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Date: October 11, 2022

Re: **Pedestrian Wind Assessment**
1 Columbia Street
Waterloo, ON
SLR Project #241.30640.00000

Prepared by

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For

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TABLE OF CONTENTS

1.0 Introduction 3

1.1 Existing Development 3

1.2 Proposed Development 5

1.3 Areas of Interest 5

2.0 Approach 7

2.1 Methodology 7

2.2 Wind Climate 10

3.0 Pedestrian Wind Criteria 11

4.0 Results 12

4.1 Building Entrances, Exits & Walkways 12

4.2 Outdoor Amenity Spaces 12

4.3 Surrounding Sidewalks 17

4.4 Wind Safety 17

5.0 Conclusions & Recommendations 18

6.0 Limitations of Liability 18

7.0 References 19

Appendix A 20

Appendix B 23

1.0 INTRODUCTION

SLR Consulting (Canada) Ltd. (SLR) was retained by Studio Limina Inc. to conduct a pedestrian wind assessment for the proposed development at 1 Columbia Street West in Waterloo, Ontario. This report is in support of the Site Plan Approval (SPA) application for the development.

1.1 Existing Development

The proposed development is located at 1 Columbia Street West, on the west side of King Street North, just south of Columbia Street West. The site is currently occupied by two low-rise residential buildings. Figure 1 provides an aerial view of the immediate study area. A site visit was conducted by SLR on September 15, 2022. Several images from the site visit are included in Figures 2a through 2d.

Immediately surrounding the site is a high-rise tower to the northwest and north, low-rise commercial buildings to the northeast and east, an empty lot to the southeast, a high-rise tower to the south, and low-rise residential buildings to the west and southwest. Beyond the immediate surroundings are generally low-rise commercial and residential buildings, with high-rise residential towers along King Street North to the north and south of the proposed development.

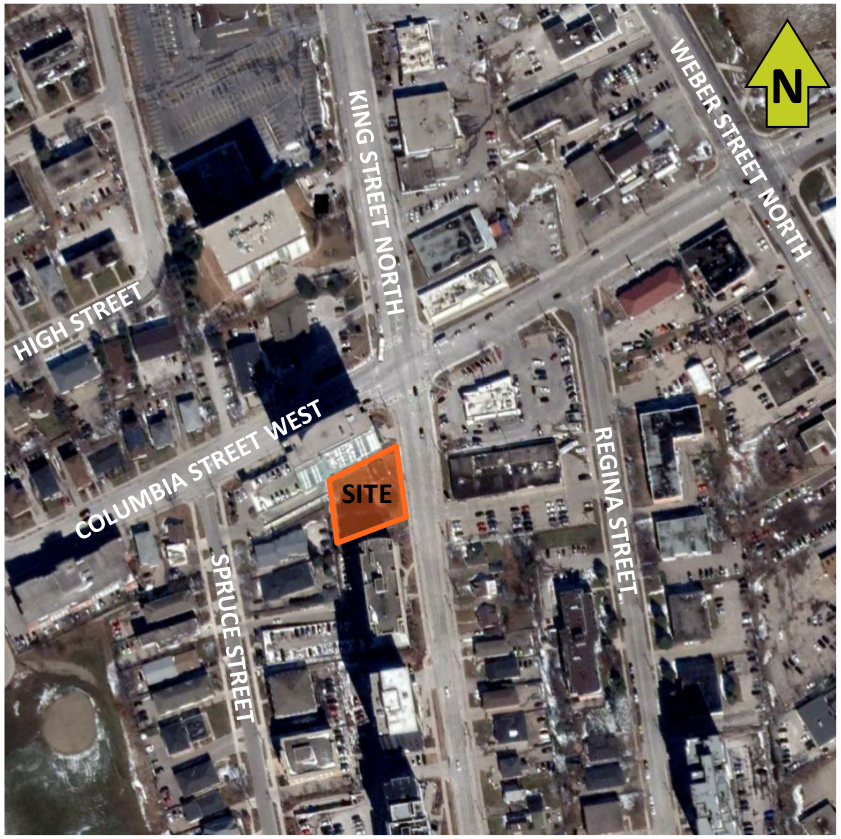


Figure 1: Aerial view of existing site & surroundings
Credit: Google Earth Pro, dated March 2022



Figure 2a: Looking west at existing site



Figure 2b: Looking south along King Street North



Figure 2c: Looking west along Columbia Street North



Figure 2d: Looking north along King Street North

1.2 Proposed Development

The proposed development includes a seven-storey residential building, approximately 30 m tall including the mechanical penthouse. This new building will be associated with the existing 22-storey tower to the north, and a one-storey amenity addition as part of the project. A rendering of the development is shown in Figure 3.

The main entrance is located at the northeast corner of the building, while there are secondary entrances and exits along the north and south facades. There is also a potential outdoor amenity space on the roof.

The amenity building has outdoor passive activity areas associated with it, between the proposed building and the existing tower. In addition, the entrances to the amenity building are located at the northeast and southwest corners of the building.

1.3 Areas of Interest

Areas of interest for pedestrian wind conditions include those areas which pedestrians are expected to use on a frequent basis. Typically these include sidewalks, main entrances, transit stops, plazas and parks. On-site areas of interest are shown in Figure 4. This includes the three nearby transit stops along Columbia Street and King Street North.

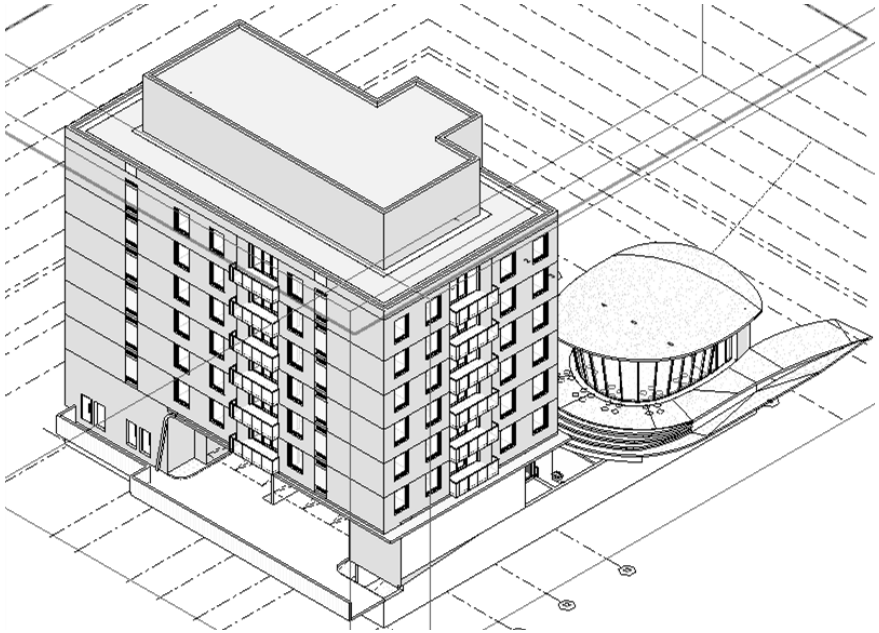


Figure 3: Rendering of proposed development
Credit: Studio Lumina

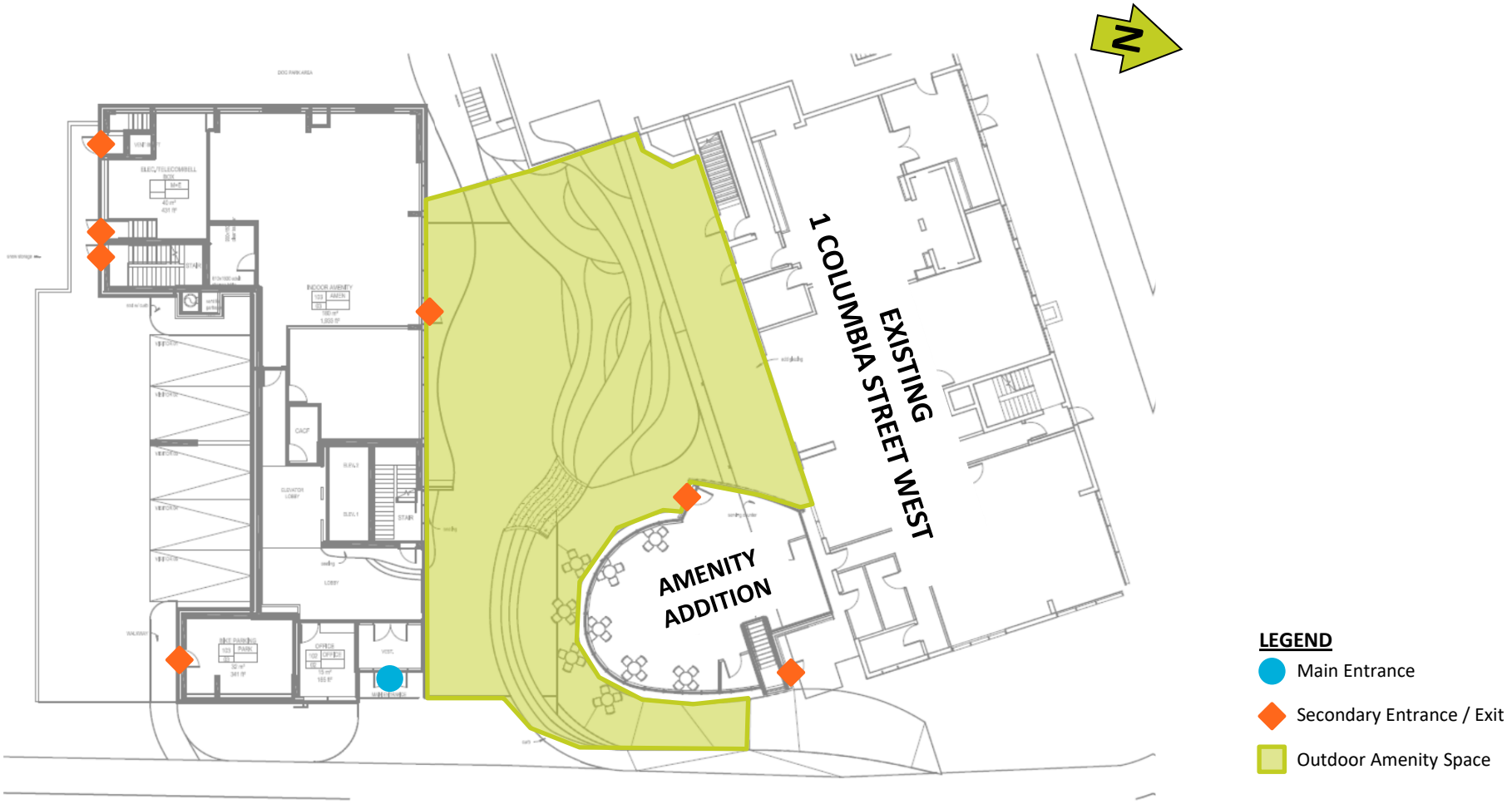


Figure 4: Areas of Interest

2.0 APPROACH

A screening-level assessment was conducted using computational fluid dynamics (CFD). As with any simulation, there are some limitations with this modeling technique, specifically in the ability to simulate the turbulence, or gustiness, of the wind. Nonetheless, CFD analysis remains a useful tool to identify potential wind issues, especially when assessing mean wind speeds. This CFD-based mean wind speed assessment employs a comparable analysis methodology to that used in wind tunnel testing. The results of CFD modeling are also an excellent means of readily identifying relative changes in wind conditions associated with different site configurations or with alternative built forms.

2.1 Methodology

Wind comfort conditions for areas of interest were predicted on and around the development site to identify potentially problematic windy areas. A 3D model of the proposed development, as well as floor plans and elevations, were provided by Studio Lumina on September 9, 2022. A view of the 3D model used in the computer wind comfort analysis is shown in **Figure 5**. This model included surrounding buildings within 500 m from the study site centre. The simulations were performed using CFD software by Meteodyn Inc.

The entire 3D space throughout the modeled area is filled with a three-dimensional grid. The CFD virtual wind tunnel calculates wind speed at each one of the 3D grid points. The upstream "roughness" for each test direction is adjusted to reflect the various upwind conditions and wind characteristics encountered around the actual site. Wind flows for a total of 16 compass directions were simulated. Although wind speeds are calculated throughout the entire modeled area, wind comfort conditions were only plotted for a smaller area immediately surrounding the proposed development.

SLR assessed two configurations for comparison purposes. The descriptions are as follows:

- **Existing Configuration:** Existing site with existing surroundings.
- **Proposed Configuration:** Proposed development with existing surroundings.

A view of two configurations are shown in **Figures 5a** and **5b**.

Wind flows were predicted for both the existing site, as well as with the proposed development for comparison purposes. The CFD-predicted wind speeds for all test directions and grid points were then combined with historical wind climate data for the region to predict the occurrence of wind speeds in the pedestrian realm, and to compare against wind criteria for comfort and safety; these results are shown in the various wind flow images. The analysis of wind conditions is undertaken for four seasons: Winter (January to March), Spring (April to June), Summer (July to September), and Autumn (October to December). However, only the seasonal extremes of summer and winter are discussed within the report. The results of the analysis for spring and autumn can be found in **Appendix A**.

Results are presented through discussion of the wind conditions along major streets and the areas of interest. The comfort criteria are based on predictions of localized wind forces combined with frequency of occurrence. Climate issues that influence a person's overall "thermal" comfort, (e.g., temperature, humidity, wind chill, exposure to sun or shade, etc.) are not considered in the comfort rating.

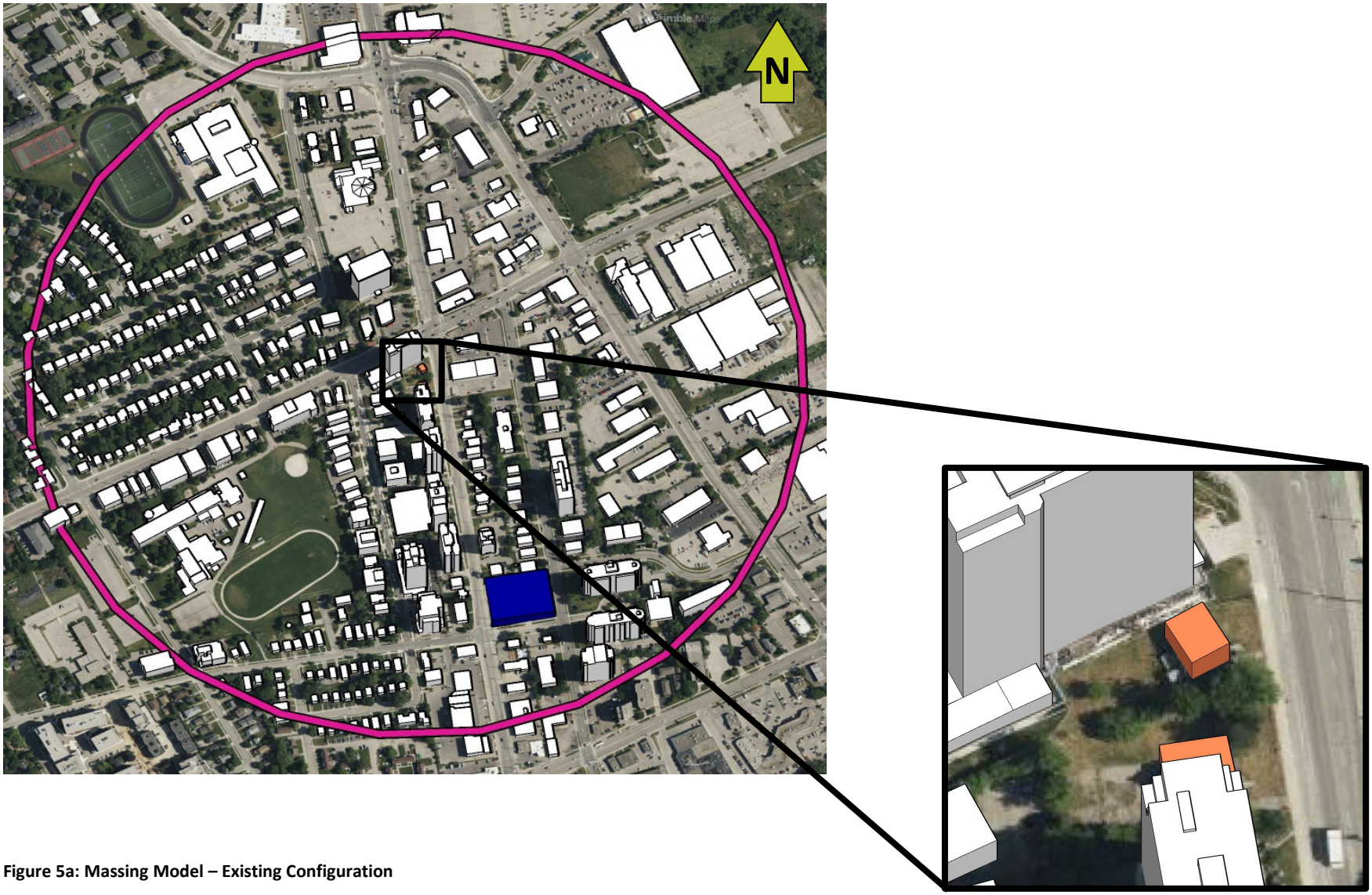


Figure 5a: Massing Model – Existing Configuration

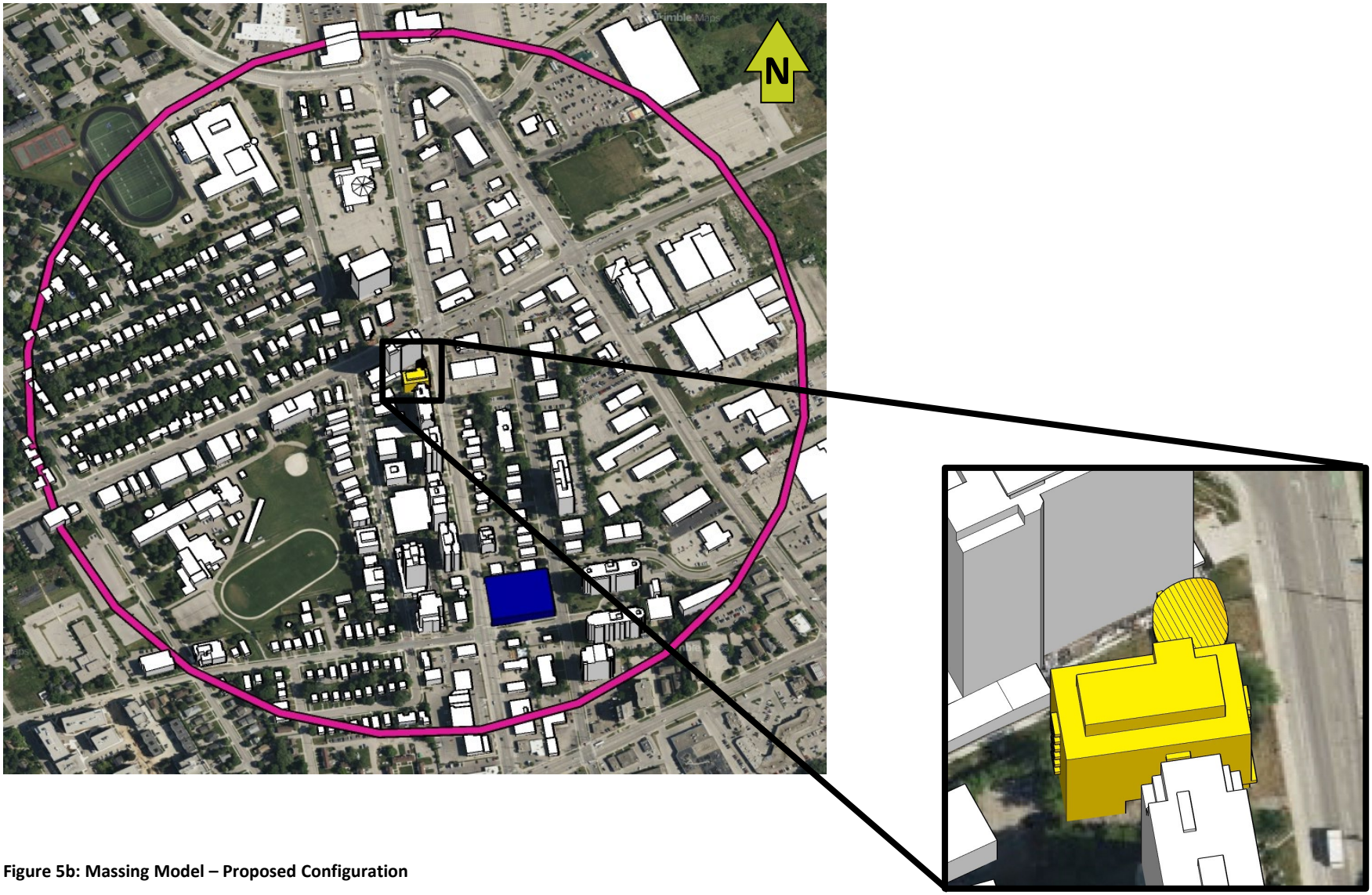


Figure 5b: Massing Model – Proposed Configuration

2.2 Wind Climate

Wind data recorded at Waterloo Regional Airport in Toronto for the period of 1993 to 2020 were obtained and analysed to create a wind climate model for the region. Annual and seasonal wind distribution diagrams ("wind roses") are shown in Figure 6. These diagrams illustrate the percentage of time wind blows from the 16 main compass directions. Of main interest are the longest peaks that identify the most frequently occurring wind directions. The annual wind rose indicates that wind approaching from the southwest through northwest and east directions are most prevalent. The seasonal wind roses readily show how the prevalent winds shift throughout the year.

The directions from which stronger winds (e.g., > 30 km/h) approach are also of interest as they have the highest potential of creating problematic wind conditions, depending upon site exposure and the building configurations. The wind roses in Figure 6 also identify the directional frequency of these stronger winds, as indicated in the figure's legend colour key. On an annual basis, strong winds occur from the northwesterly, southwesterly sectors and from the east. All wind speeds and directions were included in the wind climate model.

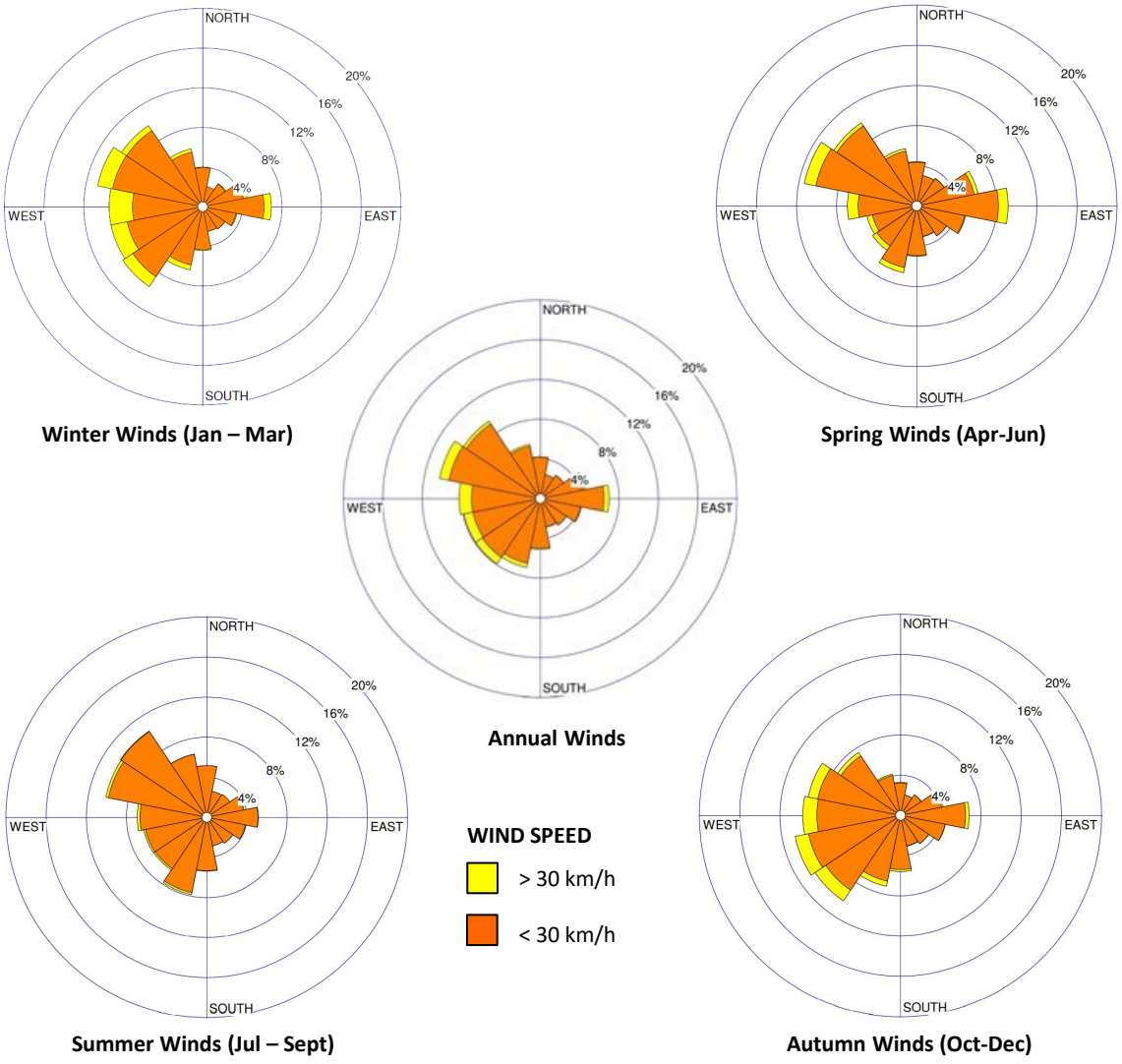


Figure 6: Wind Roses for Waterloo Regional Airport (1993 – 2020)

3.0 PEDESTRIAN WIND CRITERIA

Wind comfort conditions are discussed in terms of being acceptable for certain pedestrian activities and are based on predicted wind force and the expected frequency of occurrence. Wind chill, clothing, humidity and exposure to direct sun, for example, all affect a person's thermal comfort; however, these influences are not considered in the wind comfort criteria.

The comfort criteria, which are based on certain predicted hourly mean wind speeds being exceeded 5% of the time, are summarized in **Table 1**. Generally, this is equivalent to a wind event of several hours duration occurring about once per week.

The criterion for wind safety in the table is based on hourly mean wind speeds that are exceeded once per year (approximately 0.01% of the time). When more than one event is predicted annually, wind mitigation measures are then advised. The wind safety criterion is shown in **Table 2**.

The criteria for wind comfort and safety used in this assessment are similar to those developed at the Boundary Layer Wind Tunnel Lab of Western University, together with building officials in London, England. They are broadly based on the Beaufort Scale and on previous criteria that were originally developed by Davenport. Similar criteria are used by the Alan G. Davenport Wind Engineering Group Boundary-Layer Wind Tunnel Laboratory for pedestrian wind study projects located around the globe. For a list of references, describing the criteria and history of its development see **Section 7.0**.

Table 1: Wind Comfort Criteria

Activity	Comfort Ranges for Mean Wind Speed Exceeded 5% of the Time		Description of Wind Comfort
Sitting	0 to 14 km/h	0 to 4 m/s	Calm or light breezes desired for outdoor restaurants and seating areas where one can read a paper comfortably.
Standing	0 to 22 km/h	0 to 6 m/s	Gentle breezes suitable for main building entrances and transit stops.
Leisurely Walking	0 to 29 km/h	0 to 8 m/s	Moderate breezes suitable for walking along pedestrian thorough fares.
Fast Walking	0 to 36 km/h	0 to 10 m/s	Strong breezes that can be tolerated if one's objective is to walk, run or cycle without lingering.
Uncomfortable	> 36 km/h	> 10 m/s	Strong winds of this magnitude are considered a nuisance for most activities, and wind mitigation is typically recommended.

Table 2: Wind Safety Criterion

Activity	Safety Criterion Mean Wind Speed Exceeded Once Per Year (0.01%)		Description of Wind Effects
Any	72 km/h	20 m/s	Excessive gust speeds that can adversely affect a pedestrian's balance and footing. Wind mitigation is typically required.

4.0 RESULTS

Figures 7a through 10b present graphical images of the wind comfort conditions for the summer and winter months around the proposed development. These represent the seasonal extremes of best and worst case. Appendix A presents the wind comfort conditions for spring and autumn. The "comfort zones" shown are based on an integration of wind speed and frequency for all 16 wind directions tested with the seasonal wind climate model. The presence of mature trees can lead to wind comfort levels that are marginally more comfortable than shown, during seasons when foliage is present. Appendix B presents the wind safety conditions on an annual basis.

There are generally accepted wind comfort levels that are desired for various pedestrian uses. However, it some climates these may be difficult to achieve in the winter due to the overall climate. For sidewalks, walkways and pathways, wind comfort suitable for leisurely walking are desirable year-round but may not be feasible in the winter. The presence of benches on a sidewalk, which are an optional use, does not change the overall wind comfort requirement for sidewalk. Wind conditions of fast walking are satisfactory for loading areas, laneways, and a limited portion of a sidewalk, considering exposure is brief for pedestrians. For main entrances, transit stops, and public amenity spaces such as parks and playgrounds, wind conditions conducive to standing are preferred throughout the year. For on-site amenity areas, wind conditions suitable for sitting or standing are desirable during the summer, with stronger wind flows, conducive to leisurely walking, tolerated in the winter. The most stringent category of sitting is desirable during the summer for dedicated seating areas, such as patios, where calmer wind is expected for the comfort of patrons.

4.1 Building Entrances, Exits & Walkways

In the Existing Configuration wind conditions on the site are expected to be suitable for leisurely walking or better throughout the year (Figures 7a and 8a). The exception is along the west side of the two low-rise residential buildings where wind conditions conducive to fast walking are predicted.

With the proposed building in place, wind conditions on the site are anticipated to be suitable for leisurely walking or better (Figures 7b and 8b). At the main entrance to the building, as well as at the secondary entrances and exits, wind conditions are predicted to be comfortable for sitting or standing throughout the year (Figures 9a and 9b).

At the entrances to the amenity addition, wind conditions are expected to be conducive to sitting throughout the year, as the mass of the existing tower provides shelter from the prevailing winds (Figures 9a and 9b).

These wind conditions are considered appropriate for the intended use.

4.2 Outdoor Amenity Spaces

At grade, the outdoor amenity space between the existing building and the proposed building is expected to be comfortable for sitting throughout the year (Figures 9a and 9b).

There is the potential for an outdoor amenity space to be included on the roof of the proposed building. Wind conditions in this area are predicted to be suitable for leisurely walking or better in the summer season (Figure 10a). During the winter, wind conditions on the terrace are anticipated to be comfortable for fast walking or better (Figure 10b). If calmer wind conditions are desired for the space, we suggest including tall railings around the perimeter of the space, to disrupt the strong horizontal wind flows that occur at higher elevations.

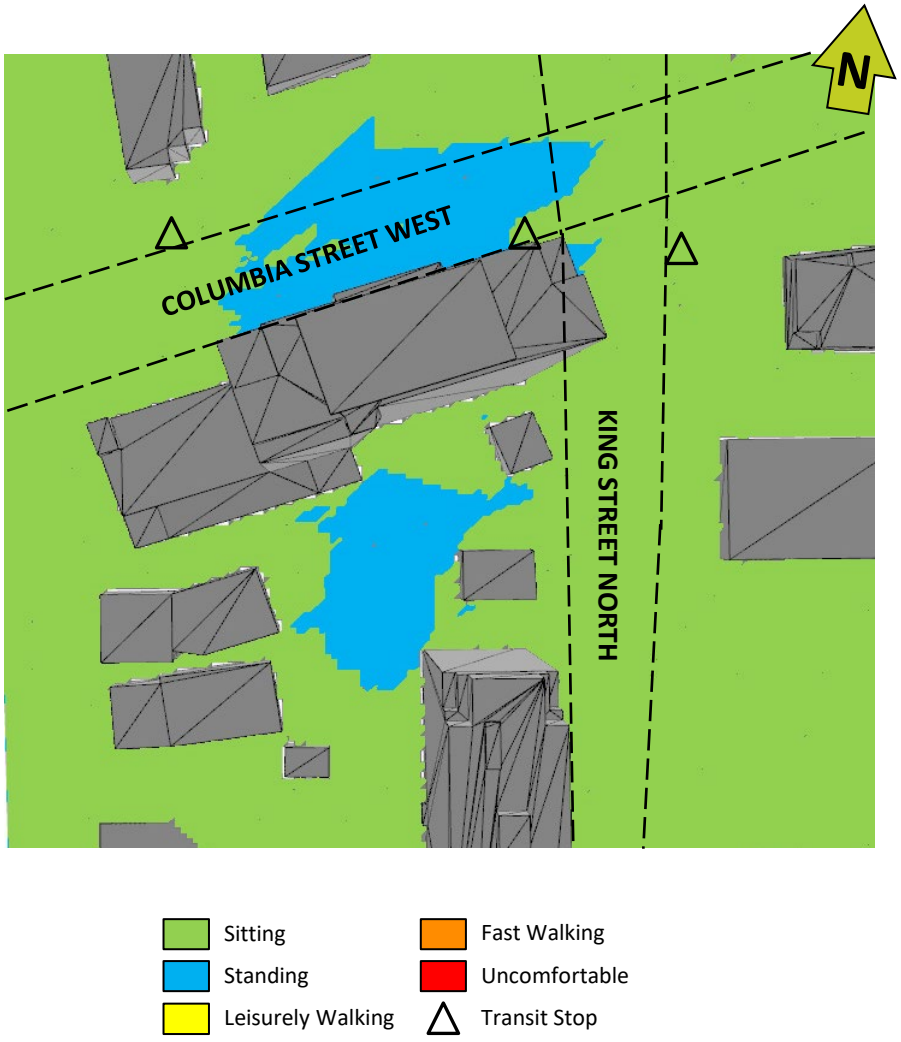


Figure 7a: Existing Configuration – Pedestrian Wind Comfort Summer – On-site & Surrounding Areas

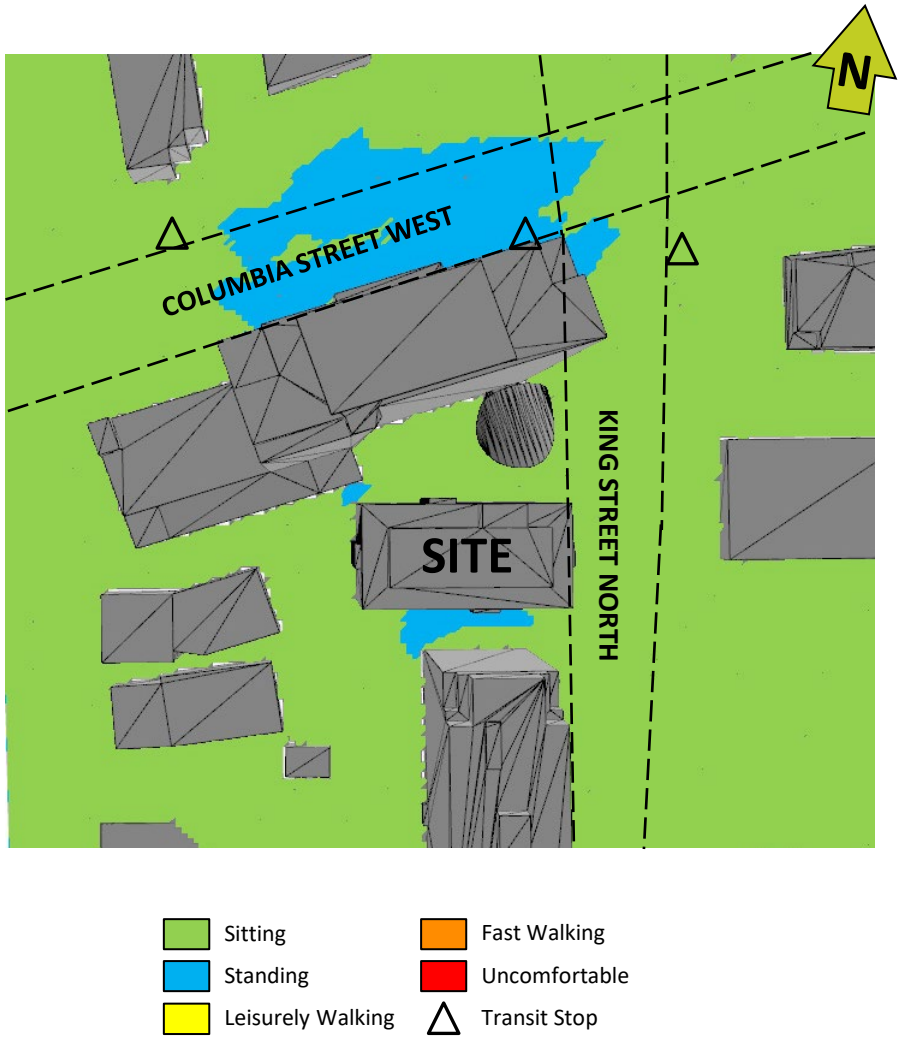


Figure 7b: Proposed Configuration – Pedestrian Wind Comfort Summer – On-site & Surrounding Areas

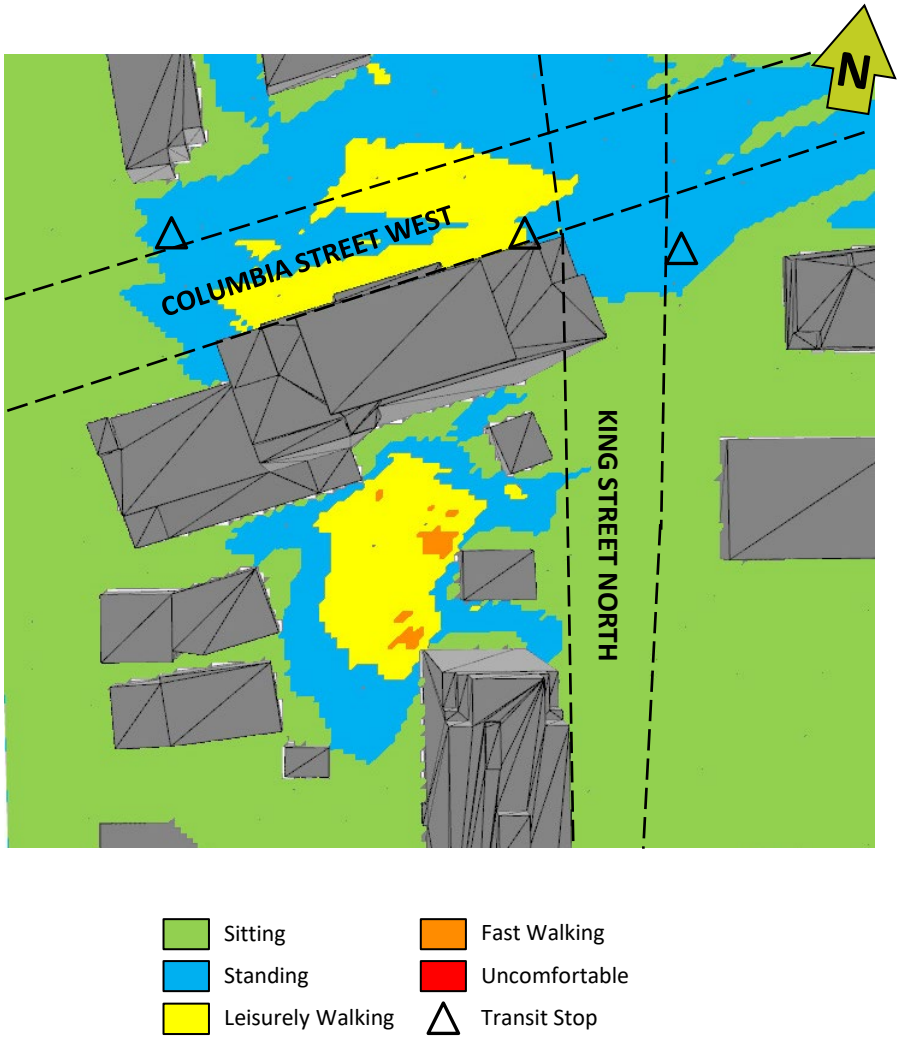


Figure 8a: Existing Configuration – Pedestrian Wind Comfort Winter – On-site & Surrounding Areas

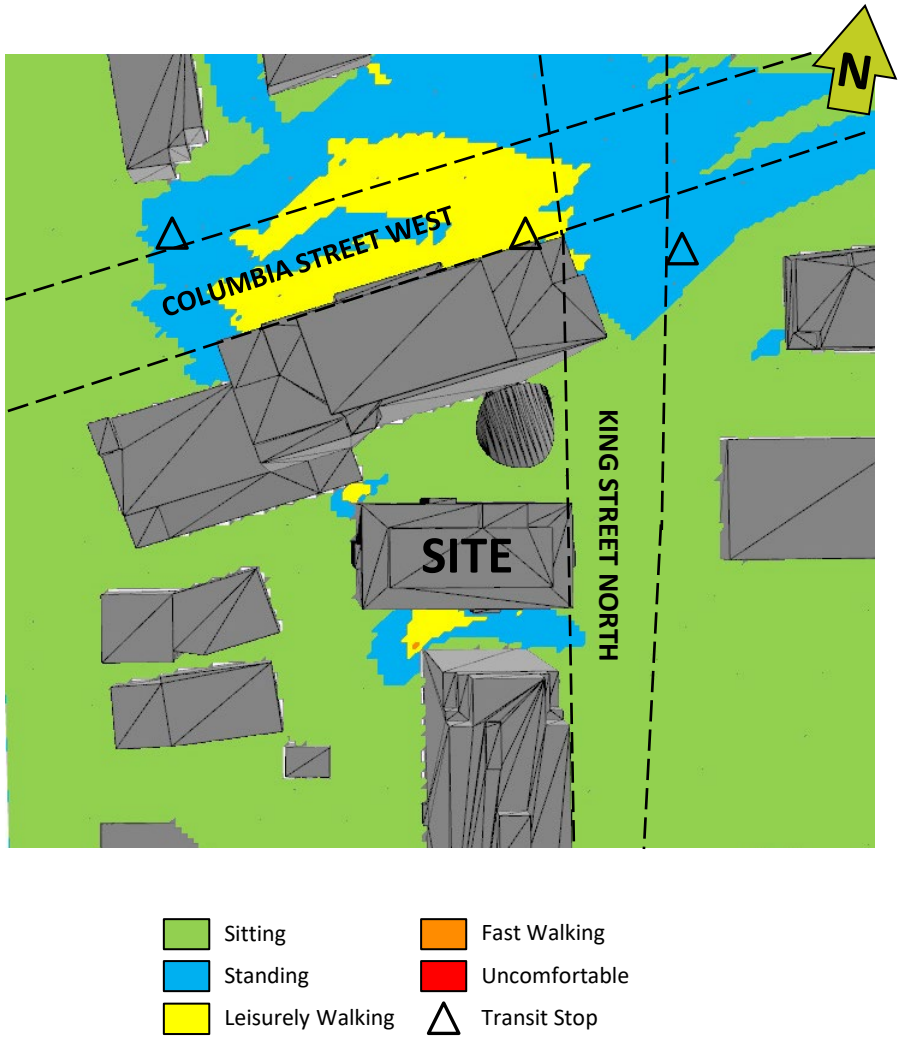


Figure 8b: Proposed Configuration – Pedestrian Wind Comfort Winter – On-site & Surrounding Areas

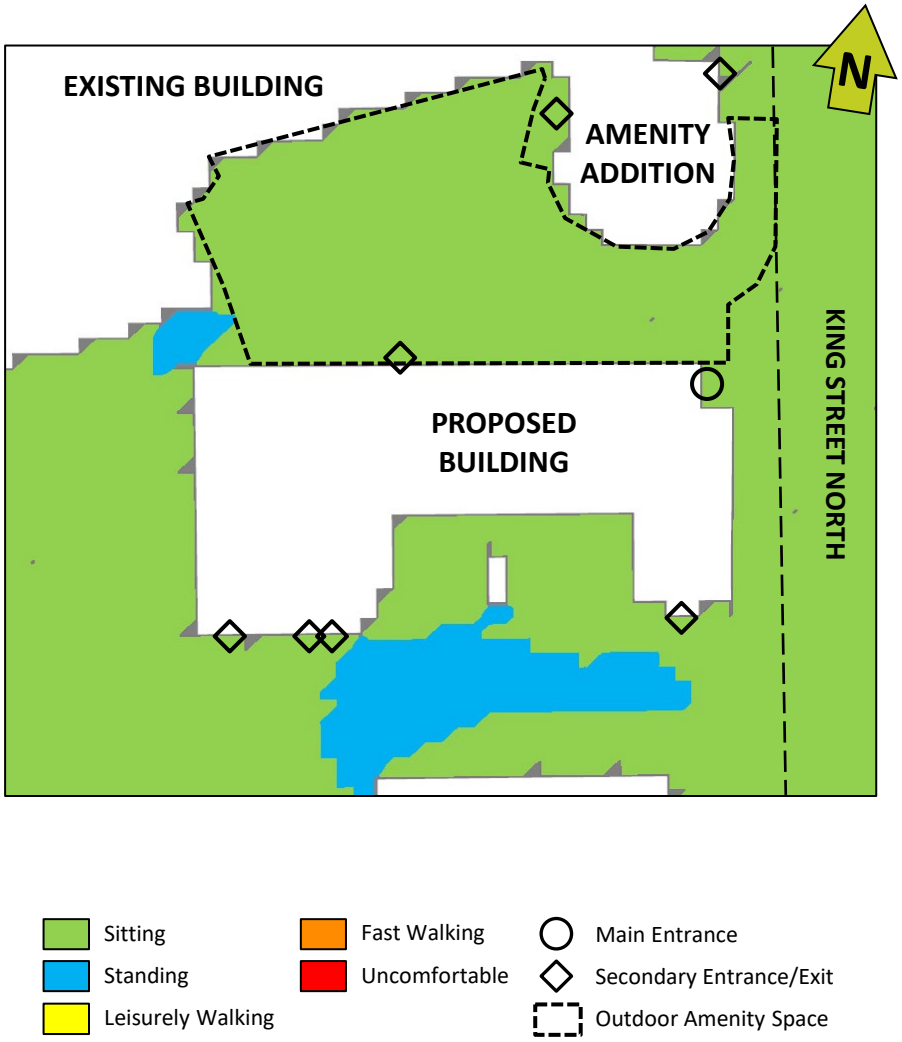


Figure 9a: **Proposed Configuration – Pedestrian Wind Comfort Summer – Building Entrances & Walkways**

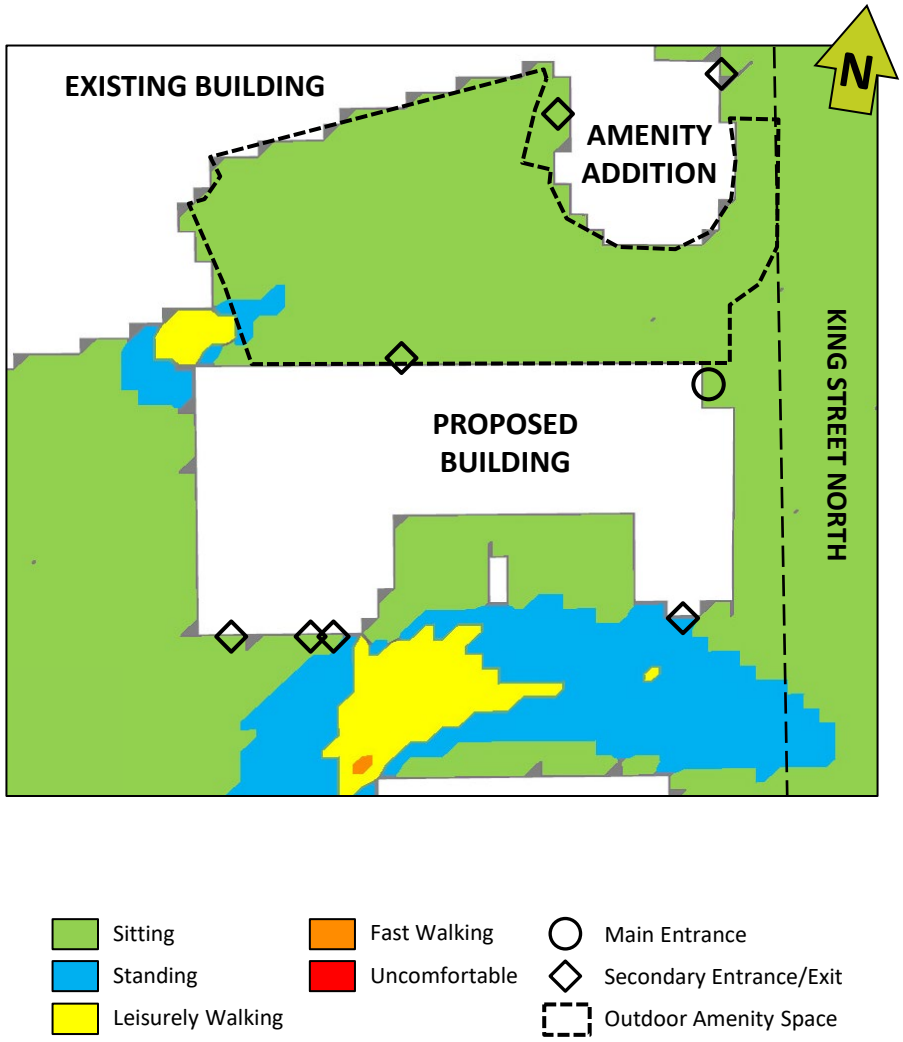


Figure 9b: **Proposed Configuration – Pedestrian Wind Comfort Winter – Building Entrances & Walkways**

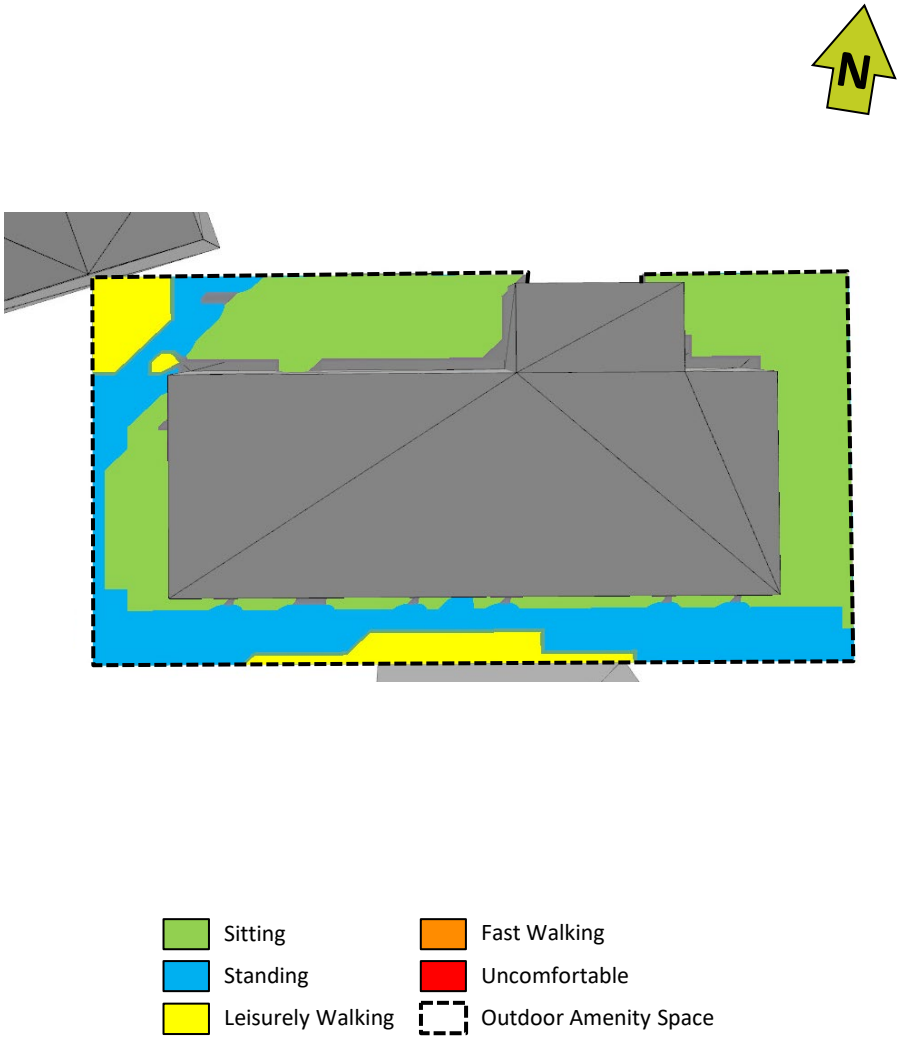


Figure 10a: Proposed Configuration – Pedestrian Wind Comfort Summer – Roof Amenity Terrace

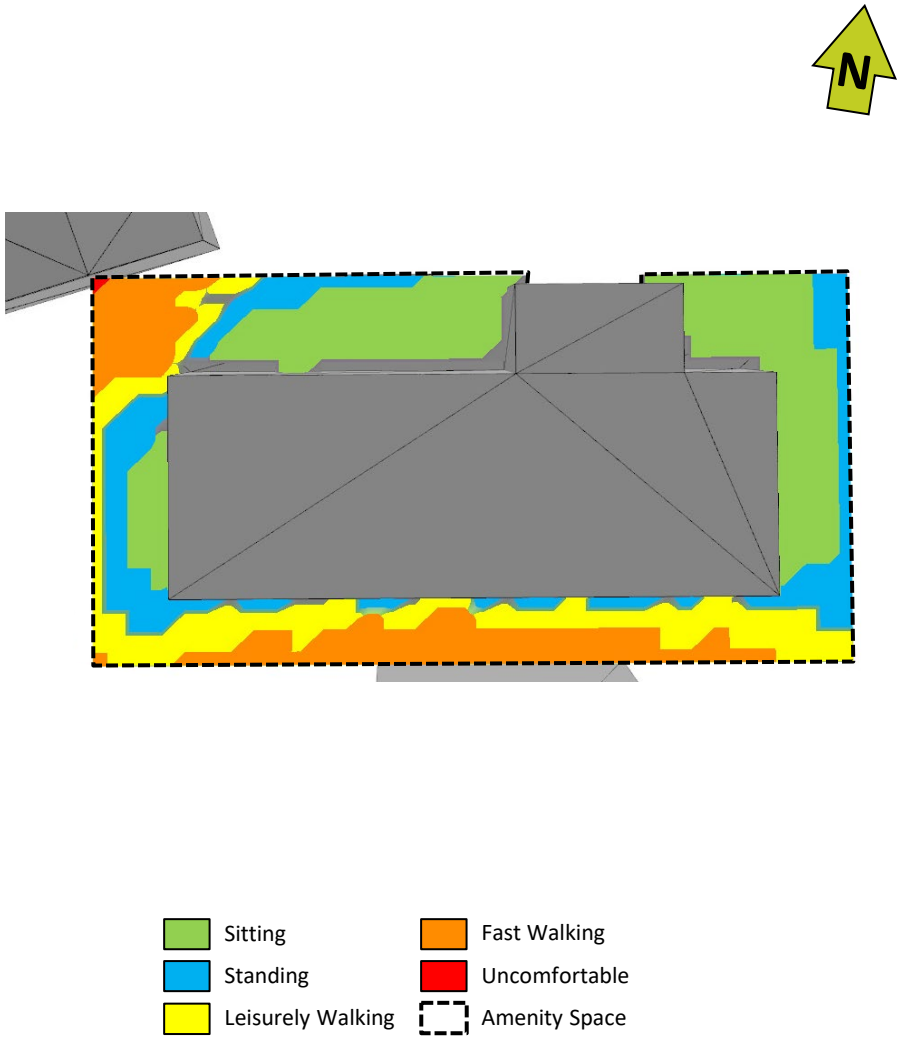


Figure 10b: Proposed Configuration – Pedestrian Wind Comfort Winter – Roof Amenity Terrace

4.3 Surrounding Sidewalks

Wind conditions on the nearby surrounding sidewalks of King Street North and Columbia Street West are predicted to be comfortable for leisurely walking or better throughout the year in the Existing Configuration (**Figures 7a** and **8a**). At the nearby transit stops wind conditions are expected to be suitable for leisurely walking or better year-round.

In the Proposed Configuration, wind conditions on the nearby surrounding sidewalks of Columbia Street West and King Street North are expected to remain suitable for leisurely walking year-round (**Figures 7b** and **8b**). At the nearby transit stops, wind conditions remain suitable for leisurely walking or better throughout the year.

These wind conditions are considered appropriate for the use.

4.4 Wind Safety

The wind safety criterion is expected to be met in all areas at grade and on the roof terrace in both the Existing and Proposed Configurations (**Appendix B**).

5.0 CONCLUSIONS & RECOMMENDATIONS

The pedestrian wind conditions predicted for the proposed development at 1 Columbia Street West in Waterloo have been assessed through computational fluid dynamics modeling techniques. Based on the results of our assessment, the following conclusions have been reached:

- The wind safety criterion is expected to be met in all areas surrounding the development in both the Existing and Proposed Configuration.
- Wind conditions on the site, including the entrances and outdoor amenity spaces, are predicted to be comfortable for the intended use year-round. If amenity space is included on the building's rooftop, mitigation measures are suggested to improve wind conditions.
- On the nearby sidewalks surrounding the proposed development, including the transit stops, wind conditions are anticipated to remain similar between the Existing and Proposed Configurations.

6.0 LIMITATIONS OF LIABILITY

This report has been prepared and the work referred to in this report has been undertaken by SLR Consulting (Canada) Ltd. (SLR) for Studio Limina Inc., hereafter referred to as the "Client". It is intended for the sole and exclusive use of the Client. The report has been prepared in accordance with the Scope of Work and agreement between SLR and the Client. Other than by the Client and by the City of Waterloo in their role as land use planning approval authorities, copying or distribution of this report or use of or reliance on the information contained herein, in whole or in part, is not permitted unless payment for the work has been made in full and express written permission has been obtained from SLR.

This report has been prepared in a manner generally accepted by professional consulting principles and practices for the same locality and under similar conditions. No other representations or warranties, expressed or implied, are made.

Opinions and recommendations contained in this report are based on conditions that existed at the time the services were performed and are intended only for the client, purposes, locations, time frames and project parameters as outlined in the Scope or Work and agreement between SLR and the Client. The data reported, findings, observations and conclusions expressed are limited by the Scope of Work. SLR is not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. SLR does not warranty the accuracy of information provided by third party sources.

7.0 REFERENCES

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Appendix A

Pedestrian Wind Comfort Analysis

Spring (April – June) and Autumn (October – December)

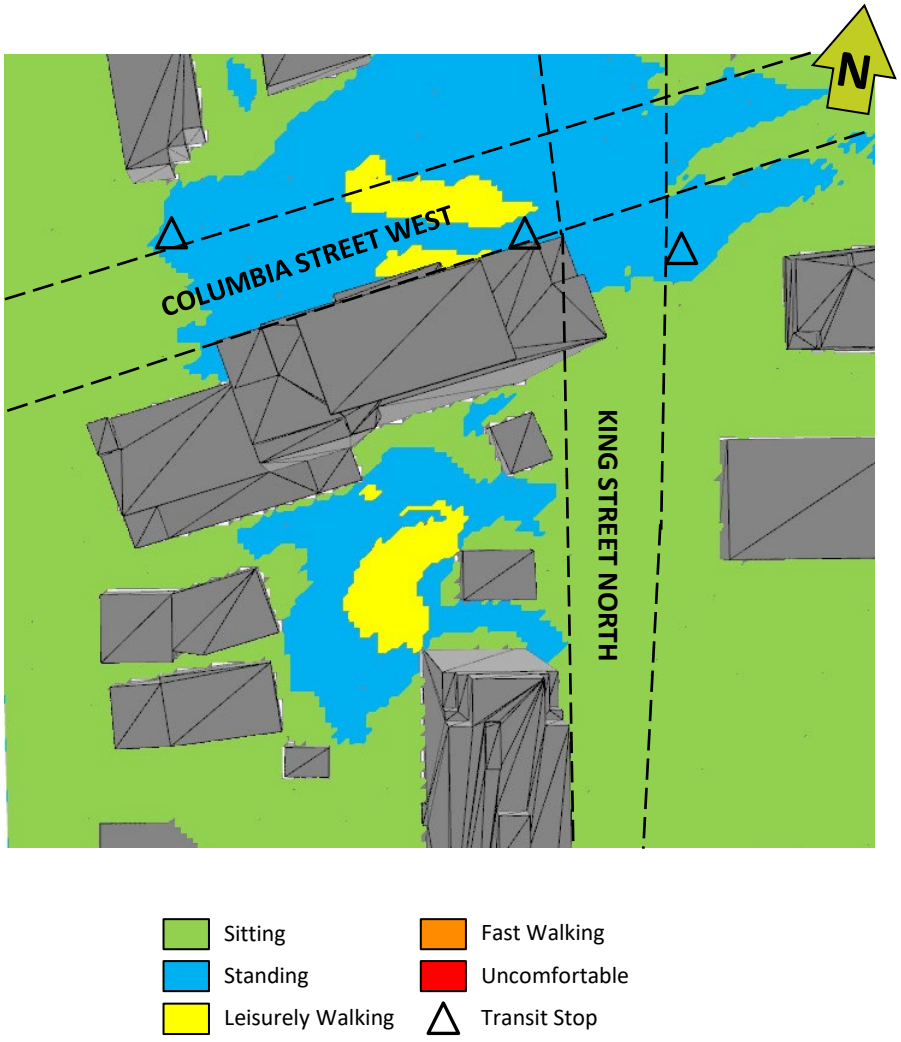


Figure A1a: Existing Configuration – Pedestrian Wind Comfort Spring – On-site & Surrounding Areas

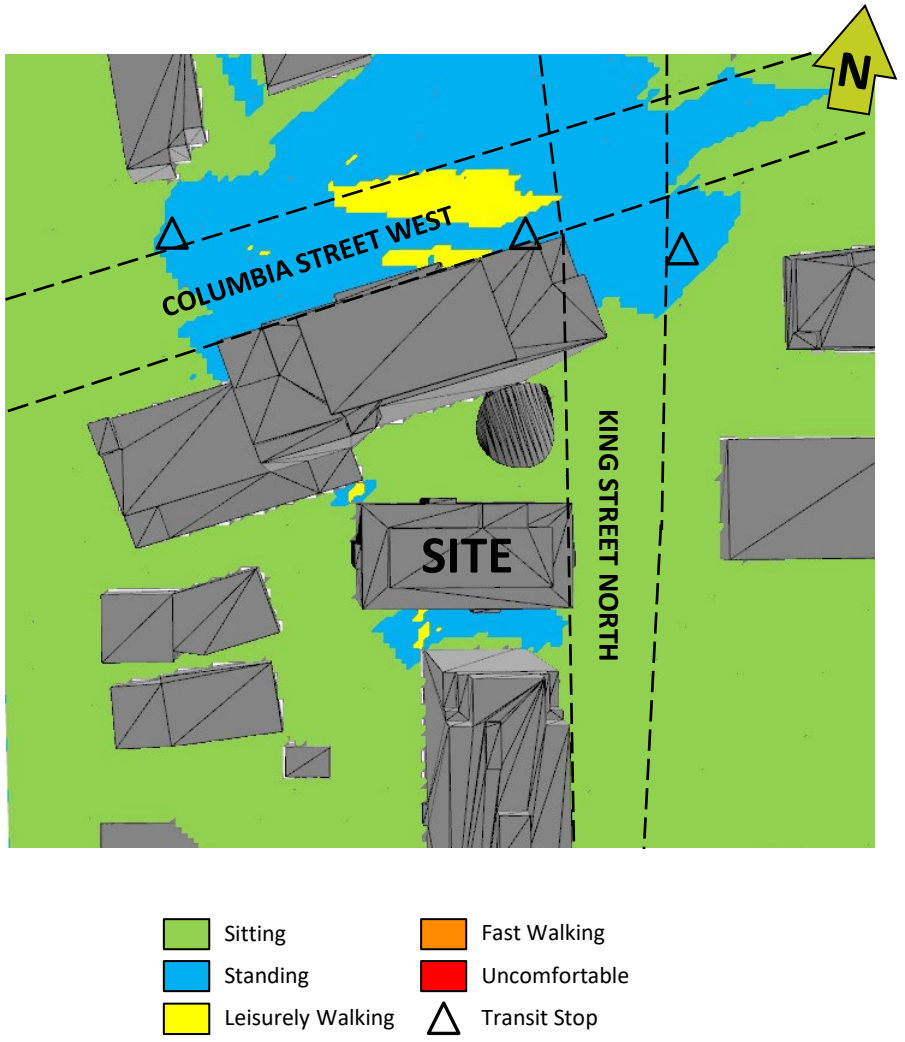


Figure A1b: Proposed Configuration – Pedestrian Wind Comfort Spring – On-site & Surrounding Areas

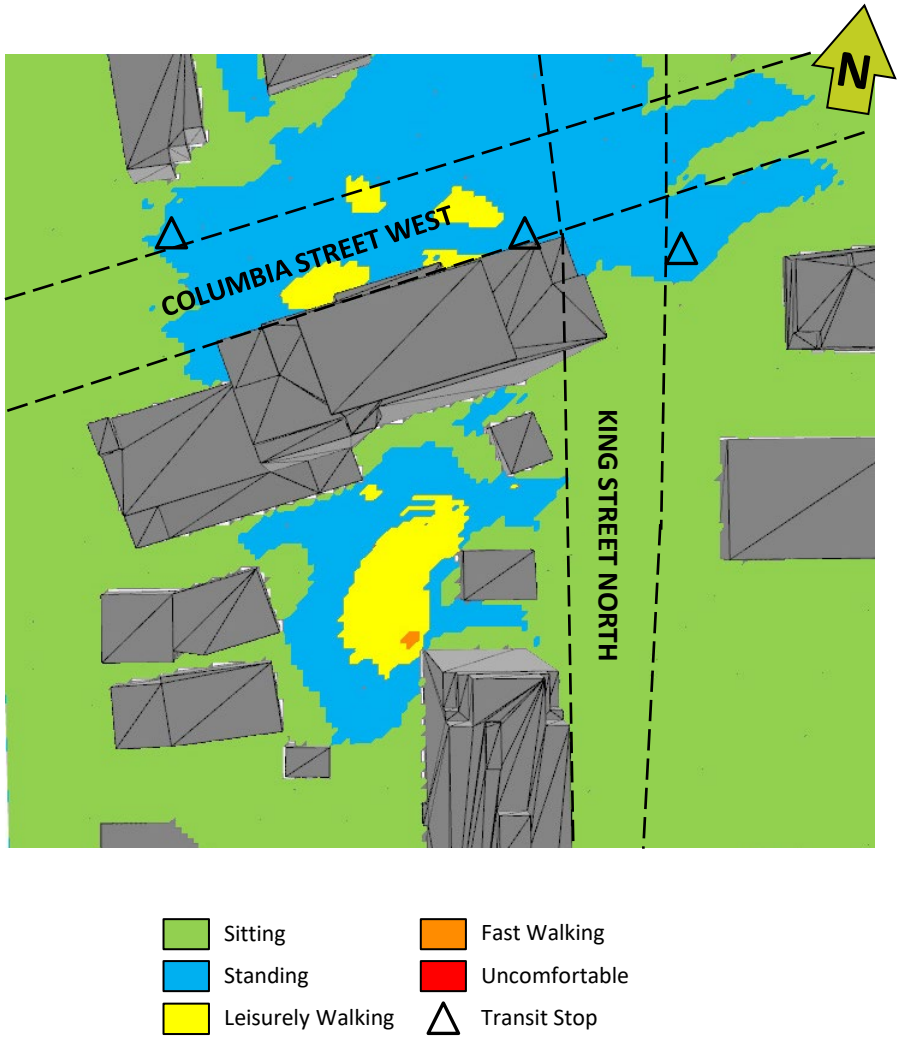


Figure A2a: Existing Configuration – Pedestrian Wind Comfort Autumn – On-site & Surrounding Areas

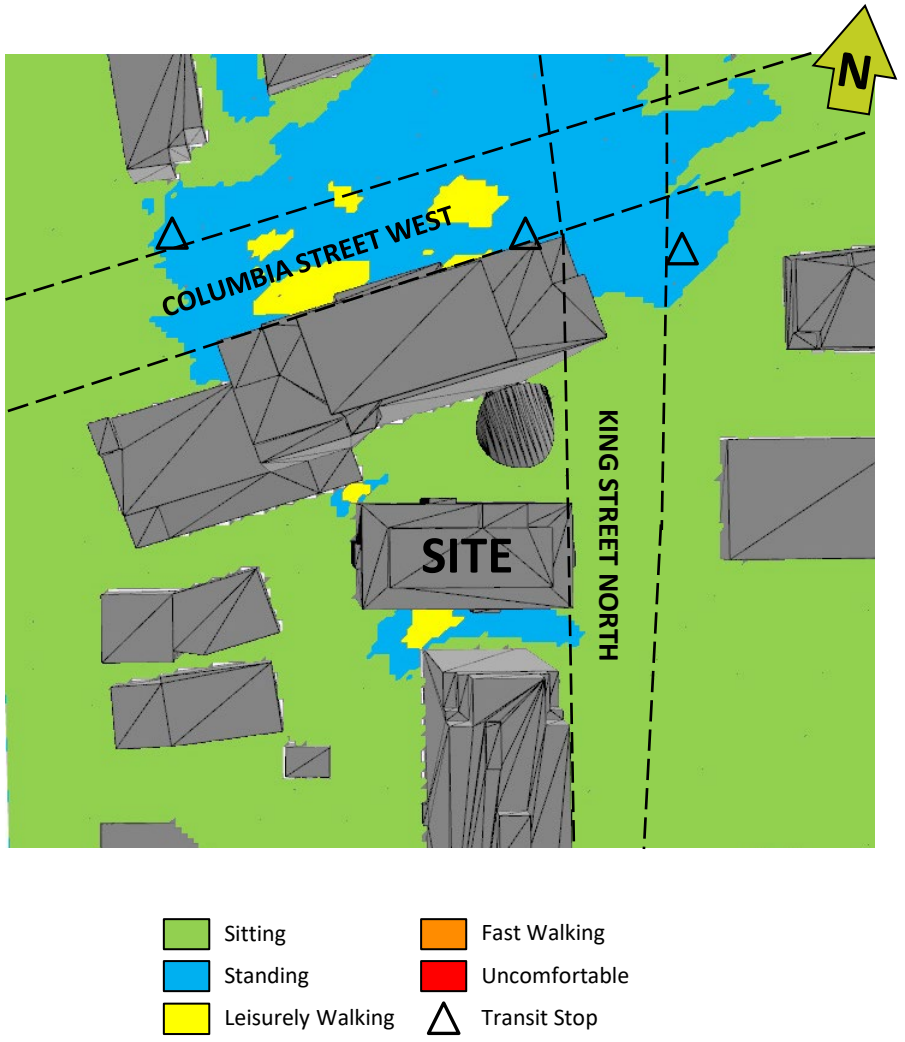


Figure A2b: Proposed Configuration – Pedestrian Wind Comfort Autumn – On-site & Surrounding Areas

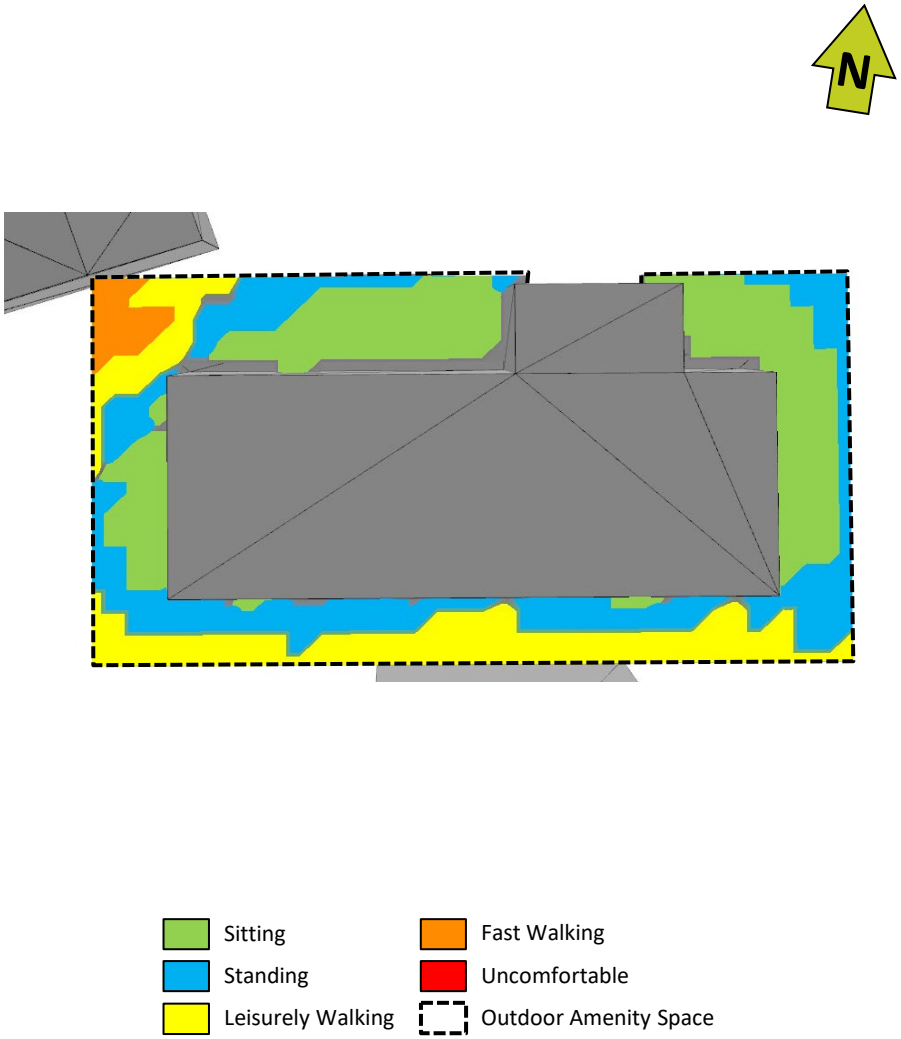


Figure A3a: Proposed Configuration – Pedestrian Wind Comfort Spring – Roof Amenity Terrace

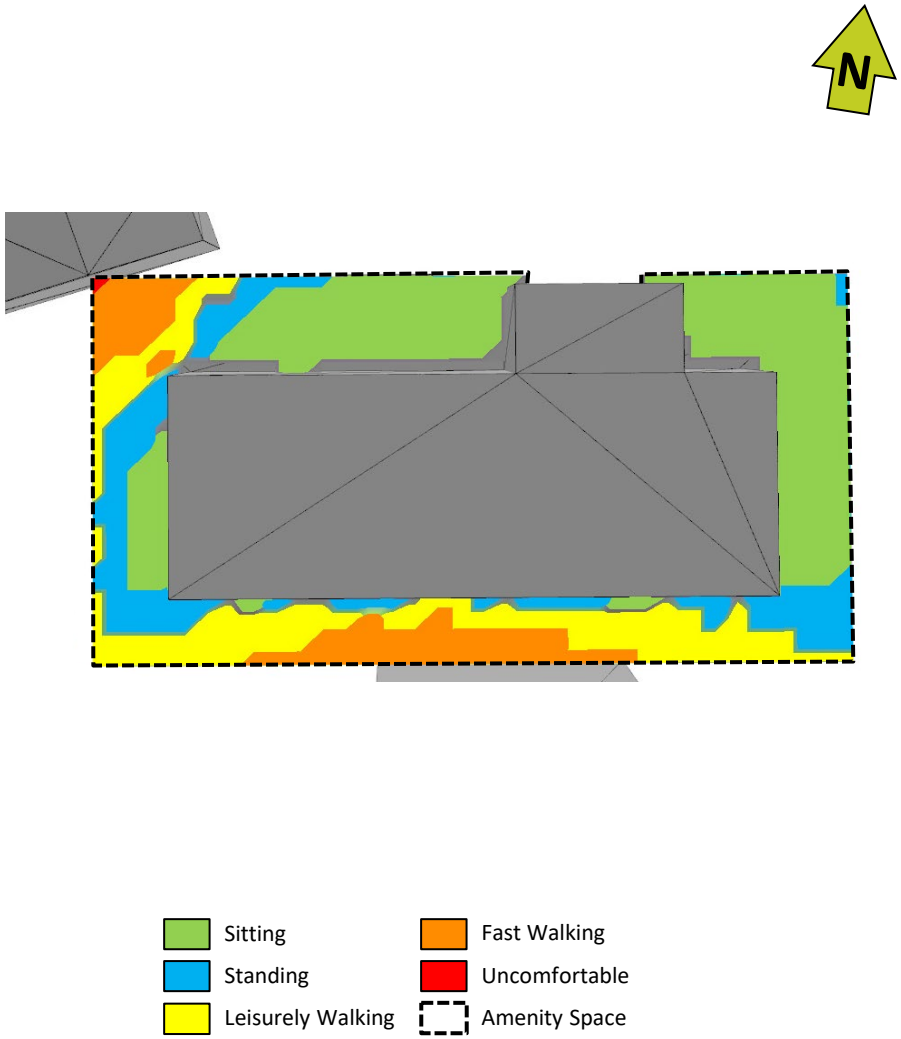


Figure A3b: Proposed Configuration – Pedestrian Wind Comfort Autumn – Roof Amenity Terrace

Appendix B

Pedestrian Wind Safety Analysis

Annual

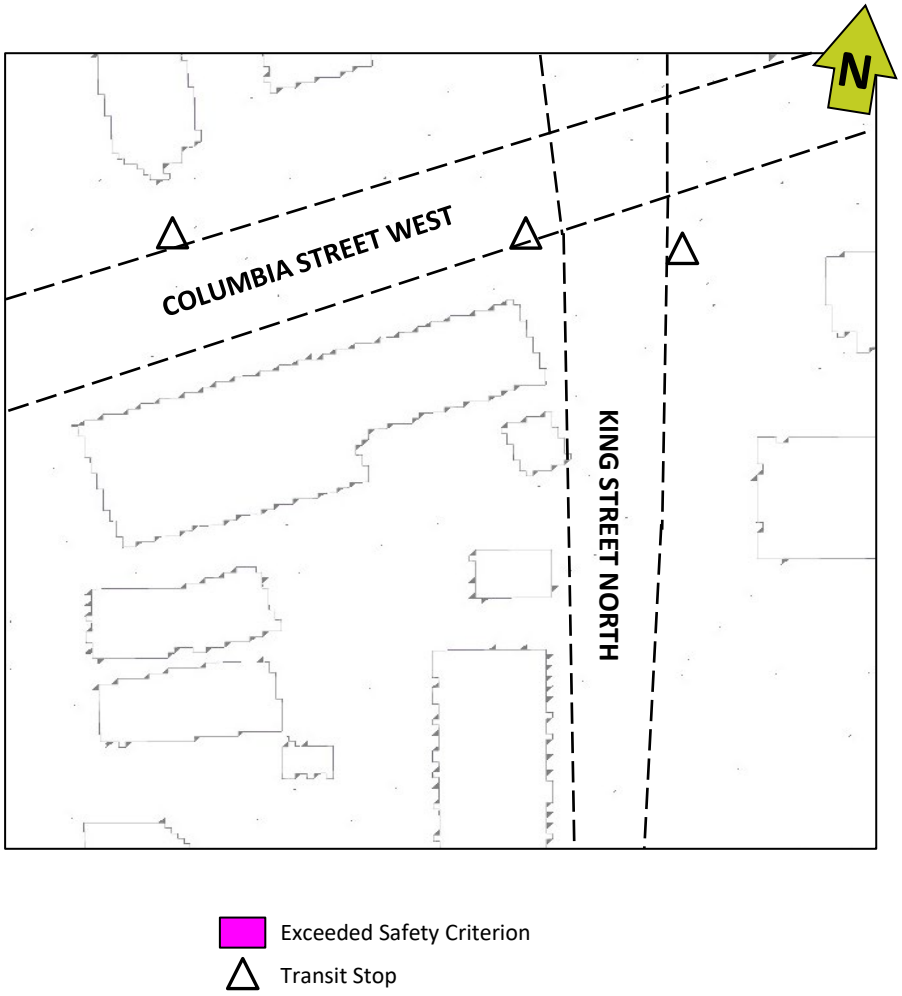


Figure B1a: Existing Configuration – Wind Safety Annual – On-site & Surrounding Areas

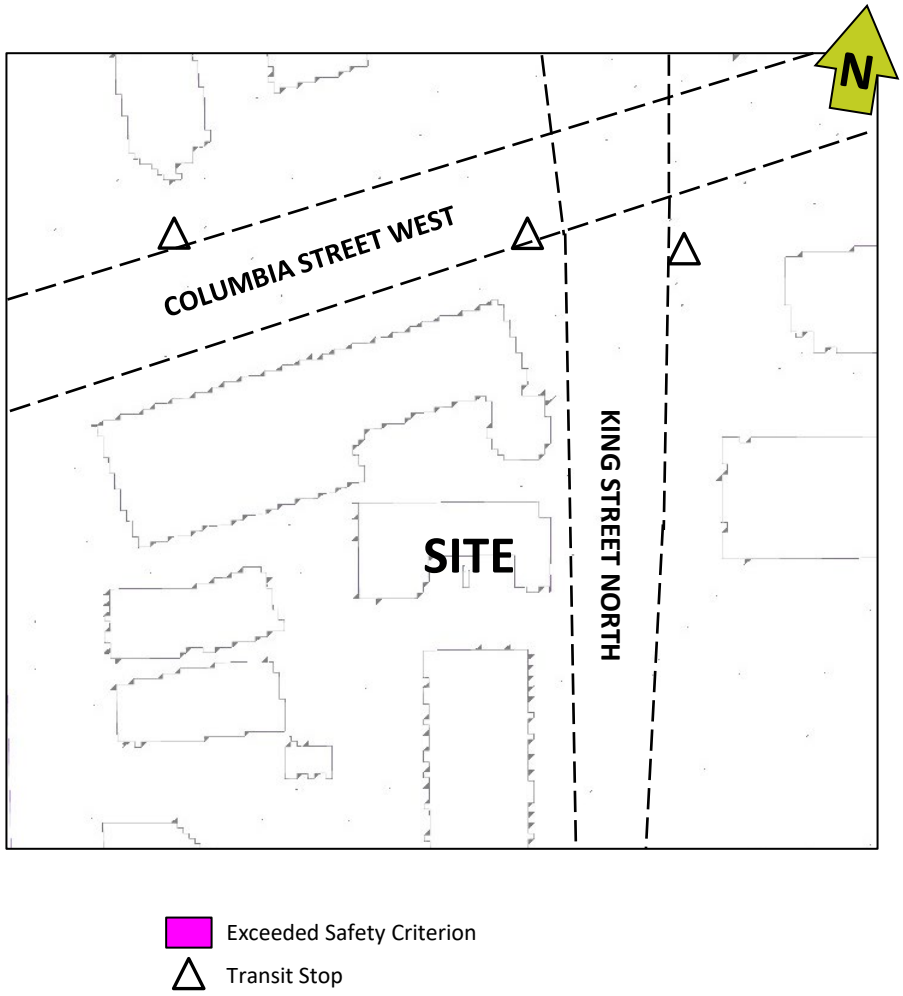


Figure B1b: Proposed Configuration – Wind Safety Annual – On-site & Surrounding Areas

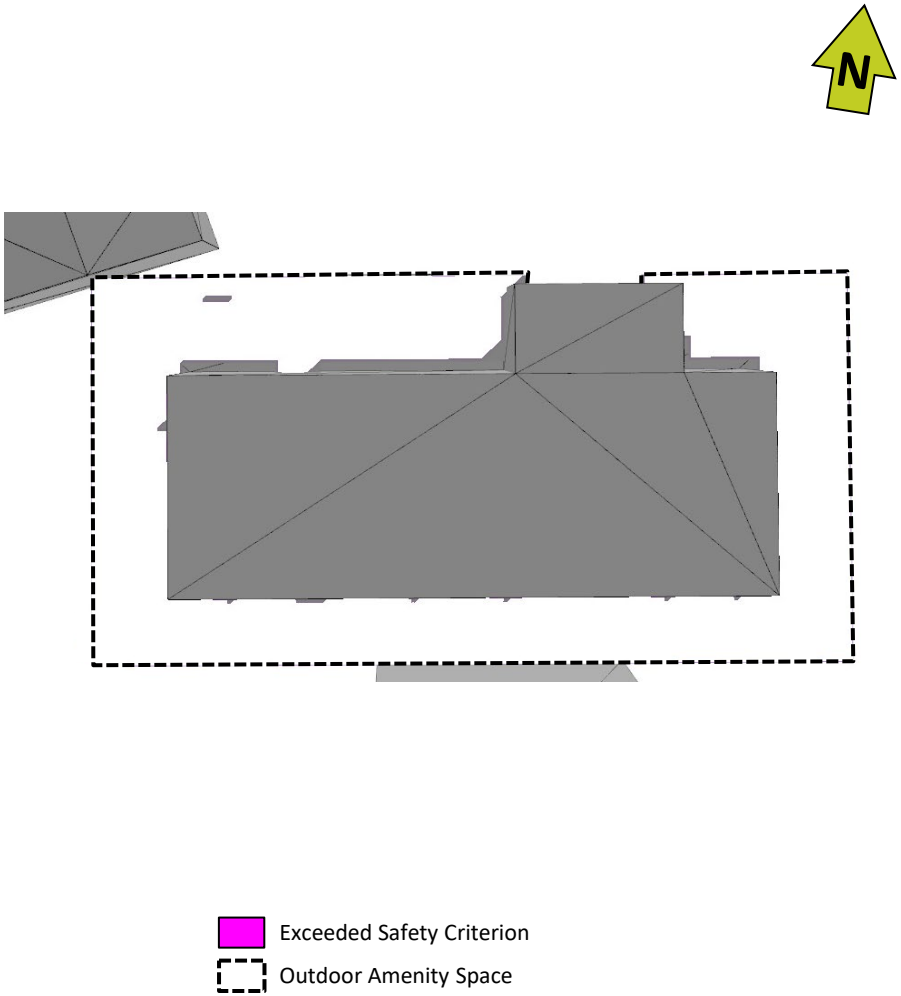


Figure B2: Proposed Configuration – Wind Safety Annual – Roof Amenity Terrace