NATIONAL GREEN VALUES™ CALCULATOR METHODOLOGY

SUMMARY

The Center for Neighborhood Technology (CNT) collaborated with the US EPA Office of Wetlands, Oceans, and Watersheds (OWOW), Assessment and Watershed Protection Division, Non-Point Source Branch to develop a green infrastructure evaluation tool, the National Green Values™ Calculator. It compares green infrastructure (commonly referred to as Low Impact Development) performance, costs, and benefits to conventional stormwater practices. The tool provides a quantified analysis of LID environmental benefits including reduced runoff volume and maintenance savings, in addition to carbon sequestration, reduced energy use, and groundwater recharge. The goal of the tool is to encourage communities to adopt green infrastructure as the preferred method for stormwater management by demonstrating the ecological and economic gains that result from implementing green infrastructure practices.

CNT has enhanced and expanded our original Green Values™ Calculator (GVC) to use precipitation data from anywhere in the U.S. and provide a range of runoff reduction goals that represent current innovation in stormwater regulation around the country. The National GVC can work in all U.S. communities because the user specifies their site location, and the calculations thereafter use precipitation data from the nearest National Oceanic and Atmospheric Administration (NOAA) weather station.

Calculator users can also choose from a list of regulations aimed at achieving varied levels of runoff volume reduction chosen from exemplary communities around the country. The specified runoff reduction goal sets a standard against which a selected suite of Best Management Practices (BMPs) performs in relation to that standard.

We also increased the functionality of the National GVC with a section allowing users to define the pre-development conditions of their site. We expanded the list of BMPs that can be applied to the conventional scenario with technologies like cisterns, amended soils, and reduced street widths. Finally, we updated the cost data underpinning the financial analysis of the GVC to better reflect recent advances and economies of scale evident in green infrastructure technologies.

The National GVC can assist planners, developers, and policy-makers in making smart, informed decisions about stormwater infrastructure investments. This report summarizes the methodology for the hydrologic and cost/benefit analyses employed in the National GVC.

ORGANIZATION BACKGROUND

The Center for Neighborhood Technology (CNT) is a 30-year old non-profit on the cutting edge of urban sustainability. Based in Chicago, CNT applies its signature method of identifying underutilized assets in urban and suburban communities and develops innovative strategies to maximize their efficient use in communities around the US, and increasingly, the world. CNT combines rigorous research with effective action to achieve substantial improvements in public policy, urban programs, and private markets. CNT's long-term goals are to increase household wealth and regional productivity; improve environmental quality; and build stronger and more equitable local economies across the nation.

CNT has organized its work toward achieving these goals into four urban sustainability portfolios focusing on: Climate, Energy, Natural Resources, and Transportation & Community Development. Our Natural Resources Program focuses on demonstrating and capturing the multiple economic and social benefits of green infrastructure, utilizing natural systems to restore the value of rainwater from a waste to a resource in Chicago and elsewhere. The Natural Resources program works towards large-scale implementation of green infrastructure through policy advocacy, research and demonstration projects, and easily-accessible tools for informed decision-making.

THE GREEN VALUES™ CALCULATOR

Developed in 2004, the original Green Values® Calculator takes user-defined site specifications, such as size, impervious cover, street design, soil type, and life cycle to model the volume and peak discharge of runoff produced by that site. The original GVC can apply up to six green infrastructure Best Management Practices (BMPs) to the scenario, thereby creating a comparison between "conventional" (i.e. pipes, curbs, gutters, and detention ponds) and "green" scenarios (i.e. green roofs, rain gardens, vegetated swales, trees, native vegetation, and permeable pavement). The GVC displays hydrologic and financial results of the two scenarios side-by-side, highlighting the differences in runoff reductions and financial performance.

The GVC is unique in its attempt to account for and quantify all of the cost and benefit factors that need to be considered over the full life cycle of the site. The GVC determines the first-time construction costs for the developer, as well as the life cycle operation and maintenance costs and benefits to the public and to the private property owner. Some of the quantified benefits of green infrastructure included in the GVC are the dollar values for the carbon sequestration capacity provided by the increased green area and per acre foot of groundwater recharged, and an estimate of the increased property value attained by increased tree canopy on an individual lot. We are studying many of the additional socio-economic benefits, e.g. the improved attention span and decreased incidence of violence that corresponds with access to green space, in order to include them as a quantified benefit in future iterations. The additional socio-economic benefits of green infrastructure are included in the spreadsheet detailing benefits in a qualitative, narrative format.

In 2006, CNT developed an alternative version of the GVC that is specific to the requirements of the new City of Chicago Stormwater Management Ordinance (effective January 2008). The City contracted with CNT to develop this spreadsheet tool to encourage the use of LID techniques in develo
pment and redevelopment projects. Developers and contractors can quickly evaluate the optimal combinations of BMPs to use on specific sites that will meet Chicago ordinance requirements for runoff volume capture, impervious area reduction, and peak discharge control. The Chicago ordinance calculator also compares the construction cost differences between using green infrastructure BMPs to meet the ordinance requirements versus using non-green BMPs (e.g. underground tanks and oversized pipes) that provide no additional benefits.

The methodologies for the original GVC and Chicago Stormwater Management Ordinance (SMO) GVC can be found at:
http://greenvalues.cnt.org/calculator/methodology
http://greenvalues.cnt.org/chicago/methodology

THE NATIONAL GREEN VALUES™ CALCULATOR

The National GVC operates on a few key assumptions that differentiate it from the original GVC and the Chicago Ordinance GVC:

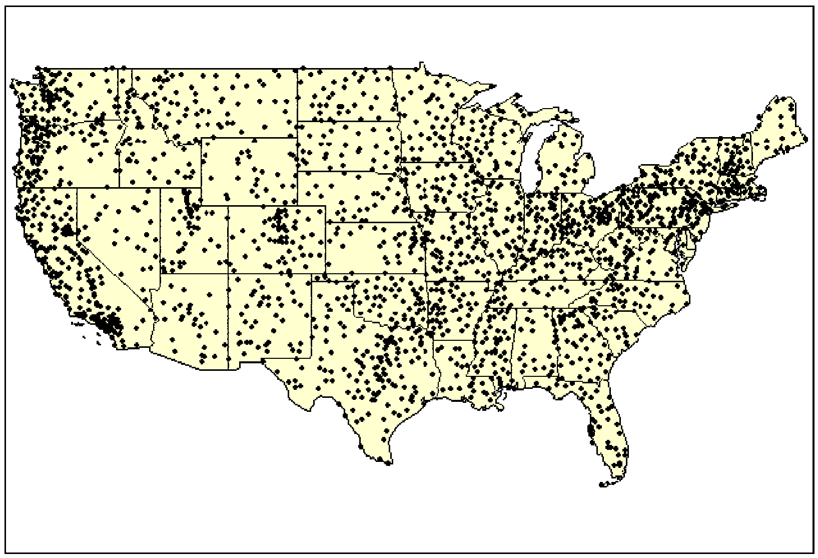
1. The primary goal of the National tool is to assess performance of BMPs for infiltrating, evapotranspirating, and reusing stormwater runoff. This is modeled through calculating the runoff volume capture capacity of each BMP. Volume capture in this context implies infiltration, evapotranspiration and reuse, not detention in ponds or vaults for gradual discharge into the sewer. All runoff volume captured is kept on site.

2. The National GVC does not produce any peak flow results. The National GVC is currently focused on runoff volume reduction.

3. The tool is meant for a single site or a campus of buildings contained on a single site. Unlike the original GVC, the National GVC does not assume a template for the site and should not be used to determine results that require information or assumptions based on site layout or sewer pipe network routing and sizing. The original GVC may be a better tool to use when determining the impacts of green infrastructure for an 80 acre, 40 lot subdivision on a green field (an area undergoing development for the first time, as opposed to a retrofit). The original GVC produces both volume and peak flow results and assumes a site template. The National GVC can determine the runoff volume reduction that results from implementing BMPs on a single residential lot, a campus of federal buildings, or a large commercial site. The National GVC could be used to determine large-scale impacts if the user modeled a site, determined the best combination and sizing of BMPs for that site and the resulting runoff volume capture capacity, and then determined how many sites of similar make-up are represented in the larger area and aggregated the result, i.e. a tiered approach.

PRECIPITATION DATA

The National GVC calculates the annual precipitation depth and the precipitation depth associated with single storm events that occur with a range of frequencies (e.g. the 90% storm) for any site in the U.S. located by zip code. These values are determined by analyzing a 50 year historical record of precipitation data from the nearest weather station to that site. This is a significant departure from other versions of the GVC and many other stormwater assessment tools that use design storms (the 2-year, 10-year, 100-year, etc.) to assess stormwater performance. We decided to use the frequency-event storms because they address the range of smaller storms that are increasingly shown to be the primary contributors to water quality pollution and make up the majority of rainfall in any location in a year. The user can choose from a range starting at the 85th percentile and up to the 99th percentile frequency storm event. These options represent the range of precipitation depths included in both local regulation and US EPA guidelines that must be captured, infiltrated, evapotranspirated and reused as a stormwater standard. Both the annual precipitation depth and the storm event depth are used to determine total runoff volume for that site under conventional and green design scenarios.



The precipitation data comes from the Earth System Research Laboratory (ESRL) and the National Climatic Data Center (NCDC). The Hourly Precipitation Dataset (HPD) (http://precip.fsl.noaa.gov/hpd/) contains hourly precipitation amounts for more than 2500 active stations and close to 7000 total stations from 1900-1998. This map (right) shows all the unique points with a data record for at least 16 consecutive years.

We used the following guidelines to create the National GVC precipitation database from the HPD CD-ROM data:

- Some stations move over time. The latitude/longitude coordinates change for some stations. Some stations moved just a few miles over the years, but at least one station moved over 1,400 miles.
- For unique station locations (latitude/longitude coordinates), there are sometimes multiple station IDs. In most cases there is only one station recording precipitation on a given date, but in some cases more than one station records precipitation on the same date at the same location. To resolve both of these issues, stations were defined as unique latitude/longitude coordinates. We excluded the few points (91) that had more than 1 station capturing data on one or more days.
- Data is not captured every day of the year. There are records with zero precipitation for every hour of the day, so it was not clear why some days had no record at all. As a result, we have about 90 days of data per year for each point rather than 365 days worth of data for each of these.
- We discovered many instances where a storm suddenly stops at midnight because the record for the next day's precipitation is missing. We analyzed all records for days where the precipitation in the last hour was 3 inches or more, and the record for the following day if it existed. Only in a few cases was the next day missing, but in over 80% of the next day records the precipitation for the first hour of the day was 0 or a non-numeric value. The same pattern of storms suddenly stopping was also recorded at lower precipitation levels.

Analysis
We used the National GVC precipitation database to calculate the annual precipitation depth and storm event depth through the following process:

1. Iterate over all hourly data and find any hour where precipitation is greater than 0.
2. Aggregate all succeeding hours, up to the next hour where precipitation is again equal to 0, to find the sum and average precipitation for that event.
3. If the event has "a total accumulation of at least 0.1 inches together with rates averaging at least 0.01 inches per hour" (per NCDC documentation) we will consider it a storm event.
4. Find the 85-99% storm event for each station and use that precipitation depth as our value.
5. Calculate the average daily precipitation for all precipitation (including 0s, and all non numeric values are ignored) and then multiply by 365 to get the average annual precipitation depth.

Calibration
We used a variety of sources to calibrate our precipitation results. One sources is a "Rainfall Statistics and Frequency Spectrum Data for Select U.S. Cities" Table 1.2 from the Center for Watershed Protection's Urban Stormwater Retrofit Practices manual.1 We were able to compare our annual precipitation depth, as well as values for the 90, 95, and 99% storm. In general, we found a high level of variation between our values and those cited in the manual. One possible source of the difference is that our values are specific to zip codes. The table refers to various cities, but does not specify what zip code they are using. It is unclear what process or data was used to derive the precipitation depths in Table 1.2, so there are a variety of reasons why our values are different.

The other source used for calibration is NCDC's Hourly Precipitation Data Rainfall Event Statistics (http://hurricane.ncdc.noaa.gov/cgi-bin/HPD/HPDStats.pl). These data are very similar to the database we created for use in the calculator; however NCDC does not provide these statistics for all stations in operation as a stand-alone database. It would be necessary to go through and download the compiled statistics for each station in each state by hand. Additionally, the statistics are given as monthly averages and could not be used to determine precipitation depth for frequency event storms, or to calibrate the storm event precipitation depths found in the National GVC.

The NCDC statistics do have a value for average annual precipitation depth for each station and can be used to calibrate the National GVC results. Again we found considerable variation between the National GVC values and the NCDC values, although less than compared to the CWP values. The NCDC statistics are determined by calculating a monthly average precipitation depth (using all available years) and then adding each month's total together to determine and annual average. The differences in our results may be due to our different methodologies in calculating annual precipitation depth. The zip codes of individual stations are known, so we were able to compare the NCDC stats for a station directly to the National GVC values produced for that zip code.

[1] Schueler, Tom, David Hirschman, Michael Novotney, and Jennifer Zielinski, P.E. "Urban Subwatershed Restoration Manual No. 3: Urban Stormwater Retrofit Practices Version 1.0", Center for Watershed Protection, August 2007

STORMWATER REGULATION EXAMPLES

The Chicago Stormwater Ordinance Calculator was tailored to the runoff volume and rate control standards that took effect in January 2008. Those regulations require that the first 0.5 inches of rain over the site impervious area be captured and retained on site. For the National GVC we researched similar progressive stormwater regulation requiring on site capture, infiltration, evapotranspiration, and reuse of a certain portion of stormwater runoff. These examples are displayed on the National GVC "Runoff Reduction Goals" page. The user can choose an example regulation or input a custom value. In addition to the precipitation-over-site-area regulations, we include other examples that require maintaining pre-development hydrology, decreasing site effective impervious area, or maintaining groundwater recharge rates. The sources for these examples are included on the page and we hope to keep the list updated as more localities develop runoff volume regulations.

NATIONAL GVC HYDROLOGIC METHODOLOGY

The National GVC produces two primary hydrologic results:

1) It determines the runoff volume capture capacity of the green infrastructure BMPs defined for the green scenario; and
2) It calculates the total runoff volume produced by the pre-development, conventional development, and green development scenarios.

Volume Capture Capacity
The runoff volume capture capacity is determined by the area of the BMP and the depth and void ratio of prepared soil and/or aggregate included as the base for the BMP. The National GVC calculates this quantity as a static measure of volume that is not affected by infiltration rates. The Chicago Stormwater Ordinance GVC applied this methodology because the ordinance developers determined it was not feasible to broadly assess site infiltration rates based on the basic available information. Assessing and including infiltration capacity for each BMP would require knowledge of site slope, underlying soils, rainfall durations, and antecedent soil moisture conditions. With guidance from the EPA, we decided to maintain this methodology in order to return a simple and accurate volume capture result for each BMP.

The National GVC uses the specified runoff volume reduction goal to determine the volume capacity required to meet that goal. The Calculator sums volume capacity calculated for each BMP to determine the degree to which a selected scenario an BMP suite achieves the chosen runoff volume reduction goal. It is possible to provide more storage than is required by the chosen regulation. In that case, the results show that the user is providing more than 100% of the required volume capture capacity. The user adjust the size and type of BMPs provided until they meet the goal with the most cost-effective combination of BMPs.

Assumptions for calculating BMP volume capture capacity:

1. The full storage capacity of each BMP is available every time it rains. This assumption is obvious in considering BMPs like rain barrels. We assume that the entire capacity of the barrel is available for any single rain event even though in reality, any rain barrel may still contain rain from the previous event.
2. All of the BMPs provide both a volume capture benefit and a total runoff volume reduction benefit EXCEPT Cisterns/ Rain Barrels, Native Vegetation, Reduced Street Width, and Trees.
    a. As explained above, we are not assuming a template for the hydrologic calculations. Therefore we do not distinguish between connected and unconnected impervious areas when establishing a curve number.
    b. Cisterns/Rain barrels do not contribute significantly to the definition of land cover and composite curve number. They are not assigned a curve number and are not considered part of the total runoff volume equation.
    c. Native Vegetation does change the composite curve number of the site and affects the total runoff volume equation, but it does not provide a volume capture benefit. By using the Amended Soil BMP a user can indicate lawn areas that have been designed with soil of a specific depth and void ratio that can provide a quantifiable storage capacity for runoff.
    d. Reduced Street Width affects the total runoff volume by changing the composite curve number for the site. It may also affect progress towards the runoff reduction goal by decreasing the site impervious area that is used to determine the volume of precipitation/runoff that must be captured on site.
    e. Trees affect progress towards the runoff reduction goal by decreasing the site impervious area that is used to determine the volume of precipitation/runoff that must be captured on site. This methodology was used in the Chicago SMO GVC. The theory is that the canopy of the tree prevents a portion of rainfall from hitting the ground and becoming runoff, thereby decreasing impervious area. Tree box filters provide a volume capacity benefit when the user defines the area and depth of the filter box installed around the tree.
3. We chose to provide Downspout Disconnection as a BMP in conjunction with other BMPs that are designed specifically to receive runoff from a roof, rather then provide a BMP option for downspout disconnection alone. The reasoning behind this is that if a user only indicates disconnecting the downspout there is no way to know if the roof runoff is infiltrated and/or stored for reuse, or leaves the site. The BMPs associated with disconnecting a downspout are planter boxes, rain gardens, and cisterns/rain barrels. The calculator will include a downspout disconnection cost for each of these BMPs that the user applies to the green scenario, under the assumption that each of these BMPs would be built near a unique downspout, i.e. one would not disconnect a single downspout and direct that water into both a rain garden and a rain barrel.
4. We chose to provide the Elimination of Curbs and Gutters in conjunction with the implementation of a roadside swale. The single site nature and lack of a defined template for the national calculator also makes it difficult to define standard specifications of curb, gutter, and pipe systems. However, even with a template that defined the linear feet required for curbs and numbers of gutters required, removing them would not affect the volume capture capacity of the site, which is the main focus of this tool. The user also has the option of implementing a vegetated swale in a parking lot.

Total Runoff Volume

The National GVC calculates the total volume of runoff produced by the pre-development, conventional, and green scenarios. This result is separate from the volume capture capacity provided by the green infrastructure BMPs and is not affected by the runoff volume reduction goal selected by the user. The comparison of total runoff volumes provides an additional perspective on the potential stormwater performance benefits of green infrastructure.

The National GVC calculates total runoff volumes for each scenario using the USDA Soil Conservation Service Runoff Curve Number Method:

$$Q = \frac{(P - Ia)^2}{(P - Ia) + S}$$

Q = runoff in inches,
P = rainfall in inches, (determined from NOAA data)
S = potential maximum runoff after runoff begins (in) (determined by site definition and curve numbers from TR-55), and
Ia = initial abstraction (in) (Ia = 0.2S).

This equation was chosen because it reflects land cover and infiltration capacity changes through the curve number and the variable S, and because it requires the total precipitation amount rather than the frequency, intensity, and/or duration of the storm. Although there is some concern about accuracy when using this method for storms less than one inch or for sites less than one acre, it is commonly used in practice for scenarios under both limits. In addition, this the National GVC is not meant for designing stormwater management systems. It is meant to assess the hydrologic performance and costs/benefits of using green infrastructure. We believe that the established curve number method is sufficiently accurate for an estimate of compared performance.

We used the types of land cover specified by the user for each of the three scenarios (predevelopment, conventional, and green) to determine an area-weighted composite curve number for each. The curve number values for different land covers and BMPs are shown on the Advanced Options page of the tool. The default values shown are from the USDA Soil Conservation Service Technical Release 55 (TR-55): Urban Hydrology for Small Watersheds Table 2.2a-d[2]. The curve numbers for the Green Infrastructure BMPs are taken from the original version of the GVC and from industry literature.

[2] Urban Hydrology for Small Watersheds – Technical Release 55, US Department of Agriculture Soil Conservation Service, 1986.

NATIONAL GVC COST/BENEFIT ANALYSIS METHODOLOGY

Cost/Benefit Components and Equation

The National GVC compares the lifecycle costs and benefits of green infrastructure BMPs to those of a conventional stormwater design. The costs of the conventional and green scenarios are estimated by calculating the construction and maintenance costs of each infrastructure component and adding them together for a total scenario cost. For simplicity's sake, only the costs of the stormwater infrastructure components of the site are utilized. For example, the cost of a standard roof and any green roof applied by the user are compared. However the other construction and maintenance costs of the implied building are not compared.

The infrastructure components included in the cost calculation are:

- Concrete Sidewalk and Driveway
- Curbs and Gutters
- Standard Roof
- Streets
- Parking lots
- Conventional Stormwater Storage
- Turf Grass
- Green Roof
- Planter Boxes
- Vegetated Filter Strips
- Native Vegetation
- Rain Garden
- Trees
- Vegetated Swales
- Rain barrels
- Cisterns
- Amended soil
- Downspout disconnection
- Permeable Pavers
- Porous Asphalt
- Porous Concrete
- Gravel

Conventional stormwater storage is assumed to be an underground vault that would be needed to meet the on-site runoff volume capture specified by the selected regulation if no LID BMPs are applied. This cost is calculated from the "Required Volume to Capture on Site" value. This cost changes for the green scenario as additional volume capacity is provided through applying Green BMPs. There is no cost included in the National GVC for pipes or detention ponds because the National GVC does not determine peak flow and therefore cannot accurately determine the necessary storage required to meet local allowable release rates. (The original GVC includes peak flow calculations.)

All costs are calculated per square foot of component built. Much of the cost data reported on green infrastructure is given relative to the drainage area served. We chose to stay with the original GVC methodology of cost per square foot of component because the tool does not input sufficient site information to determine what area of the site is draining into each BMP. Nor do we assume a site template that can automatically calculate the drainage area served by each BMP.

The volume capacity of each BMP is determined by the component's area, depth, and porosity of subsurface media. Although we cite and use costs based on the square foot area of the component, those costs often include several layers of prepared soil and/or aggregate. For each BMP we determined a typical depth of soil and/or aggregate required by design specifications. The default depth of soil and aggregate shown by the calculator is assumed to be included in the square foot cost; however, if the user enters a soil or aggregate depth greater than the default defined for each BMP, the scenario incurs an additional cost for extra cubic yards of subsurface media.

The annual benefits of a scenario are calculated based on values from the original GVC. Where possible, we include financial estimates for each type of benefit, but many of the benefits of green infrastructure have not yet been quantified. CNT is leading an effort to develop a methodology for quantifying the full range of socio-economic benefits resulting from green infrastructure, which may be integrated into future calculator versions.

The National GVC does include the following quantified benefits:

- Reduced Air Pollutants
- Carbon Dioxide Sequestration
- Compensatory Value of Trees
- Groundwater Replenishment
- Reduced energy use
- Reduced treatment benefits

The cost model also includes the design life of each infrastructure component. The user can analyze the lifecycle cost and benefits for a 5, 10, 20, 30, 50, and 100 year span. In the case of the 100 year span, a roof that has a design life of 37 years will accumulate construction costs approximately 3 times for that life span and maintenance for each year in between. The National GVC assumes all infrastructure components, both green and conventional, are newly installed and therefore will not be replaced for the first full design life span.

The lifecycle cost/benefit equation is:
(Construction cost) X (number of times the component would have to be replaced) + (annual maintenance costs) X (total number of years) – (annual benefits) X (total number of years).

Net Present Value of Costs
The net present value worksheet calculates the 5, 10, 20, 30, 50, and 100 year costs as described above, but discounts future year costs at a Real Discount Rate "r" annually using the following equation:

$$NPV = \sum_{t=0}^{T} \frac{Cost_t}{(1+r)^t}$$

Financial Data Sources
Construction costs, maintenance costs, and lifespan data were gathered from the available literature for both green infrastructure and standard stormwater infrastructure. This data is provided through the "See how costs are calculated" link on the Cost results tab. A table in that section gives low, middle and high estimates of construction costs, annual maintenance costs, and design life for each component. In each case, CNT has used the middle cost.

We have updated the cost data used in this analysis from the original GVC. We are using the most recent industry data for conventional infrastructure components and have gone through a lengthy process to collect and compile the green infrastructure BMP cost data newly available from the many municipalities, public utilities, and research projects aimed at investigating performance and cost-effectiveness of green infrastructure. As stated earlier, these data are often provided as a cost per square foot of drainage area served unit. When sufficient detail on the size of the BMP and the size of the drainage area was provided, we converted those data into cost per square foot or cost per linear foot. Many of the sources include different elements of feature construction in their reported cost. By analyzing a range of sources and costs together, we were able to reflect the real world variety of construction and maintenance costs in the National GVC pricing sheet. Sources of all new cost data are provided on the table.

Information about the basis for estimating benefits, while less specific in most cases, can likewise be evaluated for applicability by the user. The data used to calculate benefits is provided through the "See how benefits are calculated" link on the Benefits results tab.

The user currently cannot input custom values for the cost and benefits data, but we will consider adding that functionality to future versions.

CONCLUSION

The projected increase for growth of impervious surfaces and the need for cost-effective innovative solutions to stormwater management issues have created a new market of ideas for sustainable stormwater practices. The existing stormwater infrastructure of curbs, gutters, and sewers does not have the capacity to manage the quantities of runoff that result from high impervious surface coverage, nor the ability to remove the pollutants carried in that water before its introduction into a local stream or river by overflow in the case of combined sewer systems or direct flow in the case of separate sewer systems.

Many communities nation-wide are investing heavily in conventional stormwater conveyance and treatment approaches, including large tunnel systems, to expand their combined sewer stormwater infrastructure capacity. However, this solution alone cannot account for the projected increase in capacity demand as extreme precipitation events become the new average and developed land areas continue to grow.

Innovative and efficient land use policies and green urban design can be employed to address the problem at its source. A growing forum of policy-makers, regulators, local officials, and committed individuals are promoting the use of green infrastructure as a means of addressing stormwater management concerns while providing essential, additional environmental and quality of life benefits. The U.S. EPA recognizes the important role that green infrastructure will play in meeting Clean Water Act regulations and maintaining healthy and viable watersheds.

The National Green Values™ Calculator is an evaluation tool that demonstrates to non-technical users the performance results that can be achieved with green infrastructure, provides users with planning-level capital cost estimates, and serves as an outreach tool to encourage users to experiment with different potential stormwater management scenarios. The National GVC can encourage decision-makers and community members to choose green infrastructure as the preferred method for stormwater management.

Appendix A

Cost Data:
Source Details and Components

List of Sources for Cost Data

#	Reference Type	Citation	Link
1	Book - Construction Data	RSMeans Building Construction Cost Data - 63rd Annual Edition (2005)	
2		RSMeans Site Work & Landscape Cost Data - 28th Annual Edition (2009)	
3	City Public Works/ Engineering Department	City of Oxnard, California, Streets and Waterways Division. "Street Maintenance & Repair Funding." Accessed July 2005	
4		City of Victoria, California, Dept. Of Engineering Accessed March 2009	http://www.victoria.ca/cityhall/departments_engstreets.shtml
5		Halifax Regional Municipality, Canada; New Design for Asphalt/ Concrete Sidewalks - Information Report Accessed March 2009	http://www.halifax.ca/council/agendasc/documents/070116cai2.pdf
6		PlaNYC 2030 Sustainable Stormwater Management Plan Accessed March 2009	http://www.nyc.gov/html/planyc2030/html/stormwater/stormwater.shtml
7		City of Oakland, California, Oakland Redevelopment Agency. "Instruction for Project Record Request." Revised July 14, 2005.	http://www.oaklandnet.com/budgetoffice/Project%20Request%20Form%2009_17_03%20Issued%20instruction.pdf
8		City of Ventura, California, Public Works and Utilities. "Street Maintenance." Accessed July 2005.	http://www.cityofventura.net/public_works/maintenance_services/st_main
9		City of Portland, Bereau of Environmental Services Cost Benefit Evaluation of Ecoroofs 2008	
10		City of Portland, Bereau of Environmental Services,Willamette Watershed Program - Task Memorandum 4.1 August 2005	
11		Southeast Wisconsin Regional Planning Commission. "Costs of Urban Nonpoint Source Water Pollution Control Measures." Technical Report Number 31. June 1991.	http://www.sewrpc.org/publications/techrep/tr-031_costs_urban_nonpoint_water_pollution.pdf
12		Southwest Florida Water Management District, Downspout Diconnection Report Accessed March 2009	http://www.swfwmd.state.fl.us/files/social_research_docs/Downspout_Disconnection_Final_Report.pdf Pg3
13		Milwaukee Metropolitan Sewerage District Stormwater Runoff Reduction Program December 2005	

#	Reference Type	Citation	Link
14		Metropolitan Water Reclamation District of Greater Chicago Accessed March 2009	http://www.mwrd.org/barrel/
18	Toolbox	Water Environment Research Federation Low Impact Development Best Management Practices Whole Life Cost Model 2007	
19		Seattle Public Utilities, Decentralized Stormwater Control Unit Cost Model November 2008	
20	Online Resource/ Blog/ Magazine	Zimmer Consultants Inc, Illinois; Keeping parking lots on solid ground Retail Traffic Magazine, February 1st 1998	http://retailtrafficmag.com/mag/retail_keeping_parking_lots/
21		CHEC Consultant, Civil Engg Services, California; Keeping Parking lots on Solid ground Retail Traffic Magazine February 1st 1998	http://retailtrafficmag.com/mag/retail_keeping_parking_lots/
22		Residential Construction and Remodelling Estimates Accessed March 2009	http://www.homechek.ca/price-guide.html
23	Factsheet	"Grassy Swales Fact Sheet." Accessed March 2009	http://www.oaklandpw.com/Asset512.aspx
24		California Stormwater BMP Handbook; Pervious Pavements Factsheet January 2003	http://www.cabmphandbooks.com/Documents/Development/SD-20.pdf
25		Minnesota Local Road Research Board To Pave or Not to Pave November 2006	http://www.mnltap.umn.edu/Publications/FactSheets/documents/ToPaveorNot/ToPaveOrNotToPaveNoAudio.pdf
26		University of New Hampshire Stormwater Center, Treatment Unit Factsheets Accessed March 2009	www.unh.edu/erg/cstev/fact_sheets/tree_filter_fact_sheet_08.pdf
27		New York Stormwater Management Design Manual Accessed March 2009	http://www.westchestergov.com/Planning/environmental/SoilWaterReports/altpractices.pdf
28		City of Virginia, Fairfax County; LID BMP Factsheet - Soil Amendments Febraury 2005	http://www.lowimpactdevelopment.org/ffxcty/5-1_soilamendments_draft.pdf
29	Paper/ Journal/ Article/ Report/ Study/ Presentation	Low Impact Development Center, Inc; Low Impact Development for Big Box Manufacturers November 2005	http://www.lowimpactdevelopment.org/lid%20articles/bigbox_final_doc.pdf

#	Reference Type	Citation	Link
30		U.S. Department of Transportation, Federal Highway Administration. "Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring." Accessed July 2005.	http://www.fhwa.dot.gov/environment/ultraurb/uubmp3p6.htm
31		Audit of Pavement Standards in the Upper Saluda-Reedy Watershed, Saluda-Reedy Watershed Consortium, 2006	http://www.saludareedy.org/resInDepthReports/LID%20audit%20for%20Pickens%20and%20Greenville%20Counties%20(print%20version).pdf
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Notes on Specific Components of Cost input

1. Costs cited from RS Means Building Construction Cost Data and RS Means Site Work and Landscape Cost Data – 28th Annual Edition includes Cost of Material, Labor, Equipment, Overhead and Profit.

2. Bureau of Environmental Services, Portland
   Capital Cost of implementing BMP includes
   Total Capital Cost = (A) Direct Construction cost + (B) Contingency cost (30% of A) + (C) Indirect Factor * (A+B)
   (C) = Construction Management & Inspection (15%) + Design (30%) + Startup and closeout (1%)

3. Bureau of Environmental Services, Portland defines a "basic" ecoroof that is appropriate for Portland's climate. This includes a moisture mat, protection board, a 5-inch growing medium and gravel drainage, a simple irrigation system and a plant palette composed of sedums, grasses and wildflowers. The capital cost cited for Ecoroof includes $10.0/ sq ft cost of installing a standard/ conventional roof.

4. Green Roof – WSSI
   - Combination of extensive (3-4" soil) and intensive (4-9" soil) planting areas
   - Reduces impervious area by 3,626 sq ft
   - Reduces roof runoff
   - Engineered to support 62 lbs/sq ft

5. Seattle Public Utilities – Decentralized Stormwater Control Unit Cost

   Model Capital Cost = Direct Cost (A) + Allied Cost (B)
   Direct Costs (A) include material, labour, mobilization, excavation, connection/disconnection to water sources, traffic control
   Allied Costs (B) include Planning, Design, permits, contingencies, construction management, taxes and close-out

   In calculating the Life-cycle costs Operation & Maintenance (O&M) Costs were categorized into O&M Costs for Establishment phase and O&M costs for Mature phase.

6. Downspout Disconnection - Low costs assume costs only for cutting downspouts and aiming the extension to the nearest vegetated space

7. Rain Barrels – Costs cited from Milwaukee Metropolitan Sewerage Department. High costs include cost of material and installation. Mid costs consider cost of material only

8. Water Environment Research Foundation Whole Life Cost Models (WERF Tool) – Spreadsheet tool for calculating whole life costs for BMP's. The tool gives options for cost calculations for a Generic (default) Application and a user-defined Site-specific Application. Costs cited from the WERF tool are costs quoted for Generic Application

9. Permeable Pavement - Gravel –
   Low Costs cited from RSMeans Site Work and Landscaping Cost Data 2009 quote cost for 6″ gravel, spread and compacted
   High Costs cited from Wetland Studies and Solutions Inc quote
   Third-party/ Manufactured BMP GravelPave2 – A porous paving mat containing 1″ thick 2″ diameter rings filled with smaller gravel aggregate

10. Parking Lot – Cost cited from RSMeans Site Work and Landscaping Cost Data 2009
    Low Cost cites cost for paved parking lot with asphalt/ concrete
    Mid Cost cites cost for bituminous paving with 6″ gravel base

11. Vegetated Filter Strips – Costs cited from United States Environment Protection Agency, Office of Water.
    Low Costs include cost of establishment from seed
    Mid Costs include cost of establishment from sod

12. Amended Soil – Costs cited from Low Impact Development Center, Inc
    Low Costs quoted for compost amended soil
    High Costs quoted for Ecology Mix – A composite made from Mineral aggregate, Perlite, Dolomite and Gypsum

Appendix B

Cost Data:
Metadata of Compiled Costs

Low Impact BMP Implementation Cost Data
compiled for
CNT Nation Green Values® Calculator

BMP	Source	Source Document/ Tool	Source Date	BMP Cost	BMP Maintenance Cost	Life
Ecoroof (retrofit)	Seattle	SPU - Decentralised SW Control unit cost model		$ 53.81/ sf area managed	$ 2.15/ sq ft	40 yrs
Ecoroof/ Green Roof -New Building	Seattle	SPU -Decentralised SW Control unit cost model		$ 13.84/ sf area managed	$ 2.15/ sq ft	40 yrs
Ecoroof Retrofit	Portland	TM4[1].1_Final.pdf		High Density Downtown $6/sf Moderate Density Midtown $5/sf Low Density Suburban $5/sf	$ 850/acre	
Ecoroof New Construction	Portland	TM4[1].1_Final.pdf		High Density Downtown $7/sf Moderate Density Midtown $6/sf Low Density Suburban $5/sf	$ 850/acre	
Ecoroof	Portland	TM4[1].1_Final.pdf		$ 371800/ acre	$ 935/acre treated	30 yrs
Ecoroof	Portland	Final_costbenefitofEcoRoofNov2008.pdf	Nov-08	$ 5.75/sq ft of measure built	$ 0.025/sq ft of measure	40 yrs
Ecoroof	Portland	WEF Costs CIP assumptions	Sep-07	$ 528242/acre of impervious area managed	935/ac of impervious area managed	40 yrs
Green Roof	Portland	TM4[1].1_Final.pdf	Aug-05		$ 850/acre	Twice conventional

BMP	Source	Source Document/ Tool	Source Date	BMP Cost	BMP Maintenance Cost	Life
Ecoroof	Portland	Cost Benefit Evaluation of Ecoroof FinalCostBEnefitof Ecoroof Nov2008.pdf	Nov-08	$ 15.75/sq ft	$ 0.025/sq ft of measure	40 yrs
Blue Roof (2 inch detention)	NY	NY - Draft Sustainable SWM Plan		$4.00/ sq ft	0	20 yrs
Blue Roof (1 inch detention)	NY	NY - Draft Sustainable SWM Plan		$ 4.00/ sq ft	0	20 yrs
Green Roof	NY	NY - Draft Sustainable SWM Plan		$ 24.25/ sq ft	$ 2.89/ sq ft	40 yrs
Green Roof (Vegetated Roof)	Louisville,KY	IOAP Louisville Kentucky LTCP		$ 4.25/sq ft		
	LID	LID_BigBox_Final.pdf	Nov-05	$ 250,000 per ½ acre	$ 500/ ½ acre	25 yrs
	WSSI	WSSI_LID_2007.pdf	May-07	$ 31.80/sq ft		
Rain Garden/ Infiltration Basin	Seattle	SPU - Decentralised SW Control unit cost model		$ 2.58/sq ft	$1.45/sq ft	50 yrs
Rain Garden	Louisville, Ky	IOAP Louisville Kentucky LTCP		$ 48000 for 0.53 MG removed		
Rain Garden	Louisville, Ky	IOAP Louisville Kentucky LTCP		$ 20/sq ft		
	Portland	WEF Costs CIP assumptions	Sep-07	175465/ ac of impervious area managed	$ 2744/acre of impervious area managed	30 yrs
	Portland	GS_MaintenanceCosts.xls	Jun-06		$611/sq ft of measure	
Infiltration Planter	Portland	TM4.1_final.pdf	Aug-05	$ 33880/acre treated	$ 660/acre treated	30 yrs

BMP	Source	Source Document/ Tool	Source Date	BMP Cost	BMP Maintenance Cost	Life
Infiltration Planter w/o parking	Portland	WEF Cost-CIP Assumptions	Sep-07	$ 184700/acre treated	$ 1830/acre treated	30 yrs
Planter without parking	Portland	PeerReview112807_final.doc	Nov-07	$77/cu ft storage volume		
Infiltration basin with sidewalk improvements	Portland	SSMP Recent Project Cost Summary	Nov-07	$ 60300 / acre treated		
Bioretension Basin	LID	LID_BigBox_Final.pdf	Nov-05	$15000 for a 900 sq ft rain garden designed to handle 0.5" storm	$ 550 per BMP designed with given specs	25 yrs
Bioretension Cell	LID	LID_BigBox_Final.pdf	Dec-05	$ 10000 for a 900 sq ft rain garden designed to handle 0.5" storm	$ 550 per BMP designed with given specs	25 yrs
	Virginia - WSSI	WSSI_LID_2007.pdf	May-07	$ 2.60/sq ft of impervious area treated		
	Milwaukee Metropolitan Sewerage Dist	MMSDbmpreport12.05.pdf	Dec-05	$ 23.30 - $47.62/ sq ft (Shorewood) $ 10/ sq ft (ARCCP)		
Sidewalk Biofiltration	NY	NY - Draft Sustainable SWM Plan		$ 36.81/sq ft	$ 0.25/ sq ft	
Vegetated Curb Extension	Portland	SSMP Recent Project Cost Summary	May-08	$ 111000 for BMP measure 240 sq ft and drainage area 3200 sq ft		

BMP	Source	Source Document/ Tool	Source Date	BMP Cost	BMP Maintenance Cost	Life
Large Curb extension with ADA Ramps	Portland	SSMP Recent Project Cost Summary	Sep-07	$ 24200 for BMP measure 290 sq ft and drainage area 7000 sq ft		
Lined curb extension with sidewalk improvements	Portland	SSMP Recent Project Cost Summary	Sep-07	$ 17400 for BMP measure 160 sq ft and drainage area 8700 sq ft		
curb extension w/ sidewalk improvements, underground tank removal	Portland	SSMP Recent Project Cost Summary	Jan-08	$ 85500 for BMP measure 720 sq ft and drainage area 11000 sq ft		
Curb Extension	Portland	TM4.1_final.pdf	Aug-05	$ 77300 per impervious acre managed	$ 1000 per impervious acre managed	
Greenstreet Planter/ Curb Extension	Portland	TM4.1_final.pdf	Aug-05	$ 50050 per impervious acre managed	$ 660 per impervious acre managed	
Curb Extension	Portland	WEF Cost - CIP Assumptions	Sep-07	$ 129475 per impervious acre managed	$ 1830 per impervious acre managed	
Infiltration Planter w/o parking	Portland	WEF Cost-CIP Assumptions	Sep-07	$ 184700 per impervious acre managed	$1830 per impervious acre managed	

BMP	Source	Source Document/ Tool	Source Date	BMP Cost	BMP Maintenance Cost	Life
Largeplanting strip swale	Portland	SSMP Recent Project Cost Summary	Jun-07	$ 14600 for BMP measure 880 sq ft and drainage area 4000 sq ft		
Small planting strip swale	Portland	SSMP Recent Project Cost Summary	Jul-07	$ 5170 for BMP measure 340 sq ft and drainage area 4000 sq ft		
Green Street Swale	Seattle	SPU - Decentralised SW Control unit cost model		$ 7.83/ sq ft	$ 1.45/sq ft	
Curb Extension	Portland	PeerReview112807_final.doc	Nov-07	$ 49/cu ft storage volume		
Bioretension Swale	LID	LID_BIGBOX_Final.pdf	Nov-05	$ 10000 for BMP measure 900 sq ft and drainage area ½ acre	$ 200 for BMP measure 900 sq ft and drainage area ½ acre	
Grassy Swale	LID	LID_BIGBOX_Final.pdf	Nov-05	$ 6000 for BMP measure 900 sq ft and drainage area ½ acre	$ 200 for BMP measure 900 sq ft and drainage area ½ acre	
Grassy Swale	WSSI	WSSI_LID2007.pdf	May-07	$ 3.68/sq ft of impervious area treated		

BMP	Source	Source Document/ Tool	Source Date	BMP Cost	BMP Maintenance Cost	Life
Infiltration Planter w/ parking (includes step out zone, pavers, trench grates) [based on one project]	Portland	WEF Costs CIP assumptions	Sep-07	369400 per impervious acre managed	1830 per impervious acre managed	30 yrs
	Portland	WEF Cost - CIP Assumptions	Sep-07	71110 per impervious acre managed	2744 per impervious acre managed	30 yrs
Swales	NY	NY - Draft Sustainable SWM Plan		18.73 / sq ft	0.25/ sq ft	40 yrs
Swales	EPA	WERF Tool		16500 per impervious acre managed	527 per impervious acre managed	
Bioswales	Louisville, Ky	IOAP Louisville Kentucky LTCP		$ 80000 in a year to remove 0.88 MG		
Bioswales	Louisville, Ky	IOAP Louisville Kentucky LTCP		$ 96000 in a year to remove 1.1 MG		
Bioswales	Louisville, Ky	IOAP Louisville Kentucky LTCP		$ 48000 in a year to remove 0.53 MG		
Vegetated Swale/ landscaped infiltration site	Portland	TM4[1].1_Final.pdf	2005	$ 5.50 - $ 13.00 / sq ft of measure	$ 0.58 / linear ft	

BMP	Source	Source Document/ Tool	Source Date	BMP Cost	BMP Maintenance Cost	Life
Vegetated Swale/ Grassy Swale	Portland	TM4[1].1_Final.pdf	Aug-05	$ 50150 per acre treated	$ 660 per acre treated	50 yrs
Grassy Swale	Portland	GS_MaintenanceCosts.xls	Jun-06		306 /sq ft	
Rock Swale	Portland	GS_MaintenanceCosts.xls	Jun-06		131 /sq ft	
Vegetated Swale	Portland	GS_MaintenanceCosts.xls	Jun-06		349 /sq ft	
Infiltration Planter	Portland	GS_MaintenanceCosts.xls	Jun-06		218 /sq ft	
Flow-through Planter	Portland	GS_MaintenanceCosts.xls	Jun-06		218 /sq ft	
Planter with parking	Portland	PeerReview112807_final.doc	Nov-07	$ 122/ cu ft storage volume		
Planter with concrete flatwork replaced by gravel and lawn treatment	Portland	PeerReview112807_final.doc	Nov-07	$ 75/ cu ft storage volume		
Permeable Asphalt Parking Lane	NY	NY - Draft Sustainable SWM Plan		$ 8.13 / sq ft	$ 0.19 / sq ft	20 yrs
Porous Concrete	LID	LID_BigBox_Final.pdf	Nov-05	12000/ sq ft	$ 500 / sq ft	25 yrs
Pervious Concrete Cost of Asphalt	WSSI	WSSI_LID2007.pdf	May-07	6.0/ sq ft pf measure 2.56/ sq ft		

BMP	Source	Source Document/ Tool	Source Date	BMP Cost	BMP Maintenance Cost	Life
Gravel Paving	WSSI	WSSI_LID2007.pdf	May-07	4.32/ sq ft installed		
Gravel2 Material Cost	WSSI	WSSI_LID2007.pdf	May-07	$ 6.0/ sq ft $ 3.20/ sq ft		
Concrete Pavers Paver Material	WSSI	WSSI_LID2007.pdf	May-07	$ 7.10/ sq ft $ 2.55/ sq ft		
Gravel Bed Detension	WSSI	WSSI_LID2007.pdf	May-07	$ 2.28/ cu ft of treatment volume		
Pervious Pavement (full width retrofit)	Seattle	SPU - Decentralised SW Control unit cost model		$ 6.39 / sq ft	$ 0.05 / sq ft	
Porous Pavement	Portland	WEF Costs CIP assumptions	Sep-07	$ 568876 per impervious acre managed	$ 4000 per impervious acre managed	20 yrs
Pervious Asphalt, 8" curb-to-curb, cost includes excavation, erosion control, traffic control, construction and mobilization	Portland	TM4[1].1_Final.pdf	Aug-05	$ 6.34 / sq ft	$132/curb mile	20 yrs
Porous Pavement		WERF Tool		$ 28780 per impervious acre managed	$ 247 per impervious acre managed	50 yrs

BMP	Source	Source Document/ Tool	Source Date	BMP Cost	BMP Maintenance Cost	Life
Pervious Pavement (new development)	Seattle	Decentralised SW Control unit cost model		$ 1.48 / sq ft	$ 0.05 / sq ft	
Permeable Concrete Sidewalk	NY	NY - Draft Sustainable SWM Plan		$ 6.83 / sq ft	$ 0.16 / sq ft	20 yrs
Porous Asphalt	EPA	WERF Tool		$ 28700 per impervious acre managed	$ 247 per impervious acre managed	
Porous Concrete	EPA	WERF Tool		$ 186960 per impervious acre managed	247 per impervious $ acre managed	
Grass/ Gravel Pavers	EPA	WERF Tool		$ 165430 per impervious acre managed	$ 247 per impervious acre managed	
Interlocking pavers	EPA	WERF Tool		$ 287580 per impervious acre managed	$ 247 per impervious $ acre managed	
Permeable Alley	Louisville, Ky	IOAP Louisville Kentucky LTCP		$ 278400 for 1.74 MG removed		
Permeable Alley	Louisville, Ky	IOAP Louisville Kentucky LTCP		$ 154800 for 0.97 MG removed		
Permeable Alley	Louisville, Ky	IOAP Louisville Kentucky LTCP		$ 64800 for 0.41 MG removed		
Downspout Disconnection	Seattle	SPU -Decentralized Stormwater Control Unit Cost Model		$ 1.15 / sq ft	$ 0.25 / sq ft	100 yrs
Downspout Disconnection	Portland	WEF Costs CIP assumptions	Sep-07	$ 12929 per impervious acre managed	$ 25 per impervious acre managed	30 yrs

BMP	Source	Source Document/ Tool	Source Date	BMP Cost	BMP Maintenance Cost	Life
Downspout Disconnection	Louisville, Ky			$ 386250 for 1545 MG removed		
Downspout Disconnection	Portland	TM4[1].1_Final.pdf		$ 73 / household		
Downspout Disconnection	Portland	TM4[1].1_Final.pdf	Aug-05	$ 26000 /acre managed		10 yrs
Downspout Disconnection	Milwaukee Metropolitan Sewerage Distt	MMSDbmpreport12.05.pdf	Dec-05	$ 35 to $ 156.12 / downspout		
Rain barrels	NY	NY - Draft Sustainable SWM Plan		$ 0.77 per gallon per year		20 yrs
Rain barrels	Louisville, Ky	IOAP Louisville Kentucky LTCP		$ 165000 per 1000 MG removed		
Rain barrels	Portland	TM4[1].1_Final.pdf	Aug-05	$ 171000 per acre terated		20 yrs
Cisterns	NY	NY - Draft Sustainable SWM Plan		$ 0.37 per gallon per year		20 yrs
Cisterns	Seattle	SPU - Decentralized SW Control unit cost model		Cost of material Cistern (130 ga – 1800 ga) $ 150 - $ 1100	$ 200 per installtion	20 yrs
Cisterns	WSSI	WSSI_LID_2007.pdf	May-07	$ 2.88/ ga of material $ 3.88/ ga installed $ 1.23/ sf impervious area treated		
Rain barrels	Milwaukee Metropolitan Sewerage Distt	MMSDbmpreport12.05.pdf	Dec-05	$ 140 per installation $ 30 for diverter + $ 60 per rain barrel + $ 50 per installation		

BMP	Source	Source Document/ Tool	Source Date	BMP Cost	BMP Maintenance Cost	Life
Cisterns	Milwaukee Metropolitan Sewerage Distt	MMSDbmpreport12.05.pdf	Dec-05	$ 500 per cistern		
Bioretention Slope	LID	LID_BigBox_Final.pdf	Dec-05	$ 10000 with a BMP size of 3000 sq ft designed to receive run-off from 0.5 acre impervious area	$ 200 with a BMP size of 3000 sq ft designed to receive run-off from 0.5 acre impervious area	
Planter Box	LID	LID_BigBox_Final.pdf	Nov-05	$ 4000 with a BMP size of 500 sq ft designed to receive run-off from 0.5 acre impervious area	$ 400 with a BMP size of 500 sq ft designed to receive run-off from 0.5 acre impervious area	25 yrs
Planter Box	LID	LID_BigBox_Final.pdf	Nov-05	$ 8 / sq ft	$ 0.8 / sq ft	25 yrs
Planter Box	New York Stormwater Design Manual			$ 0.55 / sq ft - $ 24.52 / sq ft		
Charles River Low Impact BMP Info sheet				$ 1 / sq ft		

BMP	Source	Source Document/ Tool	Source Date	BMP Cost	BMP Maintenance Cost	Life
# Bare root trees # Container grown trees # Balled & burlapped trees	United States Deptt of Agriculture, Forest Services, Urban Forestry Manual, Part3 Urban Tree Planting Guide			$0.30 - $40.0 each $2.50 - $80.0 each $35.0 - $400.0 each		
Tree Supplies Tree Shelters (12"-72") Tree Stakes Mulch Compost	Same as above			$1.0 - $4.0 each $1.0 - $2.0 each $6.0 - $ 20.0 per cu yard $11.0 - $ 20.0 per cu yard		