City of Seattle - Stormwater Low Impact Development Practices

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Abstract

As part of the City of Seattle's commitment to sustainable development, the City is implementing Stormwater Low Impact Development (LID) practices using numerous approaches. Two approaches are presented within this paper. First, the existing City of Seattle Stormwater, Grading and Drainage Control Code provides a variety of stormwater LID guidance to be used on various projects. Second, the City is also redeveloping a 129-acre housing project using an entirely new approach towards stormwater management.

The existing stormwater code implements both flow control and water quality treatment LID practices. This existing LID guidance will be updated as part of revisions to the stormwater code to meet the revised Municipal Stormwater National Pollutant Discharge Elimination System (NPDES) permit.

The High Point redevelopment project is currently incorporating stormwater LID drainage practices. The High Point area was a low-income housing development that is now being redeveloped as a mixed-income housing development. This project redefines the stormwater management design approach to be used for infrastructure and site development. The collaboration for this project produced an unprecedented effort between the Seattle Housing Authority, Seattle Public Utilities, and other City agencies. As a result of this innovative design approach, a traditional low-income housing development was enhanced by a more livable green space. The City stormwater code and the High Point project confirm Seattle's environmental commitment for sustainable development to maintain a high quality of life.

City Stormwater Code

In 2000 the City adopted its current *Stormwater, Grading and Drainage Control Code* - Seattle Municipal Code (SMC) 22.800 – 22.808. As part of the code implementation, four Director's Rules (DR) were developed. These DRs further clarify the Code when a given project meets a specified stormwater threshold. Of the four DR's, Volumes 3 and 4 include technical guidance related to Stormwater Low Impact Development (LID) practices.

Within Volume 3, Section 1.6 of the Flow Control manual there are design options that allow for an Impervious Surface Reduction Credit using LID practices. These methodologies include: porous pavement, eco-roofs, roof gardens and landscape planters. This section also includes guidance for bioengineered and infiltration facilities that include a bioengineered planting strip, an infiltration planter, an infiltration trench, and drywells.

Within Volume 4, Section 3 of the Stormwater Treatment manual there is biofiltration facility design guidance for swales and filter strips. Section 5 of this manual also includes media filtration design guidance.

To further assist the general public with understanding various aspects of the stormwater requirements and to make suggestions for how to complete their projects, the City developed Client Assistance Memos (CAM). The CAM's 500 series is used only for only drainage related information. For example, CAM 515 – "Green Parking Lots" provides stormwater LID guidance for addressing flow control and water quality. This includes using permeable pavement, swales, and infiltration trenches.

City Stormwater Code Revision

In early 2004, the City began the process of revising existing *Stormwater, Grading and Drainage Control Code* and the DR's. Since last updating the City stormwater code in 2000, many changes have taken place that requires updating the code.

An overriding factor for revising City stormwater code is the renewal of the Municipal Stormwater NPDES Permit, of which the City of Seattle is a NPDES Phase-I community. This NPDES permit update will include guidance outlined in the Washington State Department of Ecology's *Stormwater Management Manual for Western Washington (Revised 2005)*. This State stormwater manual includes LID practices that will be added to the City code.

The stormwater code revision will improve upon existing stormwater LID practices and include the latest industry practices. The code revision will also modify permit thresholds to better implement LID features for the type of development and redevelopment occurring.

The City code revision will also utilize stormwater LID information published by the Washington State Puget Sound Action Team's *Low Impact Development Manual* (January 2005). As part of the code revision, the City will also seek to align with stormwater building certification elements of the U.S. Building Council's Leadership in Environment and Energy Development (LEED®) program.

The stormwater code revision is scheduled for completion in early 2007.

High Point Redevelopment Project - Introduction

In advance of the stormwater code revision being completed to incorporate more stormwater LID practices, a City ordinance was passed in 2003 that allowed for SHA's 129-acre High Point redevelopment project requiring stormwater LID features throughout the development. Construction on phase 1 of the two-phase project began in June 2003, with phase 2 to be completed in 2009. The redevelopment project consists of 1,600 residential mixed-income housing units and integrates an existing City Natural Drainage System (NDS) concept throughout a large and high-density residential area. The NDS system is the first of this scale to be incorporated into a new urban subdivision as part of the street grid while also creating a network of connected vegetated and grass-lined swales. This approach achieves a balance between neighborhood green space, pedestrian safety, and water quality improvements.

The High Point revitalization is a partnership between the Seattle Housing Authority (SHA), Federal Housing and Urban Development (HUD), the City of Seattle, and several community-based groups. Aside from the housing and infrastructure redevelopment of the site, project plans also include numerous public amenities such as new parks, a neighborhood center, trails, a public library, a health center, and a commercial site. One of the major commitments of the project team is to develop the project in such a way as to have a net positive impact on the environment. The NDS strategy is an innovative and very important component of this commitment.

The High Point project area is approximately 10% of the Longfellow Creek Watershed, providing an opportunity to improve water quality and stream flows to Longfellow Creek, and thus recovers depleted Coho Salmon runs. Seattle Public Utilities' (SPU) proposal to integrate an innovative drainage system into this predominately townhouse style housing development was uncharted territory. Discussions, analysis and planning took approximately two years. SHA collaborated with the City to achieve approval of the subdivision plan for the NDS that consists of a network of swales, ponds and multi-functional open space throughout the 34 blocks of Right-of-Way (ROW).

This innovative approach modified the usual design review process by including City plan reviewers, SHA staff, the design team and technical experts in a design Charette to negotiate the use of above and below ground streetscape. Charette participants gained a better understanding of other disciplines and interdepartmental issues. They also recognized the need to focus on "performance" rather than "standards" to meet the goal of balancing community and ecological needs. Following the Charette, the focus was on incorporating methods to ease future permitting while also maintaining City control for stormwater management. After considerable discussion, drainage restrictions were included in the subdivision's recorded documents and future homeowner association's covenants.

In Seattle, the term "natural drainage system" is used to describe a category of drainage capital improvement projects that strive to meet multiple goals within street ROW, which account for 25% of Seattle's total land surface. The NDS program goals include infiltration, flow attenuation, filtering and bio-remediation of pollutants by soils and plants, reduced impervious surface, increased vegetation, and related pedestrian amenities. These NDS projects use natural features to mimic the functions of nature lost to urbanization and they include open spaces, vegetated swales, stormwater cascades, and small wetland ponds. At the heart of all NDS projects are the plants and trees, and the deep, healthy amended soils that support them. All three combine to form a living infrastructure that, unlike detention pipes and vaults, increases in functional value over time.

Background and Physical Overview

The Longfellow Creek Watershed collects stormwater runoff from an area of approximately 1,730 acres and outfalls into the Puget Sound. The watershed started feeling the effects of land development as early as the 1900's. Physical barriers, piping of creek sections, unrestricted flow, and no water quality treatment reduced salmon return. Longfellow Creek is a high-priority, salmon-bearing watershed and

has been identified by "the community and the City as a significant and valuable resource." The High Point development area plays a "particularly important role in the City's environmental stewardship responsibilities" (11/5/02 Memorandum of Agreement) for the Longfellow Creek Watershed.

During the planning of High Point, SHA was approached by SPU to develop a NDS strategy for the entire project as part of an Integrated Drainage Plan. The opportunity to develop a natural drainage approach in an existing large urban redevelopment project area was important to improving the protection of Longfellow Creek and as an example of what could be done to retrofit other City neighborhoods.

As part of the partnership, SHA developed a Mission Statement for SHA's High Point Community Revitalization plan:

> "Support Seattle Housing Authority in integrating affordable housing, open space interests and critical creek habitat protection by developing and evaluating several natural drainage options for their ability to meet the interests of Seattle Housing Authority and the City of Seattle."

The two agencies also agreed to work together on funding and the interdepartmental permitting process. SPU agreed to reimburse SHA for additional costs for implementing the NDS approach. SHA would remain responsible for achieving code compliance, but SPU would assist with the analysis, modeling and design of the NDS system. The subdivision design had already achieved a tight footprint with the new urbanist approach. This was not a typical large lot development, but one where the total unit lot size including the building footprint was as small as 1,200 square feet. The overall site plan was approximately 65% impervious. The City was asking SHA to go a step further and attempt to reduce the impervious area to 60% overall with the goal of increasing stormwater filtration for small storms at the block scale. SHA was still required to meet conveyance and major stormwater discharge requirements necessitating the installations of traditional drainage systems. This included a conveyance pipe network and a stormwater pond.

Planning

A considerable amount of time from the planning through the design phase has been spent on terminology. The semantics of High Point's drainage design led to discussions of the definitions of disperse, porous, infiltrate, pervious, absorb, discharge, convey, trench, swale, perforated, gravel, filtration, etc. Words become important as they mean different things to engineers, landscape architects, architects, regulatory staff, contractors, owners, developers, builders and real estate agents. Meanings or interpretations are not minor considerations when they affect bid prices and property values.

The NDS approach at High Point needed specific requirements and standards in order to convey the intent of the development. The desire to ensure the development will follow the intended approach and the need to explain the criteria and provide options for development resulted in five levels of commitment. The first was to take the unusual step of adding drainage thresholds in the Plat. The second was to develop a "Drainage Covenant" for the Plat of High Point Community. The third was to develop technical standards for compliance with the Drainage Covenant.

These standards have evolved from the originally envisioned design guidelines to an approach facilitating permitting and implementation. The fourth level was the development of a Covenant for Maintenance of Natural Drainage Landscape, Open Space, and ROW for the High Point Community. This association involves all properties within the Plat of High Point Community and includes authority for fee assessment, maintenance and enforcement of common areas including the natural drainage landscape. The fifth level is the Memorandum of Agreement (MOA) between the City of Seattle and the Seattle Housing Authority regarding funding and maintenance of the drainage system.

The High Point NDS began as a partnership between two public entities interested in redevelopment addressing community needs for affordable housing and a pedestrian friendly neighborhood incorporating progressive infrastructure. At times partners had different priorities since SHA's primary commitment was to housing and community building. SPU's ultimate goal was fully implementing the NDS within the development and downstream water quality.

Many city departments became involved in the High Point natural drainage approach since, in one way or another, the design criteria and space needs impacted all of them. Although there was an undercurrent of "we are being compromised for drainage," the discussions were valuable in getting interdepartmental understanding of each other's requirements. SHA remained committed to trying this new approach and continually thought of ways to use the drainage design to spearhead community building. This type of commitment was crucial in keeping all parties focused on the long-term goal while intermediate hurdles popped up.

Plat

Restricting the Plat was not something SHA, the surveyor's, or the land-use attorney wanted to do. The implications to the Plat as well as the Building and Site Permitting were not part of early discussions. These restrictions came about primarily due to City concerns on their ability to control the site development after the initial project was built and the future remodeling projects came in for permit. Now the City has decided to enter the permit data into their GIS for long-term tracking.

To achieve the drainage goals, each block was identified as having an "Allowable Percent Impervious Surface Coverage." During the review of each individual project, a "Permit Submittal Chart for Drainage Requirements" is filled out and checked to ensure an applicant did not exceed a predetermined allowable percentage of impervious surface. Once the project was permitted, the actual "total percent of impervious coverage" for a given block is entered into the City GIS system. This will be used to prevent any future redevelopment from exceeding previously permitted impervious surface thresholds.

Design Goals

In developing the NDS for the High Point project, SHA and SPU looked to mitigation measures that could manage and treat the stormwater closer to its source, while at the same time meeting SHA's goal of building an affordable housing community with a traditional in-city neighborhood feel. In other words, standard

curb and gutters were a requirement in order to blend in with the adjacent older neighborhoods. Some of the stormwater mitigation measures include: allowing building roof drainage to sheet-flow across a lawn and planting areas, amending the soil of lawns and landscape areas to improve the absorption capability of the soil, developing filtration drainage swales to treat stormwater runoff from adjacent properties and streets, mitigating the allowable impervious and pervious areas for a site, and using porous paving materials.

The proposed drainage system approach for the main High Point drainage sub-basin includes an integrated network of both NDS facilities, such as vegetated swales and conveyance swales, along with the traditional catch basin/inlet structures with a drainage conveyance-piping network for the large storm events. In addition, a stormwater detention pond was included and sized to provide flow control for the 2-year, 25-year, and 100-year, 24-hour design storms. The traditional drainage systems of pipes and detention were required when it was determined that on-site soils, even with amendments, would not fully accommodate larger flows.

Subdivision design establishes the relationship between buildings and infrastructure. Yet infrastructure design is typically an afterthought to the site layout dictated by pre-existing standards. This project incorporates both planted and grassy swales throughout the development as a priority of the site layout. The swales have specially-engineered soil beneath the grass and plants that store and treat the runoff from the roadway and housing development. This system provides a much greater opportunity to cleanse, cool and infiltrate stormwater runoff than the traditional piped and centralized stormwater management approach.

Design Approach and Modeling Results

The natural drainage approach combines creative street edge alternatives and stormwater management techniques which provide infiltration, filtering and flow control to reduce pollutant discharge, decrease erosion, and stabilize the creek water temperature. For this project the NDS goal of infiltrating stormwater into the native soil was not pursued due to the steep slope adjacent to the project site. Based on modeling results, the stormwater runoff from the system will function similar to pre-developed pasture conditions despite the neighborhood's high density. In developing the natural drainage plan, the landscape architects applied the various options tailored to the needs of each neighborhood block. These included a network of grass and tree-lined streetscape treatments, along with vegetated swales throughout the new street ROW to retain and slow stormwater runoff while bringing aesthetic value to the neighborhood. The street edge treatments combine the traditional feel of an established Seattle neighborhood with garden walks, which encourage a more walkable neighborhood.

The natural drainage plan also creates multi-functional open spaces including a new pond park, pocket parks, and areas for children to play. These spaces also serve as underground water storage. The plan also calls for minimizing some street widths from 32 to 25 feet to reduce impervious areas and add to the traditional urban character of the neighborhood. To help reduce stormwater run-off, porous concrete pavement was used on two City street sections, half of the public sidewalks, and for parking and access on many of the private properties. In an effort to not only limit waste, but also to mimic a forest's natural duff layer, the project has used on-site

wood chips from trees and vegetation to protect the critical root zone of the trees that will be preserved. Amended soils are required throughout the project site to increase the rate of infiltration and water-holding capacity.

The following are additional performance goals that were used for the site:

1) Bioretention swales are estimated to infiltrate approximately 75% to 80% of the water quality storms. This is slightly less than the goal of infiltrating 100% of the water quality storm event. Additional water quality treatment was provided via biofiltration in the grass-covered and vegetated swales, gravel pocket parks, and via dead storage in the detention pond. The effectiveness of these additional water quality treatment components have not been quantified. SPU used the block-scale results to make quantitative estimates of water quality effectiveness as part of the Plat Drainage Report (2003).

2) Creek Protection Goal - The site must match the baseline flow duration and peak intensity of flows associated with the 2-year storm for the pre-developed condition identified as being pasture. Based on the modeling, the creek protection goal is being met in terms of both peak flow and flow duration standards.

3) Stormwater Conveyance – The pipe storm drain system will convey the 25-year, 24-hour storm event. The pond's outlet structures will convey the 2-year, 25-year, and 100-year design storm events. Based on modeling results at the point of compliance, the storm drain and pond overflow systems meet design goals.

Existing Soil Conditions

In order to determine the native soils properties for reuse as an amended soil base in the NDS system, a geotechnical soils analysis was completed. The study characterized the site's soils as primarily Silty Fine to Fine Sandy Silts, resulting in a potential infiltration/storage rating of "poor." This information created the need to engineer the redeveloped site's soils to achieve the desired hydraulic conductivity within the NDS swales. Because infiltration was not a key component of this project's NDS design concept, SPU's standard approach to determine native soil infiltration rates, the Pilot Infiltration Test, was not used.

Natural Drainage System Strategies

The natural system design proposed to integrate 15,000 lineal feet of vegetated and grassy swales throughout the development within the ROW planting strip. These swales include engineered soil to provide storage and infiltration opportunities. Each swale is designed to treat the runoff from the street and housing of the adjacent block. At a system scale, the NDS will provide water quality treatment for the 6-month storm and attenuate the two-year, 24-hour storm to pre-developed pasture conditions. This distributed block-scale system provides a much greater opportunity to cleanse, cool and infiltrate stormwater runoff than the traditional piped and centralized management approach. The design team developed a block-scale continuous hydrologic model to refine the design performance and predict how the system will perform under different storm events. After the project is completed, SPU will be work with the University of Washington to monitor the performance of the built system at the block and sub-basin scale.

Delineation of the NDS Swales within the Public ROW

Assumptions for the location, length and cross-section of the NDS swales within the public ROW were based upon discussions with SHA and SPU. The locations for the NDS facilities were based on a two-step process:

1) Delineate which side of the street the swale would be located: Based on the housing concept plan, the swales were located on the side of the street with the least amount of driveway crossings and existing street trees to be saved.
2) Delineate the location for each swale type: shallow grass-lined and deeper vegetated. Since the NDS swales would be located within the planter strip of the street ROW, the ability for pedestrians to easily cross the planter strip to reach their parked vehicles was a primary criterion that determined the location of shallow grass-lined and deeper vegetated swales. Vegetated swales have also been located to delineate the intersections and within areas that have parking restrictions.

Site Design

Site design strategies were also required in order to meet the 60% impervious goal for the townhouse style of housing. At the planning level this appeared very feasible, but as the design worked through programming the impervious areas (such as the overhangs, patios, walks, driveways, storage sheds, and mailbox zones), it became apparent that more aggressive strategies would be required.

The City was concerned about the ability through current City regulations to restrict development beyond the zoning. This resulted in applying restrictions to properties at a "parent-lot" level that were recorded in the Plat. These restrictions cover impervious area, drainage connection points and requirements to disperse roof drainage on-site.

Design modifications were required to keep individual parcels within the Plat's requirements. These changes primarily impacted the percent of impervious surface and required revisions to accommodate porous pavements and therefore reviews for permits became a concern. City planners and engineers did not believe their current review process could accommodate the review of the NDS design strategies. Initially, it was thought that guidelines would be sufficient however, as discussions progressed, it was apparent that a much tighter set of guidelines would be required that is now called the *High Point Community: Site Drainage Technical Standards* manual. This 86-page document will allow reviewers to work from a set of approved standards as well as give builders some certainty in the process. This manual includes stormwater LID parameters and practices to be followed for each High Point City Block's project.

Permitting

The City of Seattle Department of Planning and Development (DPD) coordinated with SPU & SHA to resolve the various permitting challenges. The various levels of permitting for a major redevelopment allowed opportunity to take advantage of this alternative approach. While it was initially thought that partnering on drainage might simplify the overall permitting, in the end it became more

complicated. The success is that two public agencies continued to work through differences and constraints to achieve the bigger goal of an example of a sustainable urban community. As mentioned within the "Plat" section of this paper, these design goals were achieved through the project permitting process and tracked via GIS by DPD.

Construction

An early goal was to develop an affordable approach to natural drainage that could be implemented in other City neighborhoods. As the design progressed it was a tough challenge to avoid engineering design criteria that would inflate construction costs. The second area of concern was not attracting potential bidders due to the unusual drainage approach and high level of attention to the project. The team attempted to describe the work with routine construction materials and terminology in order to minimize the cost impact of doing something different.

Since this is the first large scale approach for a NDS in the City of Seattle, there's a higher level of City oversight than a typical project. The contractors are required to protect the natural drainage zones and the porous pavement from both traffic and adjacent drainage until project sites are adequately stabilized. To the SHA and SPU satisfaction, successful and very competitive bids were received.

Benefits and Amenities

The natural drainage approach provides much needed green space in dense urban areas. Vegetated swales that include grasses, perennials and shrubs support the natural system and create "garden walks." Grassy swales reflect the character of the neighborhood and encourage interaction between neighbors. Multi-functional open space includes detention ponds and storage under neighborhood parks. In addition to reducing runoff and preserving the health of the creek, the benefits included attractive plantings and landscaping that create "garden walks." The result is a more walkable neighborhood reducing the desire to drive vehicles as frequently.

Reduced street width from 32 to 25 feet not only reduces impervious areas, but also gives an historical look and feel to the neighborhood streets. Using this design approach still maintains on-street parking while also serving as a traffic-calming device.

Conclusions

The High Point redevelopment provides guidelines for future construction of publicly and privately funded homes that encourages sustainable design approaches. Using a performance-based approach, the design meets the needs of the client, infrastructure stakeholders, and serves an ecological function. Most importantly, the High Point model challenges beliefs that dense urban design and ecological performance are mutually exclusive. The City stormwater code and the High Point redevelopment project confirm Seattle's environmental commitment for sustainable development to maintain a high quality of life.

Web Links

City of Seattle - Stormwater Code and the Directors Rules (SMC 22.800 – 22.808): http://www.seattle.gov/dclu/codes/sgdccode.htm

City of Seattle – Client Assistance Memos, 500 series: http://www.seattle.gov/dpd/camlist/CAMList.asp?Sort=Series#500

City of Seattle - Seattle Public Utilities, Natural Drainage Systems: http://www.cityofseattle.net/util/NaturalSystems/overview.htm

City of Seattle - Seattle Public Utilities, High Point Project: http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/Natural_Drainage_Systems/High_Point_Project/index.asp

Longfellow Creek: http://www.longfellowcreek.org

City of Seattle - Seattle Public Utilities, *High Point Community: Site Drainage Technical Standards* manual: http://www.seattle.gov/util/stellent/groups/public/@spu/@esb/@dwwsweng/documents/spu_informative/cos_003568.pdf

Washington State Department of Ecology's, *Stormwater Management Manual for Western Washington (Revised 2005)*: http://www.ecy.wa.gov/programs/wq/stormwater/manual.html#How%20to%20Get%20Printed%20Copies%20of%20the%20Stormwater%20Manual

Washington State Puget Sound Action Team's, *Low Impact Development Manual* (January 2005): http://www.psat.wa.gov/Programs/LID.htm

SvR Design Company: http://www.svrdesign.com

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Shannon and Wilson, Inc.

RW Beck Inc.

Herrera Environmental Consultants, Inc.

Seattle Housing Authority Design Consultants, lead by Mithun Architects.

References

High Point Drainage Basin Plan and Report. (May / June, 2004), SvR Design Co.

Geotechnical Engineering Report High Point Hope VI Redevelopment. (February / March, 2004), Shannon and Wilson Inc.

Technical Memorandum: Hydrologic Modeling for High Point Revitalization. (May, 2004), Herrera Environmental Consultants, Inc. and RW Beck, Inc.

Housing Concept Plan/Master Use Permit (MUP). (March, 2002), Mithun Architects

High Point Community: Site Drainage Technical Standards. (May / June, 2004)