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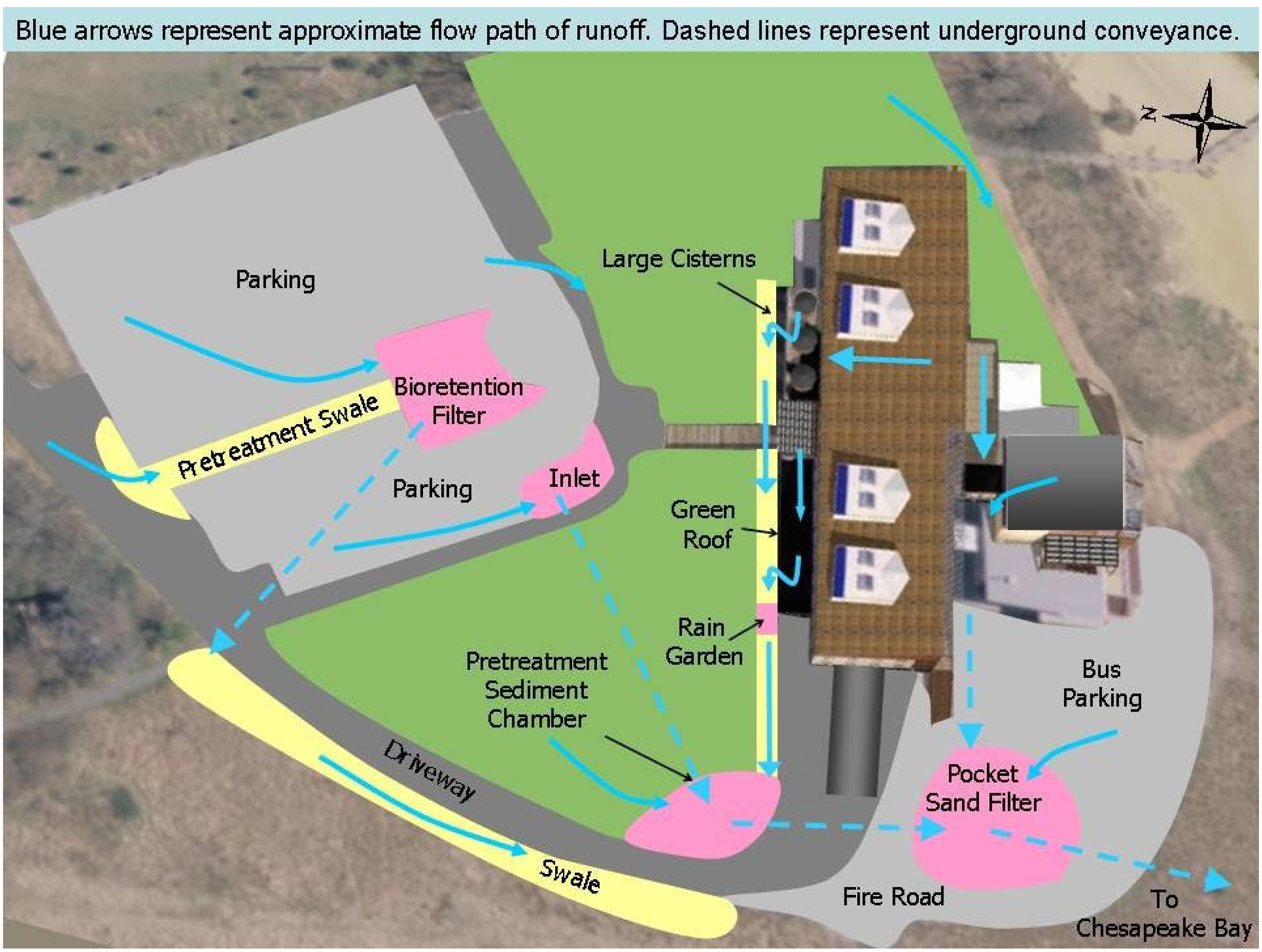
Sustainable Water Resources Management, Volume 2: Green Building Case Studies



Sustainable Water Resources Management, Volume 2: Green Building Case Studies

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Cosponsor
Water Environment Research Foundation (WERF)
635 Slaters Lane, Suite 300
Alexandria, Virginia 22314-1177

Project Manager
J. Moeller

EPRI Project Managers
T. Taylor
R. Goldstein

ELECTRIC POWER RESEARCH INSTITUTE
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com

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ORGANIZATION(S) THAT PREPARED THIS DOCUMENT

The Cadmus Group, Inc.

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CITATIONS

This report was prepared by

The Cadmus Group, Inc.
1600 Wilson Boulevard, Suite 500
Arlington, VA 22209

Principal Investigator
L. Dufresne

Co-Principal Investigator
V. Kiechel

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REPORT SUMMARY

This report evaluates how well green building rating systems address sustainable water management practices at the community level by applying three widely used rating systems to three diverse commercial green building projects. The case studies provide insight into the efficacy of green building water management practices and the relative strengths and limitations of rating systems with respect to achieving water sustainability at the community level. The intended audience for this report includes decision makers in the public and private sectors involved in community planning, building construction, energy management, and water resources management. The findings are relevant to architects, engineers, facility managers, owners, developers, and regulators.

Background

In 2006, money was appropriated to USEPA to fund a National Decentralized Water Resources Capacity Development Project (NDWRCDP). The web site for the program is located at www.ndwrcdp.org. NDWRCDP is a cooperative program that supports research and development to improve understanding, training, and practice in the field of onsite/decentralized wastewater and stormwater treatment. The Water Environment Research Foundation (WERF) administers the program. One of the principal cooperators in the Program, as designated in the appropriation, is the Electric Power Research Institute (EPRI). EPRI's involvement in NDWRCDP is based on the water sector's use of electric power and the strong interdependencies between electric power and water sustainability with respect to community social and economic vitality. This report is the result of a research project initiated and managed by EPRI with NDWRCDP funds.

Objective

To evaluate best water management practices and green building rating systems by applying the principles and standards of three green building rating systems to three diverse real world green commercial building projects.

Approach

This study examines three commercial building projects completed within the last ten years that showcase a number of innovative sustainable water management techniques. First, it investigates and documents the decision making process that led to the water management strategies implemented in each project, focusing on motives for and barriers to implementation. It examines unforeseen difficulties and surprises in the process of design and construction. The study goes beyond construction to evaluate how these buildings fare in operation and in what respects they perform differently than originally envisioned. Second, the study quantifies the environmental impact of water management technologies used at the study sites, linking the impact of green building practices to the watershed or community as a whole. Third, the study explores linkages among green building practices, green building ratings and standards, and the cumulative impact of these approaches on sustainable management of water. The study examines strengths and weakness of commonly used rating systems. Fourth, the study identifies barriers in local programs and codes to green building efforts and water resource sustainability. Finally the study identifies possible changes in green building rating systems and regulatory review processes for overcoming existing limitations.

Results

- Universal standards do not necessarily provide the greatest benefit for specific local/regional situations. Rating systems and regulators should consider the value of making ratings and regulations responsive to local factors.
- Very few aspects of current green building rating systems attempt to measure downstream or wider watershed impacts. Much of the focus is on water conservation and efficiency, with efficiency related to building plumbing fixtures—whether internal (toilets, sinks) or external (irrigation systems). There are rewards for site strategies that take into account permeability, infiltration, reuse, and evapotranspiration rates; but in general these factors are weighted equally with efficiency measures, even though they may be of greater benefit to the watershed and the environment as a whole.
- Consideration of single issues without regard for synergistic impacts is problematic. There is a need for inter- or multi-disciplinary judgments.
- Green building rating systems should consider incentivizing establishment of management frameworks to insure continuity between design and operations. Project teams should not end their involvement at the design and construction phases, but extend their involvement to operations.

EPRI Perspective

As more communities and the nation as a whole drive to become sustainable and look to green building rating systems to incentivize water resource sustainability, it is important to carefully examine the strengths and limitations of these systems and to seek ways to improve them. It is important to consider how local conditions may override universal standards and best management practices, to take into account operational as well as construction requirements, and to bear in mind the relation between individual projects and the watershed and region. The electric sector needs to understand the perspective of the building sector and work to create and test new collaborative green building technologies and practices to achieve energy/water sustainability on the community and regional levels.

Keywords

Sustainability
Water
Conservation
Green building
Low impact development
Green building rating systems

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Jennifer Brophy-Price, Associate Engineer at WSSI
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Mark O'Reilly, Resident Manager of Millennium Tower Residences
Gary Lohse, Applied Water Management
Andrew Larson, Applied Water Management
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Ed Clerico, Alliance Environmental

and the Advisory Panelists:

Blake Anderson, Blake Anderson Consulting
Nick Ashbolt, USEPA-Office of Research and Development
Paul Brown, CDM
Glen Daigger, CH2M Hill
Scott Drake, East Kentucky Power Cooperative
Bob Goldstein, Electric Power Research Institute
Robert Goo, USEPA – Office of Wetlands, Oceans & Watersheds
Mary Hansel, Carollo Engineers
Jim Kreissl, Consultant
Steve Moddemeyer, CollinsWoerman

Jeff Moeller, Water Environment Research Foundation
Dan Murray, USEPA – Office of Research and Development
Valerie Nelson, Coalition for Alternative Wastewater Treatment
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GLOSSARY

Baseflow – The component of streamflow that is derived from groundwater inputs.

Bioretention – The facilitation of water infiltration and pollutant removal by the vegetation in a swale or basin.

BMP – Best Management Practice. The term stormwater BMP is used in the U.S. to refer to any tool or practice for managing stormwater runoff, not only the ‘‘best’’ ones.

Cistern – A stormwater storage tank.

CSO – Combined sewer overflows occur when a combined (sanitary and storm) sewer system cannot transport the volume of inflowing water (typically during a rain event) and overflows into a surface water body.

Curve number – A number that describes the relationship between the amount of rainfall and the amount of runoff it produces on specific combinations of soil type and vegetative cover.

Evapotranspiration – The sum of evaporation and transpiration (the transport of water from the soil to the air by plants).

Green roof – A building roof surface that is covered with a layer of soil and planted with vegetation which functions to detain runoff, promote evapotranspiration, and reduce urban heat island effects.

Hydrograph – A graph of water flow over time, typically used to depict the temporal pattern of runoff from a rain event.

Infiltration – The movement of water into the soil.

Load(ing) – The amount (mass) of a pollutant that is delivered to a water body; usually over a specified time interval (e.g., pounds per year).

P8 – Program for Predicting the Passage of Polluting Particles through Pits, Ponds, and Puddles.

Pervious – Able to be passed through by water.

Potable water – Treated drinking water that meets federal, state, and local standards.

Raingarden – A vegetated basin in which runoff from surrounding impervious surfaces is allowed to infiltrate slowly into the ground.

Runoff – Precipitation or snowmelt that runs over the surface of the ground.

Swale – A shallow, vegetated channel that carries water and may facilitate water infiltration and pollutant removal.

ACRONYMS

ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AWWA	American Water Works Association
BDP	Best Development Practice
BMP	Best Management Practice
BOCA	Building Officials and Code Administrators International
BOD	Biological Oxygen Demand
BPC Guidelines	Battery Park City Authority Residential Environmental Guidelines
BPC	Battery Park City
BPCA	Battery Park City Authority
BREEAM	British Real Estate Establishment Assessment Method
CBF	Chesapeake Bay Foundation
CEERE	Center for Energy Efficiency and Renewable Energy
CFC	Chlorofluorocarbon
CIR	Credit Interpretation Request
CSO	Combined Sewer Overflow
DCWASA	District of Columbia Water and Sewer Authority
DO	Dissolved Oxygen
EA	Energy and Atmosphere
EB	Existing Building
ECCNYS	Energy Conservation Construction Code of New York State
EPRI	Electric Power Research Institute
ETS	Environmental Tobacco Smoke
FEMA	Federal Emergency Management Agency
FRA	Flood Risk Assessment
FT2	Square Feet
FTE	Full Time Employee
GIS	Geographic Information Systems
GPD	Gallons per Day
HVAC	Heating, Ventilation, and Air Conditioning
HVAC&R	Heating, Ventilation, Air Conditioning, and Refrigeration
ICC	International Code Council, Inc.
ID	Innovation in Design
IEQ	Indoor Environmental Quality
ISO	International Organization for Standardization

LEED	Leadership in Energy and Environmental Design
LEED-CI	LEED for Commercial Interiors
LEED-NC	LEED for New Construction
LID	Low Impact Development
MDE	Maryland Department of Environment
MR	Materials and Resources
NC	New Construction
NCDC	National Climactic Data Center
NIST	National Institute of Standards and Technology
NRDC	Natural Resource Defense Council
NTU	Nephelometric Turbidity Unit
NVRC	Northern Virginia Regional Commission
NYC	New York City
NYCDEP	New York City Department of Environmental Protection
NYSOCSCIC	New York State Office of Cyber Security and Critical Infrastructure Coordination
PECVA	Piedmont Environmental Council
PWC	Prince William County
PWC	Prince William County, Virginia
RP	Regional Priority
SCS	Soil Conservation Service
SS	Sustainable Sites
SSI	Sustainable Sites Initiative
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TRACI	Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts
TSS	Total Suspended Solids
UOSA	Upper Occoquan Service Authority
USCB	United States Census Bureau
USDA	United States Department of Agriculture
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
USGBC	United States Green Building Council
USGS	United States Geologic Service
UV	Ultraviolet
VADEQ	Virginia Department of Environmental Quality
VASMP	Virginia Storm Water Management Manual
VOC	Volatile Organic Compound
VUSBC	Virginia Uniform Statewide Building Code
WE	Water Efficiency
WRC	Water Reclamation Facility
WSSI	Wetland Studies and Solutions, Inc.

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1
INTRODUCTION

1.1 Setting the Stage

The new language of water management is transforming the way we think and practice sustainability. Concepts and terms such as low impact development (LID), biofiltration, green roofs, and decentralized wastewater treatment are on the brink of mainstream awareness, if not acceptance. Good water management is the beating heart of well-functioning ecosystems at any scale, whether as large as a watershed or as small as the human body. To sustainability, it is as critical as good energy management, and the two are in most ways interdependent.

1.1.1 The Historical Perspective

For the last 100 years, for those living in or near cities, a centralized water infrastructure as depicted in Figure 1-1 has carried clean, potable water from lakes, rivers, and underground aquifers to building faucets and fixtures. Human waste, flushed from building fixtures with potable water, becomes wastewater and is conveyed through sanitary sewers to a central treatment plant, where after cleansing it is released to local waters. Stormwater not absorbed by the ground and by vegetation is channeled to sewers – sometimes sewers combining wastewater and stormwater. Under traditionalist thinking, waste and stormwater are considered nuisances to be gotten rid of as quickly as possible.

This centralized water infrastructure, while it has gotten us far to date, has many inherent problems. Providing centralized safe drinking water and reliable wastewater services to communities are energy-intensive activities. The U.S. Environmental Protection Agency (EPA) ENERGY STAR ® program reports that approximately 3 percent of U.S. national energy consumption, equivalent to approximately 56 billion kilowatt hours (kWh), is used for drinking water and wastewater services at a cost of $4 billion annually. In California, about 20 percent of the total energy consumption is for water and wastewater services because of the need to pump water long distances (NRDC, 2009). In addition to energy needs for operation, the country is faced with a huge infrastructure gap for water and wastewater totaling into the tens of billions of dollars according to the EPA Gap Analysis Report (USEPA, 2002).

Buildings and their surrounding infrastructure create many local changes to the natural hydrologic cycle. The most evident is the increase in volume and peak flow rate of stormwater runoff. Development also increases the amounts of pollutants that accumulate on hard surfaces, which are subsequently washed into surface waters during precipitation events. Increased stormwater runoff can also cause erosion and flooding downstream. As more water runs off the landscape, infiltration and groundwater recharge are reduced. This phenomenon can affect the sustainability of local water supplies.

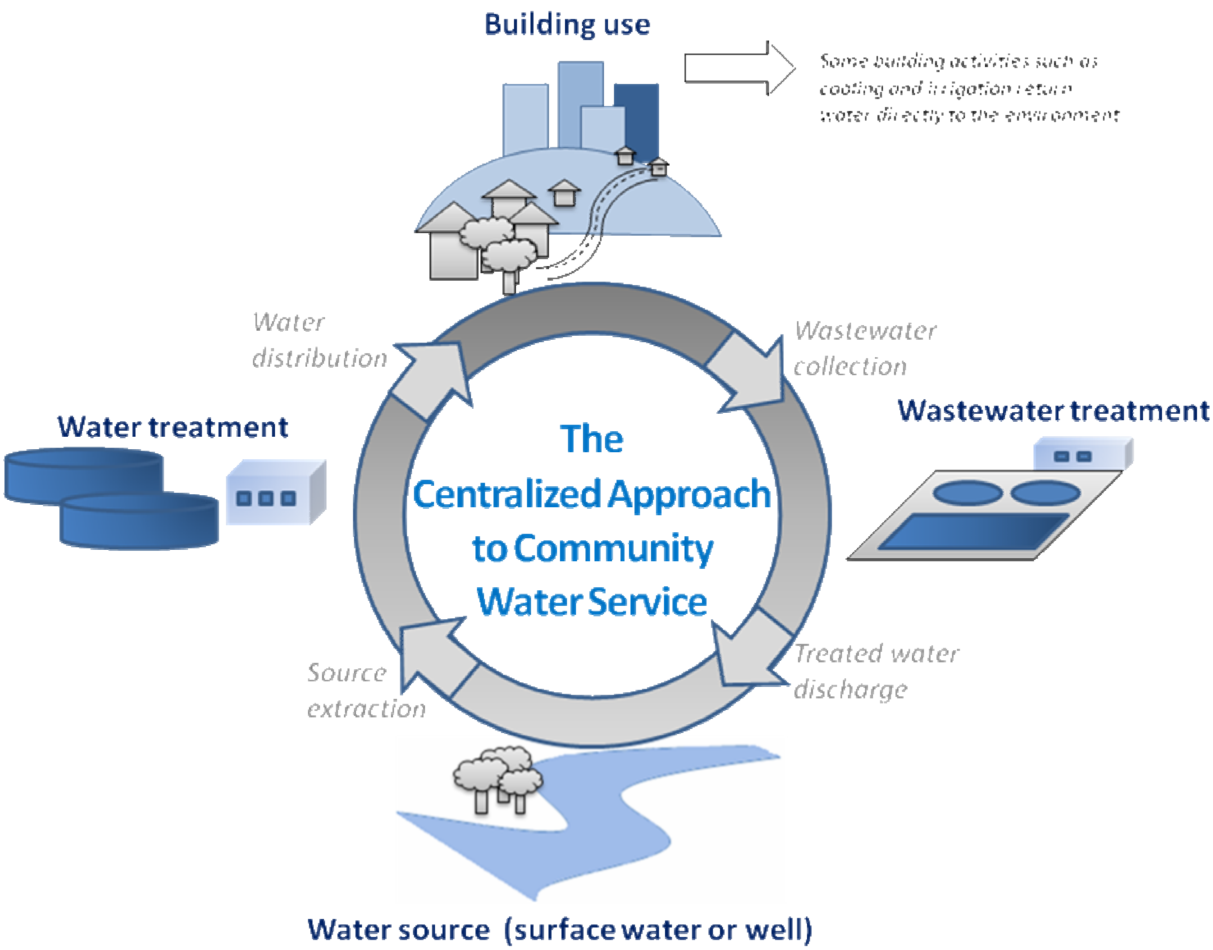


Figure 1-1
The centralized approach to community water service

In the presence of aging and overstressed centralized infrastructure, ecological impacts, concerns about energy use and climate change, and widespread water scarcity, the old ideas are changing. As many consumers, institutional and residential alike, are developing aggressive strategies to reduce energy consumption and costs, the energy and long-term environmental savings inherent in good water management are a primary focus. A critical aspect of this planning is developing strategies for buildings and sites to conserve, recycle, reuse, and enhance sustainable water cycles and systems. At the core of this focus is the green building movement and green building rating systems that incorporate the principles of sustainable water cycles and hydrology and reward, through public recognition, the pursuit of such efforts.

As it relates to water, green buildings can support sustainable water management goals in a number of ways, such as:

- Providing on-site and neighborhood water reuse for cooling systems, toilet flushing, and landscape irrigation;
- Using water- and energy-efficient appliances, lighting, and building materials;
- Providing localized energy and nutrient recovery from wastewater;
- Using green roofs and gardens to capture and filter rainwater and runoff;
- Using pervious (penetrable) hardscape surfaces and native vegetation to restore aquifers and better manage drought conditions; and
- Using low-impact development designs to slow rainwater runoff and mitigate erosion and prevent stream degradation.

These are aspects of the "decentralized" approach to water management, which relies more on site practices and less on centralized off-site infrastructure. Such an approach can supplement and enhance traditional water and wastewater treatment by conserving and reusing water resources at the local level, increasing water and energy efficiency, promoting ecological restoration, improving air quality, preserving open spaces, and reducing infrastructure expansion and replacement costs. As with energy, the underlying idea of decentralized management is that the more you can do at or on the site, the better. The more that can be gathered, treated, and reused onsite, the fewer the virgin resources consumed, and the greater the environmental and financial savings.

1.1.2 The New Thinking – Sustainable Water Management

The practice of sustainable water management considers all types of water to be valuable resources – even wastewater. It recognizes that captured stormwater is more than sufficient for many building needs such as toilet flushing and irrigation and that nutrients in wastewater can be a valuable resource for onsite fertilization. Increasingly, the internal operations of a green buildings use such management techniques as onsite water reclamation, recycling, reuse, and conservancy. Site and outdoor practices tie into internal water use. Techniques, such as rainwater capture, that facilitate storage and eventual use of such water indoors, increase a building's energy efficiency and lower its utility bills. They are ways of lessening downstream, contaminating impacts and, compared to traditional engineered or structural approaches, contribute cost-effectively to regulatory compliance. Then there are the aesthetic benefits and the increase in human comfort that new water management practices can bring. Low-impact development and "green" techniques utilizing vegetation or biomimicry can mitigate urban heat island effects, enhance animal and bird activity onsite, improve air quality, and in general contribute to improved human health and well being.

1.2 The Purpose of this Study

This study considers green building best water management practices through an examination of three case studies: (1) the Chesapeake Bay Foundation's Merrill Center located on the shore of the Chesapeake Bay in Maryland; (2) the Wetland Studies and Solutions, Inc. building in Gainesville, VA; and (3) the Millennium Tower Residences in New York City, NY. These projects have been built within the last ten years and each has incorporated innovative solutions to water management and use, the focus of this report. This study evaluates these buildings in two ways. First, it attempts to gauge their impacts within their local watersheds and attempts to quantify the environmental benefits of their water management practices. Secondly, it evaluates these case studies in the context of three green building rating systems:

- Building Research Establishment Environmental Assessment Method (BREEAM);
- Leadership in Energy and Environmental Design (LEED) for New Construction; and
- Green Globes.

This study provides insights into the efficacy of water management practices as well as the relative strengths and limitations of the rating systems with respect to rewarding and promoting water sustainability at the community level. This study includes a summary of the water management practices encouraged by each rating system; how the rating systems proportionally value specific water management practices; and the challenges and potential impediments to effective water management related to capital costs, standards, and local building codes. To help provide guidance and direction to EPRI's work on developing a new water system infrastructure paradigm, this study:

- Evaluates each project to identify the goals, limitations, and challenges associated with water use and management;
- Assesses the impacts beyond the boundary of the project itself, linking the impact of green building practices to the watershed or community as a whole;
- Explores the linkages among green building practices, green building ratings and standards, and the cumulative impact of these approaches on the environment; and
- Identifies barriers which local programs and codes must overcome to better green building efforts and water resource management.

1.3 Report Organization

This report is organized into seven chapters as follows:

- Chapter 1, this introduction, gives an overview and describes the purpose of the report.
- Chapter 2 provides detailed descriptions of the three case study sites and their local water management issues and sustainable water management features.

- Chapter 3 assesses the impact of each of the case study sites and focuses on the practices that address the priority water management issues of the communities in which the buildings are located.
- Chapter 4 provides an analysis of three prominent green building rating systems; in the context of the case studies, it compares the content of the three rating systems and their relative point values for water management practices.
- Chapter 5 describes the regulatory structure specific to each project's locality, and provides a discussion of their impact and limitations as well as any changes to the regulatory structure spurred by the example of the case studies.
- Chapter 6 provides a summary of conclusions and recommendations.
- Chapter 7 includes a detailed list of references.

Additionally, to support the discussions and analyses in the report, the following appendices are provided to supplement the information in the chapters.

- Appendix A provides ten key elements of the Water Quality Initiative in PlaNYC.
- Appendix B provides Battery Park City Authority's Residential Guidelines for Water Management.
- Appendix C provides a derivation of the baseline water use for the three case study sites.
- Appendix D provides a derivation of the actual (metered) water use for the three case study sites.
- Appendix E provides the stormwater model design parameters and results for the Merrill Center.
- Appendix F provides the stormwater model design parameters and results for Wetlands Studies Solutions, Inc.
- Appendix G provides the stormwater model design parameters and results for Millennium Towers.
- Appendix H provides an overview of the Sustainable Sites Initiative, which is a supplement to existing green building and landscape guidelines.
- Appendix I provides an overview of the ISO 14000 and Environmental management standards.

2
CASE STUDY FINDINGS

2.1 Introduction and Methodology

Buildings play a key role in water management. A value of these three case studies — Merrill Center, Wetland Studies and Solutions, Inc. (WSSI), and Millennium Tower Residences — is that they describe the range of possibilities for integrating water management into the built environment. They also provide a view into choices and decision-making on all sides of water management and sustainability: in design, in building use, and in building regulation. These are projects driven by people not only knowledgeable but expert in various aspects and practices of water management. In this, these buildings are not necessarily representative of "typical" green building projects. As examples designed to very high standards, particularly in water management practices, they provide a unique opportunity to examine the relationship between their intentions and their impacts.

> ***The common thread among these three projects is that in each case they set larger environmental goals for water — goals beyond the scope of current green rating systems — goals that are also locally or regionally specific in character, rather than universal.***

The water management goals of these projects include contaminant reduction; restoration and mitigation measures; water reuse; infiltration; and on-site, decentralized blackwater treatment. In the case of the Merrill Center, environmental water quality, specifically nitrogen reduction, resulted in the elimination of site-produced blackwater. The Merrill Center team, in its harvesting and reuse of rainwater, decided to treat stormwater as a resource rather than a liability. In the case of WSSI, the goal was the use of low-impact development practices to deal with stormwater velocity address and the "urban stream syndrome," with specific measures aimed at the restoration and conservation of an adjacent stream bank. This was a decision equally guided by business and environmental concerns, since it created a showpiece laboratory to display the expertise and skills of WSSI. In the case of Millennium Tower Residences, the goals were imposed from outside the development team. To compete successfully for the right to build on the site, the project had to conform to a high local standard, the Battery Park City Authority's (BPCA) *Guidelines for Construction*, which are regulations that evolved in recognition of the fragility of New York City's water infrastructure and low triggers for combined sewer overflows (CSOs). As a consequence, BPCA requires onsite wastewater treatment as well as green roofs, which creates a more holistic approach to the issues of urban wet weather.

The case studies chosen are single-building projects. Most sustainability measurement systems (i.e., rating systems) evaluate the built environment at the level of a single building. This is true both of regulations — such as green building and green zoning codes — and “voluntary”[1] rating systems like the Leadership in Energy and Environmental Design (LEED) and British Real Estate Establishment Assessment Method (BREEAM). More holistic, community-level rating systems are under development, but these are just beginning to be piloted. LEED for Neighborhood Development will roll out in 2010 (USGBC, 2009c). BREEAM has a similar tool for community assessment just now emerging (BRE Global LTD, 2009b). However, both LEED and BREEAM’s community-level tools still resemble tools for individual green building developments, just ramped up in scale. There are more holistic systems yet to come. Some of these are described in Chapter 4 of this report.

2.1.1 Methodology

Information for the Merrill Center’s case study was obtained through:

- A site visit conducted on June 17, 2009
- Telephone, in-person, and e-mail interviews
- Publicly available information
- Building and LEED documentation provided by the Chesapeake Bay Foundation (CBF) and Greg Mella, project architect

Prior to the site visit, Cadmus conducted phone interviews with Mary Tod Winchester, Vice President of Administration and Operations for the CBF in June 2009. In person interviews occurred with Winchester, with Paul Willey, Director of Facilities, and with Chuck Foster, Chief of Staff, all of the CBF, onsite on June 17, 2009. Cadmus interviewed Greg Mella, SmithGroup, the project architect of Merrill Center, on July 2, 2009, and in a follow-up email exchange. Cadmus subsequently interviewed representatives of the Anne Arundel County Public Works, the Maryland Department of Environment (MDE) field offices, and the Maryland Department of Health in late July, 2009.

Information for WSSI’s case study was obtained through:

- A site visit to the facility on June 10, 2009
- Telephone, in-person, and e-mail interviews
- Documentation provided by WSSI
- Publicly accessible information

[1] In many U.S. cities, there are increasing mandates for LEED certification, an otherwise “voluntary” certification. For example, through the Green Building Act of 2006, Washington, D.C. has set LEED or ENERGY STAR as a mandatory standard for both existing buildings and new construction beginning in 2011.

Mike Rolband, President of WSSI, was interviewed at the facility on May 26, 2009. Jennifer Brophy-Price, Associate Engineer at WSSI, was interviewed by telephone on June 10, 2009 as was Sean Connaughton, former Chairman of the Board of Supervisors for Prince William County, who was interviewed on June 22, 2009. The final interview consisted of a conversation with Rick Peterson, president of the local real estate and development firm, Peterson Companies, who which occurred on July 1, 2009. Any additional information was obtained through continued email correspondence with Jennifer Brophy-Price at WSSI.

Information for the Millennium Tower Residence's case study was obtained through:

- A site visit conducted on June 25, 2009
- Telephone, in-person, and e-mail interviews
- LEED documentation provided by the LEED consultants-Viridian Energy and Environment
- Publicly available information

Prior to our site visit, Cadmus conducted phone interviews with Gary Lohse (June 11, 2009) and Andrew Larson (June 15, 2009) of Applied Water Management, representatives of the group that designed and currently operates the onsite blackwater reuse plant. Cadmus representatives also spoke with Natalie Terrill (June 22, 2009) of Viridian Energy and Environment, the group that served as the LEED consultant for this project, and Rick Kearns of Handel Architects on June 23, 2009, the Manhattan architectural firm that designed Millennium Towers. During the site visit, Cadmus had an opportunity to speak with Mark O'Reilly, the resident manager of Millennium Tower Residences. Cadmus also spoke with Susan Kaplan of BPCA on July 16, 2009. Additionally, Cadmus interviewed representatives of New York State Department of Health, New York City (NYC) Department of Health, New York State Department of Environmental Conservation, and the NYC Mayor's Office Lastly, on July 23, 2009, Cadmus interviewed Ed Clerico who used to own Applied Water Management and worked with the Albanese Development Corporation on The Solaire's blackwater reuse plant.

The preliminary case study findings were sent to the primary stakeholders of each of the project sites for their review. Their comments and feedback have been incorporated into this draft report.

2.2 Merrill Center

2.2.1 Building and Site Description

Located on 33 acres on the shore of the Chesapeake Bay, the Merrill Center houses 80 employees of the Chesapeake Bay Foundation (CBF), an advocacy group for restoration and protection of the Bay. The building is located just south of the Chesapeake Bay Bridge and 2 miles east of downtown Annapolis, capital of the State of Maryland (Figure 2-1).

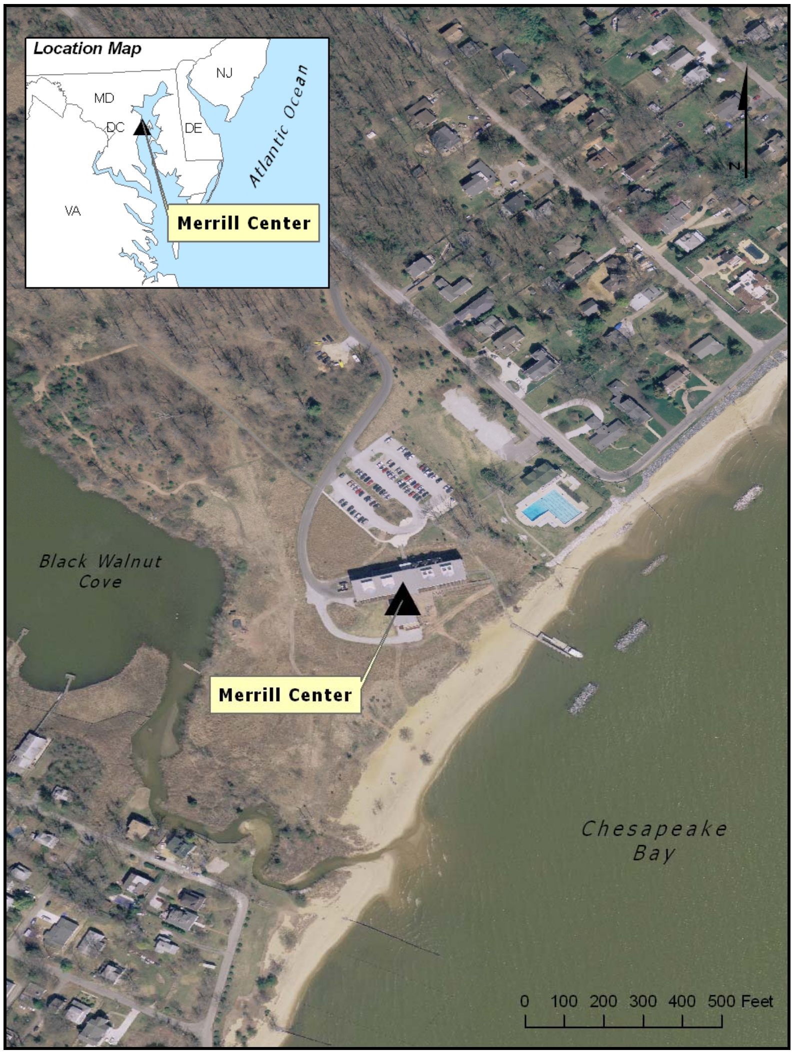


Figure 2-1
Location of the Phillip Merrill Center

The Center has a 16,000 s.f. footprint on its 33 acre site and a total of 31,000 s.f. on two floors. Outside, the building has features – like large cisterns and shed roofs – it seems to borrow from the agricultural buildings of the region. It relies on basic, “no frills” materials, such as steel and wood, some reclaimed (Figure 2-2). Inside, the building has an open plan that makes use of natural ventilation and daylighting, while enabling equal access to the best views, daylight, and breezes for everyone (Figure 2-3). After its completion, the building achieved Platinum certification from the U.S. Green Building Council’s Leadership in Energy and Environmental Design (LEED) Rating System for New Construction, the highest level conferred by the organization, for its sustainable design and features.

Figure 2-2
Merrill Center view

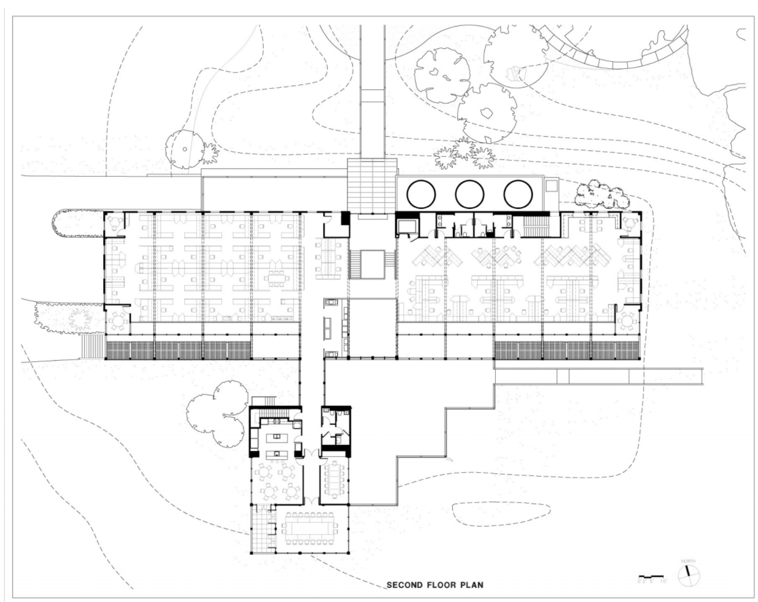


Figure 2-3
Merrill Center floor 2 plan
Source: Used with permission from SmithGroup

2.2.2 Local Water Use and Management

In designing its new headquarters, CBF wanted to ensure its building aligned with its organizational mission to protect the Bay. The CBF site is at the critical land-water juncture in the Chesapeake Bay watershed, a sensitive site with the potential for good or ill effects on the local ecology. The paramount environmental issue identified by local, state, and regional officials is the health of the Chesapeake Bay — specifically nutrient and sediment loading to the Bay.

2.2.2.1 Land Use and the Watershed

As shown in Figure 2-4, land use surrounding the Merrill Center is classified by the National Land Cover Dataset as a mix of low intensity development, developed open space, agriculture, forests, and wetlands (Vogelmann, 2001)[2]. The site is best characterized as suburban. The surrounding community is made up of single family homes, separated from each other by parks and forested areas. The following are definitions of developed space per the National Land Cover Dataset.

- Developed, Open Space-Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
- Developed, Low Intensity-Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.
- Developed, Medium Intensity-Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.
- Developed, High Intensity-Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to100 percent of the total cover.

[2] See Figure 3-3 within the Impact Assessment chapter of this report for a depiction of the stormwater runoff flows from the Merrill Center Site.

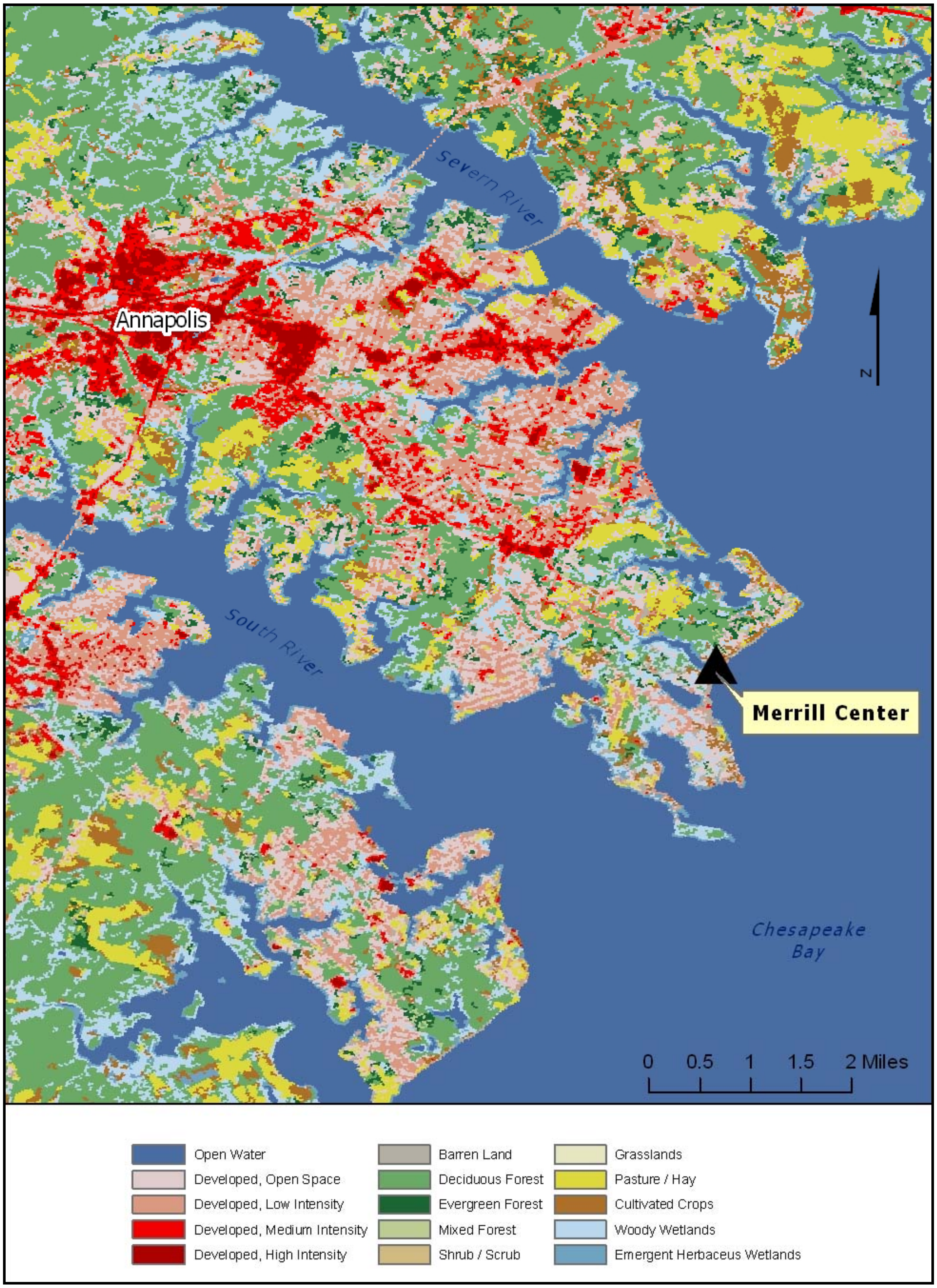


Figure 2-4
Map of land use at the Phillip Merrill Center site

The Chesapeake Bay's watershed, to which the local Merrill Center watershed belongs, is vast: 64,000 square miles (only 4,000 of these in the tidal Bay, so that land surface exponentially exceeds water surface), including parts of six states and the District of Columbia, with headwaters in Cooperstown, New York. Altogether, it has 11,600 miles of tidal shoreline, including tidal wetlands and islands. Approximately 17 million people live in the watershed and, of that, about 10 million people live along its shores or very close to them. The majority of freshwater entering the Chesapeake Bay comes from the northern and western sides; the Susquehanna River supplies almost half of the watershed's freshwater. There are more than 100,000 streams, creeks, or rivers in the watershed, including 150 major rivers. Two of the five major North Atlantic ports (Baltimore and Hampton Roads) are located on the Bay (CBF, 2009a).

The Bay provides food, water, cover, and nesting areas to thousands of migratory and colonial wildlife species; it supports 3,600 species of colonial plant and animal life, including more than 300 fish species and 2,700 plant types. The Bay was once known for its great seafood production, especially blue crabs, clams, and oysters. Although it still yields more fish and shellfish than any other estuary in the United States, it is far less productive today due to impacts from overland runoff, over harvesting, and invasion of exotic species. Of particular concern, the Chesapeake Bay has lost more than 98 percent of its oysters. Oysters serve as natural water filters, and their decline has further reduced the water quality of the Bay. It has been estimated that in pre-colonial times, oysters could filter all the water in the Bay in 3.3 days, but in 1988 it was calculated that depletion of oyster beds had increased this time to 325 days (CBF, 2009a).

The Bay estuary, 195 miles long and from 4 to 30 miles wide, is quite shallow. This shallowness — an average of 22 feet — makes it particularly vulnerable to contaminants, which cannot sink far out of the range of human and aquatic life.

Nutrient (nitrogen and phosphorous) loading is the main threat to the health of the Chesapeake Bay. In the 1970s, the Bay was discovered to contain marine "dead zones," where hypoxic waters resulted in massive fish kills. Today, the Bay's dead zones are estimated to kill 75,000 tons of bottom-dwelling clams and worms each year, depleting the base of the estuary's food chain of a primary food source, particularly the blue crab. Hypoxia results in part from large algal blooms, which are exacerbated by nutrient-rich agricultural runoff and wastewater discharges that occur throughout the Chesapeake Bay watershed. Erosion and sediment runoff into the Bay — aggravated by de-vegetation, construction, and the prevalence of impervious surfaces in urban and suburban areas — also blocks vital sunlight from penetrating the waters. The resulting loss of aquatic vegetation has deteriorated habitat for much of the Bay's aquatic life. Beds of eelgrass, the dominant variety in the southern Bay, have shrunk by more than half since the early 1970's (CBF, 2009a).

One obstacle to restoring water quality in the Bay is that much of the polluting substances originate far upstream in tributaries lying within states far removed from the Bay itself. Despite the state of Maryland spending over $100 million to restore the Bay, conditions have continued to deteriorate (CBF, 2009a). These upstream pollutants meet increasingly few barriers. The watershed has significantly changed from its natural state as forest, which included some 3.5 million acres of wetlands. Now that figure has shrunk by more than 85 percent. Nutrient and sediment pollution has correspondingly risen, as low density land use around the Bay coupled with the disappearance of the natural filtration offered by forests and wetlands has tipped the ecological balance. The suburban, residential pattern of land use has resulted in thousands of conventional septic fields and wells. According to the CBF, "approximately one quarter of the region's housing units are homes with septic tanks, not connected to public sewage treatment plants; watershed-wide, they contribute an estimated 12-13 million pounds of nitrogen per year through their septic systems." The state of municipal water systems is also an issue for the watershed. CBF particularly cites Washington, DC and Richmond, VA as examples of cities in their watershed with combined stormwater and wastewater sewers dumping raw sewage directly into streams and Bay tributaries during periods of heavy rain.

2.2.2.2 Drinking Water

Although the practice of water conservation is generally embraced by the Anne Arundel County and the State of Maryland[3] the Merrill Center obtains its potable water from its own private well, so water use onsite does not affect the public drinking water supply.

2.2.2.3 Stormwater and Wastewater

The management of wastewater and stormwater are pressing public issues in the Chesapeake Bay watershed. Nutrient loading is perhaps the paramount environmental issue at the local, state and regional level. The "Chesapeake Bay 2000 Agreement" required reduction of nitrogen loading to the Bay by 20 million pounds/year and phosphorus loading must be reduced by 1 million pounds/year. Maryland's "Bay Restoration Fund" includes what is locally referred to as a "flush tax." This consists of a monthly tax on homes and businesses that utilize a public wastewater system and an annual tax on buildings with on-site wastewater systems. This tax is used to fund upgrades to wastewater treatment plants as well as upgrades to on-site septic systems and agricultural uses.

Maryland currently has 420,000 on-site wastewater treatment systems that serve 20 percent of property owners. The Bay Restoration Fund provides grants to homeowners for a free upgrade of their septic system. This upgrade consists of the installation of an anaerobic nitrification tank between the septic tank and the drainfield to reduce nitrate load to groundwater and ultimately the Bay. Since 2006, $19 million have been awarded for on-site upgrades. The grant pays for equipment, installation, and 5 years of electricity and maintenance.

2.2.2.4 Summary of Priority Water Issues

The Chesapeake Bay watershed suffers from its inescapable position at the geographical heart of the great Eastern megalopolis. Population growth, increasing affluence, and relative lack of

[3] In their 2008 master planning document, Anne Arundel County identified as one of its environmental objectives to encourage water conservation to maintain ground water quality and minimize sewer flow (Anne Arundel County, 2008a). The county has also initiated a Jr. Smart Water Savings Program for 2nd to 4th grade children as part of their Water Conservation Public Education Initiative (Anne Arundel County, 2008b). Discussions with state and local officials confirmed the support of water conservation measures.

public transit have resulted in more automobile use and ownership, and thus more hard surfaces to serve vehicular needs. Sediment runoff from building development is great, and nutrient runoff from one of the region's economic powerhouses, the agricultural industry, pollutes groundwater and the Bay itself. Infiltration capacity, water quality issues from outflows, and wastewater reduction are of paramount importance in the region and in the State of Maryland.

2.2.3 Design and Construction

2.2.3.1 Chesapeake Bay Foundation History and Mission

In the late 1990s, after 30 years of making a name for itself as one of the preeminent environmental advocacy groups in the eastern United States, the CBF began looking for a permanent home. Understanding the history and mission of CBF is key to understanding their choices throughout the design and construction process.

CBF is an advocacy organization with ambitious legal and educational agendas. Founded in 1967, its mission — "advocate, litigate, educate, restore" — emerged as a response to the changes in Bay culture and the watershed. Population growth, the desirability of coastal living, rampant development, industry, big scale Eastern Shore chicken farming and agriculture, and other impacts threatened the traditional life and livelihood of the watermen and sailors of the Bay, as well as its environmental health. The awareness of the threats to human and natural ecology spurred the creation of CBF. CBF's emergence also coincided with the beginnings of the U.S. Environmental Protection Agency (USEPA) and the eventual passage of the first State tidal protection measures and the national Clean Water Act.

CBF's issues include land use (particularly around urban/suburban development and the diminution of wetlands, forest cover, and animal and plant species), stormwater, air pollution, and contaminants such as sewage and mercury. CBF's legal office brings suit against diverse institutions, including regulators themselves, such as the Virginia Water Control Board on regulation of nitrogen and phosphorous limits and the USEPA on rulemaking for mercury emissions in coal-fired power plants. To raise public awareness, CBF's education staff runs shipboard field investigation programs for students and teacher development courses on and around the Bay. CBF's restoration efforts include a program to plant underwater grasses in the area's water bodies.

As an institution, CBF has a deep awareness of the need for water and energy management, and this awareness extends to every CBF staff member. At the start of the Merrill Center project, many CBF staff were collaborating on what would become CBF's first "State of the Bay" Report, made public in 1998, and produced yearly since then. The Report is the vehicle through which CBF scientists gauge the health of the Bay through thirteen indicators over three categories, pollution (air as well as water), habitat, and fisheries. Thus, a primary goal for the choice of an organizational headquarters was its ability to reflect that awareness and the responsibilities it brings.

2.2.3.2 The Search for a New Headquarters

CBF's head offices were in downtown Annapolis throughout the 1990's. In 1996, the Board of Directors ("Board") asked Mary Tod Winchester, Vice President for Administration and Operations, to look for a site to purchase. After searching fruitlessly for one and a half years, she was approached by a neighborhood association in Bay Ridge, an upper middle class, suburban neighborhood fronting the Bay south of Annapolis. Their community swim club was bankrupt, and the property was shuttered. Partly motivated by fear of a developer-driven, out-scale building project, the neighborhood sought out CBF and urged them to buy the property. They agreed, and in 1999 began work.

The property contained a previous recreational development on its 33-acre shoreline site close to the center of Annapolis, and included significant impervious-surfaced parking, lawns, and a variety of commercial/institutional buildings (Figure 2-5). None of these were large or well-configured enough to accommodate the 80-person staff of CBF. Reuse of the existing structures was undesirable from this standpoint, but also because CBF was looking to make an architectural identity and presence for the organization. Setting aside, therefore, the hopes or expectations of the neighborhood for minimal change, the CBF began the process of clearing the site, disassembling as many structures as possible for resale or community donation, and grinding up the existing hardscape for use as aggregate in the poured concrete foundations to come.

Figure 2-5
Preexisting development on the site of the Merrill Center
Source: Used with permission from the Chesapeake Bay Foundation

Ultimately, the new CBF site development significantly reduced land coverage from the previously developed condition, a desirable outcome. Nonetheless, the first two significant design decisions were not inherently "green" ones. The first was the choice of a site (notwithstanding the community's invitation) on the relatively fragile Bay shore — a site accessible mostly by car rather than public transportation. The second was the decision not to keep and use the preexisting structures on the site. However, the guiding staff and Board recognized that direct Bay access could provide a literal launching ground for their educational programs. The link to the water was both symbolic and utilitarian. On the question of reuse of structures, their goal was to make the site a showcase for sustainable design and water management practices, which meant wiping away the old and starting fresh. These considerations overleaped the immediately sustainable choices in favor of a future vision. It also made the subsequent need for sustainable site development and water management even more compelling, as this would help offset the impact of these initial choices.

2.2.3.3 The Design Process

While following in the steps of so many people who have flocked to the Bay shores and done lasting damage, it was important to the CBF to differentiate itself from those who came before. In building their headquarters, they wanted to make a statement about the importance of water management and ensure they minimized their contribution to the ongoing issues plaguing the Bay. Based on this knowledge, CBF chose a team that would help them turn their vision into a reality.

The Board and key staff decided to engage a contractor even before hiring the architect. There was never an issue about who this contractor would be. The Board had always included influential people such as U.S. Senators, newspaper publishers, and powerful businessmen — including Philip Merrill, for whom the building is named, who was a philanthropist, diplomat, and publisher of the Annapolis *Capital*. Importantly, the Board also included Jim Clark, the head of Clark Construction, a regional contracting powerhouse. Clark and his company agreed to come on board at the start for a lower-than-market fee with the understanding that this was their window into sustainable construction. Indeed, in the late 1990's, the field was still in its infancy; as discussed later, the LEED Rating System for New Construction was market-ready in the year 2000. When one potential Clark subcontractor was asked if he wanted to make a bid on a "green" building, he replied, "I'll paint it any color you want."

The search for an architect began with a field of potential candidates identified by the Board and CBF staff. Successive interviews whittled the field of 50 down to 5, which included one firm with a green project under its belt: SmithGroup, of Washington, DC, the architects of the U.S. Fish and Wildlife headquarters. Having completed one sustainable project and eager for more, architect Greg Mella of SmithGroup submitted a cost proposal to CBF that was significantly below market value. Mella viewed the project, as Clark Construction did, as a learning experience and also as an opportunity to give back to the community. CBF chose SmithGroup because of three factors: the quality of their work and green experience as embodied in the U.S. Fish and Wildlife building; their low bid; and because (in common with all the bidders) as a combined architecture-engineering firm, they represented a single point-of-service for building and site design.

The earliest design approach, conducted by SmithGroup with the assistance of CBF ecologists and engineers, was site analysis. This effort attempted to document as many local natural site conditions as possible, as illustrated in Figure 2-6, SmithGroup's site analysis.

The recognition of the pressures on the local site is embedded in the design of the CBF headquarters. Water management practices are described in upcoming sections. CBF initiated two key steps in the early design process that served to plant sustainability even more firmly. The first was a team-building exercise in which the design and contracting players with CBF project leaders and Board members sailed the Bay on a three-day field trip, visiting CBF's field sites and noting first-hand the incorporation of very small scale green building measures, such as composting toilets. The second step was a strategic design charrette or "peer review" process funded by the US Department of Energy (USDOE) to examine the schematic design. The charrette helped set the larger energy agenda and vision for building and its site strategies, which had until that point included no measurable goals. One of the outcomes of the USDOE peer review was a downsizing of the photovoltaic array to invest in energy conservation features instead, a wise return on investment.

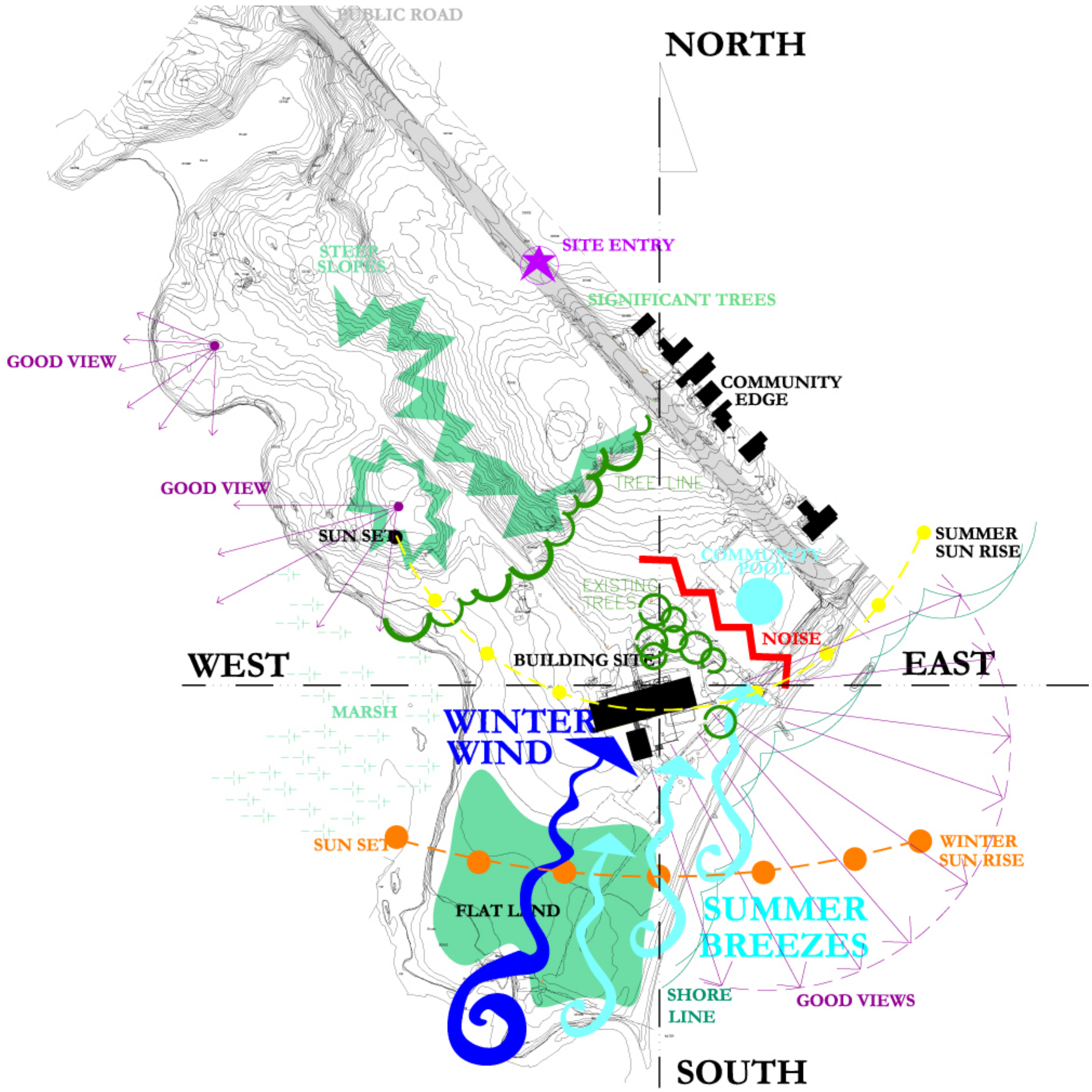


Figure 2-6
SmithGroup site analysis (courtesy of Smith Group)
Source: Used with permission from SmithGroup

The resulting building and grounds look and function more like a National Park Visitor's/Study Center than a corporate headquarters (Figure 2-7). SmithGroup mined the vernacular architecture around the Chesapeake Bay for precedents that could not only inform the look of the building, but also its ability to function well in its site. From barns came the simple shed roof, and similar to an agricultural building with its silos, the Merrill Center proudly displays its water-gathering cisterns frontally, at the building entrance. Windows open, and the Merrill Center relies exclusively on natural ventilation for about 33 percent of the year. Materials are "humble" — galvanized steel and wood on the exterior, and cork, exposed Parallam trusses, canvas-and-rope gangway railing, and medium-density fiberboard on the interior. The building sits lightly on the site, raised on columns or *pilotis* to minimize the need for site excavation and disturbance.

Figure 2-7
Merrill Center view from the Bay

In the words of project architect Greg Mella,

"What's innovative about CBF is not any one technology, since these things have been used extensively. What's innovative is that these technologies were applied to a commercial building successfully."

Many of the building's green strategies, such as the use of natural ventilation and good daylighting, rely on its open plan (Figure 2-8). Very few of its 80 employees have private offices; almost everyone sits in collaborative banks of workstations (80 s.f. each) with equal access to the best views, daylight, and breezes. The egalitarian, open nature of this workplace, its sustainable qualities, and the beauty of the site have proved to be important resources for CBF in attracting and keeping top quality staff. The senior staff has great longevity. Mary Tod Winchester, Vice President for Public Affairs, has been with CBF for 30 years. Chuck Foster, Chief of Staff, has been with CBF for more than 20 years. The facility is also a money-maker for the Foundation: its public indoor rooms and outdoor spaces are leased to private organizations for special events.

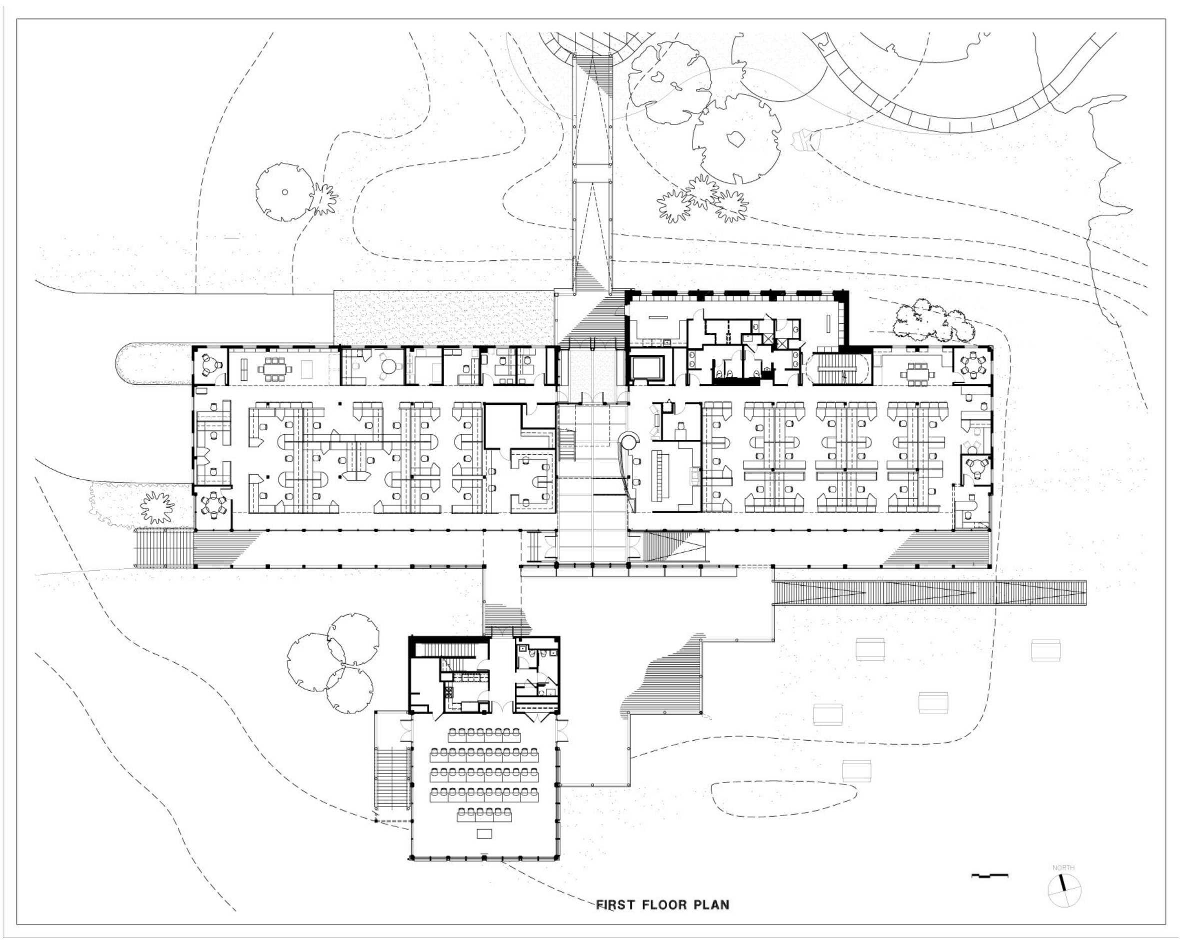


Figure 2-8
First floor open plan with workstations, Merrill Center
Source: Used with permission from SmithGroup

The design process itself was, compared to that of more conventional buildings, highly collaborative. The early team-building field trips laid the groundwork for this spirit of collaboration. The key players during design were Greg Mella, project architect for SmithGroup; Mary Tod Winchester, Vice-President, CBF; Chuck Foster, Chief of Staff; Tom French, site supervisor for Clark Construction; Janet Harrison, the CBF's own "green architect," who made many suggestions for greening the building; CBF's staff ecologists, who did the site restoration planning; Paul Willey, still the Director of Facilities for the Merrill Center and systems commissioner and solutions man; and the Board, who, according to Mary Tod Winchester, gave the project team "a long leash" while fundraising tirelessly to support the growing budget for construction. Table 2-1 summarizes the key players for this project.

Table 2-1
Key stakeholders in the Chesapeake Bay Foundation's Merrill Center

Stakeholder	Role in Merrill Center Design and Construction
CBF Board of Directors	The "owner"; design review; fundraising
Mary Tod Winchester	VP, CBF Administration/Operations; identified site; member of core design team
Greg Mella, SmithGroup	Project architect
Chuck Foster	CBF Chief of Staff; member of core design team
CBF ecologists and scientists	Site and Low Impact Development design
Janet Harrison, CBF in-house consulting architect	Green building/LEED advising
Clark Construction	Contractor
Jim Clark, owner, Clark Construction and member, CBF Board	Dual stakeholder roles as Board member and project contractor
Paul Willey	Merrill facilities manager; responsible for operations and maintenance
The neighborhood	Sought out CBF to buy the site

Indeed, the Merrill Center process is an example of the kind of collaborative process that allows for sustainable design. The Merrill Center method was in many respects the opposite of the conventional process, which might be described "balkanized:" under the old model, the client and architect talked separately; the architect then talked to the engineers after (not during) schematic design, and only after design and strategies had been set; neighbors were shown as little as possible during design for fear of objections; regulators got a look at a project only after construction documents were complete.

None of this was true for the Merrill Center. During design, the Merrill Center stakeholders were at or near the table from start to finish. The newness of the undertaking led to an openness, and an open-endedness, in an exploratory process.

Importantly for the Center's operational life, after construction Winchester, Foster, Willey, and Harrison continued (and continue) as stewards and aides-memoires of the building, working out its idiosyncrasies and making improvements when necessary.

2.2.4 Green Building Rating

The CBF Board led the decision to achieve LEED certification.

The design of the Merrill Center was begun before LEED certification was available, but LEED v.1.0 was on the horizon. According to Greg Mella, the Board had four stated goals in constructing the facility:

- to create the best workplace for staff;
- to be a good neighbor;
- to create the most environmentally sensitive building possible; and
- to lead by example so that others might create further green buildings.

A LEED rating would help the last two immeasurably. LEED could provide a third party, independent certification of "environmental sensitivity." Since its creation, CBF's own self-image and its truth had coincided happily: it was a pioneer. Where best to strike forth anew than with LEED?

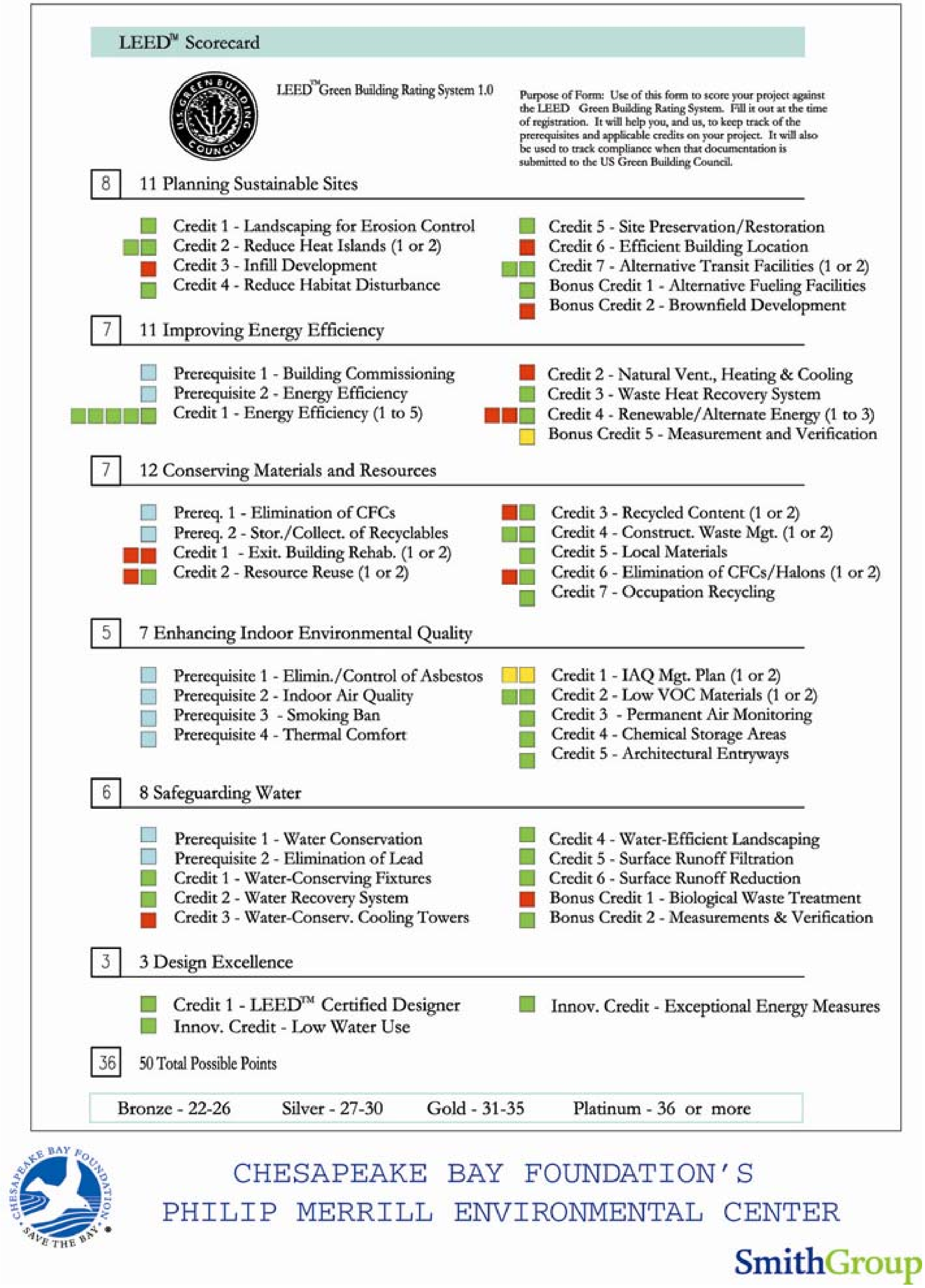
Even before design, CBF's Board understood the power of incorporating their new Center into their educational and public outreach goals. According to Mella,

"In the U.S., there was no holistic view of green until LEED. LEED looked at water quality and efficiency, not just energy. We [the CBF team] began by coming up with environmental goals. CBF does the State of the Bay Report. We looked at the contributing factors. Nitrogen pollution: where is it coming from? 90 percent is coming from water treatment plants, which get rid of biological contaminants, but not nitrogen. So: don't send wastes to treatment plants! Next goal: managing stormwater on site. Don't rely on heavy fertilizers! We saw the importance of wetlands in the watershed, of minimizing site disturbances. One million lbs of nitrogen comes from air quality. The building uses 50 percent less energy than a code-compliant office building. Our priority was water quality. LEED was unique in that it had credits for stormwater and water efficiency. This was a perfect alignment with what the Foundation was trying to do. EQ [Indoor Environmental Quality] credits were good, important goals. If you map out what CBF was trying to do, LEED mirrors that."

The project team was aware of BREEAM, but chose LEED as a U.S. standard and did not discuss Green Globes. The team's goal for LEED certification was Gold; they achieved Platinum, remaining one of the few buildings in the United States so designated, in 2001. They have not recertified under LEED (recertification is required every five years) but in 2009 have begun to discuss devoting their resources (both of time and money) to this effort. They have begun to take steps to qualify for ENERGY STAR. This ENERGY STAR rating is based on energy and water efficiency and is thus not a holistic rating system attempting to reward the whole range of a building's sustainable endeavors. So far in internal assessments CBF has fallen short of the 75 points needed for an ENERGY STAR rating.

The LEED Water Credits under LEED v.1 are different and more numerous from those in present day v.3, in part because they include the stormwater credits, now in the Sustainable Sites category. Figure 2-10 shows the “Water Tab” of the original Merrill Center LEED submission. Note the Bonus Credit for Biological Waste Treatment (on-site). The LEED Scorecard of the Merrill Center (LEED for New Construction v. 1.0) is shown in Figure 2-9. Green means achieved; blue is required; red means not applicable; yellow means not awarded.

While no green building rating system alternative to LEED was deemed well-known enough to be a viable measure of success, the project team had a basic approach to the project more compelling even than LEED: ***they devised a clear vision of locally based environmental goals and then met them.*** This internal goal-setting became the basis for the Merrill Center’s sustainable achievement, and LEED Platinum followed from that. Especially in water management, goals like nutrient reduction were met with tangible strategies like the use of composting toilets and stormwater management practices. Regional and site specific content, whether in terms of planting schedules, remediation strategies tailored to the site, or maximum use of prevailing breezes informed design decisions. This specificity gives the Merrill Center a sense of achievement beyond LEED.



LEED™ Scorecard

LEED™ Green Building Rating System 1.0

Purpose of Form: Use of this form to score your project against the LEED Green Building Rating System. Fill it out at the time of registration. It will help you, and us, to keep track of the prerequisites and applicable credits on your project. It will also be used to track compliance when that documentation is submitted to the US Green Building Council.

8 — 11 Planning Sustainable Sites

- Credit 1 - Landscaping for Erosion Control
- Credit 2 - Reduce Heat Islands (1 or 2)
- Credit 3 - Infill Development
- Credit 4 - Reduce Habitat Disturbance
- Credit 5 - Site Preservation/Restoration
- Credit 6 - Efficient Building Location
- Credit 7 - Alternative Transit Facilities (1 or 2)
- Bonus Credit 1 - Alternative Fueling Facilities
- Bonus Credit 2 - Brownfield Development

7 — 11 Improving Energy Efficiency

- Prerequisite 1 - Building Commissioning
- Prerequisite 2 - Energy Efficiency
- Credit 1 - Energy Efficiency (1 to 5)
- Credit 2 - Natural Vent., Heating & Cooling
- Credit 3 - Waste Heat Recovery System
- Credit 4 - Renewable/Alternate Energy (1 to 3)
- Bonus Credit 5 - Measurement and Verification

7 — 12 Conserving Materials and Resources

- Prereq. 1 - Elimination of CFCs
- Prereq. 2 - Stor./Collect. of Recyclables
- Credit 1 - Exit. Building Rehab. (1 or 2)
- Credit 2 - Resource Reuse (1 or 2)
- Credit 3 - Recycled Content (1 or 2)
- Credit 4 - Construct. Waste Mgt. (1 or 2)
- Credit 5 - Local Materials
- Credit 6 - Elimination of CFCs/Halons (1 or 2)
- Credit 7 - Occupation Recycling

5 — 7 Enhancing Indoor Environmental Quality

- Prerequisite 1 - Elimin./Control of Asbestos
- Prerequisite 2 - Indoor Air Quality
- Prerequisite 3 - Smoking Ban
- Prerequisite 4 - Thermal Comfort
- Credit 1 - IAQ Mgt. Plan (1 or 2)
- Credit 2 - Low VOC Materials (1 or 2)
- Credit 3 - Permanent Air Monitoring
- Credit 4 - Chemical Storage Areas
- Credit 5 - Architectural Entryways

6 — 8 Safeguarding Water

- Prerequisite 1 - Water Conservation
- Prerequisite 2 - Elimination of Lead
- Credit 1 - Water-Conserving Fixtures
- Credit 2 - Water Recovery System
- Credit 3 - Water-Conserv. Cooling Towers
- Credit 4 - Water-Efficient Landscaping
- Credit 5 - Surface Runoff Filtration
- Credit 6 - Surface Runoff Reduction
- Bonus Credit 1 - Biological Waste Treatment
- Bonus Credit 2 - Measurements & Verification

3 — 3 Design Excellence

- Credit 1 - LEED™ Certified Designer
- Innov. Credit - Low Water Use
- Innov. Credit - Exceptional Energy Measures

36 — 50 Total Possible Points

Bronze - 22-26 Silver - 27-30 Gold - 31-35 Platinum - 36 or more

CHESAPEAKE BAY FOUNDATION'S
PHILIP MERRILL ENVIRONMENTAL CENTER

SmithGroup

Figure 2-9
Merrill Center LEED scorecard
Source: Used with permission from SmithGroup

Safeguarding Water

Water Prerequisite 1 - Water Conservation
☑ Subcontractors are to provide stamped submittal cut sheets of all plumbing fixtures specified for the project that demonstrates compliance under the 1992 Energy Policy Act.

Water Prerequisite 2 - Water Quality
☑ For new buildings:
Provide highlighted specifications noting that all new construction materials shall be "lead free." Provide highlighted cut sheets that show all plumbing materials are lead free for piping, fixtures, solders, and flux used in the project. Provide a letter of certification by the Architect, Engineer or Builder verifying the installation per design documents.

NA For existing buildings to be rehabilitated:
Provide a Safe Drinking Water Plan. Provide a letter of certification by the Architect, Engineer or Builder verifying implementation of the plan. The plan is to contain:

- ☐ A plumbing materials list of all piping, fixtures, solders, and flux used in the project.
- ☐ A water sampling plan for water testing procedures and schedule (initial and follow-ups).
- ☐ A replacement plan for plumbing materials that contribute to lead in drinking water to meet Standard.
- ☐ A specified procedure to communicate lead testing results and corrective measures, if needed, to building occupants.

Water Credit 1 - Water-Conserving Fixtures
☑ Provide stamped submittal cut sheets of pertinent plumbing fixtures specified with water conservation information highlighted and calculations that show that overall water meets the require percentage reduction.

Water Credit 2 - Water Recovery System
☑ Subcontractors are to provide stamped submittal or shop drawings and/or cut sheets of the water recovery system(s) with water recovery information including calculations highlighted.

Water Credit 3 - Water-Conserving Cooling Towers
☐ Provide stamped submittal or shop drawings and highlighted specifications of the cooling tower system(s) with notes of the delimiters (to reduce drift and evaporation) highlighted.

Water Credit 4 - Water-Efficient Landscaping
☑ Provide stamped landscape as-built drawing(s) listing all plants to be installed. Additionally, provide verification from the Landscape Consultant that confirms all plants specified will meet the Credit criteria.

Water Credit 5- Surface Runoff Filtration
☑ Provide stamped shop drawings and highlighted specifications of the water quality ponds or oil grit separators for pre-treatment of runoff from surface parking areas.

Water Credit 6 - Surface Runoff Reduction
☑ Provide stamped drawings and highlighted specifications documenting that demonstrate compliance with Credit.

Water Bonus Credit 1 - Biological Waste Treatment
EXTRA ☐ Provide stamped shop drawings and highlighted specifications of the on-site waste water treatment system and a letter of compliance from the local health department documenting compliance with local codes.

Water Bonus Credit 2 - Measurement and Verification
☑ Provide a copy of the measurement and verification plan along with a signed letter of certification by the commissioning engineer or the respective design engineer(s) confirming that the design intent has been achieved. The certification shall be provided on company letterhead of the certifying engineer.

Figure 2-10
Merrill Center LEED water tab
Source: Used with permission from the Chesapeake Bay Foundation

2.2.5 Sustainable Water Management Features

2.2.5.1 Sustainable Water Management for the Building Interior

The Merrill Center's LEED documentation summarized the approach to incorporating sustainable water strategies into the internal building design in this way:

"The Chesapeake Bay Foundation Headquarters has a very aggressive water conservation strategy. There are no standard toilets in the building; all toilets in the office are composting toilets which use no water at all. Rainwater is collected for most of the other needs; fire suppression, hand washing, mop sinks, desiccant unit make-up, laundry, and gear washing. The only consumption of potable water is in the showers and the kitchen sink.

These strategies are expected to reduce water consumption by at least 70 percent. The wastewater load is also greatly reduced. The connection to the public sewer system will remain because it was already in place, but the building will produce only greywater."

Of the types of water – drinking water, grey wastewater, and stormwater – used or produced onsite, drinking water has a conventional source (a private onsite well) and a portion of greywater has a conventional destination, back to the public sewer system. Although potable water is not a resource under particular local stress, the Merrill Center captures stormwater from the roof and stores it in 3,000 – 6,500 gallon cisterns to minimize its reliance on its well source (See Table 2-2 for CBF's estimate of well water saving). The cisterns supply the Merrill Center through separate piping with the non-potable uses described above, including hand washing and laundry. This captured rainwater, if used internally in the building rather than for site uses, as well as potable, well-supplied water, is sent to the public sewer system.

In recognizing and sharing a larger concern for excessive nitrogen levels within the watershed, CBF's environmental goals for the Merrill Center precluded sending human waste to treatment plants. The direct result of this goal was that all toilets in the project are composting toilets. Water conservation alone does not necessarily work toward nutrient load reduction goals. Less water with the same usage will produce smaller volume of waste, but the same organic and nutrient load. However, composting toilets result in a direct load reduction. With the composting toilets in place, the Merrill Center produces no blackwater.

CBF gained experience with composting toilets in their smaller study facilities located in remote locations where no municipal water system was at hand. Here, in the year 2000 and even now, it seems like a radical idea: an office building that relies on users to "lighten" their waste by using the sawdust provided in a bucket by the toilets; an office building that turns its own composting human waste. The Clivus Multrum system installed by the Merrill Center takes about one year to produce a stable compost end-product – a year in which, through the addition of wood shavings and the growth of aerobic bacteria, the volume of human waste is reduced by about 95 percent. When the composting process is complete, CBF spreads this waste onsite on its native plantings, but never, by regulation, on its gardens growing edibles.

Table 2-2
Water use efficiencies of Merrill Center fixtures

Water Saving Fixture/Appliance	Number Installed	Flow Rate or Water Consumed per Use			Percent Savings of Well Water
		Well Water Used for Water Saving Unit	Rainwater Used for Water Saving Unit	For a Conventional Unit	
Composting toilets	10	none	none	1.6 gallons/flush	100%
Composting Urinals	2	none	none	1 gallon/flush	100%
Lavatory Sinks	12	none	0.5 gallons/minute	0.5 gallons/minute	100%
Showers	3	2.5 gallons/minute	none	2.5 gallons/minute	0%
Mop Basins	4	none	20 gallons/minute	20 gallons/minute	100%
Washing Machine	1	none	7.5 gallons/minute	7.5 gallons/minute	100%
Laundry Sinks	1	none	10 gallons/minute	10 gallons/minute	100%
Hand Sinks	1	none	0.75 gallons/minute	0.75 gallons/minute	100%
Dishwashers	1	10 gallons/minute	none	10 gallons/minute	0%
Kitchen Sinks	1	2.5 gallons/minute	none	2.5 gallons/minute	0%

Source: Merrill Center LEED Application

Greywater produced internally to the building, through showers and through the use of captured rainwater, is sent via piping to the County treatment plant. (There is no piping tie-in for site-produced stormwater.)

Water use from all sources (well and cistern) is metered and tracked. This study will include estimated or measured water consumption savings in the impact analysis section of the report.

2.2.5.2 Sustainable Water Management for the Building Exterior

The Merrill Center, as characterized by its project architect, Greg Mella, is "a laboratory of ideas." CBF implemented all of the best management practices (BMPs) it could with respect to stormwater. The overall plan focuses on maintaining as much open space as possible (84 percent of the site) and restoring the site's wetlands, meadows, forests, and beach. The emphasis, in keeping with the original act of lessening the hardscape surfaces and extent of previous site development, is not only on water conservation – it is on site remediation and restoration (Figure 2-11). The Merrill Center goes considerably beyond the LEED water credits in this respect. The restoration is intended to have beneficial effects watershed- and community-wide.

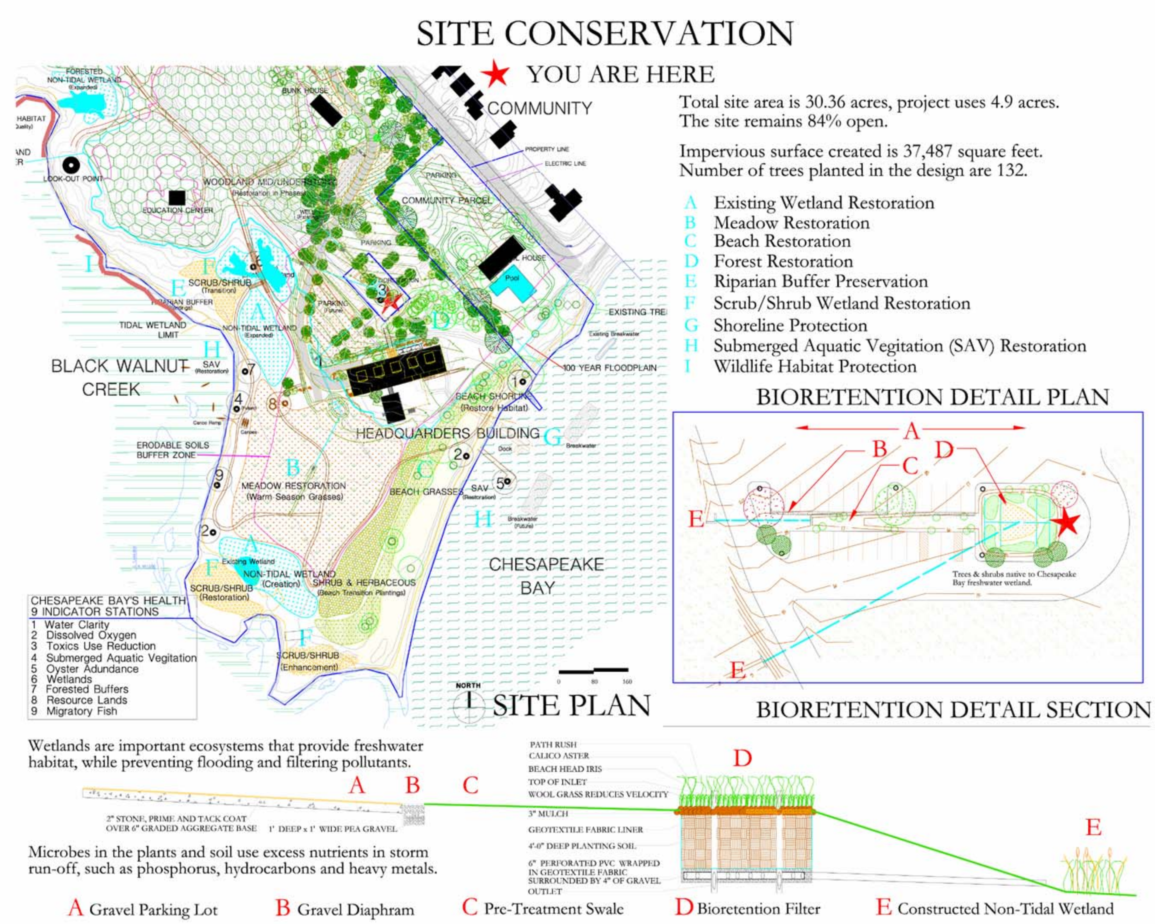


Figure 2-11
Merrill Center site conservation strategies
Source: Used with permission from SmithGroup

CBF's year 2000 LEED summary of stormwater management summarizes the basics of their management plan (see Figure 2-12).

The Chesapeake Bay Foundation Headquarters site was designed to control sediment and treat stormwater runoff both during and after construction. The standards of the Maryland Department of the Environment for both Sediment and Erosion Control as well as Stormwater Management were utilized to design the site.

During construction, most of the runoff from disturbed areas is directed to Sediment Trap No. 1, where the sediment will settle out in the trap before being released to overland flow through a sandy vegetated area. Silt Fence will treat a small area at the beginning of the entrance drive which could not be directed to the trap. The grading of the site has been designed to prevent on-site erosion and off-site sedimentation.

The stormwater plan is designed using the latest guidelines and standards. There are two formal devices, a Bioretention Area and a Pocket Sand-Filter. Both filters have been designed according to the Maryland Stormwater Design Manual-Volumes I & II, dated September 1998. This manual is still in draft format, but contains design methodologies that effectively present the most current information on how to effectively filter pollutants from stormwater runoff. The two devices treat all the proposed parking area.

Because we discharge to tidal waters, there was no purpose in providing stormwater management quantity control. There are stable flow paths for all outfalls from the developed area to tidal water.

Figure 2-12
Merrill Center LEED stormwater final submission
Source: Used with permission from the Chesapeake Bay Foundation

The path of water moving onsite is established by the bioswale at the building's front entry, to the north. Bioretention is the cornerstone of onsite BMPs, through swales and dry ponds. There are three bioretention collection points onsite. The bioretention swales throughout include native plantings and grasses which slow down the flow, allowing it to be gradually infiltrated onsite – or else passed on to the sand filter at the southwest corner of the building (Figure 2-13). The site stormwater does not tie to the public wastewater system. Any greywater not site-absorbed or stored for interior uses sheds eventually to the tidal waters of the Bay, but the lengthy run through a rill of native plantings and grasses acts to cleanse it of nutrients.

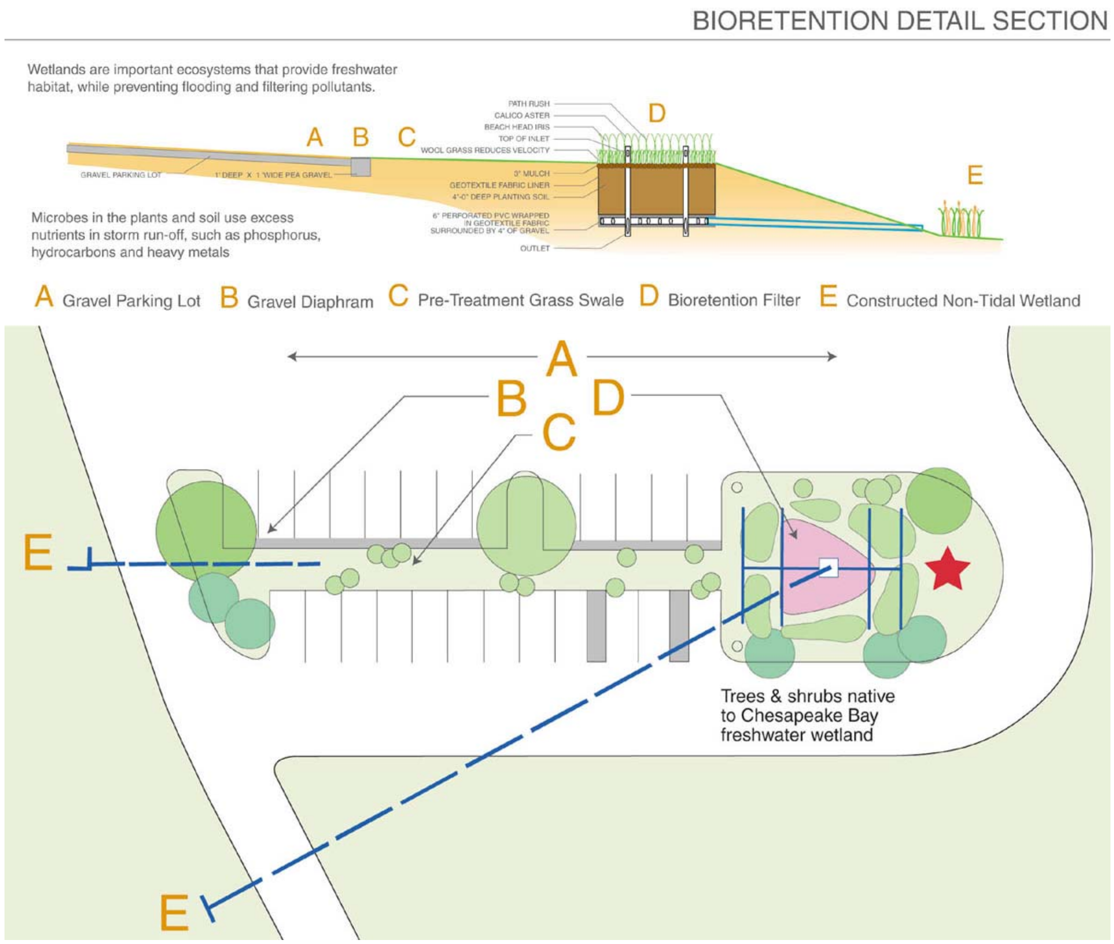


Figure 2-13
Merrill Center Bioretention details
Source: Used with permission from SmithGroup

The planting schedule was developed according to the site's micro-ecologies, with a schedule for woodland plantings, for beach plantings, for the retention bioswale, and for three distinct meadows. Species were native to the Tidewater region (Figure 2-14).

Figure 2-14
Merrill Center landscape
Source: Used with permission from the Chesapeake Bay Foundation

In 2006 the Merrill Center retrofitted its lower, flat roof near the entry as a green roof, the first on site. A green roof was not one of the first goals of the design, which instead prioritizes rainwater collection and reuse through roof run-off. The high roof drains to the cisterns at the front of the building, away from the Bay, towards the bioswale which slows and holds overflow water.

Figure 2-15
Merrill Center roof catchment photo

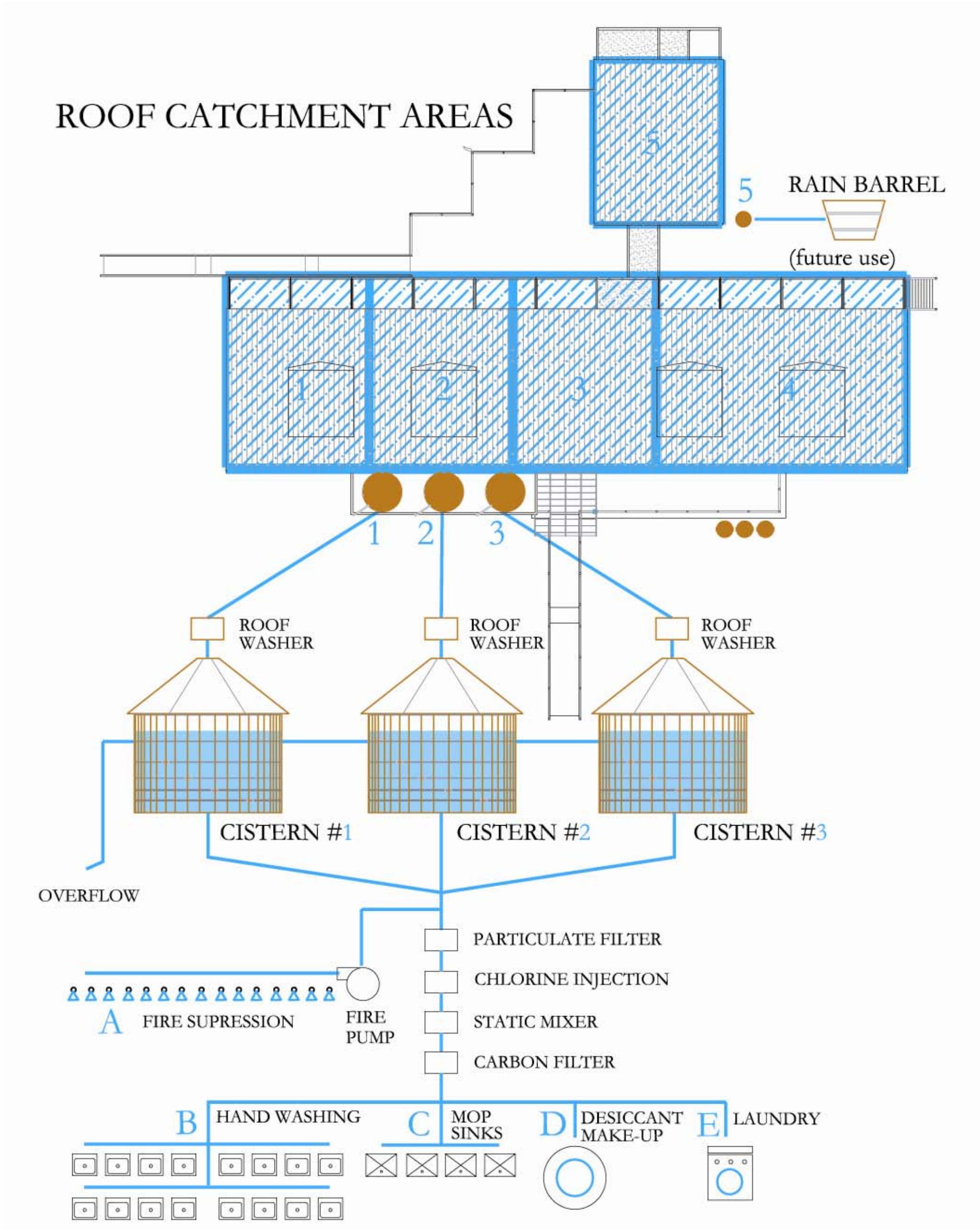


Figure 2-16
Merrill Center roof catchment water flow diagram
Source: Used with permission from SmithGroup

The 37,000 square feet of impervious surface on site is largely asphalt road leading up to the parking lot. The lot itself is pervious gravel, and the extent of parking in relationship to building and visitor occupancy is minimal.

2.2.6 Challenges in Design and Implementation

The State of Maryland now has a reputation as an environmentally forward-thinking state, but the encouragement of green alternatives to conventional building had not, in the year 2000, trickled down to the local code officials and building inspectors of Anne Arundel County.

The composting toilets, a keystone of CBF's onsite environmental strategies, were a source of contention between the design team and local regulators. One challenge came from the Fire Marshall. The review of the Clivus Multrum toilet system revealed that the waste shafts, 10 inches in diameter, led directly to the composting pit. Since occupant behavior, even in a non-smoking building, cannot be absolutely controlled, for officials these direct shafts represented a fire hazard in the event of lighted cigarette disposal. The solution was to make these shafts, at some expense, the constructional equivalent of conventional chimneys. "Fire-rating" the shafts – enclosing them and the composting chamber in non-combustible material – separated them from the rest of the building, inhibiting any potential spread of fire.

The second challenge came from building reviewers who objected to the width of these open toilet shafts, which exceeded the 4 inches maximum allowed by code. This is the "baby's head" rule: unobstructed openings near the floor with greater than four inches clearance allow children to fall through them. Eventually the design team persuaded officials that while it was extremely unlikely that a baby would fall down the toilet shaft, if a baby did so it would have a safe and cushioned, if filthy, landing on the compost heap. The County reviewers accepted this explanation and allowed the shafts to remain as designed.

The third challenge came from the Health Department. The Merrill Center's proposed use of rainwater for hands washing – human contact – was an issue even though CBF proposed to treat this captured water as it was stored in cisterns. The Health Department finally allowed this use, but required signage at all hands washing sinks as follows (Figure 2-17).

In addition to local regulators, a second and potentially even greater roadblock was the CBF staff itself. Staff feared the composting toilets on the grounds of smell and hygiene. Chuck Foster recalls the repeated requests that at least one conventional toilet be included in the design. These fears evaporated once the building was occupied and the toilets proved unremarkable. Similarly, there was significant staff resistance to the idea of the open spatial plan. Privacy and acoustical concerns dominated this discussion, but here, too, the design team held these concerns at bay until the Center was occupied. Foster recalls staff coming to him during the first week the Center was open and admitting that they were wrong, and that the advantages and delights of the open plan outweighed the desire for private space. These instances, for Foster and for the design team, were sweet validation, recounted with pride, gratitude, and relief.

In fact, the Merrill Center was realized with no significant compromises to its design. This was due to several strategic decisions on the part of the CBF board and design team. First, CBF worked to keep the neighborhood apprised of its design decisions, recognizing the neighborhood's role as supportive and solicitous of CBF's presence. Though no public comment or review was required, CBF met with the neighbors as a courtesy to keep relations good. Similarly, CBF bird-dogged any potential controversies well in advance for local regulators and officials, leaving little to chance and minimizing surprise rulings.

Figure 2-17
Rain Water warning sign
Source: Used with permission from the Chesapeake Bay Foundation

The greatest challenges to the full realization of the Merrill Center were two: subcontractor ignorance and overall cost.

Clark Construction and SmithGroup were riding the same green wave, but the subcontractors were far behind or contrary-minded. For example, Greg Mella had specified low volatile organic compound (VOC), formaldehyde-free cabinetry and casework. The cabinetry subcontractor installed a product he assured the team met these standards. Mella, on a hunch, had a scrap of it tested. It proved rife with formaldehyde, and the subcontractor had to remove it. The project team recounted other wrong turns leading to more waste, through do-overs, than is perhaps consistent with green construction. Indeed, the one stakeholder group not regularly involved in team discussions throughout was the subcontractors. Mistakes were in part due to this lack of extending communication, and the project paid for these mistakes in the amount of work that had to be redone or reinstalled. This exclusion of subcontractors -- perhaps the stakeholder whose work was most critical to the project's built integrity -- was a regret voiced by the architect, the general contractor, and the CBF.

Notwithstanding its bow to the vernacular in simplicity of form and straightforward detailing — characterized by architect Mella as “frugal” — the Merrill Center paid a premium for building green. To quote Mella, “the building saves its big moves and big money for energy-efficient systems, not for luxurious finishes.” Costs came in at $197 per square foot as compared with a price of $150 per s.f. for a conventional office building. Cost overruns during the process were due to a combination of factors: unfamiliarity with the methods and components of green building, wrong turns by subcontractors, and “scope creep” — the addition of programmatic architectural content during the design. The final price more than doubled from initial estimates, rising from $3.2 million to $7.1 million. The final total square footage on two raised floors is 31,000 s.f.; the ground level under the building is unenclosed parking.

Other costs were the result of an expanding vision and desires during the design. Cost overruns could have killed a project with a less determined Board, but CBF’s Board of Directors kept fundraising pace with costs. Nonetheless, there had to be some “value engineering” in the end. Architect Mella credits this “tightening” with the achievement of LEED Platinum, since it forced CBF to center priorities on their environmental goals:

“During design, there was not a lot of value engineering, not at a lot of resifting. The final bid, by the same firm that did preconstruction pricing, came in 200 percent higher. We got out of that situation: we had to VE [value engineer]. CBF asked the contractor to cut some of their fee. The deck got smaller. Five dormers were cut to 4. We stripped down finishes. We exposed the ceiling at the 1st floor. We stripped down: everything not giving the project sustainable qualities, we cut. We were able to cut $1million.

The act of cutting is when the project went from LEED Gold to Platinum. It became a very sustainable, no-frills barn that housed people.”

The sustainable qualities of the final building include sensors on many systems. Water use is monitored through two meters, one for potable water from the public system and one tracking cistern flows. The challenge for operations is using the information acquired to operate the building even more efficiently. In fact, maintenance of the building is an ongoing challenge. According to Paul Willey and Chuck Foster of CBF, to respond to the information from systems on sensors, considerable operational tweaking is necessary and time-consuming. The maintenance of a green building like the Merrill Center has additional tasks not shared by more conventional buildings, like the periodic cleanout of compost from the toilet composting chambers and maintenance duties associated with stormwater filtration devices like the onsite sand filter.

2.2.7 Lessons Learned

Lessons learned from the case study apply to processes, as these dictate outcomes:

Subcontractors need scrutiny and education. For the process of design and construction, the project team learned that the subcontractors should have had a place at the table, and that they are often the weak link between sustainable vision and implementation. In this case, they were the part of the team most in need of education and understanding. The story of the formaldehyde in the cabinetry is one example of waste that could have been avoided if the subcontractor had clearly understood the project’s priorities.

Allow for mistakes -- in terms of both time and cost -- in implementing the new and the untried. SmithGroup had not worked with a then relatively new technology, the Structural Insulated Panel. They assumed, wrongly, that Structural Insulated Panels had their own structural integrity, only to discover later that an extra layer of structural bracing was necessary. Retrofitting this into the project proved expensive.

Gather and inform as many project stakeholders as constantly as possible. The Merrill Center benefited from the ongoing collaborative "feel" and trading of information among the project team members, the neighbors, the Board of Directors, and the regulators. Most of the challenges to aspects of water management were met head-on and addressed early.

Question major design views and strategies. One assumption was the more daylight, the better. This proved disastrous for glare control, and the project had to retrofit shading devices into the extensive window walls. Less glazing would, in retrospect, have been better.

Educate occupants. Manage the expectations of those using the building, and educate them in their role of ensuring that the building operates as it was designed.

Strive for continuity and creativity in operations staff. Learning to operate a simple building with complex sensor systems is a time-consuming challenge. Having facilities managers with problem solving skills and a higher understanding of the interconnectedness of systems keeps a sustainably designed building sustainable.

Understand the importance of local conditions and responses. Like politics, all sustainability is local. Universal guidelines will help, but are no substitute for strategies geared towards the ecology, both human and natural, of the site.

2.2.8 Continuing Impacts

The Merrill Center is a tangible expression of the work and goals of the CBF. To its function as an educational center for environmental issues, it has added its status as a resource for sustainable site and building design. The Merrill Center has visitors who come to tour the building, and for whom the work of the Foundation is of secondary interest. It remains a catalyst for regional sustainability initiatives. Let project architect Greg Mella have the last word:

"This project was the poster child of LEED. CBF had a pretty quick impact on the State of Maryland. Shortly after it opened, [Governor] Glendenning issued the LEED Silver requirement for public buildings. That's an outgrowth of Merrill. It had a big impact on the State, and across the country. It won the Business Week award. It was great to get a good business decision award as well as good design awards. It's been over 10 years. I'm still getting calls. I'm still getting case study calls."

2.3 Wetland Studies and Solutions, Inc. (WSSI)

2.3.1 Building and Site Description

Wetland Studies and Solutions, Inc. (WSSI) is a natural resources consultancy whose services include delineation of wetlands and streams, assessments, restorations, permitting aid, and more. It is staffed by a multi-disciplinary team of scientists, engineers, architects, regulatory specialists, and archeologists who provide their services to developers and public works agencies throughout the Chesapeake Bay region. WSSI was established as a single person firm in 1991 by Mike Rolband, and has since grown to 73 employees. Rolband is a licensed professional engineer, professional wetland scientist, holds a MBA, and is a LEED Accredited Professional. While Rolband led the effort he was supplemented by a team of professionals within the private and public sector (Table 2-3).

Table 2-3
Key stakeholders of WSSI

Stakeholder	Role within WSSI's Development
Mike Rolband	Company Founder and President of WSSI
Rick Peterson	Developer and President of the Peterson Companies
Sean Connaughton	Chairman of the Board of County Supervisors for Prince William County (2000-2006)
Jennifer Brophy-Price	Associate Engineer at WSSI
National Life Group	Bank, provided financing
Urban Engineering	Civil Engineer
W.A. Browne & Associates P.C.	Architect
KT Industries	Landscaping
Furbish Group	Green roof maintenance

The WSSI facility consists of a two-story, 44,645 s.f. building occupying a footprint of 28,738 s.f. (Figure 2-18 & 2-19). Of this, 37,400 s.f. are devoted to finished office space on two levels while 7,245 s.f. are reserved for unfinished warehouse space. The office portion of the building contains all conditioned workspaces such as individual offices, small conference rooms, laboratory areas, and a large conference room on the second floor. The unfinished warehouse space is used to house the facility's heavy equipment and also contains a small gym for employee use. This portion of the building contains no plumbing or heating, ventilation, air conditioning, and refrigeration (HVAC) systems. WSSI's offices are typically occupied for 45 hours per week, and the company currently has 73 full-time employees. The plans below illustrate the space.

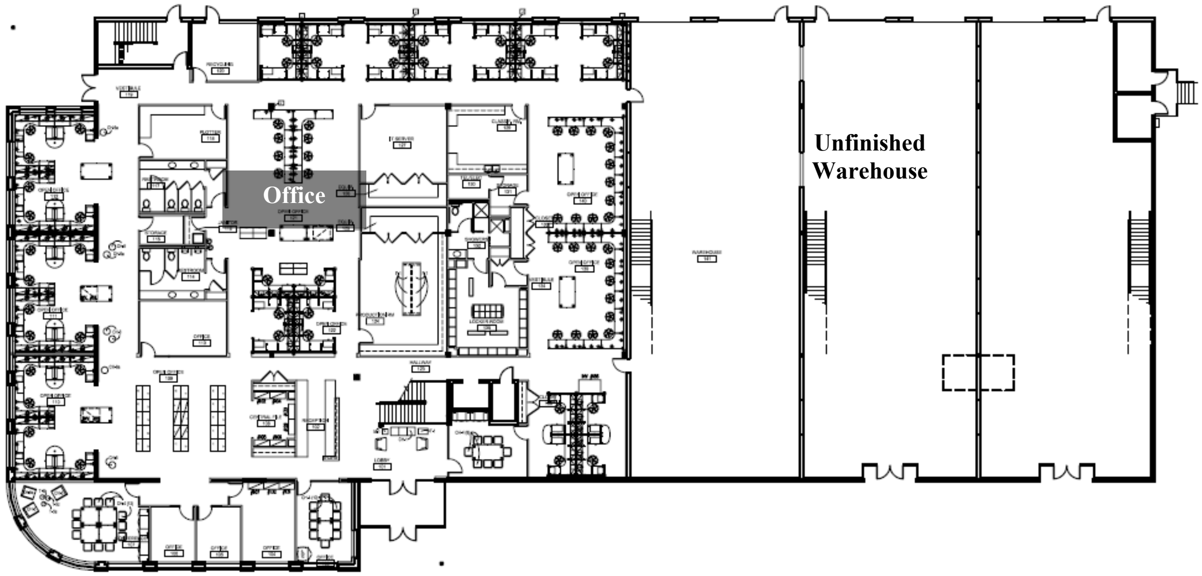


Figure 2-18
First floor plan of WSSI
Source: Used with permission from WSSI

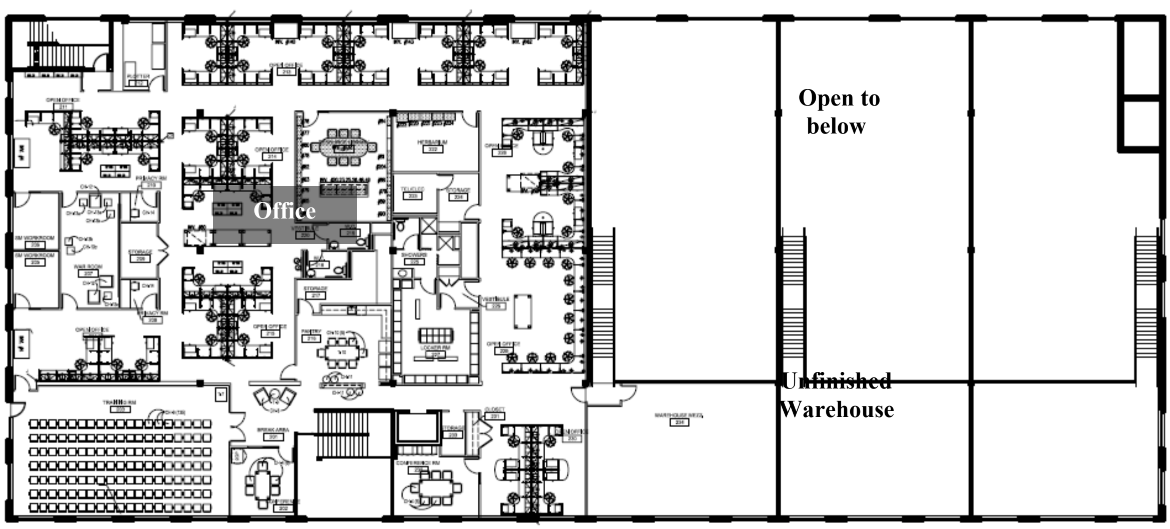


Figure 2-19
Second floor plan of WSSI
Source: Used with permission from WSSI

WSSI is located in the Virginia Gateway Development Park, near the junction of Interstate 66 and the Lee Highway, Route 29, in Gainesville, VA (Figure 2-20). Gainesville is a rapidly growing satellite community of the Washington, D.C. metropolitan area. The population was reported as 4,381 in the 2000 census and estimated to be 28,662 in 2009 (USCB, 2009). This area of northern Virginia is located at the foothills of the Appalachian Mountains. The foremost conservation areas of the region are Lake Manassas, the Occoquan Reservoir, and the Manassas National Battle Park.

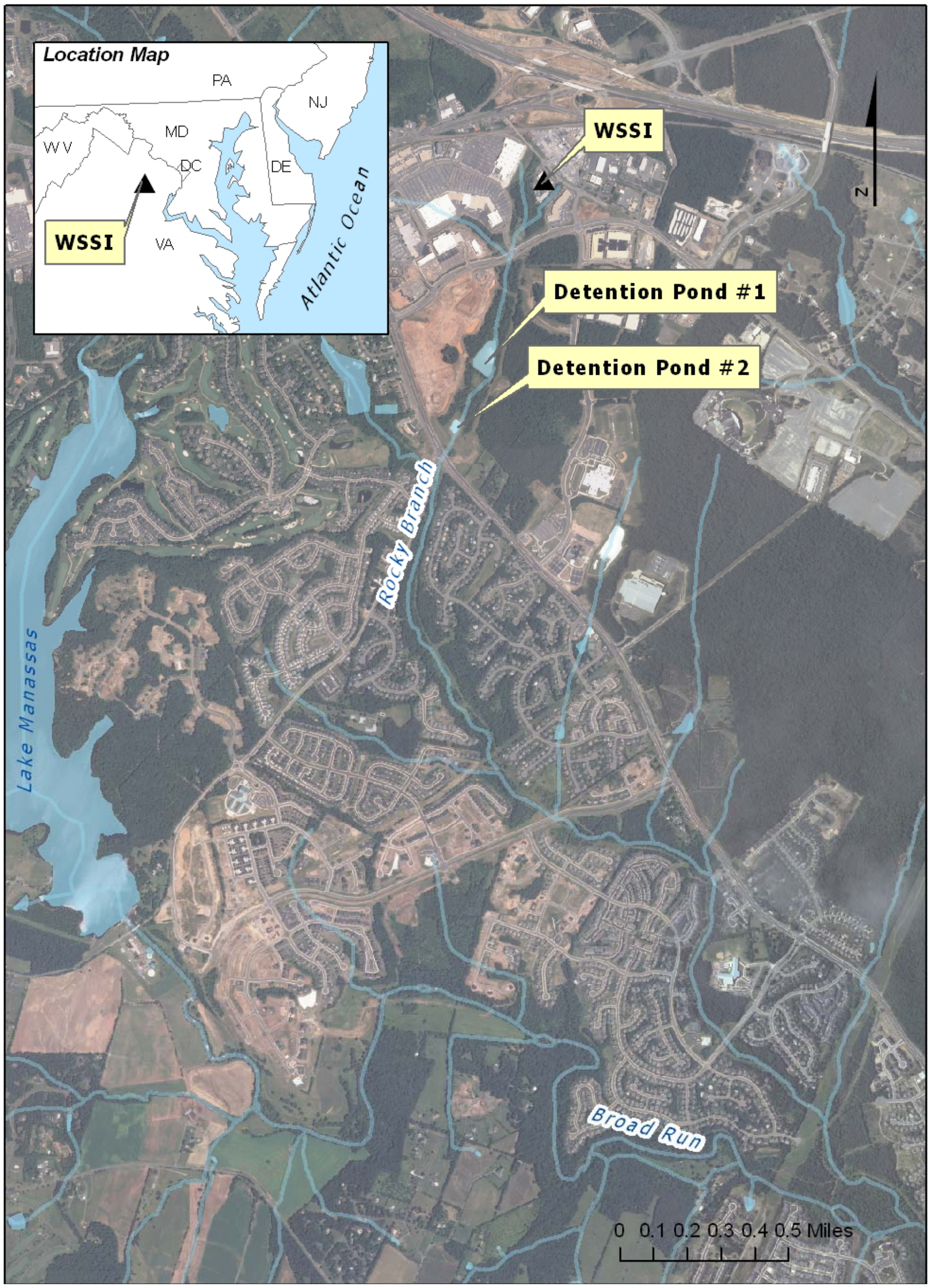


Figure 2-20
Location of the Wetland Studies and solutions, Inc. site

2.3.2 Local Water Use and Management

Similar to the Merrill Center, water conservation, while an important overall goal, does not appear to be the most significant local issue for the WSSI site. The more critical concern for this area is the effect of the wastewater effluent load and stormwater runoff on downstream water resources, which include several streams and rivers, and ultimately, the Chesapeake Bay.

2.3.2.1 Land Use and the Watershed

The land use in the Virginia Gateway Development Park is classified by the National Land Cover Dataset as medium intensity developed and high intensity developed (commercial) land (Figure 2-21)[4]. The medium intensity developed land includes areas with a mixture of constructed materials and vegetation, with impervious surfaces accounting for 50-79 percent of the total cover. These areas most commonly include single-family housing units. The high intensity developed land includes areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial or industrial complexes. A mix of low intensity development (residential), forest, and agricultural lands surround the Virginia Gateway Development Park (Figure 2-21). See Section 2.2.2.1 of this report for the definitions of land use types.

2.3.2.2 Drinking Water

Water is supplied to WSSI by the Prince William County Authority. The Authority has no sources of its own, but purchases from Fairfax Water and the City of Manassas. Discussions with representatives from Prince William County and the State of Virginia indicate that the county and state generally embrace water conservation. Although the county does not have green building requirements, there is an awareness of environmental conservation including a required limitation on landscape irrigation (odd/even days). However, as with the Merrill Center, water conservation does not appear to be the most significant issue. The recent economic slow-down and corresponding slowing of growth has relieved pressure on any need to expand the water or wastewater facilities.

2.3.2.3 Stormwater and Wastewater

There are two intermittent streams abutting the WSSI site on the SE and NW sides. These streams converge to form the Rocky Branch. The Rocky Branch flows into a Detention Pond #1 (Figure 2-20) south of WSSI. The stream then continues to flow southwardly to Detention Pond #2. Stormwater constituents settle within the detention ponds and then exit via a large culvert, the Rocky Branch Stream then flows approximate 2.5 miles into the Broad Run River.

The Broad Run River originates 13 miles to the northwest in Morgantown, Virginia**.** From its headwaters, the Broad Run flows through the Virginia country-side and into Lake Manassas. It then flows out of Lake Manassas at the Broad Run Dam, upstream from the confluence with the Rocky Branch. The Broad Run eventually converges with the Cedar Run River to form the Occoquan River at the Occoquan Reservoir.

The Occoquan Reservoir serves as a major source of drinking water for parts of Fairfax and Prince William Counties, VA (NVRC, 2009). After passing through the Occoquan Reservoir, the Occoquan River flows into the Potomac River and eventually to the Chesapeake Bay. For a description of the Chesapeake Bay, please see the Watershed Characterization for the Merrill Center.

[4] See Figure 3-9 in the impact assessment chapter of this report for a depiction of stormwater flows from the WSSI site.

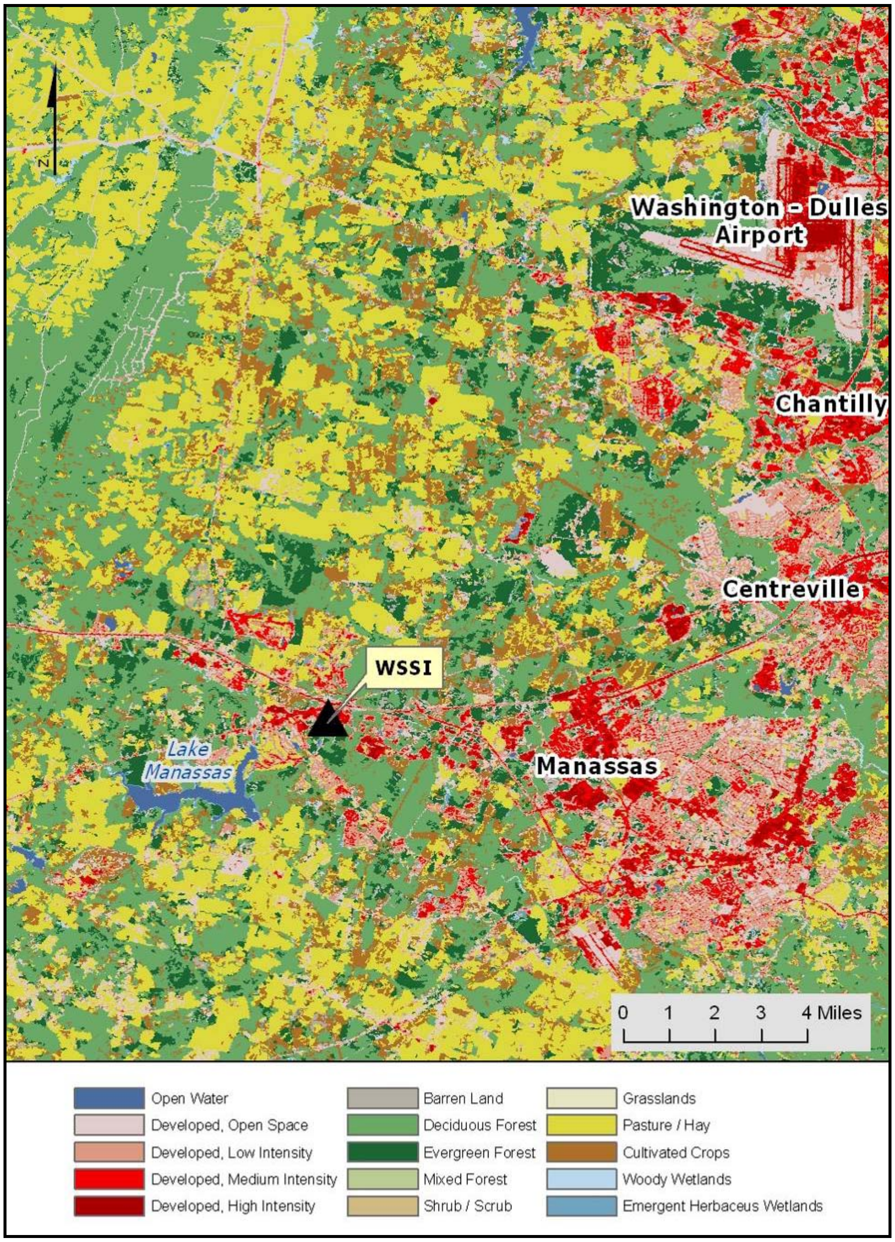


Figure 2-21
Map of Land use at the Wetland Studies and solutions, Inc. site

In 2006, the USEPA approved fecal coliform bacteria Total Maximum Daily Loads (TMDL's) for impaired water bodies within the Occoquan River Watershed (VADEQ, 2006). One of the bacteria-impaired segments (VAN-A19R-01) is located immediately downstream of the WSSI site. The TMDL report indicates that polluted runoff from agricultural areas (47.30 percent) and residential areas (34.1 percent) are the predominant sources of bacteria impairments in this segment of the Broad Run. The report further indicates that indirect bacteria loads from residential areas will dominate during wet weather conditions (VADEQ, 2006).

Numerous mammals, birds, and plants reside in the riparian areas of the Broad Run River Watershed. Many of these species are listed by the State of Virginia as “in need of conservation” (PECVA, 2009) and are affected by stream bank erosion, sediment deposition, changes in water quality, and the loss of natural riparian vegetation that degrades many streams in Northern Virginia. These impacts can be attributed in part to changes in land cover, runoff patterns, and stream flows associated with increased development. In addition, increased sediment loads resulting from the loss of natural riparian vegetation and construction in the Broad Run River Watershed are transported downstream, contributing to degradation of the Potomac River and Chesapeake Bay.

Figure 2-22
Location of the WSSI site and Rocky Branch Stream

Wastewater from the WSSI site is treated by the Upper Occoquan Service Authority (UOSA) and discharged to Bull Run. Discussions with several county and state staff indicate that reducing nutrient loading to both surface water bodies is a major local and state priority. UOSA has a state of the art phosphorus removal system and the treatment plant has a very strict phosphorus limit of 0.1 mg/L. Although nitrogen is also a factor in the reservoir and the Bay, the plant has a somewhat higher waste load allocation for nitrates because of the benefits of nitrate levels in the cold Bull Run water entering the reservoir and moving to the lowest sections where natural denitrification takes place and provides badly needed oxygen to this part of the reservoir.

2.3.2.4 Local and State Initiatives Addressing Water Management Priorities

Based on discussions with various County and State Public Health officials, popularity of reclamation and reuse of water is being driven by the lessening of available groundwater. As groundwater permits are becoming more difficult to obtain, the reuse of water is more attractive.

The Department of Conservation and Recreation reports moving toward requiring all new buildings to be LEED certified, and existing buildings to make improvements

With regard to onsite wastewater, septic system regulations went through major changes in the 1990s to move from a singular priority of protecting public health from exposure to sewage (a disposal-driven regulation) to regulations to protect the environment and groundwater aquifer.

These regulations are focused on reuse on the large scale (wastewater treatment plants) and do not address reuse or rainwater harvesting within a building.

2.3.3 Design and Construction Process

In 2004, officials at WSSI realized that their then-existing building in Chantilly, Virginia in Fairfax County could no longer accommodate expected growth. Jennifer Brophy-Price, Associate Engineer at WSSI, recounted that there was no available room for additional staff or summer interns, to the point where desk space was non-existent.

While conducting a site search for a new building, Rolband, familiar with both local County and private sector activity, learned that Prince William County, Virginia (PWC) had provided various concessions to other businesses for relocating to the County. He approached County officials and inquired about what could be offered to WSSI for relocating to PWC from Fairfax County.

Sean Connaughton, then the acting Chairman of the Board of County Supervisors (2000-2006), had previous experience working with WSSI on behalf of PWC and was receptive to Rolband’s request. According to Connaughton, at the time of WSSI’s proposed move, PWC was growing very rapidly and facing challenges to its school system, transportation, public safety, and other infrastructure. Counties in Virginia vary from the national norm in that they are responsible for funding and running their infrastructure — everything from schools, to water supply, to sewage treatment facilities. As a means of addressing future growth in a more responsible way, Connaughton had begun to look at measures for conservation, sustainable development, and aspects of Low Impact Development (LID), and was attempting to use his position as Chairman of the Board of Supervisors to educate the County and embed these strategies. From the side of environmental awareness, Connaughton was, like Rolband, a visionary.

He proposed to offer WSSI an expedited permitting process tailored to the type of development Rolband expected to build. The value of this proposition was considerable. First, it resulted in a more streamlined and comprehensive permitting process than would otherwise be granted to a more typical development. As a part of this offer, WSSI reported that PWC reduced the County Review fee by 50 percent and eventually waived all review comments relevant to the LID design features, including those around its atypical curb-and-gutter design. During the interview process, Rolband mentioned that without this expedited review; WSSI would have encountered significant permitting difficulties that would have limited the implementation of many of its green building features.

The building was conceived as a design-build project with the Peterson Companies in March of 2004. The Peterson Companies is a regional real estate and development firm that has partnered with WSSI on development projects for many years. Rick Peterson, president of the Peterson Companies, is a longtime personal and professional friend of Rolband. WSSI and the Peterson Companies have worked together on developing such projects as the National Harbor, a 534-acre, mixed-use entertainment complex in Prince George's County, Maryland and Virginia Gateway, a 417-acre, mixed-use project that neighbors WSSI. WSSI's role was to conduct wetland delineation, permitting aid, investigation, and assessment duties on these projects. In 2003, WSSI and the Peterson Companies established, as a business partnership, the Northern Virginia Stream Restoration Bank. The bank sells "Stream Condition Units", which are used to assess how much restoration work WSSI will conduct for projects deemed to degrade local stream quality.

Because of their high level of mutual professional trust and respect, WSSI is a preferred environmental consultant to the Peterson Companies. During an interview, Rick Peterson stated that "he [Mike Rolband] is one of the best business partners you could want to have." Peterson respected Rolband's combination of professional skills and his background in both business and science. Peterson was educated by Rolband on sustainability; Rolband had brought Peterson into the world of LID and LEED.

Rolband first broached the subject of WSSI's need for a new building with Peterson in 2004. This conversation led to a formal agreement to build a headquarters, with the Peterson Companies undertaking project management duties and Rolband leading the design process. The Peterson Companies had some limited experience with green buildings and saw this project as an opportunity to position themselves strategically as a leader in the green building sector, which Peterson recognized as a source of growth and future business. Like Rolband, he wanted WSSI to be a reflection of his company's commitment to green building. From Peterson, WSSI would receive a customized financial arrangement under which typical cash requirements that would have been demanded for other projects were, for WSSI, relaxed. This would not have been possible without this circumstance of trust since, as Peterson pointed out, the spreadsheet values for return on investment did not support moving forward. But Peterson leaped. Rolband planned for the new building to be owned, rather than leased, a first for WSSI.

During the interview process, when asked about financing for the project, Rolband expressed larger concerns about the potential financial barriers to developing green buildings. In fact, he uses his own construction and LEED process as a means of educating others; he has developed extensive illustrations of the hard costs of LEED, which he makes available through the WSSI website. Rolband contends that financing depends almost exclusively on market value and leasing potential. The additional value and leasing appeal of green building practices, such as marketability and improved quality of occupancy, may present even better prospects for future profitability, but may easily be unacknowledged and thus not rewarded with financing. Most banks are reluctant to allocate enough additional value to green building features to cover the associated extra costs.

After encountering initial difficulties in finding a lender, Rolband finally made contact with The National Life Group of Vermont, who were fully supportive of WSSI's green building intent and agreed to finance the project. Eventually, a site 35 miles west of Washington, D.C. in PWC was selected.

WSSI conducted the conceptual planning of the site's LID features while Urban Engineering served as the Civil Engineer charged with implementing them. W.A. Browne & Associates P.C. was the architect. Landscaping was designed and is currently maintained by KT Industries, while the Furbish Group conducts yearly green roof maintenance. Interim green roof maintenance is done by WSSI employees; many of their desks look out onto the green roof, and all of them enjoy its use.

As president of WSSI, Rolband served as the main decision maker and influenced all phases of the design and construction process. His scientific and financial training enabled him to understand both the financial and technical aspects of this project, a key combination. Project team meetings were held once a week for design and construction discussions. No public input or review was required, and none conducted.

LID was the guiding principle informing the building's design and its public image and goals. WSSI strives to promote its mission and values through its building. As Rolband said, "Our building is meant to be a statement of the purpose of our work."

Rolband provided significant design input at every stage of the process and created the conceptual LID plan. The new building was occupied on November 15, 2005, approximately 18 months after the start of conceptual design discussions — a fast track.

During the interview process, Rolband mentioned that he did not seek to have the WSSI building distinguish itself architecturally from other similar buildings. It was his intent to show that having a green building did not require an unconventional appearance or aesthetic. This strategy was meant to make green building and LID practices more accessible to others who would otherwise be reluctant to adopt seemingly "unusual" practices. In fact, until noticing the green roof and the LID practices surrounding it, the building looks like any standard suburban low-rise office building — unremarkable (Figure 2-23).

Figure 2-23
WSSI rendering
Source: Used with permission from WSSI

In separate interviews, Rolband and Peterson both referred to the Merrill Center example and spoke of the WSSI development as embodying the antithesis of the Merrill Center approach, which is more architecturally unique. This building's structure consists of a steel frame, concrete roof, and floors cast on metal deck, as well as a building envelope made with tilt-up walls — a structural prototype for a medium-sized suburban office building. As a result of the building not distinguishing itself as "green" at a glance, it did not attract the immediate recognition that a more architecturally impressive, customized building would. One reason Rolband decided to pursue LEED certification was the need — which he perceived as a business as well as an environmental need — for public recognition for WSSI's green building investments.
The image below shows the building after the exterior envelope was completed (Figure 2-24).

Figure 2-24
WSSI aerial view
Source: Used with permission from WSSI

2.3.4 Green Building Rating

Obtaining LEED certification was not initially a priority. The funds required to achieve LEED certification were preferred for other uses. Originally Rolband aimed to “build to LEED standards” but not to certify. Design of the building was primarily guided by LID principles; the project also looked to its own institutional principles for guidance. LID was very important because it is consistent with the work carried out by WSSI, and was thus linked to WSSI’s business goals and growth. The building was meant to be a case study exhibit of LID principles for the wider world, but also for potential WSSI clients. Throughout the case study investigation, Rolband expressed a commitment to LID principles and to the use of his project site as a laboratory for LID experimentation and public education.

At the time of construction, LEED was seen as the only viable rating system for third-party verification. Green Globes was considered briefly but was deemed undeveloped and lacking in market recognition. Because the goal of such a third-party certification was publicity and recognition, LEED proved to be the only choice.

Rolband commented that the LEED rating system exhibits a design preference for urban rather than rural building sites — high versus low density sites — which might discourage a project such as WSSI from pursuing LEED. Of special concern was the low point value assigned to LID associated credits. Rolband felt that the system did not properly address erosion and rural water management needs associated with this project. While it could be said that part of the reason for this was that the project sought certification under LEED for Commercial Interiors (LEED-CI), this study’s section on Green Building Rating Systems will examine the question of whether even under LEED for New Construction (LEED-NC), LID practices are given the full measure they are due for their larger watershed benefits. Overall for WSSI, only two points were awarded (CI SSc1) in return for approximately $620,000 WSSI spent on LID water management features. Rolband noted ruefully that the bicycle rack, an inexpensive amenity, provided the equivalent of half of all the LID points the project gained under LEED-CI. For these and other reasons, LEED was not pursued until the project was under construction, and Rolband reluctantly understood that certification was necessary for public recognition. “People kept asking me, what rating is it going to get? What rating is it going to get? I finally had to do something about it,” he said.

Because certification was needed to obtain the full publicity value of WSSI’s green intent and monetary investment, and because this was decided after the start of construction — when the building already consisted of a warehouse core and shell — Rolband decided to pursue LEED-CI as the more certain path to achievement. WSSI recognized that LEED certification results in a number of business benefits not clearly quantifiable at the design stage. It grants the project more visibility within the green building community, and its status would attract potential employees as well as clients, according to Rolband.

In 2006, WSSI became the first LEED Gold rated project in Virginia.

After completing the certification process, WSSI conducted an assessment to determine and document the cost of LEED Certification. The total building cost was $5,696,100, of which $697,060 were expenses associated with LEED certification. These expenses effectively represented 12.2 percent of total building costs for the LEED Gold building. Rolband makes all this information publicly available on the WSSI website. The following tables detail the LEED-CI credits obtained by WSSI and their costs (Table 2-4).

Table 2-4
LEED point breakdown by credit & cost premium

	Name	Points Attained	Premium	$/Credit	Methods & Techniques
	Sustainable Sites				
SSc1	Site Selection	1	$260,590	$86,863	Heat Island Reduction
		1			Stormwater Management
		0.5			Water Efficient Irrigation
		0.5			Light Pollution Reduction
SSc3.2	Bicycle Storage & Changing Rooms	1	$51,490	$51,490	Bicycle Storage and Changing Rooms
	Category Subtotal	**4**	**$312,080**	**$78,020**	
	Water Efficiency				
WEc1.1 & 1.2	Water Use Reduction	3	$6,100	$2,033	Achieved 50.6% water use reduction, 30% required
	Category Subtotal	**3**	**$6,100**	**$2,033**	
	Energy and Atmosphere				
EAp1	Fundamental Commissioning	Required	$17,000		
EAp2	Minimum Energy Performance	Required	$29,675		
EAp3	CFC Reduction	Required	$4,000		
EAc1.2	Lighting Controls	1	$15,850	$15,850	Supply Daylight
EAc1.3	Optimize Energy Performance HVAC	1	$18,100	$18,100	Use 17.8% less energy than baseline
EAc1.4	Optimize Energy Performance , Equipment and Appliances	2	$0	$0	Use 92% ENERGY STAR rated appliances
EAc3	Measurement and Payment Accountability	2	$6,700	$3,350	Supply continuous metering equipment to verify building energy consumption over time
EAc4	Green Power	2	$7,600	$3,800	Purchase "Green Energy Credits" for 100% of the buildings energy consumption for 2 years (2,000,000 kWh total)
	Category Subtotal	**8**	**$98,925**	**$12,366**	

Table 2-4
LEED point breakdown by credit & cost premium (continued)

	Name	Points Attained	Premium	$/Credit	Methods & Techniques
	Materials and Resources				
MRp1	Storage and Collection of Recyclables	Required	$4,450		Provided recycling spaces/receptacles
MRc1.1	Long-term commitment	1	$0	$0	Signed a 15 yr lease agreement on the building.
MRc4.1	Recycled Content	2	$26,860	$13,430	Using 26% recycled content in the interior spaces, 10% required
MRc5.1	Regional Materials	1	$7,560	$7,560	Purchasing 35% of the building materials from regional manufacturers, 20% required
MRc6	Rapidly Renewable Materials	2	$5,025	$2,513	Using 11.75% rapidly renewable materials in the interior spaces, 5% required
	Category Subtotal	**6**	**$43,895**	**$7,316**	
	Indoor Environmental Quality				
IEQp1	Minimum IAQ Performance	Required	$24,931		Comply with ASHRAE Standard 62.1-2004
IEQp2	Tobacco Smoke Control	Required	$0		No smoking within 25 feet of building OA intakes & entrances
IEQc1	Outdoor Air Delivery Monitoring	1	$3,750	$3,750	
IEQc2	Increased Ventilation	1	$28,681	$28,681	
IEQc3.1	IAQ Management Plan	1	$3,300	$3,300	Implement indoor air quality management plan during construction.
IEQc4.2	Low Emitting Paints and Coatings	1	$1,400	$1,400	
IEQc4.3	Low Emitting Carpet Systems	1	$2,550	$2,550	
IEQc4.5	Low Emitting Furniture and Seating	1	$5,025	$5,025	
IEQc6.1	Controllability of Lighting Systems	1	$10,500	$10,500	
IEQc6.2	Controllability of Temperature and Ventilation Systems	1	$24,931	$24,931	
IEQc7.1-7.2	Thermal Comfort	2	$22,681	$11,341	
IEQc8.1	Daylight and Views	1	$0	$0	
	Category Subtotal	**11**	**$127,749**	**$11,614**	
	Innovation and Design				
IDc1	Demonstration Project	1	$3,000	$3,000	
IDc2	LEED AP	1	$250	$250	
	Category Subtotal	**2**	**$3,250**	**$1,625**	
	Total	**34**	**$591,999**	**$17,412**	

Source: LEED Application and data provided by WSSI

The above total does not take into account expenses per credit related to additional project documentation and consulting fees. Table 2-5 provides a more complete estimate.

Table 2-5
LEED cost summary

Credit Category	Credits	Premium	$/Credit
Sustainable Sites	4	$312,080	$78,020
Water Efficiency	3	$6,100	$2,033
Energy and Atmosphere	8	$98,925	$12,366
Materials and Resources	6	$43,895	$7,316
Indoor Environmental Quality	11	$127,750	$11,614
Innovation and Design Process	2	$3,250	$1,625
Documentation, Paperwork, and Consulting Fees	34	$111,900	$3,291
Total LEED Certification Premium	34	$703,900	$20,703
Total Building Cost	$5,696,100		
% Premium	**14.10%**		

Source: LEED Application and data provided by WSSI

A brief review of the water, electricity, and gas utility savings related to installed LEED components with the exception of those related to the LID plan offer both significant savings, in the 30-50 percent range, and reasonable payback periods within the expected lifetime of each component. Overall, all implemented utility reducing measures with the exception of the LID components are projected to pay for themselves within 8 years or less. Measures implemented to reduce electric and natural gas consumption are expected to yield $28,896 in yearly savings alone and also present the shortest payback period at approximately 5.5 years. Electric and natural gas consumption represents nearly 90 percent of WSSI's utility expenses. With regard to energy utility costs, these measures present themselves as the most cost effective from a purely economic point of view.

The LID systems which present the longest payback period possess additional value beyond simply a reduction in utilities cost. They hold additional value as both a marketing tool to current and prospective clients, as well as function as an on-site test case for the future use of these systems, as initially intended. See Table 2-6 for a LID cost summary.

Table 2-6
LID cost summary

LID Feature	$/s.f. Impervious	Cost
Rain Garden	$2.60	$90,000
Cistern	$1.23	$31,000
Green Roof	$31.80	$115,316
Pervious Concrete Pavers	$7.90	$39,000
Gravel Pavement	$4.32	$5,500
GravelPave2 System	$6.00	$143,500
Pervious Concrete	$6.00	N/A
Gravel Bed Detention	$0.32	$24,000
Swale	$3.68	$46,525
Native Landscaping & Drip Irrigation	N/A	$125,864
Total		$620,705
Standard Asphalt/Curb and Gutter Estimate		$360,115
LID Cost Premium		**172%**

2.3.5 Sustainable Water Management Features

WSSI incorporated a number of practices that were projected to reduce interior potable water use by an estimated 50 percent. This reduction was achieved primarily through the use of low flow flush and flow fixtures — through fixture efficiency. Additional reductions have been made through the installation of a cistern for rainwater collection and reuse, which is used exclusively for flush water. See Figure 2-25 for depiction of WSSI's stormwater flows at a glance. The cistern was installed in March of 2009. Please refer to the impact analysis for detail on actual performance.

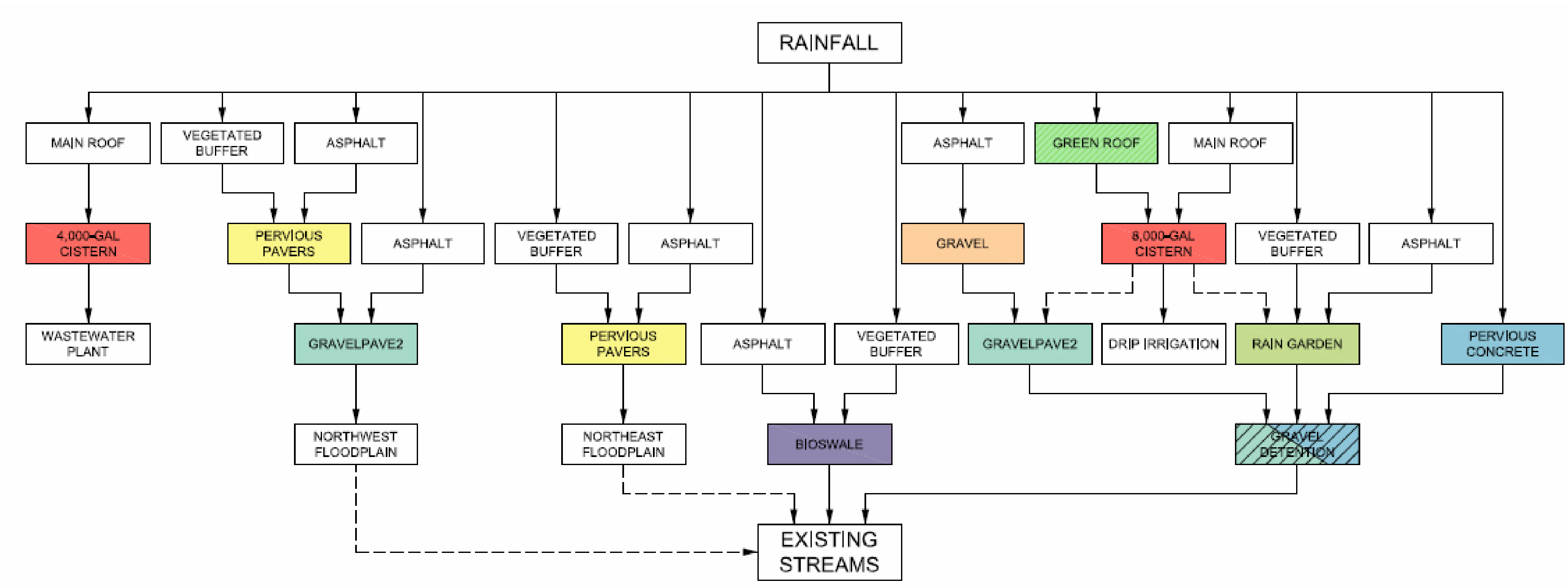


Figure 2-25
WSSI stormwater flows at a glance
Source: Used with permission from WSSI

2.3.5.1 Toilet Cistern

The 4,000-gallon cistern collects roof runoff for flush fixture use (Figure 2-26). The local health department initially prohibited its use unless the water was treated to tertiary standards. WSSI revisited the project two years later and new staff at the Health Department permitted a lower level of treatment, sediment and solid removal through a vortex filter. The Cistern was not installed until March 2009. PWC's Department of Health required that the cistern's water outflow be metered to charge appropriately for sewage services.

County officials required that clear signage be posted above every toilet to indicate that the water is non-potable. The cistern is projected to be empty only 4 days/yr, and any overflow water is routed to an underground cistern. In conjunction with the use or waterless urinals, WSSI has effectively eliminated all potable water use for flush fixtures.

Remaining fixtures such as bathroom sinks, kitchen sinks, and showers are low flow and sensor controlled where appropriate. In its present state, WSSI has reduced its potable water use beyond the LEED documented 50 percent potable water use reduction, which was attained before the installation of the toilet cistern. Wastewater is processed by the local wastewater treatment plant, rather than on-site.

Figure 2-26
Indoor cistern
Source: Used with permission from WSSI

WSSI was initially motivated to reduce potable water use due to its commitment to water use BMPs; however, it did conduct a cost premium, utility savings assessment for the implemented water reduction strategies.

2.3.5.2 Gravel Bed Detention System

The project includes a variety of LID features, such as various types of impervious paving as well as stormwater quantity and quality treatment methods (Figure 2-27).

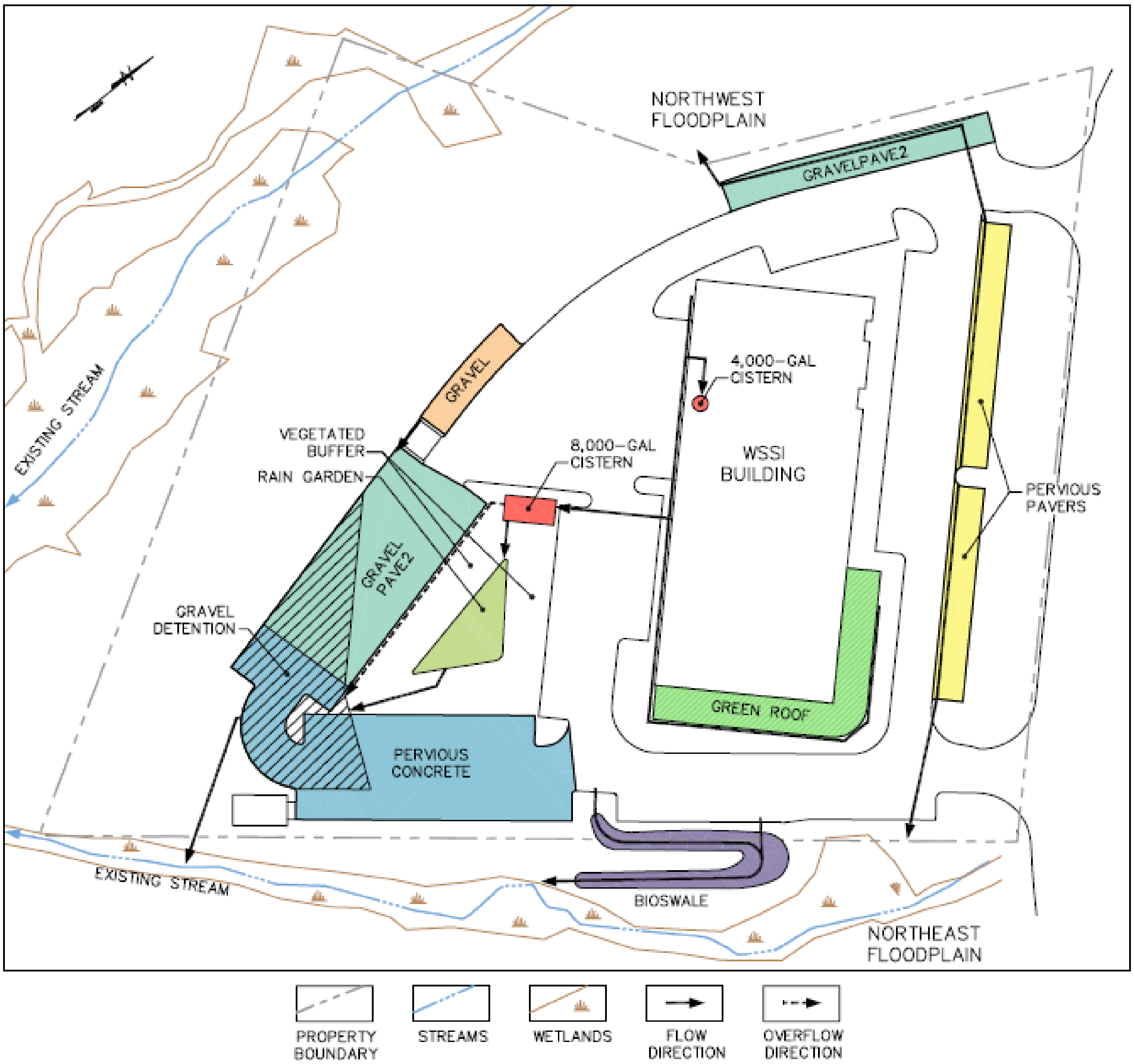


Figure 2-27
Exterior water management features and flow regime plan
Source: Used with permission from WSSI

The 10,513 c.f. gravel bed detention system is the largest component of WSSI's stormwater management plan. It collects runoff from the roof, parking, and rain garden areas. It also functions as an overflow reservoir for other stormwater management subsystems and is connected to the various parking surfaces through a system of underdrains. To assist with controlling the velocity of stormwater, it is sized to retain the volume of water associated with a 1-year storm and then release it over a 24-hour period at a slow speed and acute angle to an existing stream's flow path through a 1.65-inch pipe sized specifically for this purpose. This approach minimizes stream erosion.

2.3.5.3 Pervious Parking Surfaces

The WSSI parking area is composed of 29,979 s.f. of a variety of pervious parking surfaces and 55,896 s.f. of conventional asphalt (Figure 2-28). Asphalt parking surfaces drain primarily to the gravel bed detention system, and then the bioswale or floodplains located to the north of the site. The company, in the spirit of experimentation, decided to use a mix of pervious parking techniques to conduct on-site case studies and evaluate the successes of each (Table 2-6).

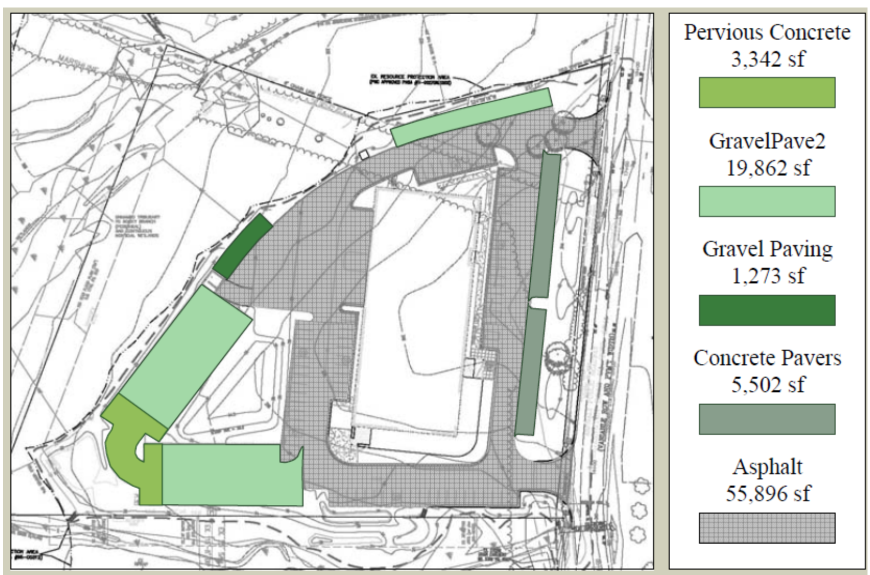
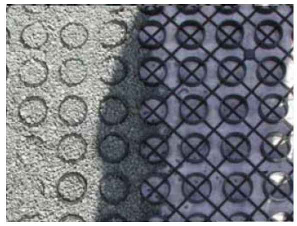


Figure 2-28
Pervious parking surfaces
Source: Used with permission from WSSI

Table 2-7
Parking surfaces

			
Pervious Concrete	**GravelPave2**	**Gravel Paving**	**Concrete Pavers**

Source: Used with permission from WSSI

The pervious parking areas are paved with 1,273 s.f. of typical gravel and 19,862 s.f. of GravelPave2, a product that provides a filter fabric backed mesh to hold gravel in place. These surfaces are highly permeable and drain directly to the gravel layers below the surface. Standard gravel paved parking was only intended for infrequently used areas for WSSI equipment, such as trailers and All-Terrain Vehicles. The GravelPave2 area is located to the rear of the site. Areas paved with these two systems also collect runoff from the impervious asphalt parking areas and drain into the gravel bed detention area.

The two more permanent pervious parking surfaces include 3,342 s.f. of pervious concrete and 5,502 s.f. of concrete pavers. The pavers contain spaces within the joints, which effectively amount to 10 percent open space and are filled with gap graded gravel that allows infiltration into the gravel bed below.

Due to the site's high clay content and limited infiltration capacity, all parking areas contain underdrains that channel water to the gravel bed detention area. Some issues have been encountered with the gravel parking areas, such as gravel migration and inconsistent coverage. In retrospect, WSSI indicated that they would have preferred to use more concrete pavers and less gravel. Maintenance costs and considerations would have been fewer, since gravel systems proved less consistent in their performance, and installing the concrete pavers was actually at lower cost than initially estimated by the contractor.

2.3.5.4 Rain Garden

The rain garden provides 1,536 s.f. of vegetated area for stormwater collection and pollutant filtration. It receives runoff from the surrounding asphalt parking area and indirectly from the roof through an 8,000-gallon cistern buried below grade within the garden. The soil and plant composition filter the runoff before it is directed to the gravel bed detention area (Figure 2-29), and then back to the neighboring stream. It is populated with vegetation appropriate for occasional flood conditions, has pleasing aesthetic qualities, and aids in pollutant filtration. Success of the rain garden required that a curb not be installed at the parking area's perimeter; this exception to local codes for vehicular parking was made possible through the expedited permitting process granted to WSSI (Figure 2-29).

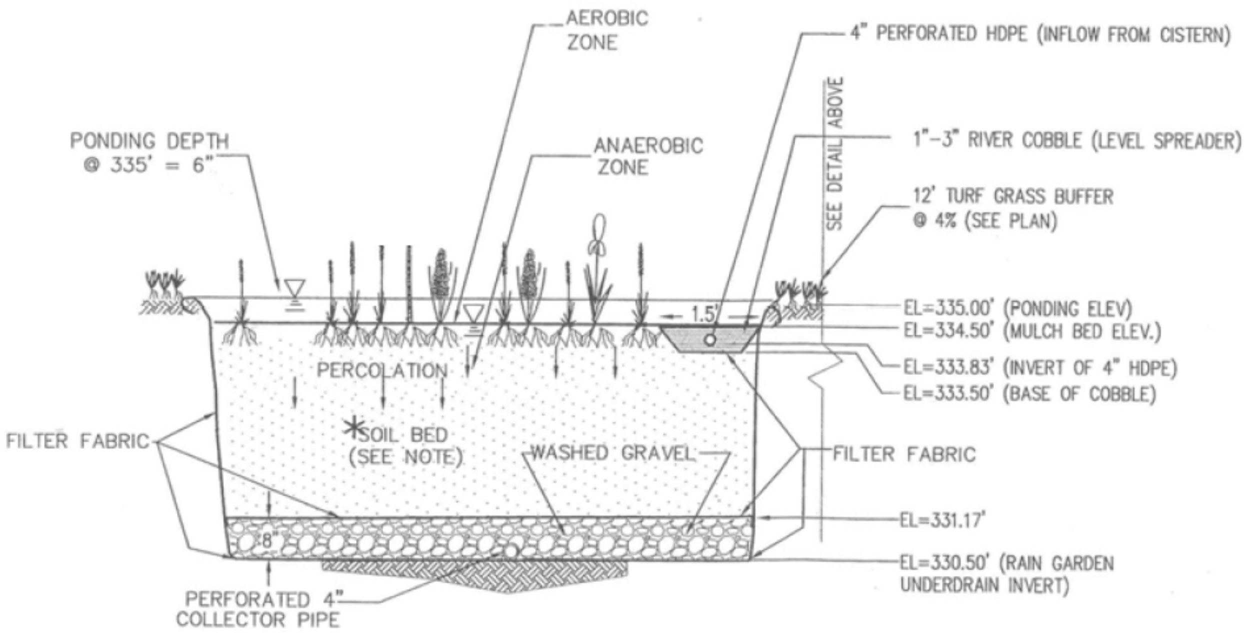


Figure 2-29
Rain garden section
Source: Used with permission from WSSI

Figure 2-30
Rain garden
Source: Used with permission from WSSI

2.3.5.5 Rain Garden Cistern

Within the rain garden, WSSI installed an 8,000-gallon cistern that collects roof runoff, which is then used to irrigate vegetation through a highly efficient drip irrigation system. Using this system results in the reuse of captured nutrients contained within the runoff, which are then fed to the site vegetation and prevented from entering the local streams. The cistern also collects overflow water from the indoor cistern and itself overflows to the rain garden and then to the gravel bed detention system (Figure 2-31).

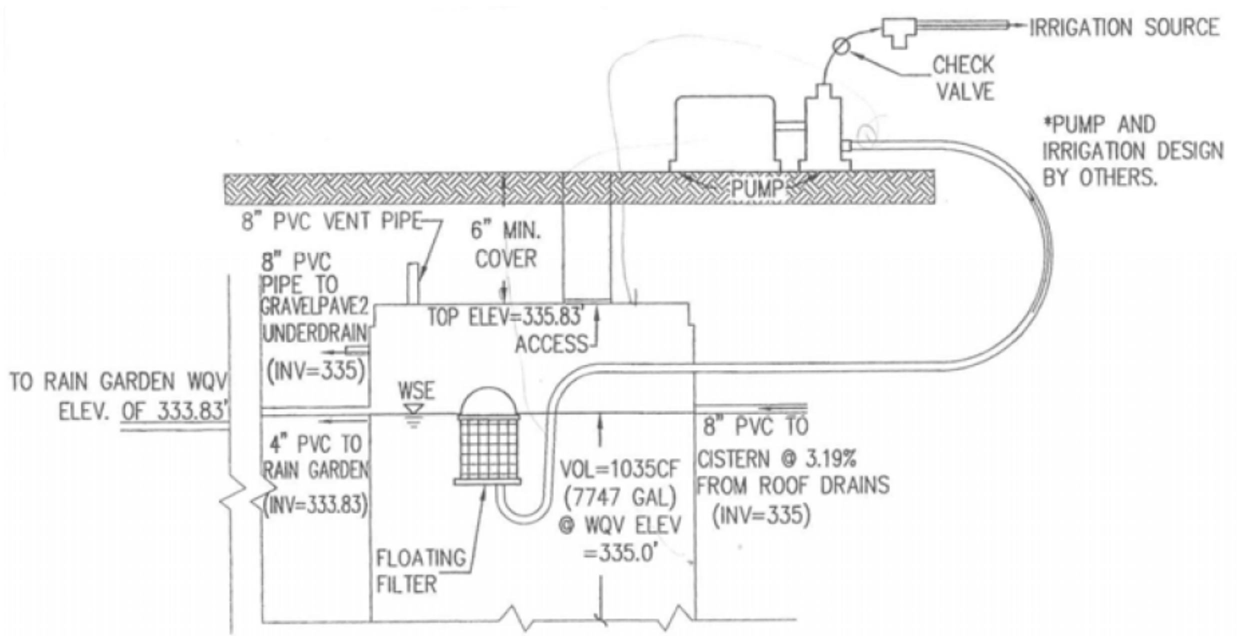


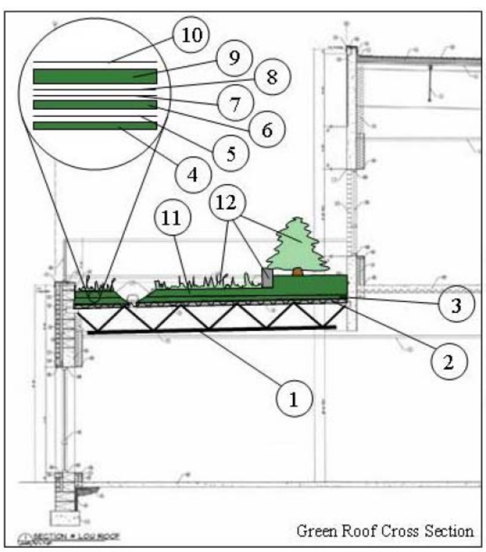
Figure 2-31
Rain garden cistern detail
Source: Used with permission from WSSI

2.3.5.6 Green Roof

As a part of its roof runoff collection systems, the WSSI building has a 3,626 s.f. green roof located above the first floor corrugated roof deck (Figure 2-32). It contains both intensive, less than 4” soil depth, and extensive, greater than 4” soil depth; sections covered in vegetation; as well as patios and a small constructed wetland. A conference room on the second floor opens to the green roof, which is also visible from various offices.

Figure 2-32
Green roof photo & plan
Source: Used with permission from WSSI

To guarantee impermeability to the building interior, the first floor roof was covered with layers of protection board, membrane, root barrier, insulation, and drainage (Figure 2-33). Because the team chose native and site-specific green roof vegetation, it neither needs nor has any permanent source of irrigation. Rain overflow from the green roof flows into the rain garden cistern, which is used for occasional watering.



1. Steel joist
2. Metal roof deck
3. 5" R-30 foam insulation
4. ½" gypsum protection board
5. 75 mil ethylene propylene diene monomer (EPDM) membrane
6. ½" foam protection board
7. 40 mil high-density polyethylene (HDPE) root barrier
8. Protection fabric
9. 1" drainage layer
10. Filter fabric
11. 3-9" lightweight growing medium
12. Stone features, sedum, and native perennials and shrubs

Figure 2-33
Green roof section
Source: Used with permission from WSSI

2.3.5.7 Bioswale

The swale is located on the eastern perimeter of the parking area and collects runoff from 12,650 s.f. of impervious asphalt parking surface. It is 265 linear feet and serves to slow and filter pollutant runoff as it progresses through vegetation media and a series of check dams and eventually into the stream (Figure 2-34 and 2-35).

Figure 2-34
Swale
Source: Used with permission from WSSI

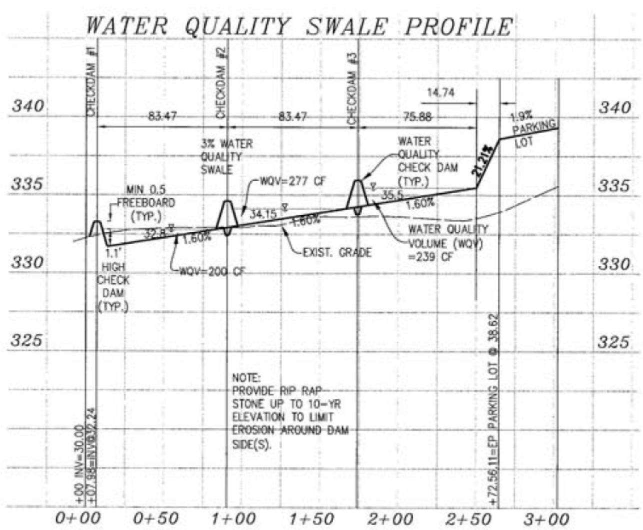


Figure 2-35
Swale profile
Source: Used with permission from WSSI

2.3.6 Challenges in Design and Implementation

As mentioned previously, WSSI faced a number of challenges, which were addressed through the participation of individuals — by temperament, training, or assignment — prepared to take on a project as ambitious as WSSI. Three circumstances made this an atypical project. First, initial financing is not readily available for projects such as this, a challenge overcome with the help of the Peterson Company. Secondly, it is rare to find a developer willing to include as much client input as Rolband sought to provide. Third, a municipal permitting office as receptive and relatively quick to act as PWC is not the typical case. All three situations required partnerships with receptive companies and local government officials who already understood the significance of green building. This involvement led to National Life providing the financing, and the Peterson Companies contributing preferential project management.

While it did receive a streamlined and significantly simpler permitting process, WSSI still faced a number of challenges from PWC. Existing staff at the permitting office were unfamiliar with many of the LID techniques and did not understand how to evaluate them. Enforcement of county code requirements would have invalidated a number of LID efforts. For instance, enforcement of standard curb and gutter requirements would have invalidated the full use of the swale and rain garden. The greatest regulatory resistance was with regard to the toilet flushing cistern. The Department of Health initially prohibited WSSI from proceeding with installation and eventually required that it treat the roof runoff to tertiary standards. It was not until four years after the building was completed that the cistern was operated as originally intended.

Deciding to begin the LEED Certification process after construction had already started resulted in complications with construction material waste stream management, which typically requires that a plan be established during the design phase. In addition, the already installed HVAC equipment was not fully compliant with LEED standards and required additional work. The assumption to "build to LEED standard without certifying" to save money revealed the actual value of green building certification. In the end, it was a necessary component to gain full public recognition for green building efforts.

2.3.7 Lessons Learned

The development process of the WSSI facility reveals the importance of having a well-organized team committed to the principles of green building. Green building is a comprehensive process that spans financiers, designers, developers, engineers, builders, contractors, building occupants, local government, and consultants. Beyond vision, the following were critical to the success of the WSSI project:

- A lender who is able to recognize the additional value of the green building techniques invested within the project.
- A municipal authority that can accurately assess and permit green building techniques, thus minimizing financial and regulatory barriers to their spread.
- A committed leader providing oversight throughout the construction process to ensure compliance with all LEED required construction practices and waste management methods.

Mike Rolband believes that in retrospect, the LEED certification process should have been initiated at the conceptual stage of the process. This early beginning would have facilitated the organization of documentation, as well as eased the auditing process. This level of documentation may also be used as a reference and point of education for others.

With regard to specific design features, WSSI determined that while the extensive green roof they installed is beautiful, it is highly cost inefficient. They believe it accounted for approximately 20 percent of all funds spent on LID initiatives — $115,316 — and did not provide a proportionate stormwater benefit. A simpler green roof, with less soil depth, would have been a more financially responsible alternative.

Use of low flow fixtures rewarded the project with three LEED points and also reduced water utility expenses. The only complication created by the use of water-saving features came from waterless urinals. They require that the cleaning contractor be trained to appropriately clean them to maintain effectiveness.

Installation of the concrete pavers was very successful and came in below the projected estimate ($16.00/sf estimated vs. $7.10/sf installed). In retrospect, WSSI would have preferred more of it in place of the GravelPave2 system. The cistern system would have been a better investment if gray water use had been permitted by the County; currently it remains full throughout the winter. The gravel bed detention area accomplished its intended purpose and was deemed a success.

As part of the LEED certification process, WSSI entered a two-year contract to purchase renewable energy, which proved to be an economical way of obtaining two LEED points. Favorable local market prices for renewable energy proved this a good business decision. WSSI is also currently in the process of collecting water use data from both cisterns, which it will use to further evaluate its systems.

2.3.8 Continuing Impacts

As a community resource, the building is accessible to visitors and local businesses. It hosts the County’s Green Breakfast Group monthly and also allows local businesses to hold events. Both are held in the large second floor conference room, which looks out onto the verdant roof.

WSSI now serves as a local green building knowledge base for PWC. As a result of having to evaluate the project, a number of County officials are now familiar with LID design principles. WSSI is currently working with the state and local government to facilitate greater understanding of green building techniques. The building currently serves as an example and teaching resource for the Northern Virginia Regional Commission, which is working to issue LID recommendations for the region.

2.4 Millennium Tower Residences

2.4.1 Building and Site Description

Millennium Tower Residences is a luxury, high-rise residential building located in Battery Park City (BPC), just north of the Battery, the area comprising the southern tip of Manhattan. Fifty years ago, the land for BPC did not exist. It was built on fill, using dirt and rocks excavated during the construction of the World Trade Center and other construction projects, as well as from sand dredged from New York Harbor just off Staten Island (Howe, 1982). It now covers 92 acres of former Hudson River swampland (see Figure 2-36 for a location map).

BPC is a planned community with pocket parks, a Hudson River esplanade, the World Financial Center and numerous housing, commercial, and retail buildings. The population of BPC is dense; as of the 2000 Census, there were 7,951 people residing in only 0.2 square miles (USCB, 2000). When fully developed, the BPC neighborhood is projected to have 14,000 residents (Hughes, 2007).

As one of the southernmost buildings in BPC, Millennium Tower Residences overlooks the New York Harbor and the Statue of Liberty. Brick-clad and 35-stories tall, the building houses 234 residential condominium units and a doorman. The property site is 22,610 square feet, and the building area is 442,099 square feet. The units have 9-foot floor-to-ceiling heights and are available as one-bedroom, two-bedroom, three-bedroom, and four-bedroom apartments. Millennium Towers is 100 percent occupied, and 96 percent of its approximately 560 residents regularly live in the building. The building officially opened in January 2007. The building was one of the first "green" buildings to be constructed in NYC since September 11th without the use of government incentives (New York State Department of Environmental Conservation, 2009).

Millennium Towers was one of the first residential buildings in the city to achieve a LEED Gold rating and it exceeds current New York State codes. The Millennium Tower's LEED Gold certification plaque is proudly displayed on the exterior façade of the building. It is one of the few visual clues that this is a sustainable building, which otherwise looks like a conventional, sleek luxury high-rise (see Figure 2-36).

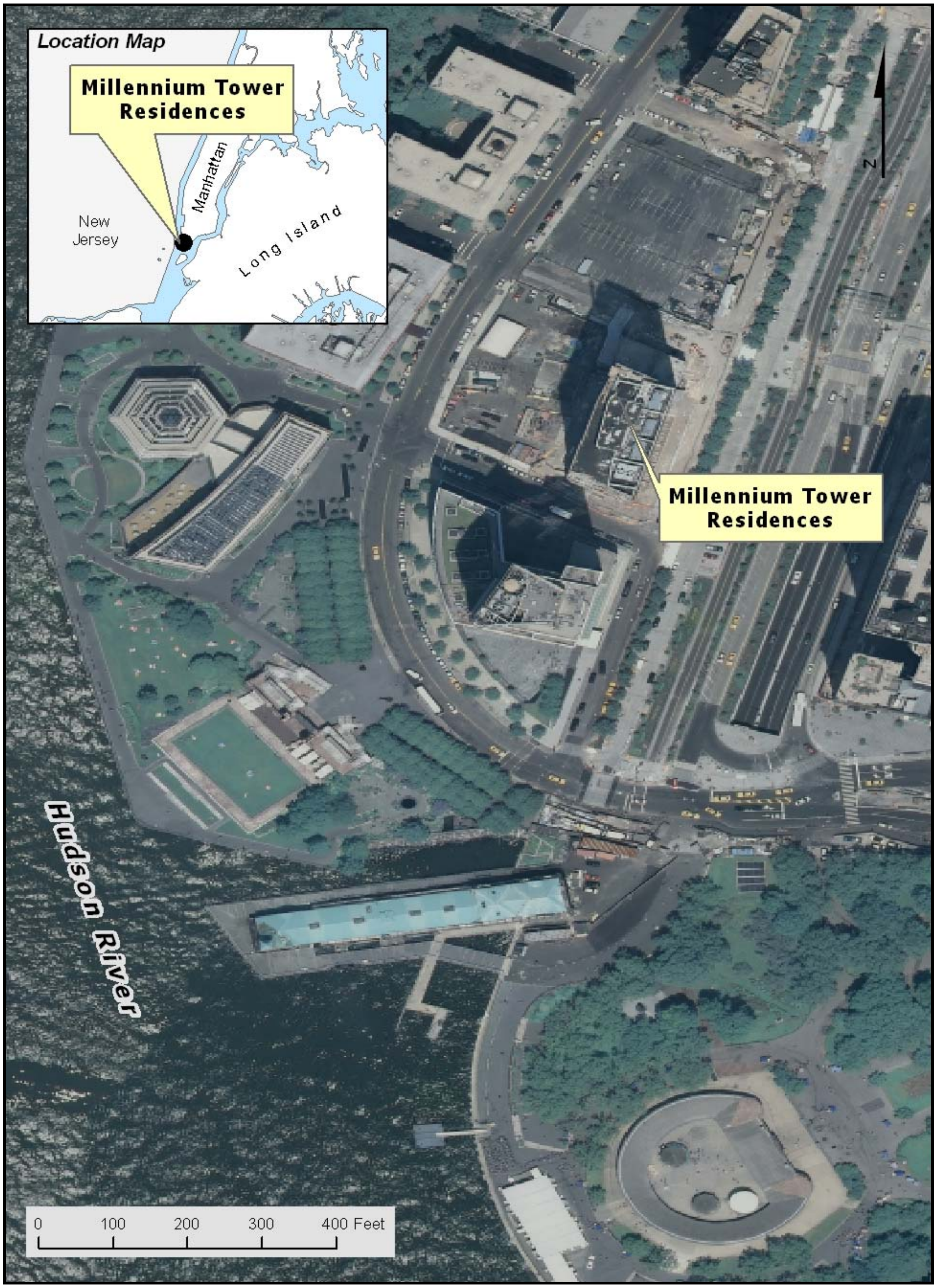


Figure 2-36
Location of the Millennium tower residences site
Source: Contains information copyrighted by the New York State Office of Cyber Security and Critical Infrastructure Coordination, 2009.

Figure 2-37
Millennium tower residences, LEED gold certification plaque and view

The Millennium Tower Residences is owned and operated by Millennium Partners, developers who specialize in service-oriented, concierge-type apartment developments. The building was designed by Handel Architects, a Manhattan architectural firm. Handel Architects and Millennium Partners have a history of involvement as they have worked together on many projects prior to Millennium Towers. The general contractor was Gotham Greenwich Construction Company, LLC – the same contractor used for the Solaire, which essentially served as a model for Millennium Towers. Table 2-8 provides a summary of the key stakeholders and their role in the design and operation of the Millennium Tower Residences. Subcontractors included a leader in the sustainable industry: Applied Water Management.

A key feature of buildings in BPC is onsite blackwater reuse. Millennium Tower Residences has a 25,000 gallon per day (gpd) design capacity blackwater reuse system housed in the basement of the building. The onsite blackwater reuse plant was designed by Applied Water Management, a subsidiary of American Water, who won the design contract in 2005 and completed construction in 2007. Viridian Energy and Environmental served as the LEED consultant for this project.

Table 2-8
Key Stakeholders in millennium tower residences

Stakeholder	Role in Millennium Tower Residences	Key Contact
Battery Park City Authority	Land owner and project reviewer	Susan Kaplan
Millennium Partners	Operates Millennium Tower Residences	Mark O'Reilly
Handel Architects	Designed Millennium Tower Residences	Rick Kearns
Applied Water Management	Designed and currently operate onsite blackwater reuse system	Gary Lohse
		Andrew Larson
WSF Flack + Kurtz	Provided mechanical engineering	N/A
DeSimone Consulting Engineers PLLC	Provided structural engineering	N/A
Gotham Greenwich Construction Company, LLC	Provided construction management	N/A
Steven Winter Associates	Served as green consultants	N/A
Viridian Energy and Environmental	Served as LEED consultants	Natalie Terrill

2.4.2 Local Water Use and Management

Land use in the area is classified mainly as high intensity developed land with patches of developed open space (parks) (Vogelmann et al., 2001). The environmental challenges associated with such high density development are substantial. In contrast to the previous two case studies, the primary water management challenge facing BPC is the capacity of the combined sewer system and water quality problems associated with combined sewer overflows (CSOs).

2.4.2.1 Land Use and Watershed

Land use in BPC is classified mainly as high intensity developed land with patches of developed open space (parks) (Vogelmann et al., 2001). Examples of high intensity developed land include apartment complexes, row houses, and commercial/industrial areas. Impervious surfaces account for 80 to 100 percent of the total land cover (Vogelmann et al., 2001). The large expanse of impervious surfaces in NYC raises significant water quantity and water quality issues for water resource managers.

New York Harbor is located at the mouth of the Hudson River Estuary, which was historically one of the most productive estuaries on the Atlantic Coast of the United States (NYCDEP, 2009a). The growth of NYC severely degraded water quality and habitat for resident aquatic organisms, particularly in the 1950s. Since then, pollution control efforts have resulted in widespread environmental improvements (Stoddard et al., 2002). Heavy metals discharge from regulated businesses has decreased from 2,000 lb/day to 37 lb/day in the period from 1987 to 2007. Despite these improvements, the harbor and surrounding waters remain impaired, mainly due to the discharge of untreated wastewater and stormwater runoff.

2.4.2.2 New York City's Drinking Water

NYC uses the "largest unfiltered surface water supply in the world" (NYCDEP, 2009a). 90 percent of NYC's 1.3 billion gallons of water a day comes from the Catskill and Delaware watershed reservoirs. NYC has a total of 19 reservoirs and three controlled lakes in the Hudson Valley and Catskill Mountains. These water bodies can hold up to 580 billion gallons of water, and are located in the Croton, Catskill, and Delaware watersheds, which take up about 1,972 square miles of land. Because their water is naturally clean enough to not need filtration, keeping the reservoirs and surrounding watersheds pristine is a very high priority. By doing so, the city avoids the cost of a filtration plant, with eight to twelve billion dollars in capital costs, and 350 million dollars in operating costs yearly.

The water delivery system (which brings water to the city from upstate) is 95 percent gravity fed. Because pumping is not needed, energy and costs required to distribute water to NYC is less on a per gallon basis than other large systems.

Currently, NYC water is treated with chlorine, fluoride, food grade phosphoric acid and sodium hydroxide. Construction is underway for a new ultraviolet (UV) disinfection plant for water from the Catskill and Delaware reservoirs. Construction of a full water treatment plant is underway for the Croton reservoirs. The city is also in the process of replacing its current groundwater treatment plant with a state-of-the-art one.

NYC water is used by over nine million people. The city is planning to expand its water supply to accommodate an additional 1 million people by 2030, mainly by expanding the use of groundwater, and recharging those aquifers when there is excess water available from reservoirs.

2.4.2.3 Stormwater and Wastewater

NYC's stormwater and wastewater is collected through an extensive piping system that stretches over 6,600 miles. The City's wastewater is treated by one of 14 wastewater treatment plants located throughout the City's five boroughs. The plants currently treat approximately 1.3 billion gallons of wastewater per day. Stormwater is also managed by this vast network of conveyances. In approximately 70 percent of the City, stormwater and domestic wastewater are collected in the same sewers and conveyed together to the City's treatment plants (NYCDEP, 2009a). This design is known as a combined sewer system. Sometimes, during heavy rains or snow, these sewer systems fill to capacity and are unable to transport all of the combined sanitary sewage and stormwater runoff to the treatment facilities. When this occurs, the mix of excess stormwater and untreated sewage is discharged directly into the City's waterways via one of 494 combined sewer overflow (CSO) outfalls (HabitatMap, 2009) (see Figure 2-38).

In NYC, overflow events can be triggered by as little as 0.1 inches of rain and occur an average of once per week. During a CSO event, approximately 500 million gallons of raw sewage may be discharged directly into New York Harbor, resulting in the single largest impairment to the quality of NYC's waters (City of New York, 2007).

CSO discharges reduce water quality impacts on the overall water quality in the New York Harbor and can have significant impacts where they are discharged. They deliver pathogens which can limit human uses and cause shellfish closures. The can increase the concentration of organics and nutrients that can result in depleted dissolved oxygen (DO) levels. Although annual means for fecal coliform (an indicator of pathogens) and DO in the harbor meet federal water quality standards, they are exceeded during rainfall events and as a consequence, NYC frequently issues swimming advisories for its beaches.

CSO discharges can be minimized by reducing the volume of stormwater runoff and the volume of wastewater discharged into the combined sewer system. NYC continues to conduct CSO abatement projects, including the creation of separate sewer systems, the expansion of wastewater treatment plants, and the construction of CSO storage facilities (NYCDEP, 2009a). The New York City Department of Environmental Protection (NYCDEP) measures levels of conventional pollutants daily and EPA priority pollutants annually at all 14 wastewater plants, as a means of monitoring discharge quality.

The Millennium Tower site is serviced by a combined sewer system that, when stormwater runoff is low, delivers wastewater to the Newtown Creek Sewage Treatment Facility (310 mgd capacity plant serving roughly 1.1 million people). The plant provides secondary treatment to remove organic material and provides disinfection. Solids are processed and reused as fertilizer. Treated effluent is discharged into Newtown Creek, which then feeds into the East River. The East River, a tidal strait with flow that changes direction with the tides, connects New York Harbor to Long Island Sound.

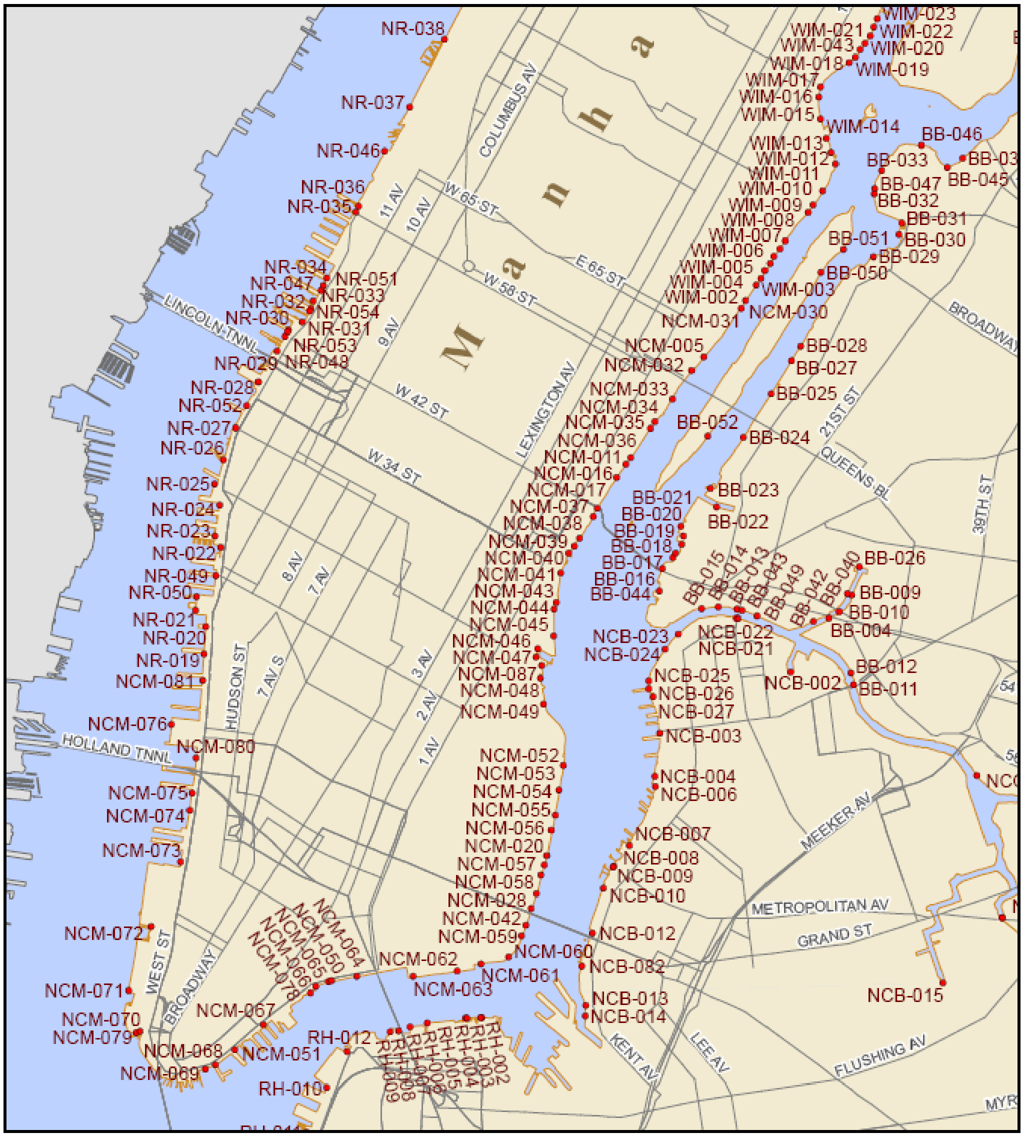


Figure 2-38
Map of NYC CSO outfalls
Source: Used with permission from NYCDEP (NYCDEP, 2009b).

2.4.2.4 Local Initiatives Addressing Water Management Priorities

In 2009, NYC announced PlaNYC, which describes the city's plan to address critical goals for transportation, land, water, air, energy, and climate change by the year 2030 (City of New York, 2009). The plan includes two overall goals related to water: (1) to ensure reliability of the drinking water supply and (2) to improve water quality by reducing water pollution and preserving natural areas. Although water conservation is included in the drinking water reliability initiatives, the bulk of the water quality initiatives are focused on addressing impacts of stormwater, particularly its contribution to CSOs. PlaNYC includes financing for a diverse range of efforts aimed at minimizing CSOs, including creating green roofs, minimizing impervious areas, and expanding wastewater treatment capacity. See Appendix A for a full listing of PlaNYC water quality initiatives and related key elements.

2.4.3 The Design and Construction Process

The Millennium Towers story is tied intimately with the ground breaking work of the Solaire, which essentially provided a model for Millennium Towers. Two key members of the Millennium Towers' design team-Gotham Greenwich Construction Company, LLC and Applied Water Management were from Solaire's design team. Key lessons learned from the Millennium Towers case study may be best understood by looking carefully at two external factors which drove its design: 1) the BPC Guidelines; 2) the Solaire as a precedent.

2.4.3.1 Battery Park City Residential Environmental Guidelines to Address Water Management Priorities

BPC is located at the southern-most tip of Manhattan Island, and is the last stop in Manhattan in the water supply chain from the reservoirs of upper New York State — meaning it is affected by the activity of all of Manhattan. Partly in response to being situated at the end of the pipeline, the Battery Park City Authority (BPCA) adopted its own green development guidelines in 2000 as an acknowledgement of the state of the local environment and the water management needs of NYC. Tim Carey, appointed to head the BPCA, and Governor Pataki, his patron, were instrumental in promoting a green agenda in BPC. Green features at Millennium Tower Residences, and its precedent the Solaire, were driven by Battery Park City Authority *Residential Environmental Guidelines* (BPC Guidelines).

BCPA requires that developers follow BPC Guidelines for all new construction. Because developers must compete for rights to a leasehold from BPCA, which owns and leases all BPC land to developers, BPCA is able to make willingness to conform to BPC Guidelines an integral part of the competition.

Early on in BPC, LEED was available, but it classified buildings of four or more stories as commercial. LEED had no high-rise multi-family development rating capability. Because of this, the BPCA researched ways to build upon LEED categories and referenced standards to develop their own green guidelines to apply to high-rise residential buildings. The stated purpose of the BPC Guidelines is to "establish a process for the creation of environmentally responsible residential buildings that are appreciably ahead of current standards and practices for development." Not only do the BPC Guidelines require developers to attain a LEED for New Construction minimum certification level of Gold plus a LEED for Existing Buildings certification every 5 years from the time that the building is occupied, they ask developers to exceed the standards of the 2002 Energy Conservation Construction Code of New York State (ECCCNYS) and the standards of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 by 30 percent.

Although onsite blackwater reuse plants are not specifically mandated by BPC, all buildings constructed in BPC after the establishment of the BPC guidelines have incorporated blackwater reuse in their buildings. Essentially, blackwater treatment has become an entrenched part of the competitive process to win the right to be able to build in BPC. BPCA recognized the opportunity to remove some of the burden from the local wastewater treatment plants. Although it was not initially the case, the water department now has a lower water rate for customers using reuse water in their building.

For economic reasons, developers in BPC have chosen to install onsite blackwater treatment systems instead of onsite greywater treatment systems (note: BPC Guidelines require buildings to “Treat all wastewater and reuse to maximum extent possible”, but do not specifically require blackwater systems). Blackwater systems have an economic edge over greywater systems because they require only one set of pipes to carry all types wastewater from within the building to the onsite wastewater treatment plant. By contrast, greywater systems require two sets of pipes: one to convey the greywater (from sinks, showers etc.) to the onsite wastewater treatment system, and one to convey the blackwater (from toilets) to the sewer system. In a large building, the cost of the additional piping can be considerable.

BPCA provides oversight during each phase of the new construction design process. In addition to the design approvals, developers must also seek the usual approval from the City Health Department. After overseeing the initial design stages, BPCA conducts minimal or no follow up and no ongoing oversight. According to Stephanie Gelb, Vice President of Planning and Design at the BPCA, the BPCA may cease to exist after all sites in BPC are built, leaving the enforcement of standards for any future rebuilding to market forces — in spite that fact Gelb notes that, judging by the conversion of previous green design skeptics, the BPC Guidelines have been “wildly successful.”

The BPC Guidelines have general energy efficiency guidelines that apply to water use. The developer is asked to install dedicated meters to provide enough data to evaluate individual energy efficiency measures including monitoring of water use by the cooling tower, and blackwater or greywater recovery and reuse. In addition, the developer is asked to provide training and educational resources to inform building and maintenance staff of green building practices and to keep tenants well-informed of the building’s features as well as their role in its performance. The BPC Guidelines contain information about water management technologies as well as sustainable landscaping which can help to conserve water resources. Specific water management guidelines are reprinted in their entirety in Appendix B.

2.4.3.2 The Solaire as a Precedent for Millennium Towers

The development team essentially modeled the Millennium Tower Residences after the Solaire. The Solaire, constructed in August 2003, is a LEED Gold certified building designed by the Albanese Development Corporation, a contractor with a commitment to green building. The Solaire is the first important precedent in BPC for green buildings as it was the first building winning the right to build on a site following BPCA Guidelines. It was also the first LEED certified residential high-rise building in North America. It was the Solaire that upped the ante for subsequent developers, becoming the *de facto* green standard by voluntarily incorporating measures such as an onsite blackwater treatment plant.

The Solaire is 357,000 square feet, 27 stories high, and has 293 condominium units averaging 1,100 square feet. It is designed to consume 35 percent less energy than New York State 1991 code requirements and 50 percent less potable water than its baseline potable water usage (source: Steven Winter Associates Inc. case study). The Solaire also has a green roof and a 25,000 gpd onsite blackwater treatment system consisting of a settling tank, bioreactor, membrane filter, and ozone system. The Solaire has solar panels rated to provide 5 percent of peak power demand.

Both the Solaire and Millennium Tower Residences are high-rise, luxury condominium buildings in BPC that used the same construction company, the Gotham Greenwich Construction Company. This previous experience resulted in a more streamlined construction process for Millennium Towers. Additionally, the blackwater reuse systems at both buildings were designed by Applied Water Management.

2.4.4 Green Building Rating

Following the example of the Solaire, LEED was the only green building rating system considered in the design of the Millennium Tower Residences. This decision was largely based on the fact that it was mandated by the BPC Guidelines that all new buildings must be LEED Gold certified. Therefore, LEED was integrated into the design process from the inception of the project. See Table 2-9 for a summary of LEED points earned.

Table 2-9
Summary of LEED points

Prerequisite/ Credit Number	Prerequisite/Credit Name	Points Earned
Sustainable Sites		
P1	Erosion and Sediment Control	-
C1	Site Selection	1
C2	Urban Redevelopment	1
C4.1	Alternative Transportation, Public Transportation Access	1
C4.2	Alternative Transportation, Bicycle Storage and Changing Rooms	1
C4.4	Alternative Transportation, Parking Capacity	1
C5.1	Reduced Site Disturbance, Protect or Restore Open Space	1
C5.2	Reduced Site Disturbance, Development Footprint	1
C6.1	Stormwater Management, Rate and Quantity	1
C7.1	Landscape & Exterior Design to Reduce Heat Islands, Non-Roof Surfaces	1
C7.2	Landscape & Exterior Design to Reduce Heat Islands, Roof Surfaces	1
C8	Light Pollution Reduction	1

Table 2-9
Summary of LEED points (continued)

Prerequisite/ Credit Number	Prerequisite/Credit Name	Points Earned
Water Efficiency		
C1.1	Water Efficient Landscaping, Reduce by 50%	1
C1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	1
C3.1	Water Use Reduction, 20% Reduction	1
C3.2	Water Use Reduction, 30% Reduction	1
Energy and Atmosphere		
P1	Fundamental Building System Commissioning	-
P2	Minimum Energy Performance	-
P3	Chlorofluorocarbon (CFC) Reduction in Heating, Ventilation, Air Conditioning and Refrigeration (HVAC&R) Equipment	-
C1.1	Optimize Energy Performance, 20% New/10% Existing	2
C3	Additional Commissioning	1
C4	Ozone Protection	1
C5	Measurement & Verification	1
C6	Green Power	1
Materials & Resources		
P1	Storage & Collection of Recyclables	-
C2.1	Construction Waste Management, Divert 50%	1
C2.2	Construction Waste Management, Divert 70%	1
C4.1	Recycled Content, Specify 5%	1
C4.2	Recycled Content, Specify 10%	1
C5.1	Local/Regional Materials, 20% Manufactured Regionally	1
C5.2	Local/Regional Materials, 50% Extracted Regionally	1
C7	Certified Wood	1
Indoor Environmental Quality		
P1	Minimum IAQ Performance	-
P2	Environmental Tobacco Smoke (ETS) Control	-
C1	Carbon Dioxide (CO_2) Monitoring	1
C3.1	Construction IAQ Management Plant, During Construction	1
C4.1	Low-Emitting Materials, Adhesives & Sealants	1
C4.2	Low-Emitting Materials, Paints	1
C4.3	Low-Emitting Materials, Carpet	1
C4.4	Low-Emitting Materials, Composite Wood	1
C5	Indoor Chemical and Pollutant Source Control	1

Table 2-9
Summary of LEED points (continued)

Prerequisite/ Credit Number	Prerequisite/Credit Name	Points Earned
C6.2	Controllability of Systems, Non-perimeter	1
C7.1	Thermal Comfort, Compliance with ASHRAE 55-1992	1
C7.2	Thermal Comfort, Permanent Monitoring System	1
C8.1	Daylight and Views, Daylight 75% of Spaces	1
C8.2	Daylight and Views, Views for 90% of Spaces	1
Innovation & Design Process		
C1.1	Comprehensive Building Maintenance Plan	1
C1.2	Exemplary Performance of MRc4	1
C1.3	Exemplary Performance of WEc3	1
C1.4	Exemplary Performance of MRc5.1	1
C2	LEED Accredited Professional	1
TOTAL		**45**

Note: WE C2.1-Innovative Wastewater Technology, and IEQ C6.1-Controllability of Systems, Perimeter.
Source: Millennium Towers LEED Application.

At the time that Millennium Tower Residences was being designed, LEED was not as widespread, so Handel Architects had to invest time, effort, and money to verify that the materials and practices utilized in the design satisfied LEED requirements. Handel Architects assigned one staff member to conduct research and be available to specify sustainable materials and components on a full-time basis.

The LEED process for the Millennium Tower Residences building was modeled on that of the Solaire. Rick Kearns of Handel Architects noted that over time, LEED approved materials have become easier to locate and that the industry is simply moving in the direction of LEED as the default.

2.4.5 Sustainable Water Management Features

Millennium Tower Residences uses a water management strategy that integrates efficiency and sustainability in both interior and exterior water use. It's most innovative feature is the blackwater treatment and reuse system as described in section 2.4.5.1.

2.4.5.1 Sustainable Water Management for Building Interior

Water use reduction within the building is accomplished by installation of water efficient fixtures and reuse of treated blackwater for toilet flushing and maintenance activities.

Water fixtures for the Millennium Tower Residences were chosen on the basis of their efficiency and their ability to earn LEED credits in the water efficiency credit category. Because the building is a luxury residence, residents' comfort was also a key and equal design consideration. Table 2-10 presents the percent of water savings based on highly-efficient fixtures. These percentages of water savings are based on an approximate 726 residents and 10 staff members.

Table 2-10
Percent water savings of highly-efficient fixtures over conventional units

Water Saving Fixture/Appliance	Flow rate or Water Consumed per Use		Percent Savings
	For the Water Saving Unit	For a Conventional Unit	
Toilet	1.1 gallons per flush	1.6 gallons per flush	31%
Urinal	0.5 gallons per flush	1 gallon per flush	50%
Lavatory faucet	0.5 gallons per minute	2.5 gallons per minute	80%
Showerhead	2 gallons per minute	2.5 gallons per minute	20%
Kitchen faucet	2.2 gallons per minute	2.5 gallons per minute	12%

Note:
1) The water usage per fixture is based on information provided in the Millennium Tower Residences' LEED application.
2) Urinals are only located in the common area restrooms.

According to the LEED documentation, these water saving fixtures are projected to save the building 2.2 million gallons of water per year, or 24 percent of baseline water use. An analysis of real savings based on water use data is provided in the impact assessment (chapter 3).

The blackwater reuse treatment plant, housed in the basement of the Millennium Tower Residences, is designed to treat up to 25,000 gpd. Applied Water Management (a subsidiary of American Water) was part of the team that designed and currently operates the wastewater treatment and reuse system.

The plant is designed for high-level removal of organic material (commonly measured as biochemical oxygen demand or BOD) and nitrogen using a membrane bioreactor design. Wastewater from the building is collected in an aerated 9,500 gallon feed tank and flows to a trash trap to remove larger non-biodegradable solids. A three-stage biological system consisting of an anoxic tank, an aerobic tank, and a membrane filter removes BOD, nitrogen, and solids. Ozone is added for color removal and UV light is used for disinfection. The piping in the mechanical room is delineated by color to assist operations and maintenance workers. The black pipes are used to mark water coming from toilets to the treatment plant; purple pipes designate greywater that is coming from sinks and showers to the treatment plant. Photographs of various components of the blackwater reuse treatment plant are provided in Figures 2-39 and 2-40.

Figure 2-39
Aeration tank

Figure 2-40
Controls for pumping and ozonation

On average, a plant operator from Applied Water Management spends about 4 hours a week on plant maintenance and operation. At full capacity each process within the plant is operated approximately 6 hours per day.

Because the system is located in the basement of a residential building, precautions have been taken to reduce odor and noise originating from the plant. The plant has an enclosed blower and each tank is sealed with a hatch for operator access. The air from the head space of the feed tank is piped to a carbon absorption system housed in the basement, which is then exhausted above the roof level to eliminate chances of odor from the plant entering the building. One improvement made to the Millennium Tower design based on experience from the Solaire is the use of a dedicated trash pump to remove heavy solids. At the Solaire, solids were removed by directing them continuously through a pipe to a truck parked outside of the building. This was unpopular with building residents because it was too visible and there was a possibility of leaks or spillage. At Millennium Towers, designers added a trash pump that can be manually operated to direct the solids to the sewer system. Operators avoid using the pump during a rain event to minimize potential impacts of a CSO discharge. The Solaire has since installed a similar trash pump and eliminated the need for the truck on site.

To date, the residents of Millennium Towers have not complained about operational issues, but they have noticed that the temperature of the reuse water is different from the city water. The reuse water runs at about 70 to 80 degrees F, which is 15 to 20 degrees warmer than the city water.

Applied Water Management reports that the BOD of Millennium Tower Residences' wastewater influent is typically between 270 mg/L and 300 mg/L, and the effluent BOD and suspended solids are typically between 1 mg/L and 4 mg/L. The pH of treated water is maintained between 6.8 and 7.2 by adding caustic soda to the aerobic tank. Finished water is stored in a 9,000 gallon storage tank. The finished water from the reuse system is remarkably clear (0.27 NTU, as shown in Figure 2-41).

Figure 2-41
Finished water from onsite blackwater reuse plant

Because the onsite reuse system receives all of its influent from the building residents, flow can vary greatly, especially during summer and winter times when residents leave the building to go on vacations. During periods of low wastewater flow, bacteria in the wastewater treatment system are kept alive by the addition of dog food to the system (essentially the bacteria in the wastewater treatment plant use the dog food as an alternative carbon source).

The design capacity of the reuse plant is based on the following assumptions:

- 5,300 gpd for toilet flushing
- 17,000 for the cooling tower
- 2,000 gpd for hosing down the floor in the maintenance shop

This last application required approval from the City Health Department as an acceptable use of reuse water. Millennium Partners only uses reclaimed water for non-potable purposes and does not supply other hose bibs with this water to prevent pets from drinking the reclaimed water.

To date, the 17,000 gpd of reuse water allocated for cooling tower use has not been treated or used on site. According to Mark O'Reilly, it was the original building manager who resisted the use of reuse water for the cooling tower citing potential problems with scale build-up. Applied Water Management reported that an average of 8,000 gpd was treated by the plant; 6,000 of which was used for toilet flushing and 2,000 for wash down of the maintenance room flow. The plant is operated so that when the 9,000 gallon treated water storage tank is full, untreated wastewater flows from the blackwater system feed tank into the public sewer system.

The decision to install a blackwater treatment plant was influenced by the BPC guidelines as well as the success of the Solaire. Another powerful incentive to include onsite blackwater treatment was financial. Water bill savings resulting from reuse of water for toilet flushing are not directly passed onto residents as water is not separately metered for each residential unit in the building — water is included in each resident's condo fee. Any savings are realized by Millennium Partners. Mark O'Reilly, the resident manager of Millennium Tower Residences, reports that as a result of using reuse water, the Millennium Tower Residences' potable water use is decreased by roughly 50 percent.

Millennium Partners hoped to get credit for the wastewater reuse system under LEED, but the U.S. Green Building Council (USGBC) ruled that they had not met the requirement for reducing the use of municipally provided potable water for building sewage conveyance by a minimum of 50 percent or treating 100 percent of wastewater to tertiary standards. Because the building had already earned enough points to obtain LEED Gold certification, Millennium Partners had little incentive to dispute the ruling. The blackwater system, however, did help Millennium Partners earn the Water Use Reduction LEED credit.

2.4.5.2 Sustainable Water Management for Building Exterior

Green features external to the Millennium Tower building include a green roof and a rain garden. The green roof has a total area of 4,113 square feet (ft^2). It is made available to residents only through participation in resident tours; there is no open-ended, unsupervised access to the green roof (see Figure 2-42). It is a water management strategy, not a resident amenity. In addition to the green roof, the rain garden in the front of the building provides pervious cover to help reduce runoff (see Figure 2-43). Table 2-11 provides a summary of pervious and impervious surface at the Millennium Towers site.

The blackwater reuse system is used exclusively for non-potable purposes within the building, and not used for irrigating the green roof or landscaped areas. Irrigation needs of the green roof, terrace, and front bed/rain garden are met by stormwater alone. As listed in Table 2-11, there are 870 square feet of ground level vegetation and 4,113 square feet of roof garden, resulting in almost 5,000 square feet of native plantings that need to be irrigated.

Irrigation needs of the green roof and rain garden are met by capture, treatment, and recycle of stormwater onsite. A rainwater catchment system collects all water from the roof and directs it through a cartridge filtration and UV disinfection system located in the basement of the building. This treated water is stored until it is needed for irrigation of the green roof and rain garden. Millennium Towers estimates that their stormwater collection and reuse system reduces their potable water use by 33 percent as compared to comparable green buildings. (See Chapter 3, Impact Assessment, for an independent assessment of this reduction).

In addition to meeting all irrigation needs of the building's gardens, the stormwater storage tank has the potential to help reduce the pulse of stormwater runoff from the building's impervious surfaces. Until recently, however, the tank was generally kept full to ensure water availability for irrigation, which left little residual volume to capture stormwater runoff. As a consequence, most runoff bypasses the tank and drains directly to the NYC's combined sewer system, which frequently overflows.

Figure 2-42
Green roof at millennium tower

Figure 2-43
Rain garden at millennium tower

Table 2-11
Summary of pervious and impervious surface at millennium towers residences

Surface Type	Area (ft^2)
Green Roof	4,113
Impermeable Roof Surface	11,106
Ground-level rain garden	870
Ground-level impervious surface	6,521
TOTAL	**22,610**

Source: Data provided in Millennium Towers LEED Application

Most stormwater goals focus on suburban solutions, and pre- versus post- development. In highly urbanized areas such as NYC, there is little or no "pre" development and little or no permeable paving and infiltration leaving few infiltration options. Thus, the permeability of a green roof and rain garden and their ability to reduce velocity and enhance the evapotranspiration process takes on additional strategic importance for this building. Important and in line with local priorities, collection and reuse of stormwater from the roof significantly reduces the direct runoff to the combined sewer system and helps minimize CSOs.

2.4.6 Challenges in Design and Implementation

For Millennium Tower Residences, the incidence of problems experienced during design and implementation was likely reduced by the fact that the design team had worked together previously on other projects. Additionally, the contractors used for the Millennium Tower project had experience with its proposed green building systems and in turn hired subcontractors and specialist subcontractors for green elements that could have otherwise proved difficult to implement. Applied Water Management's previous experience with the design and operation of the Solaire's blackwater treatment system was a significant help in the design and operations of the treatment system at Millennium Tower Residences.

Challenges encountered during design and implementation include the following:

Space for the blackwater treatment unit. The blackwater plant design had little to do with the building's overall design and architectural features. Essentially, the constrained space for the reuse system was a given, and within that area the reuse system had to be built. Applied Water Management found that it was a challenge to work within the limited space of the basement of the residential building.

Problems with LEED documentation and LEED credit achievement. According to Viridian Energy and Environmental, portions of the LEED documentation process had to be reworked, which led to confusion among some project members who were not as familiar with the documentation process. Viridian was surprised that the project did not receive Water Efficiency Credit 2 "Innovative Wastewater Technologies" under the LEED rating system for the onsite blackwater reuse plant, which would have been an acknowledgement of the virtues of the onsite treatment system. Even so, Millennium Partners was satisfied to have reached the LEED Gold level, so an appeal was not sought. Additionally, the project did not receive an innovation credit for education, although they have worked hard to provide optional educational tours.

Challenges with resident education. Natalie Terrill of Viridian Energy and Environmental explained that the residents are excited to be part of something "green" but that in paying a premium, they also expect high-end luxuries such as Italian marble and fine wood finishes. Occupant education is difficult: some residents may associate sustainable practices with inferior performance, associating, for example, water conservation with low water pressure. Few residents have taken the tour of the blackwater treatment system or the green roof. Also, complaints from the Solaire's residents of the visibility of a trash truck removing their wastewater plant solids prompted installation of an internal pump at Millennium Towers, avoiding the need for a pump-out truck.

Early operations and maintenance challenges. Mark O'Reilly, the Resident Manager of Millennium Tower Residences since 2007, said that operating a green building is different from operating a more conventional building in two ways: it requires more oversight of operations as well as sophisticated sensor equipment. O'Reilly reported that it took some time to get the blackwater system online (the treatment and reuse system was bypassed during initial stages of building operation). He has reported that building operations have been running more smoothly as time goes by. To address operational challenges, the building management staff has monthly meetings where they conduct training sessions (such as valve training and safety training) and collaborate with engineers from other buildings. The building has an automated building management system, and there are three engineers on staff. The Building Links program is a software program that functions similar to a listserv to notify operators of developments and news. It was developed by engineers at NYC buildings. Residents use it as well and have a personal login to access it to place requests for work orders.

The blackwater treatment system is not used to capacity. Because the original building manager was concerned with scaling (mineral deposits forming on the inside of the cooling tower), reuse water has not been used for cooling. Thus, the plant currently operates at a fraction of its capacity (8,000 gpd rather than 25,000 gpd). Treated water is not wasted; however, the potential for water conservation is not realized. Ed Clerico of Applied Water Management reported similar issues with reuse water for cooling at the Solaire. His team addressed the issue by adding phosphorus removal capabilities to the blackwater plant. The design was also changed to use 50 percent potable water and 50 percent reuse water for the cooling tower, which enabled the Solaire to ensure a consistent blend. According to Clerico, there is currently only limited coordination between the cooling tower manufacturers and the reuse industry. Clerico reported that for changes to be made to the design of a system a champion of the cause is needed. As noted in Section 2.4.7 below, the Millennium Towers condominium board has considered making the necessary infrastructure and operation changes to use water from the blackwater treatment plant for cooling tower makeup; however, to date, they have found the cost of the design change to be prohibitive.

Lack of regulatory oversight. Because BPC is under the purview of the State rather than NYC, regulatory oversight of the blackwater system has fallen through the cracks. The NYC Health Department played an early role by visiting the plant during design and startup and reviewing data, but their involvement has been minimal during operations. The Millennium Tower Residences plant operators still send quarterly and semi-annual reports to the NYC Health Department as well as monthly sample results, but they do not believe that they are reviewed. Operators say that the NYC health department has confidence in the onsite blackwater treatment system's performance; however, they prefer ongoing regulatory oversight, since a change in personnel or other lack of continuity at the NYC Health Department may change the requirements under which the blackwater treatment system is operated. Therefore, they see a need for ongoing education and open communication with the NYC Health Department.

2.4.7 Lessons Learned

The main lesson of the Millennium Tower Residences is the disconnect between design and operations. This finding applies to both the blackwater treatment plant and the stormwater management system.

Blackwater Treatment Plant

In light of the cooling tower issue, the blackwater treatment plant is not operating as designed. Mark O'Reilly said initially the original building manager did not want to use reuse water for the cooling tower because of scaling concerns. The Solaire experienced a similar setback but was able to overcome it by modifying its treatment procedures. The Millennium Towers condominium board has considered making the necessary infrastructure and operation changes to use water from the blackwater treatment plant for cooling tower makeup. However, given the expense that was required to make this transition at The Solaire --approximately $12,000 – $15,000 on a monthly basis -- along with some technical considerations that still need to be worked out, Millennium Towers has decided to not make this change to the blackwater reuse plant at this time. The condominium board, however, will consider making the adjustment to the reuse plant in the future if it becomes more technically feasible as well as economical.

Millennium Partners reported that the blackwater treatment system was not operational when the building went on line in 2007. Only *after* occupancy was the system put online, although at much lower capacity than designed. This underscores the disconnect between LEED certification and building operation. Although the building did not receive credit for the blackwater treatment system, it was part of the project's initial LEED submission package, and was intended to be a key design feature of the Millennium Tower Residences. However, until recently, the blackwater treatment plant was not online, and this water use reduction was not realized.

Regulation and oversight remain, for the building engineers of Applied Water Management, nagging concerns. Because there is no discharge to a surface water body, no NPDES discharge permit is required and therefore no federal standards are applied[5]. Many states and/or local regulatory agencies regulate the design of onsite wastewater systems that discharge to groundwater, and some have taken the next step of requiring sampling and monitoring of the effluent from these systems. However, for this building, all effluent is either utilized onsite or discharged to the sanitary sewer. Therefore, there is no discharge to groundwater either. There is no regulatory framework in place to address the design standards, operator certification requirements, operational requirements, or effluent standards for this system. If something goes wrong, or if the building decides to suspend investment in its treatment plant, the consequences, without oversight, could be severe.

Design and operational lessons for the blackwater treatment plant are summarized below:

- Flow and load equalization to deal with sporadic flows would have helped immensely in operation of the plant. As discussed earlier, sometimes a form of organic input, often dog food, is added during low load periods to maintain the biological community essential to an activated sludge process.
- Complicated treatment processes require a qualified operator, just like a full scale plant. There is no requirement for operator certification, training, or on-going education of the blackwater reuse system in BPC.
- Potential for cross connections is a challenge because many different types of water are under pressure within a single building: drinking water/ greywater/ blackwater/ reuse water. Rick Kearns said one of the biggest successes was one of the simplest: the color coding of the pipes in the wall of the reuse plant that can help anyone to distinguish between different types of water pipes, thus helping to prevent accidents and errors from any retrofit work.

Stormwater Storage

The stormwater storage tank was designed to serve two purposes: 1) To reduce the pulse of stormwater runoff from the building's impervious surfaces to help mitigate NYC's combined sewer overflow problem, and 2) To replace the use of potable water for irrigating the building's gardens. Until recently, the tank was generally kept full, which provided more than enough water for irrigation, but provided almost no stormwater control. Given that stormwater runoff is a greater resource concern in NYC than water use, this management choice was incongruent with local priorities. Managing the fill level of the stormwater tank to optimize irrigation water availability and stormwater control requires an active approach. Based on preliminary recommendations from this study, building staff recently instituted weekly drawdowns of the tank during dry weather. Based on the impact assessment, this practice will provide at least as much control over runoff peaks as the green roof and rain gardens combined.

[5] Note, when CSOs occur some portion of the effluent from the building may be discharged directly to a surface water body. However, because the combined sewer system is designed to carry waste to the wastewater treatment plant, which has its own NPDES permit, the building is not liable for potential discharges to surface water bodies during CSOs.

2.4.8 Continuing Impacts

Millennium Partners retains two-thirds control of the building until 2011, after which it will devolve to the management board of owners. Handel Architects remains the design team for other Millennium Partners projects. Applied Water Management is onsite and interacts frequently with building management. Continuity in project team could mean more streamlined design, construction, and operation of BPC projects.

A relatively new initiative that will affect water management in the city is the PlaNYC. In December 2006, Mayor Michael Bloomberg challenged NYC residents to generate ideas to achieving sustainability goals in five sectors of the city's environment: land, transportation, energy, air, climate change, and water. Information on PlaNYC water quality and water network initiatives is in Appendix A of this report.

3
IMPACT ASSESSMENT

3.1 Introduction and Methodology

Many designers are incorporating water conservation, stormwater management, water reuse, and other sustainable practices into new building and building retrofit projects to address a growing concern regarding the availability and sustainability of our nation's water resources. The purpose of this chapter is to quantify the environmental impacts of sustainable water practices for the three individual building projects detailed in Chapter 2:

- The Phillip Merrill Center of the Chesapeake Bay Foundation (CBF) in Annapolis, MD;
- The Wetland Studies and Solutions, Inc. (WSSI), office building in Gainesville, MD; and
- The Millennium Tower Residences in Battery Park City (BPC), New York City, NY (NYC).

This impact assessment builds on the case study findings by quantifying the effects of the sustainable water management features employed using measured data and modeling. Detailed descriptions and evaluations of the sustainable water management features employed by the three case studies are in Chapter 2, Sections 2.2.5, 2.3.5, and 2.4.5. The priority for the impact assessment is to consistently compare results from the three case study sites. The calculations presented in this chapter are for comparative purposes and may or may not match exactly with results from similar calculations performed by the project sites. Assumptions were required in some cases and are noted throughout this chapter and in the appendices.

This chapter focuses on the practices that address the priority water management issues of the communities in which the buildings are located. Chapter 4 and 5 build on the impact assessment results by comparing the rewards and incentives given by green building rating systems and by local planning programs, respectively.

3.1.1 Methodology: Reductions in Potable Water Use and Discharge to Sanitary Sewer

The objective of this portion of the impact assessment is to estimate the reductions in water use and wastewater discharge resulting from innovative water management practices. These estimates are made by comparing water and sewer meter records provided by case study participants to estimated "baseline" values. The baseline values are theoretical water use and sewer discharge patterns (and in the case of wastewater, nutrient loads) as if water conservation or reuse measures did NOT exist. In other words, the baseline answers the question, "what would the water use pattern look like for the same building with no conservation or reuse measures in place?"

The LEED (Leadership in Energy and Environmental Design) Rating System application for each case study site provided the starting point for the baseline estimate. LEED applicants are required to estimate the baseline wastewater flow for a building and show a minimum percent reduction compared to the baseline to achieve the water efficiency pre-requisite. Because LEED baseline estimates include only fixture use, alternative methods (e.g., manufacturer's data, national survey data) were used to estimate additional baseline flow for appliances, cooling requirements, and irrigation. Engineering manuals were used to estimate baseline loadings of nitrogen and phosphorus in wastewater.

Reductions in water use and wastewater discharge were derived by comparing the baseline to metered water use records from the building. Where possible, the analysis attributed the reductions to specific water conservation practices.

3.1.2 Methodology: Impact of Stormwater Management Practices

The objective of this portion of the impact assessment is to evaluate improvements in environmental performance at the three study sites resulting from the implementation of innovative stormwater best management practices (BMPs). The analysis focused on the performance relative to the primary resource concern(s) in each site's geographic setting (described in Chapter 2). When possible, the performance of individual sites was extrapolated to a broader area to illustrate the potential cumulative effect of widespread adoption of similar practices.

The stormwater evaluation was conducted using the P8 Urban Catchment Model (Walker, 2007). This model runs a continuous water budget simulation for a system of runoff-generating areas and treatment/infiltration/detention devices (i.e., BMPs). Runoff water can be routed in P8 through multiple devices in series or in parallel, making the model particularly useful for estimating the cumulative effects of a linked system of BMPs.

Three management scenarios were modeled for each site to evaluate the effect of various BMPs:

1. Existing scenario — Existing building and surrounding developed site with existing stormwater BMPs.
2. Baseline scenario — Existing site configuration (e.g., building footprint and parking areas) with no stormwater management practices or minimally required BMPs intended to reflect local stormwater management requirements.
3. Site-specific — One additional scenario that was designed and modeled for each site to address relevant site-specific questions.

Model inputs were obtained from various data sources. Dimensions and other characteristics (such as infiltration rate) of stormwater management practices were assembled from available LID and LEED material, site design and engineering schematics, communication with site personnel, and literature values. Dimensions of runoff-generating areas were derived from site plans or measured in the Geographic Information Systems (GIS) project created for each case study site. For each of these runoff-generating areas, runoff generation was modeled using the "curve number" approach (USDA, 1969) for pervious areas, and either the curve number or runoff coefficient approach for impervious surfaces. A curve number describes the relationship between the amount of rainfall and the amount of runoff it produces on specific combinations of soil type and vegetative cover. Very high curve numbers (near 100) describe the rainfall-runoff process from impervious surfaces.[1]

The P8 model makes several important assumptions when predicting the pollutant loading from a site. First, P8 assumes that any rainfall that percolates directly into the soil does not carry any pollutants from the ground surface. In other words, contact with soil is assumed to remove all pollutants. However, P8 assumes that infiltrated runoff water retains dissolved pollutants such as nitrogen and orthophosphate that were picked up from the runoff surface. Particle size distribution and pollutant concentration data in runoff water from each surface type (parking lots, roofs, landscaped areas, and undeveloped areas) were adapted to the P8 format from datasets compiled by the U.S. Geological Survey (USGS) for WinSLAMM (Source Loading and Management Model) (USGS, 2008).

The National Climatic Data Center provided precipitation and temperature data for the period of 1999 through 2008. While the entire period was evaluated for peak storm events, this report presents pollutant loading and water budgets from October 2004 through September 2008.

The following results are reported for each case study:

- Annual average load of several pollutants (suspended solids, phosphorus, nitrogen, zinc, lead, copper, and hydrocarbons) delivered to nearby surface waters for each model scenario. These pollutants are the root causes of water quality impairments such as low dissolved oxygen and excessive algal growth.
- Hydrographs for a small and a large rain storm for each model scenario. The magnitude and duration of runoff flows indicates their erosive power and likelihood of causing floods and/or combined sewer overflows.
- The proportion of water leaving the site as runoff and baseflow[2]. This statistic integrates flows from all rain events and can be compared with pre-development values for the same site to determine the overall degree of hydrologic alteration.

3.2 Results: The Merrill Center

The Merrill Center has implemented numerous water management strategies to conserve water, reduce wastewater discharge, and control stormwater runoff. This section presents estimated impacts of these measures on potable water use and discharge to sanitary sewer (Section 3.2.1) and stormwater runoff (Section 3.2.2). Section 3.2.3 provides a discussion of the potential effects of widespread implementation of the Merrill Center's water management strategies.

[1] For a complete description of the curve number approach, see www.cpesc.org/reference/tr55.pdf.
[2] This results is presented for the Merrill Center and WSSI site only – water does not follow a natural drainage pathway once it leaves the Millennium Towers site.

3.2.1 Potable Water Use and Discharge to Sanitary Sewer

3.2.1.1 Baseline Estimate

The baseline estimate is the hypothetical use of water as if no conservation measures were put in place at the facility. It provides a point of reference for evaluating actual (metered) water use. Table 3-1 summarizes the components of the water use baseline for the Merrill Center.

Table 3-1
Components of the water use baseline for the Merrill Center[1]

Type of Water Usage	Annual Water Usage (gal)	Equivalent Daily Water Usage (gal/day)
	A	B = A/365
Flush Fixture Type	153,032	419
Flow Fixture Type	110,775	303
Appliances	3,000	8
Irrigation	1,506,662	4,128
Cooling Tower (Theoretical)	700,000	1,918
Total[2]	2,473,470	6,777

Notes:

1. See Appendix C, Section C.2 for assumptions and detailed calculations for each baseline component.
2. The total value represents the potable water use baseline. The wastewater discharge baseline, which does not include irrigation or evaporation from the cooling tower, is 406,807 gallons per year.

The CBF, owners and operators of the Merrill Center, estimated water use for flush fixtures (i.e., toilets and urinals) and flow fixtures such as faucets, sinks, and showers as part of their LEED application. The small amount of water used for appliances is based on infrequent use of the single clothes washer at the facility. The irrigation baseline is a hypothetical estimate of water use assuming that all vegetated areas are planted with trees, shrubs, and grasses that are not native to the region or drought-tolerant and thus require watering. In contrast, the actual landscape of the Merrill Center is planted with native species that do not require watering; operations personnel are able to use stormwater for any irrigation needs. The second to last row in Table 3-1 shows the projected amount of water that would be used to cool the building if it employed a conventional cooling tower system. In reality, the Merrill Center uses natural ventilation combined with a ground-source heat pump that does not consume water (fluid instead circulates in a closed loop). Appendix C contains details about the derivation of each baseline component.

The potable water use baseline for the Merrill Center, which totals approximately 2.5 million gallons per year, includes all components listed in Table 3-1. The wastewater discharge baseline flow, which is estimated from Table 3-1 to be approximately 406,800 gallons per year, does not include the estimated water needs for irrigation or evaporation from the cooling tower as there is no discharge to the municipal system for these two uses. It is assumed that 80 percent of the water used for cooling evaporates (Harfst, 2009), while the rest (20 percent or 140,000 gallons per year) is discharged to the municipal system.

3.2.1.2 Actual (Metered) Water Use

The Merrill Center uses treated well water for its building needs instead of purchasing potable water from the local utility. Building operations staff reviewed pump records to determine the total volume of water withdrawn from the well and used at the center for each month in 2008. These data were used to estimate the total measured water use for the facility: approximately 15,400 gallons for 2008.

CBF also meters the rainwater that is used within the facility for hand washing. A review of 2008 records revealed that the center used a total of approximately 20,000 gallons in 2008. Water used within the facility (both rainwater and potable water) are collected and treated at the County wastewater treatment plant. Thus, the total estimated wastewater flow from the Merrill Center is the sum of the potable water and rainwater use: 35,400 gallons for 2008. Appendix D contains detailed calculations.

3.2.1.3 Comparison of Baseline to Actual (Metered) Use

Figure 3-1 compares the baseline water use to the metered well water use. The figure depicts an extremely large difference between the baseline and measured value, with the measured value representing ***approximately 1 percent*** of the total baseline. The baseline is more than two orders of magnitude higher than the metered well water use.

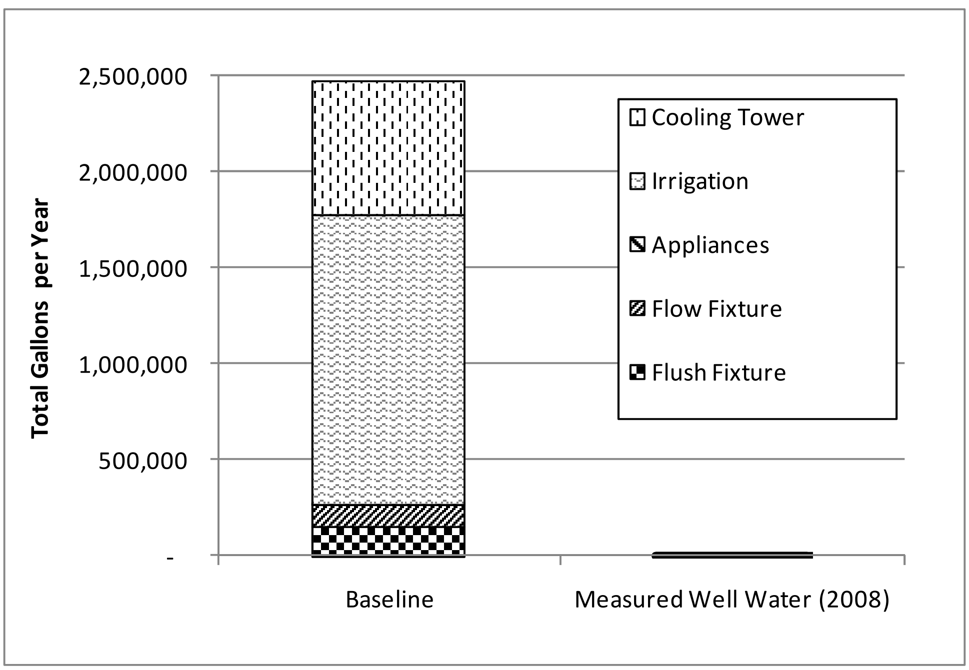


Figure 3-1
Baseline water use compared to actual (metered) well water use for the Merrill Center

Much of difference between baseline and metered water use can be attributed to two factors: (1) an "unconventional" cooling system (ground-source heat pump) with no water demand and (2) irrigation practices which do not rely on potable water. For the baseline assumption, a conventional cooling system at the Merrill Center working without the benefits of natural ventilation is estimated to use roughly 700,000 gallons per year[3], making up nearly 30 percent of the total baseline potable water demand. Although water conservation is not typically a driving factor in selecting a cooling system design, cooling systems can have a substantial impact on water use at a facility. Irrigation can generate an extremely large demand on the potable water system in the absence of native, drought-tolerant plants. The estimate varies greatly from month to month with the highest demand in the summer months.

To assess the impacts of water conservation measures installed within the building, Figure 3-2 compares the measured water use to the fixture and appliance baseline estimates only. Even without the irrigation or cooling estimates, the measured well water use for 2008 (15,400 gallons) is still 97 percent less than the projected baseline use for all fixtures and appliances within the building (approximately 270,000 gallons per year). The total measured yearly well water and rain water use (35,400 gallons for 2008) is 87 percent less than the fixture and appliance baseline.

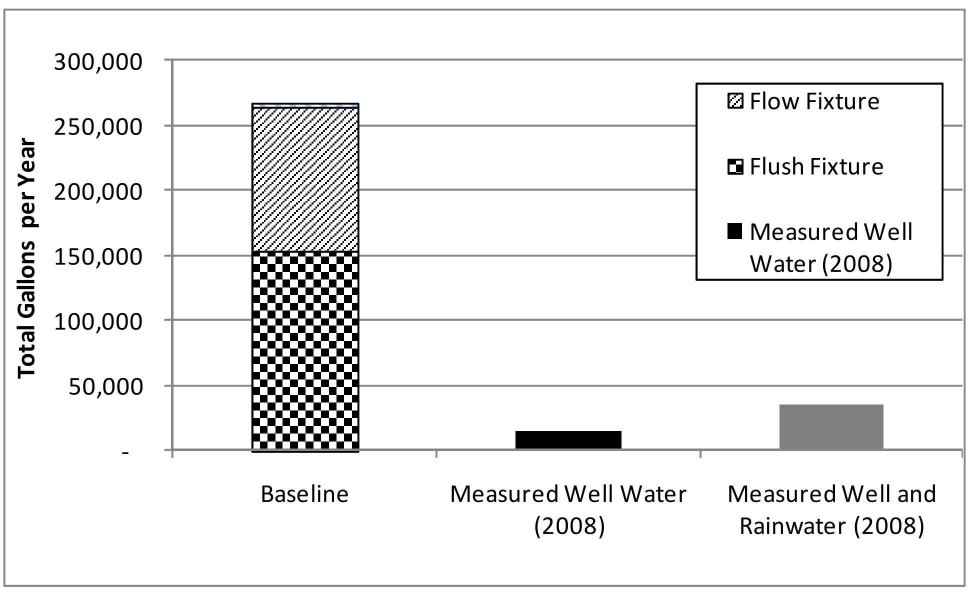


Figure 3-2
Fixture and appliance baseline compared to actual (metered) water use for the Merrill Center

[3] Although this value may appear high at first read, it is comparable to published information. In a national study, the American Water Works Association (AWWA) found that the median cooling tower use was 15 gallons per sf per year based on audits of 44 office buildings (*Commercial and Institutional End Uses of Water*, 2000, Table 6.18). The baseline estimate of water used for cooling for the Merrill Center is roughly 700,000 gallons for 32,000 square feet, or 22 gallons per square feet per year. See Appendix C, Section C.5 for a description of the approach used to estimate cooling water usage.

The significant reductions in water use and wastewater discharge compared to the baseline fixture and appliance estimate can be attributed to two main factors. First, the Merrill Center uses composting toilets. The baseline estimate for flush fixtures (toilets) as documented in the Merrill Center's LEED application was approximately 153,000 gallons per year. As depicted in Figure 4-2, flow from toilets is more than half of the baseline flow estimate. The Merrill Center completely eliminated this water use demand and source of wastewater flow. Secondly, treated stormwater is used for hand washing in bathroom sinks. The savings from this feature is equivalent to the measured rainwater flow, approximately 20,000 gallons per year. The remaining difference can be attributed to minimal water use for cleaning and in the facility's kitchen.

3.2.1.4 Reduction in Nutrient Loading

In addition to water conservation, one of the design features of the Merrill Center, the composting toilets, reduces the nutrient load being delivered to the wastewater treatment plant. The toilets recycle human waste into fertilizer by composting it for an average of three years. The compost product is used as a fertilizer for on-site native plantings.

For comparison purposes, a baseline estimate of nutrient loading from toilets was derived from literature values and occupancy information provided by the CBF (see Table 3-2). The composting toilets are projected to remove the total contribution of nutrients from toilets, approximately 240 pounds of nitrogen and 33 pounds of phosphorus, from the waste stream each year.[4]

It is important to note that the baseline values in Table 3-2 represent savings in the nutrient oad to the wastewater treatment plant, not in the loading to the Bay itself. Wastewater from the Merrill Center is treated at the Annapolis Water Reclamation Facility (WRC) where substantial nutrient reduction takes place. In addition, there is currently a project underway to equip the plant with enhanced nutrient removal to achieve a total nitrogen goal of 3 mg/L and a total phosphorus goal of 0.3 mg/L (Maryland Department of the Environment, 2009).

[4] What happens to the nutrients in a composting toilet? Composting converts nitrogen in human waste from ammonia to nitrate. When the composted waste is spread on vegetated areas, plants take up much of the nitrate and phosphorus (the nutrients act as natural fertilizer). It is possible that some of the nutrients aren't incorporated into plant material and may leach or runoff into the Bay. This amount is expected to be minimal as long as application of composted waste is timed to coincide with the seasonal growth cycle of the plants.

Table 3-2
Derivation of baseline nutrient loading for the Merrill Center

Nutrient	Typical Loading (lbs per Person per day)	Percent of Total Load Attributed to Human Waste	Average Occupancy	Days Occupied per Year	Total Loading per Year
	A	B	C	D	E = A*B*C*D
Nitrogen[1]	0.0145	80%	82.4	251	240 lbs
Phosphorus	0.0035	45%	82.4	251	33 lbs

1. The nitrogen is reported as Total Kjeldahl Nitrogen (TKN), which is organic and ammonia nitrogen. Nearly all nitrogen in wastewater is TKN.

Sources:

(A) The typical per capita contribution to wastewater from individual residences as presented by Tchobanoglous et al. 2003, Table 3-12 was reduced by half to account for the lower number of hours occupied for offices (8 hours) compared to residences (16 or more waking hours).

(B) Approximate percent of total annual nutrient load in municipal wastewater that originates from urine (most nutrient pollution from human waste is in urine). Figures reported by Wilsenach and Loosdrecht (2003) based on studies conducted in Sweden (Hanæus et al., 1997) and Switzerland (Larsen and Gujer, 1996).

(C) Estimated current occupancy of the Merrill Center is based on full time occupancy of 80 people *(personal communication with Mary Todd Winchester, Chesapeake Bay Foundation, on June 17, 2009).* In addition, the Chesapeake Bay Foundation hosts numerous educational events at the center each year. An average value of 50 people per month was added to the original estimate, making the total 80 + (50*12/251).

(D) Estimated number of days occupied for a typical office building is 50 weeks per year, 5 days per week, which is equivalent to 251 days.

3.2.2 Stormwater Runoff

The P8 Urban Catchment Model (Walker, 2007) was used to evaluate impacts of stormwater management practices at the Merrill Center. Section 3.2.2.1 provides a description of the modeled scenarios. Section 3.2.2.2, supplemented by detailed modeling information and results in Appendix E, presents results of the stormwater impact assessment.

3.2.2.1 Description of Scenarios

Three scenarios were used to evaluate the effects of stormwater management practices on runoff quality and quantity at the Merrill Center: existing, baseline, and uncontrolled. The Merrill Center building is located on a 33-acre site immediately adjacent to the Chesapeake Bay. Most of the site remains undeveloped and includes woodlands, wetlands, and beaches. The stormwater BMPs for this site were primarily installed to manage runoff from a 3.67 acre portion of the site that includes the building footprint, parking areas, driveway, and vegetated areas immediately adjacent to the building. To emphasize the impact of the stormwater BMPs, the results presented are for this smaller developed portion of the site.

The ***existing scenario*** was designed to replicate the performance of the current suite of stormwater BMPs at the Merrill Center. In this scenario, the following BMPs contribute to the management of stormwater:

- Stormwater runoff from the roof is collected in several exterior cisterns and is used for fire suppression and other non-potable indoor uses (showers, hand washing, and equipment cleaning).
- A green roof collects rainwater from a portion of the site and receives water collected in rain barrels.
- Above-ground parking is minimized due to underground parking. Most of the above-ground parking areas are paved with pervious materials.
- Runoff from above-ground parking areas is routed through a bioretention filter, a pre-treatment sedimentation chamber, and a pocket sand filter, before being discharged to a vegetated area above the beach.
- Vegetated swales carry some runoff and overflow from the large cisterns to a raingarden, whose overflow is collected by the pre-treatment sedimentation chamber.
- Overflow from the primary treatment devices is directed to open vegetated areas for infiltration.

Figure 3-3 provides an illustrative depiction of this existing scenario for the Merrill Center.

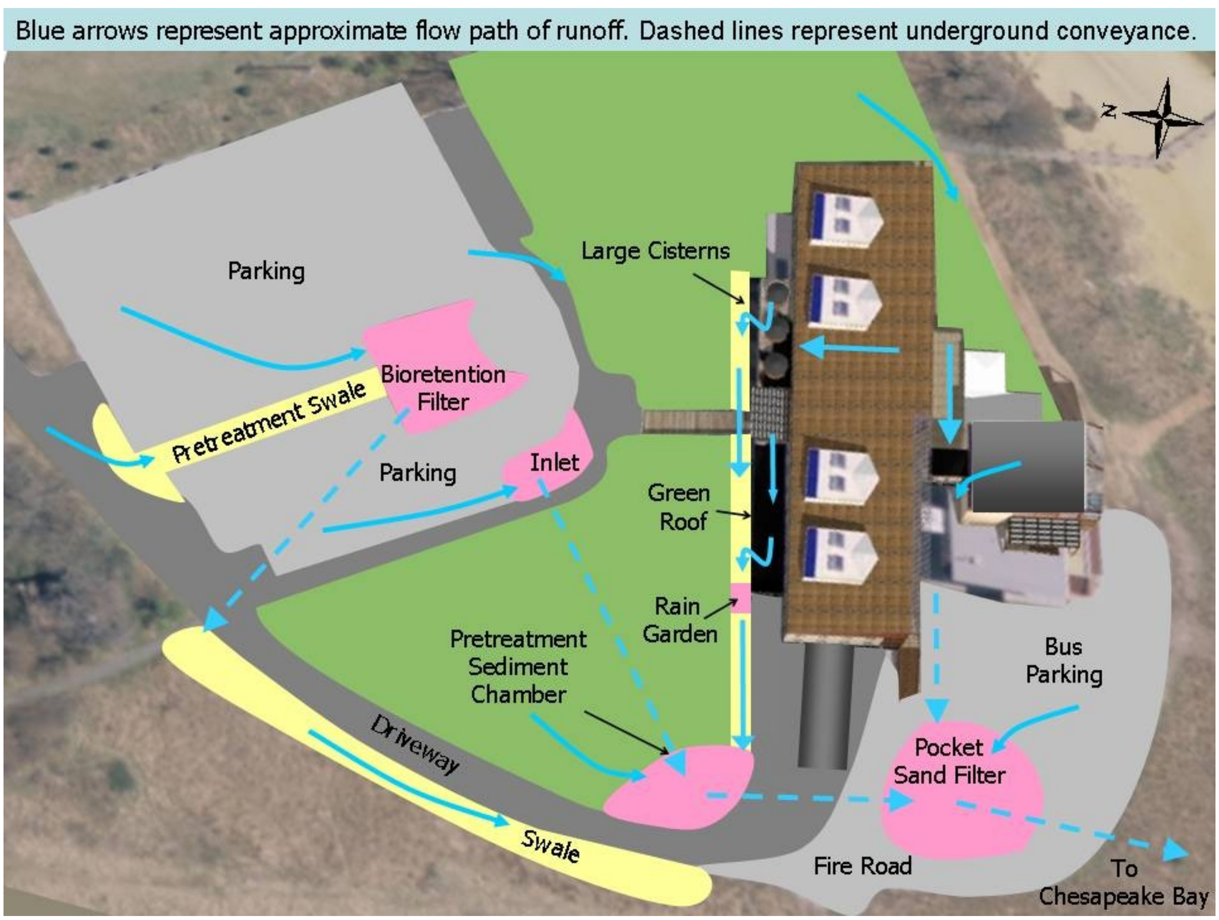


Figure 3-3
Merrill center stormwater infrastructure
Source: Prepared by Cadmus

The ***baseline scenario*** was designed as a more traditional alternative to the existing scenario. All existing BMPs were removed and replaced with a detention basin in the approximate location of the pocket sand filter. This basin was modeled as an infiltration basin using specifications listed in plans for managing stormwater during construction of the building. This scenario assumes that the basin was never removed and remained on site after construction. This assumption is consistent with local stormwater regulations designed to protect the Chesapeake Bay.[5]

The ***uncontrolled scenario*** assumes no stormwater BMPs are used on the site. This is not a realistic scenario for redevelopment of this site given the stormwater regulations described above. This scenario is designed as a point of reference for the performance of the other two scenarios.

See Appendix E for flow diagrams showing the movement of water through the various BMPs for each scenario.

3.2.2.2 Results

Table E.1 in Appendix E presents detailed results for contaminant loading for all scenarios. The next several paragraphs discuss how the stormwater BMPs performed, in particular for the primary issues of concern at the Merrill Center site. A discussion of which measures had the greatest effect and possible design and operational improvements follows.

Compared with the uncontrolled scenario at the Merrill Center, the existing scenario contributes 5 times less phosphorus and half as much nitrogen to the Bay (see Figure 3-4). Simulated annual phosphorus loads from the site in the existing scenario (0.07 lbs/acre) are well below the average for urban areas in the Chesapeake Bay watershed (0.76 lbs/acre) (CBF, 1994). The baseline scenario performed well for phosphorus (although not as well as the existing site BMPs), but was similar to the uncontrolled scenario for nitrogen. The retention rates of these two nutrients are different for the baseline scenario because most phosphorus is attached to sediment particles, which settle out in the detention pond, whereas more than half of nitrogen in runoff is dissolved and passes through the pond to the Bay.

[5] The Merrill Center is within the Chesapeake Bay Critical Area (within 1,000 feet of tidal waters and wetlands) and is subject to requirements established by the Chesapeake Bay Protection Act.

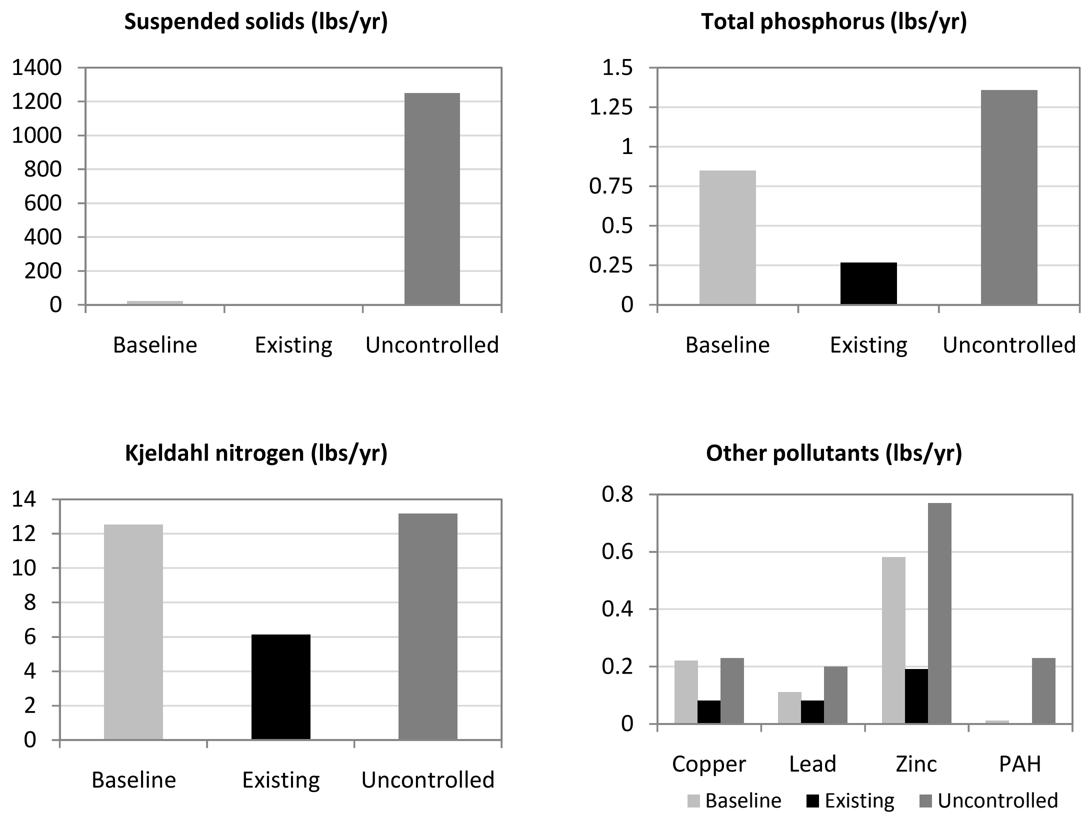


Figure 3-4
Pollutant loads (lbs/year) from Merrill Center that discharge to the Chesapeake Bay and Black Walnut Creek under the three scenarios

Figure 3-5 shows that most of the runoff is infiltrated on the site for the both the existing and baseline scenarios. As a result, most of the particulate exports (shown as suspended solids in Figure 3-4) are negligible. In contrast, suspended solids loads in the uncontrolled scenario total 341 lbs/acre/year based on simulated load of 1,251.3 lbs/year (from Table E-1) across 3.67 acres. This value is comparable with values from other small urban watersheds (average = 348 lbs/acre/year) (Corsi et al., 1997).

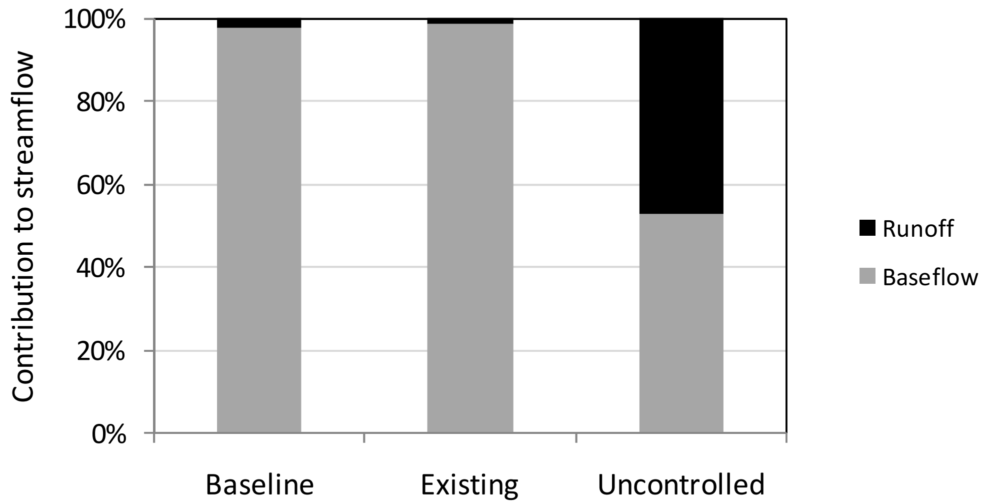


Figure 3-5
Contributions of baseflow (rainwater that follows subsurface flowpaths to surface water) and surface runoff to the Merrill Center site's water exports to Chesapeake Bay and Black Walnut Creek

As shown in Figures 3-6 and 3-7 storm runoff peaks for small and large storms are lowest in the existing scenario. The differences among scenarios, however, are greatest during small storms (Figure 3-6). Very large storms (Figure 3-7) overwhelm the detention capacity of the BMPs. Storm runoff peaks themselves are not a significant issue at the Merrill Center because the Bay's volume and open connection to the ocean provide almost unlimited assimilative capacity for water inflows. However, because runoff carries more pollutants than subsurface flow, the same practices that reduce storm runoff peaks typically reduce pollutant loading, which is a priority issue at this site.

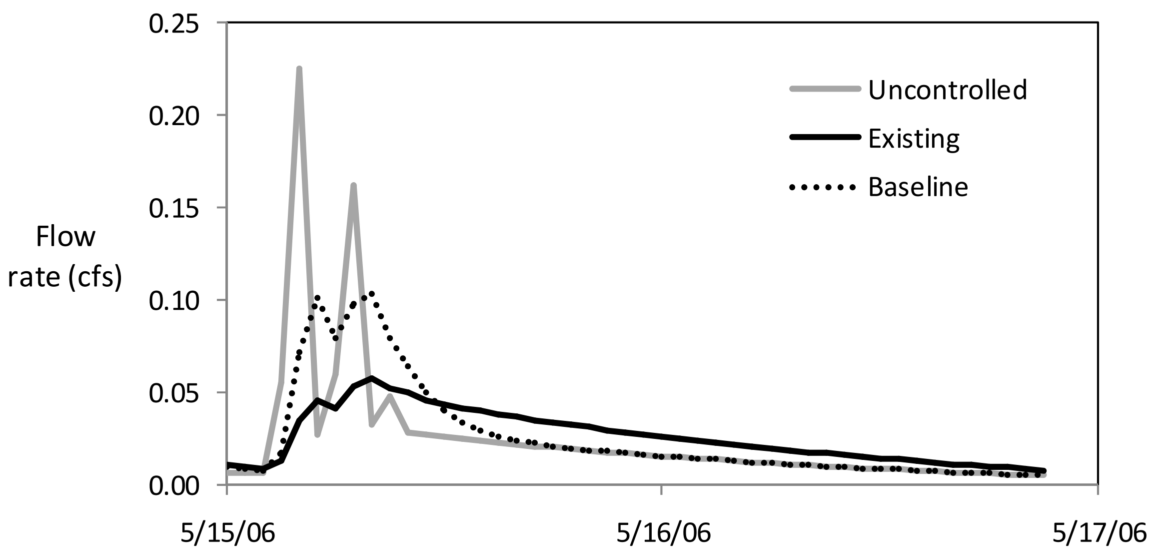


Figure 3-6
Runoff rates from a small (0.46 in) storm under the three stormwater management scenarios

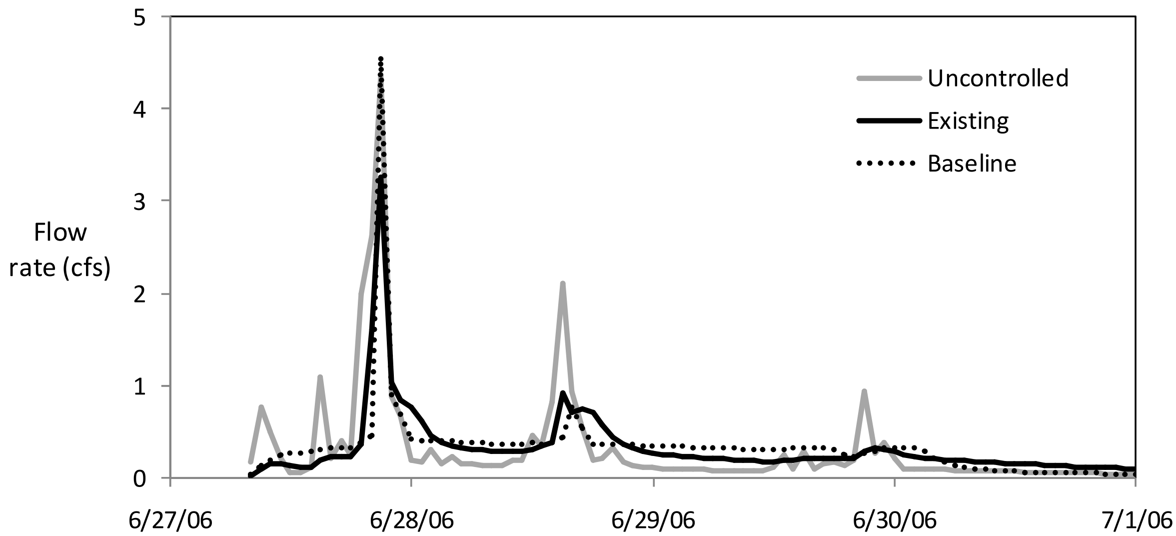


Figure 3-7
Runoff rates from a large (9.33 inch) storm under the three stormwater management scenarios

Which measures had the greatest effect?

The stormwater management practices at the Merrill Center act as a system. Attempting to isolate the performance of a particular practice would not recognize the synergies among practices that were accounted for in the design of the system. Nevertheless, modeled results show that the most effective measure in reducing nitrogen runoff in the existing scenario compared to baseline was the reduction in impermeable surface. Thus, for the Merrill Center, BMPs that reduced the volume of runoff generation rather than capturing and storing it perform better with respect to nutrient control.[6]

The existing suite of BMPs outperforms the single detention pond in the baseline scenario for all pollutants and particle sizes, although it is noteworthy that conventional stormwater management devices provide some benefits to receiving waters. Conventional approaches, however, do not provide the unique ancillary benefits that are realized at the Merrill Center site. For example, stored stormwater is available for fire suppression, which obviates the need to connect the site to a high-pressure municipal water line. In addition to practical cost concerns, the Merrill Center was designed to serve as a showpiece for a diverse suite of innovative approaches. Using a detention pond, the most traditional of stormwater management practices, would not have contributed to this goal.

How could the design or operation be improved to better address primary concerns?

The large exterior cisterns must remain 90 percent full to provide water for fire suppression. As a result, the capacity of these cisterns to collect runoff from storm events is diminished. In addition, indoor water uses to do not typically empty the cisterns fast enough to make the other

[6] The difference between pollutant loading (particularly nitrogen) between the baseline and existing scenarios may be exaggerated by the methods that P8 models subsurface pollutant transport (see methodology in Section 3.1.2).

10 percent of the cistern volume available for capturing stormwater runoff. As a result, the cisterns typically overflow during rain events. Overflow from the cisterns has little effect on pollutant loading to the Bay, however, because the water passes through several treatment devices before final discharge. The requirement to keep the cisterns at 90 percent capacity for fire suppression limits any opportunity for changing how the cisterns are managed.

The infiltration capacity of basins, swales, and pervious pavements can be reduced if pores are clogged by fine sediments. Regular maintenance can ensure that their performance does not degrade.

3.2.3 Potential Impact of Widespread Implementation

The composting toilets and suite of stormwater BMPs at the Merrill Center reduce nutrient loading to the Chesapeake Bay and could have significant benefits if they were used in the entire Bay watershed. The composting toilets eliminate the human waste component of the nutrient loading from the Merrill Center, representing an estimated reduction of approximately 80 percent of the total nitrogen and 45 percent of the total phosphorus load (Wilsenach and Loosdrecht 2003). The remaining wastewater from the Merrill Center is collected and pumped to the Annapolis Water Reclamation Facility (WRC). The Maryland Department of the Environment reports on an existing project to equip the Annapolis WRC with enhanced nutrient removal. Upon completion of the project, the plant will be able to meet new goals of less than 3 mg/L of total nitrogen and less than 0.3 mg/L of total phosphorus in the wastewater discharge to the Bay[7]. Although the projected nutrient removal of the upgraded Annapolis WRC is aggressive by industry standards, the plant will still be allowed to discharge up to 158,369 lbs/year of nitrogen and 11,878 lbs/year of phosphorus to the Bay each year (Maryland Department of the Environment, 2009). Any reduction in nutrient loadings to the plant will reduce the energy needed to remove nutrients and reduce the residual nutrient concentration discharged to the Bay.

Simulated annual total nitrogen loads (8.8 lbs/acre) from stormwater were comparable to the Bay watershed urban average (9.9 lbs/acre)[8]. However, simulated annual phosphorus loads from the Merrill Center in the existing scenario (0.07 lbs/acre) are well below the average for urban areas in the Chesapeake Bay watershed (0.76 lbs/acre) (CBF, 1994). Based on the scenario comparisons, much of the reduction in phosphorus loading is due to the system of stormwater management practices at the site. However, even loads in the uncontrolled scenario are lower than the watershed's urban average. This finding is probably a function of three characteristics of the site that are not typical for urban areas in general:

- Even when only the areas within the limit of disturbance are included, almost half the site is covered in natural vegetation. (This limited site coverage was a conscious decision on the part of the CBF, and can be emulated by other development.)
- For purposes of this analysis, the swale that runs across the front of the building was kept in the uncontrolled scenario because it is a landscaping feature in addition to a water quality BMP.

[7] From fact sheet published by the Maryland Department of the Environment in August 2009. Available on-line at http://www.mde.state.md.us/assets/document/enr/Annapolis.pdf (Maryland Department of the Environment 2009).
[8] Total nitrogen was estimated by multiplying the Kehldahl nitrogen value (3.42 lbs/acre/year) by 2.57, which was the average total nitrogen:Kehldahl nitrogen ratio in stormwater runoff from a study where both were measured (Bannerman et al. 1996).

- The sandy soils at this site are more permeable than typical soils across the watershed.

Because these factors combine to create a "best-case" uncontrolled scenario for stormwater, the low pollutant loads from this site will probably not occur for other sites.

A modeling study of the entire Chesapeake Bay watershed found that 17 percent (for all) of the phosphorus and 11 percent of the nitrogen loads to the Bay come from urban and suburban stormwater (CBF, 1994). If the proportional reductions from the baseline to the existing scenario could be achieved on all urban lands in the watershed, approximately 12 percent of the total phosphorus load and 6 percent of the total nitrogen load could be eliminated.

3.3 Results: Wetland Studies and Solutions, Inc. (WSSI)

WSSI uses a suite of strategies to conserve water, reduce wastewater discharge, and control stormwater runoff. This section presents estimated impacts of these measures on potable water use and discharge to sanitary sewer (Section 3.3.1) and stormwater runoff (Section 3.3.2). Section 3.3.3 provides a discussion of the potential effects of widespread implementation of WSSI's water management strategies. Note that nutrient loading in the waste stream is not addressed by any of the water management strategies at WSSI; therefore, it is not evaluated in Section 3.3.

3.3.1 Potable Water Use and Discharge to Sanitary Sewer

3.3.1.1 Baseline Estimate

The baseline estimate is the hypothetical use of water as if no conservation measures were put in place at the facility. It provides a point of reference for evaluating actual (metered) water use. Table 3-3 summarizes the components of the water use baseline for WSSI.

Table 3-3
Components of the water use baseline for WSSI[1]

Type of Water Usage	Annual Water Usage (gal)	Equivalent Daily Water Usage (gal/day)
	A	B = A/365
Flush Fixture Type	84,336	231
Flow Fixture Type	123,774	339
Appliances	3,380	9
Irrigation	836,490	2,292
Cooling Tower	700,000	1,918
Total[2]	**1,747,981**	**4,789**

1. See Appendix C, Section C.3 for assumptions and detailed calculations for each baseline component.
2. The total value represents the potable water use baseline. The wastewater discharge baseline, which does not include irrigation or evaporation from the cooling tower, is 351,490 gallons per year.

Water use for flush fixtures (i.e., toilets and urinals) and for flow fixtures such as faucets, sinks, and showers were estimated by the building owner as part of their LEED application. The amount of water used for appliances is based on one clothes washer and one dishwasher in the building. Based on conversations with WSSI, the clothes washer was assumed to be used three times per week and the dishwasher was assumed to be used twice per week.

The WSSI irrigation baseline was established using only the current total irrigated area and did not include a large tract of non-irrigated undisturbed pre-existing vegetation within the site boundary. WSSI's LEED submittal landscape plans specified surface areas devoted to native or adapted trees, shrubs, and groundcover irrigated by potable and non-potable water sources. For the baseline analysis, the plant selection for these areas was replaced with plant selections with average species factors and conventional irrigation methods[9].

The potable water use baseline for WSSI, which totals approximately 1.7 million gallons per year, includes all components listed in Table 3-3. The wastewater discharge baseline flow, roughly 351,500 gallons per year, does not include the estimated water needs for irrigation or evaporation of tower water as there no discharge to the municipal wastewater system. It is assumed that 80 percent of the water used for cooling evaporates (Harfst, 2009).

3.3.1.2 Actual (Metered) Water Use

WSSI personnel provided the study team with water meter records for 2008. Separate meter readings were provided for irrigation. WSSI estimated that approximately 1,000 gallons per month is used by another building resident, Gainesville Garage. See Appendix B for detailed assumptions and derivation of 2008 water use for WSSI.

The total measured water use for the WSSI office for 2008 was approximately 233,500 gallons which represents an average of 640 gallons per day.

3.3.1.3 Comparison of Baseline to Actual (Metered) Use

Figure 3-8 comparing the baseline water use to the metered well water use shows a significant difference between the baseline and measured value, with the measured value representing approximately 13 percent of the total baseline. The third column in Figure 3-8 represents the measured use of city water in 2008 (233,500 gallons) reduced by the estimated use of stormwater from the cistern for toilet flushing (40,311)[10] which only recently came on-line.

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[9] Note that the estimate for irrigation shown in Table 5.1 is lower than the irrigation estimate of 2.6 million gallons provided by WSSI in their LEED documentation. The LEED rating system under which the project was certified, LEED for Commercial Interiors (LEED-CI), did not require a detailed calculation for irrigation water use. Because the estimate could not be reproduced, a baseline irrigation estimate was derived for this impact assessment following the same methodology used for the other two case study sites. Note that natural areas were not assumed to require irrigation in the baseline estimate. See Appendix A, section A.4 for additional assumptions and calculations for the irrigation baseline estimate.

[10] The estimated use of stormwater from the cistern, 40,311 gallons per year, assumes 73 current employees, 2 flushes per employee per day, 251 work days per year ((52 x 5) – 9 days for holiday), and 1.1 gallons per flush (LEED application Water Efficiency credits 1.1-1.2 documents the use of low-flow, 1.1 gallon per flush toilets). Note that WSSI's cistern came on line in March of 2009.

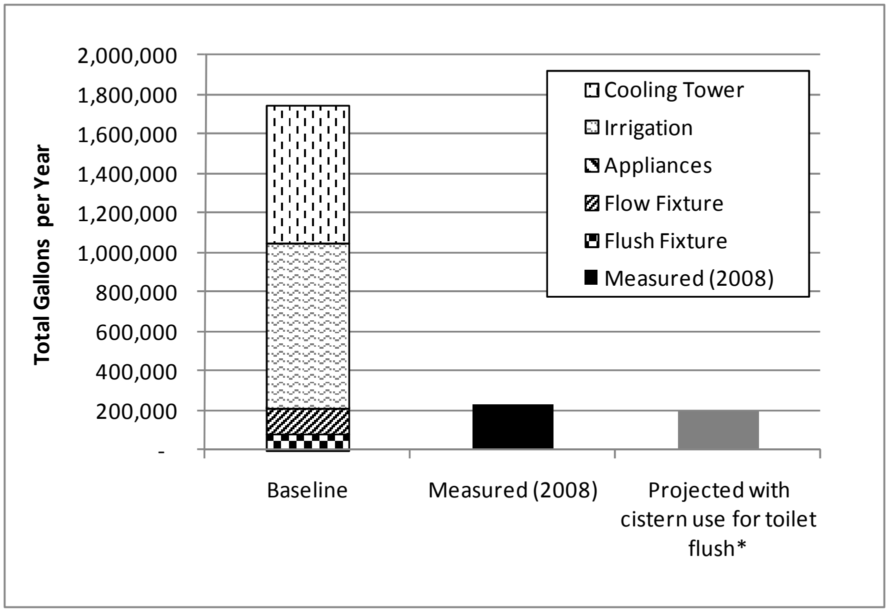

Figure 3-8
Baseline water use compared to actual (metered) well water use for WSSI

3.3.2 Stormwater Runoff

The P8 Urban Catchment Model was used to evaluate impacts of stormwater management practices at the WSSI office building. Section 3.3.2.1 provides a detailed description of the modeled scenarios. Section 3.3.2.2, supplemented by detailed modeling information and results in Appendix F, presents results of the stormwater impact assessment.

3.3.2.1 Description of Scenarios

Three scenarios were used to evaluate the effects of stormwater management practices on runoff quality and quantity at the WSSI office building: existing, baseline, and pre-development.

The ***existing scenario*** was designed to replicate the performance of the current suite of stormwater BMPs at WSSI. In this scenario, the following BMPs contribute to the management of stormwater:

- The WSSI building is located on a 5-acre site, of which only 37 percent is covered with impervious surfaces.
- Stormwater runoff from WSSI's roof is collected in an interior cistern, which is used to flush toilets, and in an exterior cistern, which is used to irrigate gardens. Thirteen percent of the roof area is a green roof, which absorbs rainfall.
- Runoff from impervious parking areas is routed to a bioswale, a raingarden, and areas of pervious pavement.
- Infiltration from pervious pavement and the raingarden is routed through underground drains to a gravel bed detention system, which releases water slowly into the adjacent stream.

Figure 3-9 provides an illustrative depiction of the existing scenario for WSSI.

The ***baseline scenario*** was designed to replicate the minimum stormwater practices required by Virginia stormwater regulations, which are summarized in the Virginia Storm Water Management Manual (VASMP, 2009). According to Section 4.1 of the manual, requirements for on-site stormwater management practices at new developments may be waived if:

> *Provisions are made to manage stormwater by an "off-site" facility. The off-site facility is required to be in place and to be designed to provide a level of stormwater control that is equal to or greater than that would be afforded by on-site practices,[and] has a legally obligated entity responsible for long-term operation and maintenance of the stormwater practice. (VASMP, 2009)*

A regional stormwater management facility is located just downstream of the WSSI site and was designed to serve the entire Virginia Gateway Development, including the WSSI development. As a consequence, no stormwater BMPs were required for the WSSI site. Therefore, the baseline scenario assumes that all parking surfaces and roof surfaces are impervious and that stormwater runoff from the impervious surfaces is routed through a swale to the streams. The swale is used to prevent undirected runoff from eroding soils on the site, which is a basic expectation for development projects, not a stormwater BMP *per se*.

The ***pre-development scenario*** was designed to replicate conditions prior to construction of the WSSI building. The entire site was modeled as a pervious surface with runoff curve numbers assigned to various portions according to soil class and vegetated cover.

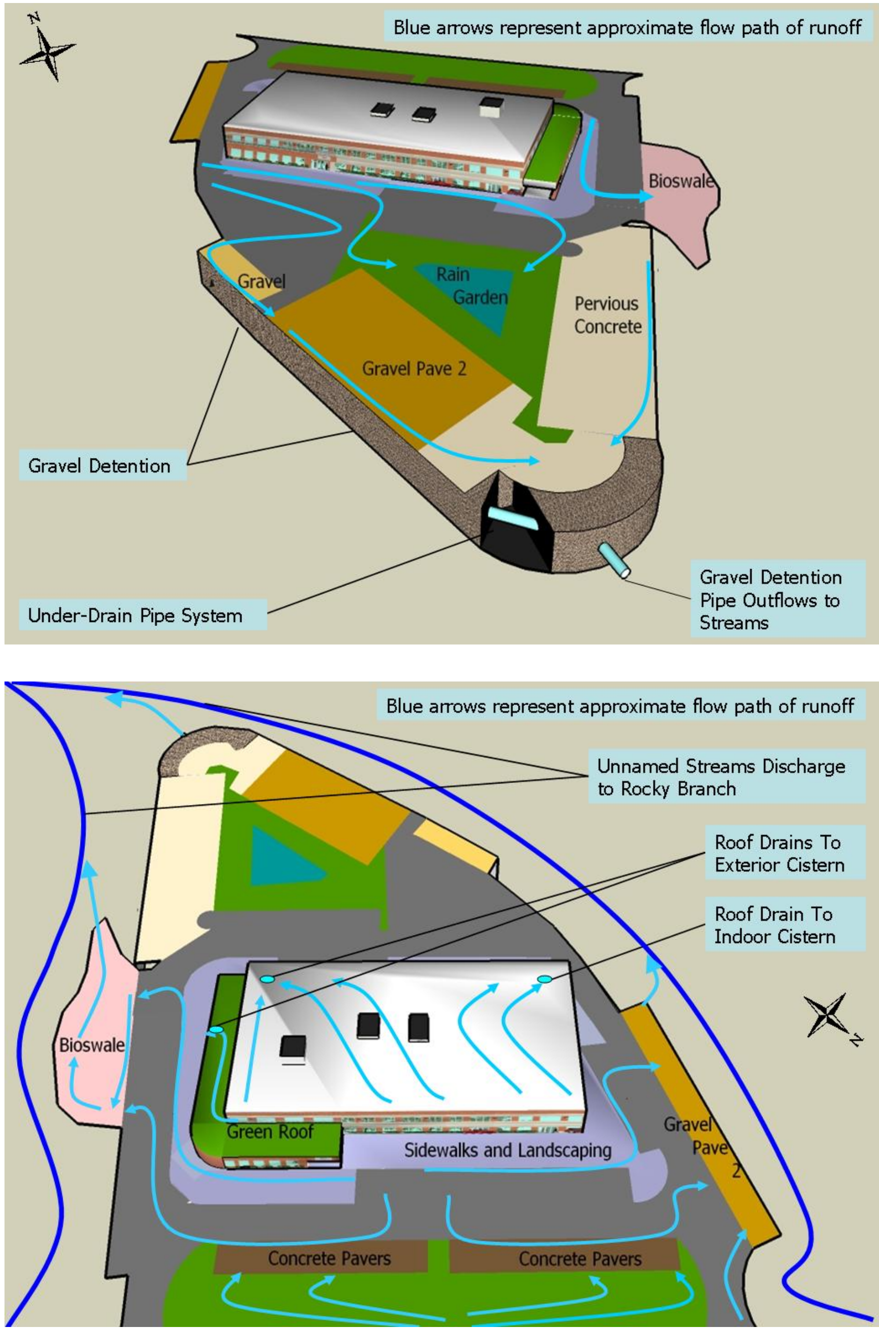

Figure 3-9
WSSI stormwater infrastructure
Source: Prepared by Cadmus
Note: The two figures show stormwater drainage patterns from different views to provide a more complete picture for the site.

3.3.2.2 Results

Table F.1 in Appendix F presents detailed results for contaminant loading for all scenarios. The next several paragraphs discuss how the stormwater BMPs performed, in particular for the primary issues of concern at the WSSI site. A discussion of which measures had the greatest effect and possible design and operational improvements follow.

Storm runoff peak flows and pollutant loads are significant concerns in Rocky Branch and downstream waters. The prevalence of low permeability, clay soils in the region exacerbates the effects of development on runoff. Suspended sediment loads, which are often used as an indicator of overall stormwater pollution, were more than seven times lower in the existing scenario than in the baseline scenario (see Figure 3-10). Simulated annual phosphorus loads from the site in the existing scenario (0.12 lbs/acre) are well below the average from urban areas in the Chesapeake Bay watershed (0.76 lbs/acre) (CBF, 1994). Simulated annual nitrogen loads from the site in the existing and baseline scenarios are similar[11] (5.0 and 4.9 lbs/acre[12], respectively), and are about half the average from urban areas in the Chesapeake Bay watershed (9.9 lbs/acre) (CBF, 1994).

As shown in Figure 3-11, the contribution of baseflow (in other words, water that follows an underground path) to streamflow was highest in the existing scenario, exceeding even the pre-development scenario. This result is due to the detention and slow release of water from the gravel bed detention in the existing scenario. This detention has the greatest influence on instantaneous runoff peaks during large storms, which cause the most channel erosion (see Figure 3-12).

In summary, the WSSI site performs best on the most important criteria. Storm runoff peaks and suspended sediment loads are the most significant sources of degradation to headwater streams and are significantly reduced in the existing scenario. Of the two nutrients, phosphorus most often limits algae growth in freshwaters and is moderately reduced in the existing scenario. Reducing nitrogen loads from a site like WSSI is less important because nitrogen is primarily a problem in estuarine systems, and much of the nitrogen that enters the stream at WSSI will be removed by natural processes before it reaches Chesapeake Bay.

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[11] The estimated nitrogen loading is slightly higher for the existing scenario compared to the baseline scenario because of the green roof in the existing scenario. Green roofs provide many benefits for controlling stormwater runoff and pollution; however, they may contribute a small amount of nitrogen to runoff because of the presence of the plants and vegetation. The small amount of additional nitrogen loading from green roofs varies depending on how the plants are fertilized and the type of vegetation.

[12] Total nitrogen was estimated by multiplying the Kehldahl nitrogen value by 2.57, which was the average total nitrogen:Kehldahl nitrogen ratio in stormwater runoff from a study where both were measured (Bannerman et al. 1996).

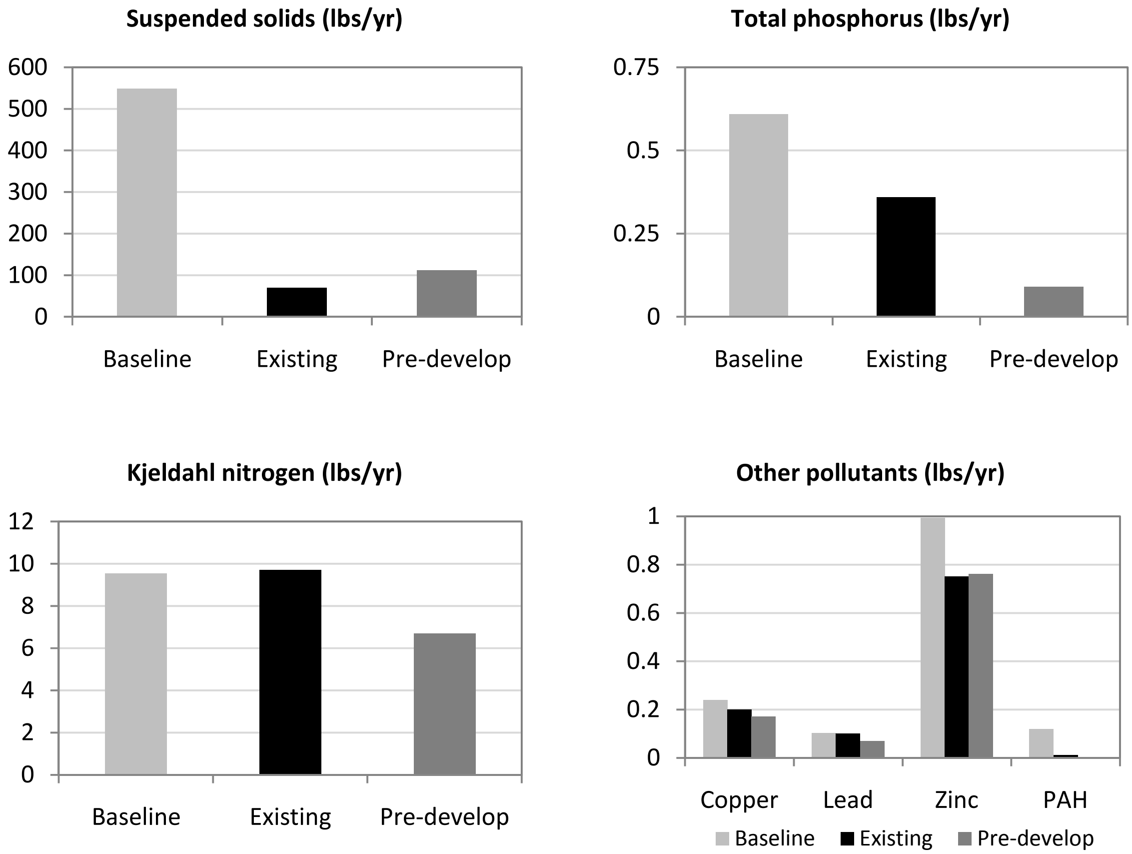

Figure 3-10
Pollutant loads (lbs/year) from WSSI that discharge to the surrounding surface waters under the three scenarios

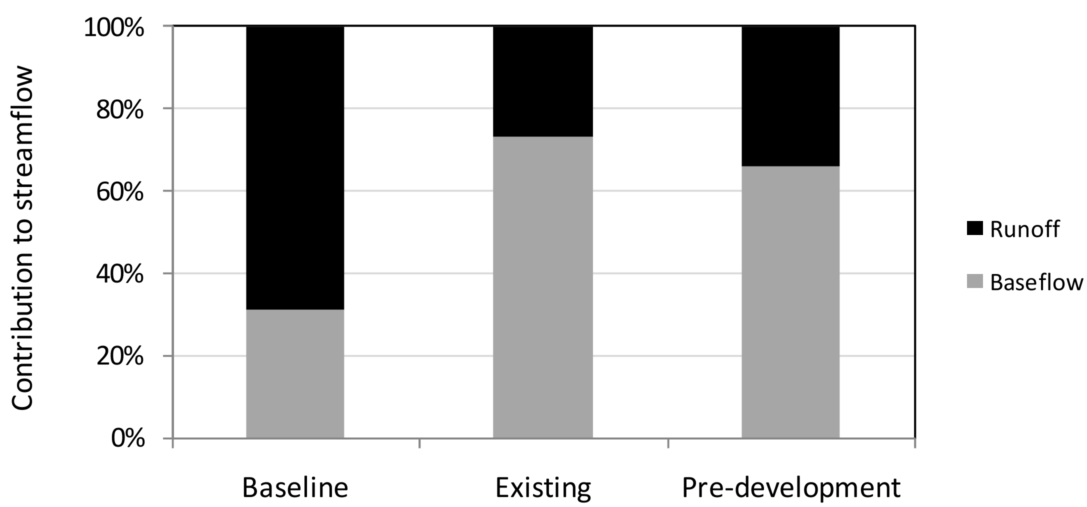

Figure 3-11
Contributions of baseflow (which follows subsurface flowpaths to stream) and surface runoff to the site's water exports to Rocky Branch

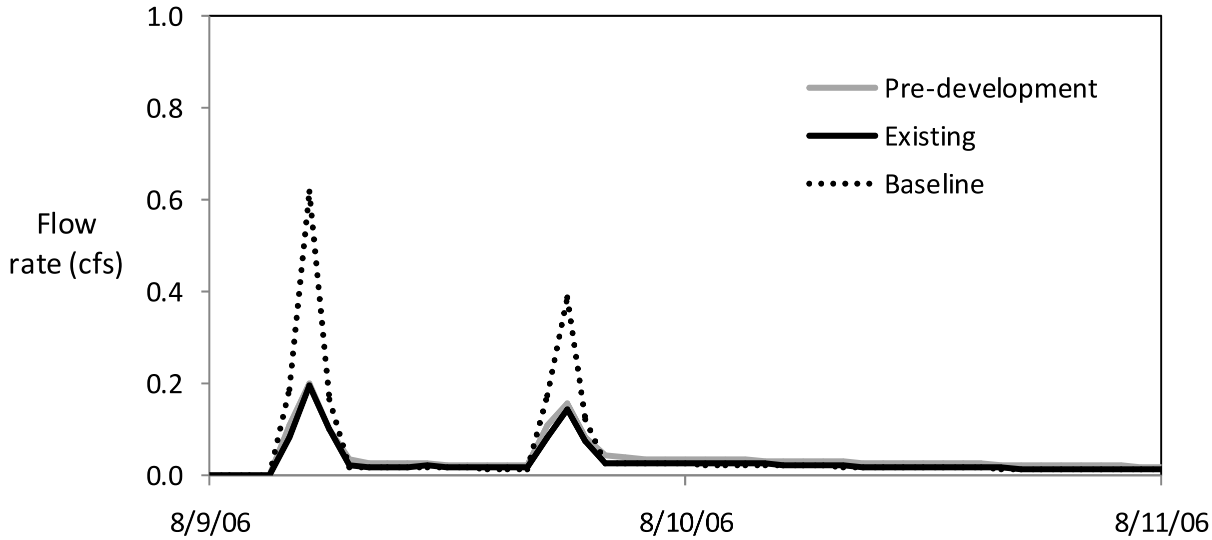

Figure 3-12
Runoff rates from a small storm (0.97 inches) under the three stormwater management scenarios

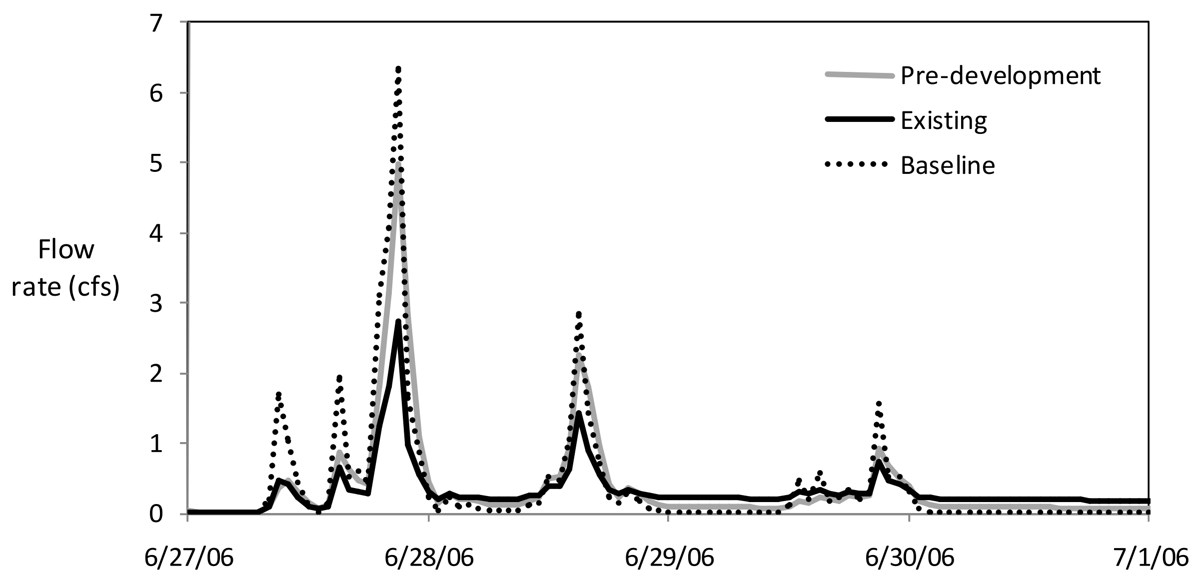

Figure 3-13
Runoff rates from a large storm (9.33 inches) under the three stormwater management scenarios

Which measures had the greatest effect?

The stormwater management practices at WSSI are intended to function as a system, so it is not possible to isolate and evaluate them individually. A reasonable division, however, can be made between the components that drain to the gravel bed detention and those that drain to the bioswale (see the schematic in Appendix F). Of these two subsystems, the gravel bed detention system is most effective at removing pollutants and attenuating peak storm flows. Because the gravel bed detention retains water for at least 24 hours, all particulate pollutants are removed from runoff by settling. In contrast, water moves relatively quickly through the bioswale, so only 50 percent of the suspended particles can settle out. The volume of runoff from a 1-year recurrence interval storm can move through the bioswale in 1 hour; the gravel detention releases this volume over 30 hours.

Are there tradeoffs in design or operation?

Similar to the other case study sites, water use at WSSI does not normally empty the cisterns in the periods between rain events. As a consequence, there is less volume available to store stormwater runoff than if these cisterns were intentionally drained in anticipation of rain, or at least on a more frequent basis. Overflow from the cisterns has little effect on peak storm flows and pollutant loading because it passes through the rain garden and gravel detention system before entering Rocky Branch.

How could the design or operation be improved to better address primary concerns?

This analysis did not identify any significant opportunities for improving operation of stormwater management facilities. The infiltration capacity of basins, swales, and pervious pavements can be reduced if pores are clogged by fine sediments. Regular maintenance can ensure that their performance does not degrade. Currently WSSI performs the following maintenance on their water management features: sweeping of the pervious concrete and pavers every few months, raking of the GravelPave area every few months, trimming and mulching the raingarden. No maintenance is performed on the swale since it is desired for it to perform as a forested swale. The cisterns are also able to be cleaned, but a schedule has not been determined.

3.3.3 Potential Impact of Widespread Implementation

Gainesville is rapidly being developed. Virginia's stormwater management regulations require that all new development manage stormwater onsite to the extent that the site's 10-year storm hydrograph peak does not exceed pre-development levels. As discussed in the scenario descriptions above, this requirement may be waived if an offsite facility provides the same level of runoff control. The detention pond downstream from the WSSI site was designed to meet this requirement and would provide aggregated stormwater control for several developed sites. Despite this legal exemption, WSSI elected to implement an extensive and very effective system of onsite management practices. There are many benefits to the approach taken by WSSI, including:

1. ***Volume control*** — Detention ponds are usually effective at reducing flood peaks, but unless they include significant infiltration capacity, they do not limit the total volume of water that moves through the stream network following a rain event. Thus, even when stormwater detention maintains the pre-development peak flow for the two-year storm, the duration of this peak flow level is greatly increased due to increased total runoff volume. Because sediment transport is a function of the magnitude and the duration of storm flows, it may be necessary to limit overall runoff volumes to maintain stream channel integrity (Holman-Dodds et al., 2003). Distributed, onsite management practices are better at facilitating infiltration and evapotranspiration, which are important parts of the hydrologic cycle in natural settings (Echols, 2007).

2. ***Protection of headwater streams*** — Because the first detention ponds are typically located downstream of the area where stream channels first form in a watershed, these headwater streams are afforded no protection from the erosive power and pollutant loads carried by stormwater. Furthermore, the outlet structures of detention ponds are typically barriers to the movement of aquatic organisms, many of which require at least periodic access to headwater habitats. Managing stormwater upstream of where it first creates aquatic habitat affords protection to the full extent of these habitats in a watershed.
3. ***Increased use of recycled water*** — Some onsite management practices can collect and store relatively clean runoff water (e.g., cisterns that collect roof runoff), which can be used to replace municipal water use. Irrigation, equipment washing, and toilet flushing do not require the same level of purity that municipal water provides, and particularly in the case of irrigation, often consume large quantities of municipal water.

As illustrated above, traditional aggregated management approaches only address a subset of the environmental problems created by stormwater runoff. By better emulating the hydrologic processes that occur in natural watersheds, the onsite practices used at WSSI provide a more comprehensive solution to stormwater's potential for environmental damage. Widespread adoption of these types of practices would likely result in:

- Less channel erosion throughout the stream network, particularly in headwater streams.
- Improved water quality in headwater streams.
- Improved connectivity (fewer obstructions) among parts of the stream network, which would improve the ability of aquatic organisms to travel between habitats.
- Reduced municipal water use.

3.4 Results: Millennium Tower Residences

The Millennium Tower Residences includes many design features to conserve water, reduce wastewater discharge, and control stormwater runoff. This section presents estimated impacts of these measures on potable water use and discharge to sanitary sewer (Section 3.4.1) and stormwater runoff (Section 3.4.2). A discussion of the potential effects of widespread implementation of the site's water conservation measures is provided in Section 3.4.3.

3.4.1 Potable Water Use and Discharge to Sanitary Sewer

3.4.1.1 Baseline Estimate

The baseline estimate is the hypothetical use of water as if no conservation measures were put in place at the facility. It provides a point of reference for evaluating actual (metered) water use. Table 3-4 summarizes the components of the baseline water use for the Millennium Tower Residences. Appendix C, Section C.4 provides detailed calculations.

Table 3-4
Components of the water use baseline for the Millennium Towers[1]

Type of Water Usage	Annual Water Usage (gal)	Average Daily Water Usage (gal/day)
	A	**B = A/365**
Flush Fixture Type	2,135,250	5,850
Flow Fixture Type	6,801,775	18,635
Appliances	711,598	1,950
Irrigation	77,638	213
Cooling Tower	8,000,000	21,918
Total[2]	17,726,261	48,565

Notes:

1. The total value represents the potable water use. The wastewater discharge baseline, which does not include irrigation or evaporation from the cooling tower, is 11,248,623 gallons per year.
2. See Appendix C, Section C.4 for assumptions and detailed calculations for each baseline component.

Water use for flush fixtures (i.e., toilets and urinals) and for flow fixtures such as faucets, sinks, and showers were estimated by the building owner as part of their LEED application. The amount of water used for appliances is based on one clothes washer and one dishwasher per condominium. As a rough estimate, residents of one-bedroom units were assumed to use their clothes washer once per week and their dishwasher every other day. Residents of two-bedroom (and larger) units were assumed to use their clothes washer twice per week and their dishwasher every day.

The irrigation baseline is a hypothetical estimate of potential use for the site as if all vegetated areas were planted with traditional trees, shrubs, and grasses (instead of native plants) that required regular watering. Note that in contrast, the landscape of Millennium Towers includes native plants in its rain gardens and a green roof planted with drought-resistant succulents, and that operations personnel are able to use stormwater for any irrigation needs. The last row in Table 3-4 shows the projected water that would be used to cool the building using a conventional cooling tower system (see Appendix C, Section C.5 for a detailed derivation of this estimate).

The potable water use baseline for Millennium Towers, which totals approximately 17.7 million gallons per year or an equivalent of roughly 50,000 gallons per day (gpd), includes all components listed in Table 3-4. The wastewater discharge baseline flow, 11.2 million gallons per year, does not include the estimated water needs for irrigation or evaporation of cooling water as there is no discharge to the municipal wastewater system. It is assumed that 80 percent of the water used for cooling evaporates (Harfst, 2009).

3.4.1.2 Actual (Metered) Water Use

Millennium Towers uses roughly 8,000 gpd of reuse water, which is collected and treated onsite to offset a portion of their potable water use demand (2,000 gpd for wash down and 6,000 gpd for toilet flushing). Additional water-saving fixtures are installed in the units to reduce potable water use demands. The resident manager at Millennium Towers provided water bill data for a representative year (July 2007 – July 2008). These data were used to estimate the total annual measured water use for the facility of approximately 8,742,300 gallons, which is an average of 24,000 gpd. See Appendix D for detailed calculations.

3.4.1.3 Comparison of Baseline to Actual (Metered Use)

Figure 3-14 compares the baseline estimate to the measured water usage. Millennium Towers realized an estimated 51 percent reduction in water use from the baseline. This reduction can be attributed to the following: 1) the use of reuse water to reduce potable water needs, 2) native plantings and the use of stormwater to satisfy irrigation needs, and 3) efficient water-saving fixtures.

As described in Section 3.4.1.2, a total of 8,000 gpd of reuse water is treated onsite and used for toilet flushing and wash down. The baseline estimate for flush fixtures (toilets) is 5,850 gpd (see Table 3-4); this demand is fully satisfied by reuse water. The approximate 78,000 gallons per year of water needed for irrigation as calculated in the baseline is satisfied entirely by choosing native plantings that need minimal watering, and satisfying all irrigation water needs by only using stormwater. Lastly, highly efficient fixtures have been installed in all units in Millennium Towers, which significantly reduces the 18,635 gpd water demand calculated in the baseline.

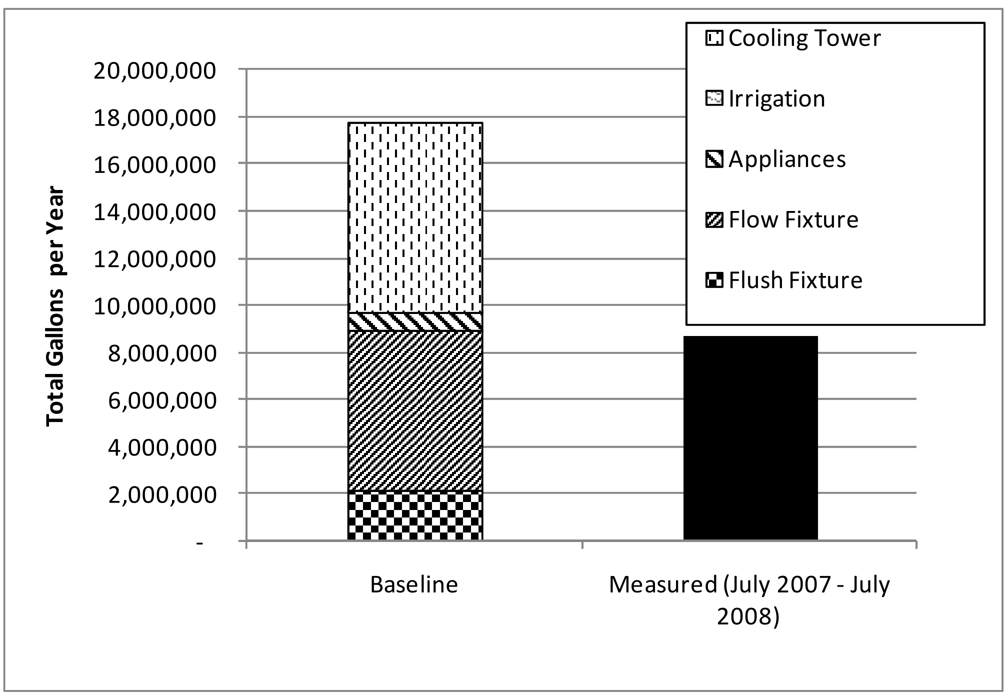

Figure 3-14
Baseline water use compared to actual (metered) data for the Millennium Tower Residences

3.4.1.4 Reduction in Nutrient Loading

In addition to water conservation, one of the design features of Millennium Towers, the onsite blackwater reuse plant, has a significant impact on reducing the nutrient load being delivered to the local wastewater treatment plant. The blackwater reuse plant is designed to supply 25,000 gpd of reuse water for toilet flushing, maintenance floor washing, cooling tower use, and landscape irrigation. The 25,000 gpd reuse system is designed based on approximately 5,300 gpd for toilet flushing. For comparison purposes, a baseline estimate of nutrient loading from toilets was derived from a commonly used wastewater engineering reference and site use information as provided by Millennium Tower Residences.

As shown in Table 3-5, in absence of the onsite backwater treatment plant, Millennium Towers would contribute roughly 6,000 lbs of nitrogen and 850 lbs of phosphorus to the centralized wastewater treatment plant (Newtown Creek Sewage Treatment Facility) each year. Based on the information provided by Applied Water Management, approximately 50 percent of the total nitrogen is removed by biological conversion to nitrogen gas at the onsite blackwater treatment plant, resulting in a potential reduction of approximately 3000 lbs of nitrogen to the centralized plant each year. Some phosphorus is also removed at the onsite blackwater treatment plant; however, because the phosphorus is sent with the rest of the solids to the centralized wastewater treatment plant, the phosphorus load is not reduced by the onsite blackwater reuse plant.

Table 3-5
Derivation of baseline nutrient loading for Millennium Tower Residences

Nutrient	Typical Loading (lbs per Person per day)	Percent of Total Load Attributed to Human Waste	Average Occupancy	Days Occupied per Year	Total Loading per Year
	A	**B**	**C**	**D**	**E = A*B*C*D**
Nitrogen [1]	0.029	80%	736	365	6,232 lbs
Phosphorus	0.0070	45%	736	365	846 lbs

1. The nitrogen is reported as Total Kjeldahl Nitrogen (TKN), which is organic and ammonia nitrogen. Nearly all nitrogen in wastewater is TKN.

Sources:

(A) Typical per capita contribution to wastewater from individual residences as presented by Tchobanoglous et al. 2003, Table 3-12.

(B) Approximate percent of total annual nutrient load in municipal wastewater that originates from urine (most nutrient pollution from human waste is in urine). Figures reported by Wilsenach and Loosdrecht (2003) based on studies conducted in Sweden (Hanæus et al. 1997) and Switzerland (Larsen and Gujer 1996).

(C) Estimated current occupancy of Millennium Towers is based on data provided in Millennium Tower's LEED application. (726 people were estimated to live in Millennium Towers, plus an average of 10 people who use the public bathrooms per day.)

(D) Estimated number of days occupied for a typical residential building is 365 days.

3.4.2 Stormwater Runoff

The P8 Urban Catchment Model (Walker, 2007) was used to evaluate impacts of stormwater management practices at Millennium Tower Residences. Section 3.4.3.1 provides a detailed description of the modeled scenarios. Section 3.4.3.2, supplemented by detailed modeling information and results in Appendix G, presents results of the stormwater impact assessment.

3.4.2.1 Description of Scenarios

Three scenarios were used to evaluate the effects of stormwater management practices on runoff quality and quantity at the Millennium Tower Residences: existing, baseline, and drawdown.

The ***existing scenario*** portrays the current practices at Millennium Tower, which include a green roof, rain gardens, and a stormwater storage tank. In this scenario, stormwater is stored until it is used for irrigation. Irrigation needs are small compared with the tank's volume; therefore, the tank is always nearly full, and can thus store only a limited amount of water from each rainfall event. The existing scenario is depicted in Figure 3-15.

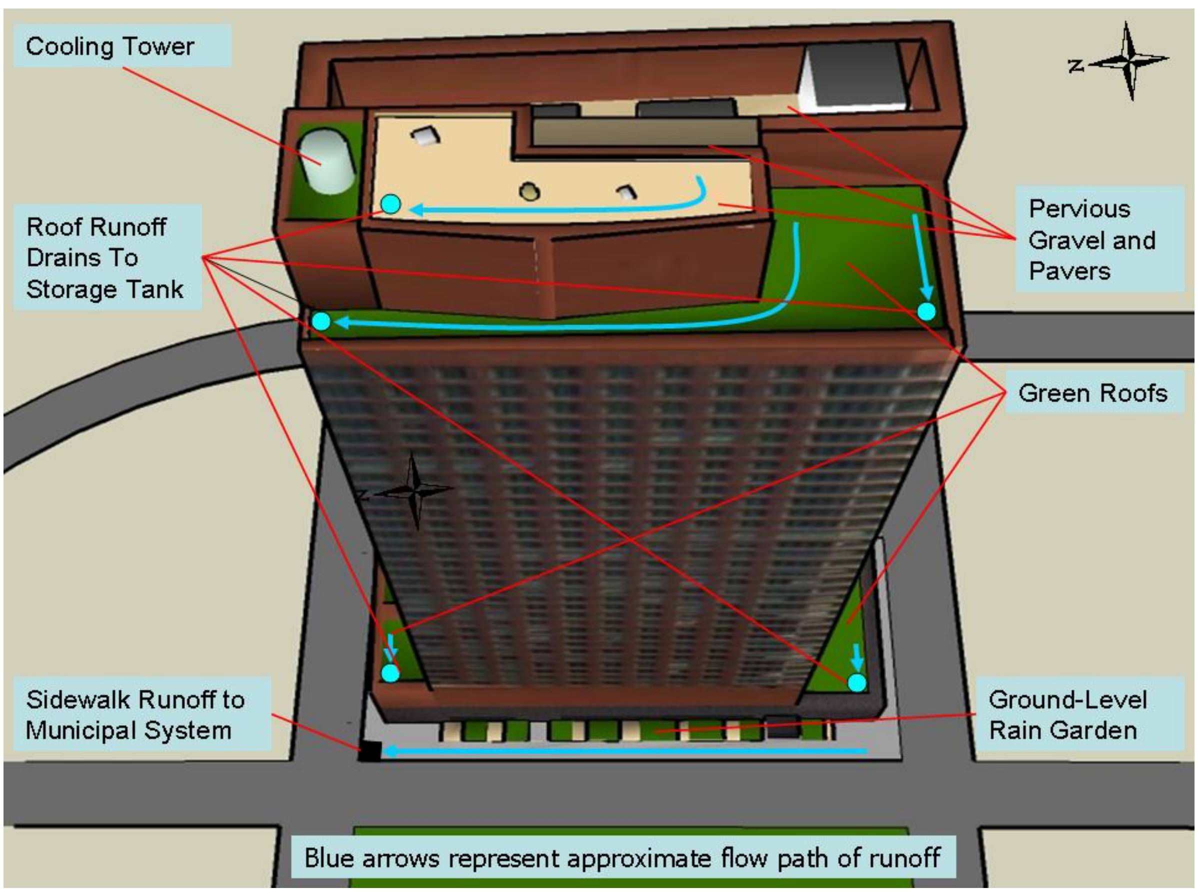

Figure 3-15
Millennium Tower Residences stormwater infrastructure (existing scenario)
Source: Prepared by Cadmus

The ***baseline scenario*** represents a typical Manhattan building, with no on-site stormwater detention or infiltration practices.

The ***drawdown scenario*** uses the existing stormwater practices at Millennium Tower, but operates them to minimize peak runoff during rainfall events. In the drawdown scenario, collected stormwater is discharged slowly over one week into the combined sewer system. The low flow rate of this extended release is not likely to contribute to CSOs and would be treated at the treatment plant before being discharged to surface waters.

3.4.2.2 Results

Table G.1 in Appendix G presents detailed results for contaminant loading for all scenarios. The next several paragraphs discuss how the stormwater BMPs performed, in particular for the primary issues of concern at the Millennium Towers site. A discussion of which measures had the greatest effect and possible design and operational improvements follow.

The primary stormwater concern in Manhattan is the occurrence of combined sewer overflows (CSOs), which lead to bacterial contamination in the Hudson and East Rivers. The stormwater management infrastructure at Millennium Tower Residences is focused on runoff storage, and therefore has the potential to reduce peak stormwater flows following rain events. Current operation of these facilities is oriented toward reducing potable water use for irrigation, and as a consequence, often sacrifices most of the stormwater storage potential[13]. Model results show that peak flows and total volumes of storm runoff are affected only slightly by the existing scenario, but could be substantially reduced by the drawdown scenario. The drawdown scenario is most effective at reducing runoff from small rain events; runoff volumes from large events far exceed the storage capacity of the stormwater tank (See Figures 3-16 and 3-17).

[13] As a result of this study, operation of Millennium Towers stormwater tank has been changed to draw the tank down weekly during dry periods to minimize CSOs.

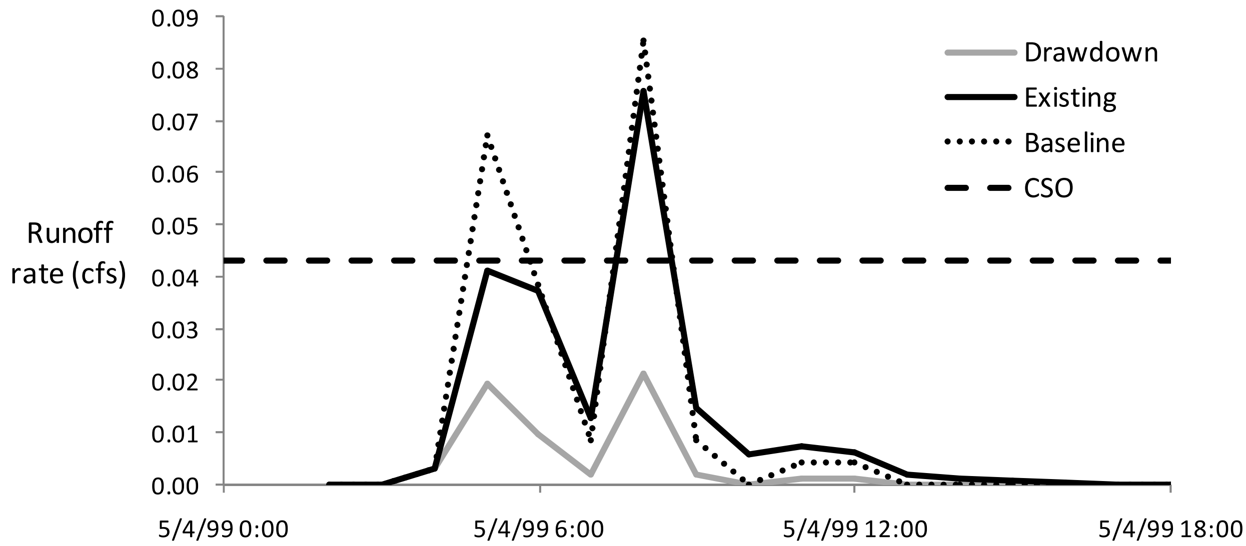

Figure 3-16
Runoff rates from a small (0.58 in) storm under the three stormwater management scenarios at Millennium Tower Residences
Note: The dashed line indicates the flow rate that is likely to produce a CSO.

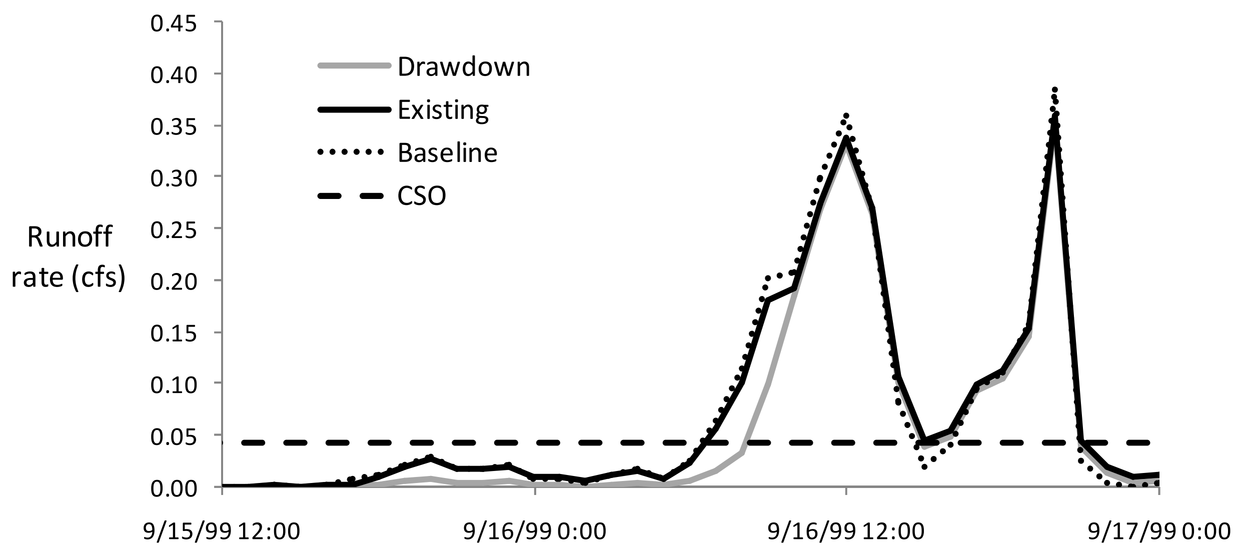

Figure 3-17
Runoff rates from a large (5.45 in) storm under the three stormwater management scenarios at Millennium Tower Residences
Note: The dashed line indicates the flow rate that is likely to produce a CSO.

Compared with the baseline scenario, the existing scenario of stormwater management practices at Millennium Tower Residences reduces pollutant loads to the NYC combined sewer system, and when CSOs occur, the Hudson River. Reductions in annual loads are variable among pollutants, but are all less than 35 percent (Figure 3-18). The drawdown scenario provides pollutant removal comparable to the existing scenario.

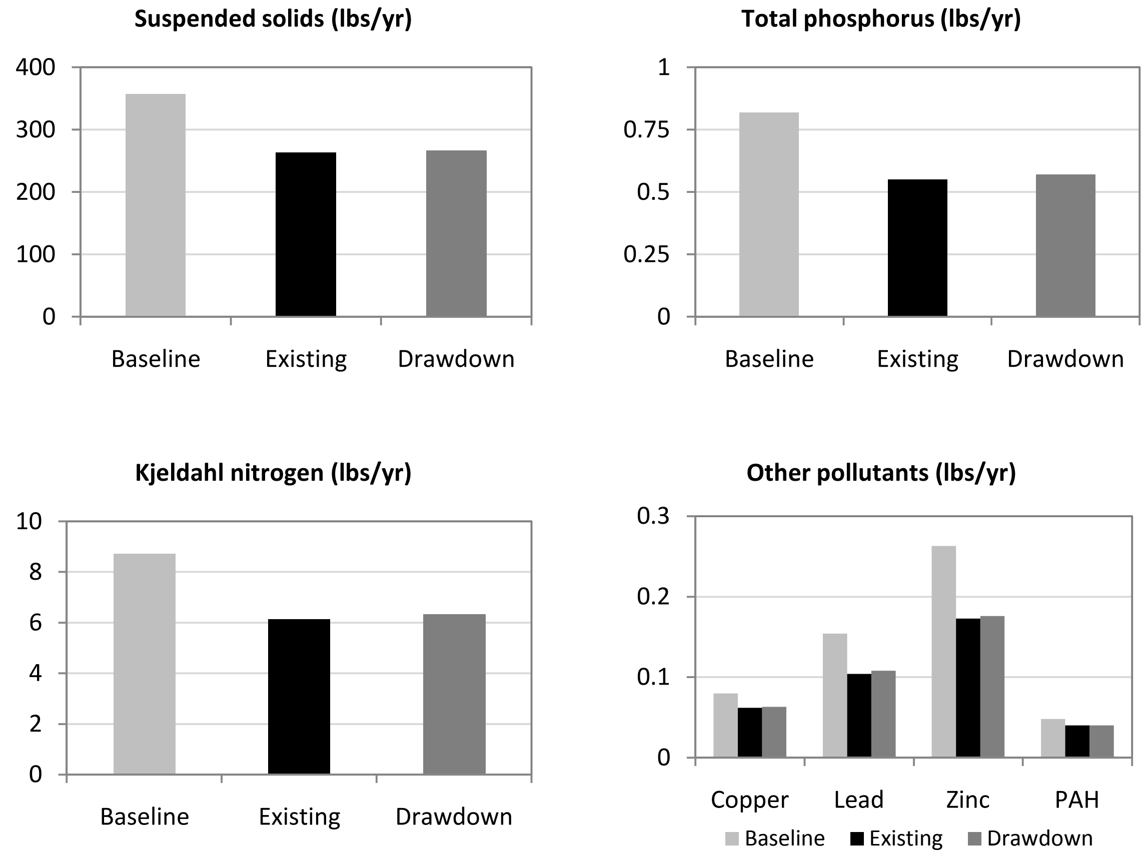

Figure 3-18
Pollutant loads (lbs/year) from the Millennium Tower Residences that enter the NYC combined sewer system under the three scenarios

Which measures had the greatest effect?

The stormwater storage tank has the greatest effect on the frequency of CSOs. If the captured water is slowly released into the sewer system after the storm runoff pulse has passed, it can be treated and will not contribute to CSOs. The green roof attenuates the peak runoff rate from the building, which increases the threshold rainfall event that triggers a CSO from 0.2 inches in two hours to 0.3 inches in two hours.

Are there tradeoffs in design or operation?

The mode of operating the water management facilities at Millennium Tower strongly influences the nature of their effects. At the time of the study, water in the stormwater storage tank was only withdrawn for irrigation, which consumes a maximum of 6 percent of its volume per month. Using stormwater for irrigation reduced the use of potable water, but as a consequence, there was not enough left-over space in the tank to capture the volume of most rain events. As a result of this study, the management of the stormwater tank has been revised to draw down the tank during dry periods.

How could the design or operation be improved to better address primary concerns?

As noted previously and in response to preliminary recommendations from this report, Millennium Towers has instituted the practice of drawing down the stormwater tank weekly during dry periods to reduce CSO impacts.

3.4.3 Potential Impact of Widespread Implementation

The primary issue of concern for the Millennium Towers site is stormwater runoff that contributes to CSO discharges. Because the Millennium Tower Residences is only one of thousands of buildings in Manhattan whose runoff contributes to CSOs, the practices at this building alone are not likely to have a significant impact on the problems associated with CSOs. However, it seems reasonable that broader adoption of practices that detain stormwater runoff could make a difference. (Indeed, many of the Battery Park City neighborhood multi-family high rises now include on-site wastewater treatment and green roofs, a practice NYC would like to encourage at other sites.) The approach used to evaluate this hypothesis is provided below.

The NYC Beach Surveillance and Monitoring Program has defined "preemptive standards" as a threshold level of precipitation that, when exceeded, can lead to elevated levels of bacteria due to CSOs and stormwater runoff (NYC Health, 2007). Preemptive standards vary among beaches; the most stringent standard, which is applied at all Bronx beaches, is:

- 0.2 inches of rain in 2 hours, which is designated for the purposes of this analysis as a "Type 1" storm, or
- 0.4 inches in 24 hours, which is designated for the purposes of this analysis as a "Type 2" storm.

The P8 model was used to simulate runoff from the baseline scenario on the Millennium Tower building that would result from these two storm types. Type 1 storms cause CSOs by overwhelming the capacity of the combined sewer conduits to transport water, so the peak flow rate from this type of event is the diagnostic variable here. Type 2 storms cause CSOs by overwhelming the processing capacity of the wastewater treatment plant, so total runoff volume over 24 hours is the diagnostic variable. Under the assumption that average runoff rates across Manhattan resemble the baseline scenario, these simulations provide estimates of unit-area runoff rates or volumes that would trigger a CSO. Four years of historical weather data (2005 – 2008) were run through the P8 model to determine the frequency of storms that exceeded these thresholds under the three management scenarios.

With the baseline scenario, an average of 46 rain or snowmelt events per year resulted in runoff sufficient to cause a CSO. This figure dropped only slightly (42) with the existing scenario, but dropped significantly (27) with the drawdown scenario (Figure 3-19). These results indicate that widespread adoption of stormwater detention practices could significantly benefit water quality in the water bodies around NYC.

Although stormwater runoff is the primary issue of concern, it is noteworthy that the blackwater treatment plant at Millennium Tower Residences reduces the nutrient loading from the building to the wastewater treatment plant. This, in turn, reduces the discharge of nutrients not removed at the plant to the Long Island Sound.

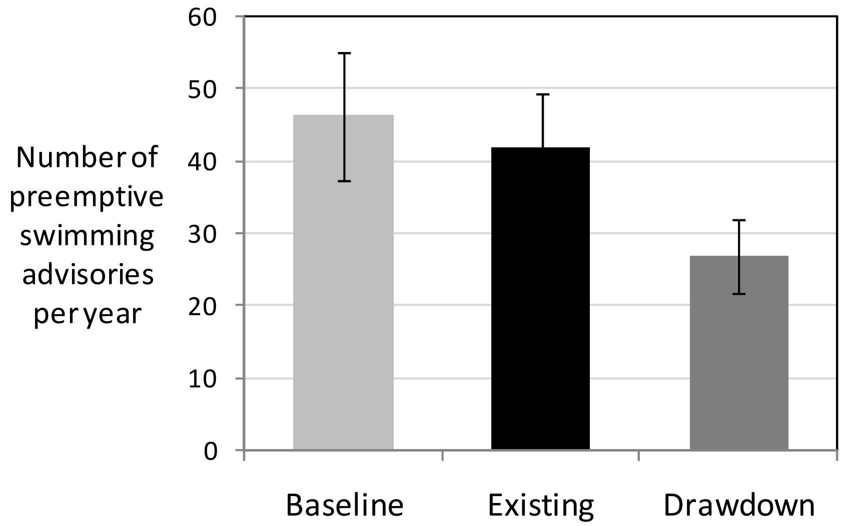

Figure 3-19
Potential effect of widespread adoption of existing and drawdown scenarios on the frequency of preemptive swimming advisories for Bronx beaches

3.5 Conclusions and Lessons Learned

All three case study sites incorporate numerous features to conserve water and control stormwater runoff. But how did each site perform according to their local environmental priorities?

3.5.1 The Merrill Center

The priority issue for the Merrill Center's watershed is nutrient loading to the Chesapeake Bay. Through the use of stormwater management practices and composting toilets within the facility, the Merrill Center performed exceptionally well in addressing this issue. The suite of existing stormwater BMPs on the Merrill Center site reduced the nitrogen load by half and the phosphorus loading by one third compared to a baseline scenario with a single stormwater strategy, a detention pond. Because of the use of composting toilets, the nutrient loading to the local wastewater treatment plant was essentially eliminated for nitrogen and reduced by half for phosphorus.

In addition to addressing local priorities, the Merrill Center's water conservation practices reduced water use by an impressive 99 percent compared to a similar office building with no conservation practices. Reuse of stormwater and onsite wastewater treatment at the Merrill Center are the two key practices that save energy, protect ground water resources, and preserve resources by recycling and reusing a waste resource, nutrients, onsite – especially when compared to the conventional alternative of offsite supply and of conveyance of black- and greywater back to the municipal system.

3.5.2 The WSSI Office Building

The priority watershed issues for WSSI are (1) pollutant loading to and physical degradation of the receiving stream caused by stormwater runoff, and (2) nutrient loading to the Chesapeake Bay. Stormwater BMPs at the WSSI site manage runoff and protect the small receiving stream (Rocky Branch) very well by emulating the hydrologic processes that occur in natural watersheds. The modeled suspended solids load to the stream for the WSSI site was approximately seven times less than the modeled load for the same site with no stormwater controls (baseline scenario). Nutrient reductions were not as dramatic; phosphorus loading was reduced by almost half, but nitrogen loading was not reduced at all. BMPs that facilitate plant uptake of nitrogen, such as constructed wetlands, would be more effective at removing nitrogen. The peak runoff flow rate during large storms was reduced by half compared to the baseline. The individual BMP that contributes most to these reductions is the gravel bed detention system.

Although the impact assessment results showed nutrient reduction from stormwater BMPs, water management strategies internal to the building such as composting toilets or blackwater treatment and reuse could have reduced nutrient loading to the Occoquan wastewater treatment plant. Because the treatment plant is equipped with enhanced nutrient removal, however, the contribution of nutrients in waste to the load on the Bay is ultimately minimized (although this is the result of centralized treatment plant practices and not onsite management).

It is noteworthy that WSSI reduced their water consumption by 90 percent compared to their baseline.

3.5.3 Millennium Tower Residences

The priority issue at Millennium Towers is combined sewer overflows (CSOs) to the Hudson River caused by stormwater runoff. The site infrastructure for black- and greywater treatment reduces the burden on the municipal treatment plant, but has little effect on the frequency of CSOs. As originally operated the stormwater storage tank was not very effective at reducing CSOs. As a result of this study, the tank is now drawn down during dry periods to increase peak flow storage capacity during storm events.

It is worth noting that the existing water use at Millennium Towers is approximately 50 percent of baseline; this could be reduced much more if stormwater or treated blackwater were used to supply the building’s cooling tower.

The Millennium Tower case study highlights two important themes. First, tradeoffs often exist between management objectives, in this case between reducing stormwater runoff and reducing potable water use. Based on the evaluation of resource concerns, the less important concern (potable water use) was being prioritized. The second is the disconnect between design and operation. For example, the blackwater reuse system was designed to provide treated water for cooling; however, because of concerns with scaling, this capacity is not utilized.

3.5.4 Conclusions

In addition to the findings related to local priorities, this impacts assessment identifies these important lessons for sustainable design construction in general:

1. **Building operations can be as or more important than design**. As the example of Millennium Tower Residences demonstrates, substantial benefits to the local watershed could be achieved by emptying the stormwater tank slowly between storm events rather than keeping it full in anticipation of irrigation uses. Indeed, the lack of continuity between building design and building operations is a threat to the ongoing sustainability of any building. The Merrill Center and WSSI benefit from having great continuity between design and operations. Here, building operators act as stewards for green, suggesting improvements and responding to changes in conditions ranging from human occupancy to rainfall to infrastructural wear.
2. **The design of cooling systems can have a substantial impact on water use**. At present, cooling systems are considered the purview of energy management, but the results of this impact assessment suggest that their environmental effects apply equally to water.
3. **Composting toilets, onsite blackwater treatment, and water reuse can have a significant impact on nutrient loading to wastewater treatment plants.** For example, at Merrill, stormwater BMPs are highly effective, but the reduction in nutrient loading realized by the composting toilets is even greater. As with other methods of nutrient reduction, like the onsite blackwater treatment plant of Millennium Tower Residences, it is important to recognize that such practices can bring with them many design and implementation issues. Examining one of the simplest technologies for nutrient reduction, the “humble” composting toilet, is instructive. Even for such a low-tech method, initial monetary cost (first cost) is a factor, as a typical composting toilet costs 10 times as much as a conventional fixture (as much as $5,000 in 2009). Because composting toilets do not use water to flush away human waste, they require more purely vertical waste stacks, and this results in less flexibility in where they can be placed. Stacks for conventional flush fixtures can angle more because water drives the waste through. Other space constraints may also be an issue, since most composting toilets require 10-inch diameter waste shafts -- twice as big as those required by conventional fixtures -- thus requiring more space within the building. Building occupants may be reluctant to accept composting rather than conventional toilets, perhaps fearing that these are less hygienic or possibly foul-smelling. Occupant education may therefore be necessary. Operator education is also key because compost requires periodic turning to aid the process of decomposition. All these limitations, however, can be overcome by the foresight of architects and engineers during design. This impact assessment suggests that for sites where nutrient loading is a severe impact, the integration of composting toilets and/or other methods of onsite waste treatment and nutrient management – such as reduction or elimination of lawns and lawn fertilization, onsite biofiltration systems which use human waste to feed the growth of plants, tree planting, and the presence of plant or grass buffers at the edges of waterways – will have environmental benefits exponential in magnitude over conventional practices.

4. **A comprehensive approach to water conservation during design can be extremely effective in reducing the environmental impact of development.** Of all three sites, arguably the Merrill Center best integrated all sustainable aspects of its design from the very beginning: water use, energy use, occupant behavior, and more. Merrill's reduction in environmental impacts, as measured by this assessment, was correspondingly great. It is perhaps not surprising that they achieved LEED Platinum, since that level of achievement seems a more certain reward for excellent planning not only in design but for the operational future.
5. **Regional considerations, especially for environmental impacts related to water, may be more important than universal considerations when pursuing truly sustainable development.** Nutrient loading, for example, is not a universal problem, yet it is critical for these three sites. Community priorities in water management are of the first order of importance; universal practices should be evaluated in their light.

4
GREEN BUILDING RATING SYSTEMS

4.1 Introduction and Methodology

Green building rating systems provide a third-party framework to verify a building's sustainable qualities and measure its performance. These systems also help building owners plan for and implement green building design, construction, operations, and maintenance measures. The details may vary between green building rating systems, but their overall objective is the same: market transformation, encouraging building owners to design for sustainability.

In the world of construction, the regulatory minimums reside in the local building and zoning codes. The virtue of green building rating systems is that they encourage and reward a higher level of performance and promote marketable benefits. To that end, these rating systems have established a set of best practices, consisting of standards, goals, and metrics – not always easy to follow, but clear in their recommendations and impacts – for those wanting to build sustainably. Public, third-party recognition of these efforts is the reward for the additional investment of time and money.

This chapter analyzes, with respect to water management, three prominent rating systems, the British Real Estate Establishment Assessment Method (BREEAM), followed by the most prevalent system in the United States, the Leadership in Energy and Environmental Design system (LEED) and then the Green Globes Rating System which originated in Canada but is used also in the U.S. All are administered by private, not-for profit organizations which create and administer the criteria for their use.

The appeal of green building rating systems is considerable and grounded in three qualities:

- First, though these are "voluntary" for most, the power of their promise – independent verification of sustainable construction – has resulted in governmental mandates for their use. By November, 2009 in the U.S., many States and Federal agencies have mandated LEED certification for their newly-constructed public buildings (USGBC, 2009c). Similarly, in the United Kingdom BREEAM is a mandatory requirement for a large share of public buildings (BRE Global LTD, 2009d).
- Secondly, the realm of private as well as public development has adopted these rating systems for their utility as roadmaps to green construction. These rating systems have become helpful *vade mecums* for the pursuit of green design, providing checklists and referenced standards to assist developers, designers, engineers, and building operators. Most rating systems also provide accreditation to their assessors, insuring a pool of experts to further the goals of sustainability as represented by these systems.

- Third, both social responsibility and corporate profitability are key reasons for market uptake. In North America, particularly in the competitive commercial real estate market, green ratings increase a property's desirability and, often, its lease rates (Cascadia Green Building Council et al., 2009). The number of studies showing the benefits to human health from green buildings (USGBC, 2009d) -- especially in the U.S. where Americans spend 90 percent of their time indoors (USGBC, 2009e) – has helped anchor green construction's triple bottom line of people, planet, and profits.

Given this power to judge, advise, and benefit our world, one of the aims of this study is to turn the mirror back towards green building rating systems themselves. These rating systems have the potential for tremendous impacts if they achieve any degree of market uptake. As intense as the focus in this country has been upon the LEED rating system, there are as of April 2009 only 2,500 LEED-certified buildings nationwide under all LEED rating systems (USGBC, 2009b). There are three times more ENERGY STAR labeled buildings (7,736, Energy Star, 2009), and even this number pales in comparison to the number of BREEAM rated buildings in the United Kingdom — over 100,000 (BRE Global LTD, 2009a). A building-by-building approach to sustainability is far better than nothing, but in the United States, "rated" green buildings are as yet drops in a very large bucket.

The focus of this Chapter is, ultimately, on only part of the content of these rating systems -- water management. After understanding the place of water management within the whole rating system, the next step is a comparison -- for each of the three Case Study projects, between the water management impacts that this report measures, and the ratings that these project have or would achieve in each green building rating system. When set against the reality of performance, how well do these rating systems do in identifying the important issues in water management for these sites, and in rewarding them?

4.2 Green Building Rating Systems Overview

4.2.1 Building Research Establishment Environmental Assessment Method (BREEAM) Rating System

BREEAM, introduced in 1990, was one of the first Green Building rating systems to offer third-party environmental certification for buildings. This rating system developed by the Building Research Establishment, a former United Kingdom government enterprise of building industry participants, was privatized in 1997 and is currently managed by Building Research Establishment Global, a subdivision of the Building Research Establishment. The current version of the system, BREEAM 2008, was launched in August 2008.

Although this system is available internationally, it is most utilized in the United Kingdom, followed by Europe and the Persian Gulf countries. Over 100,000 buildings have been certified in BREEAM; over 500,000 have been registered (BRE Global Ltd, 2008). The BREEAM Rating System covers many "standard" building types such as Retail, Offices, Education, Prisons, Courts, Healthcare, and Industrial, and for others it offers a specially-tailored compliance path through the BREEAM Bespoke method. BRE Global also offers consulting services to develop and manage BREEAM-based certification schemes adapted to the specific needs of a country or region, and is currently working with France, Spain, the Netherlands, Latvia, and the Green Building Council of the United Emirates (BRE Global Ltd, 2009c).

The BREEAM certification process is accredited under International Organization for Standardization (ISO) 9001 and United Kingdom Accreditation Service.

Certification levels for BREEAM are as follows: Unclassified (<30%), Pass (≥30%), Good (≥45%), Very Good (≥55%), Excellent (≥70%), Outstanding (≥85%). Table 4-1 provides BREEAM credit categories and point values.

In contrast to scoring in LEED or Green Globes, a simple point tally does not measure achievement in BREEAM. Each credit belongs to an "issue category" -- for example, "Health & Well-being" or "Transport." All credits achieved within an issue category are tallied and then converted to a "percentage achieved." This number is multiplied by an issue weighting number. For new office buildings, energy has the greatest percentage of weight within the system -- 19% -- followed by Health & Well-being (15%), Materials (12.5%), Management (12%), Land Use & Ecology (10%), Pollution (10%), Transport (8%), Waste (7.5%), and Water (6%). See Appendix J for conversion tables for BREEAM point values.

Table 4-1
BREEAM rating system for offices: credit categories and point values

Categories	Total Points	Environmental (Issue) Weighting	Description
Management	10 pts	12%	Implementation of systems commissioning; production of operating and building user manuals; site management during construction.
Health and Wellbeing	14 pts	15%	Occupant control of heating and lighting systems; indoor air quality; noise reduction.
Energy	21 pts	19%	Reduction of CO_2 emissions through energy management and metering.
Transport	10 pts	8%	Minimization of CO_2 emissions from transportation to and from a building.
Water	6 pts	6%	Water fixture efficiency, metering, leak detection, and water collection.
Materials	12 pts	12.5%	Use of recycled materials; consideration of the energy used to manufacture materials.
Waste	7 pts	7.5%	Resource efficiency through practices such as construction waste management and recycling.
Land Use and Ecology	10 pts	10%	Remediation of contaminated sites; ecological improvement; efficient building footprint.
Pollution	12 pts	10%	Mitigation of effects of pollution due to refrigerants, space heating, and surface water runoff.
Innovation	10 pts	10% (1% added for every point achieved)	Outstanding efforts, either truly innovative or in terms of exemplary performance
Total	**112 pts**	**110%**	

Source: BRE Global LTD, 2009e

BREEAM relies on third party assessors to verify a building's achievement, and the BREEAM assessor, rather than the project team, leads the documentation process. Figure 4-1 displays the major steps in BREEAM application and certification.

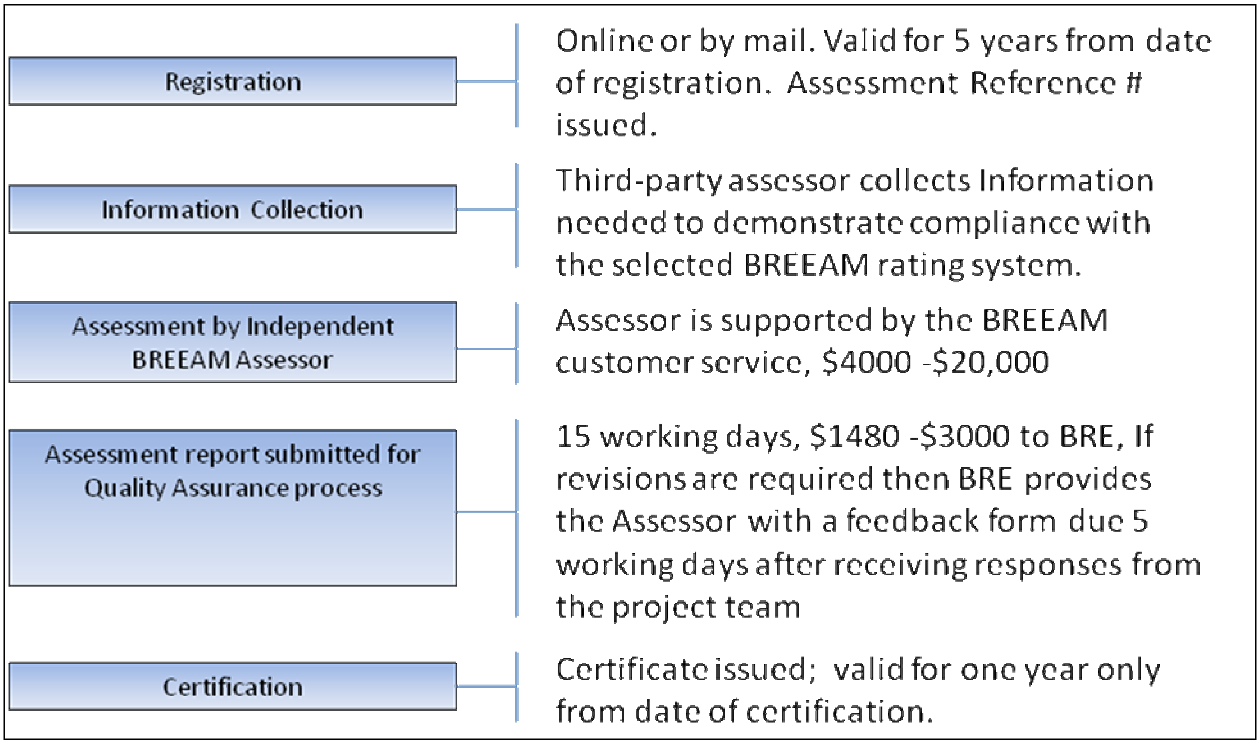

Figure 4-1
Major steps in BREEAM application and certification
Source: Prepared by the Cadmus Group, Inc.

4.2.2 The Leadership in Energy and Environmental Design Rating System

The LEED Rating System is the most widely accepted green building rating system in the United States, and is growing in international use. LEED was spearheaded by the Natural Resources Defense Council in 1996 and was influenced by the emergence of BREEAM but with the intention to identify, rate and adapt building sustainable practices to the local code and standard requirements and to address the energy, and environmental concerns within United States. After a trial period, the United States Green Building Council (USGBC) made the first LEED Green Building Rating System, LEED for New Construction (NC) available in 2000. As of January 2009, the Green Building Certification Institute manages the LEED certification and accreditation process internationally. As of April, 2009 there were 2,500 LEED certified buildings under all LEED Rating Systems in the United States (USGBC, 2009b).

LEED covers new construction and existing buildings across many project types, including residential, commercial, retail, educational institutions, and healthcare. Each project type has its own rating system – LEED-NC for New Construction, LEED-CI for Commercial Interiors, LEED for Homes, and so on. The content of LEED requirements is “consensus-based”: while the USGBC authors the material, it also publishes it on the internet so that the public can comment and propose changes. Every modification passes through two periods of public comment. The USGBC collects all suggestions for changes and, if deemed effective, incorporates them.

LEED rating systems are not certified by any international or national standardization establishments, such as ISO or the American National Standards Institute (ANSI).

For the 2009 version of the LEED-NC rating system certification levels are based on a 110 point scale. A building which attains over 80 points attains the highest rating, Platinum. Gold follows with 60-79 points; then Silver for 50 to 59 points; and finally Certified requiring 40 to 49 points. Table 4-2 presents the total points that can be achieved for each LEED credit category in the NC Rating System:

Table 4-2
LEED NC v.3 credit categories and available points

Categories	Points	Description
Sustainable Sites	26	A building's impact on waterways, ecosystems, undeveloped sites; transportation choices; stormwater runoff; reduction of erosion, light pollution, heat island effect and construction-related pollution.
Water Efficiency	10	Encourages smarter use of water, through more efficient fixtures, water-wise landscaping outside, wastewater recycling, and water harvesting.
Energy & Atmosphere	35	Encourages a wide variety of energy strategies: commissioning; energy use monitoring; efficient design and construction; use of renewable & clean sources of energy, generated on or off-site.
Materials & Resources	14	Encourages the reduction of waste, reuse, recycle, select sustainably grown, harvested, produced and transported products and materials.
Indoor Environmental Quality	15	Promotes strategies that can improve indoor air quality as well as providing access to natural daylight and views and improving acoustics.
Innovation in Design	6	Provides extra points for projects that use innovative technologies and strategies beyond what is required by LEED credits or which achieve exemplary performance in existing LEED categories; one point for involving a LEED Accredited Professional on the team.
Regional Priority	4	Additional points for achieving LEED credits deemed especially important to the project region
Total	**110**	

Source: USGBC, 2009d

The LEED certification process is different from BREEAM in that project teams are responsible for their own documentation and submittals, which are uploaded in digital form to LEED-Online. Once documentation is submitted, the review process is iterative and fairly rapid – a back-and-forth between the Green Building Certification Institute reviewing body and the project team. Figure 4-2 displays the major steps in LEED application and certification.

Registration	Online Registration of Project; submittals within 4 to 6 years
Preliminary Design Review	Review team assesses design credits & prerequisite submittals – 25 days
Preliminary Design Response	Project team can accept or respond to review-25 days
Final Design Review	Final assessment of design credits & prerequisites by review team – 15 days
Prelim. Construction Review	Review team assesses construction credits & prerequisites – 25 days
Prelim. Construction Response	Project team can accept or respond to review – 25 days
Final Construction Review	Final assessment of construction credits & prerequisites by review team – 15 days
Appeal Review	Project team can appeal credits – 25 days. Review team Response - 25 Days
Certification	Certificate issued .

Figure 4-2
LEED application and certification process

Certification fees for medium-sized buildings are based on square footage, with fixed rates for projects at the small and large ends of the spectrum (see Table 4-3). To incentivize achievement, the USGBC and now the Green Building Certification Institute remits fees for projects which earn a Platinum rating.

Table 4-3
LEED new construction fees

	Less Than 50,000 ft^2	**50,000 to 500,000 ft^2**	**More Than 500,000 ft^2**	**Appeals (if applicable)**
Type of Fee	Fixed Rate	Based on Square Footage	Fixed Rate	Per Credit
Project Registration Cost				
USGBC Members	$450			
Non-Members	$600			
Combined Design & Construction Review, Current Rates: Effective through December 31, 2009				
USGBC Members	$1,750	$0.035/ft^2	$17,500	$500
Non-Members	$2,250	$0.045/ft^2	$22,500	$500
Combined Design & Construction Review, Current Rates: Effective January 1, 2010				
USGBC Members	$2,250	$0.045/ft^2	$22,500	$500
Non-Members	$2,750	$0.055/ft^2	$27,500	$500
Expedited Fee	$10,000 regardless of square footage			
Credit Interpretation Requests (CIRs) (for all Rating Systems)				$220

Source: USGBC, 2009f

4.2.3 Green Globes

Like the LEED Rating System, the Green Globes Rating System also has its roots in BREEAM. BREEAM was introduced to Canada in 1996 by ECD Energy and Environment which published a Canadian version of BREEAM that same year. The system underwent some evolutionary steps where it was transformed into a question-based tool released in 1999 as the BREEAM Green Leaf Eco-rating program. In 2000 the system became an online assessment and rating tool which took on the name Green Globes for Existing Buildings. The BREEAM Green Leaf for the Design of New Buildings system was then integrated into the Green Globes for New Buildings system in 2002.

The rating system is owned and operated in the USA by the non-profit Green Building Initiative of Portland, OR. GBI became the distributor of Green Globes in 2004 and in 2005 became accredited by the American National Standards Institute (ANSI). In 2005, the Green Building Initiative began the process of establishing Green Globes as an official ANSI standard.

As of 2008, ECD Energy and Environment Canada, the original developer and parent organization of the Green Globes were acquired by Jones Lang LaSalle, a commercial real estate firm, though Green Globes continues to be independently operated in the U.S. (Agnese, 2008).

Green Globes covers new construction and existing buildings across residential and commercial sectors and its use is mostly limited to Canada and United States. Of the three Rating Systems used to evaluate the Case Studies, Green Globes is the most recent in origin, and has yet to experience significant market uptake in the U. S.

Green Globes ties its ratings to the use of the primary space types definitions under the EPA ENERGY STAR's® TargetFinder and Portfolio Manager, nationally used and recognized vehicles for gauging energy performance.

A unique feature of Green Globes is that it does not hold projects accountable for strategies that are not applicable, so the actual number of points available varies by project. One to four Green Globes are awarded based on percentages of achievement – 35-54%, 55-69%, 70-84%, 85-100% of eligible credits – in a scale totaling 1000 maximum available points. See Table 4-4 for maximum possible points. Table 4-5 provides a sample project from the Green Globes website.

Table 4-4
Credit categories and possible maximum points for green globes

Categories	Points	Description
Energy	360	Performance, efficiency, demand reduction, energy efficient features, use of renewable energy, transportation
Indoor Environment	200	Ventilation, lighting, thermal & acoustical comfort, ventilation system
Site	115	Ecological impact, development area, watershed features, enhancement
Resources, Building Materials, and Solid Waste	100	Low impact materials (Life Cycle Assessment , re-use, demolition, durability, recycling
Water	100	Water efficient fixtures, water conservation, treatment
Emissions and Other Impacts	75	Air emissions, ozone depletion, water & sewer protection, pollution controls
Project Management	50	Integrated design process, environmental purchasing, commissioning
Total	1000	

Source: Green Building Initiative, 2006

Table 4-5
Sample project scoring, Green Globes

Percentage Scores	
Management	68%
Site	90%
Energy	62%
Water	70%
Resources	84%
Emissions	91%
Indoor Environment	68%
Percent Overall Rating	**71%**

Source: Green Building Initiative, 2007.

Note that Green Globes distinguishes itself from LEED and BREEAM by including a category of achievement called Project Management which awards points for integrated design practices, asking for records of collaborative planning sessions among project team members and documents outlining performance goals. As a category, it is of small relative value within the whole.

A 2006 University of Minnesota Study which compared LEED and Green Globes cited Green Globes' comparative affordability and ease of use.[1] Unlike LEED, Green Globes charges a flat fee for all buildings, around $6,500 in 2009. LEED's fee for certification can top $25,000, and BREEAM is similarly expensive. The format of Green Globes is also distinctive. The Green Globes user begins the process by entering project information into an interactive online questionnaire, with questions in seven categories as outlined above. The questionnaire should ideally be started at initial (schematic) design, and should continue and modify as the project's design and construction phases unfold. The questionnaire is meant to inform the design process and the design itself: the process informs the product. This is a very different concept from the BREEAM and LEED assessment process. Green Globes is not just an assessment process, it is a design tool.

Green Globes numerically scores at two design phases, schematic design and construction documents. Project teams can use the questionnaire purely as a design tool, or can decide to contract with third-party certifiers. These independent certifiers will verify the results, allowing project teams to claim a Green Globes rating for their facility of between one and four Green Globes. Figure 4-3 displays the major steps in the Green Globes application and certification process.

[1] *Green Building Rating Systems: A Comparison of the LEED and Green Globes Systems in the US,* Timothy Smith, Miriam Fischlein, Sangwon Suh, Pat Huelman, University of Minnesota, September, 2006.

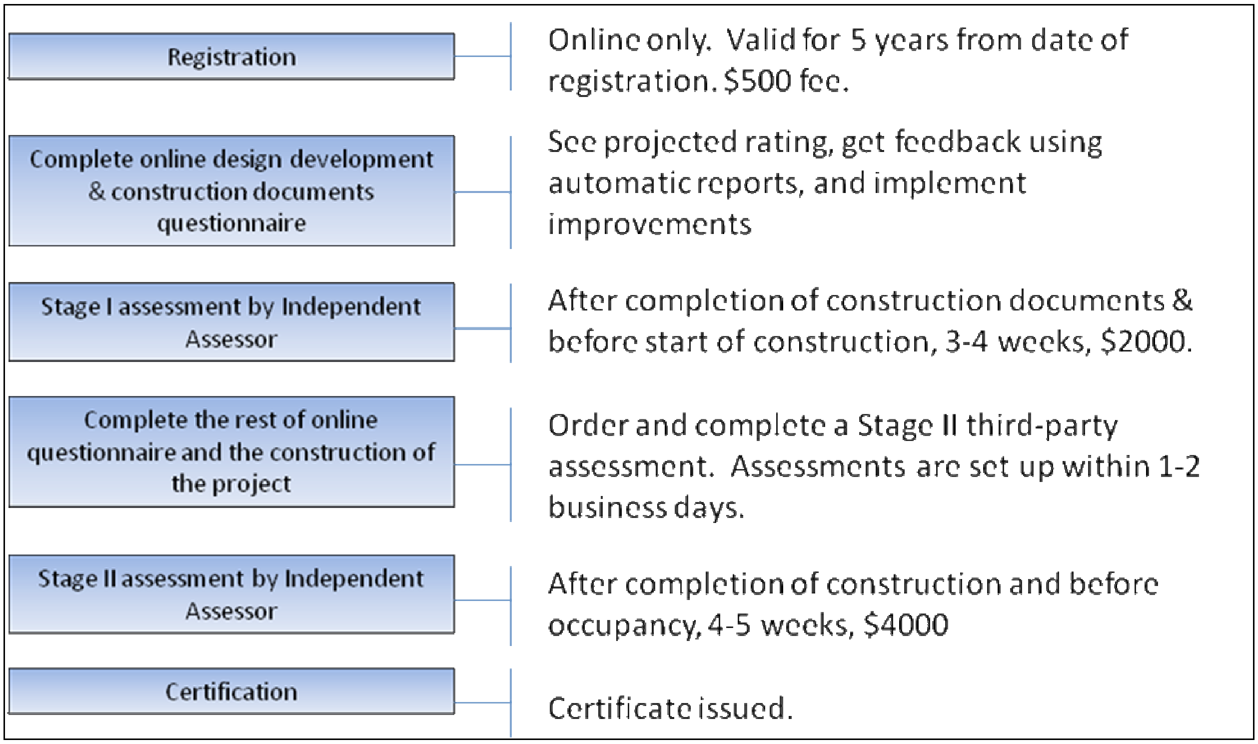

Figure 4-3
Green globes application and certification process

4.3 Rating System Comparison

4.3.1 Credit Content and Subject Areas

In terms of water management, the three rating systems have many common elements:

- Management of the construction process and sedimentation;
- Stormwater management for quantity control;
- Stormwater management for quality/ pollution control;
- Landscape/irrigation water use reduction;
- Wastewater treatment, either on-site or by reducing off-site flow;
- Internal fixture water use reduction;
- Commissioning; and
- Metering of water systems.

Green Globes deserves particular mention here because, in terms of credit content, it goes somewhat beyond LEED and BREEAM in two ways: in its scope relating to water management and in its more widespread embedding of water management impacts throughout its credits. As an example of the former, Green Globes introduces credits for water quality and pollution management in buildings using commercial processes such as laundry, photo finishing, and fuel storage. Its category entitled “Emissions and Other Impacts” includes a credit for avoiding contamination of sewers or waterways through the use of grease traps, silver recovery units, laundry filters, and other mechanisms relevant to the building type. It also reserves another credit for avoiding land and water pollution from hazardous materials. Both credits are geared towards commercial facility chemical use, and recognize the downstream impacts of water management. As an example of Green Globes’ embedding of water impacts throughout its framework, its category of Resources, Building Materials, and Solid Waste includes a multi-part credit for building durability which treats issues of water penetration and rewards effective site design for water drainage and management.

Tables 4-6 through 4-22 provide a side-by-side comparison of the rating system requirements specifically for water and site management with the total possible points that can be achieved for each category. All three Rating Systems have credits in “synergy” with one another. An example of this is landscape water use reduction. This practice dovetails with that of using native plants, usually a sites rather than a water credit. Similarly, effective water management will reduce the need for energy used in water pumping and treatment, thus enhancing the achievement of points under energy efficiency. Water management affects more than just water and water quality; it affects energy. At some level, it even affects materials, as the amount of embodied water used in manufacturing, like embodied energy, can be quantified. The outer boundaries of good water management are vast. The tabular comparison in Tables 4-6 through 4-22, however, works from snapshots of specific, delimited categories of achievement and does not consider these examples of synergistic point achievement due to good water management.

Note that BREEAM achievement levels are expressed as point values; consult Appendix J for conversion tables.

Table 4-6
Comparison of total points available for all credit categories related to water management

	BREEAM				LEED		Green Globes	
	Credit	Unweighted Points	Section Weight	Weighted Point Value	Credit	Points	Credit	Points
Construction Site Impacts	Man 3	1	0.120	0.012	SSp1	Required	B.2.4	8
Stormwater Management: Quantity Control	Pol 5	3	0.100	0.025	SSc6.1, ID	2	B.3.1, B.3.2	15
Stormwater Management: Quality Control	Pol 6	1	0.100	0.008	SSc6.2	1		
Landscape Irrigation 50% Potable Water Reduction					WEc1	2	D.2.4	5
Landscape Irrigation No potable Water					WEc1	2	D.2.3	10
Landscape Native Plant Selection	LE5	1	0.100	0.010			B.4.1, B.4.2, D.2.5, D.2.6, D.2.7	21
Green Roof					SSc7.2, ID	2	B.2.6, (B.3.2)	5
Fixture Water Use Reduction	Wat 1	2	0.060	0.020	WEp1, WEc3, ID	5	D.1.1	40
On-site Wastewater Treatment (Greywater, Blackwater)	Wat 1	1	0.060	0.010	WEc2. ID	3	D.3.1, D.3.2	20
Water Metering	Wat 2, ID	2	.06,.1	0.020			D.2.1	5
Cooling Tower Water Use							D.2.2	10
Sewer and Waterway Contamination from Process Water							F.3.1	12
Environmental Pollution							F.4.1,F.4.2, F.4.3, F.4.4	9
Leak Detection Installation	Wat 3	1	0.060	0.010				
Sanitary Supply Shut Off	Wat4	1	0.060	0.010				
Commissioning	Man 1	1	0.120	0.012	EAp1	Required	A.3.1	2
Total Water Points		14		13.73%		19		162
Total Points Available		112		110.00%		110		1000
Percent of Total		**12.50%**		**12.48%**		**17.3%**		**16.2%**

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-7
Construction site impacts

	Construction Site Impacts		
	BREEAM Man 3	**LEED SSp1**	**Green Globes B.2.4**
Requirements	Monitor, report and set targets for water consumption & CO_2 or energy arising from site activities & transport to and from site. Implement best practice policies to control air (dust) pollution & water (ground and surface) pollution occurring on the site. Main contractor must have an environmental materials policy, and implement an Environmental Management System.	Create and implement an Erosion and Sedimentation Control Plan for all construction activities associated with the project. The Plan shall describe the measures implemented to prevent sedimentation of storm sewers or receiving streams.	To reduce site contamination, contractors, subcontractors and installers should use water-efficient practices on-site, during the construction process, including the reclamation of water used in power washing, and minimal water usage for irrigation and dust control.
Points	1	Required	8
Metrics	NA	NA	NA
Notes	Plans and policies, and target setting encouraged.	Erosion and Sediment Control Plan required.	Plans and policies not emphasized.

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-8
Stormwater management for quantity control

	Stormwater Management: Quantity Control		
	BREEAM Pol 5	**LEED SSc 6.1**	**Green Globes B.3.1. B.3.2**
Requirements	The assessed development must be situated in a flood zone that is defined as having a low annual probability of flooding. A site-specific Flood Risk Assessment (FRA) must confirm that there is a low risk of flooding from all sources. The peak rate of run-off from the site to the watercourses (natural or municipal) should be no greater for the developed site than it was for the predevelopment site.	Limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, and managing storm water runoff. In a site with less than 50% previous imperviousness, do not exceed pre-development runoff OR implement a stormwater management plan to protect receiving channels. In a site with greater than 50% previous imperviousness, decrease runoff by 25%.	Preserve the site's watershed and groundwater and minimize stormwater run-off. Integrate and enhance the site's watershed features. In a previously 100% impervious site, ensure no increase in runoff. In a site with greater than 50% previous imperviousness, decrease runoff by 25%.
Points	3	1 point + 1 Innovation in Design (ID) point	15
Metrics	Stormwater runoff rates and quantities	Stormwater runoff rates and quantities	Stormwater runoff rates and quantities
Notes	Uses tough British standards for flood risk(the 100-year storm measure)	Lists Best Management Practices (BMPs)	No guidelines

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-9
Stormwater management for pollution control

	Stormwater Management: Quality/Pollution Control		
	BREEAM Pol 6	**LEED SSc 6.2**	**Green Globes**
Requirements	Specify Sustainable Drainage Systems in areas of low risk watercourse pollution. Specify of oil/petrol separators in high risk contamination or spillage sites. Adhere to Pollution Prevention Guideline 3 and where applicable the Sustainable Drainage Systems manual. Make a comprehensive and up-to-date drainage plan of the site available to the building/site occupants.	Reduce or eliminate water pollution by reducing impervious cover, increasing on-site infiltration, eliminating sources of contaminants, and removing pollutants from stormwater runoff.	None
Points	1	1	NA
Metrics	NA	80% TSS Removal Required	
Notes	British standards	Adheres to established national American practices	

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-10
Landscape irrigation: 50 percent potable water reduction

	Landscaping Irrigation 50% Potable Water Reduction		
	BREEAM	**LEED WEc1**	**Green Globes D.2.4**
Requirements	None	Reduce irrigation water consumption from a calculated baseline case. Use non-potable water collected onsite for irrigation. Use water-efficient irrigation systems. Use water-conserving landscaping or xeriscaping that includes native, drought resistant plants.	Reduce irrigation water consumption from a calculated baseline case. Use non-potable water collected onsite for irrigation Use water-efficient irrigation systems. Use water-conserving landscaping/ xeriscaping that includes native, drought resistant plants.
Points	N/A	2	5
Metrics	N/A	% water reduction	Gallons/ft^2/year
Notes	Landscape water use reduction not considered		

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-11
Landscape irrigation: no potable water use

	Landscaping Irrigation No Potable Water Use		
	BREEAM	**LEED WEc1**	**Green Globes D.2.3**
Requirements	None	Reduce irrigation water consumption from a calculated baseline case. Use non-potable water collected onsite for irrigation. Use water-efficient irrigation systems. Use water-conserving landscaping or xeriscaping that includes native, drought resistant plants.	Reduce irrigation water consumption from a calculated baseline case. Use non-potable water collected onsite for irrigation Use water-efficient irrigation systems. Use water-conserving landscaping/ xeriscaping that includes native, drought resistant plants.
Points	N/A	2	10
Metrics	N/A	% water reduction	Gallons/ft^2/year
Notes	Landscape water use reduction not considered		

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-12
Landscape irrigation: native plant selection

	Landscaping Irrigation Native Plant Selection		
	BREEAM LE5	**LEED**	**Green Globes B.4.1, B.4.2, D.2.5, D.2.6, D.2.7**
Requirements	To recognize and encourage actions taken to maintain and enhance the ecological value of the site as a result of development.	None	Use xeriscaping that includes native, drought resistant plants.
Points	1		21
Metrics			Gallons/ft^2/year
Notes	Must be approved by a suitably qualified ecologist. (SQE)		

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-13
Green roof

	Green Roof		
	BREEAM	**LEED SSc 7.2, ID**	**Green Globes B.2.6, B.3.2**
Requirements	None	Mitigate the heat island effect and reduce roof stormwater runoff through the installation of a green roof. Not specified for runoff reduction.	Mitigate the heat island effect and reduce roof stormwater runoff through the installation of a green roof.
Points		2	5
Metrics		50% green roof covered	% of roof covered by green roof

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-14
Internal fixture water use reduction

	Internal Fixture Water Use Reduction		
	BREEAM Wat 1	**LEED WEp1, WEc3, ID**	**Green Globes D.1.1**
Requirements	For 1 credit, the project must consume less than 5.5 cubic meters/year or less. For 3 credits, the project must consume less than 1.5 cubic meters/year.	As a prerequisite, fixtures must use 20% less water than standard fixtures complying with the Energy Policy Act of 1992. Points are awarded for greater efficiencies, beginning with a minimum of 30% reduction; one additional point is awarded for each 5% incremental increase.	Points are awarded for 1-30% or more water savings for the design case compared to a "base case" based on standard fixtures complying with the Energy Policy Act of 1992.
Points	2	2-4 points + 1 ID point	40
Metrics	cubic meters/person /year	% water reduction	% water reduction
Notes	No incentives to go beyond credit requirements	Exemplary performance rewarded	

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-15
On-site wastewater treatment

	On-site Wastewater Treatment		
	BREEAM Wat1	**LEED WEc2, ID**	**Green Globes D.3.1, D.3.2**
Requirements	An additional point for Wat1 is available when greywater reuse system is present.	Reduce use of municipal potable water for buildings, sewage conveyance by a minimum of 50%. Treat redistribute laundry and bathing 100% of wastewater on site to tertiary standards.	Where possible, graywater systems should be used to minimize the volume of effluent entering the municipal system and minimize the use of potable water on the site and/or within the building.
Points	1	2 points + 1 ID point	20
Metrics	N/A	% water treated or reused	Gallons/ft^2/year
Notes	Wastewater treatment not considered	Exemplary performance rewarded	

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-16
Water metering

	Water Metering		
	BREEAM Wat 2, ID	**LEED**	**Green Globes D.2.1**
Requirements	The specification of a water meter on the mains water supply to each building; this includes instances where water is supplied through a well or other private source. The water meter has a pulsed output to enable connection to a Building Management System for the monitoring of water consumption.	Not addressed as a separate credit in New Construction.	A minimum of one water meter or data logger should be specified. Major water consuming operations such as boilers, cooling tower make-up lines, water-cooled air conditioning units or special laboratory operations or high water consuming occupancies should also be metered.
Points	1 + 1 Innovation Point	None	5
Metrics	None	None	None
Notes	Wastewater treatment not considered	Applicable to existing buildings only	

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-17
Cooling towers

	Cooling Towers		
	BREEAM	**LEED**	**Green Globes D.2.2**
Requirements	None	None in NC	Reduce domestic water and sewer requirements from cooling tower water use.
Points			10
Metrics			Water data logging

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-18
Green roof

	Sewer and Waterway Contamination from Process Water		
	BREEAM	**LEED**	**Green Globes F.3.1**
Requirements	None	None	Avoid contamination of sewers and reduce the burden on municipal waste water treatment facilities.
Points			12
Metrics			

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-19
Environmental pollution

	Environmental Pollution		
	BREEAM	**LEED**	**Green Globes F.4.1,2,3,4**
Requirements	See Pol 6 in Stormwater Management: Quality Control for similar credit.	See SSc6.1 in Stormwater Management: Quality Control for similar credit.	Reduce the pollution of land or Water and minimize risk to occupants' health and impacts on local environment. Minimize the discharge of effluents Use strategies to control surface run-off and prevent sewer contamination Avoid contamination of sewers or waterways
Points			9
Metrics			
Notes			Not limited to pollution from runoff.

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-20
Leak detection installation

	Leak Detection Installation		
	BREEAM Wat 3	**LEED**	**Green Globes**
Requirements	To reduce the impact of major water leaks that may otherwise go undetected.	None	None
Points	1		
Metrics	Leakage and preset flow rates		

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-21
Sanitary supply shut off

	Sanitary Supply Shutoff		
	BREEAM Wat 3	LEED	Green Globes
Requirements	To reduce the risk of minor leaks in toilet facilities.	None	None
Points	1		
Metrics			

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

Table 4-22
Commissioning

	Commissioning		
	BREEAM Man 1	LEED EAp1	Green Globes
Requirements	Commissioning, measurement and verification of all water management systems, but at a minimum the hot water systems, and any heating, ventilation, or air conditioning processes involving the use of water.	Commissioning of (at a minimum) the hot water systems, and any heating, ventilation, or air conditioning processes involving the use of water. Measurement and verification of all water management systems.	Commissioning, measurement and verification of all water management systems including water loggers, water treatment systems.
Points	1	Required	2
Metrics	None	None	None
Notes	Requirements consistent with other rating systems	Requirements consistent with other rating systems	Requirements consistent with other rating systems

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

4.3.2 Discussion

4.3.2.1 Regional Content

The total points available for each credit category (such as Energy, Pollution, Water, or Project Management) within a rating system varies according to the importance that credit category is perceived to have in enhancing the environmental benefits of a green building. These allocations stem from the application of a “universal” definition of the environmental good to all situations where, perhaps, the order of priorities should be different. For example, all rating systems give points for water-conserving internal fixtures. For the three case study examples, however, water conservation is not the priority issue. Downstream impacts like nutrient loading and combined sewer overflows are of far greater importance to the locality. While the use of water-conversing fixtures is in line with overarching environmental goals of sustainable water management, the impacts are arguably less important that other water management strategies that target the priority issues.

Acknowledging the diverse climates and regions with the U.S., LEED began allowing for Regional Priority (RP) credits in 2009. These credits are identified by the USGBC's regional councils, chapters and affiliates as of most pressing environmental impact. The local chapters of the USGBC are allowed to assign six RP credits to zip codes within their chapter's area of coverage. A project may earn up to 4 RP points only, and each credit eligible for the RP points receives one point only. Table 4-23 shows the Regional Priority points that each of the case study buildings can earn for the water management credits of LEED.

Extra credit for regionally beneficial strategies does not exist in Green Globes or BREEAM. In LEED, RP credits are determined by the regional chapters of the USGBC according to their own regional environmental priorities. Will politics have the potential to influence these choices? Water management is in some jurisdictions – like the Southwest – a highly politicized issue.

Table 4-23
LEED regional priority (RP) credits by geographical location (zip code) of each project case study

	Merrill Center Zip Code: 21403	**Millennium Tower Residences Zip Code: 10004**	**Wetland Studies and Solutions, Inc. (WSSI) Zip Code: 20155**
WEc1 Water Efficient Irrigation	Not an RP credit in this zip code.	Not an RP credit in this zip code.	1 point
WEc2 Innovative Wastewater Technologies	1 point	1 point	Not an RP credit in this zip code
WEc3 Water Efficient Fixtures	Not an RP credit in this zip code.	Not an RP credit in this zip code.	1 point
SSc6.1 Stormwater control, quantity	Not an RP credit in this zip code.	1 point	1 point
SSc6.2 Stormwater control, quality	1 point	Not an RP credit in this zip code.	Not an RP credit in this zip code
Total Points	**2 points**	**2 points**	**3 points**

4.3.2.2 Weighting of Credit Categories

Methods (or lack of a methodology) for assigning total point values to specific credit categories (“weighting”) is a favorite subject for critics of these rating systems. In v.3, released in 2009, LEED “weights” points according to the Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI) environmental impact categories. The USGBC – and only the USGBC – can change these weightings to respond to environmental needs. This follows the example of BREEAM, which, as previously discussed, includes weightings as a part of credit calculation.

The USGBC adopted their weighting system in part to make credit values just, and to give a more rigorous, “scientific” foundation (and a better defense) of these values. The LEED Steering Committee sets these weights, not users themselves. The USGBC explained the development of its Weighting tool in this way:

> “*Weighting is a central concern when combining performance across credits and credit categories. The current LEED system [v.2.2] contains implicit weights – credits are weighted equally except when higher levels of performance receive one or more additional credits (e.g., Energy and Atmosphere Credit 1). This work is an effort to incrementally improve the weighting system.” (USGBC, 2008).*

The basic weighting equation is shown in Figure 4-4.

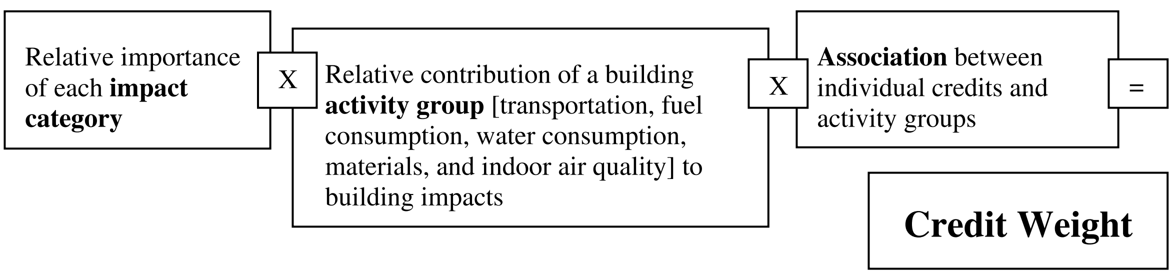

Figure 4-4
Weighting equation
Source: USGBC (USGBC, 2008)

The USGBC explains that the impact categories and “their relative weights are based directly on the National Institute of Standards and Technology (NIST) weighting exercise using impact categories defined by EPA’s TRACI project. The categories and the weights assigned during the NIST process include:

- Greenhouse gas emissions (29%)
- Fossil fuel depletion (10%)
- Water use (8%)
- Land use (6%)

- Acidification (3%)
- Eutrophication (6%)
- Ozone formation (2%)
- Smog formation (4%)
- Ecotoxicity (7%)
- Particulates (9%)
- Human health-cancer (8%)
- Human health-non-cancer (5%)
- Indoor air quality (3%)

Weights for these categories were developed by NIST through an analytical hierarchy process and sum to 100 percent.

As described earlier, BREEAM also has a system of issue weighting for each of its categories, and this affects scoring. Unlike LEED, this weighting is not embedded in the point values themselves; the assessor applies the weights to the percentage of points achieved, credit category by credit category.

Green Globes has a different approach to total point value, not involving a scientific overlay. Because Green Globes does not hold projects accountable for strategies that are not applicable, the actual number of points available varies by project. Thus, projects are not penalized in Green Globes to the extent that they can be in LEED or BREEAM for the absence of good water management practices.

4.3.2.3 Third Party Assessors

Among these three rating systems, LEED is the only one NOT using third-party assessors to verify credit compliance. BREEAM from the beginning has used third-party assessors. While Green Globes currently endorses third party assessments, their assessor certification has not yet been implemented, and is on an ad-hoc basis for now. However, in order to obtain a final rating of one to four green globes, a third party assessment is required.

4.3.2.4 Transparency

An article in the Environmental Building News (March 2005) made this observation:

> *"In terms of technical content, Green Globes is broader than LEED, including points for issues such as optimized use of space, acoustical comfort, and an integrated design process. It is much harder to compare the levels of achievement needed to claim points in the two systems, not only because they are organized differently but also because the precise requirements within Green Globes are not publicly available." (Malin, 2005).*

Green Globes, unlike LEED, does not cite many referenced standards. Transparency is an aim of LEED, and in this as in other things (such as seeking public comment and agreement) LEED has gauged the American market well. Green Globes' interactive questionnaire and assessment process are, like some of their standards, not transparent to the user.

4.3.2.5 Interactivity in Use

As untransparent as Green Globes may appear to users, it aims, by virtue of its interactive questionnaire and web-based process, to embed itself into the project design phase – a good idea geared towards better results in a building's sustainability. LEED can be approached as an add-on or an afterthought, though at considerable catch-up expense, especially in the area of water management.

4.4 Applying the Rating Systems to the Three Case Studies

The purpose of this section is to compare for each of the three case studies, ratings in areas of water sustainability for BREEAM, Green Globes, and LEED. Although none of the case study buildings applied for BREEAM or Green Globes certification, all each applied for and received some form of LEED certification, all three in different LEED systems or versions. The Merrill Center, completed in 2001, used LEED for New Construction v.1, released in 2000. That first commercially available version of LEED was different from today's LEED, and as far as the Water category went, it could be said to be quite different. There were two Water prerequisites in that day, one for water-efficient fixtures complying with EPAct 1992 mandates and another requiring the use of lead-free water pipes. LEED NC v.1 had six water credits including the stormwater credits which later became part of the Sustainable Sites category as follows:

- Water use reduction/water-efficient fixtures,
- Water recovery systems,
- Water-conserving cooling towers (later eliminated from NC, but retained in LEED for Existing Buildings),
- Water-efficient landscaping,
- Surface runoff filtration,
- Surface runoff reduction, and
- Two bonus credits, one for on-site wastewater treatment and the second for developing a water measurement and verification plan.

WSSI used LEED for Commercial Interiors (CI) version 2.0. This decision was based in part on WSSI's late start to the "official" LEED process after their base building core and shell was underway, and their mechanical systems specified. For a project with superb low impact development (LID) site design, the use of LEED for Commercial Interiors is an interesting irony, as the number of points available for good onsite water management practices is less in CI than for New Construction. Stormwater management credits in this version of LEED-CI, for example, count for half, not full, points – perhaps because it is assumed that Commercial Interiors LEED is usually implemented by tenants with little or no control over their project sites.

Millennium Tower Residences used LEED for New Construction version 2.1.

Because of these differences, this chapter cannot for purposes of comparison draw on these existing ratings in LEED. Instead, this chapter assesses the case study buildings anew by using the latest version of LEED for Building Design and Construction, version 3, released in 2009.

Because each rating system uses a different point scale and weighting system, direct comparison of points for the different categories is not useful. Instead, results are presented as a percent of the total points in the rating system, similar to the methodology used in the previous section. Sections 4.4.1 through 4.4.4 compare point values for the three rating systems for individual water management strategies of fixture use reduction, landscape water use reduction, stormwater management, and wastewater treatment. Section 4.4.5 summarizes the results for all water management categories.

4.4.1 Fixture Water Use Reduction

A universally accepted truth about water management is that reliability is paramount and should not be taken for granted. Urban and rural communities should ensure adequate water supplies for all potable and non-potable human needs, now and in the future. Buildings play a crucial role in helping reduce the pressure on a community's water infrastructure. In context of the strategies employed by a building to reduce their water consumption, all of the three rating systems -- LEED, BREEAM and Green Globes – lay great emphasis on reducing potable water use through the use of efficient water fixtures, and by reducing our use of potable water further by using treated greywater/blackwater instead. This emphasis, however, may inappropriately drive design and operations in a way that conflicts with local water management goals. For the three case study buildings, water scarcity is not as dominant an issue as is nutrient loading to receiving waters, protection of local receiving streams, or prevention of CSO discharges. In the case of Millennium Towers, no points were given for the installation of a stormwater tank to contain runoff from the site so that it could be released slowly to prevent CSOs. Instead, water reuse credits were given for the reuse of stormwater for irrigation purposes, driving management to keep the tank full for this purpose. In such a case, there is a bit of absurdity in the magnitude of the reward these rating systems automatically give for water efficient fixtures.

In order to receive points for water use reduction, water consumption of efficient water fixtures is compared to minimum baseline values established by the referenced standards in each rating system. LEED and Green Globes use the minimum water efficiency baseline levels established for "non-process" water fixtures (toilets, sinks, and so on; "process" water uses involve systems, like cooling towers, listed below) within the United States by the Energy Policy Act of 1992. BREEAM, on the other hand uses the baseline values established by the Water Supply (Water Fittings) Regulations 1999, the United Kingdom standard of comparison for the efficiency of water fixtures. The following fixtures, appliances and building components have been excluded from the calculations for this strategy, primarily because LEED does not include them. Note that LEED NC does not include cooling tower process water, though this is a major source of water use in some new buildings.

- Dishwashers
- Clothes washers
- Cooling Towers
- Water Fountains
- Commercial Ice Makers
- Steam Cookers
- Janitorial Sinks

Water use baseline estimates for each rating system involve assumptions for daily usage rates for any fixture, taking into consideration the building type (residential, office, retail, mixed use), transient nature of the occupants (Full Time Employee, visitor, resident) , occupant gender (Male/Female—in most cases, an equal split), and fixture type (urinal or water closet). LEED has usage rates for all permutations and combinations; BREEAM relies on a more restricted range; Green Globes establishes its own. Note that the Full Time Equivalent (FTE), visitor and square footage values are taken from the case studies.

Table 4-24 indicates the fixture water use reduction achieved by each of the case study buildings under the LEED, BREEAM and Green Globes Rating Systems. The water consumption reduction derived for the three project case studies under each of the three rating systems is defined by the limits established within the respective system. Therefore, while the Millennium Tower Residences may earn all 5 points possible under the LEED Rating System, the project earns only 1 of the 5 possible points under the BREEAM Multi-Residential[2] Rating System.

[2] For Millennium Towers, this report uses the BREEAM Multi-Residential Guidelines to establish compliance instead of the BREEAM Offices Guidelines used for the Merrill Center and WSSI.

Table 4-24
Comparison of points for fixture water use reduction strategies

Case Study Site	LEED	BREEAM	Green Globes
Merrill Center 31,000 ft^2 80 FTE 50 visitors, 251 working days	Total reduction achieved: 73.5% WEp1-Earned WEc3 – 4 points Exemplary points: 1 point Total Points: 5 points Percent points received of total points available: 5/110 = 4.6%	Water Consumption level: 1.44 cubic meters/person Wat 1 – 3 points Weighting Factor: 0.99 **Weighted Score: 3**	Total reduction achieved: 96.6% D.1-40 points Percent points received of total points available: 40/1000 = 4.0%
Millennium Tower Residences 442,099 ft^2 726 Residents, 365 days	Total reduction achieved: 46.7% WEp1-Earned WEc3-4 points Exemplary points: 1 point Total Points: 5 points Relative Scale Percentile Value: 5/110 * 100 = 4.55%	BREEAM multi-residential requires an effective flush volume of 4.5 liters (1.2 gallons) to earn one point and 3 liters (0.8 gallons) to earn two points. More points can only be earned if the multi-residential project meets at a minimum the above water closet efficiency level in each unit. The Millennium Towers Residences project has water closets of 1.1 GPF in each unit and therefore earns 1 point only. Weighting Factor: 0.75 **Weighted Score: 0.75**	Total reduction achieved: 20.5% D.1-30 points Relative Scale Percentile Value: 30/1000 * 100 = 3.0
WSSI 37400 ft^2 (only office space; excluding warehouse) 80 FTE, 251 working days	Total reduction achieved: 23.6% from using efficient fixtures. Taking into consideration the 4000 gallon cistern results in a 27% water reduction. The project meets the 20% threshold for WEp1 but does not earn any extra points in WEc3. WSSI has one extra point available for RP credits under WEc3. However, this point is available only to projects that achieve 40% or more fixture water use reduction. Therefore, while the total point value available for the fixture water use reduction strategy (under LEED) for WSSI increases by one point; the project does not earn this point. Relative Scale Percentile Value: 0/110 * 100 = 0	Water Consumption level: 3.06 cubic meters/person Wat 1 – 2 points Weighting Factor: 0.99 **Weighted Score: 2**	Total reduction achieved: 22.4% D.1-30 points Relative Scale Percentile Value: 30/1000 * 100 = 3

Notes:

1. Assumptions for BREEAM:
   - For staff use, unless other data is available, assume 1.3 WC uses per person per day and 2 urinal uses per person per day (assume that only 50% of the building occupants will use urinals).
   - When entering flow rates for wash hand basin taps into the Water Calculation Tool, the flow rate should be taken as 2/3 of the maximum flow rate quoted by the manufacturer.Apart from this, the baseline water use values for the fixtures were based on the BREEAM standards.
2. Assumptions for Green Globes: While the Green Globes online water questionnaire says that the points are based on water use in gallons per square foot per year, the actual water tool and water assessor indicate the percentage of reduction-based points. The water tool and assessor documents are more consistent with the information about the point allocation in the Green Globes assessor manuals. The water tool does not take into account kitchen sink, and showers for offices; therefore, the savings indicated are higher.

A comparison between the Rating Systems with respect to the Fixture Water Use Reduction strategies indicates that LEED is the most "objective" of three rating systems, since it includes the greatest number of established variables – occupancy calculations, fixture baseline rates, usage rates – while at the same time allowing project teams the flexibility to use a combination of any fixture types to achieve the required reduction in water consumption. The BREEAM Rating System uses a combination of objective and subjective guidelines. For example, while establishing required usage rates and using baseline water efficiency values for the fixtures, BREEAMhas mandatory guidelines requiring that certain project types include, at a minimum, fixtures of certain efficiency level. The Green Globes requirements for Fixture Water Use Reduction strategies were very similar to LEED; however, the calculation methodology inherent in their water calculator tool seems to allow projects to show greater reductions in water consumption. The three rating systems also allow for the inclusion of any non-potable water supply to the flush fixtures in order to reduce the amount of potable water required by a building. Non-potable water supplies can help projects earn additional points, depending on the resulting reduction in the amount of potable water used.

4.4.2 Landscape Water Use Reduction

Commercial and residential outdoor water use in the United States accounts for more than 7 billion gallons of water each day, most of which is for landscape irrigation (WaterSense Program, 2006). However, the importance of water consumption for irrigation greatly varies, depending on the climatic zone and regional location of a project building. While this issue is a matter of concern in the United States – which includes large regions of dry, arid and drought-prone areas – it is not matter of great significance in the United Kingdom, which receives rainfall throughout the year and is less prone to water shortage. Thus, BREEAM gives less weight to water conservation through efficient irrigation, since irrigation is not as widespread in the UK. This is an example of the regional variation reflected in the three rating systems considered in this report.

Table 4-25 indicates the landscape water use reduction achieved by each of the project buildings under the Rating Systems. LEED takes a three-pronged approach to evaluating a building's landscape water reduction achievement. A project can use a combination of native and drought resistant planting, efficient irrigation techniques and reallocation of planting types (for example, reducing turf areas, and increasing native shrubs) resulting in a reduction of at least 50 percent in total landscape water use compared to a baseline average case (the total landscape area is constant). Building projects can earn additional points by the 100 percent replacement of potable water use in irrigation with non-potable water from sources such as municipal, rain water or stormwater. Alternatively, project teams can provide a landscape of native and drought resistant plants that do not require any irrigation beyond one year for establishment. Green Globes allocates points for landscape water use reduction by evaluating projects based the use of non-potable water, the presence of lawn, the irrigation system used, and the presence of native planting/xeriscaping. Since the assessment of Green Globes criteria is through both document submittal as well as an on-site visit by a qualified assessor, the projected Green Globes evaluation of the landscape water use reduction here was based on project documentation as well as the on–site observations noted at the three project case studies.

Table 4-25
Comparison of points for landscape water use reduction strategies

	LEED-NC	BREEAM	GREEN GLOBES
Merrill Center	Baseline: 1,506,662 gal Design: xeriscaping and native plants used Total water reduction: >50% Potable water use reduction: 100% WEc1: 4 points **Total score: 4**	Landscape Water Use Reduction not considered under the BREEAM Offices Rating System **Total score: 0**	100% of the irrigation consists of non-potable water. Points: 6 points Landscape plantings (including lawn turf) have "low supplemental watering requirements." based on local references (e.g. a Local or State Plant Society Native Species Planting List) Points: 5 points **Total score: 11**
Millennium Tower Residences	Baseline: 77,638 gal Design: xeriscaping and native plants used Total water reduction: >50% Potable water use reduction: 100% WEc1: 4 points **Total score: 4**	For 1 point under BREEAM Residential the following criteria must be met: the irrigation method specified for internal or external planting and/or landscaping uses reclaimed water from a rainwater or greywater system in irrigation. The only planting specified is restricted to species that thrive in hot and dry conditions; a sub surface drip feed irrigation system exists and, a rainstat is installed to prevent automatic irrigation of the planting and the landscape during periods of rainfall. Where a rainwater/greywater storage system/collector is specified, this must meet the following criteria: No open access at the top (a lid is allowed). The irrigation system must be provided with a tap or other suitable arrangement for drawing-off water and must be connected to the rainwater down pipes with automatic overflow into the conventional rainwater drainage system. The system must be detachable from the rainwater down pipe with a removable top or base for cleaning the interior. Lastly, it must provide a provide a minimum of 1 liter capacity for each square meter of land allocated to the buildings, which is either planted (including grass) or left as unplanted soil, with a total minimum of 200 liters (52.85 gallons) needing to be provided. **Total score: 1** Total percentile score as per the weight assigned to each point in BREAAM Multi-Residential water category: 1* 0.75=0.75 **Total score: 0.75**	100% of the irrigation consists of non-potable water. Points: 6 points Landscape plantings (including lawn turf) have "low supplemental watering requirements" based on local references (e.g., a Local or State Plant Society Native Species Planting List) **Points: 5 points** **Total score: 11**

Table 4-25
Comparison of points for landscape water use reduction strategies (continued)

	LEED-NC	BREEAM	GREEN GLOBES
WSSI	Baseline: 836,490 gal Design: 18, 150 gal Total water reduction: >50% Potable water use reduction: < 100% from rainwater cistern and stormwater WEc1: 4 points WSSI has one extra point available for Regional Priority credits under WEc1, Option 1 in LEED. The project team has earned this point. **Total score: 5**	Landscape Water Use Reduction not considered under the BREEAM Offices Rating System **Total score: 0**	100% of the irrigation consists of non-potable water. Points: 6 points *(Please note that projects using non- potable water, are not eligible to earn points for using irrigation efficiency methods)* Landscape plantings (including lawn turf) have “low supplemental watering requirements” based on local references (e.g. a Local or State Plant Society Native Species Planting List) Points: 5 points **Total score: 11**

Notes:

LEED-NC: The baseline landscape water use for the three projects is based on the results of the three case studies. For the baseline analysis, the plant selection for the landscaped areas was replaced with plant selections with average species factors and conventional irrigation methods. See Appendix C for methodology and assumptions for the irrigation baseline.

Green Globes D.2 Water Conserving Features awards 5 points for sub-metering any water intensive process that accounts for at least 10% of total building water use; 10 points for the minimal use of water for cooling towers; 25 points for the minimal use of water for irrigation.

4.4.3 Water Sub-metering

Measuring the amount of water usage in a building helps occupants, local authorities and other stakeholders better understand the water consumption patterns in built habitat. Sub-metering takes this further by metering the water consumption by the end user group (residential, commercial, retail), water consuming operations (car washing, irrigation), and process water use (laboratories, cooling towers). Sub-metering allows for a more robust benchmarking of water consumption in buildings. Sub-metering also helps provide the most realistic evaluation of any water sustainability strategies implement on site. While LEED-NC does not address the issue of water sub-metering as a separate credit, it does recommend “tracking water use alongside energy[3]“. (LEED for Existing Buildings: Operations & Maintenance does allow one point for sub-metering.) BREEAM and Green Globes provide separate points for the implementation of sub-metering in new construction buildings.

Table 4-26 shows likely points awarded for building water sub-metering points under BREEAM and Green Globes for each of the case study sites.

[3] LEED Green Building Design and Construction 2009 Reference Guide

Table 4-26
Water sub-metering

	LEED-NC	BREEAM	Green Globes
Merrill Center	Water sub-metering is not considered a stand-alone value to achieve points **Total score: 0**	A water meter is on the main supply to each building and has a pulsed output to enable connection to a Building Management System (BMS) to monitor water consumption- YES 1 point Exemplary point is available where sub meters allow individual landscape or building areas to be monitored (such as cooling towers, car washes, catering areas) if demand is > 10%and if pulsed output to connect to BMS. The total estimated wastewater flow from the Merrill Center is the sum of the potable water and rainwater use: 35,400 gallons for 2008. The total measured water use for the facility from treated well water: approximately 15,400 gallons for 2008 which accounts for more than 10% of the total water use AND Each sub meter has a pulsed output to enable connection to a BMS. Thus, the Merrill Center achieves this additional point. Total Points: 2 Total percentile score as per the weight assigned to each point in BREAAM Offices water category: 2* 0..99=1.98 **Total score: 1.98**	A minimum of one water meter or data logger should be specified. Major water consuming operations or high water consuming occupancies should also be metered. Merrill has a Building Management System (BMS) system that sub-meters water usage including that of rainfall collected and potable water from the well. – 5 points **Total score: 5**
Millennium Tower Residences	Water sub-metering is not considered as a stand-alone value to achieve points **Total score: 0**	A water meter is on the main supply to each building and has a pulsed output to enable connection to a Building Management System (BMS) to monitor water consumption- YES 1 point Exemplary point is available where sub meters allow individual landscape or building areas to be monitored (such as cooling towers, car washes, catering areas) if demand is > 10%and if pulsed output to connect to BMS. For Millennium Towers, the total estimated annual measured water use for the facility is approximately 8,742,300 gallons or 24,000 gpd. Sub-metering through the BMS system accounts for 8,000 gpd of reuse water, which is collected and treated onsite to offset a portion of their potable water use demand (2,000 gpd for wash down and 6,000 gpd for toilet flushing) i.e. more than 10% of the total water use. System (BMS) for the monitoring of water consumption. Thus, Millennium Tower Residences achieves this additional point. **Total Points: 2** Total percentile score according to the weight assigned to each point in BREAAM Multi-Residential water category: 2* 0.75=1.5 **Total score: 1.5**	A minimum of one water meter or data logger is present. Major water consuming operations or high water consuming occupancies are metered. Millennium Tower Residences has a Building Management System (BMS) system that sub-meters water usage for every unit as well as the irrigation on site. **Total score: 5**

Table 4-26
Water sub-metering (continued)

	LEED-NC	BREEAM	Green Globes
WSSI	Water sub-metering is not considered as a stand-alone value to achieve points **Total score: 0**	A water meter is on the main supply to each building and has a pulsed output to enable connection to a Building Management System (BMS) to monitor water consumption. WSSI water meter does not have a pulsed output. – **NO** 0 points The total measured water use for the WSSI office for 2008 was approximately 233,500 gallons (that does not include the use of stormwater from the cistern for toilet flushing, about 40,311gallons). While sub-metering exists for water outflow from the cistern, it accounts for less than 10% of the total water use of the building. **Total Points: 0** **Total score: 0**	A minimum of one water meter or data logger is present. Major water consuming operations or high water consuming occupancies are metered. Although WSSI does not have a Building Management System (BMS) system, it has one water meter of the water mains as well as a separate meter that sub-meters water outflow from the water cisterns that is used for both fixture non-potable use and irrigation. **Total score: 5**

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

4.4.4 Stormwater Management

Watershed management practices to control runoff onsite have a significant impact on a project's ecological impact. Thus stormwater management, considered as both quantity as well as quality control of stormwater runoff, has been addressed in all three Rating Systems. LEED, BREEAM and Green Globes all require post-development rate and quantity of stormwater runoff to be equal to, or less than post-development rate and quantity of stormwater runoff. LEED requires that projects with less than 50 percent imperviousness, implement a stormwater management plan that results in no net increase (rate and quantity) in runoff from calculated pre-project conditions, for 1 and 2 year, 24 hour peak discharge. Alternatively, projects with less than 50 percent imperviousness that cannot meet these requirements can show that they have implemented stream channel protection and quantity control strategies on site that protect receiving stream channels from excessive erosion. For areas with greater than 50 percent imperviousness, the project must implement a stormwater management plan that results in a 25 percent decrease in volume of stormwater runoff from a 2 year, 24 hour design storm.

BREEAM requires a Flooding Risk Assessment (FRA) to evaluate whether a project site is in:

- "Low annual probability of flooding" (defined as less than 1 in 1000 chance of river and sea flooding or <0.1%)
- "Medium annual probability of flooding" (between 1 in 100 and 1 in 1000 chance of river flooding or between 1% – 0.1% and between a 1 in 200 and 1 in 1000 chance of sea flooding or 0.5% –0.1%)
- Or, "high annual probability of flooding" (1 in 100 or greater chance of river flooding, or >1%; 1 in 200 or greater chance of flooding from the sea, or >0.5%).

For projects in a flood zone defined as having a medium probability or greater, the site-specific FRA must provide confirmation from the local authority and statutory body that the development is flood-resilient as well as flood-resistant from all sources of flooding. The ground level of such project buildings and the access to the building and the site must be designed (or zoned) so that they are at least 600 mm above the design flood. Additional points are provided for stormwater strategies that ensure that the peak rate of run-off from the site to the watercourses (natural or municipal) is no greater for the developed site than it was for the predevelopment site. Compliance is required with the Interim Code of Practice for Sustainable Drainage systems published by the Construction Industry Research and Information Association, or for at least a 1 year and 100 year return period storm event with 6 hour duration. These strategies must also address climate change in accordance with current best practice.

Green Globes does not establish any referenced standards to define a storm event, or local and regional compliance. The stormwater management plan is evaluated based on the specific BMPs used on site such as storage reservoirs, directional control of runoff and green roof. For a site whose pre-development impervious area is greater than 50 percent (site previously built on), a stormwater control plan Green Globes requires the project site to achieve a 25 percent decrease in stormwater run-off.

For the purpose of this report, the three case study projects were evaluated on the basis of Federal Emergency Management Agency (FEMA) flood plain maps for the United States. Additional compliance requirements were evaluated from the site and building plans, building sections and stormwater management evaluation conducted for each of the sites. Table 4-27 shows points awarded for stormwater management under LEED and likely points that would be awarded for stormwater management under BREEAM and Green Globes for each of the case study sites.

Table 4-27
Comparison of points for stormwater control strategies

	LEED-NC	BREEAM	Green Globes
Merrill Center	Pre-Development Runoff Rate (undeveloped): 2.45 acre-feet/year Post-Development Runoff Rate: 0.51 acre-feet/year Most of the runoff is infiltrated on the site for the both the existing and baseline scenarios. As a result, most of the particulate exports are negligible. The bioretention swales throughout include native plantings and grasses which slow down the flow, allowing it to be gradually infiltrated onsite -- or else passed on to the sand filter at the southwest corner of the building. The site stormwater does not tie to the public wastewater system. Any graywater not site-absorbed or stored for interior uses sheds eventually to the tidal waters of the Bay, but the lengthy run through a rill of native plantings and grasses acts to cleanse it of nutrients. A green roof was not one of the first goals of the design, which instead prioritizes/d rainwater collection and reuse through roof run-off. The high roof sheds to the cisterns at the front of the building, away from the Bay, towards the bioswale which slows and holds overflow water. 1 point per SSc6.1 compliance path 1b-stream channel protection and quantity control strategies implemented at the project site to protect receiving stream channels from excessive erosion. BMPs treat 80% of the TSS and 90% of the average annual rainfall is captured or treated. 1 point per Ssc6.2 Total Points: 2 points Merrill has one extra point available for Regional Priority credits under SSc6.2. The project has earned this point. Relative Scale Percentile Value: 3/110 * 100 = 2.72	Pol 5: FRA Total Points available: 3 According to information available in the FEMA flood maps the project site is not in a low (ZONE C -MAP 2400080044D) annual flood risk area. However, the maps do not indicate whether low risk implies a probability of 1 in 1000 or a 1 in 500 as per FEMA rules (this zone is better than 1 in 500). Therefore a worst case scenario of medium Flood risk probability is assumed for the project site. According to local authority and statutory body requirements, the development is appropriately flood resilient and resistant from all sources of flooding AND The ground level of the building, and access to it and the site, are designed (or zoned) so they are at least 600mm (2 feet) above the design flood level of the flood zone in which the assessed development is located. The project site is located approximately 7 feet above the 100 year flood plain of the Chesapeake bay and the occupied level and access is raised an additional 10 feet above the ground level of the site.-1 Point 1 year 6 hour duration: between 2 and 2.5 inches of rainfall 100 year 6 hour duration between : between 5 and 6 inches of rainfall The attenuation measures are specified to ensure that the peak rate of run-off from the site to the watercourses (natural or municipal) is no greater for the developed site than it was for the predevelopment site. The capacity of the attenuation measures include an allowance for climate change made in accordance with current best practice.-1 additional point. Pol 6 credit: Minimizing Watercourse pollution: 1 point Total points earned: 2 Weighting factor: 0.83 **Weighted Score: 1.66**	Stormwater is directed to pervious areas or to a storage reservoir. -YES 5 points OR In the case of a site which was previously 100% pervious (green site), there is no increase in run-off. OR In the case of a site whose pre-development impervious area is greater than 50% (site previously built on), a stormwater control plan achieves a 25% decrease in stormwater run-off.YES-5 points Run-off from the roof is controlled and directed to a pervious area or to a storage reservoir-YES 5 points OR There is a green roof. Total: 15 points Relative Scale Percentile Value: 15/100 * 100 = 1.5

Table 4-27
Comparison of points for stormwater control strategies (continued)

	LEED-NC	BREEAM	Green Globes
Millennium Tower Residences	Pre-Development Runoff Rate: 2.8 acre-feet/year Post-Development Runoff Rate: 7.9 acre-feet/year Model results show that peak flows and total volumes of storm runoff are affected only slightly by the existing scenario, but could be substantially reduced by the drawdown scenario. Note: The drawdown scenario is most effective at reducing runoff from smaller rain events (1 and 2 year); runoff volumes from large events (100 year) far exceed the storage capacity of the stormwater tank. The existing stormwater BMPs at Millennium Tower neither reduce post-development runoffs and rates nor protect receiving streams from eroding velocities of stormwater runoff amounts and rates. 0 points for SSc6.1 The BMPs do not treat 80% of the TSS. Compared to the baseline case of no BMPs, and 100% untreated TSS, the existing BMPS treat only 35% of the TSS. 0 points for SSc6.2 Millennium Tower Residences has one extra point available for Regional Priority credits under SSc6.1 in LEED. However, the project has not earned SSc6.1, and therefore does not earn this point. Relative Scale Percentile Value: 0	Pol 5: Flood Risk Assessment Total Points available: 3 According to information available in the FEMA flood maps the project site is not in a high annual flood risk area (ZONE AE- MAP3604970184F). ZONE AE: Base Flood Elevation determined as 10 feet. The Base Flood Elevation is the water surface elevation for the 1% annual chance flood (100 year flood). Zone AE floodway is also the area where the channel of stream plus any adjacent floodplain areas must be kept free of encroachments so that the 1% annual chance flood can be carried without substantial increases in flood heights. According to local authority and statutory body requirements (FEMA Flood maps) the development is NOT appropriately flood resilient and resistant from all sources of flooding AND The ground level of the building, and access to it and the site, are NOT designed (or zoned) so they are at least 600mm (2 feet) above the design flood level of the flood zone in which the assessed development is located.-0 Points 1 year 6 hour duration: between 1.5 and 2 inches of rainfall 100 year 6 hour duration between : between 5 and 6 inches of rainfall Pol 6 credit: Minimizing Watercourse pollution: 0 point Total points earned: 0 Weighting Factor: 0.91 **Weighted Score: 0**	Stormwater is directed to pervious areas or to a storage reservoir. YES-5 points OR In the case of a site which was previously 100% pervious (green site), there is no increase in run-off. OR In the case of a site whose pre-development impervious area is greater than 50% (site previously built on), a stormwater control plan achieves a 25% decrease in stormwater run-off. NO Run-off from the roof is controlled and directed to a pervious area or to a storage reservoir OR There is a green roof.-YES 5 points Total: 10 points Relative Scale Percentile Value: 15/100 * 100 = 1.5

Table 4-27
Comparison of points for stormwater control strategies (continued)

	LEED-NC	BREEAM	Green Globes
WSSI	Pre-Development Runoff Rate: 15.6 acre-feet/year Post-Development Runoff Rate: 11.5 acre-feet/year To assist with controlling the velocity of stormwater, the gravel bed is sized to retain the volume of water associated with a 1-year storm and then release it over a 24-hour period at a slow speed and acute angle to an existing stream's flow path through a 1.65" pipe sized specifically for this purpose. This approach minimizes stream erosion, known as "urban stream syndrome." 1 point per SSc6.1 compliance path 1b-stream channel protection and quantity control strategies implemented at the project site to protect receiving stream channels from excessive erosion. BMPs treat 80% of the TSS and 90% of the average annual rainfall is captured or treated. 1 point per SSc6.2 Total Points: 2 points WSSI has one extra point available for Regional Priority credits under SSc6.1 in LEED. The project has earned this point. Relative Scale Percentile Value: 3/110 * 100 = 2.72	Pollution Credit 5: Flood Risk Assessment Total Points available: 3 According to information available in the FEMA flood maps the project site is not in a low annual flood risk area. The Flood risk probability (ZONE X – MAP 51153C0086D) is determined to be outside the 500 year floodplain. Areas 500 year flood: Areas of 100 year floods in an area with average depths of less than 1 foot, OR with drainage areas less than 1 square miles OR areas protected by levees from 100 year flood, therefore the project site is in a medium flood risk area. According to local authority and statutory body requirements (FEMA Flood maps) the development is NOT appropriately flood resilient and resistant from all sources of flooding AND The ground level of the building, and access to it and the site, are NOT designed (or zoned) so they are at least 600mm (2 feet) above the design flood level of the flood zone in which the assessed development is located.-0 Points 1 year 6 hour duration: between 2 and 2.5 inches of rainfall. 100 year 6 hour duration between: between 5 and 6 inches of rainfall. Pol 6 credit: Minimizing Watercourse pollution: 1 point Total points earned: 1 Weighting Factor: 0.83 **Weighted Score: 0.83**	Stormwater is directed to pervious areas or to a storage reservoir. -YES 5 points AND In the case of a site which was previously 100% pervious (green site), there is no increase in run-off. YES-5 points OR In the case of a site whose pre-development impervious area is greater than 50% (site previously built on), a stormwater control plan achieves a 25% decrease in stormwater run-off. Run-off from the roof is controlled and directed to a pervious area or to a storage reservoir-YES 5 points OR There is a green roof. Total: 15 points Relative Scale Percentile Value: 15/100 * 100 = 1.5

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

4.4.5 Wastewater Treatment Strategies

Wastewater treatment is addressed only in the LEED and Green Globes Rating Systems. LEED takes into consideration only the wastewater treatment implemented for gray and blackwater from water fixture use, and not collected rainwater. To earn this optional credit, buildings must either reduce their sewage conveyance by 50 percent, either through the use of efficient water fixtures or by using non-potable water in some water fixtures (such as for toilet flushing), or both. Alternatively, project buildings can also indicate compliance by showing that 50 percent of wastewater is treated to tertiary standards on site. LEED guidelines recommend that the project team take into consideration local and regional codes when designing a black or grey water treatment system.

The Green Globes Rating System has less stringent requirements for documenting alternative wastewater treatment. The presence of greywater and blackwater collection, treatment and distribution systems, and composting toilets is enough to earn credits in Green Globes. Therefore the project case studies have the greatest Relative Scale Percentile Value for this water strategy in the Green Globes Rating System.

Table 4-28 shows points awarded for wastewater treatment under LEED and likely points that would be awarded for wastewater treatment under BREEAM and Green Globes for each of the case study sites.

Table 4-28
Comparison of points for wastewater treatment strategies

	LEED-NC	BREEAM	Green Globes
Merrill Center	Through the use of composting toilets, potable water use for building sewage conveyance is reduced by 100%, earning maximum points under this credit (Wec2). Total Points: 3 Merrill has one extra point available for Regional Priority credits under WEc2 in LEED. The project has earned this point. Relative Scale Percentile Value: 4/110 * 100 = 3.63	Wastewater treatment is not considered separately from fixture flush and flow reduction.	Is there a gray water collection, treatment and distribution system? – **YES**-10 Points Are on-site black wastewater treatment system and/or composting toilets specified? **YES** - Composting toilets-10 points. Total Points: 20 Relative Scale Percentile Value: 20/1000 *100= 2
Millennium Tower Residences	Blackwater is treated on site and recycled for toilet flushing. Potable water use for building sewage conveyance should earn maximum points under this credit. Millennium Tower Residences has one extra point available for Regional Priority credits under WEc2 in LEED. The project has earned this point. Relative Scale Percentile Value: 4/110 * 100 = 3.63	Wastewater treatment is not considered, except as part of fixture flush and flow reduction.	Is there a gray water collection, treatment and distribution system? –YES-10 Points Are on-site black wastewater treatment system and/or composting toilets specified? YES -10 points Total points: 20 Relative Scale Percentile Value: 20/1000* 100 = 2
WSSI	For credit compliance, a sewage conveyance reduction of at least 50% earns 1 LEED point. The project after using 4000 gallons of rainwater for flushing purposes from the cistern has a reduction of only 37.5%. No points earned. Relative Scale Percentile Value: 0/110 * 100 = 0	Wastewater treatment is not considered, except as part of fixture flush and flow reduction.	Is there a gray water collection, treatment and distribution system? – YES-10 Points Are on-site black wastewater treatment system and/or composting toilets specified? NO-0 points Total Points: 10 Relative Scale Percentile Value: 10/1000 * 100 = 1

Sources: BRE Global LTD 2009e, USGBC 2009d, Green Building Initiative 2006

4.4.6 Summary

Table 4-29 presents the relative scores for the three project case studies for each water management category.

Table 4-29
Number of points and percent of total points awarded for all water management strategies

Water Management Category	Case Study Site	LEED	BREEAM (weighted)	Green Globes
Fixture Water Use Reduction	Merrill Center	5 (4.5%)	3	40 (4%)
	WSSI	0 (0%)	2	30 (3%)
	Millennium Tower	5 (4.5%)	0.75	30 (3%)
Landscape Water Use Reduction	Merrill Center	4 (3.6%)	-	11 (1.1%)
	WSSI	5 (4.5%)	-	11 (1.1%)
	Millennium Tower	4 (3.6%)	0.75	11 (1.1%)
Water Sub-metering	Merrill Center	-	2	5 (0.5%)
	WSSI	-	0	5 (0.5%)
	Millennium Tower	-	1.5	5 (0.5%)
Stormwater Control Strategies	Merrill Center	2 (1.8%)	1.66	15 (1.5%)
	WSSI	2 (1.8%)	0.83	15 (1.5%)
	Millennium Tower	0 (0%)	0	10 (1%)
Wastewater Treatment Strategies	Merrill Center	4 (3.6%)	-	20 (2%)
	WSSI	0 (0%)	-	10 (1%)
	Millennium Tower	4 (3.6%)	-	20 (2%)
Total for All Categories	**Merrill Center**	**15 (13.6%)**	**6.66**	**91 (9.1%)**
	WSSI	**7 (6.3%)**	**2.83**	**71 (7.1%)**
	Millennium Tower	**13 (11.8%)**	**3**	**76 (7.6%)**

Note: Percentages are based on 110 points available for LEED, 100 points available for BREEAM, and 1,000 total points available for Green Globes

4.5 Summary of Strengths and Weaknesses

The Impacts Assessment portion of this study assessed the relative performance of the three case studies with respect to water management. The Merrill Center achieved an impressive level of achievement, with WSSI achieving admirable reductions in impacts but of a lesser order of magnitude. Millennium Tower Residences was not as successful, but still performs far above any conventional measure. Although this order of achievement is generally consistent with the rating system rankings, it is interesting to note the different point spreads among LEED, BREEAM, and Green Globes. Among these three case studies, achievement in Green Globes is relatively similar between buildings even though their quantified impacts were clearly disparate. LEED point awards for water management are more consistent with the water management performance of these three projects. The rankings in BREEAM suggest a wider variation in achievement than may be real. While on the surface BREEAM appears to be “stricter,” awarding fewer points for water management, it excludes specialized achievement in wastewater management, a key success of the Merrill Center and of Millennium Tower Residences.

A comparison of the LEED, BREEAM, and Green Globes Rating Systems indicates the national biases of the three Rating Systems. Flooding in the United Kingdom is an issue of widespread concern, for example, and this issue is embedded in BREEAM's credits. National standards also have a great impact on the weight given to specific water strategies within these rating systems.

Other factors like population density and settlement patterns affect water strategies, and these differences, when translated into point values, work to the disadvantage of projects like Millennium Tower Residences. In dense urban areas like New York City, opportunities for water harvesting, toilet composting and bio-retention swales are limited because space is limited. Availability of water for specific requirements also can vary according to the type of activity or building program on the site. Merrill Center with its comparatively large roof surface has the ability to capture significant amounts of rainwater for reuse.

All of the rating systems do a good job of rating the impacts they set out to measure. But are they measuring the right impacts? If you believe that water management priorities are universal, then the rating systems are measuring the right impacts. But are they measuring and rewarding these impacts in the right order of priority, based on local or regional pressures? That seems unlikely.

As we have seen in the environmental impact assessments of all three case studies, an important environmental pressure is controlling stormwater runoff. As infrastructure becomes fragile, it takes little volume to overload sewers combining wastewater and stormwater – one-tenth of one inch of rainwater is enough to cause combined sewer overflows in New York City (City of New York, 2007), causing the direct discharge of waste into the Hudson River. Yet all the Rating Systems – even LEED, if it awards Regional Priority points for good stormwater management – at best give equal credit to internal water fixture efficiency and stormwater management. Water conservation through water fixture efficiency is less of a priority for these sites. Yet green building rating systems disproportionately reward water fixture efficiency. Water fixture efficiency is a good thing. But it is not the major priority.

The weakness of all three rating systems is their reliance not only on universal standards, but on universal goals. Water and water management are local and regional issues, and politically controversial: elections can be won or lost in their balance. Regional concerns should be at the top of the list of goals. In general terms, these are the innate flaws in these rating systems:

- **The absence of regional conten**t.
- **Their comparative disregard of decentralized approaches.** This is a missed opportunity. Onsite is usually better than offsite management, as this results in less load on central infrastructure, less energy used to treat water, and reduced environmental impacts from events like combined sewer overflows. Yet rewards for onsite treatment are comparatively minimal. LEED has one credit for Innovative Wastewater Technologies. Achievement of the other water credits in LEED can occur through implementation of onsite treatment strategies, but need not: onsite treatment is only one option.
- **Their contained scope,** which is by definition at the limit of site boundaries. Scope containment may be an advantage for certain credits, as it encourages their achievement. For water and water management, arguably boundaries should be set wider.

- **No or limited requirements for an integrated management framework.** The importance of such a framework is great, as it establishes holistic aims and approaches for organizations, as well as helps in setting out goals for continual improvement and compliance. Without such a framework, sustainability reverts to a checklist of practices implemented in a haphazard, ineffective way. The case study building projects can trace their successes and the continuation of their successes to the strength of their integrated management frameworks. This is what has especially set the examples of the Merrill Center and WSSI above the field. LEED and BREEAM do not incorporate requirements for environmental management systems (EMS); Green Globes gives limited credit. The International Organization for Standardization (ISO) publishes standards guiding EMS establishment (ISO 14000), and a summary of these is included here as Appendix I. The USGBC, on October 29, 2009, released their first "pilot" credit for projects including an integrated design team, but this is some way from being included as an actual, achievable credit in LEED. This "pilot" credit is only for the LEED for New Construction rating system, and does not consider integrated management as a practice continuing beyond construction, into operations.
- **Their structure of separable credits** capable of independent achievement, which reinforces the idea that you can pick and choose from a checklist of BMPs instead of considering a more integrated approach. To the credit of the Rating Systems, this element of choice is a part of their user-friendliness, as market uptake is still a key issue. Nonetheless, as green building practices and products embed themselves into conventional construction, it is time to reexamine the checklist-with-options approach. Alternatives are suggested below.

4.6 Conclusions and Recommendations

This analysis leads to some conclusions regarding the following questions surrounding green build rating systems:

- Construction of baseline scenarios
- Relevance
- Value
- Scope
- Approach
- Changes over time

An important issue for rating systems is the question of measurement against a baseline, and thus the issue of the construction of the baseline. The baseline conventions for water management, whether they involve flush or flow rates or the absence of basic stormwater BMPs, are static and also low-achievement bars. Measurement against these will usually result in points. The question of how to build progressive and dynamic goals into these rating systems rests on the ability to construct a progressive and dynamic baseline.

The second issue for the Rating Systems is relevance: the relevance of what they measure. For the ecologies of all three case studies, nutrient loading and watershed health were primary issues above water conservation, as these are not geographical areas of water scarcity. Yet in general more points in these rating systems were available in the area of water fixture efficiency than of stormwater management. The new Regional Priority credits in LEED begin to bring more weight to good practices for stormwater, but in general, all three rating systems are not regional in focus. In fact, they are dependent on referenced standards that are national, not regional. There is value in this, but there are also drawbacks. Universal best practices may not coincide with regional best practices, and in the case of avoidance of combined sewer overflows they may even conflict.

The third issue is related to the second: point value relative to the importance of impacts. In the realm of water management, all these rating systems give nearly equal reward to site practices and to practices internal to the building's water systems, again raising the issue of the need for regional content and specificity.

The fourth issue is that of scope. Measurement of water management for a single building, which is the level at which these rating systems operate, cannot adequately capture the downstream impacts of buildings in their environment. The issue is similar to that involved in setting greenhouse gas emissions boundaries. How expansive are your boundaries? For water, as for air, the effects are well beyond the site.

The fifth issue is that of approach. The current approach, the checklist method is easy to understand and implement. But true sustainability requires multidisciplinary, integrated practices.

Finally, green building rating systems are static frameworks and they assess buildings as snapshots in time. This involves a paradox, since sustainability is about change and entropy. One common neglected area for rating system achievement is the absence of reward for continuing human input and dynamic management in operations. Rating systems sorely neglect the dimension of time.

There is both a need and a demand for third-party green building certification systems. The standards and rigor that they bring to the built environment benefits us all. The cause of their limitations is their static nature, yet there are ways to make these rating systems dynamic, leading to better water management practices. Based on the issues examined here, this study recommends adoption of four basic changes in the rating systems:

- **Establish a method for the calculation of a progressive baseline, and thus ensure continuing improvement.** Some greenhouse gas measurement protocols embed progressively rising standards for baselines that are appropriate to the experience and history of the institutions they measure. Green building rating systems can do the same for their baselines by differentiating between projects beginning from different baselines depending on an individual project's awareness and history with green building. This would be especially important for rating systems geared towards Existing Buildings.

- **Allow the weighting of credits to be *dynamically* changed region by region by advisory groups of rating system users.** One of the greatest recent changes in LEED is the adoption of a Weightings System to tie point values to environmental impacts. BREEAM similarly has an issues weighting system tied to credit point values. Of the thirteen TRACI environmental assessment categories, the USGBC judged the impact of carbon emissions to represent the greatest current human threat – thus, credits that reduce these, such as for energy efficiency or alternative transportation practices, receive great weight. The same is true for the weighting of Energy credits in BREEAM. In case of both rating systems, these weightings are fixed and static. What if these rating systems made their weighting system dynamic? What if it could be changed region by region to acknowledge the regional shifts in environmental pressures? The effect of such a change could be significant: the Rating system would be finely attuned to local pressures without losing its ties to nationally-recognized referenced standards. **In the area of water management, this would be transformative.**
- **Include some new credits, especially those which reward a framework for integrated water systems design and management, bridging the gap between design and operations.** Green Globes alone of the three rating systems here does this in its credits under "Project Management" for Integrated Design. Other, alternative rating systems explore rewarding ongoing human engagement in designing and managing sustainable systems. The fledgling rating system of the Sustainable Sites Initiative (see Appendix H for an extensive summary) has prerequisites requiring an Integrated Design Process and the development of a program plan with site performance goals. It also includes a credit for engaging users and other stakeholders in "meaningful participation" in site design, one of the best ways to ensure the ongoing success and well-doing of the built environment. Importing these credits into LEED would be easy to do. The new "pilot credit" proposed for LEED for New Construction would reward projects with an integrated design team but not those with integrated management teams, leaving operations out.
- **Make the achievement of independent credits interdependent, so that, as in reality, one practice is bound to another.** It is time to abandon the checklist approach to sustainability, and to aim for integrated water management. Either award credits group by group, rather than credit by credit, or give additional points if a panoply of credits are achieved. A dynamic online tool tracking credit interdependence and adjusting the projected score accordingly could be a powerful aid.

4.7 Whole Systems Design, the Next Frontier

Whole (or "integrated") systems design is a forward-thinking alternative on the sustainable frontier. In whole systems design, project components are so interlocked and interdependent that it becomes impossible to speak of checklists and separable credits.

One example has been developed by Harrison Fraker, FAIA: the concept of Eco Blocks (Slideshare, Inc., 2009). The former dean of the UC Berkeley School of Architecture, Fraker has attempted to interest the Chinese government in this whole systems concept. Working with Arup Engineers, Fraker has developed a model of urban superblocks that are resource self-sufficient, using proven, existing technologies while attempting to provide developers an acceptable payback period (just over 10 years) and an acceptable cost premium (between 5 and 10 percent over conventional development, China Green Buildings, 2009).

Fraker's model aims to be "flexible and adaptable to multiple local conditions and climates and is widely replicable throughout China." It is, in Fraker's words, the complete reverse of typical Chinese new development,

> *"an alternative to China's typical 'gated super block' development model. The 'gated super blocks' are dependent on expensive central infrastructure support in the form of electric power plant generation and distribution, sewage collection and treatment, water treatment and distribution, and waste collection and disposal. The 'gated super block' model is also dependent on the car as the primary mode of transportation. China is currently hard pressed to satisfy the infrastructure demands of the super block model." (The Berkeley Institute of the Environment, 2008)*

Fraker has developed a model for incentives that the Chinese government can offer to developers, as well as a cost/benefit redistribution model.

The innovation behind Fraker's Eco Block is **not in the individual technologies themselves, but rather in the way they work together and are mutually dependent**. For example, the anaerobic biogas digester that powers back-up electric turbines uses food waste/garbage, green waste from the landscape, and sewage sludge from primary sewage treatment as its biomass supply. It would be a net-zero water and energy community. Water is managed through an endless loop of treatment:

> *"The water recycling is a dual system — 50% graywater, 50% potable water. Potable water from sinks and showers, gray water from washing machines and blackwater from toilets is collected in a primary treatment-settling tank. The sludge is pumped to the biogas digester. The remaining effluent is distributed to secondary treatment via constructed wetlands (or 'living machines'). 50% of the secondary treated water is collected and recycled for gray water supply to toilets and washing machines. The other 50% is combined with collected rainwater, receives tertiary treatment through reverse osmosis and ultra violet disinfection, and is then recycled as potable water for sinks and showers. Stormwater is treated on site in 'bio-swales,' collected and recycled for landscape irrigation." (The Berkeley Institute of the Environment)*

Another example of whole systems thinking is Dockside Green in Victoria, BC, Canada. Unlike Fraker's Eco Blocks, Dockside Green is a partially built and occupied developer-driven reality on a former Canadian brownfield site (see Figure 4-5).

Not as resource self-sufficient as Fraker's example, Dockside Green has deeply embedded LEED principles, but goes beyond. Similar to the individual case study examples presented in this study, it exceeds the minimum standards required for energy and water management. It will ultimately contain a bio-mass co-generation plant selling energy offsite. Waste, wastewater, and stormwater are all viewed as resources to be mined for onsite energy and water reuse. Dockside Green incorporates extensive green roofs and bioretention systems to help with stormwater velocity. Though it draws from the regional water system for potable water supply, its goals for water management are to treat 100 percent of water onsite; its treatment plant has been operational since June of 2008 (see Figure 4-6 for Dockside Green's water management diagram).

Figure 4-5
Rendered view of Dockside Green, Victoria, BC, Canada
Source: Used with permission from (Dockside Green, 2009)

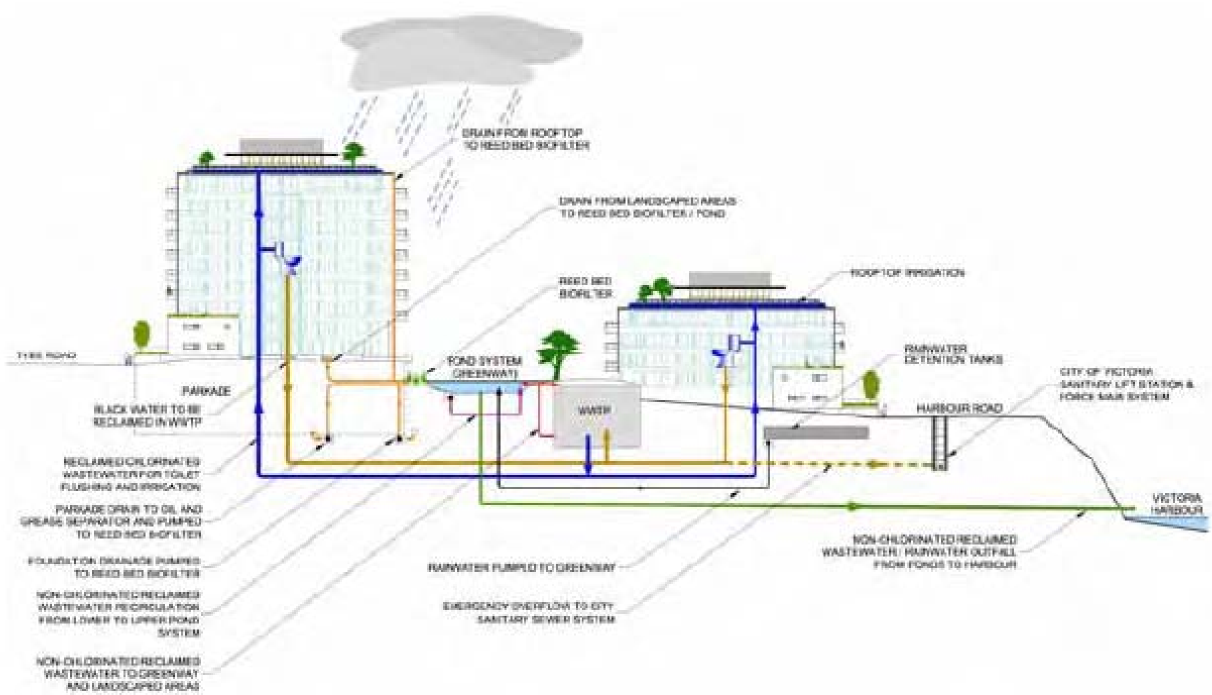

Figure 4-6
Dockside Green, Water Management Diagram
Source: Used with permission from (Dockside Green, 2008)

Dockside Green extends its definition of sustainability to issues of economic and social justice (as does the Sustainable Sites Initiative Rating System, outlined in Appendix H), and will include onsite job initiatives for Native Americans as well as on-site low income housing.

Fraker's Eco Blocks and Dockside Green are impressive examples because they attempt to transcend the scale of the individual building and apply a set of best management practices in a synergistic way across categories of neighborhood and site development. At the same time, these are developer-driven, real-world projects, and like all new construction, they will consume resources in putting forth new, rather than greening existing, development. But their goal – to be self-sustaining systems which minimize upstream demands and downstream impacts – is an object to which green building rating systems should aspire.

5
PLANNING AND ZONING

5.1 Introduction and Methodology

Architecture – and our constructed environment in general – expresses the character and goals, environmental or aesthetic, of those who built it. Or does it? In the United States, our buildings and our cities look and act in accordance with the constraints of public regulation, the objective of which is human well-being. Such regulation governs both the form and function of buildings.

Building regulations include zoning concerns, such as allowed uses of structures, height of buildings, setback areas from adjacent properties, and sometimes even the materials and style of construction. Building codes govern health and safety issues, such as the presence of handrails in stairs, the proportion of stairs, minimum floor-to-ceiling heights, the width of hallways, the placement of exit doors, and many more concerns that have a direct effect on architectural form. Environmental regulations ensure that construction does not contaminate the air, water, and land of or near the site, and within the building.

Regulation may place logistical or financial barriers in the way of green thinking in a number of ways:

- The regulatory review process in most jurisdictions involves many different local and even State agencies ruling on distinct, specialized "pieces" of regulatory content. This approach conflicts with the essence of the sustainable design process, which promotes holistic thinking, integrated planning, and collaborative decision-making and review. The piecemeal nature of regulatory review can lead to misunderstandings that impede green thinking.
- Many regulatory agencies experience significant backlog of projects awaiting review. This puts pressure on reviewers and limits their capacity to interpret and understand unfamiliar aspects of sustainable design.
- As with sustainability in general, education – knowledge of the latest best practices – is key. The availability and scope of training of permitting officials varies, and in some cases does not exist.
- Limited financial resources often mean that green zoning and building rewrites received are at the bottom of the priority list. In many jurisdictions, zoning codes in particular have been essentially the same for one or two generations, modified as needed but without significant reform.

In a variety of ways and as documented within the individual case studies, local building and development regulations played a significant role in the design and construction of each project and its surrounding areas. To help us understand the relationship between these projects and the regulations that governed them, Section 5.2 describes the specific regulatory structure of each project site, the impact and limitations confronted as well as any changes to the regulatory structure spurred directly by the case studies. Section 5.3 follows with a brief overview of zoning and planning reform in four diverse regions of the country. A set of recommendations are presented in Section 5.4 based on the case studies and "best practice" examples of green zoning initiatives.

5.2 Impact of Local Planning and Zoning for Each Case Study

5.2.1 The Merrill Center

5.2.1.1 Local Regulatory Structure for Anne Arundel County

The Chesapeake Bay Foundation's (CBF) Merrill Center was built in Annapolis, Maryland in 2000. The Merrill Center was subject to the code restrictions of Anne Arundel County, Maryland, as part of its construction.

5.2.1.1.1 The Anne Arundel County Building Code

The Anne Arundel County Building Code makes up one article (Article 15) of the Anne Arundel County Code. It is derived from the International Building Code, created by the International Code Council, Inc. (ICC). Protection of the environment is mentioned as an objective of the Anne Arundel County Building Code; however, it is last in order after quite a few other objectives. The Anne Arundel County Building Code also adopts the following codes:

- International Energy Conservation Code (by the ICC)
- National Electric Code (by the National Fire Protection Association, Inc.)
- International Fuel Gas Code (by the ICC)
- International Mechanical Code (by the ICC)
- International Plumbing Code (by the ICC)
- Portions of the Anne Arundel County Plumbing Code of 1993.

Article 16 of the Anne Arundel County Code (Floodplain Management, Sediment Control, Stormwater Management) is not part of the building code, but regulates construction in floodplains and requires permits for grading as well as stormwater management plans for construction[1]. Article 16 has some standards that are stricter than conventional standards. For example, in recognition of stormwater issues in the area, this Article requires that redevelopment reduce impervious surface area by 20 percent, and it requires payment of a fee in intensely developed areas based on the square footage of impervious surface. (Anne Arundel County, 2008).

[1] Grading applications and stormwater management plans must fulfill the standards of the Maryland Stormwater Design Manual Volumes I and II, and USDA Natural Resources Conservation Service Maryland Conservation Practice Standard Pond Code 378.

5.2.1.1.2 Specialized Code Requirements

As outlined in the Case Study description, the State of Maryland now has a reputation as an environmentally forward-thinking state. The encouragement of green alternatives to conventional building had not, however, trickled down to the local code officials and building inspectors of Anne Arundel County at the time of the Merrill Center's construction (2000), and there were no green building regulations in place within the County.

5.2.1.2 General Permitting Process

A developer must secure a building permit before beginning construction in Anne Arundel County. A separate trade permit is required for plumbing, mechanical, or electrical work. This work must be performed by an Anne Arundel County licensed Master Plumber, Master Mechanic, or Master Electrician, respectively. The permit application must report the total cost of construction, including labor and current market prices for materials. The approved permit must be displayed on the construction site.

The two phases of the building permit process are plan review, in which county staff verifies compliance of the permit documents with building codes, and construction inspection, which is conducted onsite during construction by a building inspector experienced in field inspections but uninvolved in the earlier permit reviews. In terms of oversight from the County, there is no link between permit review and approval and field review and approval other than the record documents kept on site. This is typical for many governmental jurisdictions. After all inspections have been made, a Certificate of Occupancy is issued, allowing the building to be occupied.

The following table (taken from the Anne Arundel County website) details the process from start to finish:

Table 5-1
Steps to obtain a work permit in Anne Arundel County

Step	Responsible Party
1. Obtain evidence of a legally owned and platted lot.	Customer
2. Determine zoning and setback requirements.	Customer
3. Complete application and submit plans to County.	Customer
4. Submit grading plan if grading permit is required.	Customer
5. Pay appropriate fees.	Customer
6. Plans are reviewed.	County
7. Correct all noted deficiencies.	Customer
8. Return plans and other requested documents to County for review.	Customer
9. Review plans and other documents and mail comment letter.	County
10. Repeat steps 8 and 9 until all corrections are approved.	County
11. Prepare any required agreements, if applicable.	Both
12. Record signed and notarized agreements at County Courthouse.	Customer
13. Pay fees, receive permit and approved plans.	Customer
14. Post permit where work is being performed.	Customer

Source: (Anne Arundel County, 2008c)

The first phase of the building permit process (plan review) is conducted by five full-time plan reviewers. There is currently (October 2009) a backlog of about ten days worth of reviews; however, the backlog is normally much longer than that (electronic correspondence with Tracie Reynolds, 10-6-2009). The amount of time the permitting process takes varies with the size of the project and the completeness of submissions (electronic correspondence with Tracie Reynolds, 10-6-2009).

5.2.1.2.1 Training and Continuing Education for Code Officials

Anne Arundel County Code requires that building, electrical, mechanical, and plumbing inspectors be trained according to an established program to perform all of the matters required for a complete final inspection of a residence. However, there is no requirement for retraining or continuing education of permit review officials and field inspectors.

Permit review officials are trained through International Building Code Council classes. None of the permit review officials currently on staff are Leadership in Energy and Environmental Design (LEED) Accredited Professionals and none are familiar with green building techniques (electronic correspondence with Tracie Reynolds, 10-6-2009).

5.2.1.3 Merrill Center Approval Process

The CBF reported that they had to educate the local regulators on a number of novel green building techniques they intended to use (interview with Mary Tod Winchester, 6-17-2009). The regulators were hesitant on a number of issues, but kept open minds. There were many Building Officials and Code Administrators International (BOCA) code issues, and CBF had to bring in a national expert on BOCA to mediate and resolve these. In the end, the CBF only needed a waiver of variance on the parking lot size.

As outlined in the case study description, the composting toilets, a keystone of CBF's onsite environmental strategies, were a source of contention between the design team and local regulators. The Fire Marshall objected to the Clivus Multrum composting toilet system because its waste shafts led directly to the composting pit. Although the building is non-smoking, officials were worried about lit cigarette disposal down the shaft. The costly solution implemented by CBF was to make these shafts the constructional equivalent of conventional chimneys, inhibiting any potential spread of fire.

The second challenge with the composting toilets came from permit reviewers who objected to the width of the open toilet shafts (10 inch diameter). This violated the "baby's head" rule: unobstructed openings near the floor with greater than four inches of clearance could allow children to fall through them. Eventually, the design team persuaded officials that in the extremely unlikely event that a baby fell down the toilet shaft it would have a safe and cushioned, if filthy, landing on the compost heap. The County reviewers accepted this explanation and allowed the shafts to remain (interview with Mary Tod Winchester, 6-17-2009).

Originally, CBF wanted to use harvested rainwater entirely for the building's potable water supply, but the Health Department was concerned that air pollutants might be present in harvested rainwater and cause health problems. The eventual compromise was for Merrill to use well water in the kitchen sink and the showers and rainwater for all other uses including bathroom faucets. CBF was required to prominently post signs reading "RAINWATER: DO NOT DRINK" above the bathroom sinks.

5.2.1.4 Code Changes Spurred by the Design of the Merrill Center

Governor Parris Glendening, in recognition of the environmental benefits presented by the example of the Merrill Center, pushed for legislation to require that public buildings in the State of Maryland be built to LEED standards. This legislation, the Green Power and Energy Efficient Executive Order, was enacted in 2001, making Maryland among the first States with such a requirement for the public sector.

5.2.2 Wetland Studies and Solutions, Inc.

5.2.2.1 Local Regulatory Structure for Prince William County

The building permitting process in Prince William County (PWC) involves three separate Departments. The PWC Department of Development Services reviews initial site plans for new buildings. The PWC Planning Office, Building Development Division is in charge of actual building permits. In addition, the PWC Health Department has jurisdiction over wells and septic systems.

The overall document governing land development in PWC, and which effectuates and supplements all applicable regulations, is the PWC Design and Construction Standards Manual. Its policies and regulations are primarily pertinent to the project review, approval, and construction process. The Manual initially became effective on February 1, 1981 and has been continually amended. The last amendment was performed on June 6, 2006 (Prince William County Design and Construction Standards Manual, 2006). The Manual outlines that the development must also comply with the following:

- Virginia Uniform Statewide Building Code
- Zoning Ordinance
- Subdivision Ordinance
- Health Laws of Virginia
- State Soil Erosion and Sedimentation Control Law
- Chesapeake Bay Preservation Area Designation and Management Regulations 9VAC 10-20-10etseq
- Virginia Department of Transportation Standards and Specifications
- PWC Administrative Procedures Manual (Administrative Procedures for the Management of Site Development Projects)

5.2.2.2 General Permitting Process

The PWC Department of Development Services must approve the building's site plan before work can begin. Developers submit building plans and documentation to the Building Development Division of PWC. Commercial projects require a plan review. New commercial buildings take up to four weeks for the initial plan review as the design documents make the round of zoning and life safety code specialist reviewers (interview with Ray Jackson 9-24-2009). Each reviewer assesses the project according to their subject area only – looking, for example, for adequate fire suppression measures. The subject areas of review are Architecture, Electrical, Structural, Plumbing, Mechanical, and Fire (these reviewers work in the office of the Fire Marshal, and the relevant information for each project is sent to them by Plan Review branch).

Rarely are these plans approved and the permit granted in the first round of reviews. More commonly, the Building and Development Division will provide review comments and revision requests. The development team makes the requested changes, and then resubmits revised plans for review (interview with Sia Shahrzad 9-24-2009). The Building Development Division of PWC can work with contractors if the contractors wish to use an alternate technique from what is specified in code (such as green building features), as long as the contractors uphold the same level of health and safety standards in their alternate design as the code does (interview with Ray Jackson 9-24-2009).

The PWC Department of Development Services does not require reviewers to complete each project review within a certain number of hours. Instead, the time it takes to review a project is at the discretion of the reviewer and depends on the size and complexity of the project. The department has a system that tracks how many reviews each reviewer completes in a day, and how many weeks it takes a project to work its way through their system. An official at the Department of Development Services estimated that reviewers complete 5 to 15 reviews per day, and that it takes an average of two to four weeks for a project to work its way through their system (interview with Sia Shahrzad 10-7-2009).

5.2.2.2.1 Training and Continuing Education for Code Officials

PWC requires building officials to have 16 hours of training every two years. When the building code is updated (every three years), building officials are given special training on the changes between the new and old codes. Additionally, PWC has their own state-approved academy for training code reviewers. However, this training is exclusively on the subject of the applicable building codes and does NOT cover green building techniques (interview with Ray Jackson 9-24-2009).

Some of the permit review staff are in the process of becoming LEED Accredited Professionals. However, interest in green building has been somewhat impaired by the current economic recession, as concern with surviving the recession and holding onto jobs assumes a higher importance than promoting green building. Most recently, PWC is experiencing a slight recovery in permit applications submitted. (interview with Sia Shahrzad 9-24-2009).

5.2.2.3 Wetland Studies and Solutions' Approval Process

5.2.2.3.1 Decision Makers within the Project and Regulatory Teams

Sean Connaughton, the Chairman of the Board of County Supervisors for PWC (2000-2006), was the primary regulatory stakeholder for this project. Within PWC and working below Sean Connaughton, Martin Briley also played a key role, as it was Briley who acted as the project's "expediter" in the County's permitting process. As mentioned within the case study, Mike Rolband was the most influential decision maker on the project team.

WSSI's most significant green building initiatives revolved around the Low Impact Development (LID) plan created by WSSI and its civil engineer. This was not required by any local regulatory bodies; WSSI sought to establish itself as a local example of green building practices, as detailed in the case study section of this report.

5.2.2.3.2 Incentives for Green Building Practices

Due to the existing relationship between Mike Rolband and Sean Connaughton, WSSI received a favorable streamlined permitting process by the PWC Economic Development Office identifying the building as a "Targeted Industry Project." This proved to be a major incentive for WSSI's move from Fairfax to PWC. Designation of WSSI as a Targeted Industry Project was based on the anticipated benefits to PWC's economy from WSSI's relocation. It entitled the WSSI building project to expedited processing– two weeks instead of four for the initial building plan review. WSSI reported that PWC reduced the County Review fee by 50 percent and eventually waived all review comments relevant to the LID design features, including those around its atypical curb-and-gutter design (see the WSSI case study in Chapter 2 of this report for more information). During the onsite interview, Rolband mentioned that without this expedited review, WSSI would have encountered significant permitting difficulties that would have limited the implementation of many of its green building features. WSSI was approved under the 2000 version of the Virginia Uniform Statewide Building Code (VUSBC) which was partially based on 1997 ICC code. WSSI was issued an occupancy permit on 1-2-2006, allowing them to occupy the building (interview with Sia Shahrzad 9-24-2009).

As a result of evaluating the WSSI building, a number of County officials are now familiar with LID design principles. The building also serves as an example and teaching resource for the Northern Virginia Regional Commission, which is working to issue LID recommendations for the region. The Northern Virginia Regional Commission has completed a draft document; however the Commission is waiting on issuing that draft until a rewrite of the state stormwater regulations is completed (electronic correspondence with Jennifer Brophy-Price, October 5, 2009).

5.2.2.3.3 Barriers to Green Building Practices

Although it did receive a streamlined and significantly simpler permitting process, WSSI still faced a number of challenges from PWC. Existing staff at the permitting office were unfamiliar with many of the LID stormwater management techniques and did not understand how to evaluate them. Enforcement of a number of county code requirements would have invalidated a number of LID efforts, such as runoff collection into the swale and rain garden, which a standard curb and gutter system would have rendered impossible. However, PWC eventually waived most of these requirements. WSSI also had to obtain a formal waiver for the lack of striping on the gravel portion of their parking lot (electronic correspondence with Jennifer Brophy-Price, October 5, 2009).

One example of a code requirement that was not waived was the requirement that the site's stormwater outfall pipe be 18 inches in diameter. Stormwater from the parking lot and other sources collects in an underground gravel bed, where it is purposely held and slowly released through a 1 5/8 inch diameter orifice. Despite the fact that it was contrary to the purpose of that design, WSSI was required to have an 18 inch outfall to the stream. The result is that the water is detained in the gravel bed and slowly released through a 1 5/8 inch orifice, after which it flows in a trickle along the bottom of a very oversized 18 inch pipe to reach the stream.

The greatest regulatory resistance was with regard to using treated rainwater for toilet flushing. The Department of Health initially prohibited WSSI from proceeding with installation unless water was treated to tertiary standards. It was not until four years after the building was completed and a change of the Department of Health staff that the cistern was installed and operated as originally intended. PWC's Department of Health also required that the cistern's water outflow be metered to charge appropriately for sewage services.

5.2.2.4 Code Changes Spurred by the Design of the WSSI Building

As mentioned previously, WSSI serves as the local model of green building practices for the PWC area. Regulators are able to visit the building and view actual green building techniques in built form. Through the use of WSSI as a no-cost venue for meetings and conferences (a practice established by Mike Rolband) private sector professionals become aware of LID practices and now view them as viable options for their own work. The overall objective in granting this level of accessibility to the building is the education of public and private sector professionals, increasing the implementation of green and LID techniques by showcasing their beauty and impacts.

The ability of PWC to make code changes is severely limited by their lack of authority to modify building codes to make them different from the VUSBC (interview with Ray Jackson 9-24-2009). Section 102, chapter 1 of the VUSBC states that in accordance with sections 36-98 of the Code of Virginia, the VUSBC "shall supersede the building codes and regulations of the counties, municipalities and other political subdivisions and state agencies." Due to its proximity to Washington DC and Arlington, VA, both which have or are currently in the process of enacting more demanding planning and zoning specifications elaborated upon later in this report, there is an opportunity for knowledge-sharing through inter-jurisdictional cooperation (interview with Ray Jackson 9-24-2009). There is an inter-jurisdictional building code meeting in Fairfax County, VA every three months which includes all surrounding counties and municipalities including Washington DC and Arlington. While the goal of this meeting is to promote code uniformity in order to make building codes more user-friendly (interview with Ray Jackson 9-24-2009), this could become a mechanism for PWC to learn and to follow in the footsteps of Arlington and Washington DC.

5.2.3 Millennium Tower Residences

5.2.3.1 Local Regulatory Structure, Battery Park City

Millennium Tower Residences was constructed in Battery Park City (BPC) (in New York City) in 2006. Development within Battery Park City (BPC) is conducted in accordance with the 1979 Master Plan for the area, which is designated as a special zoning district within New York City (NYC). The Master Plan provides zoning requirements as well as design guidelines with which a project must comply. The design guidelines deal more directly with aesthetic characteristics; zoning addresses the land use and volume.

The Battery Park City Authority (BPCA) was established by the State of New York, which owns the leaseholds on the land and awards these to developers. Thus, BPCA because of State ownership but NYC presence is in many ways in a jurisdictional grey area. Buildings in BPC are still subject to the requirements of NYC's Building Department, Department of Transportation, Health Department and Fire Marshal.

Contrary to the typical land development process, BPC maintains ownership of a building's site and issues long term leases on the property. Thus, development is tightly controlled by BPCA, and a lot is not developed until decided upon by BPCA. A different Request for Proposals is created for each site and developers are identified and engaged during this process. Ultimately, developers are chosen based on the merits of their proposal to develop the site. The NYC Department of Planning is in charge of zoning review.

5.2.3.1.1 The Battery Park City Residential Environmental Guidelines

BPCA created its own green development guidelines in 2000, the Battery Park City Authority Residential Environmental Guidelines (BPC Guidelines) (Hugh L. Carey BPCA, 2005). The BPC Guidelines are not mandatory. Because developers compete for the right to build on available lots, however, they are effectively mandatory since compliance with the Guidelines is a major factor in developer selection.

The BPC Guidelines were created to, "establish a process for the creation of environmentally responsible residential buildings that are appreciably ahead of current standards and practices for development" (Hugh L. Carey BPCA, 2005). In areas of sustainable design and construction, the BPC Guidelines are more specialized and advanced compared to a normal building code, mainly because they were created independently, and not based on national or international code.

In their introduction, the BPC Guidelines acknowledge the influence of LEED. However, unlike LEED which mainly awards points for using particular "best practices," the BPC Guidelines are "deliberately goal-oriented to provide for creative solutions that take advantage of rapidly changing technologies or evolving policies, regulations, and building codes" (Hugh L. Carey BPCA, 2005). Some of the BPC Guidelines are required, and some are suggestions.

BPC Guidelines require the developer to install dedicated meters to measure all of the following: potable water, black/greywater, and stormwater used by the cooling tower, total stormwater used, total blackwater recovered, and total blackwater used. The BPC Guidelines also mandate the use of Energy Star appliances and fixtures. Energy Star dishwashers save at least 33 percent of the water use of a standard dishwasher (Energy Star, 2009a), and Energy Star clothes washers save over 50 percent of the water use of a standard clothes washer (Energy Star, 2009b). A copy of the BPC Guidelines for water management are provided in Appendix B.

The BPC Guidelines have a section devoted to Water Conservation and Site Management that aims to "Conserve potable water by reducing demands for water use including domestic water, landscaping, irrigation, cooling tower, laundry, maintenance and other non-potable uses" (Hugh L. Carey BPCA, 2005). One requirement states that buildings must have collection, treatment, storage, and reuse for 2.4 inches of rain falling on all building roofs and setbacks. Buildings must also follow U.S. Environmental Protection Agency Best Management Practices (BMPs) for harvesting and reuse of stormwater. Buildings are required to reuse stormwater for "cooling tower, irrigation, and building and sidewalk maintenance, and laundry, if allowed by municipal codes." Treated stormwater is also to be used in preference to treated blackwater, since it requires less energy to treat. Buildings must also provide labeled reclaimed water taps outside for landscaping and maintenance.

The Water Conservation and Site Management section of BPCA requirements also states that water fixtures, dish washers, and clothes washers must in aggregate use 10 percent less water than the Energy Policy Act of 1992, as well as being designated water conserving fixtures. Irrigation must be drip irrigation and must use non-potable water, and plantings must be drought-tolerant. Additionally, the buildings are required to treat and recycle wastewater using a non-chemical process to the "maximum extent possible", and use that water for toilet flushing, cooling tower make-up, irrigation, laundry, and maintenance.

BPCA requires a minimum LEED certification of LEED Gold for New Construction. The BPC Guidelines also propose that developers attain a LEED Existing Building certification every 5 years from the time that the building is occupied. In order to attain LEED certification, a building must implement minimum water saving technologies or strategies; however, a building following BPCA Guidelines will achieve LEED points for technologies or strategies implemented in following these Guidelines. There is not necessarily an added water savings as a result of LEED.

5.2.3.1.2 New York City Administrative Code

As part of NYC, BPC and all the buildings built in it are subject to the NYC Administrative Code, specifically Title 27, Chapter 1: Building Code. This building does not appear to have any specifically green provisions. It is largely generated by the City of New York, rather than being adopted from a national code, however it does employ some reference standards.

5.2.3.2 General Code Approval Process

Developers must submit the following to BPCA:

- The following submittal packets
  1. Schematic Design
  2. Design Development
  3. Construction Documents
  4. As-Built submissions
- A cost analysis of all the green features in the building
- A narrative describing how each of the BPC Guidelines' requirements was met
- Tenant Guide and Maintenance Manual, separately bound and included as appendices
- Any requested variation from the Guidelines and an explanation of this variation

In general BPCA reviews proposals for one site at a time. BPCA also provides oversight during each phase of the new construction design process. In addition to these BPCA design approvals, developers must also seek approvals from the City Health Department so that there are two review processes: one from at BPCA level and one at the City level.

A typical competition for development rights includes a field of about 8 developers, each of whom submits a proposal. BPCA attempts to keep the process objective by using a matrix which gauges and compares significant development issues relevant to the site. Once all proposals have been submitted, BPCA typically takes three to six months to review and choose a proposal for a particular site. A typical proposal is about the size of a phonebook for a large city. It contains the developer's preliminary design and financial documents. The green Guidelines add another layer of documentation to be examined during the review process. The proposal is reviewed by the legal, design, finance, and construction departments of BPCA, as well as being subject to the review of BPCA president and the Board. The Board has the ultimate power to decide whether to approve a proposal – however, this is a *pro forma* approval, as it only looks at BPCA staff's recommended proposal and verifies that it is acceptable to the Board (interview with Stephanie Gelb 10-1-2009).

5.2.3.2.1 Training and Continuing Education for Code Officials

BPCA is composed of approximately 60 staff members who review project proposals or support that activity. Each department within BPCA is staffed by professionals with the relevant professional degrees and certifications. Currently there are two architects and two support staff members within the Planning Department, of whom three are LEED accredited professionals. BPCA views every building as a learning opportunity leading to refinement and modifications of the Green Guidelines (interview with Stephanie Gelb 10-1-2009).

5.2.3.3 Millennium Tower's Permit Process

Plans for Millennium Tower conformed to the Residential Environmental Guidelines of BPCA in order to win the right to build on the construction site. The first building built according to the BPC Guidelines, the Solaire, raised the bar on green features for subsequent buildings, as outlined in the Case Study description earlier in this study. Due to the intense bidding pressure for the prime real-estate available in BPC, a set of *de facto* requirements beyond even the BPC Guidelines has arisen, which buildings must meet in order to have a hope of achieving the winning bid for a site.

The approval from the NYC Department of Health and Hygiene for their water reuse system, took some time for Millennium Tower to receive. The NYC Health Department visited during startup of the system. After overseeing the initial design stages, and as documented in the case study chapter (see section 2.4.6), BPCA conducts minimal ongoing oversight, as it lacks the mandate to do so at this time. The City of New York's inspectors are responsible for any subsequent project reviews (interview with Stephanie Gelb 10-1-2009). The lack of City oversight, as they expressed in interviews for this study, makes them nervous. They would prefer to manage the system in the presence of regulatory oversight.

BPCA must negotiate with developers and with NYC regulatory bodies in order to achieve approval of certain green project features. Since Millennium Tower Residences was not the first building to include green building features, it did not experience as difficult a review process as did previous development.

5.2.3.4 Code Changes Spurred by the Design of Millennium Tower Residences

Unlike the other case studies in which the owners, as green building trailblazers, were attempting to implement green building practices far beyond the local code requirements, the Millennium Tower Residences was built green to satisfy BPCA Guidelines and compete with other proposed projects. Thus, the Millennium Tower Residences was following regulations and guidelines rather than leading them. The construction of the cluster of multi-family residential developments in BPCA cumulatively has had an effect on code initiatives and the consideration of green building techniques in NYC. For example, PlaNYC, the water quality objectives of which are outlined in Appendix A, is an ambition step forward that sets far reaching goals for many aspects of environmental management including water.

Recently, the economic recession has resulted in a slowdown in developing the last two available BPC sites. After these two sites are finished being developed, there will be no more sites within BPC free for construction. During an interview, BPCA's Stephanie Gelb stated that she didn't know what BPCA will do next. It may be disbanded. Future redevelopment of BPC would thus have an uncertain review process (interview with Stephanie Gelb 10-1-2009).

LEED Existing Building certification and recertification every five years has become a new suggested requirement for all BPC development. In addition, retrofitting existing buildings for better performance has been suggested as an ongoing goal of BPCA Guidelines. However, BPCA's future level of involvement is unclear. If BPCA ceases to exist, there may be no ongoing implementation.

5.3 Examples of Best Practices for Green Planning and Zoning

There are local governments that at the forefront of green zoning initiatives. These leaders in reform include Portland, OR; Seattle, WA; Washington, DC; Salt Lake City, UT; and Franklin, MA. Common to all is the notion of developing private sector incentives as a spur to sustainable development, thus balancing the initial costs of green and the demands of regulation with financial reward.

5.3.1 Portland, Oregon

Located in a region known for its high annual precipitation rates, Portland (like Seattle to come) has developed forward-thinking stormwater management programs and policies. Through a mix of regulation and incentive, Portland has addressed a spectrum of issues related to local waterway pollution, combined sewer overflow events, lack of open space, and watershed sensitivity. Proposed changes are presently being discussed, emphasizing the importance of continued efforts to improve water management and quality.

5.3.1.1 Portland's Drainage Management Policies and Standards

In effect since 2008, the Portland City Code & Charter Chapter 17.38 Drainage and Water Quality sets strict guidelines for new development. All new development must meet requirements for drainage way protection, stormwater management facilities, impervious surfaces, and discharge flow rates and quality (City of Portland, Oregon, 2009). In addition, the policy requires the on-site treatment of stormwater or, alternatively, the payment of an off-site stormwater fee. Enforcement is carried out through a series of monetary penalties. Particular attention is given to the protection of local streams and rivers. Here is select language from Chapter 17.38.035 that might serve as a best practice in water management code for both quantity and quality (underlines added for emphasis). Note that onsite water treatment and contaminant mitigation are constant themes,

> *17.38.035* Drainage *Management Policies and Standards*
>
> *A. Stormwater shall be managed in as close proximity to the development site as is practicable, and stormwater management shall avoid a net negative impact on nearby streams, wetlands, groundwater, and other water bodies.*
>
> *B. The quality of stormwater leaving the site after development shall be equal to or better than the quality of stormwater leaving the site before development, as much as is practicable, based on the following criteria:*
>
> 1. *Stormwater management facilities required for development shall be designed, installed and maintained in accordance with the Stormwater Management Manual, which is based on achieving at least 70 percent removal of the Total Suspended Solids (TSS) from the flow entering the facility for the design storm specified in the Stormwater Management Manual…*

2. Stormwater discharge which is not practicable to fully treat to the standards of this Section and the Stormwater Management Manual, shall be either: (a) managed in an offsite facility or (b) given the option of paying a stormwater offsite management fee…

C. The quantity and flow rate of stormwater leaving the site after development shall be equal to or less than the quantity and flow rate of stormwater leaving the site before development, as much as is practicable, based on the following criteria:

1. Development shall mitigate all project impervious surfaces through retention and on-site infiltration to the maximum extent practicable…

2. Any development that discharges to a tributary of the Willamette River, other than the Columbia Slough, shall design stormwater management facilities such that the rate of flow discharging from such facilities for up to a two-year design storm event does not lengthen the period of time the tributary channel receiving the discharge sustains erosion causing flows, as determined by the Bureau…

3. Stormwater discharge which cannot be practicably managed for quantity or flow rate control as defined in this Subsection and the Stormwater Management Manual shall either be: (a) managed in an offsite facility designed for the pollutant load, volume and rate of flows from subject property and managed by the site developer/site owner or another legal agent, or (b) managed in an offsite stormwater management facility operated by the City subject to paying a stormwater offsite management fee…

5.3.1 2 Requirement for Stormwater Management Facilities

Chapter 17.38.040 requires permanent stormwater management facilities for all development projects, select portions of which are cited here (City of Portland, Oregon, 2009). By requiring on-site treatment of runoff, the City of Portland favors distributed stormwater management, reducing the burden on existing and future centralized treatment infrastructure:

17.38.040 Stormwater Management Facilities Required

No plat, site plan, building permit or public works project shall be approved unless the conditions of the plat, permit or plan approval requires installation of permanent stormwater management facilities designed according to standards or guidelines established by the Director and as specified in the Stormwater Management Manual.

D. Maintenance of Stormwater and Groundwater Management Facilities.

1. All new development, redevelopment, plats, site plans, building permits or public works projects, as a condition of approval, shall be required to submit an operation and maintenance plan for the required stormwater management facilities for review and approval by the Bureau of Environmental Services…

In Chapter 17.38.041, the city explicitly calls out parking lots and refers to guidance contained within the Stormwater Management Manual, which explains that traditional parking lots and other impervious surfaces "increase the pollution levels and temperature of stormwater that is transported to streams, rivers, and groundwater resources" (City of Portland, Oregon, 2009).

17.38.041 Parking Lot Stormwater Requirements

Stormwater runoff from parking lots must be managed in parking lot interior or perimeter landscaping to the extent required by the Stormwater Management Manual…

5.3.1.3 Portland's Proposed "Feebate" System

Already a leader in green buildings, Portland is pursuing a new incentive-based revenue collection mechanism that would assess a fee to buildings merely constructed to code in order to finance high-performance green buildings (City of Portland Bureau of Planning and Sustainability, 2008). The proposed "feebate" would affect new commercial and multi-family residential development. The new policy would also require existing commercial and multifamily residential buildings to publicly disclose energy consumption data by 2013 (Wendt, 2009). Reward *requirements include the fulfillment of a specified number of credits for water efficiency,* as shown below.

Table 5-2
Feebate structure for new commercial buildings

Feebate Option	Green Building Standards	Minimum Requirements (LEED Credits)	Reward or Fee
Reward	Living Building Challenge	Net-zero energy and water documentation (1 year)	$8.65 - $17.30/sf
	LEED Platinum	10 energy efficiency 4 water efficiency	$3.46 - $6.92/sf
	LEED Gold	8 energy 3 water	$1.73 -$3.46/sf
Waiver	LEED Silver	5 energy 2 water	Not Applicable
Fee	None		(-)$1.73 – (-) $3.46/sf

Source: (City of Portland Bureau of Planning and Sustainability, 2008).

Table 5-3
Feebate structure for new multi-family buildings less than 5,000 square feet

Feebate Option	Green Building Standards	Minimum Requirements (LEED Credits)	Reward or Fee
Reward*	Living Building Challenge	Net-zero energy and water documentation (1 year)	$2.58 – $5.15/sf
	LEED Platinum or Earth Advantage**	10 energy efficiency 4 water efficiency	$1.03 – $2.06/sf
	LEED Gold or Earth Advantage**	8 energy 3 water	$0.51 – $1.03/sf
Waiver	LEED Silver or Earth Advantage**	5 energy 2 water	Not Applicable
Fee	None		(-) $0.51 – (-)$1.03/sf

Source: (City of Portland Bureau of Planning and Sustainability, 2008)

5.3.1.4 City of Portland Code Updates

The City of Portland proposed a "green bundle" of code updates which were provided to the Planning Commission in August 2009. Part of the 2009 Regulatory Improvement Program, the green amendments to Regulatory Improvement Code Amendment Package 5 contain provisions for water cisterns and eco-roofs (City of Portland Bureau of Planning and Sustainability, 2009). Specifically, the amendment would *allow water cisterns to be placed, to a reasonable degree, within zoning code setbacks* and *remove the requirement for water cisterns to go through Design Review* (with narrower exemptions in Historic Districts).

5.3.1.5 Bureau of Environmental Services Stormwater Management Program

The City of Portland also maintains a robust stormwater management program within the Bureau of Environmental Services, featuring a number of opportunities for developers and property owners. In an effort to increase stormwater management capacity in new and existing development, Portland runs an eco-roof incentive program which offers cost-sharing opportunities of up to $5 per square foot of installed vegetative roof (City of Portland Bureau of Environmental Services, 2009a). Portland's Green Street Program assists public and private development to incorporate LID techniques and stormwater management mechanisms such as retention basins and permeable pavers (Portland Bureau of Environmental Services, 2009b).

5.3.2 Seattle, Washington

5.3.2.1 Seattle's Green Factor

Seattle's Neighborhood District Business Strategy, adopted in 2006, features a unique planning element called the Green Factor. The Green Factor is a landscape requirement designed to "increase the quantity and quality of planted areas in Seattle while allowing flexibility for developers and designers to meet development standards" (Seattle Department of Planning and Development, 2009). The standard currently applies to all new construction projects in commercial and neighborhood commercial zones outside of downtown. The Green Factor scoring system is "designed to encourage larger plants, permeable paving, green roofs, vegetated walls, preservation of existing trees, and layering of vegetation along streets and other areas visible to the public" (Seattle Department of Planning and Development, 2009). Additional Green Factor bonus points are granted for rainwater harvesting and drought-tolerant plants.

5.3.2.2 Saving Water Partnership

The Saving Water Partnership's Water Smart Technology Program provides monetary incentives to commercial, industrial and institutional eligible customers who implement water conservation and efficiency measures. Rebates of varying amounts are available to pre-approved projects installing toilets and urinals, irrigation system improvements, commercial laundry, conventional food steamers, cooling and refrigeration systems, medical equipment, and process water improvements and water use technologies (Saving Water Partnership, 2005). The program also offers free services to promote conservation, including technical information on water efficient technologies, bill analysis, on-site water audits, life cycle cost analysis, free brochures and speaking engagements on water conservation, water efficient irrigation information, and end-use metering.

5.3.2.3 Zoning Incentives

Since 2006, Seattle's downtown zoning regulations have included a provision which grants a density or height bonus to any project that achieves a LEED Silver rating or higher (Seattle Department of Planning and Development, 2006). Projects must submit a letter of intent with the permit application, and proof of the LEED Silver rating or higher must be provided within 90 days of the issuance of the certificate of occupancy. The city has developed a fee schedule to penalize non-compliant buildings.

5.3.2.4 Comprehensive Plan Elements

The environment section of Seattle's Comprehensive Plan offers a number of suggestions and policy approaches toward water-related issues. The document proposes policies that would protect ecosystems that improve water quality and expand the urban forest and increase vegetated and permeable surfaces for increased stormwater management capacity (City of Seattle, 2009). The relevant suggestions are listed here:

> *Relationship to Economic Development*
>
> *E2: Incorporate the improvement of the natural environment into the City's planning efforts and capital development projects. For instance, plan for transportation systems that control impacts on air quality and climate change, as well as on water pollution and the consumption of fossil fuels.*

Natural Systems Approach

EG3: Use natural systems to maintain and enhance environmental quality by having them perform such functions as cleaning air and water, and controlling stormwater runoff.

E8.1: Where there would be measurable benefits to people or wildlife, place priority on solving drainage problems, such as flooding and frequent reliance on the combined sewer overflow system, with natural drainage system approaches and by restoring watershed elements such as forest, wetlands, and natural channels.

E9: Work to achieve a sustainable urban forest that contains a diverse mix of tree species and ages in order to use the forest's abilities to reduce stormwater runoff and pollution, absorb air pollutants, provide wildlife habitat, absorb carbon dioxide, provide shade, stabilize soil, and increase property values.

E10: Strive to increase the amount of permeable surface and vegetative cover in the city in order to mitigate the heat island effect of developed areas, control stormwater flows and reduce pollution.

Seattle's Trees

E22: Work to achieve a sustainable urban forest that contains a diverse mix of tree species and ages in order to use the forest's abilities to reduce stormwater runoff and pollution, absorb air pollutants, provide wildlife habitat, absorb carbon dioxide, provide shade, stabilize soil, and increase property values.

5.3.2.5 King County, Washington State Incentives, Fees, and Design Standards

King County offers a number of permitting incentives to promote sustainable development, including free technical consulting services, priority processing and free customized review (for residential projects only), dedicated staff for green building projects, and cost sharing and fee discounts for use of LID BMPs (King County Water and Land Resources Division, 2009a). Seattle's LID incentives include inspection fee discounts for stormwater flow control or water quality treatment facilities, surface water management fee discounts for pervious surface absorption, and cost sharing for converting from impervious surfaces.

King County assesses a surface water management fee to homeowners and building owners, based respectively on the average impervious surface area on residential properties and the area of impervious surface on commercial properties (King County Water and Land Resources Division, 2009b). There are discounts and cost-sharing incentives for projects seeking to reduce the amount of impervious surface.

Pursuant to Ordinance 16264, King County's Department of Natural Resources and Parks recently revised its Surface Water Design Manual, a set of highly developed standards for water management. The 500-plus page manual offers guidelines on issues related to analysis, BMP flow rates, low impact design, biofiltration, swales, infiltration, runoff, pollution and quality.

5.3.2.6 Street Edge Alternatives Project

Constructed in 2001, the Street Edge Alternatives Pilot Project transformed a section of 2nd Avenue, NW into a model for exemplary water management. By reducing the imperviousness of the street by 11 percent and planting 100 evergreen trees and 1100 shrubs, the project reduced the total volume of stormwater leaving the street by 99 percent (Seattle Public Utilities, 2009).

5.3.3 Washington, DC and Salt Lake City: Reviewing Code for Sustainability

In both the nation's capital and the state capital of Utah, government is enlisting the help of the community to update zoning codes to increase capacity for sustainability. Both cities recruited the help of Denver-based Clarion Associates, nationally-recognized planning and zoning consultants, to provide diagnosis assessments, facilitate community participation, and draft new language for code. Though the process is still underway in both cities, much work has been done to identify key concerns and establish priorities for addressing urban water management and quality issues.

5.3.3.1 Washington DC

5.3.3.1.1 Green Building Act of 2006 and Proposed Code Changes

Section 13, subsection (a) of the Green Building Act of 2006 requires the Mayor to "submit to the Council for approval construction code revisions that shall incorporate as many green building practices as practicable for the Washington, DC urban environment" (District of Columbia Council, 2007). Further, the legislation states that if "conflicts arise between the existing Construction Codes and green building practices, green building practices shall have priority." In February 2008, the Mayor's Green Building Advisory Council assisted in providing suggestions to a comprehensive overhaul of the city's building codes to incorporate environmental standards, including the energy standards included in ICC 2006 and ASHRAE 189.1. The proposed codes also call for increased water efficiency (low-flow fixtures), more flexibility in disconnecting downspouts and retain rainwater on site, and the removal of waiver requirements for waterless urinals and green piping (District of Columbia Council, 2007). Table 5-3 summarizes the recommendations under review.

Table 5-4
Proposed low flow fixture standards in Washington, DC building codes

Plumbing Fixture	Maximum Flow Rate or Quantity	
	Old	New
Lavatory (private)	2.2 gpm	1.5 gpm
Shower	2.5 gpm	2 gpm
Urinal	1.0 gpf	0.5 gpf
Toilet	1.6 gpf	1.28 gpf

Source: (Majersik, 2008)

5.3.3.1.2 Sustainability and the DC Zoning Review

The DC Office of Planning is currently working to update the city's zoning code, found in Chapter 11 of the DC Municipal Regulations. A number of working groups were established to allow for community input and guidance on a number of issues, including sustainability. With the help of consultants, the sustainability working group helped to inform a series of recommendations provided by Office of Planning to the DC Zoning Commission. Water issues are addressed at length in the recommendations, which include the following proposed changes to the zoning code:

- Explicit permitting of rain harvesting devices and allowance for those devices in yard setbacks, underground and on rooftops
- Buffer requirements for streams, slopes, and wetlands
- Use limits in floodplains, with particular attention to vulnerable populations (such as child care or senior housing)
- Exemption of vegetated roofs from rooftop setbacks, up to 4 feet
- Site design requirements to encourage vegetated roofs, native and low-water use landscaping, and pervious pavement
- Requirements for design and distribution of landscaped areas in parking lot (such as minimum planting bed size)

(Source: Government of the District of Columbia Office of Planning, 2009)

5.3.3.1.3 Comprehensive Plan

The 2006 Comprehensive Plan offers guidance on water quality and management issues in the context of green buildings. Though many components of the Comprehensive Plan have yet to be implemented, the document contains an array of progressive strategies for addressing environmental concerns related to urban development, many of which can easily be replicated in peer jurisdictions. These strategies seek to reduce the impact of stormwater pollution on waterfront areas, increase the area and quality of vegetated space to treat runoff, and improve regulatory mechanisms to promote water management in new and existing buildings. Chapter 6, Environmental Protection Element, offers the following guidance on policies and actions (underlines added for emphasis):

> *E-1 Protecting Natural and Green Areas, E-1.1 Conserving and Expanding Our Urban Forest*
>
> *Policy E-1.1.2: Tree Requirements in New Development*
>
> *Use planning, zoning, and building regulations to ensure that trees are retained and planted when new development occurs, and that dying trees are removed and replaced. If tree planting and landscaping are required as a condition of permit approval, also require provisions for ongoing maintenance.*
>
> *Policy E-1.2.2: Waterfront Habitat Restoration*
>
> *Undertake a range of environmental initiatives along the Anacostia River to eliminate combined sewer overflows, reduce urban runoff, restore wetlands and tributary streams, increase oxygen levels in the water, remediate toxins in the riverbed, clean and redevelop contaminated brownfield sites, and enhance natural habitat.*
>
> *E-1 Protecting Natural and Green Areas, E-1.5 Sustaining Urban Plant and Animal Life*
>
> *Policy E-1.5.3: Habitat Management on Private Land*
>
> *Encourage environmentally sound landscaping and gardening techniques by DC homeowners and institutional landowners to maximize the habitat value of privately owned land. Such techniques should include reduction of herbicide and pesticide use; the selection of disease, drought-resistant, and native species; the removal of invasive plants; the use of rain gardens to reduce urban runoff; and landscaping that provides food and cover for wildlife.*

A number of policies and actions within the Comprehensive Plan address the importance of water conservation in buildings. Specific attention is paid to the use of water-efficient deign approaches for both plumbing and irrigation purposes.

> E-2 Conserving Natural Resources, E-2.1 Conserving Water
>
> *Policy E-2.1.1: Promoting Water Conservation*
>
> *Promote the efficient use of existing water supplies through a variety of water conservation measures, including the use of plumbing fixtures designed for water efficiency, drought-tolerant landscaping, and irrigation systems designed to conserve water.*
>
> *Action E-2.1.B: Building Code Review*
>
> *Continue efforts by the DC Building Code Advisory Committee to review building, plumbing, and landscaping standards and codes in order to identify possible new water conservation measures.*

Washington's Comprehensive Plan recognizes the opportunity to integrate sustainable design through low impact development. Vegetated spaces, permeable surfaces, rainwater harvesting and other structural and non-structural best management practices feature prominently within the document. To address regulatory hurdles, the plan encourages the evaluation of barriers to water capture and reuse within building and construction codes. The Comprehensive Plan also recommends the completion of at least one low impact development demonstration project per year, making project plans and specifications available to the public so that the design and results can be replicated.

> *E-3 Promoting Environmental Sustainability, E-3.1 Low Impact Development*
>
> *Policy E-3.1.1: Maximizing Permeable Surfaces*
>
> *Encourage the use of permeable materials for parking lots, driveways, walkways, and other paved surfaces as a way to absorb stormwater and reduce urban runoff.*
>
> *Policy E-3.1.2: Using Landscaping and Green Roofs to Reduce Runoff*
>
> *Promote an increase in tree planting and landscaping to reduce stormwater runoff, including the expanded use of green roofs in new construction and adaptive reuse, and the application of tree and landscaping standards for parking lots and other large paved surfaces.*
>
> *Policy E-3.1.3: Green Engineering*
>
> *Promote green engineering practices for water and wastewater systems. These practices include design techniques, operational methods, and technology to reduce environmental damage and the toxicity of waste generated.*
>
> *Action E-3.1.A: Low Impact Development Criteria*
>
> *Establish Low Impact Development criteria for new development, including provisions for expanded use of porous pavement, bioretention facilities, and green roofs. Also, explore the expanded use of impervious surface limits in the District's Zoning Regulations to encourage the use of green roofs, porous pavement, and other means of reducing stormwater runoff.*

(Source: Government of the District of Columbia Office of Planning, 2006)

5.3.3.1.4 Incentives for LID

The District Department of the Environment offers a number of incentives for residential LID. DC's RiverSmart Homes program offers grants of up to $1,200 for installation of shade trees, rain barrels, pervious pavers, rain gardens, and native plant landscaping.

5.3.3.1.5 Stormwater Fee Billing

The District of Columbia also collects a monthly stormwater fee from property owners based on the impervious surface area on a given lot. The nearly $13 million raised annually goes toward water pollution control efforts in the city (District Department of the Environment, 2009). In addition, property owners are required to pay an impervious area charge to the Water and Sewer Authority, which provides revenue to recover the cost of the $2.2 billion Combined Sewer Overflow Long-Term Control Plan, a federal mandate to relieve the overburdened combined sewer outflow system in the District of Columbia (DCWASA, 2009).

5.3.3.1.6 Regional Guidance

The Metropolitan Washington Council of Governments' 2007 report, "Greening the Metropolitan Washington Region's Built Environment," called for water-efficient buildings and low-impact design techniques, noting the regional imperative and urgency for increased stormwater management practices and protection of the Chesapeake Bay watershed. One of the Metropolitan Washington Council of Governments' recommendations was the development of a "COG Regional Green Standard" for private development. This standard would encourage the pursuit of LEED credits which address regional priorities, including LEED- New Construction Sustainable Sites credit 6.1, stormwater design for both quality and quantity control.

5.3.3.2 Salt Lake City Sustainable Community Code Revision Project

Salt Lake City is currently undertaking a Sustainable Community Code Revision Project. The Division of Sustainability and the Environment is leading the effort, currently in its final phase. The first phase was an inventory of sustainability policies and goals, completed in October 2008 with the help of Clarion Associates, a firm simultaneously assisting Washington, DC's Zoning Review for sustainability recommendations. The report generated at the conclusion of phase one addressed 10 categories, including water quality and conservation, urban forestry, and open space, parks, and trails (Salt Lake City Green, 2009).

5.3.3.2.1 Phase One Findings

Within the water quality and conservation discussion, a number of key policies and goals were mentioned which primarily sought to preserve drinking water source quality, protect regional watersheds, promote water assurance during low-precipitation periods, and maintain fish and wildlife habitat. Key Policy/Goal 4 supports a previously established tangible goal for decreased water consumption, set by the Salt Lake City Department of Public Utilities, to reduce overall consumption within the service area by 13 percent by the year 2025, equivalent to 5.4 billion gallons annually. The phase one report suggests that this can be achieved through reductions in indoor water use by 5 percent of 1.1 billion gallons per year and outdoor water use by 20 percent or 4.3 billion gallons per year. In addition, Key Policy/Goal 5 seeks to maintain current annual water reductions of 20 percent while reducing the ratio of indoor to outdoor water use from 1:6 to 1:4.5 (Salt Lake City Division of Sustainability and the Environment, 2008).

The urban forestry section of the phase one report contains a number of possible land use regulations for sustainable development, including the requirement for large tree preservation on private property or for new construction projects to plant seed trees. The report also suggests that new development consult with the city forester early in the review process and that landscape credit bonuses be provided for the inclusion of native and drought-resistant species and the removal of invasive species. Though the discussion on Salt Lake City's urban forest has a number of qualitative objectives, Key Policy/Goal 3 within the section calls for all street trees to be retained or replaced on at least a one-to-one ratio where appropriate (Salt Lake City Division of Sustainability and the Environment, 2008).

The phase one report also recognizes the need for increased open space, calling for an expansion of the 172-acre Salt Lake City park system. The report cites the *Salt Lake City Parks and Recreation Action Plan*, which reported a ratio of 1.24 acres to 1000 residents, calling this "an extremely low number, especially for a western city" (Salt Lake City Division of Sustainability and the Environment, 2008). The diagnosis supports an increase more consistent with the National Recreation and Parks Association's suggested ratio of 6.5 acres of parkland to 1000 residents.

5.3.3.2.2 Phase Two Recommendations

The second phase, completed in February 2009, provided a diagnosis of regulations. The phase two report, presented to the Mayor and City Council for solicit feedback and direction, outlined four main priority areas listed below, reflecting the regional imperatives for reducing potable water used for irrigation and protecting fragile watershed areas:

- Expand existing water-conserving landscaping regulations (including limits on irrigation) and restrict the use of turf grass, especially in commercial and residential development.
- Remove barriers to "green" infrastructure approaches like pervious pavement, rain gardens, and rain barrels that can both improve water quality and conserve water, in keeping with state law.
- Require residential subdivisions to include plumbing in structures and infrastructure for recycled water.
- Expand the scope of the existing steep slope regulations from the Foothills to apply city wide.

The diagnosis also laid out a series of suggestions related to urban forestry, emphasizing the vital role of city trees in managing runoff from existing and new development sites:

- Clarify the role of the city forester and other staff/bodies in tree protection and landscape plan reviews. Involve the city forester early in the development/site plan review process.
- Give stormwater management and landscaping credit for protecting existing trees on a site.
- Adopt clear and comprehensive tree and vegetation protection regulations with tailored provisions for urban infill sites. (e.g., allow tree removal and off-site mitigation where replanting on small site not feasible). See new Riparian Corridor protection provisions as potential model.

In the open space category, the diagnosis report called for the following provisions, addressing the need for increased open space and elevating the importance of vegetated areas:

- Establish clearer standards for provision of open space by new developments that specifically address amount, type, and location.
- Allow community gardens and green roofs to count towards open space requirements. Give additional open space credit for tree preservation.

(Source: Clarion Associates, 2009)

The city is currently in the third and final phase of the Sustainable Community Code Revision Project and is in the process of writing a series of specific revisions to zoning and subdivision ordinances based on the information gathered thus far.

5.3.4 Franklin, Massachusetts: A Small Town Example

Franklin is a small town of approximately 30,000 people located in Norfolk County, Massachusetts (Town of Franklin Massachusetts, 2009). In 2001, the township of Franklin issued a Best Development Practices Guidebook, a set of required guidelines for water management in all new development seeking approval from the Planning Board or Board of Zoning Appeals. The Guidebook provides policies surrounding stormwater management, erosion and sedimentation control, and landscape design. Each is followed by a checklist containing specific, relevant Best Development Practices (BDPs). Selected language from the policies and checklist BDPs is below (underlines added for emphasis):

5.3.4.1 Stormwater Management Policies

(A) All new development projects in Franklin shall meet the following three stormwater management performance standards. All redevelopment projects shall meet the standards to the maximum feasible extent, and, if they fail to meet the standards, shall retrofit or expand existing stormwater management systems to improve existing conditions.

1. *Post-development peak discharge rates from the site shall not exceed pre-development peak discharge rates from the site.*

2. *Annual groundwater recharge from the post-development site shall approximate annual recharge from the pre-development site.*

3. *The stormwater management system shall remove at least 80 percent of the average annual load of total suspended solids (TSS) from the post-development stormwater created on developed site.*

(B) Non-structural stormwater management systems should be used wherever site conditions allow, as outlined in the Guidebook. Drain pipe/catch basin systems may be used, in part or in whole, only if the applicant can demonstrate that other systems are not feasible due to site conditions.

The Stormwater Management Policies require the incorporation of at least one of the items in the following list of BDPs in the project design:

- Vegetated swales
- Vegetated filter strips
- Constructed wetlands
- Bioretention cells
- Pervious paving surfaces
- Roof gardens
- Retention basins
- Detention basins
- Drain pipe/catch basin systems

5.3.4.2 Erosion and Sedimentation Control Policies

A) Any proposed project on a previously undeveloped site shall accommodate the development program in a way that minimizes clearing and regrading, especially in areas of steep slopes, erosion prone soils, or sensitive vegetation. For redevelopment projects, the site plan shall concentrate development in previously-disturbed areas to the extent possible.

(B) As a condition of approval, every proposed project shall submit and adhere to a construction management plan that addresses soil stabilization, sediment retention, perimeter protection, construction scheduling, traffic area stabilization and dust control.

The Erosion and Sedimentation Control Policies require compliance with all items in the following list of BDPs:

- Clearing and regrading have been minimized
- Development is focused in previously disturbed areas (for redevelopment projects)
- A construction management plan has been prepared
- The construction management plan addresses:
  - Soil stabilization
  - Sediment retention
  - Perimeter protection

5.3.4.3 Landscape Design Policies

(A) Site plans and landscape plans for all proposed projects shall take appropriate steps, as outlined in the Guidebook, to minimize water use for irrigation and to allow for natural recharge of groundwater.

(B) Landscape plans shall follow the guidelines in the Guidebook for selecting species that are most appropriate to the site conditions. Native species and habitat-creating species shall be used in all landscape plans to the maximum extent possible while still meeting the site's landscaping needs. Invasive species identified in this Guidebook may not be planted in Franklin under any condition.

The Landscape Design Policies require compliance with all items in the following list of BDPs:

- Clearing and regrading have been minimized
- Irrigation, if present, is water efficient
- Landscaped areas retain water
- No invasive species are used
- Native and habitat-creating species are used
- Species are appropriate to the soil, site, and microclimate conditions

5.4 Recommendations for Regional and Local Codes Programs

The lessons from the three case studies and from a review of best practices for planning and zoning point to three desirable types of reform:

- Reform of procedures for permit and public review,
- Reform of education and training of permit officials and field inspectors, and
- Reform of zoning laws and building codes to "green" them; to incentivize sustainable construction, perhaps involving legislation; and to allow these laws and codes, within the limits of human safety and health, the flexibility to respond to local environmental goals.

What are the objectives of these reforms? They are profound:

- Shared understanding of green principles among government officials and those who seek to build – if not a common vision, at least a common understanding of principles (a common language) as the foundation for discussion.
- Breaking down of the rigid divisions between zoning and code "specialties" without sacrificing the advantages of depth of knowledge in favor of breadth of knowledge, and more wide-ranging understanding. The permit review process should be a part of the holistic design process which includes many team members: patrons, architects, engineers, neighbors, and now review officials.
- Consistency of approach between initiatives and policies, guidance and metrics.
- Continuity of and consistency in regulations extending into the operational life of buildings. Any sustainable regulatory framework should, ideally, consider the total lifecycle of a development.
- Regular reforms of building and zoning regulations to ensure that they reflect the latest thinking and to stretch targets beyond minimum standards, setting progressive goals.

- Reforms of building and zoning regulations to ensure that they not only address but prioritize local environmental goals.

5.4.1 Reform Procedures for Permit and Public Review and Education of Review Officials

Water resource management in urban areas and sustainable construction in general increasingly requires an integrated approach. Much like the hydrologic cycle in nature, the flow of water through developed spaces is a continuous system. Management techniques should not be linear and segmented among traditional departmental authority within a given jurisdiction. If responses to present and future water issues are to be truly effective, they require comprehensive planning, implementation, and monitoring mechanisms that acknowledge the cyclical nature of water processes.

The following actions could help achieve integrated resource management goals:

Create interdisciplinary, cross-sector code review teams to provide recommendations. Capturing a diverse set of voices from government, non-profit groups, and businesses within the appropriate watershed geography will provide a 360-degree perspective on water management and quality issues.

Create interdisciplinary, cross-sector permit reviewers. Educate permit review officials and field inspectors so that they bring their wide ranging knowledge to bear on every review. Understanding the synergies and interlocking nature of sustainable design means being able to acknowledge the synergistic effects of piece-by-piece regulation. If one aspect of a project must change to conform to standards, what are the effects on another? Holistic thinking about projects in the review stage will benefit them. It may be worth assigning permit review officials, project by project, to be regulatory "expeditors," devoted stewards, and advisors capable of knowing and reporting the big picture.

Spend civic funds on education, not only of permit review officials but also the public. Thomas Edison said that vision without implementation is hallucination. A project's sustainable qualities are only as good as they are allowed to be implemented. Investment in civic and reviewer education and continuing education not only makes this possible, it raises the level of debate, and helps with progressive standards-setting.

5.4.2 Reform of Zoning Laws and Building Codes: Process and Incentives

Use legislation to require code updates. Community priorities, technology costs, and institutional knowledge shift over time. It is critical to have built-in requirements that ensure building and zoning codes undergo regular updates.

Conduct an assessment of barriers to sustainable design and development. Improving regulatory frameworks requires careful consideration of the existing impediments to sustainability, including the challenges and opportunities associated with the removal of barriers.

Update building code and zoning code simultaneously to maximize complimentary goals and minimize conflicts. In many ways, water-sensitive development requires that the development site and the contextual area in which it is situated are planned and designed to complement one another.

Undertake a cost-benefit analysis for each proposed change. Where feasible, each recommended change to code should be tested with a thorough regulatory impact assessment covering social, economic, and environmental implications.

Incentivize competition to be green. The BPC Guidelines have baseline requirements for energy and resource use, but much of the development built since the establishment of the guidelines has gone above and beyond compliance. As a result, proposed new development is consistently designed to outperform existing residential building stock.

Give priority to green building practices over existing practices. Washington, DC's green building legislation explicit awards preference to sustainable practices over conventional approaches when conflicts arise in the revision of code.

Use a combination of process, development, and financial incentives to promote sustainable development, including the following:

- Expedited permitting for water-sensitive and water-responsible development,
- Technical assistance from municipal green building officials,
- Density bonuses through increased Floor Area Ratio allowances,
- Additional height allowance in exchange for preservation of open space,
- Project review and permitting fee waivers and rebates for exemplary design and/or performance,
- Stormwater fee reductions and credits where applicable, and
- Structural- and non-structural BMP cost sharing.

5.4.3 Reform of Zoning Laws and Building Codes: Standards and Approach

Adopt the most up-to-date national and international standards (such as the 2009 ICC Code). Conforming to widely-accepted benchmarks relies on up-to-date industry knowledge and provides a basis of comparison to peers.

Re-examine – judiciously, so as not to endanger human life or health – common, universal standards when they lead to conflict with local and regional environmental priorities. For example, a local environmental priority at the Battery Park City site of the Millennium Tower Residences is the reduction of CSO incidents and the resulting contamination of the Hudson River. Millennium Tower Residences' cistern, operated to keep full until very recently, could increase the incidence of CSOs. The main driver for keeping the cistern full was to reduce reliance on piped city water for irrigation. In this case, the desire to conserve potable water conflicts directly with the main priority of the site, preventing CSOs. Similarly, for WSSI, local priorities are stormwater control, reduction in stream erosion, and an increase in water infiltration, all of which are hindered by the common zoning requirement of curbs in parking lots.

Reflect local and regional priorities through regulatory response mechanisms. For example, Boston's Green Building Credits provide credit opportunities in addition to those offered in the LEED green building rating systems to encourage development that addresses the need for greater groundwater recharge (City of Boston, 2007).

For water management issues, use comprehensive watershed-based management approaches rather than site-by-site planning. Large, contiguous vegetated and pervious areas perform better and are more resilient than smaller, separated areas. Blackwater treatment systems could benefit from economies of scale if they are designed to treat wastewater from multiple buildings. Coordinate priorities and invite participation at the community, city, and regional levels, and even between government agencies. Travis Parker, manager of the District of Columbia's current effort to review zoning code, emphasized the role that the District Department of the Environment played in assessing sustainability opportunities. Parker explained that District Department of the Environment ensured that proposed policies were complimentary and did not re-regulate while recognizing reasonable limits (Parker, 2009).

Use nature as a model. For water management, the aim is to maintain existing hydrology and flow patterns whenever possible. Minimizing impact on local hydrology is a often a challenge, but urban development and infrastructure should serve to facilitate the water cycle and reduce energy use for processes like conveyance.

5.4.4 Steps in Implementation

Prior to formal policy and program implementation, consider carrying out a thorough assessment of current conditions in the built and natural environment and the state of water management regulations. Such an inventory will serve to highlight current obstacles and potential pathways to improvement. Managing agencies should also engage the appropriate community stakeholders to establish a comprehensive set of priorities specific to area in focus. Cities and regions with little or no regulatory framework for stormwater management should first phase in small programmatic incentives and then move toward adoption of enforced standards. The following summary offers a gradual approach to water management goal setting, from primary adoption to cutting-edge leadership.

5.4.4.1 Phase One: Reduce Negative Impacts Through Cost-Sharing Incentives and Fee Credits

- Promote the installation of LID techniques through the use of structural and non-structural BMPs.
- Support partial detention or retention of stormwater and on-site infiltration.
- Encourage use of native vegetation and preservation of older trees.

5.4.4.2 Phase Two: Address Quality and Quantity Issues Through Required Reporting

- Reward no increase in flow rates from property between pre- and post-development scenarios.

- Support the removal of at least 80 percent of Total Suspended Solids from runoff, a threshold which contributes to compliance with Sustainable Sites credit 6.2 in the LEED- New Construction version three rating system.

5.4.4.3 Phase Three: Require On-site Treatment of All Stormwater

- Require development to incorporate one or more design-based, technological, or management approaches in proposed development to obtain a permit.
- Write into code or ordinance the mandatory on-site treatment of 100 percent of stormwater.

5.4.4.4 Phase Four: Offer Attractive Incentives to Invite Leadership

- Create rebates and reward schedules for "net-zero water" buildings, in which 100 percent of a building's demand is met by on-site harvesting and treatment. Such incentives are being proposed in Portland to support the Living Building Challenge, a project of the International Living Building Institute and the Cascadia Region Green Building Council. The paradigm shift is that this "dirty" water is a resource, not a liability. The relationship between water supply and energy use in central infrastructural pumping and treatment favors onsite treatment as a cost and energy saving measure.

Support the planning of entire communities with a closed-loop water system to serve as demonstration projects. As an internationally-recognized model for water management, Dockside Green in Victoria, British Columbia treats 100 percent of its water on-site (including black water) for reuse.

5.4.4.5 Phase Five: Ensure Longevity

Long-term sustainability of stormwater management programs and regulations will result from a combination of efforts. In addition to refining code and permitting processes to improve physical development, there needs to be a substantial investment in human capital. The following suggestions include the present and proposed components of a number of water management programs at the local government level:

- Establishment of design and performance based requirements for development.
- Dedication of funding to support cost-sharing, rebate, fee credits, grants, and other opportunities for property owners and developers.
- Build government oversight capacity through training for municipal program staff, including LEED accreditation.
- Public outreach and engagement mechanisms through workshops and hands-on experience.
- Continuous inspection and enforcement.
- Required operations and maintenance plans complimented by easy-to-use end-used management tools for property managers.

6
SUMMARY OF LESSONS LEARNED AND RECOMMENDATIONS

Our need for new ways to think about and assess water management systems speaks to some fundamental disconnects in our thinking on sustainability. What are these disconnects?

The first is that in the old paradigm, we had a blinkered view of potable water, wastewater, and stormwater. Potable water was a resource; wastewater and stormwater were not — they were to be carried away from the site as quickly as possible. With the trend to water recycling, the old way of thinking is changing, and the potential of storm- and even wastewater for reuse means that the boundaries between these sources will be much more fluid, literally and figuratively. There is likely to be more onsite water treatment to higher standards for storm and wastewater, which will make them approach potable water in purity. These possibilities will cause a complete rethinking of our practice of water management.

A second disconnect in our sustainable thinking is between a building's design and its operations. The current emphasis in green building rating systems is heavily on design, on a proposed condition. The transition to operations is often weak or non-existent, and building performance and water management suffer as a result. This is something within the ability of green building rating systems to correct, as this transition and correspondence between theory, practice, and measurement of that practice must be tighter; long-term requirements for operational cost and maintenance need to be addressed.

A third disconnect in our sustainable thinking is between an individual building's site practices and its downstream or wider impacts. Very few aspects of current green building rating systems attempt to measure larger-scale watershed effects, in part because no methodology has emerged to do so. Instead, with respect to water, much of the focus of today's green building rating systems is on water conservation and efficiency. This efficiency resides with building plumbing fixtures — whether internal (toilets, sinks) or external (irrigation systems). There are rewards for site strategies considering permeability, infiltration, reuse, and evapotranspiration rates. These are in general weighted equally with efficiency measures, even though they may be of greater benefit to the watershed and the environment as a whole.

A fourth disconnect is the need for better water management across many patterns of development, not just one accepted pattern. The New Urbanism, Smart Growth, and their principles have greatly influenced both Leadership in Energy and Environmental Design (LEED) and British Real Estate Establishment Assessment Method (BREEAM), which favor urban density and connectivity. Yet there is a need for considering water management and sustainability measures for low-density sites, which predominate in the United States. This is something with which a decentralized water infrastructure can help.

The new water management thinking stresses a decentralized, watershed-specific approach, developed in a comprehensive way that links a variety of sustainable strategies (including those beyond water management) into an interdependent and inseparable whole.

The new water management paradigm is one skeptical of the ability of a universal model to provide the best solution for everyone. The concept of site specificity, as well as site treatment, as being the gold standard without losing the tremendous advances in public health and safety gained by now traditional water and sanitary systems is a challenge for the immediate future. Our last paradigm served us well for many years. We needed a safe and ready water supply, and the sanitation of wastewater sent to a central plant. Part of the new skepticism of such overarching solutions and urban infrastructure coincides with the breakdown or obsolescence of that water infrastructure. We are replacing our faith in water infrastructure with skepticism that it can endure. The example of New York City's infrastructural fragility, where one-tenth of an inch of rainfall an hour can cause sewage to overflow into the Hudson River, is telling.

The next generation of decentralized infrastructure will look very different. If onsite treatment options are the future, these will require heavy building investment in components and systems. There will be a need for redundant piping, and space must be made for site collection measures. Additionally, more energy at the building level must be expended to drive these systems, both to pump and to treat water. In the best case scenario, this cost, both in dollars and in space, will be compensated by lowered public water fees, cleaner water, more plentiful water, and more reliable water.

The ultimate challenge is how this decentralized model will be regulated. It is unthinkable to give up the advances in the last 100 years in the public health and safety of our water supply. What is clean water? Section 101 of the Clean Water Act speaks to the need to restore and maintain the "chemical, physical, and biological integrity of the Nation's waters." So in gauging chemical, physical, and biological purity, what are the implications of reuse, and how do we measure clean? Who goes to the site? Can the public regulatory sphere intrude on private property? What are the reporting requirements and their frequency? Would public discharge permits be required of private treatment systems? Regulation needs to follow this emerging practice of decentralization. Another challenge is that regulatory agencies are also concerned about lost revenue. There is already a question of how onsite water savings will be measured or metered. Payment, taxation, and revenue are a big concern for most municipalities. For example, in the case of Wetland Studies and Solutions, Inc. (WSSI), Prince William County (PWC) put a meter on the rainwater cistern to monitor and price outflow to the County system.

6.1 Moving Forward

There are immediate steps we can take to improve our outcomes and further the goals of sustainable water management:

1. **Reconsider the relationship between the universal standards and local/regional practices, and make assessment frameworks respond to local priorities.** Regulations governing practices like electrical work or the design of handrails for human safety can often have universal content. Water management, however, is a practice that must rely on region-specific contents and standards. One very simple example of regional variability is the basic divide between the arid west where conservation is paramount, and the humid east where

urban issues tend to dominate. Local and regional context and interrelationships are critical factors in water management decisions. For example, British Columbia, Canada, has an interactive web forum which facilitates discussion of regional water management issues and standards: http://www.waterbucket.ca/. Here are links to discussions and resources for various "communities of interest," among them Water Centric Planning; Water Use and Conservation; Rainwater Management; Green Infrastructure; Agriculture and Water; Convening for Action; and Small Community Infrastructure Sustainability.

In the area of water management, the weaknesses of green building rating systems are partly due to their reliance on practices considered to be universally correct. This study suggests that rating systems can incorporate regional standards by allowing credit weightings to be determined regionally. LEED's new regional priority credits were chosen by local United States Green Building Council (USGBC) chapters. Why not cede authority for credit weighting on a region-by-region basis, thus keeping the best aspects of national and universal standards while responding to local priorities?

2. **Within green building rating systems, rework the distribution of point values among water management credits to reward practices with the greatest potential for environmental good.** It's not that green building rating systems reward the wrong things. It's that they get the proportional rewards for certain practices wrong. Buildings like the Merrill Center, WSSI, and Millennium Tower Residences use onsite water management practices considerably to lessen and even undo their watershed impacts (see Table 6-1 for a summary of quantified impacts). This study not only quantifies this reduction in harm, it projects the benefits of onsite management approaches if adopted more widely

   As illustrated in Table 6-2, all three green building rating systems give more points for water saving fixtures as they do for reductions in stormwater rate, improvement in stormwater quality, or for onsite strategies like water capture, treatment, or reuse. All these deserve greater proportional reward.

Table 6-1
Summary of impact assessment results for the three case study sites

Case Study	Water Use (Total Annual)			Nutrient Loading to WWTPs (Total Annual)			Pollutant Loading from Stormwater Runoff (lbs/yr)		
	Baseline	Metered	Percent Reduction	Baseline	Predicted	Percent Reduction	Baseline Scenario	Existing Scenario[2]	Percent Reduction
The Merrill Center	2.5 MG	15,000 gal	99 %	TKN:240 lbs	TKN: 0 lbs	100 %	TKN: 12.5	TKN: 6.4	49 %
							P: 0.9	P: 0.3	67 %
				P:33 lbs	P: 0 lbs	100 %	TSS: 21.7	TSS: 5.5	75 %
WSSI	1.75 MG	193,000[1] gal	87 %	NA	NA	0 %	TKN: 9.5	TKN: 9.7	0 %
							P: 0.66	P: 0.36	45 %
							TSS: 549	TSS: 70.6	87 %
Millennium Tower Residences	17.7 MG	8.7 MG	51 %	TKN: 6000 lbs	TKN: 3000 lbs	50 %	TKN: 8.7	TKN: 6.3	28 %
							P: 0.82	P: 0.57	30 %
				P: 850 lbs	P: 850 lbs	0 %	TSS: 357	TSS: 267	25 %

Notes:

MG = million gallons; TKN = total kjeldhahl nitrogen which is organic and ammonia, P = phosphorus, TSS = total suspended solids.

All values shown are approximate, see Chapter 3 for detailed calculations.

1. Metered use for WSSI reflects predicting reduction in water use resulting from the use of stormwater for toilet flushing
2. Results for the drawdown scenario, in which the stormwater tank is drawn down between rain events, is presented for Millennium Towers in anticipation of a future change in tank operation.

Table 6-2
Summary of LEED rating achievements for the case study sites

Case Study	LEED Rating System and Version	Year of Certification	Total Points Earned/LEED Level	Number of Water Points	Number of Stormwater Points
The Merrill Center	LEED for New Construction v. 1.0	2000	36/Platinum	5	2
WSSI	LEED for Commercial Interiors v. 2.0	2006	34/Gold	3	1
Millennium Tower Residences	LEED for New Construction v.2.1	2007	45/Gold	4	1

3. **Within green building rating systems, make the establishment of a water management plan a prerequisite to certification.** It is possible to achieve certification in each of these rating systems merely by demonstrating a reduction in water use. Green building rating systems could go further in requiring a water management plan of each applicant at the building level. Such plans would map an approach to all water passing through the site, establishing goals, including for water quality; discussing methods and operational requirements collecting and treating water onsite; and incorporating occupant education, behavior, and responsibilities. Such a requirement would also promote the establishment of an integrated, multi-disciplinary project management team. One example of such a plan is that of EPA's Region 4 Science and Ecosystem Support Division Facility in Athens, GA, available for view at http://www.epa.gov/oaintrnt/documents/athens_sesd_508.pdf. In 2006, the facility developed a water management plan to set goals for a range of onsite practices, including measurement and leak detection. As a result, they have begun gradual implementation of improvements, beginning with xeriscaping the landscape; in 2008 they began capturing air handler condensate and routing it to the cooling tower to use as make-up water.

4. **Do away with the checklist approach to green building rating systems and to codes and regulations for water management.** Consideration of single issues without regard for synergistic impacts is unwise. This way of thinking will compromise true sustainability. There is a need for inter- or multi-disciplinary judgments particularly in local building and zoning considerations for water management. In the cases of Merrill Center and WSSI, building, fire, and zoning codes were in occasional conflict with environmentally beneficial project details. Mandates for curbs could have compromised WSSI's stormwater strategies. At the Merrill Center, the width of the waste shafts contradicted building code restrictions on openings, and could have resulted in the elimination of composting toilets there. These barriers were overcome by persistence and persuasion, but other projects might find these more daunting.

5. **Within green building rating systems, give rewards for the establishment of management frameworks to insure continuity between design and operations.** Project teams should not end their involvement at the design and construction phases, but extend their involvement to operations. A particularly vivid example from this study is Millennium Tower Residences, where operation of the storm- and reuse water tank was not optimal to prevent combined sewer overflows. In addition, the cooling tower, though designed to make use of recycled water, was not operated as planned. Continuity between design and operations is a surer way to a sustainable building. Here is where green building rating systems can help: they can reward this connection, and thus incentivize it. After all, you can have the most sustainably designed system in the world, but if it is not operated sustainably most benefits are lost.

7
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A
PLANYC WATER QUALITY INITIATIVES

The Water Quality Initiative in PlaNYC consists of the following 10 key elements:

- Develop and implement long-term control plans for all 14 New York City Watersheds, to protect the public water supply reservoirs.
- Expand wet weather capacity at treatment plants and reduce CSO discharges by more than 185 mgd during rainstorms.
- Increase use of high level storm sewers (HLSS) projects where feasible in combined sewer areas citywide and integrate HLSS into major new developments, where appropriate.
- Capture the benefits of the public realm plan to expand the amount of green, permeable surfaces across the city to reduce storm water runoff.
- Expand the Bluebelt program in Staten Island and other boroughs, where possible.
- Form an interagency Best Management Practice (BMP) task force to make the reduction of CSO volumes and other environmental issues a priority for all relevant City agencies.
- Pilot promising BMPs.
- Require greening of parking lots — modify the zoning resolution to include design guidelines for off-street parking lots for commercial and community facilities.
- Provide incentives for the installation of green roofs.
- Protect wetlands by assessing the vulnerability of existing wetlands and identifying additional policies to protect them.

The Water Network Initiative in PlaNYC consists of the following nine key elements:

- Continue the watershed protection program to aggressively protect watersheds and maintain a Filtration Avoidance Determination for the Catskill and Delaware Water Supplies.
- Construct an ultraviolet disinfection facility for the Catskill/Delaware system to destroy disease-causing organisms in the upstate watershed.
- Construct a water filtration plant to protect the Croton supply.
- Launch a water conservation program to reduce citywide consumption by 60 mgd.
- Maximize existing facilities and add 245 mgd to the city's supply potential through increased efficiency.
- Evaluate projects to meet the shortfall needs of the city during a prolonged shutdown of the Delaware Aqueduct.

- Complete water tunnel #3.
- Complete a backup tunnel to Staten Island.
- Accelerate upgrades to water mains, increasing replacement rate to over 80 miles annually.

See the Plan NYC website at http://www.nyc.gov/html/planyc2030/html/plan/plan.shtml for more information.

B

BATTERY PARK CITY AUTHORITY RESIDENTIAL GUIDELINES FOR WATER MANAGEMENT

B.1 Storm Water Management

- Collect 2.4 inches of rain that falls on building roofs and setbacks using the Best Management Practices (BMPs) developed by the EPA Office of Wastewater Management. Treat and store onsite for reuse in cooling towers, irrigation, building and sidewalk maintenance, and laundry if applicable. The Guidelines prioritize the use of storm water over reclaimed water due to lower treatment requirements.
- Provide clearly labeled reclaimed water taps at the building exterior for reuse needs.
- Design a Sediment and Erosion Control Plan. See EPA 832-R-92-005 (September 1992), Storm Water Management for Construction Activities, Chapter 3, or follow local standards on erosion control if they are more stringent.

B.2 Water Use Reduction

- Use water fixtures that use (aggregate) 10 percent less potable water than the requirements of the Energy Policy Act of 1992. Exclude fixtures that use reuse water from the calculation.
- Specify low flow fixtures, dishwashers, dual flush or 1.6 gallon toilets, and front-loading laundry machines (water factor of 7.5 or less).
- Use non-potable drip irrigation.
- Other suggestions are to use individual apartment water metering, install timers on irrigation systems, and install waterless urinals in non-apartment environments.

B.3 Innovative Water Technologies

- Operate an onsite reclaimed water treatment system.
- Use membrane separation (e.g. ultrafiltration) over chemical treatment.
- Minimize use of chemicals in cooling tower maintenance; address chloride build-up in cooling tower systems.

B.3.1 Responsible Landscaping Practices

- 100 percent of plants to be native/indigenous/adapted and use low amounts of water, and be pest and disease-resistant. Plant selections are subject to the review and approval of the BPCA and Battery Park City Parks Conservancy (BPCPC).
- Use appropriate organic topsoil to allow for appropriate organic maintenance.
- Develop a sustainable landscape maintenance plan.

B.3.2 Reduce "Urban Heat Islands"

- Designate 75 percent of roof area that is not being used for mechanical equipment or skylights as "green" roof garden that is open to all residents.[Note: Millenium Tower Residences deviates from this recommendation; it's green roof is not open.]
- Use light colored/high-albedo materials with a solar reflectance ratio of 78 for roofs with a slope less than 2:12.
- Provide street trees per BPCA/BPCPC requirements.

C

DERIVATION OF BASELINE WATER USE FOR THE STUDY SITES

Matrix of Appendix C Contents	
Table Description	**Table Number**
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Conversion Factors for Cooling Tower Calculations	C-13
Cooling Tower Calcuations	C-14

Appendix C shows the derivation of the theoretical baseline potable water usage for The Merrill Center, WSSI, and Millennium Towers based on: Flush Fixture, Flow Fixture, Appliance, Irrigation, and Cooling Tower water usage. Much of the information used to construct this baseline is derived from the study sites' LEED Applications and estimates are based on data provided by the site manager at each of the study sites. A summary of the baseline water usage calculated for each site is shown in Table C-1.

Exhibit C.1
Summary of baseline water usage based on calculations

Site	Type of Water Usage	Annual Water Usage (gal)	Equivalent Average Daily Water Usage (gal/day)
	A	B	C=B/365
Merrill Center	Flush Fixture Type	153,032	419
	Flow Fixture Type	110,775	303
	Appliances	3,000	8
	Irrigation	1,506,662	4,128
	Cooling Tower (Theoretical)	700,000	1,918
	Subtototal	**2,473,470**	**6,777**
WSSI	Flush Fixture Type	84,336	231
	Flow Fixture Type	123,774	339
	Appliances	3,380	9
	Irrigation	836,490	2,292
	Cooling Tower	700,000	1,918
	Subtototal	**1,747,981**	**4,789**
Millennium Towers	Flush Fixture Type	2,135,250	5,850
	Flow Fixture Type	6,801,775	18,635
	Appliances	711,598	1,950
	Irrigation	77,638	213
	Cooling Tower	8,000,000	21,918
	Subtototal	**17,726,261**	**48,565**

Source: Tables C-1 – C-14.

C.1 Fixture, Appliance, and Irrigation Baseline for the Merrill Center

Table C-1
Merrill Center baseline potable water usage (flush fixtures)

Flush Fixture Type	Number of Fixtures	Number of Full-time Users	Number of Uses by Full Time-users (per day)	Number of Uses by full-time users (per year)	Number of Part-time Users	Number of Uses by Part Time-users (per day)	Number of Uses by Part-time users (per year)	Flush Flow Rate (gallons per flush)
	A	B	C	D = C*251	E	F	G = F*12	H
Conventional Water Closet (public toilet)	10	80	4	1,004	50	4	48	1.6
Conventional Urinal (public urinal)	2	40	2	502	25	2	24	1.0
Total Annual Flush Fixture Water Usage (gal)								
Estimated Average Daily Flush Fixture Water Usage (gal)								

Source: (A), (B), (H) Merrill Center LEED Application.

Notes:
(A) With the exception of urinals, includes both males and females.
(B) Based on 80 employees, equal number of men and women.
(C), (F) Best Professional Judgement. Assumes single flush per use.
(D) Assumed 251 Workdays. Based on 5 day work week, and 9 holidays.
(E) Assumed 50 non-employees spend the day at the Merrill Center for events per month.

Table C-2
Merrill Center baseline potable water usage (flow fixtures)

Flow Fixture Type	Number of Fixtures	Number of Uses by Full-time Users (per day)	Number of Uses by Full Time Users (per year)	Number of Uses by Part-time Users (per day)	Number of Uses by Part Time Users (per year)	Duration of Usage (seconds)	Duration of Usage (minutes)	Fixture Flow Rate (gpm)
	A	B	C = B*251	D	E = D*12	F	G = F/60	H
Conventional Lavatory (sink in public bathroom)	12	400	100,400	250	3,000	15	0	0.5
Shower (in public bathroom)	3	12	3,012	-	-	300	5	2.5
Kitchen Sink	1	80	20,080	50	600	60	1	2.5
Laundry Sink	1	3	753	-	-	20	0	10.0
Hand Sink	1	5	1,255	-	-	383	6	0.75
Mop Basin	4	1	126	-	-	30	0	20.0
Total Annual Flow Fixture Water Usage (gal)								
Estimated Average Daily Flow Fixture Water Usage (gal)								

Source:
(A), (B) Merrill Center LEED Application.
(B) and (F) for Laundry Sink, Hand Sink, and Mop Basin based on intended reuse water information from Merrill Center LEED Application.
(H) LEED Flow Fixture Chart (LEED NC 2.2)

Notes:
(B) Assumed 15% of Full-time employees shower at work. Best Professional Judgment.
(C) Assumed 251 Workdays. Based on 5 day work week, and 9 holidays.

Table C-3
Merrill Center additional baseline potable water usage (appliances)

Appliance Type	Number of Appliances	Number of Uses (per week)	Number of Uses (per year)	Appliance Water Usage (gal/usage)	Total Amount of Water to be treated by Wastewater Treatment Plant (gal)
	A	B	C = B*50	D	E = C*D
Clothes Washer	1	3	150	20	3,000
Total Annual Appliance Water Usage (gal)					**3,000**
Estimated Average Daily Appliance Water Usage (gal)					**8**

Notes:
Dishwashers are no longer used at the Merrill Center, therefore to avoid showing a disproportional percent water use reduction, dishwashers have not been included in the baseline potable water usage calculations for appliances.
(B) Assumed Washing Machine run three times per week. Best Professional Judgment.
(C) Assumed 251 Workdays. Based on 5 day work week, and 9 holidays. Roughly equivalent to 50 weeks.
(D) Usage based on Whirlpool clothes washer (model GHW9100LQ, type 199-AWM 075/BL), actual model used at Merrill Center unknown.
Based on manufacturer's data and manual, assumed 20.0 gal/usage.

Table C-4
Merrill Center additional baseline potable water usage (irrigation)

Landscape Type	Area (ft^2)	Species Factor	Density Factor	Microclimate Factor	Irrigation Type	Landscape Coeffiecient	Month	Regional Evapotranspiration Rate	Site Specific Evapotranspiration Rate	Total Potable Water Applied (gal)
	A	B	C	D	E	F = B*C*D	G	H	I = F * H	J =A* I/E *0.623
Trees	2,400	0.5	1.0	1.0	0.900	0.5	January	0.2	0.10	166
Groundcovers	102,320	0.5	1.0	1.0	0.625	0.5		0.2	0.10	10,205
Shrubs	4,800	0.5	0.5	1.0	0.625	0.3		0.2	0.05	239
Subtotal - January										**10,610**
Trees							February	0.3	0.15	249
Groundcovers								0.3	0.15	15,307
Turfgrass								0.3	0.08	359
Subtotal - February										**15,915**
Trees							March	0.7	0.35	582
Groundcovers								0.7	0.35	35,717
Turfgrass								0.7	0.18	838
Subtotal - March										**37,136**
Trees							April	1.8	0.90	1,496
Groundcovers								1.8	0.90	91,842
Turfgrass								1.8	0.45	2,154
Subtotal - April										**95,493**
Trees							May	3.8	1.90	3,158
Groundcovers								3.8	1.90	193,890
Turfgrass								3.8	0.95	4,548
Subtotal - May										**201,596**
Trees							June	5.3	2.65	4,405
Groundcovers								5.3	2.65	270,425
Turfgrass								5.3	1.33	6,343
Subtotal - June										**281,173**
Trees							July	6.0	3.00	4,987
Groundcovers								6.0	3.00	306,141
Turfgrass								6.0	1.50	7,181
Subtotal - July										**318,309**
Trees							August	5.1	2.55	4,239
Groundcovers								5.1	2.55	260,220
Turfgrass								5.1	1.28	6,104
Subtotal - August										**270,563**
Trees							September	3.2	1.60	2,660
Groundcovers								3.2	1.60	163,275
Turfgrass								3.2	0.80	3,830
Subtotal - September										**169,765**
Trees							October	1.8	0.90	1,496
Groundcovers								1.8	0.90	91,842
Turfgrass								1.8	0.45	2,154
Subtotal - October										**95,493**
Trees							November	0.2	0.10	166
Groundcovers								0.2	0.10	10,205
Turfgrass								0.2	0.05	239
Subtotal - November										**10,610**
Trees							December	0.0	0.00	-
Groundcovers								0.0	0.00	-
Turfgrass								0.0	0.00	-
Subtotal - December										**-**
Total Annual Irrigation Water Usage (gal)										**1,506,662**
Estimated Average Daily Irrigation Water Usage (gal)										**4,128**

Sources:

(A) Chesapeake Bay Foundation Environmental Center Plans, drawings: C–10, C–10a, A910, and aerial photos of Merrill Center.

(B) – (E) USGBC Baseline assumptions specified in Species Factor Chart, Density Factor Chart, Microclimate Factor Chart, and Irrigation Chart of LEED NC 2.2 Reference Guide.

(H) P8 Model results calculated from temperature, daylight hours, and vegetative cover using an equation from the following paper: Haith, D.A. and L.L. Schoemaker, “Generalized Watershed Loading Functions for Stream Flow Nutrients”, Water Resources Bulletin, American Water Resources Association, Vol. 23, No. 3, pp. 471-48, June 1987.

Notes:

(A) Square footage of beach plantings (31,000 ft2), bioretention swale (2,500 ft2), and sand filter meadow mix (3,500ft2) not included in baseline square footage of groundcover as they were never irrigated. Including these areas would indicate a un–realized large percent reduction in potable water use since these areas are not included in the irrigation paradigm of The Merrill Center.

C.2 Fixture, Appliance, and Irrigation Baseline for WSSI

Table C-5
WSSI baseline potable water usage (flush fixtures)

Flush Fixture Type	**Number of Users (Persons)**	**Number of Uses (per day)**	**Number of Uses (per year)**	**Flush Flow Rate (Gallons per Flush)**	**Total Amount of Water to be Treated by Wastewater Treatment Plant (gal)**
	A	B	C = B*251	D	E = A*C*D
Conventional Water Closet (public toilet)	80	2	502	1.6	64,256
Conventional Urinal (public urinal)	40	2	502	1.0	20,080
Total Annual Flush Fixture Water Usage (gal)					**84,336**
Estimated Average Daily Flush Fixture Water Usage (gal)					**231**

Source:
(A), (B), (D) WSSI LEED Application.

Notes:
(A) With the exception of urinals, includes both males and females.
(B) Assumes single flush per use.
(C) Assumed 251 Workdays, as specified in WSSI LEED Application.

Table C-6
WSSI baseline potable water usage (flow fixtures)

Flow Fixture Type	Number of Users (persons)	Number of Uses (per day)	Number of Uses (per year)	Duration of Usage (seconds)	Duration of Usage (minutes)	Fixture Flow Rate (gpm)	Total Amount of Water to be treated by Wastewater Treatment Plant (gal)
	A	B	C = B*251	D	E = D/60	F	G = A*C*E*F
Conventional Lavatory (sink in bathroom in public bathroom)	80	6	1506	15	0.25	2.5	75,300
Shower (in in public bathroom)	5	1	251	300	5	2.5	15,688
Kitchen Sink	80	1	251	15	0.25	2.5	12,550
Kitchen Sink	80	1	251	15	0.25	2.5	12,550
Electric Water Cooler	80	3	753	15	0.25	0.5	7,530
Janitor Sink	1	1	251	15	0.25	2.5	157
Total Annual Flow Fixture Water Usage (gal)							**123,774**
Estimated Average Daily Flow Fixture Water Usage (gal)							**339**

Source:
(A), (B), (D), (F) WSSI LEED Application.

Notes:
(C) Assumed 251 Workdays, as specified in WSSI LEED Application.

Table C-7
WSSI baseline additional potable water usage (appliances)

Appliance Type	Number of Uses (per week)	Number of Uses (per year)	Appliance Water Usage (gal/usage)	Total Amount of Water to be Treated by Wastewater Treatment Plant (gal)
	A	B = A*50	C	D = B*C
Clothes Washer	3	150	20.0	3,000
Dishwasher	2	100	3.8	380
Total Annual Appliance Water Usage (gal)				**3,380**
Estimated Average Daily Appliance Water Usage (gal)				**9**

Notes:
(A) One clothes washer and one dishwaster at WSSI.
(B) Assumed 251 Workdays, as specified in WSSI LEED Application. Roughly equivalent to 50 weeks.
(C) Whirlpool clothes washer (model GHW9100LQ, type 199-AWM 075/BL). Based on manufacturer's data and manual, assumed 20.0 gal/usage.
ASKO dishwasher (model D3112 (8-Steel System). Manufacturer data: 3.8 gal/usage.

Table C-8
WSSI additional baseline potable water usage (irrigation)

Landscape Type	Area (ft^2)	Species Factor	Density Factor	Microclimate Factor	Irrigation Type	Landscape Coeffiecient	Month	Regional Evapotranspiration Rate	Site Specific Evapotranspiration Rate	Total Potable Water Applied (gal)
	A	B	C	D	E	F = B*C*D	G	H	I = F * H	J =A* I/E *0.623
Trees	15,000	0.5	1.0	1.0	0.900	0.5	January	0.2	0.10	1,039
Groundcovers	46,174	0.5	1.0	1.0	0.625	0.5		0.2	0.10	4,605
Shrubs	4,950	0.5	0.5	1.0	0.625	0.3		0.2	0.05	247
Subtotal - January										**5,891**
Trees							February	0.3	0.15	1,558
Groundcovers								0.3	0.15	6,908
Turfgrass								0.3	0.08	370
Subtotal - February										**8,836**
Trees							March	0.7	0.35	3,636
Groundcovers								0.7	0.35	16,118
Turfgrass								0.7	0.18	864
Subtotal - March										**20,618**
Trees							April	1.8	0.90	9,350
Groundcovers								1.8	0.90	41,445
Turfgrass								1.8	0.45	2,222
Subtotal - April										**53,017**
Trees							May	3.8	1.90	19,739
Groundcovers								3.8	1.90	87,496
Turfgrass								3.8	0.95	4,690
Subtotal - May										**111,925**
Trees							June	5.3	2.65	27,531
Groundcovers								5.3	2.65	122,034
Turfgrass								5.3	1.33	6,541
Subtotal - June										**156,106**
Trees							July	6.0	3.00	31,167
Groundcovers								6.0	3.00	138,151
Turfgrass								6.0	1.50	7,405
Subtotal - July										**176,723**
Trees							August	5.1	2.55	26,492
Groundcovers								5.1	2.55	117,429
Turfgrass								5.1	1.28	6,294
Subtotal - August										**150,215**
Trees							September	3.2	1.60	16,622
Groundcovers								3.2	1.60	73,681
Turfgrass								3.2	0.80	3,949
Subtotal - September										**94,252**
Trees							October	1.8	0.90	9,350
Groundcovers								1.8	0.90	41,445
Turfgrass								1.8	0.45	2,222
Subtotal - October										**53,017**
Trees							November	0.2	0.10	1,039
Groundcovers								0.2	0.10	4,605
Turfgrass								0.2	0.05	247
November										**5,891**
Trees							December	0.0	0.00	-
Groundcovers								0.0	0.00	-
Turfgrass								0.0	0.00	-
December										**-**
Total Annual Irrigation Water Usage (gal)										**836,490**
Estimated Average Daily Irrigation Water Usage (gal)										**2,292**

Source:

(A) WSSI Plans submitted for LEED Certification.

(B) – (E) USGBC Baseline assumptions specified in Species Factor Chart, Density Factor Chart, Microclimate Factor Chart, and Irrigation Chart of LEED NC 2.2 Reference Guide.

(C) P8 Model results calculated from temperature, daylight hours, and vegetative cover using an equation from the following paper: Haith, D.A. and L.L. Schoemaker, "Generalized Watershed Loading Functions for Stream Flow Nutrients", Water Resources Bulletin, American Water Resources Association, Vol. 23, No. 3, pp. 471-48, June 1987.

Notes:

(A) Square footage of shrubs assumed to be 1/3 of the square footage of the trees. Best Professional Judgement. Remaining areas of shrubs not included in baseline square footage as they were never irrigated. Including these areas would indicate an un-realized large percent reduction in potable water use since these areas are not included in the irrigation paradigm of WSSI. WSSI provided limited documentation establishing a potable water use baseline for outdoor irrigation of 2,600,000 gallons/year. Due to a lack of specific information regarding the factors used to produce the WSSI established baseline it was not included in this analysis.

C.3 Fixture, Appliance, and Irrigation Baseline for Millennium Towers Residences

Table C-9
Millennium towers baseline potable water usage (flush fixtures)

	Number of Users (Persons)	Number of Uses (per day)	Number of Uses (per year)	Flush Flow Rate (Gallons per Flush)	Total Amount of Water to be Treated by Wastewater Treatment Plant (gal)
	A	B	C = B*365	D	E = A*C*D
Conventional Water Closet (toilet in bathroom in individual units)	726	5	1,825	1.6	2,119,920
Conventional Water Closet (public toilet)	5	4	1,460	1.6	11,680
Conventional Urinal (public urinal)	5	2	730	1.0	3,650
Total Annual Flush Fixture Water Usage (gal)					**2,135,250**
Estimated Average Daily Flush Fixture Water Usage (gal)					**5,850**

Source: (A), (B), (D) Millennium Tower LEED Application.

Notes:
(A) With the exception of urinals, includes both males and females.
(B) Assumes single flush per use.

Table C-10
Millennium towers baseline potable water usage (flow fixtures)

Flow Fixture Type	Number of Users (persons)	Number of Uses (per day)	Number of Uses (per year)	Duration of Usage (seconds)	Duration of Usage (minutes)	Fixture Flow Rate (gpm)	Total Amount of Water to be treated by Wastewater Treatment Plant (gal)
	A	B	C = B*365	D	E = D/60	F	G = A*C*E*F
Conventional Lavatory (sink in bathroom in individual units)	726	5	1,825	15	0.25	2.5	828,094
Shower (in individual units)	726	1	365	300	5	2.5	3,312,375
Kitchen Sink	726	4	1,460	60	1	2.5	2,649,900
Conventional Lavatory (sink in public bathroom)	10	3	1,095	15	0.25	2.5	6,844
Shower (in public bathroom)	10	0	37	300	5	2.5	4,563
Total Annual Flow Fixture Water Usage (gal)							**6,801,775**
Estimated Average Daily Flow Fixture Water Usage (gal)							**18,635**

Source: (A), (B), (D), (F) Millennium Tower LEED Application.

Table C-11
Millennium towers additional baseline potable water usage (appliances)

Appliance Type	**Number of Uses (per week)**	**Number of Uses (per year)**	**Appliance Water Usage (gal/usage)**	**Total Amount of Water to be Treated by Wastewater Treatment Plant (gal)**
	A	B = A*52	C	D = B*C
Clothes Washer	435	22,620	25.0	565,196
Dishwasher	1,523	79,170	1.8	146,402
Total Annual Appliance Water Usage (gal)				**711,598**
Estimated Average Daily Appliance Water Usage (gal)				**1,950**

Notes:

(A) One clothes washer and one dishwaster per unit. 234 units in total (33 one-bedroom, 201 two-four bedroom).

One bedroom units - clothes washer (run once/week), dishwasher (run every other day).

Two bedroom (and larger) units - clothes washer (run twice/week), dishwasher (run every day).

(B) 52 weeks per year.

(C) Stacked Maytag washer/dryer (model MLE2000AYW). Washer drum capicity = 25.0 gallons. Assumed washer is half-filled with water, twice per wash cycle: 25.0 gal/usage.

Miele dishwasher (model Incognito G863SCVI). Manufacturer data: 1.85 gal/usage.

Table C-12
Millennium towers additional baseline potable water usage (irrigation)

Landscape Type	Area (ft^2)	Species Factor	Density Factor	Micro-climate Factor	Irrigation Type	Landscape Coeffiecient	Month	Regional Evapotranspiration Rate	Site Specific Evapotranspiration Rate	Total Potable Water Applied (gal)
	A	B	C	D	E	F = B*C*D	G	H	I = F * H	J =A* I/E *0.623
Trees	150	0.5	1.0	1.0	0.900	0.5	January	0.2	0.10	10
Groundcovers	720	0.5	1.0	1.0	0.625	0.5		0.2	0.10	72
Turfgrass	4,113	0.7	1.0	1.2	0.900	0.8		0.2	0.17	479
Subtotal - January										**561**
Trees							February	0.2	0.10	10
Groundcovers								0.2	0.10	72
Turfgrass								0.2	0.17	479
Subtotal - February										**561**
Trees							March	0.6	0.30	31
Groundcovers								0.6	0.30	215
Turfgrass								0.6	0.50	1,436
Subtotal - March										**1,682**
Trees							April	1.7	0.85	88
Groundcovers								1.7	0.85	610
Turfgrass								1.7	1.43	4,068
Subtotal - April										**4,767**
Trees							May	3.6	1.80	187
Groundcovers								3.6	1.80	1,293
Turfgrass								3.6	3.02	8,614
Subtotal - May										**10,094**
Trees							June	5.2	2.60	270
Groundcovers								5.2	2.60	1,867
Turfgrass								5.2	4.37	12,443
Subtotal - June										**14,580**
Trees							July	5.9	2.95	306
Groundcovers								5.9	2.95	2,115
Turfgrass								5.9	4.95	14,094
Subtotal - July										**16,515**
Trees							August	5.0	2.50	260
Groundcovers								5.0	2.50	1,795
Turfgrass								5.0	4.20	11,964
Subtotal - August										**14,019**
Trees							September	3.2	1.60	166
Groundcovers								3.2	1.60	1,149
Turfgrass								3.2	2.69	7,657
Subtotal - September										**8,972**
Trees							October	1.8	0.90	94
Groundcovers								1.8	0.90	646
Turfgrass								1.8	1.51	4,307
Subtotal - October										**5,047**
Trees							November	0.3	0.15	16
Groundcovers								0.3	0.15	108
Turfgrass								0.3	0.25	718
Subtotal - November										**841**
Trees							December	0.0	0.00	-
Groundcovers								0.0	0.00	-
Turfgrass								0.0	0.00	-
Subtotal - December										**-**
Total Annual Irrigation Water Usage (gal)										**77,638**
Estimated Average Daily Irrigation Water Usage (gal)										**213**

Source:

(A) Millennium Tower LEED Application.

(B) – (E) USGBC Baseline assumptions specified in Species Factor Chart, Density Factor Chart, Microclimate Factor Chart, and Irrigation Chart of LEED NC 2.2 Reference Guide.

(H) P8 Model results calculated from temperature, daylight hours, and vegetative cover using an equation from the following paper: Haith, D.A. and L.L. Schoemaker, “Generalized Watershed Loading Functions for Stream Flow Nutrients”, Water Resources Bulletin, American Water Resources Association, Vol. 23, No. 3, pp. 471-48, June 1987.

C.4 Cooling Tower Baseline for the Merrill Center, WSSI, and Millennium Tower Residences.

C.4.1 Background

Conventionally built office buildings generally rely on air conditioning systems with a cooling tower for heat rejection. Water-cooled, or “Wet” cooling towers are commonly used because they are more energy-efficient than air-cooled, “Dry” systems (Capehart, 2007). In a wet cooling tower, water is re-circulated over porous media while air is passed through the media (Cooling Technology Institute, 2009). A portion of the water evaporates, and the rest is cooled to the wet-bulb air temperature (which depends on the ambient humidity, but is generally much lower that the ambient, or dry-bulb temperature). The cooled water can either be used directly to cool the building under economizer modes, or as a reservoir for a heat pump to reject the building’s heat to (Cheresources 2008). In its interaction with the atmosphere, cooling towers will lose moisture to the air. Cooling towers lose water mainly in three ways: evaporation, drift (water droplets being carried out by the air stream) and blow-down (a portion of the circulating water that is removed and replaced with fresh water to keep the dissolved solids levels down) (Cooling Tower Institute, 2009).

C.4.2 General Approach

Two of the case study buildings (Millennium Tower and Wetland Studies and Solutions office) use a cooling tower. The Merrill Center uses a ground-source heat pump. Ground-source heat pumps are more energy efficient and consume no water: the fluid circulates in a closed loop (Capehart, 2007). However, to create baseline water calculations (how much water the building would use if built to conventional building standards), we have calculated the baseline cooling tower water loss for all three buildings for a conventional built and operated cooling tower.

Many factors contribute to the cooling load of a building: among them heat generated by the occupants, heat conduction through the exterior walls, air changes (air leaking into or out of the building or actively moved by the ventilation), and heat generated by electricity use in the building. For these case studies, initial calculations indicated that the first two factors were not significant in comparison to the last two. For that reason, only air changes and electrical generation were considered.[1]

These calculations assume uniform inside (65°F) temperatures as a base for the cooling degree days, because that is the base that our source, the National Climactic Data Center (NCDC) calculated them to. Additionally, since the NCDC calculates cooling degree-days based on the whole year, these calculations inherently assume 24/7 climate control rather than only during the day when people are in the building. However, most of the cooling load occurs during work hours, so the difference is small enough to be within the range of uncertainty for these calculations. These calculations also assume average or national building code compliant buildings.

[1] Standard cooling load calculations, such as those employed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), are used to size cooling systems and calculate peak loads. Since this calculation is concerned with total energy and water use (not peak), standard ASHRAE calculations were not applicable, and were not used.

C.4.3 Calculations

Inputs to the calculations include estimates of electrical use by building area in conjunction with the area of each case study building (see Tables C-13 and C-14). Because nearly all electrical use in a building is eventually converted to heat, no conversion factor was necessary to change electricity into heat (the conversion from kilowatt-hours to Btu's was simply to make the units match with the calculations that follow).

To estimate the impact of air changes (bringing in warm outside air) on the cooling load of the building, the volume of each case study building was multiplied by the air changes per year, the specific heat of air, and the average temperature difference (cooling degree days divided by the number of days in a year), as is demonstrated in Table C-13 and C-14. Lastly, a conversion factor for gallons of water lost (evaporation, drift, and blow-down) by an average cooling tower per Btu of heat expelled by that cooling tower was used to convert cooling load to water loss.

Table C-13
Conversion factors for cooling tower calculations

Average Electricity Use in Offices (kWh/(ft^2*year))	Average Electricity Use in Offices (Btu/(ft^2*year))	Minimum Required Air Changes per Hour	Minimum Required Air Changes per Year	Specific Heat of Air (Btu/(ft^3* °F))	Average Water Loss of a Cooling Tower (gal/Btu)
A	B = A * 3412	C	D = C * 24 * 365	E	F
17.3	59,030	2	17,520	0.0168	0.000264

Sources:
(A) Office survey data from U.S. Department of Energy, Energy Information Administration, 2008.
(C) Minimal building standard from Brumbaugh 2004.
(E) Constant from CEERE 2009.
(F) Conversion factor derived from standard estimate of cooling water loss rate per cooling tower ton (15,000 Btu/hr) from Engineering Toolbox, 2005.

Table C-14
Cooling tower calculations

Building	Building Area (ft^2)	Electrical Heat Generation (Billion Btu's/yr)	Building Interior Volume Estimate (ft^3)	Cooling Degree Days (°F*day)	Air Change Heat Generation (Billion Btu's/yr)	Total Cooling Water Loss (Thousand gal/yr)
	A	B = 64,489 * A	C	D	E = C * 17520 * 0.0168 * D/365	F = (B + E) * 0.000264
Wetland Studies and Solutions Office	37,400	2.21	561,000	1,075	0.49	700
Merrill Center	32,000	1.89	662,933	1,162	0.62	700
Millennium Tower	442,099	26.1	3,978,891	1,151	3.69	8,000

Sources:
(A) E-mail correspondence with WSSI dated 7/2/2009, Merrill Center LEED application package (site tab), and Millennium Tower LEED application package (SSc2 Template).
(B) Column B, Exhibit A.5a.
(C) Estimates based on e-mail correspondence with WSSI dated 7/2/2009, Merrill Center plans drawings A101-103, A301, Millennium Tower LEED application package (SSc2 Template), and New York Bits 2009.
(D) National Climactic Data Center, 2002.
(E) Columns D and E, Exhibit C.5a.
(F) Column F, Exhibit C.5a.

Note: Although these figures are shown to three or more significant digits, due to the approximate nature of the calculations, the results (F) and intermediate calculations should be only be relied upon to the first digit.

D

DERIVATION OF ACTUAL (METERED) WATER USE FOR THE STUDY SITES

Matrix of Appendix D Contents	
Exhibit Description	**Exhibit Number**
Summary of Water Usage based on Recorded Meter Readings	D.1
Merrill Center Water Usage based on Recorded Meter Readings	D.2
Wetland Studies and Solutions Water Usage based on Recorded Meter Readings	D.3
Millennium Tower Usage based on Recorded Meter Readings	D.4

Appendix D presents water usage data based on recorded water meter readings for the Merrill Center, WSSI, and Millennium Towers. Water meter data was obtained for a representative year for each site and was used to calculate the annual water usage and the estimated daily water usage. Exhibit D.1 presents a summary of the water usage data based on recorded water meter readings for the three sites, followed by detailed exhibits for each of the three sites (Exhibits D.2 - D.4).

Exhibit D.1
Summary of water usage based on recorded meter readings

Site	Annual Water Usage (gal)	Estimated Daily Water Usage (gal/day)
	A	B = A/365
Merrill Center	15,384	42
WSSI	233,500	640
Millennium Towers	8,742,297	23,951

Source: Exhibits D.2 - D.4.

Exhibit D.2
Merrill Center water usage based on recorded meter readings

Month	Number of Days per Month	Average Daily Rainwater Use (gal/day)	Average Daily Wellwater Use (gal/day)	Baseline Water Use	Baseline Wastewater Flow
	A	B	C	D = A*C	E = A*(B+C)
January 2008	31	95	27	837	3,782
February 2008	29	28	14	406	1,218
March 2008	31	38	15	465	1,643
April 2008	30	43	46	1,380	2,670
May 2008	31	42	45	1,395	2,697
June 2008	30	93	61	1,830	4,620
July 2008	31	14	67	2,077	2,511
August 2008	31	32	40	1,240	2,232
September 2008	30	87	83	2,490	5,100
October 2008	31	15	62	1,922	2,387
November 2008	30	119	22	660	4,230
December 2008	31	52	22	682	2,294
Annual Water Usage (gal)				**15,384**	**35,384**
Estimated Daily Water Usage (gal/day)				**42**	**97**

Source:
Chesapeake Bay Foundation internal meter records
(B), (C) This water meter data was provided in an e-mail from Paul Wiley to Richard Moore dated 06/24/2009

Note: Estimated daily water use based on 365 days/year

Exhibit D.3
Wetland studies and solutions water usage based on recorded meter readings

Billing Period	Irrigation Meter (Potable Water Use)			Main Site Meter (Total Site Water Use)			Allowance for Gainesville Garage (gal/month)	Water Discharged to Sanitary Sewer (gal/month)
	Start Reading (1000's gal)	End Reading (1000's gal)	Water Use (gal/month)	Start Reading (1000's gal)	End Reading (1000's gal)	Total Water Purchased (gal/month)		
	A	B	C = (B-A)*1000	D	E	F = (E-D)*1000	G	H = F-G
01/04/2008 - 02/05/2008	9.05	9.30	250	2,804	2,818	14,000	1,000	13,000
02/06/2008 - 03/04/2008	9.30	9.30	0	2,818	2,828	10,500	1,000	9,500
03/05/2008 - 04/02/2008	9.30	9.30	0	2,828	2,841	13,000	1,000	12,000
04/03/2008 - 05/05/2008	9.30	23.25	13,950	2,841	2,878	36,500	1,000	35,500
05/06/2008 - 06/03/2008	23.25	25.65	2,400	2,878	2,896	18,500	1,000	17,500
06/04/2008 - 07/02/2008	25.65	26.30	650	2,896	2,936	40,000	1,000	39,000
07/03/2008 - 08/05/2008	26	26	0	2,936	2,984	48,000	1,000	47,000
08/06/2008 - 09/03/2008	26	26	0	2,984	2,998	14,000	1,000	13,000
09/04/2008 - 10/02/2008	26	26	0	2,998	3,015	17,000	1,000	16,000
10/03/2008 - 11/04/2008	26	26	0	3,015	3,031	16,000	1,000	15,000
11/05/2008 - 12/03/2008	26	26	0	3,031	3,042	11,000	1,000	10,000
12/04/2008 - 01/02/2009	26	26	0	3,042	3,049	7,000	1,000	6,000
Annual Water Usage (gal)								**233,500**
Estimated Daily Water Usage (gal/day)								**640**

Source:

(A), (B), (D), (E) Water billing information for Wetland Studies and Solutions (Prince William County Service Authority).

G) This estimate was made by WSSI personnel (Jennifer Brophy-Price) in an e-mail to Jaime Alvarez dated 8/26/2009.

Note: Estimated daily water use based on 365 days/year.

Exhibit D.4
Millennium tower usage based on recorded meter readings

Billing Period	Meter				Pre-Adjustment		Post-Adjustment
	V84011786 - High Flow Dial	V84011786 - Low Flow Dial	V83036395	D52230113	Total Water Use for Billing Period (ft^3)	Adjustment (ft^3)	Total Water Use for Billing Period (ft^3)
	A	B	C	D	E = (A+B+C+D)	F	G = (A+B+C+D)-F
Bill #1 (07/02/07 - 10/01/07)							
Usage (ft3)	261,700	19,100	5,800		286,600	7,000	279,600
Days	91	91	96				
Bill #2 (10/01/07 - 01/02/08)							
Usage (ft3)	239,200	18,700	5,500		263,400	5,800	257,600
Days	93	93	92				
Bill #3 (01/02/08 - 04/02/08)*							
Usage (ft3)	244,100	18,900	5,400		268,400	5,500	262,900
Days	91	91	90				
Bill #4 (04/02/08 - 4/22/08)**							
Usage (ft3)	54,200	4,100	4,400	1,400	64,100	5,800	58,300
Days	20	20	421	131			
Bill #5 (04/22/08 - 07/05/08)							
Usage (ft3)	308,800	700	700		310,200		310,200
Days	70	74	74				
Annual Water Usage (ft^3)							**1,168,600**
Annual Water Usage (gal)							**8,742,297**
Estimated Daily Water Usage (gal/day)							**23,951**

Source: NYC Department of Environmental Protection - Millennium Tower Residences' Water Bills.
Notes:
Estimated daily water use based on 365 days/year.
* D52230113 - One bill from 12/13/07 - 04/22/08.
** V83036395 - One bill from 02/26/07 - 04/22/07.
(A) - (D) Water meters IDs per NYC Department of Environmental Protection.
(F) Downward adjustments to water bill by NYC Department of Environmental Protection based on measured water readings.
(G) Represents water use based on adjusted water readings.

E

STORMWATER MODEL DESIGN PARAMETERS AND RESULTS FOR THE MERRILL CENTER

Table E-1
Pollutant loads from Merrill Center model (lbs/yr)

Entire Property

Scenario	Existing	Existing	Existing	Existing	Baseline	Baseline	Baseline	Baseline
Pollutant/Source Area	Undeveloped	Parking	Roof	Total	Undeveloped	Parking	Roof	Total
Suspended solids	90.2	0.0	0.0	90.2	90.2	0.2	0.0	90.4
P10%	22.6	0.0	0.0	22.7	22.6	0.1	0.0	22.8
P30%	22.5	0.0	0.0	22.5	22.5	0.0	0.0	22.6
P50%	22.5	0.0	0.0	22.5	22.5	0.0	0.0	22.5
P80%	22.5	0.0	0.0	22.5	22.5	0.0		22.5
Total phosphorus	0.14	0.22	0.15	0.51	0.14	0.65	0.18	0.97
Kjeldahl nitrogen	11.53	2.36	4.03	17.92	11.42	6.86	4.74	23.02
Copper	0.288	0.059	0.031	0.379	0.286	0.171	0.037	0.493
Lead	0.110	0.007	0.066	0.183	0.109	0.020	0.078	0.207
Zinc	1.312	0.179	0.002	1.493	1.299	0.520	0.003	1.823
PAH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Areas within limit of disturbance

Scenario	Existing	Existing	Existing	Existing	Baseline	Baseline	Baseline	Baseline	Un-controlled	Un-controlled	Un-controlled	Un-controlled
Pollutant/Source Area	Un-developed	Parking	Roof	Total	Un-developed	Parking	Roof	Total	Un-developed	Parking	Roof	Total
Suspended solids	0.8	3.3	1.1	5.2	0.9	18.8	1.9	21.7	3.9	1210.9	36.5	1251.3
P10%	0.4	1.4	0.9	2.7	0.4	8.0	1.5	9.9	1.1	245.2	26.7	273.0
P30%	0.2	1.1	0.2	1.5	0.3	6.2	0.3	6.8	1.0	243.4	6.8	251.2
P50%	0.1	0.6	0.0	0.8	0.2	3.4	0.1	3.7	0.9	241.7	3.0	245.7
P80%	0.0	0.2		0.2	0.1	1.2		1.3	0.9	480.7	0.0	481.5
Total phosphorus	0.01	0.10	0.16	0.27	0.01	0.65	0.20	0.85	0.01	1.05	0.31	1.36
Kjeldahl nitrogen	0.92	1.03	4.20	6.14	0.57	6.72	5.25	12.54	0.42	7.18	5.58	13.18
Copper	0.023	0.026	0.033	0.081	0.014	0.167	0.041	0.222	0.010	0.179	0.041	0.231
Lead	0.009	0.003	0.069	0.081	0.005	0.022	0.086	0.113	0.004	0.097	0.095	0.196
Zinc	0.105	0.079	0.004	0.187	0.065	0.513	0.005	0.582	0.047	0.678	0.044	0.769
PAH	0.000	0.001	0.000	0.001	0.000	0.005	0.000	0.006	0.000	0.228	0.002	0.229

*PX% values are size fractions of suspended solids. In each size fraction, X% of the mass of particles in runoff are smaller than the lower limit of that fraction.

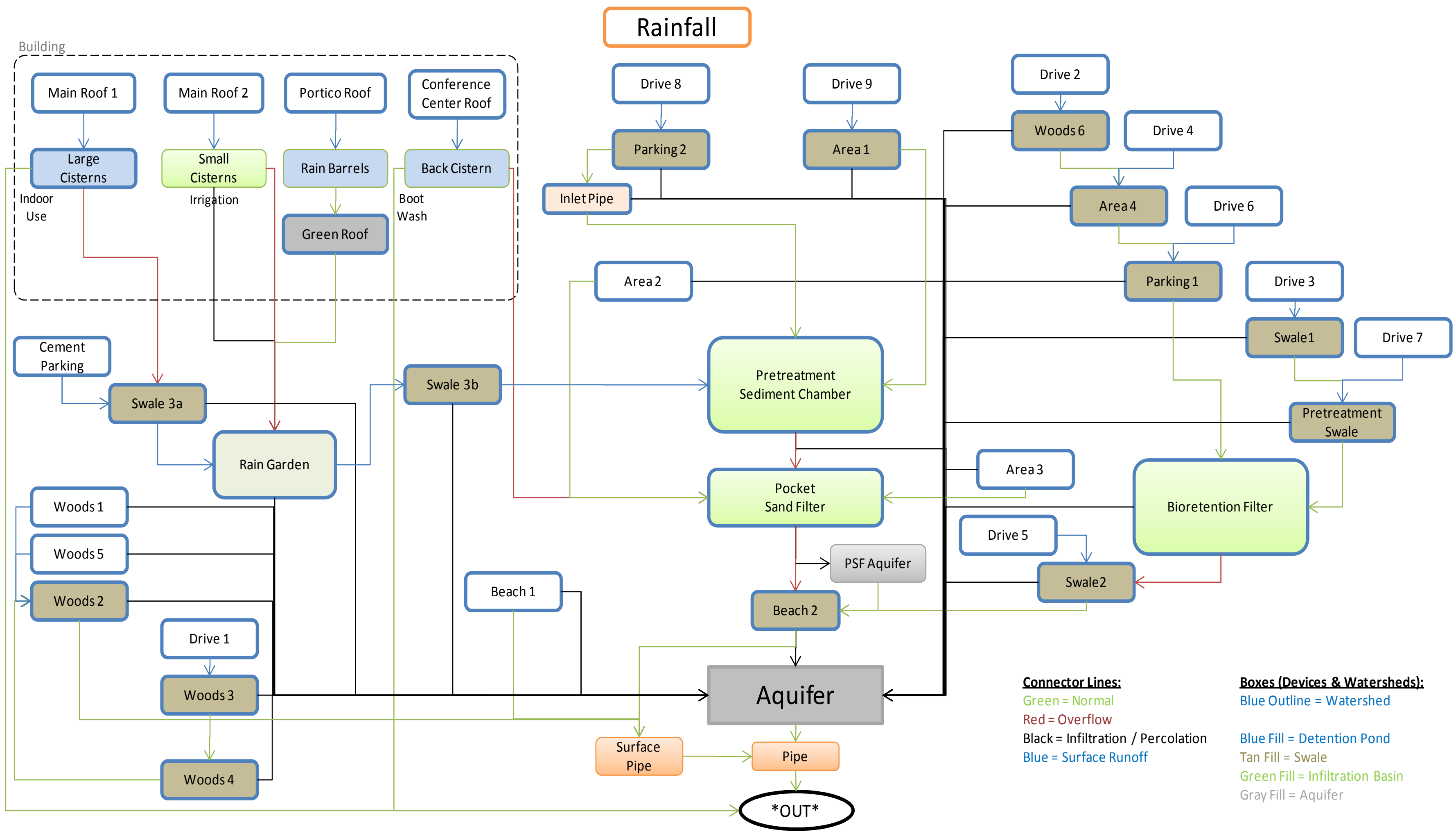


Figure E-1
Merrill Center existing scenario schematic (entire property)

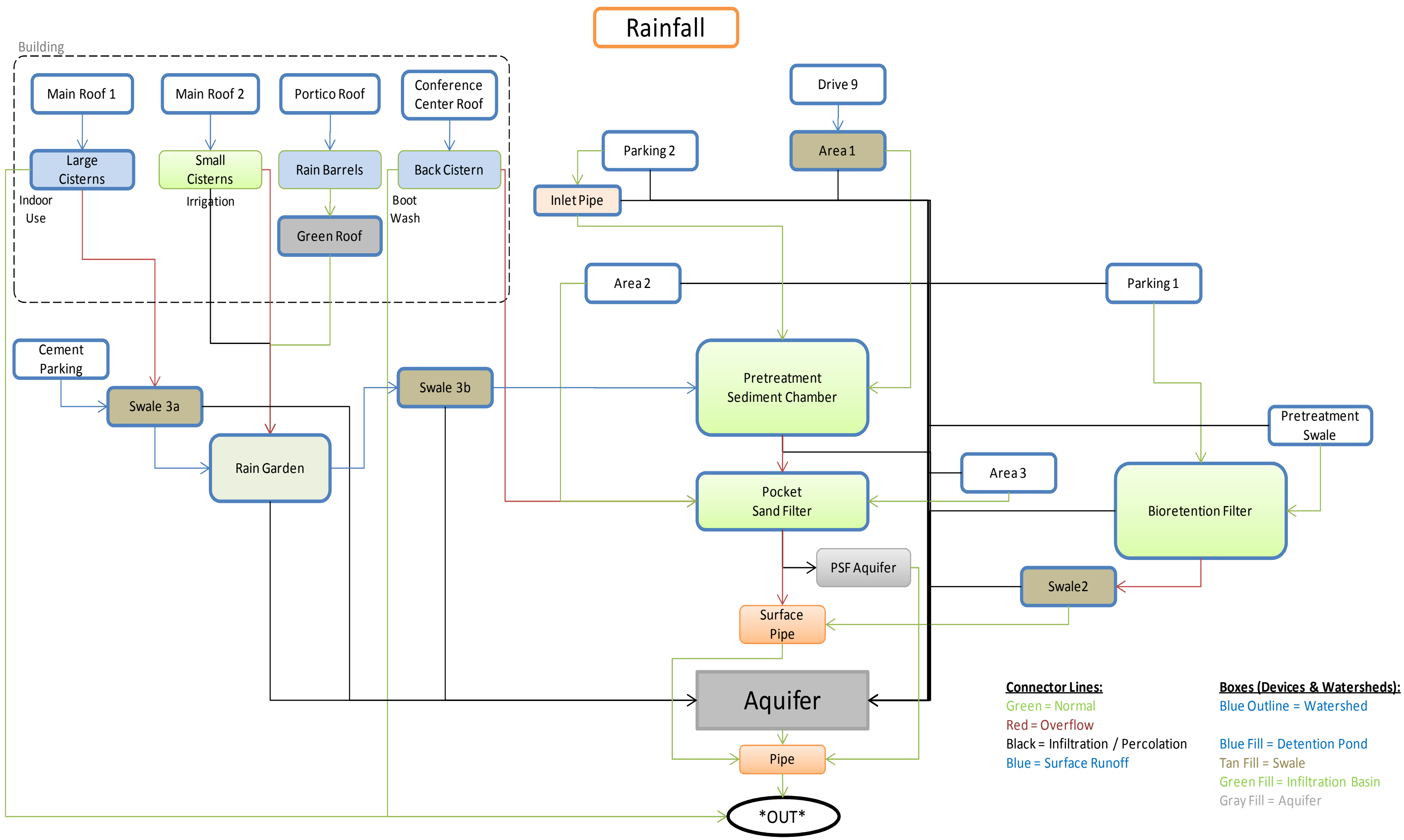


Figure E-2
Merrill Center existing scenario schematic (areas within limit of disturbance)

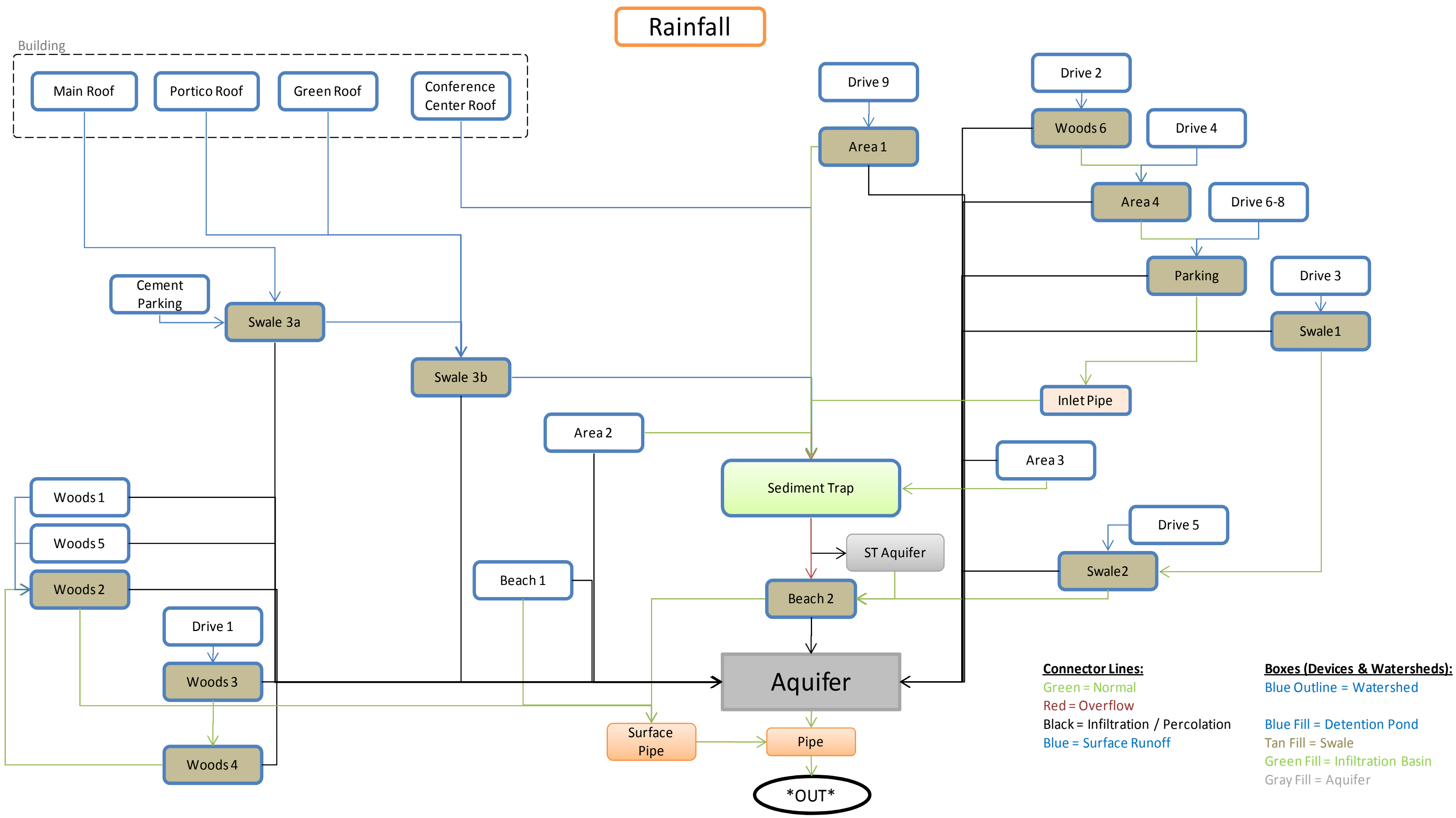


Figure E-3
Merrill Center baseline scenario schematic (entire property)

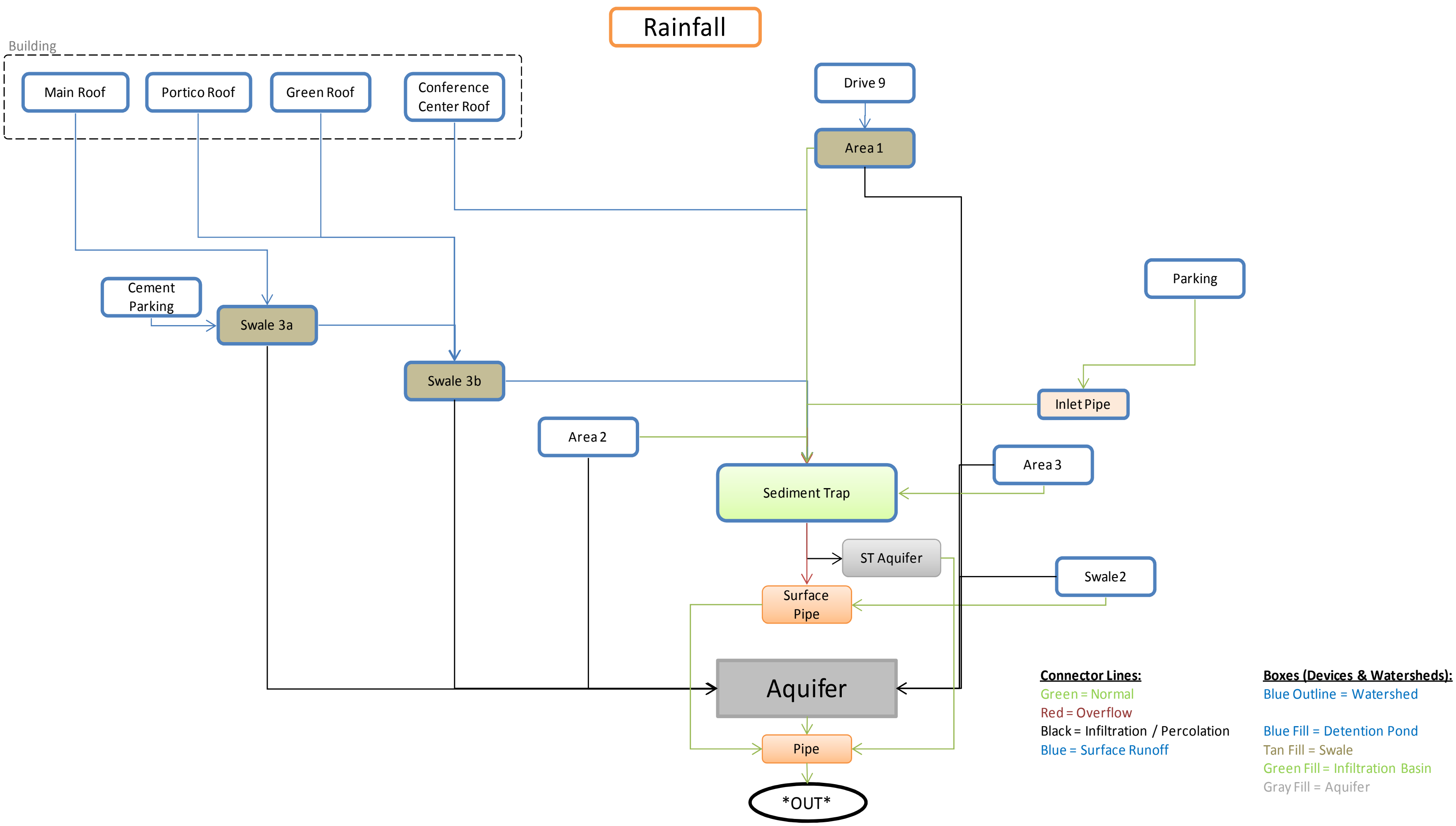


Figure E-4
Merrill Center baseline scenario schematic (areas within limit of disturbance)

E.1 Merrill Center P8 Model Design Parameters

Each P8 model is configured as a network of **watersheds** and treatment **devices** (Walker 2007). In simulating particle removal, each device is assumed to be "completely mixed" (i.e., one stirred tank), as opposed to plug flow (infinite stirred tanks). This assumption may be conservative in some cases, particularly swales/buffer strips.

Swales can be used within P8 to model overland flow. For all swales, the flow length is measured along the longest path within the device area that follows the slope of the device. Swale lengths were calculated with desktop GIS software. Elevations for all devices, including swales, were acquired from the construction plans for the Merrill Center.

P8 does not keep track of precipitation falling directly on a device. In order to provide a complete water budget, watershed areas and weighted curve numbers are specified to include device areas.

Watersheds and devices used for the "existing condition" model are described below.

E.1.1 Watersheds

These areas are located within the property boundary. Watersheds that are also included in the Limit of Disturbance (LOD) models are noted. Watershed areas were calculated using desktop GIS software or from schematics.

The names assigned to watersheds within the Merrill Center models are ambiguous. Figures E-5 and E-6 may be used as keys to identify the location of watersheds on the Merrill Center site. The schematics in this appendix can be used to determine how water was routed between areas in the Merrill Center models.

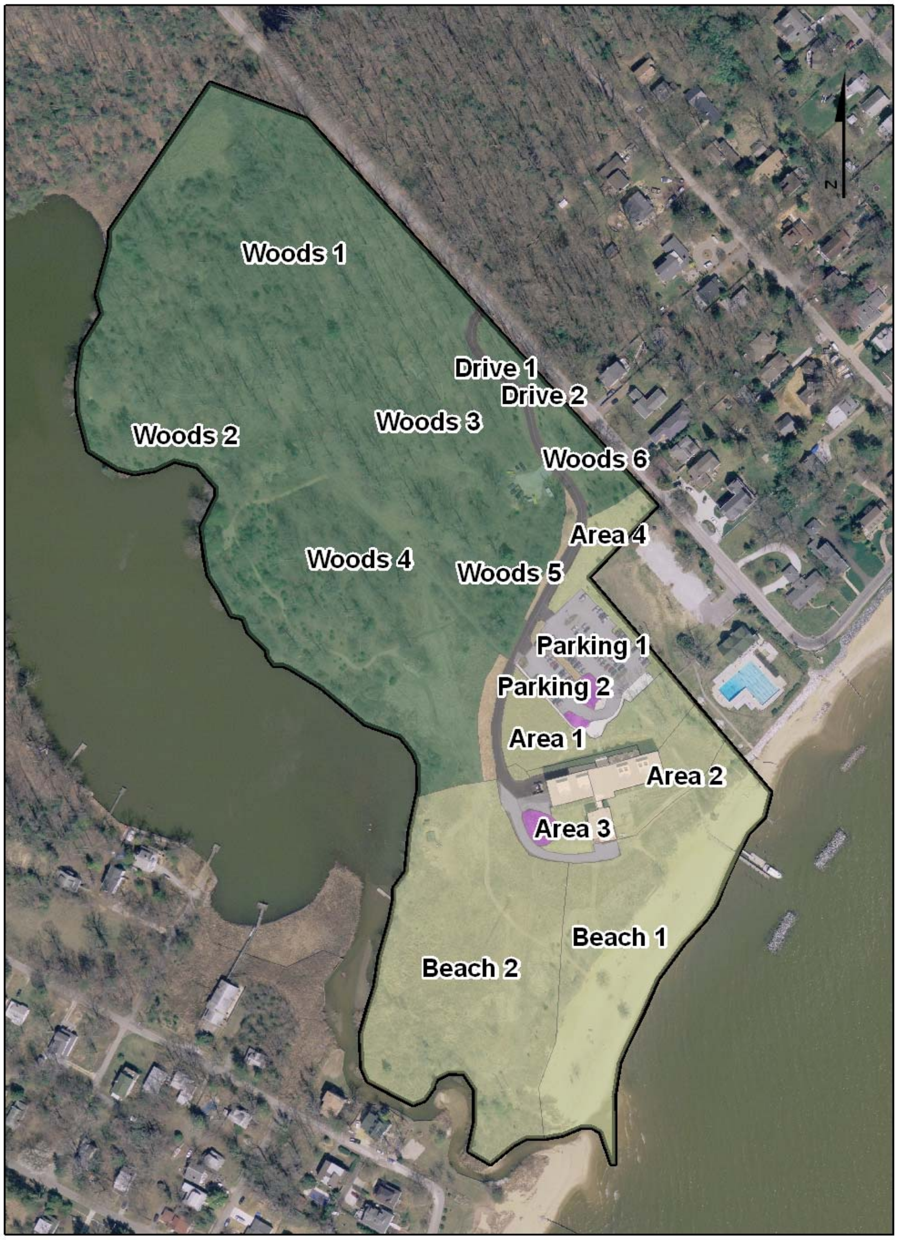


Figure E-5
Watersheds used in the Merrill Center 'existing condition' P8 model. Many of these areas are outside of the limit of disturbance. For watersheds near the building, please see Figure E-6

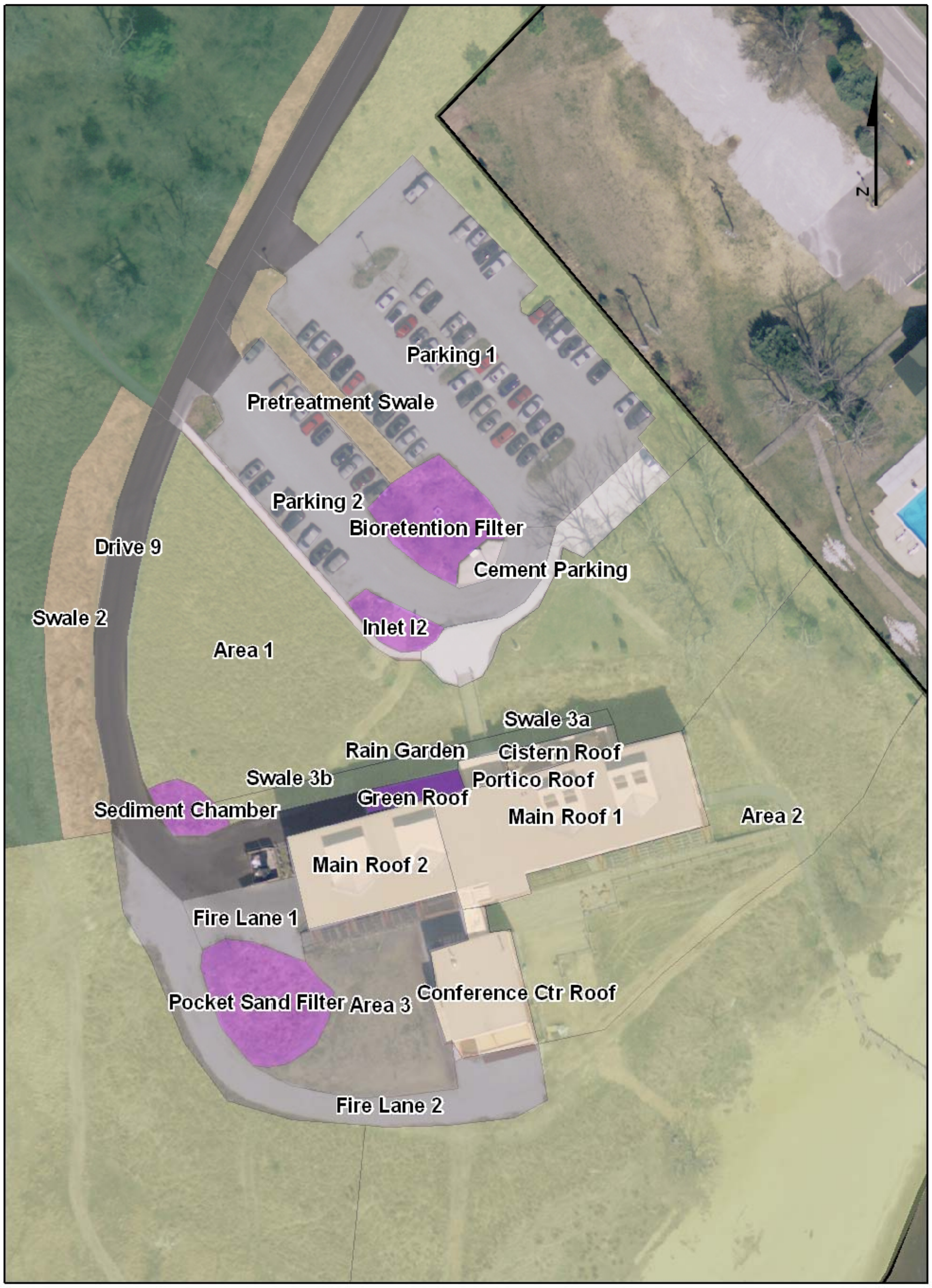


Figure E-6
Watersheds used in the Merrill Center 'existing condition' P8 model. The labeled watersheds are included in the Limit of Disturbance (LOD) models

E.1.1.1 Pervious Watersheds

Curve numbers for pervious areas derived from the Table of Runoff Curve Numbers originally developed by the U.S. Soil Conservation Service in 1977 (and updated at irregular intervals since then based on new research), unless otherwise noted. The site was generally assumed to have sandy soils with relatively high infiltration rates (Group B), with the exception of some wetland areas in the undeveloped portions of the site. This assumption may overestimate infiltration in portions of the site where previous development has resulted in soil compaction.

AREA1

- Area = 0.8716 acres
- Curve number = 58 (Meadow/Idle)
- This watershed is included in the LOD models.

AREA2

- Area = 0.5289 acres
- Curve number = 61 (Good grass cover > 75%)
- This watershed is included in the LOD models.

AREA3 (Bus Parking)

- Area = 0.3930 acres
- Curve number = 61 (Gravel)
- This watershed is included in the LOD models.

AREA4

- Area = 0.4664 acres
- Curve number = 61 (Good grass cover > 75%)

BEACH1

- Area = 3.360 acres
- Curve number = 86 (Beach/Barren) (Dillow 1996)

BEACH2

- Area = 4.618 acres
- Curve number = 86 (Beach/Barren) (Dillow 1996)

BRF (Bioretention Filter)

- Area = 0.06981 acres
- Curve number = 98 (directs all runoff to underlying Bioretention filter device)
- This watershed is included in the LOD models.

GREEN_ROOF

- Area = 0.01509 acres
- Curve number = 58 (Meadow/Idle)
- This watershed is included in the LOD models.

INLET_I2

- Area = 0.02171 acres
- Curve number = 61 (Good grass cover > 75%)
- This watershed is included in the LOD models.

PARKING1

- Area = 0.5092 acres
- Curve number = 61 (Gravel)
- This watershed is included in the LOD models

PARKING2

- Area = 0.2323 acres
- Curve number = 61 (Gravel)
- This watershed is included in the LOD models.

PreSWALE (Pretreatment Swale)

- Area = 0.0517 acres
- Curve number = 98 (directs all runoff to underlying Pretreatment Swale device)
- This watershed is included in the LOD models.

PSC (Pretreatment Sediment Chamber)

- Area = 0.02113 acres
- Curve number = 98 (directs all runoff to underlying Pretreatment Sediment Chamber device)
- This watershed is included in the LOD models.

PSF (Pocket Sand Filter)

- Area = 0.08339 acres
- Curve number = 98 (directs all runoff to underlying Pocket Sand Filter device)
- This watershed is included in the LOD models.

SWALE1

- Area = 0.09458 acres
- Curve number = 98 (directs all runoff to underlying Swale1 device)

SWALE2

- Area = 0.1586 acres
- Curve number = 98 (directs all runoff to underlying Swale2 device)
- This watershed is included in the LOD models.

SWALE3

- Area = 0.05680 acres
- Curve number = 98 (directs all runoff to underlying Swale3b device)
- This watershed is included in the LOD models.

WOODS1

- Area = 5.366 acres
- Curve number = 55 (Woods, Good cover)

WOODS2

- Area = 6.976 acres
- Curve number = 55 (Woods, Good cover)

WOODS3

- Area = 1.779 acres
- Curve number = 55 (Woods, Good cover)

WOODS4

- Woods 4 represents the internally drained wetlands located in the undeveloped portion of the site. The underlying wetland is modeled as an infiltration basin.
- Area = 2.218 acres
- Curve number = 98 (directs all runoff to underlying Woods4 device)

WOODS5

- Area = 0.8532 acres
- Curve number = 55 (Woods, Good cover)

WOODS6

- Area = 0.6861 acres
- Curve number = 55 (Woods, Good cover)

E.1.1.2 Impervious Watersheds

PCEMENT (Cement Parking area + Front Sidewalk)

- Area = 0.07214 acres
- Unswept impervious fraction = 1 (Driving surface assumed to prohibit percolation. No sweeping program described in Merrill Center documentation.
- Depression storage = 0.018 inches (3% slope) (Kidd 1978)
- Assumed to be completely impervious and not swept.
- Runoff coefficient = 0.701 (Smooth-textured street) (Walker 2007)

E.1.1.3 Entry Driveway Surfaces

Drainage pathways for the watersheds representing the entry drive were estimated using the Merrill Center construction schematics. A runoff coefficient of 0.701 (smooth-textured street) (Walker 2007) was used for all entry drive watersheds. The entry driveway was assumed to be crowned, with a slope of 2% (Merrill Center Construction Sketch C-7). Using the 2% slope, depression storage of 0.021 inches (Kidd 1978) was used for all entry drive watersheds. Driving surfaces were assumed to prohibit percolation (Impervious fraction = 1). Areas of each entry drive watershed are listed below:

DRIVE1

- Area = 0.1056 acres

DRIVE2

- Area = 0.1089 acres

DRIVE3

- Area = 0.06939 acres

DRIVE4

- Area = 0.05046 acres

DRIVE5

- Area = 0.02175 acres

DRIVE6

- Area = 0.01635 acres

DRIVE7

- Area = 0.1056 acres

DRIVE8

- Area = 0.01509 acres

DRIVE9

- Area = 0.1730 acres
- This watershed is included in the LOD models.

E.1.1.4 Roofs

Stormwater from every portion of the roofs at the Merrill Center is directed to either a cistern or a rain barrel. Depression storage values and runoff coefficients for the roofs are derived from values included in the P8 documentation that were calibrated with the Source Loading and Management Model (SLAMM) (Walker 2007). Depression storage and runoff coefficients vary based on the pitch of the roof. All roofs were assumed to be unswept and fully impervious (Unswept impervious fraction = 1).

RCISTERNS (Flat Roof Surrounding Large Cisterns + Area of Cistern "lids")

- Area = 0.02051 acres
- Depression Storage = 0.08 inches
- Runoff coefficient = 0.907
- This watershed is included in the LOD models.

RCONF (Pitched Conference Room Roof)

- Area = 0.07499 acres
- Depression Storage = 0.03 inches
- Runoff coefficient = 1
- This watershed is included in the LOD models.

PORTICOROOF (Pitched Portico Roof)

- Area = 0.009893 acres
- Depression Storage = 0.03 inches
- Runoff coefficient = 1
- This watershed is included in the LOD models.

ROOF1 (Pitched Main Roof – This Portion of the Roof is Directed To the Large Cisterns)

- Area = 0.1868 acres
- Depression Storage = 0.03 inches
- Runoff coefficient = 1
- This watershed is included in the LOD models.

ROOF2 (Pitched Main Roof – This Portion of the Roof is Directed To the Small Cisterns)

- Area = 0.1022 acres
- Depression Storage = 0.03 inches
- Runoff coefficient = 1
- This watershed is included in the LOD models.

E.1.1.5 Devices

E.1.1.6 Overland Flow Areas

AREA1

- P8 Model Device Type = Swale
- Flow Path Slope = 4.6%
- Flow Path Length = 130 feet
- Bottom Width = 160 feet
- Side Slope = 1
- Maximum Depth = 0.25 feet
- Infiltration rate = 1.795 in/hr. (Loamy sand) (McCuen et al. 1986, Shaver 1986)
- Manning's N = 0.35 (Dense turf) (McCuen 1982)
- This device is included in the LOD models.

AREA4

- P8 Model Device Type = Swale
- Flow Path Slope = 3.3%
- Flow Path Length = 300 feet
- Bottom Width = 60 feet
- Side Slope = 1
- Maximum Depth = 0.25 feet
- Infiltration rate = 1.795 in/hr. (Loamy sand) (McCuen et al. 1986, Shaver 1986)
- Manning's N = 0.35 (Dense turf) (McCuen 1982)

BEACH2

- P8 Model Device Type = Swale
- Flow Path Slope = 0.67%
- Flow Path Length = 450 feet
- Bottom Width = 380 feet
- Side Slope = 1
- Maximum Depth = 0.25 feet
- Infiltration rate = 4.64 in/hr. (Sand) (McCuen et al. 1986, Shaver 1986)
- Manning's N = 0.1 (Dense turf) (Bedient & Huber 1988)
- According to Merrill Center staff, very little surface runoff flows into Black Walnut Creek from this area.

PARKING1

- P8 Model Device Type = Swale
- Flow Path Slope = 5%
- Flow Path Length = 150 feet
- Bottom Width = 150 feet
- Side Slope = 1
- Maximum Depth = 0.25 feet
- Infiltration rate = 1.7 inches/hour
- Manning 's N = 0.05 (sparse vegetation) (Bedient & Huber 1988)
- This device is included in the LOD models.

PARKING2

- P8 Model Device Type = Swale
- Flow Path Slope = 2.4%
- Flow Path Length = 85 feet
- Bottom Width = 90 feet
- Side Slope = 1
- Maximum Depth = 0.25 feet
- Infiltration rate = 1.7 inches/hour
- Manning 's N = 0.05 (sparse vegetation) (Bedient & Huber 1988)
- This device is included in the LOD models.

PreSWALE (Pretreatment Swale)

- P8 Model Device Type = Swale
- Flow Path Slope = 2.4%
- Flow Path Length = 85 feet
- Bottom Width = 90 feet
- Side Slope = 1
- Maximum Depth = 0.9 feet
- Infiltration rate = 1.795 in/hr. (Loamy sand) (McCuen et al. 1986, Shaver 1986)
- Depth-dependent n. (Claytor & Schuler 1996)
- This device is included in the LOD models.

SWALE1

- P8 Model Device Type = Swale
- Flow Path Slope = 6.6%
- Flow Path Length = 275 feet
- Bottom Width = 3 feet
- Side Slope = 1
- Maximum Depth = 1 foot
- Infiltration rate = 1.795 in/hr. (Loamy sand) (McCuen et al. 1986, Shaver 1986)
- Depth-dependent n. (Claytor & Schuler 1996)

SWALE2

- P8 Model Device Type = Swale
- Flow Path Slope = 0.38 %
- Flow Path Length = 260 feet
- Bottom Width = 8 feet
- Side Slope = 1
- Maximum Depth = 1 foot
- Infiltration rate = 1.795 in/hr. (Loamy sand) (McCuen et al. 1986, Shaver 1986)
- Depth-dependent n. (Claytor & Schuler 1996)
- This device is included in the LOD models

SWALE3a

- P8 Model Device Type = Swale
- Flow Path Slope = 0.9 %
- Flow Path Length = 130 feet
- Bottom Width = 8 feet
- Side Slope = 1
- Maximum Depth = 1 foot
- Infiltration rate = 1.795 in/hr. (Loamy sand) (McCuen et al. 1986, Shaver 1986)
- Depth-dependent n. (Claytor & Schuler 1996)
- This device is included in the LOD models

SWALE3b

- P8 Model Device Type = Swale
- Flow Path Slope = 0.9 %
- Flow Path Length = 80 feet
- Bottom Width = 8 feet
- Side Slope = 1
- Maximum Depth = 1 foot
- Infiltration rate = 1.795 in/hr. (Loamy sand) (McCuen et al. 1986, Shaver 1986)
- Depth-dependent n. (Claytor & Schuler 1996)
- This device is included in the LOD models

WOODS2

- P8 Model Device Type = Swale
- Flow Path Slope = 5%
- Flow Path Length = 200 feet
- Bottom Width = 400 feet
- Side Slope = 1
- Maximum Depth = 0.25 feet
- Infiltration rate = 1.795 in/hr. (Loamy sand) (McCuen et al. 1986, Shaver 1986)
- Manning's N = 0.5 (Dense turf and small increased for forested areas) (McCuen 1982)
- Anecdotally, very little surface runoff flows into Black Walnut Creek.

WOODS3

- P8 Model Device Type = Swale
- Flow Path Slope = 6.25%
- Flow Path Length = 315 feet
- Bottom Width = 200 feet
- Side Slope = 1
- Maximum Depth = 0.25 feet
- Infiltration rate = 1.795 in/hr. (Loamy sand) (McCuen et al. 1986, Shaver 1986)
- Manning's N = 0.8 (Forest with dense grass understory) (McCuen 1982)

WOODS6

- P8 Model Device Type = Swale
- Flow Path Slope = 7%
- Flow Path Length = 115 feet
- Bottom Width = 95 feet
- Side Slope = 1
- Maximum Depth = 0.25 feet
- Infiltration rate = 1.795 in/hr. (Loamy sand) (McCuen et al. 1986, Shaver 1986)
- Manning's N = 0.8 (Forest with dense grass understory) (McCuen 1982)

E.1.1.7 Cisterns and Rain Barrels

BACK_CISTERN

The back cistern is collects water from the conference center roof. The collected stormwater is used for washing boots and other equipment.

- P8 Model Device Type = Detention Pond
- Overflow is routed through a drain to the Pocket Sand Filter.
- Dimensions: Diameter = 6 feet, Height = 4 feet.
- Flood pool volume = 873 gallons = 0.00268 acre-feet. (Based on diameters of cistern)
- Fixed drawdown assumed to be 10 gallons/day = 87 days = 2095 hours. (According to Merrill Center staff, this cistern is "never empty."
- This device is included in the LOD models

BIG CISTERNS

The large cisterns collect runoff from the main roof. 90% of the cistern volume is reserved for fire suppression. If the water level in the cisterns drops below 90%, the water supply is replenished with potable well water. However, according to Merrill Center staff, the water level in the cisterns has never dropped to a level that would require well water to be added to the cisterns. The remaining 10% of the cistern volume is filtered and used for a variety of non-potable indoor uses, including showering and hand washing. Approximately 60 gallons per day are routed from the cisterns to these indoor uses.

In the P8 models, the three large cisterns are modeled as a single device.

- P8 Model Device Type = Detention Pond
- Overflow is routed to Swale 3a.
- The combined capacity of the cisterns is 19,500 gallons (0.05983 acre-feet)
- Flood pool volume = 0.005983 acre-feet
- Infiltration = N/A
- Flood pool drawdown = 1000 hours. (This is approximately the amount of time required to deplete the flood pool at a rate estimated by Merrill Center staff of 60 gallons per day during 5 working days per week.)
- This device is included in the LOD models

RAIN BARRELS (2 Barrels Located Near Front Door)

Two rain barrels located near the front door collect water from the portico roof. The collected stormwater is used to irrigate the green roof as needed. In the P8 models, these two barrels are modeled as a single device.

- P8 Model Device Type = Detention Pond
- Overflow is routed to the Rain Garden.
- The combined capacity of the rain barrels (flood pool volume) is 0.000246 acre-feet.
- Infiltration = None
- Flood pool drawdown = 336 hours. (Estimated based on personal communication with Merriill Center staff).
- This device is included in the LOD models

SMALL CISTERNS

Three small cisterns are located near the green roof collect water from a portion of the main roof. The collected stormwater is used to irrigate vegetation in the rain garden. In the P8 models, these three small cisterns are modeled as a single device.

- P8 Model Device Type = Detention Pond
- Overflow is routed to Rain Garden.
- The combined capacity of the cisterns (flood pool volume) is 0.00804 acre-feet.
- Infiltration = None
- Flood pool drawdown = 500 hours. (Estimated based on personal communication with Merriill Center staff).
- This device is included in the LOD models

E.1.1.7 Infiltration Basins

BRF (Biorention Filter)

- Bottom area = 0.032 acres
- Storage Pool Area = 0.07 acres
- Storage Pool Volume = 0.0765 acre-feet
- Void Volume = 90% (substantial vegetation present)
- Infiltration rate = 1.795 in/hr. (Loamy sand) (McCuen et al. 1986, Shaver 1986)
- This device is included in the LOD models

PSC (Pretreatment Sedimentation Chamber)

- Bottom area = 0.012 acres
- Storage Pool Area = 0.021 acres
- Storage Pool Volume = 0.025 acre-feet
- Void Volume = 100%
- Infiltration rate = 1.795 in/hr. (Loamy sand) (McCuen et al. 1986, Shaver 1986)
- This device is included in the LOD models

PSF (Pocket Sand Filter)

- Bottom area = 0.031 acres
- Storage Pool Area = 0.083 acres
- Storage Pool Volume = 0.0513 acre-feet
- Void Volume = 100%
- Infiltration rate = 6.45 inches/hour. (Sand) (McCuen et al. 1986, Shaver 1986)
- This device is included in the LOD models

WOODS4

- Bottom area = 0.034 acres
- Storage Pool Area = 2.22 acres
- Storage Pool Volume = 4.7 acre-feet
- Void Volume = 100%
- Infiltration rate = 0.1 inches/hour. (Poorly drained soils – wetland)

E.1.1.8 Aquifer Devices

AQUIFER

- P8 Model Device Type = Aquifer
- Time of Concentration = 72 hours
- This device is included in the LOD models

GREEN ROOF

- This device represents the “aquifer” portion of the green roof, which lies underneath the pervious green roof watershed.
- Time of concentration = 8 hours

- This device is included in the LOD models

PSF AQUIFER (Pocket Sand Filter)

- This device represents the "aquifer" portion of the pocket sand filter.
- Time of concentration = 2.79 hours (based on infiltration rate of 6.45 in/hr through 18" of sand.
- This device is included in the LOD model.

Pipes can be used in P8 as accounting devices for tracking outflow, or to represent actual conveyances. The following pipes were used in the Merrill Center model:

- **INLET I2 –** This pipe conveys water from a portion of the parking area to the Pretreatment Sediment Chamber. Time of Concentration = 0.1 hours (est.)
- **PIPE –** This represents the total outflow for each model
- **SFLOW PIPE –** This pipe is used to track surface outflow in each model.

F

STORMWATER MODEL DESIGN PARAMETERS AND RESULTS FOR WETLANDS STUDIES AND SOLUTIONS, INC.

Table F-1
Pollutant loads from WSSI model (lbs/yr)

Scenario	Existing	Existing	Existing	Existing	Baseline	Baseline	Baseline	Baseline	Pre-Development
Pollutant/Source Area	Undeveloped	Parking	Roof	Total	Undeveloped	Parking	Roof	Total	Total
Suspended solids	23.0	42.8	4.8	70.6	49.8	311.1	188.1	549.0	112.9
P10%	13.1	21.8	4.2	39.1	20.1	102.2	51.8	174.1	28.2
P30%	6.2	12.3	0.5	19.0	14.2	85.8	46.0	146.0	28.2
P50%	2.6	5.5	0.1	8.2	9.4	60.2	36.9	106.5	28.2
P80%	1.0	3.2		4.2	6.1	62.9	53.4	122.4	28.2
Total phosphorus	0.06	0.18	0.11	0.36	0.07	0.39	0.20	0.66	0.09
Kjeldahl nitrogen	5.36	1.69	2.67	9.72	5.32	2.81	1.40	9.53	6.69
Copper	0.134	0.042	0.020	0.196	0.134	0.070	0.035	0.239	0.170
Lead	0.051	0.009	0.044	0.104	0.051	0.034	0.018	0.103	0.065
Zinc	0.610	0.136	0.007	0.753	0.604	0.258	0.131	0.993	0.759
PAH	0.000	0.012	0.000	0.012	0.000	0.077	0.042	0.119	0.000

*PX% values are size fractions of suspended solids. In each size fraction, X% of the mass of particles in runoff are smaller than the lower limit of that fraction.

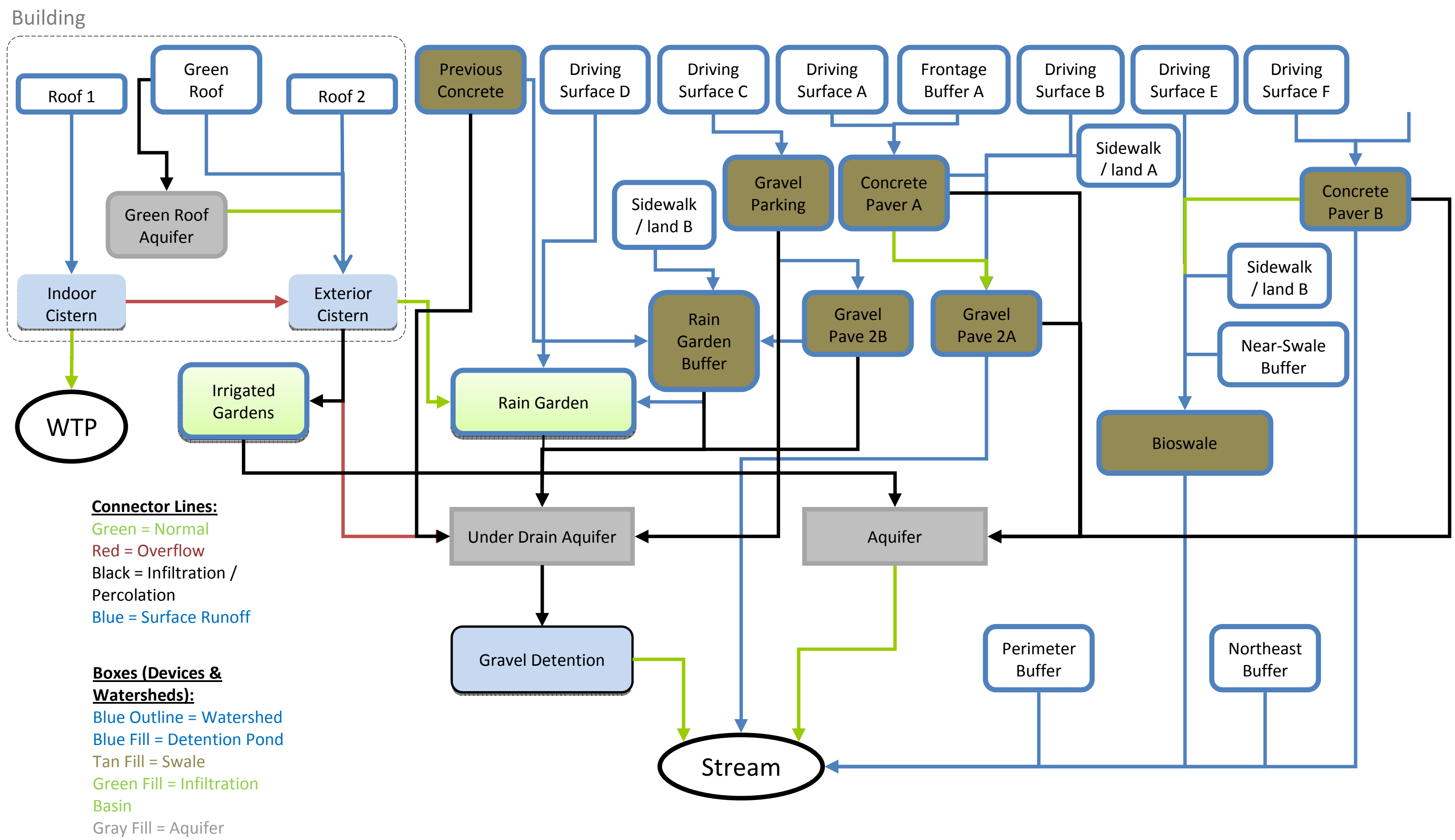


Figure F-1
WSSI existing scenario schematic

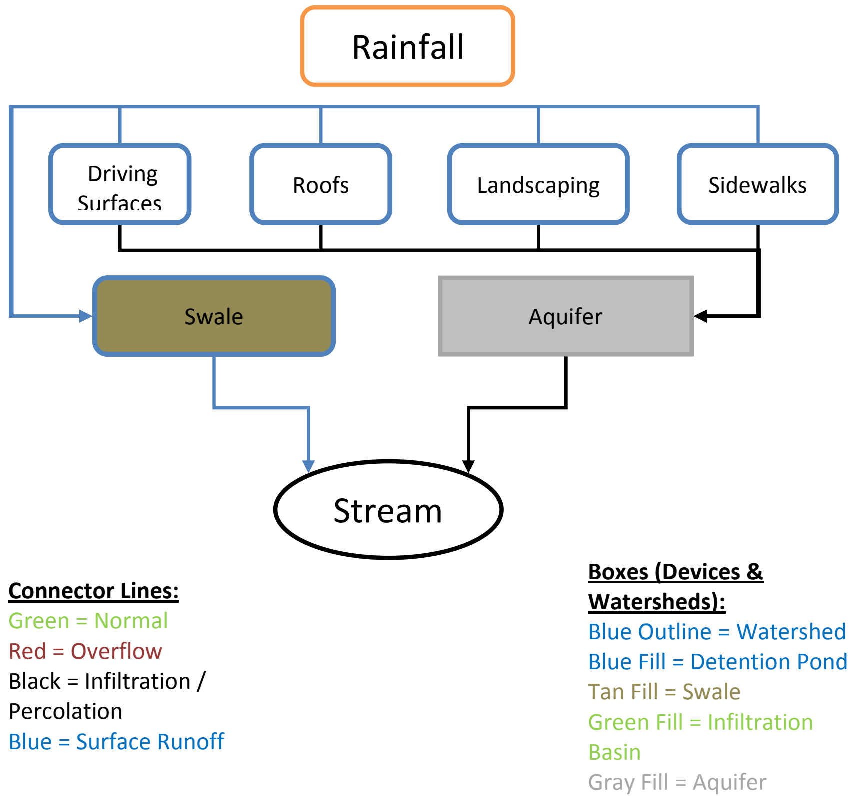


Figure F-2
WSSI baseline scenario schematic

F.1 WSSI P8 Model Design Parameters

Each P8 model is configured as a network of **watersheds** and treatment **devices** (Walker 2007). In simulating particle removal, each device is assumed to be "completely mixed" (i.e., one stirred tank), as opposed to plug flow (infinite stirred tanks). This assumption may be conservative in some cases, particularly swales/buffer strips.

Swales can be used within P8 to model overland flow. For all swales, the flow length is measured along the longest path within the device area that follows the slope of the device. Swale lengths were derived from WSSI Engineering Schematics.

P8 does not keep track of precipitation falling directly on a device. In order to provide a complete water budget, watershed areas and weighted curve numbers are specified to include device areas.

Watersheds and devices used for the "existing condition" model are described below.

F.1.1 Watersheds

These areas are located within the "Field Verified RPA" line (site boundary). The areas of most watersheds were compiled using values listed in WSSI LID and LEED Engineering Schematics 12a, 12b, and 12c. Remaining area measurements were calculated using desktop GIS software.

F.1.1.1 Pervious Watersheds

Curve numbers for pervious areas are derived from the WSSI LID and LEED Engineering Schematics 12a, 12b, and 12c or SCS (1977). Areas for Frontage Buffer A, Frontage Buffer B, Northeast Buffer, and Near-Swale Buffer areas estimated via personal communication with WSSI.

Green Roof

- Area = 3,626 square feet = 0.08324 acres
- Curve Number = 30

Rain Garden

- Area = 1,536 square feet = 0.03526 acres
- Curve Number = 71 (New soil material was not brought on-site for the construction of the rain garden (WSSI), so existing C soil was assumed)

Gravel Parking

- Area = 1,275 square feet = 0.02922 acres
- Curve Number = 76

Gravel Pave 2 A

- Area = 2,898 square feet = 0.06652 acres
- Curve Number = 56

Gravel Pave 2 B

- Area = 8,502 square feet = 0.1952 acres
- Curve Number = 56

Pervious Concrete

- Area = 11,800 square feet = 0.2709 acres
- Curve Number = 56

Concrete Pavers A

- Area = 0.06728 = acres
- Curve Number = 65

Concrete Pavers B

- Area = 2571 square feet = 0.05902 acres
- Curve Number = 65

Bioswale

- Area = 0.51 acres
- Curve Number = 100 (this routes all rainfall on the bioswale directly into the bioswale device)

Frontage Buffer A (top of berms to pavers)

- Area = 0.04272 acres
- Curve Number = 78 (D soil, meadow)

Frontage Buffer B (top of berms to pavers)

- Area = 0.04098 acres
- Curve Number = 78 (D soil, meadow)

Rain Garden Buffer

- Area = 11,693 square feet = 0.2684 acres
- Curve Number = 71

Perimeter Buffer (includes Garden)

- Area = 23,656 square feet – 4,368 (outside RPA boundary) = 19,288 square feet = 0.4428 acres
- Curve Number = 78 (D soil, meadow)

Northeast Floodplain Buffer

- Area = 3,589 square feet – 1,019 square feet (area of Near-Swale Buffer) = 2,570 square feet = 0.05899 acres
- Curve Number = 78 (D soil, meadow)

Near-Swale Buffer

- Area = 1,019 (square feet) = 0.02339 acres
- Curve Number = 78 (D soil, meadow)

F.1.1.2 Impervious Watersheds

Main Roof

According to WSSI, “The two downspouts farthest from the green roof (northwest) drain to the interior cistern. The remainder (3 on the main roof and 5 on the green roof) drain to the exterior cistern.”

Roof to Indoor Cistern

- Area = 0.24 acres
- Curve Number = 98

Roof to Exterior Cistern

- Area = 0.40 acres
- Curve Number = 98

Kennel

- Area = 576 square feet = 0.01322 acres
- Curve Number = 98

Driving Surfaces

Areas and drainage pathways for Driving Surface watersheds and runoff were estimated using Civil Engineering Schematics, elevation contours, and drainage arrows from the 2009 LID CAD files. Driving surfaces were assumed to prohibit percolation.

Driving Surface A

- Area = 5,896 square feet = 0.1354 acres
- Curve number = 98

Driving Surface B

- Area = 10,569 square feet = 0.2426 acres
- Curve number = 98

Driving Surface C

- Area = 13,318 square feet = 0.3057 acres
- Curve Number = 98

Driving Surface D

- Area = 6,008 square feet = 0.1300 acres
- Curve number = 98

Driving Surface E

- Area = 0.3680 acres
- Curve number = 98

Driving Surface F

- Area = 0.0820 acres
- Curve number = 98

F.1.1.3 Partially Impervious Watersheds

The P8 model can incorporate watersheds that with a mix of pervious and impervious areas. For some areas near the WSSI building, this mixed watershed model was used. The percentage of pervious and impervious areas of the sidewalk/landscaping areas were estimated using the 2009 WSSI CAD Files and the LID and LEED Engineering Schematics, 12a, 12b, 12c.

Sidewalk and Landscaping A

- Total Acres = 0.1202
- Pervious Acres = 0.03370
- Impervious Acres = 0.08640
- % Impervious = 72%
- % Pervious = 28%

Sidewalk and Landscaping B

- Total Acres = 0.06850
- Pervious Acres = 0.05130
- Impervious Acres = 0.01717
- % Impervious = 25%
- % Pervious = 75%

Sidewalk and Landscaping C

- Total Acres = 0.02396
- Pervious Acres = 0.02116
- Impervious Acres = .002800
- % Impervious = 12%
- % Pervious =88%

F.1.1.4 Devices

Exterior Cistern

Information obtained via personal communication with WSSI and from Xerxes Corporation (2009). For the purposes of modeling, the cistern was modeled as an upright cylinder with a volume equivalent to the volume of the cistern below the overflow outlet (7,747 gallons). The permanent pool in this device represents the volume of water that resides below the outlet to the rain garden. The flood pool in this device represents the volume of water that resides above the outlet to the rain garden and below the overflow outlet to the gravel bed detention area.

- P8 Model Device Type = Detention Pond
- Normal Outflow = Rain garden
- Overflow Outflow = Underdrain Aquifer
- Infiltration = Irrigated gardens

- Bottom Elevation = 0
- Bottom area = 0.00115 acres
- Permanent pool area = 0.00115 acres
- Flood pool area = 0.00115 acres
- Permanent pool volume = 7,747 gallons = 0.02378 acre-feet *3/4 = 0.01783
- Flood pool volume = 7,747 gallons = 0.02378 acre-feet *1/4 = 0.005950
- Permanent pool infiltration rate = 3.122 inches/hr. This infiltration rate represents the volume of water required to irrigate the native vegetation acreage (1.17 acres) with 0.5 inches per week.
- Flood pool infiltration rate = 0
- Outflow pipe to Gravel Bed Detention = 4" diameter orifice
- Orifice coefficient = 0.6 (Bedient & Huber, 1988)

Indoor Cistern

Information obtained via personal communication with WSSI and from Xerxes Corporation (2009). The indoor cistern collects runoff from 3 of the roof's 5 outflows and the collected water is used to flush the toilets inside the building. The cistern has been sized to detain the first 1/2inch of rainfall on the roof without overflowing (~4,000 gallons). The following usage estimates provided by WSSI were used for the modeling: "We assumed 2 flushes per person per day for the interior cistern. Each flush is 1.9 gallons, and there are 75 employees."

- P8 Model Device Type = Detention Pond
- Normal Outflow = Wastewater Treatment Facility
- Overflow Outflow = Exterior cistern
- Flood pool area = 0.000577 acres
- Bottom area = 0.000577 acres
- Flood pool volume = 4,000 gallons = 0.01227 acre-feet
- Bottom Elevation = 0
- No permanent pool
- Infiltration Rate =0.7579 in/hr = 285 gallons/day = 75 people * 2 flushes/day * 1.9 gallons/flush

Gravel Detention

According to WSSI, this device currently releases the stormwater generated during a 1 year storm (3 inches in 24 hours) over 24-30 hours.

- P8 Model Device Type = Detention Pond
- Normal Outflow = Baseflow
- Infiltration = Aquifer
- Overflow= N/A (According to WSSI, the gravel detention does not overflow, even during extreme events)
- Bottom Elevation = 328.7 feet
- Bottom Area = 7,529 square feet (0.17284 acres) (Estimated from WSSI documents)
- Flood pool area = 7,529 square feet (0.17284 acres)
- Flood pool Volume = 1 acre-ft (this volume is inflated to prohibit overflow in the model during June 2006 storm)
- Flood pool Infiltration Rate = 0.5 inches/hour
- Orifice Diameter = 1.625 inches.
- Orifice Coefficient = 0.6 (Bedient & Huber, 1988)

Rain Garden Basin

- The total volume of the Rain Garden Basin includes the Rain Garden Area and the Rain Garden Buffer.
- P8 Model Device Type = Infiltration Basin
- Bottom Elevation = 330.5 (elevation of under-drain pipe)
- Bottom Area =1,536 (square feet) = 0.01607 acres
- Storage Pool Area = 0.3037 acres
- Storage Pool Volume = 1.586 acre-feet
- Void Volume = 100%
- Infiltration Rate = 7.37 inches/hour. This reflects the gravel drainage system underlying the rain garden. According to WSSI, the basin drains within 12 hours of a storm.

Irrigated Gardens

These gardens are irrigated with water from the exterior cistern.

- P8 Model Device Type = Infiltration Basin
- Bottom Elevation = 0
- Bottom Area = 1.17 acres
- Storage Pool Area = 1.17 acres
- Storage Pool Volume = 1.17 acre-feet

- Void Volume = 100%
- Infiltration Rate = 0.13 in/hr.

Rain Garden Buffer Swale

- P8 Model Device Type = Swale
- Outflow = Rain Garden
- Infiltration = Underdrain Aquifer
- Open Space Vegetated Buffer Area = 11,693 square feet = 0.2684 acres
- Maximum Flow Path Length = 12 feet
- Maximum Bottom Width = 255. This is the approximate length of the perimeter of the rain garden pond.
- Bottom Elevation = 331.17 feet. This is the elevation of the gravel bed detention.
- Maximum Depth = 0.25 ft
- Side Slope =10
- Flow Path Slope = 4%
- Infiltration Rate = 0.13 inches/hour (C Soils) (Yousef et al., 1986)
- Manning's N = 0.25 (Bedient and Huber, 1988)

Green Roof Swale

- P8 Model Device Type = Swale
- Outflow = Green Roof Pipe
- Infiltration = Green Roof aquifer
- Maximum Flow Length = 18 feet
- Area = 3,626 square feet = 0.08324 acres
- Maximum Depth = 0.25. According to WSSI, water never overflows capacity.
- Slope = 1%. This is the slope value recommended by the manufacturer of this system.
- Side Slope = 10.
- Infiltration rate = 0.43 inches/hour. "Lightweight Growing Medium" was translated to Sandy Loam (Yousef et al. 1986).
- Manning's N = 0.20. This is the minimum value for light turf, lawns (Bedient and Huber, 1988).

Gravel Parking

- P8 Model Device Type = Swale
- Outflow = Gravel Detention
- Infiltration = Under Drain Pipe
- Maximum Flow Path Length = 69 feet
- Maximum Bottom Width = 18 feet
- Bottom Elevation = 331 feet
- Maximum Depth = 1 ft (arbitrary to prevent overflow)
- Infiltration rate = 7.37 inches/hour for Gravel Pave 2
- Side Slope = 10
- Manning N = 0.02
- Flow Path Slope = 1.9% (WSSI LID documentation)

Gravel Pave 2A

- P8 Model Device Type = Swale
- Outflow = Northwest Floodplain Pipe
- Infiltration = Aquifer
- Maximum Flow Path Length = 162 feet
- Maximum Bottom Width = 18 feet
- Bottom Elevation = 335 feet
- Maximum Depth = 1 ft
- Infiltration rate = 7.37 inches/hour for Gravel Pave 2
- Side Slope = 10
- Manning's N = 0.25 (Ferguson, 2005).
- Flow Path Slope = 1.9% (WSSI LID documentation)

Gravel Pave 2B

- P8 Model Device Type = Swale
- Outflow = Gravel detention
- Infiltration = Under drain Pipe
- Maximum Flow Path Length = 178 feet
- Maximum Bottom Width = 62 feet
- Bottom Elevation = 331 feet

- Maximum Depth = 1 ft
- Infiltration rate = 7.37 inches/hour for Gravel Pave 2
- Side Slope = 10
- Manning's N = 0.25 (Ferguson, 2005).
- Flow Path Slope = 1.9% (WSSI LID documentation)

Pervious Concrete

- P8 Model Device Type = Swale
- Outflow = Gravel detention
- Infiltration = Under drain Pipe
- Bottom Elevation = 331.00
- Maximum Flow Path Length =194 feet
- Maximum Bottom Width = 62 feet
- Maximum Depth = 1 ft
- Bottom Elevation = 331
- Infiltration rate = 7.37 inches/hour
- Side Slope = 10
- Manning's N = 0.25 (Ferguson, 2005).
- Flow Path Slope = 1.9% (WSSI LID documentation)

Concrete Pavers A

- P8 Model Device Type = Swale
- Outflow = Gravel Pave 2 A
- Infiltration = Aquifer
- Maximum Flow Path Length = 147 feet
- Maximum Bottom Width = 18 feet
- Bottom Elevation = 342 feet
- Maximum Depth = 1 ft
- Side Slope = 10
- Infiltration rate = 7.37 inches/hour
- Manning's N = 0.25 (Ferguson, 2005).
- Flow Path Slope = 1.9% (WSSI LID documentation)

Concrete Pavers B

- P8 Model Device Type = Swale
- Outflow = Northeast Floodplain Pipe
- Infiltration = Aquifer
- Bottom Elevation = 342
- Maximum Flow Path Length = 127 feet
- Maximum Bottom Width = 18 feet
- Maximum Depth = 1 ft
- Side Slope = 10
- Infiltration rate = 7.37 inches/hour
- Manning's N = 0.25 (Ferguson, 2005).
- Flow Path Slope = 1.9% (WSSI LID documentation)

Bioswale 1

- The Bioswale has 3 "rock check dam filters holding 270 cubic feet." These check dams consist of gravel piles in the middle of the swale and are designed to slow the flow of water in the swale.
- P8 Model Device Type = Swale
- Outflow = Runoff
- Infiltration = Aquifer
- Area = 0.51 Acres
- Bottom Elevation = 332.8
- Flow Path Length = 255 feet
- Flow Path Slope = 0.5% (According to WSSI schematics, the actual slope is 1.6%, but the check dams effectively lower slope).
- Maximum Bottom Width (around curve) = 14 feet
- Side Slope = 3.5
- Maximum Depth = 1.1 foot (estimated from height of check dams)
- Infiltration Rate = 0.13 (Yousef et al. 1986) for Hydro Soil Group C
- Manning's N = 0.25. (Bedient and Huber, 1988)

Aquifer

- P8 Model Device Type = Aquifer
- Time of concentration = 168 hours (1 week)

Green Roof Aquifer

- P8 Model Device Type = Aquifer
- Time of concentration = 1.09 hours (8 inches of media below green roof / infiltration rate of 7.37 inches per hour)

Underdrain Aquifer

- P8 Model Device Type = Aquifer
- Time of concentration = 12 hours (observed gravel detention outflow lag)

Pipes

Pipes can be used in P8 as accounting devices for tracking outflow. The following pipes were used in the WSSI model:

- **Unexpected Overflow** (checks for overflows from raingarden or gravel bed detention)
- **WTP** (water that goes to wastewater treatment plant from indoor fixtures)
- **Baseflow** (sum of aquifer and gravel bed detention outflows)
- **Runoff** (sum of all surface runoff from watersheds)
- **Stream** (sum of baseflow and runoff)

G

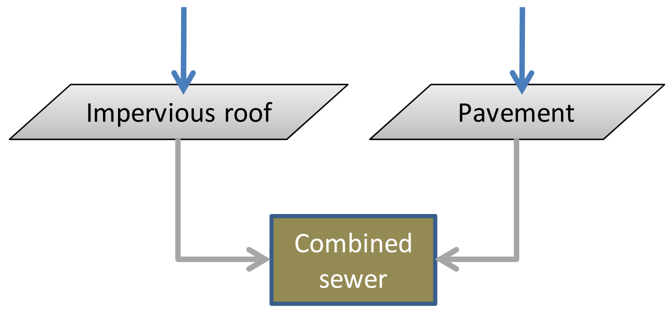
STORMWATER MODEL DESIGN PARAMETERS AND RESULTS FOR MILLENNIUM TOWERS

Table G-1
Pollutant loads from millennium tower model (lbs/yr)

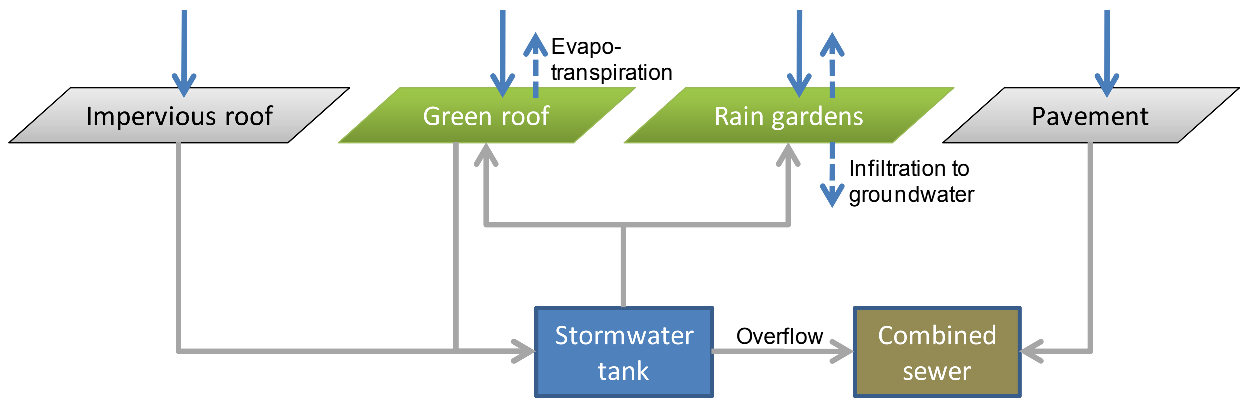
Scenario	Baseline	Baseline	Baseline	Existing	Existing	Existing	Existing	Drawdown	Drawdown	Existing	Drawdown
Pollutant/ Source Area	Roof	Sidewalk	Total	Impervious Roof	Green Roof	Sidewalk	Total	Impervious Roof	Green Roof	Sidewalk	Total
Suspended solids	127.5	229.7	357.3	59.1	2.0	202.7	263.7	62.2	2.0	202.7	266.9
P10%	85.0	45.9	131.0	45.5	0.7	40.5	86.7	50.2	0.7	40.5	91.4
P30%	27.1	45.9	73.0	9.6	0.6	40.5	50.7	9.2	0.6	40.5	50.3
P50%	15.5	45.9	61.4	3.9	0.4	40.5	44.9	2.8	0.4	40.5	43.8
P80%	0.0	91.9	91.9	0.0	0.3	81.1	81.4	0.0	0.3	81.1	81.4
Total phosphorus	0.64	0.18	0.82	0.35	0.04	0.16	0.55	0.37	0.04	0.16	0.57
Kjeldahl nitrogen	7.50	1.20	8.71	5.01	0.07	1.06	6.14	5.19	0.07	1.06	6.33
Copper	0.050	0.030	0.080	0.035	0.000	0.027	0.062	0.036	0.000	0.027	0.063
Lead	0.136	0.018	0.154	0.088	0.000	0.016	0.104	0.092	0.000	0.016	0.108
Zinc	0.147	0.116	0.263	0.069	0.001	0.103	0.173	0.072	0.001	0.103	0.176
PAH	0.005	0.043	0.048	0.002	0.000	0.038	0.040	0.002	0.000	0.038	0.040

*PX% values are size fractions of suspended solids. In each size fraction, X% of the mass of particles in runoff are smaller than the lower limit of that fraction.

G.1 Baseline Scenario



G.2 Existing Scenario



G.3 Drawdown Scenario

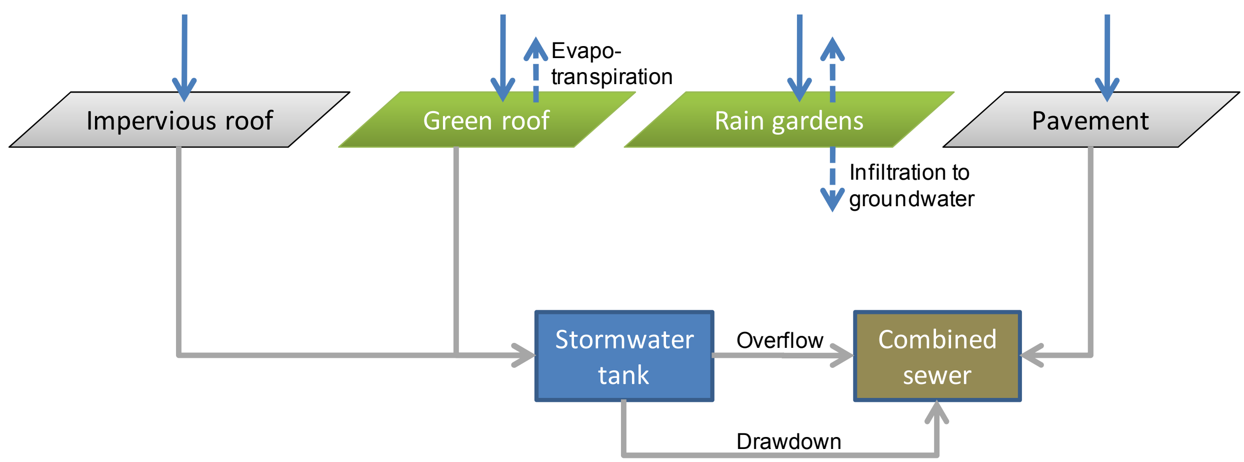


Figure G-1
Millennium tower scenario schematics

G.4 Millennium Tower P8 Model Design Parameters

Each P8 model is configured as a network of **watersheds** and treatment **devices** (Walker 2007). In simulating particle removal, each device is assumed to be "completely mixed" (i.e., one stirred tank), as opposed to plug flow (infinite stirred tanks). P8 does not keep track of precipitation falling directly on a device. In order to provide a complete water budget, watershed areas and weighted curve numbers are specified to include device areas.

Watersheds and devices used for the "existing condition" model are described below.

G.4.1 Watersheds

These are areas within the site boundary. Curve numbers are derived from SCS (1977). Watershed areas were derived from LEED documentation.

G.4.1.1 Green Roof

- Area = 0.0944 acres
- SCS Curve Number (Pervious) = 61 (from P8 help)

G.4.1.2 Rain Gardens

- Area = 0.02 acres
- Unswept Impervious Fraction = 1 (routes all rain to Rain Gardens device)
- Unswept Depression Storage = 0 inches
- Unswept Impervious Runoff Coefficient = 1

G.4.1.3 Impervious Roof

- Area = 0.255 acres
- Unswept Impervious Fraction = 1
- Unswept Depression Storage = 0.08 inches (from P8 help)
- Unswept Impervious Runoff Coefficient = 0.907 (from P8 help)

G.4.1.4 Sidewalks

- Area = 0.1497 acres
- Unswept Impervious Fraction = 1
- Unswept Depression Storage = 0.022 inches (from P8 help)
- Unswept Impervious Runoff Coefficient = 0.701 (from P8 help)

G.4.2 Devices

G.4.2.1 GreenRoofAquifer

- The GreenRoofAquifer device represents the water-bearing media underneath the rain garden.
- P8 Model Device Type = Aquifer
- Time of Concentration: 8 hours (8 inches deep, assumed 1 in/hour infiltration)

G.4.2.2 StorageTank

- P8 Model Device Type = Pond
- No infiltration and no permanent pool
- Normal outlet = Raingardens
- Overflow outlet = Runoff
- Flood pool bottom area = 0.00265 acres
- Flood Pool Area = 0.00265 acres
- Flood Pool Volume = 0.0285 acre-feet
- Flood Pool Infiltration Rate =0 inches/hour
- Outlet Type = FIXED_T (Fixed drawdown time)
- Flood pool drain time = 13,392 hours = (9,300 gallons [tank volume]/500 gallons [monthly irrigation use]) * 30 days *24 hours

G.4.2.3 Raingardens

- P8 Model Device Type = Infiltration Basin
- Bottom area = 0.02 acres
- Flood Pool Area = 0.02 acres
- Flood Pool Volume = 0.01 acre-feet (assumed 0.5 ft ponding depth before overflow to sidewalk)
- Flood Pool Infiltration Rate = 1 inch/hour
- Infiltration Basin Void Fraction = 100%

G.4.2.4 Runoff

- P8 Model Device Type = Pipe (Pipes can be used in P8 as accounting devices for tracking outflow).
- Time of concentration = 0

H
ALTERNATIVE GREEN BUILDING RATING SYSTEMS

H.1 The Sustainable Sites Initiative

The Sustainable Sites Initiative (SSI) is a set of guidelines and performance benchmarks developed by the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center – University of Texas at Austin, and the United States Botanic Garden. With a goal of transforming land development and management practices, SSI "aims to supplement existing green building and landscape guidelines as well as to become a stand-alone tool for site sustainability."[1]

The SSI rating system differs from green building rating systems in these significant ways:

- **Its impacts scope is broad and its credits relational.** The Initiative's benchmarks are designed within the context of the ecosystem rather than the individual building, and are meant to be used in an interconnected way. SSI's rating system gauges the broader effects of site management practices, as well as understanding the synergies between separate BMPs. There is an entire section of the Guidelines which describes the concept of ecosystem cycles, and, intriguingly "ecosystem services" which are the human and economic benefits of well-functioning ecosystems.
- **There is an emphasis on the use of an integrated design process which brings all project stakeholders to the table.**
- **Practices are evaluated from the point of view of the total life cycle of the site and its design.** This results in credits that assess operations and maintenance concerns even in new construction.
- **SSI places greater proportional rewards on restoration** – on things ranging from soils themselves to natural features like streams.
- **SSI includes a greater diversity of credits that address onsite management strategies.**
- **SSI evaluates sites from the aspect of specific human use and interaction,** not just from the point of view of human health.
- **SSI addresses achievement "on three fronts -- not only environmental but also economic and social."** A discussion of the economic and social implications of good sites practice is woven into the Guidelines. Values are foremost: SSI's foundation is a statement of ten "Guiding Principles of a Sustainable Site". These principles include concepts not mentioned in other rating systems: concepts like "systems thinking," "ethical approach," and "stewardship."

[1] P.3

1. **Do no harm.** Make no changes to the site that will degrade the surrounding environment. Promote projects on sites where previous disturbance or development presents an opportunity to regenerate ecosystem services through sustainable design.
2. **Precautionary principle.** Be cautious in making decisions that could create risk to human and environmental health. Some actions can cause irreversible damage. Examine a full range of alternatives including no action—and be open to contributions from all affected parties.
3. **Design with nature and culture.** Create and implement designs that are responsive to economic, environmental, and cultural conditions with respect to the local, regional, and global context.
4. **Use a decision-making hierarchy of preservation, conservation, and regeneration.** Maximize and mimic the benefits of ecosystem services by preserving existing environmental features, conserving resources in a sustainable manner, and regenerating lost or damaged ecosystem services.
5. **Provide regenerative systems as intergenerational equity.** Provide future generations with a sustainable environment supported by regenerative systems and endowed with regenerative resources.
6. **Support a living process.** Continuously re-evaluate assumptions and **values** and adapt to demographic and environmental change.
7. **Use a systems thinking approach.** Understand and value the relationships in an ecosystem and use an approach that reflects and sustains ecosystem services; re-establish the integral and essential relationship between natural processes and human activity.
8. **Use a collaborative and ethical approach.** Encourage direct and open communication among colleagues, clients, manufacturers, and users to link long-term sustainability with ethical responsibility.
9. **Maintain integrity in leadership and research.** Implement transparent and participatory leadership, develop research with technical rigor, and communicate new findings in a clear, consistent, and timely manner.
10. **Foster environmental stewardship.** In all aspects of land development and management, foster an ethic of environmental stewardship—an understanding that responsible management of healthy ecosystems improves the quality of life for present and future generations.[2]

Here is the list of the 2008 draft prerequisites and credits of the SSI. The credits in red are those unique to SSI, and not covered by the BREEAM, LEED, or Green Globes in the area of new construction.

[2] P.7

1 SITE SELECTION

Select locations to preserve existing resources and repair damaged systems

1.1 Prerequisite Preserve threatened or endangered species habitat

1.2 Prerequisite Protect and restore floodplain functions of riparian and coastal zones

1.3 Prerequisite Limit disturbance of prime farmland soils, unique soils, and soils of statewide importance

1.4 Credit Select brownfields or greyfields for redevelopment

2 PRE-DESIGN ASSESSMENT AND PLANNING

Plan for sustainability from the onset of the project

2.1 Prerequisite Conduct a pre-design site assessment

2.2 Prerequisite Use an integrated design process

2.3 Prerequisite Develop a program plan with site performance goals

2.4 Credit Engage users and other stakeholders in meaningful participation in site design

3 SITE DESIGN—ECOLOGICAL COMPONENTS

Protect and restore site processes and systems

3.1 Prerequisite Control and manage invasive species

3.2 Prerequisite Use appropriate, non-invasive plants

3.3 Prerequisite Preserve special status trees

3.4 Prerequisite Reduce potable water consumption for irrigation

3.5 Credit Minimize or eliminate potable water consumption for irrigation

3.6 Credit Preserve and restore plant biomass on-site

3.7 Credit Minimize building heating and cooling requirements with vegetation

3.8 Credit Reduce urban heat island effects

3.9 Credit Promote a sense of place with native vegetation

3.10 Credit Preserve and restore native wildlife habitat

3.11 Credit Protect and restore riparian and wetland buffers

3.12 Credit Repair or restore damaged or lost streams, wetlands, and coastal habitats

3.13 Credit Preserve existing healthy soils

3.14 Credit Preserve existing topography

3.15 Credit Restore soils disturbed by previous development

3.16 Credit Manage water on-site

3.17 Credit Cleanse water on-site

3.18 Credit Eliminate potable water use in ornamental or stormwater features

3.19 Credit Minimize use of potable water in water features designed for full human contact

3.20 Credit Mitigate potential wildfire risks

4 SITE DESIGN—HUMAN HEALTH COMPONENTS

Build strong communities and a sense of stewardship

4.1 Credit Promote equitable site design, construction, and use

4.2 Credit Promote sustainability awareness and education

4.3 Credit Provide for optimum site accessibility, safety, and wayfinding

4.4 Credit Provide views of the natural environment to building occupants

4.5 Credit Provide opportunities for outdoor physical activity

4.6 Credit Connect site to surrounding resources, amenities, and services

4.7 Credit Provide outdoor spaces for mental restoration

4.8 Credit Provide outdoor spaces for social interaction

4.9 Credit Design stormwater management features to be a landscape amenity

4.10 Credit Prevent and abate sensory stress

4.11 Credit Protect and promote unique cultural and historical site attributes

5 SITE DESIGN—MATERIALS SELECTION

Reuse/recycle existing materials and support sustainable production practices

5.1 Prerequisite Eliminate use of lumber from threatened tree species

5.2 Credit Support sustainable practices in plant production

5.3 Credit Support sustainable practices in materials manufacturing

5.4 Credit Reuse on-site structures, hardscape, and landscape amenities

5.5 Credit Use salvaged and recycled content materials

5.6 Credit Use certified wood

5.7 Credit Use products designed for reuse and recycling

5.8 Credit Use adhesives, sealants, paints, and coatings with reduced VOC emissions

5.9 Credit Conduct a life cycle assessment

6 CONSTRUCTION

Minimize effects of construction-related activities

6.1 Prerequisite Create a soils management plan

6.2 Prerequisite Restore soils disturbed during construction

6.3 Credit Achieve a carbon-neutral site

6.4 Credit Divert construction and demolition materials from disposal

6.5 Credit Control and retain construction pollutants

6.6 Credit Use excess vegetation, rocks, and soil generated during construction

7 OPERATIONS AND MAINTENANCE

Maintain the site for long-term sustainability

7.1 Prerequisite Plan for sustainable landscape maintenance

7.2 Credit Minimize exposure to localized air pollutants

7.3 Credit Recycle organic matter generated during site operations and maintenance

7.4 Credit Provide for storage and collection of recyclables

7.5 Credit Use renewable sources for site outdoor electricity[3]

[3] P. 41-42.

I

ISO 14000 AND ENVIRONMENTAL MANAGEMENT STANDARDS

The International Organization for Standardization (ISO), a voluntary, non-government, international organization, and the world's largest standards developing organization. ISO has published international standards since 1947, covering many scientific and management fields; it forms technical committees of experts to develop standards proposed by ISO member nations. These standards are then debated in national delegations of experts until they reach consensus, when the draft standard is submitted to ISO members for voting and comment.

ISO provides a summary of their standards and guidelines for establishing an **environmental management framework** at http://www.iso.org/iso/iso_catalogue/management_standards/iso_9000_iso_14000/iso_14000_essentials.htm

Table I-1, below, provides the text of that summary.

Table I-1
ISO 14000 summary of standards

ISO 14000 essentials

The ISO 14000 family addresses various aspects of environmental management. The very first two standards, **ISO 14001:2004** and **ISO 14004:2004** deal with environmental management systems (EMS). ISO 14001:2004 provides the **requirements** for an EMS and ISO 14004:2004 gives general EMS **guidelines**.

The other standards and guidelines in the family address specific environmental aspects, including: labeling, performance evaluation, life cycle analysis, communication and auditing.

An ISO 14001:2004-based EMS

An EMS meeting the requirements of ISO 14001:2004 is a management tool enabling an organization of any size or type to:

- identify and control the **environmental impact** of its activities, products or services, and to
- **improve** its environmental performance continually, and to
- implement a **systematic approach** to setting environmental objectives and targets, to achieving these and to demonstrating that they have been achieved.

How it works

ISO 14001:2004 does not specify levels of environmental performance. If it specified levels of environmental performance, they would have to be specific to each business activity and this would require a specific EMS standard for each business. That is not the intention.

ISO has many other standards dealing with specific environmental issues. The intention of ISO 14001:2004 is to provide a **framework for a holistic, strategic approach** to the organization's environmental policy, plans and actions.

ISO 14001:2004 gives the **generic requirements** for an environmental management system. The underlying philosophy is that whatever the organization's activity, the requirements of an effective EMS are the same.

This has the effect of establishing a **common reference** for communicating about environmental management issues between organizations and their customers, regulators, the public and other stakeholders.

Table I-1
ISO 14000 summary of standards (continued)

Because ISO 14001:2004 does not lay down levels of environmental performance, the standard can to be implemented by a **wide variety of organizations**, whatever their current level of environmental maturity. However, a **commitment to compliance** with applicable environmental legislation and regulations is required, along with a commitment to **continual improvement** – for which the EMS provides the framework.

The EMS standards

ISO 14004:2004 provides **guidelines** on the elements of an environmental management system and its implementation, and discusses principal issues involved.

ISO 14001:2004 specifies the **requirements** for such an **environmental management system**. Fulfilling these requirements demands objective evidence which can be audited to demonstrate that the environmental management system is operating effectively in conformity to the standard.

What can be achieved

ISO 14001:2004 is a tool that can be used to meet **internal objectives**:

- **provide assurance to management** that it is in control of the organizational processes and activities having an impact on the environment
- **assure employees** that they are working for an environmentally responsible organization.

ISO 14001:2004 can also be used to meet **external objectives**:

- provide assurance on environmental issues to **external stakeholders** – such as customers, the community and regulatory agencies
- comply with environmental regulations
- support the organization's **claims and communication** about its own environmental policies, plans and actions
- provides a framework for **demonstrating conformity** via suppliers' declarations of conformity, assessment of conformity by an external stakeholder - such as a business client - and for certification of conformity by an independent certification body.

J
BREEAM POINT VALUES CONVERSION TABLES

Table J-1
Environmental weightings, BREEAM offices (O) rating system

BREEAM Section	Maximum Points Available (A)	Percentage Value for One Point in each Category (B)	New Builds, Extensions & Major Refurbishments (C)	Percentile Score for one Point in each Category After Weighting (D=B*C)
Management	10 (O)	1/10 * 100 = 10%	12%=0.12	10*0.12=1.2%
Health & Wellbeing	14 (O)	1/13 * 100=7.692%	15%=0.15	7.692*0.15=1.15%
Energy	21 (O)	1/24 * 100= 4.166%	19%=0.19	4.166*0.19= 0.79%
Transport	10(O)	1/10 * 100= 10%	8%=0.08	10*0.08= 0.80%
Water	6 (O)	1/6 * 100=16.666%	6%=0.06	16.666*0.06=0.99%
Materials	12 (O)	1/13 * 100=7.692%	12.5%=0.125	7.692*0.125=0.96%
Waste	7 (O)	1/7 * 100=14.285%	7.5%=0.075	14.285*0.075=1.07%
Land Use & Ecology	10 (O)	1/10* 100= 10%	10%=0.1	10*0.1=1%
Pollution	12 (O)	1/12* 100=8.333%	10%=0.1	8.333*0.1=0.83%
Innovation	10 (O)	1/10* 100=10%	10%=0.1	10*0.1=1%
Total	115 (O)			

Source: (BREEAM Assessor Manual, 2008)

Table J-2
Environmental weightings, BREEAM residential (R) rating system

BREEAM Section	Maximum Points Available (A)	Percentage Value for one Point in Each Category (B)	New Builds, Extensions & Major Refurbishments(C)	Percentile Score for one Point in each Category after Weighting (D=B*C)
Management	12 (R)	1/12 * 100= 8.333%	12%=0.12	8.333*0.12=0.99%
Health & Wellbeing	17(R)	1/17 * 100=5.882%	15%=0.15	5.882*0.15=0.88%
Energy	23(R)	1/23 * 100=4.34%	19%=0.19	4.34*0.19=0.82%
Transport	7(R)	1/7 * 100=14.28%	8%=0.08	14.28*0.08= 1.14%
Water	8(R)	1/8 * 100=12.5%	6%=0.06	12.5*0.06=0.75%
Materials	15(R)	1/15 * 100=6.666%	12.5%=0.125	6.666*0.125=0.83%
Waste	8(R)	1/8 * 100=12.5%	7.5%=0.075	12.5*0.075=0.937%
Land Use & Ecology	10(R)	1/10* 100=10%	10%=0.1	10*0.1= 1%
Pollution	11(R)	1/11* 100=9.090%	10%=0.1	9.09*0.1= 0.909%
Innovation	10(R)	1/10* 100=10%	10%=0.1	10*0.1=1%
Total	121 (R)			

Source: (BRE Global LTD., 2009e)

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1020602

Electric Power Research Institute
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com