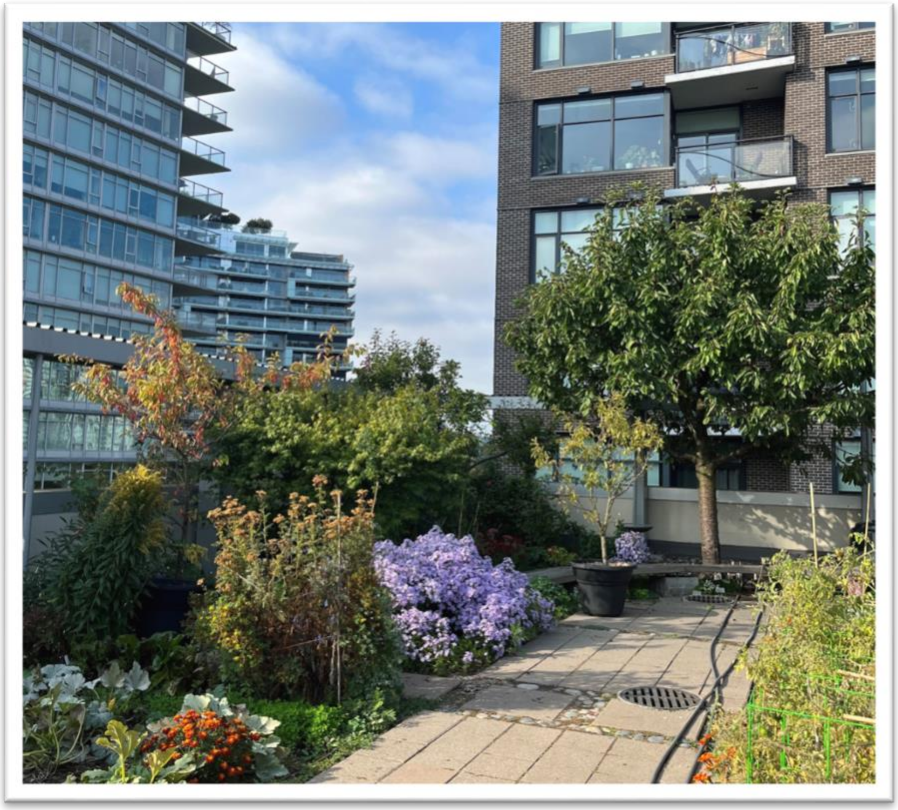
Workshop #3 Engagement Summary



City of Vancouver, Green Rainwater Infrastructure (GRI)
Pathways Study

Workshop #3: Findings, Policy Considerations and Next Steps

Engagement Summary

Prepared by: MODUS Planning, Design & Engagement Inc.
Version: 2
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1 About the Project

The City of Vancouver and surrounding region was once covered by a temperate rainforest, which allowed for water to be managed naturally and the water cycle to function normally. Over time, the natural watersheds have been altered. As development of the region increased, trees were cleared, impervious surfaces were expanded, streams were filled in and the natural water cycle was altered. Sanitary and stormwater systems were also developed, contributing to community health but leading to other challenges.

The City of Vancouver is facing many challenges with respect to rainwater management, including sewer capacity and water quality impacts. In response, the City is advancing implementation of the Rain City Strategy (RCS) across private, public, and park spaces. The RCS treats rainwater as a valuable resource and encourages designers and developers to mimic the natural hydrologic cycle by capturing and treating rainwater where it lands using green rainwater infrastructure (GRI). The RCS identifies the following target and performance standards:

- Target: Capture and clean 90% of average annual rainwater in the city
- Performance standard: Capture and clean rainwater from a minimum of 48 mm per day

As part of the work related to private property, the City has retained a consultant team to better understand what GRI tool combinations (“compliance pathways”) can be used to meet the City’s rainwater management design standards and performance targets (capture, clean, discharge) for new development across a range of representative building-site “typologies;” from single family homes to large, dense developments.

As part of this work, the City is also seeking to better understand the cost of these GRI “compliance pathways,” the co-benefits that they offer, and the barriers and corresponding solutions to implementation. This work will produce a preferred set of GRI tool “pathways” for each building-site typology. The work will also provide commentary/ recommendations that will inform the development of new and/or improved rainwater management policies for the City that will achieve the goals of the Rain City Strategy in a fair and consistent manner.

The GRI Pathways Study has four sections each with its own focused workshop. Workshop #1, which addressed building typologies, GRI tools, and GRI implementation barriers, was held in October 2021. Workshop #2, which focused on the solutions to implementation barriers for a particular GRI (green roofs), was held in July 2022. Workshops #3, which occurred in September 2023, focused on study findings, policy considerations, and next steps.

2 About Workshop #3

2.1 Workshop Objectives

The purpose of this final workshop in the series was to provide an overview of all work to date and to ask participants for feedback on the identified feasible GRI tool combinations ("pathways")on various property types, GRI co-benefits, and preliminary policy considerations to support the implementation of GRI to manage rainwater on private sites in the City of Vancouver.

2.2 Workshop Methodology and Format

2.2.1 Workshop format

The virtual workshop was held on Zoom on September 14, 2023 from 9am – 11:30am. The consultant team took notes and facilitated discussion in plenary.

2.2.2 Agenda

Time (estimated)	Description
9.00-9.05	Welcome, Pathways Study project purpose
9.05-9.10	Introductions to team and agenda
9.10-9.40	Presentation on overall project and work completed
9.40-10.10	Q&A / Discussion
10.10-10.20	Break
10.20-10.40	Presentation on policy options and implementation recommendations
10.40-11.10	Q&A / Discussion
11.10-11.15	Thank you, closing, and next steps

2.2.3 Attendees

The workshop had 41 attendees, which included about 10 City staff. Invitations were sent to 74 people (not including invites to City staff). External participants were identified by City staff and the consultant team, based on their relevant experience and area of expertise. The City desired representation from all sectors of the development industry. Invitations were sent by email a few weeks prior to the workshop and reminders sent the week before. The invitation is included in Appendix B.

Invitees were selected from the following industries and organizations:

Area of expertise	Organization
Project team	City of Vancouver Staff *(attended)* Consultant team *(attended)*
Builders and Roof Contractors	Roofing Contractors Association of BC *(attended)* Architek*(attended)* Next Level Stormwater Management *(attended)* Soprema Canada *(attended)* Structure Monitoring Technology Columbia Green NAATS Nursery Ltd. *(attended)*
Developers	Urban Development Institute *(attended)* BOMA *(attended)* Wesgroup Darwin Concert Properties Third Space *(attended)* PCI Group
Insurance Industry	BC Housing / Homeowner Protection Office *(attended)* Insurance Bureau of Canada Travelers Canada *(attended)*
Civil Engineering	Aplin Martin Consultants Creus Engineering *(attended)* InterCAD *(attended)* RF Binnie & Associates *(attended)* Vector Geopacific *(attended)* Kerr Wood Leidel *(attended)* Urban Systems *(attended)*
Mechanical Engineering	AME Consulting Group Integral
Landscape Architects	Sharp + Diamond Landscape Architecture *(attended)* Ginkgo Sustainability BC *(attended)* Groundswell Landscape Architectur e *(attended)*
Government Agencies	BC Housing *(attended)* Vancouver Coastal Health *(attended)* City of Toronto City of San Francisco
Academia and Green Roof Groups	UBC Land and Food Systems *(attended)* BCIT *(attended)* Green Roofs for Healthy Cities Green Up Roofing *(attended)*

2.3 Information Presented

The workshop began with an introduction by the City's project manager (Gord Tycho), which included context about the Rain City Strategy and introduction to the Pathways Study. This was followed with an overview of the project from the lead consultant (Lotus Engineering), which included an overview of:

Part 1

- Project purpose
- Representative Building Site Typologies
- Overview of Rainwater Management Tools (GRI and non-GRI)
- Implementation Barriers
- Pathway Modelling Variables | modelled 70,000 variables
- Performance Modelling
- Other Values and Co-Benefits (economic, environmental, community, resiliency)
- Construction Cost Estimates
- Pathways Matrix and Categories

Part 2

- Policy Context
  - Recent developments of VBBL Revisions; Healthy Waters Plan; Groundwater Strategy
- Policy Recommendations
  - Expanding the Use of Specific GRI Types

Slides from each presentation are included in Appendix A.

3 What We Heard

The following section summarizes what we heard during the workshop through the Q&A Sessions. These comments do not reflect a consensus from participants. Rather, this qualitative summary reflects individual comments from participants.

<u>Questions via Chat</u>

- **Q:** What will be the process for getting support for the 3 metre setback? Seems very important but counter to many people's interpretation of the building code.
  - **A (Lotus):** The Vancouver Building Bylaw (VBBL) has a clause stating a rainwater infiltration setback requirement of 5m from a building foundation *(for reasons such as avoiding short-circuiting of water, protecting integrity of building foundations).* This setback is currently interpreted to be in effect for all forms of infiltration. The study scope of work did not include how to reduce the 5m setback requirement. This Study did include a "sensitivity analysis" that sought to understand what rainwater benefits would happen if the setback was reduced. From our experience working with other jurisdictions, the 5m setback is relatively high; 3m is common in other jurisdictions.

Many other jurisdictions also allow 0m setback with appropriate design modifications, when needed.
    - **A (City):** The Vancouver Building Bylaw (VBBL) is administered by the City – applicants are able to apply for an "alternative solution" that proposes a reduced setback distance but that still meets the objectives of the building bylaw. Although the Vancouver Charter authorizes the City to develop their own building code, many items in the VBBL, including this setback requirement, flow from the National Building Code of Canada and the BC (Provincial) Building Code requirements. Interpretation of requirements can vary among jurisdictions.
- **Q:** Why were tree trenches excluded from the GRI tools included in the Pathways Study?
    - **A (Lotus):** They were not excluded per se, but considered to be comparable in performance to a Bioretention Facility but with more specific siting criteria. The presentation is just displaying the tools that are comparable.
- **Q:** Is amended topsoil cover considered Bioretention for small lots?
    - **A (Lotus):** A bioretention facility would include amended topsoil but include other important design elements. Absorbent landscape (i.e. self-managing vegetated area) is a form of GRI but we assume absorbent landscape would be included in all typologies. We wanted a greater focus on tools like bioretention.
    - **A (Ryan Vasseur, workshop attendee):** It depends on the quality of the topsoil which can vary greatly. We build green roofs and work to use correct engineered soils and amend them with the correct types of compost that are necessary, but we've seen a lot of green roofs that are built incorrectly with cheap topsoil, and the consequences can be dire for drainage, for plant health and the impression of green roofs, and we've been asked to fix many green roofs that have been built incorrectly.
    - Recommendations:
        - One of our recommendations is to build a contractor training and maintenance program to improve the implementation of designs.
        - I also recommend to biologically test topsoils to ensure it has enough beneficial micro-organisms. Also, for grade level, if the soil below is heavily compacted additional considerations will need to be made to ensure infiltration occurs. High quality topsoil is very important.
    - **James Klassen, workshop attendee:** We agree with Ryan that the use of topsoil on a vegetated (green) roof is not good practice.
- **Q:** Can you further explain why the non-residential building typology has so few viable GRI pathways (e.g. tool) options/or "N/A" under 24mm scenario?
    - **A (Lotus):** We assumed that the non-potable water demand would not be high enough to allow for the GRI tool "rainwater harvesting" in the smaller non-residential buildings.
- **Q:** Where there is no infiltration, it's likely that the retention criteria would not have been met in a natural state either. Even in nature, perched water tables and seepage occurs. Is it not important to clarify that retention does not necessarily mean ZERO runoff, but rather to prevent any direct surface runoff or runoff to a storm sewer? The retention volume leaves the site either through evaporation, deep infiltration, or seepage? Should no infiltration fully eliminate ground level treatments?
    - **A (Lotus):** That is a good point. Our goal was to hit the 24mm retention target. But we agree that it is important to emphasize that even if its not possible to meet the 24/48mm target, it is still worth implementing rainwater management measures to achieve partial retention.

  - **Response (Workshop Attendee):** Infiltration capacity of the site is becoming a significant defining moment for municipalities when reviewing development applications; so common that developers cannot meet the infiltration target. I think we have set poor expectations and haven't communicated the retention target well. Often, we have places without deep infiltration, run-off occurs often in nature. We want to replicate the "sponge" layer on the surface.
- **Q:** Was there consideration for how the Pathways Category 2 would be affected if it were a small lot but implemented as part of the neighbourhood plan? Jericho for example where large areas being developed - if this were a planned small lot development.
  - **A:** This study did not consider this, it was a site-level analysis. However, we recognize that this is a critical part, and a very important next step in the process to understand what will be achieved.
- **Q:** What is the lot size that the study was based on? My experience is that zero to very low infiltration rates are common.
  - **A (Lotus):** We based the modelling work on the "Representative Building-Site Typologies" that were developed, in turn, based on the review of applicable City data sets. The typologies included assumptions on lot size, building footprint, setbacks, permeable area, etc.
  - **A (City):** Infiltration potential throughout the City ranges from good to poor,. The City has data sets from different areas (project-by-project geotechnical reports, etc.), as well as testings from public GI implementation, which suggest there may be more potential for infiltration than some suggest. Further to the City's response on infiltration rates in the City, the first batch of long term results for GI are published here: https://vancouver.ca/files/cov/green-infrastructure-performance-monitoring-report.pdf

- **Q (City):** For green roof systems, Bryce mentioned these could assist with specifically the "retention" target. Was seasonal performance considered in Vancouver's context, specifically the fall/winter seasons (i.e., high precipitation, low evapotranspiration)?
  - **A (Lotus):** To a degree, yes. The primary performance standards tested (i.e., retention of either 24 or 48 mm of rainfall in 24 hours) are event-based and we did not test for differing initial conditions (i.e., both facility media and subgrade are assumed to be unsaturated at the start of the rain event) or seasonality. However, we did some testing of performance over a typical annual year and a green roof looked promising for retaining >70% of annual rainfall.
    - Fully agree with Bryce to look at retention on an annual basis to achieve an equivalent of 24mm.
- **Q:** When the pathway solution states more than one option like "Green Roof" and "Rainwater Harvesting", does it mean either of the two is feasible for that scenario or both options are needed to be feasible? Could you please clarify? Also, are the 2 options connected - say, for example, harvested rainwater is reused as green roof irrigation to leave site as evapotranspiration, or as part of a treatment train? How is that feasibility is determined? Thank you!
  - **A (Lotus):** These are not "either/or" options – they are referring to solutions that use multiple facilities. For example, a portion of the roof runoff is managed via green roof (and is retained through evapotranspiration), and the remainder of the roof and all surface hardscape runoff is managed via rainwater harvesting system (i.e., captured in a tank and used for building non-potable demand). The GRI tools are not connected, but each manage a portion of the site runoff.

- **Q (City):** For green roofs, do you have a rough estimation of the percentage of rooftop that would need to be occupied by a green roof?
    - **A (Lotus):** This varies and there are options, depending on if the green roof is the only tool or if there are multiple tools being used. If the intention is to manage a majority of the rainwater with the green roof, the coverage will have to be high (only a small proportion of adjacent roof run-on can be routed to a 450mm thick intensive green roof and still retain 24mm, and no adjacent run-on is possible if 48mm is the retention target). For peak flow (release rate) control, a green roof can be designed with additional detention capacity above/or below the soil (i.e., what would typically be referred to as a "blue-green roof"). *Within the pathways there is a percentage of roof that is covered by a green roof itself, and a portion of roof that is managed by a GRI tool – possibly the same green roof or another GRI tool such as ground infiltration. In most cases, roughly 50% of the available roof is covered in a green roof. We recognize that a 75-100% coverage is incredibly difficult. Within the 40-60% coverage range, there will need to be additional rainwater management (i.e. routing into a rainwater harvesting facility or surface level bioretention)*.

Questions via Zoom Video Call

- **Q (City):** The City is working on reducing parking requirements. The setback work in this study is very interesting. Will there be a recommendation about reducing the parkade extents (i.e. building footprint size) – would this make a big difference for rainwater retention?
    - **A (Lotus):** Yes, the foundation setback and the distance that on-site parkades extend beyond the building footprint impact rainwater retention capabilities; some city requirements may be conflicting if you want to achieve cost-effective GRI retention (such as parking requirements that necessitate a large parkade and rainwater requirements that prefer room onsite to locate). It would be preferrable to locate GRI tools on the site (rather than on/in the building), as they are typically easier/cheaper to build and maintain, but for constrained sites this would only be possible if there is space on site to locate them, i.e., the setbacks or parkade are adjusted to allow.. Suggestion to, first, determine onsite rainwater management requirements and, second, determine what parking can fit on site.
- **Q (UDI):** Happy to hear about parking reductions. We must consider the aquifer (if we go too deep, this will create problems). Was going deeper for parking considered in terms of cost? Was there a reaction from the insurance industry? How easy will it be for developers to get warranty and insurance?
    - **A (Lotus):** We couldn't look at the nuance of a changing cost for a wider/shallower parkade versus a slightly narrower/deeper footprint parkade. Instead, we were looking at variable shifts in horizontal parkade footprint, and implications of parkade changes as it relates to the GRI tools. With regards to insurance and liability, this study doesn't look to solve that issue, but we did discuss this topic at length at the previous workshop. We recognize this needs to continue to be addressed and recommend that the City coordinate with green roof professionals, building envelope professionals, and insurance representatives to review insurance challenges (e.g., concerns with leaking or maintenance) and the City's building envelope certifications in order to determine how the City's regulations or policies could be revised to address the warranty and liability issue. Green roofs are very helpful for constrained sites to provide a retention-based approach.

PART 2 – Policy and Implementation Options

- **Q:** Can you elaborate on your recommendations for resilient / green roofs for Single Family / duplex residential. Will the recommendation force change in acceptable building architecture?
  - **A:** We did not go into detail of what the specific green roofs policy would be for the various typologies. We do know there is a lot of work to do to clarify green roof policy, including warranty requirements. We recommend that this move forward.
- **Comment (UDI):** In terms of maintenance and enforcement, suggestion to involve strata councils, Homeowners Association, Landlords BC, and BOMA. In terms of their management of this, that would be a concern of mine. Other recommendation – consider pilot projects (i.e. City projects) to help with education and training.
  - **Response (Lotus):** There is also great potential to have a manual that covers inspections and certifications for post-construction compliance. This could work through existing housing councils or other bureaucratic levels of oversight on housing.
- **Comment (Attendee):** Rather than the ZDBL – use the Sewer & Watercourse Bylaw to set watershed/catchment specific RWM requirements. The VBBL continues to regulate the construction, health and safety of buildings using the targets from the Sewer & Watercourse Bylaw.
  - **A:** (Lotus) We like that suggestion. The VBBL revision work was not underway when we started this work. Either way, we need to ensure that future private property rainwater management redevelopment requirements contribute to achieving the Healthy Waters Plan performance measures and whatever basin targets that plan comes up with.
- **Comment (Attendee):** *The RCABC is developing a comprehensive Standard for the design and construction of vegetated roof systems/assemblies, as part of our Quality Assurance RoofStar Guarantee Program. It will include an enforceable mandatory maintenance component, and is targeted to support municipal requirements for Vegetated Roof Assemblies (VRAs), including the City of Vancouver*. RCABC Technical hopes to have final approval for the development of a Vegetated Roof Assembly Guarantee in the very near future, with a view to implementing it early in 2024. Our Standard and the Guarantee it will support will inject necessary and long-looked for certainty and objectivity into the design and construction of green roofs. More to come from the RCABC within the next months.
- **Q (Attendee):** In our work, we are struggling with private systems getting properly maintained over time. What is the City's view on the operations and maintenance responsibility?
  - **A (Lotus):** Many ways to design an inspection and certification program that is reasonable for capacity/resources. Very important pieces.
  - **A (City):** Non-potable water systems in the City of Vancouver do require an annually-renewable Operating Permit. This includes mandatory reporting and regular inspections. See www.vancouver.ca/operating-permit for details.
  - **A (Lotus):** There are also apps and services that allow property owners do self-reporting with mobile phones. These types of platforms combined with spot inspections can provide an efficient way to ensure maintenance and ongoing performance. Here is an example of one: https://www.3r-water.com/
- **Comment:** In regards to the RCABC Green Roof Standards in developments. I think it would be important to include New Home Warranty providers representative in the committee, so that parallel acceptable technical and maintenance standards can be achieved.
- **Comment: (2:17:06)** Considering the many interests of green roofs in the group, thought I'd share an upcoming regional event happening in Nov here in Vancouver: https://greytogreenconference.org/cascadia-2023

- **Comment**: I don't see credit trading as a workable option, as there is no Total-Daily Maximum Load (TDML) type requirements
  - **A (Lotus)**: Total daily maximum load, that's part of our clean water requirements in the United States. Washington DC's retention credit trading program has a TDML (often measured in pounds of nutrients), but DC's program uses retention volume as the currency, so similar to Vancouver, they use one-inch detention (similar to 24 millimetres). We're not looking at pollutant loading as the currency, but there are examples where you can use alternate currencies.
- **Q (UDI):** Do you have to meet the metrics? How can we tie in-lieu fees to area plans? Can we develop alternative infrastructure as part of the in-lieu fee?
  - **A: (Lotus)** Yes, an area plan is helpful. If a project has a known performance and cost, it can quickly be related to regulatory structure. The metrics depend on how you define compliance, (i.e. is compliance for GRI only, or is it a site-level performance standard?) If you have a site-level performance standard, you can meet that performance standard through GRI detention or a combination of both, that would be a different scenario where you're defining what compliance is.
  - Recommendation: We would recommend a site-level performance standard. This allows you to find the most cost-effective way to meet the standard. The in-lieu fees are voluntary.
- **Question:** It seems that GRI is a preferred solution, even though there are equivalent grey infrastructure solutions. Is there a policy mechanism that you're recommending or offering that preferences GRI as the preferred solution and the grey infrastructure the second choice?
  - **A (Lotus):** This is a question for the City, in terms of what the priorities are. The premise of this study is that GRI is the preference (because of the co-benefits and the other ways in which it can meet the Healthy Water Plan's goals). Assuming that GRI is the preference, there are ways to write code/bylaw language that supports that priority.
  - **A (CoV):** The Rain City Strategy advocates for rainwater retention (not detention). For this study, we asked Lotus to test a suite of GRI tools in combination, and to also look at detention tanks/treatment devices. The modelling exercise used a rainwater management "tool hierarchy" approach to meet on-site targets. First, only GRI tools were modelled to meet targets. If using only GRI did not work, Lotus was asked to identify and assume changes to any policy barriers that may be impeding successful implementation of GRI. If this still did not work, then Lotus examined grey plus green infrastructure combinations. Finally, just grey infrastructure (detention tanks and jelly filters) were examined. This was the hierarchy that Lotus used to study the compliance pathways.
- **Question:** What about supporting retrofitting older buildings? The number of old buildings in the city still outweigh the number of new buildings and if the City also has the idea that they want to preserve some of the heritage of the city, then there must be some support for helping out those properties to come up to speed with rainwater.
  - **A:** Achieving the targets of the Rain City Strategy requires onsite rainwater management contributions from both new developments and current (retrofitted) developments. A phased approach was taken by the City, with the initial phase focusing on new developments. Retrofitting was out of scope of the Pathways Study. There are many programmatic solutions for existing buildings and retrofitting existing buildings. Some examples include grant programs, performance-based contracts, energy upgrade funding programs. The existing building stock is a huge challenge in this discussion, but it has a whole other category of solutions. It's a different approach.

  - **Comment:** But is using green roofing still a possibility for older buildings?
    - A: Yes, if you're building has the structural capacity to hold up a green roof, there's testing and analysis to be done on the building, depending on when it was built and what it was built for.
- **Comment:** What about off-site compliance? I had a successful experience with offsite mitigation where the developer negotiated with the municipality about two different projects in the same watershed. One parcel was transformed to greenspace while the other was developed on to meet the overall performance requirements.
  - A: (Recommendation) We don't recommend the off-site compliance programs. It is challenging to implement (complicated ownership agreements). But if the regulatory structure allows for off-site compliance, and if the scenario makes sense, it is a great solution.
- **Comment:** Would you recommend the City invest in studies that use full cost accounting methods to evaluate the net present value of all the co-benefits of GRI tools? Is that a missing piece in the financial trade-offs equation for city systems (water, ecosystems, air, etc.) ?
  - **A:** It depends. There is value to do financial return on investment review. This may help inform decision-makers. But it is important to present the complete picture of co-benefits and how it relates to other city-goals. For example, GRI tools can help meet urban treen canopy goals. In previous experience, we worked on a triple-bottom line tool to calculate those costs and externalities of infrastructure choices. *It resulted in a lot of debate about the assumptions, and we never got to something that was quantifiable*. The research about tree canopy is very helpful and well-quantified, which may be a good place to start.

3.1 Closing

During this workshop, there was significant discussion about the details of the GRI Pathways Study. The project team provided updates and participants shared thoughts, feedback and questions related to the feasible GRI Tool combinations, GRI co-benefits, and preliminary policy considerations to support the implementation of GRI to manage rainwater on private sites in the City of Vancouver.

Recommendations from attendees and the project team include:

- Consider avoiding off-site compliance programs. These are challenging to implement. However, if the regulatory structure allows for it, it can be considered as a solution.
- Consider a site-level performance standard. This allows one to find the most cost-effective way to meet the standard. The in-lieu fees are voluntary.
- Consider pilot projects to help with education and training.
- Build a contractor and training maintenance program to improve the implementation of designs
- Biologically test top soils to ensure it has enough beneficial micro-organisms
- Coordinate with green roof professionals, building envelope professionals, and insurance representatives to review insurance challenges (e.g., concerns with leaking or maintenance) and the City's building envelope certifications in order to determine how the City's regulations or policies could be revised to address the warranty and liability issue.
- Involve strata councils, Homeowners Association, Landlords BC, and BOMA when considering maintenance and enforcement.

4 Appendix A: Workshop Invitation

RE: Online Workshop Invitation | City of Vancouver Green Rainwater Infrastructure – Pathways Study | September 14 2023

Hello,

On behalf of the City of Vancouver and its project consultant team, I would like to invite you to the third and final online Green Rainwater Infrastructure (GRI) Pathways Study Workshop on September 14, from 9 AM to 11:30 AM.

Workshop Purpose

The purpose of this final workshop in the series is to provide an overview of all work to date and to ask participants for feedback on the identified feasible GRI tool combinations ("pathways") on various property types, GRI co-benefits, and preliminary policy considerations to support the implementation of GRI to manage rainwater on private sites in the City of Vancouver. Specifically, this workshop will:

- Provide a brief overview of the Pathways Study purpose and its relationship to evolving City rainwater regulations (VBBL) and longer-term policy development (Rain City Strategy, Healthy Waters Plan, Groundwater Strategy).
- Present an overall update on the Pathways Study (review of overarching objectives and the work completed to date).
- Describe the different GRI pathways identified to meet onsite rainwater management targets, and associated construction costs.
- Gather feedback on:
    - GRI pathway tool sets and co-benefits (e.g., urban heat reduction, biodiversity enhancement, access to nature, etc.),
    - potential solutions identified to address key barriers,
    - preliminary policy options and associated considerations (e.g., toolkits, capacity building) to support implementation of GRI and help advance rainwater management.

About the project

The City of Vancouver is facing a number of challenges with respect to rainwater management, including sewer capacity and water quality impacts. In response, the City is advancing implementation of the Rain City Strategy (RCS) across private, public, and park spaces. The RCS treats rainwater as a valuable resource and mimics the natural hydrologic cycle by capturing and treating rainwater where it lands using Green Rainwater Infrastructure (GRI). Concurrent with these efforts is the ongoing development of related citywide strategies, including the Healthy Waters Plan and the Groundwater Strategy.

As part of the work on private property, the City of Vancouver has retained a consultant team to better understand how GRI can be used to meet the City's rainwater management design standards (capture, clean, discharge) for new development across a range of representative building-site 'typologies' from single family homes to large, dense developments.

Though this work the City is seeking to better understand the cost of these GRI "compliance pathways", the co-benefits that they offer, and the barriers and solutions to implementation. The work will also provide commentary/ recommendations that will inform the development of new and/or improved rainwater management policies for the City that will achieve the goals of the Rain City Strategy in a fair and consistent manner.

Please join us:

- Date: Thursday, September14, 9 AM-11:30 AM
- Platform: Zoom, register here: https://us02web.zoom.us/meeting/register/tZwsf-GuqjspGtDPrFUoco1GRpAm5ZWo5UO8

Attendees: For this workshop, we have invited green roof and other GRI subject matter experts, policy makers, representatives from the building industry, development community, design community, academia, insurance industry, and City of Vancouver staff.

Tentative Agenda

Time	Description
15 min	Welcome and introductions
30 min	Presentation: Project overview (pathways, performance benefits, costs, and co-benefits)
15 min	Q&A, Discussion
10 min	Break
15 min	Presentation: Potential solutions, policy options, and toolkits
35 min	Breakout Group Discussions
20 min	Report Back, Plenary Discussion
5 min	Thank you, closing, next steps
2.5 hours	*Total time*

Questions & Contact

For any questions about the event, please email Jean Roe, the workshop coordinator, at jean@thinkmodus.ca. Additionally, if you cannot attend this event but have a delegate who could attend, please send the delegate's name and email address to Jean Roe.

For any other City-related questions, please email Gord Tycho, the Project Manager for the GRI Pathways Project, at Gord.Tycho@vancouver.ca

We look forward to seeing you on September 14

Best regards,

Jean Roe, MODUS Planning Design & Engagement Inc.
On behalf of the project team

MODUS

5 Appendix B: Workshop Presentation

RCS Green Rainwater Infrastructure Pathways Study

Workshop #3: Findings, Policy Considerations and Next Steps – September 14, 2023

Sustainability Group | Planning, Urban Design & Sustainability | City of Vancouver

This place is the unceded and ancestral homelands of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səl̓ilwətaʔɬ (Tsleil-Waututh) nations (MST) and has been traditionally stewarded by them since time immemorial.

These lands continue to be occupied by settlers, and Indigenous peoples face ongoing dispossession and colonial violence.

Despite systemic and institutional efforts to eradicate communities and cultures, the resilience, strength and wisdom of MST have allowed them to revitalize their languages and cultures, and exercise sovereignty over their lands.

Meeting Preamble

1. **Welcome & Context: the Rain City Strategy**
2. **Pathways Study – Purpose**
3. **Which City departments are involved in the Study?**
4. **Who is in the room today? – partners and stakeholders**

Context

The city was once a **temperate rainforest.**

Image: Capilano River Regional Park, North Vancouver
Photo Credit: Robert Pennings

Over time, we have changed the **natural watersheds…**

(sanitary & stormwater are collected, combined, concentrated, and conveyed away from where they originate)

Image: View of Yaletown from Charleson Park in 1893, Vancouver
Photo Credit: www.onthisspot.ca, 10/25/2015

…to service today's **Vancouver.**

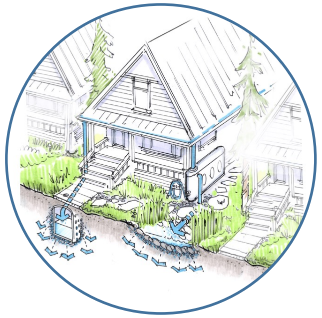
SOURCE: METRO VANCOUVER *N. GRIFFITHS / POSTMEDIA NEWS*

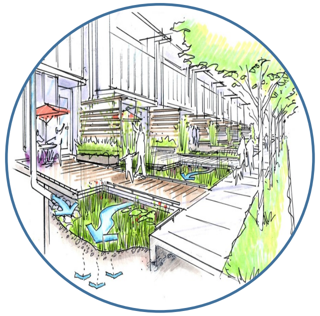
…to service today's **Vancouver.**

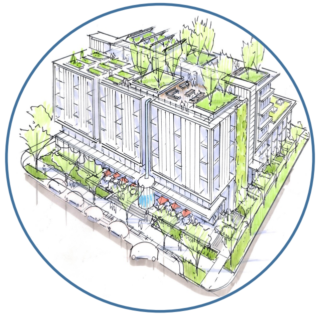
- Combined system near capacity
- CSO's, aquatic pollution
- Climate change, future growth

Response: Rain City Strategy

RCS & GRI Pathways Study







	Single Family	Mid-Rise	High-Rise
Capture and Re-use		✓	✓
Infiltration	✓	✓	
Resilient Roofs		✓	✓

GRI Pathways Study

1. 8-10 'Building-Site' **Typologie**s that represent CoV building stock

2. GRI Tools - infiltration, blue/green roofs, water reuse

Design methodologies

24mm/day & 48mm/day

3a. Model/ rank GRI tool 'pathways' that meet Bulletin – site, policy, and form & massing assumptions

3b.Broadway zero discharge

4. Understand Pathway **Costs** and rank **Co-benefits** of GRI tool combinations

5. Understand **Barriers and Solutions** to GRI implementation

Develop **Policy considerations –** recommended pathways, prescriptive or performance, policy barriers, targets not achieved, risk mitigation, **Policy Implementation, Standards, Toolkits, Capacity building**

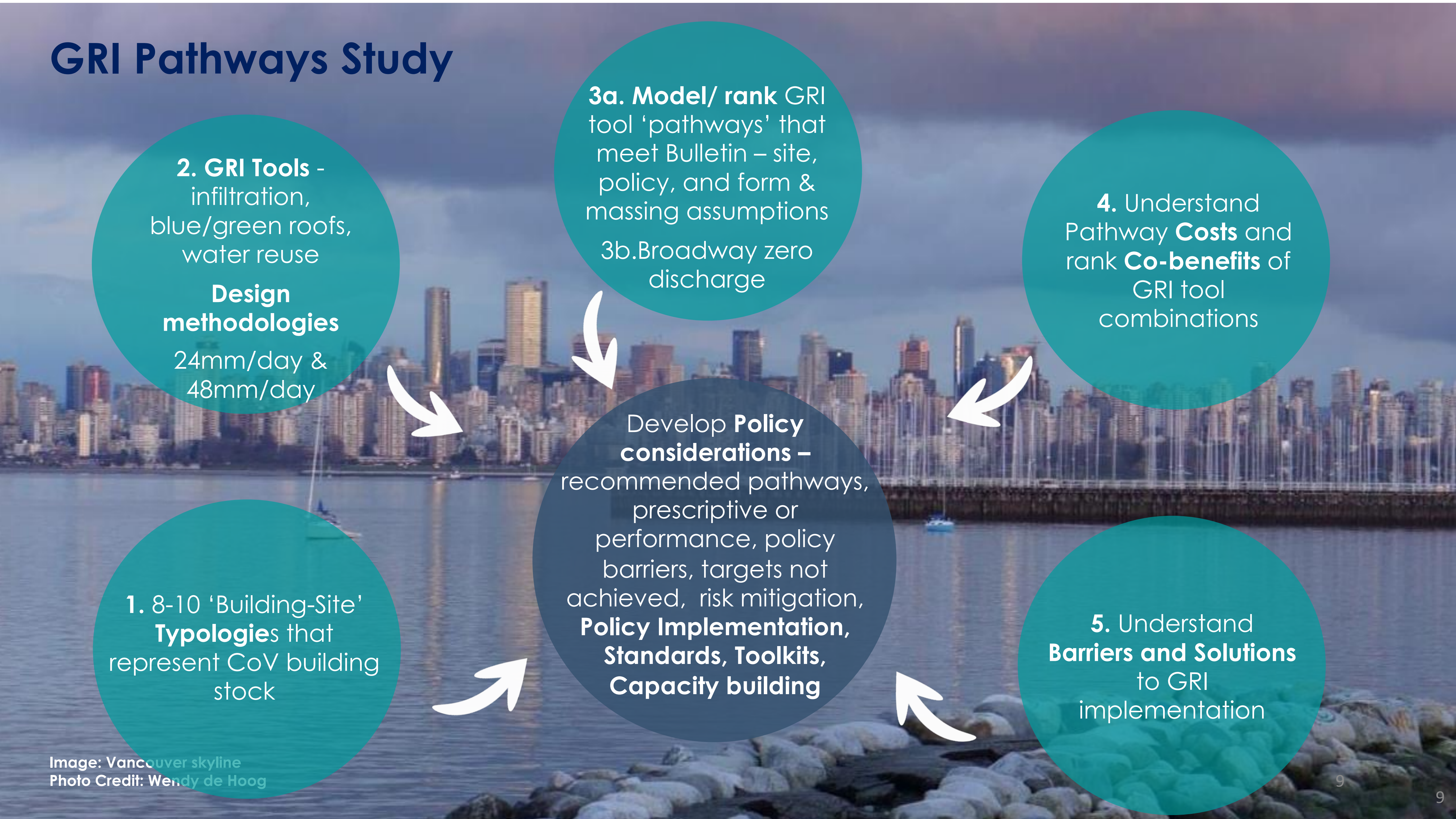


Image: Vancouver skyline
Photo Credit: Wendy de Hoog

9

Which departments are involved?

- Landscape Department
- Sustainability Group
- Development Planning, PDS
- Development Water Resources Management
- Integrated Sewer & Drainage Planning
- Clean Waters Planning
- Chief Building Official's Office
- Strategic Business Advisory
- Development Review Branch, DBL
- Citywide and Regional Planning
- Community Planning
- Housing Policy and VAHA
- Rezoning Centre
- Vancouver Plan
- Sewer & Drainage Design
- Facilities Planning and Development, REFM
- Long Term Financial Strategy
- Park Board
- Environmental Services
- Social Policy and Projects Division
- Green Infrastructure

Which partners & stakeholders are involved?

- Civil Consultants
- Structural Consultants
- Architects (SF, Townhome, Low Rise)
- Architects (Institutional, Mid Rise, Towers)
- Townhome and Low Rise Developers
- Urban Development Institute
- Mid Rise and Tower Developers
- Landscape Architects
- Certified Professionals
- Mechanical Consultants
- Large Site Developers
- Insurance Industry
- Single Family Developers
- ASPE & Other Associations
- Coastal Health
- BC Housing
- Metro Vancouver
- Stewardship Groups
- Academia
- First Nations (ongoing)

Green Rainwater Infrastructure (GRI) Pathways Study

WORKSHOP #3

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AGENDA

Time (estimated)	Description
9.00-9.05	Welcome, Pathways Study project purpose
9.05-9.10	Introductions to team and agenda
9.10-9.40	Presentation on overall project and work completed
9.40-10.10	Q&A / Discussion
10.10-10.20	Break
10.20-10.40	Presentation on policy options and implementation recommendations
10.40-11.10	Q&A / Discussion
11.10-11.15	Thank you, closing, and next steps

STUDY OVERVIEW

SECTION 1 Typologies, Tools, & Barriers	SECTION 2 Design Standards, Modeling, Costs	SECTION 3 Benefits & Solutions	SECTION 4 Policy Considerations
• Representative Building-Site Typologies • Rainwater Management Tools • Implementation Barriers	• GRI Design Methodology • Performance Modeling • Pathway Development • Cost Estimates	• Rainwater Management Co-benefits • Solutions to Barriers • Identified Pathways	• Findings • Policy Options • Implementation Recommendations

Workshop #1
Typologies, Tools, & Barriers Identification

Workshop #2
Green Roofs

Workshop #3
Findings, Policy Considerations, & Next Steps

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Representative Building-Site Typologies

Create building-site typologies to be used as the basis for developing compliance pathways and costs.

Compile

- Parcel Size • Existing Land Use • Proposed Land Use • Building Footprint • Permits

Categorize

- Land Use • Development Scenarios • Defining Site and Building Characteristics

Create

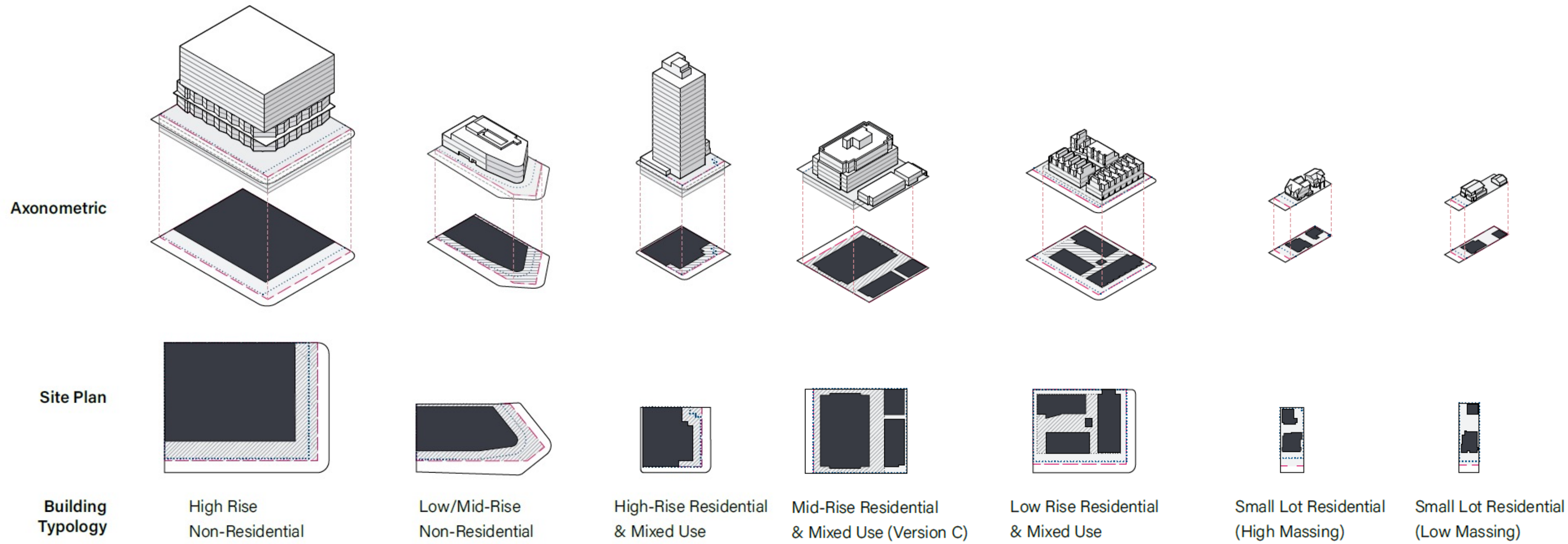
- Representative of future applications
- Commonalities of building type, land use, and site characteristics

Representative Building-Site Typologies

Create building-site typologies to be used as the basis for developing compliance pathways and costs.

Building-Site Typology	Representative Value				
	Parcel Area (m^2)	Building Area (% of parcel)	Building Stories	Gross Floor Area (m^2)	Parkade
Small Lot Residential – Low Massing	375	30%	2	225	no
Small Lot Residential – High Massing	375	50%	2	375	no
Low-Rise Residential & Mixed Use	2,500	40%	3	3,000	yes
Mid-Rise Residential & Mixed Use	3,000	65%	6	11,700	yes
High-Rise Residential & Mixed Use	1,200	70%	20	16,800	yes
Low/Mid-Rise Non-Residential	2,500	40%	3	3,000	yes
High-Rise Non-Residential	8,000	55%	14	61,600	yes

Representative Building Site Typologies



Building Site Typology	Parcel Area (m^2)	Building Area (% of parcel)	Building Stories	Gross Floor Area (m^2)	Parkade
High-Rise Non-Residential	8,000	55%	14	61,600	yes
Low/Mid-Rise Non-Residential	2,500	40%	3	3,000	yes
High-Rise Residential & Mixed Use	1,200	70%	20	16,800	yes
Mid-Rise Residential & Mixed Use	3,000	65%	6	11,700	yes
Low-Rise Residential & Mixed Use	2,500	40%	3	3,000	yes
Small Lot Residential – High Massing	375	50%	2	375	no
Small Lot Residential – Low Massing	375	30%	2	225	no

Rainwater Management Tools

Identify and define tools to be used in development of compliance pathways and costs

TOOLBOX DEVELOPMENT

Proposed tools were selected due to their ability to be:

- collectively applied across a range of hydraulic and hydrologic processes
- applicable for the range of building-site typologies
- tested across the anticipated range of benefits, costs, and barriers likely to be encountered

KEY DATA SOURCES

Vancouver Building By-Law
Metro Vancouver Stormwater Source Control Design Guidelines
City of Vancouver Integrated Resource Management Plan - Volume II
Cambie Integrated Water Management Plan
King County, Washington
Seattle, Washington
San Francisco, California
Best Professional Judgement

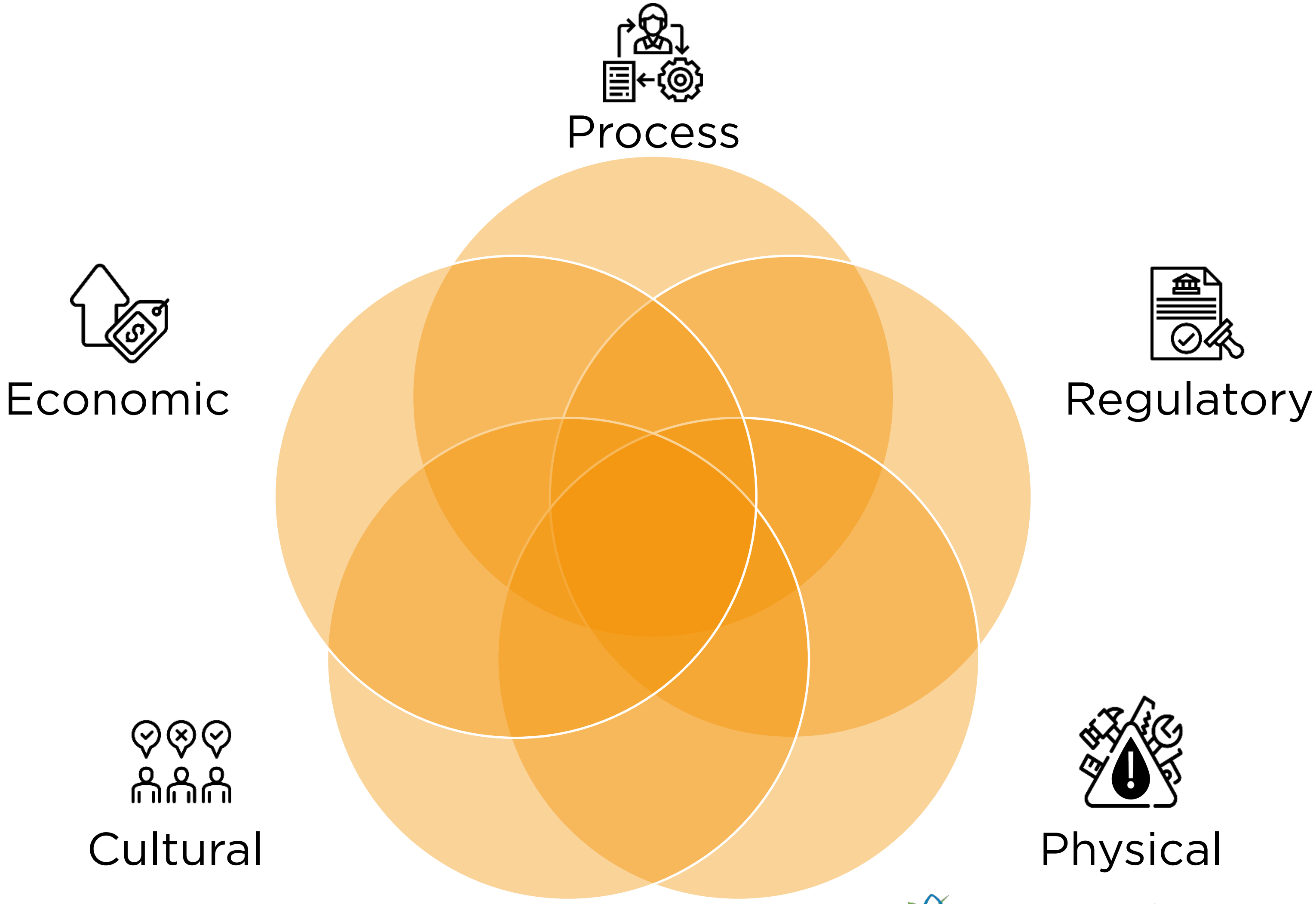
Rainwater Management Tools: GRI

Tool Type	***Tool Sub-types***
Green roof	Extensive (<150 mm soil depth) green roofs
	Intensive (≥150 mm soil depth) green roofs
	Blue-green roofs
Bioretention planter	Infiltrating (unlined)
	Non-infiltrating (liner and/or underdrain)
Tree trench	Structural soils
	Soil cells
Permeable pavement	Permeable pavers/concrete/asphalt (unlined)
	Liner and/or underdrain
Subsurface infiltration system	Small-scale near-surface infiltration (e.g., drywells)
	Large-scale near-surface infiltration (e.g., infiltration chambers)
	Deep infiltration (e.g., drill drains)
Non-potable water system	Rainwater harvesting systems (rooftop)
	Rainwater harvesting systems (all)
	Groundwater + rainwater harvesting

Rainwater Management Tools: Non-GRI

Tool Type	*Tool Sub-types*
Detention tank	Surface detention tanks Subsurface detention tanks/vaults Blue roofs
Proprietary water quality device	Basic treatment (80% TSS removal)

Implementation Barriers



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Pathway Modeling Variables

Scenario Variable	Design Standard	Site Conditions		Infiltrative Area Available	
		Pre-Development Condition	Soil Condition	Foundation Setback	Parkade Extents
Variable Values	• 24 mm retention • 48 mm retention	• No pre-development (0% impervious) • Less than post-development (50% of post-construction impervious) • Equivalent to post-development (100% of post-construction impervious)	• High Infiltration (50 mm/hr) • Medium Infiltration (20 mm/hr) • Low Infiltration (5 mm/hr) • No infiltration (0 mm/hr)	• Existing setback (5 m) • Reduced setback (3 m) • No setback (0 m)	• Parkade occupies only the building footprint • Parkade extends to impervious extent

Pathway Modeling Variables

Scenario Variable	Design Standard	Site Conditions		Infiltrative Area Available	
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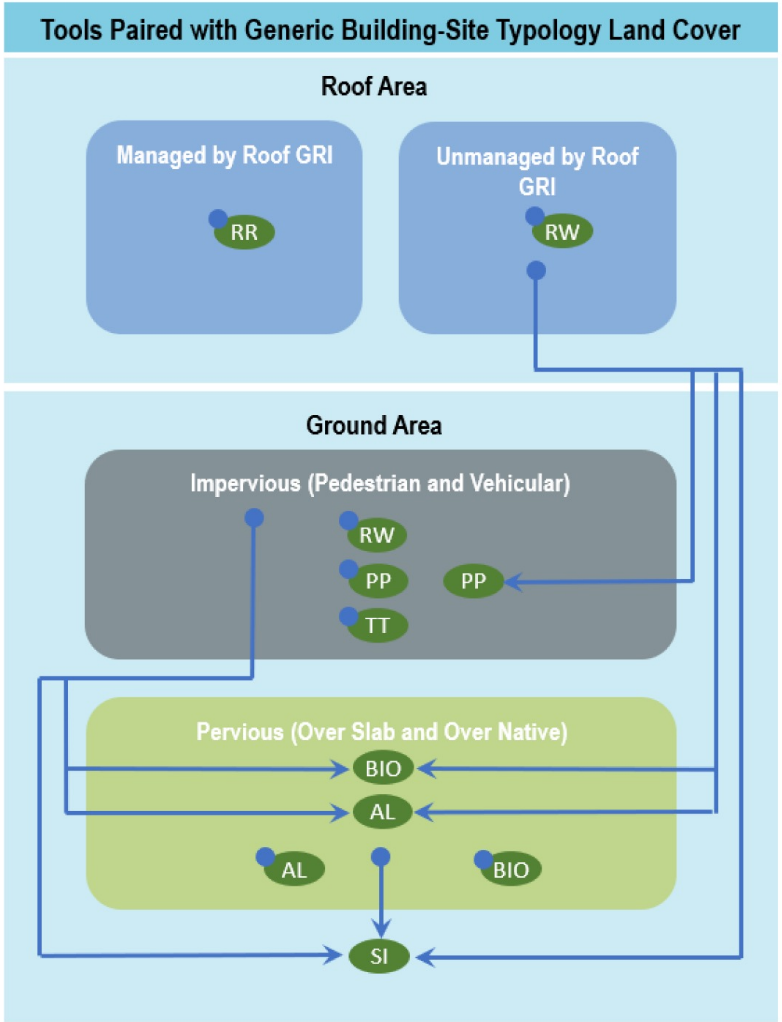
Performance Modeling

Available Tools to Meet Standard

Tier 1 Tools

- RR Resilient Roofs
- RW Rainwater Harvesting Systems
- BIO Bioretention (Unlined)
- AL Absorbent Landscapes (Over Native)
- TT Tree Trenches
- PP Permeable Pavement (Unlined)
- SI Subsurface Infiltration



Key

XX — Runoff associated with land cover managed with tool sited on that land cover

→ XX — Runoff associated with land cover managed with tool sited on a different land cover

Performance Modeling

Example Findings – 48 mm retention (low infiltration scenario)

Typology	Existing Policy and Development Practice						Modified Policy and/or Development Practice					
	Compliant Scenarios Possible	GRI Tool Performance and Importance for Compliance					Compliant Scenarios Possible with Modified Practice/ Policy	GRI Tool Performance and Importance for Compliance				
		Resilient Roof (RR)	Rainwater Harvesting (RWH)	Permeable Pavement (PP)	Bioretention (Bio)	Subsurface Infiltration (SI)		Resilient Roof (RR)	Rainwater Harvesting (RWH)	Permeable Pavement (PP)	Bioretention (Bio)	Subsurface Infiltration (SI)
Small Lot Residential – Low Massing	Yes	Optional	Optional	Optional	Optional	Optional	Yes, with 3 m setback	Optional	Optional	Optional	Optional	Optional
Small Lot Residential – High Massing	Yes	***Critical***	Optional	Optional	Optional	Optional	Yes, with 3 m setback	Optional	Optional	Optional	Optional	Optional
Low-Rise Residential & Mixed-Use	No						Yes, with Reduced parkade	Optional	Optional	Optional	Optional	Optional
Mid-Rise Residential & Mixed-Use	No						Yes, with 3 m setback + Reduced parkade	Optional	Optional	Optional	Optional	Optional
High-Rise Residential & Mixed-Use	Yes	Optional	Optional	Not viable	Optional	Optional	Yes, with 3 m setback	Optional	Optional	Not viable	Optional	Optional
Low/Mid-Rise Non-Residential	No						Yes, with Reduced parkade	Optional	Optional	Optional	Not viable	Optional
High-Rise Non-Residential	No						Yes, with Reduced parkade	Optional	Optional	Optional	Not viable	Optional

KEY: Color-coding indicates the relative retention performance of the tool for all typology scenarios modeled:
- (green) tool could potentially manage a large percentage of site runoff (>75%)
- (yellow) tool could potentially manage between 25% and 75% of the site runoff but would need to be paired with other tools to manage all runoff from the site
- (pink) tool could potentially manage a limited percentage of site runoff (<25%)

Tools are noted to be "Critical" if they must be used to achieve the associated retention standard, "Optional" if they could be part of a compliant pathway but are not required to be, and "Not Viable" if they cannot be used based on site characteristics

Other Values and Co-Benefits

Account for other benefits and intrinsic values of rainwater management tools outside of performance (water quality and quantity) and capital costs.

Benefit Category	Criteria	Metric
Economic	Life Cycle Considerations	Ease of O&M
		Replacement frequency
	Property Values	Property value uplift
	Energy Efficiency	Energy savings
	Other Cost Implications	Other costs
Environmental	Ecosystem Health	Biodiversity and habitat enhancement
	Water Preservation	Potable water savings
		Groundwater recharge
	Climate	Carbon sequestration potential
Community	Community Health	Air quality improvement
		Urban heat island mitigation
	Social Equity and Community Cohesion	Provides or enhances access to nature
Resiliency	Long-Term Stresses (e.g., Climate Change)	Adaptability
	Short-Term Stresses & Shocks (e.g., Earthquake)	Service disruption potential

Rating scores weighted and combined for each tool and pathway (1 to 5 stars)

Construction Costs – Rainwater Infra.

Rainwater Management Tool	Unit	**Construction Unit Costs ($ per unit)**	*Const. Unit Cost Range*	
			Low	*High*
Green roof - Extensive (<150mm soil)	$ / Area	**$220 per sq. m.**	*$154*	*$330*
Green roof - Intensive (≥150 mm soil)	$ / Area	**$430 per sq. m.**	*$301*	*$645*
Bioretention Raingarden (simple basin)	$ / Area	**$160 per sq. m.**	*$112*	*$240*
Bioretention Planter - Sloped-side	$ / Area	**$1,500 per sq. m.**	*$1,050*	*$2,250*
Bioretention Planter - Full-walled planter	$ / Area	**$2,100 per sq. m.**	*$1,470*	*$3,150*
Permeable Pavement	$ / Area	**$250 per sq. m.**	*$175*	*$375*
Subsurface Infiltration Gallery	$ / Volume	**$3,500 per cu. m.**	*$2,450*	*$5,250*
Detention tank	$ / Volume	**$900 per cu. m.**	*$600*	*$1,350*
Water quality treatment device	$/ Flow Rate	**$34,000 + $1,900 per Lps**	*-30%*	*+50%*

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Construction Costs - Buildings

Description		Category from Altus Canadian Cost Guide	Construction Unit Costs ($ per sq. m.)		
			Median	*Low*	*High*
Building Structure	Small Lot Residential – Low Massing	*Single Family Residential w/ Unf. Basement*	**$2,691**	*$1,991*	*$3,391*
	Small Lot Residential – High Massing	*Row Townhouse with Unfinished Basement*	**$2,530**	*$1,938*	*$3,122*
	Low-Rise Residential & Mixed-Use	*3 Storey Stacked Townhouse*	**$2,772**	*$2,314*	*$3,229*
	Mid-Rise Residential & Mixed-Use	*Up to 6 Storey Wood Framed Condo*	**$3,202**	*$2,637*	*$3,767*
	High-Rise Residential & Mixed-Use	*Condominiums/Apartments 13-39 Storeys*	**$3,929**	*$3,552*	*$4,306*
	Low/Mid-Rise Non-Residential	*Office Building Under 5 Storeys (Class B)*	**$3,579**	*$3,122*	*$4,037*
	High-Rise Non-Residential	*Office Building 5 - 30 Storeys (Class A)*	**$3,633**	*$3,175*	*$4,090*
	Parkade	*Underground Parking Garages*	**$1,884**	*$1,292*	*$2,476*
Site Hardscape/Paving		*Surface Parking*	**$188**	*$108*	*$269*
Site Landscape (absorbent landscape)		*(n/a)*	**$17**	*$12*	*$26*

Construction Costs - Pathways

Representative Building Site Typology	Example Compliance Pathway (Rainwater Management Tools and Sizes)	Construction Cost Estimate Summary	
		Rainwater Compliance Pathway Cost	Building/Other Components Cost
Small Lot Residential – Low Massing	**Bioretention Planter(s)** (12 sq. m.)	$10,000	$620,000
Small Lot Residential – High Massing	**Green Roof** (50% of roof) & **Subsurface Infiltration Gallery** (9 cu. m.)	$72,000	$960,000
Low-Rise Residential & Mixed-Use	**Green Roof** (50% of roof) & **Bioretention Planter(s)** (60 sq. m.)	$410,000	$12,790,000
Mid-Rise Residential & Mixed-Use	**Green Roof** (50% of roof) & **Subsurface Infiltration Gallery** (80 cu. m.)	$720,000	$48,380,000
High-Rise Residential & Mixed-Use	**Rainwater Harvesting System** (Toilets and Irrigation Use)	$620,000	$72,200,000
Low/Mid-Rise Non-Residential	**Bioretention Planter(s)** (50 sq. m.) & **Permeable Pavement** (220 sq. m.)	$200,000	$15,600,000
High-Rise Non-Residential	**Detention Tank** (180 cu. m.) & **Water Quality Treatment Device** (5 Lps)	$210,000	$284,700,000

Pathways Matrix

Pathway Category:	1	2	3	4	5
Retention Standard:	**24 mm**			**48 mm**	**n/a (Tier 3)**
Soil Conditions:	No Infiltration	Low Infiltration (5 mm/hr)		Low Infiltration	n/a
Setback/Parkade Conditions:	n/a	Typical	Reduced	Reduced	n/a
Small Lot Residential – Low Massing	No viable pathway	Bioretention	Bioretention	Bioretention	Detention + Treatment Device
Small Lot Residential – High Massing	No viable pathway	Green Roof Bioretention Permeable Pavement	Bioretention	Green Roof Subsurface Infiltration	Detention + Treatment Device
Low-Rise Residential & Mixed-Use	No viable pathway	Green Roof Bioretention	Bioretention	Bioretention Permeable Pavement	Detention + Treatment Device
Mid-Rise Residential & Mixed-Use	Green Roof Rainwater Harvesting	Green Roof Rainwater Harvesting Bioretention	Bioretention Permeable Pavement	Green Roof Subsurface Infiltration	Detention + Treatment Device
High-Rise Residential & Mixed-Use	Rainwater Harvesting	Green Roof Bioretention	Bioretention	Bioretention Permeable Pavement	Detention + Treatment Device
Low/Mid-Rise Non-Residential	No viable pathway	n/a	Bioretention Permeable Pavement	Green Roof Bioretention Permeable Pavement	Detention + Treatment Device
High-Rise Non-Residential	Green Roof Rainwater Harvesting	n/a	Bioretention Permeable Pavement	Green Roof Bioretention Permeable Pavement	Detention + Treatment Device

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Mid-Rise Residential & Mixed-Use	Green Roof Rainwater Harvesting	Green Roof Rainwater Harvesting Bioretention	Bioretention Permeable Pavement	Green Roof Subsurface Infiltration	Detention + Treatment Device
High-Rise Residential & Mixed-Use	Rainwater Harvesting	Green Roof Bioretention	Bioretention	Bioretention Permeable Pavement	Detention + Treatment Device
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High-Rise Residential & Mixed-Use	Rainwater Harvesting	Green Roof Bioretention	Bioretention	Bioretention Permeable Pavement	Detention + Treatment Device
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High-Rise Non-Residential	Green Roof Rainwater Harvesting	n/a	Bioretention Permeable Pavement	Green Roof Bioretention Permeable Pavement	Detention + Treatment Device

Pathways Matrix

Pathway Category:	1	2	3	4	5
Retention Standard:	**24 mm**			**48 mm**	**n/a (Tier 3)**
Soil Conditions:	No Infiltration	Low Infiltration (5 mm/hr)		Low Infiltration	n/a
Setback/Parkade Conditions:	n/a	Typical	Reduced	Reduced	n/a
Small Lot Residential – Low Massing	No viable pathway	Bioretention	Bioretention	Bioretention	Detention + Treatment Device
Small Lot Residential – High Massing	No viable pathway	Green Roof Bioretention Permeable Pavement	Bioretention	Green Roof Subsurface Infiltration	Detention + Treatment Device
Low-Rise Residential & Mixed-Use	No viable pathway	Green Roof Bioretention	Bioretention	Bioretention Permeable Pavement	Detention + Treatment Device
Mid-Rise Residential & Mixed-Use	Green Roof Rainwater Harvesting	Green Roof Rainwater Harvesting Bioretention	Bioretention Permeable Pavement	Green Roof Subsurface Infiltration	Detention + Treatment Device
High-Rise Residential & Mixed-Use	Rainwater Harvesting	Green Roof Bioretention	Bioretention	Bioretention Permeable Pavement	Detention + Treatment Device
Low/Mid-Rise Non-Residential	No viable pathway	n/a	Bioretention Permeable Pavement	Green Roof Bioretention Permeable Pavement	Detention + Treatment Device
High-Rise Non-Residential	Green Roof Rainwater Harvesting	n/a	Bioretention Permeable Pavement	Green Roof Bioretention Permeable Pavement	Detention + Treatment Device

Pathways Category 1

Retention Standard: 24 mm
Soil Condition: No infiltration
Setback/Parkade: n/a

Typology	Pathway (Tool Combination)			Performance Summary			Costs Summary				Co-benefit Score
	Code	Meets Retention Standard	Rainwater Management Tools	Reten-tion	Release Rate – Peak Flow		Pathway Construction Cost			Qualitative O&M Cost	
					Unit Rate (L/s/ha)	Reduction from Pre-development	Total	Impact on Building Construction Cost (compared to baseline Tier 3)			
Small Lot Residential – Low Massing	SLRLM1	No	Bioretention w/ UD	13 mm	5 L/s/ha	87%	$15,000	Decrease	-3.6%	Medium	****
Small Lot Residential – High Massing	SLRHM1	No	Green Roof & Bioretention w/ UD	16 mm	4 L/s/ha	92%	$73,200	Increase	3.2%	Medium/High	***
Low-Rise Residential & Mixed-Use	LRMU1	No	Green Roof & Bioretention w/ UD	12 mm	5 L/s/ha	91%	$442,500	Increase	2.7%	Medium/High	***
Mid-Rise Residential & Mixed-Use	MRMU1	Yes	Green Roof & Rainwater Harvesting	24 mm	0 L/s/ha	100%	$808,700	Increase	1.5%	High	**
High-Rise Residential & Mixed-Use	HRMU1	Yes	Rainwater Harvesting	24 mm	0 L/s/ha	100%	$624,300	Increase	0.8%	High	**
Low/Mid-Rise Non-Residential	LMNR1	No	Green Roof & Bioretention w/ UD	7 mm	5 L/s/ha	93%	$335,000	Increase	1.5%	Medium	****
	LMNR1ALT	No	Green Roof & Rainwater Harvesting	18 mm	0 L/s/ha	100%	$625,500	Increase	3.4%	High	***
High-Rise Non-Residential	HNR1	Yes	Green Roof & Rainwater Harvesting	24 mm	5 L/s/ha	92%	$3,526,100	Increase	1.2%	High	**
	HNR1ALT	No	Green Roof & Bioretention w/ UD	10 mm	0 L/s/ha	100%	$1,659,500	Increase	0.5%	Medium	***

Pathways Category 2

Retention Standard: 24 mm
Soil Condition: Low Infiltration
Setback/Parkade: Typical

Typology	Pathway (Tool Combination)			Performance Summary			Costs Summary				Co-benefit Score
	Code	Meets Retention Standard	Rainwater Management Tools	Reten-tion	Release Rate – Peak Flow		Pathway Construction Cost			Qualitative O&M Cost	
					Unit Rate (L/s/ha)	Reduction from Pre-development	Total	Impact on Building Construction Cost (compared to baseline Tier 3)			
Small Lot Residential – Low Massing	SLRLM2	Yes	Subsurface Infiltration Gallery	24 mm	0 L/s/ha	100%	$9,900	Decrease	-4.3%	Medium/High	**
	SLRM2ALT	Yes	Bioretention	24 mm	0 L/s/ha	100%	$15,000	Decrease	-3.6%	Medium	****
Small Lot Residential – High Massing	SLRHM2	Yes	Green Roof & Bioretention & Perm Pavement	24 mm	2 L/s/ha	95%	$71,700	Increase	3.1%	Medium/High	***
Low-Rise Residential & Mixed-Use	LRMU2	Yes	Green Roof & Bioretention	24 mm	0 L/s/ha	99%	$412,500	Increase	2.5%	Medium/High	***
Mid-Rise Residential & Mixed-Use	MRMU2	Yes	Green Roof & Bioretention & Rainwater Harvesting	24 mm	0 L/s/ha	100%	$721,700	Increase	1.3%	High	**
High-Rise Residential & Mixed-Use	HRMU2	Yes	Green Roof & Bioretention	24 mm	0 L/s/ha	99%	$233,100	Increase	0.2%	Medium/High	***
Low/Mid-Rise Non-Residential	*n/a because parkade/setback cover full site*										
High-Rise Non-Residential	*n/a because parkade/setback cover full site*										

Pathways Category 3

Retention Standard: 24 mm
Soil Condition: Low Infiltration
Setback/Parkade: Reduced

Typology	Pathway (Tool Combination)			Performance Summary			Costs Summary				Co-benefit Score
	Code	Meets Retention Standard	Rainwater Management Tools	Reten-tion	Release Rate – Peak Flow		Pathway Construction Cost			Qualitative O&M Cost	
					Unit Rate (L/s/ha)	Reduction from Pre-development	Total	Impact on Building Construction Cost (compared to baseline Tier 3)			
Small Lot Residential – Low Massing	Same as Category 2	Yes	Subsurface Infiltration Gallery	24 mm	0 L/s/ha	100%	$9,900	Decrease	-4.3%	Medium/High	**
		Yes	Bioretention	24 mm	0 L/s/ha	100%	$15,000	Decrease	-3.6%	Medium	****
Small Lot Residential – High Massing	SLRHM3	Yes	Bioretention	24 mm	0 L/s/ha	100%	$31,500	Decrease	-0.9%	Medium	****
Low-Rise Residential & Mixed-Use	LRMU3	Yes	Bioretention	24 mm	0 L/s/ha	100%	$195,000	Increase	0.8%	Medium	****
Mid-Rise Residential & Mixed-Use	MRMU3	Yes	Bioretention & Permeable Pavement	24 mm	10 L/s/ha	82%	$243,000	Increase	0.2%	Medium	***
High-Rise Residential & Mixed-Use	HRMU3	Yes	Bioretention	24 mm	0 L/s/ha	100%	$115,500	Increase	0.1%	Medium	****
Low/Mid-Rise Non-Residential	LMNR3	Yes	Bioretention & Permeable Pavement	24 mm	38 L/s/ha	45%	$205,000	Increase	0.2%	Low / Medium	***
High-Rise Non-Residential	HNR3	Yes	Bioretention & Permeable Pavement	24 mm	32 L/s/ha	48%	$641,000	Increase	0.1%	Medium	***

Pathways Category 4

Retention Standard: 48 mm
Soil Condition: Low Infiltration
Setback/Parkade: Reduced

Typology	Pathway (Tool Combination)			Performance Summary			Costs Summary				Co-benefit Score
	Code	Meets Retention Standard	Rainwater Management Tools	Reten-tion	Release Rate – Peak Flow		Pathway Construction Cost			Qualitative O&M Cost	
					Unit Rate (L/s/ha)	Reduction from Pre-development	Total	Impact on Building Construction Cost (compared to baseline Tier 3)			
Small Lot Residential – Low Massing	SLRLM4	Yes	Bioretention	48 mm	0 L/s/ha	100%	$27,000	Decrease	-1.8%	Medium	****
Small Lot Residential – High Massing	SLRHM4	Yes	Green Roof & Subsurface Infiltration	48 mm	1 L/s/ha	98%	$58,900	Increase	1.8%	High	***
Low-Rise Residential & Mixed-Use	LRMU4	Yes	Bioretention & Subsurface Infiltration	48 mm	0 L/s/ha	100%	$282,500	Increase	0.9%	Medium	***
Mid-Rise Residential & Mixed-Use	MRMU4	Yes	Green Roof & Subsurface Infiltration	48 mm	0 L/s/ha	100%	$608,500	Increase	1.0%	High	***
High-Rise Residential & Mixed-Use	HRMU4	Yes	Bioretention & Permeable Pavement	48 mm	0 L/s/ha	100%	$222,500	Increase	0.2%	Medium	****
Low/Mid-Rise Non-Residential	LMNR4	Yes	Green Roof & Bioretention & Permeable Pavement	48 mm	37 L/s/ha	47%	$420,000	Increase	1.6%	Low / Medium	***
High-Rise Non-Residential	HNR4	Yes	Green Roof & Bioretention & Permeable Pavement	48 mm	24 L/s/ha	62%	$1,759,500	Increase	0.5%	Low / Medium	***

Pathways Category 5

Retention Standard: 0 mm (Tier 3 Solution)
Soil Condition: n/a
Setback/Parkade: n/a

Typology	Pathway (Tool Combination)			Performance Summary			Costs Summary				Co-benefit Score
	Code	Meets Retention Standard	Rainwater Management Tools	Reten-tion	Release Rate – Peak Flow		Pathway Construction Cost			Qualitative O&M Cost	
					Unit Rate (L/s/ha)	Reduction from Pre-development	Total	Impact on Building Construction Cost (compared to baseline Tier 3)			
Small Lot Residential – Low Massing	SLRLM5	No	Detention Tank & Treatment Device	0 mm	25 L/s/ha	35%	$38,500	Baseline	0.0%	Low	**
Small Lot Residential – High Massing	SLRHM5	No	Detention Tank & Treatment Device	0 mm	29 L/s/ha	39%	$40,800	Baseline	0.0%	Low	**
Low-Rise Residential & Mixed-Use	LRMU5	No	Detention Tank & Treatment Device	0 mm	26 L/s/ha	51%	$89,300	Baseline	0.0%	Low	**
Mid-Rise Residential & Mixed-Use	MRMU5	No	Detention Tank & Treatment Device	0 mm	23 L/s/ha	57%	$103,900	Baseline	0.0%	Low	**
High-Rise Residential & Mixed-Use	HRMU5	No	Detention Tank & Treatment Device	0 mm	44 L/s/ha	18%	$62,400	Baseline	0.0%	Low	**
Low/Mid-Rise Non-Residential	LMNR5	No	Detention Tank & Treatment Device	0 mm	27 L/s/ha	61%	$91,600	Baseline	0.0%	Low	**
High-Rise Non-Residential	HNR5	No	Detention Tank & Treatment Device	0 mm	10 L/s/ha	84%	$209,800	Baseline	0.0%	Low	**

STUDY OVERVIEW

Policy and implementation recommendations to be covered next.

SECTION 1 Typologies, Tools, & Barriers	SECTION 2 Design Standards, Modeling, Costs	SECTION 3 Benefits & Solutions	SECTION 4 Policy Considerations
• Representative Building-Site Typologies • Rainwater Management Tools • Implementation Barriers	• GRI Design Methodology • Performance Modeling • Pathway Development • Cost Estimates	• Rainwater Management Co-benefits • Solutions to Barriers • Identified Pathways	• Findings • Policy Options • Implementation Recommendations

CITY OF VANCOUVER
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DISCUSSION

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Context/Recent Developments

Two major developments unknown or undeveloped at the time the GRI Pathways Study was initiated:

- Vancouver Building Bylaws (VBBL) revisions for rainwater management in redevelopment
- Advancement of the Healthy Waters Plan (HWP)
- Groundwater Strategy

Example Policy Framework Process

1. HWP sets the City-wide performance measures and goals.
2. Leverage HWP models to determine site/project level GRI design standard to meet overarching goals (layered with grey and programmatic investments).
3. Implement policy by updating the VBBL; develop technical tools for certainty and predictability
4. Continuously monitor and model to ensure overarching goals and targets are being met.

Recommended Implementation Steps

Recommendations for Implementation of Policy

- Finalize HWP Performance Measures and Complete Performance-Based Modeling Analysis
- GRI Design Manual and Technical Resources
- Develop Alternative Compliance Options
- Facilitate GRI Engagement and Training
- GRI Maintenance Standards and Enforcement

Recommended Implementation Steps

Recommendations for Specific GRI Types

- Develop Resilient Roofs Policy
- Expand Alternative Water Sources Allowed for Onsite Reuse
- Increase Retention Opportunities within Parcels

Near-Term Recommendations

1. **Align with HWP Performance Measures**
   - Using the MBM and VSA modeling analyses can provide an initial direction for near term policy decisions at the basin-scale.
   - Combined results of modeling and GRI Pathways Study can provide the City with a basis for initial reasonable expectations for site-level retention or detention that are feasible and can be used in the implementation of the VBBL Phase 2 effort.

2. **Determine Performance-Based Standard**
   - Two near term options:
     - Strengthen Current ZDBL Requirements, or
     - Modify Release Rate Reduction in VBBL Revisions

Discussion Topic Ideas

- General questions/feedback
- Tools and recourses
- Alternative compliance
- Process and implementation

Discussion on Alternative Compliance

- Modified Compliance
- Fee In Lieu
- Credit Trading Program
- Off-Site Compliance

Alternative Compliance

Tool to allow flexibility in meeting stormwater requirements

Traditional: ordinance requires onsite BMPs

Why seek alts: constrained sites (SF), streamline review (LA), revenue stream* (WA)

Alternatives:

- In-lieu fee: site pays city*
- Credit trading: site buys compliance via open credit market
- Mitigation bank: site buys compliance from city-managed credit bank
- Offsite mitigation: site owner builds stormwater management offsite
- Modified requirements: reduced volume reduction (CSS), alternative treatment? (MS4)

Nationwide Survey (2016, 2020, 2021)

In Lieu Fee

- Washington, DC
- Chattanooga, TN
- Grand Rapids, MI
- St. Paul, MN
- Lake County, IL
- Prince George's Co, MD
- Aspen, CO
- Portland, OR
- Tacoma, WA
- Kitsap County, WA

Credit Trading

- Washington, DC
- Chattanooga, TN
- Grand Rapids, MI
- St. Paul, MN
- Lake County, IL
- Cook County, IL

San Francisco Public Utilities Commission
(2016-2019)

Driver	Provide additional compliance options
Barriers to Implementation	Management approval process stalled; priorities shifted

Lotus Tasks
Nationwide precedent study
In-lieu Fee Framework (CSS only) - Fee estimate - Revenue use - Eligibility - Participation & revenue projections
Offsite Compliance Framework (CSS only) - Eligibility - Offsite project requirements
Credit Trading Framework – not completed (see barriers)

San Francisco Public Utilities Commission
(2016-2019)

San Francisco Water Power Sewer
Services of the San Francisco Public Utilities Commission

In-lieu fee program

Highlights – we learned:

- CSS only (no planned capital projects in MS4)
- Constrained SMO compliance cost ≈ capital costs (OOM)
- Set fee per program goals (i.e., high enough to encourage onsite BMPs where feasible)
- In-lieu fee program could generate $10M/yr with current MC criteria

Offsite compliance program

Highlights – we learned:

- Difficult to make work in MS4 (minimal opportunity, no "hammer")
- Deciding offsite completion deadline was tricky

Status – these did not advance for various reasons