutant reductions in urban watersheds. Numerous cities including the District of Columbia, Philadelphia and Los Angeles have recently revised their stormwater regulations to achieve greater compliance at redevelopment sites, while still offering flexibility in how it is achieved.

Principle 5: Integrate Erosion and Sediment Control (ESC) and ESD Together at Construction Sites. The new regulations, model ordinance, and manual should set forth requirements for the earliest use of non-structural erosion and sediment control practices from the beginning of the land disturbance process. Such practices should be incorporated into the early ESD map so that it is clear that they extend throughout the actual construction and post development phases. The construction general permit should acknowledge this link and promote maximum use of phasing, avoidance of work on steep slopes, clearing and grading restrictions, preservation of soils, retaining natural vegetative cover and trees and rapidly stabilizing soils during construction.

The regulations should require integration of non-structural practices during construction and the post development phase by using site fingerprinting, forested buffer strips, construction phasing, avoiding work on steep slopes, clearing and grading restrictions, preservation of soils, retaining natural vegetative cover and rapidly stabilizing soils during and after construction. Non-structural practices are considered an integral element of Environmental Site Design.

Current stormwater and sediment regulations and manuals tend to emphasize structural solutions at the expense of non-structural ones. Both need to be updated to ensure all site planning opportunities are exhausted before resorting to an engineering solution. Currently, the State ESC regulations and erosion control manual are separate from the stormwater regulations and manual. The updated regulations and manual should contain expanded provisions to:

- Ensure that the limits of disturbance shown on ESC and stormwater plans are inclusive, consistent and prevent disturbance to streams, natural drainage features, stream buffers, soil conservation areas, wetlands, and forest conservation areas during construction
- Ensure that construction equipment and vehicles do not enter areas reserved for future stormwater infiltration or recharge
- Limit site clearing to the minimum needed to accommodate the building and transportation footprint at low density sites
- Specify a minimum site area where construction phasing or sequencing must be used
- Reduce the time period to protect exposed soils through hydro-seeding or mulch
- Require advanced stabilization techniques, such as geotextile erosion control mats and blankets, mulch and turf reinforcement, for soils at high risk for erosion
- Limit clearing on steep slopes
- Establish a maximum upper limit for the upstream drainage area to drain to individual sediment basins or traps and prohibit direct discharge to streams
- Establish a maximum time-frame from when grading begins and construction actually commences
- Decrease the minimum area of land disturbance for which an ESC and stormwater management plan are required
- Establish an upper limit of the number of acres that can be exposed to erosion at any one time.

The Consortium strongly believes that each of these provisions should be supported by numeric performance benchmarks that can be measured and verified at individual construction sites (**25**) and also suggests that a new chapter be added to the stormwater manual on integrating erosion and sediment controls.

V. Core Principles Relating to Implementation

Principle 6: Provide Adequate Financing to Implement the Act and Technical Assistance and Incentives for Early Adopters. The Consortium encourages the State to review the existing stormwater fee system as outlined in Title 2 of the Act to ensure that fees are updated to fully recover local and State costs of implementing the changes, including funds for expanded stormwater research, establishment of an ESD training and certification program, and increased compliance and enforcement staffing. In the short term, the Consortium encourages MDE to allocate funds to hire an outside engineering consultant to help update the manual and regulations.

The Consortium also encourages local stormwater managers and design consultants to become early adopters and reduce the time-frame by which effective ESD and stormwater practices are actually applied on real development projects. The Consortium further recommends that the State offer a blend of technical assistance, incentives, and recognition to motivate local early adopters that go beyond current minimum requirements.

The transition to ESD will require considerable financial and staff resources at the local and State level. The Consortium believes that it is important for the state, localities and other stakeholders to come together to define adequate funding levels to make the full transition to ESD, including research, training, and increased staffing for compliance monitoring and enforcement (**26**). The group should work together to identify funding mechanisms, including permit fees, that can fully support them.

There is a potentially long pipeline before new practices and methods envisioned in the permit, regulations and stormwater manuals actually appear on the ground. The State regulation adoption process, local development review and grandfathered projects may collectively delay the arrival of new practices. Given the urgency of the stormwater problem, it is crucial that local stormwater managers and design consultants become early adopters and work to implement the Core Principles on current development projects as quickly as possible. Early adopters should be rewarded for their leadership through a blend of technical assistance, faster permit approvals, reduced application fees, project recognition and other incentives.

Principle 7: Develop an ESD Ordinance that Truly Changes Local Codes and Culture. The model ESD ordinance should provide specific benchmarks as to what constitutes effective environmental site design practices, as defined by a group of stormwater stakeholders **(27).** The ordinance should also chart a pathway by which local governments are required to define the individual ESD practices they can currently offer and the specific development and redevelopment conditions where they apply within a prescribed time limit. Further, communities should identify the ESD practices they cannot currently offer because they would require a change in local codes, and embark on a process to change them in a timely manner. Reasonable progress in making ESD code changes should be a municipal stormwater permit reporting condition.

Progress in actually changing local codes to promote ESD has been extremely slow, despite consensus achieved in Baltimore, Harford, Frederick, Worcester and Cecil counties that they should be changed **(28).** The 2000 manual introduced limited stormwater credits to promote the use of better site design and ESD practices, but few communities in the State have encouraged their use. Under the proposed ordinance, communities will need to define the suite of ESD practices and stormwater credits that will presumptively apply to development and redevelopment projects, within a prescribed time limit. To provide accountability, communities would submit the list of ESD practices they offer as part of their required municipal stormwater NPDES annual report, and report on progress made in changing local codes to add new ESD practices.

The ordinance (and the regulations) shall also state that stormwater and ESD practices must be fully considered at the earliest stage at which development plans are submitted or reviewed. If a community currently does not require concept design review, it shall modify its development review process to provide it in a timely manner.

Principle 8: Strengthen Design Standards for ESD and Stormwater Practices. The stormwater manual should contain stringent performance criteria for the design, installation and maintenance of all stormwater and ESD practices. The regulations should reference the most current edition of the design manual as the authoritative version, require the design manual be updated every three years to reflect new research and field experience and establish an ongoing and independent technical committee to review future changes in the design manual.

Although the 2000 manual advanced the design of many practices, it needs to be updated to include new design standards for individual stormwater and ESD practices to enhance their performance and longevity, based on emerging research and local experience **(29)**. In particular, enhanced design specifications are needed for small infiltration, green roofs, expanded stream buffers, permeable pavers, reforestation, bioretention, wooded wetlands, coastal plain outfall practices, soil amendments, dual use rain tanks, expanded tree pits, and linear bioretention swales compatible with local rights-of-way requirements. The manual should also be re-ordered to present ESD practices first and traditional ponds last.

Principle 9: Ensure that all ESD Practices Can Be Maintained. The Consortium readily acknowledges that real and/or perceived concerns about maintenance are a major barrier to adoption of ESD practices. ESD design criteria should reflect the same approach to plan review, construction inspection and maintenance inspections as done for traditional stormwater practices. In particular, every ESD practice should possess either a conservation or stormwater easement, be accessible from the street right of way, be subject to an enforceable maintenance agreement, undergo a construction inspection checklist during and after construction, and be designed in a manner so as to reduce future maintenance burden.

ESD practices should also be subject to the same verification as structural stormwater practices, including construction and maintenance checklists, performance bonds and other measures to ensure their proper installation and function. It is recognized that the progression to ESD practices will require localities to shift toward a hybrid public-private maintenance system, and change the manner by which post-construction inspections are conducted. It is important to keep in mind that traditional stormwater practices already require costly maintenance to operate safely and effectively, which in many cases, is not fully performed. Localities will need to carefully plan how they will maintain the new ESD system.

VI. Core Principles Relating to Enforcement

Principle 10: Devise an Enforceable Design Process to Require ESD. Both the regulations and the manual should require the use of a decision tree that outlines that ESD practices were thoroughly evaluated and maximized at the site, promotes the use of a treatment train and discourages needless use of curb and gutter and large diameter storm drain pipes.

An enforceable mechanism must exist to ensure that ESD is not just an option, but the first tool utilized at site. It is recognized that some development sites may not be able to fully implement all elements of ESD for various reasons. The Act itself defines maximum extent practicable by stating that a developer has to demonstrate that standard best management practices (i.e., ponds) are used only when absolutely necessary. The Consortium believes that a decision-tree documentation approach is needed to show why any element of the ESD approach described herein is abandoned. The step-wise decision tree would document that the full list of locally approved ESD practices were explored at the development site, and supply a specific rationale in the event approved ESD practices are rejected as infeasible, which would be subject to review and approval or disapproval.

Principle 11: Establish Turbidity Standards for Construction Sites. Maryland streams need more effective protection from construction site sediment pollution. The regulations, manual and ordinance should establish numeric turbidity standards for runoff leaving construction sites and should also prohibit visible off-site discharges of sediment. The regulations should also specify a maximum three-day time frame for local governments to respond to citizen reports of erosion and sediment control problems and take appropriate enforcement action to correct them.

Numeric enforcement criteria are needed to define what constitutes an egregious water quality violation at construction sites and provide a technical criterion to measure the effectiveness of erosion and sediment control practices. Erosion and sediment control continues to be extremely variable in communities across the state. This section of the regulations would finally establish definitive criteria as to what constitutes a direct sediment control violation and triggers an assessment for remediation and prevention actions. For example, the regulations, manual and ordinance might establish a numeric turbidity limit of 150 NTUs (Nephelometric Turbidity Units) as an instantaneous maximum for rainfall events less than an inch and 50 NTUs as a monthly average and would prohibit visible sediment in water discharged from upland construction sites **(30).** If turbidity limits are exceeded, a detailed assessment of site conditions and remediation actions would be required. If turbidity limits continue to be exceeded, penalties and enforcement actions would be imposed.

Erosion, sediment and turbidity control requires constant inspection, maintenance and monitoring throughout each stage of construction to prevent off-site sediment discharges. This response requirement presents an opportunity to introduce some reasonable performance benchmarks for local governments to respond to and resolve to ESC problems at individual construction sites in a timely manner. Failure to adhere to the three-day time frame would constitute an actionable offense

Principle 12: Craft Special Stormwater Criteria for Sensitive and Impaired Waters. Both the stormwater regulations and the manual should define more stringent stormwater criteria to protect sensitive waters and maintain the biotic integrity of sensitive aquatic resources, including the State's threatened trout streams. In addition, the regulations, ordinance and the manual should contain more stringent criteria to reduce pollutant loads to 303(d) listed impaired waters of the State.

The current stormwater regulations and manual only contain limited provisions to protect sensitive receiving waters. It is proposed that the regulations contain more specific criteria that govern the sizing, selection and restrictions for stormwater practices in watersheds that drain to the following sensitive receiving waters**:**

- Trout streams
- Discharges to tidal and non-tidal wetlands
- Drinking water reservoirs
- Coastal creeks and tidal guts
- Swimming beaches and shellfish harvesting areas

Several state stormwater manuals and other design resources outline the needed design criteria for each of the watershed receiving water conditions noted above (**31**). The other key concern is developing more effective stormwater criteria and practices that work in all regions of the State, including karst topography, and flat terrain and high water table conditions of the coastal plain. Temperature criteria to protect Maryland's Eastern, Central, and Western trout streams must be a high priority for this effort (**32**). Trout streams are highly vulnerable to heat pollution from inadequately-controlled stormwater discharges. Much more stringent, infiltration-based ESD stormwater practice selection, sizing and performance criteria should be developed by MDE and required for application to all Use III (Natural Trout) and Use IV (Recreational Trout) waters in Maryland.

In addition, the regulations should outline the procedures for no net increase of specific pollutants for any impaired waters defined under the MDE 303(d) list. In many cases, the nutrient-based stormwater criteria described in Principle 3 should be sufficient to meet the no-net increase for the impaired water, but the regulations should require that an analysis be done to confirm it.

Principle 13: Develop a Statewide ESD Training and Certification Program. MDE and other parties should rapidly develop a system of professional ESD training and certification to ensure that both designers and plan reviewers fully understand and correctly apply the new practices. Plan reviewers and design consultants would need to attend a minimum number of hours of professional training to be certified to submit or review proposals. The training could be administered by a third party and financed through permit application fees. In addition, existing Green Card training programs should be enhanced to provide training on how to install and maintain ESD practices during and after construction**.** Third-party private inspectors should be trained and certified to inspect construction sites for full compliance with ESC and ESD requirements (**33**).

A new stormwater system cannot be implemented until local plan reviewers and design consultants fully understand it and are confident on how to apply it to real world sites. Certification is now required for stream restoration, agricultural nutrient management plans, erosion and sediment control and even forest conservation plans--but not for environmental site design or stormwater treatment. ESD requires specialized knowledge on the part of the design consultant and local plan reviewer, as well as early and frequent collaboration to produce quality ESD practices. It is conservatively estimated that nearly 500 engineers and plan reviewers work on local stormwater and site plan review in Maryland. Many of these individuals will need intensive and interactive training to learn how to effectively apply ESD practices at real world development sites. There is some debate about whether training should be mandatory or voluntary, but there is a strong need to develop and pilot an intensive curriculum that rewards progressive designers and reviewers with formal certification. Staffing inspections and enforcement will be needed at both the State and local levels, although MDE is encouraged to explore innovative ways to provide additional inspection and enforcement resources via third-party inspectors.

VII. The Consortium Commitment to Moving Forward

The Consortium realizes that it will take a lot of hard work and effort to make an effective shift to ESD, and pledges to constructively assist MDE throughout the process to develop regulations, update the manual, and craft a model local ESD ordinance. The Consortium plans to undertake actions over the next six months to partner with MDE and other stakeholders to help make ESD a reality in the State of Maryland. Members will undertake the following general actions:

> Assemble the most recent stormwater science and engineering data and pass it on to MDE staff
>
> Continue outreach efforts with the design community, local governments, soil conservation districts and the development industry
>
> Stand ready to support allocation of supplemental resources to fully develop the manual and supporting engineering tools in a timely manner

Provide prompt and constructive feedback at forums and other meetings organized by MDE to develop the regulations, manual and ordinance.

The Consortium will also work with MDE and other stakeholders to refine implementation issues in regard to specific core principles, as follows.

- Provide documentation for Maryland nutrient-based load limits, and offer a detailed framework on how they can be effectively implemented (Principle 3).
- Work with urban communities to define effective strategies to integrate ESD with redevelopment and urban watershed restoration efforts (Principle 4).
- Work with local governments and other stormwater stakeholders to define ESD benchmarks and draft model language for an early adopter ESD code change ordinance (Principle 7).
- Provide peer-reviewed design specifications for innovative ESD practices (Principle 8).
- Participate in a workgroup of designers, plan reviewers and public works staff to define enhanced maintenance standards for ESD practices (Principle 9).
- Provide draft guidance on special stormwater criteria for sensitive receiving waters, such as trout streams, as well as needed ESD adaptations for coastal plain, clayey soils, karst and mountainous regions of the state. (Principle 12).
- Work with stakeholders to further refine monitoring, compliance and enforcement tools needed to effectively implement ESD practices (All Principles)

VIII. Contributors and Contact Information

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IX. Notes and Sources

Note 1. Bay growth and development statistics. The statistics shown are from the following sources: Jantz et al (2005). Urbanization and the loss of resource lands in the Chesapeake Bay watershed. *Environmental Management*. 36(6): 808-825; Mid-Atlantic RESAC (2006). Modeling future growth in the Washington, DC-Baltimore Region 1986-2030. Mid-Atlantic Regional Earth Sciences Applications Center. University of Maryland, College Park. Clagget (2006). Chesapeake Bay estimates of impervious cover presented at December 2006 USWG meeting; STAC (2003). Chesapeake Futures: Choices for the 21st Century; Center for Smart Growth (2007). Smart Growth in Maryland 1990 to 2004. University of Maryland. Maryland populations forecasts through 2030 provided by MDP (2006).

Note 2. Impacts to streams, estuaries and wetlands. For a general review of research on the relationship between impervious cover and resource quality, see CWP (2003). Impacts of impervious cover on aquatic ecosystems. *Watershed Protection Techniques Monograph No. 1*. and Schueler (2004). An integrated framework to restore small urban watersheds. Appendix A. Manual 1. *Small Watershed Restoration Manual Series*. Cohn-Lee and Cameron (1992) Urban stormwater runoff contamination of the Chesapeake Bay: sources and mitigation. *The Environmental Professional*. (14): 10-27 and Moore and Palmer (2005). Invertebrate diversity in agricultural and urban streams: implications for conservation and management. *Ecological Applications* 15(4): 1169-1177.

Specific Chesapeake Bay studies on the impacts of land development on coastal streams and estuaries can be found in Bilkovic et al (2006). Influence of land use on macrobenthic communities in near shore estuarine habitats. *Estuaries and Coasts*. 29(6B):1185-1195, and Paul et al 2002. Landscape metrics and estuarine sediment contamination in the mid-Atlantic and southern New England region. *JEQ*: (31):836-845 and Comeleo et al (1996). Relationships between watershed stressors and sediment contamination in Chesapeake Bay estuaries. *Landscape Ecology* 11:307-319.

Urban development is currently responsible for more than 60% of freshwater wetland loss nationally. Dahl (2006). *Status and trends of wetlands in the coterminous United States: 1998-2004.* U.S. Department of the Interior. Fish and Wildlife Service. Washington, D.C. and the direct impact of stormwater runoff in degrading wetland quality is predicted to affect an even greater acreage-- Wright et al (2006). *Direct and indirect impacts of urbanization on wetland quality.* Wetlands and Watersheds Article 1. CWP.

The developed land as share of Chesapeake Bay nutrient load statistics were derived from **v**arious historical and current Chesapeake Bay Program Documents. Most recent numbers for 2005 reflect CB Model version 4.3 estimates provided in Office of the Inspector General. (2007). *Development growth outpacing progress in watershed efforts to restore the Chesapeake Bay.* U.S. EPA. Report No. 2007-P-00031. Washington, D.C. The sharp increase in the urban nutrient load share reflects both increased urban sprawl and reductions in nutrient loadings from wastewater treatment plants.

Note 3. Bacteria, chloride, pesticides and PCBs. Key research papers that document the link between urbanization and bacteria include: Mallin (2006). Disease causing microbes fouling beaches and shellfish beds. *Scientific American*. Schueler (1999). Microbes and urban watersheds. *Watershed Protection Techniques* 3(1): 545-594. For increased chloride levels in urban streams or reservoirs, see Kaushal et al (2005). Increased salinization of fresh water in the northeastern U.S. *Proceedings of the National Academy of Sciences.* 102: 13517-13520. Nationally, pesticides were detected in 97% of urban stream water samples, and exceeded human health and aquatic life benchmarks 6.7% and 83% of the time, respectively. USGS. (2006*). The quality of our nations waters: pesticides in the nation's streams and ground water: 1992- 2001*. National water quality assessment program. USGS Circular 1291. Reston, VA. For PCB impacts, see King et al (2004). Watershed land use is strongly linked to PCBs in White Perch in Chesapeake Bay subestuaries. *Environmental Science and Technology*. (38): 6545-6552.

Note 4. Cost savings and runoff reduction achieved by ESD. Numerous reports have documented the cost effectiveness of ESD practices in comparison to conventional stormwater management systems utilizing large diameter storm drain pipes. See Alexander and Heaney (2002). *Comparison of conventional and low impact development drainage designs*. Final Report to the Sustainable Futures Society. University of Colorado, Boulder, CO, CWP (1998). *Better Site Design: A handbook for changing development rules in your community*. Ellicott City, MD, Huber et al (2006). *BMP Modeling Concepts and Simulation.* Oregon State University Corvallis, Oregon. U.S. Environmental Protection Agency. EPA/600/R-06/033, Kloss and Calarusse (2006). *Rooftops to rivers: green strategies for controlling stormwater and combined sewer overflows*. Natural Resources Defense Council. Washington, DC and Lloyd et al (2002). *Water sensitive urban design: a stormwater management perspective.* Cooperative Research Centre for Catchments. Monash University, Victoria 3800 Australia. Industry Report 02/10 and Conservation Research Institute (2005) *Changing Cost Perception*s *– an analysis of conservation development.*

Numerous modeling studies have also demonstrated the pollutant reduction benefits associated with ESD practices at the scale of the individual site, including CWP (1998). *Nutrient loading from conventional and innovative site development*. Ellicott City, MD. and CWP (2002) *An assessment of the better site design principles for communities implementing Virginia's Chesapeake Bay Preservation Act.*

Note 5. Early ESD Site Assessment. One benefit of the early ESD map is that it would ensure that all environmental considerations contained in state and local development regulations would be identified and analyzed simultaneously- such as the Forest Conservation Act, Critical Area Act, Non-tidal wetland protection and flood hazard mitigation requirements, various Sensitive Areas elements of local comprehensive plans, habitat protection for rare, threatened and endangered species, and local stream buffer, steep slopes and other regulations, where applicable. The new elements of the unified ESD map/plan would include initial estimates of site forest, turf and impervious cover, projected nutrient loads, and soils information with respect to soil infiltration capability, soil conservation reserve areas, and maximum limits of disturbance needed to construct the site.

Note 6. Stormwater forestry. The basic concepts of stormwater forestry can be found in Cappiella et al.(2006). *Urban Watershed Forestry Manual. Part 2:* Conserving and planting trees at development sites. USDA Forest Service, Newtown Square, PA. The economic benefits of preserving forest cover at development sites is reviewed in Chapter 1 of Cappiella et al (2006). *Urban Watershed Forestry Manual. Part 2:* Conserving and planting trees at development sites. USDA Forest Service, Newtown Square, PA. For a broader look at trees as part of an overall vegetation-based stormwater management and bioretention strategy, see: Minnesota Pollution Control Agency (2003) *Plants for Stormwater Design: Species Selection for the Upper Midwest*.

Note 7. Soil compaction and soil restoration. For reviews of the effect of construction and earthworks on soil compaction and stormwater runoff, see Pitt et al (2005) Soil structure effects associated with urbanization and the benefits of soil amendments. World Water and Environmental Resources Congress. *Conference Proceedings*. American Society of Civil Engineers. Anchorage, AK, Lichter and Lindsey (1994). Soil compaction and site construction: assessment and case studies. *The Landscape Below Ground*. International Society of Arboriculture, Schueler (2001). Can urban soil compaction be reversed? *Watershed Protection Techniques.* 3(2): 666-669 and Pitt et al (1999). Infiltration through disturbed urban soils and compost-amended soil effects on runoff quality and quantity. *Research Report* EPA/600/R-00/016. Office of Research and Development. U.S. EPA. Washington, D.C. Performance research on soil restoration methods can be found in Roa-Espinosa (2006). *An introduction to soil compaction and the subsoiling practice.* technical note. Dane County Land Conservation Department. Madison,Wisconsin and Balusek (2003). *Quantifying decreases in stormwater runoff from deep-tilling, chisel-planting and compost amendments*. Dane County Land Conservation Department. Madison, Wisconsin.

Note 8. Rain tank research and guidance. Most of the research and implementation of residential rain tanks has been performed in Australia and New Zealand. Some links to the research can be accessed at http://www.watercare.net/images/Rainwater_Factsheet.pdf
On a Bay-wide basis, rooftops comprise 30% of total impervious cover, according to Clagget (2006) *Chesapeake Bay estimates of impervious cover* presented at December 2006 USWG meeting on Impervious Cover and the Bay. Dual use rain tanks can provide a supplemental source of potable or grey-water in low density areas served by wells.

Note 9. Front yard bioretention. Drainage from roof leaders, driveways and lawns are directed to shallow depression which becomes the first cell in the dry swale system along the street. Recent research in North Carolina by Smith and Hunt (2007) indicates that a turf cover performs as well as a mulch landscaping treatment for small bioretention areas. Public works managers have had a legitimate concern that homeowners might convert rain gardens over time as part of their changing landscaping preferences, but the turf design should greatly reduce this risk. Recent research on bioretention performance can be accessed from North Carolina State **http://www.bae.ncsu.edu/topic/bioretention/**

Note 10. Dry swales. Recent research has shown that the primary benefit of dry swales is a sharp reduction in runoff volumes and consequently a greater pollutant mass reduction. See Horner et al. (2003). *Hydrologic monitoring of the Seattle ultra-urban stormwater management project.* University of Washington. Department of Civil and Environmental

Engineering. Water Resources Series. Technical Report 170. and Lantin and Barrett (2005). *Design and pollutant reduction of vegetated strips and swales.* Proceedings 2005 ASCE conference. Anchorage, AK. At some point, the slope, lot density or drainage area to a dry swale becomes too great to prevent swale erosion during extreme storm events. The traditional solution has been to shift to an underground storm drain system. Several design modifications including concrete weir walls, stone drop structures and driveway slot drains can be used to keep drainage on the surface, rather than underground.

Note 11. Linear wetlands. The basic concept was introduced in 1992 in *Design of Stormwater Wetlands*, but major changes in design philosophy have emerged in recent years. This trend has been driven by the impressive performance and habitat value of coastal plain outfall wetlands developed by Underwood et al (2005). *Atlantic white cedar species recovery and wetland enhancement project at Howard's Branch, Anne Arundel County, MD.* In Atlantic white cedar: ecology, restoration and management. Proceedings. Forest Service Southern Research Station GTRS SRS-91. The Center for Watershed Protection will be releasing updated guidance on the design of constructed wetlands in 2008 to improve the performance, runoff reduction potential, and habitat quality of the next generation of wetlands.

Note 12. Stream Corridor Management. Riparian forest cover is defined as canopy cover within 100 feet of a stream, and is measured as the percentage of the upstream network in this condition. Riparian forest cover is important in maintaining stream health at low levels of catchment IC (less than 15%). Numerous researchers have evaluated the relative impact of riparian forest cover and impervious cover on stream geomorphology, aquatic insects, fish assemblages and various indexes of biotic integrity. As a group, the studies suggest that indicator values for urban streams increase when riparian forest cover is retained over at least 50 to 75% of the length of the upstream network (Wang et al, 2003, Cianfrina et al 2006, Sweeney et al 2004, Moore and Palmer, 2005 and Morley and Karr, 2002). The beneficial impact of riparian forest cover is lost when catchment IC exceeds 15%, at which point degradation by stormwater runoff overwhelms the benefits of the riparian forest according to Roy et al (2005), Roy et al (2006) and Walsh et al (2007). Data on riparian reforestation costs were derived from Manual 2 of the *Small Watershed Restoration Manual Series*. Data on economic benefits is drawn from Cappiella (2005) and Burke et al 2006. *The State of Chesapeake Forests*. Conservation Fund. Annapolis, MD.

Note 13. The adaptation of ESD practices for highly urban areas. Highly urban watersheds can be challenging to manage stormwater. Lack of space constrains but does not eliminate ESD practices. Several creative ESD practices exist to improve water quality, and their use in the redevelopment process represents the best strategy to reduce urban pollutant loads in the future. Creative approaches to implement ESD on the surface are supplied in Portland Bureau of Environmental Services. 2004. *Portland Stormwater Management Manual.* Portland, OR. Underground approaches to water quality treatment are discussed in the 2002 *District of Columbia Stormwater Manual,* which is currently being updated by the Center for Watershed Protection and the Low Impact Development Center. The use of stormwater infiltration and rainwater capture and reuse has been demonstrated for commercial and industrial redevelopment at the Enviro Center in Jessup, Maryland in Howard County (see: www.asgidd.com and www.greenbuildinginstitute.org.)

Note 14. The full text of the Stormwater Management Act of 2007 can be obtained by contacting the Maryland Legislative Information Service, http://mlis.state.md.us.

Note 15. Site and watershed variability. The Consortium fully understands that the application of ESD is dependent on individual site conditions, and the manual should carefully delimit constraints and opportunities for effective ESD practice application, with respect to terrain (karst, ridge and valley, and coastal plain), site density and size, soil types and other factors. In addition, the manual should help provide the watershed context for designing individual ESD practices, including, but not limited to safe handling of extreme flood events.

Note 16: Stormwater at the site and watershed scale. Several progressive communities in the State have developed or are in the process of developing local watershed protection or restoration plans. These plans serve multiple objectives including assessing flooding hazards, reducing pollutants as specified in a Total Maximum Daily Load implementation plan, protecting or restoring aquatic resources, and implementing Chesapeake tributary strategies. These watershed analyses can provide valuable information about which areas merit conservation, are must vulnerable, or may encounter problems in the future. These plans can inform and shape the selection of ESD and other practices to meet plan goals and objectives. Localities are strongly encouraged to translate core watershed recommendations into actionable terms that can be implemented at new development sites.

Note 17. Deriving runoff reduction requirements for sites and the operational sequence for achieving it. The proposed runoff reduction would apply to all rainfall events up to and including the one-year 24 hour rainfall event, which ranges from 2.4 to 2.7 inches across the State (see 2000 MDE manual for specific County estimates). This rainfall depth is then multiplied by three site cover runoff coefficients (forest, turf, and impervious cover) present at the site to derive the runoff reduction volume (RRv). Designers then follow a sequential five-step approach to maximize ESD opportunities at the site, progressively working from the roof to the stream:

1. **Prevent New Runoff** through natural area conservation, forest protection, stream buffers, soil conservation and zero-order stream protection
2. **Minimize Impervious Cover** through site design (e.g., narrower roads, smaller cul-de-sacs, fewer parking spaces, open space subdivisions)
3. **Reduce Rooftop Runoff** through green rooftops, rain tanks, cisterns, dry wells or other structural means
4. **Utilize Site Design ESD Practices** such as site reforestation, soil restoration, sheetflow to buffers, rooftop disconnection, and filter strips
5. **Utilize Engineered ESD Practices** to treat the remaining RRv through infiltration, bioretention, dry swales

Designers then apply simple equations for each ESD application (inches reduced multiplied by area treated) progressively working down-gradient from the site, until the progressive accumulation of runoff reduction volume meets the final RRv. If the full RRv cannot be collectively met through these five steps, designers may treat the remainder in a conventional stormwater practice that does not provide runoff reduction, such as a linear wetland, wet pond or sand filter. If it is verified that compliance with the remaining RRv is still not physically possible at the site, the designer may apply for a fee-in-lieu corresponding to that portion of stormwater generated, but not captured or treated on-site, as specified in Principle 4.

On-Site Runoff Reduction Requirements
$$PostRv = \frac{P * (Rv_I * \%I + Rv_T * \%T + Rv_F * \%F) * SA}{12}$$
Where PostRv = Runoff reduction volume in acre feet P = Depth of one year rainfall event (2.4 to 2.7 inch) Rv_I = runoff coefficient for impervious cover Rv_T = runoff coefficient for turf cover or disturbed soils Rv_F = runoff coefficient for forest cover % I = percent of site in impervious cover %T = percent of site in turf cover %F = percent of site in forest cover SA = total site area, in acres
The predevelopment runoff volume for the site is defined as $PreRv = (P * Rv_F * SA)/12$
Where $PreR_v$ = Pre-development runoff volume in acre feet P = Depth of one year rainfall event (2.4 to 2.7 inch) Rv_F = Runoff coefficient for forest cover SA = total site area, in acres
The RRv is then computed as (PostRv – PreRv)

Site Cover Runoff Coefficients	
Soil Condition	Runoff Coefficient
Forest Cover	0.02 to 0.05*
Disturbed Soils	0.15 to 0.25*
Impervious Cover	0.95
*Range dependent on original Hydrologic Soil Group (HSG) Forest A: 0.02 B: 0.03 C: 0.04 D: 0.05 Disturbed Soils A: 0.15 B: 0.20 C: 0.22 D: 0.25	

Note 18. Operational definition of runoff reduction. Runoff reduction is defined as the total runoff volume reduced through canopy interception, soil infiltration, evaporation, rainfall harvesting, engineered infiltration, extended filtration or evapo-transpiration. Extended filtration includes bioretention or dry swales with underdrains that delay the delivery of stormwater from small sites to the stream system by six hours or more. Note that bioretention can also be designed as an infiltration practice. A comprehensive review of the quantitative runoff reduction potential for various site planning and engineered practices will be released soon by CSN. Runoff reduction is the primary strategy to effectively achieve the predevelopment runoff coefficient for each storm. The table below summarizes recent studies on the runoff reduction capability of ESD practices, ranging from bioretention, biofiltration swales, permeable pavers and rain tanks. The reduction in runoff volume achieved by ESD practices is impressive—ranging from 40 to 99% with a median reduction of about 75%. By contrast, current designs of wet ponds and constructed wetlands have been shown to have little value in reducing stormwater runoff volumes-- less than 5% according to Strecker et al (2004). The nominal runoff reduction they achieve is solely due to evaporation.

Review of Research on Volumetric Runoff Reduction by ESD Practices		
ESD Practice	**% Runoff Reduction**	Reference
Bioretention	99	Dietz and Clausen (2006)
Bioretention	58	Seters et al (2006)
Bioretention	98	Rushton (2002)
Bioretention	50	Hunt et al (2006)
Bioretention	40 to 60	Smith and Hunt (2006)
Bioretention	75	Ballestro et al (2006)
Bioretention	80	Traver et al (2006)
Bioretention	73	Lloyd et al (2002)
Biofiltration Swale	98	Horner et al (2003)
Biofiltration Swale	94	Jefferies (2004)
Bioflitration Swale	46 to 54	Stagge (2006)
Permeable Pavement	75	Rushton (2002)
Permeable Pavement	99	Seters et al (2006)
Permeable Pavement	95 to 97	Traver et al (2006)
Permeable Pavement	60 to 90	Hunt and Lord (2006)
Permeable Pavement	50	Jefferies (2004)
Rainwater Harvesting	60 to 90	Coombes et al (2004)

Note 19. Stormwater Hotspots. The ESD plan should also specify whether the proposed land use or operation contained in a development plan will be designated as a stormwater hotspot and merit special stormwater treatment and pollution prevention measures. Stormwater hotspots produce higher pollutant concentrations that other sites and have a greater risk of spills, leaks or illicit discharges**.** The concept of stormwater hotspots was first introduced in MDE (2000) *Maryland Stormwater Design Manual*. The methods to find and correct discharges from existing stormwater hotspots are described in CWP (2005*).* Pollution source control practices*. Manual 8. Small Watershed Restoration Manual Series.* Ellicott City, MD. The regulations should also delegate the authority to local communities to take enforcement actions to identify and correct existing stormwater hotspots. The high rate of non-compliance for stormwater hotspots is documented in Duke and Augustenborg (2006). Effectiveness of self-identified and self reported environmental regulations for industry: the case of stormwater runoff in the US. *Journal of Environmental Planning and Management.* 49(3): 385-411.

Note 20. Nutrients in Non-Chesapeake waters. Current and future nutrient loading reduction requirements pertaining to the Ohio River basin waters of Garrett County should also be examined, and numeric performance criteria derived pertaining to this geographic region.

Note 21. How limits are addressed in Virginia. A draft of the proposed regulations can be found in Virginia DCR (2007). Chapter 60 Virginia Stormwater Management Program Permit Regulations. The computational method to ensure that ESD and stormwater practices comply with the nutrient-based limits is presented in Hirschman (2007). Draft *Virginia Stormwater Management Nutrient Design System*. Prepared for Technical Advisory Committee and Virginia DCR. Richmond, VA.

The load limits were computed using the Chesapeake Bay Model Tributary Strategy Confirmation Runs. State-wide TP and TN loads were calculated for each land use in the VA Bay watershed. Point source and atmospheric nutrient inputs were subtracted to focus entirely on non-point pollution sources. Existing, already developed urban lands were also excluded from the calculations. This existing load may be reduced by future retrofits, but is not germane to the calculation. The land use loads reflect implementation of agricultural and forestry best management practices as outlined in Virginia's tributary strategy (i.e., they reflect future reductions as a result of BMPs). The load limits were established as the total of forest, crops, pasture and mixed open space, adjusted for delivery to the Bay (3,418,105 lbs for TP), divided by their total land area in the state (12,209,171 acres). This yields an average load of 0.28 lbs/ac/yr for TP and 2.68 lbs/ac/yr for TN. The basic concept is that new development on non-urban land must not exceed the average load for non-urban land using effective stormwater practices in the watershed.

The load limits proposed in the core MD ESD principles are 0.25 lbs/ac/yr for TP and 2.5 lbs/ac/yr for TN, respectively. The difference is entirely due to rounding and simplicity in presentation in a policy document. A similar spreadsheet calculation for Maryland could be quickly computed using land use loads outlined in the tributary team strategy numbers. This would not be very difficult to do, but it is doubtful the load limits would change appreciably.

The calculation is most sensitive to the ratio of farmland to forest in each state. Surprisingly, that ratio is not very different between the two states: 0.62:1 in MD and 0.59:1 in VA. Virginia developed a computational scheme where loads are calculated for development sites using the Simple Method based on site impervious cover and Virginia specific stormwater EMCs for nitrogen and phosphorus derived from more than 200 station storms sampled in Virginia. The phosphorus load requirement applies to residential development and the nitrogen load to commercial development. A range of removal rates for various structural BMPs were derived from the updated CWP national pollutant removal database (CWP, 2007). A series of nutrient removal rates were derived for different levels of stormwater practice design using a quartile approach. Compliance on most sites is generally not possible using structural stormwater practices alone, so designers must employ LID or ESD practices to demonstrate that they have reduced runoff volumes on the development site to satisfy the load limits.

Key data references to support nutrient load and removal calculations can be found in Schueler et al (2007). Stormwater Retrofit Practices. Manual 3. *Small Watershed Restoration Manual Series,* Pitt et al. (2004). *National Stormwater Quality Database. Version 2.0.* University of Alabama and Center for Watershed Protection. Final Report to U.S. Environmental Protection Agency and CWP (2007). National pollutant removal performance database – 3rd Edition. Ellicott City, MD.

Note 22. MD Critical Area Phosphorus Load Requirements. A phosphorus load limit has been in place for developing land in the Maryland Critical Area for nearly 15 years (0.45 lbs/ac/yr), and updated guidance has been published as of three years ago. See Winer (2003). *Critical area 10% rule guidance manual: Maryland Chesapeake and Atlantic Coastal Bays.* Maryland Department of Natural Resources. Critical Area Commission, Annapolis, MD. It would not be very difficult to modify this material to reflect the lower load limits, in the context of the updated stormwater manual.

Note 23. Redevelopment policy. Redevelopment is expressly included in both the Stormwater Management Act of 2007, and in the 2000 Maryland Stormwater Design Manual. The Stormwater Management Act requires MDE to include redevelopment in its regulations aimed at minimizing pollutants in stormwater runoff. The 2000 Manual defines redevelopment as "Any construction, alteration, or improvement exceeding five thousand square feet of land disturbance performed on sites where existing land use is commercial, industrial, institutional, or multifamily residential." The current MDE criteria for redevelopment require that the site impervious area be reduced by at least 20%,. Where site conditions prevent a 20% reduction of impervious area, BMPs must be used to provide control for at least 20% of the site area. This level of control can be achieved through a combination of impervious area reduction and water quality BMPs. In other words, redevelopment projects are only required to provide 20% of the water quality volume associated with new development. MDE's policy has been driven by a concern that meeting the more stringent stormwater objectives could create a hardship that might discourage redevelopment opportunities including an opportunity for water quality improvement, however slight. Clearly, redevelopment projects should be required to provide a clear technical justification to receive any relief from the new stormwater management requirements. Recent experience with urban redevelopment projects and innovative, green-infrastructure approaches in Maryland and around the country indicates that innovative ESD approaches are cost effective and yield a range of benefits for developers.

Note 24 Linking redevelopment and watershed restoration. The Consortium supports the development of a carefully constructed fee-in-lieu program to support local equivalent watershed restoration when on-site compliance at redevelopment projects is not feasible. To be eligible, local plan reviewers would have to certify that the designer fully exhausted each of the five steps in ESD sequencing outlined in Note 17. The 2000 stormwater regulations allow local governments to require developers to pay a fee-in-lieu to finance highest priority local restoration projects outlined in local watershed restoration plans. This is an extremely important element of the regulations to retain since it would not unduly penalize redevelopment action within existing urban areas, but also creates a reliable funding source to support local restoration projects in highly urban watersheds

Note 25. More defined performance benchmarks for ESC controls. Numeric performance benchmarks are needed in the regulations and the manual to clearly define correct ESC practice in terms that local plan reviewers and construction site inspectors can clearly define and measure. An example of a performance benchmark for site stabilization is that the ground must be 100% covered by a one inch layer of approved mulch such that no exposed soils are visible to the inspector. Similar benchmarks should be defined for all ESC practices.

Note 26. Performance monitoring. There are still some data gaps about the performance of both innovative and traditional ESD practices due to a lack of performance monitoring. No organized monitoring system currently exists in the State to conduct needed stormwater research and feed it back into the design process. State, federal and private sector funds are needed to finance a monitoring program to evaluate the real world performance of innovative ESD practices at the scale of the site and the watershed. The resulting performance monitoring data could then be used to revise future editions of the stormwater manual.

Note 27. Stormwater stakeholders. The Consortium is particularly interested in working with public works officials, developers, road engineers and others to define specific ESD benchmarks (and impediments) to consider when evaluating local subdivision, parking, road and other codes.

Note 28. History of local site planning roundtables in MD. Five communities have engaged in the local site planning roundtable process and reached consensus on model development principles. Actual implementation of new code has been limited. See Frederick County (2000). *Recommended model development principles for Frederick County, MD.* Cecil County (2001). *Recommended model development principles for Cecil County, MD.* Harford County. (2003). *Recommended model development principles for Harford County, MD*. Worcester County (2004). *Recommended model development principles for Worcester, County, MD*. Baltimore County (2006). *Recommended model development principles for Baltimore County, MD*. All documents produced by the Center for Watershed Protection, the

Alliance for the Chesapeake Bay and Home Builders Association of Maryland. Carroll County, MD has recently initiated a local site planning roundtable.

Note 29. Need for enhanced design criteria. Some recent research and design specifications for innovative ESD practices can be found in Underwood et al (2005). *Atlantic white cedar species recovery and wetland enhancement project at Howard's Branch, Anne Arundel County, MD*. General Technical Report SRS-91. Hunt and Lord (2006). *Bioretention performance, design, construction, and maintenance*. North Carolina Cooperative Extension Service. *Urban Waterways*. AG-588-05, Davis (2005). Green engineering principles promote low impact development. *Environment, Science and Technology*. 39(16): 338-344, Traver (2006). Monitoring summary: Villanova University stormwater best management practice study. U.S EPA. Philadelphia, PA. University of New Hampshire Stormwater Center (2005). *2005 stormwater data report*. Durham, NH and Cappiella et al (2006). *Urban Watershed Forestry Manual. Part 2:* Conserving and Planting Trees at Development Sites. USDA Forest Service, Newtown Square, PA. See Appendix B for design point method in Schueler et al. (2007). Stormwater retrofit practices. Manual 3. *Small* W*atershed Restoration Manual Series*. CWP.

Note 30. Turbidity and NTUs. Nephelometric Turbidity Units (NTU's) are an accepted method of measuring the impact of construction sediments on instream resources. See extended discussion of impact of turbidity and typical construction turbidity levels in *Watershed Protection Techniques.* 2(3):393-444.

Final construction site discharge levels of 50 NTU, and achievement of the "no visible off site sediment discharge' have been observed at construction projects in the Appalachian Piedmont through the use of a systems approach that maximizes the effectiveness of construction E,S&T controls from the beginning to the end of a project. Two major methods have been documented; these can be used separately or in combination. The first method (exemplified by the Big Creek School Construction Project in Fulton County, Georgia), relies upon a system of advanced erosion, sediment, and turbidity controls that ends with a sand filter and with sheet flow through forested, preserved buffers, but does not use chemical coagulants; the second approach uses some of the same sediment basin enhancements (e.g. baffles and skimmer) along with chemical coagulants to remove the fine clay particles, notably anionic polyacrylimide (PAM). For examples of the first treatment approach, see: *Warner, R. and F. Collins-Comargo. 2001. Erosion Prevention and Sediment Control Computer Modeling Project for the Chattahoochee-Flint Regional Development Center's Dirt II Committee. Surface Mining Institute. Lexington, Kentucky.* and *National Academy of Public Administration. 2001. Policies to Prevent Erosion in Atlanta's Watersheds: Accelerating the Transition to Performance. Washington, D.C.* *http://71.4.192.38/NAPA/NAPAPubs.nsf/17bc036fe939efd685256951004e37f4/1085b708cb159e4b85256a0100711feb?OpenDocument*.

For an example of the use of PAM (a chemical coagulant) in achieving final construction site discharge levels of 50 NTU or less, see: *McLaughlin, R. 2007. Presentation to the Sediment and Erosion Control Workshop for Contractors. French Broad River Watershed*

Education Training Center. Asheville, North Carolina. February 2007. *www.bae.ncsu.edu/programs/extension/wqg/frenchbroad/presentations/Arboretum07.pdf*. .

Note 31. States with special criteria for sensitive waters. See Minnesota Stormwater Steering Committee (2005). *Minnesota Stormwater Manual*. Emmons & Oliver Resources, Inc. Minnesota Pollution Control Agency. St. Paul MN. Special protections for trout waters are needed since Eastern brook trout are present in intact populations in only 5% of more than 12,000 subwatersheds in their historical range in eastern North America. Urbanization is cited as a primary threat in 25% of the remaining subwatersheds with reduced populations. Trout Unlimited (TU). 2006. *Eastern Brook trout: status and threats.* Eastern Brook Trout Joint Venture. Arlington, VA. For the need to control stormwater wetland discharges see Wright, et al (2007). Direct and indirect impacts of urbanization on wetland quality. *Wetlands and Watersheds Article 1*: U.S. EPA OWOW and Center for Watershed Protection. For recommended stormwater criteria to protect wetlands see pages 34-49 in Cappiella et al (2005). Adapting watershed tools to protect wetlands. *Wetlands and Watersheds Article 3*: U.S. EPA OWOW and CWP.

Note 32. Stormwater criteria for trout: Documented scientific studies indicate that brook trout will die with short exposure to water at 72 degrees Fahrenheit and brown and rainbow trout die with short exposure to water at 82 degrees Fahrenheit. Current stormwater management regulations allow for 12 hour extended detention in Use III waters even though the States own studies show that this technique violates temperature standards for both Use III and Use IV waters. Infiltration of the hot runoff that occurs at the onset of summer storms is necessary to protect trout streams from thermal impacts. Impervious surfaces that become heated in the summer will superheat the first flush of runoff that flows off these surfaces.

MDE needs to promulgate a scientifically-based minimum infiltration requirement to protect trout streams from the thermal impacts of stormwater discharges. Scientific literature reviews need to examine whether a requirement to infiltrate the first full inch of rainfall from each storm would be adequate statewide to protect Use III and IV waters. Maryland's water quality criteria for temperature are: 90 degrees F for Use I (general aquatic life protection); 68 degrees F for Use III and 75 degrees for Use IV.

Also, to the extent that ponds continue to be used as part of stormwater management plans, they can cause thermal exceedances particularly in the summer months. Some of these impacts can be mitigated to some extent by shading impervious surfaces. Thermal pollution is a lethal problem for trout waters in Maryland and some serious research and monitoring of potential solutions is urgently needed.

Note 33. Third party inspectors. Additional inspection and enforcement resources can be leveraged through third-party inspectors, as is done under the Certified Construction Reviewer program in Delaware. In this program, developers are required to hire their own third-party inspectors who are trained and certified by the State and are required to send written reports of inspections.