A PATHWAY TO ROOFTOPS: A FEASIBILITY STUDY OF GREEN ROOF TYPOLOGIES AT 105 BOND STREET

by

Jack Douglas Lawson
Bachelor's of Journalism Honours, Carleton University, 2014

A Major Research Paper
presented to Ryerson University

in partial fulfillment of the requirements for the degree

Master of Planning
in
Urban Development

Toronto, Ontario, Canada, 2021

Author’s Declaration for Electronic Submission of a MRP

I hereby declare that I am the sole author of this MRP. This is a true copy of the MRP, including any required final revisions.

I authorize Ryerson University to lend this MRP to other institutions or individuals for the purpose of scholarly research.

I further authorize Ryerson University to reproduce this MRP by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

I understand that my MRP may be made electronically available to the public.

Acknowledgements

This paper would not have been possible with the generous contributions of both Professor Nina-Marie Lister and Nic De Salaberry. I would also like to thank Mark Dettweiler, Molly Anthony, Stephanie MacPhee, Jean-Francois Landry, Kristiina Mai, Jeremy Wright, Arlene Throness, Sharene Shafie, Zack Bradley and both Neil Loewen and Taylor Gascoigne for their insights into this project’s feasibility.

Thank you as well to my friends in the arts community for helping to keep me grounded throughout this degree. Finally, I would like to thank my mother and father for their support and encouragement in pursuing this degree.

A PATHWAY TO ROOFTOPS: A FEASIBILITY STUDY

OF GREEN ROOF TYPOLOGIES AT 105 BOND STREET

Master of Planning

in

Urban Development

Ryerson University

ABSTRACT

This paper examines the feasibility of a green roof at the School of Urban and Regional Planning (SURP), located at 105 Bond Street, Toronto. Green roofs have proven benefits within the energy-air-stormwater nexus that often translate in direct operating cost savings. With a history of prior proposals, SURP is well positioned both ideologically and practically for the implementation of a green roof. Ryerson University is also undergoing a period of vertical growth which will dramatically increase visibility on existing heritage structures like 105 Bond. Ultimately, this paper proposes a semi-intensive green roof split across the building's upper and lower tiers. Over time the School of Urban and Regional Planning will continue to develop its robust culture of custodianship among faculty, students, and alumni to allow for the long-term health of the green roof and reduced on-going maintenance load. The addition of dedicated research beds included on the upper tier of the proposed green roof are another key long-term benefit that will produce year-to-year project outcomes.

Key words:

Green roof, resiliency, Canada, planning, vegetation

Table of Contents

On the Path: How do we get There?

Keeping up the Momentum: What comes next?

The Current State: Why 105 Bond and the School of Urban and Regional Planning?

1/ Executive Summary

This paper argues that Campus Facilities Management and Development should consider aiding in the development of a semi-intensive green roof at 105 Bond Street.

The South Bond Building is a 3.5 storey heritage structure that is home to one of Ryerson University's professional departments, the School of Urban and Regional Planning. For 40-years the School has endeavoured to facilitate the construction of a green roof. Key decision-makers for this project include both the Dean of the Faculty of Community Services, Lisa Barnoff, and the interim Provost, Dr. Saeed Zolfaghari, in addition to Facilities Management and Development. During the initial purchase of the building faculty members noticed that employees at 105 Bond were using the roof to eat lunch at picnic tables (Amborski, Personal Communication, 2021). This gave rise to early discussions about the possibility of a useable roof space for the School, and this ambition has been carried through multiple proposals for a green roof at the faculty. The most recent proposal was developed in 2015 when Sustainable SURP, a student organization, proposed four

Figure 1 - a photograph of 105 Bond Street following its 2006-2007 Renovation (Compass Construction Resources LTD., 2021).

scenarios to Campus Facilities Management and Development, and engaged the Ryerson Planning Alumni Association in fundraising discussions for this goal (Bradley, personal communication, 2021).

This Masters Research Project builds on this prior work in an effort to determine what kind of Green Roof would best suit the current state of the roof at 105 Bond Street. Secondary research conducted for this paper indicates that green roofs produce the most cost-savings when applied as a retrofit (Clark, Adriaens, & Talbot, 2008). The 2020-2030 Campus Master Plan also notes that, "Existing Ryerson-owned buildings present the most significant opportunities to create new space through intensification and renewal (Ryerson University, 2019)." The roof at 105 Bond street is in a poor to fair condition, based on reporting commissioned by Ryerson University in 2013 (TREMCO, 2013). This indicates that there is an opportunity to dramatically improve the insulation-based energy costs, reduce air pollution, and reap stormwater benefits provided an intervention is targeted with the end of the current, conventional roof's life cycle.

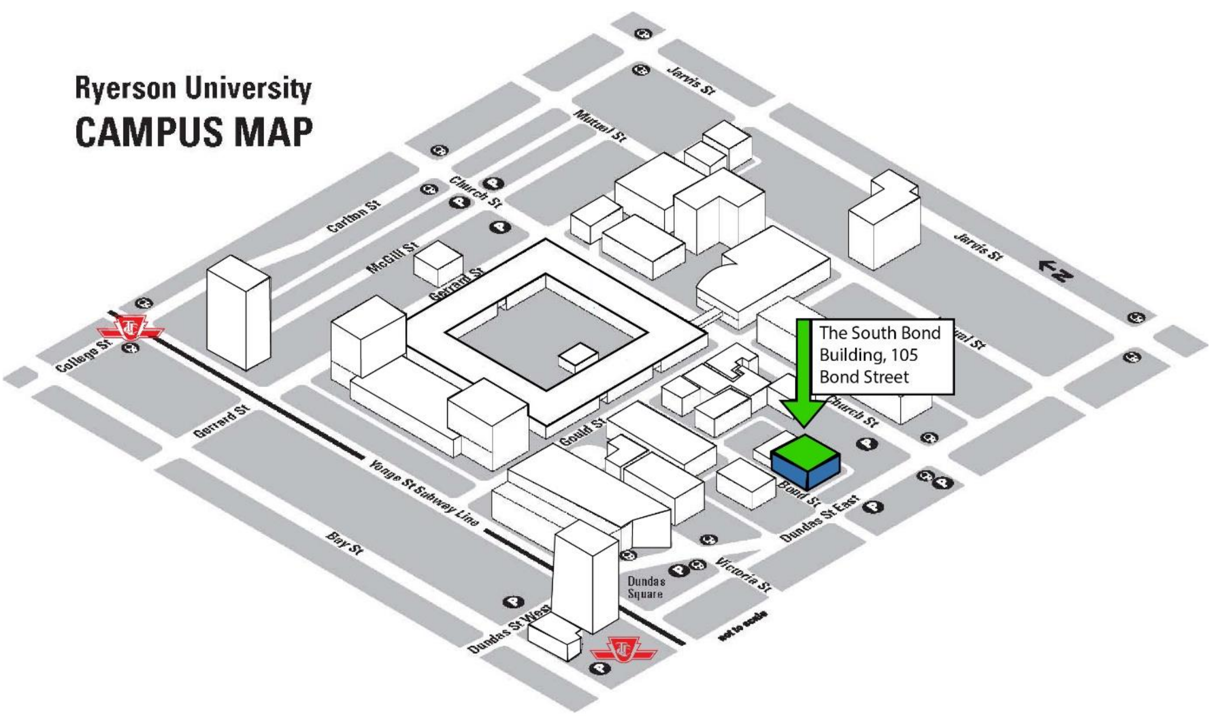


Figure 2 – a map illustrating 105 Bond's location in terms of the University Campus. Prepared by the author utilizing files from Ryerson University and Adobe Illustrator.

The image above places 105 Bond Street in the context of Ryerson University's already dense, downtown-integrated campus. As a heritage structure 105 Bond has limited room for vertical growth compared to its neighbours (Compass Construction Resources LTD., 2021). This means that innovative design solutions that respect the façade while maximizing density will need to be considered. A green roof is one such solution for growing the building as it does not interact with the façade, save for the parapet. Research indicates that even the simplest, most cost-efficient green roof would produce energy, air pollution reduction, and stormwater savings (Clark, Adriaens, & Talbot, 2008). A green roof at 105, regardless of typology, would provide a number of campus and School-wide benefits. Greening a roof is a key element of beautifying what has traditionally been a grey campus, in addition to the savings outlined above (Ryerson University, 2019). However, due to the two-tiered nature of the roof a precise approach must be taken to identify distinct usages for each tier that carefully consider liability and safety concerns.

Ryerson University will benefit from this project in several ways. Firstly, the proposed development aligns with the direction given in the 2020-2030 Campus Master Plan, which is in turn informed by higher orders of planning documents. Secondly, green roofs are proven to generate operating cost savings through maximizing the efficiency of the energy-air-stormwater nexus. Thirdly, due to 105 Bond's existing LEED© gold certification any improvements to overall efficiency will only strengthen a sustainability-focused narrative for marketing purposes. Fourth, Green Roofs have proven benefits for enhancing community wellbeing, mental health, and feelings of connectivity. These are all principles that Ryerson University seeks to enhance through innovative, density-focused developments. Finally, 105 Bond's roof is currently in a state of disrepair, which conveys inefficiencies onto the building's HVAC systems. Research proves that retrofits such as the one proposed are in fact best timed to coincide with the natural end of a conventional roof's lifecycle. In the case of 105 Bond this deadline is rapidly approaching.

2/ Making the Case: A Green Roof at SBB

The City of Toronto is one of North America's leaders in green roof design and implementation. In 2006, following a study commissioned by the City and produced by a Ryerson University team, Toronto adopted its inaugural Green Roof Strategy (Wright, Lytle, Santillo, Marcos, & Mai, 2021). During its first two years the program would result in 30 green roofs being approved via the planning process (City of Toronto, 2021).

Since then, the City has made Green Roofs mandatory on any new builds greater than 2,000 square metres (City of Toronto, 2021). What's more, between 2006 and 2018 a grand total of 620 green roof projects had been permitted at an estimated 500,000 square metres of roof area either completed or planned (Peck, 2019). After the first set of 30 permits were issued the City deemed the program successful enough to create an offshoot: The Eco-Roof Incentive Program (City of Toronto, 2021). This program, to be discussed in detail under **Section 9.2**, resulted in 73 green roofs and 353 reflective roofs (Peck, 2019).

Due to intense development interest and a rapidly growing population Toronto is only becoming a denser, more vertical city. Space is already at a premium, which has been represented by low vacancy rates and high cost of living. When it comes to the campus, however, Ryerson University itself acknowledged that the current built form at the campus-core level is mid-rise, the most notable recent exception being the Daphne Cockwell Centre for Health Sciences. This is largely out of line with current development trends in the City, as illustrated below through 3D massing. The black buildings are properties owned and operated by Ryerson University, while the magenta and violet structures represent newer developments (Ryerson University, 2019).

Figure 3 – a 3D massing assessment included in the Campus Master Plan, indicating density contexts surrounding the downtwo-core campus (Ryerson University, 2019).

This means that structures with heritage considerations like 105 Bond will likely remain roughly the same height barring another full renovation and corresponding vertical expansion while preserving the façade. If Ryerson's Campus intends to grow at a pace equal to that of the city then 105 Bond will eventually become a highly visible grey, mechanically dominated roof unless something is done. In addition, the type of dense urbanization Toronto and Ryerson are experiencing tends to increases stress on both public and private utility services such as energy, water and sewer systems (Clark, Adriaens, & Talbot, 2008). Green roofs play a key long-term role in increasing a given city's resilience to climate change (Shafique, Kim, & Rafiq, 2018). Taken together, this suggests that an effectively implemented green roof will produce cost savings for both the City and the University over time while increasing elements of pedestrian to place connectivity through intelligent design and wayfinding.

As an integrated campus Ryerson University shares many of the same development needs as the city. This has translated into a dedicated push at Ryerson University for denser, vertically-inclined spaces that have clearly communicable pathways (Ryerson University, 2019). In its new 2020-2030 Campus Master Plan, Ryerson University identifies its primary objective as guiding growth and facilitating placemaking initiatives to create a fulfilling, inclusive and accessible student experience on campus. Due to limited surrounding real estate Ryerson has identified three prongs to guide this push to the 2030s.

The University is seeking projects that increase verticality, provide more green space on what has been a traditionally grey campus, and facilitate interconnectivity between students of all walks of life through enhanced wayfinding and placemaking (Ryerson University, 2019).

The objective of this paper is to propose a green roof that would serve as (1) a holistic meeting space for students, faculty and school-side donors or stakeholders on its lower tier along with both (2) a native pollinator garden, and (3) research and food production beds on the upper tier. This feasibility study will assess and consider the research on various types of green roofs to recommend a suitable option for the Dean of the Faculty of Community Services, the Provost, and Facilities Management and Development.

Ultimately this project shows that 105 Bond Street, the home of the School of Urban and Regional Planning, is an ideal location for the installation of a green roof assembly split across the lower tier, hereafter referred to as tier-1, and the upper tier, hereafter referred to as tier-2. Furthermore, this paper argues that splitting the usages described above across these tiers will lead to a more precise project that will allow for growth over the next decade. For more information on how and why these tiers were separated please see **Section 5/ SBB Site Context.** In addition to the ideal direction described above several scaled-back options have been provided under **Section 10. 4 / Scenario Summary and Conclusion**.

3/ Policy Alignment with the 2020-2030 Master Plan

Toronto's green roof policy landscape is largely defined by the City of Toronto rather than the province.

The Provincial Policy Statement (PPS) provides high-level policy direction to guide development of green roofs specifically. Firstly, it encourages planning authorities to promote green infrastructure as a compliment to regular growth (The Government of Ontario, 2020). The PPS makes special mention of the necessity to prepare for the expected stormwater system stress increases due to climate change as well, under Section 1.6.6.7. (c). Likewise, subsection 1.8.1 states that planning authorities must support energy conservation and efficiency improvements that promote several key government-wide objectives. For the purposes of a Green Roof at 105 Bond Street only a few of these apply. In particular, the PPS encourages mandates that planners should: (1) promote compact form, (2) promote design and wayfinding in such a way to maximize energy efficiency and conservation, and (3) maximize vegetation within settlement areas wherever feasible (The Government of Ontario, 2020). This is also reflected in detail in the Planning Act. Under section 1.2 Provincial Administration it notes that the Minister, council of a municipality, local board, or planning board and tribunal shall protect ecological systems, prioritize efficient energy conservation as well as water, and aid in the mitigation of green house gases (GHGs) in the age of a changing climate (The Government of Ontario, 2020). In short, projects such as the proposed green roof at 105 Bond should consider the energy-air-stormwater nexus in addition to providing innovative, compact solutions with a high degree of vegetated cover.

At the municipal level, the City of Toronto offers significantly more guidance on key aspects of green roof implementation and planning. The two most pertinent documents for green roofs are the Toronto Green Roof Construction Standard and the Design Guidelines for Biodiverse Green Roofs (City of Toronto, 2021). These guidelines lay out best practices for maximizing biodiversity and compact-form while meeting health and safety guidelines and conforming to the Ontario Building Code itself. These rules and regulations are important as they define the amount of roof that must be covered with vegetation based upon gross floor area (City of Toronto, 2021). They also outline key permitting aspects to the project. For instance, a retrofit such as the one proposed at 105 Bond Street means that the permitting fee will be equal to the "Re-Roofing with structural work, raise roof structure" permit cost (City of Toronto, 2021).

Finally, at the campus scale Ryerson University is currently seeking to accomplish many of the same directives. It bears mentioning that due to its nature as an integrated campus—meaning one that blurs the line between anchor institution and its surroundings—Ryerson University is experiencing many of the same pressures that have produced the above policy considerations. In the 2020-2030 Campus Master Plan the University identified that projected enrollment cannot be accommodated with the current density on campus. New facilities such as classrooms, research space, and social and support spaces – to name a few – will be needed by 2030 and beyond (Ryerson University, 2019). Given the integrated nature of the campus with surrounding residential, office, and mixed-use buildings it will be important for the University to grow up as much as out. The 2020-2030 Campus Master Plan also puts forward three main objectives to support campus growth over the decade. Firstly, Ryerson encourages increased verticality on campus – this is partly due to limited surrounding real estate for expansion. Second, the University should increase pedestrianization through improved intra-campus connectivity and wayfinding. Third, the school should endeavour to make sure that projects undertaken to facilitate the previous objectives are grounded in design excellence that leads to a distinct architectural identity for the University (Ryerson University, 2019).

4/ Review of Literature

Research surrounding green roofs has grown exponentially over the last two decades. Although originally implemented in post-war Germany during the 1950s, Green Roofs are now becoming progressively more ubiquitous internationally (Shafique, Kim, & Rafiq, 2018). Green roofs tend to generate benefits through reducing energy consumption, stormwater management, increased biodiversity, and reduced air pollution (Clark, Adriaens, & Talbot, 2008).

Generally, there are three broad categories of green roofs. Extensive green roofs offer minimal soil substrate and by and large require little to no on-going maintenance. They tend to have a thin soil layer dominated by hardy sedums and moss species to function as a self-sustaining system (Fabricio & Kasun, 2012). These kinds of roofs are popular due to their low-effort maintenance; however, they offer correspondingly lower functionality as well. Importantly, extensive roofs typically have low soil depth in the substrate medium. The complexity of green roofs in terms of cooling and soil depth can be best represented by the diagram below.

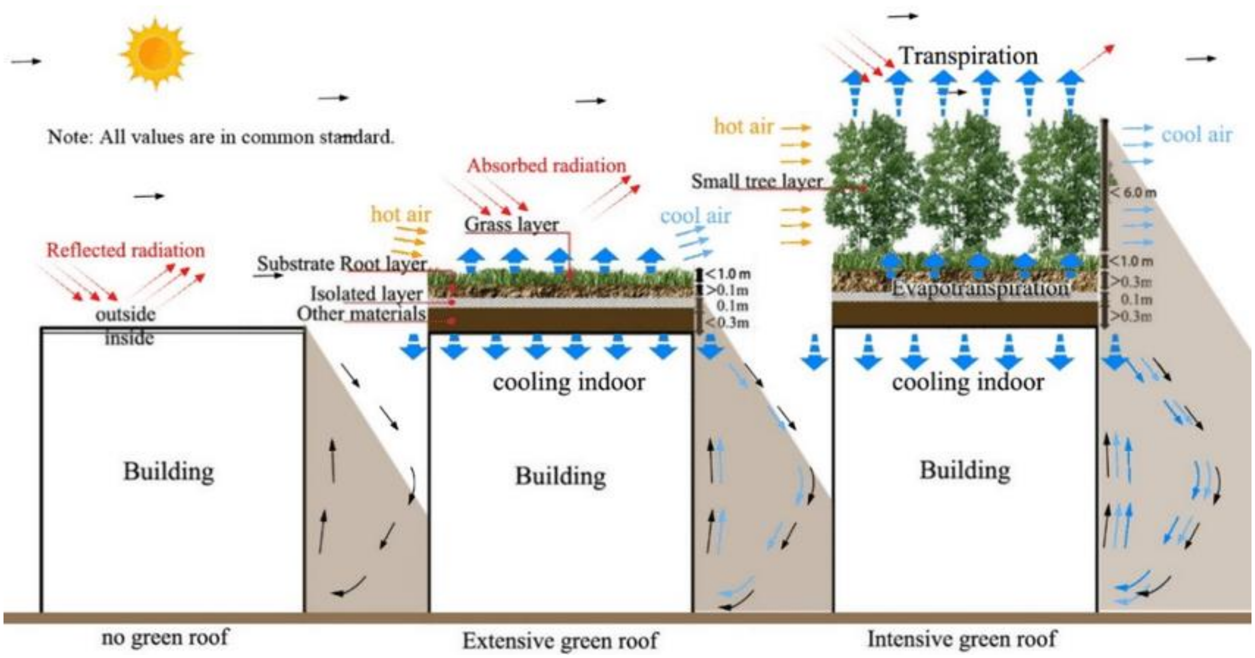


Figure 4 – an illustration of the differences between no green roof, an extensive roof, and an intensive roof. This diagram also showcases the improved evapotranspiration, or the process where water moves from land to atmosphere via plants, when examining intensive green roofs (Zhang, He, Zhu, & Dewancker, 2019).

Although substrate, or soil depth, varies depending on the region intensive green roofs always have deeper beds than extensive green roofs. Meanwhile, semi-intensive green roofs use a combination of extensive beds and intensive beds depending on site context. Intensive roofs, as the name suggests, have a higher intensity of usage and corresponding load increase when compared to extensive roofs. They require reasonable soil depth for root system uptake and support from skilled labourers in addition to irrigation features and maintenance (Fabricio & Kasun, 2012). Finally, semi-intensive roofs are defined by limiting any extensive green roof beds to no more than 25% of the total roof area (Fabricio & Kasun, 2012). Pursuing a semi-intensive typology may be particularly beneficial due to the limited functionality of tier-1 of the roof. Here, extensive beds can provide a low-cost beautification and energy-air-stormwater feature that can be the foundation for further growth. For instance, the Ryerson Urban Farm planted *Hemerocallis Liliasphodelus,* or Daylilies at an early stage in the farm's development. Over the following decade, prior to produce production, these Daylilies created their own robust ecosystem that led to a corresponding increase in soil quality for produce growing (Throness, Personal Communication, 2021). In terms of weight increases an extensive roof can add 9.1 kg per square foot while a complete intensive roof assembly, including shrubs up to 1-metre tall, can add up to 27.2 kg per square foot (Dettweiler, Personal Communication, 2021).

Meanwhile, substrate depth is particularly important in the Canada context. Research shows that deeper substrates are more effective in winter climates such as in Canada (Sailor, Elley, & Gibson, 2011). Given this, it is possible to look closer to home for inspiration. Researchers in Quebec, for instance, discovered that substrate depth directly mitigates the risk of root systems sustaining freezing injuries. Based on Quebec's climate they suggested a minimum substrate depth of 4cm to 10cm (Boivin, Lamy, Gosselin, & Dansereau, 2001).

	Soil Depth					
	5cm	10cm	15cm	5cm	10cm	15cm
Plant Species	Winter Damage Severity (1995-96)			Winter Damage Severity (1996-1997)		
Ajuga reptans	3.15	**2.25**	2.55	4.65	**3.00**	1.75
Arenaria verna	2.20	**2.25**	3.00	2.30	***1.50***	*1.80*
Armeria maritima	4.20	**2.65**	2.65	2.60	**4.55**	3.90
Draba aizoides	3.95	**3.95**	3.40	4.40	**4.05**	3.20
Gypsophila repens	2.75	**1.90**	1.65	2.60	**1.70**	1.10
Sedum xhybridium	4.00	**1.60**	1.65	4.00	**1.60**	1.60

Table 1 – this table showcases on a scale of 1-5 a species' survivability during Quebec Winters. A score of 1, or close to it, indicates that the leaves were 100% green following the study period. Meanwhile a value of 2 indicates that 75% of the plant is

alive, a value of 3 indicates 50%, a value of 4 indicates 25%, and a value of 5 indicates complete plant death (Boivin, Lamy, Gosselin, & Dansereau, 2001).

The results of Boivin, Lamy, Gosselin and Dansereau's research indicate that, in most cases, the 10cm beds performed best – as indicated by the bolded values. However, this was not always the case as each perennial under study had unique cold responses. For instance *Armeria maritima*, otherwise known as whitlow grass, reacted severely to yearly variations in temperature. During a milder winter roughly 75% of the plant survived while a harsher winter the following year nearly killed the plant completely (Boivin, Lamy, Gosselin, & Dansereau, 2001). Examining which plants will perform best on a green roof requires additional, case-specific research for the Ontario context. However, given the intensity of Quebec winters this may act as a strong, initial guideline for a minimum substrate depth of 4cm, with an ideal depth of 10cm. In terms of energy, green roofs actually perform best in cold climates that require heating after dark (Sailor, Elley, & Gibson, 2011). Additionally, the majority of green roofs around the world are located in colder climates (Shafique, Kim, & Rafiq, 2018).

The sample image below showcases the 4-6 distinct layers that can make up a vegetated bed.

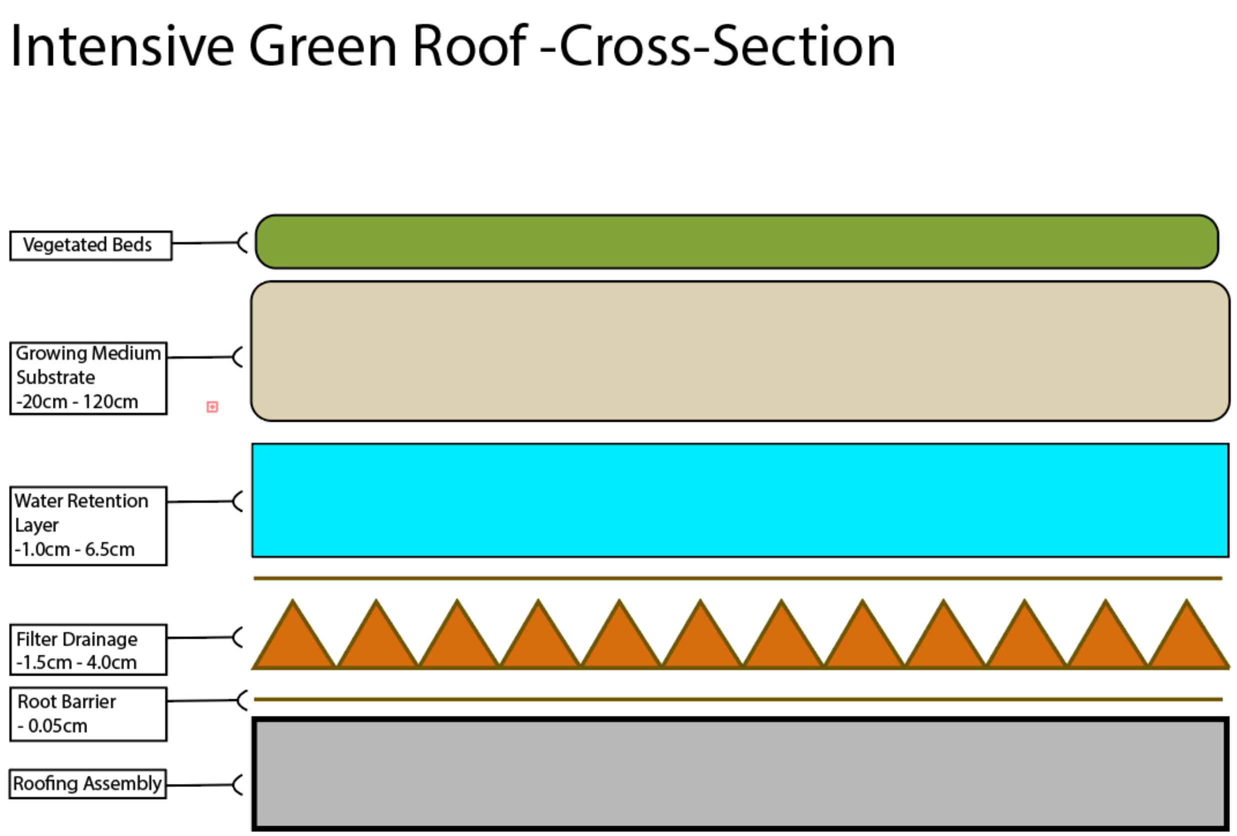


Figure 5 – This composite image prepared by the author summarizes some of the measurements most commonly associated with intensive green roofs. However, substrate depth and many of these factors should be considered relative to the specific climatological conditions in Toronto.

The filter drainage later and roof barrier are occasionally rolled into a single measurement, as are the vegetated beds and growing media substrate. Soil depth, or substrate medium, is one of the most important considerations for any green roof. The following sections will examine energy-based considerations, including insulation, resiliency features, stormwater benefits, and air pollution considerations.

4.1 / Green Roofs Produce Energy Savings

One of the most important factors about a green roof's efficiency is its substrate depth. This is tied directly to the way that green roofs can save on energy-associated costs in a given structure. Green roofs have many well-established benefits. They reduce energy demand for heating and cooling, thereby mitigating the urban heat island effect generated by cities (Fabricio & Kasun, 2012). Green roofs can also reduce peak pricing during the daytime through reducing solar load and additional insulation from soil depth (Sailor, Elley, & Gibson, 2011). This is particularly relevant if Facilities Management and Development chooses to pursue Hydro One's *Save on Energy* program, to be discussed under **Section 9.5**.

One of the biggest benefits of a green roof is the reduction in the Urban Heat Island Effect. This refers to the difference in ambient air temperature between urban areas and nearby, climatically similar rural or peri-urban environments. Conventional roofs tend to have surfaces that absorb and retain a significant amount of heat. The roof at 105 Bond shares many of these characteristics, such as black flashing and dark gravel (TREMCO, 2013). This attracts additional solar radiation, which in turn increases HVAC load through compounding energy demands and air-conditioning costs (Fabricio & Kasun, 2012). However, it is important to note that HVAC load tends to account for less than 50% of the total energy use in a building (Sailor, Elley, & Gibson, 2011). Another important caveat to the energy savings discussion is to acknowledge that a significant amount of the HVAC load is determined through windows and walls in addition to the roof. This means that a green roof alone is not capable of solving outstanding maintenance issues or air leaks in older buildings, for instance (Sailor, Elley, & Gibson, 2011). Typical measures for urban heat island reduction are utilizing green roofs, cool roofs, and white roofs to generate energy savings. Cool roofs function similarly to green roofs, but instead prioritize heating and energy savings through reflective coatings or thermoplastics (Pisello, Piselli, & Cotana, 2015).

The research suggests that even a simple extensive roof can lead to an overall decrease in Net Present Value (NPV) of 20.3% to 25.2% over the green roof's 40-year lifespan when compared to 40-years with a conventional roof, assuming a full conventional roof replacement at 20-years (Clark, Adriaens, & Talbot, 2008). The assumption that conventional roofs will need to be replaced once during a 40-year period is present in other literature as well (Niu, Clark, Zhou, & Adriaens , 2010). This second, shorter lifecycle directly impacts the materials costs associated with conventional roofs versus green roofs. Finally, note that the R-value described below refers to the per unit area of thermal resistance, sometimes denoted as an RSI value.

Benefit Scenario	Conventional Roof NPV at 40-years	Green Roof NPV at 40-years	Percent Change in NPV
R-value; mean stormwater	$613 969	$468 366	23.72
R-value; high stormwater	$619 828	$463 944	25.15
low air valuation; R-value; mean stormwater	$613 969	$443 644	27.74
low air valuation; R-value; high stormwater	$619 828	$439 222	29.14
high air valuation; R-value; mean stormwater	$613 969	$374 611	38.99
high air valuation; R-value; high stormwater	$619 828	$370 190	40.28

Table 2 – This table showcases the changes in NPV depending on different combinations of varying R-values, air valuation, and precipitation caused by peak stormwater events (Clark, Adriaens, & Talbot, 2008).

Table 2 presents a variety of scenarios using a combination of insulation benefits, Nitrogen Dioxide (NO_2) reduction through air pollution uptake, and stormwater savings. When considering these factors the NPV of a green roof can be discounted by as much as 40% under the final scenario in the table when compared to a conventional roof. Importantly, the NPV of conventional roofs only ever exceeds the NPV of a green roof when assuming a replacement at the 20-year benchmark (Clark, Adriaens, & Talbot, 2008).

Ultimately, this shows that over 40-years green roofs will cost substantially less than conventional roofs primarily due to energy efficiency, air quality, and stormwater savings (Clark, Adriaens, & Talbot, 2008). Overall roofing energy efficiency can be thought of in the following order from lowest annual energy cost to highest; green roofs with a high amount of vegetated cover were followed by white roofs, baseline (extensive) green roofs, and conventional roofs (Sailor, Elley, & Gibson, 2011). Clark, Adriaens and Talbot also note that the health and energy related benefits described above help alleviate the initial up-front costs associated with building a green roof. The literature further indicates that intensive roofs and semi-intensive roofs will outperform the values for extensive roofs outlined above, provided both air pollution reduction and energy savings are taken into effect. Adding the social benefits of a green roof, such as connectivity to place and respiratory health for example, are also key social co-benefits of installing a green roof. Research conducted by Bianchini and Hewage noted that, "when social benefits are considered, the financial loses of intensive green roofs become insignificant." Finally, it is important to recall that when these benefits are analyzed together green roofs emerge as low financial risks with high potential profits split across both social and economic subtypes (Bianchini & Hewage, 2012).

Clark, Adriaens and Talbot constructed their energy modelling scenario based upon Ann Arbor, Michigan. Like Toronto, Canada Ann Arbor shares significant temperature swings during between the summer and winter. The National Oceanic and Atmospheric Association provides the following yearly averages for Ann Arbor:

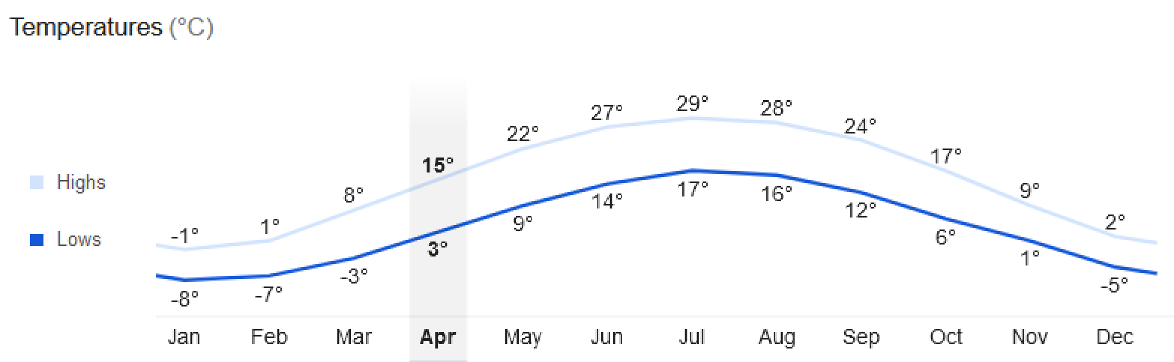


Figure 6 - National Oceanic and Atmospheric Administration, Ann Arbor, MI

While the City of Toronto had the following yearly averages.

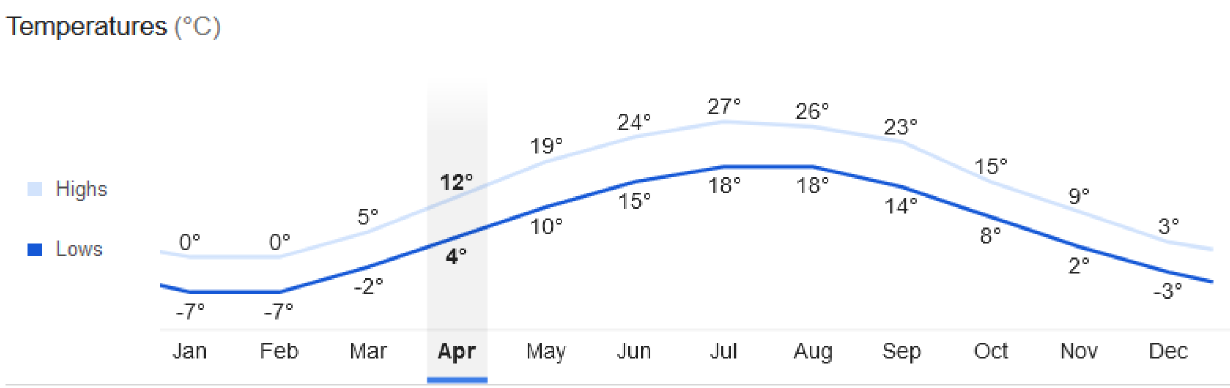


Figure 7 - National Oceanic and Atmospheric Administration, Toronto, ON

Based on the above, Ann Arbor Michigan experiences higher summer temperatures than Toronto on average and slightly colder winter temperatures. This suggests that the modelling conducted by Clark, Adriaens and Talbot can likely be applied to the City of Toronto. Local research also supports these findings. For instance, green roofs in Toronto have been found to potentially reduce summer heat exchanged from the roof substrate to the indoor environment by 90% during the summer. The same study also identified that indoor heat loss during the winter was reduced by up to 30% when compared to a conventional roof (Sookham, Margolis, & MacIvor, 2018).

As such, this project should consider an ideal roof thermal resistance, or R-value, of r=20 (Landry, Personal Communication, 2021). Thermal resistance is yet another important factor in energy savings and one that results from a combination of insulation levels relative to climate (Sailor, Elley, & Gibson, 2011). In the US, reroofing projects or retrofits tended to have an r value of r=12.4. This is further evidence that green roof retrofits are preferred options (Sailor, Elley, & Gibson, 2011). Vegetated beds can also provide additional insulation through robust foliage and substantial substrate depth (Clark, Adriaens, & Talbot, 2008).

4. 2 / Soil Depth, Insulation and Winter Resiliency

When discussing the thermoregulatory capacity of a green roof it is important to consider soil depth, vegetated canopy cover, and plant species. Although all three criteria are important, research has shown that plant selection is the the most significant factor in cooling during the summer and heat retention during the winter. This is partially because green roofs are extreme microclimates for plants. They are subjected to higher wind speeds, temperatures, and solar radiation compared to vegetation at ground level. (Sookham, Margolis, & MacIvor, 2018). Typically, hardy species such as sedums, mosses or the like are selected for extensive, or shallow, beds. During the summer months extensive beds with an above average soil depth of 15cm were found to be most effective at cooling buildings during the summer (Sookham, Margolis, & MacIvor, 2018). Installations like Intensive beds, meanwhile, allow for greater soil depth to house the denser root systems of grasses or herbaceous plants (Shafique, Kim, & Rafiq, 2018). The soil used for these beds should ideally be fine-textured and rich in organic matter to best promote both moisture and nutrient retention (Sookham, Margolis, & MacIvor, 2018).

During the Winter months both extensive and intensive beds undergo significant changes. Extensive roofs are already cold tolerant; however they can be optimized to produce stronger effects with careful plant selection. For instance, targeting evergreen succulents such as *Sempervivum*, otherwise known as Hens and Chicks or Houseleek, will produce more efficient temperature regulation (Fabricio & Kasun, 2012). This is because *Sempervivums* leaves shift from green to red or burgundy during the exposure to cold. As a result of this change the *Sempervivums* intentional reduce their photosynthesis capacity and increasing their solar absorption, thereby warming the plant canopy and improving cold tolerance (Sookham, Margolis, & MacIvor, 2018). This process is accomplished through using a Crassulacean Acid Metabolic response (CAM) to modify behaviour. These plants exchange carbon and oxygen during the dark periods, such as on long Canadian nights (Fabricio & Kasun, 2012). Research indicates that *Sedums* may maintain active photosynthesis for between four months to two years depending on climactic conditions (Shafique, Kim, & Rafiq, 2018). Meanwhile, intensive beds are much more likely to undergo seasonal plant death due to mixing a variety of perennials, produce, grasses, and herbaceous plants. Despite all appearances, this is in fact an opportunity. By strategically planting grasses with the intention of letting them expire the University can increase the biomass density separating vegetation from substrate. Dead plant matter acts as an excellent snow trap, leading to greater insulation values due to the increased degree of separation between the snow and the roof base (Sookham, Margolis, & MacIvor, 2018).

Based on the research conducted in Quebec four initial species were identified for an extensive bed with a minimum depth of 4cm (Boivin, Lamy, Gosselin, & Dansereau, 2001) and a maximum potential bed depth of 10-15cm depending on climate conditions (Sookham, Margolis, & MacIvor, 2018). These include *Ajuga reptans*, *Arenaria verna*, *Gypsophila repens*, and *Sedum xhybridium* (bugleweed, sandwort, creeping baby's breath, and stonecrop respectively). These plants all responded well to the proposed 10 cm depth (Clark, Adriaens, & Talbot, 2008). *Sedum xhybridium* and *Sedum* *spathulifolium* in particular are appealing as they both undergo the same CAM response as *Sempervivums* (Sookham, Margolis, & MacIvor, 2018). Likewise, intensive beds offer a number of appealing species that support the energy-air-stormwater nexus. For example, *Achillea millefolium* (Yarrow) and both *Festuca rubra* and *Festuca arundinacea* (red fescue and tall fescue respectively) develop the highly desirable canopy described above provided they utilize an organic growing medium (MacIvor, Margolis, Puncher, & Matthews, 2013). Choosing the correct vegetative cover Meanwhile, air pollution can be reduced in two ways through a green roof; (1) by reducing heat and cooling demands a green roof can drive down the carbon footprint of the site, and (2) the process of photosynthesis sequesters carbon that is then stored as biomass in the plants themselves (Fabricio & Kasun, 2012).

Figure 8 – a hummingbird feeds on a bright red flower (David Suzuki Foundation, 2021).

Installing a green roof at 105 Bond also allows for the University to take initiative when it comes to biodiversity by prioritizing native pollinator species through careful plant selection (Fabricio & Kasun, 2012). The former can be accomplished through courting native pollinator species as part of the vegetation selection process. In Ontario this refer to butterflies, hummingbirds, bees, and wasps – among others (David Suzuki Foundation, 2021). Pollinators are a key aspect of maintaining the health of a green roof. Making sure that they have a rotating array of flowering plants during the Spring to Fall growing season will benefit the entire garden (Throness, Personal Communication, 2021).

Figure 9 – a monarch alights upon a thistle in search of nectar (David Suzuki Foundation, 2021).

Figure 10 – Bee baths located near a pollinator garden allow for an easy and effective resting place for a cool drink after a long flight (David Suzuki Foundation, 2021).

Creating space for pollinators can be as simple as installing a bee bath, as seen to the bottom left. In addition, hummingbirds can be courted through bright red flowers such as *Alceas* (Hollyhocks), *Hibiscus rosa*-sinensis, summer *Phlox*, or *Salvia officinalis* (garden sage) (David Suzuki Foundation, 2021). Aside from these specific examples wildflowers, long-growing drought tolerant plants, and alpines are most suitable for a pollinator garden with an expected soil minimum soil depth of at least 10cm. Meanwhile, produce beds are expected to have a soil depth of 10-20cm based upon the necessity for well-protected root networks (Shafique, Kim, & Rafiq, 2018). Any additional shrubs or the like may exceed this height. Of special note here are *Helianthus* annuus, or the common sunflower. These act as appealing "beacons" to pollinators and serve the dual purpose of beautifying their environment (David Suzuki Foundation, 2021). Finally, vegetated beds designed for produce production also provide higher insulation values than other comparable beds. (Wright, Lytle, Santillo, Marcos, & Mai, 2021). This is largely accomplished through a dense canopy, something that is also achievable during the summer pollinating months.

4. 3 / Water Quality and Stormwater Management

One of the most significant impacts of climate change in Canada is an anticipated increase in precipitation over the next century. Some estimates suggest that Ontario could experience an increase of between 20-40% in terms of precipitation (Government of Canada, 2019). This is important as another key benefit to green roofs is improved stormwater management practices and in some cases an increase in water quality that can lead to domestic water savings (Clark, Adriaens, & Talbot, 2008). Due to the expected precipitation increases as a result of climate change it is imperative to maximize the efficiency of Ryerson University's rooftop stormwater network. Intensive green roofs that have grasses and herbaceous flowering plants are particularly effective at mitigating stormwater runoff (Sookham, Margolis, & MacIvor, 2018).

Green roof systems with a well-built drainage layer enhance both overall energy and stormwater efficiency, while also supporting the overall resiliency of the roof. Resiliency can be thought of as asking, "how prepared is this structure for an extreme event?" In the Canadian context this primarily refers to mitigating the risks surrounding peak precipitation events and extreme cold. This is accomplished through retaining stormwater runoff through the drainage layer, which delays the movement of water from roofs to streets and then into sewer or sanitation systems (Wright, Lytle, Santillo, Marcos, & Mai, 2021). This can be especially useful during peak rain events such as 25-year or 50-year storms. The longer water is retained at the roof level the less load is added to city sanitation systems. Studies show that green roofs can retain up to 70% of rainfall depending on climate depending on bed depth and type (Clark, Adriaens, & Talbot, 2008). This also confers insulation benefits. The University can take advantage of this by integrating an irrigation system into the Green Roof. Generally speaking, supplemental irrigation has the greatest impact on grasses and herbaceous plants when compared to *sedums*, succulents and mosses (Sookham, Margolis, & MacIvor, 2018).

The angle that vegetated beds are set at has also been found to affect water retention rates. Generally speaking, vegetated beds with a 2% angled-slope and a minimum 4-cm media depth produce up to a mean water retention of 87%. By comparison, traditional gravel systems maintain a mean retention rate of 48.7%. Sailor, Elley and Gibson utilized one gravel test bed, an extensive bed, and an intensive bed in their testing – as illustrated graphically by the authors below.

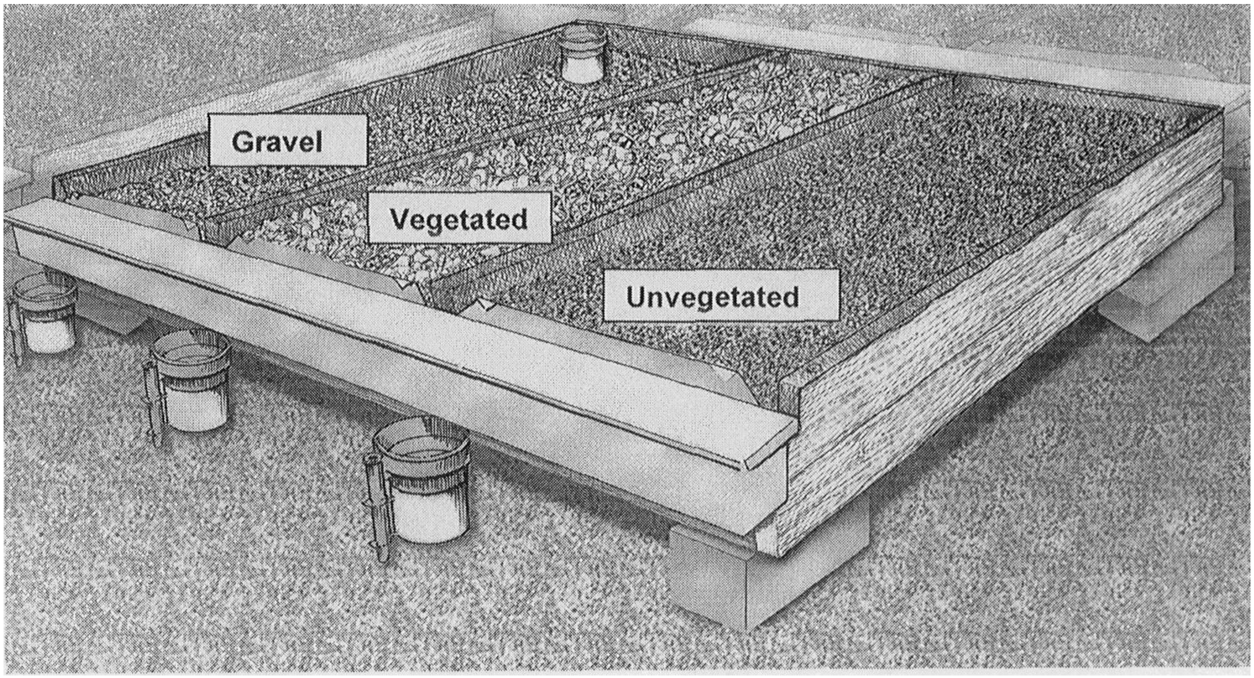


Figure 11 – This graphic illustration showcases three testing beds used to determine how the angle of a bed impacts stormwater retention. Here, buckets can be seen at drainage points for each bed (Sailor, Elley, & Gibson, 2011).

Importantly, these sloped beds allow for stormwater to not only reduce rain-event based runoff, but also provide extended benefits beyond the rain-event itself (VanWoert, Rowe , Anderson, Clayton, & et al, 2005). This can be accomplished through retaining water from peak and medium-range precipitation events for irrigation or purification purposes (VanWoert, Rowe , Anderson, Clayton, & et al, 2005). Dense canopy covers aids in this water capture (MacIvor, Margolis, Puncher, & Matthews, 2013). As the proposed media depth is a minimum of 4cm to 10cm it is likely that the project will exceed these numbers, provided adequate irrigation-collection tools are in place. The addition of additional drainage and stormwater retention systems will also naturally increase rooftop insulation (Sailor, Elley, & Gibson, 2011). The combination of angled beds, an irrigation system, and a mix of grasses and herbaceous plants should produce a significant amount of stormwater retention, which will contribute to plant health and survivability (Sookham, Margolis, & MacIvor, 2018). This increase in plant cover leads to corresponding increases in stormwater retention and optimized thermoregulatory benefits (MacIvor, Margolis, Puncher, & Matthews, 2013).

With that said any irrigation system, will involve post-installation maintenance even one designed to optimize runoff irrigation potential. Research conducted at the University of Toronto's GRIT lab indicates grasses and herbaceous plants, as discussed under **4. 2 / Soil Depth Insulation and Winter Resiliency**, actually reduce this on-going maintenance burden. This is accomplished through a more robust substrate depth and type as well as the natural benefits of irrigation in terms of plant health. (Sookham, Margolis, & MacIvor, 2018). Plant survival is tied directly to the outcomes discussed above. As such maximizing survivability results in the offloading of certain burdens from Facilities Management and Development.

5/ The 105 Bond Building & Site Context

Originally purchased by the University in the mid-70s, 105 Bond Street is a City of Toronto designated heritage structure. This means that any development applications, including for a green roof, must be considerate towards the façade of the building. In the context of a green roof installation this will most likely take the form of examining the sightline impact of both changes to the parapet and any unclimbable fences installed for liability protection. Suffice to say, the School of Urban and Regional Planning has been considering the possibility of a green roof since the faculty moved into 105 Bond in 2006-2007.

The structure itself is 3.5 storeys tall with only tier-1 directly accessible via the elevator, and tier-2 accounting for the additional half storey. Calculations indicate that the roof's gross floor area is approximately 1,475 square metres. A structural summary provided by Facilities Management and Development likewise indicates that the net building area is over 4,645 square metres.

The School of Urban and Regional Planning has already achieved extensive, heritage-status consistent redevelopments following the purchase of 105 Bond Street. In 2007 the South Bond Building underwent significant interior renovations and the addition of a wheelchair accessible entrance, some of which are depicted below. It is important to note that Ryerson's Department of Psychology shares this space with the School of Urban and Regional Planning. As such any green roof would ideally benefit this faculty as well through the development of a shared vision during consultations.

Figure 12 – Above are a series of image showcsing the 2006-2007 renovation, which resulted in a LEED© Gold Certification (Compass Construction Resources LTD., 2021).

These alterations were done in conjunction with Facilities Management and Development, Compass Construction Resources Ltd., and Farrow Partnership Architects Incorporated (Compass Construction Resources LTD., 2021).

All in all, this retrofit covered almost 6,503 square metres of redevelopment work at a contract valuation of 10,400,000 dollars. This process included the relocation of the Department of Psychology, the School of Urban and Regional Planning and the Ryerson Shipping and Receiving Services to 105 Bond Street. This means that in addition to a personnel-class elevator, the School of Urban and Regional Planning has both a surplus of loading bay space, and direct freight elevator access to the south end of the third floor of 105 Bond. This would allow for the convenient, accessible and rapid delivery and movement of materials from the ground floor to the roof, leading to savings in labour costs. Even then, it may be possible for earth and soil to be moved from the ground floor to the roof using a blower truck as SBB is less than six storeys (Wright, Personal Communication, 2021). With that said, materials such as timber would need to utilize the existing freight elevator and loading bay at the South end of the building. In addition, the Ryerson Urban Farm has indicated that it would be willing to consider seed sharing initiatives to help get the green roof off the ground (Throness, Personal Communication, 2021).

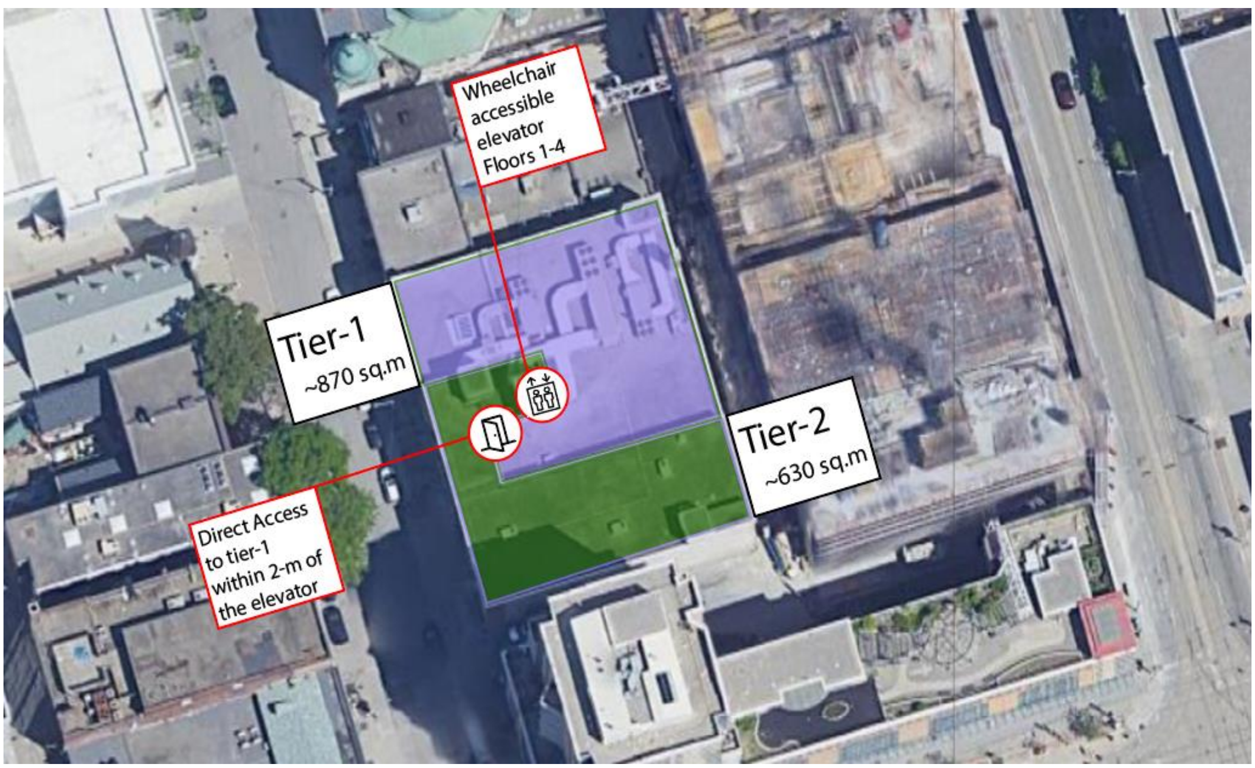


Figure 13 - An aerial overview of 105 Bond, showcasing the split between each tier. This edited image also summarizes square metres for each plot, as well as noting direct access to the roof via the door located next to the wheelchair accessible elevator.

As part of this extensive retrofit 105 Bond secured LEED© Gold certification. This was accomplished through energy saving initiatives that were tied to the extensive interior demolition efforts to better house classrooms, meeting spaces, studio classrooms, administrative offices, computer labs and support areas such as washrooms or the like.

A major aspect of this re-development was the installation of accessibility features on the ground floor. These features included wheelchair accessible ramps and buttons that lead directly to a personnel-class elevator. Importantly, this elevator goes directly to the fourth floor and is within one metre of the doorway leading to tier-1 rooftop access. This means that with wayfinding improvements there could be an easily identifiable pathway to reach the publicly accessible lower tier of the green roof. Increased visibility and pedestrian flow to green space is another consideration expressed in the 2020-2030 Campus Master Plan (Ryerson University, 2019).

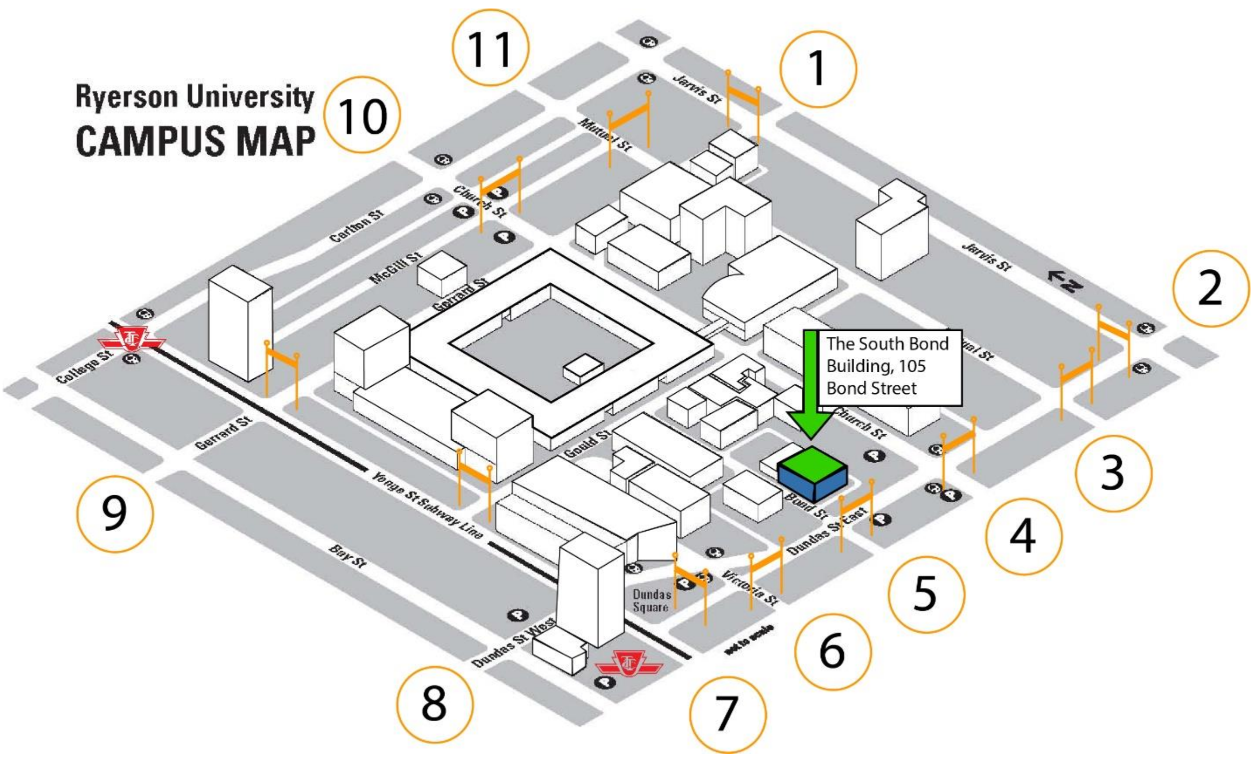


Figure 14 – An edited diagram of Ryerson University's Campus Map. This figure places 105 Bond not only in the campus context, but also considers "gateways" to the campus-core and proximity to transit.

Finally, it is important to remember that the South Bond Building abuts the natural southern bounds of the campus. Of the eleven street-based gateways, two through eight or 6/11 are located nearby to 105 Bond. In addition, the presence of a high-volume subway stop at Yonge-Dundas leads to an increase in East-moving foot traffic as students, staff and other professional move into the campus. All this to say that as long as the campus continues to grow the South Bond Building will only experience increasing adjacent foot traffic and correspondingly increased visibility.

5. 1 / 2013 Rooftop Health Audit

In 2013 Ryerson University contracted TREMCO to perform a roof audit at 105 Bond Street.

These types of report are designed to identify outstanding maintenance or materials lifecycle issues with a site. TREMCO utilized a combination of thermal mapping and on-site visits to assess the state of repair for both tier-1 and tier-2 of the roof. The roof audit discovered two wet patches of insulation on tier-1. The first, located at the North end of the building measured 5 inches by 9 inches, while the second is located on the east side of the roof near tier-2's north facing wall. These two areas are marked in cross-hatched red below.

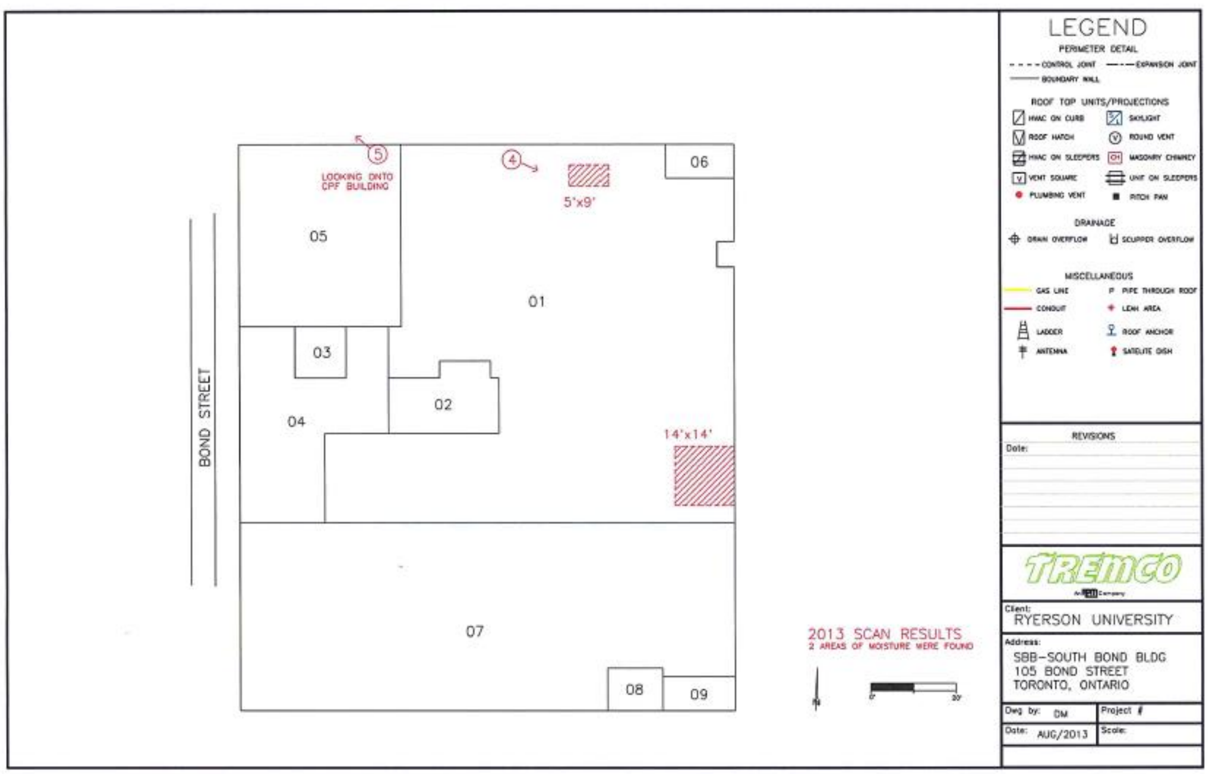


Figure 15 – This image shows the result of thermal imaging conducted in 2013 to ascertain where there was wet insulation on the roof. Note that this process was accomplished via on-sight inspection note an aerial sweep (TREMCO, 2013).

The presence of two wet pieces of insulation below the roof membrane indicate that tier-1 may need to be repaired soon, if it has not been already. In addition, the report concluded that there were flashing leaks and clogged drains across both tier-1 and tier-2. Importantly, although no wet insulation was found on tier-2 of the roof TREMCO concluded that there was significant ponding around the Modified Bitumen flashing on both currently accessible subsections of tier-2. This highlights additional insulation leak risks considering the more advanced state of disrepair on tier-1. As discussed in the literature

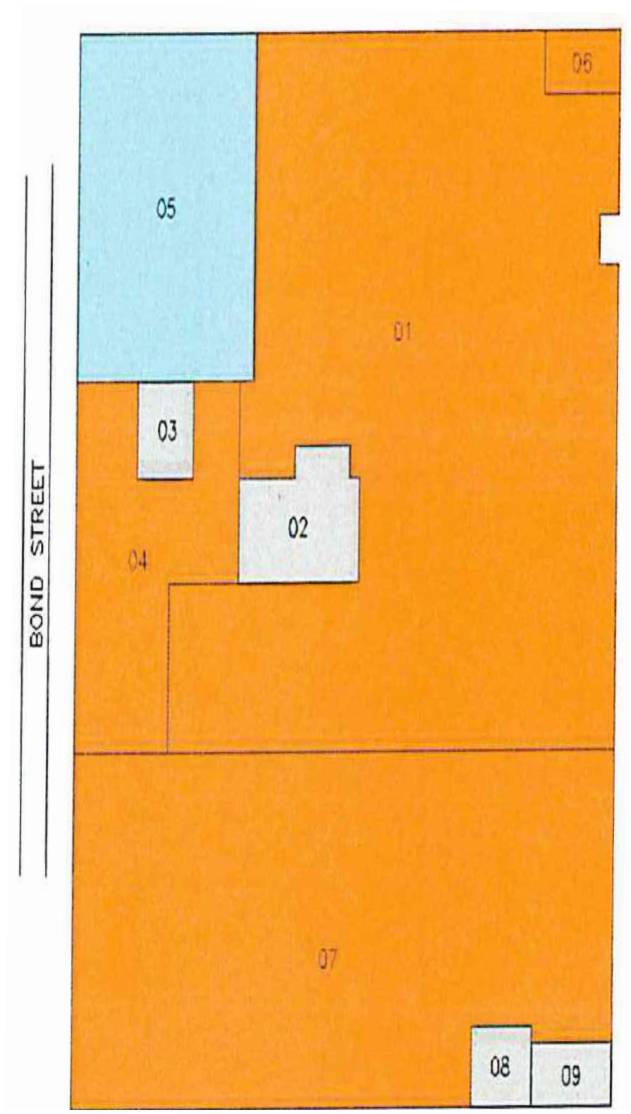


Figure 16 – This image, also from the 2013 TREMCO report, showcases the state of repair of the roof at 105 Bond.

review, timing the replacement of a conventional roof with the end of its natural lifecycle allows for maximized gains in terms of energy and air quality. That is to say, the insulation-based benefits of a green roof retrofit are inversely correlated with the quality of the existing roof installation.

Figure 16 depicts the 2013 overall rooftop quality audit conducted by TREMCO on behalf of Ryerson University. Generally speaking, the report found the roof at 105 Bond to be in poor repair – represented here by the quadrants in orange. Blue indicates sections of the roof that are in a fair state, while grey sections indicate parts of the roof where no condition was recorded. Although not displayed here, a green section would indicate a good quality of repair (TREMCO, 2013).

The only section of the roof to be found in fair repair was subsection 05, which is located some distance from the entrance to tier-1 of the roof at the elbow-bend of subsection 04. Unlike the rest of the roof, there was no significant water build up. As mentioned above, the grey areas represent parts of the roof that were inaccessible and were thus not assessed. However, a planned overhaul to the existing roof membrane with strong design sensibilities may allow for the reconnection of subsections 03, 02, 08 and 09 to tier-2. This would increase the available roof space, provided these subsections do not provide or otherwise house important operational functions for the 105 Bond Street.

Tier-2, which makes up sub sectioons03, 04, 07, 08, and 09, has its own challenges. Although both patches of wet insulation were located on tier-1, tier-2 has experienced moderate ponding and flashing loss. This means that the roof membrane itself has weakened to the point where water has passed through an impermeable barrier. These factors when combined suggest that there may be the risk of additional moisture penetration to the insulation layer – especially on tier-2 where TREMCO discovered both plant growth and extensive water ponding.

Figure 18 - Moss and lichens have already taken hold of tier-2 due to moisture retention (Compass Construction Resources LTD., 2021).

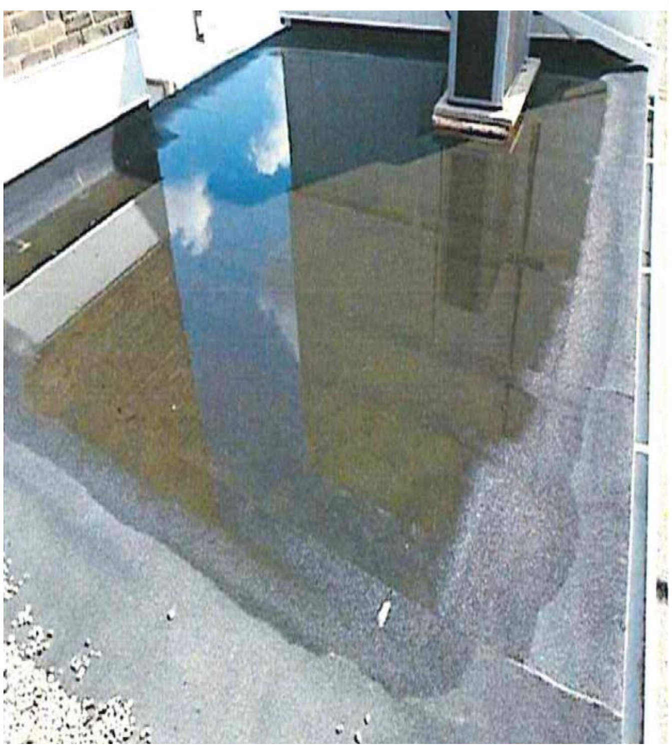


Figure 17 - Significant ponding was also discovered on tier-1 of the roof (Compass Construction Resources LTD., 2021).

The adjacent images are from the TREMCO 2013 roof audit. They showcase not only the build-up of water on the roof, but also the presence of naturally developed mosses. If rooftop moisture collection is already significant enough to produce plant life then capitalizing on the available roof area could be advantageous. Based on the research, there is the opportunity for green roofs to improve water quality through rain barrel and purification systems. This excess water can be re-directed for irrigation provided it is clean enough, thereby decreasing water demand. If this system involves water purification it is likewise possible to re-use this water to reduce domestic water consumption within 105 Bond, something that has been observed with other successful green roofs (VanWoert, Rowe , Anderson, Clayton, & et al, 2005). However, it is recommended that the benefits of irrigation for produce production and purification for domestic water savings be compared directly to determine the correct course of action.

Older structures tend to be less securely insulated and result in a correspondingly high annual energy use for cooling and warming. Retrofitting a green roof on a less efficient structure, such as 105 Bond, tends to produce the maximum resulting economic and environmental benefits (Shafique, Kim, & Rafiq, 2018). This is supported by probabilistic estimates conducted in similar climates (Niu, Clark, Zhou, & Adriaens , 2010) (Bianchini & Hewage, 2012) (Clark, Adriaens, & Talbot, 2008). In addition, a green roof retrofit may be able to decrease the ambient air temperature by up to 0.4 degrees centigrade during the day, and double that figure at night (Shafique, Kim, & Rafiq, 2018).

Generally speaking, green roofs require more significant up-front costs to construct, but recoup these losses over a longer, more efficient lifecycle. Conventional asphalt shingle roofs last between 20 to 25 years, while green roofs can easily last for 40-years with proper care (Niu, Clark, Zhou, & Adriaens , 2010). The initial construction costs are varied – from lifting materials with cranes and hoists, expensive labour related fees, and high insurance premiums due to potential liability issues (Fabricio & Kasun, 2012). Likewise beams, slabs and supports will quite likely need to be reinforced given the age of 105 Bond's roof and the state of the roof membrane (TREMCO, 2013). Since green roofs tend to last longer, they also provided compounding savings in terms of the energy-air-stormwater nexus. Over time these benefits recoup the extra, up-front costs of constructing a green roof compared to a conventional roof (Clark, Adriaens, & Talbot, 2008).

Finally, a caveat: One of the most persistent threats to any green roof over time is the quality of its root barrier layer. This is an extremely important part of the assembly as it prevents plant root systems from cracking the roofing base. In the event of a leak all layers typically need to be removed to service the flaw (Fabricio & Kasun, 2012). Thermal imaging like that conducted by TREMCO in 2013 is the industry standard for identifying wet insulation. This means that there are opportunities to use this technology both to check the current quality of the roof and perform preventative maintenance (TREMCO, 2013). It is also important to note that additional water build-up in the drainage layer can encourage root growth. This means that just as much attention should be given to the way in which the drainage and root barrier layer interface (Fabricio & Kasun, 2012). If this is not adequately addressed then the root systems themselves may break through the root-barrier and cause damage to the roof itself. This is an additional long-term maintenance concern to be considered.

5.2 / Surrounding Development Context: Shadows and Shade

As discussed under the literature review, **Section 4**, the City of Toronto is only growing more dense and more vertical by the year, and this has implications for building shade generally and site-specific shadows.

Condominium developments in the area surrounding Ryerson University can easily exceed 20 plus storeys. Given the integrated campus' need to match vertical growth in similar fashion to the city it is reasonable to assume that 105 Bond will one day too face additional shadows. This would naturally impact the effectiveness of the prime produce production months over the summer. In 2021, Wang conducted an illustrative analysis examining what sort of impact a similarly styled development would have on Bond Street (Wang, 2021).

Figure 19 – a modified shade study diagram, highlight the proposed green roof in green and the shadowing impacts in red. Here, the shadows cover parts of tier-2, but very little of tier-1 (Wang, 2021).

The image above showcases the possible shadow footprint of a similarly sized possible development to the city standard. Although there is minimal morning impact on 105 Bond by 3:00pm the shadows have reached the western edges of the roof.

Figure 20 - a modified shade study diagram, highlight the proposed green roof in green and the shadowing impacts in red. By 5pm shadow cover obstruct most of tier-2, while leaving the hard-reach-space on the other side of HVAC units remains in sun (Wang, 2021).

By 5:00pm these shadows are much more pronounced, covering almost the entirety of tier-2, but leaving the majority of tier-1 in the sunlight (Wang, 2021).

Ultimately, Wang's theoretical shadowing exercise showcased two important considerations going forward. Firstly, the overall year-round impact of increased vertical density is primarily felt at 105 Bond during the winter months. Between late September and the Winter Solstice in December the South Bond Building as a whole is almost entirely in shadow through the day (Wang, 2021). However, during the summer months these impacts are mitigated save for in March and September as light availability shifts more rapidly (Wang, 2021). Given 105 Bond Street's limited capacity for vertical growth it is therefore recommended to prioritize the summer growing season for produce production while focusing on other interests through the year. For instance, due to Canada's traditionally cold climate the research beds could be used for testing a variety of cold-tolerant plants and their impact on the energy-air-stormwater nexus between October and April. This aspect of green roof planning is especially important as the speculative study largely represents the direction of surrounding development applications in terms of height and potential shadowing impacts (Wright, Personal Communication. Video-conferencing interview., 2021).

6/ A Compliment to LEED©: SITES Certification Potential

The South Bond Building is already a LEED© Gold Certified structure, thanks in part to the retrofit conducted in 2007.

The SITES program is operated by the United States Green Building Council, just like LEED©. Unlike leaders in energy efficient design however SITES is applied to smaller projects. SITES focus on combining environmental, economic and social benefits base upon water, soil, and material usage. The core belief behind the SITES initiative is that any project – whether University Campus or private residence – has the potential to regenerate the benefits of a health ecosystem (The United States Green Building Council, 2014). Green roofs are specifically mentioned multiple times throughout the SITES handbook. In particular, they are frequently referenced relative to the benefits of vegetation in terms of reducing urban heat island effects and increasing biodiversity (The United States Green Building Council, 2014).

The SITES program was most recently overhauled in 2015 as version 2.0. Much like LEED© certification, there are up to 200 points that can be obtained during the project's lifecycle – stretching from engagement operations and maintenance. There are ten categories for the scorecard, which are outlined below:

No.	SITES Subsection	Individual Point Score	Cumulative Point Score
1	Site Context	13	13
2	Pre-Design Assessment + Planning	3	16
3	Site Design – Water	23	39
4	Site Design – Soil and Vegetation	40	79
5	Site Design – Materials Selection	41	120
6	Site Design – Human Health and Well-being	30	150
7	Construction	17	167
8	Operations and Maintenance	22	189
9	Education and Performance Monitoring	11	200
10	Innovation or Exemplary Performance	Bonus Points: 9	200+9

Table 3 – Adapted from the SITES Guidebook, these individual points each carry multiple, complex criteria. However, a high standard of site design, up until No. 6, may produce the minimum threshold for a SITES Gold Certification or SITES Platinum Certification (The United States Green Building Council, 2014).

Unlike with traditional LEED© certification SITES presents a different rating system. For a project to become at minimum SITES certified a total of 70 points must be accrued across the above ten stages. To match 105 Bond Street's current LEED© Gold certification this proposed green roof would need 100 points in total. To exceed this benchmark and acquire a Platinum rating this project would need to generate a total of 135 points (The United States Green Building Council, 2014).

For owners, SITES also offers a number of benefits beyond the performance related metrics inherent to green roof systems. First, the SITES rating system is aspirational where Toronto Green Roof By-law is actual. This means that the grading components detailed above are designed to drive innovation beyond industry standards through the methodology outlined in the program. This in turn leads to an additional guarantee that a proposed project will achieve rigorous testing through field-tested standards. Finally, the owner – in this case Ryerson University – would be advantaged in being able to leverage the SITES narrative in terms of marketing materials (The United States Green Building Council, 2014). Given 105 Bond Street's previous LEED© gold certification this would allow the University to double down on a sustainability-backed donor narrative. This also has clear precedent from previous projects such as the Ryerson Urban Farm, which was funded in part by the Pringle family, which gave a substantial gift at a threshold to earn naming rights (Throness, Personal Communication, 2021).

Research Methods: How did we get here?

7/ Secondary Research, Interviews, and Course Sweep

There were three major research components for this applied Master's Research Project.

The first step was gathering documents cited in the literature review, policy context and site context described under **Section 4**, **Section 3**, and **Section 5** respectively. A key part of this project was accessing documents held by organizations like Facilities Management and Development, or Sustainable SURP. Generally speaking, documents such as the roof health audit and shade studies are not easily acquired without a direct access request through the appropriate organization.

The second element of the research were a series of interviews conducted between February 1, 2021 and April 2, 2021. This paper consulted four distinct categories of best practice, professional interviews in a fact-finding format. These interviews were informed by journalistic best practices. This includes avoiding double barreled questions, leadings questions, and the like. In addition, subjects were encouraged to take their time formulating answers with minimal contributions from the interviewer in most cases. Overall, ten interviews were conducted in order to build a picture of the possibilities and problems with a green roof 105 Bond. Four interviews were conducted with members of Ryerson University's department of Facilities Management and Development. Two interviews were conducted with members of the Ryerson Urban Farm. An additional two interviews were conducted with technically focused practitioners. Finally, three current and former student leaders were consulted as well, one of which involved two subjects and one interviewer (Loewen & Gascoigne, Personal Communication, 2021). These interviews, including position are summarized on the following page. These were best practice professional interviews following a dedicated fact-finding format.

Interviewee	Affiliation
Mark Dettweiler	Executive Director, Facilities Management and Development
Nic de Salaberry	Director of Planning and Development, Facilities Management and Development
Stephanie MacPhee	Sustainability Manager, Facilities Management and Development
Jean-Francois Landry	Energy Engineering Project Manager, Facilities Management and Development
Arlene Throness	Urban Farm Manager, Ryerson Urban Farm
Sharene Shafie	Research Coordinator, Ryerson Urban Farm
Kristiina Mai	Director, Ryerson Engineering Resilience Lab
Jeremy Wright	Graduate Student, Engineering Resilience Lab Project Manager, Zinco Green Roofs
Zack Bradley	Project Lead, Sustainable School of Urban and Regional Planning (S-SURP)
Neil Loewen and Taylor Gascoigne	Co-chairs, Ryerson Planning Alumni Association (RPAA)

Table 4 – This table groups together interviews based on organizational affiliation.

Cells highlighted in yellow indicated interviews conducted with Facilities Management and Development. These interviews were conducted with the intention of determining key feasibility concerns and barriers to implementation that would limit the functionality of a green roof. Green cells refer to members of the Ryerson Urban Farm, who were consulted on matters of winter resiliency and opportunities for collaboration. Interviews with Dr. Mai and Jeremy Wright, shaded in grey, were geared towards understanding the potential research applications and installation options. Finally, the cells coloured a light orange were conducted with key members of Sustainable SURP and the Ryerson Planning Alumni Association. These interviews were aimed at determining what interest or history the organizations had with prior applications for a green roof at 105 Bond. Additionally, Mark Dettweiler, Nic de Salaberry, Jean-Francois Landry, Sharene Shafie, Kristiina Mai, and Zack Bradley were instrumental in accessing some of the documents that informed this paper.

The final element of secondary research was a survey of undergraduate and graduate courses solely within the SURP curriculum. In particular, courses were considered relative to their overlap with green infrastructure, resiliency, ecological design, environmental and site planning, not to mention sustainability. Existing labs at the School of Urban and Regional Planning such as the Ecological Design Lab are dedicated to this kind of research direction. In addition to studio projects there are also opportunities to align lab-based interests, as shown below:

Figure 21 - two examples of past lab work conducted by the Ecological Design Lab.

Whether lab or studio, there are strong opportunities to tie research capacity to a green roof at 105 Bond. This would enhance the work conducted at the School of Urban and Regional Planning. It would also allow for additional cross-disciplinary collaboration, not to mention a stronger visual narrative for those interested in the faculty. In many ways, this element of the research was a capacity analysis to determine what percentage of courses at the School of Urban and Regional Planning might be able to make use of the production, research, and learning opportunities on a green roof.

Synthesizing the Research: Emerging Challenges and Opportunities

8/ Lessons Learned and Key Takeaways

Over the course of this project 10 interviews were conducted with stakeholders beyond faculty at the School of Urban and Regional Planning. All interviews save for the interview with both Neil Loewen and Taylor Gascoigne were conducted with a single interviewer and single subject. Again, these interviews were geared towards tapping the professional expertise of participants. These interviews generated an evolving set of concerns, which are represent below as challenges and opportunities.

8. 1 / Interviews: Challenges

All in all, there were several key themes raised during the interview process. Firstly, members of Facilities Management and Development were concerned with both increased structural load due to a green roof assembly, liability concerns, and up-front costs (Landry, 2021) (Dettweiler, 2021) (MacPhee, 2021). Second, interviews with members of the Ryerson Urban Farm focused on ways to engineer a healthy growing medium and an overview of how the Living Labs program interacts with research opportunities on campus (Throness, 2021) (Shafie, 2021). Sharene Shafie was also willing to provide a sample research bed application, which has been converted to plain text and filed under Appendix Fig 2.0. Third, discussions with technical experts such as Jeremy Wright and Dr. Kristiina Mai focused on maximizing space efficiency and potential research bed projects, such as rotating solar panelling located above an already dense vegetated canopy (Wright, Lytle, Santillo, Marcos, & Mai, 2021) (Wright, Personal Communication. Video-conferencing interview., 2021) (Mai, 2021). Finally, members of the extended student community, which includes alumni, identified the regular rotation of students in and out of the program as a potential barrier in addition to a current state assessment of Sustainable SURP (Loewen & Gascoigne, 2021) (Bradley, 2021). All of these interviews fall under the APA designation of "Personal Communication." These interviews identified key challenges, which have been summarized below:

1. 105 Bond Street needs a comprehensive structural inspection by a licenced civil engineer. Due to the older nature of SBB's roof it will likely require additional supports for the installation of a

green roof, especially considering the current assembly was likely designed solely for snow loads. Based on the proposed site area this paper estimates an additional applied load of 26,845 kg per square foot under the assumption of a fully vegetated roof.[1] Scaled back models will produce a correspondingly lower load bearing impact.

2. The warranty and status of the roof's waterproofing membrane needs to be assessed.
3. Any publicly accessible aspect of a green roof must have unclimbable fencing for liability protection.
4. The safety railings outlined under (3) may lead to conflict with the building's heritage features.
5. There is currently no direct access between tier-1 and tier-2 of the site. The addition of a staircase or lift would be necessary to connect the two, thereby increasing weight and reducing the gross floor area on tier-1.
6. More than 50% of the available site area on tier-1. This adds to both noise and heat bleed considerations, which would impact both socialization and plant bed temperature respectively.
7. Based on current development trends 105 Bond Street will likely become surrounded by taller structures over the next decade. This means that there will be increased visibility downwards onto what is currently a very grey, mechanically dominated roof.
8. Student populations fluctuate significantly in their engagement due to the cycle of graduation and subsequent hiring.

Ultimately these challenges were raised consistently among participants. All of those interviewed believed in the power of green roofs for significant personal and economic benefits. With that said, many of these concerns were addressed by other interviewees during the project.

8. 2 / Interviews: Opportunities

With all that said, each of these potential issues carries with them the potential for innovative, forward thinking solutions grounded in good design. In fact, many of the concerns raised by participants in one interview were directly answered during other interviews. This directly impacted the interview process by allowing for the issues detailed above to be brought up with future participants in search of solutions.

[1] (gross roof area * an estimated 18.2 additional kg per square foot on average for an intensive to semi-intensive roof).

This resulted in a set of eight solutions that evolved over the course of subsequent interviews. Overall a combination of secondary research and best-practice interviews indicate that many of the issues described above are solvable. A combination of grants, student-led initiatives, and direct-research alignment with existing labs and past studio create a strong framework for moving this project forward. These themes and overall direction emerged as a result of the way one interview built off of another in order to create a more complete picture of the context surrounding 105 Bond.

1. Structural grants are offered as a compliment to the City of Toronto's Eco-Roof Incentive Program.
2. Green roof retrofits maximize their efficiency when working with poor quality roofing surfaces.
3. Tier-1 allows for some savings on unclimbable fencing. Due to sharing a wall with tier-2 the perimeter of the lower tier and its required fencing is reduced.
4. Safety railings are a necessity, as per bullet (3). Given the extensive interior retrofit in 2006-2007 it is unlikely that fencing would significantly impact the building's façade. Rather, there is the potential for parapet obstruction, which would be a manageable heritage-based concern.
5. The construction of a staircase on tier-1 could double as non-climbable fencing on the east side of the roof while also integrating beautification elements through extensive vegetated beds directed towards the tier-1 entrance from the 4th floor. It is also possible that climbing vegetation may be planted around the staircase in order to further beautify tier-1.
6. Just as there are Eco-Roof grants there are also funding opportunities for the mechanical and air-handling units on tier-1. This means that
7. Due to 105's heritage status it is extremely unlikely that the building will add significant vertical additions without a complete renovation and expansion of the interior. As a result of these restrictions aggressively greening 105 Bond will get ahead of later-stage beautification issues due to increased roof visibility as a result of higher density.
8. Although essential for on-going engagement students are best supported in their engagement efforts through dedicated programming and curated, faculty, lab, or studio driven opportunities to interact with the roof. Students come and go, but programs, recurring tours, and strong student groups have the potential to significantly improve continuity from year to year. In addition, the presence of a physical representation of the school's commitment to green infrastructure can lead to inspiring students and visitors to greater degrees of engagement.

Naturally, issues such as on-going maintenance costs and energy savings are also quite relevant. Of particular import, it the fact that as 105 Bond's roof nears the end of its lifecycle any potential savings will be maximized. This aligns with the research the longer, more resilient lifecycle provided by green roofs allows for significant improvements over conventional roofs (Clark, Adriaens, & Talbot, 2008). However, additional research needs to be done in a site-specific context to accurately gauge both personal and economic benefits.

8. 3 / Course Sweep

This section of the secondary research was based upon the traditional communications practice of a media sweep, or policy scan. Course descriptions in the undergraduate and graduate planning programs and their respective curricula were reviewed and assessed across the School of Urban and Regional Planning. These courses were then organized based on aligned discipline. Examples include economics, sustainability, statistics, design, and law.

It is also important to note that Faculty members with tenure are free to engage in any research opportunities they deem important. This allows for two-fold benefits. First, Faculty are able to engage with the garden based on the terms of their own research. Secondly, professors regardless of tenure are required to teach certain courses every year. In this way research opportunities can emerge both from any research activities proposed on the site as well as from classes themselves.

Both the undergraduate and graduate program have been examined in their fullest capacities, meaning the 4-year and 2-year streams for the undergraduate and graduate program respectively. This decision was made as these streams represent every skill-generating opportunity presented by the school, where accelerated streams relying on higher degrees of industry knowledge prior to program admittance.

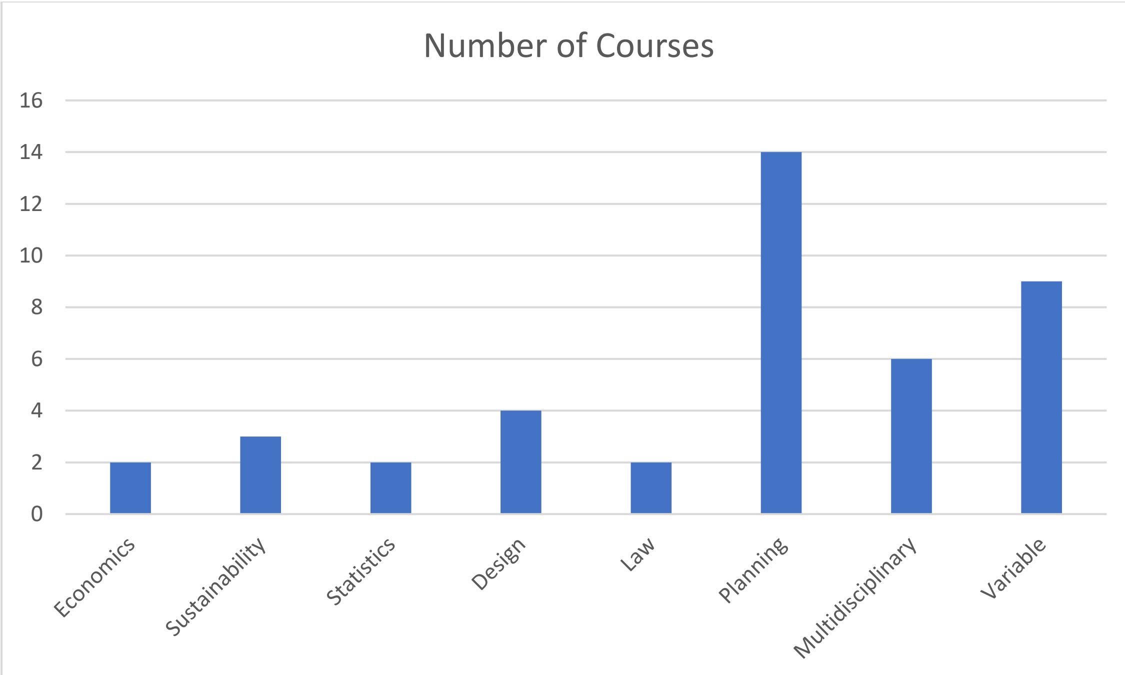


Figure 22 – This figure summarizes content present in the undergraduate and graduate course calendars

Overall, the course sweep identified a relatively small number of specialized courses relative to the program size. The vast majority of courses offered by the School of Urban and Regional Planning share overlapping interests with other aligned professions like architecture and urban farming. Planning itself inherently blurs industry barriers through consultation. As such, the planning course described above can be thought of as occasionally crossing into multidisciplinary territory.

The 'variable' bar above universally describes studio projects. These change every semester and are driven by a combination of Faculty research direction and student participation. These studios represent direct contact with external stakeholders and stakeholder groups. For instance, notable past studio projects include *WET INFRASTRUCTURE: Building Blue and Green for Resilience* and *Planning for Sustainable Communities* (Ryerson University, 2021). Professors at the School or Urban and Regional Planning have a substantial amount of flexibility in developing these projects on a semester-to-semester basis. Studio projects, special topics courses and the like could be geared towards both existing or new research goals through the use of a green roof. Offering these hands-on learning opportunities is a key program element. This will allow for further specialized work and collaboration that will only strengthen the reputation of Ryerson University's planning program further. A green roof will only expand these opportunities.

A major on-going focus for the School of Urban and Regional Planning is the way cities will need to change as climate change and rapid population growth exert an increasing toll. SURP already has significant resources invested in this direction. Ongoing labs like The Ecological Design Lab, The Together Lab, the Centre for Urban Research and Land Development (CUR) and the City Building Institute (CBI) all engage with the impacts of these changes through research. It also bears repeating that these research opportunities can have significant real-world impacts. The City of Toronto's Eco-Roof Incentive Program, for instance, would not have been realized without research commissioned by the City and Conducted by Ryerson University (City of Toronto, 2021). This engagement-drive is a core aspect of the program and can in fact be reinforced through the introduction of controlled research opportunities on the roof of 105 Bond. In a previous proposal submitted for the construction of a green roof at the Image Arts Centre Zinco Green Roofs proposed a number of sample studies. They sought to install solar energy generation technology, and a comprehensive water management system incorporating elements of water harvesting, irrigation and water purification (Wright, Personal Communication. Video-conferencing interview., 2021). The work described above is often referred to as 'resiliency' and shares strong connections with other departments at Ryerson such as the Centre for Studies in Food Security, Engineering, Environment and Urban Sustainability (in Geography), Ryerson Urban Water, and Architecture (to name only a few). Proposed projects including cross-departmental collaboration may be something that the School wishes to examine in more detail where it aligns with Faculty and course direction.

8.4 / Preferred Scenario

Based on the information outlined above this paper argues that a two-tiered green roof with split functionality across tier-1 and tier-2 can achieve significant personal and economic benefits. This can be accomplished through robust, targeted programming split across both levels. Tier-1 is best utilized as an "entranceway" that welcome people out onto the roof. This controlled element of public access naturally produces safety concerns. However, due to tier-1 abutting tier-2 the amount of perimeter fencing require is lessened. In addition, the installation of a staircase or similar apparatus connecting tier-1 to tier-2 can double as liability protection as well as providing site beautification. Based upon the research tier-1 seems best suited extensive beds planted with hardy *sedums* and the like, in particular those species who undergo CAM during exposure to cold. Due to the current mechanical obstructions on tier-1 it is not recommended that labour intensive functions such as research beds, pollinator gardens, or produce beds be place on this level.

By comparison, tier-2 offers an almost entirely clear floor area to work with. This provides ample space for a combination of produce beds, research beds, and a pollinator garden to reinforce biodiversity on the site. Finding a way to transport labourers, researchers and the like to this level is essential over the long term. In the event that a staircase or lift is constructed on tier-1 it is recommended that the entrance to tier-2 remain locked with keys only circulated to those working there, conducting research, or for specific functions such as tours. This is to reduce liability concerns through strictly managing access.

Figure 23- a rough overview of what increased vegetative cover would look like at 105 Bond.

All in all, the proposed Ryerson Green Roof could look something like the above image. Regreening this particular roof is an important, albeit bespoke, step in meeting the objectives outlined in the 2020-2030 Campus Master Plan. Given 105 Bond's heritage designation and its recent renovation there are limited opportunities for vertical development. Site-specific projects like green roofs are good fits for older buildings with these sorts of inherent restrictions. Provided, of course, they don't interfere with the parapet.

On the Path: How do we get there?

9/ Essential Project Milestones

As discussed under the previous sections there are a number of opportunities that can be developed from challenges established in the interviews and secondary research. This component of the paper addresses several of the funding opportunities available to alleviate financial burdens. Sections are ordered It also includes a sweep of organizations at the student-alumni level that may aid in long term custodianship at the school.

9.1 / Structural Assessment

This project cannot proceed with a structural assessment. Fortunately, there are several means by which to advance this critical path. The School of Urban and Regional Planning can apply for up to $1,000 for a structural assessment under the Eco-roof Incentive Program (ERIP). This is a distinct component of the broader program designed to help determine if the next phase of grant-based funding will be appropriate (City of Toronto, 2021).

However, the onus rests on the school to source and commission a licensed structural engineer to conduct the assessment. Following the successful completion of the inspection the School of Urban and Regional Planning will need to submit to the City of Toronto[2] both a copy of the structural assessment, as well as a copy of the invoice paid to the aforementioned individual (City of Toronto, 2021).[3]

Jeremy Wright of Zinco, (a green roofing and engineering firm with experience on campus), has indicated that conservative minimum for such an inspection would be $1,000. However, Arlene Throness of the Ryerson Urban Farm was willing to provide the structural inspection quote for Ryerson Urban Farm. She estimated the cost for the inspection to be $5,500 including HST. Given that the Urban Farm has 10,000 square metres this breaks down to roughly 55 cents per square metre of space. Rough calculations indicate that 105 Bond Street's would then require $811.25 at the minimum to receive a

[2] The current Program Manager is Annemarie Baynton, reachable at ecoroof@toronto.ca or by phone at 416-392-1848.

[3] This means that the school will need to pay out of pocket to be reimbursed at a later date for the structural assessment.

licenced structural inspection. This means that the school would be reimbursed for $811.25 rather than the maximum amount of $1,000 (City of Toronto, 2021).

9.2 / Municipal Grant Opportunities: The Eco-Roof Incentive Program

The City of Toronto's Eco-Roof Incentive Program offers a direct line of funding for the next stage of the project. Eligible participants can receive $100 per square metre to help subsidize the cost of a green roof. Below is a table provided by the City of Toronto that showcases the relationship between Gross Floor Area and the available roof space.

Coverage requirements

Gross Floor Area* (Size of Building)	Minimum Coverage of Available Roof Space** (Size of Green Roof)
Less than 4,999 m²	20%
5,000 – 9,999 m²	30%
10,000 – 14,999 m²	40%
15,000 – 19,999 m²	50%
20,000 m² or greater	60%

* Gross Floor Area – The total area (all floors) of a building, above and below average grade, measured from the exterior wall of each floor level, including voids at the level of each floor, such as an atrium, mezzanine, stairwell, escalator, elevator, ventilation duct or utility shaft, but excluding areas used for the purpose of parking or loading.

** Available Roof Space – The total roof area minus areas designated for renewable energy, private terraces, and residential outdoor amenities (to a maximum of 2 square metres per unit).

Figure 24- Sourced from the City of Toronto's Eco-Roof Incentive program.

Given that the gross floor area for the South Bond Building is 7,700 square metres a green roof would then require a minimum of 30% vegetated space. With a roof surface area of 1,475 square metres this means that at least 442.5 square metres of roof space must be vegetated. This would translate to $44,250 dollars in funding required. For reference, this means installing even an extensive vegetated bed solely on tier-2 of the roof would result in exceeding the 30% vegetated space minimum (City of Toronto, 2021). It is also important to note that the roof of 105 Bond features both a natural gas line, highlighted in purple below, and numerous storm drains that would need to be accounted for in addition to tier-1's exposed air handling units.

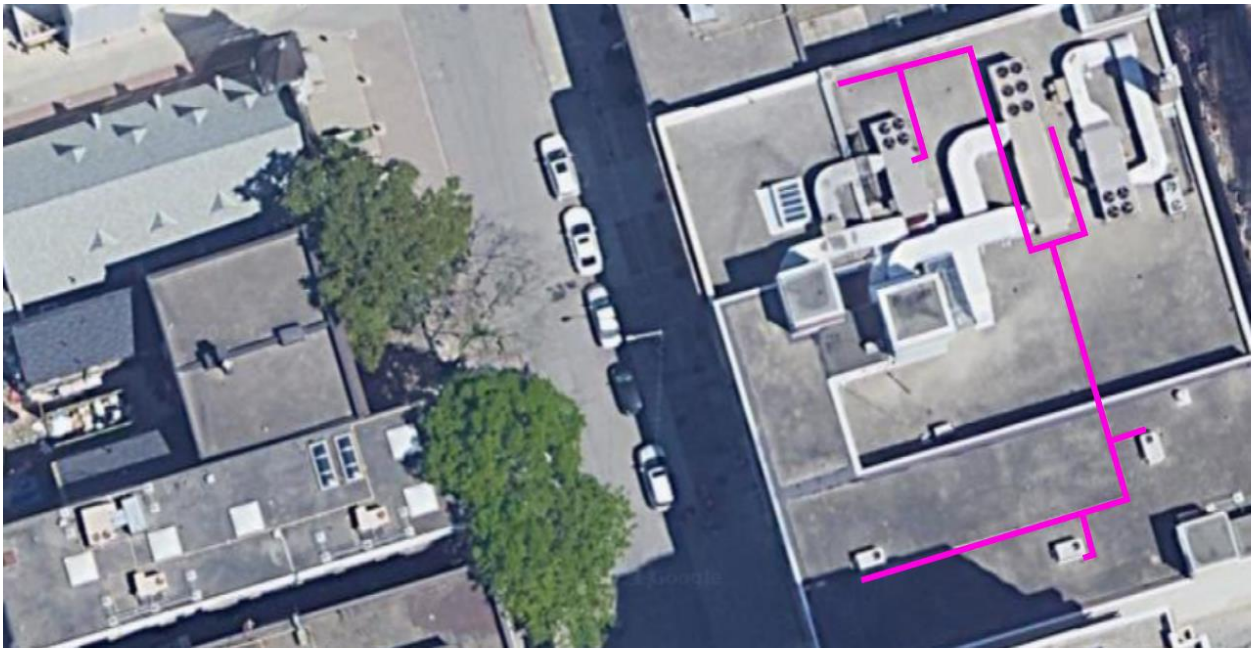


Figure 25 - an aerial of 105 Bond with gas lines highlighted.

This may further reduce the amount of available space. Additionally, due to the two-tiered nature of the roof a staircase would need to be constructed connecting tier-1 to tier-2, likely in the location indicated below.

Figure 26- a visualization of the most likely area for a stair or lift.

9. 3 / The Federation of Canadian Municipalities Grant-Loan System

Pursuing fund grant opportunities with the Federation for Canadian Municipalities is a complex process, but one that represent some of the largest potential allotments provided the University collaborates with the City of Toronto to some extent.

The Federation of Canadian Municipalities, or FCM, declares itself as “the national voice of municipal government since 1901 (The Federation of Canadian Municipalities, 2021)” Membership represents almost 2,000 municipalities, or just about 90% of all Canadians from coast to coast. This organization prioritizes work that allows for Municipalities to tackle local challenges.

Of particular relevance to this project is the Green Municipal Fund. This fund is used to fund methods of improving water quality, minimizing pollution, and restoring contaminated land. Although the latter is likely targeted at brownfield typologies these are, fundamentally, underutilized spaces due to external or historical factors (e.g. soil contamination due to hard metal processing). Rooftops are another such massively underutilized space, especially in the urban context where heavy metal processing has traditionally taken place on the fringes of cities. In this context, it may be feasible to pursue a Pilot Project Signature Initiative grant.

Successful acquisition of a Pilot Project grant would cover 50% of eligible costs capped at $350,000. A feasibility study can also be undertaken through a separate stream that allows for 50%, or up to $175,000 of eligible costs for that stage of the project. The signature project designation also means that, unlike many of the Federation’s other grants, the school does not require the pre-submission of environmental targets or success benchmarks (The Federation of Canadian Municipalities, 2021)

In addition, the Federation outlines several other funding streams that may be more useful at later project stages. For instance, the pilot water conservation and community project stream allows for 50% of costs, or up to $500,000 provided potable water use is reduced by 20% in facilities. With that said, the barrier of entry for many of these other pilot project streams is extremely high.

Finally, it is important to note that this process includes a significant number of supporting documents before confirmation of a successful application. These include:

1. A feasibility study or equivalent that provides quantifiable environmental benefits

2. Executive summary details the initiative, if required under Federal or Provincial regulations.
3. A municipal plan approved by your municipal council
4. Evidence of communication with municipal government
5. A cash contribution equal to at least 10% of eligible costs
6. Letters from each confirmed funding source indicating the amount of cash or in-kind contributions to the initiative.

Although the application process is extensive the benefits are likewise exhaustive provided a grant can be acquired (The Federation of Canadian Municipalities, 2021).

9. 4 / Tier-1 Air Handling Replacement Grants

As has been discussed at length, one of the key long-term considerations for 105 Bond Street is the quality of operational features on the roof. The exposed mechanical and air-handling systems outlined below restrict the available roof space significantly on tier-1. Given this, there is the opportunity to replace these systems with smaller, more efficient models in the future. Due to the poor-fair state of the roof established in TREMCO's 2013 report it may be reasonable to examine the warranty, lifecycle, and output measurements associated with these units.

This paper has identified two potential funding streams for replacing these HVAC components when the time is right. Again, the lifecycle of a Green Roof must be relatively long, a minimum of 20-years, in order to reap all of the energy, pollination, air-pollution reduction, and urban heat island reduction benchmarks (Clark, Adriaens, & Talbot, 2008). This is especially pertinent as it will allow Facilities Management and Development, or an associated researcher, to cross-refence existing warranty information with the expected project lifecycle in order to maximize the project's long-term potential.

9. 5 / Hydro One, Save on Energy Program

One of the most accessible mechanical-operational grants for HVAC replacement offered through Toronto Hydro, sometimes referred to as Hydro One.

This program is targeted specifically at owners, leaseholders or institutions such as universities that provide measurable, sustainable, and verifiably savings in peak electricity demand or general electrical consumption. Green roofs, as discussed under the review of literature, can provided peak electrical savings due to decreases in HVAC load. It is possible that the school could argue an installed Green Roof is an inherent component of modern HVAC systems, which is support by the City of Toronto's permitting direction. The school would also be able to apply for more direct funding to redesign the rooftop HVAC equipment to be more efficient. However, this would operate under the assumption that the current air-handling units on tier-1 of the roof are operating inefficiently or below ASHRAE standards.

Funding levels are pre-defined based on how much energy or demand-related savings the new equipment will produce. By going through an online portal the Save on Energy program will help members of the School of Urban and Regional Planning or Facilities Management and Development calculate incentive amounts. It is important to note however that a minimum incentive of $500 must be assigned and pre-approved for the project to be considered for eligibility. It is anticipated that due to the current state of the roof that potential efficiency-related gains could be substantial. As such this paper recommends that the School or Urban and Regional Planning collaborate with Facilities Management and development to prioritize this program for HVAC related improvements.

Keeping up the Momentum: What comes next?

10/ A Culture of Custodianship at the School of Urban and Regional Planning

Regardless of the build quality of the roof it will have to be sustained over time through high levels of engagement.

Students will ideally occupy both the public space on tier-1 and volunteer, find employment, or collaboration opportunities on tier-2 of the green roof. Undergraduate and graduate students along with alumni tend to move on, creating turnover and potential disconnects in this culture of custodianship. Faculty members and cyclical studio projects are a much more reliable way of creating continuity. Providing opportunities to take ownership of the green roof is what will create long-term stewardship at SURP. This can look like walking tours for new or prospective students, donors, or research-partners. A simple, recurring example is inviting the clients from aligned studio projects onto the roof. For instance, in 2021 the School of Urban and Regional Planning worked with the ARC Partnership and Yellowstone to Yukon to produce a Green Infrastructure toolkit. If there had been vegetated beds at 105 several opportunities would have been realized. Firstly, from the School's sister disciplines would have had the opportunity to see the school emphasize its experiential learning, which is already a flagship aspect of the program. Secondly, in the pre-studio planning phase there would have been the chance to devote some amount of space to research related to the project. Over time it is also expected that research projects will build on each other to create an archive of information which may be tapped by labs, studios, and perhaps at some point in the future reference in course work. The University of Toronto's GRIT lab and the Ryerson Urban Farm are two nearby environments that have clearly shown how green roofs can facilitate, leverage and amplify both research and teaching opportunities. It is important to remember that the two constants in terms of usage are (1) Faculty led research and (2) Course generated research opportunities. Students and student organization deal with significant, predictable turnover (Bradley, Personal Communication, 2021). Having support from Faculty in these endeavours can help create a sense of continuity that outlasts the changes in a given student body.

Finally, it bears repeating that green roofs are not, despite the volume constructed in Toronto, a blanket policy that can be applied to any site. Rather, they are bespoke projects that accomplish specific goals over long lifecycles. As such, it is absolutely necessary to support the physical space of the green roof through generating a culture of custodianship at the School of Urban and Regional Planning. Overall, this project would ideally lead to Students and Faculty at SURP taking increasing responsibility of the green roof over time. This would in turn decrease the burden of care applied to Facilities Management and Development in terms of maintain every feature of the site. However, due to high level engagement across all levels of planning-related student government it is likely that over time these organizations will pull together and support one another to create a positive environment on 105 Bond Street's roof as has been the case with the Ryerson Urban Farm and the University of Toronto's GRIT Lab.

10. 1 / Ryerson Planning Alumni Association (RPAA)

One such example of a strong student organization is the Ryerson Planning Alumni Association, which has been active on-campus since 1998.

Comprised of alumni from the School of Urban and Regional Planning, RPAA is made up of 20 active voting members who help plan and organize events, seeks sponsorships, and determine where to allocate funds for endowments and the like (Ryerson University, 2021). At the time of writing RPAA is composed of two co-chairs, an administrative coordinator, a treasurer, an events coordinator, a sponsorship coordinator, a student liaison, an equity coordinator, and a dedicated multi-media communications team of four, and several additional members-at-large (Ryerson University, 2021).

RPAA is also one of the oldest and strongest alumni networks on Ryerson's campus. On March 15, 2021 RPAA successfully surpassed $100,000 in contributions to support both undergraduate and graduate student awards. On the same date, RPAA was recognized by Ryerson University as the first alumni association campus-wide to achieve this benchmark (Minnema, 2021). According to members of RPAA consulted for this project, this milestone has been in the making for almost 22-years (Loewen & Gascoigne, Personal Communication, 2021). It is no exaggeration to posit that RPAA is capable of long-term planning and objective completion.

This is, in many ways, one of RPAA and the School of Urban and Regional Planning's competitive advantage: an extensive network of industrial professionals and high industry visibility. Organizations like RPAA, not to mention the Ryerson Planning Graduate Student association, augment the school's competitive nature with other comparable programs.

In addition to the activities described above RPAA also hosts a swathe of networking and industry-side social events throughout the year. For instance, the Spring Reception organized by RPAA regularly attracts around 300 attendees – although the COVID-19 pandemic has resulted in a shift to a digital format for 2021 (Loewen & Gascoigne, Personal Communication, 2021). Mixer style events are also run by RPAA to allow for the mingling of professionals and students.

RPAA is also committed to aiding student groups when requested. For instance, the communication team mentioned above currently consists of a coordinator, podcast host, blog and newsletter coordinator, and a communications committee member. This team is capable of providing social media and network-growth related support to student-run organizations (Ryerson University, 2021). A simple example would be sharing social media content created by another student organization through RPAA's social media channels. In terms of network broadening support, RPAA is also capable of sourcing guest lecturers or through the hosting of events (Loewen & Gascoigne, Personal Communication, 2021)

The Ryerson Planning Alumni Association is also engaged with walking tours during the academic school year. It is possible that 105 Bond Street's proposed green roof could become a stop on such an event. Neil Loewen and Taylor Gascoigne, the two current co-chairs or RPAA, were consulted regarding who attends these walking tours. Both chairs noted in the past walking tours have involved public sector staff, private sector staff, planning alumni, and current students (Loewen & Gascoigne, Personal Communication, 2021). These kinds of events offer strong holistic networking possibilities, provided the proposed green roof at 105 is as much place as space. Finally, RPAA has shown commitment to raising funds for sustainability initiatives. In preparation for Sustainable SURP last push for a green roof they had prepared a lump sum $7,000 to $8,000 dollars to aid in funding smaller elements of the project (Pages & Wilson, 2014). These funds were later retracted as SURP was considering moving away from 105 Bond at the time.

10. 2 / Ryerson Planning Graduate Student Association (RPGSA)

The Ryerson Planning Graduate Student Association is responsible for helping welcome in first year Master's students.

Orientation week in the fall is always a busy time for RPGSA. It is when they advertise the organization, run planning related scavenger hunts, and prepare for the election of year-1 representatives. The organization has a long history of collaborating favourably with other planning student groups such as the Equity, Diversity and Inclusivity Committee or for student-run events like the City Building Expo held every year. Like RPAA, RPGSA offers both mentor-based services and social-media reach extension. Typically, at least one year-1 representative carries on into the second-year executive body. This coupled with RPGSA's extensive record keeping allow for a clear image of the green roof to be preserved and presented across the graduate stream.

The Ryerson Planning Graduate Association also hosts its own set of events throughout the year. For instance, in January RPGSA holds its annual speed networking night. This single evening regularly hosts between 80-100 industry professionals and former students at all levels of their careers.

10. 3 / Sustainable SURP (S-SURP)

Sustainable SURP was originally founded for the express purpose of improving sustainable practices across Ryerson's Campus (Pages & Wilson, 2014).

Originally, the organization intended to push sustainability initiatives campus wide through indicatives like waste audits or fundraising for projects such as a green roof (Pages & Wilson, 2014). Their goal was to use these sorts of initiatives as a way of mobilizing the student body to enact positive change. During the early days of Sustainable SURP engagement was high with several successful campaigns enacted. This culminated in a sit-down presentation with Campus Facilities and Sustainability where four sustainable scenarios were presented (Bradley, Personal Communication, 2021). However, by 2013 Sustainable SURP had lost considerable momentum and membership. This was also the same year that RPAA withdrew its support for a street-front revitalization project.

Currently, Sustainable SURP has at best 3 active members. Their website was shut down several years ago due to inability to pay server fees. In many ways S-SURP is in hibernation currently. This means that there is the opportunity to jump-start the organization in conjunction with actualizing this project. By redrafting the constitution by quorum S-SURP could become in part dedicated to the long-term health of the green roof. In the past bot RPGSA and RPAA have been willing to provide logistical support to other student groups. It is unlikely that this will change any time soon considering both organizations long histories, not to mention their consistency. Sustainable SURP would likely benefit from both increased constitutional responsibility and a physical representation, through the garden or roof, of the organization's goals and aspirations.

10. 4/ Scenario Summary and Conclusion

To summarize, this project proposes a two-tier green roof with split functionality. The upper tier will serve as the home for dedicated research beds, produce production, and a native pollinator garden. The lower tier, meanwhile, will be open in a controlled fashion to the public. The area extending directly east from the tier-1 rooftop access point is an ideal area for both an "entranceway" to other roof features and could serve as the location for a staircase or the like connecting tier-1 to tier-2.

Due to the roof's last known condition, it is extremely likely that any green roof retro at 105 will produce operating costs savings when considering energy, air pollution reduction, and stormwater. To compliment this, it is recommended that Facilities Management and Development conduct a lifecycle assessment examining total costs over, for instance, a 20-year period. Likewise, the School of Urban and Regional Planning's solid reputation and extensive professional network also for multiple engagement opportunities with non-university actors such as potential donors or partners. Over the years there has been a clear commitment by both faculty and alumni leadership to aid in fundraising through varying mechanism. These can include both research grants or endowments as well as tapping professional networks.

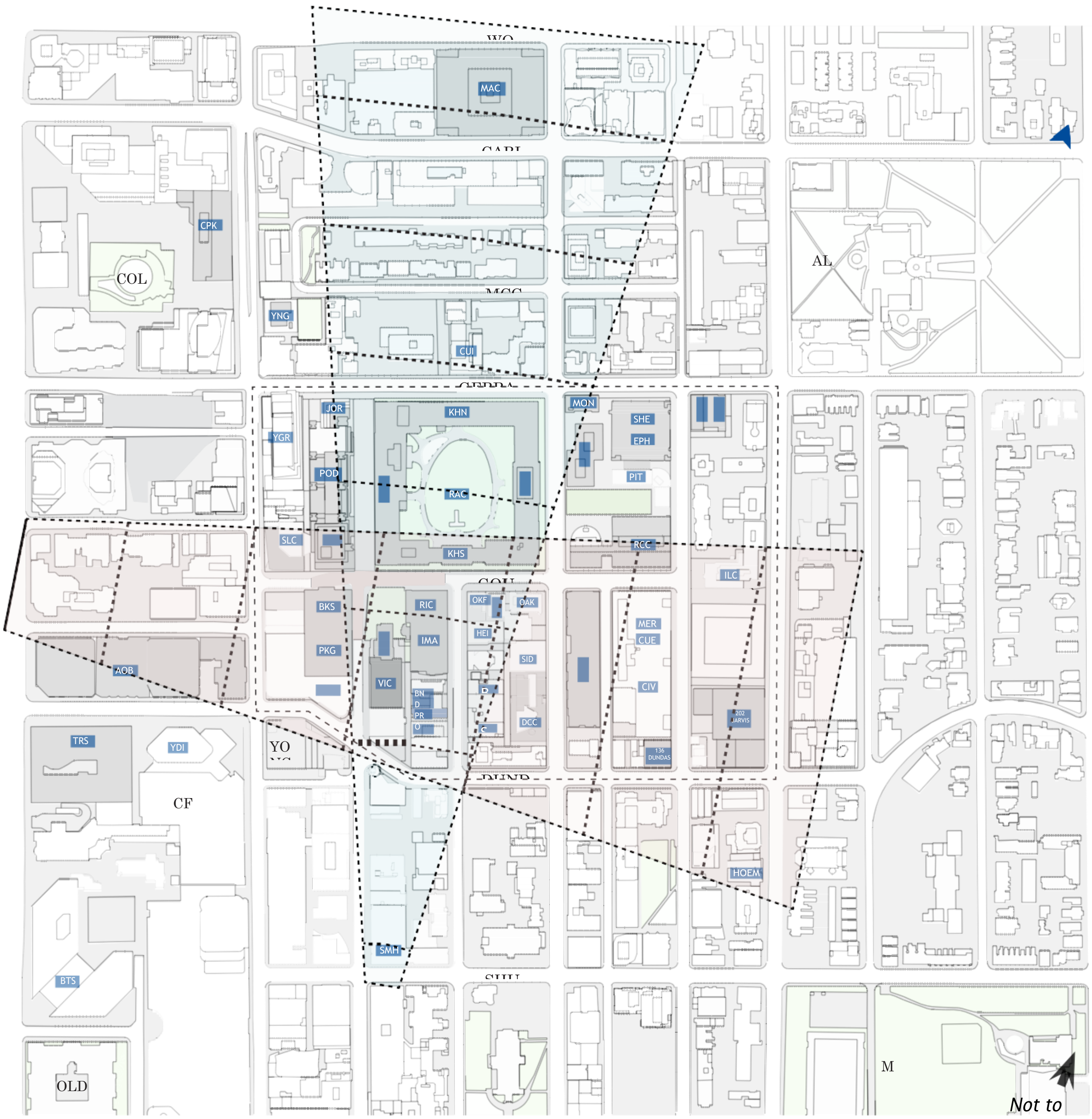
Over time this project can be supported through dedicated funds for a structural assessment, through the Eco-Roof Incentive Program, and possibly via the Federation of Canadian Municipality's Signature Pilot Project grant. In addition, when it comes time to replace the existing HVAC units on tier-1 the School may be interested in applying for Hydro One's Save on Energy Program. The addition of a green roof already provides significant energy savings as explained above, which will hopefully compound the effectiveness of the application.

In addition, the Ryerson Planning Alumni Association and its family of student organizations may be able to help further develop the green roof. This could be accomplished through dedicated programming and, in the case of research and production beds, some elements of day-to-day maintenance. It is important to remember that these organizations have a vested interest in both utilizing the space and leveraging it for both research and networking initiatives. There are clear opportunities to redefine the relationship between Sustainable SURP and other student groups for the better. A recruitment drive in the Fall following Summer preparatory work is thereby recommended. Finally, the proposed green roof at 105 Bond Street in in direct alignment with Ryerson University's stated goals in the 2020-2030 Campus Master Plan.

Appendix

Fig 1.0

Helicopter flight paths to and from St. Michael's Hospital obstruct development above a certain height to the southwest.



<u>Fig. 2.0</u>
<u>Living Lab Research Proposal Application – Adapted for the SURP Green Roof Project</u>

Personnel Information

9. Which one of the following are you? (Student, Prof/ Advisor, Other)
10. Last name
11. First name
12. Email address
13. Phone number
14. Student academic level (UG, G, Other)
15. If you are a student is this research for academic credit? (Y/N/ I am not a student)
16. Which faculty do you belong to? (Fitb/ Not Applicable)

Research Proposal

1. Title
2. Proposed start date
3. Proposed end date
4. Please provide a short description of the proposed research
5. Why is the School of Urban and Regional Planning a good fit for this research project?
6. Please identify any potential risks and challenges associated with the project.
7. How will the issues identified under (6) be managed?
8. How does this research interact with **[the community-informed research priorities identified by Sustainable SURP]**?
9. Does this project involve interdisciplinary collaboration, collaboration with external partners, or outside-of-University actors with additional funding?
10. If applicable, what is the expected publication date for the findings resulting from this research proposal?
11. Has the time undergone Research Ethics Board approval if necessary? (Y/ N/ Not Applicable)

Required Resources

1. What space requirements, materials, and human resources are needed for this project? Please provide details relating directly to installation, maintenance and clean-up – including both who will be involved in what elements of the project and what physical resources will be required.
2. If the proposal includes regularly scheduled visits, please provide a breakdown of a rough schedule. (Not Applicable / Fitb)
3. How frequently will researchers need to access the roof? (One-time, monthly, weekly, twice a month, daily, Fitb).
4. How much time do you anticipate spending on the rooftop per visit? (Fitb)
5. How with these research activities be funded?

6. What resources will you require from the School or Urban and Regional Planning? Please select all that apply.
    a. Rooftop tour
    b. Interview with SURP staff
    c. Usage of existing data
    d. Use of tools such as shovels, gloves, wheelbarrow and buckets
    e. Soil samples from vegetated beds – 1 cup, 1 litre, 5 gallons etc
    f. Access to the rooftop irrigation system
    g. Access to drainage system
    h. Other (Fitb)
7. If you require any of the material outlined under 6.d. or 6.e please provide details below. (Fitb)
8. Do you require winter storage/ access?
9. How does the team intend to remove any installed research infrastructure?
10. What impact will the removal of this infrastructure have on the School or Urban and Regional planning's rooftop garden?

SURP Communications

1. Do you consent to having your name, project description and research findings published in relevant annual reports, on? SURP website, or through the Ryerson Planning Alumni Association? Please check all that apply/ **[you must click 'I agree' in order to proceed with the application process]**

Works Cited

Amborski, D. (2021, February 25). Personal Communication. Video-conferencing interview. (J. Lawson, Interviewer)

Bianchini, F., & Hewage, K. (2012). Probabilistic social cost-benefit analysis for green roofs: A lifecycle approach . *Building and Environment*, 152-162.

Boivin, M.-A., Lamy, M.-P., Gosselin, A., & Dansereau, B. (2001). Effect of Articifical Substrate Depth on Freezing Injury of Six Herbaceous Perennials Grown in a Green Roof System. *HortTechnology*, 409-412.

Bradley, Z. (2021). Personal Communication. Video-conferencing interview. (J. Lawson, Interviewer)

City of Toronto. (2021). *City of Toronto Green Roof Bylaw*. Retrieved from toronto.ca: https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/green-roofs/green-roof-bylaw/

City of Toronto. (2021). *Eco-Roof Incentive Program* . Retrieved from toronto.ca: https://www.toronto.ca/services-payments/water-environment/environmental-grants-incentives/green-your-roof/

City of Toronto. (2021). *Green roof Overview*. Retrieved from toronto.ca: https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/green-roofs/green-roof-overview/

Clark, C., Adriaens, P., & Talbot, B. (2008). Green Roof Valuation: A Probabilistic Economic Analysis of Environmental Benefits. *Environmental Science & Technology*, 2155-2161.

Compass Construction Resources LTD. (2021). *https://compasscon.com/projects/26-ryerson-university.html*. Retrieved from compasscon.com: https://compasscon.com/projects/26-ryerson-university.html

David Suzuki Foundation. (2021). *How to create a pollinator-friendly garden*. Retrieved from davidsuzuki.org: https://davidsuzuki.org/queen-of-green/create-pollinator-friendly-garden-birds-bees-butterflies/

Dettweiler, M. (2021, February 26). Personal Communication. Video-conferencing interview. (J. Lawson, Interviewer)

Fabricio , B., & Kasun, H. (2012). How “green” are the green roofs? Lifecycle analysis of green roof materials. *Building and Environment*, 57-65.

Government of Canada. (2019, April 9). *Changes in Preciptation*. Retrieved from canada.ca: https://www.canada.ca/en/environment-climate-change/services/climate-change/canadian-centre-climate-services/basics/trends-projections/changes-precipitation.html

Landry, J.-F. (2021, March 31). Personal Communication. Video-conferencing interview. (J. Lawson, Interviewer)

Loewen, N., & Gascoigne, T. (2021, March 29). Personal Communication. Video-conferencing interview. (J. Lawson, Interviewer)

MacIvor, J. S., Margolis, L., Puncher, C. L., & Matthews, B. J. (2013). Decoupling factors affecting plant diversity and cover on extensive green roofs. *Journal of Environmental Management*, 297-305.

MacPhee, S. (2021, March 29). Personal Communication. Video-conferencing interview. (J. Lawson, Interviewer)

Mai, K. (2021, February 26). Personal Communication. Video-conferencing interview. (J. Lawson, Interviewer)

Minnema, B. (2021, March 15). *FCS News and Events - Ryerson Planning Alumni Association celebrates a fundraising milestone*. Retrieved from ryerson.ca: https://www.ryerson.ca/fcs-news-events/news/2021/03/ryerson-planning-alumni-association-celebrates-a-fundraising-milestone/

Niu, H., Clark, C., Zhou, J., & Adriaens , P. (2010). Scaling of Economic Benefits from Green Roof Implementation in Washington, DC. *Environmental Science & Technology*, 4302-4308.

Pages, T., & Wilson, G. (2014, Decemeber 12). Sustainability Initiatives at SURP: Options and Recommendations for Ryerson Planning Alumni Association. Toronto, Ontario, Canada.

Peck, S. W. (2019, November 18). *Lessons From Toronto's Mandatory Green Roof By-Law: A Decade In The Making And A Decade Making Positive Change*. Retrieved from livingarchitecturemonitor.com: https://livingarchitecturemonitor.com/news/2019/11/18/lessons-from-torontos-mandatory-green-roof-by-law-a-decade-in-the-making-and-a-decade-making-positive-change

Pisello, A. L., Piselli, C., & Cotana, F. (2015). Thermal-physics and energy performance of an innovative green roof system: The Cool-Green Roof. *Solar Energy*, 337-356.

Ryerson University. (2019). *Campus Master Plan.* Retrieved from ryerson.ca: https://www.ryerson.ca/facilities-management-development/campus-development/campus-master-plan/

Ryerson University. (2021). *School of Urban and Regional Planning - Ryerson Planning Alumni Association*. Retrieved from ryerson.ca: https://www.ryerson.ca/school-of-urban-and-regional-planning/student-resources/undergraduate/ryerson-planning-alumni-association/

Ryerson University. (2021). *School of Urban and Regional Planning - Two-year Regular Stream*. Retrieved from ryerson.ca: https://www.ryerson.ca/school-of-urban-and-regional-planning/programs/urban-development/two-year-regular-stream/

Ryerson University. (2021). *Studio Projects*. Retrieved from ryerson.ca: https://www.ryerson.ca/school-of-urban-and-regional-planning/student-resources/studio/studio-projects/

Sailor, D. J., Elley, T. B., & Gibson, M. (2011). Exploring the building energy impacts of green roof design decisions – a modeling study of buildings in four distinct climates. *Journal of Building Physics*, 372-391.

Santamouris, M. (2014). Cooling the cities – A review of reflective and green roof mitigation technologies to fight heat island and improve comfort in urban environments. *Solar Energy*, 682-703.

Shafie, S. (2021, February 26). Personal Communication. Video-conferencing interview. (J. Lawson, Interviewer)

Shafique, M., Kim, R., & Rafiq, M. (2018). Green roof benefits, opportunities and challenges – A review. *Renewable and Sustainable Energy Reviews*, 757-773.

Sookham, N., Margolis, L., & MacIvor, J. S. (2018). Inter-annual thermoregulation of extensive green roofs in warm and cool seasons: Plant selection matters. *Ecological Engineering*, 10-18.

The Federation of Canadian Municipalities. (2021). *Funding Opportunities*. Retrieved from fcm.ca: https://fcm.ca/en/funding

The Government of Ontario. (2020, May 1). *Provincial Policy Statement, 2020*. Retrieved from ontario.ca: https://www.ontario.ca/page/provincial-policy-statement-2020

The United States Green Building Council. (2014). *Sustainable SITES Initative.* Green business Certification Inc.

Throness, A. (2021, Februart 14). Personal Communication. Video-conferencing interview. (J. Lawson, Interviewer)

TREMCO. (2013). *SBB - South Bond Building Roof Audit.* Toronto: Ryerson University.

VanWoert, N. D., Rowe , B., Anderson, J., Clayton, L., & et al. (2005). Green Roof Stormwater Retention: Effects of Roof Surface, Slope, and Media Depth. *Journal of Environmental Quality*, 1036-1044.

Wang, R. R. (2021). *Bond Shadow Study.* Toronto.

Wright, J. (2021, February 22). Personal Communication. Video-conferencing interview. (J. Lawson, Interviewer)

Wright, J., Lytle, J., Santillo, D., Marcos, L., & Mai, K. V. (2021). Addressing the Water–Energy–Food Nexus through Enhanced Green Roof Performance. *Sustainability*, 1-13.

Zhang, G., He, B.-J., Zhu, Z., & Dewancker, B. J. (2019). Impact of Morphological Characteristics of Green Roofs on Pedestrian Cooling in Subtropical Climates. *International Journal of Environmental Research and Public Health*, 179-199.