Smart Growth on the Ground: Prince George
FOUNDATION RESEARCH BULLETIN #5

Prepared by:

Cynthia Girling

Lindsay Raftis

Sheryl Webster

The Design Centre for Sustainability,

University of British Columbia

Rainwater Management

1.0 Introduction

This bulletin describes the role of urban rainwater management as a contributor to overall ecosystem health. Focusing on downtown Prince George, the conventional management system will be reviewed and specific green infrastructure strategies will be offered that can improve system functions.

2.0 Rainwater Management

Rainfall and snowmelt can be captured, stored or infiltrated, and filtered to reduce their impacts. Such innovative rainwater management techniques can mimic natural conditions in an urban landscape, thereby reducing the volume and improving the quality of runoff.

General Background

Rainwater refers to all precipitation runoff generated by either rainwater or snowmelt, conventionally known as stormwater. It is proposed that rainwater and snowmelt, if managed well, are a valuable resource. In urban conditions, the development of roads, parking lots and rooftops creates surfaces that are impervious to water, thus creating high volumes of runoff. Conventional urban runoff infrastructure collects, stores, and transports water through large, buried sewer systems that drain into natural aquatic environments.

This urban runoff carries high amounts of "non-point source" pollution (NPS). Contaminants such as oil and fuels, sediment, road salt and litter collect on surfaces during dry weather. These contaminants are then washed off by precipitation and enter the sewer system. They are eventually deposited in nearby watercourses, directly and adversely affecting local aquatic health.

However, urban runoff does not have to be considered a waste that must be disposed of quickly. Rainfall and snowmelt can be captured, stored or infiltrated, and filtered to reduce their impacts. Such innovative rainwater management techniques can mimic natural conditions in an urban landscape, thereby reducing the volume and improving the quality of runoff. This in turn helps to mitigate the negative impacts of rainwater runoff on the environment and alleviate the demand on current stormwater infrastructure.

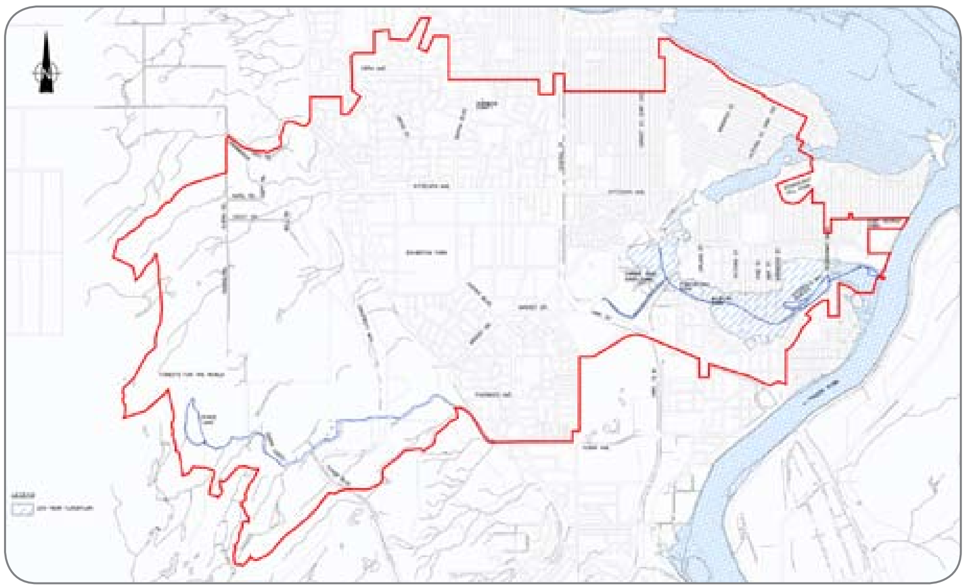
Produced by:

Smart Growth BC

Real Estate Institute of BC

Rainwater Management in British Columbia

Stormwater Planning- A Guidebook for British Columbia was developed in 2002 by the provincial government to provide a framework for effective stormwater management that is usable in all areas of the province. The publication refers to "Integrated Stormwater Management Plans" (ISMPs) – a concept that describes a comprehensive approach to stormwater planning, which has gained widespread acceptance by local governments and environmental agencies. The purpose of an ISMP is to provide guidance on how to apply land use planning tools in a proactive manner to protect property and aquatic habitat while accommodating land development and population growth. While the stormwater planning guidebook provides effective recommendations for the province at large, it does not include more site-specific solutions that are suitable for existing developments (MWLAP 2002).



credit: Associated Engineering Ltd.

Figure 1: Hudson's Bay Slough Watershed (2007).

3.0 Rainwater Management in Prince George

Context

Prince George is situated at the confluence of the Nechako and Fraser Rivers and is located within the Hudson Bay Slough Watershed (Figure 1). Prince George receives precipitation every month of the year, and temperatures drop below zero between the months of October and April. The average annual precipitation is 600mm, of which approximately 30% falls as snow (Figure 2) (Environment Canada 2009). Therefore, Prince George faces winter challenges such as heavy snow loads, freeze-thaw cycles and river ice jams (City of Prince George 2008).

In the downtown core of Prince George, the high amount of impervious area combined with the annual precipitation and snowmelt causes large volumes of runoff that place a significant load on the current stormwater system. In December 2007, an ice jam at the confluence of the Nechako and Fraser Rivers caused a flood in downtown Prince George. "A major factor in the flooding of low lying areas in Prince George is the limited capacity of the open channel system that conveys all runoff from the watershed to the Fraser River" (Associated Engineering Ltd. 2007).

The Hudson's Bay Slough Watershed Drainage Plan

The *Hudson's Bay Slough Watershed Drainage Plan*, which was completed in January 2007, recommends a range of effective best management practices (BMPs) and Low Impact Development (LID) strategies for application in the Hudson's Bay Slough Watershed, which encompasses the downtown of Prince George (Associated Enineering Ltd. 2007). Recommendations in the plan include infiltration based runoff controls, structural peak flow controls, water quality improvement measures, sediment management facilities, and construction site sediment control.

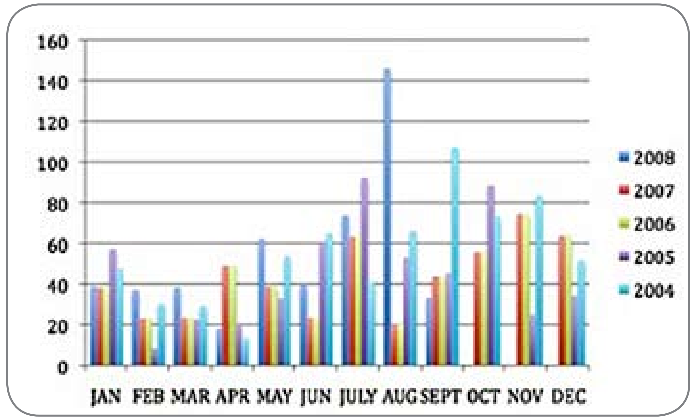
This plan addresses prominent watershed management BMPs and LID goals for the City of Prince George, including:

- Safeguard human life and property
- Enable orderly, cost effective and sustainable development
- Preserve and improve environmental quality
- Reduce creek processes (erosion, sedimentation, and slope instabilities)
- Control surface ponding and flooding
- Integrate storm water management functions with other planning initiatives, such as Park Use, Transportation Improvements and Land Development Projects
- Optimize the cost/benefit of the proposed drainage system, including capital, maintenance, environmental and liability costs.

In addition to adopting this plan and implementing recommendations from *Stormwater Planning--A Guidebook for British Columbia*, more specific strategies are needed to address the high amounts of runoff from the urbanized downtown core of Prince George.

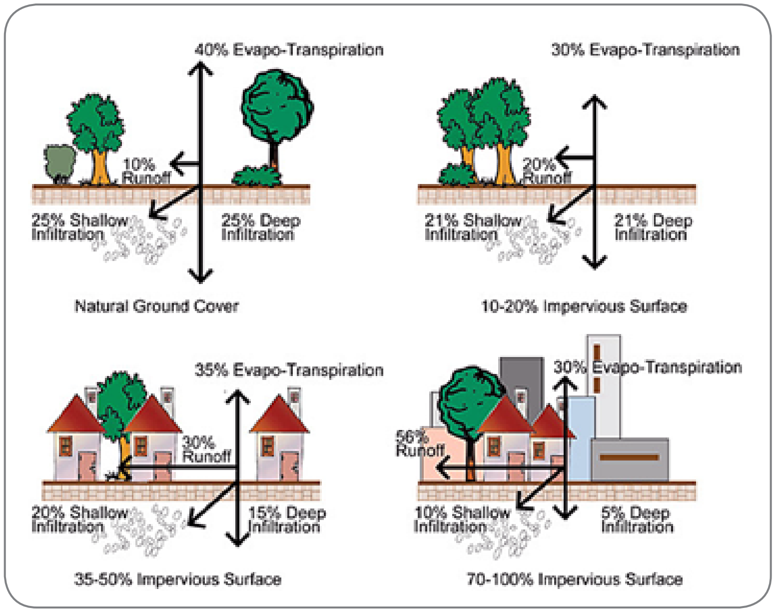
4.0 Recommended Urban Rainwater Strategies for Prince George

As mentioned earlier, rainwater and pollutants can be managed by implementing appropriate urban rainwater strategies in downtown Prince George. Although the *Hudson's Bay Slough Watershed Management Plan* suggests techniques for managing rainwater drainage, it pertains to the entire watershed at a much broader scale



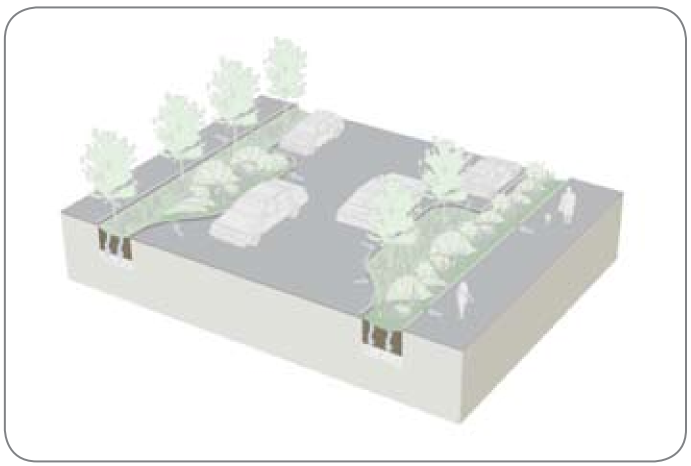
credit: Environment Canada

Figure 2: Prince George annual precipitation distribution in millimeters per month from 2004 to 2008. The Average Annual Total Precipitation between 2004 and 2008 is 544.68 mm.



credit: Milwaukee Metropolitan Seweage District

Figure 3: Percentages of surface impermeability with altered land use.



credit: Girling, et al.

Figure 4: Rain garden.

than the downtown core. This section will highlight specific practices that are appropriate and suitable for effectively managing runoff in downtown Prince George.

Reduce Total Impervious Area

Total Impervious Area (TIA) refers to the area of all impervious surfaces such as roofs and paving in an urban area. Urban TIA can be reduced by narrowing street widths to make room for planting trees and vegetation, using pervious pavements, directing runoff to areas that allow infiltration, and greening the rooftops of buildings (Figure 3).

Detain and Delay Runoff for Reuse and/or Infiltration

Rainwater cisterns and green roofs can be installed on new and existing buildings as a simple way to delay flow and reduce volumes of urban runoff.

- *Rainwater Cisterns* reduce runoff volumes by capturing rainwater and snowmelt from rooftops. This water can be re-used for watering lawns, gardens, or trees.

- *Green Rooftops* delay and reduce runoff volumes by storing water in the substrate, absorbing water in the root zone, and retaining precipitation in the plant foliage where it is returned to the atmosphere through transpiration and evaporation (Urban Design Tools 2009).

Infiltrate Rainwater

Integrating infiltration areas into an urban landscape is an effective technique for redirecting large volumes of runoff through designated pervious areas.

- *Infiltration Galleries* are underground trenches composed of drainage rock enclosed in filter fabric beneath pervious pavements or vegetated areas (Girling, C., M. Galdon, L. Davis, and R. Kellet 2008).

- *Rain Gardens* are planted depressions suitable for pedestrian oriented, public spaces. Plants are carefully selected to suit the community and climate in which they are located (Figure 4) (Girling, C., M. Galdon, L. Davis, and R. Kellet 2008).

- *Vegetated Swales* are graded and landscaped channels vegetated with flood-tolerant, erosion-resistant plants. They promote the conveyance of rainwater at a slower, controlled rate while filtering pollutants and infiltrating rainwater (Lake Superior/Duluth Streams 2009) (Figures 5 and 6).

- *Bioretention Swales* are a type of vegetated swale that uses soil, plants and microbes to remove water pollutants. They consist of a two-layer treatment soil system in which a layer of compost sits atop a deeper rooting layer.

Increase Green Landscapes

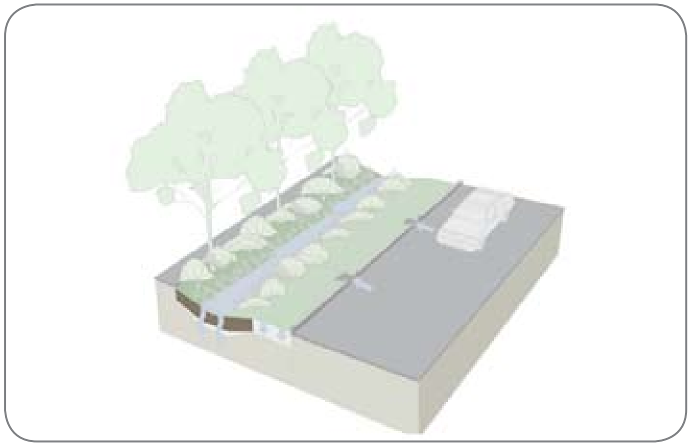
Citizens of Prince George requested enhanced vegetation as a priority for improving the livability and safety of downtown (City of Prince George 2002). In addition to improving air quality, habitat and quality of life, landscaped plants and green space offer additional layers of vegetation to detain and reduce runoff.

- *Street Trees* decrease urban runoff by intercepting and detaining rainfall in their canopies and by absorbing water in their root zones.

- *Green Parking* refers to reducing the impervious surface area within parking lots by restricting the number of parking lots created, reducing the size of each parking space, utilizing pervious pavements, and planting trees and vegetation to intercept rainfall (Storm Water Center 2008).

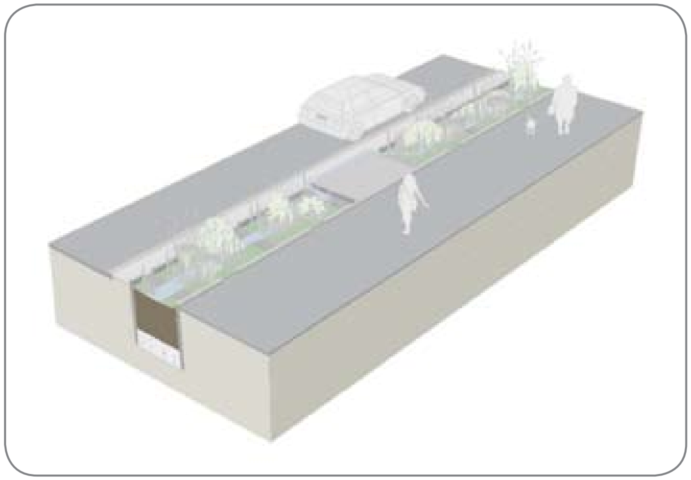
5.0 Setting Rainwater Management Indicators and Targets for Prince George

The amount of surface area within a region that is unable to detain, absorb or infiltrate rainwater dictates the volume of runoff within that region. This volume directly affects the level of impacts on and net change in water quality of nearby watercourses and waterbodies. Therefore, it is important to set goals and targets that will decrease both current and future amounts of surface area runoff. Goals and targets in this regard can be achieved by applying certain rainwater management



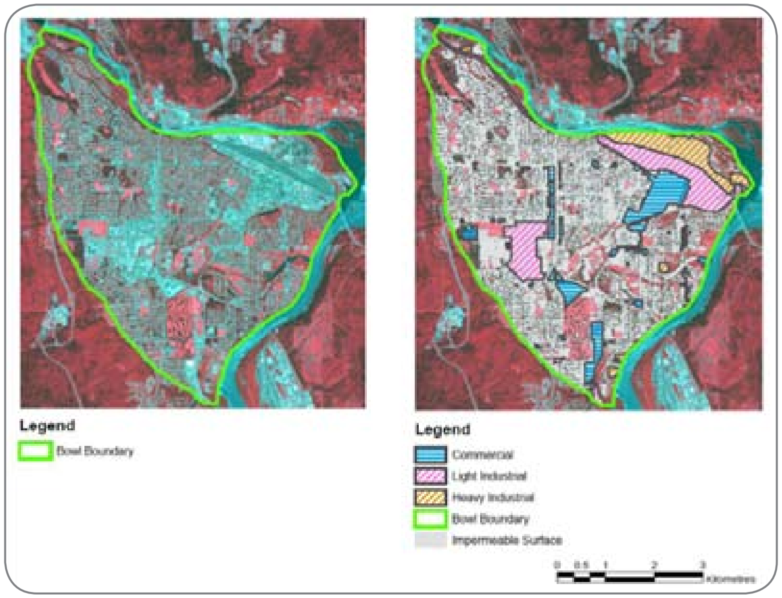
credit: Girling et al.

Figure 5: Vegetated Swale with grass filter strip adjacent to the road.



credit: Girling et al.

Figure 6: Vegetated Swale in tight urban conditions.



credit: Stanton-Kennedy

Figure 7: Images demonstrating land use type and surface impermeability in Prince George Bowl.

strategies, as mentioned above, to both existing and emerging residential, commercial, and industrial developments, roads and open spaces.

Urban rainwater management goals for downtown Prince George may include: net improvement in water quality and net reduction in impervious area and runoff for new developments, as well as no increase in Total Impervious Area (explained above) or Effective Impervious Area (described below) in existing developed areas. Indicators commonly used to quantify these improvements include:

- Percent Total Impervious Area
- Percent Effective Impervious Area
- Percent Area of Tree Canopy Coverage

Percent Total Impervious Area Indicator

“Percent Total Impervious Area” is a feasible indicator to measure improvements in rainwater management for the Smart Growth on the Ground project in downtown Prince George.

A first step in setting Total Impervious Area indicators and targets includes determining the current conditions and establishing maximum and minimum levels of impervious surfaces. The following equation calculates Percent Total Impervious Area:

*% Total Impervious Area = Impervious Area (ha)/ Total Area (ha) * 100*

Using this equation, a student at UNBC measured the Total Pervious Area of the Prince George “bowl”, the extent of which is defined by the Nechako and Fraser Rivers and the base of Cranbrook Hill. The study concluded that “approximately 46% of the surface area in the Prince George ‘bowl’ is impermeable” (Figure 7) (Stanton-Kennedy 2005). Residential areas are generally more permeable than their commercial and industrial counterparts, and the downtown core of Prince George currently has very few permeable surfaces. Although the current percent Total Impervious Area for the downtown area of Prince George has not been calculated, it is estimated to be 85-95%, based on measures of comparable, highly built-up downtown areas (Ferguson 1998).

Several studies report that detrimental measured effects on water quality and aquatic habitat are small or absent below a threshold of around 10% effective imperviousness of a watershed (Zandbergen 1998). Hence, higher values imply potentially detrimental effects. Consequently, the suggested target for Prince George is a Total Impervious Area of the Hudson's Bay Slough watershed of less than 10%.

Percent Effective Impervious Areas

An impervious area that collects and moves water directly into streams or wetlands via pipes or sheet flow is considered an Effective Impervious Area (EIA). Reducing the EIA is an effective strategy for an existing urbanized area. It involves disconnecting impervious surfaces from the drainage system by way of infiltration and detainment so that runoff does not flow directly into streams. Percent EIA can be used as an indicator for measuring rainwater runoff reduction and management. It can be measured by substituting the total area with effective area in the TIA equation (above); however, calculating the effective area requires a more rigorous approach and the involvement of certain professionals, such as geotechnical engineers.

Percent Area of Tree Canopy Coverage

Increasing tree canopy coverage in the downtown core of Prince George could be an effective strategy for decreasing urban runoff. Currently, Prince George has few street trees, and of those that exist in the downtown core, 44% are in medium to poor condition. These existing trees intercept a total of 681m3 of rainfall. The species with the largest absorption properties include American Elm, Green Ash and Blue Spruce, respectively (Macias 2009). Rather than number of trees, the Percent Canopy Coverage is becoming a preferred method of quantifying urban trees and calculating environmental benefits, such as reduced runoff. The suggested target for tree canopy coverage in the downtown core of Prince George is between 15-30%.

6.0 Examples of Successful Urban Rainwater Management Projects in British Columbia

Dockside Green (www.docksidegreen.com)

Dockside Green is a LEED® Platinum targeted project that will achieve a largely self-sufficient community where waste from one area will provide fuel for another. This is particularly relevant in its application to wastewater, which is treated and re-used within the environmental system. Dockside Green will produce no off-site runoff.

UniverCity (www.univercity.ca)

UniverCity has developed a comprehensive, regularly monitored rainwater management system that is designed to maintain a zero net change in runoff volumes, hydrology and water quality. The UniverCity development is "returning nearly 100% of stormwater to the ground instead of into conventional drainage pipes and ditches. The objective is to maintain pre-development stormwater runoff quality and quantity so that downstream aquatic life is not adversely affected by the new development" (UniverCity on Burnaby Mountain 2009).

7.0 Conclusion

This bulletin describes the role of urban rainwater management as a contributor to overall ecosystem health in the context of downtown Prince George. In summary, the rainwater management strategies suggested reduce the Total Impervious Area as well as the Effective Impervious Area and increase the utilization of green landscapes. These rainwater management techniques decrease the volume and improve the quality of runoff that flows into nearby watercourses, thereby mitigating the impact of runoff on the environment and alleviating the demand on current rainwater infrastructure. It is recommended that these strategies be considered and implemented for the downtown core of Prince George.

References

Associated Engineering Ltd. 2007. Hudson's Bay Slough Watershed Drainage Plan (HBSWDP). Burnaby, BC.

City of Prince George. 2002. The Prince George Social Plan.

City of Prince George. 2008. Prince George Parks and Open Space Master Plan.

Clean Water Services. 2002. Effective Impervious Area Reduction Task Force Report. Tualatin Basin, OR.

Dockside Green. N.d. http://www.docksidegreen.com. Accessed January 2009.

Environment Canada. N.d. http://www.climate.weatheroffice.ec.gc.ca/climateData/canada_e.html. Accessed November, 2009.

Fergusen, B. 1998. Introduction to Stormwater. New York City, NY: John Wiley & Sons.

Girling, C., M. Galdon, L. Davis, and R. Kellett. 2008. Green Infrastructure in Calgary's Mobility Corridors. Vancouver, BC: UBC Design Centre for Sustainability, School of Architecture and Landscape Architecture, University of British Columbia.

Lake Superior/Duluth Streams. N.d. http://www.lakesuperiorstreams.org/stormwater/toolkit/swales.html. Accessed December 2008.

Macias, A. 2009. Prince George Downtown Urban Forest Modeling, posted to http://www.dcs.sala.ubc.ca/research.html. Vancouver, BC: Design Centre for Sustainability, Department of Architecture and Landscape Architecture, University of British Columbia.

Ministry of Water, Land and Air Protection (MWLAP). 2002. Stormwater Planning – A Guidebook for British Columbia.

Stanton-Kennedy, T. 2005. Calculating Impermeable Surface Area in the Prince George "Bowl." Prince George, BC: University of Northern British Columbia.

Storm Water Center. N.d. Better Site Design Fact Sheet. http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool4_Site_Design/GreenParking.htm. Accessed December 2008.

UniverCity on Burnaby Mountain. N.d. http://www.university.ca. Accessed January 2009.

Urban Design Tools (UDT). N.d. Low Impact Development (LID). http://www.lid-stormwater.net/greenroofs_benefits.htm. Accessed January 2009.

Zandbergen, P. 1998. Urban Watershed Assessment: Linking Watershed Health Indicators to Management. CD-ROM. Vancouver, BC: Institute for Resources and Environment, University of British Columbia.

Resources

Benedict, M. and E. McMahon. 2001. Green Infrastructure: Smart Conservation for the 21st Century, Sprawl Watch Clearinghouse Monograph Series.

Buholzer, B. and R. Wark. 2006. Regulatory Options for Promoting Green Roofs in British Columbia. http://commons.bcit.ca/greenroof/publications/gr_regulatory_options.pdf. Accessed January 2009.

California Green Solutions. N.d. http://www.californiagreensolutions.com/cgi-bin/gt/tpl.h,content=692. Accessed November 2008.

City of Prince George. 2002. Watershed Drainage Plans – Gladstone, Varsity and Trent Catchments.

Cochran, J., S. Clark and M. Lalor. 2008. Effect of Canopy Cover on the Volume of Rain Throughfall. http://cedb.asce.org/cgi/WWWdisplay.cgi?0521979. Accessed February 2009.

Curran, D. 2004. A Smart Growth Direction for the City of Prince George: Development Concept for the 5th and Tabor Site. http://www.city.pg.bc.ca/city_services/lrp/fifthtabor/report.pdf. Accessed January 2009.

Girling, C. 2005. Green Infrastructure: A Future for Urban Landscapes. Vancouver, BC: UBC Design Centre for Sustainability, School of Architecture and Landscape Architecture, University of British Columbia. Green Highways Partnership. 2007. http://www.greenhighways.org/dev/Template.cfm?FrontID=5104. Accessed December 2008.

Hager, M. The Journal for Surface Water Quality Professionals, "Low Impact Development". 2003. http://www.lowimpactdevelopment.org/lid%20articles/stormwater_feb2003.pdf. Accessed November 2008.

Infiltration Systems, Minnesota Urban Small Sites BMP Manual. N.d. http://www.metrocouncil.org/environment/Watershed/BMP/CH3_STInfilTrenches.pdf. Accessed December 2008.

Smart Growth on the Ground. 2004. Technical Bulletin: Rainwater Management in Maple Ridge.

Smart Growth on the Ground. 2005. Downtown Squamish Concept Plan.

Tree Canopy Cover Study: Garland, TX – 3.86 Acre Site. N.d. http://www.medinaswcd.org/reducing%20storm%20water%20runoff%20on%20your%20homesite.pdf

U.S. Environmental Protection Agency. N.d. "Managing Wet Weather with Green Infrastructure," http://cfpub.epa.gov/npdes/home.cfm?program_id=298. Accessed December 2008.

Authors

Cynthia Girling is Chair of the Landscape Architecture Program in the School of Architecture and Landscape Architecture at the University of British Columbia. With Professor Ronald Kellett, she co-directs the elementssLAB, a research group that closely collaborates with the Design Centre for Sustainability at the University of British Columbia.

Lindsay Raftis (B.Sc., Mechanical Engineering, Queen's University). Ms. Raftis' work and research concern the interrelationship of sustainability and engineering, with a focus on renewable energy projects. She currently works as Researcher and Technician with the Design Centre for Sustainability at the University of British Columbia.

Sheryl Webster (Certificate in Landscape Architecture and M.A. in Culture, Ecology and Sustainable Communities). Based on her work in both the non-profit and private sectors in Canada, Honduras and the United States, Ms. Webster brings a depth and breadth of expertise in urban sustainability with a focus on green corridors, native habitats, and urban agriculture. She currently works as Project Coordinator with the Design Centre for Sustainability at the University of British Columbia.