COMMUNITY INFRASTRUCTURE LIFECYCLE COSTING ANALYSIS

A Baseline Analysis for Wesbrook Place, University of British Columbia

David Sametz
UBC School of Community and Regional Planning
July 23, 2017

ACKNOWLEDGEMENTS

Many thanks to the people who provided data and much needed insight for this research.

UBC Campus and Community Planning

Chris Fay, Manager of Policy and Development

UBC Engineering and Sustainability

Doug Doyle, Associate Director, Municipal Engineering

UBC School of Community and Regional Planning

Martino Tran

Mark Stevens

UBC Social Economic and Environmental Development Studies (SEEDS)

David Gill, SEEDS Coordinator

Rhiannon Herbert, my best friend

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

This report summarizes the results of a study conducted at the University of British Columbia (UBC), Canada, recently completed by David Sametz as part of the Social, Economic, and Ecological Development Studies (SEEDS) program. The purpose of the study was to provide a baseline financial analysis of community infrastructure at Wesbrook Place, and highlight the long-term economic and environmental benefits of incorporating green infrastructure services into future development plans. The primary objectives of this report are to highlight how integrated planning can shape and influence the type of growth that occurs on campus, and to provide UBC with a new way of thinking about asset management—one that incorporates land use planning—that will support UBC's sustainability goals by providing a rationale for working collaboratively and for investing in sustainable land use and green infrastructure projects. The results provide a framework for developing, analysing, communicating and presenting the demand for infrastructure, while incorporating economic, social and environmental issues into long-term strategic planning objectives. This is intended to provide UBC with a baseline to evaluate the capital, annual O&M and annual lifecycle costs between multiple planning scenarios, the details of which are explored in greater detail in the report discussion. The full life-cycle cost of a capital investment allows UBC to plan more accurately for future operating and capital budget allocations, and avoid O&M budget shortfalls. In effect, UBC is able to make informed decisions regarding capital project planning.

The preliminary results and objectives for this project were presented at a PIBC-APEG BC workshop in February 2017, entitled, "Land Use and Asset Management: The Sustainability Connection". The project was discussed with planners and engineers from across BC and received positive feedback from participants.

INTRODUCTION

SCOPE OF WORK

In January of 2017, Mr. David Sametz was retained by UBC Campus + Community Planning and UBC Sustainability and Engineering (Clients) to conduct an infrastructure lifecycle costing analysis for Wesbrook Place at UBC.

The project was initiated as part of the Social, Economic, and Ecological Development Studies (SEEDS) program at the University of British Columbia. The SEEDS program fostered a collaborative planning process by integrating faculty, student and community planning operations on campus.

The scope of work for the ensuing analysis and project includes the following deliverables:

- Collection and synthesis of a variety of data, including demographics, housing typology, land use, unit costs for roadworks, sanitary, storm water, schools, and recreation facilities;
- Production of a report with compiled data tables and graphs demonstrating the relative costs of community infrastructure annualized over the course of 100-years;
- A comparative analysis of the full lifecycle costs associated with green roof construction.

The following section will now outline the main purpose of the project through the lens of the initially proposed assessment.

PROJECT PURPOSE

This project's primary purpose is to assess the infrastructure costing parameters associated with residential development on campus, and to provide a baseline for which to measure future development scenarios on campus.

Infrastructure investments are often made in advance of growth and development, and without sufficient funds set aside to operate, maintain and replace assets, deterioration may accelerate and result in asset failure. "Each time a planning committee makes a land use decision without knowing if revenues will support infrastructure, it is gambling with its fiscal health" (Federation of Canadian Municipalities, 2006). With this in mind, the project provides a Tool with which to rectify these unknowns and associated risk. This was motivated by the desire to make a valuable contribution to the understanding of applied sustainable asset management at UBC and support improved fiscal and environmental sustainability on campus.

Bridging aspects of engineering, community planning and finance, this project contributes to an integrated planning process on campus by providing a planning approach that will help UBC make decisions on the best use of land and resources by breaking down the silos of physical planning and community design. The result is a new way of thinking about asset management—one that incorporates land use planning—that will support UBC's sustainability goals by providing a rationale for working collaboratively and for investing in sustainable land use and green infrastructure projects. These assessments also enable the improved ability to intelligently plan for efficient use of land while working with natural systems to achieve a sustainable relationship between development and environmental protection measures, integrating of municipal (in this case, campus) infrastructure and land use planning for the result of improved services that benefit both residents and the environment (Federation of Canadian Municipalities, 2006).

The utility and insight yielded by conducting estimations as per planning level costs and revenues are supported by the findings of professional planners such as Fowler, (2010), who found that land use planning significantly improved the financial performance of municipal assets when integrated with asset management planning. Since the majority of costs and revenues are generated from land uses, it is necessary to complete a fiscal analysis before land use plans and strategies are approved. The results are intended to support and inform future decision-making by the University Neighbourhood Association (UNA) Board, the Board of Governors, Campus and Community Planning, Infrastructure Services, and Properties Trust at the University.

Prior to the discussion of these results and their arrival via the associated assessment methodologies, it is useful to be acquainted with the context of the site and financial parameters. The following section outlines the neighbourhood context for the assessment and a brief background on UBC finance relevant to the project.

CONTEXT

Neighbourhood Context

FIGURE 1 - CONTEXT MAP

Location of Study Area: Wesbrook Place at the University of British Columbia.

The focus area of this research is centred on Wesbrook Place, an independent and complete community on the south campus of UBC. The neighbourhood is based on the principles of mixed-use development, which includes a village commercial centre, a community centre and a community school. Because of the diversity inherent to its mixed-use model, it is an ideal location upon which to establish an infrastructure baseline for the evaluation of future development scenarios.

Wesbrook Place has a current population of 3,700 and is expected to reach a population of 12,500 by 2024 (UBC, 2016). By 2024, residential density at Wesbrook Place is expected to reach a net density of 286 units/residential ha, including both market (89.2%) and off-market/rental housing (10.8%). In addition, it is expected to accommodate a total of

5,602,981 square feet of residential development (UBC, 2016). As such, the assessment undertaken in this project will compile and forecast infrastructure services and demographic assumptions and forecast the values to the year 2024. The current residential population at UBC is 24,600.

Also important to understanding the context of this project is the University's finances, which plays a vital role in all development projects and the nature of which tends to mirror that of a local government or municipality, making it ideal for the application of the Tool used to develop future scenarios.

Background on UBC Finance

UBC functions much like a small municipality within a metropolitan area. UBC Properties Trust oversees the development of all building projects on campus, including Wesbrook Place, while the University Neighbourhood Association (UNA) functions like a municipal council for the neighbourhood areas on campus (UNA, 2017). However, unlike a municipality, UBC functions as the landowner, developer, and regulator, thus having total control over development on campus.

At Wesbrook Place, infrastructure requirements are funded through development charges that are collected primarily through residential development. UBC's development charges are similar to municipal charges used in the City of Vancouver and other municipalities to fund a variety of infrastructure requirements. Property owners pay a Rural Tax to the Province of British Columbia and the Services Levy to UBC. The two added together are the same as the City of Vancouver municipal tax due on a property with the same assessed value.

The government of British Columbia collects taxes (or in UBCs case, a service levy) on these properties on an annual basis to fund municipal-like services. The services levy is like the municipal portion of property taxes, but is called a levy rather than a tax because UBC is on unincorporated land and is not a municipality (UNA, 2017). The BC provincial government also collects taxes on behalf of other organizations, such as Translink, the Vancouver School District, and the Greater Vancouver Regional District (UNA, 2017).

This will be articulated in the following section dealing with the problem statement of the project.

PROBLEM STATEMENT

A fundamental problem with managing community infrastructure is that decisions about land use, infrastructure efficiency and cost are generally not integrated into a holistic decision-making process. The result is a disconnect between land use planning and the cost of supporting community infrastructure systems.

The Federation of Canadian Municipalities (FCM) estimates that local government infrastructure deficits in Canada are approaching $123 billion and increasing at $5 billion a year (Felio, 2012).

As with local municipalities, academic institutions involved in residential development are not immune to this phenomenon. Much like the financial structure of a municipality, property tax is the largest source of revenue for residential development at UBC.

For example, if development projections are overly optimistic in terms of timing and/or amount of development in a newly serviced area, the UBC/UNA may not collect enough money to fully offset the infrastructure costs incurred.

developing a long-term plan that takes revenue and operations and maintenance (O&M) into account will allow UBC to prepare and implement a long-term strategy to ensure an adequate level of service for both existing and proposed developments.

The following section will now outline the scope of literature and study that both precede and inform the assessment and methods of the project.

LITERATURE REVIEW

Hard Infrastructure

Planning, finance and engineering services have had few opportunities to collaborate on the long-term sustainability of infrastructure systems and projects. This often results in a disconnect between infrastructure capital planning and development planning processes

Previous studies have presented mixed results when it comes to the relationship between different forms of development, infrastructure costs, and how development impacts public investment in infrastructure services, private user costs, and environmental costs (Federation of Canadian Municipalities, 2006).

According to the Federation of Canadian Municipality (2006), the density of development (expressed as the number of units/residential hectare) is not the key generator of the cost of infrastructure. However, it is suggested that density is a tool that can help municipalities manage demand for services.

The cost savings and environmental benefits of compact, mixed-use development have all been documented in the literature (Saheed, 2007) (CMHC, 2008) (Litman, 2015) (Spier & Stephenson, 2002) (Thomson, 2013).

Density (people and jobs per square mile), mix (combination of homes, jobs and services), roadway connectivity (density of road network connections) and centricity (the portion of jobs in major centers) all have an impact on the long-term financing of community infrastructure.

Multimodal development reduces per capita land consumption, thereby reducing the costs of providing public infrastructure and services. According to Litman (2015) low density single-use neighbourhoods impose various economic costs on local governments, households and businesses by increasing infrastructure and transport cost—largely as the result of longer roads and pipes.

From a sustainability perspective, planning needs to be carried out not only over large areas of space, but over long periods of time. A "systems thinking" approach addresses this issue by incorporating infrastructure interdependencies across space and time. Terms such as New Urbanism and Smart Growth apply some form of systems thinking related to compact mixed-use development, sustainable urban form, increased density, multimodal transportation systems, or integrated ecological planning principles. Engel-Yan *et. al* (2005) support these principles by emphasizing the importance of adopting a systems perspective and considering infrastructure interconnections in the planning and design of communities.

Careful consideration of the aforementioned connections and relationships implicated in neighbourhood design could also yield significant improvements in infrastructure resource efficiency as well as reductions in pollutant emissions and overall costs. According to the

Federation of Canadian Municipalities (2006), mixed-use developments typically make better use of infrastructure because residential and commercial land uses generate demand for water consumption and discharge waste-water at different times of the day.

Other research has been influential in supporting these planning principles as well. Speir and Stephenson (2002) found a relationship between lot size and water demand. Here, smaller lots were found to be more cost effective due to the longer distribution mains required for larger lots.

In addition, the effects of clustering (minimize lot coverage) allows for narrow roads and thus more land to be used for additional dwellings or parks. Because there are more units per buildable area, infrastructure installation and maintenance costs are spread out over a larger number of units, resulting in reduced costs per household.

Green Infrastructure

In addition to the essential community infrastructure services presented above, green infrastructure services provide a sustainable alternative to traditional development. For example, green roofs deliver many ecosystem services and a suite of public and private benefits that are generally not factored into the long-term costs of community infrastructure services. Green roofs can be constructed to model an ecosystem and provide a setting for testing ecological concepts, serving as a living laboratory for students and researchers alike.

The ecological and economic benefits to constructing green roofs is well documented in the literature (Getter, 2006, Sutton, 2015, Oberndorfer, 2007, Lawlor, 2006). According to Lawlor (2006), Increased control of stormwater runoff is one of the most important public benefits of green roof infrastructure. Green roofs may reduce flooding and erosion impacts on property, reduce the need for stormwater infrastructure expansion, and alleviate some of the cost of stromwater infrastructure investment sometimes required for new development, by reducing the frequency of replacement costs for other infrastructure services.

A local study conducted by the British Columbia Institute of Technology (BCIT) found that an extensive green roof system in Vancouver can delay or reduce the total volume of stormwater runoff by as much as 86 - 94% in the dry season, and 13 - 18% in the wet season (BCIT, 2005). The study also revealed that a green roof can delay stormwater runoff between 95 minutes and 4 hours, compared with reference roofs (for which the runoff was nearly instantaneous). In the context of UBC, this can yield significant savings, considering the cost of storm sewer collection is approximately $700/m and the estimated capital cost of stomwater storage tanks at UBC (Nobel Park) is over $900,000/1,500 cubic metres of storage (data obtained through conversations with UBC Engineering and Infrastructure Services).

In a green roof system, much of the precipitation is captured in the media or vegetation, and will eventually either evaporate from the soil surface or be released back to the atmosphere by transpiration.

From an energy perspective, other studies have reveled a relationship between green roof technology and the heat flux in the buildings. Getter *et. al.*, (2006) concluded that green roof technology provides an alternative to spending "millions of dollars" to renovate outdated stormwater infrastructure, and to power air conditioning units. The shade from plant material, and transpiration can reduce solar energy gain by as much as 90% compared with nonshaded buildings (Getter *et. al*., 2006). In addition, green roofs have the potential to reduce indoor temperatures by 3 – 4° C, and provide significant insulation during the winter (Getter *et. al*., 2006). BCIT (2005) found that green roofs in Vancouver can reduce the heat flow through the roof by 83 - 85% in the spring/summer and 40 - 44% in the fall/winter, with an overall annual reduction of 66%.

In addition, because most extensive green roofs are inaccessible to the public, they can provide undisturbed habitat for microorganisms, insects and birds. Sutton (2015) found that flowering plants on vegetated roofs allow the introduction of bees, and support other pollinators, which can also filter our airborne contaminants, gaseous pollutants, and particulate matter.

From a purely conditional perspective, a roof membrane on a conventional roof system is exposed to temperature fluctuations and ultra-violet radiation which accelerates the aging process in modified bitumen roofing membranes and reduces its durability (BCIT, 2005). In addition, temperature fluctuations create thermal stress in the membranes, creating stress on seams and flashings and affect the long-term performance of the roof system. Typically, most roof membranes have a lifespan of about 20 years largely because of ultraviolet light degradation and micro-tears caused by diurnal heating and cooling cycles.

Green roofs protect a membrane from those deleterious effects and may double membrane life thus reducing life cycle costs and delaying worn out membranes from entering the landfill (Sutton, 2015 + Interviews with building consultants contractors).

By accounting for the lifecycle costs associated with green roof construction in conjunction with the total costs of community infrastructure required over its lifetime, planning agencies can provide an incentive for incorporating green infrastructure alternatives into long range planning initiatives.

WHAT IS LIFECYCLE COSTING?

Asset management is defined as "the application of sound technical, social and economic principles that considers present and future needs of users, and the service of the asset" (Federation of Canadian Municipality, 2006). Lifecycle costing analysis is a component of that process, and is a tool for evaluating the total economic cost of an asset by analyzing initial costs and future expenditures, such as operations, maintenance and replacement.

The lifecycle cost of an asset is therefore defined as the total cost, in present value or annual value, that includes the initial costs, maintenance, repair and renewal over the specified lifecycle (Rahman & Vanier, 2004).

Simply put, lifecycle costs represent the amount of money we would have to be banked today to pay for the infrastructure services over a specified period of time.

The next portion of this report will now present the methodology for the assessment and outline the means through which lifecycle costing was applied via the Community Infrastructure Lifecycle Costing Tool.

METHODOLOGY

The methodology for this project was primarily quantitative in nature, involving data collection, comprehensive research, interviews with building and engineering consultants, policy analysis, and financial calculations. These activities centered on the application of the Community Infrastructure Lifecycle Costing Tool (hereafter referred to as the Tool) to Wesbrook Place on UBC campus. The Tool, created by the Government of British

Columbia's Ministry of Community, Sport and Cultural Development (BCMSCD), was developed to assist local governments with evaluating the long-term implications of residential development, and to estimate capital and operating costs, and related revenues over a 100-year projection period.

Data was retained through a variety of sources including Campus + Community Planning (CCP), Sustainability and Engineering Services, British Columbia Ministry of Sport and Cultural Development (BCMSCD), Vancouver School Board (VSB), TransLink, Stats Canada, and the Canadian Mortgage and Housing Corporation (CMHC). Refer to Appendix A for a detailed breakdown of sources and references.

The methodology of this project centres on planning level costs related to residential development, including roads, water and sewage infrastructure and schools, and are annualized over the course of 100 years. Life-cycle costs are expressed in present value dollars by discounting the cash flow at a rate of 6%.

The Tool is best used to provide high-level planning costs and revenue estimates, which can be used to evaluate whether proposed projects result in acceptable long-term costs. However, for the purposes of this report, revenue costs were excluded from the assessment. In the case of UBC, the allocation of costs for community infrastructure is complex and difficult to accurately represent.

For the purposes of this study, the term infrastructure includes the following services:

- Roads
- Sanitary sewers
- Stormwater management
- Water distribution
- Community Centres and Schools
- Green infrastructure (green roofs)

Data for Regional Services (water distribution, sanitary and sewer collection, wastewater treatment, and potable water treatment) were based on default values included in the costing tool. The default values can be found it the Tool's User Guide, Version 1.0, entitled

"Community Infrastructure Lifecycle Costing Tool (CLIC): User Guide", dated May 2015. Refer to Appendix A for additional details on Regional costing.

The findings of this study and its methods are presented in a series of graphs summarizing the relative proportions of initial capital costs, annual operation an maintenance costs (O&M) and lifecycle costs of Wesbrook Place over the course of 100-years. The results were applied to a scenario analysis of different forms of development as a means of highlighting the relationship between land use and infrastructure costs.

Also included in the scenario analysis was an assessment of the costs associated with incorporating a green roof into long-term development plans. Here, a lifecycle costing analysis was conducted on a proposed roofing system, which evaluated the costs and benefits of constructing a green roof on partially funded public infrastructure at UBC. This research was partly inspired by the initiatives set forth by the City of Portland, Oregon, who applied a similar lifecycle costing approach to build three new fire stations with green roofs as a means of reducing energy costs and managing storm water in the long term. To this day, Portland City Council requires a full lifecycle analysis for all capital project proposals (Boudreau *et. al.*, 2003).

RESULTS AND DISCUSSION

Before discussing the results of this study, it is important to note that the analysis is not a budgeting tool providing accurate costing estimates, but rather, a planning tool that gives high-level numbers for relative comparison purposes.

The main objective of the tool and this study is to provide a baseline upon which to evaluate future development scenarios on campus, and to highlight the long-term economic benefits of incorporating green infrastructure services into future development plans.

The results provide a framework for developing, analysing, communicating and presenting the needs for infrastructure, and incorporating economic, social and environmental issues into the long-term, strategic planning for infrastructure.

It is assumed that the researcher/planner/engineer/developer making use of this research will provide-up-to-date costing estimates for the type of built form under consideration, thereby applying the tool for projects on a case-by-case basis. These variables should be updated regularly to reflect changes in materials, technology, level of service and external geopolitical forces. This is crucial to maintain contemporary accuracy in one's own results.

As will be seen in the following discussion, changes in density, road allocation, demographics, and unit mix, will all impact the lifecycle costs of community infrastructure. This type of integrated planning can shape and influence the type of growth that occurs and where it occurs. It can also optimize or maximize the use of existing infrastructure (i.e., infill and compact design goals in land use plans with related instruments to target development in certain areas).

While the costing analysis as seen in this study is applied to an existing neighbourhood at UBC, the results can also be applied to a variety of other planning scenarios and characteristics across campus, ranging in size from a collection of houses, a block-by-block infill development, to a large subdivision. A good measure of the applicability of this research to a given project is whether alternatives can be conceived that would result in significantly different densities or infrastructure requirements.

With this note now in mind, the following section will discuss the details of the results of the baseline analysis, followed by an example scenario analysis.

Baseline Analysis

This discussion begins with an overview of the expressed costs, calculations and results visible in the adjoining figures. For each cost summary, pie charts provide a visual breakdown of the estimated relative infrastructure costs, expressed as the residential portion of infrastructure costs.

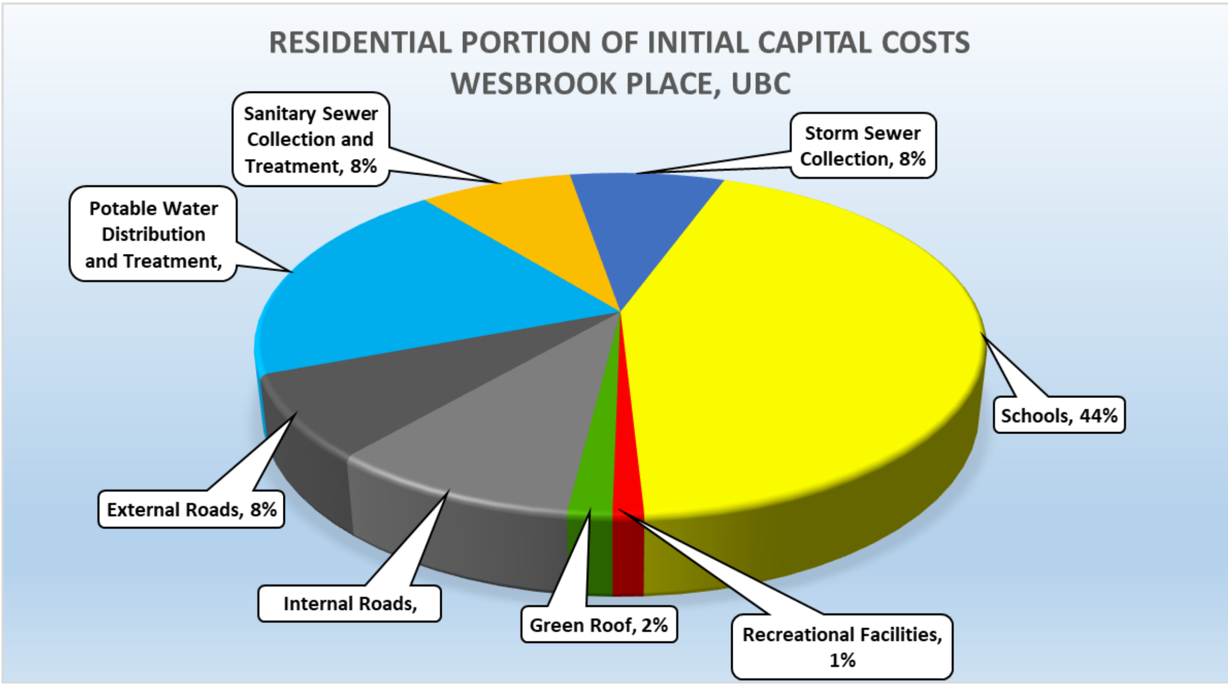
The baseline provided here provides a tool not only for sustainability projections, but a data-based and backed proposal case for developments incorporating any or all the entailed design elements.

The costs can be used to identify alternative investment scenarios (see Tables 1 and 2 below) and any operational limitations.

A visual breakdown of the data follows:

DISTRIBUTION OF INITIAL CAPITAL COSTS

FIGURE 2 - DISTRIBUTION OF INITIAL CAPITAL COSTS



It is important to note that the funding for school construction and operations is provided by the provincial government which collects school taxes through the property tax system. UBC residents pay their school taxes directly to the province, which then funds the Vancouver School Board (VSB) to provide neighbourhood schools. The Province then provides to the VSB the capital funding for school construction, operation, renovation.

The residential distribution of initial capital costs is separated into schools, roads, green infrastructure, potable water, sanitary collection and treatment, and recreational facilities.

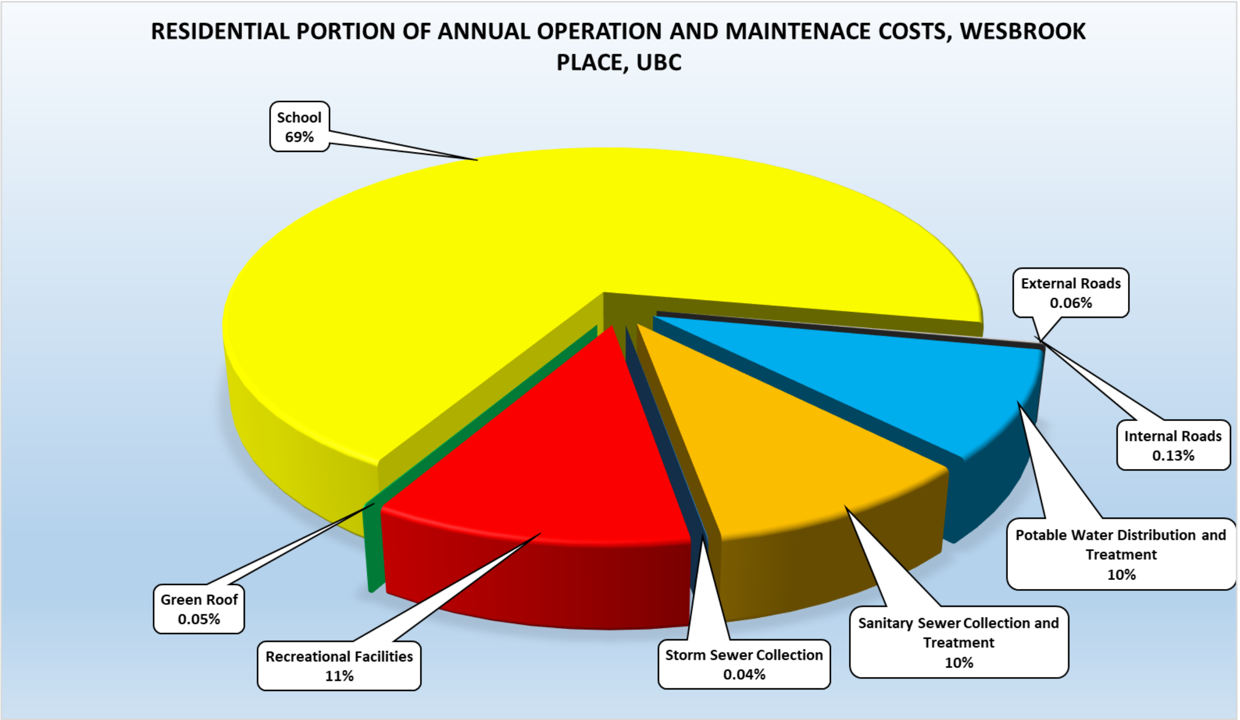
Residential costs refer to the infrastructure and service costs with the residential portion of the development and are calculated as the total costs multiplied by the percent Residential Land Area.

As can be seen in Figure 2, school costs make up approximately 44% of the initial capital costs (note that the green roof for the school is just 3% of the total costs). For details on the costs associated with the green roof, see Table 4. When comparing this to the costs of recreational facilities and the costs of the school, the results become an incentive for project proponents and the public to consider and support sustainable community services.

DISTRIBUTION OF ANNUAL OPERATING COSTS

Linking capital with O&M budgets promotes better decision making and reliable budget planning. Adapting this approach will ensure sufficient funding is in place before a project is approved. As can be seen in Figure 3, the relative O&M costs range from less than 1% for the green roof, internal roads, and storm sewer collection, to more than 69% for the school.

FIGURE 3 - DISTRIBUTION OF ANNUAL OPERATING COSTS



ANNUALIZED LIFECYCLE COSTS

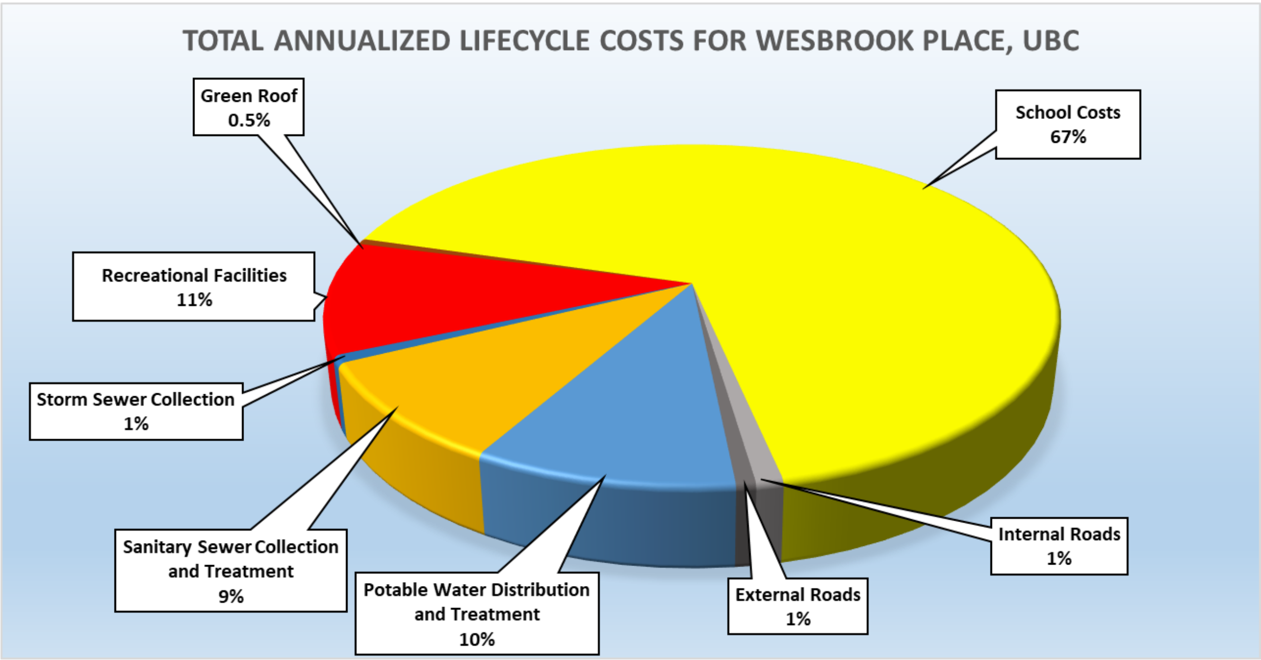
The lifecycle cost for all community infrastructure at Wesbrook Place is expressed on an annual basis and calculated as initial capital costs, annual O&M costs and replacement costs, amortized over a 100-year time-horizon.

As previously discussed, this is the baseline data for which to evaluate future development scenarios. In terms of the annualized lifecycle costs, the green roof (see Table 4 for details of costing) makes up less than 1% of the total lifecycle costs for community infrastructure. When comparing this to the cost of water services, roads and sewers, the results become increasingly significant.

It is important to note that the funding for school construction and operations is provided by the provincial government which collects school taxes through the property tax system.

UBC residents pay their school taxes directly to the province, which then funds the Vancouver School Board to provide neighbourhood schools. The Province then provides to the VSB the capital funding for school construction, operation, renovation.

FIGURE 4 - ANNUALIZED LIFECYCLE COSTS



To make these data meaningful for a proposed development elsewhere on campus, they can be used to provide an incentive for project proponents and the public to consider and support sustainable community services.

This data also becomes useful for evaluating such aspects as stormwater mitigation, including cost savings associated with government grants or feebates on operations.

Scenario Analysis

Now that the baseline has been established, the results can be used to evaluate different forms of development. This section will outline the featured scenarios in terms of what they reveal, and how they compare. The results can be used to identify the financial implications of adjusting density, street patterns, housing typology and land use. This is also valuable when analyzing secondary benefits not normally included in the planning process, such as the benefits of green infrastructure services.

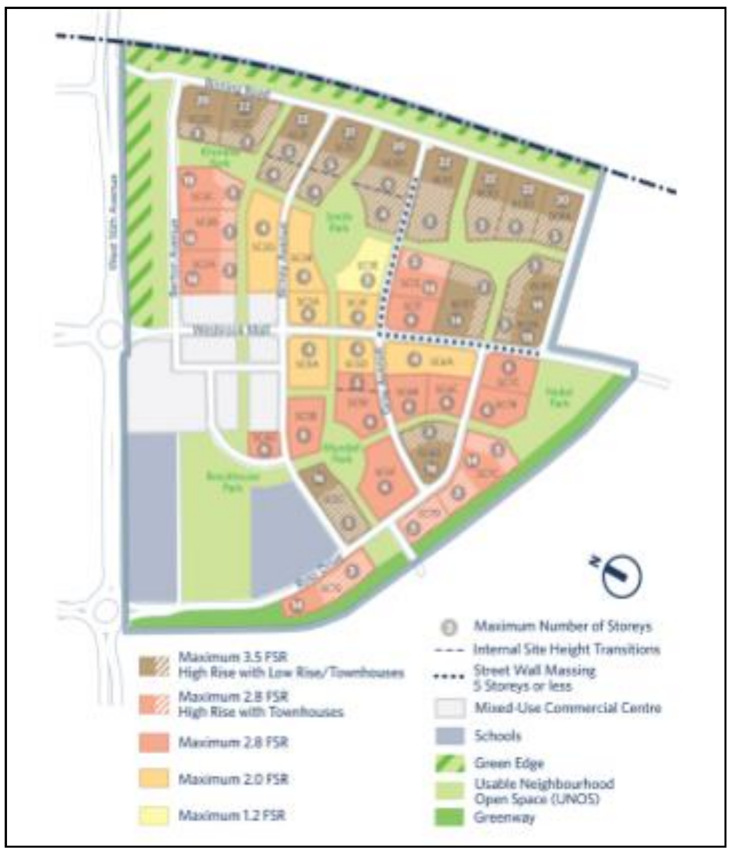
The green roof analysis in this research proved to be more economically viable than a modified bitumen system, when considered over the lifecycle of the investment. In the case of land use and built form, by decreasing the net residential density of Wesbrook Place by 57%, the total per household lifecycle costs of hard infrastructure, municipal services and school costs for Wesbrook Place decreases by 28%. This suggests that the hard infrastructure capital costs per household is, in fact, impacted by residential density, further supporting the findings of Fowler (2010). In financial terms, the total lifecycle cost of the alternative Wesbrook plan is 28% more expensive than the current Wesbrook plan. The findings are attributed to the per-unit cost savings associated with the residential sector's share of operation and maintenance costs.

Figures 5 and 6 (below) highlight the relative differences between the current Wesbrook land use Plan, and an alternative Wesbrook land use Plan. Note: the alternative scenario was created for comparative purposes only, and is intended highlight the long-term economic benefits of increasing density and diversity.

LAND USE SCENARIO ANALYSIS

FIGURE 5 - EXISTING WESBROOK PLAN

The current Wesbrook Plan (Figure 5) contains a mix of low-rise, high-rise and townhouse units. In contrast, the alternative Wesbrook Plan (Figure 6) allocates all future residential development to semi-detached townhouse development. The areas in white represent existing building stock, and the areas in blue represent proposed land use designations allocated to townhouse development.



Source: UBC Campus and Community Planning (2016).

FIGURE 6 - ALTERNATIVE WESBROOK PLAN

Source: David Sametz (2017).

COMPARISON OF LAND USE PLANS

Tables 1 – 2 compare development statistics for each plan, including data on land use and dwelling units. The data are presented with the degree of variation between each costing variable to highlight the relative percentages of each variation.

Land Use Plans

TABLE 1 - COMPARATIVE ANALYSIS OF LAND USE

Land Use Footprint	**Expected Wesbrook Place**		**Alternative Wesbrook Place**		**Variation**	
	(sq. ft.)	% of total	(sq. ft.)	% of total	(sq. ft.)	%
Residential						
Townhouse	95,900	2%	541,660	11%	+445,760	+83%
Low Rise	639,901	13%	250,000	5%	- 389,901	- 60%
High Rise	95,992	1.9%	40,133	0.9%	- 55,859	-58%
Sub Total (net site area)	831,793	16.9%	831,793	16.9%	0	-35%
Institutional						
Secondary	73,205	1.5%	73,205	1.5%	0	0
Community Centre	27,469	0.5%	27,469	1.5%	0	0
Total Neighbourhood Open Space	1,619,646	33%	1,619,646	33%	0	0
Other	2,390,427	48%	2,390,427	48%	0	0

Total Land Area	4,942,540	100%	4,942,540	100%	0	0

Source: Wesbrook Place Land Use Plan (2016) and Calculated Projections by David Sametz

Dwelling Units and Population Plans

TABLE 2 - COMPARATIVE ANALYSIS OF DWELLING TYPES

Dwelling Type	Expected Wesbrook Place		Alternative Wesbrook Place		Variation	
	# Units	% of total	# Units	% of total	# Units	%
Townhouse	180	3%	828	33%	+648	+26%
Low Rise	1,682	28%	642	26%	-1040	- 62%
High Rise	4,059	69%	1,059	41%	-1000	- 74%
Total	5,991	100%	2,529	100%	-1,392	-58%
Population	12,500	-	7,085	-	-5,415	-43%
Net Density U/ha	290	126	-	-	-	-

Source: Wesbrook Place Land Use Plan (2016) and Calculated Projections by David Sametz

The current Wesbrook Plan contains approximately 180 townhouse units, 1, 682 low rise units, and 4,059 high rise units, for a total of 5,921 units. In contrast, the Alternative Wesbrook Plan contains 828 townhouse units, 642 low-rise units, and 1,059 high-rise units. While each scenario contains the same net residential land area, the proposed Wesbrook plan is 57% more dense (i.e. 290 units/ha vs. 126 units/ha respectively).

RESULTS OF COMPARATIVE ANALYSIS

On a per-household basis, the increase in residential density spreads the cost of potential services (roads, sewer, water) over more dwelling units, thereby reducing the household costs associated with the public portion of development charges. Because there are more units per buildable area, infrastructure installation and maintenance costs are spread out over a larger number of units, resulting in reduced costs per unit. Furthermore, analysis of these scenarios shows significant cost savings in the areas of storm and sanitary sewers, water distribution, and other services which parallel the road network, all of which are associated with increased density (see annualized lifecycle costs in Figure 8 below).

The result for the books: the total lifecycle cost of the alternative Wesbrook plan is 28% more expensive (approximately $4,798/hh) than the current Wesbrook plan ($3,445/hh). Again, the per-unit cost savings are associated with the residential sector's share of operation and maintenance costs. Figures 7 and 8 show the relative costs of each scenario.

FIGURE 7 - INITIAL CAPITAL COST PER HOUSEHOLD

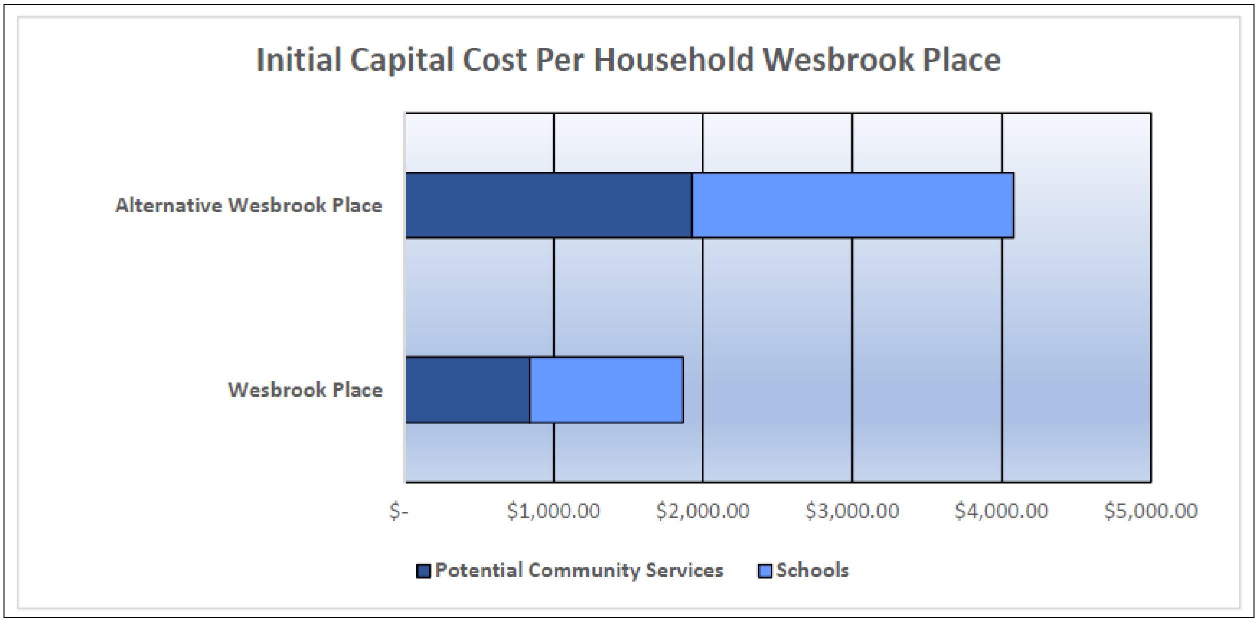
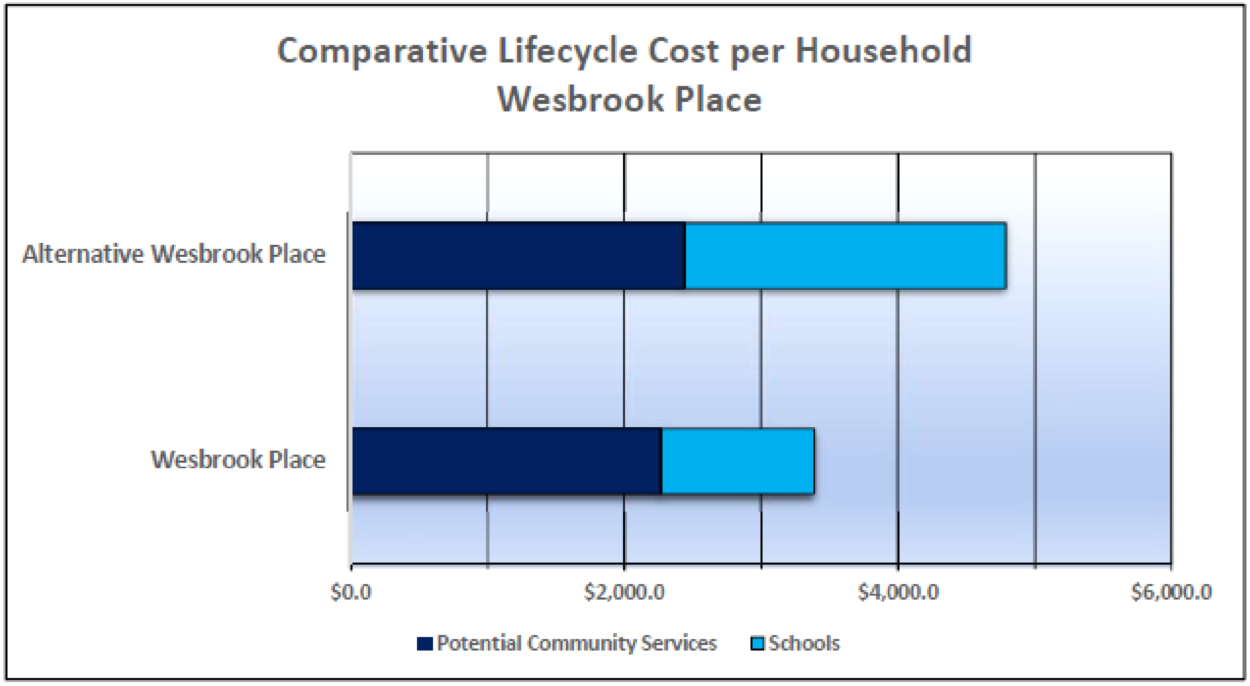


FIGURE 8 - LIFECYCLE COST PER HOUSEHOLD



In summary, while the net residential density increases by 57%, the total per household lifecycle costs of hard infrastructure, municipal services and school costs for Wesbrook Place decreases by 28%. This suggests that the hard infrastructure capital costs per household is, in fact, impacted by residential density, further supporting the findings of Fowler (2010) (see literature review presented above).

Further reflection on this inverse relationship yields a logical finding: you'll essentially need more of everything to cover the distance between people if they're spread out. Water pipe, sewer pipe, electrical wire, roads materials, sidewalks, bus routes, bikes lanes, will all be impacted by the type of development under consideration.

Refer to Appendix A for a detailed explanation of the variables involved in these calculations.

LIFECYCLE COST OF GREEN INFRASTRUCUTRE

This section provides a case study to demonstrate the utility of thinking long-term about investment choices. A green roof was envisioned to be constructed on the new elementary school as an example of the relative costs associated with green infrastructure alternatives. The results can be used to assist UBC (and other project proponents) with evaluating the long-term costs and revenues associated with financing future green infrastructure projects. This portion of the research was inspired by the initiatives set forth by the City of Portland, Oregon who applied a lifecycle costing approach to build three new fire stations with green roofs as a means of to reducing energy costs and managing storm water in the long term. To this day, Portland City Council requires a full lifecycle analysis for all capital project proposals (Bourdeau *et. al*., 2003).

A summary of roofing quotes and project statistics are presented below.

Project Statistics

A preliminary "back of envelope" costing estimate for the green roof was provided by interviewing six architectural technology companies based in Vancouver, BC.

Life cycle costs of a green roof and conventional roof alternative were calculated using a lifecycle costing method developed by the Athena Sustainable Materials Institute (Toronto and Region Conservation Authority, 2013). Capital and long-term cost (and savings) data used as inputs to the tool were based on the best information obtained from surveying roofing consultants and reviewing the most up-to-date literature.

According to the estimates provided in the interviews, the capital cost associated with an engineered/layered (extensive) green roof at would range between \$28 and \$35 per square foot (supplied and installed) with a weight of approximately 20 lbs/square foot/saturated. This results in a total cost of \$2,800,000 for the 9,920 m^2 structure, and includes all materials and labour.

TABLE 3 - PROPOSED PROJECT STATISTICS FOR GREEN ROOF

Site Area	Building Coverage (existing)	Percent Coverage	Building Height
1.65 ha	9,920 m^2	43%	13.4 m

Source: Interview with Roofing Consultant (2017).

TABLE 4 - ROOFING QUOTES AND ANALYSIS

	Conventional Modified Bitumen	**Extensive Green Roof**
Initial installed cost[1]	\$2,300,000	\$2,800,000
Cost per square foot	\$20 - \$25	\$28 - \$35
Roof durability	20	35
Annual Maintenance Cost[2]	\$46,000	\$30,000
Estimated replacement cost[3]	\$1,450,400	\$0
Landfill cost at replacement[4]	\$35,925	\$0
Estimated replacement salvage value[5]	\$0	\$560,000
End of life residual value	\$1,533,333	\$0

[1] Initial capital cost includes labour and materials (e.g. membrane, vapour barrier, insulation, flashing, drainage plane, root barrier, filter fabric, 6" of soil and plant materials – total \$20 - \$25/square foot – assumes 100,000 square foot roof

[2] The annual maintenance cost for modified bitumen is estimated at 2% of initial capital cost. Green roof annual maintenance cost is estimated at \$0.30/square foot

[3] Estimated replacement cost equals the initial installed cost + tear off cost. Tear off cost is estimated at \$2.00/ft2.

[4] Assumes \$85/m per tonne

[5] The conventional roof does not have a salvage value at the end of its designated replacement period. The extensive green roof will salvage a portion (approximately 20%) of its insulation, soil and plant materials when its replaced.

Source: Interviews with Roofing Consultants, Vancouver, BC and Toronto, Ont. (2017).

According to the consultants interviewed (note: at the request of those interviewed, names of contractors have been excluded), maintenance is required two to three times a year, which includes a cleaning charge in the range of $2,500 per annum per 10,000 sq. ft (2ply SBC, black/grey, granular). This results in an annual maintenance cost of $30,000 (based on hypothetical 100,000 square foot building). A discount rate of 6% was applied to each scenario over the course of the study period.

Note: this assessment is for comparative purposes only and should not be considered a feasibility study or budget estimate. The intent is to demonstrate the relative costs associated with green roof construction in conjunction with other "municipal services".

In the case of UBC, the green roof analysis in this research proved to be more economically viable than a modified bitumen system, when considered over the lifecycle of the investment. The results reveal that the green roof is the least cost option over the 100-year holding period (study period). The results were calculated considering all future cash flows for each system. The net present value (NPV) considers the time value of money (discount rate) by accounting for capital costs, interest rates, replacement costs, landfill costs, etc.

The results (see table 5) indicate that the green roof system investment considered does not yield a positive return on investment or payback until 20 years (approximate lifespan of the modified bitumen roofing system). After 20 years, the extensive green roof system is the most cost competitive.

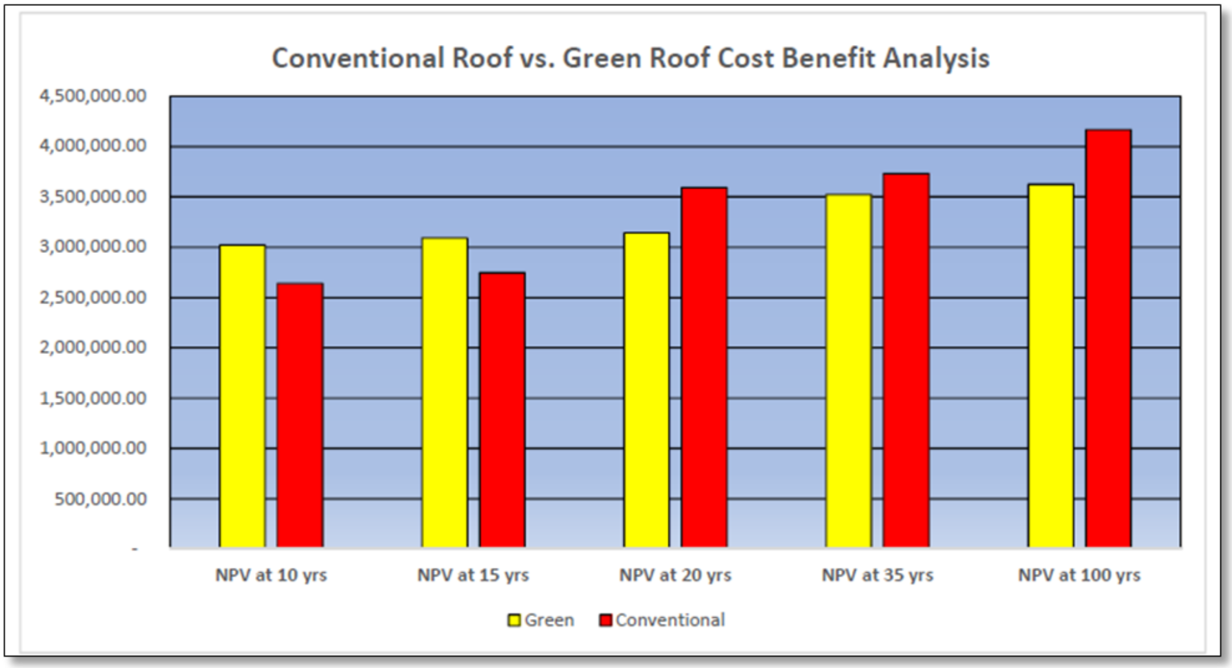
LIFECYCLE COST OF ROOFING SYSTEM

TABLE 5 - LIFECYCLE CALCULATIONS FOR ROOFING SYSTEM

NET PRESENT VALUE	At year	Extensive Green Roof	Conventional Modified Bitumen
NPV at 10 years	10	$3,020,802.61	$2,638,564.00
NPV at 15 years	15	$3,091,367.47	$2,746,763.45
NPV at 20 years	20	$3,144,097.64	**$3,592,785.18**
NPV at 35	35	$3,522,479.92	$3,732,088.13
NPV at 100 years	100	$3,623,468.40	$4,165,746.15

Source: David Sametz Calculations (2017).

FIGURE 9- COMPARATIVE ANALYSIS OF ROOFING SYSTEM



Source: David Sametz Calculations (2017).

CONCLUSIONS

A significant portion of the "municipal budget" is affected by the geographic pattern of development. Traditionally, planning, finance, engineering and operations have had few opportunities to collaborate on the long-term sustainability of infrastructure systems/projects. This has the potential to result in a disconnect between infrastructure capital planning and development planning processes.

Fortunately, UBC is on the cutting-edge of innovation with respect to sustainability planning. The Social, Economic and Environmental Development Studies (SEEDS) program is setting the stage for an exciting new paradigm in the planning profession. By making the connection between academia and operations, the SEEDS program is fostering a new way of thinking about asset management—one that incorporates land use planning— that will support UBC's sustainability goals by providing a rationale for working collaboratively and for investing in sustainable land use practices.

The results of this study provide a baseline costing analysis for community infrastructure services at UBC, and highlight the long-term benefits of incorporating green infrastructure alternatives into future development plans.

The findings highlight the economic benefits to the high-density mixed-use development as seen in Wesbrook. The result for the books: the total lifecycle cost of the alternative Wesbrook plan is 28% more expensive than the current Wesbrook plan.

The per-unit cost savings are associated with the residential sector's share of operation and maintenance costs. Because there are more units per buildable area, infrastructure installation and maintenance costs are spread out over a larger number of units, resulting in reduced costs per household. When comparing the cost of the green roof to the traditional modified bitumen, it was shown that the green roof system did not yield a positive return on investment or payback until the 20-year mark (approximate lifespan of the modified bitumen roofing system). After 20 years, the extensive green roof system was the more competitive option.

By collecting and synthesizing the infrastructure data (see Appendix A for a breakdown of individual costs) much of the legwork for this type of analysis has been completed. The results can be applied to a variety of other planning scenarios and characteristics across campus, ranging in size from a collection of houses, a block-by-block infill development, to a large subdivision. However, the costing variables should be updated regularly to reflect changes in materials, technology, level of service and external geopolitical forces. This is crucial to maintain contemporary accuracy in one's own results. While the intent of this research was to incorporate all infrastructure services into the analysis, some data was unobtainable at the time of this assessment.

With that in mind, the following list of recommendations will ensure the most accurate and up-to-date results.

- Incorporate the cost of heating, cooling and stormwater management into the green roof comparative analysis;

- Collaborate with external stakeholders (Vancouver School Board, TransLink, Provincial Government, Waste Management services) to obtain the most recent costing estimates;
- Verify all costing parameters built into the Tools' default values (RS Means Data), and update to match the area under consideration; and
- Provide a more thorough analysis of the external costs associated with climate change, air pollution and vehicle collisions.

REFERENCES

Boudreau, Sylvain, and D. Brynildsen (2003). "National guide to sustainable municipal infrastructure." Ottawa, Ontario, Canada: National Research Council of Canada.

British Columbia Ministry of Community, Sport and Cultural Development (2015). Community Lifecycle Infrastructure Costing Tool: User Guide (Version 1).

British Columbia Ministry of Municipal Affairs (2000). Development Finance Choices Guide.

Canada Mortgage and Housing Corporation (2005). Research Report. External Research Program. BCIT Green Roof Research Program.

Center for lean Air Policy (2017) Transportation Emissions Guidebook. Accessed online. April 12, 2017 http://www.ccap.org/safe/guidebook/guide_complete.html

Canadian Transit Factbook (2016). Conventional Operating Data.

Desjardins, E. P. (1997). Conventional and Alternative Development Patterns: Phase I-Infrastructure Costs.

Engel-Yan, J.; Kennedys, C.; Saiz, S. and Pressnail, K. (2005). Toward sustainable neighbourhoods: the need to consider infrastructure interactions. Canadian Journal of Civil Engineering.

Erica Oberndorfer, Jeremy Lundholm, Brad Bass, Reid R. Coffman, Hitesh Doshi, Nigel Dunnett, Stuart Gaffin, Manfred Köhler, Karen K. Y. Liu, Bradley Rowe, (2007). Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services.

Fowler, K. Local Government Land Use and Asset Management Planning in BC (2010). Proposed Sustainable Services Improvements.

Félio, G. (2012). Canada's Infrastructure Report Card. VICTORIA.

Federation of Canadian Municipalities and National Research Council (2006). Infraguide. Infrastructure and Land Use Planning.

IBI Group and CMHC (2000). Research Report. Greenhouse Gas Emissions from Urban Travel: Tool for Evaluating Neighbourhood Sustainability. Prepared by IBI Group.

KPMG LLP. University of British Columbia Neighbours' Fund. October 14, 2015

Lawlor, G. (2006). Green roofs: a resource manual for municipal policy makers (Vol. 6). Canada Mortgage and Housing Corporation.

Litman, T. (2015). Understanding smart growth savings. Victoria Transport Policy Institute.

Mirza, S. (2007). *Danger ahead:* The coming collapse of Canada's municipal infrastructure. Federation of Canadian Municipalities.

Means, R. S. (2012). "RS Means construction cost data." Sourced from CLIC Costing Tool Default Values (2017).

Narissa Chadwick and Lourette Swanepoel (2015). An Integrated Planning Approach to Addressing the Infrastructure Challenge: British Columbia's Community Infrastructure Planning Decision Support Tool" Planning West Volume 58, #2.

Natural Resources Canada (2015). National Energy Code of Canada for Buildings.
http://www.nrcan.gc.ca/energy/efficiency/buildings/eenb/codes/4037
Accessed online. April 2, 2017.

Rahman, S., & Vanier, D. J. (2004). Life cycle cost analysis as a decision support tool for managing municipal infrastructure. In *CIB 2004 triennial congress* (Vol. 2, No. 1, pp. 11-8). Ottawa: National Research Council (NRC).

Scheuer, Chris, Gregory A. Keoleian, and Peter Reppe. (2003) "Life cycle energy and environmental performance of a new university building: modeling challenges and design implications." Energy and buildings.

Speir, C., & Stephenson, K. (2002). Does sprawl cost us all? Isolating the effects of housing patterns on public water and sewer costs. *Journal of the American Planning Association*, *68*(1), 56-70.

Stantec Consulting (2015). Community Lifecycle Infrastructure Costing Tool (CLIC).

Sustainable Prosperity Institute (2012). Sustainable Communities. Policy Brief. Managing Urban Sprawl: Reconsidering Development Cost Charges in Canada.

Toronto and Region Conservation Authority (2013) Assessment of Life Cycle Costs for Low Impact Development - Stormwater Management Practices. Sustainable Technologies Evaluation Program.

Thomson, D. (2013). Suburban Sprawl: Exposing Hidden Costs, Identifying Innovations.

UBC (2005). Wesbrook Place Neighbourhood Plan.

UBC (2015). Land Use Plan. UBC Campus and Community Planning.

UBC (2014). Vancouver Campus Plan. Campus and Community Planning.

UBC (2011). Update on Public Realm and Community Amenity Plans and Associated Funding (Infrastructure Impact and Community Amenity Charges) for the Vancouver Campus. Report to the Board of Governors.

UBC (2012). Update on Infrastructure Impact Charge (IIC) Plan for the Vancouver Campus.

UBC (2017) University Neighbourhood Association (2017). https://www.myuna.ca/

Accessed online April 14, 2017

Vancouver School Board (2017). FTE Vancouver Typical Costs Per School.
https://www.vsb.bc.ca/sites/default/files/publication-files/Typical%20cost%20per%20school_March24.pdf

Accessed online June 4, 2017.

Vannnstruth Consulting Group (2016). UNA Budget Analysis Study. Final Report.

APPENDIX A - INFRASTRURE DATA AND SOURCES

Step 1 - Defining the Neighbourhood

The first step in the formulation of the lifecycle costing analysis is data collection, and an evaluation of neighbourhood statistics (including density, land use, road allocation, built form, building footprints, infrastructure requirements). A thorough review of the neighbourhood characteristics in paramount to achieving accurate results.

Step 2 – Specifying Costing Variables

This step specifies the unit costs for all variables, as well as related costing parameters. The infrastructure costs are expressed per physical unit of infrastructure (e.g. per metre, per household, etc.).

The following tables provide and breakdown of the costs associated with each parameter, and each parameter is associated with a reference on where best to obtain this data.

General Cost Assumptions

TABLE 6 - DISCOUNT RATE

Interest Rate for Amortizing Capital Cost	6%

Source: RS Means Construction Cost Data (2009).

The costs of potable water, sanitary sewer, storm sewer, and storm sewer distribution services are assumed to be directly related to length of roads. Therefore, the costs are developed by multiplying the costs of the standard mains by the length of roads within the scenario. The interest rate is typically between 0 – 1% above the current long-term lending rate (RS Means Construction Cost Data, 2009).

Local water, sanitary and storm distribution costs include the cost of both local distribution lines as well as trunk lines internal to the development.

Costs associated with non-linear water distribution networks, such as pump station upgrades, are not included.

Capital Costs - Roads, Water, Sanitary, Storm[6]/[7]

The capital costs of roadworks, water, sanitary and storm were obtained through conversations with Engineering and Infrastructure Services. To ensure the most up-to-date costing estimates, ensure this is updated on a regular basis.

TABLE 7 - CAPITAL COSTS

SERVICE	TYPE 3 – TWO LANE LOCAL ROAD	TYPE 4 – TWO LANE COLLECTOR
BASIC ROADWORKS[8] ($/M)	$1800[9]	$1800
POTABLE WATER DISTRIBUTION[10] ($/M)	$400	$400
SANITARY SEWER COLLECTION[11] ($/M)	$440	$440
STORM SEWER COLLECTION[12] ($/M)	$700	$700

Source: Data obtained through conversations with UBC Engineering and Infrastructure Services.

Local Storm Water Management – Capital Cost

NOBEL PARK STORMWATER DETENTION TANK	$900,000 (PER 1500 M^3 STORAGE)

Source: Data obtained though conversations with UBC Engineering and Infrastructure Services.

Road Operation and Maintenance Cost ($/m)

Operation and maintenance values were unavailable at the time of the assessment; therefore, the Tool default values were applied. For a breakdown of the costs associated with road operations and maintenance, refer to the RS Means Construction Cost Data (2009). Data needs to updated to reflect 2017 construction cost data.

[6] Capital cost of roads is a function of length, width and types of design features included
[7] Utility costs are not included assuming that the utility companies would carry these costs
[8] Includes excavation, granular fill, asphalt sidewalks
[9] Includes road, sidewalk, curb + gutter, and lighting
[10] Includes 150 mm watermain, connectors, hydrants
[11] Includes 200 mm pipe, connectors and maintenance holes
[12] Includes 300 mm pipe, connectors and maintenance holes

TABLE 8 - ROADS O&M COSTS

TYPE	OPERATING	MAINTENANCE	TOTAL
LOCAL	$3.00	$7.00	$10.00
COLLECTOR	$3.60	$8.40	$12.00
ARTERIAL	$6.00	$14.00	$20.00

Source: RS Means Construction Cost Data (2009).

Potable Water Treatment Operation and Maintenance Cost (($/household (hh))

TABLE 9 - WATER COSTS

TYPE	OPERATING	MAINTENANCE	TOTAL
SEMI-DETACHED/ROWHOUSE	$220.00	$55.00	$275.00
APARTMENT	$200.00	$50.00	$250.00

Source: Data obtained though conversations with UBC Engineering and Infrastructure Services.

POTABLE WATER DISTRIBUTION[13] ($/M)	OPERATION	MAINTENANCE	TOTAL
	2.00	2.00	4.00

Source: RS Means Construction Cost Data (2009).

WASTEWATER TREATMENT ($/HOUSEHOLD)[14]	OPERATION	MAINTENANCE	TOTAL
	200.00	50.00	250.00

Source: RS Means Construction Cost Data (2009).

SANITARY SEWER COLLECTION[15] ($/M)	OPERATION	MAINTENANCE	TOTAL
	4.20	2.80	7.00

Source: RS Means Construction Cost Data (2009).

Regional Services – Capital Cost

Data for regional services were unavailable at the time of this project. All values are derived from default values built into the model, and should be updated to reflect the current costing parameters.

Note: these costs may vary considerably depending on topography, environmental constraints, and distance to existing infrastructure. The costs refer to facilities that are over and above those facilities included in Wesbrook Place.

TABLE 10 - REGIONAL SERVICES

[13] Includes all costs associated with the distribution and connection system
[14] Applies to the cost of treatment and disposal
[15] Includes all costs associated with distribution and connection system

WATER DISTRIBUTION ($/M)	$400
SANITARY SEWER ($/M)	$400
STORM SEWER ($/M)	$700

Source: RS Means Construction Cost Data (2009).

School – Capital and Operation & Maintenance Cost

Data for schools and services were requested at the Vancouver School Board but was unavailable at the time of this project. All values are derived from default values built into the model. All values should be updated to reflect the current costing parameters (2017).

TABLE 11 - SCHOOL COSTS

CAPITAL COST[16] ($/STUDENT)	6,541.00

Source: Interviews with Vancouver School Board Representative (2017).

OPERATION AND MAINTENANCE ($/STUDENT)	OPERATION	MAINTENANCE	TOTAL
	6,949.00	0.00	6,949.00

Source: Public School Per Student FTE Operating Costs, Vancouver School Board (2015/16).

Recreation Facilities – Capital and O&M Cost

TABLE 12 - RECREATIONAL FACILITIES

CAPITAL COST($/HOUSEHOLD)	45.00

Source: Tool Default Vale, original source unavailable.

OPERATION AND MAINTENANCE ($/STUDENT)	OPERATION	MAINTENANCE	TOTAL
	328.00	0.00	328.00

Source: Tool Default Value/original source unavailable

Step 3 - Specifying Revenue Variables

This step inputs revenue information specific to UBC such as property tax rates (levies) and development charges (DCCs, IICs). For the purposes of this report, revenue variables were excluded from the analysis. Given the complexity of allocating costs to UBC infrastructure services, this type of analysis should be completed as a separate component.

The following categories are based on data obtained from a variety of sources. Refer to the references listed below for details on where to obtain the data.

[16] VSB unable to provide information – data is based on defined defaults values – includes construction of schools and facilities

Development charges – based on housing type and amount of built area

Property Taxes – based on average assessment value of housing

User charges – e.g: transit fare, water charges

Development Charges

At UBC, development charges are based on housing type and square footage, and include an Community Amenity Charge and Cost of Sale.

Development Cost Charges – Allocation

Table 13 - Development Cost Charges

Development charges per square foot of gross building area		Notes
Market housing (leasehold, rental)	$35.32 – infrastructure Impact Charge $3.25 – Community Amenity Charge $14.00 – Cost of Sale	89.2% of Wesbrook Residential Development
non-Market housing (faculty/staff rental)	$6.00 Infrastructure Impact Charge	10.8% of total Wesbrook residential development

Source: UBC IIC and CAC Rates (2016).

Development Cost Charges – Household Type

Type	Market housing	$/Unit	non-Market housing	$/Unit
Townhouse	224,784 ft^2	$73,855.59	27,216 ft^2	$8,164.80
apartment/low rise	1,831,261 ft^2	$51,582.82	221,723 ft^2	$5,886.45
Apartment/High Rise	3,503,773 ft^2	$50,011.76	424,224 ft^2	$6,395.33

Source: Data Compiled from UNA Website (2017).

UBC Tax Rate

The services levy is like the municipal portion of property taxes, for residential properties on UBC's campus. Property owners on UBC's campus pay a Rural Tax to the Province of British Columbia and the Services Levy to UBC. The two added together are the same as the City of Vancouver municipal tax due on a property with the same assessed value. The basic calculation of the UBC tax rate is therefore that of the City of Vancouver tax rate, minus the BC Rural Tax rate.

Residential service levies, general municipal service levies and funding from the University are recognized as revenue (UNA, 2015. Residential service levies and general municipal service levies are charged to tenants on a calendar year basis, and are reported in the financial statements on an accrual basis.

The annual Services Levy is deposited into the Neighbours' Fund, which is a separate fund within UBC finances. The UNA Annual Operating Budget receives funds from the Neighbours' Fund to provide municipal-like services to the residents of the UNA.

Table 14 - Tax Rates and User Charges

UBC PROPERTY TAXES PER $1000 OF ASSESSED VALUE	
GENERAL RESIDENTIAL (PAID TO PROVINCE)	0.56
SCHOOL	1.1859
TRANSLINK	0.2834
BC ASSESSMENT	0.0543
MFA	0.0002
GVRD ELECTORAL A	0.1013
POLICE TAX (PAID TO PROVINCE)	0.0851
SERVICES LEVY (PAID TO UBC)	0.8955

Source: UBC Campus and Community Planning (2017).

Median Assessment Value Per Unit

The UBC service levy amount is based on the value of each property as determined by BC Assessment.

ROWHOUSE/TOWNHOUSE/DUPLEX	$1,000,413
APARTMENT LOW RISE	$649,748
APARTMENT HIGH RISE	$752,503

Source: BC Assessment (2017).

Land Use and Locational Characteristics

Defining Development characteristics

Development characteristics includes an evaluation of land use, demographics, residential densities, and the amount of infrastructure required to service Wesbrook Place. These data determine the different costs associated with different form of development.

For example, land use and location characteristics are used in the calculation of travel activity and related costs as well as in the allocation of costs.

Costs for residential development are used to determine per household costs, which are then used to compare the cost efficiency of different developments.

Step 4 - General Scenario Characteristics

TABLE 15 - DEVELOPMENT ASSUMPTIONS

DISTANCE TO CENTRAL BUSINESS DISTRICT	11.0 KM
GROSS LAND AREA (HA)[17]	45.88 HA
% RESIDENTIAL LAND AREA	45%

Source: UBC Campus and Community Planning (2017).

Development Densities

Residential Development Footprint

The number of units of each dwelling type is calculated based on percentages, the typical coverage values, and the amount of residential land. All values are projected to full build-out in 2024.

The number of residential units by housing type is required to determine many factors, such as the number of households and household costs.

[17] Includes residential and employment lands

TABLE 16 - DEVELOPMENT FOOTPRINT

DEVELOPMENT FOOTPRINT			
TYPE	TOWN HOME	LOW RISE[18]	HIGH RISE
TOTAL AT BUILD-OUT (2024)	252,000 FT^2	2,052,984 FT^2	3,927,997 FT^2
TOTAL MARKET UNITS	160	1867	3,285
TOTAL NON-MARKET UNITS	20	226	398
TOTAL UNITS	180	2093	3683

Source: UBC Campus and Community Planning (2017).

Demographic Assumptions

Demographic assumptions are important calculations regarding auto ownership and use, and school costs.

TYPE[19][20]	HOUSEHOLD SIZE (PERSONS/UNIT)	ADULTS (16+) (PERSON/UNIT)	SCHOOL AGES CHILDREN (PERSON/UNIT)
ROWHOUSE/TOWNHOUSE/DUPLEX	2.79	2.00	0.79
LOW RISE	2.29	2.00	0.79
HIGH RISE	2.22	2.00	0.79

Source: Data obtained by UBC Campus and Community Planning (2017).

DEVELOPMENT POPULATION	
ADULTS	2045
CHILDREN	520
TOTAL	12,500

Source: UBC Campus and Community Planning (2017).

Potential Community Services

The amount of required road, water, waste-water, and storm water infrastructure determines much of the costs of the development. The following tables are roads within the development only.

[18] Implies 6 stories or fewer
[19] Used to calculate auto ownership and use as well as school costs
[20] Data provided by Campus and Community Planning

Roads

Internal: Roads within the development	Road Type	Length of Road (m)
Type 2 Two-lane local	15 m R.O.W	2479
Type 3 Two-lane local	18 m R.O.W	2059

Source: Interview with UBC Engineering and Sustainability (2017).

Step 5 - Allocation of Costs

A key factor in determining the cost of development is the question of who pays. Allocation of capital costs and operating costs associated with hard infrastructure and municipal services is specified. The allocation of costs was split between the developer, user, Vancouver School Board, TransLink, Regional and Provincial Governments.

The Wesbrook development includes both market and non-market rental accommodation. Renters typically pay directly for operating costs[21]

Allocation of capital costs

Table 17 - Allocation of Costs

Services	Allocated to	Percentage
Internal Roads	Developer	100%
External Roads	Province	100%
Potable Water Distribution and Treatment	Developer	100%
Sanitary Sewer Collection and Treatment	Developer	100%
Storm Sewer Collection	Developer	100%
Schools Construction and Operation	Vancouver school board	100%
Recreational Facilities	Vancouver school board	100%
waste management	Contactors	100%

Source: UBC Campus and Community Planning (2017).

[21] Market renters pay for capital costs through their rents. Non-market renters pay a lower rent and would not be covering the full cost of the capital costs of their facilities.

Allocation of Operation and Maintenance Costs

SERVICES	ALLOCATED TO	PERCENTAGE
INTERNAL ROADS	USER	100%
EXTERNAL ROADS	USER	100%
POTABLE WATER DISTRIBUTION AND TREATMENT	USER	100%
SANITARY SEWER COLLECTION AND TREATMENT	USER	100%
STORM SEWER COLLECTION	USER	100%
SCHOOLS CONSTRUCTION AND OPERATION	VANCOUVER SCHOOL BOARD	100%
RECREATIONAL FACILITIES	VANCOUVER SCHOOL BOARD	100%
WASTE MANAGEMENT	USER	100%

Source: UBC Campus and Community Planning (2017).

Step 6 - Cost Savings and Replacement

Allocation of Replacement Costs[22]

This step enables users to specify replacement periods for all assets, and discount costs to account for infrastructure already in place.

Cost savings and replacement was used to account for green infrastructure savings (e.g. when green roofs are performing part of the storm water function that reduces the overall investment needed for storm collection.

The age of existing infrastructure is used to calculate when the initial replacement cycle that would occur in calculating lifecycle cost. Infrastructure ages and requires replacement once the asset has reached its end of life.

The typical lifespan (years from new to replacement) of various assets was used. All data was provided by UBC Infrastructure Services, interviews with roofing contractors, or various academic sources.

Note: this calculation assumes complete renewal and not varying replacement periods for different parts of the asset (e.g. the top asphalt layer of the road having a shorter replacement period vs base layer, etc.)

[22] Replacement Cost is automatically allocated to UBC

Existing Infrastructure

TABLE 18 - EXISTING INFRASTRUCTURE AND REPLACEMENT

SERVICE	PERCENT IN PLACE	AGE (YEARS)
ROADS	100%	12
POTABLE WATER DISTRIBUTION AND TREATMENT	100%	12
SANITARY SEWER COLLECTION AND TREATMENT	100%	12
STORM SEWER COLLECTION	100%	12
WASTE MANAGEMENT	100%	10
SCHOOL CONSTRUCTION AND OPERATION	100%	2
RECREATIONAL FACILITIES	100%	2

Source: UBC Engineering and Sustainability (2017).

The replacement cost percentage is used to calculate the total lifecycle investment, which represents the percentage of the original cost that would be required to replace the infrastructure.

SERVICE[23]	YEARS FOR REPLACEMENT	REPLACEMENT COST[24] (%)
ROADS	50	100%
POTABLE WATER DISTRIBUTION AND TREATMENT	80	100%
SANITARY SEWER COLLECTION AND TREATMENT	100	100%
STORM SEWER COLLECTION	100	100%
WASTE MANAGEMENT	20	100%
SCHOOL CONSTRUCTION AND OPERATION	50	100%
RECREATIONAL FACILITIES	50	100%
POLICE SERVICE	50	100%

Source: UBC Engineering and Sustainability (2017).

[23] Required to calculate the total investment needed during the lifecycle. The replacement cost % represents the percentage of the original cost that would be required to replace the infrastructure (in today's dollar value)
[24] Percent of total