Neighbourhood Stormwater Storage Space

Helping Meet Vancouver's Water Conservation Target

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ABSTRACT This case study examines how much space would be needed in order to collect enough stormwater to meet the irrigation needs of ground level green roofs within an urban watershed in Vancouver, BC. Stormwater harvesting is presented as a method for water conservation that has the potential to help meet Vancouver's water conservation objectives. Specifically, goal eight of Vancouver's Greenest City Action Plan stipulates a reduction in per capita water use by 33% from 2006 levels. The results indicate that a public open space adjacent to the urban watershed studied provides adequate space to store enough stormwater to meet the irrigation need of ground level green roofs within that watershed. Furthermore, this water infrastructure is similar in scale to that which already exists on the site.

INTRODUCTION

In recent years, Vancouver has taken steps to ensure that the high quality of life enjoyed by its residents is maintained for future generations. The Greenest City Action Plan is one such initiative with the goal of helping Vancouver become the "Greenest" city by 2020. Within this ten point plan, goal eight specifies the provision of clean water for all residents of Vancouver, addressing both issues of water quality and water consumption (COV, 2012). Currently, Vancouver enjoys some of the best quality drinking water in the world in which mountain reservoirs in protected and undeveloped watersheds supply the city with drinkable water (Welsh, 2011).

While issues of water quality have largely been addressed, the future availability of water is in question. Climate change research shows that a 15% decrease in snowpack throughout BC can be expected by 2050 and a 25% decrease by 2080 (Cohen et. al, 2010, Columbia Basin Trust). Located in the North Shore mountains, Vancouver's reservoir levels are largely driven by winter snowpack accumulation. Consequently, a decrease in North Shore mountain snowpack will have detrimental effect on the supply of potable water in Vancouver. Furthermore, the demand for potable water is expected to increase as migration to Vancouver grows. Some estimates predict that as many as 40 million to 700 million people will move to Vancouver as a result of the climate change displacement (Welsh, 2011).

To address the simultaneous decrease in supply and increase in demand for water in Vancouver, the Greenest City Action plan calls for a water conservation target by 2020 of a 33% decrease in per capita potable water use below 2006 levels. The measures that have already been introduced include summertime outdoor watering education, water metering, and a mandate to install low flow fixtures in all new construction (Welsh, 2011). However, this effort is expected to fall short of the 2020 target by approximately 12%, meaning further consumption reductions will have to be addressed through new and innovative methods.

Residential water use accounts for over half of the water consumed in the city of Vancouver (Welsh, 2011). During the summer months, 30% of this residential water consumption is a result of landscape irrigation (Welsh, 2011). Thus, limiting the use of potable water for landscape irrigation has the potential to have a significant impact on per capita water consumption. While Metro Vancouver acknowledges the role of rainwater and wastewater harvesting in achieving the city's water conservation targets, municipal bylaws stand in the way of any such scheme (DWMP, 2011). The Metro Vancouver Drinking Water Management Plan does, however, suggest that such bylaws should be reviewed and that alternatives to potable water should be considered for in-ground irrigation systems (DWMP, 2011).

ALTERNATIVE SOLUTIONS FOR IRRIGATION

A large fraction of the potable water consumption in Vancouver's downtown residential neighbourhoods is the result of ground level green roof irrigation. Green roofs of this kind have traditionally served to increase the amount of accessible open space within the dense downtown core. Increasingly, they are also being designed to take on the role of green infrastructure, performing as systems for stormwater mitigation and wildlife habitat (Oberndorfer, 2007). Whatever the desired function, the success of a greenroof is dependent on the health of the plant material of which it is composed. Vancouver's climate necessitates a significant input of water to maintain the health of green roof plabt material throughout the dry summer season (Roehr and Kong, 2010). As a result, ground level green roofs represent a significant burden on water consumption in Vancouver's downtown.

In order for Vancouver to decrease its per capita water consumption, green roof design needs to be optimized so that less potable water is required to maintain roof health and function. Design of a green roof system which utilizes winter precipitation instead of potable water would help Vancouver move towards meeting its water conservation targets.

Throughout most of the year water is a ubiquitous entity in the city of Vancouver. The average annual precipitation depth in the city is a generous 1300mm (CCN, 2012). The problem from a water conservation perspective is that precipitation accumulation is spread unevenly throughout the year. The summer, when green roofs require the most water, sees very little precipitation accumulation at all (Figure 1). To make rainwater available for consumption throughout the year, the design challenge is to collect and store water that falls in the winter for use on green roofs in the summer.

Given the abundant rainfall in Vancouver, the city's infrastructure is adept at quickly moving large volumes of water away from areas where it is a nuisance. An extensive network of dedicated stormwater sewers that collect rainwater off of impervious surfaces exist throughout large parts of the downtown peninsula (COV, 2010) (Figure 2). These sewers concentrate runoff in specific areas throughout downtown and organize this part of the city into a patchwork of drainage basins. The sewers that make up these drainage basins effectively serve as a neighbourhood scale rainwater collection system. Currently rainwater in downtown Vancouver is being collected, but not effectively utilized.

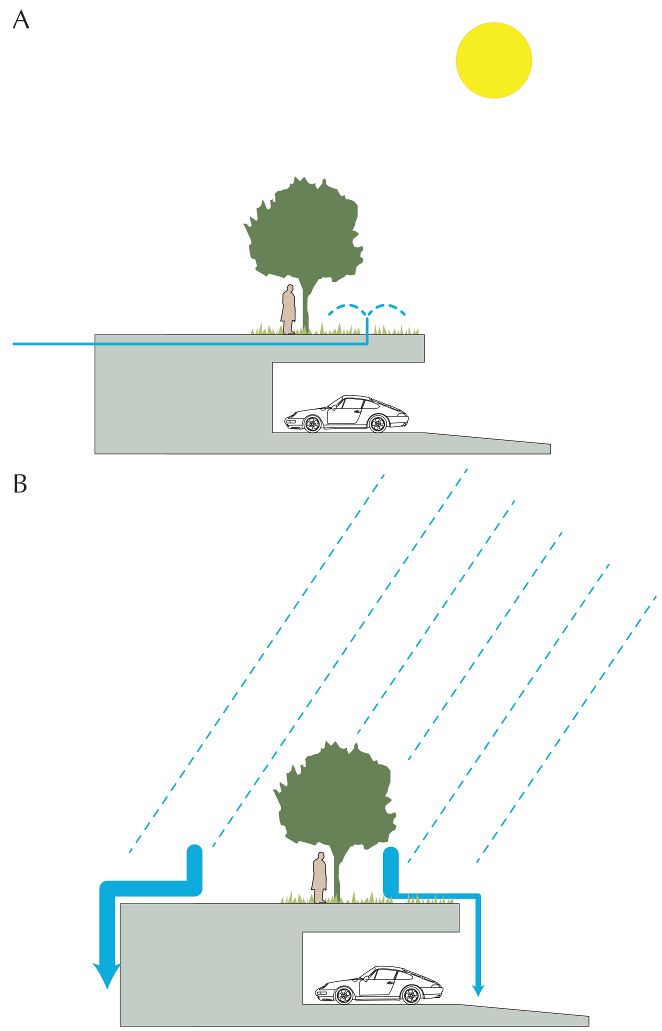


Figure 1. Green roofs require irrigation in the summer dry season (A) While they help mitigate stormwater in the winter wet season (B)

Figure 2. Stormwater sewer network in downtown Vancouver. Site boundary is outlined in red.

SITE INVESTIGATION

The use of stormwater to meet irrigation needs on ground level green roofs may be the answer to meeting Vancouver's water conservation targets. The present research seeks to identify the irrigation need of ground level green roofs in a single drainage basin in downtown Vancouver as well as the volume of stormwater which moves through the same area in order to explore how the proximity of green roof water need to stormwater source can be organized into a holistic water recycling system.

With the help of maps provided by the City of Vancouver's Department of Engineering and Vancouver Police Departmen,t an urban watershed in downtown Vancouver was identified as the study area. It is bordered by Jervis Street, the north side of Harwood Street, Beach Avenue and the Burrard Street Bridge. Stormwater within this watershed is concentrated at the foot of Jervis street where it is picked up buy Jervis Forcemain No. 2 or allowed to spill into False Creek. Residential towers populate the site with construction that ranges from the 1960's to the present day. To the south-west of the site is Sunset Beach Municipal Park. The site was picked due to its abundance of accessible ground level green roofs, its modest size, and its proximity to a large public open space. An inventory of ground level green roofs was undertaken, being defined as any landscaped areas that can be visually identified as existing on top of a built structure. In this case, they were found exclusively on top of residential parking garages.

Figure 3. Study site with adjacent municipal park

Green roof typologies were identified based on the type of plant material to which they played host. The green roof types identified within this study were as follows:

- turfgrass
- groundcover and shrubs
- trees shrubs and groundcover
- trees shrubs and turfgrass

(Figure 4,5,6,7)

Figure 4. Turfgrass

Figure 5. Groundcover and Shrubs

Figure 6. Trees, Shrubs, and groundcover

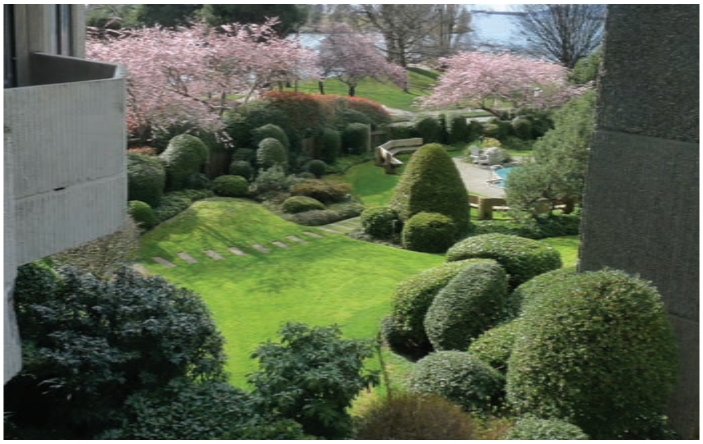


Figure 7. Trees, Shrubs and Turf

METHODOLOGY

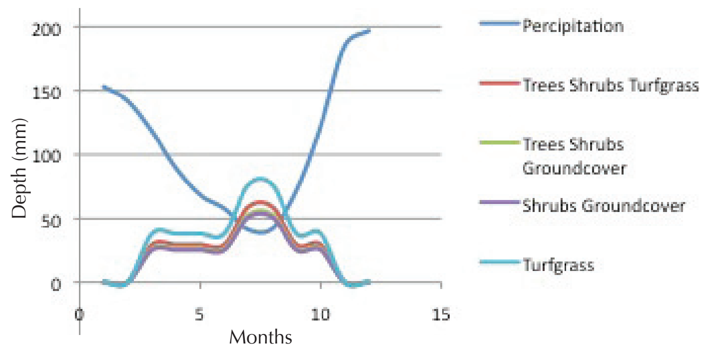
The crop coefficient method, as described by (Allan et al., 1998) was used to calculate evapotranspiration of green roofs identified within the study area. Green roof evapotranspiration rates, (ETCG) were calculated using a reference evapotranspiration rate, (ETO) as described by the British Columbia Ministry of Agriculture, Food and Fisheries (Van der Gulik, 2002).

To convert the ETCG to the green roof irrigation requirement (IRG) a conversion factor which takes into account the irrigation system efficiency is often applied (Van der Gulik, 2001). However, irrigation system efficiency should be determined by actual field measurements which was not possible in the present study. For the purposes of the study, a hundred percent efficiency was assumed and an irrigation efficiency conversion factor was not applied.

The rational method was used to estimate peak runoff volume generated at the study site. The method used was modeled after a similar technique employed by (Roehr and Kong, 2010). However the current study uses a rainfall intensity (i) that is measured in mm/year as employed by LMNO engineering (LMNO, 2003).

RESULTS

By comparing the monthly irrigation need and monthly precipitation, the time of year when potable water input is required was identified as July and August, when irrigation need exceeds precipitation. (Graph 1) Irrigation therefore needs to be applied to the green roofs during these months. The volume of irrigation needed during the dry months is calculated by subtracting the monthly precipitation from monthly irrigation during the dry months (Table 2). Adding the above values together yields the total volume of water required to irrigate all ground level green roofs within the study site. The resulting total volume of water necessary for irrigation of all greenroofs within the study site is 168 000 liters.



Graph 1. Percipitation crosses with irrigation curves. This shows the time of year when the irrigation is higher than percipitation

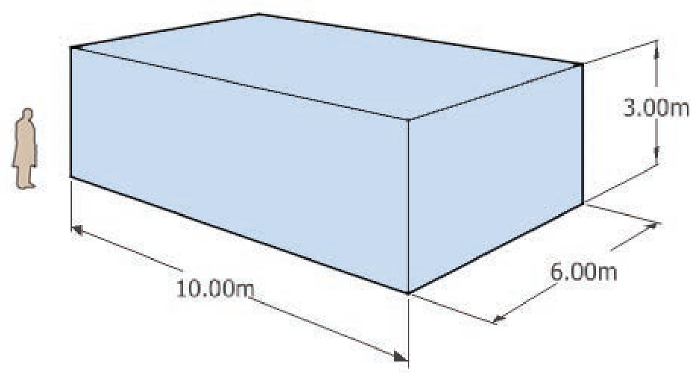


Figure 8. Size of neighbourhood ground level green roof irrigation need (volume of water)

An estimate of peak yearly runoff of the urban drainage basin was calculated by applying the rational method to the total site area. The coefficient of runoff used for this calculation is .75, which corresponds to a high density residential area (LMNO, 2003). The total site area (A) is104 580 m2 and the rainfall intensity used in the calculation is 1.288m/ year. The yearly runoff volume produced by the study area is approximately 101 024 000L of water, more than enough to cover the yearly irrigation need.

DISCUSSION

The results of this study indicate that there is more than enough stormwater runoff during the rainy season to feed the irrigation needs of ground level green roofs through the dry season in Vancouver. The volume of stormwater necessary to perform irrigation functions within a single urban drainage basin in the downtown could theoretically be stored at a neighbourhood collection point relatively close to all the green roofs in the same urban watershed. In this case, that storage point is Sunset Beach Park (Figure 9). Vancouver's low-lying waterfront green spaces make ideal locations to store stormwater because they are already the sites of neighbourhood outfalls.

Figure 9. Neighbourhood cistern in site context

The advantage of considering stormwater harvesting at the urban watershed scale is that the stormwater collection system is already in place. One neighbourhood cistern can collect all the stormwater necessary for multiple residences at a low point in the drainage basin. As a result, storage and treatment infrastructure only need to be constructed once, and multiple households can benefit from one neighbourhood infrastructure project.

Figure 10. Stormwater pipes that do not culminate in public open space

There are, however, significant obstacles to the wide scale implementation of neighbourhood stormwater harvesting, especially when the technique is to be implemented in existing residential neighbourhoods. One major obstacle is stormwater storage space. While the cistern depicted in this study is modest in size, land in the city is expensive and even the $60m^2$ cistern footprint suggested here would be difficult to situate. Furthermore, not all drainage basins culminate in open space, making stormwater storage placement more difficult in areas of high density (Figure 10). Another major obstacle to neighbourhood stormwater harvesting has to do with finding a way to distribute the stormwater being harvested. A distribution system would have to be constructed separately from the potable water distribution system and would therefore represent a significant challenge to implementing a stormwater harvesting scheme. Retrofit stormwater harvesting projects would be especially difficult to construct for this reason.

CONCLUSION

This study concludes that neighbourhood stormwater harvesting schemes have the potential to significantly reduce potable water consumption, thereby helping the city o f Vancouver to meet its water conservation targets. However, it appears water scarcity is not enough yet acute enough to warrant the significant costs associated with the construction of stormwater harvesting projects.

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