IEc

Cost Analysis of Proposed District of Columbia Stormwater Regulations

Final Report | March 15, 2010

Prepared for:

District of Columbia
Department of the Environment

Prepared by:

Dan Leistra, John Weiss, and Angela Helman
Industrial Economics, Incorporated
2067 Massachusetts Avenue
Cambridge, MA 02140
617/354-0074

INDUSTRIAL ECONOMICS, INCORPORATED

TABLE OF CONTENTS

EXECUTIVE SUMMARY *1*

1. INTRODUCTION *4*

Scope of Our Analysis *5*

Report Organization *6*

2. STORMWATER MANAGEMENT LANDSCAPE *7*

Introduction *7*

Comparison of Existing and Proposed Regulations *7*

Regional Stormwater Management Initiatives *7*

- Maryland *8*
- Virginia *8*

National Stormwater Management Initiatives *9*

- Philadelphia, PA *11*
- Chicago, IL *13*
- Portland, OR *14*
- Seattle, WA *16*

3. COST ANALYSIS *18*

Introduction *18*

Methods *19*

- Scenario Development *19*
- Cost Data Collection *19*
- General Assumptions and Calculations *24*

Results *29*

- Project #1 – Anacostia Office, New Construction *29*
- Project #2 – Downtown Multi-Story Renovation *31*
- Project #3 – Ward 5 Low-Rise Commercial, New Construction *32*

Limitations and Uncertainty *35*

- Costs of Green Roofs and Conventional Roofs *35*
- Retention Capacity of Green Roofs *35*
- Sizing of Bioretention Cells *35*
- Cost of Bioretention Areas *36*

4. CONCLUSION *38*

APPENDIX A: COMPARISON OF DRAFT PROPOSED AND EXISTING STORMWATER REGULATIONS IN THE DISTRICT OF COLUMBIA

APPENDIX B: COMPARISON OF DRAFT PROPOSED DC STORMWATER REGULATIONS TO COMPARABLE REGULATIONS IN OTHER CITIES

APPENDIX C: DERIVATION OF CURVE NUMBERS FOR CALCULATING INFILTRATION

APPENDIX D: CALCULATION DETAILS: WATER TREATMENT VOLUME, BIORETENTION AREA SIZING, AND COSTS

EXECUTIVE SUMMARY

The District of Columbia Department of the Environment (DDOE) has proposed amendments to the District's regulations governing soil erosion, sediment control, and stormwater management (District of Columbia Municipal Regulations Title 21, Chapter 5). In addition to establishing a new set of District-wide stormwater management requirements, the amendments would codify enhanced stormwater management standards for private projects within the Anacostia Waterfront Corporation Development Zone. These amendments are an acknowledgement of the negative environmental impact of stormwater runoff in urban environments, and recognition of the fact that the District is in a position to offer leadership in the adoption of low impact development (LID) techniques that can more effectively manage stormwater closer to its source.

DDOE retained Industrial Economics, Incorporated (IEc) to prepare a cost analysis that examines the anticipated compliance costs under the revised regulations relative to the costs that would be incurred under existing regulations. As DDOE's proposed regulatory revision is still under development, we analyzed a preliminary proposal which may have significant differences from the final product. To the extent that such differences may exist, our analysis and conclusions therefore may not accurately reflect the Department's final proposal.

Our work comprised five research elements:

1. Comparing the preliminary proposed District regulations with existing District regulations, as well as with existing or proposed regulations in nearby jurisdictions;
2. Compiling readily available capital cost data associated with (a) the implementation of LID techniques and (b) the implementation of "traditional" stormwater management-related practices (e.g., sand filters) as mandated by current regulations;
3. Interviewing government officials in municipalities currently implementing regulations that mandate LID-based stormwater management to learn, among other things, whether the regulations have had, or are expected to have, any impact on development activity;
4. Defining three hypothetical, representative building projects that would be subject to the District's new stormwater regulations, as well as a realistic compliance strategy for each project; and

5. Estimating total incremental compliance costs for each of the building scenarios under the current and preliminary proposed regulatory regimes.

Exhibit ES-1 presents summary findings of the cost analysis. Cost data, key assumptions, and uncertainties are discussed in the body of the report; detailed calculations are provided in Appendices.

IEc draws four major conclusions based on our analysis of incremental compliance costs, research on stormwater management regulation, and discussions with officials in other cities that have implemented similar regulations, summarized here and presented in more detail in the Conclusion section:

INCREMENTAL COSTS: Incremental compliance costs are expected to be small both in absolute terms and as a percentage of total project costs. For each of three hypothetical projects in the District, we estimate an increase in first costs measured in the low tens of thousands of dollars, representing a "premium" of one-tenth of one percent or less. While it is important to reiterate that our analysis was limited in scope, and therefore cannot be presumed to be illustrative of all possible development scenarios, it is reasonable to conclude that low impact development techniques are not substantially more expensive than conventional techniques at the scale that most projects would require. We also conducted a sensitivity test using considerably more conservative assumptions, and while the compliance cost in this scenario was considerably more expensive in relative terms, it is still less than two-tenths of one percent of project first costs.

OTHER CITIES' EXPERIENCE: We heard consistently from officials in other cities that new stormwater requirements similar to those proposed by the District have not had, or are not expected to have, a discernible effect on development. However, one city with a very low threshold for regulatory applicability (500 sq ft versus the 5,000 sq ft threshold proposed by the District) voiced concerns about potential effects (related to proportionally higher management costs) on very small projects.

"GREENING" TREND: A general trend toward "greener," more stringent and LID- based stormwater management requirements is occurring regionally and at the federal level. The fact that federal buildings, comprising a third of DC's real estate, will be required to meet stringent stormwater regulations, and that neighboring Maryland and Virginia are also updating stormwater regulations, further mitigates potential concern about migration of development, activity, and also could result in a level of market activity sufficient to exert downward pressure on the costs of LID techniques.

COMPLIANCE MANAGEMENT: While the District already has a relatively low size threshold of 5,000 square feet to trigger stormwater management requirements, the proposed regulations would apply to renovations as well as new construction, increasing somewhat the number of permits requiring processing and review. Perhaps more importantly, the changes in stringency and preferred methods of stormwater management could increase the time required for the reviewing and permitting process of a given project. To avoid project delays, the District might face a need for additional staff, updated information management systems, and/or new, clearly communicated administrative procedures.

ES-1. SUMMARY FINDINGS ANALYSIS OF INCREMENTAL COMPLIANCE COSTS

	SCENARIO 1	SCENARIO 2	SCENARIO 2
Location	Anacostia/Ward 8	Downtown/Ward 2	Ward 5
Project type	New Construction	Comprehensive Renovation	New Construction
Building type	Class A Office/ground level retail	Multi-story residential/ground level retail	Low rise retail with 10,000 sq ft parking lot
Stories	8	6	1
Property size, sq ft	40,000	15,000	25,000
Building footprint, sq ft	20,000	15,000	10,000
Total building space, sq ft	160,000	90,000	10,000
Development costs	$55,000,000	$30,000,000	$ 20,000,000
Development costs per sq ft	$343.75	$333.33	$2,000
Total incremental cost of regulations	**$33,875**	**$37,625**	**$12,702**
Compliance cost / total development cost (%)	**0.06%**	**0.13%**	**0.06%**
Compliance cost / sq ft	**$0.21**	**$0.42**	**$1.27**

1. INTRODUCTION

The District of Columbia Department of the Environment (DDOE) is developing proposed amendments to the District's regulations governing soil erosion, sediment control, and stormwater management (District of Columbia Municipal Regulations Title 21, Chapter 5). In addition to establishing a new set of District-wide stormwater management requirements, the amendments would codify enhanced stormwater management standards for private projects within the Anacostia Waterfront Corporation Development Zone. These amendments are an acknowledgement of the negative environmental impact of stormwater runoff in urban environments, and recognition of the fact that the District is in a position to join other national leaders in requiring the adoption of low impact development (LID) techniques that can more effectively manage stormwater closer to its source.

The development of new stormwater management requirements is consistent with several other environmental management initiatives. For example:

- New regulations will help the District achieve the objectives outlined in its November 2007 agreement with the U.S. Environmental Protection Agency (EPA) to reduce pollutant discharges associated with the District's Municipal Separate Storm Sewer System (MS4) permit.
- The regulations would likely lead to stormwater management practices that will help to meet the Leadership in Energy and Environmental Design (LEED) green building standard, as mandated by the District's 2006 Green Building Act and the 2008 Anacostia Waterfront Environmental Standards Act.
- The regulations would ensure comparability between the District's requirements and those of the federal government, which accounts for one-third of the District's land and buildings and which may soon be subject to even stricter stormwater management targets (pursuant to Section 438 of the Energy Independence and Security Act).
- The regulations would join similar initiatives in neighboring jurisdictions (e.g., Montgomery County's "green streets" regulations and proposed MS4 permit), thereby increasing protection of shared surface water resources, particularly Chesapeake Bay.

At the same time, the DDOE is appropriately sensitive to the potential costs to the development community of implementing the proposed regulations, especially at a time of economic uncertainty, when attention must be paid to the relationships between the long-term benefits of enhanced environmental performance requirements and the near-

term costs of compliance. Therefore, the Department retained Industrial Economics, Incorporated (IEc) to prepare a cost analysis of the proposed regulations in order to assess potential compliance costs relative to the costs that would be incurred under existing regulations.

It is important to note that DDOE's proposed regulatory revision was still under development at the time of our analysis. We analyzed a preliminary proposal which may have significant differences from the final product, thus introducing a potential limitation on the precision of our results. Throughout this report, therefore, when we refer to the District's proposed changes or proposed regulations, this should be understood to mean the interim proposal that was available to us at the time of our analysis. Appendix A provides a detailed, point-by-point comparison of this preliminary proposal to the District's existing stormwater regulations, which should serve to clarify the precise package we evaluated.

SCOPE OF OUR ANALYSIS

Our work comprised five research elements:

1. Comparing the proposed regulations with existing District regulations, as well as with existing or proposed regulations in nearby jurisdictions;
2. Compiling readily available capital cost data associated with (a) the implementation of LID techniques and (b) the implementation of "traditional" stormwater management-related practices (e.g., sand filters) as mandated by current regulations;
3. Interviewing government officials in municipalities currently implementing regulations that mandate LID-based stormwater management to learn, among other things, whether the regulations have had, or are expected to have, any impact on development activity;
4. Defining three representative building projects that would be subject to the District's new stormwater regulations, as well as a realistic compliance strategy for each project; and
5. Estimating total incremental compliance costs for each of the building scenarios under the current and proposed regulatory regimes.

The purpose of our analysis is to inform the decision making process as the Department works to finalize the new regulations by offering a clear sense of the nature and general scale of any anticipated impacts. Our analysis is not intended to provide a precise, monetary estimate of these impacts, particularly since the analysis was limited to three project scenarios and did not involve detailed specification, at the level of specific engineering plans, of proposed stormwater management techniques. However, to ensure sufficient accuracy in our results, we consulted closely with LID experts, as appropriate, in developing each representative project's presumed approach to stormwater management under a new regulatory regime.

It is also important to note what was not within our scope.

1. This analysis focuses on capital costs, and does not attempt to compare the operations and maintenance (O&M) costs over time in the baseline and new regulatory scenarios.
2. We did not undertake a real estate analysis to estimate the total cost of compliance, for a specified time period, across projected development in the District.
3. We did not seek to estimate any changes in District land use (type or intensity) that might be attributable to the promulgation of new stormwater regulations.
4. We did not quantify or monetize environmental benefits (e.g., improved water quality, decreased erosion, reduced flooding, habitat restoration) that might be attributable to the adoption of LID techniques under the new stormwater regulations
5. We did not conduct a fiscal analysis to determine whether the new regulations might have a measurable effect on property taxes or government administrative costs.

Each of these issues might be an appropriate topic for future research.

REPORT ORGANIZATION

The remainder of this report comprises three sections. The first describes the stormwater management landscape, including our comparison of existing and proposed District regulations, our review of comparable stormwater regulations in the DC region, and our review of comparable stormwater regulations in other U.S. cities. The following section presents our cost analyses for the three building scenarios. The final section offers conclusions drawn from the results of the analysis.

2. STORMWATER MANAGEMENT LANDSCAPE

INTRODUCTION

The District's proposed stormwater regulations, if enacted, would reflect a national trend toward more progressive action and would reflect a growing recognition, by local, state, and federal officials, that the achievement of future water quality objectives depends in part on enhanced stormwater management practices. To place the proposed regulatory changes in context, we completed a detailed comparison of the District's existing and proposed regulations, reviewed similar efforts to develop new stormwater management regulations in neighboring jurisdictions (i.e., Maryland and Virginia), and compared the proposed regulations to similarly progressive regulations recently enacted in other cities.

COMPARISON OF EXISTING AND PROPOSED REGULATIONS

Appendix A presents a detailed comparison of the proposed stormwater regulations to the District's existing regulations. Specifically, we compared the proposed regulations to Title 21, Chapter 5 of the DC Municipal Regulations ("Water Quality and Pollution"); the Green Building Act of 2006; and the Anacostia Waterfront Environmental Standards Act of 2008 (a subtitle of the National Capital Revitalization Corporation and Anacostia Waterfront Corporation Reorganization Act of 2008). We compared each section of the proposed regulation, point by point, to corresponding sections of established DC law addressing the same issues. In this way, the table calls attention to areas where the proposed regulation describes new or substantially altered requirements, while indicating other areas where no significant change is expected. Again, it is important to note that this comparison, and indeed our entire analysis, evaluates a preliminary, not a final, proposal.

Beyond the establishment of new or increased fees associated with stormwater management, the proposed changes that have the most potential to result in significant and direct compliance cost impacts (within the scope of our analysis) are (1) the establishment of a new formula for calculating the volume of water requiring management; (2) the requirement to retain onsite a specific percentage of the managed volume and to achieve specific quality standards for any stormwater not retained onsite; (3) the emphasis on the use of vegetation-based control strategies, particularly in the Anacostia region where specific controls are identified in order of preference; and (4) the permissibility of offsite mitigation as an alternative to onsite retention. However, we also note that several other sections of the proposed regulation may also contribute substantially to increased cost, but are outside the scope of our analysis. These include but are not limited to project submissions, maintenance, and the bond requirement.

REGIONAL STORMWATER MANAGEMENT INITIATIVES

The broader regional concern about the effects of stormwater runoff is reflected in efforts by Maryland and Virginia to enact new, and in some cases, more stringent requirements

for most building projects. The following are brief descriptions of the key elements of each state's efforts.

MARYLAND

Pursuant to the state's Stormwater Management Act of 2007 (Act), Maryland enacted new stormwater management regulations in May 2009. These regulations required Maryland municipalities to submit, by November 11, 2009, drafts of updated stormwater regulations that incorporate the changes made at the state level, and to adopt the new regulations by May 4, 2010. The new regulations are structured to create a more decentralized stormwater system and maintain predevelopment runoff characteristics. The regulations further require low impact development practices (Maryland uses the term "environmental site design" or (ESD) to the "maximum extent practicable" (MEP), which means using all available ESD planning techniques and treatment practices before resorting to any structural best management practices (i.e., devices designed for the temporary storage or treatment of stormwater runoff).

As defined in the Act, ESD uses ". . . 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." More specifically, Maryland considers the following to be the primary ESD practices:

- Optimizing conservation of natural features (e.g., drainage patterns, soil, vegetation).
- Minimizing impervious surfaces (e.g., pavement, concrete channels, conventional roofs).
- Slowing down runoff to maintain discharge timing and to increase infiltration and evapotranspiration.
- Using other nonstructural practices or innovative technologies approved by the state, such as green roofs, permeable pavement, reinforced turf and other alternative surfaces.

The use of ESD meets the MEP requirement when (1) channel stability and 100 percent of the average annual predevelopment groundwater recharge are maintained; (2) nonpoint source pollution is minimized; and (3) structural management practices are used only when absolutely necessary.

The regulations apply to all developments that disturb more than 5,000 sq ft of land area. For redevelopment projects, stormwater management must reduce the existing impervious area by at least 50 percent; implement ESD to the MEP to provide water quality treatment for at least 50 percent of the existing impervious area; or use these two techniques in combination for at least 50 percent of the existing impervious area.

VIRGINIA

The state of Virginia is in the process of amending its stormwater regulations to allow for the eventual development of local stormwater management programs (as envisioned in

2004 when the state legislature created a consolidated stormwater management program within the state Department of Conservation and Recreation to replace a cumbersome, multi-jurisdictional system), and to meet the state's water quality objectives. The key proposed changes are:

- For new development, a more stringent design standard for phosphorous loading (from 0.45 to 0.28 pounds per acre per year), with phosphorous serving as an "indicator pollutant."
- For redevelopment, a minimum 20 percent reduction in phosphorous below the predevelopment load (compared to the 10 percent reduction currently required).
- Minimum water quantity conveyance requirements that address downstream channel erosion and flooding risks.
- The establishment of a fee schedule sufficient to provide full support for the administration of local management programs, as well as DCR oversight.
- Offsite compliance options to meet the water quality and/or water quantity requirements, including a pro rata fee or other funding mechanism sufficient to result in reductions at least equal to what would otherwise be required onsite.

The Virginia Board of Soil and Water Conservation adopted the new regulations on December 9, 2009. After a mandatory administrative review, the regulations will go to the Governor for final approval. By law, the regulations cannot go into effect prior to July 1, 2010.

NATIONAL STORMWATER MANAGEMENT INITIATIVES

Several major US cities have moved in recent years to enact new, more stringent stormwater regulations, often establishing requirements or strong preferences for the use of "greener" management strategies. To provide additional context for the proposed District regulations, and to gain some insight from other cities' regulatory development and implementation experiences, we compared the provisions of District's proposed regulations to other those implemented in four other cities selected in consultation with DDOE staff): Philadelphia, Chicago, Portland (Oregon), and Seattle. Appendix B includes a table summarizing our comparison of the various regulations across 14 topics that we considered to be of particular interest. We also conducted interviews with stormwater management officials in each of the cities. The findings from our interviews are presented below; all information presented in the remainder of this section comes from these interviews. Exhibit 2-1 lists contacts in each city. The questions listed in Exhibit 2-2 served to guide our conversations.

EXHIBIT 2-1. CONTACTS IN OTHER CITIES

CITY	NAME	TITLE	OFFICE
Philadelphia	Chris Crockett	Manager of Watershed Protection	Dept. of Water/Office of Watersheds
Chicago	Peter Mulvaney	Sustainable Infrastructure Manager	Department of Water Management
Portland	Dawn Uchiyama	Stormwater Manual Program Manager	Bureau of Environmental Services
Seattle	Tracy Tackett	LID Program Manager	Seattle Public Utilities

EXHIBIT 2-2. INTERVIEW GUIDE

1. Regulatory history

- What was the motivation or the driving force behind the change?
- Was there anything significantly different being considered at the time that was ultimately rejected? If so, why was it rejected?
- Do you foresee any revisions to your city's stormwater regulations in the near future? Are there any proposals being seriously discussed at present?

2. Impact of the regulations on development activity

- Have there been any changes in real estate development patterns that might be attributable to the new stormwater regulations?
- Is there any evidence of changes in real estate prices (for lots, finished properties, or rents) or property values that might be attributable to the new stormwater regulations?
- Are you aware of any projects that did not go forward or moved elsewhere as a direct result of the new stormwater regulations?

3. Techniques used to achieve compliance

- Which stormwater management techniques appear to be the most common or preferred?
- Is there evidence of declining management costs associated with increased use/experience?

4. Reaction of the development community

- Which particular provisions of the new regulations, if any, did the development community push back against most strongly?
- Which provisions, if any, did not inspire any strong reactions?
- Which provisions, if any, did the development community actively support?

5. Other information

- Have there been any particular surprises as you moved from promulgation to implementation and enforcement of regulations?
- Is there anything else you would want to call attention to for another city that may be going through a similar regulatory change?

PHILADELPHIA, PA

Philadelphia's stormwater regulations took effect January 1, 2006. The regulations were developed as part of watershed-based planning efforts ongoing with several municipalities bordering Philadelphia, but also in response to the 1976 Pennsylvania Stormwater Act, which requires municipalities to update stormwater plans as needed to incorporate changes in the regulatory environment. In recent years, the state established TMDLs in the Philadelphia watershed, and federal policy has tightened restrictions on CSO systems. As such, Philadelphia's stormwater regulations had to respond to these changes.

Major features of the new stormwater regulations included requiring retention of one inch of water volume; setting a lower threshold for regulation at between 5,000 – 15,000 sq ft (depending on building type and location); and a series of erosion and flood control measures. Philadelphia eliminated the issuance of waivers for projects that fall within the purview of the stormwater regulations, but coupled promulgation of the regulations with the roll out of transparent, online permit submission, review, and approval processes, as well as financial incentives to promote the use of LID techniques. Over the past three years of implementation, Philadelphia also gradually established policies for stormwater banking and trading to accommodate developers and institutional landholders (including the Philadelphia airport and universities in the City) who prefer to build larger green infrastructure projects that connect multiple sites (as opposed to site-specific stormwater management plans). Based on their own experience, the City recommends establishing the parameters of banking and trading programs upon promulgation of new stormwater rules, instead of taking a gradual approach.

Impact Of The Regulations On Development Activity

Philadelphia sees no impacts of the stormwater regulation on the location of development activity. Although some developers threatened to pull projects from Philadelphia when the stormwater regulation went into effect, this never happened. The Philadelphia official interviewed, Mr. Crockett of the Department of Water, indicated that projects locating within Philadelphia city limits typically need access to the City's infrastructure, including airports and roads, and business clusters. In Philadelphia, factors that commonly drive decisions about locating marginal projects in the City versus the suburbs include prevailing union wage rules for construction, school quality, and taxes. Finally, the State of Pennsylvania and other nearby jurisdictions have similar stormwater requirements for major developments, but without the expedited approval process, incentives, and customer service offered by Philadelphia (discussed below). As such, there is little incentive for developers to move a project to a neighboring jurisdiction based on the stormwater regulation.

Techniques Used To Achieve Compliance

Philadelphia does not mandate use of LID techniques to achieve compliance with the stormwater regulations. However, the City provides incentives for using LID techniques, including an expedited review process for projects that use LID techniques to manage 90

percent of stormwater; and parcel-based billing for impervious surfaces, which facilitates providing credits for LID on sewer bills. As a result, Philadelphia now regularly receives applications for "ultra-green" stormwater plans. In urban areas, ultra-green plans typically include green roofs (40 green roofs have been installed in the last three years), porous pavers, canopy-providing trees, and stormwater reuse. In more suburban areas, ultra-green plans often incorporate bioretention areas and rain gardens. Developers that do not use the ultra-green approach typically use storage tanks in basements or under parking surfaces to manage stormwater.

Reaction From The Development Community

Philadelphia worked with the development community for a year before the new stormwater regulations were put out for comment. The draft regulations were out for comments for three months but no one submitted comments; Mr. Crockett speculates that the development community did not believe that the City was serious about implementing the proposed rules. Once implemented, reaction from the development industry appears to have been largely positive. Philadelphia instituted a transparent and efficient online system for processing stormwater applications when the new regulations came online; the process drastically cut down wait times for approvals, eliminated the City's previous "spiderweb" of zoning and building permit procedures, and provided responsive customer service to the development community. As a result, developers receive their approvals faster and trust that the system is fair and consistent. The City invested heavily in information technology, management systems, and staff to effectively implement the new application and permit process, and Mr. Crockett emphasized that this investment was critical to the stormwater program's acceptance and success. In addition, the City created the fast track approval process and implemented financial incentives for green stormwater plans, which also pleased the development community. Finally, savvy developers are taking the "ultra-green" stormwater management route as part of broader green building projects, and earning rent premiums by marketing the green credentials of their buildings.

On the other hand, Philadelphia adopted a no-waiver policy, which took a long time for developers to accept as the new reality. The City's water department withstood significant political pressure during the first year of implementation regarding their stance on waivers. Under the regulations, the City will provide off-site stormwater mitigation if the applicant proves the infeasibility of on-site management. More commonly, however, the City has worked with developers and landowners to conduct stormwater banking or trading, particularly within a campus or between multiple projects held by the same developers. Communication issues with the development community still persist. Developers were accustomed to ground rules where preserving the status quo of impervious surface was allowed, which was typically 80 percent impervious to 20 percent pervious; now, that ratio is inverted. In addition, although the City responds to permit requests rapidly, it often takes a few iterations before a stormwater permit is issued, as project engineers often gloss over the submission package and submit designs that have major errors and/or are not constructable. The City will not issue an approval without a constructable drawing.

Other Information

Philadelphia currently conducts inspections of stormwater management construction when they conduct inspections for erosion control, but the City is developing a dedicated group for stormwater inspections. The City uses the enforcement tool of withholding occupancy permits in cases where a developer has not demonstrated compliance with stormwater regulations. The City also requires an operations and maintenance agreement for stormwater management systems, and that agreement is attached to the property's deed. Thus, in case of stormwater system failure, Philadelphia has the ability to fix the problem and put a lien on the property to recoup the cost.

CHICAGO, IL[1]

Chicago's current stormwater regulations were developed over the course of several years and became effective on January 1, 2008. The regulatory revisions were entirely driven by the Mayor's office as part of an effort to make stormwater management "greener." The regulations, which moved the City from a prescriptive to a performance-based set of requirements, focus on four areas: site-specific release rates (codifying existing policy that they had been applying for 10 years); volume control; best management practices for operations and maintenance; and pre- and post-construction erosion control. During the rulemaking process, the City Council considered, but ultimately rejected, a proposal to attach a property's stormwater permit to its deed. Instead, the regulations require an affidavit that simply informs future buyers of a property that stormwater-related restrictions may apply (a 'buyer beware' approach). In addition, the development community proposed a payment-based alternative compliance option that was ultimately rejected due to concerns about how the City would manage the collected funds. The regulations do include a (deliberately) burdensome variance process that has not yet resulted in any applications. The rulemaking also included significant debate about stormwater treatment, but failed to reach a resolution; as a result, the water quality issue was tabled with the expectation that it would be revisited separately at a later date.

Impact Of The Regulations On Development Activity

The stormwater regulations do not appear to have had any impact on development activity or patterns. Incremental costs are reportedly being absorbed without much complaint. There is some indication that property values are increasing in areas where open space is being maintained as part of the stormwater management regime.

Techniques Used To Achieve Compliance

Green roofs have been the most popular means for achieving compliance with the stormwater regulations, in part due to a separate Department of Planning green roof requirement established a few years ago for any project that received financial assistance from the City. Many of the buildings that are subject to the stormwater regulations (i.e., those greater than 15,000 sq ft in size) have benefited from some form of city assistance

[1] Chicago does not have a single stormwater utility. Separate agencies are responsible for stormwater collection and treatment through a system that is nearly entirely (> 99 percent) combined sewers.

and are thus subject to both sets of requirements. High opportunity costs associated with open space have also served to push developers toward green roofs. The Planning Department's initial green roof requirement has subsequently become more flexible (allowing solar panels and other measures as a way to achieve broader sustainability objectives), but for the most part developers appear to be comfortable continuing to use what they now know best. They are also benefiting from declining costs resulting from strong vendor response to the increased demand for green roofs.

Over the past year, there has been an apparent shift in the preferred compliance option for the volume control requirement. Of the two options – a prescriptive 15 percent reduction in impervious surface relative to baseline and a performance-based 0.5 inch reduction in runoff – the runoff option has become more prevalent as developers gain confidence in their ability to meet this performance standard.

Reaction From The Development Community

The City worked closely with the regulated community during the rulemaking process and received substantial public input in response to its requests for comment. As a result, with the exception of the deed proposal (noted above), there was relatively little pushback from developers. Some developers questioned the basis of the numerical targets set, but this did not become a serious point of contention.

Other Information

City officials have reportedly been pleasantly surprised that implementation has occurred largely without any significant problems, though this may be due in part to a significant decline in development activity resulting from unfavorable economic conditions. Furthermore, rather than place an additional burden on City employees, Chicago has hired outside consultants to oversee certain aspects of the permit application approval process; this could contribute to the relative ease of the implementation process thus far. Going forward, the City will most likely move to strengthen some of the requirements. For example, developers using the impervious area performance option for volume control routinely achieve greater reductions than are required (closer to 25 percent), so the City can be expected to shift the standard accordingly.

PORTLAND, OR

Portland was a pioneer in the U.S. in regulating stormwater, and promulgated its first Stormwater Management Manual in 1999. At the time, it was among the first jurisdictions to shift responsibility for stormwater management from centralized treatment systems onto individual sites. Portland increased its emphasis on vegetated techniques in its third revision to the Manual in 2004, and went further in the latest revision, which took effect on August 1, 2008. The current regulations reference a "water quality storm" (slightly lower than the two-year design storm for the City) and a "flow control storm" (equivalent to the 10-year design storm). They require management through vegetated techniques to the maximum extent feasible, first through infiltration and then through detention, with exceptions for contaminated sites, steep slopes, and

certain other site conditions. Of particular note is the City's applicability threshold; any project with 500 sq ft or greater of impervious surface is subject to the regulations.

Impact Of The Regulations On Development Activity

As with the other cities considered, Portland has seen little if any impact on major development projects from its stormwater regulations. The City experienced strong, continued growth from the promulgation of the first stormwater regulations in 1999 until the start of the current recession in 2008. Although the regulations were seen as burdensome by the developers, particularly in the early years before there was much experience locally or nationally in complying with such requirements, the effects of the regulations were more than outweighed by other real estate market factors.

One possible difference between Portland and the other cities, however, pertains to smaller development projects. Stormwater management costs can be proportionally higher for the smallest projects that fall under the regulations, given the City's extremely low threshold for exemptions (500 sq ft). While there are no hard data available, Ms. Uchiyama expressed a concern that in the current economic context, Portland's regulations may be discouraging developers from building smaller projects. Portland did not undertake an economic analysis of the likely effects of their regulations before promulgating them in 1999.

Anecdotally, Ms. Uchiyama has heard of developers who have chosen not to build in Portland. However, the City is well-known for its progressive mentality and strict laws and regulations on a wide range of environmental issues. Thus, reluctance to build in Portland may be a response to the City's whole suite of environmental regulations, and not a reaction to the stormwater regulations alone.

Techniques Used To Achieve Compliance

In the previous iteration of the Stormwater Management Manual (2004), Portland identified a large number of vegetated techniques that developers could use to satisfy the regulations, without providing any kind of differentiation or expressing a preference for any particular approach. In the latest revision, the City refined the list to emphasize basins and planters, which represent the "workhorses" among vegetated techniques.

Green roofs and permeable pavement occupy a privileged position in Portland's regulatory scheme. Rather than being considered stormwater management techniques, they are classified as "impervious area reduction techniques" that reduce the regulated amount of impervious surface in a 1-to-1 ratio. Thus, a developer could erect a lot line-to-lot line building with a green roof and have zero impervious area for the purposes of the regulations, effectively exempting the project from any further requirements. However, these techniques cannot be used to manage stormwater runoff from adjacent areas. Despite this regulatory approach, and further support by way of generous incentive programs for green roofs, these techniques have not been widely used in Portland. This is probably due to some high-profile failures of early green roofs. Hopefully, as developers in other cities continue to gain experience and confidence, these technologies will be more widely utilized in Portland as well.

Reaction From The Development Community

The development community voiced significant opposition to Portland's initial promulgation of stormwater regulations in 1999. The regulations entailed a major shift, moving the burden of treatment from large downstream facilities to individual sites and thus placing an unprecedented level of new responsibility on those properties. Much of the opposition was driven by the uncertainty involved, since the sizing requirements for vegetated areas and the attendant costs of the regulations were not yet clear.

Subsequent revisions to the regulations, including the most recent revision in 2008, have gone much more smoothly and engendered little controversy. The most recent revisions focused on process changes and clarifying the requirements without changing the actual engineering standards involved; the development community strongly advocated for these changes.

Other Information

Ms. Uchiyama noted that for several years, Portland's emphasis was on the City's Green Streets Initiative, which focused on rights-of-way in public streets rather than private property. This ended up being a major undertaking that required substantial cooperation with other city and regional departments, as well as utility companies. Only recently has the City shifted its focus to management of private property.

Ms. Uchiyama also noted that the stormwater regulations imposed significant staffing and organizational demands on the City, especially given the regulations' low applicability threshold.

SEATTLE, WA

Seattle Public Utilities' revision of the stormwater regulations was motivated by the City's need to come into compliance with its NPDES permit requirements, as set forth by Washington Department of Ecology. The new regulations took effect on December 1, 2009. A major change from the previous regulations is a significantly (approximately three times) higher standard for flow control when discharge is to a creek watershed (as it is for approximately one-third of the City area). In addition, the determination of post-development peak flow rates and flow durations now requires the use of continuous modeling, rather than the single-event modeling allowed under the prior regulations. Of particular interest, however, is the mandate to use "green stormwater infrastructure" to the "maximum extent feasible." Green stormwater infrastructure is a term that is only generally defined; as a result, the City recognizes the need for, and expects to issue, specific guidance on approaches that would satisfy this requirement.

Impact Of The Regulations On Development Activity

Since the regulations have only recently taken effect, it is too early to judge their impact, if any, on development activity. However, Seattle is essentially built out, so any changes would occur in the context of redevelopment projects, which in turn are generally driven by zoning decisions (e.g., increasing allowable density). As such, Seattle does not expect changes to development patterns to result from the stormwater regulations.

Techniques Used To Achieve Compliance

Developers in Seattle do have a choice of LID techniques, but as part of the permitting process the City requests an evaluation of the different possibilities in a prescribed "pecking order." In general, infiltration techniques are ranked above those that simply delay stormwater flow. The amount of leeway that developers are allowed in their choice of proposed management approaches depends on site characteristics including the site's natural capacity to manage stormwater and the vulnerability of the surrounding area.

Another city law (Seattle Green Factor), which has been in effect for about one year, sets out green space requirements for commercial space. Similar to the stormwater regulations, the law encourages bioretention areas, permeable pavement, and green roofs as preferred options. With open space at a premium, the Green Factor law has resulted in a larger percentage of green roofs as the preferred compliance mechanism.

Reaction From The Development Community

The sense in Seattle was reportedly that the City had little choice but to move toward the new regulations. In addition to the NPDES compliance requirement, a lawsuit in which a non-profit prevailed in its argument that the State Department of Ecology's standards were not strict enough created an atmosphere in which regulatory revisions were inevitable. As a result, there was no strong opposition from the development community. The strategy of mandating LID "to the maximum extent feasible" while deferring the specification of what this means also likely contributed to the relative ease with which the standards have been put into place.

Other Information

Some questions remain among city officials regarding the utility of a performance standard with a focus on infiltration practices when land is generally unavailable to achieve this goal. The challenge of verifying and enforcing a standard based on a "maximum extent feasible" basis (i.e., one that is not readily quantifiable or otherwise measured) has also been noted.

3. COST ANALYSIS

INTRODUCTION

This section presents our analysis of the incremental first costs that developers of three hypothetical building projects in the District might expect to incur to comply with the proposed stormwater regulations. We developed the specifications for these hypothetical projects in consultation with DDOE staff with the intention of highlighting the key requirements of the regulations through the use of broadly representative project types and development locations. The analysis of each project begins with a determination of current and proposed future stormwater management requirements. We then specify and estimate costs for one or more stormwater management techniques that the developer could be expected to employ at each project location to meet the new standards. In each case, we sought to minimize the developer's costs, subject to any constraints imposed by the regulations or the physical characteristics of the building and project site. We evaluated only those incremental capital costs that are directly attributable to ensuring compliance with the regulations.[2] For example, we account for the fact that the installation cost of a bioretention area is slightly offset by avoiding a portion of the projected baseline expense for conventional landscaping; however, we do not consider additional O&M costs that may be created by the bioretention area. We then determined a net incremental cost of compliance by comparing our cost estimate to the costs that the developer could be expected to incur to comply with existing regulations. It is important to note that we are not estimating *total* costs of compliance; expenses that would be borne under both the existing and the proposed regulations are not incremental, and therefore do not figure in our compliance cost estimates.

As a final step, we provide an estimated incremental cost for each project as a percentage of presumed total development costs and as a cost per sq ft of building space. Development costs for the hypothetical building projects reflect average values for comparably projects in the District that have either been recently completed or are planned for near-term development. To develop these cost estimates, we consulted several data sources, including a list of specific development projects available from the

[2] In determining which costs could be attributed solely to the proposed regulations, we examined the District's Green Building Act of 2006 and the Anacostia Waterfront Environmental Standards Act as well as the District's existing stormwater regulations under Title 21, Chapter 5. However, we did not find any direct link between the Green Building and Anacostia Acts and the stormwater management regime contemplated here. Both Acts require new building projects to meet the standards of LEED-NC (at varying levels of certification), but this LEED standard does not include any *mandatory* stormwater prerequisites. The Anacostia Waterfront Environmental Standards Act also sets out stormwater management requirements similar in many regards to the regulatory changes being analyzed here, but applies these requirements only to publicly-owned or financed projects (see §453.c).

office of the Deputy Mayor for Planning and Economic Development;[3] a similar list of specific projects, as well as aggregated data, from the Washington DC Economic Partnership;[4] and an older version of the latter report from the Washington, DC Marketing Center (forerunner to the DC Economic Partnership).[5] For each scenario, we were able to identify specific projects that matched fairly closely with our hypothetical examples. Aggregate data by category (office vs. retail vs. residential; new construction vs. renovation) also served to validate that our cost estimates are reasonably representative for the building types described in Exhibit 3-1.

METHODS

SCENARIO DEVELOPMENT

Exhibit 3-1 describes our hypothetical projects in detail. Our intention in developing these examples was to choose a range of buildings that would be reasonably representative of the types of development most commonly pursued in the District. Our specification of project details focused only on those attributes necessary for completion of the cost analysis. For this analysis, we elected not to model a large-scale, mixed-use project, several of which are in development within the District at costs estimated to exceed one billion dollars. While we are confident that our analyses of "typical," smaller-scale projects have produced credible results, we are less confident that our approach would be suitable for a larger project with more complex design and engineering requirements.

COST DATA COLLECTION

We conducted a targeted literature review, internet searches, and interviews with stormwater and LID experts from the public and non-profit sectors to develop unit cost estimates for the range of "traditional" and LID stormwater management techniques. We applied several criteria to determine which costs to use in our analysis, including credibility of the data source; general consistency with other published sources; applicability to the hypothetical building project parameters; and specificity to the Washington DC area, where possible. We generally found a high degree of consistency across information sources.

Exhibit 3-2 lists the data we selected for use as cost inputs to our analysis. These are implementation costs that include materials and labor. All reported dollar amounts are inflation-adjusted to 2009 dollars using the consumer price index (CPI).[6]

---

[3] District of Columbia Deputy Mayor for Planning & Economic Development. "Neighborhood Development Projects," 2009. Accessed December 4, 2009. http://dcbiz.dc.gov/dmped/cwp/view,A,1365,Q,606420,dmpedNav,|33026|,.asp

[4] Washington, DC Economic Partnership. "Development Report: 2009/2010 Edition." 2009. Accessed December 8, 2009. http://www.wdcep.com/aboutus/pubs.php.

[5] Washington, DC Marketing Center. "Washington DC By the Numbers: 2003 Edition." 2003. Accessed December 9, 2009. http://www.wdcep.com/pdf/pubs/dcno.pdf

[6] US Department of Labor Bureau of Labor Statistics. "Consumer Price Index." N.d. Accessed December 5, 2009. http://www.bls.gov/CPI/

EXHIBIT 3-1. HYPOTHETICAL BUILDING PROJECT SPECIFICATIONS

ATTRIBUTE		PROJECT		
		1	2	3
Location		Anacostia Waterfront Development Zone/Ward 8	Downtown/Ward 2	Ward 5
Project type		New construction	Comprehensive renovation	New construction
Building type		Class A Office/ground level retail	Multi-story residential/ground level retail	Low rise retail with 10,000 sq ft parking lot
Building footprint	sq ft	20,000	15,000	10,000
Property size	sq ft	40,000	15,000	25,000
Stories			6	1
Development cost (excluding LID)	2009 $	$55 million ($343.75/SF)	$30 million ($333.33/SF)	$20 million ($2000/SF)
"Green" building	Yes or No	Yes (per Anacostia Waterfront Act)	No	No
Sewer zone	CSO or MS4	CSO	CSO	MS4
Impervious cover	%	75	100	80
Compacted cover	%	5	0	0
Natural cover	%	20	0	20
Contaminated site	Yes or No	Yes	No	No
SFHA[1] discharge	Yes or No	No	No	No
Soil type[2]		Sassafras-Croom-Beltsville	Sassafras-Croom-Beltsville	Urban Land-Sunnyside-Sassafras-Muirkirk- Christiana
Proposed stormwater management approach		• No infiltration possible due to presumed site contamination • Two lined vegetated bioretention areas (large), with impermeable liner – 50% of water retained, 50% discharged through underdrain	• Green roof • Roof-based rainwater harvesting w/ basement storage tank and reuse for non-potable indoor applications (e.g., sewage conveyance)	• Unlined vegetated bioretention area (small)
Baseline stormwater management approach		Conventional landscaping (zero cost)	Underground sand filter	Conventional landscaping (zero cost)

[1] SFHA = Special Flood Hazard Area as delineated on Federal Emergency Management Agency Flood Insurance Rate Maps
[2] Per USDA soil classification

EXHIBIT 3-2. UNIT COST ESTIMATES FOR STORMWATER MANAGEMENT TECHNIQUES

TECHNIQUE	IMPLEMENTATION COST	SOURCE	SUPPLEMENTARY SOURCES	NOTES
Green roof	$10 per sq ft	DC Greenworks	• Chicago Guide to Stormwater Best Management Practices • Massachusetts Low Impact Development Toolkit • Portland EcoRoof Handbook • Paladino & Company Green Roof Feasibility Review	• Average value from range of $5 – $15 per sq ft • Reflects price of commercial extensive green roof
Conventional roof	$6 per sq ft	Paladino & Company Green Roof Feasibility Review	• IB Roof Systems • InspectAPedia	• Average value from range of $3 - $9 per sq ft • Supplementary sources indicate price is consistent with estimates for flat commercial roofs • Cost used to determine incremental cost of green roof
Rainwater storage tank	$2500 for 2,000 gallon, in-ground tank	Massachusetts Low Impact Development Toolkit	• Texas Manual on Rainwater Harvesting • Low Impact Development Center, "Rain Barrels and Cisterns"	Galvanized steel storage tank
Bioretention area (large)	Cost = $9.48 * $SWRv^{0.991}$	Brown and Schueler; referenced and adapted in numerous other sources.	• Prince George's County Bioretention Manual • Fairfax County LID BMP Fact Sheet • MA Office of Energy and Environmental Affairs, LID Matrix • Low Impact Development Center, "Bioretention" • City of Chicago	• SWRv = volume of water to be treated, in cubic feet • Supplementary sources generally provide estimates of total costs or costs per sq ft; however, these are consistent with formula cited • Cost is for unlined bioretention area
Bioretention area (small)	$8,300	Prince George's County Bioretention Manual	• Brown and Schueler • Fairfax County LID BMP Fact Sheet • MA Office of Energy and Environmental Affairs, LID Matrix • Low Impact Development Center • City of Chicago	• Based on cost for single residential lot • Unit costs are higher due to small scale of project requiring same level of engineering (see Prince George's County Bioretention Manual, p. B-6 – B-7)
Impermeable liner	$0.80 per sq ft	Idaho Association of Soil Conservation Districts	Water Reuse Foundation	• Average value from range of $0.40 - $1.20 per sq ft • Added to cost of unlined bioretention area to determine cost of lined bioretention area

TECHNIQUE	IMPLEMENTATION COST	SOURCE	SUPPLEMENTARY SOURCES	NOTES
Conventional landscaping	$3,622 per acre	Chicago Guide to Stormwater Best Management Practices		• Average value from range of $2,000 - $4,000 per acre (2003 dollars) • Cost used to determine incremental cost of bioretention area
Permeable pavers (for parking lot)	$3.87 per sq ft	New York State Stormwater Design Manual		• Average value of range from $1.50 - $5.75 per sq ft (2007 dollars) • Cost is for grass/gravel pavers
Surface sand filter	$12,130	EPA Storm Water Technology Fact Sheet: Sand Filters	Schueler 1994, cited by Federal Highway Administration	• Cost is for filter with 1 acre drainage area. Assumes there is no cost reduction for smaller systems • Average value from range of $6,600 - $11,000 (1997 dollars)
Underground sand filter	$19,300 per impervious acre	Stormwater Manager's Resource Center		• Cost is for pre-cast filter with 1 acre drainage area. Assumes no cost reduction for smaller systems

Sources (in order shown in table):

DC Greenworks. "Frequently asked Questions about Green Roofs." N.d. Accessed December 9, 2009. http://www.dcgreenworks.org/index.php?option=com_content&task=view&id=35&Itemid=64

City of Chicago. "A Guide to Stormwater Best Management Practices." 2003. Accessed September 22, 2009. http://egov.cityofchicago.org/webportal/COCWebPortal/COC_ATTACH/GuideToStormwaterBMPs.pdf

Boston Metropolitan Area Planning Council. "Massachusetts Low Impact Development Toolkit." Accessed December 14, 2009. http://www.eot.state.ma.us/smartgrowth/07toolkit/LID/regional_planning/LID/green_roofs.html#R

City of Portland Environmental Services. "EcoRoof Handbook 2009." April 2009. Accessed September 21, 2009. http://www.portlandonline.com/BES/index.cfm?c=50818&a=259381
Paladino & Company. "Green Roof feasibility Review." March 25, 2004. Accessed December 4, 2009. http://your.kingcounty.gov/solidwaste/greenbuilding/documents/KCGreenRoofStudy_Final.pdf

IB Roof Systems. "Flat Roofing Prices: IB Roof replacement costs in MA, RI and CT." Accessed December 4, 2009. http://www.coolflatroof.com/flat-roof-prices.php

InspectAPedia. "Roofing Inspections, Roofing Product Sources, Asphalt Shingles, Slates, Installation, Defects, Repairs – Articles for home buyers, home owners, home inspectors." Accessed December 4, 2009. http://www.inspectapedia.com/roof/roofing.htm

Low Impact Development Center. "Rain Barrels and Cisterns: Costs." Accessed September 11, 2009. http://www.inspectapedia.com/roof/roofing.htm

Texas Water Development Board. "The Texas Manual on Rainwater Harvesting." Accessed December 11, 2009. http://www.twdb.state.tx.us/publications/reports/RainwaterHarvestingManual_3rdedition.pdf

Brown, Whitney and Thomas Schueler. "The Economics of Stormwater BMPs in the Mid-Atlantic Region." Center for Watershed Protection, August 1997. Available at http://www.cwp.org/Resource_Library/Controlling_Runoff_and_Discharges/sm.htm. Accessed December 5, 2009.

Environmental Services Division, Department of Environmental Resources, The Prince George's County, Maryland. "Bioretention Manual." December 2007. Accessed December 8, 2009. http://www.princegeorgescountymd.gov/Government/AgencyIndex/DER/ESG/Bioretention/pdf/Bioretention%20Manual_2009%20Version.pdf

TECHNIQUE	IMPLEMENTATION COST	SOURCE	SUPPLEMENTARY SOURCES	NOTES

The Low Impact Development Center, Inc. "Fairfax County – LID BMP Fact Sheet – Bioretention Cells." February 28, 2005. Accessed December 8, 2009. http://www.lowimpactdevelopment.org/ffxcty/1-2_bioretentioncell_draft.pdf

Massachusetts Executive Office of Environmental Affairs, LID Science and Research Subcommittee. "LID Matrix." September 1, 2004. Accessed December 10, 2009. Available at http://www.mass.gov/Eoeea/docs/eea/water/lid_matrix.pdf

Low Impact Development Center. "Bioretention: Costs." Accessed September 11, 2009. http://www.lid-stormwater.net/bio_costs.htm

City of Chicago. "Bioinfiltration: Rain Gardens." N.d. Accessed December 10, 2009. Available at http://tinyurl.com/chicago-bioretention

Idaho Association of Soil Conservation Districts. "Waste Facility Construction Guidelines." 2009. Accessed December 17, 2009. http://www.oneplan.org/Stock/wasteFac/index.asp

WateReuse Foundation. "Beneficial and Nontraditional Uses of Concentrate," p. 73. 2006. Accessed December 17, 2009. http://www.watereuse.org/files/images/02-006b-01a.pdf

New York State Department of Environmental Conservation. "New York State Stormwater Design Manual," Chapter 9. 2007. Accessed December 15, 2009. www.dec.ny.gov/chemical/29072.html

U.S. Environmental Protection Agency, Office of Water. "Storm Water Technology Fact Sheet: Sand Filters." September 1999. Accessed December 2, 2009. http://www.epa.gov/OWM/mtb/sandfltr.pdf

Schueler, Thomas. "Developments in Sand Filter Technology to Improve Stormwater Runoff Quality," 1994. Watershed Protection Techniques 1(2):47-54. Cited in US. Department of Transportation, Federal Highway Administration. "Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring. Fact Sheet – Organic Media Filters." N.d. Accessed December 2, 2009. http://www.fhwa.dot.gov/environment/ultraurb/3fs9.htm

Stormwater Manager's Resource Center. "Stormwater Management Fact Sheet: Sand and Organic Filter." N.d. Accessed December 3, 2009. http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Filtering%20Practice/Sand%20and%20Organic%20Filter%20Strip.htm

GENERAL ASSUMPTIONS AND CALCULATIONS

Stormwater Management Volume

For each project we calculated the volume of stormwater that must be managed onsite under the proposed regulations using the following equation from the preliminary proposal):

$$SWRv = \frac{P \times (Rvi \times \%I + Rvc \times \%C + Rvn \times \%N) \times SA}{12}$$

where:

SWRv = volume of water to be retained, in acre-feet
P = 1 inch (90th percent rainfall event for the District),
Rv_I = 0.95 (runoff coefficient for impervious cover)
Rv_C = 0.25 (runoff coefficient for compacted cover)
Rv_N = 0.05 (runoff coefficient for natural cover
%I = percent of site in impervious cover
%C = percent of site in compacted cover
%N = percent of site in natural cover
SA = total site area, in acres

The Anacostia Waterfront Development Zone (Anacostia) faces a considerably more stringent requirement. Anacostia projects must either retain the SWRv calculated with P = 3.2 inches (a 320 percent increase over the general requirement), or retain a volume no less than the SWRv calculated above and treat the remainder in a way sufficient to remove 85 percent of total suspended solids (TSS). Throughout the District, applicants are required to use vegetated techniques to the maximum extent possible, indicating that chemical or mechanical filtration to remove TSS would generally be viewed as a last resort. The proposed regulations include provisions for relief where compliance is technically infeasible or inappropriate due to soil contamination, whereby applicants must provide off-site mitigation to offset any deficiency.

The baseline volume of stormwater to be managed is calculated according to the method prescribed in existing regulations:

$$Vw = \frac{R \times Ia}{12}$$

where:

V_w = water quality volume to be treated, in cubic feet
R = runoff depth, in inches: 0.5 in for parking lots, city streets, and high speed roads; 0.3 for rooftops, sidewalks, and pedestrian plaza areas
I_a = impervious area, in sq ft

Another element of the existing regulations is a requirement to maintain the post-development peak discharges for a 24-hour, two- and fifteen-year storm at pre-development levels. Since this stipulation is unchanged in the proposed regulations, we

do not consider it further here, as the new regulations would not create any additional incremental cost in this regard.

Baseline Stormwater Management Technique

Based on discussions with subject experts, we confirmed that sand filters are the most commonly used technique for on-site stormwater management in Washington, DC.[7] However, we assume the use of sand filters only in the baseline for the downtown renovation building example, since this case assumes a lot line-to-lot line footprint that would necessitate a below grade filtering structure. For both surface and underground filters, the information we reviewed presented costs for systems designed to serve a drainage area of one acre (43,560 sq ft), an area larger than any of the sites we are evaluating. Therefore, we have assumed that while smaller sand filters are available, they would not present any cost savings over filters designed for a one-acre site.

Our analysis indicates that the amount of natural cover presumed for the Anacostia and Ward 5 examples would be sufficient to accommodate a relatively high amount of stormwater, even in the absence of any LID techniques. We therefore assume that conventional landscaping, with no sand filter, would be the baseline management technique in these instances, with no cost to the developer (since conventional landscaping is considered a general development cost and is not attributed to stormwater management). Appendix C provides a more detailed explanation of our methodology for developing infiltration rates for conventional landscaping. Using those rates as inputs, the bioretention sizing calculations explained below and reproduced in Appendix D yield estimates not only of the retention capacity of the bioretention areas, but also of the remaining landscaped area on each site.

Infiltration Capacity And Sizing Of Bioretention Areas

The size of a bioretention area needed to manage a given volume of runoff is a critical assumption in driving both costs and the potential need for supplementary stormwater management options. Our calculations for the volume of stormwater runoff infiltrated per unit area for a bioretention cell is based on the methodology used by the Low Impact Development Center.[8] A given amount of rainfall (3.2 inches for the Anacostia example, one inch for the other scenarios) is translated into a total runoff amount for the site, based on the site area, the mix of impervious and natural cover, and the weighted curve number (CN) for the site, which measures rates of infiltration into the hardscape and other landscaping (aside from the bioretention area) based on underlying soil type. By specifying the proposed bioretention cell's ponding depth, infiltration porosity, and soil depth, we determine the total bioretention area needed to manage the prescribed amount of stormwater.

---

[7] Christopher Kloss, Low Impact Development Center. Personal communication, September 14, 2009.

[8] Low Impact Development Center, Inc. "Bioretention: Sizing." 2007. http://www.lid-stormwater.net/bio_sizing.htm.

We have assumed that a bioretention area, in itself, does not need to have capacity to accommodate the entire retention volume specified by the regulations; rather, it is our understanding that the bioretention area and any other LID techniques, in conjunction with whatever other conventional landscaping remains onsite, must have adequate infiltration capacity to handle the prescribed water volume. Thus, any stormwater that can be absorbed by conventional landscaping does not need to be addressed by a bioretention cell.[9]

In undertaking the sizing exercise described, we employed several key assumptions:

- We used a CN of 98 (out of a maximum of 100) for impervious surfaces.
- We assumed that all landscaping outside of the bioretention area would consist of turfgrass, with grass cover greater than 75 percent. Since turfgrass is relatively inefficient at capturing rainfall compared to other vegetation types, this is a conservative assumption.
- The soil type for the Anacostia and downtown examples is assumed to be Sassafras-Croom-Beltsville (based on a map of the Washington, DC area showing USDA soil profiles); for the Ward 5 example we assume an Urban Land-Sunnyside-Sassafras-Muirkirk-Christiana soil type. Each series within these soil types has its own characteristics, including soil texture. We derived a weighted average runoff curve number for each soil type, based on the hydrologic soil group of each of its constituent soil series.[10] This resulted in a CN of 65.33 for Sassafras-Croom-Beltsville (with 75 percent or greater grass cover) and 61 for Urban Land-Sunnyside-Sassafras-Muirkirk-Christiana. Appendix C explains in more detail how we derived these numbers and how we used them in calculating the size of the bioretention cells.

We chose to maximize retention capacity per unit surface area by making the filtration media in our bioretention areas as deep as possible, while remaining consistent with the site's soil type. As noted above, USDA publishes official descriptions of each recognized soil series (e.g., Sassafras, Croom, Beltsville, etc.) that make up an area's soil type. Among the soil characteristics reported are the typical depths of the various soil horizons. (Generally speaking, the A horizon in a soil profile is considered surface soil; the B horizon, subsoil; and the C horizon, the parent material or bedrock from which the soil was formed.) Using these values, we set the depth of each bioretention area equal to the bottom edge of the B horizon of the shallowest soil series within each soil type, again to be conservative in our assumptions. For example, in the Sassafras-Croom-Beltsville soil

[9] It is important to note that in the Anacostia example, our hypothetical building is on a contaminated site, where stormwater must be prevented from infiltrating into groundwater. In this case, we assume that any water that can be retained by the soil underlying conventional landscaping counts towards the requirement, but there is no capacity for water to be filtered through this soil. The bioretention cells in this example are presumed to use imported (i.e., uncontaminated) soil and therefore do not face this constraint.

[10] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Official Soil Series Descriptions. Accessed December 7, 2009. http://soils.usda.gov/technical/classification/osd/index.html.

type, the Sassafras series has a B horizon that extends down to 40 inches below the surface; the B horizon in Croom reaches down to 48 inches; and the Beltsville B horizon ends 71 inches below the surface. Thus, for this soil type, we conservatively set the bioretention cell's depth to 40 inches. For Urban Land-Sunnyside-Sassafras-Muirkirk-Christiana, Sassafras is once again the shallowest series, so we use a bioretention cell depth of 40 inches here as well.[11]

- Another critical factor in sizing bioretention areas to accommodate a set amount of runoff is the area's ponding depth – that is, the depth of standing water that will be (temporarily) pooled above ground until it can infiltrate the underlying soil, generally within 24 hours. The ponding depth is determined by the cell design (specifically, the height of the bioretention cell walls) and should account for the infiltration rate of the soil so as to avoid leaving standing water for extended periods of time. We have used a ponding depth of six inches, the maximum currently allowed in Washington, DC. Twelve inches appears to be a fairly standard choice for large commercial systems in many other jurisdictions.[12]
- In the interest of simplicity, we made no assumptions regarding the slope of the cell walls. This follows the approach taken by the LID Center's bioretention sizing calculation, in which retention capacity is a function solely of the site's soil characteristics and the horizontal surface area of the bioretention cell.
- A final issue which we confronted involved the maximum size of a bioretention cell, both in absolute and relative terms compared to the size of the site. Seattle's regulations stipulate that bioretention areas must be no larger than 800 sq ft,[13] although there is apparently no evidence that a slightly larger cell would be less effective;[14] in other jurisdictions, 1,000 sq ft is considered a standard size for a large commercial area.[15] However, the Seattle regulations also allow for multiple bioretention areas, operating independently or in series, on the same site, making the issue of maximum cell size relatively unimportant from a feasibility standpoint.

Given the other assumptions detailed above, we found that in our examples the largest bioretention area required would be 2,860 sq ft, for a 40,000 sq ft site with 30,000 sq ft of impervious surface. This would translate into 7.2 percent of the total site area, or 28.6 percent of the total non-hardscaped area. We assume that

[11] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Official Soil Series Descriptions. Accessed December 7, 2009. http://soils.usda.gov/technical/classification/osd/index.html.

[12] Christopher Kloss, Low Impact Development Center. Personal communication. December 15, 2009.

[13] City of Seattle, Seattle Public Utilities. "Stormwater Manual Vol. #: Stormwater Flow Control & Water Quality Treatment Technical Requirements Manual," p. 4-60. November 2009. Accessed December 10, 2009. http://www.seattle.gov/dpd/static/web_Vol%203%20-%20Flow%20Control%20and%20Treatment%20Manual%2020091201_LatestReleased_DPDP018337.pdf

[14] Tracy Tackett, Seattle Public Utilities. Personal communication, December 10, 2009.

[15] Christopher Kloss, Low Impact Development Center. Personal communication. December 15, 2009.

this would be split into three bioretention cells of 953.3 sq ft each, or, alternately, four cells of 715 sq ft each. Consultation with a design expert indicated that this would not be an infeasible or impractical design, given the size of the site and building, although it would occupy a significant fraction of the landscaped area.[16]

Infiltration Capacity And Sizing Of Green Roofs

Sizing calculations were more straightforward for green roofs. The Boston Metropolitan Area Planning Council reports that a 3-inch deep extensive green roof can retain about 0.6 inches of rain per event, even when storms come in quick succession.[17] This is consistent with a study by VanWoert et al., which found a proportional relationship between soil depth and rainfall retention capacity in green roofs, with roofs 6 cm (2.4 inches) deep retaining 12 mm (0.5 inches) of rain.[18] Thus, we have assumed that builders who implement a green roof will use 3-inch or deeper media that can retain 0.6 inches of rainfall per event.

We have also assumed that green roofs would not cover 100 percent of a building's roof area, due to space needed for HVAC vents and other equipment. An empirical review of extensive green roofs in Washington DC and other cities indicated that, in practice, the maximum rooftop coverage for green roofs is 75 percent. We have therefore used this number as the upper bound for our analysis.[19] This constraint has the effect of lowering the green roof's overall retention capacity, but also lowering its cost, since both of these factors are calculated on a per sq ft basis.

Application And Other Fees

In addition to requirements for the techniques used to manage stormwater, the proposed regulations also feature a revised fee schedule for plan review and other services. Under the existing regulations, a Storm Water Management Plan Review costs $72, plus an additional fee of $0.025 per 100 sq ft in excess of 5,000. Projects smaller than 5,000 sq ft are currently exempt from this fee requirement. The proposed regulation would impose a flat fee of $3,000 for Level 3 alterations and/or projects up to 10,000 sq ft, with an additional fee of $1,000 for projects that exceed this threshold. The proposed regulations also establish a $500 fee for reviewing as-built plans. Thus, the total fee cost for each of the three examples in our analysis is $4,500.[20] This appears to be fairly comparable to

---

[16] Christopher Kloss, Low Impact Development Center. Personal communication. December 15, 2009.

[17] Boston Metropolitan Area Planning Council. "Massachusetts Low Impact Development Toolkit." Accessed December 14, 2009. http://www.eot.state.ma.us/smartgrowth/07toolkit/LID/regional_planning/LID/green_roofs.html#R.

[18] Vanwoert, Nicholaus D. et al. "Green Roof Stormwater Retention: Effects of Roof Surface, Slope and Media Depth." Journal of Environmental Quality, pp. 1036-1044. 34: May/June 2005.

[19] Casey Trees and LimnoTech. "The Green Build-out Model: Quantifying the Stormwater Management Benefits of Trees and Green Roofs in Washington DC." April 19, 2007, p. 3-9. Accessed December 15, 2009. http://www.capitolgreenroofs.com/pdfs/Green_Infrastructure_Report.pdf

[20] The proposed regulations also set out several other fees for optional services. We have assumed that developers would not choose to incur any of these optional costs. Other fees regarding erosion and sediment control plans during construction are beyond the scope of this analysis and are excluded from consideration.

fees assessed in nearby jurisdictions; for example, Montgomery County, MD charges a 'Concept Fee' of $2,684, in addition to other, smaller fees.[21] While baseline fees under the existing requirements vary based on project size, they would be within a narrow range ($75 to $83) for our three examples.

Subsidies

We assumed that no grants or subsidies would be available to help projects defray the costs of implementing LID techniques. While individual projects could potentially qualify for financial assistance from, for example, DDOE's Green Roof Subsidy program,[22] there is no guarantee that such funding would be universally available.

RESULTS PROJECT #1 – ANACOSTIA OFFICE, NEW CONSTRUCTION

Key Assumptions

The Anacostia example comprises a new, eight-story, 160,000 sq ft Class A office building with ground-level retail. Due to its location within the Anacostia Waterfront Development Zone, this building faces the more stringent stormwater management requirements described above. Furthermore, since the project site is presumed to be contaminated, stormwater must be prevented from filtering through the soil into the underlying groundwater. Thus, an impermeable liner would be required beneath the contaminated soil for the entire site, regardless of the size of the stormwater management facilities.[23]

Based on a parcel size of 40,000 sq ft (0.92 acres) and 75 percent impervious cover, 5 percent compacted and 20 percent natural cover, the proposed stormwater regulations would require a stormwater management system capable of retaining at least 18,327 gallons, with retention and/or treatment of an additional 40,320 gallons. Under existing regulations, the standard would be considerably less stringent, requiring management of only 5,610 gallons. Appendix D details the calculations underlying these figures.

Given the substantial volume of water to be managed and the prohibition against infiltration, we chose a series of bioretention cells as the most cost-effective stormwater management technique for this project. We calculate that three bioretention cells, sized at just over 950 sq ft each, would be sufficient to retain 24,960 gallons. This is slightly higher than we would expect given a general rule of thumb that bioretention cells require 5 to 7 percent of the land area being drained (2000 – 2800 sq ft for a 40,000 sq ft

---

[21] Montgomery County, MD. "DPS/Water Resources – Stormwater Management. July 30, 2008. Available at http://permittingservices.montgomerycountymd.gov/dpstmpl.asp?url=/permitting/wr/nfsmc.asp Accessed February 2, 2010.

[22] DC Greenworks, "DDOE Green Roof Pilot Subsidy Program." N.d. Available at http://www.dcgreenworks.org/index.php?option=com_content&task=view&id=72. Accessed December 30, 2009.

[23] We assume that the existing soil for this site is kept in place and a liner is installed to prevent contamination from migrating into the groundwater. Site developers could also choose to implement a site remediation plan that involves removing the contaminated soil and replacing it with 'clean' soil. Such an approach would alter the soil characteristics of the site and would thereby affect our calculations regarding the infiltration rate and retention capacity of the natural cover on site (see Appendix C).

area),[24,25] most likely due to the more stringent stormwater treatment requirements and lower permissible ponding depth in effect here. An additional 20,466 gallons could be absorbed by conventional landscaping on the site; while this lancscaping would not receive runoff from impervious surfaces, it could nonetheless retain the rainfall on the site's natural cover rather than diverting it to the bioretention area. The remaining 13,221 gallons to be managed would be filtered through the bioretention media to an underdrain and not retained on site. Bioretention cells of this size should be sufficient to filter out TSS to the level required, thereby satisfying the regulatory requirement.[26]

Incremental Costs Relative To Baseline

The cost of the bioretention cells is calculated as $9.48 * $SWRv^{0.991}$, where SWRv is the volume of water in cubic feet to be retained. Researchers at the Center for Watershed Protection developed this equation through a regression analysis based on an empirical examination of the actual construction costs of several systems.[27] Although the data used to develop this formula is several years old, it is still widely cited (in adapted form) in the literature, and we therefore use it here, adjusted for inflation, with a high degree of confidence. This approach sets the cost based on the total size of the system, with very modest economies of scale. With a retention volume of 8,320 gallons (1,112.2 cubic feet) for each of three cells, this brings the cost of the biorention cells on this site to $29,697. A small portion of this cost is offset by avoided landscaping cost, which, at $3,622 per acre ($0.083 per sq ft), produces a one-time net savings of $238.

Impermeable liners add an additional cost of $0.80 per sq ft of area. Given that the function of the liner is to prevent infiltration into the surrounding soil, the liner must cover the entire site area (excluding the building and other hardscape), not just the bioretention cells. A liner extending to the perimeter of the site to a depth of 40 inches, and underlying the soil for the entire permeable area at this depth, would require 12,667 sq ft of material, adding $10,133 to the cost. (An alternative approach could include removing the contaminated soil and replacing it with 'clean' soil.) However, under current DDOE practice (not codified in regulation), this effort would be required even in

---

[24] Massachusetts Executive Office of Environmental Affairs, LID Science and Research Subcommittee. "LID Matrix." September 1, 2004. Available at http://www.mass.gov/Eoeea/docs/eea/water/lid_matrix.pdf. Accessed December 10, 2009.

[25] For systems with a ponding depth of 12 inches, Seattle sets a sizing factor of 4.1 to 6.5 percent for its "pre-developed pasture standard," depending on the soil infiltration rate. City of Seattle, Seattle Public Utilities. "Stormwater Manual Vol. #: Stormwater Flow Control & Water Quality Treatment Technical Requirements Manual," p. 4-67. November 2009. Accessed December 10, 2009. http://www.seattle.gov/dpd/static/web_Vol%203%20-%20Flow%20Control%20and%20Treatment%20Manual%2020091201_LatestReleased_DPDP018337.pdf

[26] The retention volume of 24,935 gallons matches the total volume of precipitation on the site from a 1-inch storm. A bioretention area with this retention capacity should be able to treat the remaining runoff from the 3.2-inch storm contemplated in the regulations. In fact, given the retention capacity of the conventional landscaping, 2,000 sq ft of bioretention cells may be somewhat larger than necessary. Christopher Kloss, Low Impact Development Center. Personal communication. December 15, 2009.

[27] Brown, Whitney and Thomas Schueler. "The Economics of Stormwater BMPs in the Mid-Atlantic Region." Center for Watershed Protection, August 1997. Available at http://www.cwp.org/Resource_Library/Controlling_Runoff_and_Discharges/sm.htm. Accessed December 5, 2009.

the absence of the proposed stormwater regulations. Therefore, we do not count it as a cost in this analysis.

The total stormwater management cost for this scenario is $29,393. The approximately 20,000 estimated gallons that can be infiltrated through conventional landscaping is more than enough to satisfy the requirement of the existing regulations to manage 5,610 gallons. Thus, we assume zero cost for stormwater management in the baseline case.

Finally, we calculate the incremental cost of permit fees. As noted above, the fee expense under the proposed regulations for this site is $4,500; under the existing regulations, this expense would be $72 + $0.0325 * (40,000 – 5,000)/100 = $83 (rounding to the nearest whole dollar). This $4,417 increment is added to the incremental cost to produce a total additional compliance cost of $33,875 attributable to the proposed stormwater regulations (see Exhibit 3-3). Appendix D provides further detail on all of the calculations used to develop this cost estimate.

Incremental Costs As A Percentage Of Total Development Costs

Based on available data on actual development projects in the District, we estimate the total development cost (before incremental stormwater management) for a new, eight-story, Class A office building with ground level retail comprising 160,000 sq ft of occupiable space to be $55 million, or about $344 per sq ft. Thus, the incremental cost of the revised stormwater regulation detailed would represent a premium of 0.06 percent of the baseline development cost, or $0.21 per sq ft of building area.

PROJECT #2 – DOWNTOWN MULTI-STORY RENOVATION

Key Assumptions

The second example is based on the comprehensive renovation of a six-story, 15,000 sq ft residential building with ground-level retail, located in downtown Washington, DC (Ward 2). The building is assumed to occupy the entire parcel, leaving no natural cover at ground level.

The 15,000 sq ft (0.34 acre) parcel area, with 100 percent impervious cover, requires management of 8,883 gallons of stormwater. Since this site is outside of the Anacostia area, all stormwater must be retained onsite if feasible. The existing standards would require management of 2,805 gallons.

Due to the space constraints of the site and the regulatory emphasis on vegetative techniques where possible, the most likely stormwater management approach is the installation of a green roof occupying the maximum amount of space possible (75 percent of the roof area, our assumed maximum, or 11,250 sq ft). At an assumed retention capacity of 0.6 inches per rain event, this translates into a total volume of 4,208 gallons retained. With no space available for further vegetated techniques, we assume that the remaining 4,675 gallons of runoff is harvested through a rooftop drain and piped into

several storage tanks in the building's basement, to be used for indoor, non-potable uses such as flushing toilets.[28,29]

Incremental Costs Relative To Baseline

Our assumed cost for a green roof is $10 per sq ft; or an incremental cost of $4 per sq ft relative to the assume cost of a conventional roof; thus, we assume an incremental cost of $45,000. For the storage tanks, we assume three 2,000-gallon tanks at $2500 each, for a total of $7,500 and a total cost of $52,500. After accounting for the assumed $19,300 baseline cost of an underground sand filter (considerably more expensive than a surface filter), we calculate a net cost of $33,200.

As with the Anacostia example, permit fees for the downtown example are $4,500. The baseline fee under existing regulations would be $72 + $0.0325 * (15,000 – 5,000)/100 = $75, rounding to the closest dollar. The incremental permit cost is therefore $4,425, and the total additional cost of compliance attributable to the proposed stormwater regulations is $37,625. Exhibit 3-3 summarizes these results. Again, Appendix D shows our cost calculations in greater detail.

Incremental Costs As A Percentage Of Total Development Costs

Based on available data on similar projects in the District, we estimate development cost for this renovation project at $30 million. Thus, the estimated incremental compliance costs would add 0.13 percent to this total. With 90,000 sq ft of total building space, this is equivalent to $0.42 per sq ft in addition to $333.33 per sq ft baseline cost.

PROJECT #3 – WARD 5 LOW-RISE COMMERCIAL, NEW CONSTRUCTION

Key Assumptions

The third example is a single-story, 10,000 sq ft retail building. The project site includes an additional 10,000 sq ft of surface-level parking, leaving 5,000 sq ft of natural cover on the 25,000 sq ft parcel. The building is assumed to be located in Ward 5, which features a slightly more permeable soil type (Urban Land-Sunnyside-Sassafras-Muirkirk-Christiana) compared to our other two example project locations.

For this site, with an assumed 80 percent impervious cover, 12,000 gallons of stormwater must be managed on-site under the proposed regulations. The existing regulations would require management of 4,987 gallons.

The developers of this building could choose from several potential stormwater management approaches. The 5,000 sq ft of natural cover allows sufficient space for multiple bioretention cells; the extensive parking lot introduces the possibility of

---

[28] Stormwater harvested and reused onsite, even for indoor purposes, is counted as retained water for regulatory purposes. Shane Farthing, District Department of the Environment, personal communication, December 10, 2009.

[29] We have not assumed that this site would include underground parking; however, if it did, the basement storage tanks would require space that otherwise presumably would have been given over to parking. Based on the size of the storage tanks, however (6,000 gallons = 802 cubic feet), the equivalent of only two parking spaces would need to be surrendered (three 9.5-foot long cylindrical tanks, each with a three-foot radius).

permeable pavers, which would allow infiltration into the underlying soil; or, as in the downtown example, the project could utilize its roof area with a water-retaining green roof.

In this case, due to the relative costs involved, we assume the use of a bioretention area because it is the most cost-effective option. In fact, due to the relatively large amount of open space – 20 percent of the total parcel – only a relatively small bioretention area is required; conventional landscaping should be sufficient to accommodate most of the regulatory retention volume. Based on the textural characteristics of the Urban Land-Sunnyside-Sassafras-Muirkirk-Christiana soil type present at this location, we used a CN of 61, appropriate for well-maintained grass cover (see Appendix C for a more detailed explanation). Matching this number with a CN of 98 for the impervious areas yields a weighted average CN for the site of 90.94. With this rate of infiltration, the site would be able to accommodate 10,089 gallons of water from a one-inch storm event, even without a bioretention area;[30] the only requirement would be downspouts or sufficiently conscientious landscape design to ensure that runoff from impervious surfaces is directed onto the property's landscaping. We estimate that a 230 sq ft bioretention cell would be sufficient to address the remainder of the retention requirement.

Incremental Costs Relative To Baseline

The cost calculation for this example is straightforward. In this case, because the bioretention cell is so small (230 sq ft, compared to conventional large systems of 700 to 1000 sq ft), we forego the volume-based formula used in the Anacostia example and use a flat-rate estimate of $8,300, based on the cost for a single-lot residential system that is similar is size.[31] The assumption underlying this choice is that many, but not all, of the costs of a larger project are incurred in a small commercial project as well, but there is some cost savings due to the small size and thus reduced materials and labor costs. After accounting for avoided traditional landscaping costs, the small bioretention cell is estimated to have an incremental cost of $8,281. Since there is no presumption of site contamination in this example, an impermeable liner is not required.

The 10,000 estimated gallons that can be infiltrated through conventional landscaping is more than enough to satisfy the requirement of the existing regulations to manage 4,987 gallons on-site as long as runoff is properly directed onto the parcel's landscaped area. Thus, we assume zero cost for stormwater management in the baseline case.

Fees under the proposed regulations are $4,500, as compared to a baseline fee amount of $79, for an incremental cost of $4,421 from fees and a total additional cost of $12,702

---

[30] Performing this calculation with 5,000 sq ft natural area actually produces a result of 10,236 gallons; however, an incremental portion of stormwater managed by the conventional landscaping must be subtracted as the introduction of a bioretention cell shrinks the remaining amount of natural cover outside the cell. The optimal size to minimize costs is at 160 sq ft of bioretention area, with the remaining 4,840 sq ft of natural cover infiltrating the 10,089 gallons of water cited.

[31] Environmental Services Division, Department of Environmental Resources, The Prince George's County, Maryland. "Bioretention Manual." December 2007. Accessed December 8, 2009. http://www.princegeorgescountymd.gov/Government/AgencyIndex/DER/ESG/Bioretention/bioretention.asp

attributable to the proposed regulations (see Exhibit 3-3). We note that the fees in this example account for a significant portion of the total incremental cost of compliance. Cost calculations for this site can be found in Appendix D.

EXHIBIT 3-3. SUMMARY OF COST ANALYSIS BY SCENARIO

PROPOSED REGULATIONS	SCENARIO ONE	SCENARIO TWO	SCENARIO THREE
Water quality treatment volume, gal	58,647	8,883	12,000
Traditional landscaping size, sq ft	7,140	0	4,770
Retention volume, gal	20,466	0	10,023
Remaining runoff, gal	38,181	8,883	1,977
Bioretention area size, sq ft	2,860	0	230
Retention volume, gal	24,960	0	2,007
Treatment volume, gal	13,221	0	0
Remaining runoff, gal	0	8,883	0
Green roof size, sq ft		11,250	
Retention volume, gal		4,208	
Remaining runoff, gal		4,675	
Storage tank size, gal		6,000	
Remaining runoff, gal		0	
LID Costs			
Bioretention cell			
Retention volume, gal	24,935	0	2,007
Bioretention cell cost	29,697		8,300
less avoided landscaping cost ($3,622/acre)	-238	0	-19
total bioretention cell cost	29,459	0	8,281
Green roof			
incremental cost, $/sq ft	0	4	0
green roof area, sq ft	0	11,250	0
total green roof cost	0	45,000	0
Storage tanks			
cost per 2,000 gal tank	0	0	0
# of tanks required	0	3	0
total storage tank cost	0	7,500	0
Total LID cost	29,459	52,500	8,281
less: baseline management cost (sand filter)	0	19,300	0
Total incremental LID cost	29,459	33,200	8,281
Application/permit fees	$4,500	$4,500	$4,500
less: baseline fees	$83	$75	$79
Total incremental fees	$4,417	$4,425	$4,422
Total incremental cost of regulations	**$33,875**	**$37,625**	**$12,702**
Total project development cost	$55,000,000	$30,000,000	$ 20,000,000
Total building space, sq ft	160,000	90,000	10,000
LID cost / total development cost (%)	**0.06%**	**0.13%**	**0.06%**
LID cost / sq ft	**$0.21**	**$0.42**	**$1.27**

Incremental Costs As A Percentage Of Total Development Costs

Based on data for actual retail project development in the District, we estimate that the one-story retail building in this example has an assumed total development cost of $20 million, or $2,000 per sq ft. This is far above the $344 and $333 per sq ft assumptions in the Anacostia and downtown examples, respectively. However, aggregate data from numerous Washington, DC retail development projects indicates that this relatively high cost is representative of the typical retail development and may, in fact, be somewhat conservative. The incremental compliance costs estimated therefore represent a 0.06 percent premium on total project costs. However, given that this one-story building has significantly less floor space than the other two scenarios, the incremental compliance cost per sq ft is much higher, at $1.27.

LIMITATIONS AND UNCERTAINTY

As discussed below, several factors introduce uncertainty into the results of our analysis, including critical cost input and stormwater retention rate assumptions for various management techniques. We discuss the sensitivity of our overall results to each of these factors.

COSTS OF GREEN ROOFS AND CONVENTIONAL ROOFS

Our inputs for both green roofs and conventional roofs are based on average values from larger ranges. While our results should therefore be reasonably representative, individual development projects could face substantially higher or lower roofing costs, depending on the vendor and the particular requirements of the project.

Doubling the cost per sq ft of a green roof, to match the uppermost limit of the price range we identified, and halving the cost per sq ft of a conventional roof, to match the lower limit of that price range, would raise the incremental cost of the green roof used in scenario 2 from $45,000 to $191,250. This would bring the incremental cost of regulatory compliance for the downtown example to 0.6 percent of total project development costs, or $1.99 per sq ft. Adjusting the cost inputs in the opposite manner would result in zero incremental cost or even a cost savings for the green roof.

RETENTION CAPACITY OF GREEN ROOFS

Our assumed retention capacity is based on a green roof with a three-inch deep soil medium; systems with different depths would have different retention capacities. In the downtown (green roof) example, however, the effect on overall costs would be negligible, as the secondary method of stormwater management is a relatively low-cost storage tank. In fact, the three 2000-gallon storage tanks have an estimated 1,325 gallons of excess storage space that could be used to make up the shortfall. Thus, the green roof in this example could have a capacity 1,325 gallons (31.5 percent) lower than projected with zero cost impact.

SIZING OF BIORETENTION CELLS

As enumerated above, several assumptions affect the presumed retention capacity of a bioretention cell, which in turn drives the size needed for a given site and the attendant

construction costs. These assumptions represent IEc's best assessment of actual needs. We also conducted a sensitivity analysis to test to impacts of changing our assumptions to "worst case" versions. Our purpose in doing so was to set an upper bound on the potential stormwater-related expenses typical development projects could face. The assumptions we varied for our sensitivity test included:

- A CN of 72.33 for Sassafras-Croom-Beltsville soil instead of 65.33 (representing grass cover of 50 to 75 percent instead of 75 percent or greater).[32]
- Bioretention cell depth of 36 inches instead of 40.
- A firm cell size limit of 800 sq ft, increasing the number of individual cells required, lowering the size of each, and thus reducing the modest economies of scale included in the cost equation.
- Ponding depth of 4 inches, rather than the 6 inches assumed.
- Maintain the same ratio of retention vs. TSS treatment (i.e., for Scenario 1, at least 24,960 gallons retained by the bioretention device, 45,426 retained by the bioretention device and conventional landscaping combined, and the remainder treated for TSS removal).

Taken together, these assumptions represent a very conservative (i.e., high-cost) outlook. If we revisit the Anacostia example, which requires 58,647 gallons of stormwater management capacity, and apply this alternative case, the space required for a suitably large series of bioretention areas is considerably greater: 3,880 sq ft, much larger than the 2,860 sq ft projected. This would require five bioretention cells covering nearly forty percent of the site's non-hardscaped area, a proportion that may be somewhat challenging to achieve. Alternatively, adding in a green roof over the assumed 75 percent maximum of the building's roof area would result in 5,610 gallons of additional stormwater management capacity, which would in turn allow us to reduce the required overall extent of the bioretention cells to 3,070 sq ft, in four cells occupying about 30 percent of the site's pervious area. This combination of management techniques would triple the incremental cost of compliance to $97,281, or $0.61 per sq ft. Nonetheless, while this clearly represents a significant expense, in the context of a $55 million construction project, the cost remains quite modest, totaling only 0.18 percent of total costs.

COST OF BIORETENTION AREAS

As shown in Exhibit 3-2, we reviewed several data sources that presented different methods of estimating costs of bioretention areas. We chose an approach based on the size of the system in terms of the volume of water to be treated; however, several other sources present estimates based on costs per sq ft, and at least one source separates fixed costs from variable costs. Clearly, using a different methodology for the cost calculation would produce somewhat different results, but the results are not very different in

[32] Soil Conservation Service. "SCS Curve Numbers for Urban Areas." Cited at http://www.bossintl.com/download/RunoffCurveNumbers.html. Accessed December 11, 2009.

absolute terms. The Massachusetts Executive Office of Environmental Affairs estimates costs at $11.77 per sq ft (after adjusting for inflation);[33] this would produce a gross LID cost of $33,662 in Scenario 1, as compared to our estimate of $29,459. Meanwhile the City of Chicago estimates bioretention costs at anywhere from $10 to $40 per sq ft;[34] this would translate into a range of $28,600 to $114,400 for Scenario 1, with a mean value of $71,500. Again, while this would constitute a significant expense, as a single component of a much larger real estate development project, the cost still appears to be relatively modest.

[33] MA Executive Office of Environmental Affairs, LID Science and Research Subcommittee. "LID Matrix." September 1, 2004. Available at http://www.mass.gov/Eoeea/docs/eea/water/lid_matrix.pdf. Accessed December 10, 2009.

[34] City of Chicago. "Bioinfiltration: Rain Gardens." N.d. Available at http://tinyurl.com/chicago-bioretention. Accessed December 10, 2009.

4. CONCLUSION

The research and analysis presented in this report is intended to provide DDOE with information that will help the Department give proper consideration to the potential impact of proposed revisions to the District's stormwater management regulations. Our work focused on a quantitative analysis of projected incremental compliance costs, in recognition of the fact that the development community, as well as DDOE, is primarily interested in understanding the financial implications of the proposed regulations. Secondarily, we sought to gain insight from experience in other U.S. cities that have recently adopted comparable regulations. These research and analysis paths lead us to four general conclusions.

INCREMENTAL COSTS: Our principal conclusion is that incremental compliance costs (i.e., costs to comply with the proposed regulations that are in addition to the costs that would be incurred to comply with current regulations) are expected to be small both in absolute terms and as a percentage of total project costs. As described in Section 3, for each of three hypothetical projects in the District, we estimate an increase in first costs that can be measured in the low tens of thousands of dollars. Assuming our estimates of total project costs are reasonable, these incremental costs would represent a cost "premium" of one-tenth of one percent or less. Our sensitivity test, using much more conservative assumptions, generated an estimated cost of about $100,000, less than two-tenths of one percent of total project costs. While it is important to reiterate that our analysis was limited in scope, and therefore cannot be presumed to be illustrative of all possible development scenarios, it is reasonable to conclude that so-called "low impact development" techniques and are not substantially more expensive than conventional techniques at the scale that most projects would require. Furthermore, we found that conventional landscaping of onsite open space can make a meaningful contribution to achieving proposed onsite water retention requirements, and reduce the extent of LID techniques needed.

OTHER CITIES' EXPERIENCE: We interviewed officials from four cities where comparable stormwater regulations are in place, and heard consistently that new requirements have not had, or are not expected to have, a discernible effect on development. In fact, early engagement with the regulated community, combined with a transparent rulemaking process, was a common theme and appears to have contributed in each case to a relatively easy transition to the new regulatory regime. However, one city with a very low threshold for regulatory applicability (500 sq ft versus the 5,000 sq ft threshold proposed by the District) voiced concerns about potential effects on very small projects.

"GREENING" TREND: A general trend toward "greener," more stringent and LID- based stormwater management requirements is occurring regionally and at the federal level. This trend is driven by both by ratcheting up federal water quality regulation (i.e., mandated TMDL development), as well as regional and local initiatives to improve water quality and reduce stress on aging, expensive to upgrade stormwater infrastructure. Additionally, regulatory changes in Maryland and Virginia, combined with new requirements for all federally-owned properties in the District, could l result in sufficient competition among regional LID technology and service providers to drive costs down.

COMPLIANCE MANAGEMENT: With the new regulations applying to both renovations as well as new construction, the District could experience a modest increase in the number of permits requiring processing and review. Perhaps more importantly, however, the changes in stringency and preferred methods of stormwater management could increase the time required for the reviewing and permitting process of a given project. Thus, one of the most important impacts of the revised regulations could be administrative. To avoid project delays, which could have a greater cost impact to a developer than anticipated changes in first costs, the District might face a need for additional staff, updated information management systems, and/or new, clearly communicated administrative procedures. Moreover, Philadelphia's experience indicates that defining the parameters of a mitigation program is best done before stormwater regulations go into effect. Finally, experiences from both Chicago and Philadelphia indicate that barring or strictly limiting variances or waivers may be important to the success of these policies.

APPENDIX A

COMPARISON OF DRAFT PROPOSED AND EXISTING STORMWATER REGULATIONS IN THE DISTRICT OF COLUMBIA

COMPARISON OF DDOE'S DRAFT PROPOSED STORMWATER REGULATIONS TO EXISTING REGULATIONS[35]

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
502.4	Fees (pre-existing)	Fees for land disturbing activities are set forth as follows: Storm Water Management Plan Review: $72 plus $0.0325 per additional 100 ft^2 above 5,000 ft^2. Sites smaller than 5,000 ft^2 are exempt.	502.4, as amended under Title XII of DC Act 14-543	• Fee increased to $3,000 for Level 3 alterations or sites of 10,000 ft^2 or smaller. • Additional large site fee of $1,000 for sites disturbing more than 10,000 ft^2. • $500 fee for review of stormwater management as-built plans.	The covenant review fee ($325 x 2 = $650) does not appear in current text of proposed regulation, although it is referenced in a comment and in deleted text. It appears to be covered as part of the $3,000 standard Stormwater Management Plan Review fee.
502.4	Fees (new)	N/A	N/A	**New regulation.** The fees for land disturbing activities and Level 3 alterations are set forth below: • Supplemental review fee of $750 for additional reviews of stormwater management plan beyond the first revision. • Stormwater management mitigation application review fee of $1,500. • District-sponsored off-site stormwater mitigation fee of $280,000 per impervious acre. • Stormwater management as-built plan review fee of $150.	Numerous additional fees are established for erosion and sediment control, floodplain services, other services, and resources, many of which are optional.

[35] Shaded cells indicate significant cost areas which are within the scope of IEc's cost analysis. Other sections of the proposed regulation may also contribute substantially to developers' costs, but will not be evaluated beyond this baseline regulatory comparison.

[36] All references to existing regulations are to Title 21, Chapter 5 of the District of Columbia Municipal Regulations ("Water Quality and Pollution") except as noted.

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
526.1	Applicability	No person shall, unless exempt, engage in any earth movement or land change within the District of Columbia without instituting appropriate storm water management measures to control or manage runoff from such developments. These measures shall conform to the provisions in §§ 526 through 535 of this chapter… No nonpoint source permit shall be issued by the Department for any parcel or lot unless a storm water management plan meeting the requirements of §§ 526 through 535 has been approved by the department.	526.1; 532.1	Wording has changed, but substance of this section remains the same. Proposed regulation reads as follows: "Before engaging in land disturbing activity within the District of Columbia, a person shall obtain a stormwater management permit and install and maintain appropriate storm water management measures to limit and manage runoff from the site, unless exempt as set forth in § 527 of this Chapter."	Proposed regulation goes on to add several specific new requirements, listed below, which do not appear in the existing regulation.
526.2	Applicability: Level 3 alterations	N/A	N/A	**New regulation.** Before conducting Level 3 alterations and repairs of existing buildings in which the estimated cost equals or exceeds fifty percent of the assessed value of the property before alterations and repairs are started, a person shall obtain a stormwater management permit to limit and manage runoff from the site.	
526.3	Applicability: Automotive facilities	N/A	N/A	**New regulation.** Owners of all car dealerships, repair garages, gasoline stations with grease racks, grease pits or work racks; car washing facilities with engine or undercarriage cleaning capability; and facilities where oily or flammable liquid wastes are produced shall obtain a stormwater management permit to install control measures to appropriately dispose of all oil-bearing, grease-bearing, or flammable wastes before it empties into the sewers, in compliance with the requirements of § 529.11 and this chapter.	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
526.4	Applicability: Applicant	N/A	N/A	**New regulation.** The applicant shall be the lawful owner of any property where a land disturbing activity or Level 3 alteration to an existing building is to take place, or the lawful owner's designated representative who applies to the Department of Consumer and Regulatory Affairs for a building permit. The lawful owner of the property remains responsible for securing and complying with conditions of the permit and these regulations at all times.	While this is a new regulation, it codifies existing practice and therefore creates no new requirements for developers.
526.5	Applicability: NPDES permit	N/A	N/A	**New regulation.** Before engaging in land disturbing activities on a site of one acre or above, a person shall also obtain authorization from the federal Environmental Protection Agency to discharge runoff from the construction site under the National Pollutant Discharge Elimination System, in compliance with the Clean Water Act, Title 33 of the United States Code, §1251 et seq.	While this is a new regulation, it codifies an existing EPA requirement and therefore creates no new requirements for developers.
527.1.a	Exemptions: Minor land disturbing activities	The following development activities shall be exempt from the provisions of §§ 526 through 535 of this chapter: a. Minor land disturbing activities such as home gardening and individual home landscaping repairs and maintenance work.	527.1a	Unchanged except for minor wording differences.	
527.1.b	Exemptions: Utilities	The following development activities shall be exempt from the provisions of §§ 526 through 535 of this chapter: b. Single family dwelling utility service connections and construction or utility construction where the excavated material is removed from the job site.	527.1.b	Unchanged except for minor wording differences.	
527.1.c	Exemptions: Agriculture	The following development activities shall be exempt from the provisions of §§ 526 through 535 of this chapter: c. Tilling, planting, or harvesting of agricultural or horticultural crops	527.1.c	Unchanged.	
527.1.d	Exemptions: Fence and Sign Posts	The following development activities shall be exempt from the provisions of §§ 526 through 535 of this chapter: d. Installation of fence and sign posts or poles;	527.1.d	This exemption is removed.	Exemption is likely redundant with small site exemption.

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
527.1.e	Exemptions: Emergencies	The following development activities shall be exempt from the provisions of §§ 526 through 535 of this chapter: e. Emergency work to protect life, list *[sic]* or property, and emergency repairs; provided, that if the land disturbing activity would have required an approved erosion and sedimentation control plan if the activity were not an emergency, then the land disturbed shall be shaped and stabilized in accordance with the requirements of the Department.	527.1.e	Adds requirement for compliance with all requirements within 45 days after beginning the emergency work.	
527.1.f	Exemptions: Small sites	The following development activities shall be exempt from the provisions of §§ 526 through 535 of this chapter: g. Construction or grading operations, or both, that do not disturb more than five thousand sq ft of land area, unless such construction or grading operations shall be part of an approved subdivision plan which contains provisions for storm water management.	527.1.f	Proposed regulation deletes caveat "such construction or grading operations shall be part of an approved subdivision plan which contains provisions for storm water management."	Under current plan review, if the lot is called a "subdivision" as defined by DC Survey Office, a stormwater management facility is required even if the land disturbance is less than 5,000 ft^2.
527.1.g	Exemptions: Fence and sign posts, residential	The following development activities shall be exempt from the provisions of §§ 526 through 535 of this chapter: g. Residential development consisting of single family dwellings each of which shall be situated on lots of two or more acres.	527.1.g	This exemption is removed.	
528.1	Project Submissions	N/A	N/A	**New regulation.** Before a stormwater management permit is issued, the applicant shall provide a submittal package and complete the Site Development Submittal Information Sheet with the location and description of the project, and the name and address of the owner and registered professional engineer of the project.	See also § 532 of the proposed regulation, and § 531 of the existing regulations, which address the stormwater management plan which must be submitted to the Department for approval.
528.2	Project Submissions	N/A	N/A	**New regulation.** The measures for the management of stormwater runoff used by the applicant shall be among those adopted by the Department in the *Stormwater Management Guidebook,* which is incorporated by reference, or alternative measures approved by the Department when presented as part of the applicant's stormwater management plan.	See also § 532 of the proposed regulation, and § 531 of the existing regulations, which address the stormwater management plan which must be submitted to the Department for approval.

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
528.3	Project Submissions	N/A	N/A	**New regulation.** For the initial review, the applicant shall submit two sets of the stormwater management plan(s).	See also § 532 of the proposed regulation, and § 531 of the existing regulations, which address the stormwater management plan which must be submitted to the Department for approval.
528.4	Project Submissions	N/A	N/A	**New regulation.** For any pre-cast structure included in the stormwater management plan, the applicant shall submit two sets of shop drawings for review and approval by the Department. Upon approval, the applicant shall submit three sets of shop drawings bearing the seal and signature of the registered professional engineer, licensed in the District of Columbia, before beginning construction or installation of the structure.	See also § 532 of the proposed regulation, and § 531 of the existing regulations, which address the stormwater management plan which must be submitted to the Department for approval.
528.5	Project Submissions	N/A	N/A	**New regulation.** Following the receipt of an applicant's stormwater management plan, the Department shall approve or disapprove the plan. If a decision cannot be rendered based on the information provided, the applicant shall be notified in writing.	See also § 532 of the proposed regulation, and § 531 of the existing regulations, which address the stormwater management plan which must be submitted to the Department for approval.
528.6	Project Submissions	N/A	N/A	**New regulation.** If the Department determines that more information is needed or that a significant number of changes must be made before the stormwater management plan can be approved, the applicant may withdraw the plan, make the necessary changes, and resubmit the plan. All re-submissions shall contain a list of the changes made.	See also § 532 of the proposed regulation, and § 531 of the existing regulations, which address the stormwater management plan which must be submitted to the Department for approval.

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
528.7	Project Submissions	N/A	N/A	**New regulation.** In the final submittal package, the applicant shall provide the following: a. The stormwater management plan demonstrating compliance with this chapter; b. A copy of a covenant recorded and executed in the Recorder of Deeds that provides for maintenance of the stormwater management facility as approved and designed, as set forth in § 535; c. A copy of easements for the stormwater management facility recorded and executed by the property owner, granting access to the stormwater management facility for inspections and for maintenance, as set forth in § 536.3; and d. A performance bond, letter of credit, or other improvement security in an amount considered sufficient by the Department to cover all costs of improvements, landscaping, and maintenance of improvements on sites equal to or greater than one acre of land disturbance, until the Department determines on final inspection that the completed work is constructed in accordance with approved soil erosion and sediment control plans, as set forth in § 550.	See also § 532 of the proposed regulation, and § 531 of the existing regulations, which address the stormwater management plan which must be submitted to the Department for approval.

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
528.8	Project Submissions	N/A	N/A	**New regulation.** The approved stormwater management plan shall constitute the applicant's stormwater management permit, and shall govern all construction requiring stormwater management. The stormwater management plan shall not be considered approved without the date and signature of the Director or the Director's designee stamped on the plan.	See also § 532 of the proposed regulation, and § 531 of the existing regulations, which address the stormwater management plan which must be submitted to the Department for approval.
528.9	Project Submissions	For each project, four sets of project plans shall be submitted for distribution to various review agencies.	DDOE Stormwater Guidebook, 5.1.1	Proposed regulation changes this to two sets of mylar and seven sets of prints, or any other format approved by the Department for approval.	Although the Stormwater Guidebook indicates that the current requirement is for four sets of project plans, DDOE staff indicate that in practice the current requirement is for one set of mylar and seven sets of prints. The new regulation may maintain this requirement, since DC WASA no longer requires mylar plans. See also § 532 of the proposed regulation, and § 531 of the existing regulations, which address the stormwater management plan which must be submitted to the Department for approval.

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
528.10	Project Submissions	N/A	N/A	**New regulation.** If a stormwater management plan is disapproved: a. The Department shall notify the permit applicant in writing, providing the reasons for the disapproval of the stormwater management plan; b. The Department may suggest modifications, terms, and conditions which would permit the approval of the stormwater management plan and issuance of a permit if the applicant were to resubmit the plan to the Department; and c. The applicant shall have the right to appeal the Department's decision to disapprove the stormwater management plan to the Office of Administrative Hearings within seven business days of receipt of the Department's written notice of disapproval.	See also § 532 of the proposed regulation, and § 531 of the existing regulations, which address the stormwater management plan which must be submitted to the Department for approval.
528.11	Project Submissions	N/A	N/A	**New regulation.** The permittee shall keep the permit and approved stormwater management plan on the site while work is being performed. The permit and approved stormwater management plan shall be made available upon request by the Department during the entire time of progression of the work, until the work is completed. If an on-site location is unavailable to store the approved stormwater management plan when no personnel are present, notice of the plan's location must be posted near the main entrance at the construction site.	See also § 532 of the proposed regulation, and § 531 of the existing regulations, which address the stormwater management plan which must be submitted to the Department for approval.

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
528.12	Project Submissions	N/A	N/A	**New regulation.** Upon completion of the project, the permittee shall request a final inspection from the Department to determine whether the stormwater management facility is constructed as designed. The permittee shall submit one set of mylar signed and sealed by a professional engineer licensed in the District of Columbia and one electronic copy with the professional engineer's certification of the "As-Built" Plans to the Department, within twenty-one days of the final inspection.	See also § 532 of the proposed regulation, and § 531 of the existing regulations, which address the stormwater management plan which must be submitted to the Department for approval.
529.1	Level 3 alterations: discharge	N/A	N/A	**New regulation.** Each applicant for a Level 3 alteration to an existing building shall—unless such disconnection would cause stormwater flow into public space or an adjoining lot without permission—disconnect any downspouts connected to a sewer to allow stormwater to be discharged from impermeable areas to vegetated areas on the same record lot.	
529.2.a	Peak Discharge	Every applicant shall comply with the following minimum storm water runoff control requirements: a. Submit management measures necessary to maintain the post-development peak discharges for a twenty-four hour, two- and fifteen-year frequency storm event at a level that is equal to or less tan the respective, twenty-four hour, two- and fifteen-year pre-development peak discharge rate through storm water management practices that control the volume, timing and rate of flows.	529.2.a	Unchanged except for minor wording differences.	
529.3	Water Quality Volume	N/A	N/A	**New regulation.** The applicant shall manage, through retention practice or through a combination of retention and detention practices, the water quality volume of the site (SWRv), as calculated in accordance with § 529.4.	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
529.4	Water Quality Volume: Calculation	Although not explicitly referenced in the existing Title 21, Chapter 5 regulations, the DDOE Stormwater Guidebook uses the following formula for determining the volume of water to be treated: $V_w = R \times I_a / 12$ V_w = water quality volume to be treated, in feet^3 R = runoff depth, in inches, as follows: • R= 0.5 in for parking lots, city streets, and high speed roads • R = 0.3 for rooftops, sidewalks, and pedestrian plaza areas I_a = impervious area, in feet^2	DDOE Stormwater Guidebook, 2.0	The proposed regulation introduces a new formula for the total water volume of runoff (SWRv) to be managed, based on the site's surface area and the permeability of the proposed future condition, as follows: $SWRv = (P \times (Rv_I \times \%I \times Rv_C \times \%C \times Rv_N \times \%N) \times SA) / 12$ SWRv = volume, in acre-feet P = 1 inch (90th percent rainfall event for the district) Rv_I = 0.95 (runoff coefficient for impervious cover) Rv_C = 0.25 (runoff coefficient for compacted cover) Rv_N = 0.05 (runoff coefficient for natural cover %I = percent of site in impervious cover %C = percent of site in compacted cover %N = percent of site in natural cover SA = total site area, in acres	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
529.5	Water Quality Volume: Retention	N/A	N/A	**New regulation.** The applicant shall retain on-site 100% of the water quality volume (SWRv) as calculated in accordance with § 529.4, unless on-site retention is demonstrated to be infeasible in accordance with § 533.2 or is inappropriate under § 533.3.	§ 456.a.1 of the Anacostia Waterfront Environmental Standards Act requires sites within the Anacostia area to retain on-site at least one inch of the water quality volume (SWRv), as calculated through a similar equation. This applies only to publicly-owned or financed projects. Under § 3.c of the Green Building Act of 2006, publicly-owned residential projects with more than 10,000 sq ft of gross floor area are required to meet the Green Communities 2006 standard. That standard includes an optional 5-point credit for projects which "capture, retain, infiltrate and/or harvest the first one-half inch of rainfall in a 24-hour period." Under §§ 3.b.1.C.2 and 4.b.1 of the Green Building Act of 2006, publicly-owned nonresidential projects and privately owned projects with more than 50,000 sq ft of gross floor area are required to meet LEED-NC 2.2 or LEED CS 2.0 standards. There are no stormwater-related prerequisites in either LEED standard, but both have optional credits for projects that prevent the post-development peak discharge rate and quantity from exceeding pre-development levels for the one- and two-year 24-hour design storms. See LEED NC SS Credit 6.1.

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
529.6	TSS Mitigation	N/A	N/A	**New regulation.** Any part of the SWRv not retained onsite shall be treated to achieve, at a minimum, an 80% reduction in Total Suspended Solids (TSS).	Under §§ 3.b.1.C.2 and 4.b.1 of the Green Building Act of 2006, publicly-owned nonresidential projects and privately owned projects with more than 50,000 sq ft of gross floor area are required to meet LEED-NC 2.2 or LEED CS 2.0 standards. There are no stormwater-related prerequisites in either LEED standard, but both have optional credits for projects that remove 80% of the average annual TSS from 90% of the average annual rainfall. See LEED NC SS Credit 6.2.
529.7	Vegetated Techniques	N/A	N/A	**New regulation.** In meeting the requirements of this section, the applicant shall use Vegetated Techniques to the maximum extent practicable.	§ 456.a.3 of the Anacostia Waterfront Environmental Standards Act identifies vegetated techniques as the preferred method of stormwater control for sites within the Anacostia area.
529.8	Downstream Flood Hazard Areas	Where any development is planned in which the stormwater runoff will increase the downstream discharge into an area designated as a flood hazard watershed, as delineated on the National Flood insurance Flood hazard Boundary Maps (FHBM), the developer shall complete an analysis of the downstream peak discharge for a one-hundred year frequency storm event, and shall install the appropriate controls to avoid exceeding this peak discharge.	529.2.b	Unchanged except for minor wording differences.	
529.9	Contaminated Sites: Restriction of Infiltration Runoff Management	N/A	N/A	**New regulation.** Where the applicant proposes a land use activity that has an increased potential to pollute stormwater runoff, or where the applicant or Department has knowledge of site-specific contamination issues that may result in polluted stormwater runoff, the Department may restrict use of infiltration runoff management practices to prevent contamination of groundwater and require submission of a pollution prevention plan by the applicant.	§ 456.a.7 of the Anacostia Waterfront Environmental Standards Act includes provisions addressing contaminated sites within the Anacostia area in as follows: Certify the remediation of contaminated soils or groundwater is either completed as part of the development or that properly functioning long-term remedial measures are in place. This requirement applies only to publicly-owned or funded projects.

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
529.10	Contaminated Sites: Prevention of Stormwater Migration	Ground waters shall be protected from pollution because the lack of this protection might result in the following: a. Large future cleanup costs of contaminated ground water; b. Contaminated ground water becoming a potential health hazard to the public; c. Contaminated ground water mixing with and contaminating adjacent surface waters; d. Contaminated ground water mixing with and contaminating the ground water of adjacent jurisdictions; or e. Harm to or loss of sensitive flora or fauna.	DC Municipal Regulations, Title 21, § 1150.1	The proposed regulation is more specific: "Any stormwater management facility designed to receive runoff from areas of contaminated soil or groundwater shall be designed with an impermeable liner or other measures to prevent stormwater migration into underlying soil or ground water."	Per Shane Farthing, the proposed regulation codifies current practice, as required by DDOE water quality regulations. It is possible that there is a more specific requirement than the section cited here elsewhere in the DC Municipal Regulations. § 456.a.6 of the Anacostia Waterfront Environmental Standards Act includes provisions addressing contaminated sites within the Anacostia area in as follows: Design stormwater controls to prevent migration of stormwater into contaminated underlying soils or groundwater. This requirement applies only to publicly-owned or funded projects.
529.11	Oil and Grease Contami-nation	Any storm water discharge facility which may receive storm water run-off from areas which may be potential sources of oil and grease contamination in concentrations exceeding ten milligrams per liter, shall include a baffle, skimmer, grease trap or other mechanism which prevents oil and grease from escaping the storm water discharge facility in concentrations that would violate or contribute to the violation of applicable water quality standards in the receiving waters of the District.	529.2.d	Proposed regulation adds in detailed specifications for oil separators.	Revised language may produce a material change in the applicability of this section. New language requires mitigation equipment in areas which may be potential sources of oil and grease contamination, regardless of concentration. Such equipment must prevent release of oil and grease in concentrations above 10 mg/l.
529.122	Animal Confinement Areas	Any storm water discharge facility which receives storm water runoff from areas used to confine animals and which discharges directly into receiving waters shall be designed to prevent at least eighty-five percent of the organic animal wastes from escaping the storm water discharge facility. The discharge from the facility shall not violate the water quality standards in the receiving waters of the District.	529.2.e	Proposed regulation eliminates the requirement to prevent eighty-five percent of organic animal wastes from escaping the discharge facility, but adds requirement for such facilities to be connected to a sanitary or combined sewer. Discharge into the public sewer shall meet pretreatment requirements of the District of Columbia Water and Sewer Authority.	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
529.13	Coal Tar Sealants	N/A	N/A	**New regulation.** The applicant shall not use coal tar sealants for paved surfaces.	The Anacostia Waterfront Environmental Standards Act restricts the use of coal tar sealants for paved surfaces within the Anacostia area. See § 456.a.5.B of the Act. Per Shane Farthing of DDOE, this requirement is legislative and is not within DDOE's discretion. This suggests the proposed regulation may drop this provision.
530.1	Anacostia: Level 3 alterations	N/A	N/A	**New regulation.** Before any person engages in any land disturbing activities or engages in a Level 3 alteration to an existing building within the Anacostia Waterfront Development Zone, the person shall comply with the minimum stormwater management requirements in this section, in addition to all other requirements of §§ 526 through 535. If this section conflicts with any other provision of §§ 526 through 535, the applicant shall be subject to the more stringent standard.	
530.2	Anacostia: Level 3 alterations (cont.)	N/A	N/A	**New regulation.** Within the Anacostia Waterfront Development Zone, any person engaging in Level 3 alterations to an existing building in which the estimated cost equals or exceeds fifty percent of the assessed value of the property or structure before alterations and repairs are started, and which have roof drains connected to a sewer, shall control or manage runoff from the site to comply with the provisions of this section.	
530.3	Anacostia: Effective Date	N/A	N/A	**New regulation.** For non-publicly owned or non-publicly financed projects, this section shall be effective January 2, 2012.	The requirements of the Anacostia Waterfront Environmental Standards Act apply only to publicly-owned or publicly-financed projects. See 453.c.

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
530.4	Anacostia: Water Quality Volume Calculation	Anacostia currently faces the same regulation as the rest of the District. Although not explicitly referenced in the existing Title 21, Chapter 5 regulations, the DDOE Stormwater Guidebook uses the following formula for determining the volume of water to be treated: $V_w = R \times I_a / 12$ V_w = water quality volume to be treated, in feet^3 R = runoff depth, in inches, as follows: • R= 0.5 in for parking lots, city streets, and high speed roads • R = 0.3 for rooftops, sidewalks, and pedestrian plaza areas I_a = impervious area, in feet^2	DDOE Stormwater Guidebook, 2.0	**New regulation.** The total water quality volume of runoff (SWRv) to be managed shall be determined as follows: $SWRv = P \times (Rv_I \times \%I + Rv_C \times \%C + Rv_N \times \%N) \times SA / 12$ SWRv = volume, in acre feet P = 3.2 inches (2-year 24 hour rainfall event for the District) Rv_I = 0.95 (runoff coefficient for impervious cover) Rv_C = 0.25 (runoff coefficient for compacted cover) Rv_N = 0.05 (runoff coefficient for natural cover) %I = percent of site in impervious cover %C = percent of site in compacted cover %N = percent of site in natural cover SA = total site area, in acres	
530.5	Anacostia: Water Quality Volume: Retention	Reduce stormwater quantity by retaining and beneficially reusing on-site the stormwater generated on-site by a "1 inch in 24 hours" storm following 48 hours of dry conditions, provided, that if the DDOE determines that site conditions…limit the feasibility or appropriateness of on-site stormwater management, off-site mitigation or payment in lieu of mitigation may be used.	Anacostia Waterfront Environmental Standards Act, 456.a.1	Proposed regulation establishes the following requirement for retention: "The applicant shall retain on-site at least one inch of the water quality volume (SWRv), as calculated in accordance with 530.4, unless on-site retention is demonstrated to be infeasible in accordance with 533.2 or is inappropriate under 533.3."	§ 455 of the Anacostia Waterfront Environmental Standards Act requires new construction projects to meet or exceed LEED-NC 2.2 or LEED CS 2.0 standards. There are no stormwater-related prerequisites in either LEED standard, but both have optional credits for projects that prevent the post-development peak discharge rate and quantity from exceeding pre-development levels for the one- and two-year 24-hour design storms. See LEED NC SS Credit 6.1. See also § 533 and 534 of the proposed regulations for more detail on relief and off-site mitigation.

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
530.6	Anacostia: Preferred Methods	Achieve the required level of stormwater control using the following methods, identified in order of preference: A. Vegetated controls designed to retain and beneficially use stormwater; B. Where compatible with groundwater protection, non-vegetated controls designed to promote infiltration; C. Other low-impact development practices; D. Collection and reuse of stormwater for on-site irrigation; and E. Other on-site design techniques as approved by the DDOE.	Anacostia Waterfront Environmental Standards Act, 456.a.3	Unchanged except for minor wording differences and the inclusion of specific examples.	In its current draft there is no § 530.7 in the proposed regulation.
530.8	Anacostia: TSS and Filtering Medium	Improve stormwater quality by filtering all stormwater flowing from the project, up to the volume of a 2-year design storm, by passing the flow through a vegetated filtering medium or other on-site controls designed to remove sediment and pollutants of concern as identified in permits by the DDOE or the District of Columbia Water and Sewer Authority, so that the discharges will not cause or contribute to the exceedance of any water-quality standard applicable to the receiving water or cause interference or pass-through of pollutants at the Blue Plains receiving facility.	Anacostia Waterfront Environmental Standards Act, 456.a.2	Proposed regulation adds a specific requirement for the effectiveness of the filtering medium: "Any stormwater management facility which may receive stormwater runoff shall be designed to ensure that any portion of the water quality volume (SWRv) discharged from the site passes through a filtering medium designed remove at least 85% of total suspended solids (TSS)."	§ 455 of the Anacostia Waterfront Environmental Standards Act requires new construction projects to meet or exceed LEED-NC 2.2 or LEED CS 2.0 standards. There are no stormwater-related prerequisites in either LEED standard, but both have optional credits for projects that remove 80% of the average annual TSS from 90% of the average annual rainfall. See LEED NC SS Credit 6.2. In its current draft there is no § 530.7 in the proposed regulation.
530.9	Anacostia: Public Spaces	Employ, where feasible, low-impact development technologies for public spaces regulated by District Department of Transportation.	Anacostia Waterfront Environmental Standards Act, 456.a.4	Proposed regulation adds a new requirement regarding public spaces: "Where runoff is discharged into a stormwater management facility placed in the public space, the applicant shall provide controls using on-site stormwater management practices."	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
530.10	Anacostia: Lawn Care Chemicals	Restrict the on-site use of: a. Fertilizers, pesticides, and herbicides through use of an integrated pest management plan reviewed by the DDOE.	Anacostia Waterfront Environmental Standards Act, 456.a.5.A	Wording has been altered, but the substance of the regulation appears to remain the same. Proposed regulation reads as follows: "In addition to the requirements of 532.2, the applicant shall submit a plan to prevent overuse of fertilizers, herbicides, and pesticides."	§ 532.2 lists numerous other requirements for an applicant's stormwater management plan.
N/A	Anacostia: Groundwater Treatment	Treat any groundwater produced at a project during construction or after completion of construction to remove sediment and pollutants of concern as required by the DDOE or US EPA, depending on which agency has jurisdiction.	Anacostia Waterfront Environmental Standards Act, 456.a.8	This issue is not addressed in the proposed regulation.	
N/A	Anacostia: Conformance to WASA Requirements	Require that any groundwater discharged from the site into the sanitary sewer system conform to WASA requirements designed to ensure that it will not cause or contribute to the exceedance of any water quality standard applicable to the receiving water or cause interference or pass through of pollutants at the Blue Plains receiving facility.	Anacostia Waterfront Environmental Standards Act, 456.a.9	This issue is not addressed in the proposed regulation.	
N/A	Anacostia: Public Access and Use	The project shall be designed to ensure continued public access to the Anacostia River and associated waterways and to the Anacostia riverwalk and trail system. Existing public parks shall be preserved and the Mayor shall endeavor to minimize encroachment unless there is no feasible alternative. If the project encroaches on a public park, the encroachment shall be mitigated in kind at a minimum acreage ratio of at least 1-to-1 and the mitigation shall be of equal or greater quality than the parkland that is lost. Development along both sides of the Anacostia River and along associated waterways shall, unless determined by the DDOE to be infeasible, include continuous, publicly accessible trails that comply with the Anacostia Riverparks Plan and Riverwalk Design Guidelines.	Anacostia Waterfront Environmental Standards Act, 458.1, 458.2, 458.9	This issue is not addressed in the proposed regulation.	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
N/A	Anacostia: Wetlands Protection	No construction or development shall disturb delineated wetlands or land within 100 feet of delineated wetlands, which shall be maintained as a buffer, unless the DDOE and the U.S. Army Corps of Engineers both agree that construction in these areas cannot reasonably be avoided. Any impacts on wetlands approved by the DDOE shall require mitigation in-kind at a minimum acreage ratio of 3-to-1…*[lists specific requirements]*	Anacostia Waterfront Environmental Standards Act, 458.3	This issue is not addressed in the proposed regulation. Buffers are addressed in 542.3 and 542.4.	
N/A	Anacostia: Stream Diversion	Streams that have been diverted into pipes or other constructed conveyances shall be daylit unless determined by the DDOE to be infeasible.	Anacostia Waterfront Environmental Standards Act, 458.4	This issue is not addressed in the proposed regulation.	
N/A	Anacostia: Riparian Buffer Zones	The applicant shall ensure protection or creation of woodland and meadow riparian buffer zones along each bank of the Anacostia River defined in the Anacostia Waterfront Initiative Framework Plan of between 50 and 300 feet along the main channel of the Anacostia River, except where necessary to ensure public access and use of the waterfront. Development along tributary streams of the Anacostia River shall maintain a minimum riparian buffer of 25 feet. The DDOE may require a wider buffer along the channel or tributary streams where it is determined that a wider buffer zone is necessary to protect waterways.	Anacostia Waterfront Environmental Standards Act, 458.5	This issue is not addressed in the proposed regulation. Buffers are addressed in 542.3 and 542.4.	
N/A	Anacostia: Vegetated Roadway Buffers	Roadways shall comply with the Anacostia Waterfront Transportation Architecture Design Standards developed by the DDOT. Applicants shall incorporate planted vegetated buffers within the right-of-way of all roadways to increase tree cover and shade, mitigate traffic noise, absorb toxic emissions, and minimize stormwater runoff at levels determined by the DDOE by rulemaking. Applicants shall ensure sufficient tree planting to provide canopy coverage within 20 years of project occupancy of 30% of non-roof impervious surfaces and 40% of overall-non-roof surfaces within the project area.	Anacostia Waterfront Environmental Standards Act, 458.6, 458.7, 458.8	This issue is not addressed in the proposed regulation.	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
532.1	Stormwater Management Plan	The stormwater management plan shall contain the following information: *[lists specific requirements]*	531.2	Proposed regulation is largely the same, but adds one additional requirement: e. A description of construction and waste materials expected to be stored on-site, and the pollution control measures, including storage practices and spill prevention responses, which will be implemented as part of the construction activity to minimize exposure of the materials to stormwater discharges.	
532.2.a	Stormwater Management Plan: Site Character-istics	Each plan shall include, without limitation, the following information: a. Site characteristics: 1. Topography survey showing existing and proposed contours; 2. Soils investigation including borings for construction of small ponds and infiltration practices (where applicable); 3. Description of all water courses, impoundments and wetlands on, or adjacent to the site, or into which storm water flows; 4. Delineation of one-hundred year floodplain, (if applicable); and 5. Structure classification (US Department of Agriculture Soil Conservation Service Pond Standard 378).	531.4.a	These requirements are unchanged except for minor wording differences. Proposed regulation also adds the following additional requirements: a. Site characteristics: 1. Property boundaries and the complete address of the property; 2. Lot number, square number or parcel number designation (if applicable); 3. North arrow, scale, date; 4. Property lines (include longitude and latitude)… 6. Existing and proposed structures, utilities, roads and other paved areas… 10. Areas of soil disturbance… 12. Location and size of existing utility lines.	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
532.2.b, 532.2.c	Stormwater Management Plan: Computations	Each plan shall include, without limitation, the following information: b. Computations: 1. Hydrological; 2. Hydraulic; and 3. Structural.	531.4.b	Proposed regulation is considerably more detailed in this regard. It reads as follows: b. Pre-and post-development hydrologic computations sufficient to evaluate the ecological characteristics of the site, which computations shall be included on the plan, including; 1. A summary of soil conditions and field data; 2. Pre- and post-development curve number or runoff coefficient computation; 3. Time of concentration calculation; 4. Travel time calculation; and 5. Peak discharge computation for each subwatershed for the 24-hour storms of 2-year and 15-year design frequencies. c. Hydraulic computations for the final design of water quality and quantity control structures, which may be accomplished by hand or through the use of software using equations or formulae generally accepted in the water resources industry. The summary of collection or management systems shall include the following: 1. Existing and proposed drainages areas shall be delineated on separate plans with the flow paths used for calculation of the times of concentration; 2. Hydraulic capacity and flow velocity for drainage conveyance, including ditch, swales, pipes, inlets, and gutter; 3. Plan profiles for all open conveyance and pipelines, with hydraulic gradients shown; 4. The proposed development layout including: *[lists specific requirements]* c. [sic] Structural computations.	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
532.2.d	Stormwater Management Plan: Other Items	Each plan shall include, without limitation, the following information: d. Other items: *[lists specific requirements]*	531.4.c	Unchanged, save for additional requirements on vertical scale, a legend, and information regarding mitigation of anticipated off-site impacts.	
532.3	Stormwater Management Plan: Certification	The applicant shall certify on each drawing that all clearing, grading, drainage construction, and development shall be accomplished in strict accordance with the approved plan. Each plan submitted shall be signed by a professional engineer, licensed in the District of Columbia.	531.3	Unchanged.	
532.4	Stormwater Management Plan: Maintenance	A maintenance schedule for any storm water management facility shall be developed and submitted as part of the storm water management plan.	534.3	Wording has changed, but substance of this section remains the same. Proposed regulation reads as follows: "The applicant shall submit a maintenance agreement and maintenance schedule as part of the stormwater management plan, and shall state the maintenance to be completed, the time period for completion of maintenance, and who shall perform the maintenance. This maintenance schedule shall be printed on the stormwater management plan. The plan may identify the governmental agency that has been assigned by law to perform the maintenance."	
532.5	Stormwater Management Plan: Conformance to Applicable Engineering Principles	No scheduled storm water management work shall proceed until the Department's authorized representative, accompanied by the professional engineer responsible for certifying the "As-Built" plans, inspects and approves the work previously completed.	533.4	Wording has changed, but substance of this section remains the same. Proposed regulation reads as follows: "The plan shall include design and "As-Built" certification by a registered professional engineer licensed in the District of Columbia that the design of the stormwater management facility conforms to engineering principles applicable to the treatment and disposal of stormwater pollutants. The "As-Built" stormwater management plan requirements are provided in the Stormwater Management Guidebook."	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
532.6	Stormwater Management Plan: Conformance to Other Project Submissions	N/A	N/A	**New regulation.** The stormwater management plan shall conform with all other project submissions, including but not limited to any approved erosion and sediment control plans for the location.	
533, 534	Relief and Off-site Mitigation	N/A	N/A	The proposed regulation includes new provisions for relief where compliance is technically infeasible or inappropriate due to soil contamination. Under these provisions, the applicant shall retain on-site the maximum feasible portion of the water quality volume and provide off-site mitigation for the deficiency. See §§ 533 and 534 for details. The sections have no close corollary in existing regulations. § 528 of the DC Municipal regulations allows for waivers in instances where runoff 'will not adversely impact the receiving wetlands, water course, or waterway,' but there is no accommodation for infeasibility and no requirement for off-site mitigation.	The Anacostia Waterfront Environmental Standards Act includes a similar mitigation or payment option for sites within the Anacostia area. The off-site volume of water treated must equal 1.5 times the volume that would have been required to be treated on-site or two times its financial equivalent where payment is made in lieu of mitigation. See § 456.a.1 of that Act for details.
535.1	Maintenance	The owner of the property on which a storm water management facility has been constructed, or any other person or agent in control of such property, shall maintain the facility in good condition, and promptly repair and restore whenever necessary all grade surfaces, walls, drains, structures, vegetation, erosion and sediment control measures, and other protective devices.	534.2	Unchanged.	
535.2, 535.3	Maintenance	The Department shall establish guidelines for inspection procedures to ensure proper maintenance of all storm water management facilities.	534.1	Proposed regulation develops this general principle in much greater detail. See §§ 535.2 through 535.9 for details, all of which save 535.4 are new requirements.	The Anacostia Waterfront Reorganization Act includes a provision stating that the DDOE may require appropriate monitoring, sampling, analysis, record-keeping and annual certification of ongoing compliance for stormwater management facilities within the Anacostia area. See § 456.b.2 of the Act.

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
535.4	Maintenance	Failure or refusal to maintain a storm water management facility in proper condition shall result in corrective action by the Department. Any costs incurred from corrective measures by the Department shall be assessed against the property on which the facility is located. Additionally, any violator may be fined in accordance with the penalty section of this chapter.	534.5	Unchanged, except that the phrase 'shall result in corrective action' has been replaced by '*may* result in corrective action.'	
536.1	Covenants and Easements	A covenant stating the property owner's specific maintenance responsibilities shall be recorded with the owner's deed.	534.4	The substance of requirement is essentially unchanged, except that the new regulation stipulates that the covenant must be recorded prior to approval of the stormwater management plan.	
536.2	Covenants and Easements	N/A	N/A	**New regulation.** A governmental agency shall not be required to record a covenant.	
536.3	Covenants and Easements	N/A	N/A	**New regulation.** Where an agency of the Government of the District of Columbia has conditioned closing on a property upon the successful acquisition of an approved stormwater management plan or building permit, the Director may approve the stormwater management plan prior to filing of the covenant, so long as the covenant is filed at closing.	
536.4	Covenants and Easements	N/A	N/A	**New regulation.** A covenant shall: *[lists specific requirements]*	
536.5	Covenants and Easements	N/A	N/A	**New regulation.** The property owner shall record in the land records, all easements required to provide adequate access for inspection and maintenance for the stormwater management facility.	
547.1	Duty to Comply	N/A	N/A	**New regulation.** The permittee shall comply with all conditions of the stormwater management, erosion and sediment control, or Level 3 alteration project permit. Any permit noncompliance constitutes a violation, and is grounds for enforcement action, for permit termination, for revocation and reissuance, or for modification.	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
547.2	Duty to Comply	N/A	N/A	**New regulation.** The Department is authorized to institute a civil action for a prohibitory or mandatory injunction or other appropriate relief by way of a temporary restraining order, preliminary or permanent injunction, or other judicial decree, of for a civil penalty of no more than $50,000 for each violation, or $250,000 for each willful violation. Each violation of the regulations shall be considered a separate offense.	
547.3	Duty to Comply	A violation under this chapter shall be deemed a misdemeanor. Any person who violates or fails to comply with any provision or requirement of this chapter or the amendments or orders promulgated under this chapter shall, upon conviction, be punished by a fine not to exceed three hundred dollars or imprisonment not to exceed ten days or both, for each violation or failure to comply.	515.1	Proposed regulation carries significantly harsher penalties: fines of at least $2,500 or no more than $25,000 for each day of the violation, imprisonment for no more than one year, or both. If the person has been previously convicted under this section, the penalty can range up to $50,000 for each day of the violation, two years imprisonment, or both.	
547.4	Duty to Comply	N/A	N/A	**New regulation.** It is a crime to knowingly make a false statement in an application, record, report, plan, or other document maintained under this chapter shall be guilty of a misdemeanor. Upon a determination of guilt, the penalty is no more than $10,000, or imprisonment for no more than six (6) months, or both fine and imprisonment.	
547.5	Duty to Comply	Civil fines, penalties, and fees may be imposed as alternative sanctions for any infraction of the provisions of the Water Pollution Control Act, or any rules or regulations issued under the authority of the Act, pursuant to Chapter 18 of Title 2. Adjudication of any infraction shall be pursuant to Chapter 18 of Title 2.	515.5	Similar. Proposed regulation states that sanctions and adjudication will be pursuant to Chapter 18 of Title 2.	
N/A	Duty to Comply	The Department of Consumer and Regulatory Affairs may apply to the Superior Court of the District of Columbia for injunctive relief to enjoin a violation or threatened violation under this chapter without the necessity of showing that there does not exist an adequate remedy at law.	515.3	This provision is eliminated under the proposed regulation.	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
N/A	Duty to Comply	Neither the issuance of a permit under the provisions of this chapter nor the compliance with its provisions or with any condition imposed by a government official under this chapter shall relieve any person of any responsibility for damage to persons or property resulting from the issuance of the permit, or as otherwise imposed by law, nor impose any liability upon the District of Columbia for damages to persons or property.	515.4	This provision is eliminated under the proposed regulation.	
548.1	Inspections	The Department, through its authorized representative, shall conduct on-site inspections at stages of construction as determined by the Department.	533.1	Wording has been altered, but the substance of the regulation remains the same. Proposed regulation reads as follows: "The Department shall conduct periodic inspections of all land disturbing activity to ensure compliance with the approved plan for stormwater management, erosion and sediment control, or Level 3 alteration project and to determine whether the measures in the plan are effective in controlling erosion, sedimentation, and stormwater runoff resulting from the land disturbing activity and Level 3 alteration project."	The Anacostia Waterfront Reorganization Act includes a provision stating that the DDOE may monitor and inspect stormwater management projects within the Anacostia area. See § 456.b.1 of the Act.
548.2	Inspections	N/A	N/A	**New regulation.** The permittee shall conduct all work in accordance with the approved plans for which the permit has been issued, and any later-approved amendments to the plans. Any changes to the plans or course of activity made during construction that deviate substantially from the approved plans shall be resubmitted to the Department for approval in accordance with this Chapter.	
548.3	Inspections	The developer shall notify the Department twenty-four hours prior to beginning the construction of any on-site or off-site storm water management facility subject to these regulations.	533.2	Proposed regulation lengthens the timeframe to three business days. It also adds a requirement for additional contact with the Department within fourteen days after completion to request final inspection.	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
548.4	Inspections	N/A	N/A	**New regulation.** The applicant or his agent shall notify the Department when the stages of construction that require inspection are completed, and of other critical deadlines as directed by the Department.	
548.5	Inspections	N/A	N/A	**New regulation.** The applicant may request that an inspection of stormwater management work be scheduled outside of the Department's normal business hours of operation. The Department shall be given at least forty-eight hours notice for the inspection, and the applicant or his agent shall pay an after-hour inspection fee at the rate specified in § 502.4.	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
548.6	Inspections	N/A	N/A	**New regulation.** The permittee shall allow the Department, or the Department's authorized representative, upon presentation of credentials, to: a. Enter upon the premise where the facility or activity is located or conducted, or where records are kept under the conditions of the permit; b. Access and copy, at reasonable times, any records that are kept under the conditions of the permit; c. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under the permit; and d. Sample or monitor at reasonable times or order sampling of any substances or parameters at the location, for the purposes of assuring permit compliance or as otherwise authorized by the Water Pollution Control Act of 1984 and its implementing regulations.	
548.7	Inspections	The professional engineer for the project shall accompany the Department representative on all on-site inspections.	533.3	Similar. The proposed regulation states that "the permittee shall be given the opportunity to accompany the inspector."	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
548.8	Inspections	No schedule storm water management work shall proceed until the Department's authorized representative, accompanied by the professional engineer responsible for certifying the "As-Built" plans, inspects and approves the work previously completed.	533.4	Wording has been altered, but the substance of the regulation remains unchanged. Proposed regulation reads as follows: "If the Department's approval is required at a scheduled stage of construction, the permittee shall not proceed to the next stage of construction before the Department, accompanied by the professional engineer responsible for certifying the "As-Built" plans, inspects and approves proceeding to the next stage."	
548.9	Inspections	The applicant shall promptly correct in the manner specified any portion of work which does not comply with the approved plans.	533.5	Unchanged except for minor wording differences.	
548.10	Inspections	N/A	N/A	**New regulation.** Whenever there is any change in design, construction, operation, or maintenance that affects any portion of the stormwater management or soil erosion and sediment control plan, including but not limited to any element submitted under § 531 or that has a significant effect on the discharge of pollutants to the waters of the District, the stormwater management plan or soil erosion and sediment control plan shall be resubmitted to the Department for approval.	
548.11	Inspections	A final inspection shall be conducted by the Department upon completion of the storm water management facility to determine if the completed work is constructed in accordance with approved plans.	533.6	Similar. Proposed regulation adds a requirement (also listed in 548.3) that the permittee notify the Department within fourteen calendar days of the completion of the stormwater management facility.	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
548.12	Inspections	N/A	N/A	**New regulation.** The permittee shall not utilize the stormwater management facility until the Department, accompanied by the registered professional engineer responsible for certifying the "As-Built" plans, inspects and approves the construction.	
548.13	Inspections	N/A	N/A	**New regulation.** The permittee shall submit the "As-Built" certification within fourteen calendar days of approval of the construction of the stormwater management facility by the Department.	
549	Stop Work Orders	N/A	N/A	The proposed regulation includes a new provision empowering the Department to issue stop work orders in cases where work is being conducted contrary to the provisions of the regulation, or in an unsafe and dangerous manner, or in a manner that poses a threat to the public health or the environment. Under a stop work order, work must cease at the site except as directed to correct a violation or unsafe condition. See § 549 for details. This section has no corollary in existing regulations.	
550	Bond Requirement	N/A	N/A	The proposed regulation includes a new provision requiring applicants to file a performance bond, letter of credit, or other financial security until the Department determines that the completed work is constructed in accordance with approved plans. The amount of the security shall not be less than the total estimated construction cost of the stormwater management measures, plus a ten percent contingency. See § 550 for details. This section has no corollary in existing regulations.	

PROPOSED REGS REFERENCE	TOPIC	EXISTING REGULATION	EXISTING REGS REFERENCE[36]	PROPOSED REGULATION	NOTES
551	Permit Expiration	N/A	N/A	The proposed regulation includes a new provision mandating the expiration of stormwater management or soil erosion and sediment control permits if the authorized work is not begun within one year after the permit is issued, or if the authorized work is suspended or abandoned for any one-year period. See § 551 for details. This section has no corollary in existing regulations.	
552	Permit Suspension and Revocation	N/A	N/A	The proposed regulation includes a new provision stating that any permit may be suspended or revoked for any of several reasons relating to changes in site runoff characteristics, the existence of an immediate danger in a downstream area, or violations of the conditions of the management plan or of other regulatory requirements. See § 552 for details. This section has no corollary in existing regulations.	

APPENDIX B

COMPARISON OF DRAFT PROPOSED DC STORMWATER REGULATIONS TO COMPARABLE REGULATIONS IN OTHER CITIES

COMPARISON OF PROPOSED DC STORMWATER REGULATIONS TO COMPARABLE REGULATIONS IN OTHER CITIES

TOPIC	PROPOSED DC REGULATION	PHILADELPHIA REGULATION[a]	CHICAGO REGULATION[b]	PORTLAND REGULATION[c]	SEATTLE REGULATION[d,e]
Site Size Applicability/ Small sites exemption	Existing regulations state that "Construction or grading operations, or both, that do not disturb more than *five thousand (5,000) sq ft* of land area, unless such construction or grading operations shall be part of an approved subdivision plan which contains provisions for storm water management." Proposed regulation deletes caveat "such construction or grading operations shall be part of an approved subdivision plan which contains provisions for storm water management." (527.1.f)	**Less Stringent:** Stormwater regulations apply to all sites over *15,000 sq ft*, except in two specific watersheds where the threshold is reduced to 5,000 sq ft.	**Less Stringent:** Stormwater regulations apply to all sites that disturb any land area of *15,000 sq ft* or more. Any regulated development with more than 7,500 sq ft of impervious open space may be subject flow rate control requirements.	**More Stringent:** Stormwater regulations apply to any site with *500 sq ft* or more of impervious surface.	**Different Approach:** Minimum size thresholds triggering flow control and treatment requirements are project-type specific. Some project types have varying thresholds linked to the type of discharge receptor. Across the project types, common, though not the only, thresholds include 5,000 sq ft of new or replaced impervious surface or the conversion of at least 0.75 acres of native vegetation to lawn or landscaped area.
Application Fees	The fees for land disturbing activities and Level 3 alterations are set forth below: • Fee increased to $3,000 for Level 3 alterations or sites of 10,000 sq ft or smaller. • Additional large site fee of $1,000 for sites disturbing more than 10,000 sq ft. • $500 fee for review of stormwater management as-built plans. Additional fees are listed for optional services. (502.4)	**Different Approach, appears less stringent:** • $500 for conceptual plan • $500 for post-construction stormwater management plan • In addition, $75 per hour of staff review time. *(N.B.: it would take 47 or more hours of review time per project for the total Philadelphia fees to cost more than the DC fees.)*	**Less Stringent:** Fees are set by ordinance, not regulations. The ordinance stipulates a $1,000 fee for developments less than 50,000 sq ft. or a $3,000 fee for larger projects. The fee for variance requests is 50 percent higher than the amounts listed above.	Unknown.	**Different Approach, appears less stringent:** • No base fee assessed • $166 per hour of staff review time. *(N.B.: it would take 28 or more hours of review time per project for the Seattle fees to cost more than the DC fees.)*

TOPIC	PROPOSED DC REGULATION	PHILADELPHIA REGULATION[a]	CHICAGO REGULATION[b]	PORTLAND REGULATION[c]	SEATTLE REGULATION[d,e]
Peak Discharge	Existing regulations stipulate that every applicant shall comply with the following minimum storm water runoff control requirements: a. Submit management measures necessary to maintain the post-development peak discharges for a twenty-four hour, two- and fifteen-year frequency storm event at a level that is equal to or less than the respective, twenty-four hour, two- and fifteen-year pre-development peak discharge rate through storm water management practices that control the volume, timing and rate of flows. (529.2.a)	**Similar Approach:** Both DC and Philadelphia require site discharge rate to be equal to or less than pre-development discharge rates. Philadelphia exempts those who exhibit a 20 percent decrease in peak discharge from pre-development rates.	**Different Approach:** The regulations do not require peak flow rates to reach pre-development rates, but require sites between 7500 sq ft to 1.75 acres to either use the standard maximum release rate or use a calculated maximum release rate based on outlet sewer capacity and local sewer capacity. Sites must be designed to maintain a 100 year storm when calculating their maximum release rate.	**More Stringent:** The regulations require limiting stormwater discharge to pre-development peak for 2-, 5-, 10- and 25-year, 24-hour storms when discharging into any overland storm drainage system, and 10- and 20-year, 24-hour storms to any combined sewer.	**More Stringent:** The 25-year post-development peak flow cannot exceed 0.4 cubic feet per second per acre *and* the 2-year peak flow cannot exceed 0.15 cubic feet per second per acre. This and additional flow control standards are defined with applicability to specific types of projects based on project size and discharge receptor.

TOPIC	PROPOSED DC REGULATION	PHILADELPHIA REGULATION[a]	CHICAGO REGULATION[b]	PORTLAND REGULATION[c]	SEATTLE REGULATION[d,e]
Water Quality Volume: Calculation	The applicant shall manage, through retention practice or through a combination of retention and detention practices, the water quality volume of the site (SWRv), as calculated in accordance with § 529.4. The total water quality volume of runoff (SWRv) to be managed shall be determined based on the site's surface area and the permeability of the proposed future condition, as follows: $SWRv = (P \times (Rv_I \times \%I \times Rv_C \times \%C \times Rv_N \times \%N) \times SA) / 12$ SWRv = volume, in acre-feet P = 1 inch (90th percent rainfall event for the district) Rv_I = 0.95 (runoff coefficient for impervious cover) Rv_C = 0.25 (runoff coefficient for compacted cover) Rv_N = 0.05 (runoff coefficient for natural cover %I = percent of site in impervious cover %C = percent of site in compacted cover %N = percent of site in natural cover SA = total site area, in acres For the total water quality volume for Anacostia of runoff (SWRv), P = 3.2 inches (2-year 24 hour rainfall event for the District) (529.3 and 529.4, 530.4 for Anacostia)	**Less Stringent:** The regulations requires applicants to meet a specific Water Quality Volume (SWRv); however, the calculation used to determine SWRv is more simplistic in nature and does not take into consideration the permeability of the treated surface.	**Different Approach:** The Modified Rational Method is used to determine required storage to control rate flow of the 100-year storm event. Volume flow is required in addition to rate control and both are calculated according to the c-value or curve number of the soil or surface.	**Different Approach:** The applicant must calculate the amount of discharge that can be handled at the offsite facility to which they must discharge in the event that onsite infiltration/retention cannot meet stormwater demand caused by a 10-year and/or 25-year storm event (depending on discharge location). The site's infiltration must be designed to control enough flow to prevent overburdening offsite facilities during these storm events. This is calculated using the Rational Method.	**Different Approach:** For stormwater requiring treatment, the water quality design volume is based on the daily runoff volume at or below which 91 percent of the total runoff volume for the simulation period occurs. The calculation includes three steps: 1) Rank the daily runoff volumes from highest to lowest. 2) Sum all the daily volumes and multiply by 0.09. 3) Sequentially sum daily runoff volumes, starting with the highest value, until the total equals nine percent of the total runoff volume. The last daily value added to the sum is defined as the water quality design volume.

TOPIC	PROPOSED DC REGULATION	PHILADELPHIA REGULATION[a]	CHICAGO REGULATION[b]	PORTLAND REGULATION[c]	SEATTLE REGULATION[d,e]
Water Quality Volume: Retention	The applicant shall retain on-site at least 75% of the water quality volume (SWRv) as calculated in accordance with § 529.4, unless on-site retention is demonstrated to be infeasible in accordance with § 533.2 or is inappropriate under § 533.3. (529.5) For Anacostia: "The applicant shall retain on-site at least one inch of the water quality volume (SWRv), as calculated in accordance with 530.4, unless on-site retention is demonstrated to be infeasible in accordance with 533.2 or is inappropriate under 533.3." (530.5 and Anacostia Waterfront Environmental Standards Act, 456.a.1)	**Similar Approach:** Requirements include onsite infiltration equal to one inch when possible. If applicant determines onsite infiltration infeasible they must submit written explanation to Water Department.	**Less Stringent:** The regulations do not specify percentage of SWRv that must be retained on site, but requires that one-half inch of runoff from impervious surfaces be captures through specified BMP techniques, or, if site does not directly discharge to waters of municipal separate sewer system then a 15 percent reduction in impervious surfaces is required.	**Similar Approach:** Onsite infiltration is required to the maximum extent possible, and when not possible the use of vegetative retention is required to the maximum extent feasible.	**No specific retention requirements.**

TOPIC	PROPOSED DC REGULATION	PHILADELPHIA REGULATION[a]	CHICAGO REGULATION[b]	PORTLAND REGULATION[c]	SEATTLE REGULATION[d,e]
Water Quality/ Mitigation	Any part of the SWRv not retained onsite shall be treated to achieve, at a minimum, an 80% reduction in Total Suspended Solids (TSS). (529.6) For Anacostia: Existing regulations stipulate that site must Improve stormwater quality by filtering all stormwater flowing from the project, up to the volume of a 2-year design storm, by passing the flow through a vegetated filtering medium or other on-site controls designed to remove sediment and pollutants of concern as identified in permits by the DDOE or the District of Columbia Water and Sewer Authority, so that the discharges will not cause or contribute to the exceedance of any water-quality standard applicable to the receiving water or cause interference or pass-through of pollutants at the Blue Plains receiving facility. Proposed regulation for Anacostia adds a specific requirement for the effectiveness of the filtering medium: "Any stormwater management facility which may receive stormwater runoff shall be designed to ensure that any portion of the water quality volume (SWRv) discharged from the site passes through a filtering medium designed remove at least 80% of total suspended solids (TSS)." (530.8 and Anacostia Waterfront Environmental Standards Act, 456.a.2)	**Less Stringent:** The regulations do not specify a minimum reduction in Total Suspended Solids. Requirements reference treatment levels and practices associated with separate and combined sewers.	**Not mentioned in regulations**	**Less Stringent:** The regulations require sites to achieve a 70 percent TSS removal from 90 percent of the average annual runoff. For a similar protected watershed a pollution reduction facility must be used to reduce pollutants of concern. Vegetated facilities must be used to the maximum extent possible.	**Less Stringent:** All projects require a "basic treatment facility," defined as a drainage control facility designed to reduce concentrations of total suspended solids in drainage water. In addition, oil control treatment is required for "high-use sites"; phosphorous treatment is required for projects discharging into nutrient-critical receiving waters; and enhanced treatment for reducing concentrations of dissolved metals is required for projects discharging to a fish-bearing stream or lake, and to waters or drainage systems that are tributary to fish-bearing streams, creeks, or lakes, subject to project type-based size thresholds.

TOPIC	PROPOSED DC REGULATION	PHILADELPHIA REGULATION[a]	CHICAGO REGULATION[b]	PORTLAND REGULATION[c]	SEATTLE REGULATION[d,e]
Preferred Methods/ Vegetated Techniques	In meeting the requirements of this section, the applicant shall use Vegetated Techniques to the maximum extent practicable. (529.7) Existing regulations for Anacostia stipulate that the site must achieve the required level of stormwater control using the following methods, identified in order of preference: A. Vegetated controls designed to retain and beneficially use stormwater; B. Where compatible with groundwater protection, non-vegetated controls designed to promote infiltration; C. Other low-impact development practices; D. Collection and reuse of stormwater for on-site irrigation; and E. Other on-site design techniques as approved by the DDOE. (530.6 and Anacostia Waterfront Environmental Standards Act, 456.a.3)	**Less Stringent:** The regulations and the City's Stormwater Management Guidance Manual provide detailed information on use of design techniques, including LID techniques, to minimize impervious surfaces and direct connection to drainage systems. The City provides incentives that have effectively encouraged increased use of LID techniques. However, the requirements do not specify which techniques should be used over others.	**Different/Less Stringent:** The regulations differentiate between flow rate control and volume control. The city identifies two types of structures to deal with rate control; Conveyance structures and detention structures. While the city encourages the use of non-structural BMPs, it does not require the implementation of one structure over another. The city encourages infiltration techniques for maintaining stormwater on-site and reducing off-site flow. The city does not require specific techniques in meeting volume flow requirements.	**More Stringent:** The regulations stress the use of vegetative infiltration techniques whenever possible. Vegetative infiltration or detention facilities are used in all options of the stormwater treatment hierarchy. A. Vegetative infiltration facility with no overflow. B. Vegetative facility with overflow to sump, drywell, or soakage trench. C. Vegetated detention facility with overflow to drainageway, stream, river, or storm-only pipe. D. Vegetated detention facility with overflow to a combined sewer. The city requires applicants to meet five specific criteria to downgrade from a higher category to a lower category.	**Similar Approach:** All projects that trigger minimum requirements for flow control or treatment must use "green stormwater infrastructure" to the "maximum extent feasible" to meet the requirement. Green stormwater infrastructure is defined as a "drainage control facility that uses infiltration, evapotranspiration, or stormwater reuse [such as] permeable pavement, bioretention facilities, and green roofs." Maximum extent feasible means "the requirement is to be fully implemented, constrained only by the physical limitations of the site, practical considerations of engineering design, and reasonable considerations of financial costs and environmental impacts."

TOPIC	PROPOSED DC REGULATION	PHILADELPHIA REGULATION[a]	CHICAGO REGULATION[b]	PORTLAND REGULATION[c]	SEATTLE REGULATION[d,e]
Public Spaces	(Applicable to Anacostia only)[1] Existing regulations for Anacostia stipulate that site must employ, where feasible, low-impact development technologies for public spaces regulated by District Department of Transportation. Proposed regulation adds a new requirement regarding public spaces: "Where runoff is discharged into a stormwater management facility placed in the public space, the applicant shall provide controls using on-site stormwater management practices." (530.9 and Anacostia Waterfront Environmental Standards Act, 456.a.4)	**Not mentioned in regulations**	**Not mentioned in regulations**	**Different Approach.** Public spaces are generally subject to the same requirements as private projects. In addition, Portland requires green street facilities to be incorporated into all city-funded development projects. The city also has an extensive non-regulatory program focusing on public spaces.	**Not specifically mentioned in regulations.** Minimum requirements are defined by project type, some of which (e.g., trail projects) may involve public spaces. Subject to a range of exemptions and other conditions, city and other public agencies are required to comply with the substantive requirements of the regulations.
Wetlands Protection	(Applicable to Anacostia only) Existing regulations for Anacostia stipulate that no construction or development shall disturb delineated wetlands or land within 100 feet of delineated wetlands, which shall be maintained as a buffer, unless the DDOE and the U.S. Army Corps of Engineers both agree that construction in these areas cannot reasonably be avoided. Any impacts on wetlands approved by the DDOE shall require mitigation in-kind at a minimum acreage ratio of 3-to-1…*[lists specific requirements]* (Anacostia Waterfront Environmental Standards Act, 458.3)	**Not mentioned in regulations**	**Not mentioned in regulations**	**Not mentioned in regulations**	**Different Approach:** All projects discharging to wetlands or their buffers must protect the hydrologic conditions, vegetative community, and substrate characteristics of the wetlands and their buffers. Discharges must maintain existing flows to the extent necessary to protect the functions and values of the wetlands.

[1] While this particular regulation applies only to public spaces Anacostia, the proposed regulations shown in Appendix A generally apply to both public and private land.

TOPIC	PROPOSED DC REGULATION	PHILADELPHIA REGULATION[a]	CHICAGO REGULATION[b]	PORTLAND REGULATION[c]	SEATTLE REGULATION[d,e]
Stream Diversion	(Applicable to Anacostia only) Existing regulations for Anacostia stipulate that streams that have been diverted into pipes or other constructed conveyances shall be daylit unless determined by the DDOE to be infeasible. (Anacostia Waterfront Environmental Standards Act, 458.4)	**Not mentioned in regulations**	**Not mentioned in regulations**	**Not mentioned in regulations**	**Not mentioned in regulations**
Riparian Buffer Zones	(Applicable to Anacostia only) Existing regulations for Anacostia stipulate that the applicant shall ensure protection or creation of woodland and meadow riparian buffer zones along each bank of the Anacostia River defined in the Anacostia Waterfront Initiative Framework Plan of between 50 and 300 feet along the main channel of the Anacostia River, except where necessary to ensure public access and use of the waterfront. Development along tributary streams of the Anacostia River shall maintain a minimum riparian buffer of 25 feet. The DDOE may require a wider buffer along the channel or tributary streams where it is determined that a wider buffer zone is necessary to protect waterways. (Anacostia Waterfront Environmental Standards Act, 458,4)	**Not mentioned in regulations**	**Not mentioned in regulations**	**Not mentioned in regulations**	**Not mentioned in regulations**

TOPIC	PROPOSED DC REGULATION	PHILADELPHIA REGULATION[a]	CHICAGO REGULATION[b]	PORTLAND REGULATION[c]	SEATTLE REGULATION[d,e]
Vegetated Roadway Buffers	(Applicable to Anacostia only)[2] Existing regulations stipulate that roadways shall comply with the Anacostia Waterfront Transportation Architecture Design Standards developed by the DDOT. Applicants shall incorporate planted vegetated buffers within the right-of-way of all roadways to increase tree cover and shade, mitigate traffic noise, absorb toxic emissions, and minimize stormwater runoff at levels determined by the DDOE by rulemaking. Applicants shall ensure sufficient tree planting to provide canopy coverage within 20 years of project occupancy of 30% of non-roof impervious surfaces and 40% of overall-non-roof surfaces within the project area. (Anacostia Waterfront Environmental Standards Act, 458.6, 458.7, 458.8)	**Not mentioned in regulations**	**Not mentioned in regulations**	**Not mentioned in regulations**	**Not mentioned in regulations**

[2] While this particular regulation applies only to public spaces Anacostia, the proposed regulations shown in Appendix A generally apply to both public and private land.

TOPIC	PROPOSED DC REGULATION	PHILADELPHIA REGULATION[a]	CHICAGO REGULATION[b]	PORTLAND REGULATION[c]	SEATTLE REGULATION[d,e]
Relief and Off-site Mitigation	The proposed regulation includes new provisions for relief where compliance is technically infeasible or inappropriate due to soil contamination. Under these provisions, the applicant shall retain on-site the maximum feasible portion of the water quality volume and provide off-site mitigation for the deficiency. See §§ 533 and 534 for details. The sections have no close corollary in existing regulations. § 528 of the DC Municipal regulations allows for waivers in instances where runoff 'will not adversely impact the receiving wetlands, water course, or waterway,' but there is no accommodation for infeasibility and no requirement for off-site mitigation. The Anacostia Waterfront Environmental Standards Act includes a similar mitigation or payment option for sites within the Anacostia area. The off-site volume of water treated must equal 1.5 times the volume that would have been required to be treated on-site or two times its financial equivalent where payment is made in lieu of mitigation. (533,534)	**Similar Approach:** The city will provide off-site stormwater mitigation if the applicant proves the infeasibility of on-site management. More commonly, the city works with developers and landowners to conduct stormwater banking or trading.	**Similar Approach:** If the applicant cannot apply with stormwater regulations, they must provide supporting evidence that the site currently minimizes peak rate of discharge and volume of stormwater from the site, or that they cannot comply without imposing on other public ordinances.	**More Stringent Approach:** Portland requires any discharge offsite to limit flow peak flow rates to the pre-development 2-year, 24-hour storm erosion rate when discharging into a stream or channel. Projects in combined sewer areas must first use vegetative infiltration to the maximum extent possible. Any additional discharge into the combined sewer must not create a risk for a combined sewer overflow event or localized basement flooding.	**Different Approach:** The Director of Seattle Public Utilities is authorized to approve three means of alternative compliance: 1) Implementation of an Integrated Drainage Plan specific to one or more sites where best management practices are employed such that the cumulative effect on the discharge from the site(s) to the same receiving water is the same or better than that which would be achieved by a less-integrated, site-by-site implementation of BMPs 2) Voluntary contribution of funds toward the construction of one or more drainage control facilities that mitigate the impacts to the same receiving water. 3) Voluntary construction of one or more drainage control facilities at an alternative location, determined by the Director, to mitigate the impacts to the same receiving water.

TOPIC	PROPOSED DC REGULATION	PHILADELPHIA REGULATION[a]	CHICAGO REGULATION[b]	PORTLAND REGULATION[c]	SEATTLE REGULATION[d,e]
Applicability to Level 3 alterations	Before conducting Level 3 alterations and repairs of existing buildings in which the estimated cost equals or exceeds fifty percent of the assessed value of the property before alterations and repairs are started, a person shall obtain a stormwater management permit to limit and manage runoff from the site. (526.2) For Anacostia, before any person engages in any land disturbing activities or engages in a Level 3 alteration to an existing building within the Anacostia Waterfront Development Zone, the person shall comply with the minimum stormwater management requirements in this section, in addition to all other requirements of §§ 526 through 535. If this section conflicts with any other provision of §§ 526 through 535, the applicant shall be subject to the more stringent standard. (530.1) For Anacostia, within the Anacostia Waterfront Development Zone, any person engaging in Level 3 alterations to an existing building in which the estimated cost equals or exceeds fifty percent of the assessed value of the property or structure before alterations and repairs are started, and which have roof drains connected to a sewer, shall control or manage runoff from the site to comply with the provisions of this section. (530.2)	**Different Approach:** The regulations require compliance for any redevelopment project that disturbs more than 15,000 sq ft of earth. If redevelopment site is less than one acre of earth disturbance than the project is exempt from channel protection requirements. No specification was made concerning redevelopments of buildings without land disturbance.	**Different Approach:** The regulations apply to any development which includes construction, or expansion of a building. No more specification was given regarding redevelopment projects without land disturbance.	**Different Approach:** Redevelopment includes any demolition or complete removal of existing structures. Any project that proposes new offsite discharges or new connections to a public sewer system and/or any project that develops over 500 sq ft of impervious surface are subject to the stormwater regulations. All regulations apply to redevelopment projects that apply to new development. No specification was made concerning redevelopment of buildings without land disturbance.	**Different Approach:** The regulations do not make a distinction between new construction and renovation projects. The regulations' scope covers all land disturbing activities and all new and existing land uses. A "project" subject to the regulations is defined as the "addition or replacement of impervious surface or the undertaking of land disturbing activity on a site."

TOPIC	PROPOSED DC REGULATION	PHILADELPHIA REGULATION[a]	CHICAGO REGULATION[b]	PORTLAND REGULATION[c]	SEATTLE REGULATION[d,e]
Level 3 Alterations: Discharge/ Downspouts	Each applicant for a Level 3 alteration to an existing building shall—unless such disconnection would cause stormwater flow into public space or an adjoining lot without permission—disconnect any downspouts connected to a sewer to allow stormwater to be discharged from impermeable areas to vegetated areas on the same record lot. (529.1)	**Not mentioned in regulations**	**Not mentioned in regulations**	**Not mentioned in regulations**	**Not mentioned in regulations**

[a] Philadelphia Water Department Regulations, Section 600.0, Stormwater Management

[b] City of Chicago, Department of Water Management, 2010 Regulations for Sewer Maintenance and Stormwater Management

[c] Portland Bureau of Environmental Services, 2008 Stormwater Management Manual

[d] City of Seattle, Ordinance 123105, Stormwater Code

[e] City of Seattle, Municipal Code Title 22, Building and Construction Codes

APPENDIX C

DERIVATION OF CURVE NUMBERS FOR CALCULATING INFILTRATION

The infiltration rate of a site is determined in large part by the runoff curve number, or CN, of its soil. The CN represents the percentage of precipitation landing on the area that is expected to become runoff, rather than entering the soil directly. The CN therefore affects the volume of stormwater that can be accommodated by conventional landscaping, which in turn determines supplemental stormwater management requirements for a particular site. This appendix explains IEc's methodology for deriving estimates of site-level CNs. Since scenario 2 has no landscaped area (aside from the green roof, which is treated separately), we discuss scenarios 1 and 3 only.

Based on USDA soil classifications for our particular locations within the Washington, DC area, the soil type for scenario 1 is Sassafras-Croom-Beltsville, and for scenario 3, it is Urban Land-Sunnyside-Sassafras-Muirkirk-Christiana. The hydrologic soil group classifications for these units are shown in Exhibit C-1 below.

EXHIBIT C-1. SOIL SERIES AND HYDROLOGIC SOIL GROUPS

SOIL SERIES	HYDROLOGIC SOIL GROUP
Beltsville	C
Croom	B
Christiana	C
Muirkirk	A
Sassafras	B
Sunnyside	B
Urban Land	N/A

Source: USDA Natural Resources Conservation Service. "Hydrologic Soil Group—District of Columbia." November 29, 2007. Accessed December 17, 2009. ftp://ftpfc.sc.egov.usda.gov/MD/web_documents/technical/soils/tables/hydrologic/Hydrologic_Soil_Group_dc.pdf

USDA has developed Curve Numbers corresponding to each of these hydrologic soil groups for various types of vegetative cover (e.g., open land, agricultural, woodlands, etc.). For good cover of open land (75 percent or greater grass cover), the CN is 39 for group A soils, 61 for group B, and 74 for group C).[39] We assume that conventional landscaping would fall into this category, representing a well-maintained landscape dominated by grasses. A landscape with trees or shrubs would have a lower CN, which would in turn mean that the landscaping would have a higher infiltration rate.[40] Conversely, the CN would be higher for poorly-maintained grassy areas.

[39] Soil Conservation Service, Urban Hydrology for Small Watersheds, Technical Release 55 (TR-55), 1986. Cited in Halley, Mary et al. "ArcView GIS Extension for Estimating Curve Numbers." N.d. Accessed December 17, 2009. http://proceedings.esri.com/library/userconf/proc00/professional/papers/pap657/p657.htm

[40] Christopher Kloss, Low Impact Development Center. Personal communication. December 15, 2009.

The Sassafrass-Croom-Beltsville soil type, present at the Anacostia site in scenario 1, includes two series belonging to group B, with a CN of 61, and one belonging to group C, with a CN of 74. We therefore used a weighted average of 65.33. Similarly, for the Urban Land-Sunnyside-Sassafras-Muirkirk-Christiana series in scenario 3, two soil series are from group B, one is from A and one is from C. We use the CN of 61 for group B to represent the overall array.[41]

These CNs are used for natural cover. To develop a CN for the entire site, we must also account for impervious areas, as well as any bioretention areas. The Soil Conservation Service establishes a CN of 98 for impervious surfaces, which we use here.[42] The bioretention area itself is also modeled with a CN of 98, but this is due to the particular mechanics of the bioretention sizing calculator used, and is not intended to suggest that the bioretention cell is actually an impervious surface: "In the context of this analysis, a surface's CN value indicates what proportion of the rainfall does not infiltrate locally – thus, ultimately making it to the bioretention cell for treatment. The cell itself should have a high CN value since almost all rain falling on it receives treatment, i.e. infiltration is into the cell's soils and any runoff generated does not leave the depressed basin."[43] By using these values and assigning them weights according to the relative proportion of impervious surface, bioretention area, and other natural cover each site, we calculate a total, site-level average CN, as shown in Exhibit C-2.

EXHIBIT C-2. CALCULATION OF AVERAGE RUNOFF CURVE NUMBERS, BY SITE

SCENARIO	CONVENTIONAL LANDSCAPING		IMPERVIOUS SURFACE		BIORETENTION AREA		SITE AVERAGE CN
	CN	AREA	CN	AREA	CN	AREA	
1	65.33	7,140 sq ft	98	30,000 sq ft	98	2,860 sq ft	92.17
3	61	4,770 sq ft	98	20,000 sq ft	98	230 sq ft	90.94

Due to the interactions between the size of a bioretention area, the remaining natural cover available for conventional landscaping, and the weighted average CN, sizing the bioretention area (and deriving a site CN) was an iterative process. IEc made incremental adjustments until we arrived at a balance where the bioretention area was just large enough to satisfy that portion of the stormwater management requirement that could not be met through conventional landscaping. This is how real estate developers and their contractors would approach the issue to ensure selection of the least expensive stormwater management option available.

[41] The Urban Land soil type does not have an official series description and is excluded from consideration here.

[42] Soil Conservation Service, Urban Hydrology for Small Watersheds, Technical Release 55 (TR-55), 1986. Cited in Halley, Mary et al. "ArcView GIS Extension for Estimating Curve Numbers." N.d. Accessed December 17, 2009. http://proceedings.esri.com/library/userconf/proc00/professional/papers/pap657/p657.htm

[43] Low Impact Development Center, Inc. "Bioretention: Sizing." 2007. http://www.lid-stormwater.net/bio_sizing.htm.

APPENDIX D

CALCULATION DETAILS: WATER TREATMENT VOLUME, BIORETENTION AREA SIZING, AND COSTS

EXHIBIT D-1. CALCULATION OF WATER TREATMENT VOLUME REQUIREMENTS

		SCENARIO ONE	SCENARIO TWO	SCENARIO THREE
Site area (square feet)				
Building footprint (rooftop area)		20,000	15,000	10,000
Parking lot		0	0	10,000
Sidewalk		10,000	0	0
Natural cover		10,000	0	5,000
Total		40,000	15,000	25,000
Proposed Regulations				
P, inches		3.2	1	1
Rvi (runoff coefficient for impervious cover)		0.95	0.95	0.95
% impervious		75%	100%	80%
Rvc (runoff coefficient for compacted cover)		0.25	0.25	0.25
% compacted		5%	0%	0%
Rvn (runoff coefficient for natural cover)		0.05	0.05	0.05
% natural		20%	0%	20%
SA, acres	Site area (sq ft) x 43,560	0.92	0.34	0.57
WQTv, acre-feet	P x ((Rvi x %i) + (Rvc x %c) x (RVn x %n)) / 12	0.18	0.03	0.04
x gallons per acre-foot	325,851.429	325,851	325,851	325,851
= WQTv, gallons		**58,647**	**8,883**	**12,000**
Existing Regulations	-			
R', inches (rooftops & sidewalks)		0.3	0.3	0.3
R", inches (parking lots)		0.5	0.5	0.5
Ia', square feet (rooftops & sidewalks)		30,000	15,000	10,000
Ia", square feet (parking lots)		0	0	10,000
Vw, cubic feet	R' x Ia' / 12 + R" x Ia" / 12	750	375	667
x gallons per cubic foot		7.48	7.48	7.48
= Vw, gallons		**5,610**	**2,805**	**4,987**

EXHIBIT D-2. CALCULATION OF BIORETENTION CELL SIZE, SCENARIO 1

Adapted from Low Impact Development Center, Inc. http://www.lid-stormwater.net/bio_sizing.htm

Drainage area	0.918	acres	=	40,000 sq ft
Natural cover	10,000	sq.ft.		
Bioretention device area	2,860	sq.ft.	=	29% of natural cover
storage depth (above ground)	6	inches	=	0.50 ft.
infiltration porosity (volume fraction of soil pores)	0.2			
soil depth	40	inches	=	3.33 ft.
total storage volume (above ground + soils)	**3,337**	**cubic ft./day**	**=**	**24,960 gal / day**

CN - natural cover	65.33	CN - impervious surfaces	98.00
S	5.31	S	0.20

Rainfall (P) (in / day)	Runoff (Q) (in / day)	Rainfall Volume (gal / day)	Runoff Volume (gal / day)	Landscape retention (gal / day)	Bioretention area retention (gal / day)	Total retention (gal / day)
0.05	0.000	1,247	7	1,239	7	1,247
0.10	0.010	2,494	249	2,245	249	2,494
0.15	0.029	3,740	712	3,029	712	3,740
0.20	0.052	4,987	1,305	3,683	1,305	4,987
0.30	0.109	7,481	2,712	4,769	2,712	7,481
0.40	0.172	9,974	4,283	5,691	4,283	9,974
0.50	0.238	12,468	5,945	6,522	5,945	12,468
0.60	0.307	14,961	7,661	7,300	7,661	14,961
0.80	0.449	19,948	11,190	8,758	11,190	19,948
1.00	0.593	24,935	14,791	10,144	14,791	24,935
1.25	0.778	31,169	19,388	11,781	19,388	31,169
1.50	0.968	37,403	24,149	13,253	24,149	37,403
2.00	1.366	49,870	34,062	15,808	24,960	40,768
3.00	2.206	74,805	55,004	19,801	24,960	44,761
3.20	**2.379**	**79,792**	**59,326**	**20,466**	**24,960**	**45,426**
4.00	3.086	99,740	76,942	22,798	24,960	47,758

EXHIBIT D-3. CALCULATION OF BIORETENTION CELL SIZE, SCENARIO 3

Adapted from Low Impact Development Center, Inc. http://www.lid-stormwater.net/bio_sizing.htm

Drainage area	0.574	acres	=	25,000 sq ft
Natural cover	5,000	sq.ft.		
Bioretention device area	230	sq.ft.	=	3% of natural cover
storage depth (above ground)	6	inches	=	0.50 ft.
infiltration porosity (volume fraction of soil pores)	0.2			
soil depth	40	inches	=	3.33 ft.
total storage volume (above ground + soils)	**267**	**cubic ft./day**	**=**	**1,995 gal / day**
CN – weighted average	90.94			
S	1.00			

Rainfall (P) (in / day)	Runoff (Q) (in / day)	Rainfall Volume (gal / day)	Runoff Volume (gal / day)	Landscape retention (gal / day)	Bioretention area retention (gal / day)	Total retention (gal / day)
0.05	0.000	779	0	779	0	779
0.10	0.000	1,558	0	1,558	0	1,558
0.15	0.000	2,338	0	2,338	0	2,338
0.20	0.000	3,117	0	3,117	0	3,117
0.30	0.009	4,675	144	4,531	144	4,675
0.40	0.033	6,234	525	5,709	525	6,234
0.50	0.068	7,792	1,087	6,705	1,087	7,792
0.60	0.113	9,351	1,792	7,559	1,792	9,351
0.80	0.223	12,468	3,522	8,946	2,007	10,953
1.00	**0.353**	**15,584**	**5,561**	**10,023**	**2,007**	**12,031**
1.25	0.534	19,481	8,406	11,075	2,007	13,082
1.50	0.731	23,377	11,480	11,897	2,007	13,904
2.00	1.152	31,169	18,068	13,101	2,007	15,108
3.00	2.057	46,753	32,196	14,557	2,007	16,564
4.00	3.001	62,338	46,931	15,406	2,007	17,414

EXHIBIT D-4: CALCULATION OF BIORETENTION CELL SIZE, SCENARIO 1 SENSITIVITY TEST

Adapted from Low Impact Development Center, Inc. http://www.lid-stormwater.net/bio_sizing.htm

Drainage area	0.918	acres	=	40,000 sq ft
Natural cover	10,000	sq.ft.		
Bioretention device area	4.150	sq.ft.	=	42% of natural cover
storage depth (above ground)	4	inches	=	0.33 ft.
infiltration porosity (volume fraction of soil pores)	0.2			
soil depth	36	inches	=	3.00 ft.
total storage volume (above ground + soils)	**3,873**	**cubic ft./day**	**=**	**28,975 gal / day**

CN - natural cover	72.33	CN - impervious surfaces	98.00
S	3.82	S	0.20

Rainfall (P) (in / day)	Runoff (Q) (in / day)	Rainfall Volume (gal / day)	Runoff Volume (gal / day)	Landscape retention (gal / day)	Bioretention area retention (gal / day)	Total retention (gal / day)
0.05	0.000	1,247	7	1,239	7	1,247
0.10	0.010	2,494	249	2,245	249	2,494
0.15	0.029	3,740	712	3,029	712	3,740
0.20	0.052	4,987	1,305	3,683	1,305	4,987
0.30	0.109	7,481	2,712	4,769	2,712	7,481
0.40	0.172	9,974	4,283	5,691	4,283	9,974
0.50	0.238	12,468	5,945	6,522	5,945	12,468
0.60	0.307	14,961	7,661	7,300	7,661	14,961
0.80	0.449	19,948	11,192	8,756	11,192	19,948
1.00	0.597	24,935	14,876	10,059	14,876	24,935
1.25	0.790	31,169	19,688	11,481	19,688	31,169
1.50	0.990	37,403	24,679	12,724	24,679	37,403
2.00	1.406	49,870	35,062	14,808	28,975	43,783
3.00	2.282	74,805	56,909	17,896	28,975	46,871
3.20	**2.462**	**79,792**	**61,400**	**18,392**	**28,975**	**47,366**
4.00	3.194	99,740	79,653	20,087	28,975	49,062

EXHIBIT D-5. CALCULATION OF INCREMENTAL STORMWATER MANAGEMENT COSTS UNDER PROPOSED REGULATIONS

PROPOSED REGULATIONS	SCENARIO ONE	SCENARIO TWO	SCENARIO THREE
SWRv, gallons	58,647	8,883	12,000
Traditional landscaping size, sq ft	7,140	0	4,770
Retention volume, gallons	20,466	0	10,023
Remaining runoff, gallons	38,181	8,883	1,977
Bioretention area size, sq ft	2,860	0	230
Retention volume, gallons	24,960	0	2,007
Treatment volume, gallons	13,221	0	0
Remaining runoff, gallons	0	8,883	0
Green roof size, sq ft	0	11,250	0
Retention volume, gallons	0	4,208	0
Remaining runoff, gallons	0	4,675	0
Storage tank size, gallons	0	6,000	0
Remaining runoff, gallons	0	0	0
LID COSTS			
Bioretention cell			
Retention volume, gal	24,960	0	2,007
Retention volume, cubic ft.	3,337	0	268
Number of cells	3	0	1
Retention volume per cell, cubic ft.	1,112	0	268
large bioretention cell cost (9.48 x retention volume^0.991 x # of cells)	29,697		
small bioretention cell cost (flat rate)			8,300
less: avoided landscaping cost ($3,622/acre)	-238	0	-19
total bioretention cell cost	29,459	0	8,281
Green roof			
green roof cost, $/sq ft	0	10	0
conventional roof cost, $/sq ft	0	6	0
incremental cost, $/sq ft	0	4	0
green roof area, sq ft	0	11,250	0
total green roof cost	0	45,000	0
Storage tank			
cost per 2,000 gal tank	0	2,500	0
# of tanks required	0	3	0
total storage tank cost	0	7,500	0
Total LID cost	29,459	52,500	8,281
less: baseline management cost	0	19,300	0
Total incremental LID cost	**29,459**	**33,200**	**8,281**
Fees:			
Standard plan review	$3,000	$3,000	$3,000

PROPOSED REGULATIONS	SCENARIO ONE	SCENARIO TWO	SCENARIO THREE
Large site fee	$1,000	$1,000	$1,000
Review of as-built plans	$500	$500	$500
Total fees	$4,500	$4,500	$4,500
less: baseline fees	$83	$75	$79
Total incremental fees	**$4,417**	**$4,425**	**$4,422**
Total incremental cost of regulations	**$33,875**	**$37,625**	**$12,702**
Total development cost:	$55,000,000	$30,000,000	$20,000,000
Total sq ft building space:	160,000	90,000	10,000
LID cost / total development cost (%)	**0.06%**	**0.13%**	**0.06%**
LID cost / sq ft	**$0.21**	**$0.42**	**$1.27**