THE SOCIAL FEASIBILITY OF ROADSIDE RAINGARDENS: A COMPENDIUM OF SITING, DESIGN, AND ENGAGEMENT TOOLS

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University of Washington

ABSTRACT

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Pam Emerson

Chair of the Supervisory Committee:
Associate Professor, Nancy Rottle
Landscape Architecture

How can roadside raingardens be sited and designed in a way that improves neighborhoods and fosters community acceptance or even… delight?

This study attempts to answer that question by articulating strategic siting and design ideas for roadside bioretention. It offers detailed site analysis and potential approaches at three scales: design templates at the raingarden scale, design templates at the block scale, and a phasing plan/siting options at the neighborhood/basin scale. A review of the history of stormwater control in Seattle (including GSI) coupled with a summary of current public perception of stormwater and GSI, lays the social context. A survey of relevant literature on frameworks for multi-functional landscapes, place attachment and identify, human landscape preferences, aesthetics and ecological function, and the psychological underpinnings of human well-being contextualizes the siting plans and design templates and provides a theoretical lens for the chosen approaches. The study also includes a series of draft outreach materials (text and graphics) that may be refined and used to facilitate public outreach and engagement efforts. It concludes with recommendations for how the analysis, design schematics, phasing approach and outreach materials may be used to engage residents in site selection and design development and cultivate social feasibility.

Ultimately, the study asserts that social function is a category of stormwater infrastructure performance–on par with other performance assessment variables such as CSO control volumes and pollutant removal–and that it must be intentionally designed for.

The Ballard neighborhood combined-sewer basins, where the possibility of addressing combined-sewer overflows using roadside raingardens is being examined, are used as a study case.

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Ballard
Neighborhood
Greenway

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Finally, I am deeply grateful for the loving support of friends and family, who have accompanied me on this journey and helped keep me (relatively!) healthy, happy and grounded along the way. You inspire me day in and day out with the example of how you live your lives, with how you choose to invest your care, talents, and crazy big intellects. In addition to everything else you do… You made me laugh. You took me out walking. You cooked delicious food. You offered a patient and wise ear and so much encouragement. You gave helpful feedback and perspective. You played beautiful music, danced beautiful dances, and made intriguing works of art of all sorts. In short, you made it all worth it. Karl, Sylvia, Mac, Patricia, Abel, Skinny, Amy, Trina, Trey, Michael, Kate, Chris, Kim, Monica, Ginger, Leann, Andi, Deanna, Heather, Billy, Jeanie, Trouble, Eden…

And especially Melanie, Mom, Dad, Eric, Petra and Davidkovi…

I am so blessed by your love and support.   Thank you.

DEDICATION

For Karl

"I am nominating economy for equal standing among the arts. Not economics, but economy — the making of the human household upon the earth: the arts of adapting kindly the many human households to the earth's many ecosystems and human neighborhoods."

-- Wendell Berry

For Aaron

"I never learned to doubt that the city was part of nature."
-- Anne Whiston Spirn

For Davidkovi Vaclav

"You are not expected to finish the work. Neither are you free to desist from it."
-- Talmud

A non-equilibrium view of natural processes has literally changed the way scientists think about the nature of nature; they now frequently see change as probabilistic and multi-directional, rather than as a progressive march toward clear endpoints.

…Even the most widespread expressions of cultural aspirations began in specific places. Sites allow us to preview what may become the standards of the future.

- Kristina Hill

CHAPTER 1
INTRODUCTION

Figure 1: Aerial View. Photo: wikimedia.org

Streets and their sidewalks, the main public places of a city, are its most valuable organs.

- Jane Jacobs

CHAPTER 1
INTRODUCTION

I. What is this thesis project about?

This thesis is offered as a professional project in collaboration with Seattle Public Utilities. It examines two fundamental components of urban public infrastructure: roads/public right-of-way space and drainage/stormwater systems. Specifically, it explores the social feasibility of installing green stormwater infrastructure (GSI) in the public right-of-way of established residential neighborhoods as part of the solution to combined sewer overflows (CSOs). The study asks, “how can roadside raingardens be sited and designed in a way that improves neighborhoods and fosters community acceptance or even delight?” The Ballard neighborhood CSO basins are used as a test case.

The study articulates how/why strategic siting and sensitive design of roadside bioretention is essential if these projects are to be embraced by residents, and it offers detailed site analysis and potential approaches at three scales: design schematics at the raingarden scale, design schematics at the block scale, and a phasing plan/siting options at the neighborhood/basin scale. A review of the history of stormwater control in Seattle (including GSI) coupled with a summary of current public perception of stormwater and GSI, lays the social context. Additionally, a survey of relevant literature on frameworks for multi-functional landscapes, place attachment and identify, human landscape preferences, aesthetics and ecological function, and the psychological underpinnings of human well-being contextualize the siting plans and design templates and provides a theoretical lens for the chosen approaches. The study also includes a series of draft outreach materials (text and graphics) that may be refined and used to facilitate public outreach and engagement efforts. The study concludes with suggestions for how the analysis, design schematics, phasing approach and outreach materials may be used to engage residents in site selection and design development and engender community acceptance/delight.

II. Why is this study important/meaningful?

The City of Seattle has delivered many innovative and successful green stormwater infrastructure (GSI) projects over the course of the past decade. These include SeaStreets, the Broadview and Pinehurst green grids, the Highpoint redevelopment project, and, more recently, Rainwise. In none of these previous projects, however, was a roadside GSI approach used in an established neighborhood with a fully improved right-of-way typology (curb and gutter drainage and sidewalks on each side of the street). Nor were any preceding projects designed for specific CSO volume control performance.

Impelled, in part, by the current federal mandate to control all municipally operated combined sewer outfalls to no more than one overflow per outfall, per year, SPU conducted a pilot project in the winter of 2009-2010 on the Ballard plateau–the site of the city's worst combined sewer overflow (CSO) basins, with respect to both frequency and volume of sewage overflows. The pilot tested three roadside bioretention designs as potential CSO control strategies in an established "curb and gutter" neighborhood and revealed several important technical challenges. Moreover, the pilot brought to the fore a host of essential 'social feasibility' considerations for implementing roadside GSI in established neighborhoods with fully improved right-of-ways. Landscape architecture–and an intentionally human-centered siting and design process–has particularly valuable and unique contributions to make in this latter category of considerations.

As SPU plans to move forward with a solution set for CSO control that includes GSI in the right-of-way (not only in Ballard, but also in other CSO basins across the City), it is important to solidify and build on the lessons learned from the Ballard pilot, particularly with respect to social feasibility. Furthermore, as SPU's green stormwater infrastructure work transitions from a start-up era characterized by opportunistic and entrepreneurial "pilot projects" toward a new era of integrated programmatic work across multiple utility (and City-wide) focus areas–sewer overflow prevention, creek health, water quality, climate mitigation and adaptation, tree canopy recover, etc–it is appropriate to advance the on-going process of standardizing siting and design criteria and establishing "starting place" design schematics that set a high quality standard for attractive, cohesive urban design and site detailing. In the case of this study, the proposals are specific to sewer overflow prevention and also seek to optimize a variety of additional benefits above and beyond this core objective.

Finally, the analyses and tools presented here have the potential to support not only SPU's CSO program, but also those of King County and myriad other municipalities in Western Washington and beyond, working to come into compliance with their respective NPDES permits and eager to employ the high-value solution sets offered by GSI.

III. How was the study approached?

One of the most challenging aspects of properly characterizing the value of any green infrastructure project–including green stormwater infrastructure–is the question of "cost-effectiveness." Typically, the price of a conventional technology (cost to build + life-cycle operations and maintenance costs) is compared with the parallel price of the green technology and a "cost differential" or "cost premium" is calculated. There is a potential fallacy inherent in this methodology, however, in that the approach presumes the two solutions to be of equal value and therefore, their respective prices to be comparable. This, however, is not always the case.

As an example, one conventional "gray infrastructure" solution employed for combined sewer overflow mitigation is a large underground storage tank with an associated pumping mechanism. Sized and operated correctly, this solution can fully address the sewage overflow/water quality problem at a given outfall (or group of outfalls), offering one level of value. The "green infrastructure" solution set, however, has the potential to perform at a comparable (or even higher) level with respect to water quality goals, as well as contribute additional levels of value. Aesthetically appealing roadside raingardens, for example, have the potential to protect water quality and reduce energy use/climate pollution (associated with pumping and treating stormwater runoff), beautify streetscapes and make them more safe or appealing for pedestrians and bike riders (curb bulbs can shorten pedestrian crossings, for instance), improve habitat connections (with intentional tree canopy targets), increase our connection to and understanding of ecological systems, and/or even enhance neighborhood identity or property value. These multiple benefits can be very difficult to quantify and yet, can also be an important factor in a project's acceptance in the community. Furthermore, optimizing multiple benefits (and thereby increasing overall project value) can also help ensure local government is using its limited resources to attain maximum public benefit per dollar invested.

Given the importance of this central differentiating feature of GSI, this study was initially organized around a framework of layered function or "multiple benefits." As a pushing off point, SPU's water quality (CSO control) goal for the Ballard neighborhood was overlayed with the goals of the Seattle Department of Transportation's (SDOT) "Walk. Bike. Ride." Program. The central inquiry of this exercise was how roadside raingardens for CSO control might simultaneously help improve pedestrian and bike safety in the neighborhood or make it more likely or more enjoyable for residents to walk, bike, or ride transit. City-wide tree canopy recovery goals for the public right-of-way were analyzed in a similar fashion. This approach yielded a set of variables that can be spatially analyzed in a standardized way to identify "win-win" siting locations for roadside raingardens that further Walk. Bike. Ride. goals and tree recovery goals. A phasing plan at the basin scale was developed based on this initial analysis, prioritizing those areas with the most overlap. (Though not completed for this study, a similar style of analysis could be applied by examining overlap with additional allied programs/goals, such Parks and Open Space).

However, even though a green stormwater infrastructure project that achieves both a water quality goal and a pedestrian safety goal may intrinsically offer higher value per dollar spent than a gray infrastructure project, that fact alone does not necessarily mean the project will be embraced by the community–even in the absence of technical challenges, like those experienced in the Ballard pilot. Designing via a “multiple benefits” lens, while helpful, is likely insufficient to ensure community delight or even acceptance. This may be because the “value” of pedestrian safety (or habitat connectivity or climate change mitigation or even water quality) may or may not be collectively held within a given neighborhood or city, and/or may be held to widely varying degrees by individuals within a community. And while this may be an important lens of analysis to ensure a high value return on a public investment, and even a useful way to frame projects in an on-going effort to foster a set of shared values over time, a complementary lens of analysis and mode of communication may be required to help ensure community consent (or enthusiasm) during the comparatively short design and implementation phase.

IV. The Purpose of Public Infrastructure

This line of inquiry led to a much more fundamental (and seemingly obvious) set of questions: What is the ultimate purpose of green stormwater infrastructure or any public infrastructure in cities? Or, what should its purpose be? And how can that purpose best be realized? Finding an answer to these questions required a relative step backward and an examination of history.

One hundred years ago, in the year 1912, R.H. Thomson had just completed a 20-year run as Seattle's City Engineer. He is credited with being the "father" of much of Seattle's current public infrastructure including most notably the drinking water system and combined sewer/stormwater system. Thomson oversaw the project to bring Seattle's drinking water from the Cedar River watershed and also finalized plans to install a combined sanitary / stormwater system. He was also the engineer who oversaw Seattle's famous sluicing/regrading projects that literally "laid the groundwork" for much of the city's current street grid (Thomson, 1950).

Thomson worked during the height of the Progressive Era and much like his contemporary Olmsted, described (and marketed) his work in terms of a humanitarian response to the inequities and human hardship triggered by the industrial revolution and capitalism (Thomson, 1950, p. 42). "Having put my hand to the plow," wrote Thomson to a fellow engineer in 1905, "I can't look back. There is so much to be done for the relief of the common people, and there are so few who care… It seems impossible for me to quit" (Klingle, 2007, p. 90). He spoke about his infrastructure projects as essential for human flourishing in the city and as the key to equitable economic progress (Thomson, 1950, p. 129). So while he may be most well-known for technological triumphs like those of his regrade and water supply projects, Thomson should also be remembered as a public official driven to design infrastructure projects in order to to advance human well-being. People were at the core of his work.

The scope of change realized over the past century, since Thomson's time, is truly mind-boggling. A hundred years ago, there had been no WWI, WWII, Vietnam War, Cold War, or War on Terrorism. There were no electric home appliances, no TV's, no computers, no email, and no cell phones. Women did not have the right to vote. There was no social security. No penicillin. No interstate highway system. There was nothing made of plastic. There was no Clean Air Act, no Clean Water Act, and no Endangered Species Act.

These incredible changes notwithstanding, the aspiration of designing public infrastructure with an explicit goal of supporting human well-being remains as relevant today as it was in Thomson's time, even as it begs the additional questions, "How has our understanding of what "well-being" is as well as our understanding of what supports and sustains human well-being evolved over the past century?"

A robust examination of these broad questions is well beyond the scope of this study. However, it is particularly relevant for designers of 21st century public infrastructure to at least consider three facets of these questions and incorporate modern knowledge sets unavailable to Thomson and his contemporaries: 1) What is the relationship between human well-being and “nature” or, less ambiguously, the integrity of ecological systems? 2) Where does designed/built infrastructure intersect with the physical, emotional and psychological underpinnings of human well-being? 3) How does (or how can) our current and future infrastructure support/advance human well-being?

Thomson and his contemporaries were operating firmly within a Promethean view of the human relationship with “nature”–a relationship characterized, at least to some degree, by adversity and struggle (Karvonen, 2010, p. 160). “Nature” was untamed (perhaps even dangerous) and was also unfinished/incomplete. While stewardship was a strongly held ethic, it was also the designer’s role and even his/her responsibility to both subdue and perfect what “nature” offered. “Prometheans have unlimited confidence in the ability of humans and their technologies to overcome any problems presented to them,” writes historian J.S. Dryzek (2005, p. 117).

Over the course of the past hundred years, there have been tremendous advancements in our understanding of the complex science of ecological systems (Pulliam & Johnson, 2002). And perhaps in response to this shifting scientific landscape, new philosophical and ethical frameworks have concurrently recast the relationship between humans and nature from one of “dominion over” to one of “thread within” (Capra, 1996). One of the most cogent and influential schools of thought born out of advancements in ecological science has been the Deep Ecology framework, first articulated within scientific circles by Norwegian philosopher, Arne Naess, in the early 1970’s (Naess, 2008).

Deep Ecology asserts that long-term (sustained) human well-being depends upon the elegant balance and nearly unknowable complexity of nested ecological systems, rather than on a human ability to control or pacify nature. Humans are recognized as directly dependent on the services provided by ecological systems for survival and flourishing–services such as pollination, water cleansing, climate stability and photosynthesis. And human endeavors are placed within a broader scheme, recognizing the inherent value of millions of other species and global-scale cycles such as the water cycle, nutrient and energy cycles, and climate cycles (Naess & Sessions, 1995).

While a widespread adoption of Deep Ecology principles has not been explicitly codified in U.S. law or local ordinance, its insights are increasingly compelling as contemporary municipal leaders grapple with the impacts of localized and global-scale ecological crises–climate change, energy shortages, air and water pollution– and with the concomitant human hardship these crises provoke. The framework of Deep Ecology points designers toward the patterns or “ways of doing business” common in “nature” for clues about how we might reverse these crises. These patterns include closed-loop nutrient and water cycles (zero “waste”) and system hierarchies/redundancies that facilitate adaptive and/or regenerative capacity. According to principles of Deep Ecology, then, designed infrastructure that incorporates zero waste principles and incorporates regenerative and/or adaptive capacity is most likely to align human endeavors with the larger and life-sustaining patterns of ecological systems.

The intersection of the built environment and human health and well-being has long been a central theme among professions engaged in city-building. And while in Thomson's time, public infrastructure like sewer systems and urban parks were designed specifically to promote public health and alleviate disease outcomes related to a lack of basic sanitation and access to clean air, today's leading public health officials and agencies point to built infrastructure patterns–particularly transportation systems and associated land use patterns–as a key contributing factor to disease outcomes such as childhood asthma and obesity, adult-onset diabetes and heart disease, stress disorders and depression (Shobha, O'Fallon & Dearry, 2003; Dannenberg, Frumkin & Jackson, 2012). Thankfully, much work is being done at large urban planning scales to identify viable strategies for a course correction. For example, national design/build standards and rating systems (LEED, SITES, Living Building Challenge) are now incorporating principles such as "walkability" to underscore the connection between the built environment and human well-being (U.S. Green Building Council, 2012; Sustainable Sites Initiative, 2009; International Living Building Institute, 2010). And for decades, regional and local planning boards have been establishing urban growth boundaries, changing zoning restrictions, and offering incentives for "transit-oriented development," all in an effort to rein in sprawl (Puget Sound Regional Council, 2008).

V. The Role of Landscape Architecture

While public health officials and planners are rightfully focused on turning around exponential growth rates in “environmental diseases” by addressing root causes in urban growth and transportation patterns, how can designers redouble the effort to do good, instead of simply doing less bad (McDonough & Braungart, 2002)? How can urban public infrastructure reclaim its legacy mission of making a positive contribution to human health and well-being as well as to the integrity of broader ecological systems?

The discipline of Landscape Architecture is well-suited to collaborate with civil engineers, ecologists, economists, urban planners and community residents to help answer these questions. Drawing from environmental psychology and positive psychology research, landscape architects can help municipal leaders understand place attachment and can articulate how a deep connection to place may make change challenging on the one hand and on the other, lay the foundation for long-term stewardship.

Accustomed to designing at a human scale, landscape architects can also offer designs that intentionally incorporate known contributors to human (psycho-spiritual-emotional) well-being: triggers of sensory pleasure and positive emotion (like beauty), the chance to connect informally with each other, and opportunities for meaningful engagement (Seligman, 2011, pp. 5-26). Landscape theory provides insight into our aesthetic preferences and contextualizes these preferences with both biological and social underpinnings to help define a new “ecological aesthetic”–a hybrid aesthetic that is at once ecologically integral and culturally acceptable (Wilson, E.O, 2002; Gobster, Nassauer, & Daniel, 2007). And finally, landscape theory also provides helpful frameworks for synthesizing human-scale design variables into a broader matrix of desired socio-political and ecological functions, or layered multiple benefits, and distilling these multiple goals into siting and design options that yield the highest value outcome possible (Rottle & Maryman, 2012).

CHAPTER 2
HISTORY + CONTEXT OF STORMWATER CONTROL IN SEATTLE

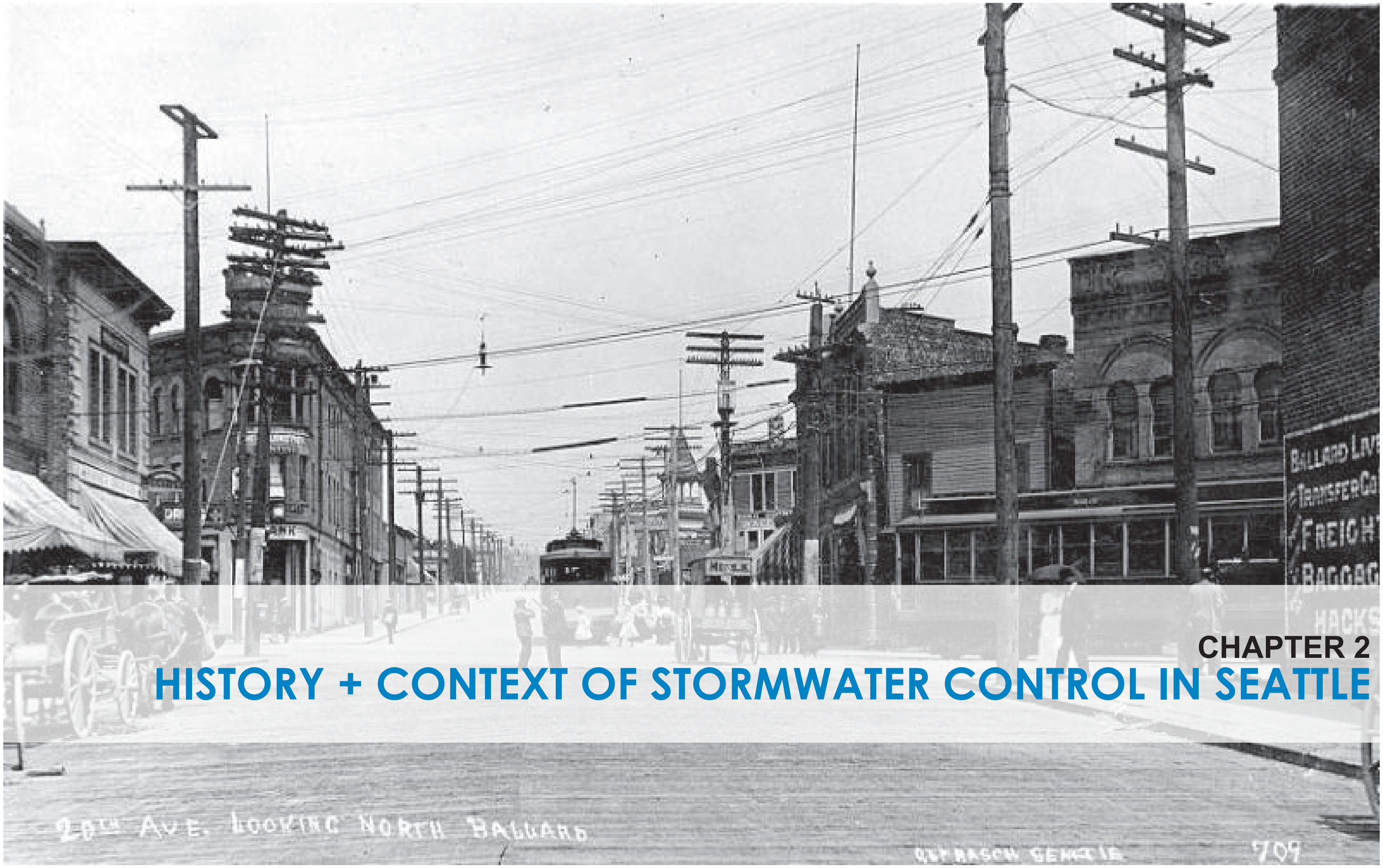


Figure 2. Photo: University of Washington archives

The basic tension is one between the parts and the whole. This tension between mechanism and holism has been a recurring theme throughout history.

-Fritjof Capra

CHAPTER 2
HISTORY + CONTEXT OF STORMWATER CONTROL IN SEATTLE

I. History of Seattle's Drainage/Stormwater System + The Modern CSO Challenge

To understand the current context and goals of Seattle's CSO reduction efforts, it is helpful to briefly outline key events and decisions that played a central role in shaping Seattle's drainage/wastewater/stormwater system over the course of the city's history. These include: 1) The decision to create a combined (rather than separated) sewer/stormwater system in 1889; 2) The establishment of a regional wastewater authority in 1958; 3) The "Forward Thrust" effort to partially separate Seattle's combined sewer/stormwater system, beginning in 1968; 4) A policy shift away from separation and toward storage and treatment, beginning in the mid-1980's; 5) The initiation of comprehensive CSO monitoring and data collection in 1997, and 6) The issuance of EPA's 2009 compliance order to the City of Seattle (to come into compliance with the NPDES permit allowance of one overflow, per outfall, per year in combined sewer basins).

The City of Seattle's 2010 CSO Reduction Plan Amendment (2010) notes that in the 1880's, "over 65% of Seattle's sewage and stormwater drained directly into Lake Union and Lake Washington." This reality, coupled with rapid population growth and a series of typhoid and diphtheria epidemics motivated municipal leaders to construct the city's first sewer line in 1883 and initiate plans for a broader, city-wide solution (Karvonen, 2010, p. 168). The then-famous sanitary engineer, Colonel George E. Waring, Jr., was hired to design the system and proposed a "separated system" designed to carry sanitary wastewater only. The "Waring Plan", as it came to be known, was never implemented, however, due to its high cost. Instead, after the devastating Seattle Fire of 1889, a second plan was commissioned. The "Williams Plan" (proposed by Benezette Williams, a sanitary engineer from Chicago) recommended a "combined system" to carry both sewage and stormwater runoff. The system could be constructed more inexpensively than a separated system and, argued Williams, the waters surrounding Seattle "provided ample room to dilute the waste" (Klingle, 2007, p. 90). The Williams Plan was adjusted (to accommodate deeper Puget Sound outfalls) and implemented under the direction of City Engineer, R.H. Thomson beginning in 1891.

While the basic sewer trunk system devised in the Williams Plan successfully brought sewage and wastewater from the northern and western quadrants of the city to outfalls in Puget Sound, the eastern-most slopes of the city were not as well-served. Consequently, small systems with outfalls in Lake Washington were constructed little by little, and by 1922, there were 30 raw sewage outfalls in the lake (City of Seattle, 2010). As population continued to balloon over the subsequent decades, increased demand for public sewer infrastructure in the greater Seattle area resulted in the creation of 22 independent sewer districts by the early 1950's. Jurisdictional challenges coupled with growing public concern over the health of both Lake Washington and Puget Sound eventually resulted in the creation of the "Municipality of Metropolitan Seattle" (Metro) in 1958. Metro was charged with providing wastewater conveyance and treatment services for the region and was identified as the lead agency for cleaning up Puget Sound and Lake Washington. In 1961, the City of Seattle transferred ownership of its wastewater treatment plants and all conveyance systems draining basins larger than 1000 acres to Metro. And in 1992, Metro was merged with King County government, so City of Seattle wastewater treatment services are now provided at the county level.

The practice of installing combined sewer infrastructure was discontinued in the early 1950's, so as the city expanded northward and southward from its initial core, separated infrastructure was installed. That fact and the new role of Metro notwithstanding, the legacy of the initial combined system coupled with increasing development (and increasing impervious surface) in the city's downtown and central neighborhoods and limited pipe capacity, led to dramatic sewer overflow problems throughout the 1950's and 1960's. The $70M Forward Thrust funding package approved by Seattle voters in 1968 was the City's first concerted attempt to reduce these overflows by partially separating nearly half of Seattle's combined system. (Stormwater runoff from the street was disconnected from the combined system and discharged, instead, directly into receiving water bodies.) When this program ended in the late 1970's, roughly 70% of the total stormwater runoff from the retrofitted combined sewers had been removed, and there had been an estimated 90% reduction in the frequency of overflows. (See Figure 3 for a current map delineating Seattle's separated, partially separated and combined sewer basins.)

In the 1980's, however, it became widely recognized that urban stormwater runoff contains a range of toxic

SEATTLE SEWER SERVICE AREAS

- Combined Sewers
- Partially Separated Sewers
- Separated Sewers
- Outside Service Area
- City Limit
- Water Body
- Ballard Study Area (CSO Basins)

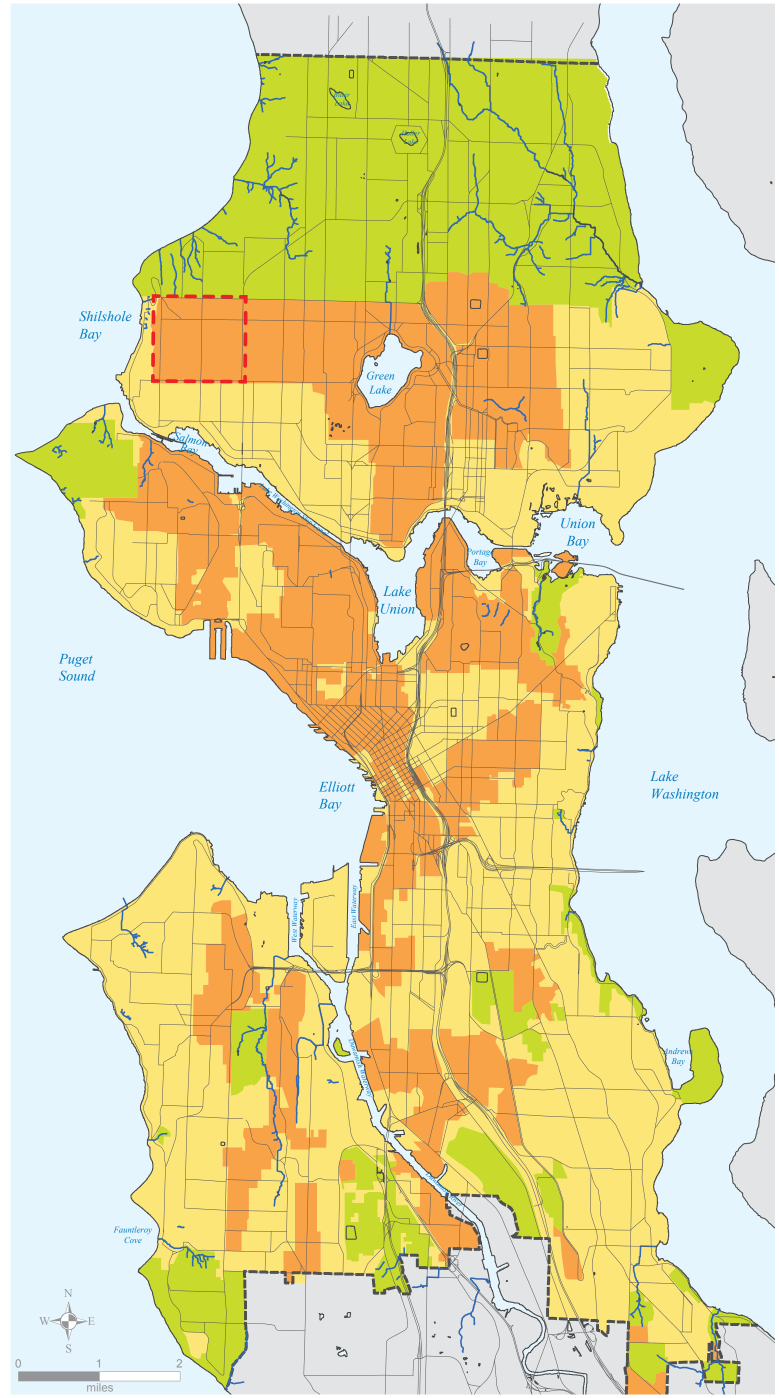


Figure 3: Sewer Service Areas

pollutants that are detrimental to fish and aquatic ecosystem health (petrochemicals, heavy metals, pesticides, etc.). With this recognition, local CSO reduction policy shifted away from separation as a preferred strategy and toward temporary storage and controlled release of combined sewage/stormwater to wastewater treatment facilities. Seattle initiated comprehensive monitoring of its combined sewer outfalls in 1997 and in 2009 was cited by the U.S. Environmental Protection Agency for failure to comply with the CSO allowances defined in its NPDES (National Pollution Discharge Elimination System) permit under the Clean Water Act. Seattle's approach for reducing CSO events to one overflow per outfall per year is being detailed in its Long Term Control Plan and negotiated consent decree with the U.S. EPA. The City of Seattle is currently considering a full range of potential solutions: retrofits to increase the current system's efficiency and capacity, "gray" storage and pumping infrastructure, and "green" stormwater infrastructure (raingardens and cisterns) that capture and cleanse stormwater and prevent it from entering the combined system.

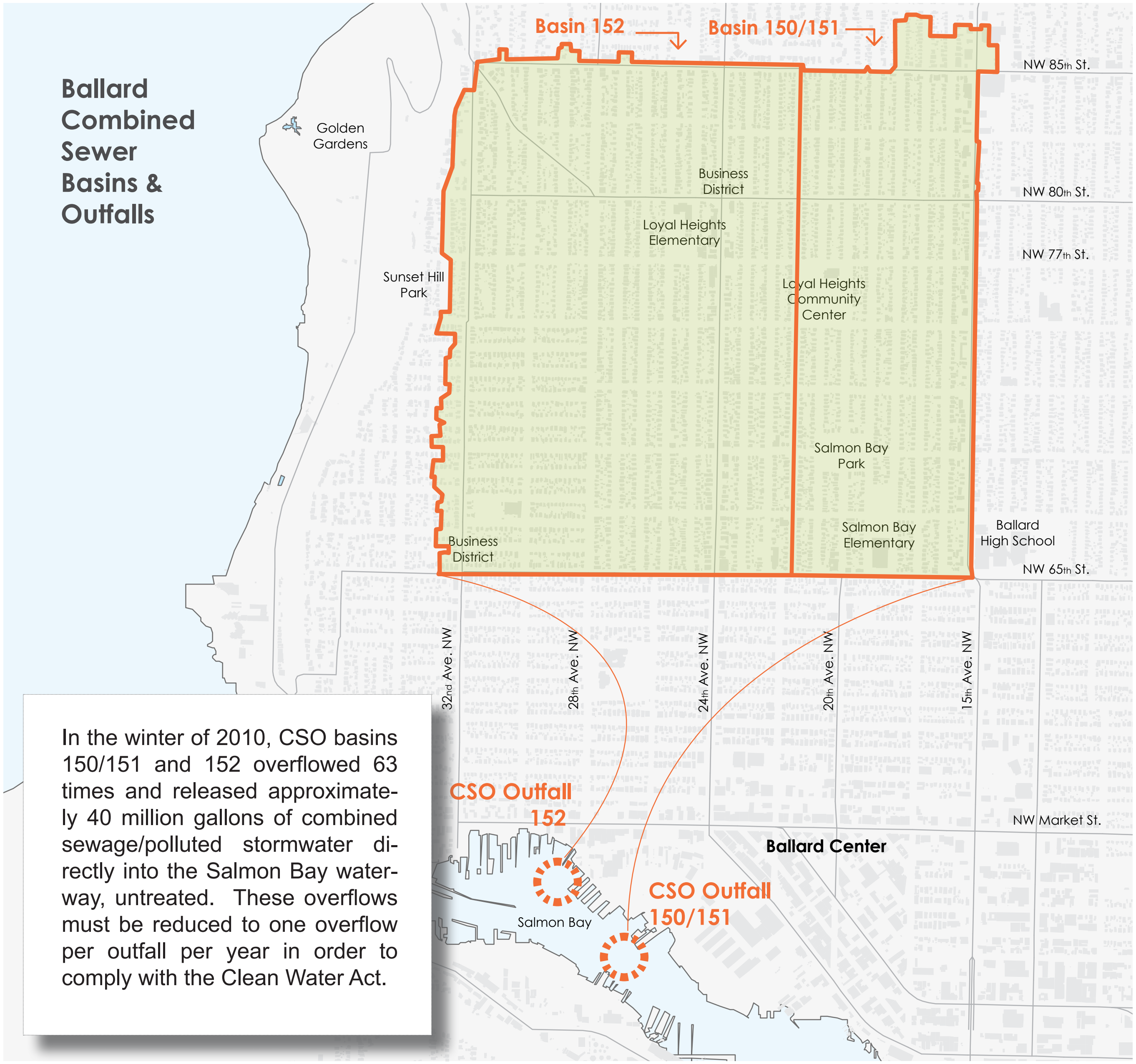
II. Overview of Previously Built Green Stormwater Infrastructure (GSI) Projects in Seattle

Seattle Public Utilities has recognized both the gravity of stormwater pollution and the promise of a natural systems (green stormwater infrastructure) approach for well over a decade. Initial applications of green stormwater infrastructure (GSI) technologies were focused in separated sewer basins and more recently have been considered as a promising option in combined sewer basins, as well. In 2000, Seattle constructed its first "Street Edge Alternatives" project to help protect the urban Pipers Creek watershed. The project collected stormwater from across 2.3 acres and showed a 99% reduction in runoff volume, and with these impressive results, "SEA Streets" became a national model (City of Seattle, 2008).

Since that initial success, Seattle Public Utilities' efforts to promote and implement green stormwater infrastructure have grown steadily. In 2003, Seattle doubled the size of its built GSI projects with the Carkeek Cascade project–a roadside intervention that collects runoff from 28 acres and reduces outflow levels of pollutants like lead, copper, and zinc by up to 90%. In 2004, the "Broadview Green Grid" was built to collect stormwater runoff across 32 acres and in the following year, the Pinehurst Green Grid was built to manage runoff across 49 acres. These "green grid" projects offered proof of concept that roadside GSI techniques could be successfully applied at the scale of an entire neighborhood.

Increased confidence in the efficacy of larger scale projects led to the well-documented Highpoint Redevelopment Project from 2005-2009. Working in close collaboration with the Seattle Housing Authority, Washington State Department of Ecology, and many other partners, Seattle built neighborhood scale GSI into the 129-acre Highpoint housing redevelopment. The Highpoint design included extensive roadside raingardens, saved over a thousand legacy trees and planted three thousand more, and integrated porous concrete sidewalks. In more recent years, Seattle has continued to innovate. In 2009, SPU updated its municipal stormwater code to require GSI be used "to the maximum extent feasible" in redevelopment projects. And as a means to mitigate the large stock of impervious surface on private property that contributes to combined sewer overflows, Seattle introduced the voluntary "Rainwise" incentive program in 2010. The program offers rebates to eligible property owners who contruct a raingarden or install a cistern on their property and also trains local contractors in best-practice construction/installation techniques.

Finally, in the winter of 2010 and 2011, Seattle completed its first GSI project in the right-of-way designed specifically to reduce combined sewer overflows, as described on the next page.



In the winter of 2010, CSO basins 150/151 and 152 overflowed 63 times and released approximately 40 million gallons of combined sewage/polluted stormwater directly into the Salmon Bay waterway, untreated. These overflows must be reduced to one overflow per outfall per year in order to comply with the Clean Water Act.

Figure 4: Ballard Combined Sewer Basins + Outfalls

III. Summary of Ballard CSO Problem + Roadside Raingardens for CSO Control Pilot

The City of Seattle currently manages 90 uncontrolled combined sewer basins. (King County also manages combined sewer basins within the Seattle city limits–only those basins which measure 1000 acres and larger–38 of these county-managed basins are also uncontrolled). “Uncontrolled” refers to those basins not currently meeting the target set in the City’s NPDES permit. The permit allows each combined sewer outfall to overflow no more than once per year. Of the uncontrolled basins under City of Seattle management, the two adjacent basins in the central Ballard neighborhood of north Seattle (basins 150/151 and 152, see Figure 2) are the worst performing basins in the city, with respect to both frequency of overflow events and total volume of overflows. In the winter of 2010, these basins overflowed 63 times and released approximately 40 million gallons of combined sewage/polluted stormwater directly into the Salmon Bay waterway.

Given the severity of the CSO problem in these basins, SPU conducted an initial study in early 2009 to determine the technical feasibility of implementing roadside bio-retention to mitigate these overflows. Streets and soils in the basins were evaluated, streets with steep grades or known seeps were eliminated, and a glacial outwash area was mapped. This analysis showed that it was potentially feasible to install infiltrating roadside raingardens on a large proportion of the public right-of-ways in the basin. Early modeling also suggested that doing so could potentially obviate the need for an end-of-pipeline tank in one basin and could significantly reduce the size of required gray infrastructure retrofits in the other. A pilot project using ARRA (Federal Economic Stimulus Bill) funding was proposed to test the concept of using roadside bioretention for CSO prevention, as this had not been done previously. The goals of the pilot were threefold:

1) To develop 3 design templates for roadside raingardens in established curb and gutter neighborhoods: a design fully within the existing planting strip, a curb extension design, and a full curb shift design
2) To refine construction cost estimates
3) To collect and refine performance data

Due to the confluence of several less-than-optimal project planning, design and delivery variables (including a dramatically compressed and externally imposed timeline, a historically wet winter, insufficient and out-of-sequence geotechnical analysis and sub-standard construction), a significant sub-set of the installed pilot rain gardens did not perform as designed. That is, cells were not draining to native soil as intended. When it became clear that some raingarden cells had failed, SPU led an intensive, and highly charged community-engaged process to retrofit (or remove) the failing cells in the context of significantly eroded neighborhood support for the project.

In order to learn everything possible from the pilot, SPU has since synthesized critical lessons into five main categories: planning, geotechnical analysis, community engagement, siting and design, and construction. And important policy recommendations have been distilled from this analysis, including:

Planning: Analyze and report risks any time an accelerated time schedule is proposed.

Geotechnical: Monitor groundwater levels for a minimum of one winter; leave time for a second round of infiltration testing, especially if the first round reveals high variability in infiltration rates.

Community Engagement: Communicate clearly and consistently about parking loss, on-going ponding in winter months, how the project will look over time and required SDOT signage; Consider demonstration infiltration tests on evenings/weekends as a form of engagement.

Siting and Design: Consider cross-slope across planting strip (and cell-depth, in general); opt for larger plants at installation for aesthetics and plant establishment; include run-on in design assumptions.

Construction: Schedule geotechnical verification of soils during construction; review TESC requirements with contractor to ensure cells are protected; avoid staging in front of residences.

Chapters 5, 6, and 7 will revisit these (and other) recommendations in greater detail and will also offer additional recommendations for siting and design of roadside bioretention that considers and incorporates community acceptance (social benefit) as a category of “function”, on par with technical/stormwater function. Chapters 3 contextualizes the proposed recommendations with a survey of current research examining public perception of stormwater issues and potential solution sets. And chapter 4 grounds both public perception and the proposed recommendations in relevant landscape theory.

CHAPTER 3
SOCIAL PERCEPTION OF STORMWATER AND GSI IN SEATTLE

Figure 5: Photo: Pam Emerson

Neither applied ecology nor direct democracy alone can overcome our problems, but when combined they offer hope.

- Randolph Hester

CHAPTER 3

SOCIAL PERCEPTION OF STORMWATER AND GSI IN SEATTLE

I. Residents' Understanding Of and Attitudes About Stormwater Pollution and Management

In August of 2011, Action Media published the results of a focus group research study, conducted in urban and sub-urban Seattle, Tacoma, and Bellingham, and aimed at characterizing residents' understanding of run-off management and attitudes toward solutions. The study results offer important insight for the siting and design of roadside raingardens and are described here.

One of the most telling findings of the study was that 80% of those participating reported they "do not live in a watershed" (Action Media, p. 1). Beyond being a semantic or vocabulary-based disconnect, this finding confirmed (with additional probing) that local residents simply do not think of water quality in terms of land use. That not-withstanding, local water protection achievements were spoken about with pride as was a perceived local culture of "being green." Both are viewed as central to regional identity and are recognized as contributing to quality of life and property values. In fact, when asked directly to describe what makes somewhere a great place to live in, common responses included the terms: "nature" and "outdoors," together with "safety," "a sense of community," "convenience," and "transportation" (Action Media, p. 2).

A Caution About Focusing on the "Problem."
According to Action Media authors, when focus group participants considered two series of statements related to stormwater management–one series describing the problem and the other describing solutions–the problem statements led to "dismay, confusion, doubt and objections" (2011, p. 2). Specifically, the problem statements precipi-tated expressions of remorse followed by despondence (the problem was viewed as too large and therefore intractable). Increases in population were identified as the main culprit and determined to fall outside our sphere of influence. A discussion of the costs of stormwater management tended to reinforce distrust of the government and a narrative around "not getting what we should for the money." Addition-ally, a discussion of high stormwater management costs reinforced a belief that the problem is so large, it cannot be solved. The authors also note that the tone of the discussion (when focused on the problem set) was "critical, doubtful, and nit-picking" and overall, appeared to lead the group toward "casting doubt on the problem" (2011, p. 2). This may point toward a broader human tendency of conflict aversion or a desire to avoid negative information and blame.

Only one problem statement of those tested was accepted by participants as credible and informative:

> Most of the pollution entering local rivers and streams and Puget Sound does not come from industry, or from anyone dumping pollution into the water. It comes from streets, parking lots and highways, from our towns and cities, and is carried into the waterways by rain running off the ground into the water. (Action Media, 2011, p. 4)

The authors point out that the statement refutes a widely held misconception that water pollution comes from industrial waste and sets the stage for a discussion about prevention–solutions that keep pollution out of our waterways. In summary, the study authors suggest that messages describing the extent of the problem should be secondary to messages promoting solutions and should "focus on the scale of pollution deriving from polluted run-off," communicating the idea that "most pollution comes from run-off" (2011, p. 13).

Talking About GSI: New Class of Pollution Requires a New Solution. How did participants react when the conversation focused on solutions? Solution statements also generated questions but were met with a more positive tone. The following solution statement generated the most positive response from participants:

> There are two kinds of infrastructure for managing water run-off from rain. We're familiar with the traditional kind–big pipes, sewers and treatment plants. Now many communities are using a different approach. Raingardens, green roofs, the use of plants and vegetation to soak up water, and new construction materials, such as permeable concrete that allows water to soak into the ground, are sometimes called 'green infrastructure' (Action Media, 2011, p. 4).

Upon hearing that statement, one respondent commented, "It seemed like that paragraph was talking about the future, what society would be moving towards [sic], the green infrastructure. I do not know what a green roof is. I really don't know what a rain garden is... It just kind of seemed like that's what life will evolve towards [sic]" (2011, p. 4). The discussion of solutions also revealed language that may reinforce mental obstacles to GSI implementation. The term "walkable," for example, was interpreted by some participants to mean "anti-car." The term "low-impact development" was not understood and the term "sustainable" was characterized as "over-used" and misleading. In summary, the authors suggest talking about solutions in specific terms–describing what works, how it works, and sharing actual results (2011, p. 6). One exception to this "be specific" recommendation is in the use of graphics. Because photographs include so much information and only some of it is pertinent to the point being illustrated, the authors recommend using schematic diagrams to demonstrate how and to what extent green infrastructure strategies work.

Talking about "Cost." Study authors underscore that most objections related to "cost" are, at their root, doubts about efficacy. Questions about costs are really saying, "Is this worth it?" This emphasizes the need to characterize the results of GSI projects as specifically as possible–and to speak particularly to the question of how much pollution will be kept out of local waterways by employing GSI solutions. Finally, it is critical to distinguish between the roles and perspectives of residents, businesses and government with respect to balancing short-term costs with long-term benefits. For example, an explicit distinction can and should be made between the variables an individual uses to make his/her decisions and the variables government entities–which hold broader responsibility for the long-term stewardship of the commons as a source of collective wealth–may use in its decision-making. "Capital expenses invested in infrastructure are not the same as home-owner decisions, and should be distinguished from them," write the study authors (2011, p. 12).

II. Residents' Understanding Of and Attitudes About Combined Sewer Overflows

Seattle Public Utilities has also conducted its own survey and focus group research to evaluate residents' understanding of combined sewer overflows and to test messaging strategies for sewer overflow prevention efforts–both written and graphic (PRR, Inc., 2011). This research offers additional insight that is immediately relevant to the community engagement, siting and design processes used to implement roadside raingardens for CSO prevention. One of the most significant findings of the research is that the term "combined sewer overflow" is unfamiliar. While Seattle residents have a high level of awareness that sewage overflows can happen during winter storm events (85% of Ballard residents are aware of this), only 12% of residents recognize and understand the term "combined sewer overflow" to mean essentially the same thing. These results suggest it may be more effective to use a more readily understandable term–such as "sewage overflow." That said, study participants also expressed that engagement efforts and particularly graphics should emphasize that overflow events pollute waterways with both sewage and stormwater run-off. The study also confirmed Action Media's finding that the majority of Seattle residents do not understand the actual connection between land use and water quality. Fully 75% of study participants identified "business and industry" as the primary contributor to water pollution in Puget Sound (PRR, Inc., 2011, p. 12), when, in fact, the primary contributor is polluted stormwater runoff (including combined sewer overflows). Engagement processes, then, should continue to stress this distinction and may have an opening to suggest that this relatively new class of pollution calls for a new class of solutions.

What Motivates People to be 'Part of the Solution'? When Ballard residents were asked directly, "Do you support the City building rain gardens in the City-owned right-of-way on your street, even if it means giving up parking spots?", 71% of those surveyed answered "yes" (averaged City-wide, 75% answered "yes") (PRR, Inc., 2011, p. 19). Residents found public health concerns associated with combined sewer overflows and a belief that addressing the problem was "the right thing to do" to be the strongest motivators for personal action and for supporting municipal action. A desire to "protect our waters for future generations" was nearly as motivating. Study participants also identified the term "raw sewage" as motivating and recommended its use over less direct terms like "human waste" and "poo."

What Are Residents' Main Concerns With Respect to CSO Solutions? Here, too, the results of the baseline survey and follow-up focus group studies corroborate Action Media's findings. Most Seattle residents (over 80% of those surveyed) are supportive of proposed City actions to address CSO's (retrofits, green infrastructure and storage tanks.) Among the 20% who expressed concern, the highest concerns were the potential cost of CSO solutions and their efficacy. Efficacy was more of a concern to Ballard residents, perhaps a result of the challenges encountered with the Roadside Raingarden pilot project. These findings notwithstanding, 77% of Ballard residents are supportive of a $5/month rate increase to pay for CSO solutions–70% of residents city-wide support the rate hike (PRR, Inc., 2011, p. 21).

III. Residents' Questions and Concerns About Roadside Raingardens

Table 1: Siting and Design Questions Raised by Residents

Siting + Design-related Questions Raised by Residents in Ballard (and SW Seattle/Barton Basin*)
Where will I park? How will the project affect parking and getting out of my car?
Are these safe, especially for children?
What about mosquitoes?
How will the project affect the value of my home?
Where will I put my trash and recycling bins?
What will these really look like?
Won't pollutants build up in the raingardens?
Will I be able to walk across the raingarden? How will I get from my car to my house?
Why are we doing this? What are the alternatives?
What will the net affect of this project be on the overall CSO problem?
What aspect of this do we really have a say in?
Will there be standing water and mud?
How/why did you choose my street?
What will happen to our street trees?*
Will you provide extra lighting if we have to walk further from our car to our home?*
Can the road be realigned to accommodate the raingarden and maintain parking?*
How do you know the raingardens will not cause wet basements?*

In addition to the aforementioned formal studies, the Ballard Roadside Raingarden pilot also identified important siting and design-related questions and concerns held by residents, relating specifically to the implementation of roadside raingardens. These surfaced via a series of public meetings as well as via neighborhood blog posts. And while these questions and concerns may not be held by the majority of residents in the neighborhood, it is nonetheless important to consider and address them to the extent possible in future design proposals as well as in communications/engagement materials. Table 1, summarizes questions raised by Ballard residents during public meetings in the winter of 2010-2011. Additional questions (marked with an *) were raised in the winter of 2011-12 by residents who live in the King County-managed "Barton Basin." Because this CSO basin is also slated for roadside raingardens as a sewer overflow prevention strategy and its street typology is very similar to that in Ballard, they are relevant to the Ballard case study.

In addition to these specific questions, residents also expressed dissatisfaction with a number of additional design elements: object markers, ponding depth, cell depth, immature plantings, and continuous water in wet weather. These concerns are illustrated further in Chapter 5.

CHAPTER 4

THEORETICAL GROUNDING FOR SITING AND DESIGN OF ROADSIDE GSI

Figure 6: Photo: wikimedia.org

Values embodied by landscapes are frequently contradictory. In the United States today, ecological integrity is valued, but so are wealth, neatness, and safety…. Culture can change only when people begin to recognize different landscape patterns as material evidence of their long held values.

-Joan Iverson-Nassauer

CHAPTER 4
THEORETICAL GROUNDING FOR SITING AND DESIGN OF ROADSIDE GSI

This chapter presents a brief summary of academic research drawn from environmental psychology, positive psychology, and landscape theory that will help focus the subsequent siting and design proposals through a people-oriented lens. The goal of this brief literature review is to underscore that "social feasibility" (manifest as community acceptance and/or delight) is a critical category of infrastructure function on par with other types of function like control volume reduction or pollutant removal. Understanding the psychological (and even biological) underpinnings of social function will help ensure designers are well-equipped to address this facet of infrastructure just as intentionally as they address stormwater management functions. The review includes a brief introduction to these key concepts:

1) Place Attachment + Place Identity

2) Human Landscape Preferences

3) Aesthetics + Ecology in the City

4) Psychological Basis for Human Well-Being

5) Multi-functional Landscapes

I. From NIMBYism to Stewardship: The Role of Place Attachment + Place Identity

People care a great deal about places, especially their homes (Manzo, 2003). And while any change may be difficult or take time to accept, proposed changes to the streetscape (and particularly the spaces directly in front of people's homes) are especially likely to be something residents will care a great deal about. If this care is expressed initially as resistance to or questioning of the proposed change, however, resource managers (who are not immediately impacted by the proposed change) may identify place-protective behavior as "NIMBYism." Environmental psychologist, Patrick Devine-Wright, who has studied this phenomenon across a range of environmental infrastructure development contexts, identifies several problems with the popular understanding of the "NIMBY" concept and challenges public officials, instead, to adopt a far more nuanced understanding of place-protective behavior (2009).

The term NIMBY has come to connote "selfishness" and/or "ignorance" and often operates in tandem with a false assumption that when additional information is brought to bear, the "NIMBY" response will dissipate. Unchecked, the "NIMBY" label (or mindset) may lead to a divisive "'us' against 'them'" dynamic that escalates tension or conflict and can obscure local knowledge or information that otherwise might have improved a project (Carpenter & Kennedy, 2001). Devine-Wright proposes an alternative framework in which resistance to change is expected as likely "whenever new developments disrupt pre-existing, positive emotional attachments to place" (p. 429) [place attachment] and/or "threaten place-related identity processes" (p. 429) [place identity]. There can be very real psychological impacts, he argues, not only when actual physical places are disrupted, but also when the social networks and sources of self-esteem and identity that are connected to those places are threatened. These threats may be perceived in a number of ways. A proposed change may challenge the "positive distinctiveness" of a place by changing a landmark, distinguishing feature, or point of local pride. Or it may imperil place-related "continuity over time" simply by changing the way residents experience a familiar place. For this reason, intensity of place attachment is likely to be proportional to how long someone has lived in the place in question (Brown & Perkins, 1992). Projects may also "threaten place-related 'self-efficacy' if processes of decision-making are perceived to be exclusive, secretive or inequitable" (Devine-Wright, 2009, p. 432). Devine-Wright reframes the behaviors of "NIMBYism," then, as behaviors used to cope with the legitimate psychological impacts of real or perceived loss of positive distinctiveness of a place, loss of continuity over time, and/or loss of self-efficacy. He goes on to describe the progression through which individuals and groups move as a natural response to disruptions in place-attachment and/or place identity:

Stage 1: Awareness – Characterized by information gathering. What kind of change will occur?

Stage 2: Interpretation – Characterized by discussion/integration. What are likely impacts of the change?

Stage 3: Evaluation – Characterized by passing judgment. Will the change be positive or negative?

Stage 4: Coping – Characterized by adjustment or withdrawal. How will I respond to the change?

Stage 5: Acting – Characterized by individual or political action. What can I do about it? (2009, p. 433)

Ultimately, Devine-Wright encourages policy makers and project developers to apply psychological principles related to place attachment and place identity in the public engagement processes connected with projects that include changes to place. Specifically, he suggests approaching such projects with the explicit intention of enhancing (rather than disrupting or threatening) place-related continuity and distinctiveness, as well as self-efficacy (2009, p. 437). In the context of roadside raingarden siting and design, the judgment stage is pivotal. For broad community acceptance or enthusiasm to take root, the proposed change to the streetscape must be experienced as a net positive.

Much as municipalities currently depend to some degree on citizen engagement/stewardship to help manage "gray" drainage infrastructure (clearing leaves from storm drains in the fall, etc.), it is also clear that the long term effectiveness and maintenance of "green" stormwater facilities is improved by a community-engaged approach involving partnerships and shared responsibility with residents (as well as businesses and non-profit organizations). This aligns directly with a federal policy focus acknowledging the critical role of "stewardship" in sustainability efforts. The U.S. Environmental Protection Agency defines "stewardship" as: "The responsibility for environmental quality shared by all those whose actions affect the environment" (U.S. EPA, 2005, p. 2). It is then worth asking, "What might place attachment, place identity and place-protective behavior have to do with long-term stewardship of a place?" We know place attachment may be expressed as place-protective behavior, and the correlation between political efficacy and place-protective behavior has also been well documented (Twigger-Ross & Uzzell, 1996)–as has the correlation between political efficacy and affluence (Livingstone, Baily, & Kearns, 2008). Empowered people are more likely to act to "protect" a cherished place.

In other words, people who exhibit "place-protective behavior" feel strongly attached to their homes/places and are empowered, engaged and participating in the decision-making process about the projected long-term viability and health of "their" place. Conversely, in the absence of strong place attachment and healthy levels empowerment, residents may be more likely to detach or withdraw from decision-making processes (Manzo & Perkins, 2006) and less likely to assume shared responsibility for the outcomes of those processes. In the context of processes to plan, design, implement and maintain roadside raingardens, this suggests that place-protective behavior may be not only a proxy for an engaged citizenry, but also a signal that achieving long-term stewardship partnerships is possible. This supposition warrants additional research and underscores the need to foster political engagement and connection to place as building blocks of long-term stewardship.

II. Human Landscape Preferences for "Nearby Nature"

What design strategies are most likely to ensure roadside raingarden projects enhance positive distinctiveness of neighborhoods or a sense of "continuity over time"? And/or, which planning and community involvement approaches are most likely to support or foster individual and community desire for self-efficacy (which may be a prerequisite for long-term resource stewardship)? There are no prescriptive answers. But while social science research on place attachment and place identity leads us to ask these difficult questions, research on landscape preferences can help us begin to answer them.

People are not drawn equally to all landscape types and appearances. While some scenes and experiences evoke calm, wonder, excitement or fascination, others may evoke fear, disgust, annoyance or bewilderment. The roots of these reactions are likely to be both biological/evolution-based (Wilson, 2002, pp. 129-32) and psycho-social, as discussed in the next section. Understanding the landscape organizing principles widely preferred by humans can help roadside raingarden designers choose approaches that are responsive to these inclinations and therefore more likely to be accepted and embraced as enhancements.

In their now-classic work, *With People in Mind: Design and Management of Everyday Nature*, researchers Kaplan, Kaplan and Ryan build on a previous body of landscape preference research to define broad categories of landscape patterns relevant to the human experience of "nearby nature" (1998). The authors differentiate "nearby nature"–the somewhat routine and small-scale encounters with "nature" (particularly flora) in city parks, school yards, and public streets–from the grand-scale, full-immersion experience of visiting a sublime landscape in a National Park or wilderness area. And they examine how human fears and preferences as well as the human affinity for the restorative qualities of nature affect our attitudes toward different urban landscapes. They also summarize a set of basic human tendencies that enable people to enjoy and be sustained by "nearby nature." Two are particularly relevant: The desire to understand and explore our surroundings and the need to recover from mental fatigue induced by the constant task of parsing incoming information and mental stimuli (the design of our immediate surroundings can either help or hinder the restorative process).

These very basic human characteristics lead directly into landscape preferences. For example, a roadside landscape with dense vegetation and obstructed views does not invite exploration and makes it difficult to know what to expect next. Not surprisingly, these types of landscapes are not preferred by city-dwellers and may even be perceived as dangerous (Kaplan, Kaplan, & Ryan, 1998, p. 12). Other landscape patterns that may invoke fear include wholly unfamiliar landscapes and landscapes that have no sign of human care or attention (p. 32). To summarize, visual access, familiarity and signs of human presence are reassuring (p. 37). The broad generalizations notwithstanding, it should also be noted that what is considered "familiar" may vary widely across ecosystem types/climates and therefore be quite place-specific. (This influence of local ecology–and our understanding of it–is explored more fully in the following section on aesthetics and ecology.)

Humans also prefer coherent planting compositions because they are easier to understand (Kaplan, Kaplan, & Ryan, 1998, p. 14). At the scale of a roadside raingarden, "coherence" may be achieved with a manageable number of plant types or other features (such as rocks), arranged in a way that makes them distinguishable from one another–perhaps differentiated spatially by function. While this definition of "coherence" may not align with how a well-functioning hydrologic system appears in a virgin forest or wetland (where many plant species are inter-mingled in close proximity), it is important to be explicit that reproducing the visual appearance of wild landscapes may be inappropriate or ineffective in urban settings where human needs for sightlines, legibility, and visual preferences must be balanced. Visual layers or bands, periodic openings (changes in a dominant landcover type) and landscape markers, or elements of distinction (like a specimen tree) are also widely preferred. Layers help establish a sense of depth and invite exploration while landmarks or focal points aid us in way-finding and prevent confusion. In the context of roadside raingarden design, then, these preferences suggest a well-thought-out planting plan is critical.

In addition to attending to human tendencies and preferences, "nearby nature" encounters can also help city-dwellers recover from mental fatigue–that universal feeling of overwhelm or being "fried." A landscape that is experienced as uncomfortable or not "compatible" with a person's lifestyle, however, will detract from rather than enhance his/her ability to recover from mental fatigue, or may even add to mental fatigue. A landscape that attends to human comfort while offering an opportunity for "quiet fascination" will support mental restoration (Kaplan, Kaplan, & Ryan, 1998, p. 70). Fascination refers to effortless attention and a degree of respite from everyday tasks and demands and "quiet" fascination allows room for reflection. Design details like a bench or footbridge across a raingarden may offer people a place to stop and experience quiet fascination, by observing, for example, changing foliage across the seasons, the interaction of birds, butterflies or other pollinators with raingarden plants, and/or the rise and fall of water levels in the garden over the course of a day.

Three specific landscape elements–trees, water's edge, and other people–are identified consistently as lending specialness to urban places. These elements are particularly relevant for roadside raingardens. Visual scenes with trees are highly preferred by humans, provided they are not dark or so densely vegetated as to be perceived as frightening. Likewise, water's edge is universally appealing with some important qualifications: vegetated or organically shaped edges are generally preferred to straight, bare edges. And foreign objects in or near the water's edge (like floating garbage) can evoke disgust. Finally, people are attracted to other people. As the intensely practical Danish urban designer, Jan Gehl, has noted,

> One hundred years ago, the city's most important qualities were its diversity and sensory impressions. And the opportunity to meet other people. Today in the 21st century, it is these same free pleasures that attract and motivate most people to visit the city… People spontaneously seek the presence of other people. (Gehl, et al., 2006, p. 110)

Gehl et al.'s analysis of different typologies of "city space" (2006, pp. 106-169) offers designers a functional hierarchy of public space organized around human use. Not all spaces are (nor should be) created equal, they argue. Ultimately, the intended human use ("life") of the space is what should dictate its facilities and spatial qualities. A side-street in a single-family residential neighborhood (the dominant land-use type within the Ballard CSO basins) would likely be defined by Gehl, et al. as a "strolling street" that serves a connective role between the home and a nearby commercial street. What makes a street good for strolling? Visual interest, safety, an invitation to pause and chat with neighbors, perhaps an element of neighborhood pride or distinction. To be socially successful, roadside raingarden design on residential side-streets should make strolling more enjoyable, whenever possible.

To summarize, in an urban context, it is the designer's challenge to integrate the goal of ecological function/integrity with the goal of human comfort and delight. Attending to pervasive human landscape preferences is a good place to start. The next section summarizes an on-going dialogue within landscape architecture around the idea of a nascent "ecological aesthetic"–the notion that humans can/will come to recognize, appreciate, and prefer ecologically healthy (or high-functioning) landscapes such as wetlands or riparian buffers–and that this evolution will, over time, affect our collective landscape preferences.

In her 2008 "MANIFESTO: Sustaining Beauty," landscape theorist, Elizabeth Meyer, argues that aesthetics and the human experience of a built design must be included in any discussion of "sustainable landscape design," together with the more typically discussed components of social equity, ecological function, and economic viability (2008). She argues that attention to human aesthetic experience can/will help humans make a cognitive connection between their behaviors and the impacts of those behaviors and can/will therefore "inspire people enough to make changes." And she urges "green" designers to attend to the human experience of place and space.

This stance is a departure from earlier writings in aesthetic philosophy which posited that having information about the health or lack thereof of a landscape significantly influences human preferences–if park visitors know or are taught that a wetland or woodland landscape is more ecologically healthy than a weed-free, manicured lawn, for example, they will tend to prefer it (Eaton, 1997). This thesis was subsequently called into question, however, via empirical testing that concluded having information about the ecological value of a given landscape had little to no influence on study participants' preference for that landscape (Hill & Daniel, 2007). Study authors pointed, instead, to the role of evolutionary biology in ingrained human landscape preferences.

This finding notwithstanding, the debate around the idea of an ecological aesthetic continues to examine challenges associated with designing for ecological function and human pleasure/appreciation, particularly in urban settings (Gobster, Nassauer, & Daniel, 2007). One of the central challenges, relevant to roadside raingarden design, is that of scale: humans can impact ecological function at very large scales (including globally) but experience landscapes only in the human "perceptible realm." This can create a disconnect between our perception of the landscape and its actual ecological health. In the case of roadside raingardens, for instance, the site of the intervention is likely to be removed spatially and temporally from the site of the ecological function it may be aimed at repairing or protecting. This is the case in Ballard. And despite evidence showing that intellectual knowledge about ecological health has little affect on landscape preference, theorists and designers continue to debate whether knowledge affects one's experience of a landscape… and that an experience of aesthetic pleasure may indeed be "central to achieving public support of, and compliance with, ecologically motivated landscape change" (Gobster, Nassauer, & Daniel, 2007, p. 965).

Meyer's manifesto references Ann Whinston Spirn's work from a generation earlier (Spirn, 1984; Spirn, 1998; Spirn, 2002) which first offered the metaphor of city as garden, a place that is intensely tended by humans. Within this frame, Spirn argued that wilderness and cities are at different ends of the same continuum of "nature" and thereby dismissed the notion that the cultural artifacts of the built environment in cities are outside of "nature." Spirn stressed that the same ecological functions occur in both settings (though in very different ways and via very different forms) and that neither one is "right" nor "wrong."

This stance freed designers to consider a multitude of forms that might accomplish ecological functions in dense human settlements, rather than feeling marginalized into a “nature” camp (where designed forms might mimic those found in the wilderness) or a “culture” camp (where designed forms might eschew a naturalistic aesthetic). More important than this false dichotomy, argued Spirn (and now Meyer), is the question of articulating an ecological aesthetic that will arouse or at least create the space for an ethical leaning toward stewardship.

The previous section briefly discussed the role of human care in landscape preferences. That is, in urban settings, people tend to prefer landscapes that offer some evidence of human care. This notion has been examined extensively by another landscape theorist, Joan Iverson-Nassauer, and has particular relevance for the design of roadside raingardens. Nassauer argues, “We should construct a cultural necessity to underpin ecological health across the landscape… and the cultural necessity that could make patterns for healthy landscapes recognizable and compelling exists ready-made” (1997, p. 67). That “necessity,” she contends, is beauty.

> We are deeply attached to beautiful landscapes, and we have strong cultural conventions for how an attractive landscape should look. Landscapes we describe as beautiful tend to conform to aesthetic conventions for the scenic, but they are relatively rare. Landscapes that we describe as attractive tend to conform to aesthetic conventions for the display of care, which can be exhibited in virtually any landscape. (Ibid, p. 67)

Nassauer outlines what these “cues to care” look like in different landscape typologies and suggests they may be particularly critical for building long-term public support for the advancement of novel landscape typologies, such as green stormwater infrastructure strategies. She identifies neatness and order as the one cultural cue that triggers a nearly universal understanding of human care. Moveover, she argues, the aesthetic of care–neatness–“…is laden with social meaning: stewardship, a work ethic, personal pride…” (Ibid, p. 68). A lack of neatness or order, conversely, may trigger moral judgments about a land owner’s personal character and integrity. In other words, when it comes to cultural expectations for aesthetics, the stakes are high. And non-conformity may be punished with social ostracism. Nassauer also explains that the cultural norm of associating only picturesque landscapes with “beauty”–and conflating scenic beauty with ecological function–presents a particular challenge for designers (or policy makers) wishing to foster acceptance for non-picturesque (but highly ecologically functional) landscape typologies such as wetlands–or roadside raingardens.

One specific design suggestion Nassauer has made for integrating a cultural expectation of “neatness” with the ecological reality of the unkempt (or “messy”) appearance of many wetland types is the idea of “messy ecosystems, orderly frames” (Nassauer, 1995). Designing a neat or orderly outward-facing edge for a landscape that otherwise appears “messy” or wild, she suggests, will provide a cue to onlookers that the site appearance is intentional and the place is cared about by humans. Nassuaer readily acknowledges that the goal of such an approach is not to minimize or marginalize ecological complexity in favor of an aesthetic more pleasing to and wholly controlled by humans. Instead, she suggests that such an approach can serve as a bridge strategy to “align the aesthetic experiences that people already value with the ecological health they do not yet know how to recognize.” By doing so, she offers that “we can build landscape ecological structure while we are building new cultural expectations for ecological health” (Nassauer, 1997, p. 82). In an era of human-dominated landscapes, this may serve as a path for integrating novel and “messy” landscape types–like green stormwater infrastructure–into a position of broader cultural acceptance.

IV. Psychological Basis for Human Well-Being

Just as the results of environmental psychology research can help policy makers and roadside raingarden designers understand and attend to place attachment, place identity and deeply engrained human landscape preferences, the results of positive psychology research are revealing the basic psycho-social underpinnings of human well-being and hinting at ways that built infrastructure might be realigned, across a range of scales, to support well-being. Positive psychology grew in response to a disease-dominated model of human functioning in the broader discipline of psychology–an "attention to pathology that completely neglected the idea of a fulfilled individual or a thriving community" (Seligman, 2005, p. 3). Its aim is to balance the study of "disease, weakness and damage" with the study of "strength and virtue" and to describe a set of societal and personal conditions that support and uplift humanity, of foster human "flourishing." The findings of positive psychology are relevant not only for therapists and allied health professionals, but also for any designer who may wish to attend to damaged ecological (and human/social) systems as well as promote and support ecological health and, within that sphere, human well-being.

While a full review of the findings of positive psychology is well beyond the scope of this study, a summary of "well-being theory" is presented here as immediately relevant for roadside raingarden siting and design. Well-being theory distinguishes between a psychological goal of "happiness" measured by self-reported "life satisfaction" and a more holistic goal of "well-being" assessed via a combination of self-reported and empirically tested positive emotion, meaningful engagement, satisfying relationships, flow, and accomplishment. These components are not described as prerequisites for well-being, but rather as observed characteristics. The first two have the greatest relevance for roadside raingarden siting and design.

"Positive emotion" includes feelings such as wonder, joy, appreciation, security, and fascination and also includes all aspects of sensory pleasure. Positive emotion may be triggered by designs that attend intentionally to the landscape preferences discussed in previous sections–preferences for visual access (safety), physical comfort, compositional coherence, and "neatness" and/or to human affinity for specific elements such as trees, water and other people. Designers are most likely to be successful in supporting this component of human well-being at the individual raingarden scale with careful human-scale detailing and attention to temporal nuances like seasonal aesthetic changes.

It may be less obvious what the siting and design of roadside raingardens has to do with meaningful engagement. As defined by positive psychology, engagement with “something larger than oneself” can refer to one’s family, professional pursuits, volunteer work, religion, political endeavors, and/or to the broader natural world. Because roadside green stormwater infrastructure literally brings the drainage system up from underground (where it is invisible and inaccessible) and into the nearby public realm of the streetscape, it offers on-going opportunities for residents to observe and understand the cyclical fluctuations of our water system as well as the broader connections between human settlement patterns/choices and ecological health. By revealing ecological process within the city, roadside raingardens may help to foster a collective understanding of “cities as sustainable ecosystems” (Newman & Jennings, 2009). And, unlike conventional (buried) “pipe and pump” systems, roadside green stormwater infrastructure can also invite non-experts to assume a resource stewardship role–extending the opportunity for this type of meaningful engagement beyond the small group of professionals formally tasked with monitoring and maintaining the integrity of urban water systems. A process that explicitly defines and invites lay-person stewardship may facilitate further engagement. Likewise, basic informational or educational tools such as maintenance and plant identification guides make engagement more accessible.

Ultimately, applying an analysis filter of “positive emotion” and/or “meaningful engagement” may help urban designers ensure that proposed public-realm infrastructure updates and retrofits are fostering conditions that support human well-being.

V. "Green Infrastructure" and Multi-functional Right-of-Way Landscapes

"Green" design (as a shorthand for ecologically integrated design) is arguably becoming a new standard of excellence for all facets of our built environment. Impelled by the creation of voluntary rating systems programs such as the U.S. Green Building Council's LEED certification in 1998, for instance, the green building movement in architecture and real estate development has focused for over a decade on enhancing the energy efficiency of buildings and promoting ecologically sensitive materials and building techniques. At a planning scale, the "Smart Growth" movement, sparked in the mid-1990's, has emphasized the benefits of compact, walkable communities and has underscored the influence of local land use policy on human and ecological health.

And at the landscape scale, cities across the U.S. are now increasingly recognizing the need for similarly cogent frameworks for "green infrastructure." "Low Impact Development" strategies, emphasizing the water quality benefits (and ancillary benefits) of slowing, cleaning, and infiltrating stormwater on site, are being written into state and municipal codes (Hinman, et al., 2012; Hinman, et al., 2005) and offer one important facet of an integrated approach. However, LID concepts and technologies do not address the full breadth of urban green infrastructure components–which may also include urban forest resources; parks and open space, distributed and renewable energy production/cycling; walking, biking and transit infrastructure; biodiversity; soil building and urban agriculture. "Infrastructure" in this inclusive definition may be taken to mean the collectively sanctioned and publicly funded/maintained structures or facilities that lay the foundation for human well-being in the city–structures whose efficacy is optimized at the neighborhood, city, or regional scale. "Green" indicates that these structures are also well aligned with the patterns and constraints of ecological systems. This may mean, for instance, that one structure is accomplishing multiple functions (integration/efficiency) or that more than one structure is accomplishing the same function (redundancy). It may mean that the "waste" of one structure is the "input" for another (zero waste), or that structures have the capacity to adapt to changing conditions or disruption (feedback loops/resilience). And one final example: it may also mean that the structure does not release toxins/pollutants and that likewise, the use of the structure does not release toxins/pollutants.

Landscape architects Rottle and Maryman have reviewed a variety of historic and contemporary definitions of "green infrastructure" and distilled these into an inclusive framework composed of five discrete yet overlapping/ interacting systems:

Table 2: “Green Infrastructure” Framework (Rottle & Maryman, 2012)

System	Example Structures	Example Functions
Community Open Space	Plazas, Parks, Community Gardens, Farmers Markets	Bring people together; Offer mental + spiritual renewal
Low-Impact Mobility	Sidewalks, Trails, Bike Lanes, Walking Streets	Move people around the city; Offer opportunity for recreation and physical exercise
Water	Cisterns, Raingardens, Green Roofs, Bioretention Swales	Prevent flooding; Prevent water pollution; Recharge groundwater; Protect habitat
Habitat	Urban Forests, Shorelines, Riparian Corridors, Wetlands	Provide nesting, foraging and spawning grounds for wildlife; Provide food sources and pollination services for humans; Offer mental + spiritual renewal
Metabolism	Community Solar Installations, Waste Heat Recovery, Urban Agricultural Production, Yard + Kitchen Waste Composting	Provide heat and/or electricity; Provide food; Repair, build or maintain soil fertility

This framework, they argue, can serve as a type of “taxonomy”–a common language and set of categories– to help designers communicate effectively both with each other and with the broader public about the role of green infrastructure in the ecological and cultural life of a city.

Due to the far-reaching influence of conventional transportation structures and land-use choices on a variety of ecological and social challenges–ranging from climate change to water pollution to childhood obesity and asthma–the land-use type of “public-right-of-way” has received particular attention in recently articulated green infrastructure frameworks. In Seattle, the public right-of-way network comprises approximately 30% of all land in the city and a much larger proportion of all public land. An evolving conception of the optimal use of this land base, from a single-purpose, automobile-dominant transportation system toward a multi-purpose, integrated "green infrastructure" system, is also emerging here–as evidenced by both City-led programs (such as the Department of Transportation's Complete Streets Program, the Pedestrian Master Plan, the Bicycle Master Plan, etc.) and citizen-led initiatives (such as the Neighborhood Greenways organizing work and Stewardship Partners' 12,000 Raingardens program). As Seattle moves toward articulating its own green infrastructure framework (for the public right-of-way and other land use types) it is instructive to review two relevant precedents for insight into how roadside raingardens might figure in.

METRO Portland; Green Streets: Innovative Solutions for Stormwater and Stream Crossings. The METRO regional government–serving the greater Portland, OR metropolitan area–published this guidance document in 2002 to build upon the earlier Creating Livable Streets handbook (1997), which had focused on aligning street design with the goals of long term regional transportation planning. Green Streets was commissioned in recognition of potential conflicts between transportation plan goals and goals to protect and restore local and regional waterways and habitat corridors. And the document was intended to "present methodologies and design solutions that protect the quality of the region's stream system while providing for an efficient multi-modal transportation system" (METRO, 2002, p. 1). Green Streets frames the roadside drainage system as "an extension of the natural drainage system" (METRO, 2002, p. 7) and uses the return of endangered salmon to urban creeks and streams as a benchmark of success. A city "is not separate from nature," state the authors. "It is itself an ecosystem, shaped by natural processes" that can and should provide for the needs of humans as well as other species.

A decade later, this document's key insight for the siting and design of roadside raingardens is the contention that the public-right-of-way may function as a water conveyance system, an infiltration system, and/or a treatment system and is therefore "a human extension of the natural creek system and its ecology" (METRO, 2002, p.8).

New York City: High Performance Infrastructure Guidelines. NYC released this guidance in 2005 as a compliment to a previous publication focused on high performance buildings. The guidance document represents the collective effort of landscape architecture consultants, a regional advisory committee, and City agencies "that have jurisdiction over right-of-way infrastructure, including the departments of Transportation, Environmental Protection, Parks and Recreation, and Housing Preservation and Development" (part 1, p. 1). The guidance recognizes that the design of right-of-way components "profoundly affects our experience of the city… By joining considerations of function and performance with concern for the human experience of the urban environment" (part 1, p. 6). The right-of-way is defined as the organizer of "the massive flow of energy and matter that courses through the city on a daily basis", the choreographer of the "complex circulation of automobiles, buses, bicycles and pedestrians." It is also defined as “shared public real estate for social and economic activity that enriches civic life–play space, rallying grounds, zones of casual interchange, shopping, dining, and display” (part 1, p. 6). The document goes on… The public right-of-way also “houses a complex and vital network of utility infrastructure” for potable water, gas, electricity, telecommunications, stormwater and wastewater and is “host to nature and natural processes” that provide services such as improving air quality and absorbing and treating stormwater. In short, the public right-of-way is a multi-functional landscape by definition.

Before detailing best management (and design) practices for right-of-way infrastructure, the New York City guidelines articulate the following three over-arching principles:

Promoting sustainable urban ecology:
-- Cities are the product of complex interactions between constructed and natural systems
-- City dwellers depend on ‘ecosystem services’ such as breathable air and safe drinking water
-- Designers can/should develop infrastructure that promotes harmony and synergy with natural systems

Enhancing public health, safety, and quality of life:
-- Streetscape design has a direct impact on human safety and comfort in cities
-- Well-designed streetscapes benefit public health, safety, and quality of life
-- Streetscape retrofits can increase civic pride and social engagement and revitalize communities

Optimizing life cycle and performance:
-- Design can balance lifecycle costs and environmental impacts with asset longevity and performance
-- Cross-departmental coordination (integrated design goals) and maintenance improves performance

These broad principles are immediately relevant for the development of roadside raingardens in Seattle, even as they suggest Seattle’s current compartmentalized approach to streetscape retrofits would likely make responding to such guiding principles a significant challenge.

In the chapters that follow, the site analysis, siting and design processes for roadside raingardens are focused through the theoretical lenses presented here and a matrix of key variables is synthesized. Variables are examined more closely at three scales: the raingarden cell scale, the block scale, and the neighborhood/basin scale.

The unfolding problems of human ecology are not solvable by repeating old mistakes in new and more sophisticated and powerful ways. We need a deeper change.

-David Orr (referring to Albert Einstein)

Chapter 5

SITING CONSIDERATIONS AND ANALYSIS

Figure 7: Photo: Pam Emerson

Chapter 5

SITING CONSIDERATIONS AND ANALYSIS

I. Technical Feasibility: Soils, Slope, Seeps, Historic Streams + Known Drainage Challenges

The first step in devising a siting strategy for roadside raingardens within the Ballard CSO basins was to assess the technical feasibility of bioretention (with infiltration to native soil) in the right-of-way. This analysis evaluated soil type, longitudinal street slope (feasibility threshold 4%), the location of historic streams, and known seeps and drainage challenges. The schematic map below summarizes the results of the technical feasibility analysis.

(NOTE: All field analyses were carried out by Seattle Public Utilities geotechnical staff, together with stormwater engineering/design staff).

Figure 8: Technical Feasibility of Roadside Bioretention in Ballard CSO Basins

II. Multiple Goals Overlay: Roadside Raingarden Feasibility + "Walk.Bike.Ride" Opportunities

Next, the Seattle Pedestrian Master Plan, Bike Master Plan, and Transit Plan were analyzed for proposed near term capital improvements within the Ballard CSO basin boundaries. Why? Because streets already slated for right-of-way improvements present the potential for a more complete green infrastructure upgrade that includes on-site stormwater management. And reciprocally, the impetus of CSO compliance could provide an opportunity to attend to any long-standing pedestrian, bicycle or transit needs of the community.

The Pedestrian Master Plan highlighted the possiblity of new pedestrian improvements along a segment of NW 80th St. but did not propose specific projects nor other proposed near-term street improvements specific to the CSO basins. Resident complaints compiled by Seattle Department of Transporation showed requests for traffic calming along 28th Ave. NW and at the corner of Loyal Way and NW 80the St.

To reveal other potential opportunities for synergy between pedestrian safety or walk-scape improvements and roadside raingraden streetscape retrofits, major pedestrian destinations within the neighborhood were also mapped. And walk distances between these destinations were measured. Existing designated "recreational walking" routes were then overlayed. (Figure 9)

Because roadside raingardens can be installed in "curb bulbs" or "curb extensions"–which narrow the drive lane, slow traffic, and shorten crossing distances for pedestrians–existing school crosswalks and "Safe Routes to School" were also mapped explicitly as potential spots for synergy. (Figure 13)

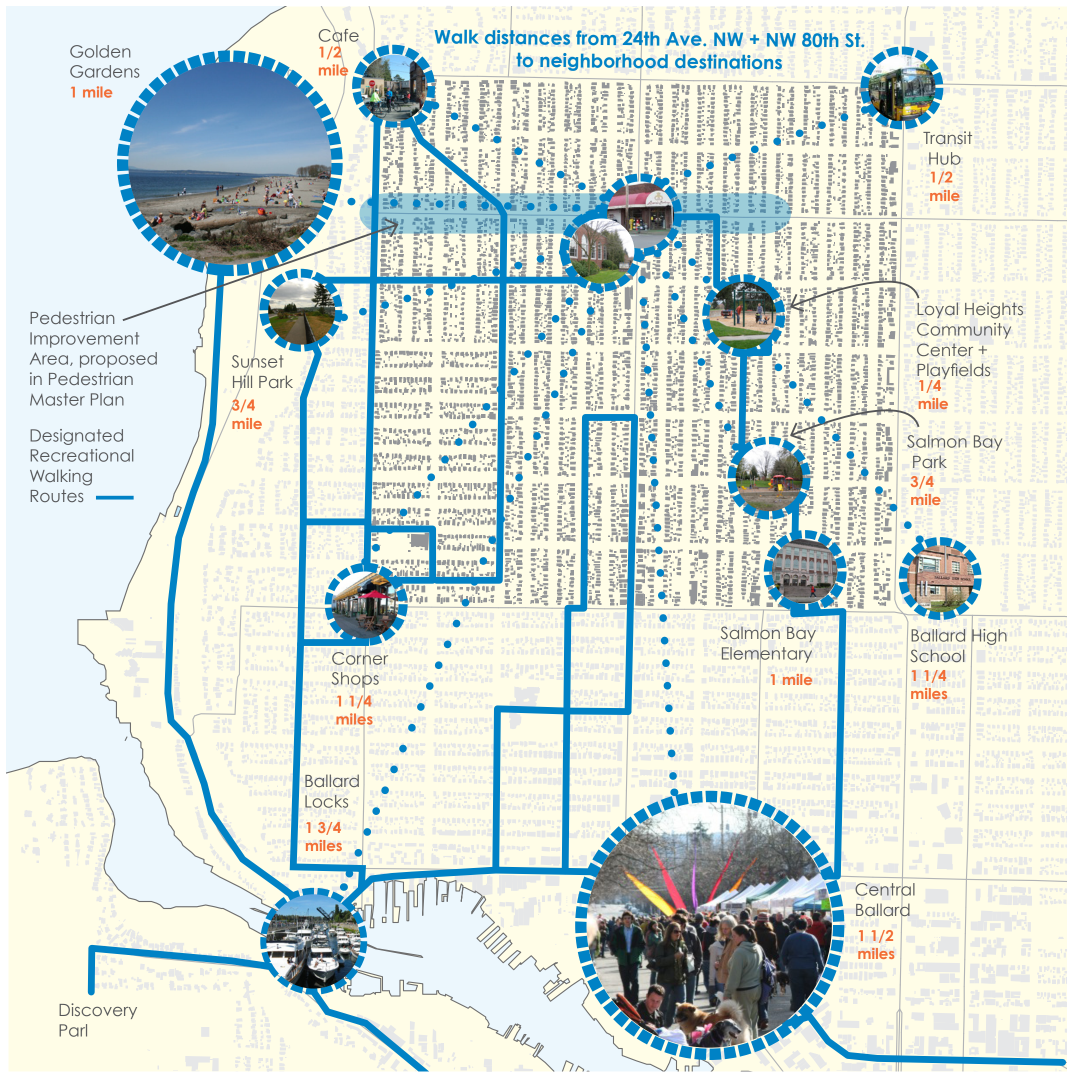


Figure 9: Pedestrian Master Plan Aspirations within the Ballard CSO Basins

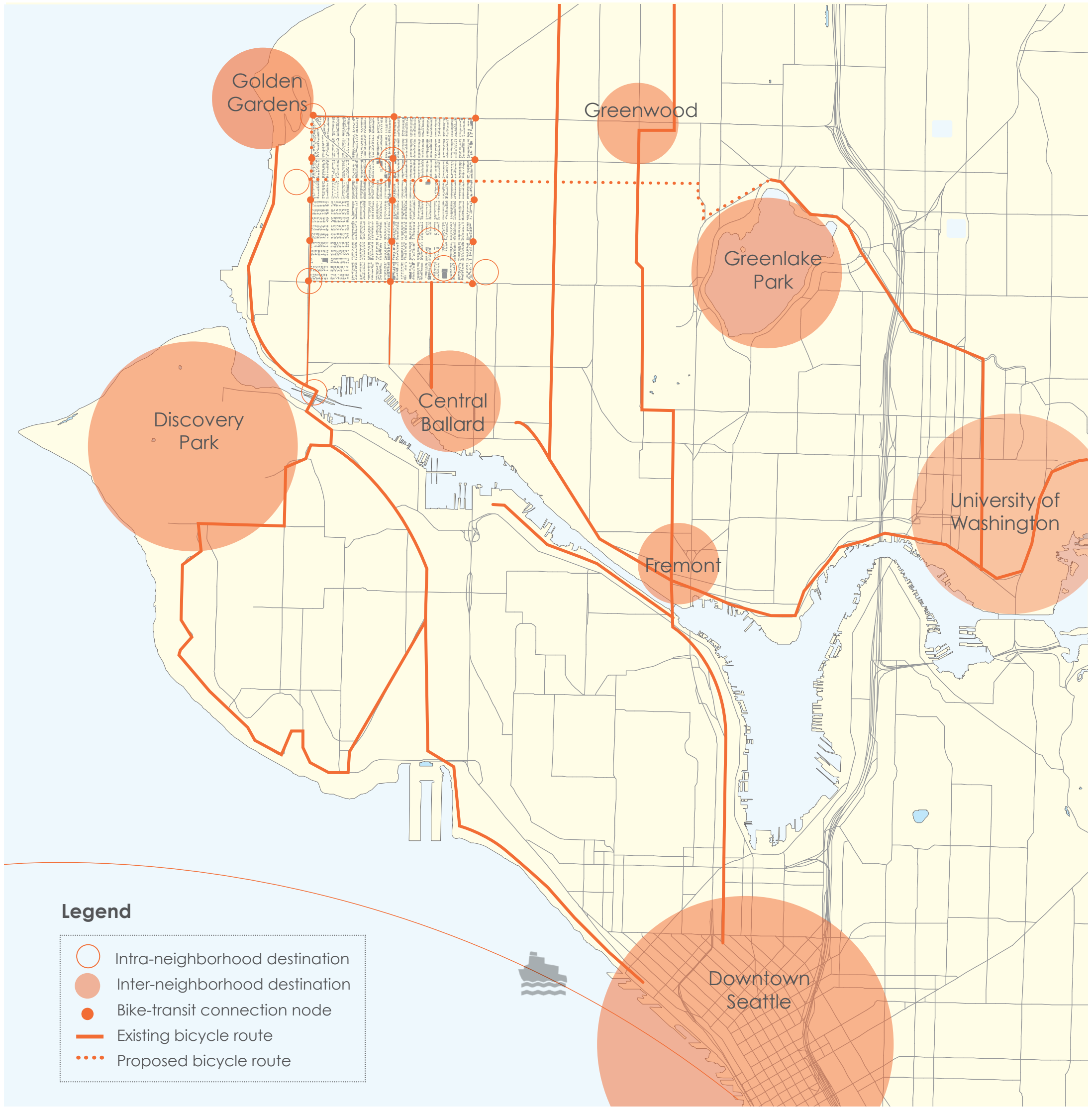


Figure 10: Bicycle Master Plan Aspirations within the Ballard CSO Basins

The Bike Master Plan calls for sharrow improvements on NW 65th St. and 32nd Ave. NW (See Figure 10) and also identifies a possible inter-neighborhood route for a "Neighborhood Greenway" on NW 77th St. Neighborhood Greenways are "low-volume and low-speed streets that have been optimized for bicycle travel using treatments such as traffic calming and traffic reduction, signage and pavement markings, and intersection crossing treatments. These treatments allow through movements for cyclists while discouraging similar through trips by nonlocal motorized traffic. Motor vehicle access to properties along the route is maintained." [Portland State University; Bicycle Boulevard Planning and Design Guidebook; July 2009; www.ibpi.usp.pdx.edu/guidebook.php]

Since the writing of the current Bike Master Plan, there has been increased interest in this type of bicycle facility among neighborhood residents in Ballard (and across the city) who seek a safe, low-stress alternative to biking on arterials with high car and truck volumes.

The Ballard-based community organization, "Totcycle", began organizing for Neighborhood Greenways in Ballard in the winter of 2011 and has since identified other promising routes, in addition to NW 77th St. These are summarized in Figure 13.

Roadside raingardens along Greenway routes can enhance safety by maintaining sightlines for cyclists and drivers alike (with low vegetation and/or no parking near intersections). And they put the "green" in "Greenways", enhancing the aesthetic appeal of the streetscape with attractive and cohesive landscape plantings.

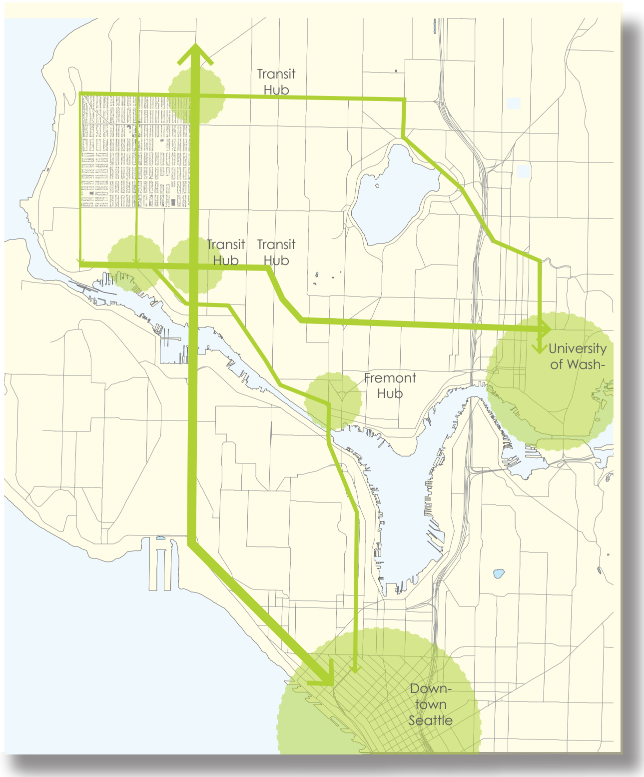


Figure 11: Rapid Ride Route Planned for 15th Ave. NW

King County Metro is also planning to begin “Rapid Ride” bus service on 15th Ave. NW in late 2012. The route will decrease travel times to Downtown Seattle as well as to east-west transit hubs at NW 85th St. and NW Market St. (See Figure 11) and is an opportunity to increase not only bus ridership but also to integrate green stormwater infrastructure into right-of-way improvements associated with the transit upgrade.

Roadside raingardens (or permeable pavement) could be intgrated with enhanced Rapid Ride stations and stops, on walking and biking routes leading to transit stops and/ or at bicycle-oriented “park and ride” junctions.

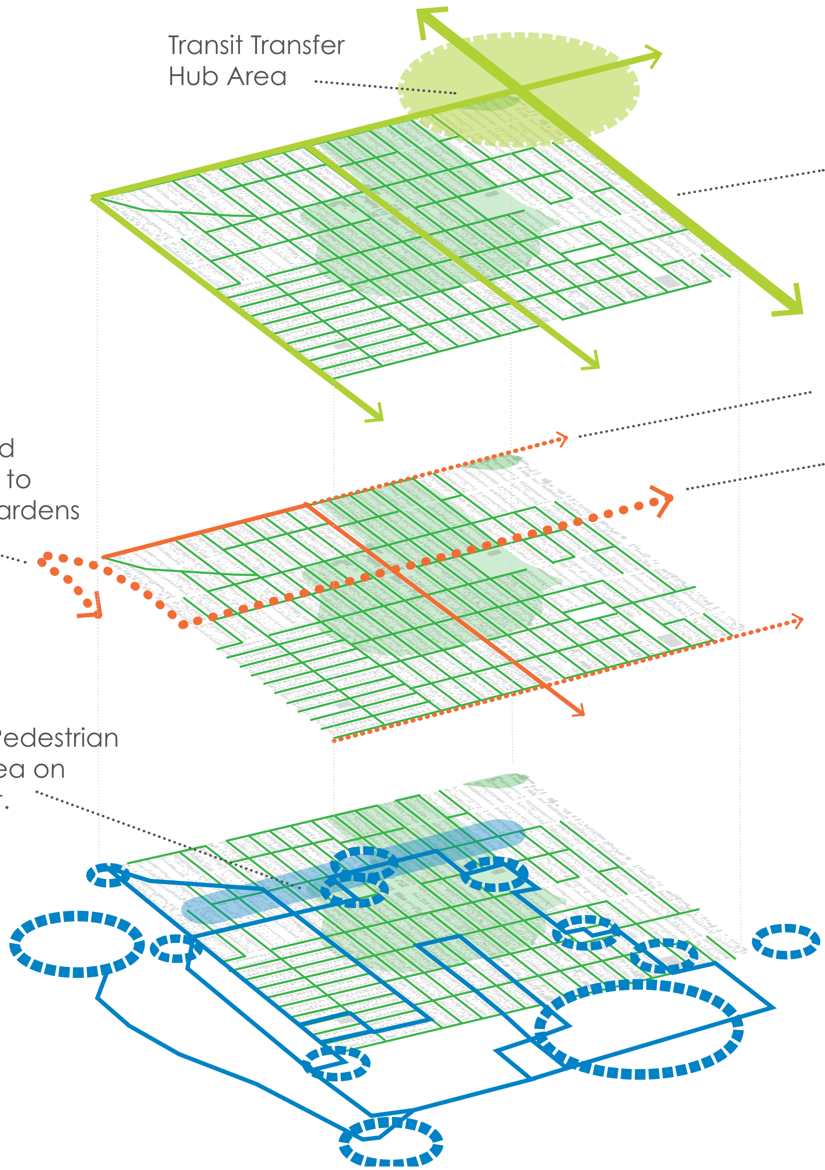


Figure 12: Summary of Existing “Walk.Bike.Ride.” Aspiraitons with the Ballard CSO Basins

The planned and potential “Walk.Bike.Ride” right-of-way improvements were then overlayed with the technical feasiblity study for roadside raingardens to identify areas with potential for significant overlap/synergy.

See Figures 12 and 13 for a summary.

walk. bike. ride.

The following areas were identified as having high potential for synergy:

- The existing "school zone" buffer areas around Loyal Heights Elementary and Salmon Bay Elementary schools.
- The intersection of NW 80th St., Loyal Way and 28th Ave. NW and points to the east and west along NW 80th St.
- Safe Routes to School crossings at NW 65th St. and 28th Ave. NW (and east)
- Along potential Neighborhood Greenway routes on NW 77th St., 17th Ave. NW, and
- NW 67th St.

It should also be noted that while curb bulbs and curb extensions shorten pedestrian crossings and calm traffic by narrowing the drive lane, these changes to the curb geometry may prevent the future establishment of bike-only infrastructure (grade-separated cycle tracks or buffered, dedicated bike lanes) in the current parking lane. Therefore, on streets that may serve as critical bike corridors in the future–even if they are NOT currently slated for improvement in the bike master plan–it may be prudent to apply roadside raingarden designs that do not alter the curb line.

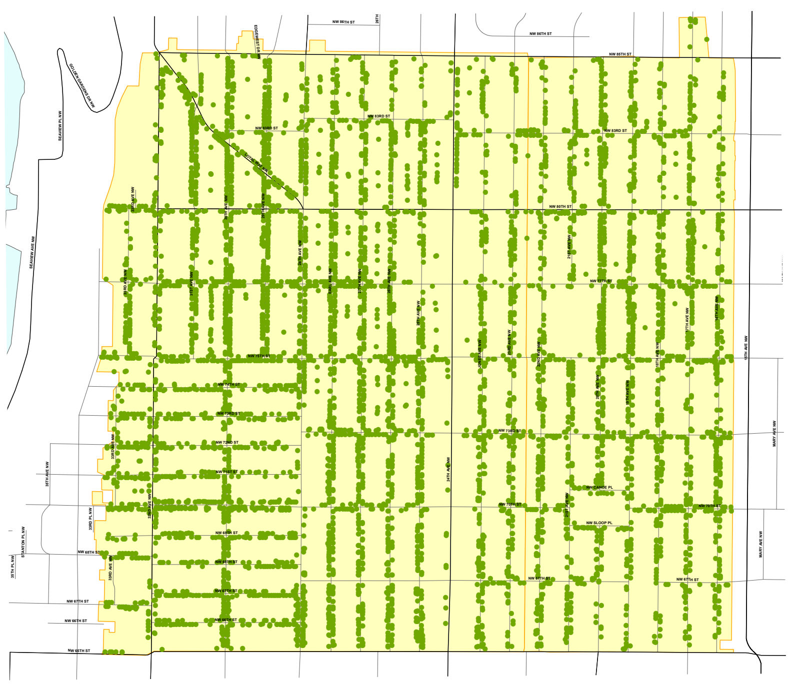
Figure 13: Ballard Opportunity Summary

Seattle is currently losing 4% of its tree canopy per year due to site development. To help reverse this trend, the city's Urban Forest Management Plan recommends replacing every tree lost with two trees planted. (Not all newly planted trees will survive to maturity). The report describes and estimates the social, environmental and economic benefits of urban trees and forests and has set a goal for increasing the current right-of-way canopy cover (city-wide) from 16% in 2007 to 24% in 2037.

Given this City-wide goal, the potential for tree canopy recovery within the Ballard CSO Basins was also examined. Figure 14 summarizes research conducted by Seattle ReLeaf Coordinator, Jana Dilley, highlighting the very high potential for tree canopy recovery in the street right-of-way throughout the Ballard CSO Basins (the highest planting potential of any neighborhood north of the ship canal). Virtually every street in the basin except 24th Ave. NW holds significant potential. The figure also excerpts information from the Urban Forest Management Plan highlighting the stormwater mitigation value of increasing street right-of-way tree canopy (city-wide).

This confluence presents an exciting opportunity to coordinate tree canopy recovery efforts with roadside raingarden siting and design.

Street Tree Canopy Recovery Potential
Ballard CSO Basins (2007)



Street Tree Canopy Recovery Value
City-Wide -- Seattle (2007)

Statistic	**Transportation Corridors/Street ROW**	
	Current	*30-year Goal*
Acres	14,412	14,412
Canopy coverage	16%	24%
Number of trees	130,000	195,000
Plantings needed		**65,000**
One-time cost of plantings		**$26,000,000**
Maintenance Costs (yr)	$3,900,000	$3,900,000
Benefits (yr)		
Stormwater Mitigation Value (yr)	**$1,820,000**	**$2,730,000**
Air Cleaning Value (yr)	**$780,000**	**$1,170,000**
Carbon Sequestration (Tons CO_2)	**4,900**	**7,400**
Carbon Sequestration (Value $)	**$150,000**	**$225,000**
Other Benefits (Energy, Aesthetics, & etc)	**$2,710,000**	**$4,065,000**
Net Benefit (All Benefits - All Costs) (yr)	$2,860,000	$4,290,000

Source: City of Seattle, Urban Forest Management Plan 2007

Figure 14: Tree Canopy Recovery Potential and Value

III. Social Feasibility: Grid Patterns, Parking Congestion, Planting Strip Width

In addition to analyzing the overlaps and potential synergies between roadside raingarden feasiblity, “Walk. Bike.Ride.” goals, and tree canopy recovery goals, it was also critical to analyze siting outcomes likely to be perceived as *negative* “place disruptions”–namely construction disruption/overall level of intervention and potential degree of parking loss. (See Figure 15). In order to deliver roadside raingardens in a way that *enhances* place-related identity and pride, these potentially negative impacts can and should be minimized. (A more specific parking loss analysis was conducted at the block scale and is detailed in Chapter 7).

The street grid pattern analysis showed that the “long blocks” (+/- 600 feet) typically ran along the frontside of residents’ homes and typically accomodated more parked cars, resulting in higher parking congestion. (See Figure 16).

In contrast, the “short blocks” (+/- 200 feet) typically ran along the side of residents’ homes and were far less congested with parked cars. Additionally, while an average of 13-14 parcels front each long block, an average of 4 parcels border each short block. Given that residents may have the strongest place attachment to the areas in front of their homes, temporary disruptions and/or changes to the streetscape on the *sides* of peoples’ homes may be less likely to trigger negative sentiments. Preferencing short blocks for roadside raingardens would also result in fewer residents being directly affected by the tempory inconveniences of construction.

The analysis also revealed that most residents in the north half of the basin have the potential for alley parking, while residents in the southern half, do not. This suggests that it may be more important to favor design solutions that mimimize parking loss in the southern portion of the basins.

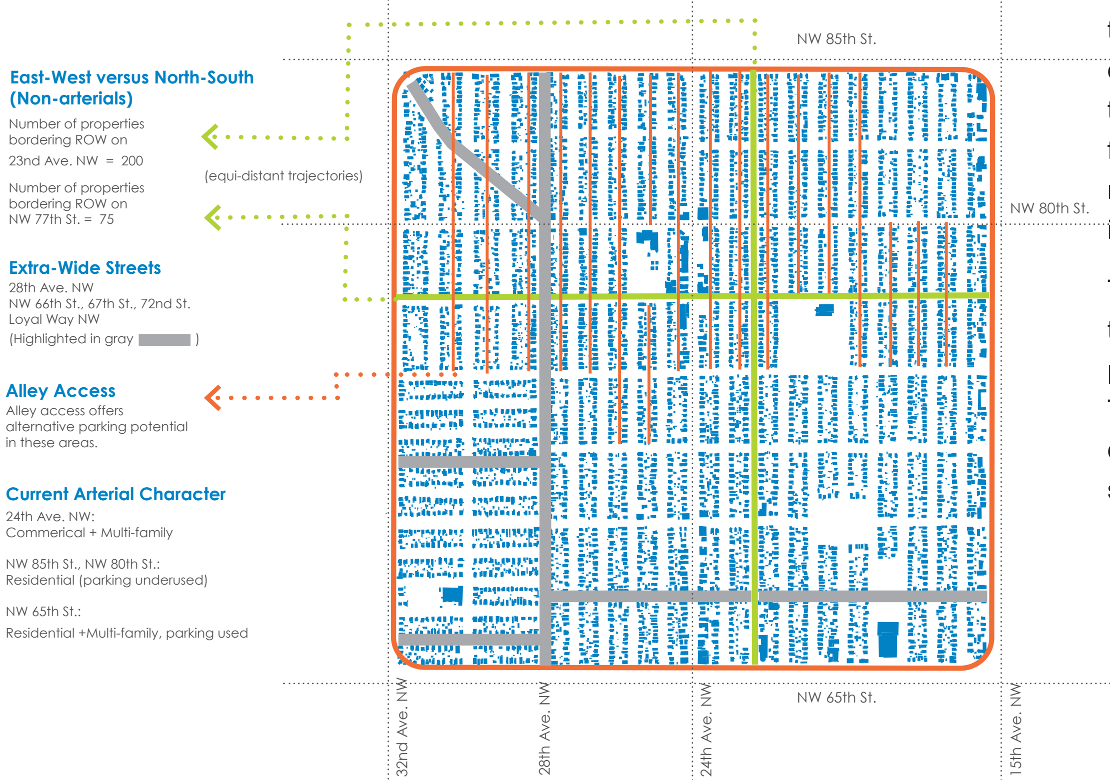
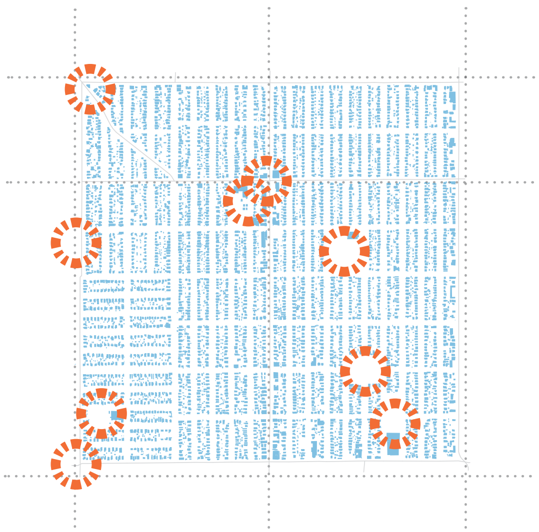


Figure 15: Street Grid Patterns Relevant to Roadside Raingarden Siting

Siting roadside raingardens on streets with less congested parking, on wider streets, in areas with patches of unnecessary paving, on residential arterials or side streets where traffic calming may be desired, or next to neighborhood destinations (where the demonstration value is high) may help ensure that changes to the streetscape are net positives for residents.



Parking Congestion: Long Block versus Short Block

Extra-Wide Streets

Residential Arterials

Awkward Intersections

Neighborhood Destinations


Sunset Hill Park


Salmon Bay Park

Larsens' Corner Bakery


Loyal Heights Elementary


Loyal Heights Play Fields

Figure 16: Parking Congestion, Problem Spots, and Neighborhood Destinations

Finally, the width of planting strips in the CSO basins vary widely and are also an important factor in determining where roadside raingardens can be implemented most effectively (with minimal or no negative social impacts and with as many positive impacts as possible). Planting strip width is an important consideration because it directly impacts which site designs may/may not be used. A design with side slopes and no curb bump out, for example, may be the least disruptive to the existing "look and feel" of the street and may also be the most cost effective, but may be impossible to install on a street with narrow planting strips. That said, it is also important to note that on streets with little to no planting strip width, this is due in nearly all cases to an unconventionally wide curb-to-curb width and is a vestige of the former street car routes through the neighborhood. Roadside raingardens on these streets may be best accomplished by *creating* a new planting strip by shifting the entire curb over, narrowing the drive lane to the standard twenty-five foot width. Streets with wide planting strips will have the largest range of available design options.

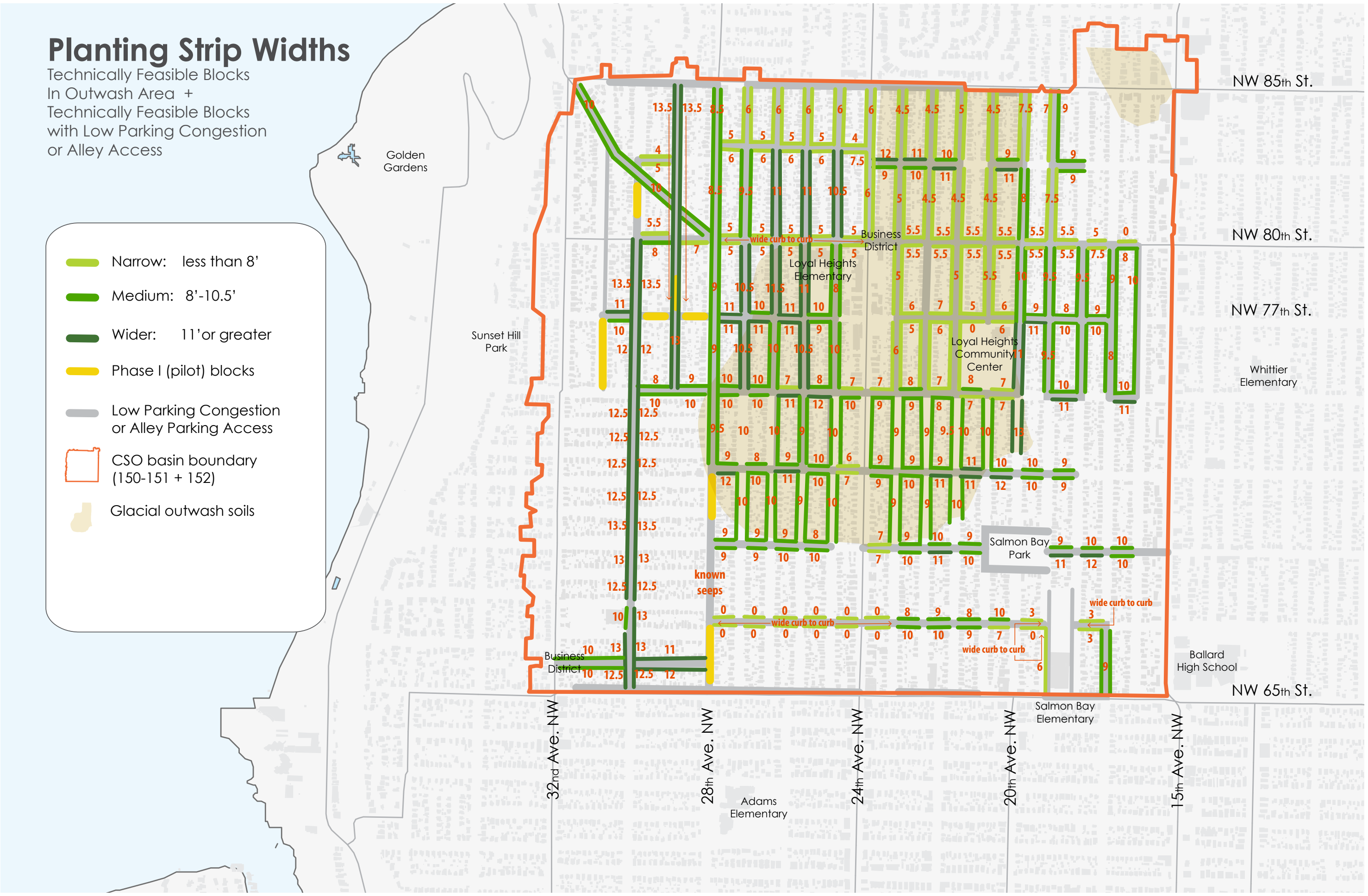


Figure 17: Planting Strip Widths

IV. Phasing Ideas Derived from Multiple Function Analysis + from Technical and Social Feasibility

One approach to phasing is to focus early interventions in areas that have a direct overlap between "Walk.Bike. Ride" goals and CSO control goals. As discussed above, this could mean locating roadside raingarden designs that have traffic calming effects near schools or on walking routes to/from schools. Proposed Neighborhood Greenways represent another opportunity for synergy as do current "problem spots" like the intersection of NW Loyal Way, NW 80th St. and 28th Ave. NW. Figure 18 summarizes the blocks with some degree of direct overlap between roadside raingarden feasiblity and "Walk.Bike.Ride." goals.

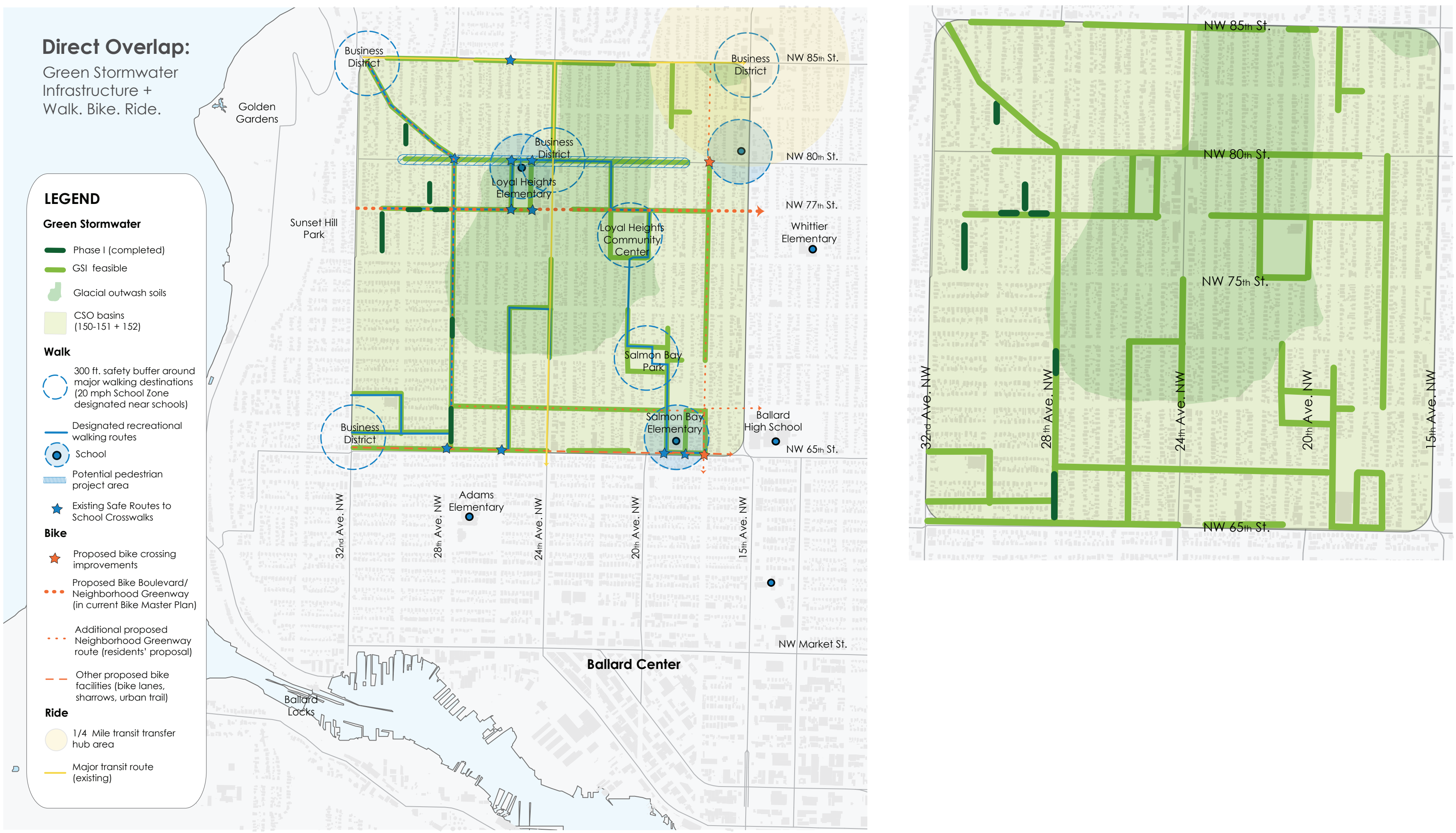


Figure 18: Green Stormwater Infrastructure + Walk.Bike. Ride. Direct Overlap

An alternative approach is to first consider the siting variables that most directly influence social function. These are: 1) soil type–outwash soils are likely to have higher infiltration rates and therefore required interventions on these blocks are likely to be smaller scale per unit of CSO function; 2) existing parking congestion and alley parking access–shorter blocks on the sides of residents' homes tend to have lower parking congestion, while blocks with alley parking access have more parking alternatives; 3) planting strip width–wider planting strips afford a higher variety of potential design solutions (opportunities to 'design out' unsightly signs or parking loss, for example) whereas narrower parking strips have more limited design options (vertical walled cells or curb bumps may be the only viable options on these blocks). One possible scheme for prioritizing and phasing interventions according to social function is offered in Figure 19.

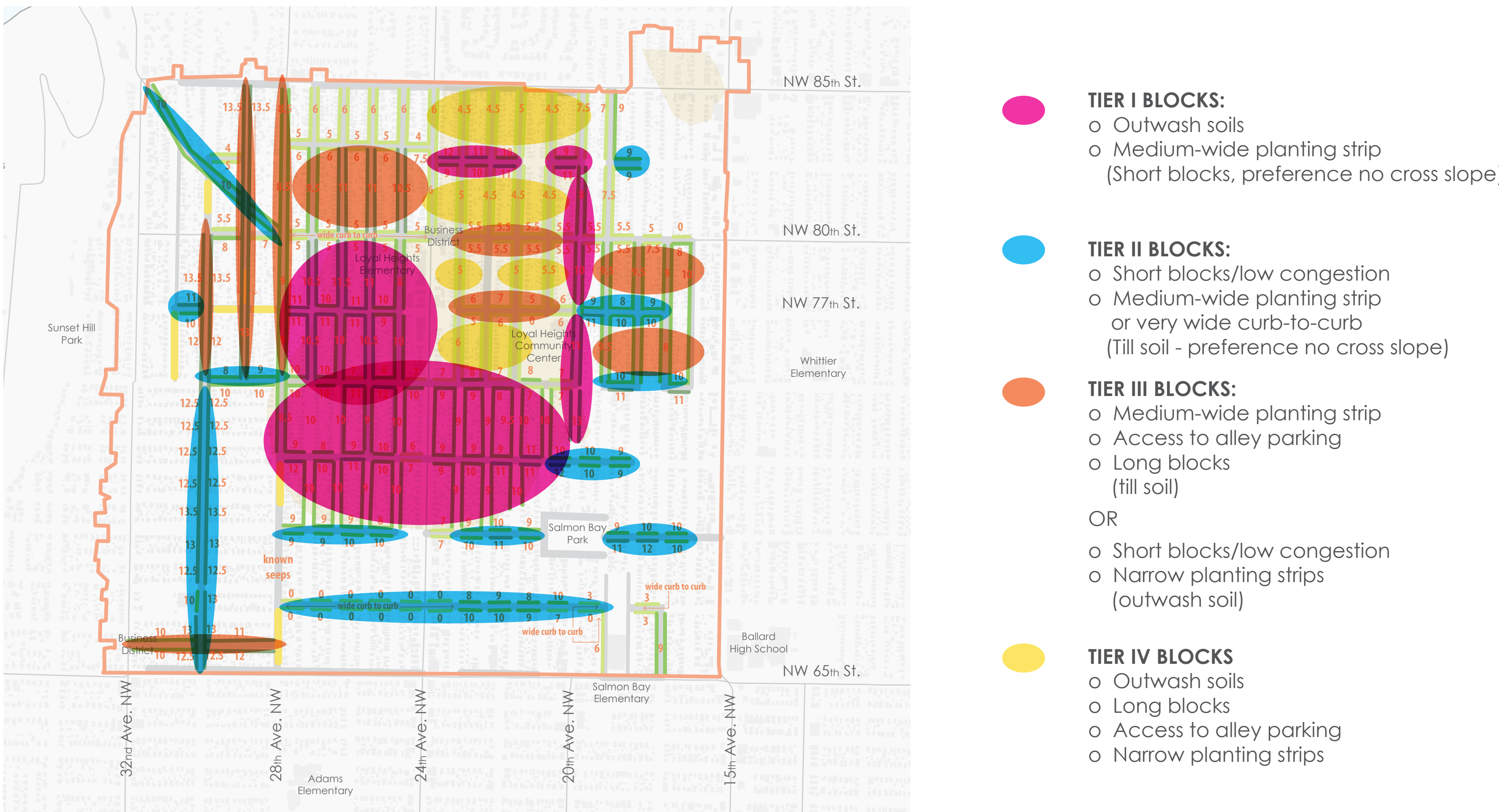


Figure 19: Prioritization/Phasing Scheme Focused on Social Function

Phasing/Block Selection: Sequenced Analysis

1

Ultimately, optimal siting should consider technical feasibility first and foremost–using filtering variables such as street slope (longitudnal slope) and proximity to steep slopes to eliminate blocks that are ill-suited or inappropriate for roadside bioretention. Soil type should be considered next. Outwash soil areas should be prioritized first (over till areas) because the range of design options (and therefore ease of social function) is likely to be higher in outwash areas with higher infiltration rates.

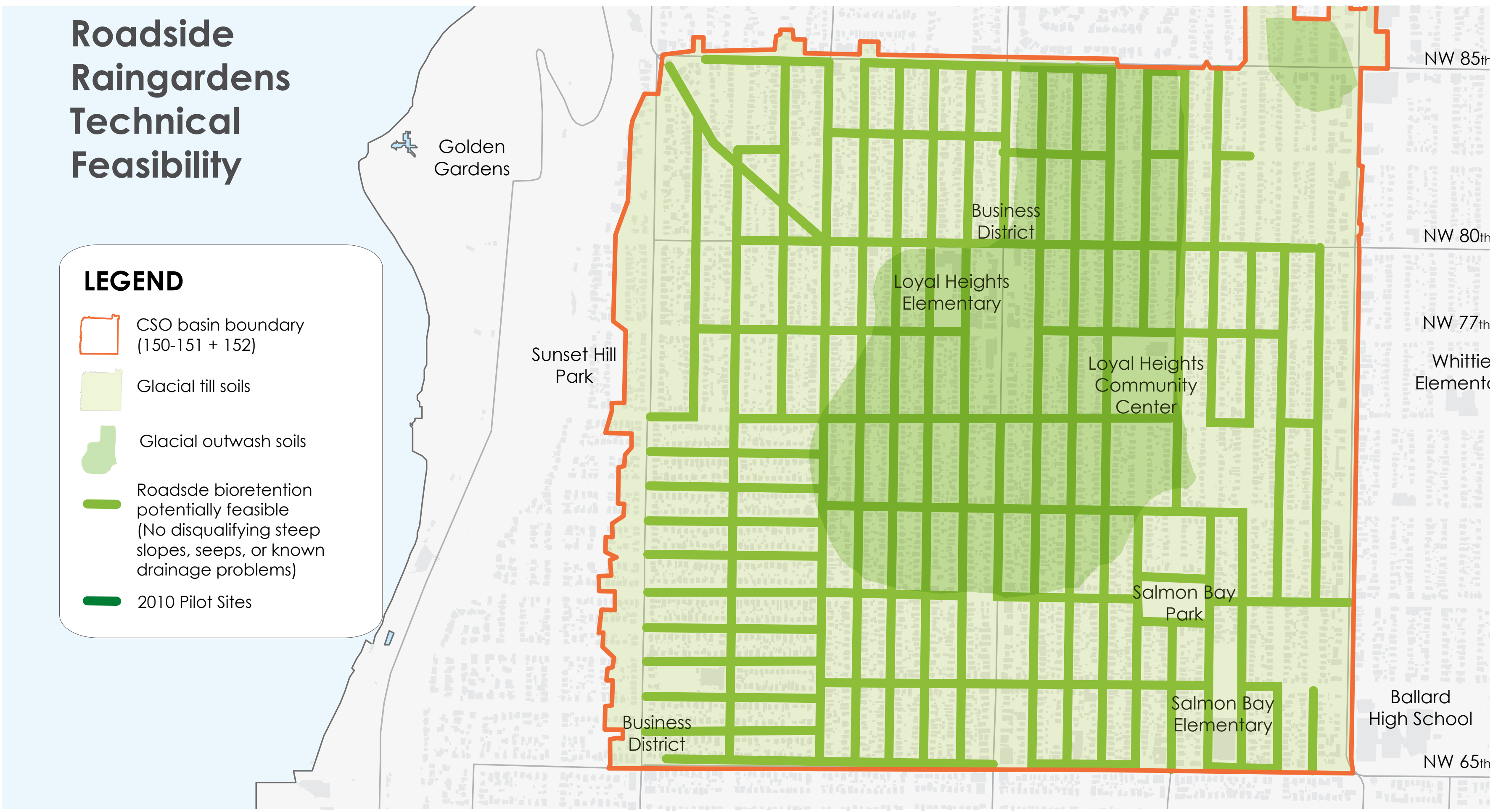


Figure 20: Roadside Raingardens Technical Feasibility

2

Next, additional variables that have a direct influence on social function should be analyzed. These include: parking congestion (short blocks vs. long blocks, access to alley parking, and planting strip width (and cross slope). Of course it also makes sense to prioritize siting of roadside bioretention on blocks that have requested or expressed support for raingardens in the past. The importance of these variables notwithstanding, high social function also depends on *design*. And many of the concerns highlighted by Ballard residents during the pilot phase–such as object markers, parking loss, and planting aesthetics–can also be addressed/overcome in the design phase.

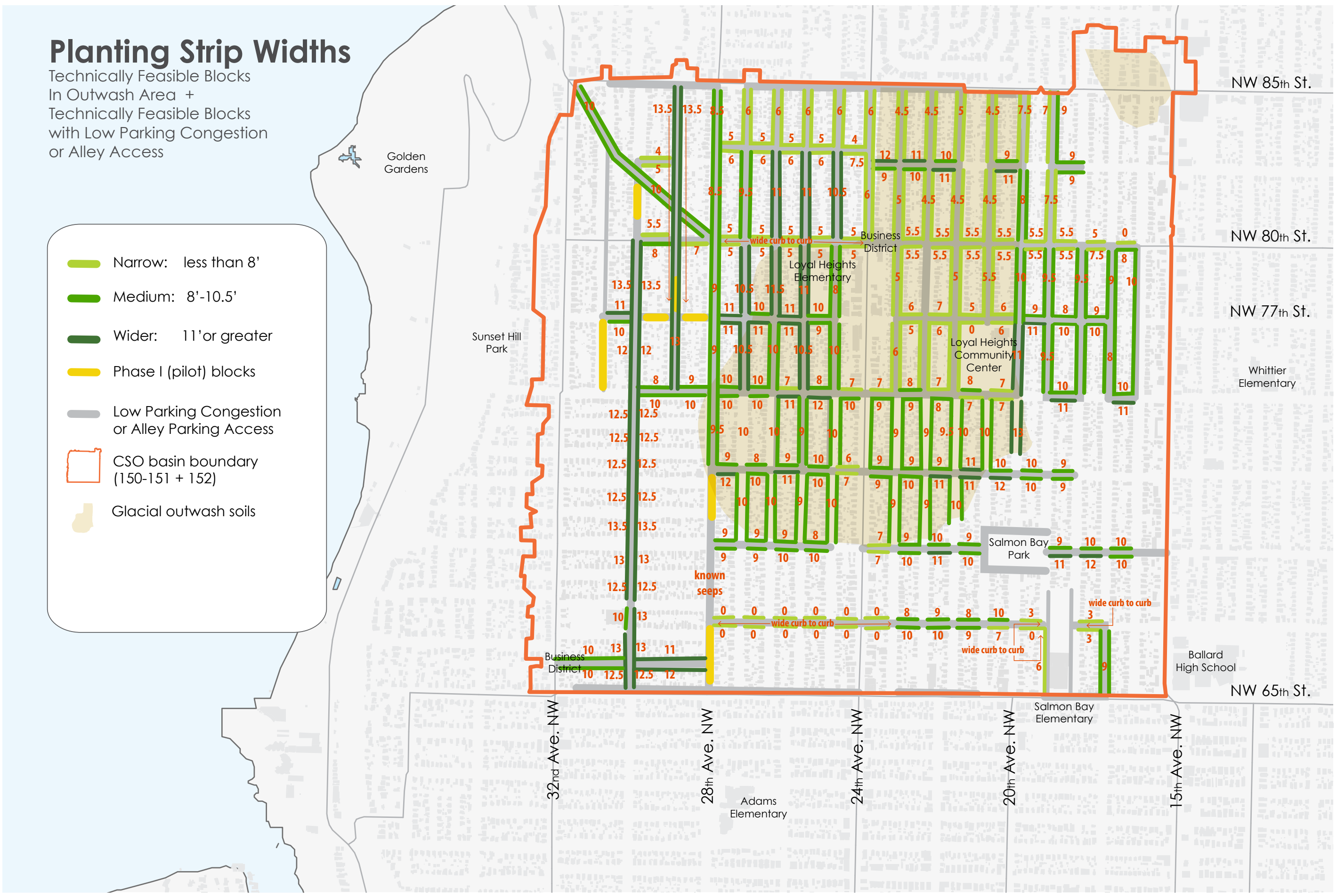


Figure 21: Planting Strip Widths

3

Finally, an overlay of multiple benefits should be applied to determine those blocks with the highest technical and social feasibility *as well as* the possibility of yielding a *higher value outcome* by acheiving multiple goals at once. City-wide plans such as the Bicycle Master Plan, Pedestrian Master Plan, Safe Routes to School, Climate Action Plan, Transit Plan and Urban Forestry Management Plan offer concrete information about neighborhood-specific improvement goals that might be furthered by roadside raingardens. Existing traffic safety concerns or neighborhood requests for pedestrian or bicycle safety improvements can also point toward opportunities. Finally, considering iconic or popular neighborhood destinations–such as schools, churches, and commercial districts–may also lead to project synergies.

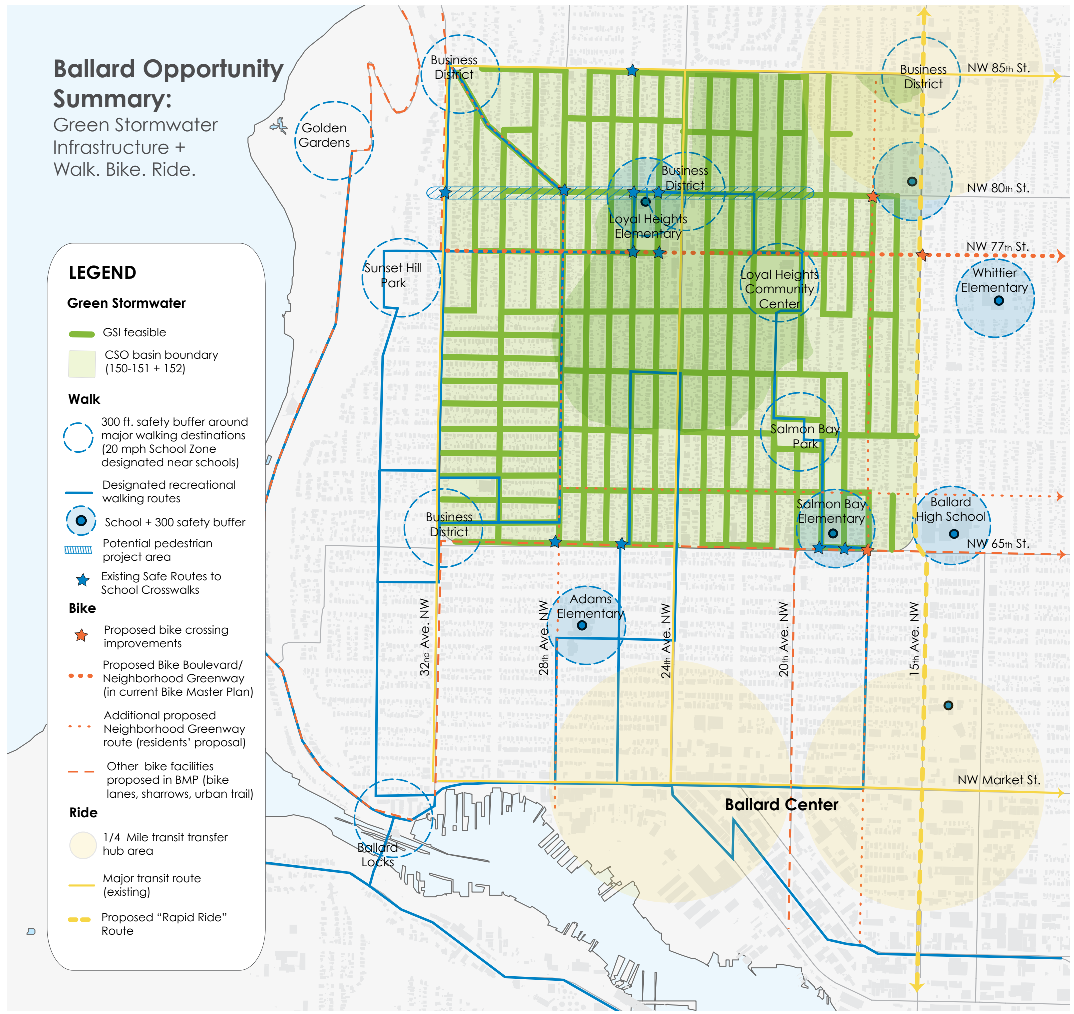


Figure 22: Ballard Opportunity Summary

Chapter 6

DESIGN CONSIDERATIONS + TEMPLATES AT THE RAINGARDEN SCALE

Figure 23: Photo: Pam Emerson

I have come to believe that the experience of beauty is a necessary component of fostering a sustainable community, and that beauty is a key component in developing an environmental ethic.

- Elizabeth Meyer

Chapter 6

DESIGN CONSIDERATIONS + TEMPLATES AT THE RAINGARDEN SCALE

I. Precedents: Portland, Malmo, Seattle [Highpoint and Ballard Pilot]

Precedents in Portland, Oregon, Malmo, Sweden, and Seattle, WA were studied to inform design at the raingarden scale as well as planting plan selections. Figure 24 highlights predominantly vertical-walled cells built in Portland, Oregon and illustrates: 1) how vertical side walls can "fit" the look and feel of residential streets; 2) how dense plantings can be used to soften hard edges; 3) how vertical side-wall designs have been utilized to maximize CSO volume reduction per square foot of intervention.

PORTLAND, OR
vertical-walled cells

Figure 24: Vertical Side Walls in Residential and High Foot Traffic Settings

The first set of photos in Figure 25 highlights hardscape and vertical-walled cells built in high foot-traffic settings in Malmo, Sweden. These designs illustrate: 1) how stormwater can be revealed artfully in a narrow right-of-way and conveyed to an opening with more flexibility for treatment and infiltration; 2) how stormwater management can be used to improve streetscape aesthetics; 3) how small details (like a viewing platform or a stepping stone) can invite exploration and add comfort. The second set of photos in Figure 16 highlights successful roadside raingarden projects built in Seattle, WA. These designs illustrate: 1) how a simple planting plan can add cohesion and interesting texture to the streetscape aesthetic; 2) how low plantings work to maintain sightlines and a sense of tidiness; 3) how foot crossings can be integrated into a series of connected cells; 4) how roadside rain-gardens can be effective tools for CSO volume control.

Malmo, Sweden
small spaces + hardscape

Seattle, WA
edge + plant alternatives

Figure 25: Small Spaces, Hardscape + Planting Alternatives

Figure 26 offers a visual summary of the primary neighborhood concerns raised during the Ballard pilot. The top series illustrates the specific design variables that are critical to attend to in order to ensure the *social function* of roadside raingardens. The bottom image illustrates how, when these variables *are attended to* (and the technical design is sound) social function is much improved.

Primary Neighborhood Concerns

1 Unattractive object markers
2 Abrupt bump outs
3 Depth of cell + ponding depth
4 Immature plantings
5 Continuous ponding in winter
6 Parking loss - Poor auto egress

Poorly functioning Ballard pilot raingardens during installation in rainy winter

Fully functional Ballard pilot raingardens after one season of plant growth (photo taken in the rain)

Figure 26: Ballard CSO Pilot Raingardens

II. Variable Set Defined: Longitudinal Slope, Ponding Depth, Cell Depth, Infiltration Rate

In order to develop starting-place design templates at the raingarden scale, a set of design parameters was defined (See Table 3).

The site-scale and block scale design concepts that follow adhere to these parameters and assume a 9' planting strip, unless explicitly stated.

Table 3: Test Case Design Parameters at the Raingarden Scale

Long Block

Catchment Area:
600' long block x 12.5' curb-to-centerline = 7500 sq ft
600' long block x 5' sidewalk = 3000 sq ft
2 of 14 roofs at 25% roof area for 1000 sq ft roof = 500 sq ft
TOTAL catchment area = 11000 sq ft (per side)

Additional Parameters

ponding depth:	6"
infiltration rate:	.25"/hr
longitudnal slope:	4%
max. cell depth (from TOC):	18"

Design Target:
95% of 2 year storm
815 sq ft. total bottom area required (per side)

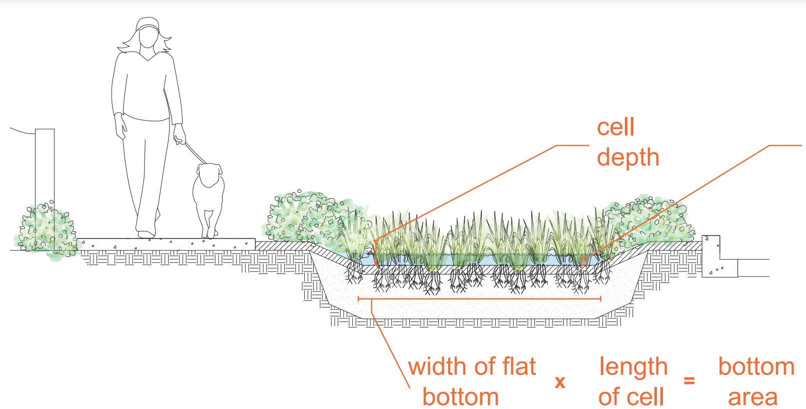
Short Block

Catchment Area:
200' long block x 12.5' curb-to-centerline = 2500 sq ft.
200' long block x 5' sidewalk = 1000 sq ft.
1 of 2 roofs at 25% roof area for 1000 sq ft roof = 250 sq ft.
TOTAL catchment area = 3750 sq ft (per side)

Additional Parameters

ponding depth:	6"
infiltration rate:	.25"/hr
longitudnal slope:	4%
max. cell depth (from TOC):	18"

Design Target:
95% of 2 year storm
280 sq ft. total bottom area required (per side)



III. Sizing, Side Slope, Parking, Object Markers: Options Analysis

A range of cell-scale morphology types was explored for a medium (9' wide) planting strip test case to reveal "social function" trade offs between varying design approaches. Social function variables that change with changing cell morphology choices include: "look and feel" (including perception of depth), parking /auto egress, curb configuration, object markers (signs) and overall level of intervention required to achieve target control volume. Representative (though not exhaustive) examples from three morphology categories were explored: side slopes, vertical walls, and hydrids.

The cell morphologies that follow are rated on a qualitiative scale for their "social function" with respect to a subset of the above-mentioned variables. "Look + feel" is not rated, as this is highly subjective. However, look + feel may trump the "rated" social functions, underscoring the need for choice.

lower social function

significant parking loss
required object markers + no parking signs
low bottom area per cell

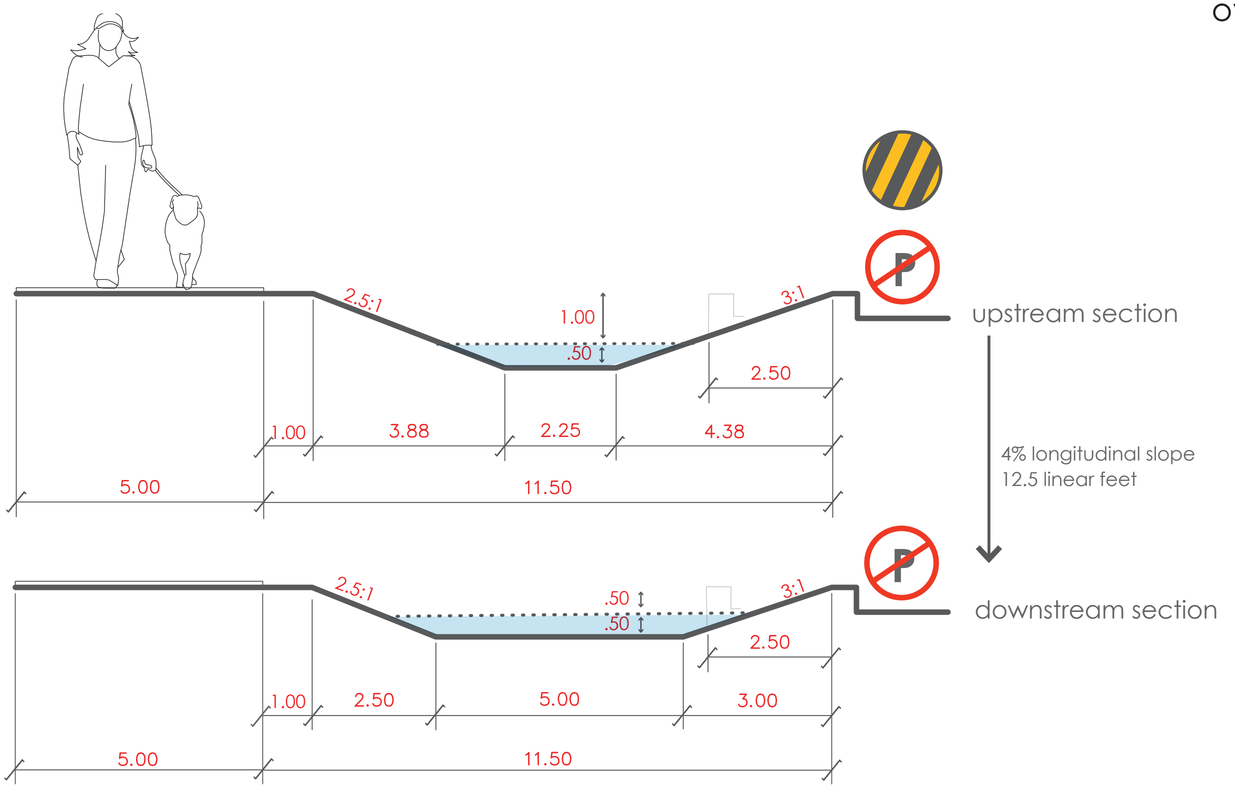
so-so social function

low parking loss
no parking signs only
medium bottom area per cell

higher social function

no parking loss
no object markers, no "no parking" signs
high bottom area per cell

parking/auto egress
signs + object markers
overall level of intervention

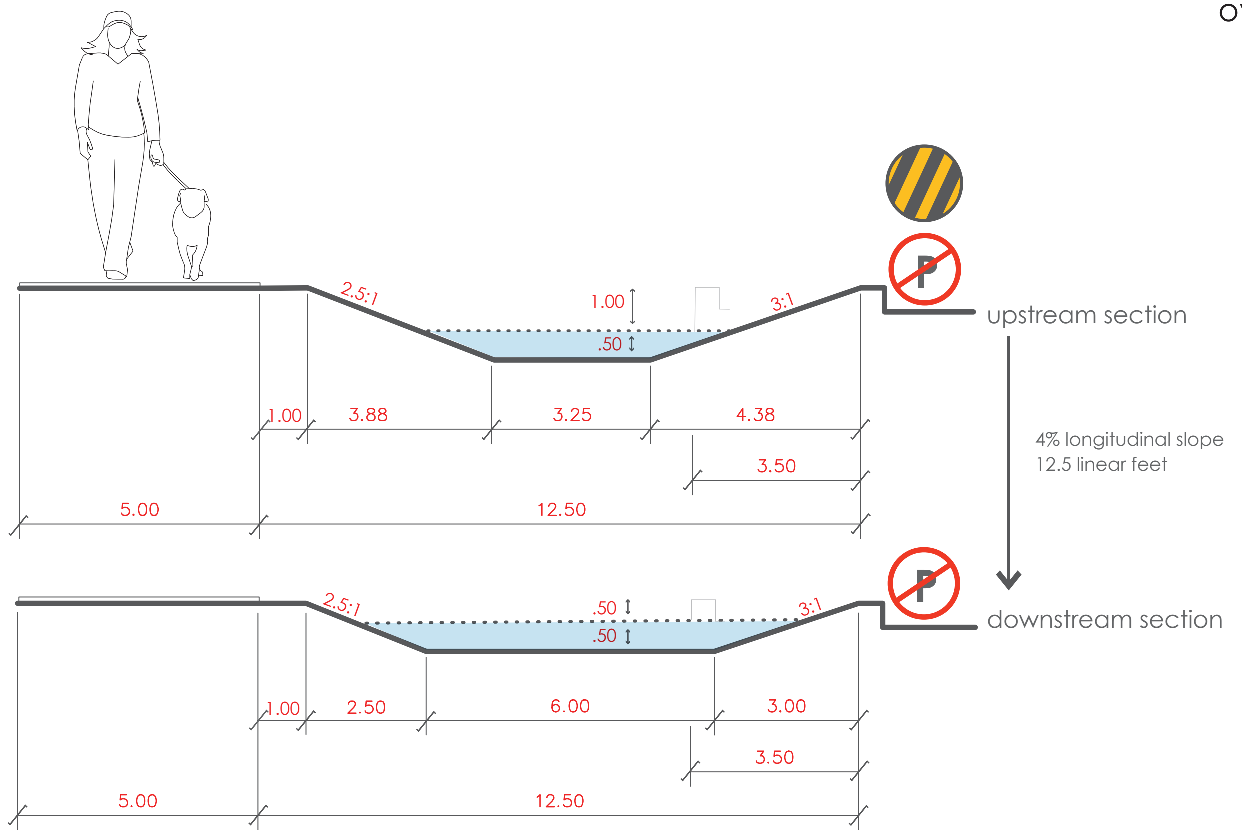


S.a BOTTOM AREA: 45 sq feet

Sloped, 2.5' Curb Bump

Figure 27: Cell Morphology: Sloped, 2.5' Curb Bump

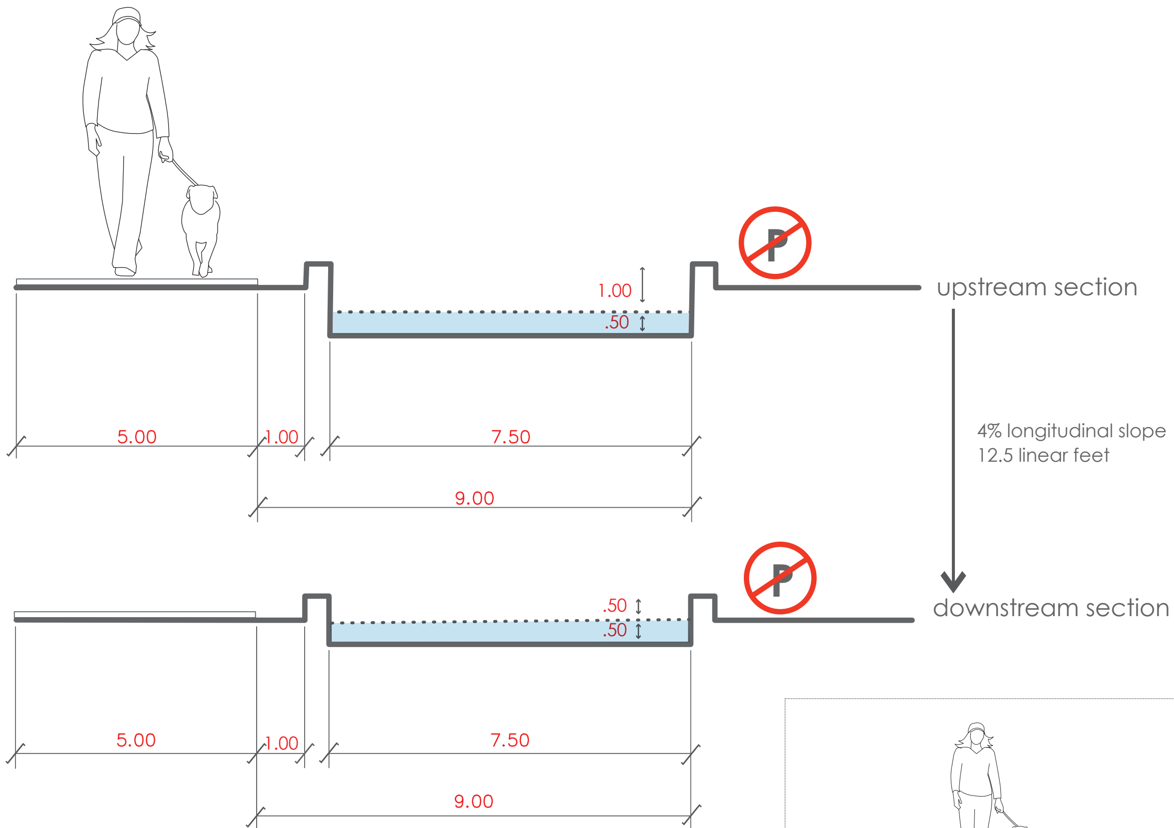
parking/auto egress
signs + object markers
overall level of intervention



S.b BOTTOM AREA: 58 sq feet
Sloped, 3.5' Curb Bump

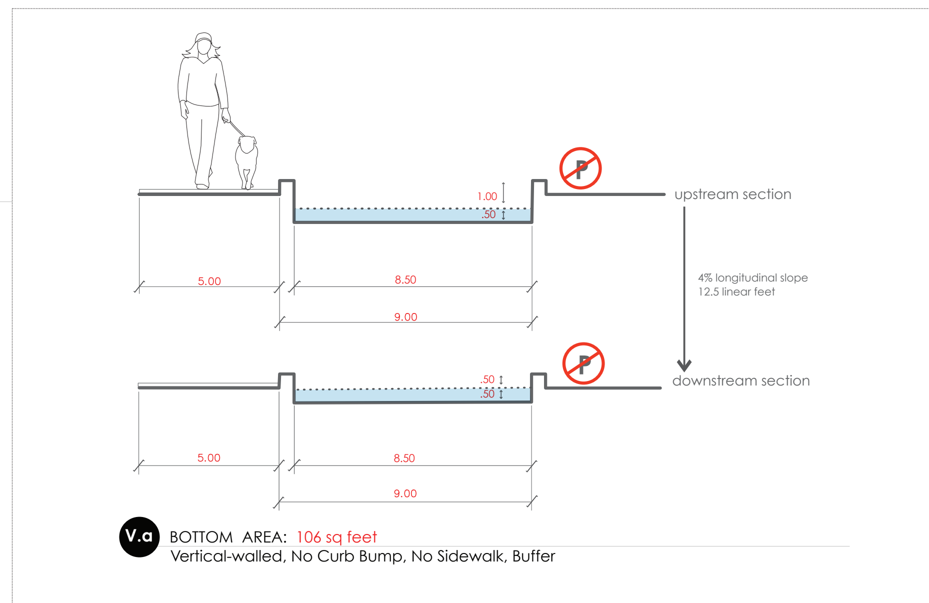
Figure 28: Cell Morphology: Sloped, 3.5' Curb Bump

parking/auto egress
signs + object markers
overall level of intervention



V.a BOTTOM AREA: 94 sq feet
Vertical-walled, No Curb Bump

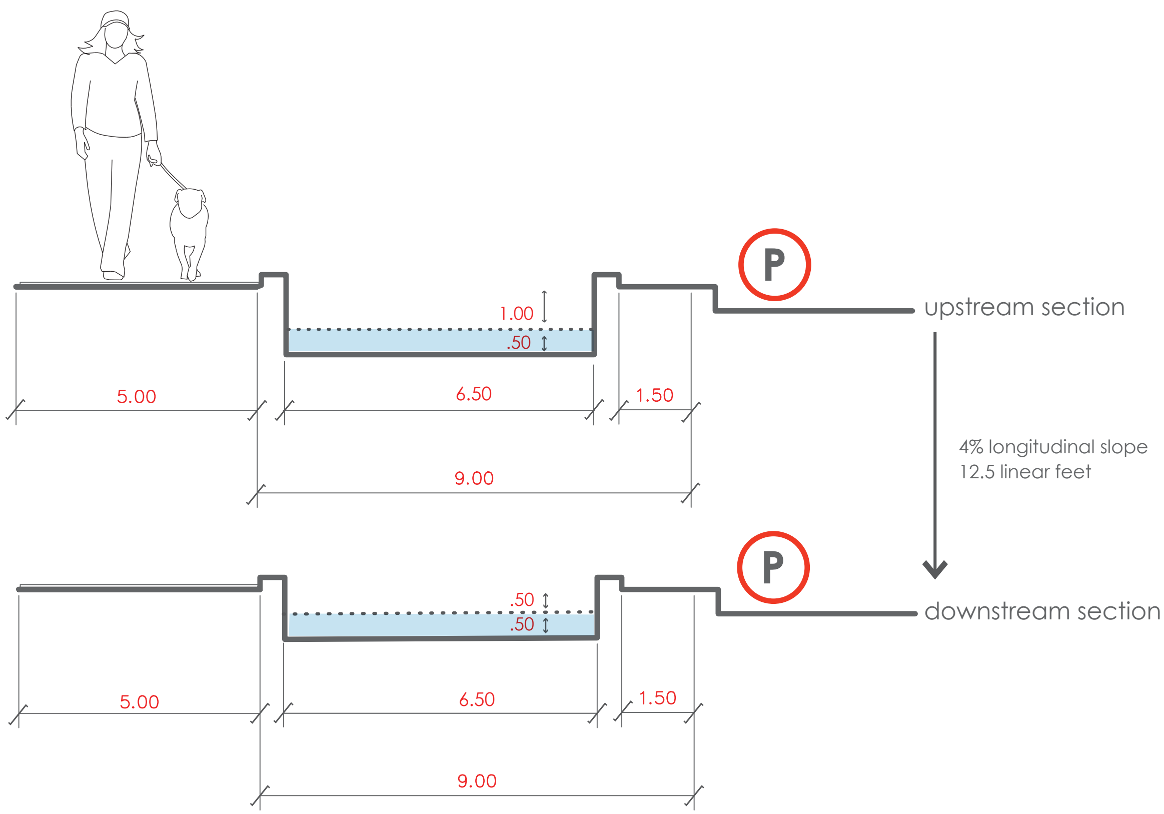
Figure 29: Cell Morphology: Vertical-walled, No Curb Bump



parking/auto egress

signs + object markers

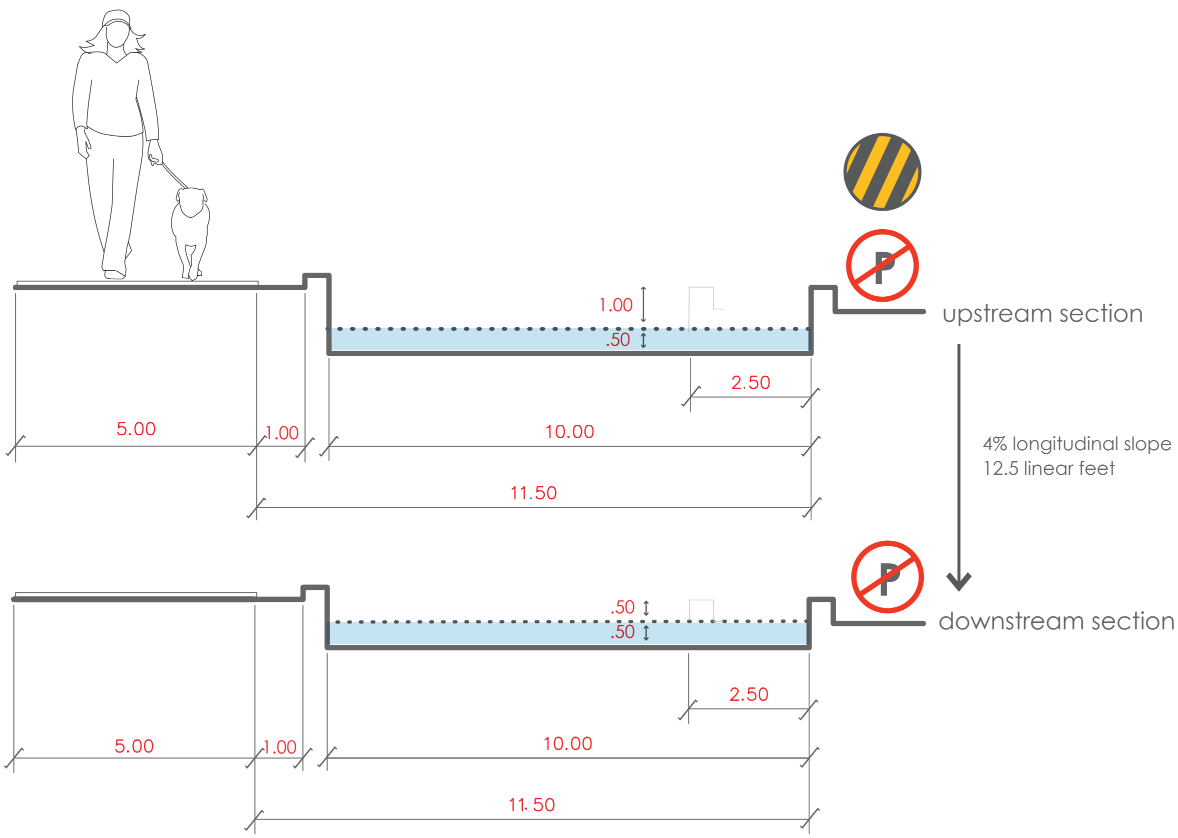
overall level of intervention



V.b BOTTOM AREA: 81 sq feet
Vertical-walled, No Curb Bump, Egress Buffer

Figure 30: Cell Morphology: Vertical-walled, No Curb Bump, Egress Buffer

parking/auto egress ○
signs + object markers ○
overall level of intervention ●

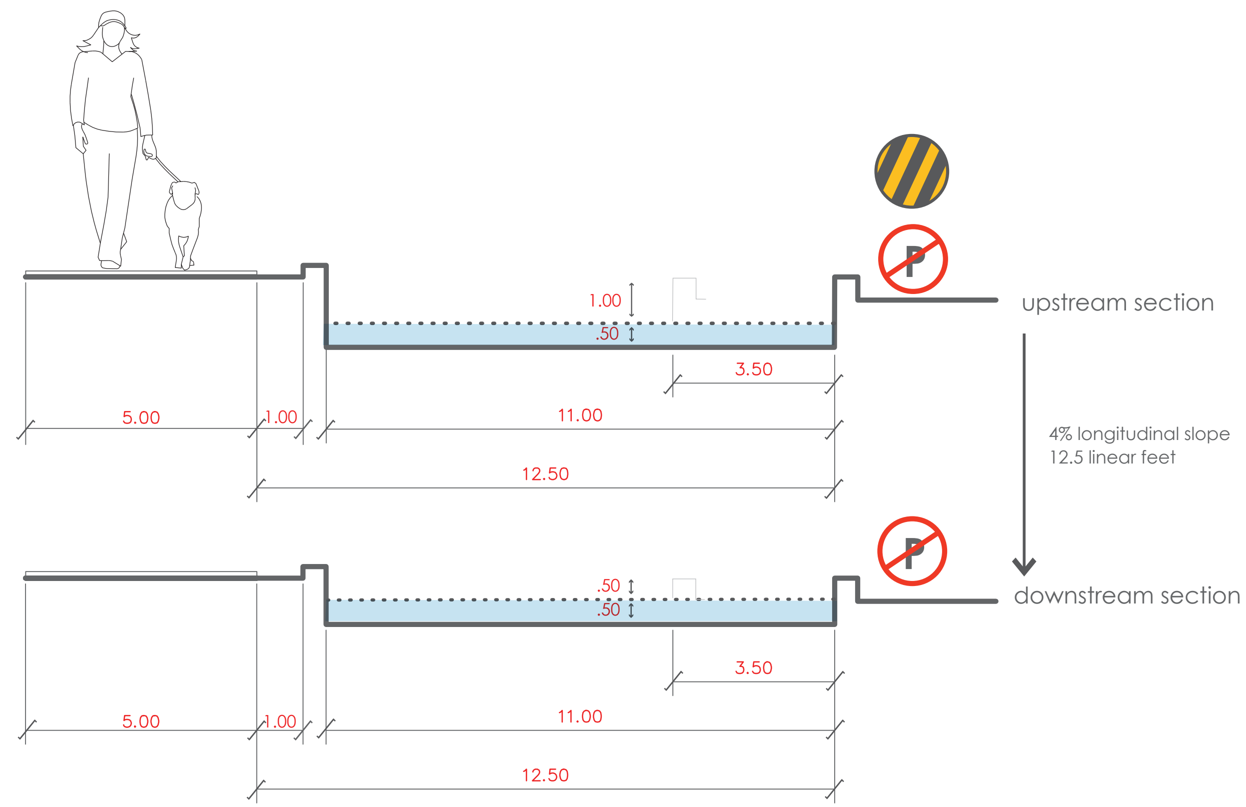


V.c BOTTOM AREA: 125 sq feet

Vertical-walled, 2.5' Curb Bump

Figure 31: Cell Morphology: Vertical-walled, 2.5' Curb Bump

parking/auto egress ○
signs + object markers ○
overall level of intervention ●

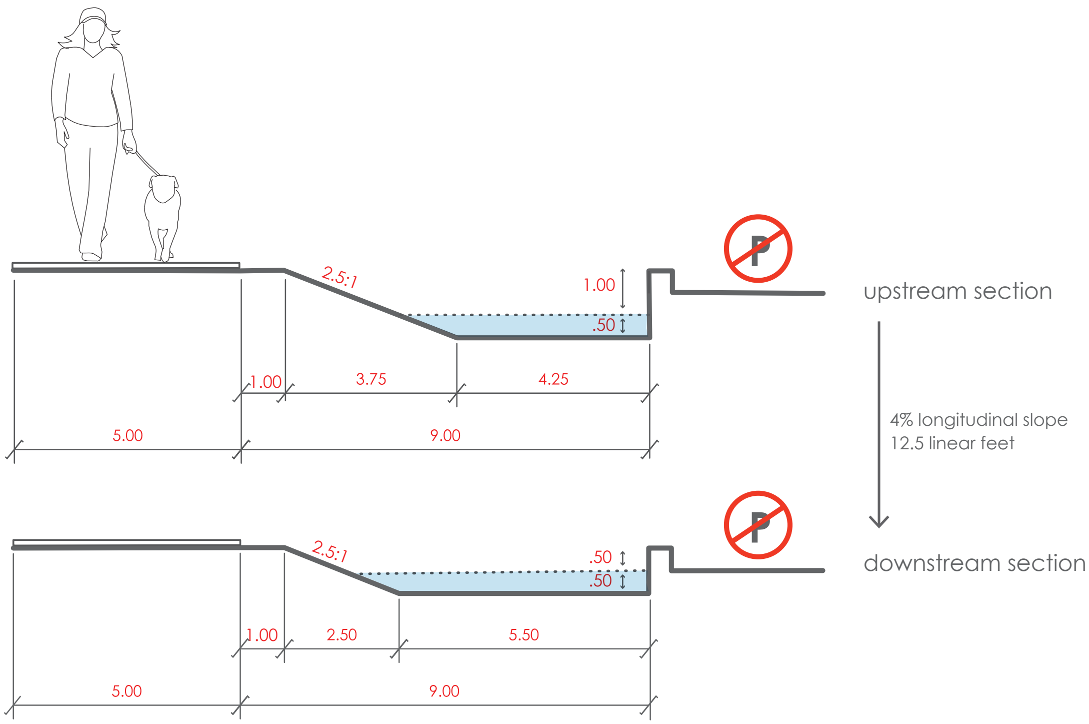


V.d BOTTOM AREA: 138 sq feet

Vertical-walled, 3.5’ Curb Bump

Figure 32: Cell Morphology: Vertical-walled, 3.5’ Curb Bump

parking/auto egress
signs + object markers
overall level of intervention

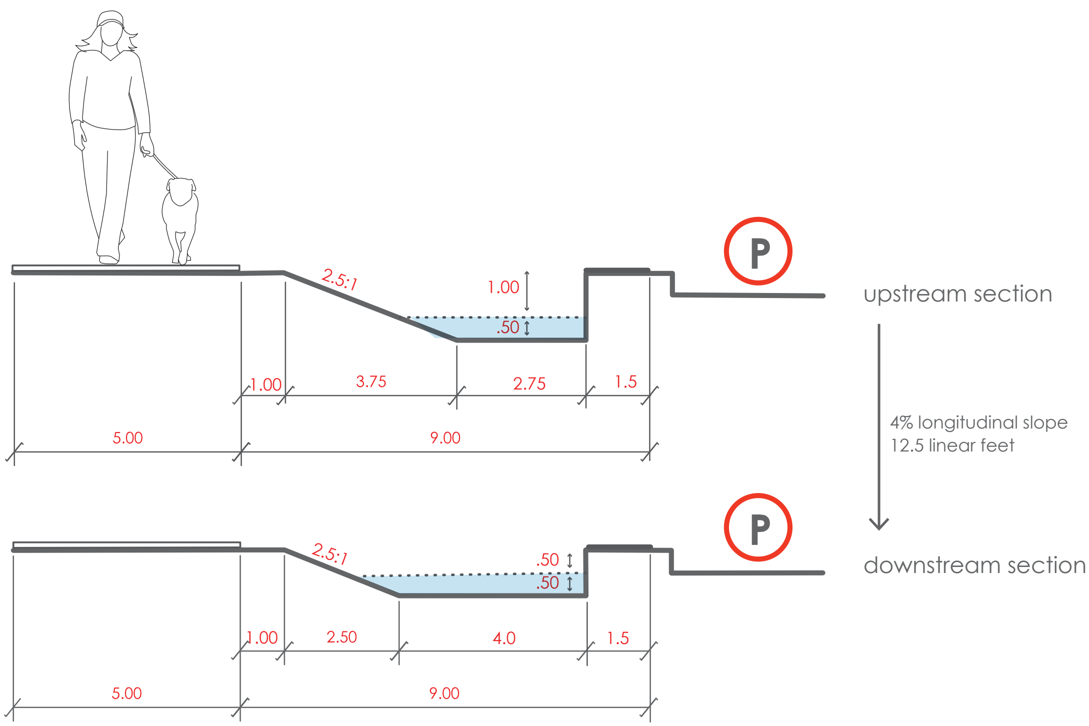


H.a BOTTOM AREA: 61 sq feet

Hybrid, No Curb Bump

Figure 33: Cell Morphology: Hybrid, No Curb Bump

parking/auto egress ●
signs + object markers ●
overall level of intervention ○



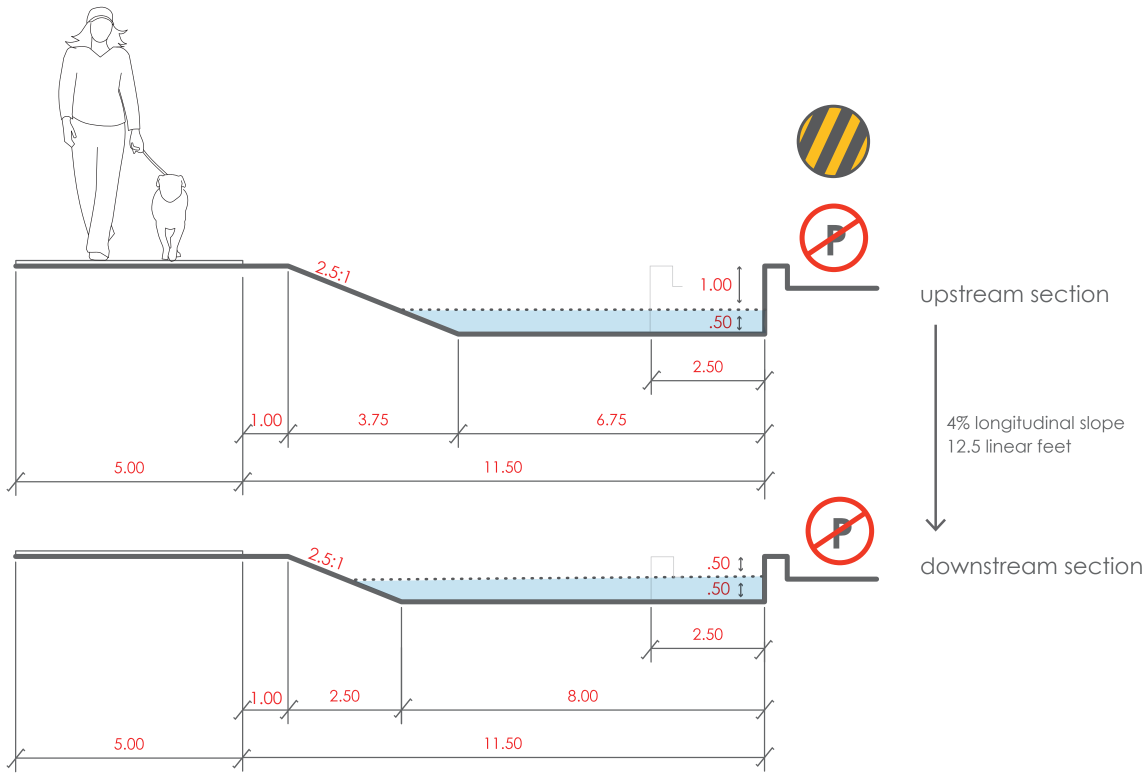
H.b BOTTOM AREA: 42 sq feet
Hybrid, No Curb Bump, Egress Buffer

Figure 34: Cell Morphology: Hybrid, No Curb Bump, Egress Buffer

parking/auto egress

signs + object markers

overall level of intervention



H.c BOTTOM AREA: 92 sq feet

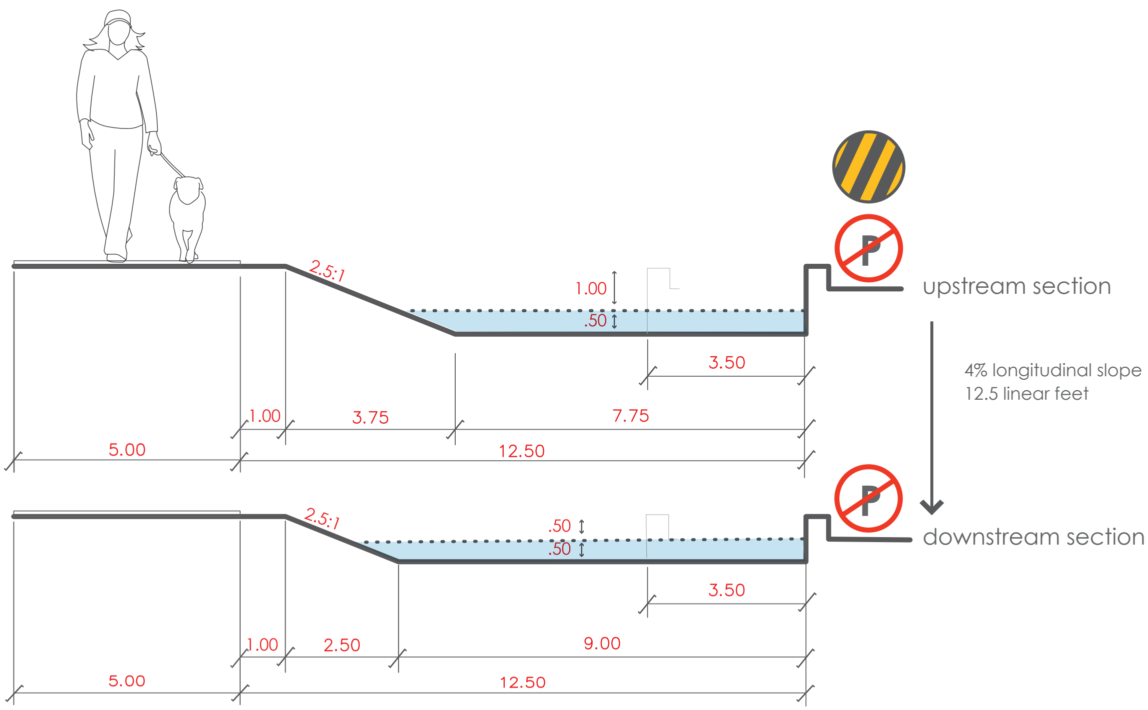
Hybrid, 2.5’ Curb Bump

Figure 35: Cell Morphology: Hybrid, 2.5’ Curb Bump

parking/auto egress ○

signs + object markers ○

overall level of intervention ●

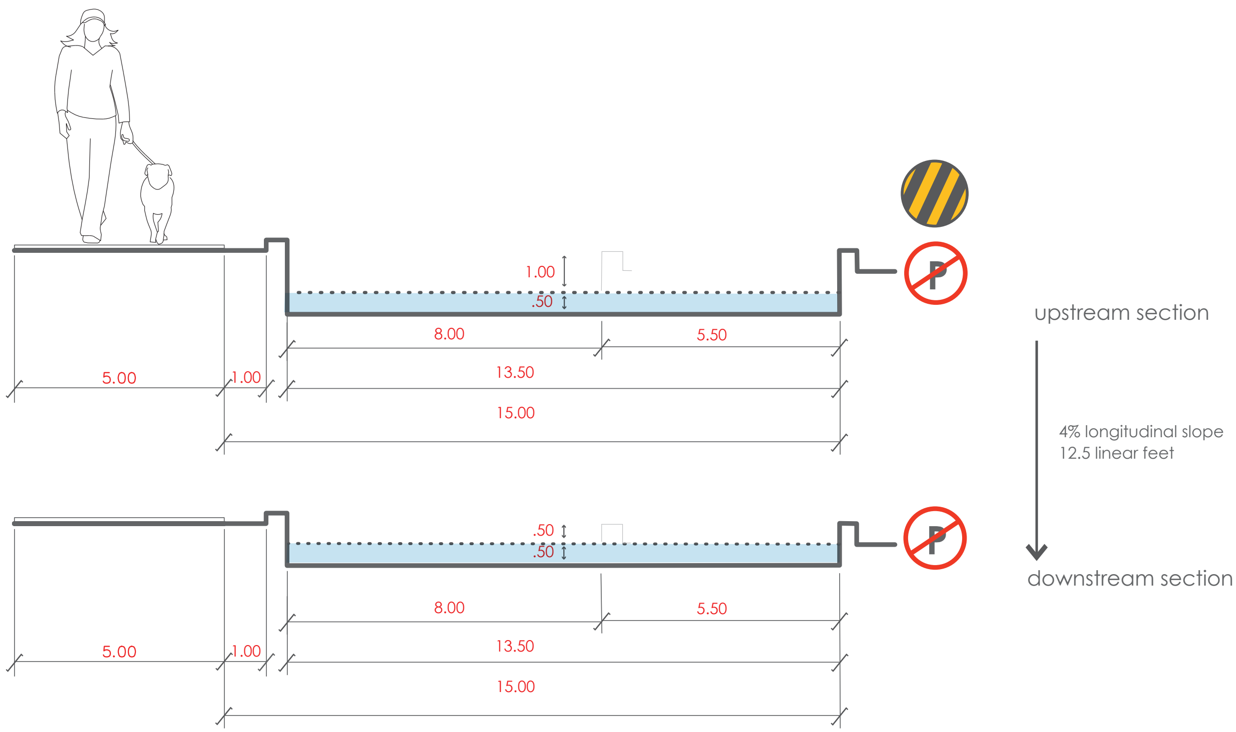


H.d BOTTOM AREA: 105 sq feet

Hybrid, 3.5' Curb Bump

Figure 36: Cell Morphology: Hybrid, 3.5' Curb Bump

parking/auto egress
signs + object markers
overall level of intervention



V.e BOTTOM AREA: 169 sq feet

Vertical-walled, 5.5' Curb Bump

Figure 37: Cell Morphology: Vertical-walled, 5.5' Curb Bump

IV. Sample Planting Plans/Layout Templates

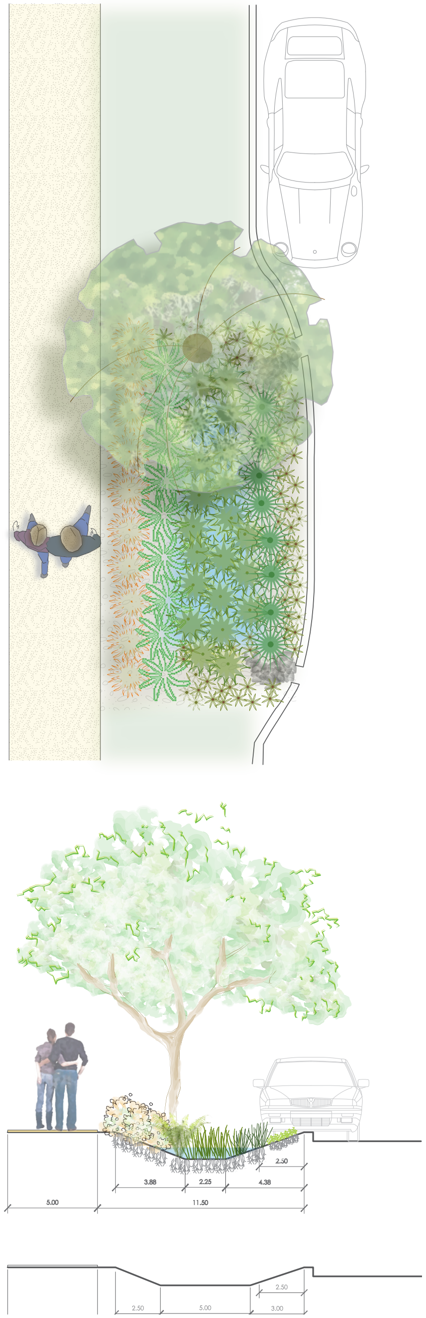


Figure 38: Side Slope Template

Street Tree Options

Winter Interest


Betula jacquemontii (Himalayan birch)


Acer griseum (Paperbark maple)


Quercus hypoleucoides (Silverleaf Oak - EVERGREEN)

Spring/Fall Interest

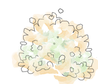

Amelanchier x grandiflora (Serviceberry - NATIVE)


Cercidiphyllum japonicum (Katsura)


Cercis canadensis (Redbud or Forest Pansy)

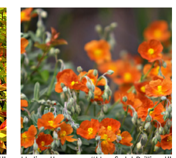
Sidewalk Edge Options

Year-round Interest




Cornus sanguinea "Actic Sun" (Dwarf yellow twig dogwood)

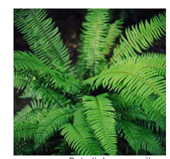

Spirea Japonica "Majic Carpet" (Spirea)


Helianthemum "Henfield Brilliant" (Rockrose - EVERGREEN)

Side Slope Options

Evergreen Texture


Nandina deomestica "Harbor Dwarf" (Dwarf Heavenly Bamboo)


Polystichum munitum (Western Sword Fern - NATIVE)


Vaccinium ovatum (Evergreen huckleberry - NATIVE)

Bottom Area Options

Adapted to Wet + Dry


Iris douglasiana (Douglas Iris-NATIVE EVERGREEN)


Juncus patens "Elk Blue" (California Grey Rush -EVERGREEN)


Carex Obnupta (Slough sedge - NATIVE)

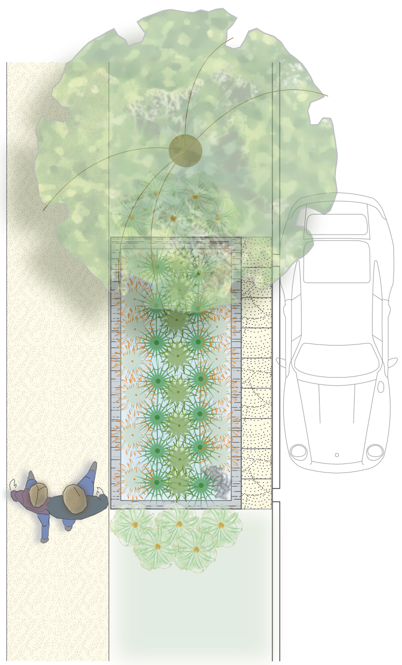
Ground Cover Options

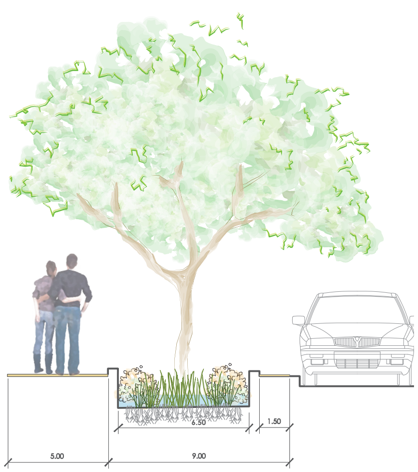
Low-growing

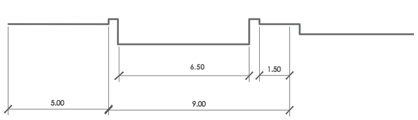

Mahonia repens (Creeping Oregon Grape - EVERGREEN)


Pachysandra terminalis (Pachysandra - EVERGREEN)


Archtostaphylos uva-ursi (Kinnikinnick -NATIVE EVERGREEN)







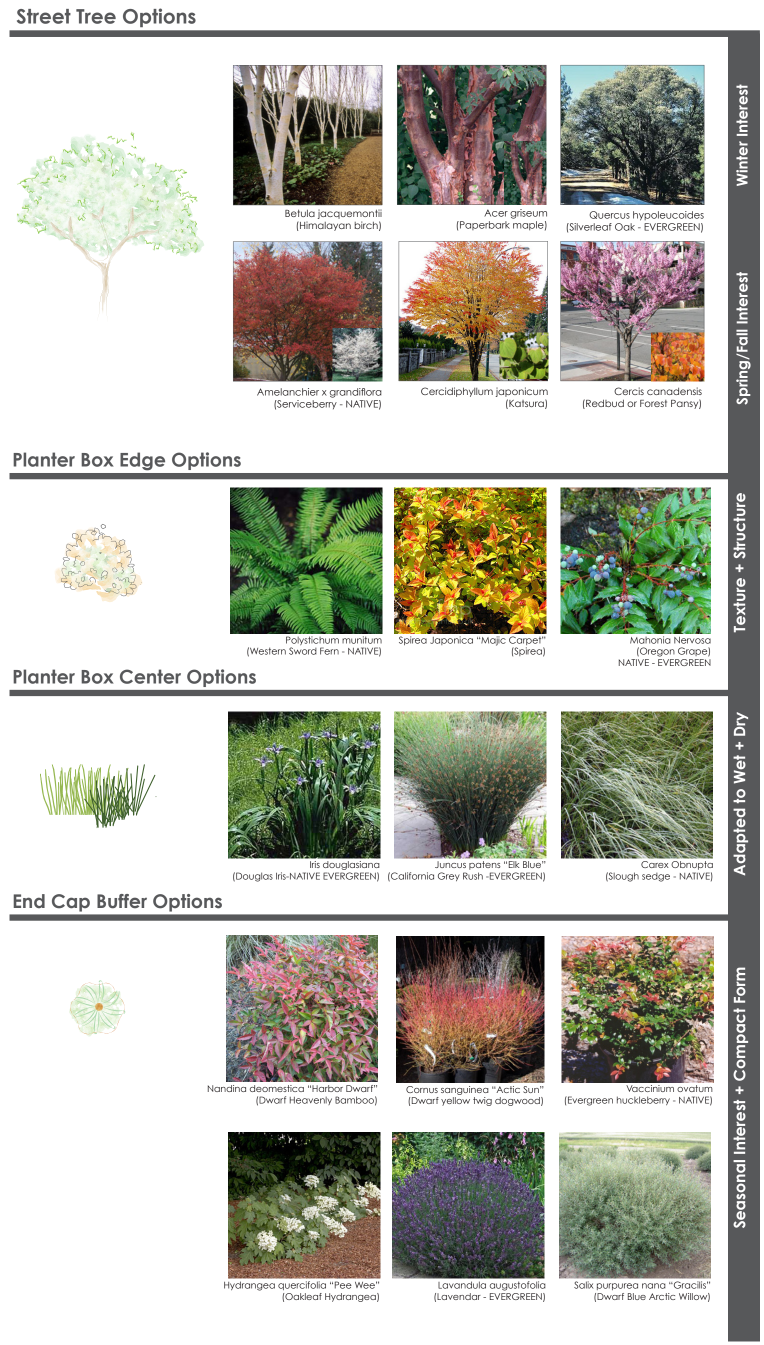
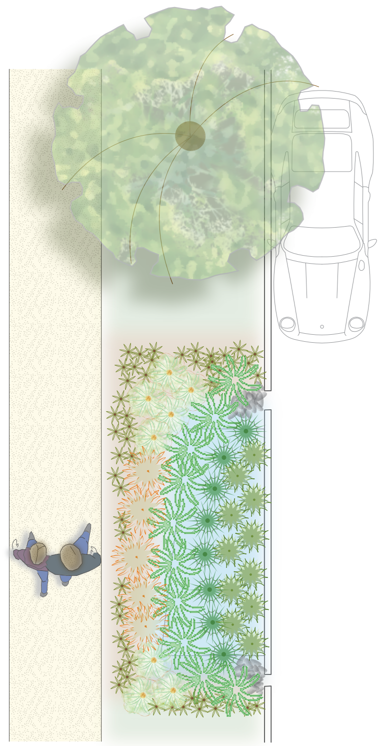


Figure 39: Vertical-Wall Template



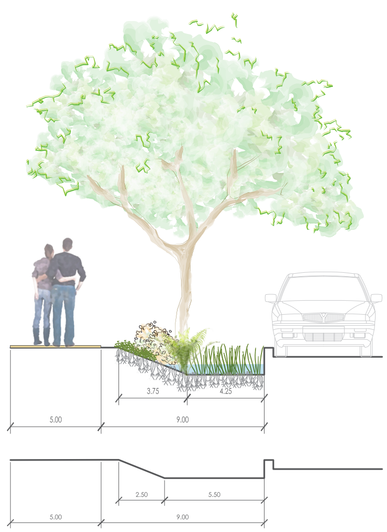


Figure 40: Hybrid Template

Most change occurs at a small scale, incrementally over time, not in the sweeping changes of a planned development… so it is important to practice ecologically sensitive design at a site scale, where changes can accumulate to produce landscape-scale patterns over time.

- William E. Wenk

Chapter 7

DESIGN CONSIDERATIONS + TEMPLATES AT THE BLOCK SCALE

Figure 41: Photo: Pam Emerson

Chapter 7
DESIGN CONSIDERATIONS + TEMPLATES AT THE BLOCK SCALE

Variable Set Defined: Drainage Area, Roof + Sidewalk Run-on, Target Volume

The block scale templates that follow are meant to illustrate trade-offs among the a set of core social function variables while holding CSO volume control performance constant. Depending on the cross-section(s) applied and the planting plans selected, the schematics differ on: 1) degree of parking loss; 2) degree of overall intervention; 3) curb geometry–bump-outs (y/n) and alignment of bump-outs; 4) presence of object markers and “no parking” signs; 5) overall look + feel.

The schematics do not differ on the level of CSO volume control (all streets are completely mitigated) nor on maximum ponding depth (6”) and maximum cell depth (18”). The schemes all assume a 4% longitudinal street slope and a negligible cross-slope across the planting strip. [It is important to note that a cross-slope increases the depth of the cell on the upslope side of the cell. Though cross-slope was not included in this study, it is nonetheless an important variable to consider in site selection. Flat or nearly flat cross-slopes are preferrable]. And an existing condition of a 9’ planting strip was assumed in all cases, as well. The drainage areas, run-on assumptions, and design targets (bottom areas) are summarized in the table below. An infiltration rate of .25”/hr. was used for schematics for till soil conditions and an infilration rate of 1” per hour was used for schematics for outwash soil conditions.

Table 4: Test Case Design Parameters at the Block Scale

Long Block

Catchment Area:
600' long block x 12.5' curb-to-centerline = 7500 sq ft
600' long block x 5' sidewalk = 3000 sq ft
2 of 14 roofs at 25% roof area for 1000 sq ft roof = 500 sq ft
TOTAL catchment area = 11000 sq ft (per side)

Additional Parameters for Till Soils
ponding depth: 6"
infiltration rate: .25"/hr
longitudnal slope: 4%
max. cell depth (from TOC): 18"

Design Target for Till Soils:
95% of 2 year storm
315 sq ft. total bottom area required (per side)

Additional Parameters for Outwash Soils
ponding depth: 6"
infiltration rate: 1"/hr
longitudnal slope: 4%
max. cell depth (from TOC): 18"

Design Target for Outwash Soils:
95% of 2 year storm
308 sq ft. total bottom area required (per side)

Short Block

Catchment Area:
200' long block x 12.5' curb-to-centerline = 2500 sq ft.
200' long block x 5' sidewalk = 1000 sq ft.
1 of 2 roofs at 25% roof area for 1000 sq ft roof = 250 sq ft.
TOTAL catchment area = 3750 sq ft (per side)

Additional Parameters for Till Soils
ponding depth: 6"
infiltration rate: .25"/hr
longitudnal slope: 4%
max. cell depth (from TOC): 18"

Design Target for Till Soils:
95% of 2 year storm
280 sq ft. total bottom area required (per side)

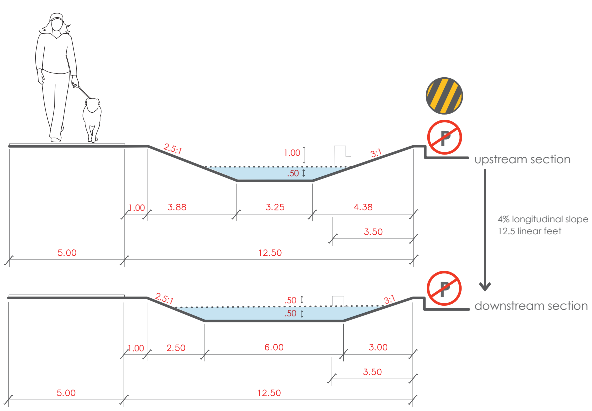
Additional Parameters for Outwash Soils
ponding depth: 6"
infiltration rate: 1"/hr
longitudnal slope: 4%
max. cell depth (from TOC): 18"

Design Target for Outwash Soils:
95% of 2 year storm
105 sq ft. total bottom area required (per side)

Side Slopes + Till Soils

Assumptions:
full block mitigation + some run-on
4% steet slope; .25"/hr infiltration rate
6" ponding for up to 48 hours

Parking Impact (per side of street):
pre-intervention: 1.8 spaces/parcel (25 total)
post-intervention: 1.1 spaces/parcel (16 total)
parking shown: 1 car per parcel



S.b BOTTOM AREA: 58 sq feet
Sloped, 3.5' Curb Bump

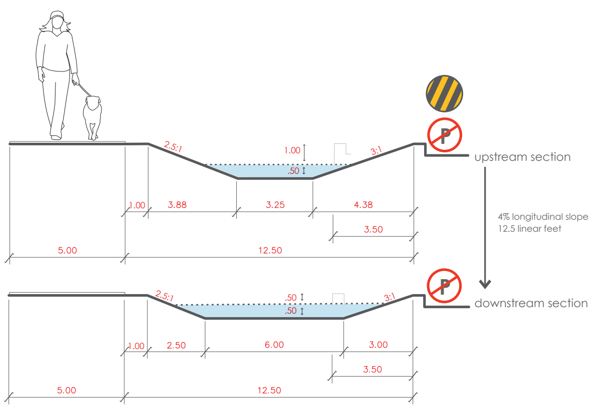
Look + Feel:

Figure 42

Side Slopes + Outwash Soils

Assumptions:
full block mitigation + some run-on
4% steet slope; 1"/hr infiltration rate
6" ponding for up to 48 hours

Parking Impact (per side of street):
pre-Intervention: 1.8 spaces/parcel (25 total)
post-Intervention: 1.6 spaces/parcel (22 total)
parking shown: 1 car per parcel



S.b BOTTOM AREA: 58 sq feet
Sloped, 3.5' Curb Bump

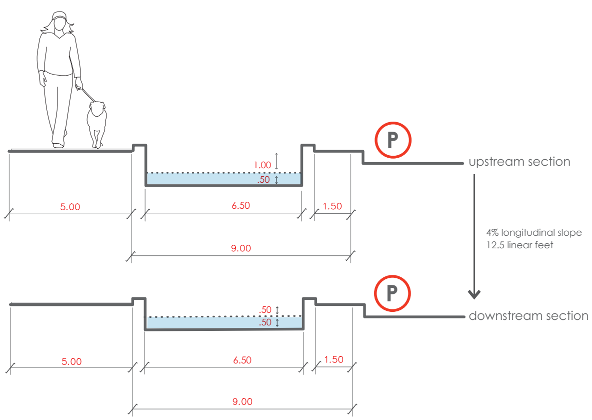
Look + Feel:

Figure 43

Vertical Walls + Till Soils

Assumptions:
full block mitigation + some run-on
4% steet slope; .25"/hr infiltration rate
6" ponding for up to 48 hours

Parking Impact (per side of street):
pre-Intervention: 1.8 spaces/parcel (25 total)
post-Intervention: 1.8 spaces/parcel (25 total)
parking shown: 1 car per parcel



V.b BOTTOM AREA: 81 sq feet
Vertical-walled, No Curb Bump, Egress Buffer

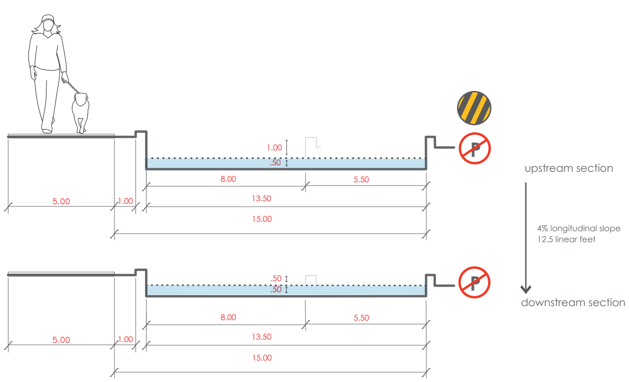
Look + Feel:

Figure 44

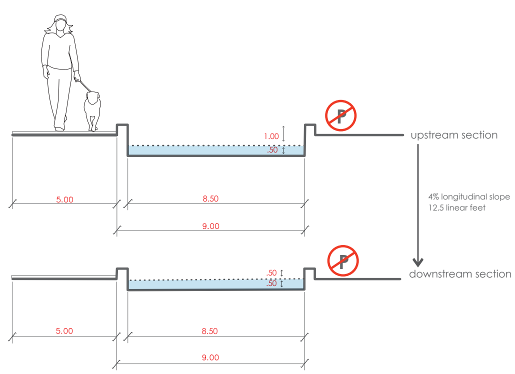
Vertical Walls + Till Soils
(neckdown)

Assumptions:
full block mitigation + some run-on
4% steet slope; .25"/hr infiltration rate
6" ponding for up to 48 hours

Parking Impact (per side of street):
pre-Intervention: 1.8 spaces/parcel (25 total)
post-Intervention: 1.5 spaces/parcel (21 total)
parking shown: 1 car/parcel



V.e BOTTOM AREA: 169 sq feet
Vertical-walled, 5.5' Curb Bump



V.a BOTTOM AREA: 106 sq feet
Vertical-walled, No Curb Bump, No Sidewalk, Buffer

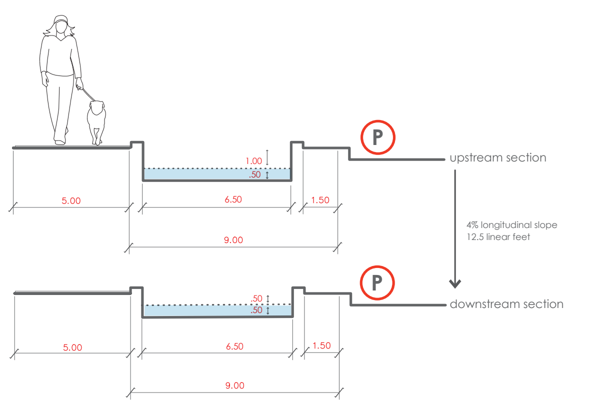
Look + Feel:

Figure 45

Vertical Walls + Outwash Soils

Assumptions:
full block mitigation + some run-on
4% steet slope; 1"/hr infiltration rate
6" ponding for up to 48 hours

Parking Impact (per side of street):
pre-Intervention: 1.8 spaces/parcel (25 total)
post-Intervention: 1.8 spaces/parcel (25 total)
parking shown: 1 car per parcel



V.b BOTTOM AREA: 81 sq feet
Vertical-walled, No Curb Bump, Egress Buffer

Look + Feel:

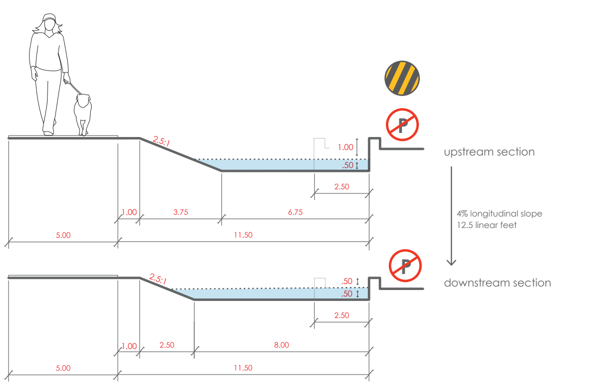
Figure 46

Hybrid and Vertical Walls + Till Soils
(short blocks)

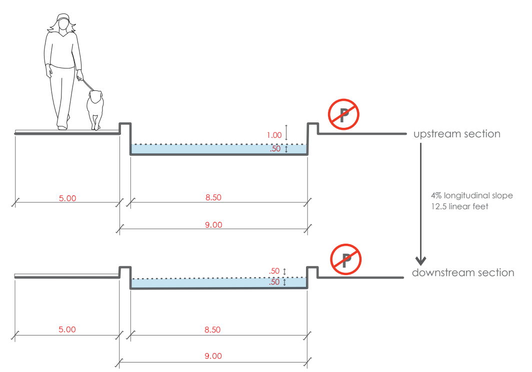
Assumptions:
full block mitigation + some run-on
4% steet slope; .25"/hr infiltration rate
6" ponding for up to 48 hours

Hybrid Look + Feel:

Parking Impact (per side of street):
pre-Intervention: 2 spaces/parcel (6 total)
post-Intervention: 1.6 spaces/parcel (4.75 total)
parking shown: 1 car/parcel



H.c BOTTOM AREA: 92 sq feet
Hybrid, 2.5' Curb Bump



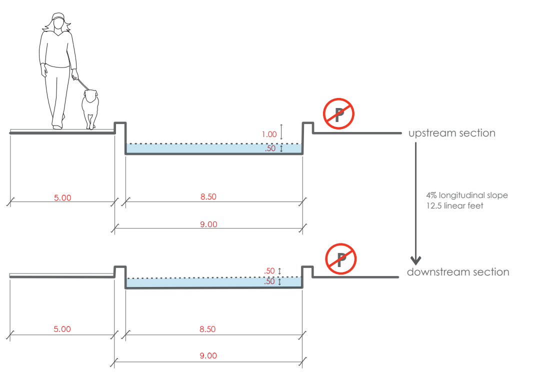
V.a BOTTOM AREA: 106 sq feet
Vertical-walled, No Curb Bump, No Sidewalk, Buffer

Figure 47

Vertical Walls + Outwash Soils

Assumptions:
full block mitigation + some run-on
4% steet slope; 1"/hr infiltration rate
6" ponding for up to 48 hours

Parking Impact (per side of street):
pre-Intervention: 2 spaces/parcel (6 total)
post-Intervention: 2 spaces/parcel (6 total)
parking shown: 1 car/parcel



V.a BOTTOM AREA: 106 sq feet
Vertical-walled, No Curb Bump, No Sidewalk, Buffer

Look + Feel:

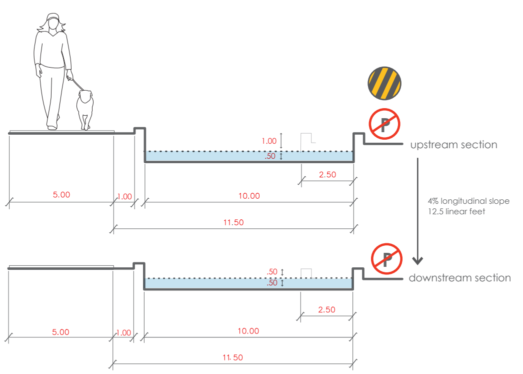
Figure 48

Vertical Walls + Till Soils
(short blocks)

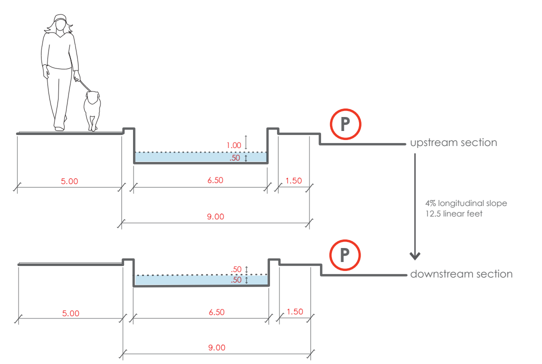
Assumptions:
full block mitigation + some run-on
4% steet slope; .25"/hr infiltration rate
6" ponding for up to 48 hours

Look + Feel:

Parking Impact (per side of street):
Pre-Intervention: 2 spaces/parcel (6 total)
Post-Intervention: 2 spaces/parcel (6 total)
Parking shown: 1 car/parcel



V.c BOTTOM AREA: 125 sq feet
Vertical-walled, 2.5' Curb Bump



V.b BOTTOM AREA: 81 sq feet
Vertical-walled, No Curb Bump, Egress Buffer

Figure 49

Table 5: Value + Benefits/Trade-offs/Quick View

VALUE + BENEFITS TRADE-OFFS QUICK VIEW	low intervention	object markers	parking preserved	pedestrian safety	greenway amenity	vehicle sightlines	habitat + tree cover	water quality	energy savings	beauty	public health	eco-literacy
Side Slopes + Till Soils	○	○	○	◒	●	●	●	●	●	●	●	●
Side Slopes + Outwash Soils	◒	◒	◒	◒	◒	●	●	●	●	●	●	●
Vertical Walls + Till Soils	◒	●	●	◒	●	●	●	●	●	●	●	●
Vertical Walls + Till Soils + Neckdown	◒	◒	◒	●	●	●	●	●	●	●	●	●
Vertical Walls + Outwash Soils	●	●	●	○	◒	●	●	●	●	●	●	●
Hybrid Walls + Till Soils (short)	◒	◒	◒	◒	◒	●	●	●	●	●	●	●
Vertical Walls + Till Soils (short)	●	●	●	○	●	●	●	●	●	●	●	●
Vertical Walls + Outwash Soils (short)	●	●	●	○	◒	●	●	●	●	●	●	●
[Large-scale Storage Tank + Pump]	○	●	●	○	○	○	○	●	○	○	●	○

Genuine politics – politics worthy of the name – is simply a matter of serving those around us: serving the community and serving those who will come after us.

- Vaclav Havel

CHAPTER 8
RECOMMENDATIONS

Figure 50: Photo: Pam Emerson

CHAPTER 8
RECOMMENDATIONS

The central assertion of this study has been that "social function" is a category of roadside green stormwater infrastructure performance, on par with other performance categories such as control volumes and pollutant removal. Furthermore, social function must be intentionally designed for if new infrastructure investments are to support human well-being and be embraced by the community. The study has contended that careful siting and design can help ensure the right-of-way changes proposed in roadside raingarden projects (such as the Ballard CSO project) are experienced by residents as a net positive and result in an enhanced streetscape and/or an improved neighborhood.

The review of landscape literature and social perception research (in Chapters 3 + 4) taken together with the example siting analyses and design schematics at the raingarden and block scale (presented in Chapters 5-7) point toward the following community engagement principles and siting/design process recommendations:

I. Refine a sub-set of "social function" siting and design variables that are formally considered–together with additional technical and code-related variables–at the neighborhood scale, block scale and raingarden scale for each project undertaken. Communicate potential trade-offs between variables and be explicit about variables that are not negotiable or are the sole purview of the Utility. Solicit resident input on siting via interactive "opportunities + challenges maps" and solicit resident input on design by offering opportunities to experiment with and respond to block-scale and raingarden-scale design schematics. Engaging residents directly in the weighing of variables via a charrette or conceptual design workshop may a way to accomplish this.

Table 6 offers a draft summary of variables that are appropriate to present and grapple with via a community engagement process designed to attend explicitly to social function:

Table 6: Social Function Variables for Roadside Raingarden Siting and Design

	RAINGARDEN	BLOCK	NEIGHBORHOOD/BASIN
SITING	- ADA needs	+ resident support	technical feasibility
	- mature trees	+ known pedestrian safety issues or improvement goals	longitudinal slope
	- longitudinal slope	+ desired bike greenways or other bike improvement goals	seeps/known drainage issues
	- cross-slope	+ access to alley parking	proximity to steep slopes
		+ short blocks (sides of homes)	soil type
		+ walking or biking routes to school, transit or other destinations	
		+ potential habitat connectivity to park/open space	
		+ potential tree canopy recovery	
		mature trees (informs RG siting)	
		planting strip width (informs design)	
DESIGN	- parking impact	+ aesthetic cohesion/look + feel	identity & cohesion
	- object markers	+ tree canopy recovery	
	+ seasonal interest	parking impact	
	+ aesthetic choice	overall impact	
	+ foot crossings	+ pedestrian safety/appeal	
	maintenance needs	+ bike safety/connectivity	
	deconstructability		

II. Distinguish between the roles and responsibilities of residents, businesses and government with respect to city-making and ecological system stewardship decisions related to roadside green stormwater infrastructure. This point was emphasized in the Voter Attitudes research summarized in Chapter 3 and bears repeating here. Because the spatial and temporal scales considered by each of these entities is (or may be) quite different, the core criteria used and variables assessed in decision-making may also be different. For example, because it is the Utility's role to make infrastructure investments at the spatial scale of the city and the temporal scale of 100+ years, its definition of "cost effective" may be quite different from the definition an individual home owner would use to make investment decisions about his/her own property. Likewise, as a municipal/public entity, it is incumbent upon the Utility to meet all relevant regulations and advance broader city-wide goals such as climate change preparedness/adaptation, salmon recovery, tree canopy recovery, pedestrian safety, open-space access, bicycle infrastructure connectivity, etc. These goals may reach beyond the temporal or spatial scales considered crucial (or even relevant) by individual residents but are nonetheless critical for municipal decision-making.

Conversely, an individual homeowner may focus on variables likely to impact home resale value over a 1-5 year time horizon and may be unaware of (or unconcerned with) water quality in Puget Sound or safe bicycle connections to adjacent neighborhoods. And a business owner may not be directly impacted by a roadside raingarden in a residential neighborhood, but may have a strong preference for that solution set if it enables less disruption in his/her downstream commercial district (because a smaller-scale gray solution may now be employed).

These inherent differences in perspective and responsibility can and should be explicitly acknowledged in written and public descriptions of the problem and in deliberations about potential solution sets.

III. Expect that proposed changes to beloved places will evoke strong interest, emotion and possibly "place protective" behavior, and create the conditions for changes to be evaluated as positive. This cannot be over-emphasized. Feelings of place attachment and place identity–related, for example, to one's home, street or neighborhood–are manifestations of a healthy and nourishing connection to place. *Any* proposed changes to the streetscape, therefore, are *likely* to raise questions and lead to an evaluation process whereby the proposed changes are ultimately judged as either positive or negative. This questioning process should not be perceived as a failure nor as "NIMBYism" but rather as evidence that people care deeply about their place–a crucial prerequisite for long-term stewardship. It is therefore essential to plan sufficient time and staffing for this discernment process to occur. Attending explicitly to known "social function" variables, human landscape preferences and universal desires for self-efficacy (having agency in decisions that affects us) can help ensure proposed changes are ultimately judged as positive.

Likewise, including a discussion of the relevant larger-scale goals/responsibilities contributing to municipal decision-making processes, such as those discussed in section II above, can contextualize place-specific decisions as a balance between individual values and community-wide values.

IV. Offer real choices. Actively engage neighborhood leaders and project-block residents in the decision-making process to reach an "optimal" combination of social function, water quality function, and broader city-wide goals. Offer insight into the full value of project choices. This may accomplished by developing a qualitative short-hand tool (such as the "value quick view matrix" illustrated in chapter 7) to provide a summary of the full spectrum of benefits/trade-offs for a given design concept. Likewise, developing a menu of planting palettes and planting plan options, such as those illustrated in chapter 6, would provide residents with an accessible way to influence the aesthetic quality of proposed streetscape changes and negotiate an evolving urban "ecological aesthetic" in a way that is comfortable/socially acceptable. Block representatives could also be involved/consulted in the development or refinement of these tools.

Because roadside green infrastructure is limited to the often very narrow planting strip (and adjacent parking lane), requiring gentle side-slopes limits the range of design options and may force undesired consequences (from a social function standpoint) such as unattractive object marker signs and parking loss. Developing/approving a set of standard details for vertical-walled roadside bioretention cells for use in residential neighborhoods will broaden design options and afford ways of avoiding negative impacts, particularly on blocks with narrow planting strips or high parking congestion.

Finally, developing a "X% for Art"-style component to any roadside green infrastructure project may provide an avenue for eliciting positive/constructive participation from project block residents (and/or businesses). A given percentage of the total project cost (5%, for instance) could be set aside solely for streetscape enhancements, above and beyond the water quality goals of the project. Funding might be used, for instance, to purchase street furniture, non-standard landscaping materials (landscape boulders, decorative pavers, etc.), interpretive signage, public art installation, electric vehicle charging station, etc.

V. Coordinate Project Timing/Delivery With Other Capital Investment Projects. A perception that municipal departments do not communicate well with one another can erode public trust and confidence. For example, if a street paving project or street tree planting project is delivered one year and disrupted the following year by a proposed roadside raingarden project, residents may be likely to judge the raingarden project as a negative change. It is critical, then, to align capital investment projects planned for the right-of-way in a given neighborhood and sequence these in a logical order. For instance, a roadside raingarden project would ideally be planned to coincide with any street paving project (to minimize construction impacts on residents). And both of these would ideally be sequenced to precede a street-tree planting effort, so that newly planted trees are not removed or damaged by construction.

VI. Talk Solutions. While a brief discussion of the "problem" is essential to garner public support for any proposed intervention, all forms of communication (written notices, websites, visuals at community meetings, etc.) should emphasize solutions. This recommendation comes directly from the focus group research summarized in Chapter 3. The research highlighted that dwelling on the problem leads to skepticism that any solution can be effective and foments a desire to dismiss or downplay the problem as either unsolveable or outside our sphere of influence. Conversely, a focus on potential solutions can arouse an interest in participating in/contributing to those solutions and can help establish credibility for the responsible agency. Solutions should be discussed in specific terms–what works, how it works, and the likely results/impacts of any given solution set. The appendix offers a draft solution-oriented set of communication/outreach materials that may be refined or adapted for different intended uses.

Appendix

OUTREACH MATERIALS TO FACILITATE COMMUNITY ENGAGEMENT

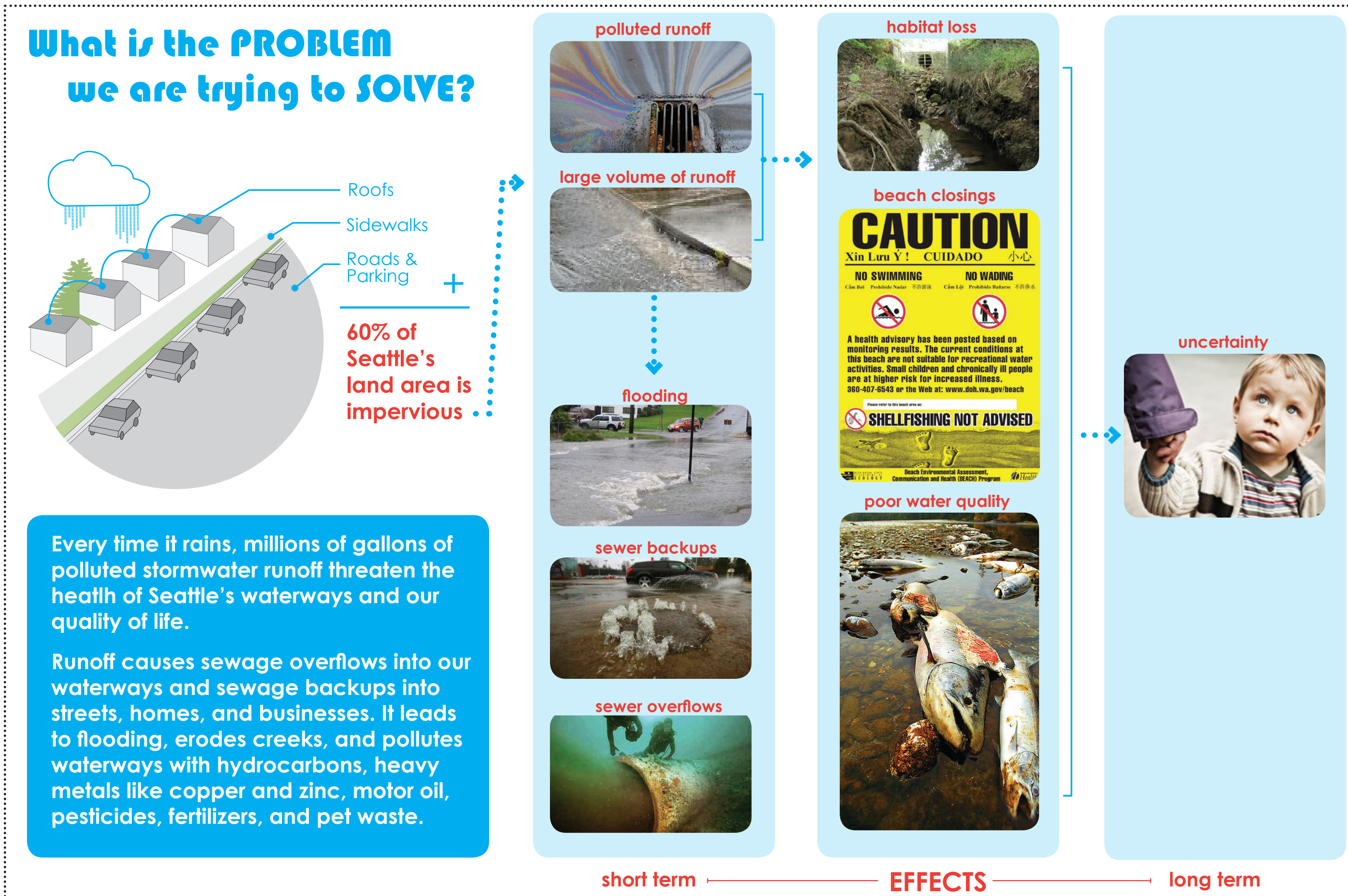
Figure 51: Photo: Pam Emerson

Appendix

OUTREACH MATERIALS TO FACILITATE COMMUNITY ENGAGEMENT

What follows is a series of draft images and products that could be integrated into community engagement materials such as mailings, brochures, fact sheets, public meeting posters, or charette briefing materials.

I. What is the problem?



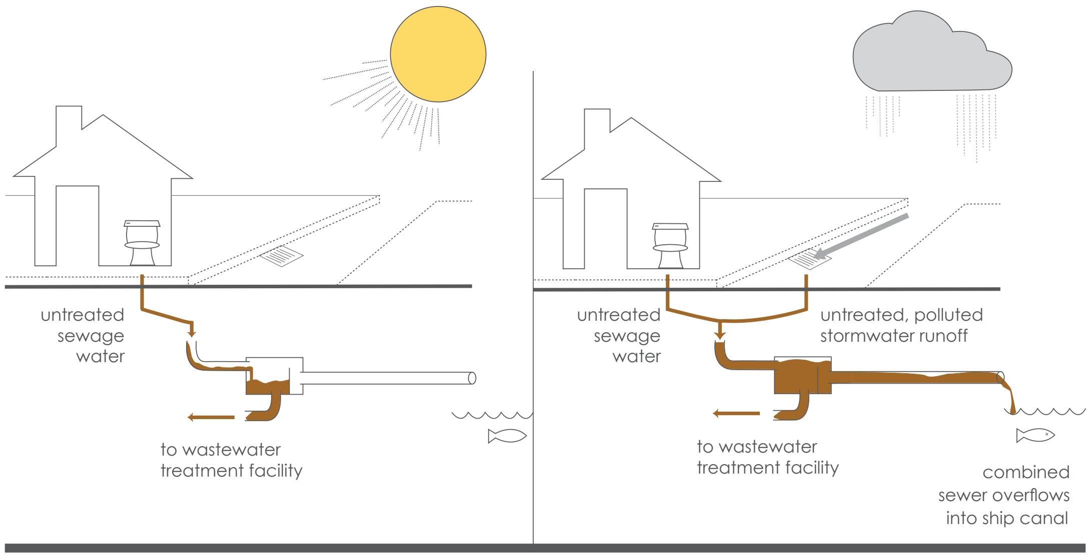
What causes sewer overflows?

Seattle's drainage infrastructure was designed as a system that combines sewage water and stormwater runoff from impermeable surfaces like roofs and roads. During heavy rains, this combined system can become overwhelmed by the volume of runoff flowing off gutters and into storm drains.

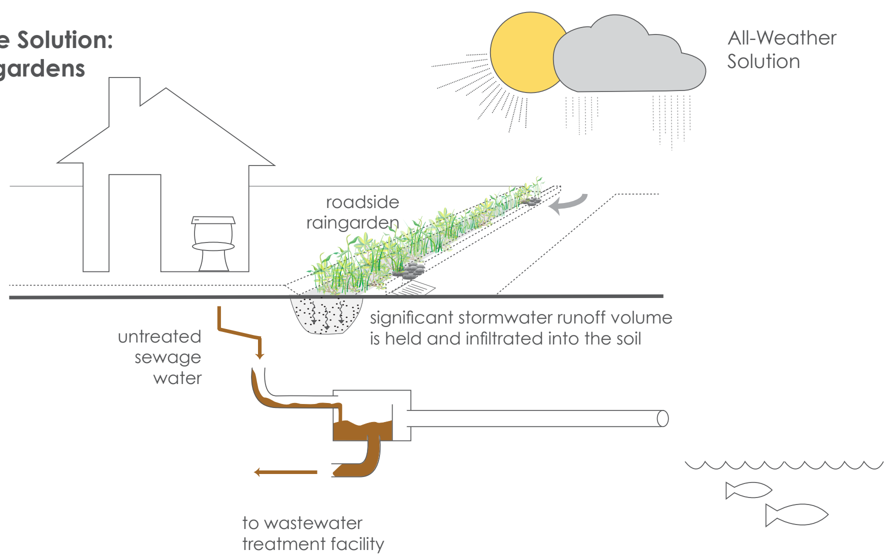
To prevent sewage water from backing up onto city streets, the system has an emergency mechanism. When the volume reaches a threshold level, the combined sewage water + polluted stormwater runoff overflows into nearby water bodies, untreated. This is called a "combined sewer overflow", or "CSO" event and is a form of water pollution regulated under the Clean Water Act.

Removing stormwater volume from the system by storing, slowing, or infiltrating the water "upstream" in the basin can help prevent CSO events.Roadside raingardens are one innovative strategy for achieving this goal and can also make our streets more beautiful and more inviting to pedestrians and bicycle riders. In other words, preventing CSO events improves habitat for aquatic life and people!

Combined Sewer Overflows



A Cost-Effective Solution: Roadside Raingardens



II. What is Green Stormwater Infrastructure? How Does It Work? Why Use It?

Green Stormwater Infrastructure

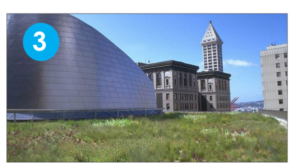
WHAT IS IT?

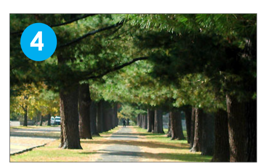
"Green stormwater infrastructure", or "GSI", helps our city's drainage system function like a forest system by slowing and cleaning polluted stormwater runoff and allowing it to soak into the ground. GSI manages polluted runoff from development (hard surfaces like roads and roofs) using infiltration, evaporation, filtration or stormwater storage + reuse.

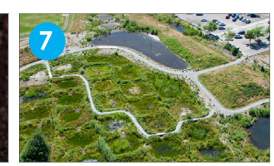
Individual GSI projects are designed to fit within a broader, integrated network of drainage systems that function at the block scale, neighborhood scale and city/regional scale. When aggregated, site-specific interventions contribute significantly to large scale system integrity and community livability. Finally, GSI helps ensure our urban water systems can adapt to changes like more severe or more frequent storms caused by climate change.

The green stormwater infrastructure practices used in Seattle include:

1. bioretention (like rain gardens)
2. permeable/porous pavement
3. green roofs
4. urban canopy cover
5. rainwater harvesting (like cisterns)
6. soil building (like mulch + compost)
7. biofiltration (like built wetlands)







HOW DOES IT WORK?

Green Stormwater Infrastructure (GSI) helps our predominanty impervious city function more like a forest by slowing, cleaning, evaporating, and storing stormwater. GSI helps rain soak into the soil close to where it falls, removes or breaks down pollutants, and also provides opportunities to store + reuse rainwater for non-potable uses.

GSI techniques are frequently designed to work together. For example, a green roof may drain into a stormwater cistern, and the cistern may overflow into an adjacent rain garden. Cistern water may be used to irrigate the rain garden in the summer and may be slowly released into the rain garden in the winter.

WHY USE IT?

Green Stormwater Infrastructure (GSI) harnesses the services and strengths of both natural water systems and the engineered water systems that have evolved over time as our city developed. The resulting infrastructure is a highly adaptive and cost-effective hybrid that ensures system resiliency and offers many additional benefits.

Stormwater systems that integrate GSI reduce the demand on over-burdened flood control and waste water treatment systems and also offer: water quality benefit, improved aquatic habitat, improved urban livability, eco-literacy value, drinking water conservation, energy conservation, and adaptability/regenerative capacity.

III. Does Green Stormwater Infrastructure Work?

PROGRAM HISTORY

Green Stormwater Infrastructure

2000 - 2012

1
2000 - SEA Streets

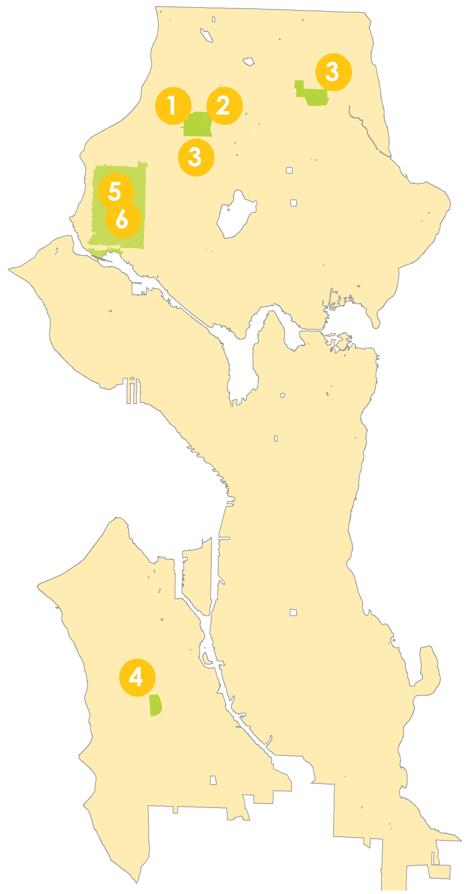
The city's first natural drainage system was constructed in the Broadview neighborhood to protect Pipers Creek from the harmful effects of stormwater runoff, to provide stormwater conveyance, and to improve the streetscape with sidewalks. Known as SEA Streets (Street Edge Alternative), the project collected stormwater from across 2.3 acres and showed a 99 percent reduction in runoff volume. SEA Streets became an international model for natural drainage projects, now known as green stormwater infrastructure (GSI).

2
2003 - Carkeek Cascade

Seattle doubled the size of its next GSI project, the Carkeek Cascade (on NW 110th St.), also in the Pipers Creek Watershed. The Cascade collects runoff from across 28 acres and reduced runoff volume by up to 74 percent. In addition to holding back volumes of water that cause damage to downstream creeks, the project also helped to clean the stormwater. Monitoring showed that levels of pollutants like lead, copper, and zinc were reduced by up to 90 percent.

3
2004 - Broadview + Pinehurst Green Grids

Seattle took another giant step forward in its GSI Program by constructing the Broadview Green Grid to collect stormwater from across 32 acres. The project demonstrated how GSI could be applied at a large scale and was followed in 2005 by the Pinehurst Green Grid which has shown the ability to reduce runoff by 82 percent each year and manage 9.7 million gallons of stormwater across 49 acres.



4
2005-2009 - Highpoint Redevelopment

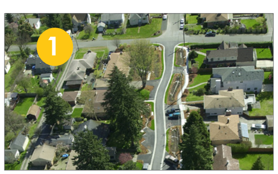
Working in close collaboration with the Seattle Housing Authority, Washington State Department of Ecology, and many other partners, Seattle built neighborhood-scale GSI into the 129-acre High Point Housing Redevelopment Project. High Point's natural drainage system design included extensive roadside raingardens, saved over a hundred legacy trees + planted three thousand more, and integrated porous concrete sidewalks. To acheive comparable stormwater benefit with a traditional piped street drainage system would have required a detention pond with five times the volume.

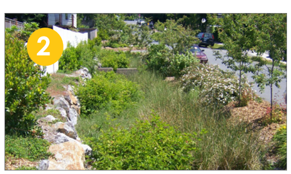
5
2010 - RainWise

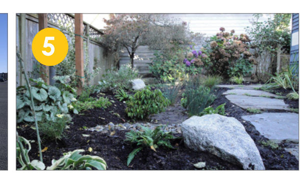
Seattle introduced an incentive program known as RainWise to provide rebates to eligible property owners who construct a rain garden or install a cistern on their property. More than 100 homeowners installed these GSI features during RainWise's first two years. Collectively these rain gardens divert about 15,000 gallons that would have overflowed and collect more than one million gallons of stormwater that would have run off. Currently the program is active in Ballard and will soon be offered in the neighborhoods of Delridge, Montlake, and the area northeast of the University of Washington.

6
2011 - Ballard Roadside Raingarden Pilot

Seattle completed its first GSI project in the right-of-way designed to reduce combined sewer overflows in 2011. Information gathered through this pilot project in Ballard has been incorporated into the approach that will be used for future GSI work for sewer overflow reduction. The pilot has informed all aspects of project delivery including geotech analysis, siting, design, construction and community engagement.







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