Studley Campus Walkability Assessment

ENVS 3502: Campus as a Living Lab

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Executive Summary

Walkability is a measurement of an overall area's awareness for transportation. An assessment for the walkability of a space can improve many areas such as safety, health, and traffic. The main goal when measuring walkability on a University campus is to advance healthy living, lower emissions and improve sustainable transportation. With obesity being an ongoing struggle in Canada today, it is important to create a sustainable and walkable campus.

A healthy lifestyle can also decrease the chance of developing other health concerns like coronary heart disease, stroke, cancer, and type 2 diabetes in the future, while promoting mental well-being (Mukherjee, 2013).Walking has no impact on the environment and in doing so, reduces traffic, emissions, and conserves energy, all while saving money that would have been spent using any other mode of transportation.

The objective of this study is to assess various segments of the Studley Campus and to determine areas on campus that require improvement in walkability. The campus was divided into five sections, and nine segments were chosen to be evaluated on three major components of walkability: (1) safety, (2) path quality, and (3) comfort. A walk score was generated, giving each segment a score out of a possible 100. The factors that scored the least throughout the segments were bikeability, night time safety, crosswalk quality, and the local terrain. Factors which scored the highest were pedestrian facilities, path maintenance, aesthetics and path size.

Walkability on campus can be improved by the addition of pathway lighting to better develop nighttime safety. An increase in the frequency of scheduled assessments and maintenance of sidewalks and crosswalks around campus is necessary to ensure overall pedestrian safety is progressive and regulated. Maintenance should include the repainting of crosswalks, the addition of proper crosswalk signage and lighting, and repaving of damaged sidewalks. And finally, the continuation of added bike racks, bike repair stations, and bike lanes around campus, is essential to promote a healthy lifestyle to staff and students. A walkability assessment should be completed every two years, or so, to determine if the campus is improving on its overall walkability over time.

This study is representative of an informative overview of what walkability is and how it is represented on Dalhousie's Studley campus, so it is beneficial as a reference for future studies, as well.

Acknowledgements

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1 Introduction

1.1 Research Problem

Walkability is a key component in a sustainable transportation network, and provides social benefits as well as benefits to human health, economic stability, and environmental protection (Park, 2008; Keating et al, 2005). Southworth (2005) has even described walkability to be the foundation for any sustainable city. The walkability of an environment can dictate the degree to which people select sustainable modes of transportation, as an inviting and safe environment is more welcoming to pedestrians and cyclists. By developing walkable environments, cities and campuses can encourage commuters to choose sustainable and healthy modes of transportation, contributing to the overall sustainability of the region.

The Dalhousie Transportation Collaboratory (Salloum and Habib, 2013) identified that for 2009, 2010, and 2012, walking was the primary mode of transportation for students, faculty, and staff of Dalhousie University, while in 2011 walking was ranked the second only to personal vehicle. The dominance of walking on campus, and the role walkability plays in health, economic, environmental, and social issues, demonstrates a need for a comprehensive assessment of campus walkability in order to identify areas for improvement and to further promote active and sustainable transportation on campus.

We aim to investigate the walkability of Dalhousie University's Studley campus, and to identify the key components of walkability that require improvement on campus in order to further promote sustainable transportation on campus.

As a leader in education, Dalhousie has a unique opportunity to influence not only its staff and students, but also the population at large across the Halifax Regional Municipality (HRM). The University has the opportunity to positively contribute to society not only by following existing sustainability principles, but also by paving the way for more innovative sustainable practices.

1.2 Objective

Walkability is a critical component to the sustainability of Dalhousie University, and while the Studley campus boasts several walkable features, the campus as a whole must more greatly encourage the use of sustainable transportation. Our proposed research seeks to identify the major components of Dalhousie University's Studley campus that require improvement in order to ameliorate the overall walkability of the campus. We aim to calculate a walkability score for the campus as a whole, and to identify the segments of the campus that are the least walkable and to propose improvements to these segments.

2 Background

2.1 What is Walkability?

Walkability is a concept that is not only difficult to define, but is also difficult to measure. A wide range of definitions for walkability have been presented in the literature over the past decade (e.g. Park, 2008; Southworth, 2005; Alberta Association Canadian Institute of Planners, 2010), however we have chosen to use an adaptation to Southworth's (2005) definition:

> Walkability is the extent to which the built environment supports and encourages walking and cycling by providing for pedestrian and cyclist comfort and safety, connecting people with varied destinations within a reasonable amount of time and effort, and offering visual interest in journeys throughout the network.

For the purpose of this research, we have chosen to include bikeability within the concept of walkability in order to include the major forms of active transportation on campus in our assessment.

2.2 Importance of Walkability

The walkability of an environment has been demonstrated to contribute to sustainable communities and healthy living habits, as well as to provide other economic and environmental benefits. Park (2008) states that "walkability has the potential to profit society in a number of ways, such as reducing air pollution, traffic congestion, and the burning of fossil fuels, while contributing to a more active lifestyle and reducing obesity".

Obesity and sedentary lifestyles are a growing problem in North America. Obesity rates in Canada have tripled over the past thirty years (Roberts et al., 2012), and more than 50% of U.S college students do not get sufficient exercise (Keating et al., 2005). The walkability of environments has been demonstrated to be a determinant of physical activity levels of local populations (Cochrane and Davey 2008; Owen, Leslie, 2000) Furthermore, communities that have been assessed as highly walkable have been associated with increased physical activity and lower body weight (Renalds, 2010). As a result, the potential benefits to human health from a walkable environment are significant. A walkable environment on campus may help to further promote walking as the dominant mode of transportation, therefore supporting healthy lifestyles in students, faculty, and staff.

Walkability has also been shown to directly reduce negative impacts to the environment by decreasing greenhouse gas emissions and conserving energy (Newman and Kenworthy, 1999). Other forms of vehicular air pollution may also be reduced as fewer vehicles are operating (Park, 2008).

Walkability has also been associated with economic benefits. Leyden (2003) demonstrated that walking behaviour benefits the local economy by increasing foot-traffic and permitting marketers and advertisers to more effectively attract customers, while promoting sociability and political and social engagement. The economic impact of increased walkability reaches significantly farther, as automobiles contribute to long-term environmental damage resulting from greenhouse gas emissions, and also present potential threats to personal injury and property damage and contributing to dependence to foreign oil (Park, 2008). Walking as a mode of transportation is also inherently economically efficient, and is a free mode of transportation, accessible to all social classes.

2.3 Walkability on Campus

University campuses present a unique opportunity for evaluating walkability, as each one supports a large population within a small region, and are composed of a number of facilities distributed across this same region. Students, faculty, and staff may travel around campus by different means such as cycling, walking, driving, or public transit. In a recent study of 15 U.S. College campuses, Horacek et al. (2012) found that more than half of the post-secondary campuses scored below the acceptable walkability score (Horacek et al., 2012). None of the assessed campuses received a satisfactory score for bikeability. These results demonstrate that walkability on campuses is often over-looked and requires further investigation in order to effectively promote sustainable transportation and encourage active lifestyles.

The Dalhousie Transportation Collaboratory (Salloum and Habib, 2013) identified that for 2009, 2010, and 2012, walking was the primary mode of transportation for students, faculty, and staff of Dalhousie University, while in 2011 walking was ranked the second most dominant form of transportation after personal vehicle. The rapid switch in preference in 2011 may suggest that people are choosing their primary mode of transportation based on some rather loose criteria, and improving walkability may be sufficient to encourage individuals with no strong preference to make the more sustainable choice. Furthermore, the dominance of walking on campus demonstrates a need for a comprehensive assessment of campus walkability in order to identify areas for improvement and to further promote active and sustainable transportation on campus. A previous walkability study of the Dalhousie Studley Campus (Christian et al., 2010) revealed that many pedestrians found it difficult to cross streets due to high vehicle traffic and the presence of sidewalks in these high traffic areas. Other major deficiencies remain to be explored on the Dalhousie Studley campus, and their identification and mitigation are essential to the development of improved sustainability on campus.

2.4 Evaluating Walkability

According to Jaskiewicz's Pedestrian Level of Services (2000) there are many factors that affect the walkability of an environment, including the complexity of path networks, the presence of buffers between pathways and roadway, and the presence of shade (Jaskiewicz, 2000). Park (2008) also found that sidewalk amenities, traffic impacts, street scale, and landscaping significantly influenced the perceived walkability of an environment. Other criteria, such as safety from both traffic and crime, quality of sidewalks, street design or aesthetics, land use patterns, and linkage to other modes of transportation have also been demonstrated to contribute to the walkability of an environment (Southworth, 2005).

Quantifying the concept of walkability is a difficult task. As described previously, the walkability of an environment is dependent on a number of factors, and perception of walkability may in many cases be subjective. One of the earliest attempts at quantifying walkability was conducted in Portland Oregon (1000 Friends of Oregon, 1993) where the Pedestrian Environmental Factor (PEF) index was developed. This index scored four indicators of walkability: (1) ease of street crossing, (2) sidewalk continuity, (3) local street characteristics, and (4) topography. Since this early investigation in measuring and quantifying walkability, many studies have attempted to further develop quantification methods for measuring walkability and have identified a number of indicators of varying importance (e.g., Saelens et al. 2003, Dixon 1996, Landis et al. 2001). While several investigators have argued that the built environment plays an integral role in the perceived and actual walkability of an urban area (e.g. Boarnet et al., 2006; Day et al., 2006), the major categories used to assess the walkability of an environment vary from study to study. Boranet et al. (2006) also identified four major indicators of perceived walkability (accessibility, pleasurability, perceived safety from traffic, and perceived safety from crime), however these indicators differ significantly from those described by the PEF index. Southworth (2005) identified similar criteria for walkable cities, including connectivity of path networks, linkage with other modes of transportation, varied land use patterns, safety from both traffic and crime, and quality of path.

A variety of audits have been developed and used in walkability studies (e.g. Clifton et al., 2007). Such audits, such as the Pedestrian Environmental Data Scan (PEDS) (Clifton et al., 2007), the Systematic Pedestrian and Cycling Environmental Scan (SPACES) (Pikora et al., 2002), and Walk Score ® (WalkScore, 2014) provide consistent and efficient methods of evaluating the walkability of urban environments. Furthermore, such audits are generally easy-to-use and practical, and have also demonstrated high reliability (e.g. Pikora et al., 2002; Clifton 2007). This makes the audits useful in identifying barriers to walkability in urban environments, and in addressing these barriers in order to improve accessibility to pedestrians and cyclists.

3 Proposed Research Methods

3.1 Overview

Based on a thorough literature review of walkability assessments, audits, and studies, we have identified physical and environmental attributes that can be measured objectively in order to produce an accurate assessment of the Studley Campus walkability at Dalhousie University.

3.2 Site Description

Dalhousie University is composed of three campuses: the Studley, Sexton, and Carleton campuses. We conducted our assessment of the walkability of the Studley campus. The Studley campus is the largest campus of Dalhousie University and houses key buildings and resources such as the Killam Library, the Life Sciences Center (LSC), the Student Union Building and a number of residences as well as athletic facilities. The campus is approximately 0.42 km^2 and is located in the South End of Halifax, Nova Scotia. This campus was selected for our study because it is the largest campus and is also most accessed by the investigators, which facilitated data collection over our limited time frame.

3.3 Experimental Design

Walkability has been defined as a construct (Park, 2008), meaning that it is an intangible concept. As defined previously, the conceptual definition of walkability is insufficient to allow for accurate and concrete measurement of walkability. As such, walkability must be operationalized in order for empirical research to be conducted. By operationalizing walkability, we have defined the concept in a manner that allows for such empirical research and will yield quantitative measurements. This was done by identifying and defining smaller, more tangible and measurable components of walkability. These components were then used as proxies to objectively measure the construct of walkability in order to address our research questions (Park, 2008).

In operationalizing walkability, it was important to consider both environmental indicators and the perceptions and behaviours of pedestrians and cyclists. However, because of the limited scope of this project, we chose to focus on the environmental components of walkability. As in Park (2008), we used deductive operationalization to identify the indicators that were used to assess walkability on campus. This was done by using existing theory in the literature as a reference for identifying components for measuring walkability. It should be noted that deductive operationalization may introduce a degree of human bias that was present in past research into our assessment of walkability on Dalhousie campus (Park, 2008).

We assessed three major components of walkability on campus: (1) safety, (2) path quality, and (3) comfort, as outlined in our audit (Appendix 1). The safety of pathways on campus was assessed by measuring:

- the presence and quality of pedestrian facilities (such as gravel pathways and sidewalks)
- the potential for pedestrian-vehicle conflicts
- the quality of crosswalks
- night time safety features (presence and quality of lighting, presence of emergency call boxes)

Path quality was assessed based on five criteria:

- maintenance
- path size
- buffer size (between the pathway and vehicle traffic)
- bikeability (presence/absence of bike lanes and bike racks)
- aesthetics

Finally, comfort was measured by assessing the terrain (presence/absence of shade, and the steepness of the terrain). Each investigator was briefed on the indicator ranking system, as outlined in the audit (Appendix 1) to minimize any variation resulting from differing subjective assessments among investigators. The indicators were selected from a similar study that assessed the walkability of 15 post-secondary campuses in the United States (Horacek et al., 2012), and the audit design was adapted from the Centers for Disease Control and Prevention (CDC, 2010) in order to assign an overall walkability score to the campus.

Using a map of the Dalhousie University Studley campus, we identified likely pedestrian destinations such as major campus buildings, parking lots, bus stops, coffee shops, and fitness facilities. As in Horacek et al., (2012) we assembled a network of walking segments that were likely pedestrian routes among the above-mentioned pedestrian destinations in the hopes that these segments were representative of common pedestrian and cyclist routes through campus. A total of nine segments were identified, and each group member was assigned one-two segments for assessment. Using the audit tool we adapted from the U.S. Department of Health and Human Services Centers for Disease Control and Prevention (Appendix 1), we assessed each segment's walkability based on the indicators described above. The audit tool was used to rank each walkability feature on each pathway segment. After assessing the walkability of each segment using the audit-tool, each investigator further answered the following four questions, as adapted from for Disease Control and Prevention (CDC, 2010). These assessments were helpful in providing suggestions for the improvement of walkability on campus.

1. What is the most dangerous location along this segment? Why?
2. What is the most unpleasant element of this segment? Why?
3. What improvements could be made to make this segment more appropriate or safer for pedestrian use?
4. Are the conditions of this segment appropriate and attractive for exercise or recreational use?

Each walkability indicator was assigned an importance value (high, medium, low) reflecting its relative contribution to the walkability of an environment, as reflected in several investigations (e.g. Park, 2008; Horacek et al., 2012; Jaskiewicz, 2000). This gave more weight to those walkability features that have been identified as most important to the overall walkability of pathways. Equations 1-4 demonstrate how the importance of each indicator will be incorporated into the overall walkability score of each segment.

The audit was completed for a total of nine pathway segments across the Studley campus (Table 1). Once completed, the data was compiled and each segment was given a walkability score and was assessed. Scores between 0-39 were described as being high-risk areas and unattractive, scores between 40-69 were ranked as medium risk and of average aesthetic value, and any score greater than 70 was assessed as low risk with a pleasant atmosphere, based on the guidelines of the Center for Disease Control (CDC, 2010). We compared the segments and identified those that were most walkable based on their scores, and identified the strengths and weaknesses of each segment.

Finally, we assigned an overall walkability score to the Studley campus based on the hazards, connectivity, accessibility, aesthetics, and recreational potential of campus pathways. We also made recommendations for potential improvements to the walkability of the campus as a whole.

Table 1 Nine pathway segments assessed on the Studley campus of Dalhousie University using the walkability audit.

Segment Number	Section on Campus
1	Coburg Road west of Lord Dalhousie Drive to the intersection at Oxford Street
2	Area surrounding the Life Sciences Center, the Henry Hicks Building, and Sherriff Hall
3	Henry Street between South Street and Coburg Road
4	University Avenue between the Killam Library and Robie Street
5	Robie Street between South Street and Coburg Road
6	Coburg Road east of Lord Dalhousie Drive to the intersection at Robie Street
7	Edward Street between South Street and Coburg Drive
8	Castine Way to Oxford Street
9	Seymour Street between South Street and Coburg Drive

3.4 Limitations and Delimitations

The major limitations of this research were the time constraints of the study. Given the short time-frame available for collecting the data, we limited our assessment of walkability to three major factors and excluded pedestrian perceptions and behaviours from the study. We delimited the study spatially by confining the research to the Studley campus in order to focus our efforts more effectively and use our limited time as efficiently as possible. We further delimited our project by selecting a total of only 10 walkability indicators for our audit to satisfy the time constraints of each individual. The number of segments assessed was also delimited and set to a total of nine to allow sufficient time for data collection and analysis.

4 Results

The average overall score for walkability on the Studley campus was 74.5 out of a possible 100. This score falls within the highest category as defined in the methods, and evaluates the campus as being a low-risk environment for pedestrians and cyclists, while generally providing a welcoming and aesthetically pleasing environment. Across all nine segments, the mean score for maintenance of walking facilities was found to be the highest (mean = 4.67) while bikeability had the lowest average score of only 1.33 (Fig. 1; Table 1).

Table 2 Results of the walkability audits for nine segments on Dalhousie University's Studley campus. Audits were completed using a modification of the audit developed by the CDC (2010).

Walkability Feature	**Segment**									
	1	2	3	4	5	6	7	8	9	Mean
Pedestrian facilities (H)	5	5	5	3	5	5	5	4	2	4.33
P-V conflicts (H)	3	4	4	4	3	4	4	2	5	3.67
Crosswalk quality (M)	3	3	3	4	5	3	3	4	3	3.44
Night time safety (M)	4	4	3	3	5	3	3	3	3	3.44
Maintenance (M)	4	4	5	5	5	4	5	5	5	4.67
Path Size (L)	5	5	4	4	5	4	4	3	4	4.22
Buffer (M)	4	4	4	5	4	3	5	3	5	4.11
Bikeability (M)	2	3	1	1	1	1	1	1	1	1.33
Aesthetics (M)	5	5	5	5	4	4	5	2	5	4.44
Terrain (L)	3	4	3	4	4	4	4	2	3	3.44
High Importance	24	27	27	21	24	27	27	18	21	24
Medium Importance	44	46	42	46	48	36	44	36	44	42.89
Low Importance	8	9	7	8	9	8	8	5	7	7.67
Total Score	76	82	76	75	81	71	79	59	72	74.5

Note: H: high importance features; M: medium importance features; L: low importance features

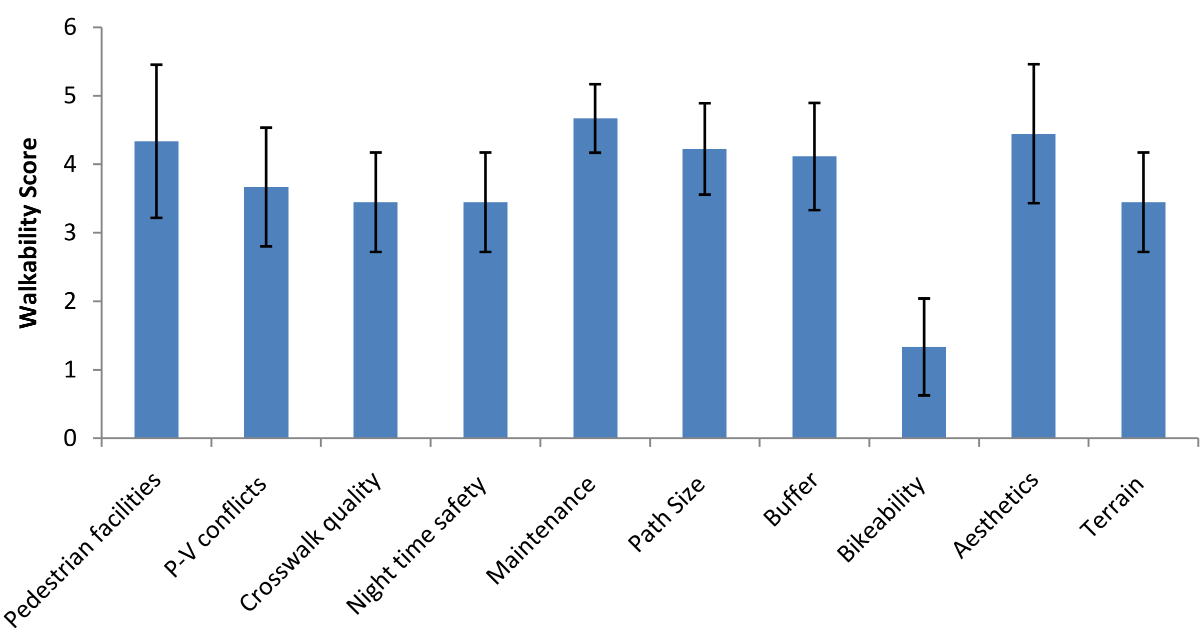

Figure 1. Mean walkability score and standard deviation across all nine segments audited on Dalhousie University's Studley campus.

Pedestrian facilities scored high across most segments on campus with a mean of 4.33 (Table 2). Six of the nine segments evaluated were given a perfect score of five for pedestrian facilities, while University Avenue (segment 4), Castine way through to Oxford Street (segment 8), and segment 9 (Seymour Street) all scored lower (Fig. 2).

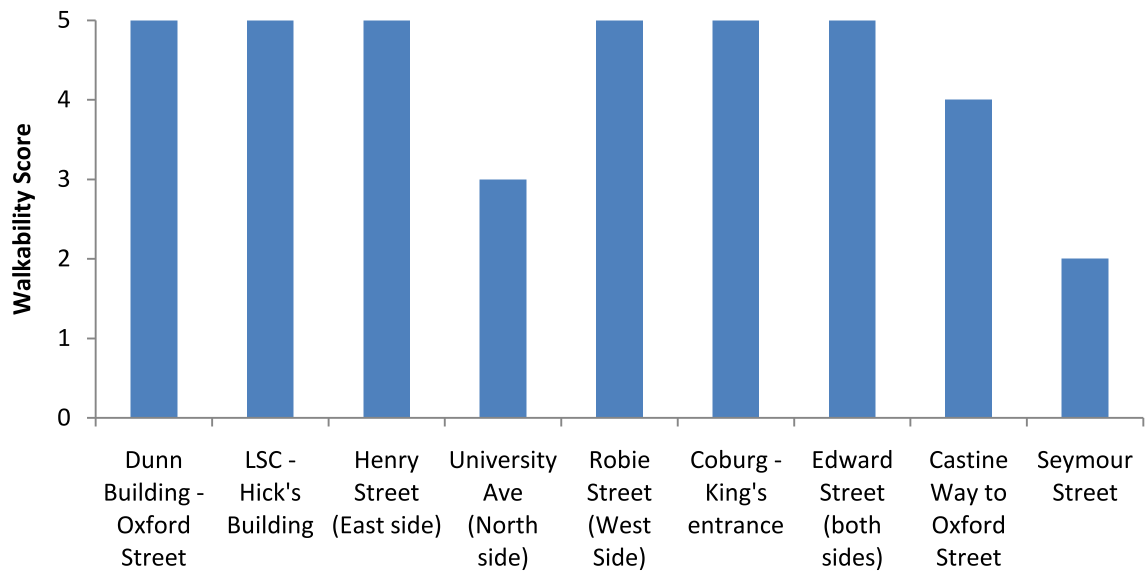

Figure 2. Walkability score (out of a possible 5) of each segment for pedestrian facilities.

Risk of pedestrian-vehicle conflicts was generally low, with the average score across all segments of 3.67 (Table 2). However, segments that transected major streets such as Robie Street (segment 5), Coburg Road (segment 1), and Oxford Street (segment 8), scored lower for risk of potential pedestrian-vehicle conflicts (Fig. 3).

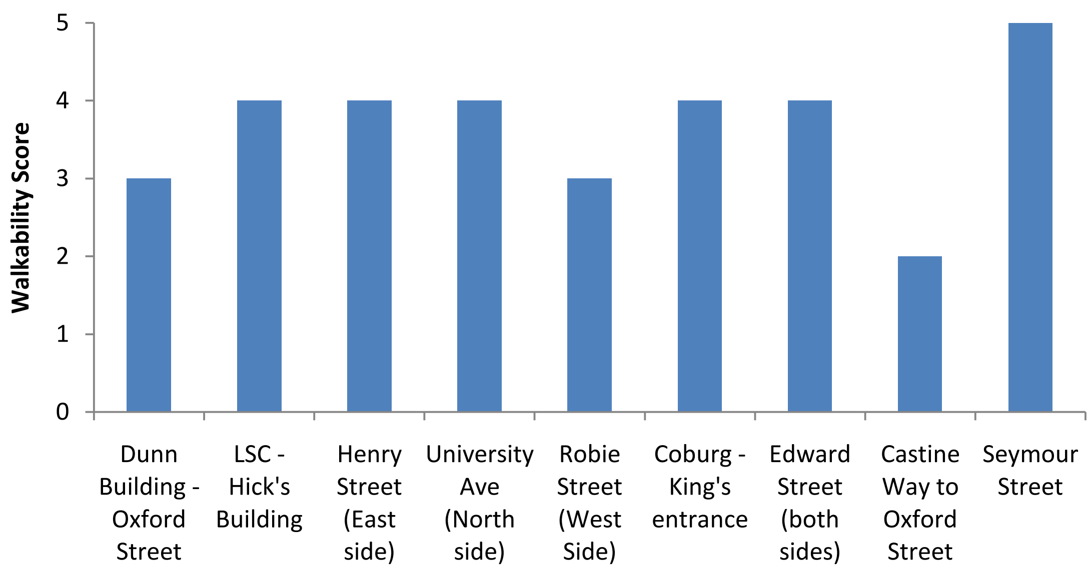

Figure 3. Walkability score (out of a possible 5) of each segment for pedestrian-vehicle conflicts

Mean crosswalk quality was evaluated as 3.44 out of a possible 5. Most segments scored 3, while segment 5 on Robie Street scored the highest with a perfect score of 5, the result of crossing lights at all crosswalks for this segment (Fig.4).

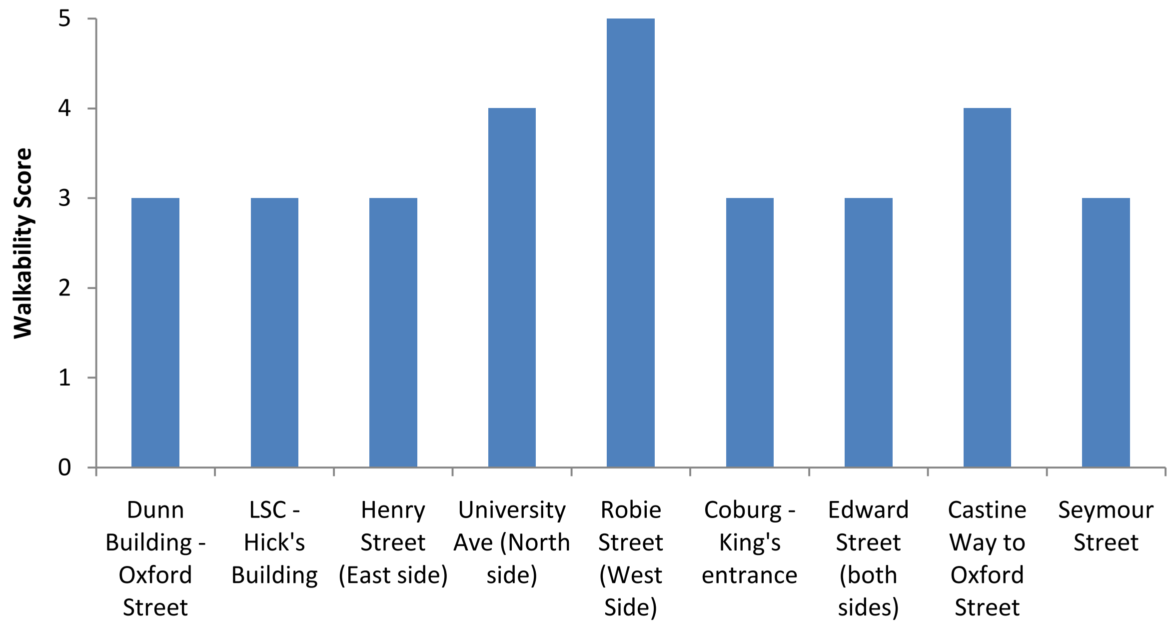

Figure 4. Walkability score (out of a possible 5) for each segment for crosswalk quality

Night time safety features also earned an average of 3.44 across all segments. Robie Street (segment 5) received the highest score for safety features as a result of its ample illumination (Fig. 5). Most other segments received a score of 3 as they lacked sufficient lighting to make the area well lit and safe for pedestrians.

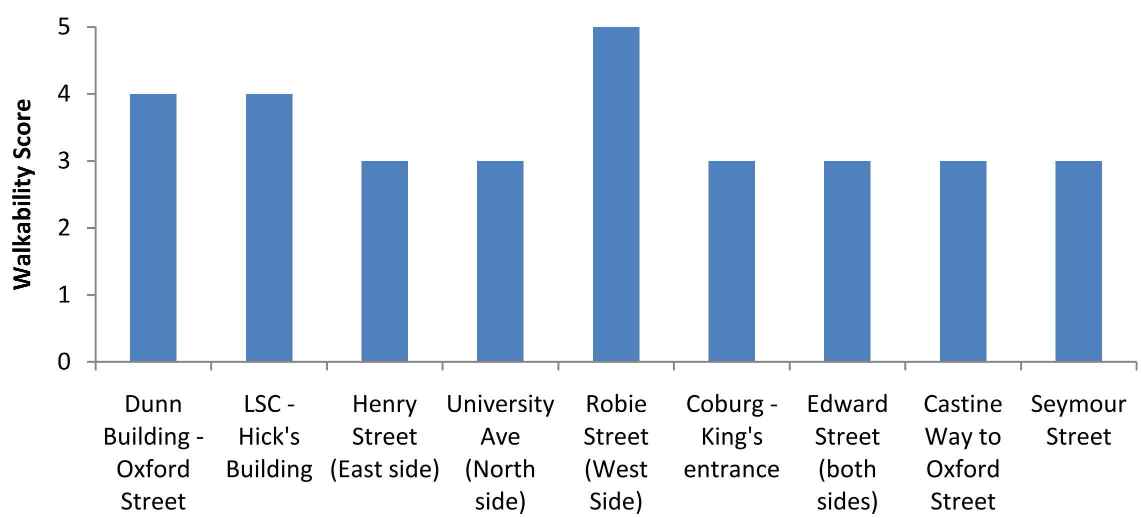

Figure 5. Walkability score (out of a possible 5) of each segment for night time safety features.

Path maintenance scored the highest overall across all segments, with most segments scoring a perfect 5 (Fig. 6). Most walkways were well maintained and contained few hazards. Path size also scored relatively high (average of 4.22; Table 2) as most paths were found to be of sufficient width to permit high pedestrian traffic flow (Fig. 7).

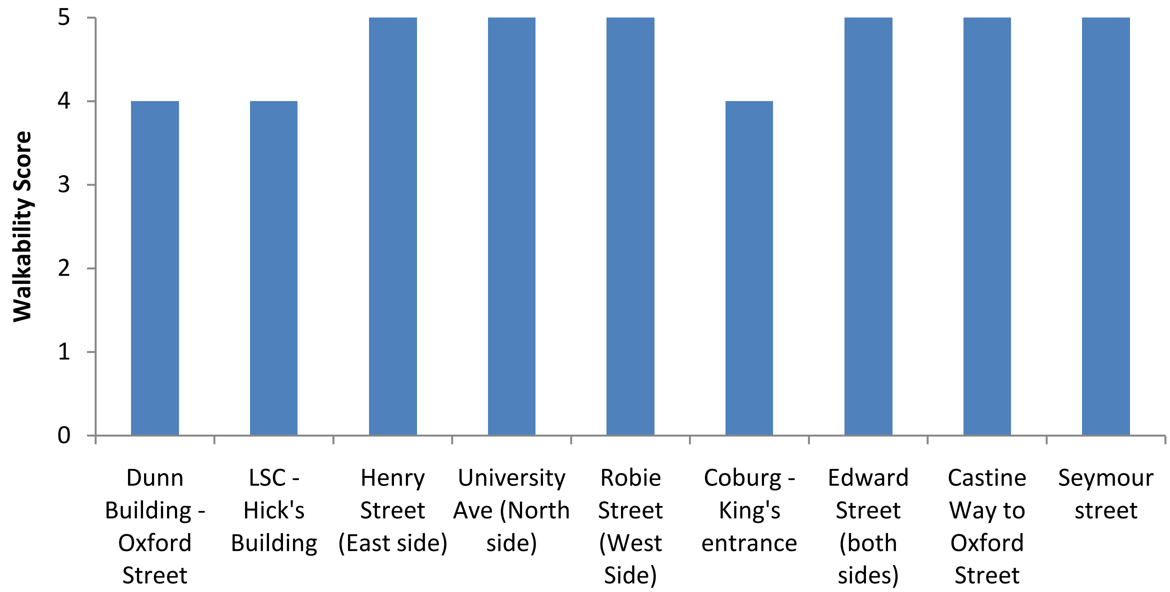

Figure 6. Walkability score (out of a possible 5) for each segment for path maintenance.

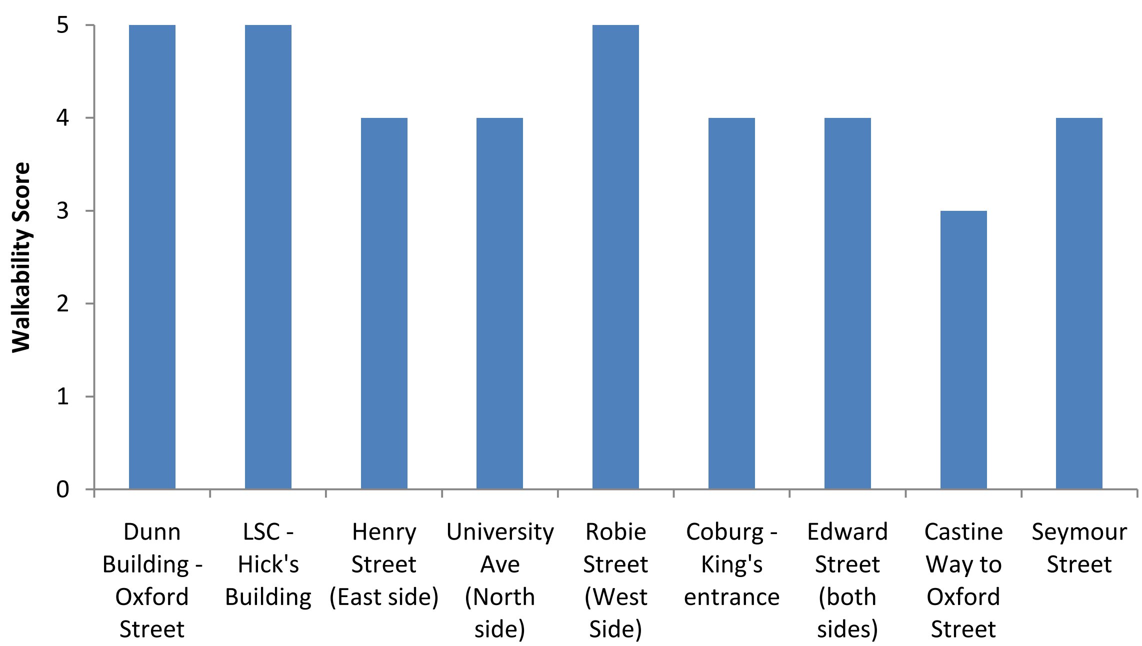

Figure 7. Walkability score (out of a possible 5) for each segment for path size.

The mean score for buffer zones across all segments was 4.11, with the segments 4, 7, and 9 having the highest scores for this feature (Fig. 8). The lowest score was given to segment 6 and 8, with a score of 3. Bikeability (Fig. 9) was the poorest feature across all segments, with an average score of just 1.33 (Table 2). Most segments scored only 1 for this feature (Fig. 9). Only segment 3 received an acceptable score.

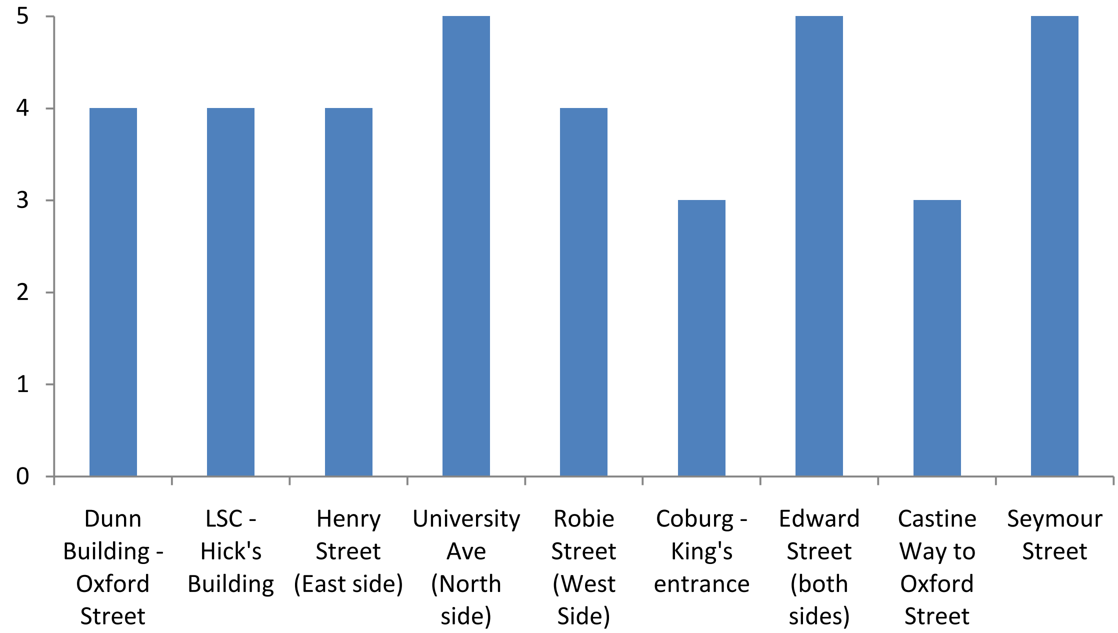

Figure 8. Walkability score (out of a possible 5) of each segment for buffer zones.

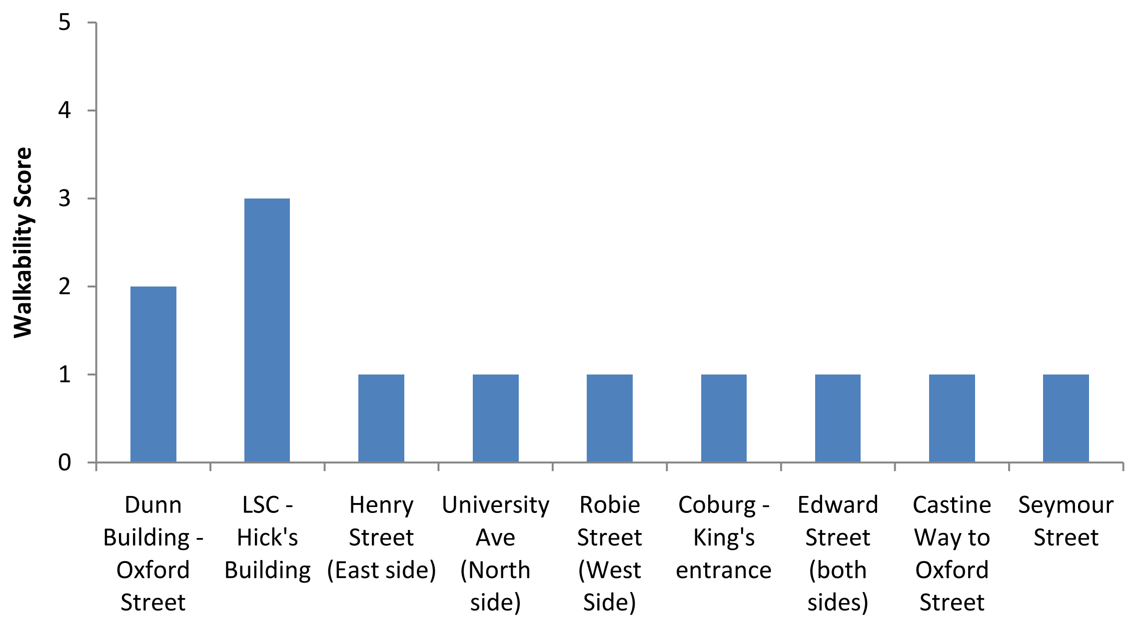

Figure 9. Walkability score (out of a possible 5) of each segment for bikeability.

Aesthetics scored well across most segments, with a mean score of 4.44. The lowest score was observed at segment 8 with a score of 2 (Fig. 10). Most segments received a score of 5, illustrating the generally pleasant environment of the Studley campus. Terrain earned a moderate average score of 3.44 with the lowest score observed on segment 8 (Castine way to Oxford Street) (Fig. 11).

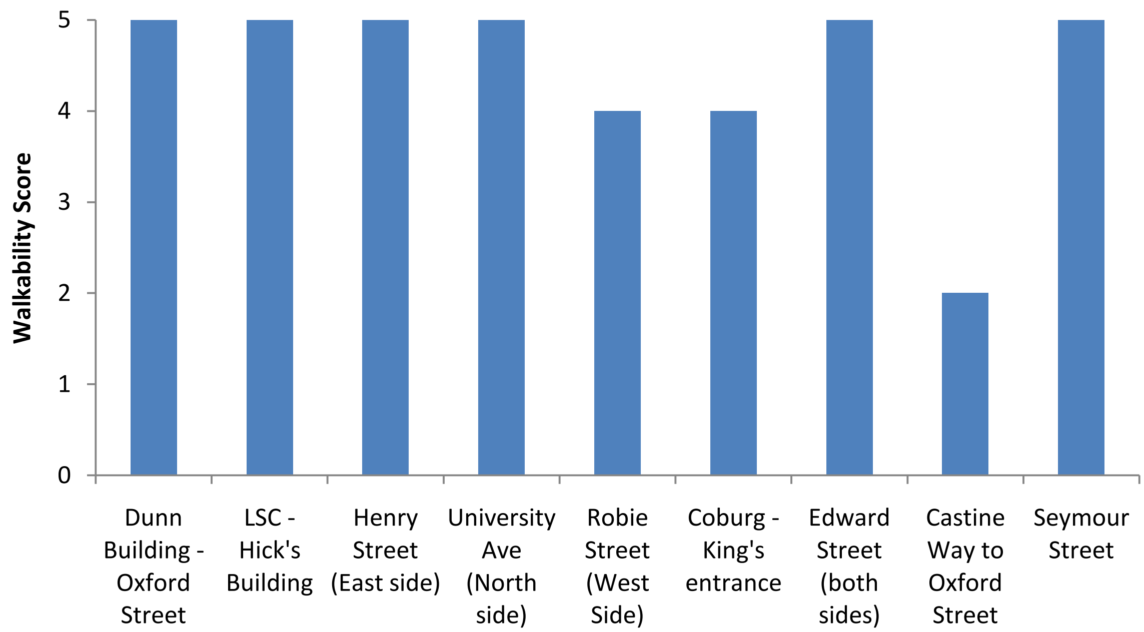

Figure 10. Walkability score (out of a possible 5) of each segment for aesthetics.

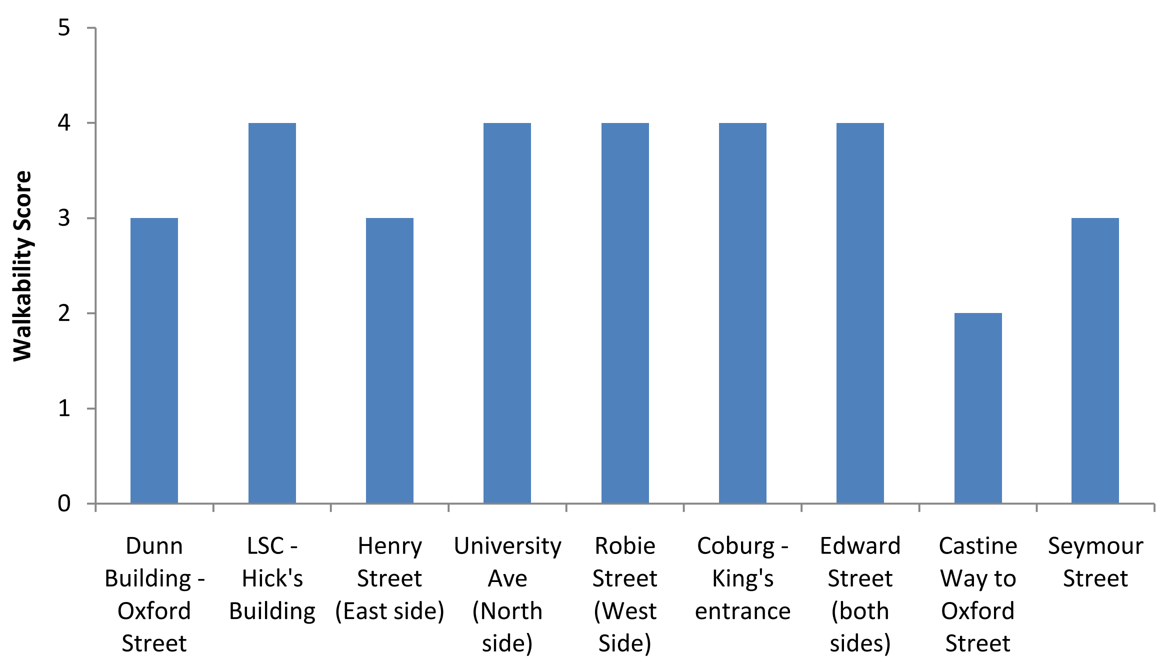

Figure 11. Walkability score (out of a possible 5) of each segment for terrain.

4.1 Segment 1

The first segment (segment 1) investigated Coburg Road beginning near the Dunn Building on campus and extending to the intersection with Oxford Street, as well as Lord Dalhousie Drive. This segment scored a 76, which by our definitions is considered to be low-risk and aesthetically pleasing (Appendix B). Coburg Road experienced heavy traffic, and had no bike lanes, increasing the potential for cyclist-vehicle conflicts. Lord Dalhousie Drive received a high score (5) for aesthetics (Table 2). There was great connectivity in this section; a path lead from the LSC to Lord Dalhousie Drive, to the Killam Library, and to the Henry Hicks building. The weakest portion in this section was the crosswalk score (3) and bikeability (2) as the crosswalk lacked safety features such as stop signs and lights, and because there were no bike facilities.

4.2 Segment 2

The second segment (segment 2) scored an 82/100, also receiving an assessment of low-risk and pleasant environment. This segment included the area surrounding the LSC, the Henry Hicks Building, and Sherriff Hall. The major road through this section was South Street. There were no bike lanes on South Street, and as a result the segment scored poorly for bikeability (3) (Appendix C). However, there were many bike racks present around Sheriff Hall and the LSC, which raised the bikeability score slightly. There was also a crosswalk on South Street which led to the Dalplex exercise facility. The crosswalk lacked signs, signals or lights. Sheriff Hall was the most aesthetically pleasing feature of this segment and contributed to the high aesthetics score (Table 2). There was great path connectivity throughout the segment. There was also great lighting approaching Sheriff Hall.

4.3 Segment 3

Segment 3 assessed the walkability of Henry Street. This segment received a total score of 76 on the Walkability Audit (Appendix D). The strengths of this segment were the availability of pedestrian facilities and the low potential for conflict between pedestrians and vehicles. The sidewalks themselves were very well maintained and there were minimal issues with hazards. The pathways were also of ample depth which provided good walking space for groups. The natural features along the sidewalks greatly enhanced the walkability of the segment. Tall trees provided not only an aesthetically pleasing environment, but also provided shading along the pathway. The green space between the road and sidewalk provided an excellent buffer between pedestrians and vehicles.

With regards to the build environment, buildings did not typically exceed 3-4 storeys; they were also in most instances set back from the sidewalk by means of a small front lawn. This greatly supported the human scale of the street by minimizing street wall and visually creating openness. There were also typically side yards on most residential properties.

The third segment did poorly with regards to providing adequate biking infrastructure. There was a lack of bike lanes and insufficient bicycle storage spaces. Other areas of concern were the crosswalks. Crosswalks were present; however they were in most cases poorly maintained or designated. With respect to the night time safety of the street, street lighting was present and consistent throughout the length of the segment.

4.4 Segment 4

University Avenue (segment 4) received a total score of 72 on the Walkability Audit (Appendix E). The strengths of this segment were largely related to the well maintained surfaces of the sidewalks. This provided ease of walking. The path size was also of sufficient width to provide a comfortable walking experience. Aesthetics along University Avenue was one of the strongest characteristic of the segment with a perfect score of 5 (Table 2). The use of the central green space contributed to the pleasant aesthetic experience of walking along this street by providing tree coverage. Building setbacks were also present, and spaces between buildings helped to minimize street wall and helped to open up the street for the pedestrian experience. Similar to Henry Street (segment 3), vehicle pedestrian conflict was relatively low (with a score of 5). This was in part due to the separation of traffic flow into two one way roads separated by a wide, central, green barrier space. However buffer zones between the street and sidewalk were not present. Characteristics that received lower scores for segment 4 were related to insufficient lighting during night time hours and lack of biking infrastructure. There was only one crosswalk that provided sufficient traffic control along this segment, this was the crossing that lead East/West across Robie Street. The other crosswalks in the segment failed to provide sufficient traffic control (such as traffic lights) or adequate signage for pedestrian crossing.

4.5 Segment 5

Robie Street (segment 5) received a total score of 80 on the Walkability Audit (Appendix F). The strengths of this segment were the result of the simple, but essential pedestrian services it provided. Firstly, all crossing locations were clearly marked and traffic controlled. The segment also provided adequate and well-maintained walking surfaces with minimal to no hazards on both sides of the road. Furthermore, the segment provided wide walkways to accommodate large groups of pedestrians. The walkability of this segment was again enhanced by natural features such as large trees that provided ample shading and protection as well as green buffer zones that separated pedestrians from vehicle traffic. Bright lighting was present during the night to help increase safety and visibility. These three elements combined not only provide a greater sense of security but also enhance the aesthetics of the segment.

The buildings that lined the street were all residential houses that did not exceed 3 storeys. The only exceptions were the Dalhousie Dentistry building on the furthest east side of the street, and the Nova Scotia Archives building. In addition to the minimal height of buildings, they all maintained a buffer between the sidewalks with front yards. They also all have side yards which help to mitigate the formation of a street wall. Most of these residential buildings were vastly different in character, form, and structure, which served to enhance the aesthetics of the segment.

The largest negative characteristic of this segment was that it did not provide adequate bikeability. No designated bike paths or bicycle storage spaces were available within this segment. There was also greater volume and traffic flow on Robie Street due to it being a main connector on the Peninsula. This decreased the walkability score of the segment slightly; however the buffer zones and street trees did a satisfactory job at mitigating this conflict.

4.6 Segment 6

The sixth segment (segment 6) consisted of Coburg Road running north east from Lord Dalhousie Drive to Robie Street. This segment received a total score of 71 on the Walkability Audit (Appendix G). Continuous sidewalks were located on each side of the street along this segment and they were relatively well maintained. Buffer zones and street trees provided the necessary safety characteristics from vehicle traffic, as well as contributing to enhancing the aesthetics of the segment. Buildings along this segment were similar to those previously described for segment 5. Setbacks, front lawns, and side yards promoted aesthetic value, safety and visibility, and human scale of the segment, as well as negating street wall and monotony of the built environment.

Some of the crosswalks within this segment had traffic control features; however most did not. Biking infrastructure was again an issue along this segment. No designated bike lanes were present and there were no places to store bicycles.

4.7 Segment 7

Edward Street (segment 7) received a total score of 77 on the Walkability Audit (Appendix H). It was a much quieter segment than those previously discussed. It had very wide green buffer zones along the length of the road and had very large and attractive street trees which provided the necessary shading and protection that pedestrians often seek. There were minimal risks of conflict between pedestrians and vehicles due low flow and low speed traffic along the segment. There was some ongoing construction to the sidewalk and underlying sewage pipes during the time of the audit. This represented a temporary walkability issue that in the near future would be resolved and therefore did not affect the score of the audit. The same features of visibility, sight lines, and openness found in the other segments were found in this segment as well.

Crosswalks, lighting, and bicycle infrastructure were the main walkability issues along this segment. Most of the crosswalks were unmarked on the street level and did not have appropriate signage, resulting in a low score overall for crosswalk quality (3).

4.8 Segment 8

Castine Way is the small entrance to the LSC parking lot, off of Oxford Street, that is regularly used by students and staff as a drop-off area, in addition to its intended use as a parking lot. Many large trucks were seen dropping packages off for the university, and the area is used by many students to and from classes. This segment scored a 59 out of a possible 100 on our walkability audit (Appendix H). This segment had fairly good pedestrian facilities (4 out of a possible 5; Table 2), with it having two sidewalks, however they were not continuous all the way down to Oxford Street. It did include a stop sign before turning into Oxford Street, and the overall area was pleasant, as there was no litter on the ground or drabby looking buildings/scenery, and it had a gentle slope.

4.9 Segment 9

Seymour Street received a total score of 72/100 (Appendix I). The sidewalk was consistent along Seymour and had a consistent buffer of about a metre and a half. The sidewalks were well paved and relatively new. There were no bike lanes along Seymour Street, but there were bike racks at the intersection with University Avenue. The Seymour section was aesthetically pleasing, receiving a score of 5. It was very clean, had consistent grass and trees on either side of the road, and ran between some of the newest and most modern buildings on campus. The street in general was relatively well shaded due the stature of the Dalhousie buildings on either side. The segment also includes several of the campus' statutes that are situated around the University Avenue intersection. Lighting was particularly poor at night, and therefore the night time safety score was low (3) (Table 2). The hazards along this segment, being the various parking entrances and exits, were mostly visible, and most were marked appropriately.

5 Discussion

5.1 Segment 1

In order to improve segment 1, lights should be implemented to make the crosswalk safer for pedestrians, as crosswalk safety was identified as one of the weaker features for this segment (Table 2). Further recommendations for this segment include the installation of bike lanes and maintenance of sidewalks. Improvements in this area should include more marked crosswalks, parking lot lighting, extensive parking lot pavement repairs, and more greenery to make this area more appealing.

5.2 Segment 2

Bike lanes should also be added throughout segment 2, as it also scored low for the bikeability feature. However, the presence of several bike racks throughout this segment did provide some incentive for commuters to choose active modes of transportation. Furthermore, lighting should be improved in this segment, in order to provide a safe walking environment at all times.

5.3 Segment 3

Overall, segment 3 was a pleasant area to walk; however, there were several areas that could be improved to enhance the walkability of the segment. First and foremost, bicycle infrastructure should be supported within the network of transportation that the street provides. This would support the existing bike users of the campus and further promote and support an increased number of cyclists in the future. As mentioned above, crosswalks should be improved. This can be achieved by providing adequate signage of pedestrian crosswalks as well as maintaining the on-road crosswalk designations to a higher standard. Street lighting at night should also be considered for improvement. LED street lighting provides greater luminosity in street surfaces and it consumes less electricity than standard street lights, further promoting both walkability and sustainability in terms of energy consumption on campus. Although replacing the existing lights with brighter and more energy efficient LED lights may be more costly, the energy efficiency and the effects of security with regards to walkability at night would offset the installation and purchasing costs over the long term.

5.4 Segment 4

To improve the overall walkability of the segment 4 biking infrastructure should be promoted and installed. University Ave is the main access street to the campus for pedestrians and vehicles alike. University Avenue, when compared to all other streets on Studley Campus, represented the mobility and connection to Dalhousie the strongest and should reinforce the active, walkable and sustainable University that Dalhousie strives to be. Lighting should also be enhanced for this segment, where possible. Furthermore, crosswalks should be designated more clearly to avoid any pedestrian and vehicular conflict. Strong consideration should be given to providing pedestrian infrastructure, in the form of pathways, on the central green buffer zone between the two one-way roads on University Avenue. Currently natural pathways can already be seen within this area and it would provide a greater pedestrian experience if infrastructure was available in these locations.

5.5 Segment 5

Providing biking infrastructure to the street would greatly enhance the walkability and bikeability along segment 5. By providing this infrastructure active transportation can be greatly increased on Studley campus. Although traffic flow cannot be changed or minimized to further promote a walkable environment along this segment, emphasis should be placed on maintaining the existing buffer areas and the importance of street trees. The clearly marked crosswalks helped to minimize the chances of conflict between pedestrian and vehicles.

5.6 Segment 6

To enhance the walkability of segment 6, several features could be improved. Bicycle infrastructure in the form of designated bike lanes should be considered for this segment and installed where feasible. Upgrades to the existing crosswalk designations, both in the form of signage and on street markers, should be considered. This will improve the security of pedestrian movement as well as mitigate the chance of conflict between pedestrian and vehicles. The green buffer zone is of significant importance to the walkability of this segment. Although it is relatively small is holds great value to promoting a walkable environment. It has the potential to be threatened by both sidewalk and roadway expansion. It can be argued however, that these buffer zones provide an invaluable service to the safety of the pedestrians that use this area for transportation. It is of utmost importance that the buffer zone be protected from expansion or any other activities that would minimize the already small buffer that exists. To improve this segment, crosswalks should be sure to be clearly marked and maintained, with the addition of a buffer zone to pathways on both sides of the street, and the addition of an emergency call box located nearby, to make walking home in the evenings safer for students that live in the area.

5.7 Segment 7

To improve the walkability of segment 7, attention should be given to enhancing the luminosity of the street during the night. This will enhance the feeling of security while using the paths in this segment and if light sources such as LED’s are used, they will provide sustainable energy benefits as well. Bicycle infrastructure should be considered and promoted if applicable to this segment.

5.8 Segment 8

This segment lacked lighting, resulting in an unsafe environment for night time walkability. As with other segments, more lighting should be installed. Another area that requires improvement in this segment is bikeability, as there were no bike lanes present. A buffer is also recommended in order to make the segment more walkable by creating a greater separation between vehicles and pedestrians.

5.9 Segment 9

Overall the segment was visually pleasing during the day, but night time safety, and bikeability were issues, especially since it is a high-traffic area. This segment could be improved by including buffer zones and night time lighting for the sidewalks, re-painting crosswalks at the major intersection, and to adding bike lanes on the street.

6 Conclusion

Walkability is a way in which we calculate the suitability of a particular area for walking as a mode of transportation. Walkability is also a fundamental principle of a sustainable infrastructure and further promotes active living while providing social and economic benefits. Assessing walkability can help identify and better understand the infrastructural flaws and safety hazards of a crowded area. The majority of Dalhousie students, staff, and faculty utilize walking as their primary method of transportation on and around campus, and evaluating the various paths on Dalhousie's Studley campus helps to improve them these walkways to further promote sustainable transport on campus.

Assessing walkability and improving safety and aesthetics allows us to promote walking as preferable means of transportation, as well as indirectly reducing carbon emissions, and promoting overall health, safety and well-being. The walkability of urban areas plays a significant role in improving overall infrastructure, aesthetics, safety, traffic reduction, as well as emissions.

In terms of the Studley campus, our analysis of particular pathways provided us with conclusive results, which allowed us to make recommendations on how to improve overall campus walkability. Consistent deficits across the various segments on campus were a lack of bike lanes and general cycling infrastructure, a lack of marked crosswalks, as well crosswalk visibility and lighting. More minor issues included the general upkeep of walking paths and sidewalks in certain segments, general lack of lighting, and absence of sufficient green aesthetics.

6.1 Recommendations for the future

The lack of crosswalk and cycling infrastructure, as well as a general night time lighting deficit were the most consistent issues overall. A greater number of crosswalks, particularly where our street sections intersect with Coburg and South Street, would greatly improve walking safety on campus. In addition, improving the overall visibility of crosswalks through lighting and more strategic placement of streetlight signs.

For the number of students that utilize bicycles on campus, there is a severe lack of bike lanes. Incorporating bike lanes onto main streets such as University Avenue, as well as increasing the consistency of bike racks on less prominent paths such Seymour, would definitely help make cycling more preferable for students on the Studley campus.

Finally, the lack of sufficient nighttime lighting makes the campus somewhat threatening in the evening hours. The addition of brighter lighting in areas such as University Avenue, the Killam Library, and most of the minor streets and paths would greatly improve nighttime walkability on campus.

6.2 Recommendations for action

For future action to improve overall campus walkability, we propose that a walkability assessment be performed every two years to assess the recommended changes to campus infrastructure and safety. More specifically, we recommend the implementation of greater cycling infrastructure and night time safety features (such as street lamps) in order to increase the safety on campus. We also recommend installing speed bumps along University Avenue to slow the flow of traffic without requirement the investment of significant infrastructure. This will improve the safety of this major thoroughfare through the campus for pedestrians. Students should feel safe walking on campus, and the campus should also promote walking by actively adapting to suit its students.

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8 Appendices

Appendix A

Table 1 Walkability audit (adapted from CDC, 2010).

	Indicator Ranking					
Indicator	**1**	**2**	**3**	**4**	**5**	**Score**
			Safety			
Pedestrian facilities[1] (High)	No permanent facilities (such as sidewalks)		Sidewalk on one side of the road		Continuous sidewalk on both sides of the road	
Pedestrian-vehicle conflicts (High)	High conflict: fast-moving vehicles, high traffic volume				Low conflict: no vehicle traffic; good visibility for pedestrian/ cyclist traffic	
Crosswalk quality (Medium)	No crosswalk at a major intersection	No crosswalk at a low volume intersection	Crosswalk present but no traffic control (i.e., no stop signs or lights)	Crosswalk with traffic control	No intersection or crosswalks are clearly marked and traffic controlled	
Night time safety features (Medium)	No lights or no visible emergency call box	Dim light; no visible emergency call box	Partial light or no visible emergency call box	Partial light and visible emergency call box	Well-lit and visible emergency call box	
			Path Quality			
Maintenance (Medium)	Major or frequent hazards[2]				No hazards	
Path size (Low)	No permanent facilities	<3 feet wide or significant barriers to passage			>5 feet wide, no barriers	
Buffer (Medium)	No buffer from roadway			Pathway >4 feet from roadway	Pathway not adjacent to roadway	

Bikeability (Medium)	No designated bike lane or infrastructure (bike racks)	Designated bike lane shared with parking area	Narrow (< 3 feet) designated bike lane on road, bike racks available	Wide (>3 feet) designated bike lane on road or pathway	Wide designated bike lane separated from roadway and pathway	
Aesthetics (Medium)	Uninviting[3]				Pleasant[4]	
			Comfort			
Terrain (Low)	No shade; steep slope		Moderate shade; moderate slope		Full shade; flat or gentle slope	

[1] Pedestrian facilities include sidewalks, pathways, and footpaths
[2] Hazards are defined as tripping of falling risks such as cracked or buckled pavement, standing water
[3] Uninviting environment is defined as the presence of construction zones, noise, poor landscaping, dirty no benches); litter, graffiti, discarded items
[4] Pleasant environment defined as visually inviting, quiet, clean, appealing building infrastructure, benches available)

Sum of High importance: __________ x **3** = __________
Sum of Medium importance: __________ x **2** = __________
Sum of Low importance: __________ x **1** = __________
Total Score: __________ / 100

Observations
1. What is the most dangerous location along this segment?
2. What is the most unpleasant element of this segment?
3. What improvements would make this segment more appropriate for pedestrian use?
4. Would it be possible to design a more direct route to connect the ends of this segment?

Appendix B

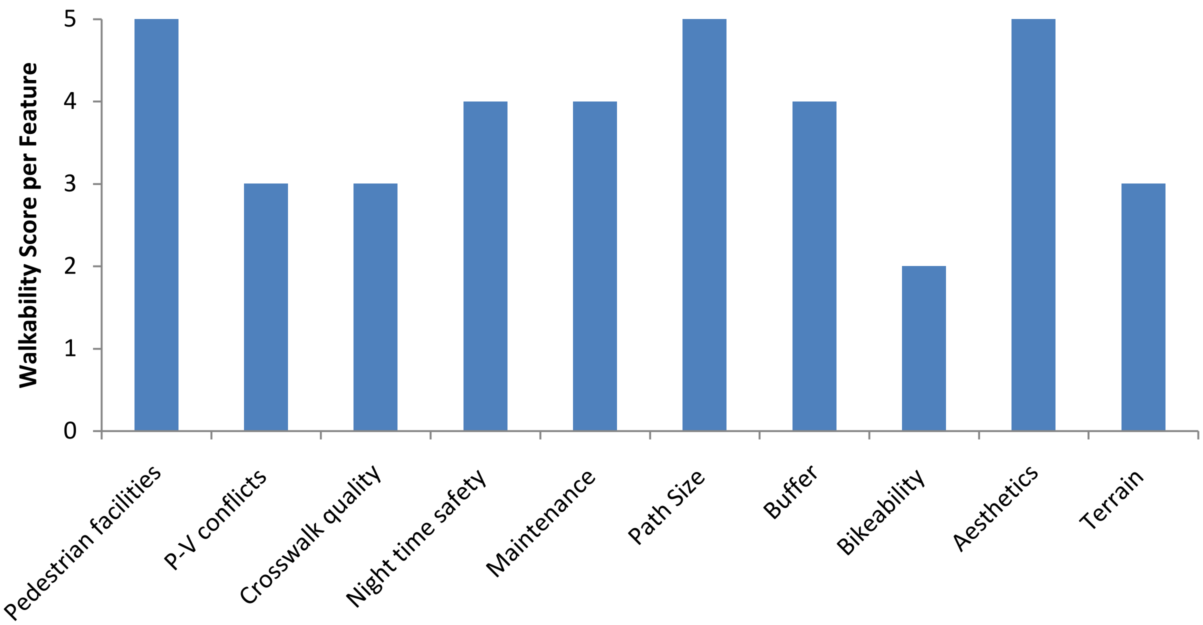

Figure 12. Walkability score (out of a possible 5) of each feature for street segment 1 (Dunn Building to Oxford Street). P-V conflicts represents pedestrian-vehicle conflicts.

Appendix C

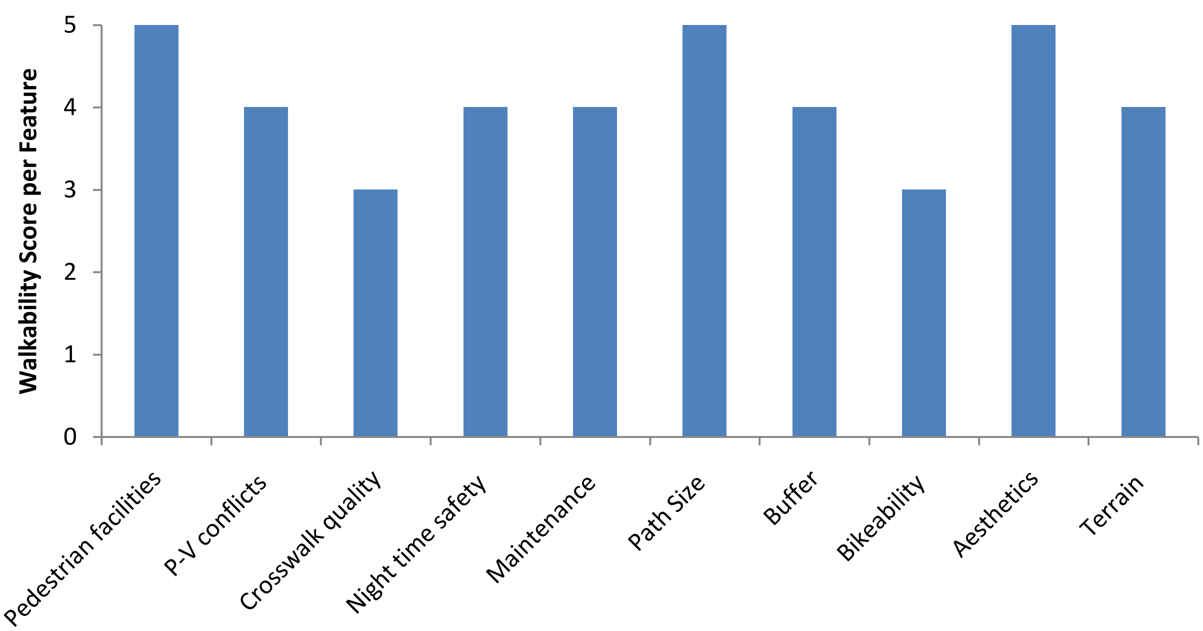

Figure 13 Walkability score (out of a possible 5) of each feature for street segment 2 (LSC to Henry Hick's Building and Sherriff Hall). P-V conflicts represents pedestrian-vehicle conflicts.

Appendix D

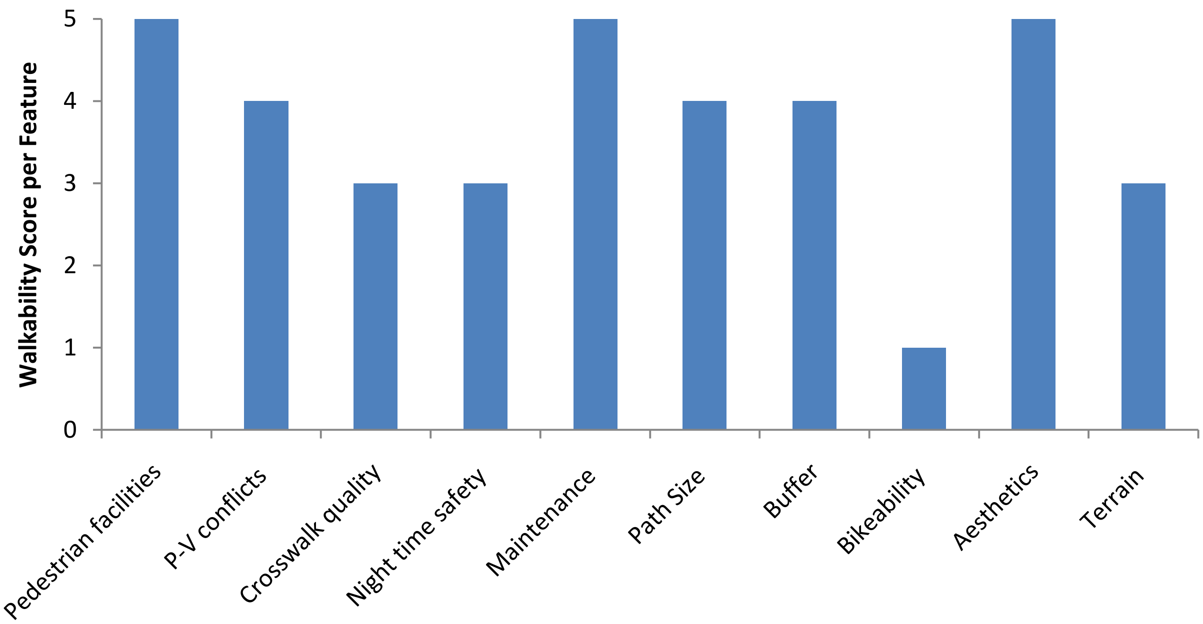

Figure 14 Walkability score (out of a possible 5) of each feature for street segment 3 (Henry Street – East Side). P-V conflicts represents pedestrian-vehicle conflicts.

Appendix E

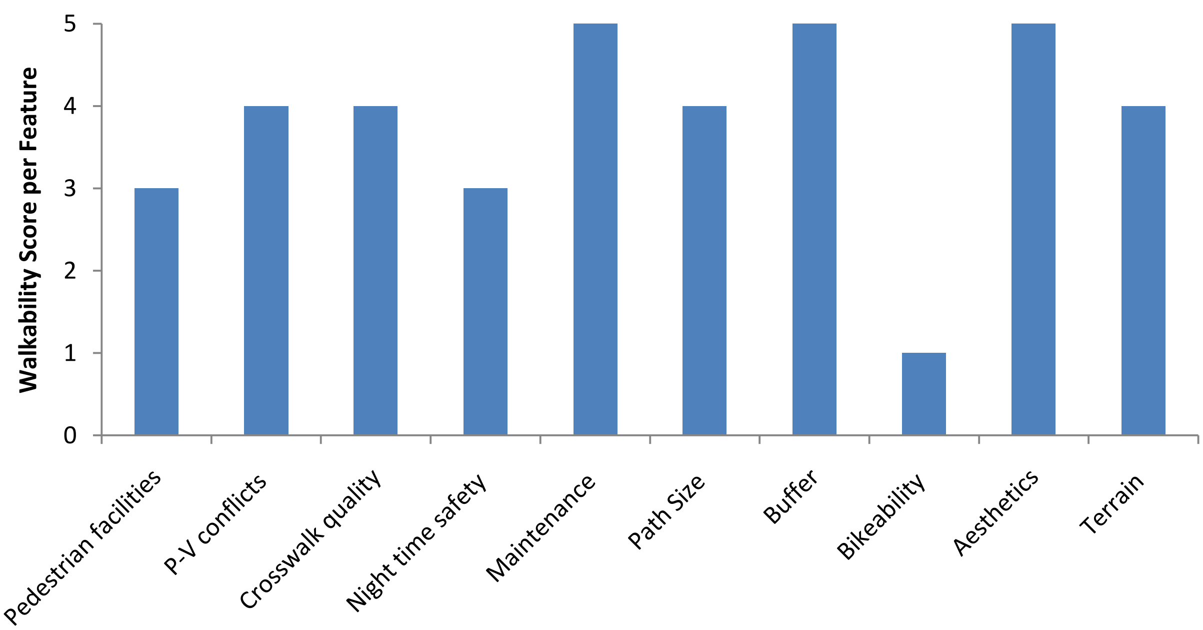

Figure 15 Walkability score (out of a possible 5) of each feature for street segment 4 (University Avenue – North Side). P-V conflicts represents pedestrian-vehicle conflicts

Appendix F

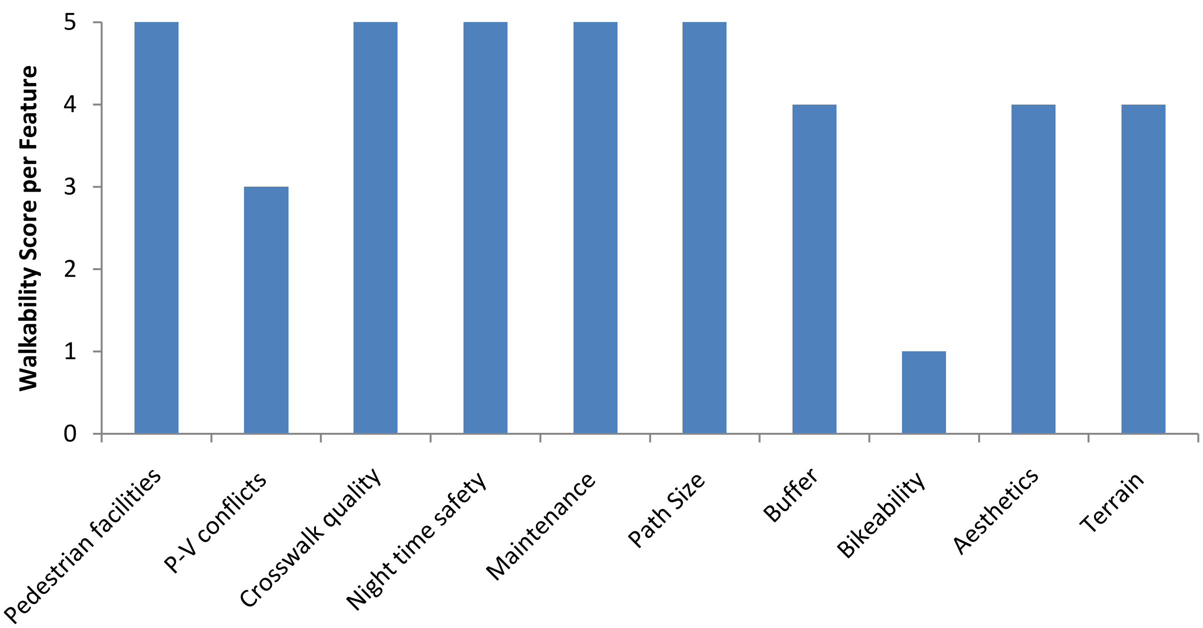

Figure 16 Walkability score (out of a possible 5) of each feature for street segment 4 (University Avenue – North Side). P-V conflicts represents pedestrian-vehicle conflicts

Appendix G

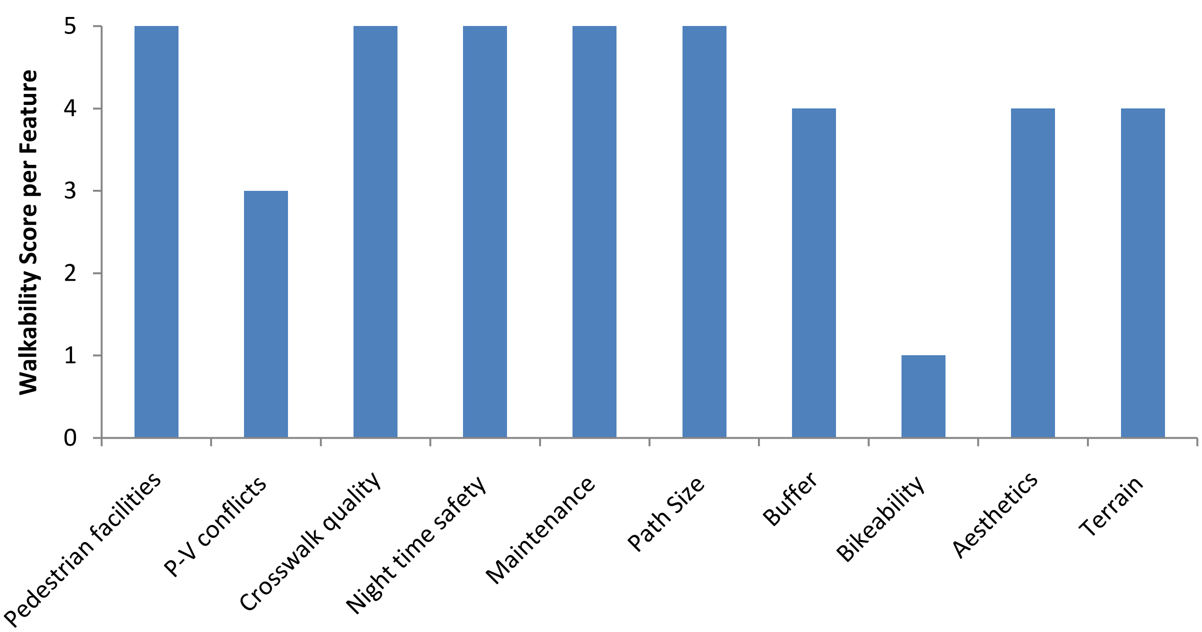

Figure 17. Walkability score (out of a possible 5) of each feature for street segment 5 (Robie Street). P-V conflicts represents pedestrian-vehicle conflicts.

Appendix H

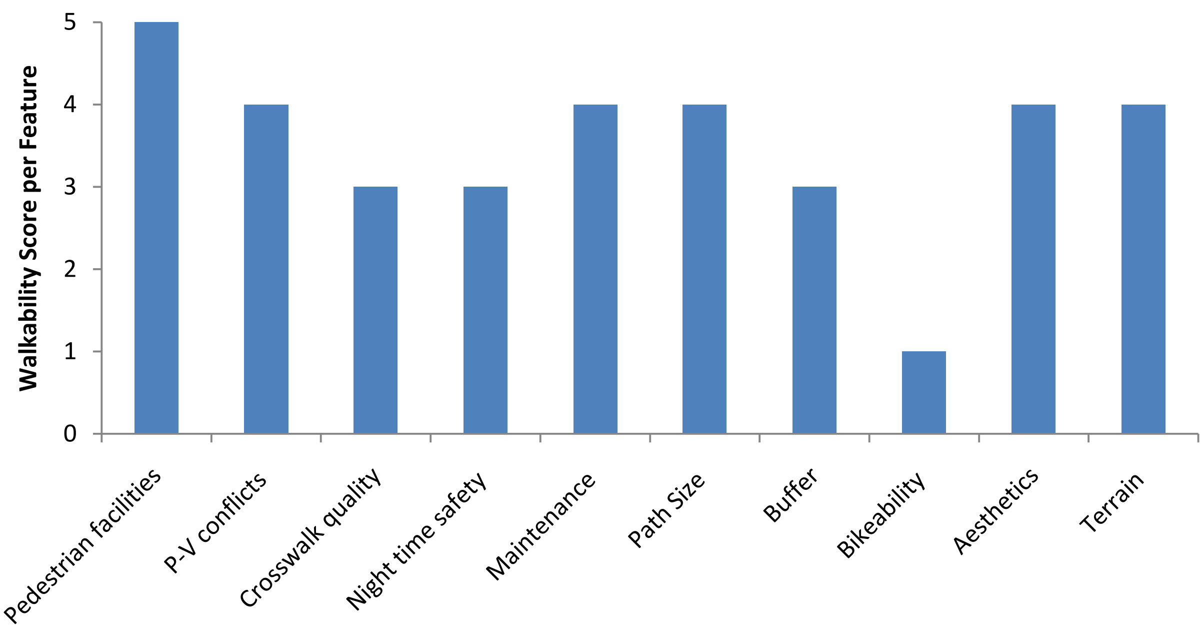

Figure 18. Walkability score (out of a possible 5) of each feature for street segment 6 (Coburg Street to the entrance of King's College). P-V conflicts represents pedestrian-vehicle conflicts.

Appendix I

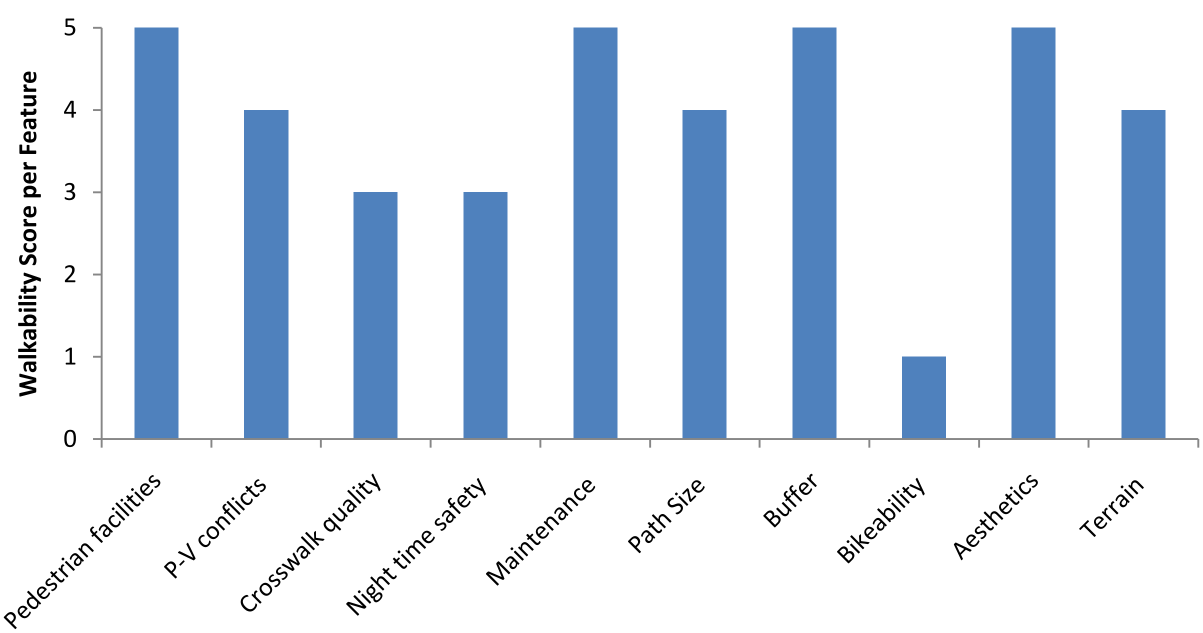

Figure 19. Walkability score (out of a possible 5) of each feature for street segment 7 (Edward Street). P-V conflicts represents pedestrian-vehicle conflicts.