Clean Water for Maryland: Local Ordinances for Environmental Site Design

Decades of rapid development and suburban sprawl throughout Maryland have burdened the state's rivers, lakes and coastal waters with increasing amounts of polluted stormwater runoff. In 2007, the state took a major step towards reversing this growing threat by passing a law requiring the use of Environmental Site Design (ESD) to reduce runoff from all development and redevelopment projects. As a result, localities throughout the state must adopt an ordinance that requires sustainable stormwater management practices. As communities begin to formulate and implement these ordinances, it is essential that they incorporate the strongest possible protections to preserve and restore clean water for future generations. Moreover, by better integrating the built and natural environment, ESD also reduces flooding and the burden on existing, conventional infrastructure. This document describes the benefits of sustainable stormwater practices and details the key elements of a strong stormwater ordinance that will meet the clean water challenges we face using innovative and cost-effective techniques.

Environmental Site Design: Water Infrastructure for the 21st Century

Environmental site design (ESD) is an innovative form of stormwater management that can improve the health of water resources, create wildlife habitat, beautify neighborhoods and save communities money. The goal is to minimize the impact of land development on our streams, rivers and the Chesapeake Bay by using natural and small-scale or distributed stormwater management practices to control runoff. ESD, also referred to as low impact development or green infrastructure, can take many forms. For a new development, it includes maintaining the natural contours of the land, preserving existing soil, vegetation and tree cover, minimizing impervious surfaces and using wetlands, forested stream buffers or other vegetated systems to absorb and filter any remaining runoff. In existing developments, the principles of ESD require restoring natural features by replacing impervious surfaces with vegetation or permeable pavement and infiltrating stormwater. The unifying factor among these techniques is that they absorb rainfall and keep stormwater on site rather than allowing it to run off the site untreated, carrying pollutants to nearby waterways. ESD is integral to the entire development process. The practices are considered from the earliest stage of site design and used to minimize the impacts of construction.[1]

While ESD is considered most often as a way to minimize the impacts of sprawling suburban residential developments, it is also effective for more intensely developed commercial, urban and redevelopment projects. The suite of practices includes green roofs, cisterns, foundation planters, smaller parking lots, permeable pavers, swales, restoration of natural area remnants, impervious cover removal and restoration of stream corridors.

ESD has an impressive array of benefits that makes it an essential foundation of any community's clean water infrastructure looking forward. As a group, ESD practices are more effective in protecting water resources, have lower maintenance costs and are more protective during extreme storms than conventional stormwater practices. Traditional development covers the landscape with impervious surfaces such as streets, parking lots, roofs and pavement that prevent rain from soaking naturally into the ground and instead cause large volumes of fast-moving water to pollute nearby streams and trigger sewer overflows in some places. In contrast, ESD keeps more water on site, reduces erosion and runoff, and ensures cleaner water. ESD also promotes infiltration, which recharges groundwater and provides a buffer against droughts. Rather than treating rain water as a waste product, ESD preserves runoff as a resource that can safely recharge groundwater and surface streams and be reused on-site.

<u>Cost Effectiveness of ESD</u>

Given the current economic climate, it is important to recognize the cost-effectiveness of ESD. An Environmental Protection Agency study comparing costs of development using traditional stormwater management versus ESD found savings ranging from 15% to 80% in eleven of the twelve cases using low impact development.[2] This is a significant benefit for communities struggling to meet stormwater goals and countless other needs with a limited budget.

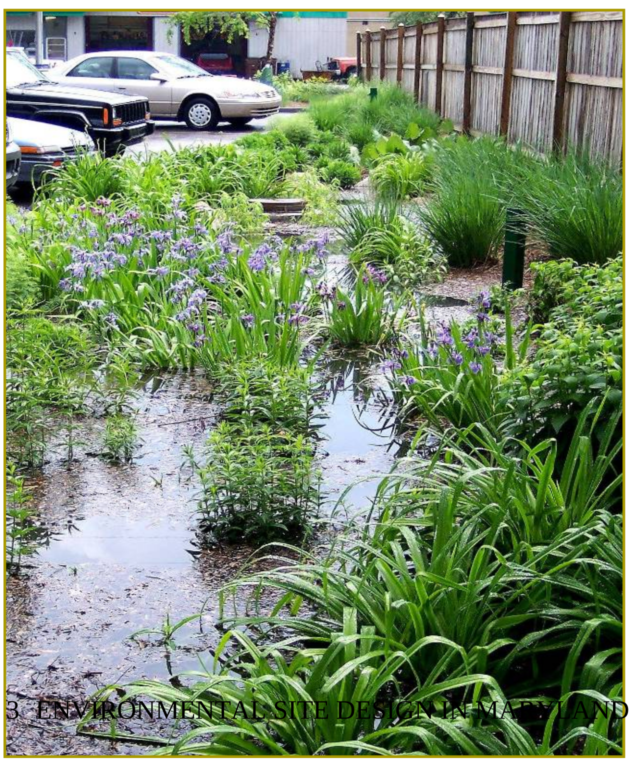
In Maryland, four potential and actual ESD developments have been analyzed for purposes of comparing costs to conventional stormwater designs. One study analyzed three sites in urban and suburban settings. Two sites were actual redevelopment sites in urban settings in Baltimore and Bethesda, where costs for ESD were modeled although ESD was not used. In a third, hypothetical case, ESD was modeled for converting a hotel and its parking area into a medium density residential project in Calverton, Prince George's County. For all three sites, ESD cost forecasts for two design storms (1" and 2.6") compared favorably in cost with the conventional stormwater design options to achieve the same high level of water quality and water quantity treatment with only one exception.[3]

The fourth case, an actual new residential development site based on ESD concepts, was the 70-lot Pembroke development in Frederick County. The use of ESD at this site, completed in 2003, eliminated the need for two conventional stormwater ponds, reducing infrastructure costs by $200,000. This change allowed additional space for two lots at a $90,000 value; conversion of 3,000 linear feet of urban roadway into a rural roadway saved another $60,000. These immediate cost savings were in addition to the benefits to downstream communities of less flooding and erosion, cleaner water and added open space.[4]

ESD practices also provide a number of benefits in addition to cleaner water. Green roofs reduce urban heat island effects, lower building energy costs and reduce air pollution by absorbing particulate matter. Wetlands and stream buffers provide important habitat for wildlife and bird species. These practices also help communities prepare for the impacts of a changing climate by providing flexible solutions that will help communities adapt to more extreme weather patterns such as more frequent and intense floods or droughts.

The Need for Sustainable Stormwater Management

Maryland's streams, rivers and the Chesapeake Bay are threatened by low density sprawl development that replaces wetlands and forests with roofs, parking lots and roads. As discussed above, these surfaces increase the volume of stormwater runoff during a storm and send it flowing rapidly to nearby streams and rivers. This additional runoff causes flooding, erodes stream banks and carries excess nutrients, toxics, pathogens and other contaminants into nearby waters. Maryland's suburban sprawl is also accompanied by an expansion of lawn area, or turf cover, which contributes fertilizers and pesticides to local waterways during rain and storms. Between 1990 and 2000, population in the Chesapeake Bay region climbed by 8%, while in the same period impervious cover increased by 41% and turf cover increased by nearly 80%. In Maryland, this trend is expected to continue to 2030 by which time the state's population is expected to increase by nearly 17%, and pavement and turf cover will increase further.[5]



The continuing wave of land development constitutes a major threat to the quality of Maryland's waterways and the Chesapeake Bay. As a result of this development, the water quality and ecosystems in over 10,000 miles of Bay coastline and tributaries have been degraded or destroyed.[6] Hundreds more stream miles are at risk from future degradation. The following statistics indicate the impact that unchecked development and stormwater runoff are having on area streams and coastal waters.

- Urban areas are the fastest growing source of nutrient pollution in the Chesapeake Bay. In 1985, developed land produced less than 5% of the nutrient load. By 2005, developed land contributed 19% and 30% of the total nitrogen and phosphorus load delivered to the Bay, respectively.[7]
- Developed lands currently produce nearly 20% of the annual sediment load to the Bay, primarily due to urban stream bank erosion and construction site runoff.[8]
- Bacteria levels in urban stormwater runoff routinely exceed water quality standards and cause closures of streams, beaches and shellfish harvesting areas after significant rains throughout much of the Chesapeake Bay watershed.[9]
- Urban stormwater runoff has been linked to PCB detections in Bay watersheds.[10]
- Nationally, pesticides have been detected in 95% of urban streams.[11]

Maryland as a Leader in Reducing Polluted Stormwater Runoff

After decades of attempting to control the polluted stormwater runoff from Maryland's rapid development with conventional infrastructure such as stormwater pipes and detention ponds, with ESD the state has begun to embrace less structural, more flexible, decentralized approaches. The Maryland General Assembly passed the Maryland Stormwater Management Act of 2007 (Act) which established ESD as the primary method of controlling stormwater runoff, sediment and erosion from development sites (for more information on the Act, see Appendix A). The Act requires localities to adopt a stormwater ordinance to integrate the use of ESD. While the passage of the 2007 law establishes Maryland as a leader in sustainable stormwater management, the ultimate effect of the legislation depends on changes at the local level. The content of these local ordinances and their robust implementation is critical for clean water. For that reason, the following set of recommendations based on the requirements of the law will help local governments establish the most effective stormwater ordinances.

Local Stormwater Ordinances

The stormwater ordinances that local governments across Maryland adopt will determine the health of the state's water resources for years to come. Strong protections will prevent the continued expansion of impervious surfaces that contribute to flooding and pollution. By taking these necessary steps, local communities can preserve their clean and drinking water resources for current and future generations. The following recommendations outline the essential elements of a strong stormwater ordinance that will accomplish this task.

These recommendations adhere to regulatory changes and changes to the *2000 Maryland Stormwater Design Manual* (Design Manual) that have been proposed in final form by the Maryland Department of the Environment (MDE). However, more protective ordinance provisions are also set forth where stronger protection of Maryland's water resources is warranted and where such changes can be incorporated by local governments in their ordinances. Each will be clearly identified.

Definitions

The following new definitions should be added to local ordinances. These definitions reflect the new terms being used in the regulations and changes to the *Design Manual*:[12]

1. "<u>Concept plan</u>" means the first of three required plan approvals that includes the information necessary to allow an initial evaluation of a proposed development project.

2. "<u>Environmental site design</u> (ESD)" means using small-scale stormwater management practices, nonstructural techniques and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of land development on water resources. Methods for designing ESD are specified in the *Design Manual*. Further design specifications can be created or added by local governments with MDE approval.

3. "<u>Site development plan</u>" means the second of three required plan approvals that

includes the information necessary to allow a detailed evaluation of a proposed project.

4. "Final stormwater management plan" means the last of three required plan approvals that includes the information necessary to allow all approvals and permits to be issued by the appropriate authority.

5. "Maximum extent practicable" (MEP) means designing stormwater management systems so that all reasonable opportunities for using ESD planning techniques and treatment practices are exhausted and, only where absolutely necessary, a structural Best Management Practice (BMP) is implemented. *Note*: The Act, itself, states that standard BMPs can be used only where absolutely necessary.[13]

6. "Planning techniques" means a combination of strategies employed early in project design to utilize the natural features of the site itself to reduce impacts from development and to incorporate those natural features into a stormwater management plan.

7. "Stormwater management system" means natural areas, ESD practices, stormwater management measures and any other structure through which stormwater flows, infiltrates or discharges from a site.

Additional Definition
Defining the term "runoff reduction" will further strengthen local ordinances. While neither the Stormwater Act nor the MDE regulations define runoff reduction, because the concept is central to the requirements of the law, a definition will provide clarity to stormwater design practitioners, developers and plan reviewers.

8. "Runoff reduction" means the total annual runoff volume reduced by ESD practice through canopy interception, soil infiltration, evaporation, rainfall harvesting, engineered infiltration, evapotranspiration or extended filtration that delays the delivery of stormwater from sites to a stream system by six hours or more. The rate of runoff reduction is expressed as a numerical percentage, as based on current available science.

New ESD Implementation/Minimum Control Measures

Local stormwater ordinances must require developers to use ESD to meet minimum stormwater volume reduction standards for both new development and redevelopment. All new development and redevelopment projects subject to stormwater management under the Act should be required to determine how ESD will be used to reduce the stormwater volumes at the site.[14]

New Development: MDE Requirements
In new development settings, MDE requires that for each site developers must control post development runoff to the "woods in good condition" standard through use of ESD. This standard is better than what most states now require. However, MDE's regulations further require that only the first one inch of rainfall must be controlled by ESD and any rainfall over that amount could be treated with conventional BMPs. We believe that this standard is not fully protective of water resources.

New Development: More Protective Proposal
To achieve the best protection and provide the clearest instruction to the design community, communities should consider that for new development, the full channel protection volume (CPv), ranging from 99% of 2.4" to 2.8" rainfall events, must be reduced (retained on site) through use of ESD.[15]

This level of volume protection for new development aims to satisfy the highest volume protection through use of ESD. However, note that the use of ESD to achieve this highly protective volume reduction requirement must be met to the "maximum extent practicable." Where ESD cannot succeed in meeting this full volume protection goal requirement, conventional BMPs can be used if absolutely necessary, making this design requirement reasonable.

Redevelopment: MDE Requirements
Local stormwater ordinances should use strong runoff volume reductions in redevelopment settings. MDE requires that there be a 50% reduction in impervious coverage and/or treatment of 50% of site imperviousness.[16] This is an improvement over current redevelopment requirements.

Redevelopment: More Protective Proposal
The following is a more protective approach: developers should be required to treat on site the water quality volume (WQv) to manage for the 95th percentile of average annual runoff volume using ESD to the maximum extent practicable, consistent with new requirements for federal facilities. This will ensure that strong volume controls are implemented during redevelopment in a manner that best protects our streams, rivers and the Chesapeake Bay. Federal facilities must now maintain predevelopment hydrology as mandated by the Energy Independence and Security Act, and final draft guidance for development and redevelopment requires preventing the off-site discharge from all rainfall less than the 95th percentile rain event.[17]

Groundwater Recharge
The Act and MDE regulations require that all stormwater management plans "maintain 100% of the average annual predevelopment groundwater recharge volume," and local stormwater ordinances must reflect this requirement. Developers can make recharge volume calculations based upon data available from MDE indicating predevelopment groundwater recharge levels.

Stormwater Management Planning Techniques and Treatment Practices

MDE has set forth ESD planning techniques and treatment practices in its regulations. These are to be included in the local stormwater ordinances. However, this is not an exhaustive list and local ordinances may include other techniques and practices that are considered appropriate for local circumstances pending MDE approval. Local governments are urged to consult the Chesapeake Stormwater Network and other resources listed on page 12 for such examples.[18]

The following is the list of ESD planning techniques included in the changes to the regulations:[19]

1. Preserving and protecting natural resources;
2. Conserving natural drainage patterns;
3. Minimizing impervious area;
4. Reducing runoff volume;
5. Achieving groundwater recharge using ESD practices;
6. Using green roofs, permeable pavements, reinforced turf and other alternative surfaces;
7. Limiting soil disturbance, mass grading and compaction; and
8. Clustering development.

The following are ESD treatment practices included in MDE regulations:

1. Disconnection of rooftop runoff from storm sewers or streams;
2. Disconnection of non-rooftop runoff from storm sewers or streams;
3. Directing sheetflow to conservation areas;
4. Rainwater harvesting;
5. Submerged gravel wetlands;
6. Landscape infiltration;
7. Infiltration berms;
8. Dry wells;
9. Micro-bioretention;
10. Rain gardens;
11. Swales;
12. Enhanced filters; and
13. Other practices approved by MDE.

Local governments should clearly state in their stormwater ordinances that the above planning techniques and treatment practices must be maintained are not to be altered by succeeding property owners without approval.

Stormwater Management Plans

The stormwater management plan is the critical documentation showing how the developer is going to prevent construction-related erosion and sedimentation and post-construction stormwater runoff. This plan must receive careful review by local government reviewers pursuant to the comprehensive review and approval process specified in the MDE regulations.[20] Maryland is currently working to integrate existing erosion and sediment control provisions with the new ESD requirements. The local ordinances should carefully reflect these stormwater management plan requirements.

There are three stormwater management plan design submittals required under the new regulations: the concept plan, the site development plan and the final erosion/sediment control and stormwater management plan.[21] Each of these plans is reviewed by the local reviewing authority, and the review comments and notes become part of the subsequent submittal.

Note: Although not required by MDE, to make the review process more effective, local communities should require that if during any of the three plan reviews, deficiencies or insufficiencies are found by reviewers, the plan should be returned to the developer and resubmitted only when they are addressed.

In addition, in jurisdictions where stormwater and water resources plan review is conducted separately from overall preliminary building and site plan review, then “dual” or coordinated review by these separate departments should be established to ensure full integration of ESD.

Concept Plan

The concept plan must provide sufficient information for an initial assessment of the proposed project and whether stormwater management can be provided.[22]

The concept plan will include (but not be limited to) the following:

A. A map at an approved scale showing the site location, existing natural features, water and other sensitive resources, topography and natural drainage patterns;
B. The anticipated location of all proposed impervious areas, buildings, roadways, parking, sidewalks, utilities and other site constructed facilities;
C. The proposed location of the limits of disturbance, erodible soils, steep slopes and areas to be protected during construction;
D. Preliminary estimates of stormwater management requirements, the selection and location of ESD practices to be used and the location of all points of discharge from the site;
E. A narrative that supports the concept design and describes how ESD will be implemented to the maximum extent practicable.

Site Development Plan

The next submission, following approval of the concept plan, is the site development plan, which will reflect comments received during the previous review phase.

The site development plan will include (but not be limited to) the following:[23]

A. All information provided in the concept plan phase;
B. Final site layout, exact impervious area locations and acreages, proposed topography, delineated drainage areas at all points of discharge from the site and stormwater computations for ESD practices and quantity control structures;
C. A proposed erosion and sediment control plan that contains the construction sequence, any phasing necessary to limit earth disturbances and impacts to natural resources and an overlay plan showing the types and location of ESD and erosion and sediment control practices to be used;
D. A narrative that supports the site development design, describes how ESD will be used exhaustively to meet the minimum control requirements, and justifies as being absolutely necessary any proposed conventional stormwater management measures.

Final Erosion and Sediment Control Plan and Stormwater Management Plan

The third submittal from the developer to the reviewing authority is the final erosion and sediment control and stormwater management plan that reflects the comments received during the previous review phases. Plans submitted for final approval shall be of sufficient detail to allow all approvals and permits to be issued and will include: final erosion and sediment control plans and final stormwater management plans submitted in the form of construction drawings and accompanied by a report that includes sufficient information to evaluate the effectiveness of the proposed runoff control and stormwater management design.

The report submitted for final stormwater plan approval shall include (but not be limited to):[24]

A. Geotechnical investigations including soil maps, borings, site-specific recommendations and any additional information necessary for the final stormwater management design;
B. Drainage area maps depicting predevelopment and post-development runoff flow path segmentation and land use;
C. Hydrologic computations of the applicable ESD and unified sizing criteria according to the *Design Manual* for all discharges from the site;
D. Hydraulic and structural computations for all ESD practices and conventional structural stormwater management measures to be used;
E. A narrative that supports the final stormwater management design and describes how ESD will be used exhaustively to meet the minimum control requirements and justifies as being absolutely necessary any proposed conventional structural stormwater management measures.

Maryland's regulations also require that construction drawings be submitted with the final stormwater management plan for approval, which shall also include:[25]

A. Existing and proposed topography and proposed drainage areas, including areas necessary to determine downstream analysis for proposed stormwater management facilities;
B. Structural and nonstructural details including representative cross sections for all components of the proposed drainage system or systems and stormwater management facilities;
C. A table showing the ESD and unified sizing criteria volumes required in the *Design Manual*;

D. An inspection and maintenance schedule.

Construction Inspection and Enforcement

State regulations set forth additional inspection and enforcement requirements that must be included in the local stormwater ordinance.[26]

A. Regular inspections shall be made and documented for each ESD planning technique and practice at the stages of construction specified in the *Design Manual*. At a minimum, all ESD and other nonstructural practices shall be inspected upon completion of final grading, the establishment of permanent stabilization and before issuance of use and occupancy approval. Note: As part of their local ordinance, local governments may add requirements, such as quicker site stabilization, upon MDE approval.
B. "As built" certification shall be submitted by either a professional engineer or professional land surveyor licensed in the State to ensure that ESD planning techniques, treatment practices and structural stormwater management measures and conveyance systems comply with specifications contained in approved plans. At a minimum, as built certification shall include a set of drawings comparing the approved stormwater management plan with what was constructed. Other information shall be submitted as required by the local approving authority.

Maintenance

MDE regulations require that all local stormwater ordinances contain provisions relating to inspection and maintenance of stormwater facilities.[27] ESD treatment practices and measures will be added to the list of what should be inspected. In addition, inspection reports must include an assessment of the efficiency of the ESD treatment practice and its success in controlling stormwater runoff.

The current fee structure should be reviewed by local jurisdictions to determine if it covers the complete cost of implementing the new stormwater, erosion and sediment control provisions including inspection and enforcement. In addition, we recommend that local jurisdictions explore using a third-party inspection and enforcement program to reduce costs (a similar program has been established in Delaware).[28] Such a program would require the development industry to pay inspectors' salaries. The inspectors would be certified or licensed by the State of Maryland or by the local government and would be in a pool of inspectors. This would ensure that an inspector for a specific project would be selected by the state or local government without any participation by the developer or contractor. Such an inspection process would reduce the cost to the State and to local governments and provide a sufficient pool of independent inspectors so that the timely inspection of projects could be assured to both the development community and the public.

Review and Remove Impediments to ESD

The Act requires that local governments review and modify, if necessary, planning, zoning or public works ordinances to remove impediments to ESD implementation such as limitations on the use of permeable pavements and parking space ratios that may be too high.[29]

The best approach is to consider both the removal of impediments to ESD implementation and provide opportunities and incentives to use ESD. Below are just a few examples of how local ordinances can be modified to better enable the full implementation of ESD. Resources to help review and remove impediments include:

- *Local Water Policy Innovation - A Road Map for Community Based Stormwater Solutions*, American Rivers, September, 2008. http://www.americanrivers.org/library/reports-publications/

- U.S. EPA Water Quality Scorecard, http://cfpub.epa.gov/npdes/greeninfrastructure/munichandbook.cfm.

Landscaping, Setback and Open Space

Zoning codes generally contain landscaping and setback requirements that could be amended to promote on-site stormwater management. In many cases, developers are already designing projects with landscaped features that could be slightly altered to reduce stormwater. If developers are already required to maintain a certain percentage of open space, they could be encouraged to use this space to reduce stormwater from a developed area.

Parking

Instead of setting minimum parking requirements, communities can set a maximum limit to eliminate unnecessary parking areas. At the very least, the zoning code should determine parking requirements on a per site basis and allow for flexibility. Increasing the amount or percentage of landscaping required in parking areas, and encouraging such requirements to be integrated with stormwater management practices are additional recommendations.

Road Width

In many localities, roads are often unnecessarily wide, which creates more stormwater runoff. Localities can reduce this cause of stormwater problems by reviewing their road width requirements to see if new roads can be narrower. This should be undertaken in a collaborative fashion with public works and fire and police departments. There are examples where local road width review has resulted in substantial runoff volume reduction.

Storm Sewer Disconnection

Far from encouraging on-site stormwater management, many local codes require landowners to connect impervious areas to the storm sewer system. Such requirements are out of date given the potential for ESD to retain and treat water on site and reduce the impact of storm sewer systems on streams, rivers and the Chesapeake Bay. Such requirements should be removed.[30]

Maintenance

Restrictive covenants and easements can be used in common subdivision lots or individual lots to require landowners to maintain the ESD features on their lot. For example, rain gardens require long-term maintenance to adequately manage stormwater. Restrictive covenants and easements "run with the land" and are binding on all future landowners. Localities should also consider creating local stormwater utilities whereby modest impervious surface fees may be used to support maintenance of stormwater management practices by local governments.

Appendix A - The Maryland Stormwater Management Act of 2007

The Maryland Stormwater Management Act of 2007 (Act) was passed by the Maryland General Assembly and signed into law by Governor O'Malley.[31] It fundamentally alters the way we manage stormwater runoff from new development and redevelopment by requiring the use of environmental site design (ESD). The Act defines ESD as:

> "Using small-scale stormwater management practices, nonstructural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of land development on water resources."

The Act further describes ESD as:

> "Optimizing conservation of natural features, such as drainage patterns, soils and vegetation, minimizing use of impervious surfaces, such as paved surfaces, concrete channels, roofs and pipes, slowing down runoff to maintain discharge timing and to increase infiltration and evapotranspiration and using other nonstructural practices or innovative stormwater management technologies approved by the Department."

The Act requires the Maryland Department of Environment (MDE) to prepare regulations to implement the law, to revise the *2000 Maryland Stormwater Design Manual* and to prepare a model ordinance which local governments are to enact. All of these must achieve the following statutory provisions found in the Act:[32]

1. Implement ESD to the maximum extent practicable;
2. Review and modify, if necessary, planning and zoning or public works ordinances to remove impediments to ESD implementation;
3. Require developers to demonstrate that ESD has been implemented to the maximum extent practicable and standard best management practices have been used only where absolutely necessary;
4. Prevent soil erosion from any development site;
5. Maintain the integrity of stream channels for biological function and for drainage;
6. Minimize pollutants in stormwater runoff from new development and redevelopment;
7. Protect public safety;
8. Maintain 100% of average annual predevelopment groundwater recharge volume for the site;
9. Capture and treat stormwater runoff to remove pollutants and enhance water quality;
10. Implement a channel protection strategy to reduce downstream erosion in receiving streams;
11. Implement quantity control strategies to prevent increases in frequent out-of-bank flooding from large, less-frequent storms;
12. Establish a comprehensive process for approving grading and sediment control plans and stormwater management plans;
13. Specify that the above comprehensive process takes into account the cumulative impacts of both plans.

This new law is a comprehensive change to stormwater management in Maryland. MDE has promulgated new regulations and new *Design Manual* text.

The full text of the Act can be found at: http://mlis.state.md.us/asp/web_statutes.asp?gen&4-201

Appendix B - Glossary

These two terms maintain their definition in the revised *Design Manual* and stormwater regulations. They are stormwater volumes which must be controlled at development sites.

WQv (Water Quality Volume) is the storage (in acre-feet) needed to capture and treat the runoff from 90% of the average annual rainfall to avoid pollution to receiving waterbodies. Treatment of the WQv shall be provided at all developments where stormwater management is required. The WQv is directly related to the amount of impervious cover treated at a site. For ESD purposes, this is important because the less impervious a site is, the less WQv to be controlled.[33]

Cpv (Channel Protection Storage Volume) is the volume of runoff to be controlled so that receiving waterway channels will not erode (because erosive velocities will not be reached) in bankfull or near bankfull storm events. The goal is to use ESD to reduce the volume of water coming off a site to avoid downstream erosion.[34]

Additional Resources

Montgomery County Rainscapes
http://www.montgomerycountymd.gov/Content/DEP/Rainscapes/home.html

Villanova Stormwater Partnership
http://www3.villanova.edu/vusp/

Center for Neighborhood Technology
http://greenvalues.cnt.org/green-infrastructure

Chesapeake Stormwater Network
http://www.chesapeakestormwater.net/

Low Impact Development Center
http://www.lowimpactdevelopment.org/

Center for Watershed Protection
http://www.cwp.org/

U.S. EPA, Green Infrastructure
http://cfpub.epa.gov/npdes/home.cfm?program_id=298

[1] Stormwater Management Act of 2007, Md. Environ. Article Code Ann., Section 4-201 (1) (a) and (b), Section 4-203 (b) (9) (i and ii)(2008); "Core Environmental Site Design Principles," Maryland Stormwater Consortium, January, 2008, pp 7, 9, 10.
[2] Environmental Protection Agency (2007), Reducing stormwater costs through low impact development (LID) strategies and practices. Washington, DC.
[3] Audubon Naturalist Society, Anacostia Watershed Society, Chesapeake Bay Foundation (2008), A comparison of feasibility and costs: environmental site design and conventional site design for stormwater management for four redevelopment sites in Maryland, Meliora Environmental Design, LLC. Note that runoff from the 2.6" design storm was predicted to be less expensive to treat with conventional techniques on the site in Prince Georges County due to lower land prices.
[4] Clar, M. 2003. Pembroke Woods Low Impact Development (LID) Residential Subdivision, Emittsburg, Maryland. EcoSite, Inc. Columbia, Maryland.
[5] The data shown are from: 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 (207), Growth in Maryland 199 to 2004, University of Maryland. Maryland Population forecasts through 2003 by Maryland Department of Planning (2006).
[6] Specific Bay studies on the impact 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; Paul et al (2002). Landscape metrics and estuarine sediment contamination in the Mid-Atlantic and southern New England region. JEQ: (31): 836-845.
[7] EPA Chesapeake Bay Program, Chesapeake Bay Model version 4.3 referenced in EPA Office of Inspector General, Development growth outpacing progress in watershed efforts to restore the Chesapeake Bay, US EPA Report No. 2007-P-00031, Washington, D.C.
[8] Comoleo et al (1996), Relationships between watershed stressors and sediment contamination in Chesapeake Bay estuaries," Landscape Ecology 11: 37-319.
[9] 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.
[10] King at al. (2006), Watershed land use is strongly linked to PCBs in white perch in Chesapeake Bay subestuaries. Environmental Science and Technology 38: 6545-6552.
[11] United States Geological Survey (2006), The quality of our nation's waters: pesticides in the nation's streams and ground water: 1992-2001. National Water Quality Assessment Program, USGS Circular 1291. Reston, VA.
[12] Code of Maryland Regulations (COMAR) 26.17.02.02, May, 2009.
[13] Environment Article, Maryland Code, Section 4-203 (b) (5) (II) (3) (B).
[14] Changes to 26.17.02.06 COMAR; proposed new Chapter 5, *Design Manual*, pp 5.18-5.24 (2008). Note: The Maryland Uniform Sizing Criteria are unaffected by the Stormwater Act and the MDE regulations and changes to the *Design Manual*. This unified approach to sizing stormwater BMPs in Maryland to meet pollutant removal goals, maintain groundwater recharge, reduce channel erosion, prevent overbank flooding and pass extreme floods is found in Chapter 2 of the *Design Manual*, Section 2.0 at p. 2.1.
[15] Maryland Stormwater Consortium (2009), Letter to the Maryland Department of the Environment, January 5, 2009, p. 3.
[16] Code of Maryland Regulations (COMAR) 26.17.02.05.
[17] U.S. EPA, Draft Technical Guidance on Implementing Section 438 of the Energy Independence and Security Act (2009).
[18] Chesapeake Stormwater Network, www.chesapeakestormwater.net
[19] Code of Maryland Regulations (COMAR) 26.17.02.08.
[20] Code of Maryland Regulations (COMAR) 26.17.02.09.
[21] Ibid.
[22] Ibid.
[23] Ibid.
[24] Ibid.
[25] Ibid.
[26] Code of Maryland Regulations (COMAR) 26.17.02.10.
[27] Code of Maryland Regulations (COMAR) 26.17.02.11.
[28] Delaware Sediment and Stormwater Regulations, Section 12.0 Certified Construction Reviewer Requirements, http://www.dnrec.state.de.us/DNREC2000/Divisions/Soil/Stormwater/Regs/SSRegs_4-05.pdf.
[29] Environmental Article, Maryland Code, Section 4-203(b)(ii)2,2008.
[30] Denzin and Belan (2008), Local water policy innovation: a road map for community based stormwater solutions. American Rivers and Midwest Environmental Advocates, Inc., pp 8-10.
[31] Environment Article, Maryland Code, Section 4-201 et seq, 2008
[32] Id. Section 4-203 (b).
[33] *2000 Maryland Stormwater Design Manual*, p 2.1.
[34] Ibid, p 2.8.

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