British Columbia Water and Waste Association
2020 Student Design Competition
Problem Statement

Contents

Attachments – Provided Separately Upon Registration

1. City of Vancouver Rainwater Management Bulletin
2. Figure 1 – RS-1 Layout (Single Family Lot)
3. Figure 2 – RM-8 Layout (Townhouse Lot with Underground Parking)
4. Continuous rainfall data for Kitsilano Rain Gauge

Questions

For information or questions related to the Student Design Competition or Problem Statement, please contact

Email: SDC@bcwwa.org

Student Design Competition:
Jason Leong, M.A.Sc., EIT
Jessica LeNoble, M.A.Sc., EIT

Acknowledgements

Special thanks to:
Karline McCawley, City of Vancouver
Sara Pour, City of Vancouver
Kirsten Behler, City of Vancouver
Marie Linehan, City of Vancouver
Paula Huber, City of Vancouver
Phil White, City of Vancouver
Chris Radziminski, City of Vancouver
Haizea Aguirre, City of Vancouver
Donny Wong, City of Vancouver

Disclaimer

The project statement is intended only for use during the 2020 BCWWA Student Design Competition. Information provided in this document may not reflect actual conditions or requirements and is provided for the sole purpose of providing context for the design competition. Supporting information remains the property of the City of Vancouver.

1 PROBLEM STATEMENT

In 2016, the City of Vancouver ('the City') published the 'Citywide Integrated Rainwater Management Plan,' which is a plan that aims to treat rainwater as a resource, encourage water reuse, and support urban and natural ecosystems with clean water. These aims translate into a target to capture and treat 90% of Vancouver's average annual rainfall by implementing green infrastructure tools and design guidelines on public and private property throughout the City.

As people flock to Vancouver for its livability, Vancouver is experiencing population growth and densification. As single family lots redevelop into more dense building forms, the water and drainage character of each lot is impacted in several ways, including:

a. increased impervious surfaces (buildings, underground structures and paved areas) that both increase runoff and prevent rainwater from soaking into soils,
b. increased foundation depth leading to groundwater interception and groundwater being pumped into the sewer systems which are not designed to convey groundwater,
c. reduction in groundwater recharge due to decreased infiltration
d. increased potable water demand

Unmitigated rainwater runoff can have negative environmental consequences due to erosion, habitat depletion, poor water quality, decreases in sewer capacity, increased risk of Combined Sewer Overflows (CSOs), or other impacts.

Students interested in entering the 2020 BC Water & Waste Association (BCWWA) Student Design Competition (SDC) are encouraged to form teams of maximum six (6) persons (refer to competition guidelines for further requirements) to:

- Complete a comparative analysis and design of two (2) rainwater management solutions: one (1) for the RM-8 townhouse development and a one (1) reconfigured layout for the RM-8 townhouse development in the City of Vancouver
- The solutions must maintain pre-existing runoff characteristics while meeting social, environmental, and financial criteria and all regulatory requirements.
- Students are to provide real-world solutions that are practical and creative while thinking critically about the constraints and design goals.

It is each team's responsibility to review the information and data provided. It is not mandatory to use all data provided for the analysis. It is highly recommended that teams review all information provided in the attachments, as some key design data and information is provided only in the attachments. Refer to the competition guidelines for policies regarding questions on project scope, objectives, and information.

2 BACKGROUND

Beginning in 2009, the construction of the Canada Line through the Cambie Corridor has spurred rapid redevelopment of the area. The Corridor has undergone several major transformations, with Phases 1 (2010) and 2 (2011) of the Cambie Corridor Plan resulting in significant residential development along Cambie Street and connecting arterials. Phase 3 of the Plan is now underway and addresses areas off the arterials and a new Municipal Town Centre.

Redevelopment in the Cambie Corridor has consisted mainly of conversion of existing single-family lots to townhome or condominium developments. As a result of densification, reduction in permeable surfaces results in increased surface runoff from rainfall events. Therefore, new developments must incorporate features that maintain the site runoff characteristics to pre-development levels.

To this effect, the City of Vancouver has adopted a City-wide Integrated Rainwater Management Plan (IRMP) that encourages the use of green infrastructure to reduce runoff and improve water quality. Design challenges exist in trying to integrate these green infrastructure techniques into the smaller footprint of redevelopments. For example, some developers, who are working to convert single family lots into townhouse developments, have had challenges when aiming to capture and treat rainfall landing on their sites.

The City has been working to investigate rainwater management possibilities for different townhouse scenarios using green infrastructure. The results of this investigation are being used to support densification and rainwater management along the Cambie Corridor.

2.1 STUDY AREA AND HISTORICAL RUNOFF CHARACTERISTICS

2.1.1 Existing Site – Single Family Lot (RS-1)

The single-family lot, or baseline case, has previously been studied by the City. Characteristics for the single-family lot are summarized as follows:

- An average single-family lot includes two living suites, a laneway house, and a single parking stall beside the laneway house.
- The average single-family lot is approximately 37 meters long by 10 meters wide for a total site area of 370 m^2.
- The average single-family lot has a 3% surface slope from the back of the lot to the front of the lot.
- From past modeling, for a 1 in 5-year storm with a 15-minute duration, the peak flow exiting the single-family lot is 0.005 m^3/s or 0.14 $m^3/s/ha$.

Table 1 summarizes the surface coverage for a single-family lot.

Table 1. Single Family Lot Surface Coverage

Description	Area (m^2)	% of Total
Dwelling Unit	134.7	36.1%
Green Area	170.2	45.6%
Patios – Porches	25.9	7.0%
Paved Pathways	6.1	1.6%
Stairs – Access	10.5	2.8%
Structure	4.4	1.2%
Surface Parking Stalls	21.3	5.7%
Total	**373.11**	**100.0%**

An illustration of the single-family lot layout is provided in Figure 1.

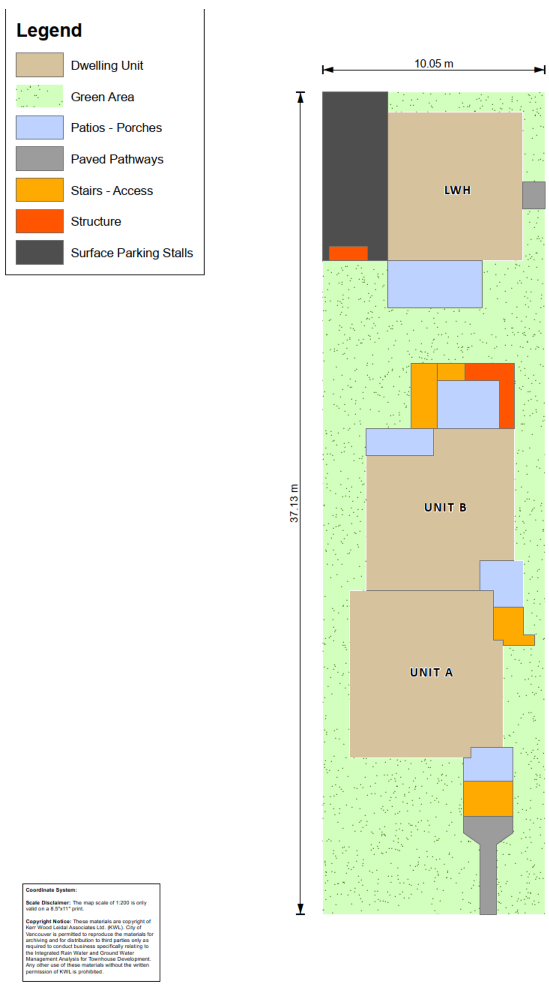

Figure 1. Single Family Lot

2.1.2 Future Site – Townhouse Lot with Underground Parking (RM-8)

The townhouse development with underground parking, or future case, is of interest for further study by the City. Characteristics for the townhouse lot with underground parking are summarized as follows:

- An average townhouse lot includes nine living suites.
- The average townhouse lot is approximately 33 meters long by 28 meters wide for a total site area of 905 m^2.
- The average parkade is situated under 80% of the lot.
- The average townhouse lot has a 3% surface slope from the back of the lot to the front of the lot.

Table 2 summarizes the surface coverage for a townhouse lot with underground parking.

Table 2. Townhouse Lot with Underground Parking Surface Coverage

Description	Area (m^2)	% of Total
Green Area	125.2	13.8%
Patios – Porches	74.0	8.2%
Paved Pathways	144.6	16.0%
Ramp	29.1	3.2%
Stairs – Access	54.2	6.0%
Planter Box (Raised or Ground Level)	79.0	8.8%
Other Structure	4.9	0.5%
Townhouse Unit	393.6	43.5%
Total	**904.6**	**100.0%**

An illustration of the townhouse lot layout is provided in Figure 2.

Figure 2. Townhouse Lot with Underground Parking

2.2 RAINWATER MANAGEMENT DESIGN CRITERIA:

The City requires developers to provide a rainwater management plan that demonstrates that their on-site rainwater management systems meet the City's IRMP requirements, such as:

- The first 24 mm of rainfall from all areas must be retained and treated on-site. Prioritization of infiltrating (Tier 1) over non-infiltrating (Tier 2) source controls and justification must be provided use using either Tier 2 or Tier 3 (release rate approaches)
- The post-development peak flow rate (using 2100 IDF table) should not exceed the pre-development peak flow rate (using 2014 IDF table).
- The first 24 mm of rainfall from all surfaces, and first 48 mm from roads, driveways, and parking lots should be treated to remove a minimum 80% of Total Suspended Solids (TSS). Vegetated practices that infiltrate water through a minimum 450 mm of growing medium are assumed to meet the TSS removal requirement of 80%.

Refer to the City's rainwater management bulletin (Appendix A) for additional details and justification for the rainwater management criteria.

Note that proprietary systems are allowable, if sufficient justification and engineering rigor is provided. It is recommended that teams contact vendors for pertinent design information.

2.3 RAINWATER HARVESTING REUSE DESIGN CRITERIA:

Onsite rainwater harvesting and reuse is a potential method for rainfall source control. In Vancouver rainwater harvesting is regulated by the following codes and bylaws:

- CSA B805-18 - Rainwater harvesting systems
- City of Vancouver Building and Plumbing Bylaws

Suitable application for harvested rainwater is to be considered solely for non-potable reuse. Examples of this include irrigation and toilet flushing.

Note that proprietary systems are allowable, if sufficient justification and engineering rigor is provided. It is recommended that teams contact vendors for pertinent design information.

2.4 BUILDING AND PLUMBING CODES

All new developments in Vancouver BC are subject to design criteria in the City of Vancouver Building and Plumbing Bylaws. Designs should refer to specific requirements within these bylaws. For example, infiltrating surfaces (e.g. rain gardens) have setback requirements or minimum distance requirements from building foundations (5 m) and property lines (3.5 m).

Refer to the latest editions of the BC Building Code 2018, BC Plumbing Code, and City of Vancouver Building Bylaw to ensure that proposed designs meet basic regulatory code requirements.

2.5 EXISTING CLIMATE AND PLANNING FOR A FUTURE WITH CLIMATE CHANGE

The closest rain gauge to the Cambie Corridor is the VA01 Kitsilano High School Rain Gauge, which is owned and operated by Metro Vancouver. On average, this rain gauge records roughly 1200 mm of rainfall each year. A continuous dataset from 1988 to 2000 has been compiled and will be provided electronically to all design teams. A summary of the rainfall totals for each year of the record is provided in Table 3.

Table 3. Annual Rainfall Summary - VA01 Kitsilano High School Site

Year	Total Rainfall (mm)
v	1239.5
1989	1127.0
1990	1395.0
1991	1232.9
1992	900.9
1993	997.0

1994	1208.0
1995	1396.5
1996	1540.0
1997	1691.4
1998	1349.2
1999	1527.2
2000	1200.4

The Intergovernmental Panel on Climate Change (IPCC) has published greenhouse gas emissions-based climate change scenarios since 2000. Due to uncertainty in economic growth, the extent of regionalization versus globalization, and emphasis on environmental sustainability, modelled scenarios have projected global average temperature increases between 1.1°C and 6.4°C by 2100. The Paris Climate Agreement within the United Nations Framework on Climate Change has committed 195 signatory countries to hold average global temperature increases to 2°C by 2100. While global average temperatures form the international targets, it is widely recognized that the impacts of climate change will differ regionally and locally.

The 2°C global temperature increase scenario is frequently used by policymakers and modellers in Canada and forms the basis for accepted climate change impact models developed for southwestern BC. In addition, it is widely accepted that the Vancouver area will experience drier summers and rainier winters with more frequent high intensity storms due to climate change.

Current designs should account for future climate change as a measure of good engineering practice.

2.6 SOILS, INFILTRATION AND GROUNDWATER

The City has undertaken several studies in the Cambie Corridor. Below is a summary of the outcomes. Students may assume these conditions hold true at the RS-1 and RM-8 lots.

- The water table in the Cambie Corridor lies approximately 10 meters below ground.
- Surficial geology in the Cambie Corridor is dominated by the Vashon tills overlying the Quadra sands aquifer.
- The till layer extends from surface to between 5 – 8 meters below ground, and the till is well drained.
- Measured infiltration capacities along the Cambie Corridor have a wide range but the majority of the Cambie Corridor has relatively low infiltration potential.
- The current study should use an infiltration rate of 2 mm/hour at the base of the source controls as a precautionary approach, and in alignment with the Rainwater Management Plan and Infrastructure Strategy (City of Vancouver, 2016).

2.7 BACKGROUND RESOURCES

Below is a list of useful resources to start this process. This list is not intended to be comprehensive; student teams are encouraged to complete their own literature review.

Pacific Climate Impact Consortium:
https://www.pacificclimate.org/

Online GIS database for BC
https://www2.gov.bc.ca/gov/content/data/geographic-data-services/web-based-mapping/imapbc

Applicable Regulations & Guidelines

City of Vancouver Integrated Rainwater Management Plan
https://vancouver.ca/home-property-development/city-wide-integrated-stormwater-management-plan.aspx

City of Vancouver Sewer and Watercourse Bylaw 8093
https://vancouver.ca/your-government/sewer-and-watercourse-bylaw.aspx

City of Vancouver Building and Plumbing Bylaws
www.vancouver.ca/building-bylaw
bulletins.vancouver.ca

City of Vancouver Operating Permit
https://vancouver.ca/home-property-development/operating-permit.aspx?utm_campaign=operating-permit&utm_medium=Vanity&utm_source=operating-permit_Vanity

Metro Vancouver Intensity Duration Frequency Curves and Source Control Guidelines
http://www.metrovancouver.org/services/liquid-waste/drainage/stormwater-management/resources/Pages/default.aspx

3 OBJECTIVES

Student teams are required to complete and prepare two conceptual design options for the management of onsite rainwater runoff in a manner compliant with the City of Vancouver's IRMP, and relevant codes, guidelines, and bylaws. The systems should be designed to meet capacity and treatment requirements for current and future climactic conditions up to a design horizon of 2100.

Refer to the appended Rainwater Management Bulletin for descriptions of tiered source control, flow rate control, and water quality requirements.

Scenario 1- "Baseline" RM-8
Develop a conceptual design that meets City of Vancouver IRMP and Rainwater Management Bulletin requirements and:

- Utilizes the proposed RM-8 Site Layout (refer to Figure 2)
- Utilizes Tier 1, 2, and 3 rainwater source controls, prioritizing the use of passive source controls where possible. If non-passive solutions are utilized, incorporate their carbon footprint and operational costs into Triple-Bottom-Line Analysis. Prioritize the use of Tier 1 controls over Tier 2 and 3 where possible, per the Rainwater Management Bulletin.
- Utilizes source controls in an integrated manner that promotes the design elements as "livable and usable spaces".
- Meets all applicable municipal, provincial, and federal regulations, codes, bylaws, and guidelines.

Scenario 2 – "Modified" RM-8
Develop a concept design that meets City of Vancouver IRMP and Rainwater Management Bulletin requirements and:

- Utilizes an alternative site layout that maintain the existing lot dimensions lot, surface coverage (see Table 2), and ensures the same number of dwelling units.
- Utilize Tier 1 source controls, with emphasis on rainwater harvesting and reuse. Prioritize the use of passive source controls where possible. If non-passive solutions are utilized, incorporate their carbon footprint and operational costs into Triple-Bottom-Line Analysis.
- Utilizes source controls in an integrated manner that promotes the design elements as "livable and usable spaces".
- Meets all applicable municipal, provincial, and federal regulations, codes, bylaws, and guidelines. Note that infiltrative setback requirements from building foundations can be reduced to 1 m. Setback from property lines should be maintained per bylaw requirements.

Consider and evaluate the options using quantitative and qualitative criteria, sensitivity analyses, and a triple bottom line analysis of economic, social and environment advantages and disadvantages. Present the recommended approach and design with justification. The deliverables will be judged considering depth and robustness of analysis, selection of integrated and creative designs, practicality of implementation, and operation and maintenance requirements.

3.1 SCOPE OF WORK

Student teams should adhere to the following scope of work, identified for this evaluation:

3.1.1 Rainfall Analysis

- Establish current (2020) and future (2100) rainfall conditions based off historical monitoring and estimated climate changed based of an RCP8.5 scenario.
- Refer to data provided electronically for 1988 to 2000 at the VA-01 Kitsilano Rain Gauge.
- Refer to Metro Vancouver IDF curves for the years 2014 and 2100.

3.1.2 Evapotranspiration Analysis

- Establish daily potential evapotranspiration for pervious and impervious surfaces in the City of Vancouver.

3.1.3 Rainwater Management Option Evaluation, Development, and Layout

- Establish rainwater quality objectives and treatment methods
- Develop one scenario for rainwater management using the RM-8 site layout
- Develop a second scenario for rainwater management using a reconfigured RM-8 site layout

3.1.4 Stormwater Model

- Develop a continuous model for rainwater management scenario under each design option, using a spreadsheet, online resource, or applicable modelling software.
- Justify any assumptions made for input parameters including soil characteristics or groundwater effects.
- Use the model to determine the % capture of runoff for each design option with a typical day that received 24 mm rainfall and for all rainfall reaching the site each year.
- Use an applicable engineering method to determine the change in peak runoff per hectare for the proposed design options compared to the single-family lot.

3.1.5 Triple-Bottom-Line Assessment:

3.1.5.1 Social

- Evaluate the social benefit of each option with emphasis on "Livability."
- Consider and comment on opportunities in each design option for dual purpose land uses. For example, an infiltrating surface that is also park space.

3.1.5.2 Environmental

- Estimate the GHG (as CO_2e) reduction or contributions from scenarios
- Estimate of resource recovery (e.g. water reuse) opportunities.
- Estimate the % capture of a 24 mm storm and of annual rainwater.
- Estimate benefits to water quality as a % reduction of total suspended solids (TSS) compared to rainwater leaving the single-family lot.
- Comment on each design option's expected ability to remove emerging contaminants (such as microplastics and pesticides) from the rainwater.

- Comment on other environmental advantages and disadvantages.

3.1.5.3 Economic

- Provide a Class D Capital Cost estimate for each design option
- Provide a Class D Life Cycle cost estimate including revenue generated or costs offset by recoverable resources such as reduced potable water needs.

3.1.5.4 Preferred Design Solution

- Use the results of the triple bottom line assessment to determine which of the two design options are the preferable solution for townhouse developments with underground parking in the Cambie Corridor.

3.2 DESIGN CONSIDERATIONS AND CONSTRAINTS

- **Climate Change:** consider future climate effects of an RCP8.5 scenario
- **Site Constraints:**
    - Parking ratio for units can be between 1 to 2 parking spots per unit. Guest parking can be accommodated via street parking.
    - Lots must include 8 townhouse units.
    - Lots must match the dimensions provided for the RM-8 scenario.
    - Site configurations must meet all applicable codes, bylaws, and regulatory requirements
- **Regulatory Requirements:** meet all applicable municipal, provincial, and federal regulatory requirements.
- **Project Lifespan:** design horizon is approximately 70 years (2020 to 2100). Assume a discount rate of 5%.
- **3D Design Drawings:** communication of design elements using 3D modelling software, such as SketchUp, is highly encouraged.

3.3 DELIVERABLES

1. Progress Report
2. Design Notebook formatted to Competition Guidelines and containing the following:
    a. Rainfall Analysis
        i. Analysis of current and future climactic conditions
    b. Evapotranspiration analysis
        i. Estimation of current and future daily evapotranspiration for pervious surfaces
    c. Conceptual design of two options
        i. Design description
        ii. Preliminary sizing and layout
        iii. Stormwater Model
        iv. Plans, figures or drawings illustrating design concepts
    d. Recommendation of preferred solutions
        i. Evaluation of resource recovery opportunities
        ii. Evaluation of GHG reduction or contributions
        iii. Class D Cost Estimates for two options and comparison to current operations

1. Life cycle cost estimate
2. Capital NPV estimate

iv. Triple Bottom Line (TBL) assessment to and recommendation of preferred solution

3. Oral Presentation