



## Case Study #1

The Barton Combined Sewage Overflow (CSO) Control Project is the inaugural case study conducted by the Center for Sustainable Infrastructure.

# Green solutions in concert with public interests: Profiling the Barton combined sewage overflow control project

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## EXECUTIVE SUMMARY

The Barton combined sewage overflow (CSO) control project refers to the installation of 93 roadside rain gardens in the Barton basin of West Seattle, Washington. This project is an example of a local agency utilizing *green (vegetated) infrastructure* strategies to complement traditional *gray (pipe) infrastructure* facilities within a cost-effective design to achieve regulatory objectives in addition to multiple community co-benefits.

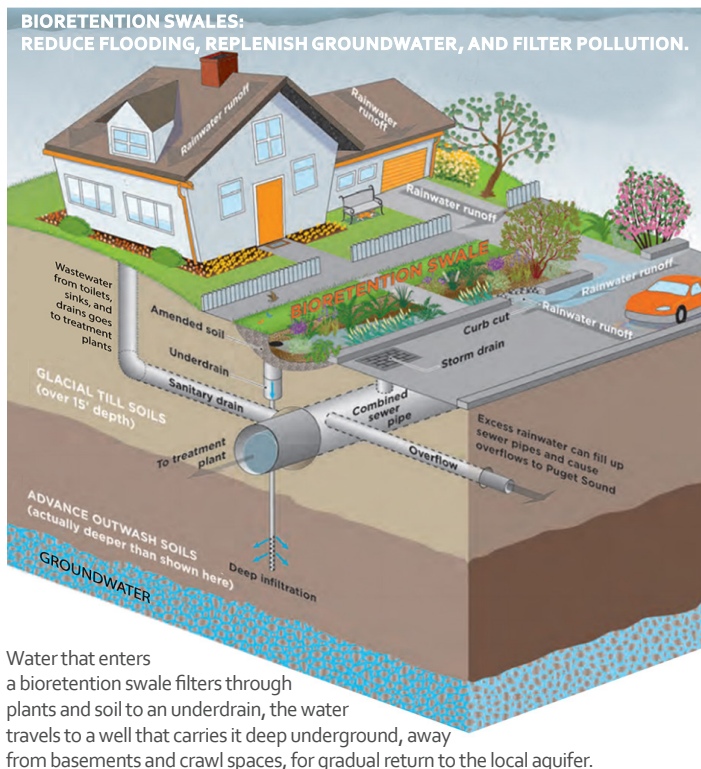
During peak rain events, combined stormwater and sewage flows can overwhelm the Barton pump station, resulting in untreated discharges into the Puget Sound near Lincoln Park. These discharges carry pollutants into shared water bodies and pose a substantial threat to public health and the aquatic ecosystem. The Washington State Department of Ecology (Ecology) regulates water quality of discharges from watershed basins under authority delegated from the U.S. Environmental Protection Agency (EPA). King County (KC) began constructing a project in 2013 to improve the Barton combined sewer system (CSS) flow control to the point of limiting untreated discharges to the state standard of no more than one per year on average (averaged over a 20-year rolling period).



Courtesy of King County

**Author's note:** while technically the installed facilities are bioretention swales, King County's documentation consistently refers to them as "rain gardens." Thus, this case study reflects this choice of verbiage.

The Barton rain gardens capture and retain stormwater by infiltrating stormwater using soils and "thirsty" plant communities, then collecting infiltrated water with an underdrain. This infiltrated water is then conveyed to a deep infiltration well which disperses the water beneath a layer of till material allowing for deep infiltration into the soils for further treatment before recharging groundwater. This increased natural capacity for stormwater capture and retention helps the Barton pump station, also updated as part of the project, keep up with flow rates during peak rain events. Barton is one of many urban CSSs that need updating to improve flow control capacity to meet Ecology and federal Clean Water Act regulations. Thus, the Barton CSO control project stands as a model for restoring needed ecosystem services (stormwater capture, retention, and infiltration) within a moderately cost effective and highly adaptive project design. Further, KC's design process for the project demonstrated outstanding public outreach efforts. This attention paid to public interests increased the beneficial scope of the project to support social values such as neighborhood aesthetics and parking availability. Overall, KC should be applauded for their proactive approach to improving the Barton basin's CSO control infrastructure with green solutions in concert with public interests.



Water that enters a bioretention swale filters through plants and soil to an underdrain, the water travels to a well that carries it deep underground, away from basements and crawl spaces, for gradual return to the local aquifer.



**SUSTAINABLE INFRASTRUCTURE KEY WORDS:**  
rain gardens, **green stormwater infrastructure (GSI)**, community engagement, flow modelling, groundwater recharge, assessment criteria development, bioretention, bioinfiltration, passive control, adaptive management.

## A. Introduction

This case study will review the steps taken by King County (KC) to reduce the number of combined sewage overflow (CSO) discharges from the Barton basin to no more than one per year on average. The Barton CSO control project can be used as a model for sustainable infrastructure because of its successful utilization of green stormwater infrastructure (GSI), cost effective implementation, adaptive design, and careful attention paid to community values that were integrated into the project design.

The Barton combined sewer system (CSS) drains about 1,111 acres of homes and streets for sewage and stormwater runoff. Stormwater is defined as rainfall that runs off of impervious surfaces like roads or rooftops and often carries high levels of pollutants. Impervious surfaces limit natural soil infiltration and therefore spike the water volume entering the CSS. The 93 installed rain gardens within the Barton CSO control project area are designed to increase natural stormwater capture and retention, thus decreasing the amount of stormwater entering the CSS.

Rain gardens are a form of GSI where shallow depressions utilize absorbent soils and “thirsty” plant communities in order to maximize stormwater retention and filter pollutants out. Within the project area, captured stormwater is either absorbed by plants, infiltrates down through soils, or overflows into the CSS when swales fill with stormwater. With impermeable surfaces, stormwater quickly enters the Barton CSS and can generate erratic spikes in the flow rate. These spikes in the flow rate are the greatest challenge for the Barton pump station’s capacity to keep up with inputs.

When spikes in the flow rate outpace the Barton pump station’s capacity, the excess is discharged directly into Puget Sound,

untreated. Such untreated discharges consist of approximately 10% sewage and 90% storm water, posing a significant threat to public health. Further, aquatic ecosystems are especially sensitive to pollution levels and Puget Sound regionally supports numerous aquatic keystone species like salmonids. Thus, minimizing CSO events using GSI provides multiple and important environmental benefits. Between 2000 and 2007, the Barton CSS averaged approximately four overflows for a total of 4.3 million gallons of untreated discharge per year.

This rate of untreated discharge events exceeded the no more than one per year per outfall on a twenty-year average required by the Revised Code of Washington (RCW) 90.48.480 and Clean Water Act regulations. Ecology implements water quality regulations for discharges into watershed basins and entered into an agreement with KC to bring the Barton basin into compliance. This is an infrastructure problem currently confronting many other jurisdictions in Washington and across the U.S. Many urban CSS pipe systems, including those in the Barton basin, were constructed when population levels and associated urban development were much lower than today’s levels. Also, historically fewer impervious surfaces allowed for greater natural stormwater capture and infiltration down to groundwater.

Barton combined sewage overflow (CSO) control project



BEFORE



AFTER



## B. Stakeholders

The primary stakeholders for this project were the Barton basin community, Ecology, the City of Seattle and KC. Ecology serves in a regulatory capacity to ensure the Barton basin limits CSO events to no more than one per year on a twenty year average. KC, as the agency responsible for compliance in this part of



**King County**



**City of Seattle**

the sewer system, entered an agreement with Ecology and EPA to bring the Barton basin into compliance with water quality limits. KC completed and began to build this project to improve public and environmental health by limiting untreated discharges.

Around the time that the roadside rain garden option was selected for Barton CSO control, a similar project constructed by the City of Seattle in Ballard (another Seattle neighborhood) began experiencing performance problems and consequently resistance from the local community. This reaction led to expensive modifications to the already completed Ballard project in an effort to better fit the neighborhood aesthetics and address performance and parking concerns. Through observing the community reaction in Ballard, KC recognized the need to first design and construct a system that works, and also be more actively engaged in the community to consider their concerns. These collaborative efforts helped KC provide community benefits, gain acceptance, and avoid expensive post project completion modifications while still meeting regulatory goals.

King County worked closely with local community members to determine the optimal implementation of GSI for both environmental quality and social values such as neighborhood aesthetics and parking availability. Specifically, the county reached out to community members most affected by the rain garden installations. Some of these effects include but aren't limited to construction disturbance, tree removal/installation, impacts to on-street public parking spaces, and altered street access. At the time construction began on the first rain gardens, KC had conducted 6 community meetings, 24 block-level meetings, 2 neighborhood surveys, 2 rounds of neighborhood canvassing, and 10 small group meetings for affected landowners.

## C. Approach

To establish the Barton CSS's necessary flow control capacity, KC used data collected between 1978 and 2008 to model local rainfall patterns and peak flow frequency. The modeling indicated that the basin needed to accommodate a flow rate of 45 million gallons per day (mgd) in order to limit untreated discharges to no more than one per year on average. Initially, the Barton pump station could only handle 26 mgd of the necessary 45 mgd. Thus, as a direct capacity improvement measure, the pump station was upgraded to handle 33 mgd. The remaining 12 mgd represented the necessary flow control capacity pursued for the Barton CSO control project.

The carefully balanced selection process is deserving of note because of its pivotal role in leading KC toward the successful utilization of GSI. The methodology for developing and evaluating control options was broken up into two phases:

- **Phase 1** developed assessment criteria and generated a list of possible control options;
- **Phase 2** refined a short-list of control options for a fully informed evaluation.

Specifically, options were assessed under 7 criteria: land use and permitting, property acquisition, environmental, technical, operation and maintenance, costs, and community.

GSI was short-listed and considered against a pipe storage option and a tank storage option. GSI was determined to be technically the simplest option with straight forward installation, passive operation, routine maintenance, and linear potential for expanded flow control capacity with additional rain garden facilities. GSI also offered community benefits through streetscape beautification and additional environmental benefits through enhancing natural hydrological processes and adding tree cover. In contrast, the pipe and tank storage options would have required careful management of flow rates, increased staffing and maintenance, and limited potential for cost effective flow control expansion. Further, installing the pipes or tanks presented significant archaeological concerns that could halt construction, extending street closures and escalating costs. GSI represented the most expensive option, estimated at \$13M-16M, against approximately \$9M for the pipe and tank storage options. However, KC decided the extensive benefits, lower risk of delay, and favorable long term operations and maintenance costs for the GSI option was a worthy exchange for the increased initial financial investment.

## D. Funding

The Barton CSO control project was financed by three separate State Revolving Fund (SRF) loans through the Washington State Water Pollution Control Revolving Fund Program. The SRF loan program is administered by Ecology and each loan received went through three separate annual competitive application processes that funded various phases of the project. Total construction costs for the project came in at \$9,231,048, well below the \$13M-16M estimates. The SRF loan for the construction phase covers \$8,559,416, of which \$766,117 is SRF Forgivable Principal. This means that King County will not have to repay this amount of the SRF loan since the project met the Green Project Reserve Guidance per the funding guidelines. During each application cycle a percentage of the total SRF funds available for that fiscal year are directed specifically to projects that meet the criteria of the Green Project Reserve.

Funding to cover costs not eligible under the SRF loan funding guidelines and to make the 20-year term loan repayments are derived from the regional customer's sewer rate paid into the County Wastewater Treatment Division's Capital Improvement Program. The sewer rate is levied uniformly to all system users.

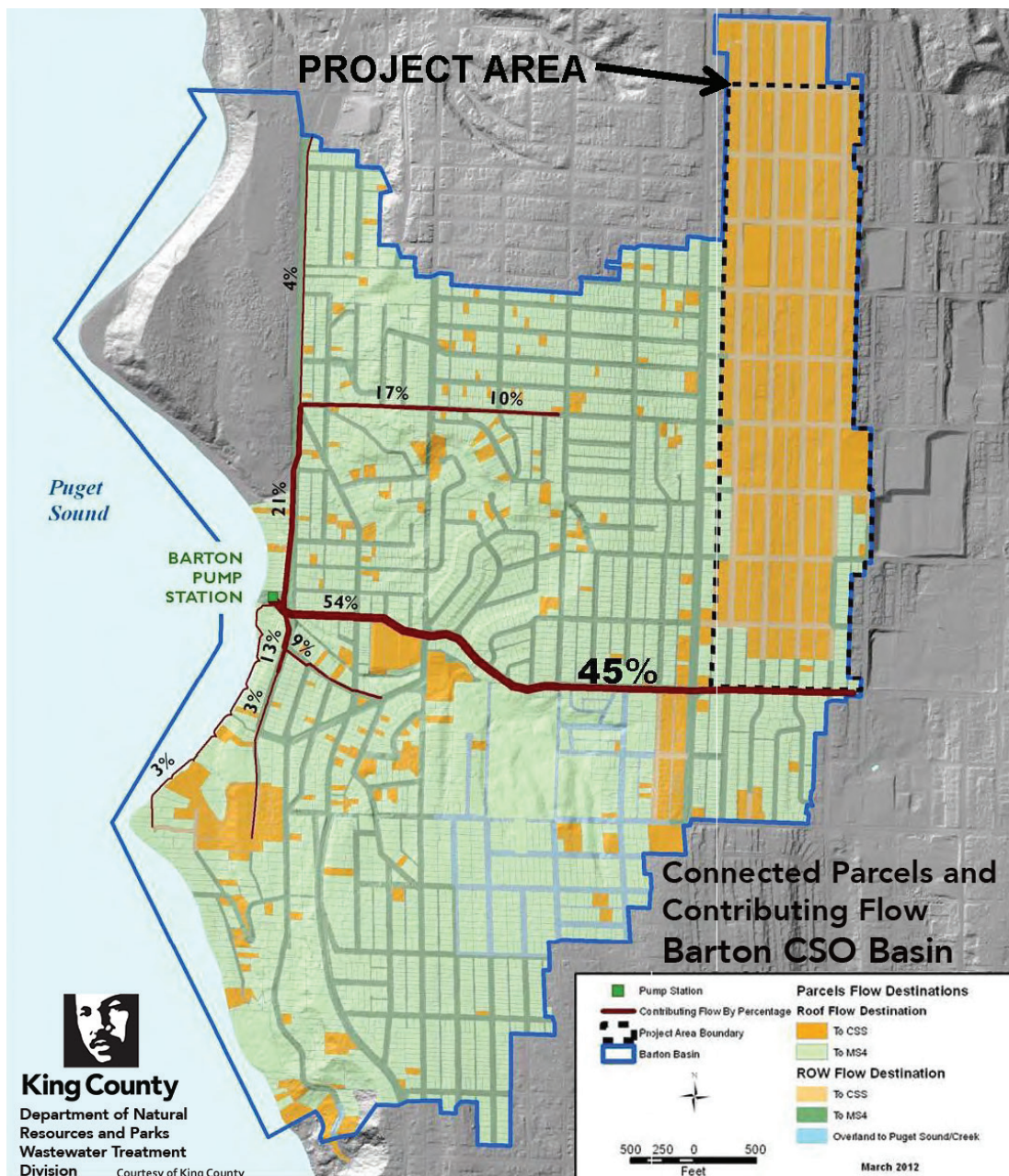
## E. Design

KC utilized numerous flow modeling techniques to gauge the blocks where roadside rain garden facilities would have the greatest benefit. A 64 block project area of about 32 acres was selected because the modeling indicated 45% of the Barton CSS's stormwater comes from this area. Specific roadside rain garden sites were considered through observation of runoff patterns over the course of several high rainfall months. Optimal roadside rain garden locations were balanced against construction considerations like existing infrastructure and large trees in order to rank the most feasible project sites.

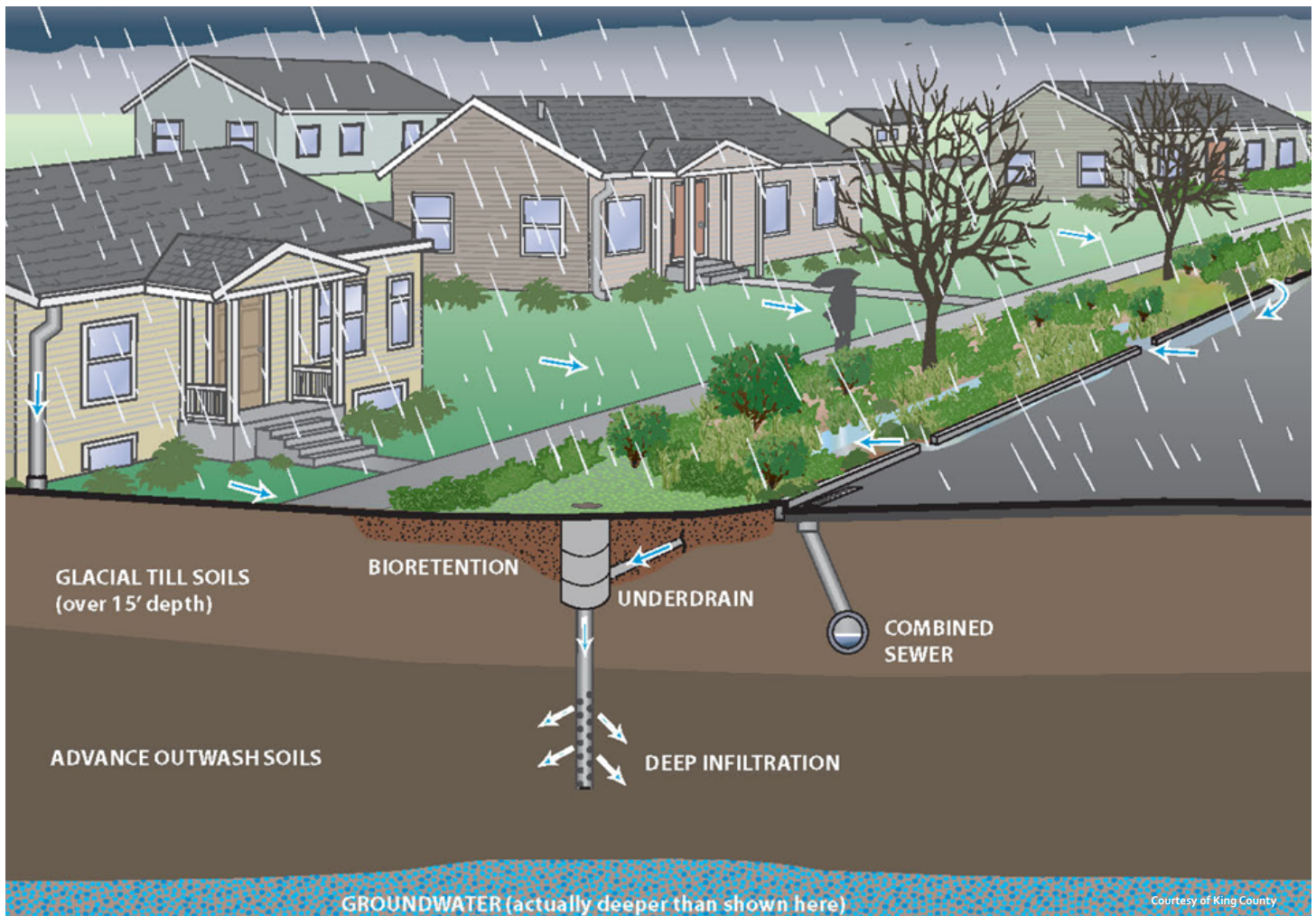
Geotechnical explorations were conducted in the project area to identify existing soil conditions including infiltration capacity. These tests revealed a mostly impermeable layer of glacial till near the surface that would severely limit flow control capacity.

To account for this challenge, the project design team implemented deep infiltration wells on each of the 19 project blocks. These wells convey stormwater below the glacial till (65-100 feet down) into the outwash soils below, which have a much higher infiltration rate.

KC hired an independent consultant team primed by SvR Design Company to design the roadside rain gardens in order to leverage the company's previous experience with GSI. Important for community values and street aesthetics, SvR developed four distinct planting palettes designed to complement the surrounding area and differentiate the blocks. Additional rain garden customization occurred on an individual basis depending on unique factors like large trees. This high attention to the detail helped maintain the mutual benefit for the county and community alike.







As a direct response to feedback elicited from the community, KC installed fewer and smaller curb bulbs (sidewalk extensions on street corners). Also, roadside rain gardens were outfitted with permeable pavement paths to connect the street to the sidewalk. Other benefits include the saving of 21 trees that were transplanted into the yards of willing community members. Perhaps most notably, KC adjusted its project design to limit the number of on-street parking spaces lost to 15 while still meeting project goals, down from 80 spaces lost in the original project design.

Through public meetings conducted early in the planning process, KC learned that personal incentives would increase community support for the project. In response, KC enlisted the City of Seattle's RainWise rebate program, as a compliment to the GSI right-of-way improvements, which offers 50%-100% refunds to community members who install rain gardens or cisterns on their property. This both incentivized the public to support the project and also decreased the volume of stormwater entering the CSS. These private facilities provide additional stormwater capture and are not directly relied upon to achieve the project's flow control targets. Current estimates indicate around 60 rain gardens and 30 cisterns have been installed with RainWise support.

Courtesy of King County

## F. Maintenance

One of the most appealing aspects of the rain garden option was its low operations and maintenance costs relative to the tank storage and pipe storage options. As the responsible party for limiting Barton CSO overflows, KC has committed to regular maintenance of the rain gardens throughout the year. Maintenance crews of 1-2 workers will conduct plant maintenance and trash/debris removal at least once a month throughout the year. These regular maintenance activities will



be supplemented with irrigation during the dry season and mulch application at least once per year. Plant support activities will occur more frequently during the first two to three years following project completion in order to ensure that the plants become established.

The maintenance schedule meets the county's need for compliance while maintaining aesthetic appeal. The county also posted signs near the roadside rain gardens with a hotline phone number for concerned neighbors to call if they witness anything out of the ordinary, like excessive trash buildup or water ponding that lasts more than 24 hours.

## G. Performance Measures

Central to the project's primary goal, the success of the project can be assessed in how well the roadside rain gardens divert stormwater from the Barton CSS. This assessment is currently being conducted by KC to determine if more roadside rain gardens need to be installed. However, projections show that the project's GSI should absorb runoff at a rate of 14.6 mgd, which is 2.6 mgd beyond the 12 mgd needed to limit untreated discharges to no more than one per year based on a twenty-year moving average. Diversion of stormwater at the levels projected will thus bring the Barton basin into compliance with state law and federal regulations. If testing determines that the Barton CSS will still exceed one discharge per year on a twenty-year average, KC already has four sites permitted for additional roadside rain garden installations.

## H. Conclusion

Construction of the Barton CSO control roadside rain gardens was completed in the summer of 2015. The projected untreated discharge amount has been reduced from 4.3 million gallons per year to 0.5 million gallons per year on average. The graph below models a past CSO event that would have been avoided post project completion.

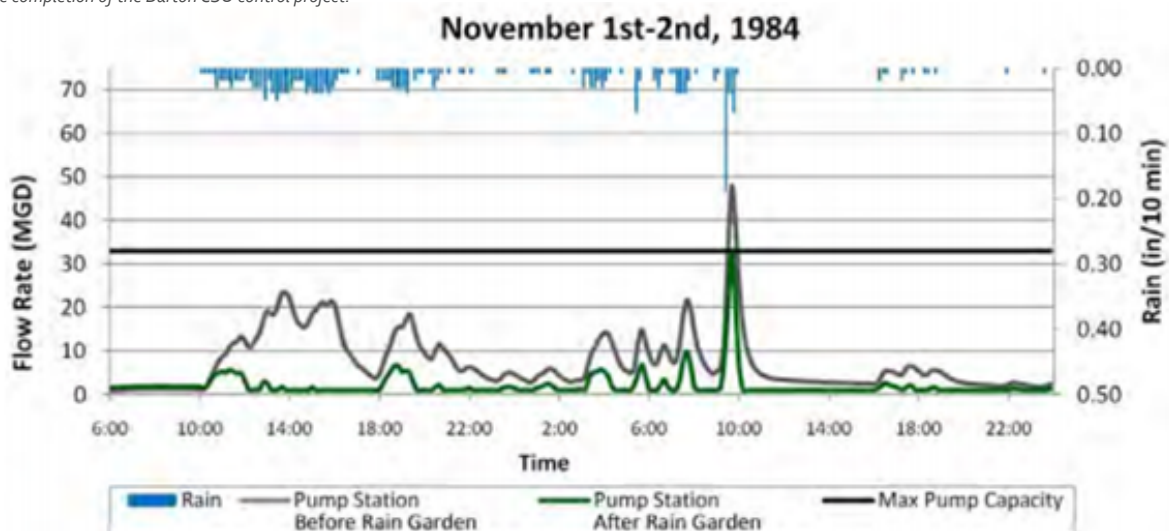
Beyond the successful implementation of GSI to meet regulatory goals, this project stands as an exemplary model for public outreach and mindfulness of individual landowner preferences. The community's response to these rain gardens has been overwhelmingly positive. One community member had this to say about the project:

*"I'm slightly outside the area of the completed gardens but all of my neighbors have seen them, of course, and talked about how astounded they are with the sheer beauty of these well-designed, well-planted areas. Apart from their utilitarian value, they are truly an aesthetic asset to the neighborhood."*

As discussed in this case study, the Barton CSO control project serves as an outstanding model of sustainable infrastructure because of its restoration of natural hydrological processes, careful planning to ensure accuracy and adaptability, cost effective implementation, and collaboration with the neighbors to support community values. For other municipalities pursuing improved CSO flow control, the success of the Barton CSO control project demonstrates that GSI should be strongly considered as a potential control option.



Example of a past CSO event that can now be avoided because of the completion of the Barton CSO control project:



Courtesy of King County



## I. Appendix All courtesy of King County

### 34th Ave SW: SW Cloverdale to SW Thistle



Before



After

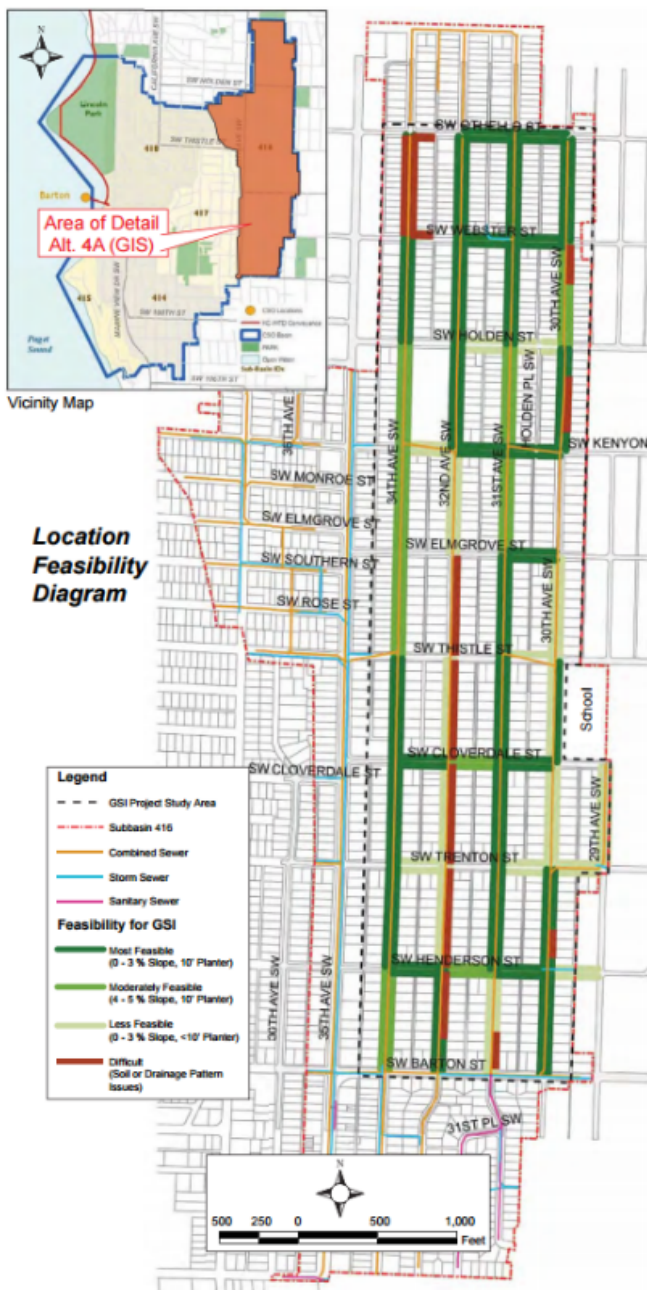
### 31st Ave SW: SW Webster to SW Holden



Before

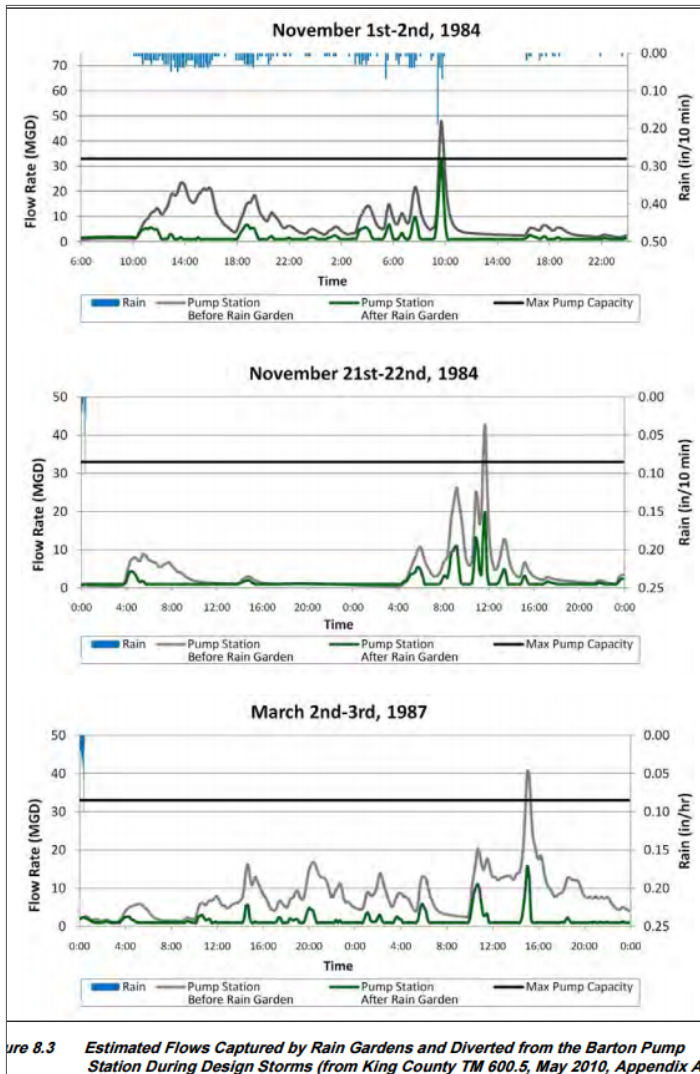


After

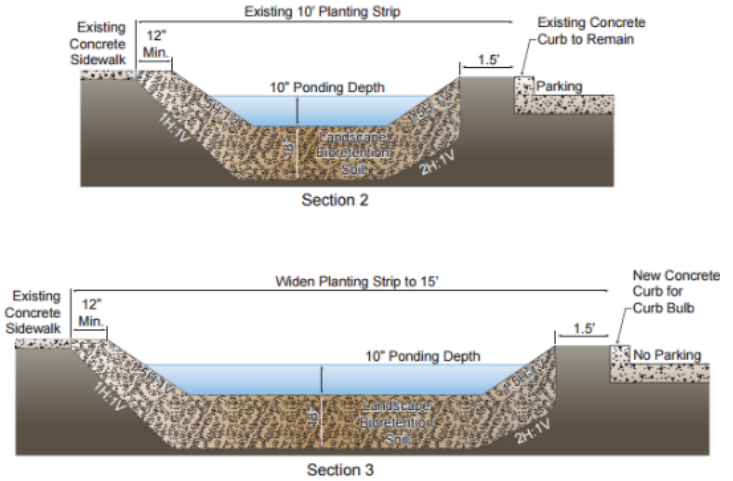


### Layout of Rain Garden Cells on a Typical Block





### Typical Cross-Sections



### Typical Planting Strip



## J. References

Primary source content came from the Barton and Murray Combined Sewage Overflow Facilities Plan, completed in September, 2011. Accessed here (11/15): [http://your.kingcounty.gov/dnrp/library/wastewater/wtd/construction/CSOBeach/TechDocs/FacilityPlans/WS/1109\\_V1\\_BartonMurrayCSOControlFacilityPlan.pdf](http://your.kingcounty.gov/dnrp/library/wastewater/wtd/construction/CSOBeach/TechDocs/FacilityPlans/WS/1109_V1_BartonMurrayCSOControlFacilityPlan.pdf)

Additional information came from the "Project updates" section of the "Barton CSO Control Project Library" webpage. Accessed here (11/15): <http://www.kingcounty.gov/environment/wtd/Construction/Seattle/BartonCSO-GSI/Library.aspx>

Phone interview with King County contact Kristine Cramer on November 24, 2015.



**Center for Sustainable Infrastructure**

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innovation. CSI is working to provide thought leadership and tools to build a future of sustainable, resilient, affordable, and integrated infrastructure systems that will provide vital services accessible to all—supporting healthy, prosperous, beautiful, and inclusive communities.

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