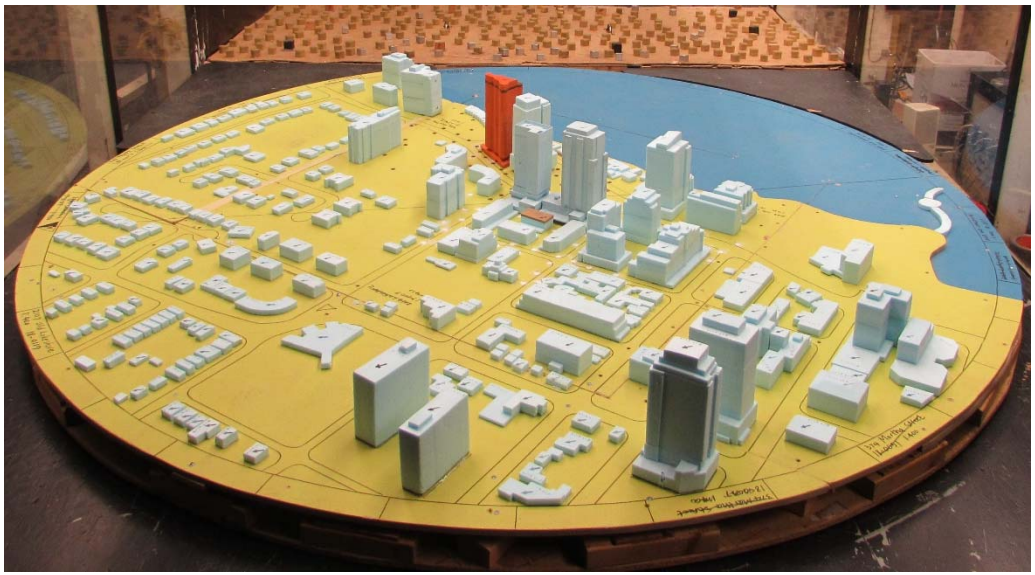
University of Guelph Research Park
150 Research Lane, Suite 105
Guelph, ON, N1G 4T2
226.706.8080 | www.novusenv.com

Date: December 16, 2019

To: Carriage Gate Homes
421 Brant Street, Suite 200
Burlington, Ontario L7R 2G3

Re: **Pedestrian Wind Study**
2107 & 2119 Old Lakeshore Road
Burlington, Ontario
SLR Project #241.18119.00000



Team:

Senior Engineer: Jenny Graham, P.Eng.
Specialist: Tahrana Lovlin, MAES, P.Eng.

LICENSED PROFESSIONAL ENGINEER
T.B. LOVLIN
10056279
16/12/19
PROVINCE OF ONTARIO

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1.0 INTRODUCTION

Novus Environmental Inc., now part of SLR Consulting (Canada) Ltd. (NovusSLR) was retained by Carriage Gate Homes to conduct a pedestrian wind study for the proposed 2107 & 21119 Old Lakeshore Road development in Burlington, Ontario. This report is in support of the Zoning By-law Amendment (ZBA) application for the project.

1.1 Existing Development

The proposed development is located at 2107 & 2119 Old Lakeshore Road, just west of the intersection with Lakeshore Road. The site is currently occupied by two low-rise commercial buildings. **Figure 1** provides an aerial view of the immediate study area. A virtual site visit was conducted by NovusSLR using Google Earth images dated August 2018; these images are included in **Figures 2a** through **2d**.

Immediately surrounding the site are low-rise residential buildings to the east, low-rise residential and commercial buildings to the southeast through west, mid-rise residential buildings to the northwest and north, and a low-rise infrastructure building to the northeast. Beyond the immediate surroundings there is Lake Ontario to the east through south, low through high-rise residential buildings to the southwest and west, and low-rise residential buildings to the northwest through northeast.

As per the direction of the City of Burlington, the following nearby developments were included as existing surroundings for the analysis: 374 Martha Street, 2069 Lakeshore Road, 421 Brant Street, 2042 Lakeshore Road, and 2100 Lakeshore Road.



Figure 1: Aerial view of existing site & surroundings
Credit: Google Earth Pro™, dated May 7, 2018



Figure 2a: Looking west at existing site



Figure 2b: Looking northeast along Lakeshore Road



Figure 2c: Looking east along Old Lakeshore Road



Figure 2d: Looking northwest along Pearl Street

1.2 Proposed Development

The proposed development is 26-storeys in height, plus a mechanical penthouse, for a total height of approximately 99 m (**Figure 3**). The tower is triangular shape, with a footprint of approximately 56 m by 44 m, with the long axis parallel to Lakeshore Road. The main residential entrance is located in the middle of the south facade, with a secondary entrance on the north facade. There are exits on the south and west facades as well. Atop the one-storey podium there is an outdoor amenity space around the perimeter of the tower, in addition to the outdoor amenity space on the roof. These areas are shown in **Figure 4**.

Updated architectural information received after the analysis was completed (dated November 15, 2019) shows the building is now 27-storeys tall, for a total height of approximately 103 m. This slight increase in height will have negligible influence on the overall wind conditions. Hence, the wind conditions presented in this report are valid.

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. There are three transit stops nearby along Lakeshore Road, between Martha Street and Torrance Street.

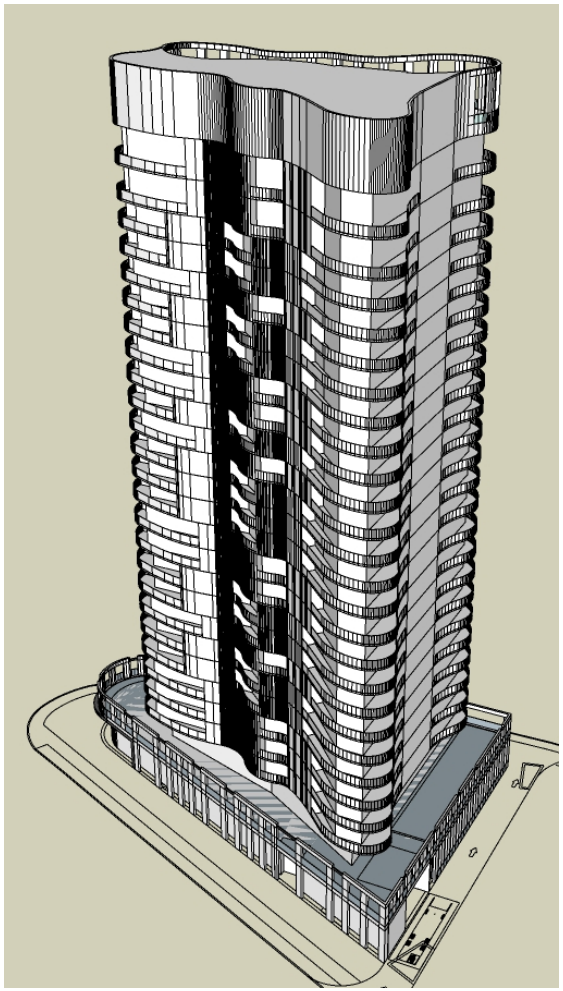


Figure 3: Rendered concept of proposed development
Credit: Graziani + Corazza

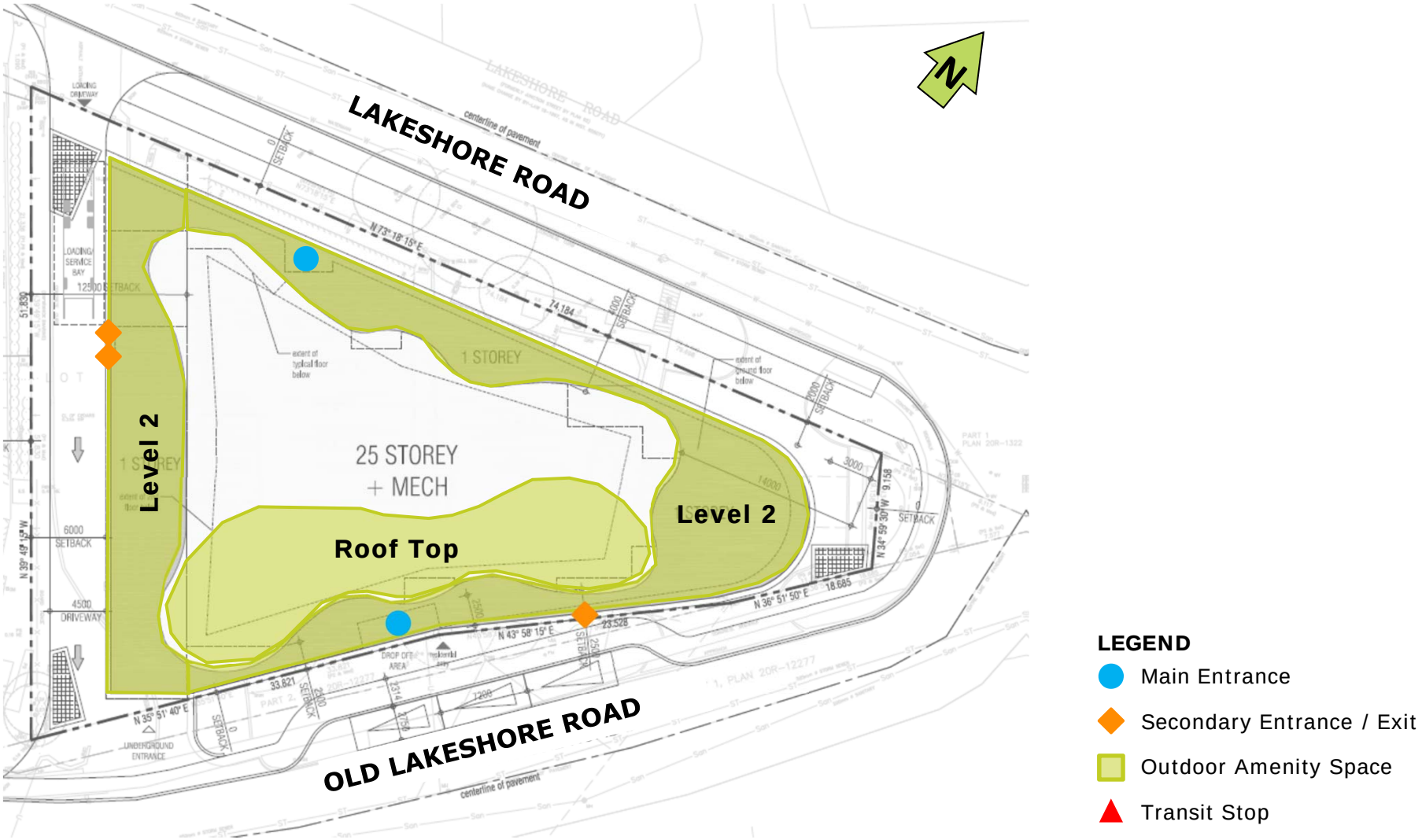


Figure 4: Areas of interest

2.0 APPROACH

The objective of the wind tunnel study is to assist the design team and City Planning officials in making informed decisions about the building form considered and its influence on pedestrian comfort. This quantitative analysis involves the construction of a physical model of the development and surrounding features that influence wind flow. The physical model is instrumented with probes and tested in a wind tunnel. Afterwards, the wind tunnel data are combined with regional meteorological data; this analysis is then compared to the relevant wind criteria and standards in order to determine how appropriate the wind conditions are for the intended pedestrian usage.

2.1 Scale Model Construction

A 1:400 scale model of the 2107 Old Lakeshore Road development was constructed based on up-to-date drawing information received by NovusSLR on August 16th and 26th, 2019.

The proximity model of the surrounding area was built in block form for a radius of approximately 480 m from the site centre. As existing buildings surrounding the site will influence wind characteristics, existing buildings, those under construction and those buildings with Site Plan Approval (SPA) have been included in the model for both the Existing and Proposed Configurations. In addition, the City of Burlington directed the team to include current development proposals in the vicinity as part of the existing surroundings, as per **Section 1.1**. Grade differences within the limits of the model were found to be minor, thus the site was modeled as flat, with a 5m drop for Lake Ontario.

Photographs of the wind tunnel model showing both the Existing and Proposed Configurations are included in **Figures 5a and 5b**.

2.2 Wind Tunnel

Wind tunnel tests were conducted in the Alan G. Davenport Wind Engineering Group Boundary-Layer Wind Tunnel Laboratory at the University of Western Ontario. The upstream test section of the wind tunnel included generic roughness blocks and turbulence-generating spires to modify the wind flow approaching the model. These features develop characteristics of the wind flow that are similar to the actual site. The test model is rotated on a turn-table to simulate different wind directions with the upstream terrain being changed as appropriate to reflect the various upwind conditions encountered around the site.

The test model was equipped with 82 omni-directional probes to record wind speed at the pedestrian-level (approximately 1.5 m above grade). The orientation of the model was rotated in 10° intervals on the turn-table to permit measurement of wind speed at each probe location for 36 wind directions. The wind tunnel data were then combined with the wind climate model for this region to predict the occurrence of wind speeds in the pedestrian realm and compare against wind criteria for comfort and safety.





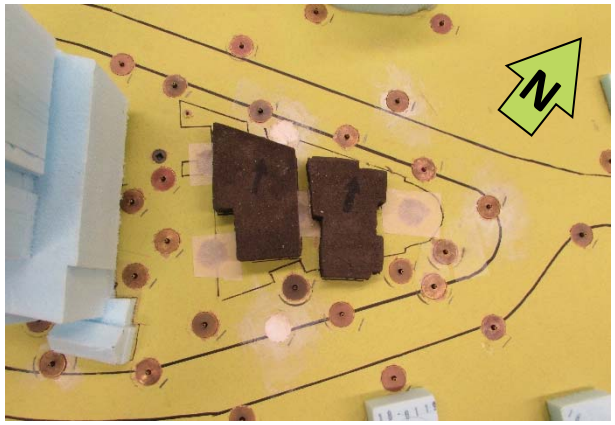
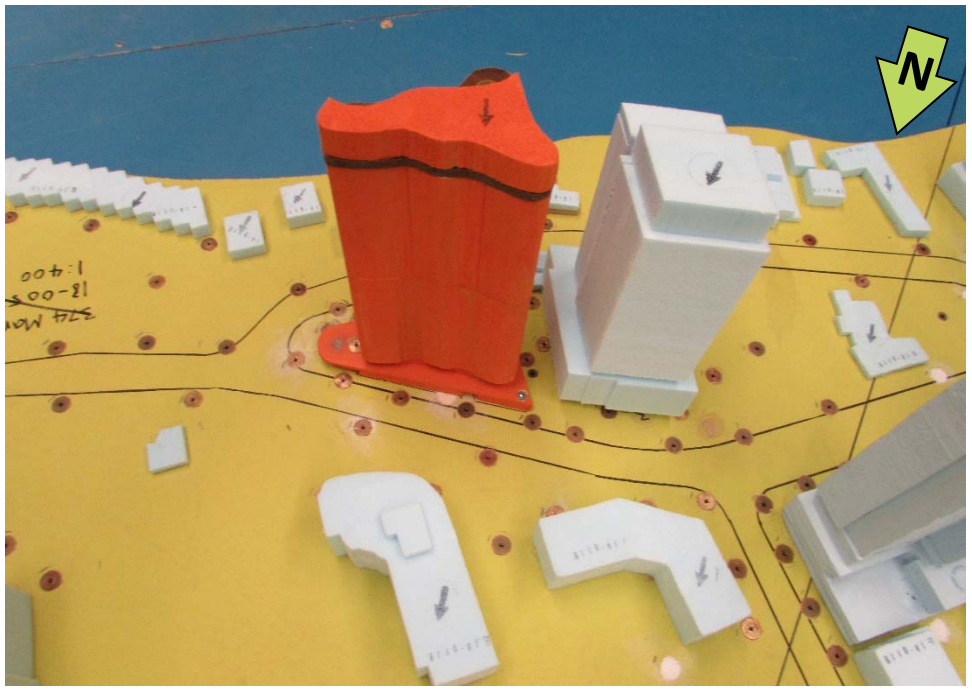


Figure 5a: Existing Configuration





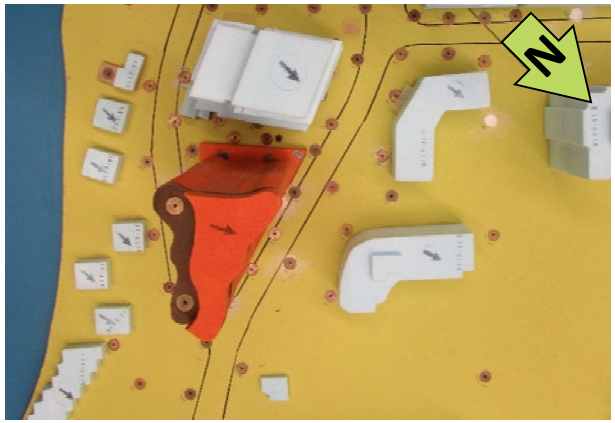


Figure 5b: Proposed Configuration

2.3 Wind Climate

Wind data recorded at Burlington Piers for the period of 1991 to 2011 were obtained and analysed to create a wind climate model for the seasonal extremes. 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 winds approaching from the west through southwest 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 building massing/alignment. 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 northeasterly and easterly directions. All wind speeds and directions were included in the wind climate model.

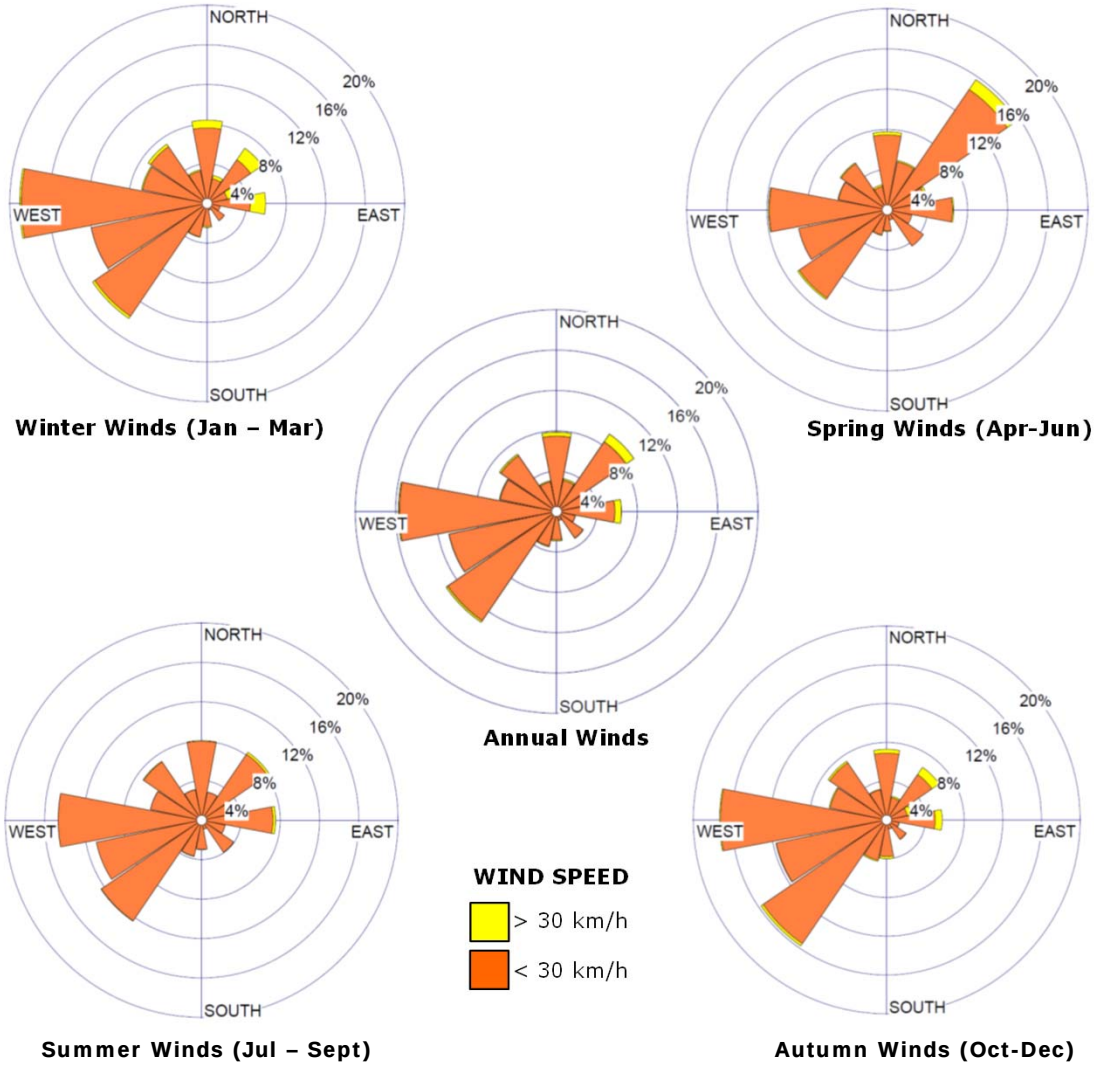


Figure 6: Wind Roses for Burlington Piers (1991-2011)

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 measure 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 the University of Western Ontario, 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 Effects
Sitting	0 to 14 km/h	0 to 4 m/s	• Light wind felt on face • Leaves rustle
Standing	0 to 22 km/h	0 to 6 m/s	• Hair is disturbed, clothing flaps • Light leaves and twigs in motion • Wind extends lightweight flag
Leisurely Walking	0 to 29 km/h	0 to 8 m/s	• Moderate, raises dust, loose paper • Hair disarranged • Small branches move
Fast Walking	0 to 36 km/h	0 to 10 m/s	• Force of wind felt on body • Trees in leaf begin to move • Limit of agreeable wind on land
Uncomfortable	> 36 km/h	> 10 m/s	• Small trees sway • Umbrella use becomes difficult

Table 2: Wind Safety Criterion

Activity	Safety Criterion Mean Wind Speed Exceeded Once Per Year (0.01%)		Description of Wind Effects
Any [1]	72 km/h	20 m/s	• Difficult to walk straight • Wind noise on ears unpleasant

[1] Equivalent to the "Fair Weather Location" criterion of UWO's Criteria, which applies to frequently accessed areas.

4.0 RESULTS

Results are presented through discussion of the wind conditions on the site, and along nearby major streets. Note the comfort criterion are based on wind force alone, thus climate issues that influence a person's overall "thermal" comfort (e.g., temperature, humidity, wind chill, shade, etc.) are not considered in this analysis. The analysis of wind comfort was undertaken for all four seasons in this study. The results for the summer and winter seasons are the focus of the discussion within this report and are displayed on plans. Full detailed results for the summer and winter can be found in **Appendix A**, while **Appendix B** provides the spring and autumn seasons. Annual wind safety is provided in **Appendix C**.

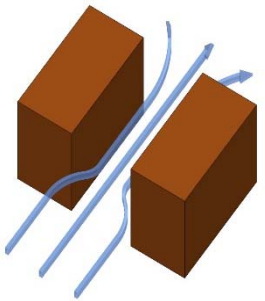
There are generally accepted wind comfort levels that are desired for various pedestrian uses. For example, for public sidewalks, wind comfort suitable for **leisurely walking** would be desirable year-round. For main entrances and transit stops, wind conditions conducive to **standing** would be preferred throughout the year, but can be difficult to achieve in regions where winter winds are inherently harsh. For amenity spaces, wind conditions suitable for **sitting** and/or **standing** are generally desirable during the summer months. The most stringent category of **sitting** is considered appropriate for cafes and dedicated seating areas, while for public parks **sitting** and/or **standing** would be appropriate in the summer.

Overall, the wind conditions with the proposed development in place are generally suitable for the intended usage. However, there are some areas near building corners, as well as on the outdoor amenity spaces, where wind control measures are recommended.

4.1 Building Entrances & Walkways (Locations 1–10)

In the Existing Configuration wind conditions are comfortable for leisurely walking or better year-round (**Appendices A** and **B**).

In the Proposed Configuration wind conditions at both main entrances (Locations 5 and 10) are suitable for sitting and/or standing throughout the year (**Figure 7**). On the walkways surrounding the development wind conditions are generally conducive to leisurely walking or better in both the summer and winter seasons. The exceptions are along the west side of the building (Locations 7 and 8) where the winds are channeled between the proposed development and adjacent, proposed 2100 Lakeshore. In this area, wind conditions are suitable for leisurely walking in the summer, while in the winter wind conditions are comfortable for fast walking or are uncomfortable (**Figure 7**). As this area is a driveway, with limited pedestrian usage, these strong flows may not be concern. If improved wind conditions are desired, we recommend including a canopy along the west side of the podium.



Channeling Flow

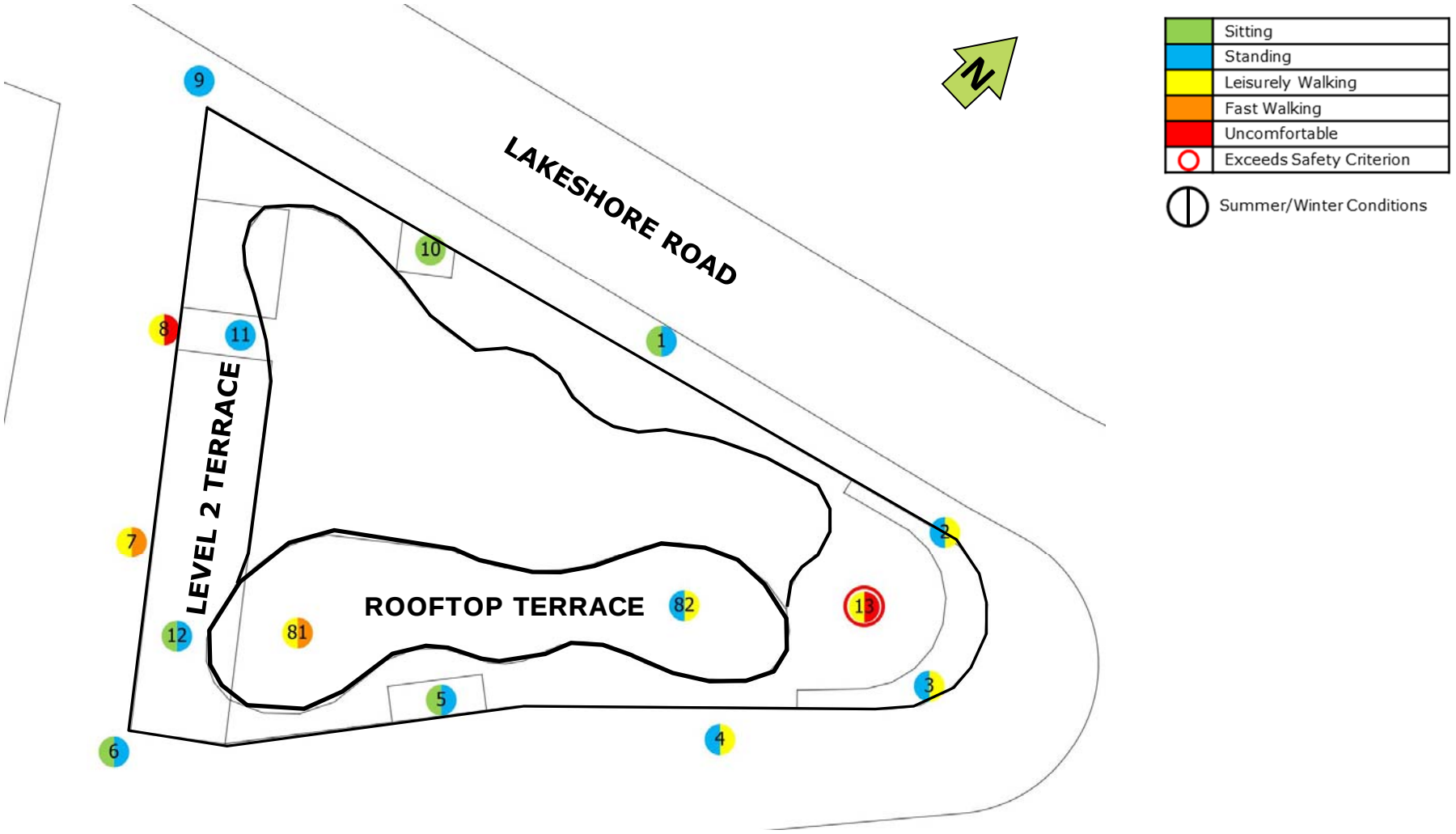


Figure 7: Pedestrian Wind Conditions – Proposed Configuration
Building Entrances, Walkways & Terraces

4.2 Amenity Terraces (Locations 11–13, 81 & 82)

In the Proposed Configuration wind conditions on the Level 2 outdoor amenity terrace are comfortable for sitting and/or standing in both the summer and winter seasons along the west side of the tower (Locations 11 and 12 in **Figure 7**). These wind conditions are considered ideal for the intended usage. However, at the east corner of the terrace (Location 13) wind conditions are suitable for leisurely walking in the summer and are considered uncomfortable in the winter (**Figure 7**). In addition, the wind safety criterion was exceeded in this area (**Appendix C**). These strong wind flows are due to the downwashing of the northerly winds around the east corner of the tower. If improved wind conditions are desired in this area, we recommend including a large trellis above the terrace in this area. Alternatively, we recommend management limit access to between May and October.

On the rooftop terrace (Locations 81 and 82) wind conditions are suitable for standing or leisurely walking in the summer, while in the winter wind conditions are conducive to leisurely or fast walking (**Figure 7**). To provide shelter on the terrace a tall wall has been included around the perimeter, as shown in the drawings. We recommend that the wall have a minimum solidity of 50%. This will allow for passive activity usage in the spring, summer, and autumn seasons.

4.3 Surrounding Sidewalks (Locations 14 – 80)

In the Existing Configuration wind conditions on the surrounding sidewalks of Lakeshore Road, Old Lakeshore Road, Martha Street, and Torrance Street are generally comfortable for leisurely walking or better year-round (**Appendices A** and **B**). The exceptions are along Old Lakeshore Road (Location 17), Torrance Street (Location 40), and Lakeshore Road (Locations 67) where wind conditions are suitable for fast walking in the winter. Wind conditions are also uncomfortable at the northwest corner of adjacent 2100 Lakshore Road in the winter (Location 77); the wind safety criterion was also exceeded in this area (**Appendix C**). At the nearby transit stops along Lakeshore Road (Locations 36, 45, and 55) wind conditions are generally comfortable for sitting or standing year-round; the exception is on the north side of Lakeshore Road (Location 45) where wind conditions are suitable for leisurely walking in the winter in the Existing Configuration.

In the Proposed Configuration, wind conditions on the surrounding sidewalks of Lakeshore Road, Old Lakeshore Road, Martha Street, and Torrance Street remain generally comfortable for leisurely walking or better throughout the year (**Figures 8a** and **8b**). One exception is to the east of the proposed building (Location 14) where wind conditions are conducive to fast walking in the winter. For this area, we recommend the design team consider including architectural features at the east corner of the site (e.g., art features, wind screens) to disrupt the downwashing flows from the proposed building. The other exceptions are existing issues at the northwest corner of the adjacent 2100 Lakeshore development (Locations 67 and 77) where wind conditions are suitable for fast walking or are uncomfortable in the winter (**Figures 8a** and **8b**). The wind safety criterion was also exceeded in this area (Location 77) in the Proposed Configuration.

At the nearby transit stops (Locations 36, 45, and 55) wind conditions in the Proposed Configuration remain suitable for sitting or standing year-round; the exception is on the north side of Lakeshore Road (Location 45) where wind conditions are suitable for leisurely walking in the winter. These wind conditions are similar to those of the Existing Configuration for these areas.

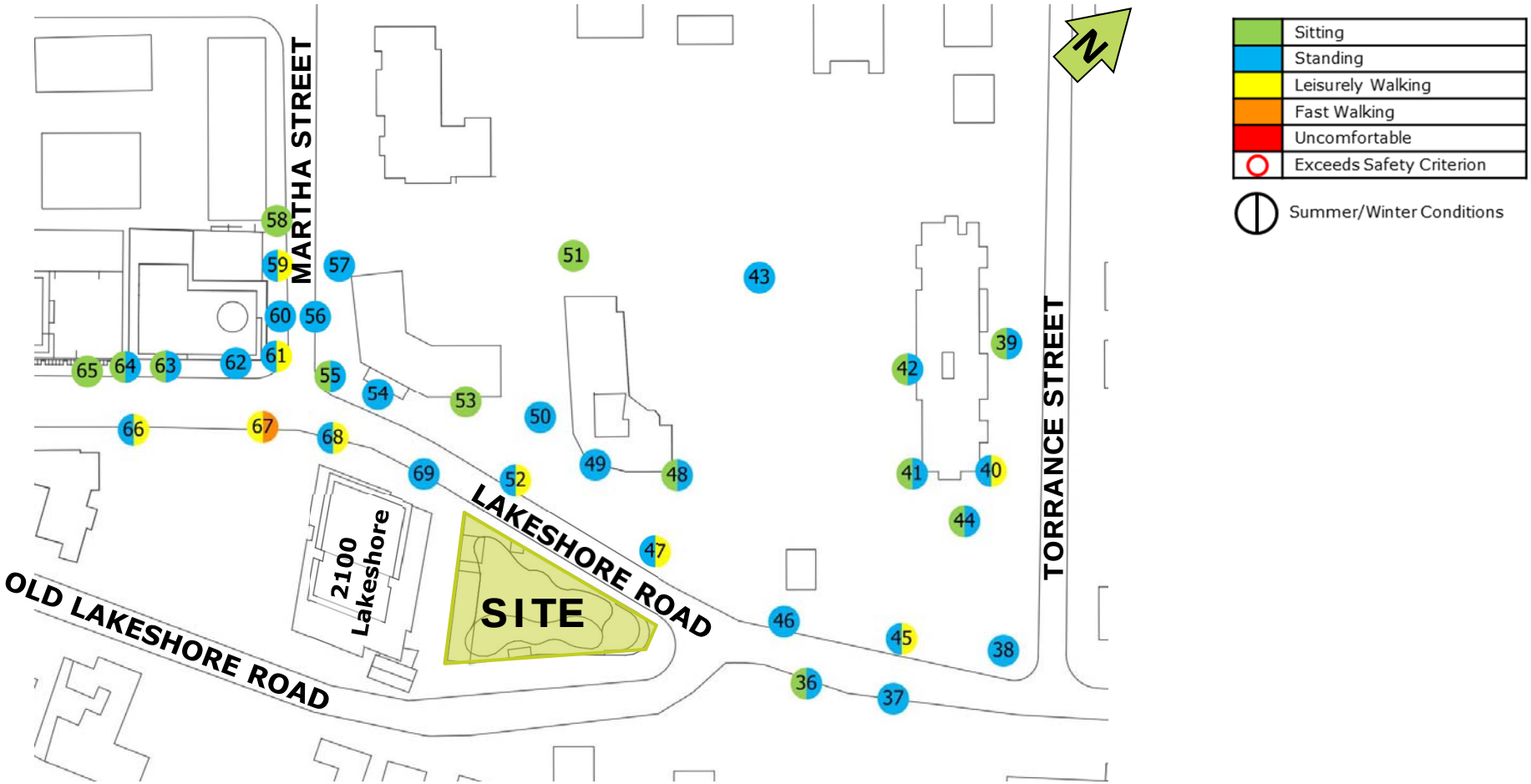


Figure 8a: Pedestrian Wind Conditions – Proposed Configuration Surrounding Sidewalks to the north



Figure 8b: Pedestrian Wind Conditions – Proposed Configuration Surrounding Sidewalks to the south

5.0 CONCLUSIONS & RECOMMENDATIONS

The pedestrian wind conditions for the proposed development at 2107 Old Lakeshore Road in Burlington have been assessed through wind tunnel modelling techniques. Based on the results of our study, the following conclusions and recommendations have been reached:

- The wind safety criterion was exceeded on the roof top terrace of the proposed development in the Proposed Configuration. In addition, the wind safety criterion was exceeded at the northwest corner of the adjacent 2100 Lakeshore development in both the Existing and Proposed Configuration.
- Wind conditions at the main entrances are suitable for the intended usage. Wind conditions on the outdoor amenity spaces are generally suitable for the intended usage. Recommendations for wind control measures are provided for the east corner of Level 2 as well as on the rooftop.
- Wind conditions on the walkways surrounding the proposed building are generally suitable for the intended usage. Recommendations for wind control measures are provided for the driveway along the west side of the property, as well as for the east corner of the building.
- Wind conditions on the surrounding sidewalks, including the transit stops are generally similar between the Existing and Proposed Configurations, including the uncomfortable wind conditions in the winter at the northwest corner of the adjacent development.
- We understand the project design will continue to evolve through planning submissions. NovusSLR will work with the design team prior to the SPA submission to determine the efficacy, practicality, and details of the recommendations provided herein.

6.0 STUDY APPLICABILITY

This study is based on wind tunnel testing and provides a quantitative analysis of the pedestrian wind comfort conditions on and around the proposed development. Any subsequent alterations to the design may influence these findings. NovusSLR should be contacted to provide additional comments and/or recommendations for additional analysis of the design revisions.

Should you have any questions or concerns, please do not hesitate to contact the undersigned.

Sincerely,
SLR Consulting (Canada) Ltd.





Jenny Graham, P.Eng.
Senior Engineer

Tahrana Lovlin, MAES, P.Eng.
Specialist- Microclimate

7.0 REFERENCES

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Kapoor, V., Page, C., Stefanowicz, P., Livesey, F., Isyumov, N., (1990) "Pedestrian Level Wind Studies to Aid in the Planning of a Major Development", *Structures Congress Abstracts*, American Society of Civil Engineers, 1990.

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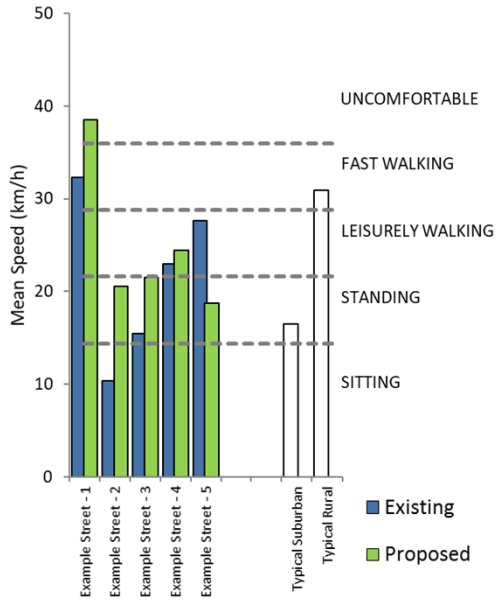
Appendix A

Pedestrian Wind Comfort
Summer (July – September) & Winter (January – March)

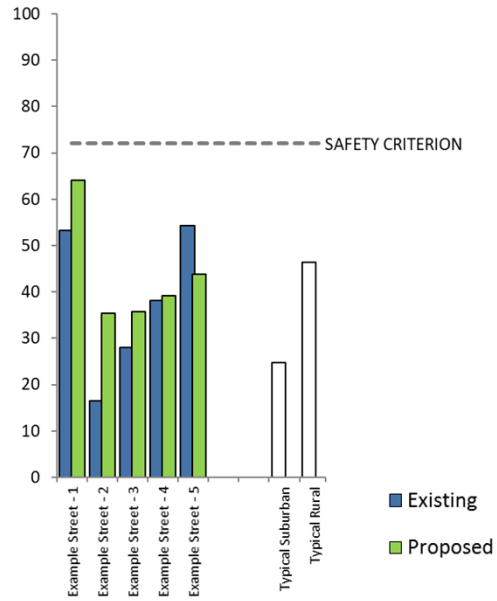
Interpretation of Results

In the graphs, the vertical bars represent the mean wind speed (in km/h) exceeded 5% of the time for the test configurations at each location. The dashed horizontal lines represent wind speed thresholds for the wind comfort criteria (left figure). At the right side of each graph are white bars that represent ambient wind conditions for typical suburban and rural areas of this region.

The blue bars represent wind conditions in the Existing Configuration, while the green bars represent the Proposed Configuration. For example, wind conditions at Sensor #2 were suitable for leisurely walking in the Existing Configuration and fast walking in the Proposed Configuration. The figure below illustrates the safety criteria, which should not exceed 72 km/h more than once per year. For example, all sensors passed the wind safety criterion in both configurations.



Example Results – Comfort Criteria (5% Mean Wind Speeds)



Example Results – Safety Criteria (Annual 0.1% Mean Wind Speeds)

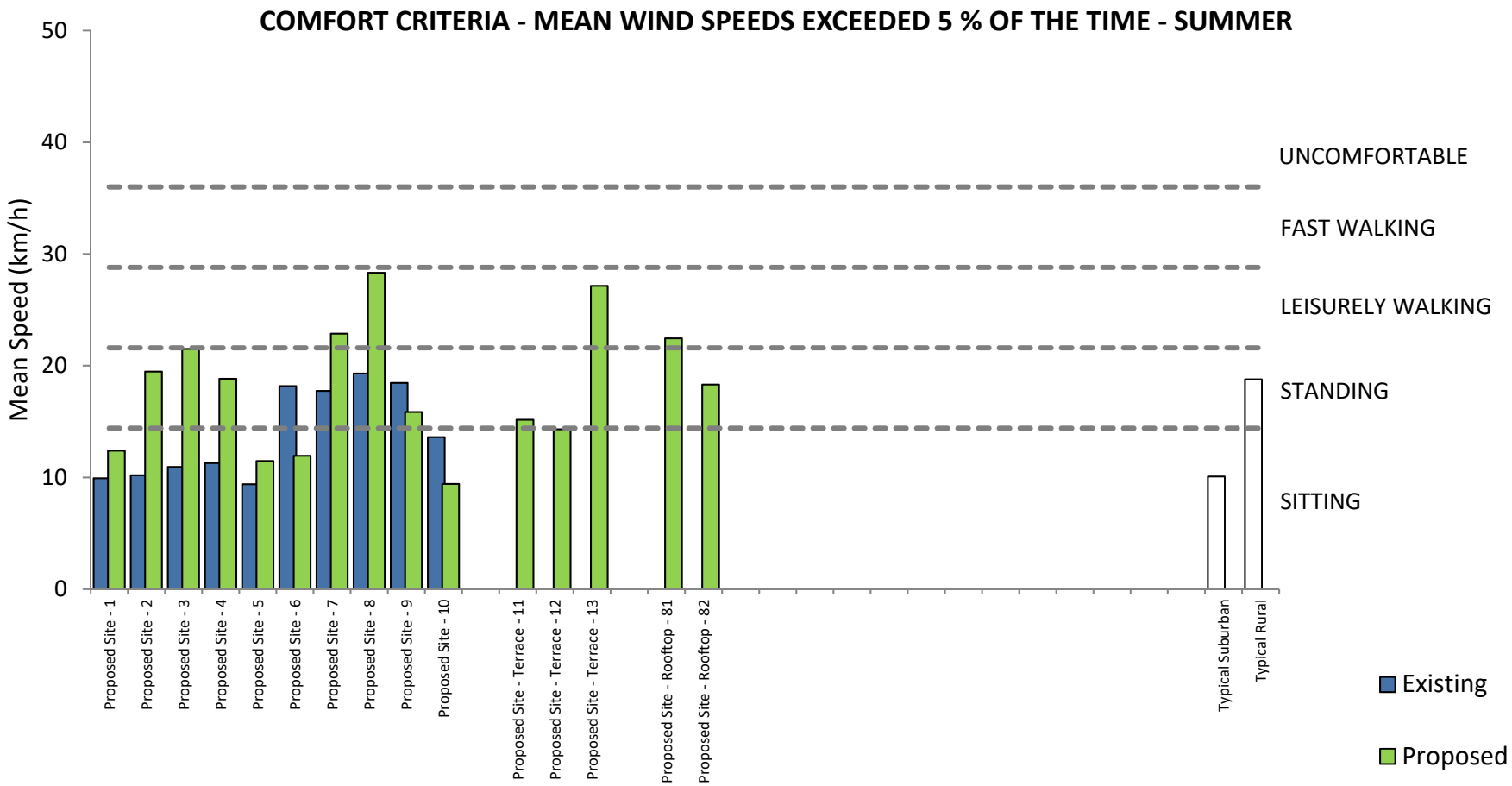


Figure A1a: Pedestrian Wind Conditions – Summer Season – Building Entrances, Amenity, & Walkways

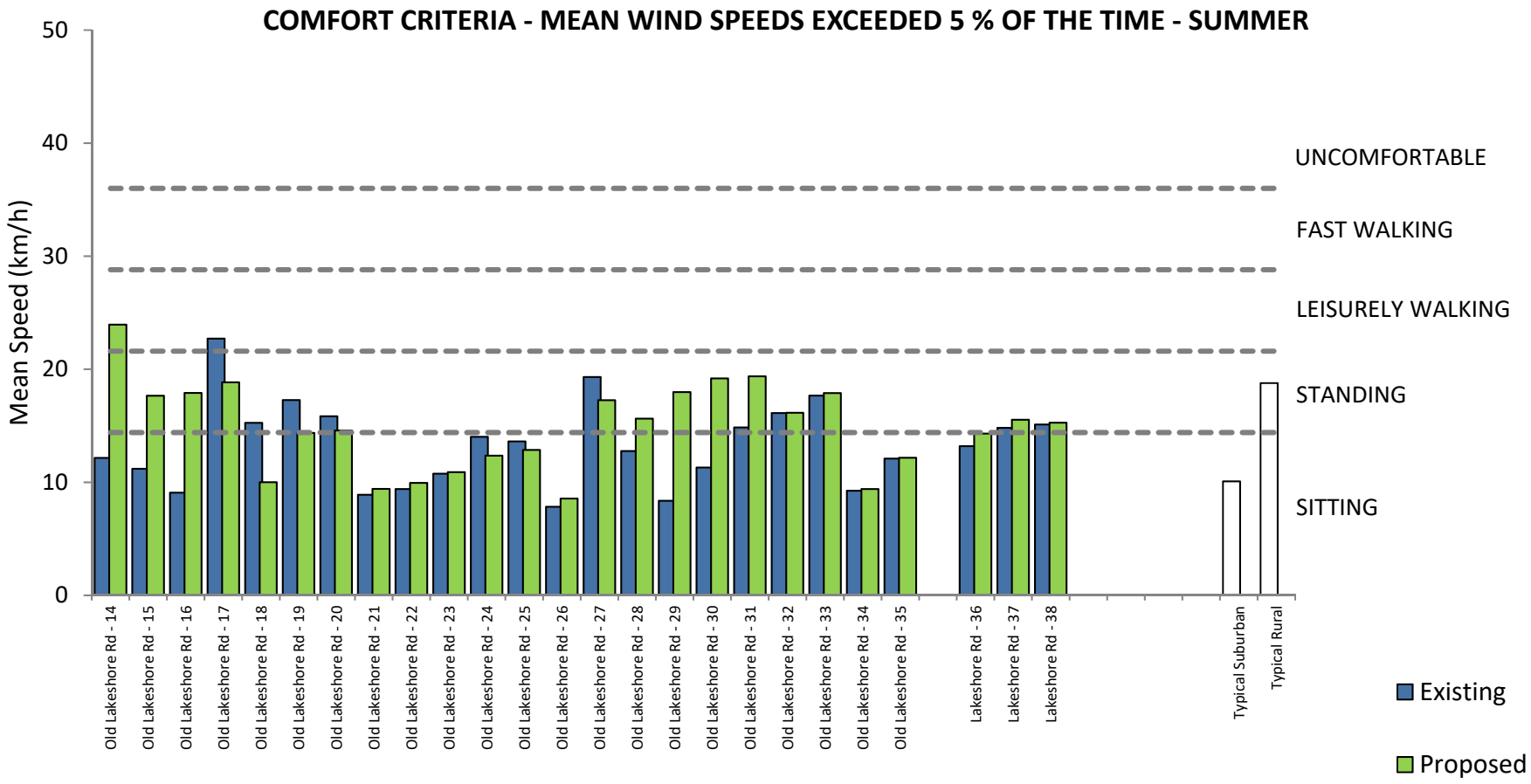


Figure A1b: Pedestrian Wind Conditions – Summer Season – Lakeshore Road & Old Lakeshore Road

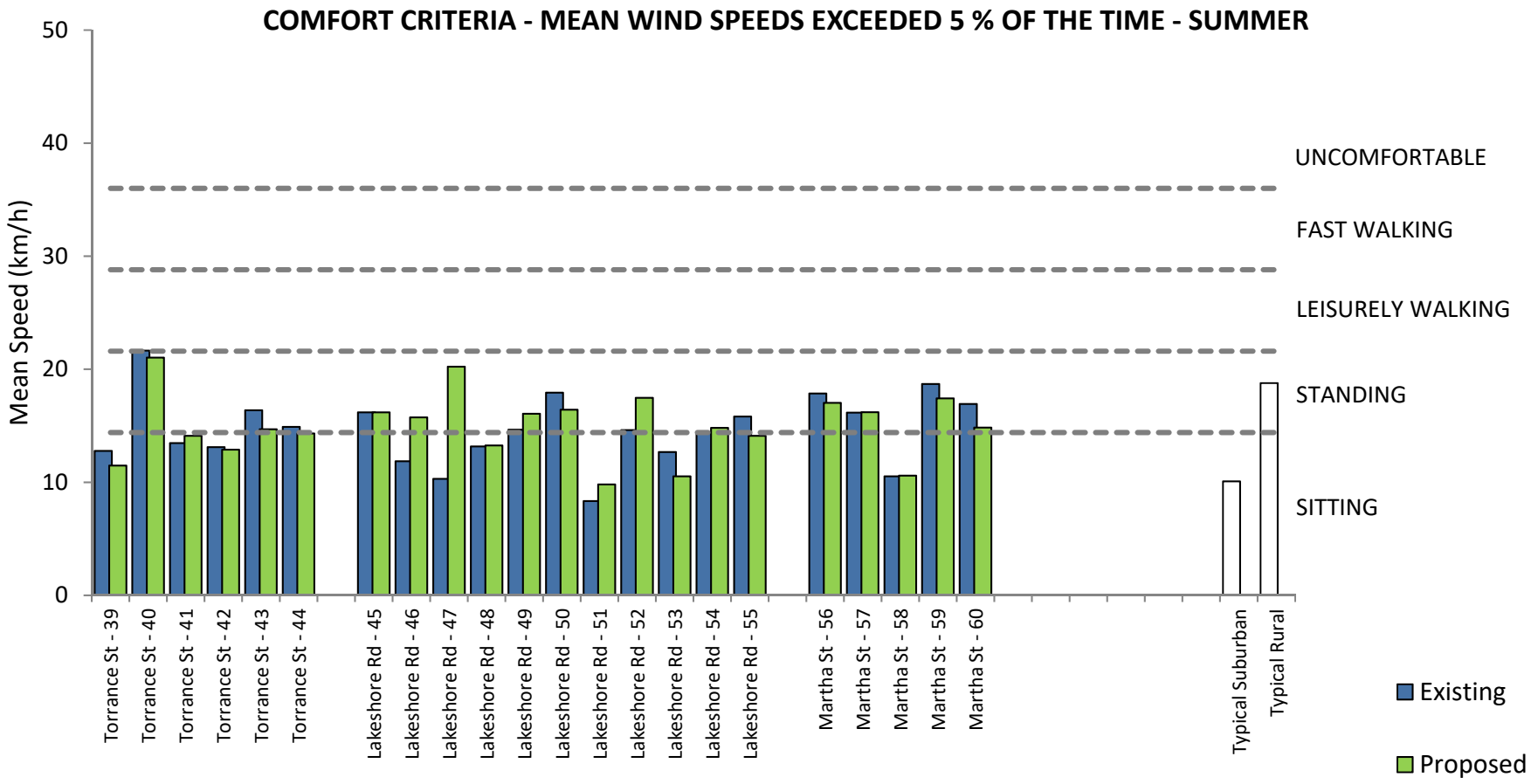


Figure A1c: Pedestrian Wind Conditions – Summer Season – Torrance Street, Lakeshore Road & Martha Street

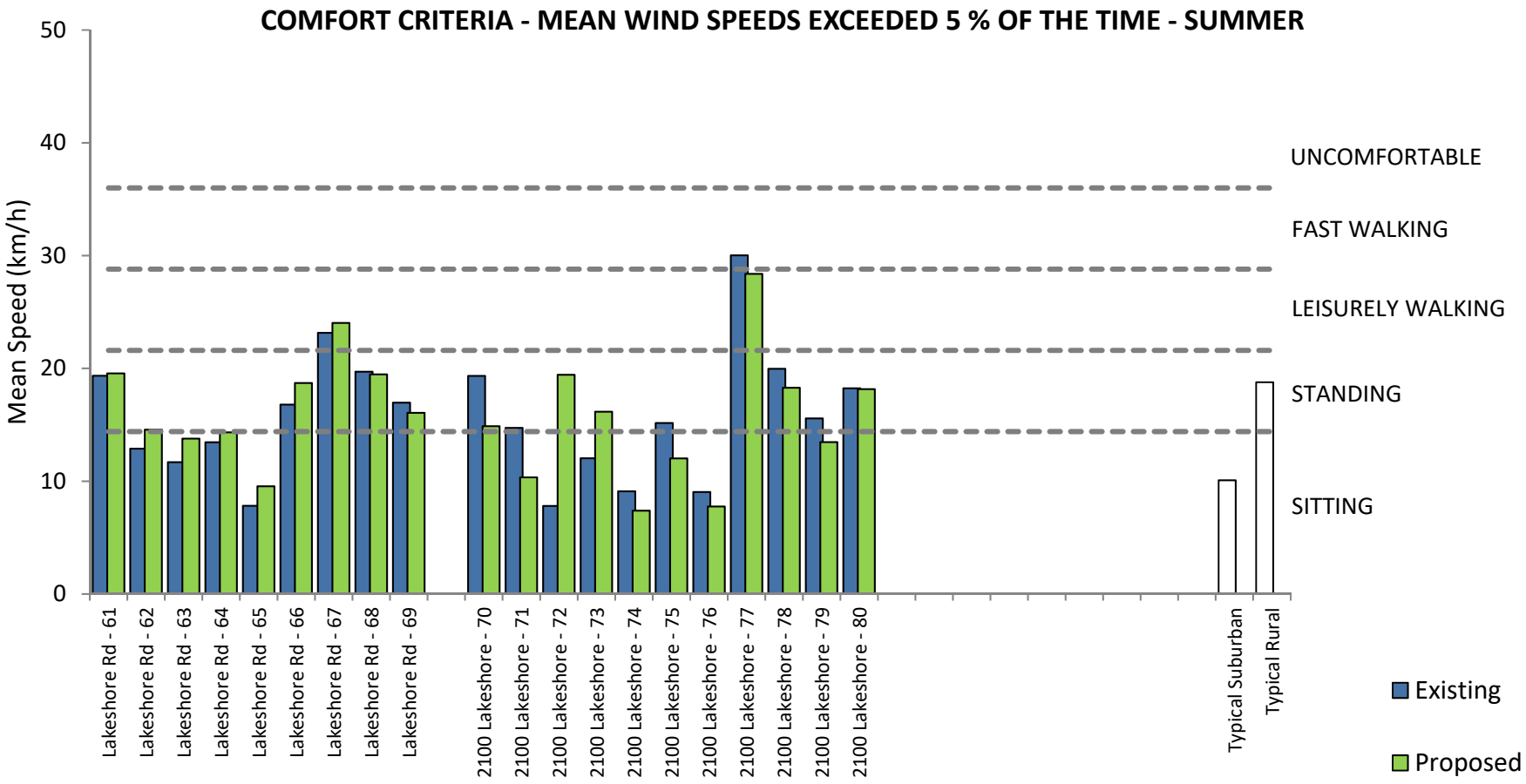


Figure A1d: Pedestrian Wind Conditions – Summer Season – Lakeshore Road & 2100 Lakeshore

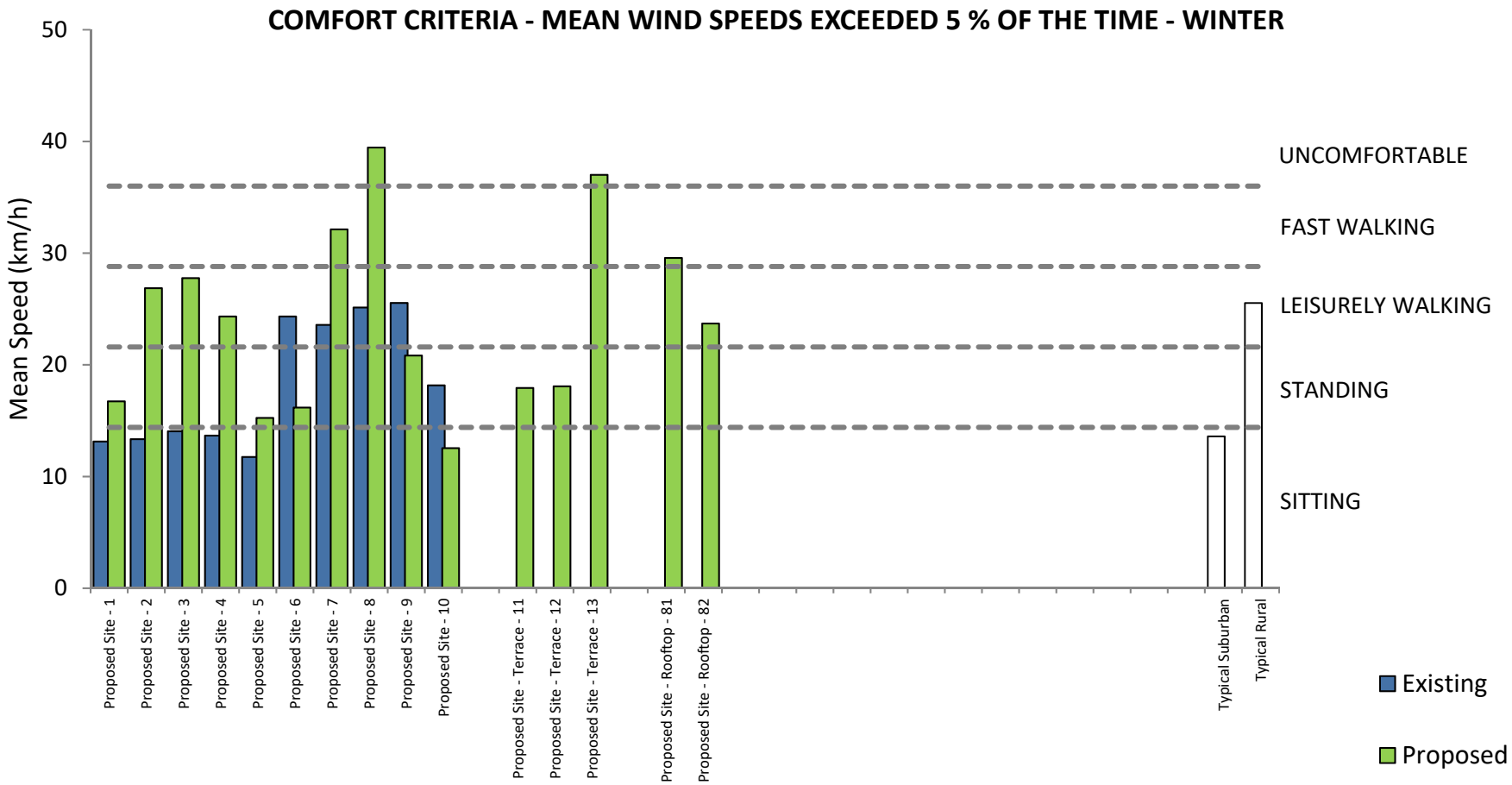


Figure A2a: Pedestrian Wind Conditions – Winter Season – Building Entrances, Amenity, & Walkways

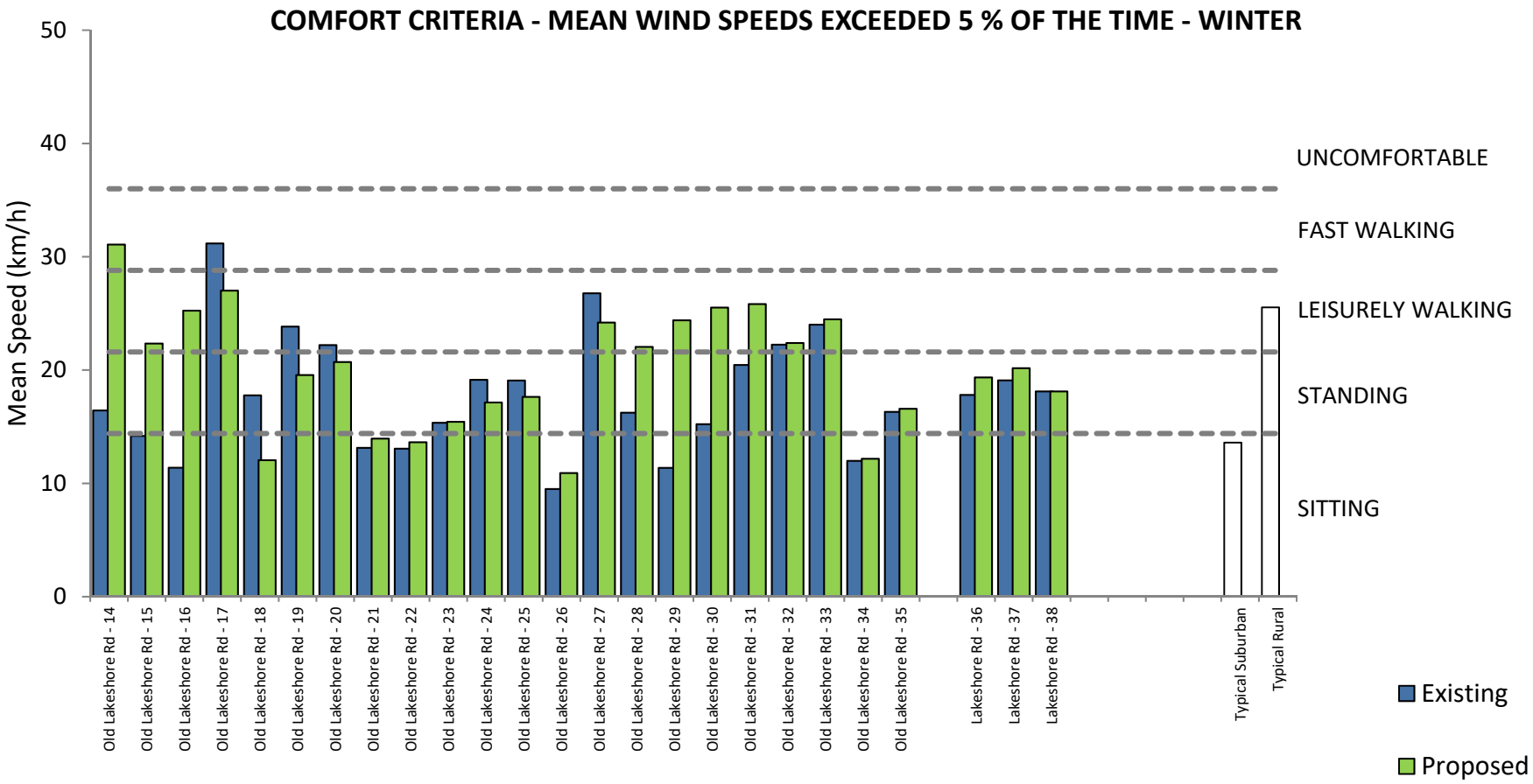


Figure A2b: Pedestrian Wind Conditions – Winter Season – Lakeshore Road & Old Lakeshore Road

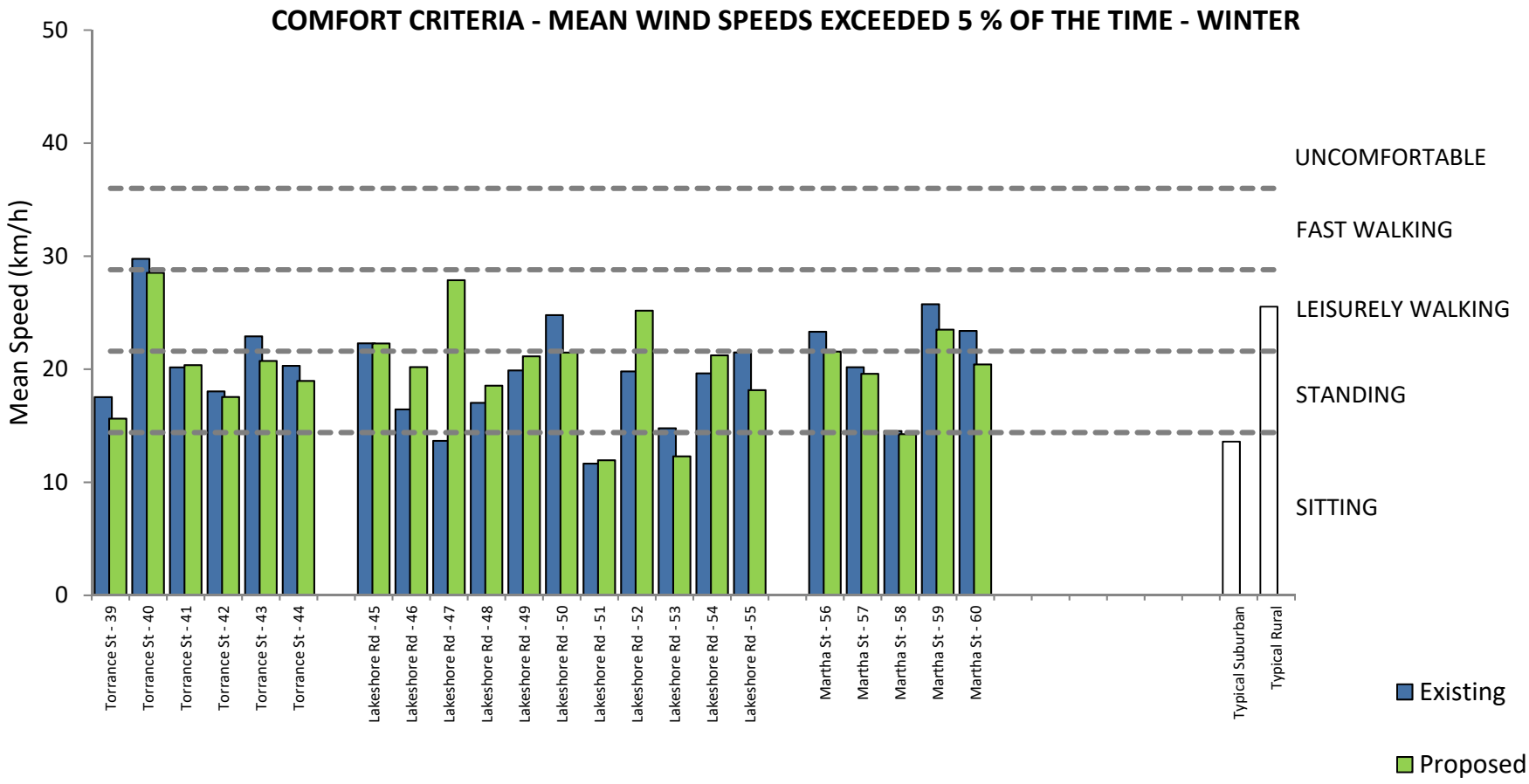


Figure A2c: Pedestrian Wind Conditions – Winter Season – Torrance Street, Lakeshore Road & Martha Street

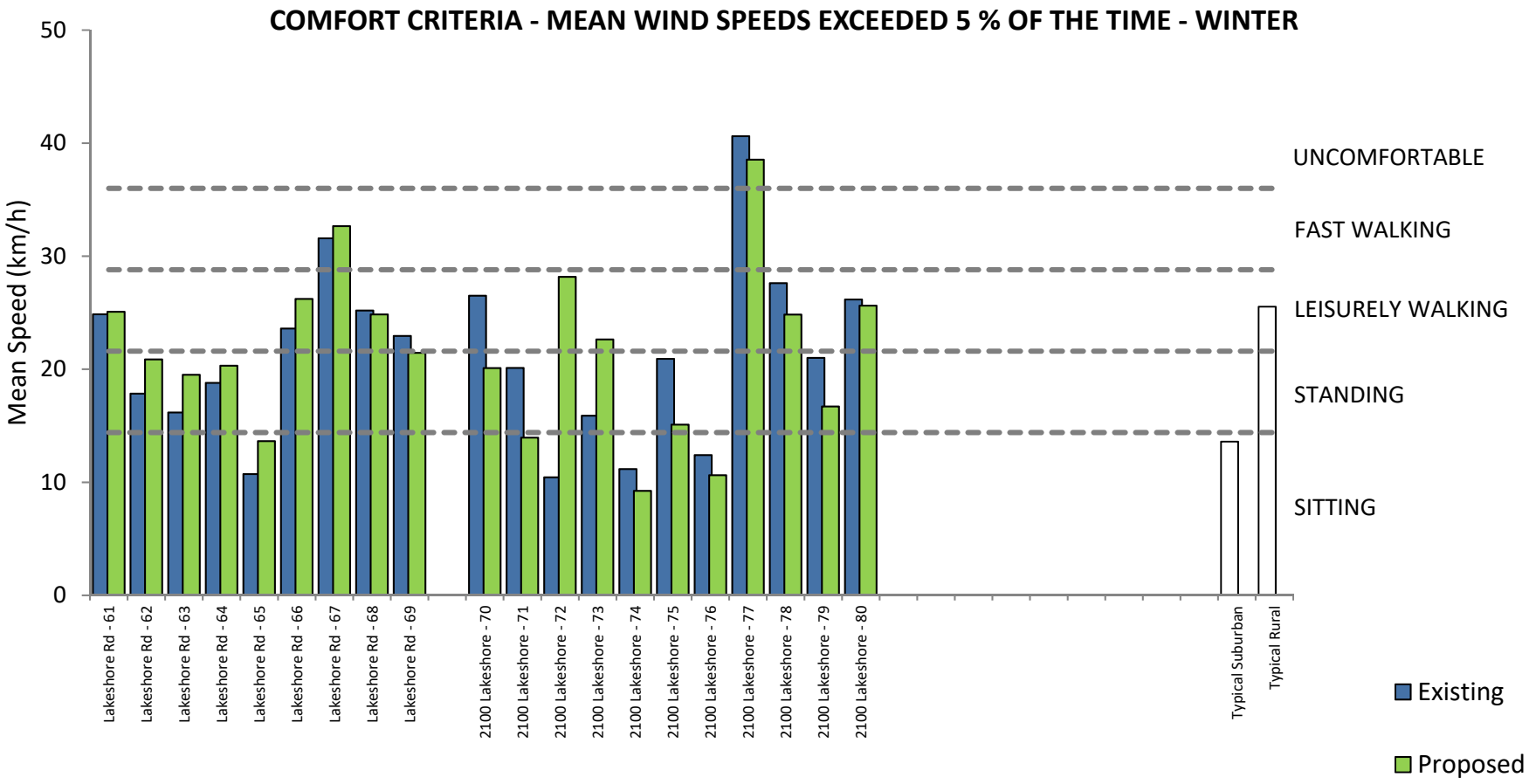


Figure A2d: Pedestrian Wind Conditions – Winter Season – Lakeshore Road & 2100 Lakeshore

Appendix B

Pedestrian Wind Comfort Results
Spring (April – June) & Autumn (October – December)

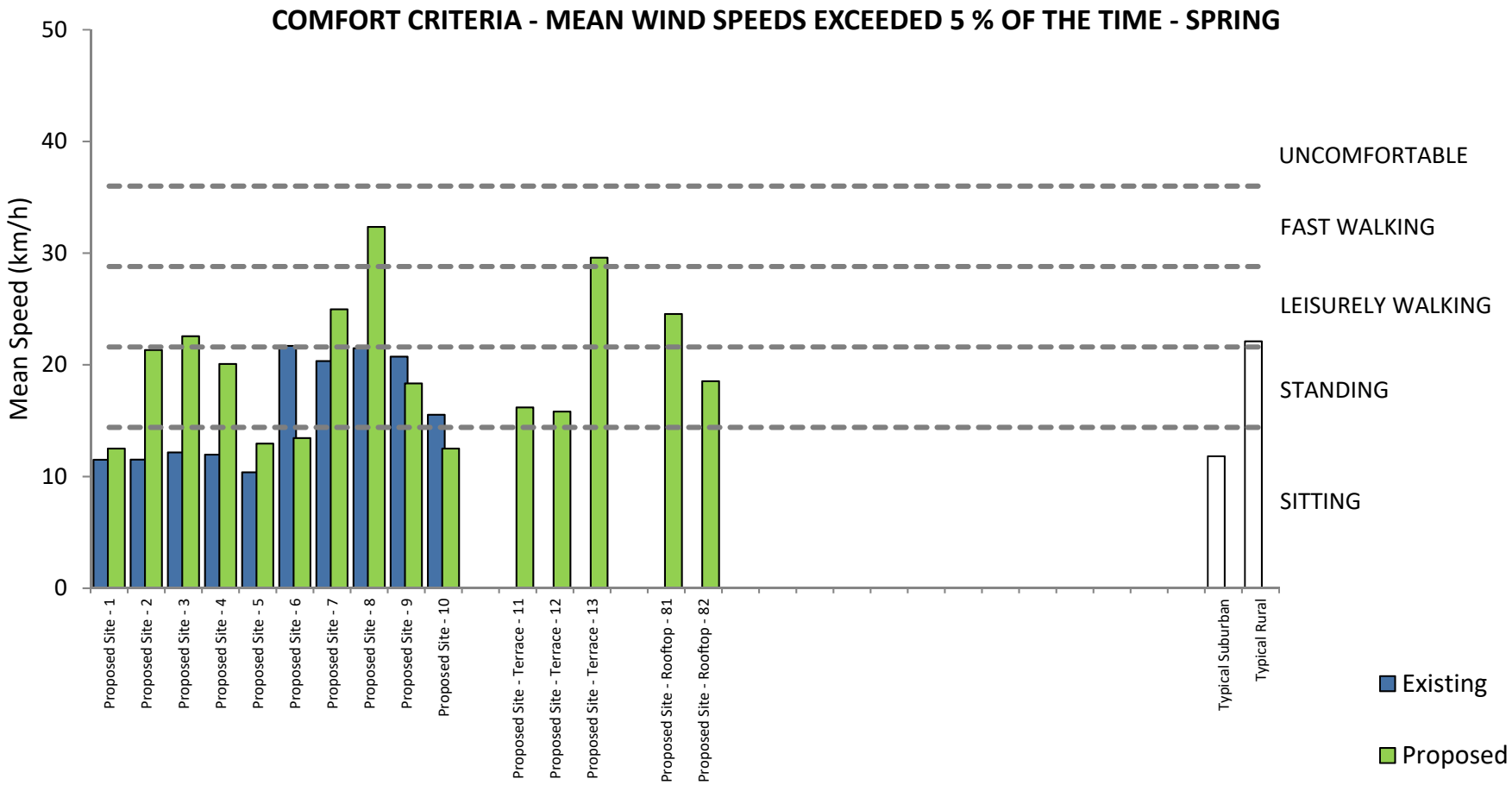


Figure B1a: Pedestrian Wind Conditions – Spring Season – Building Entrances, Amenity, & Walkways

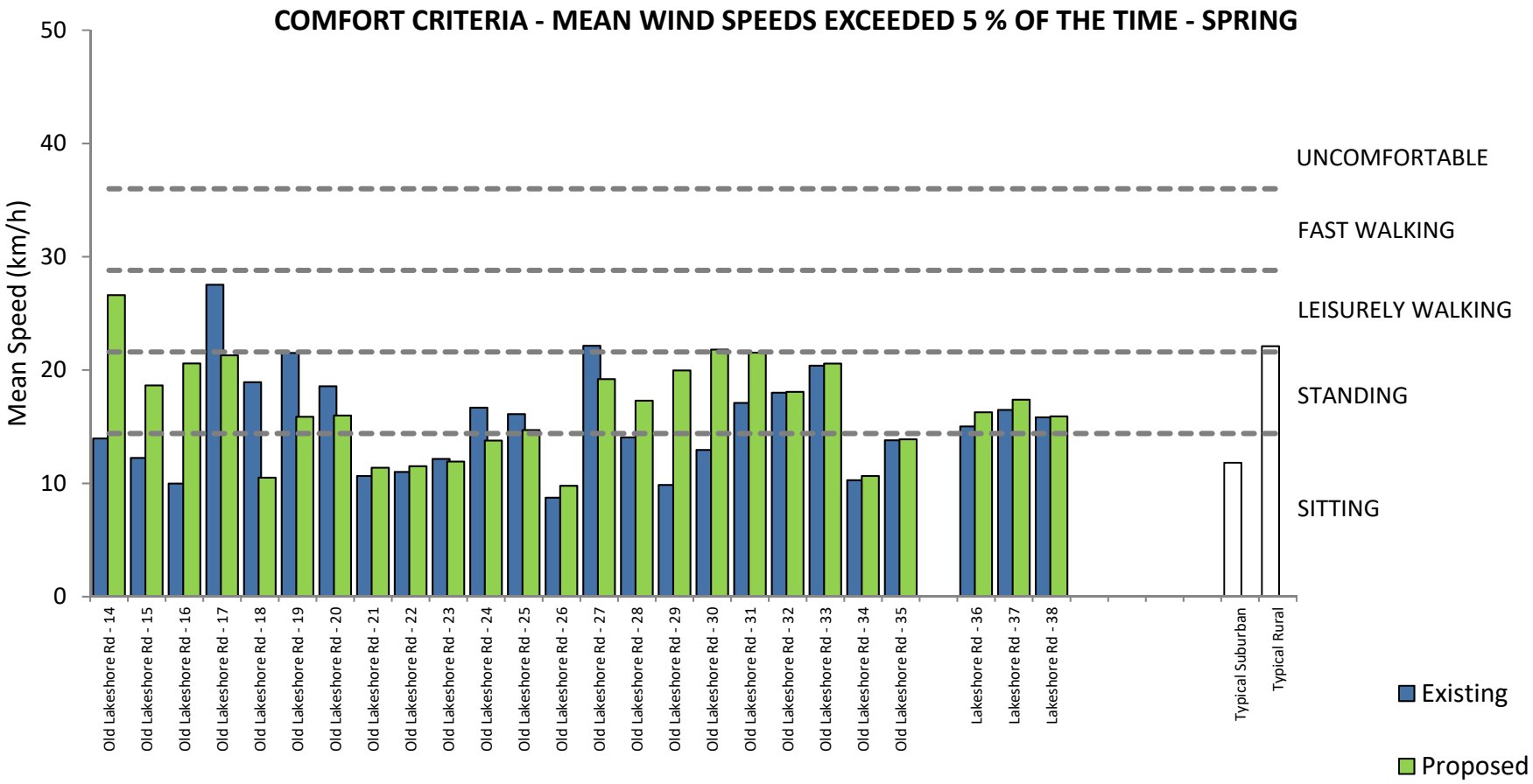


Figure B1b: Pedestrian Wind Conditions – Spring Season – Lakeshore Road & Old Lakeshore Road

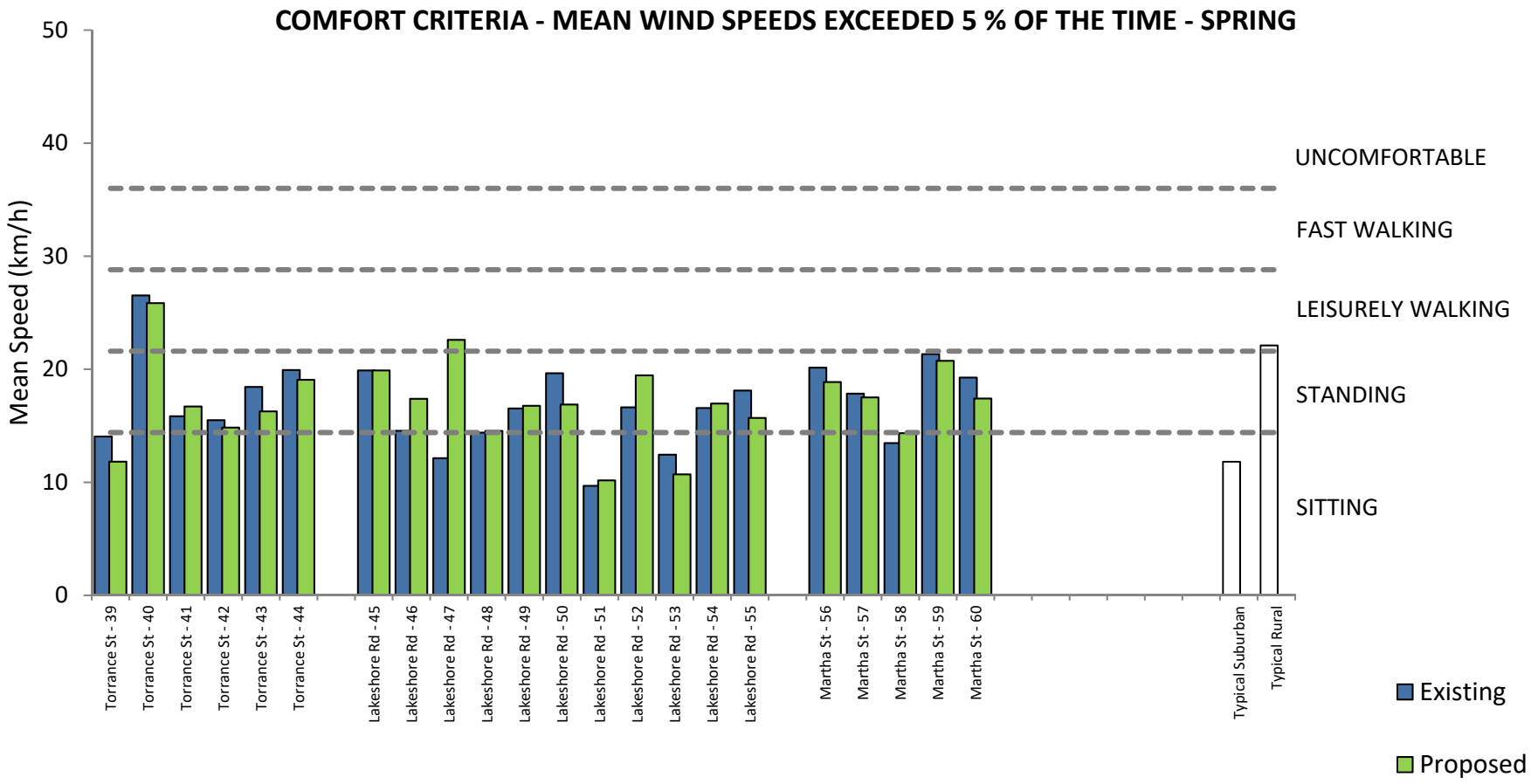


Figure B1c: Pedestrian Wind Conditions – Spring Season – Torrance Street, Lakeshore Road & Martha Street

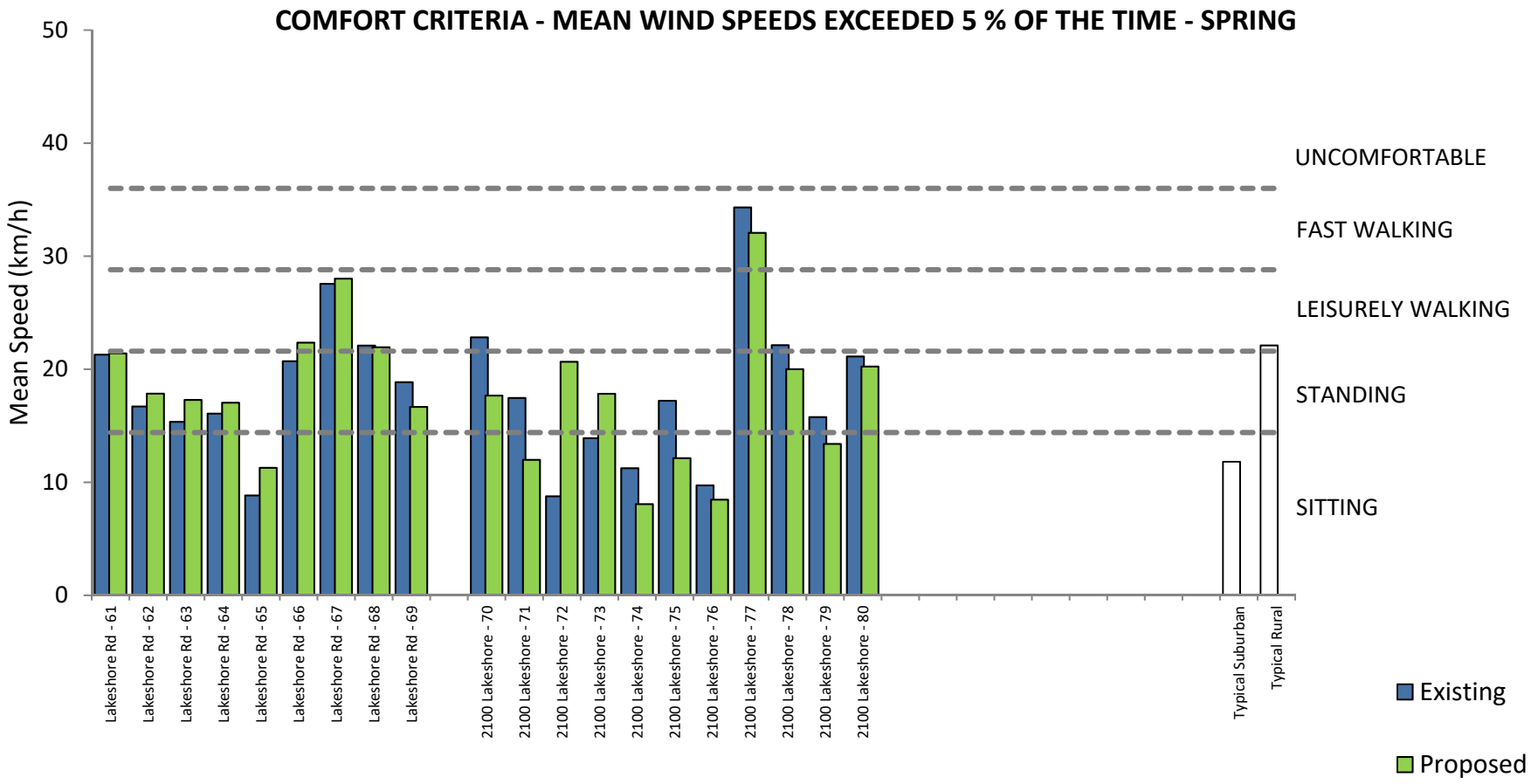


Figure B1d: Pedestrian Wind Conditions – Spring Season – Lakeshore Road & 2100 Lakeshore

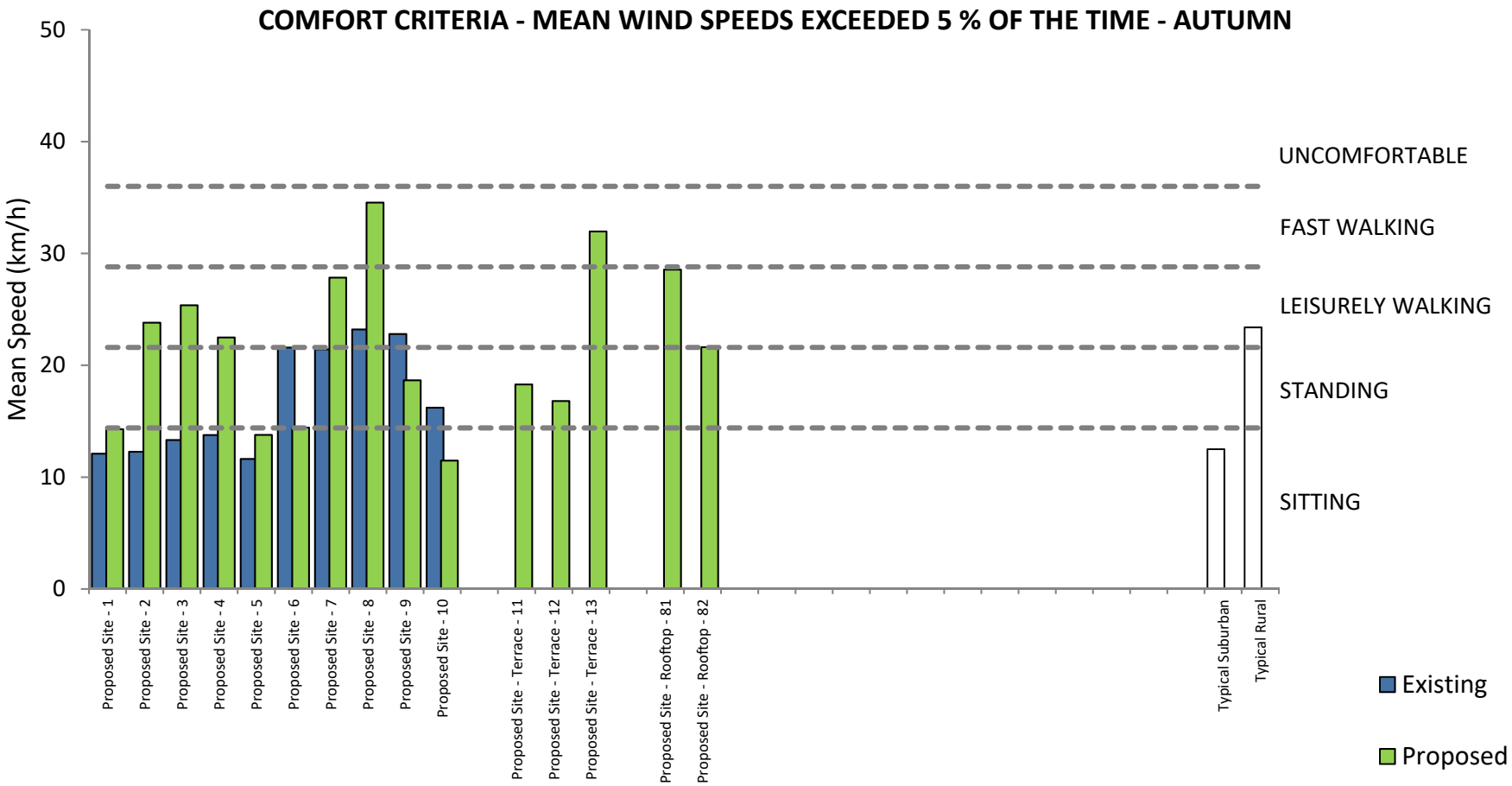


Figure B2a: Pedestrian Wind Conditions – Autumn Season – Building Entrances, Amenity, & Walkways

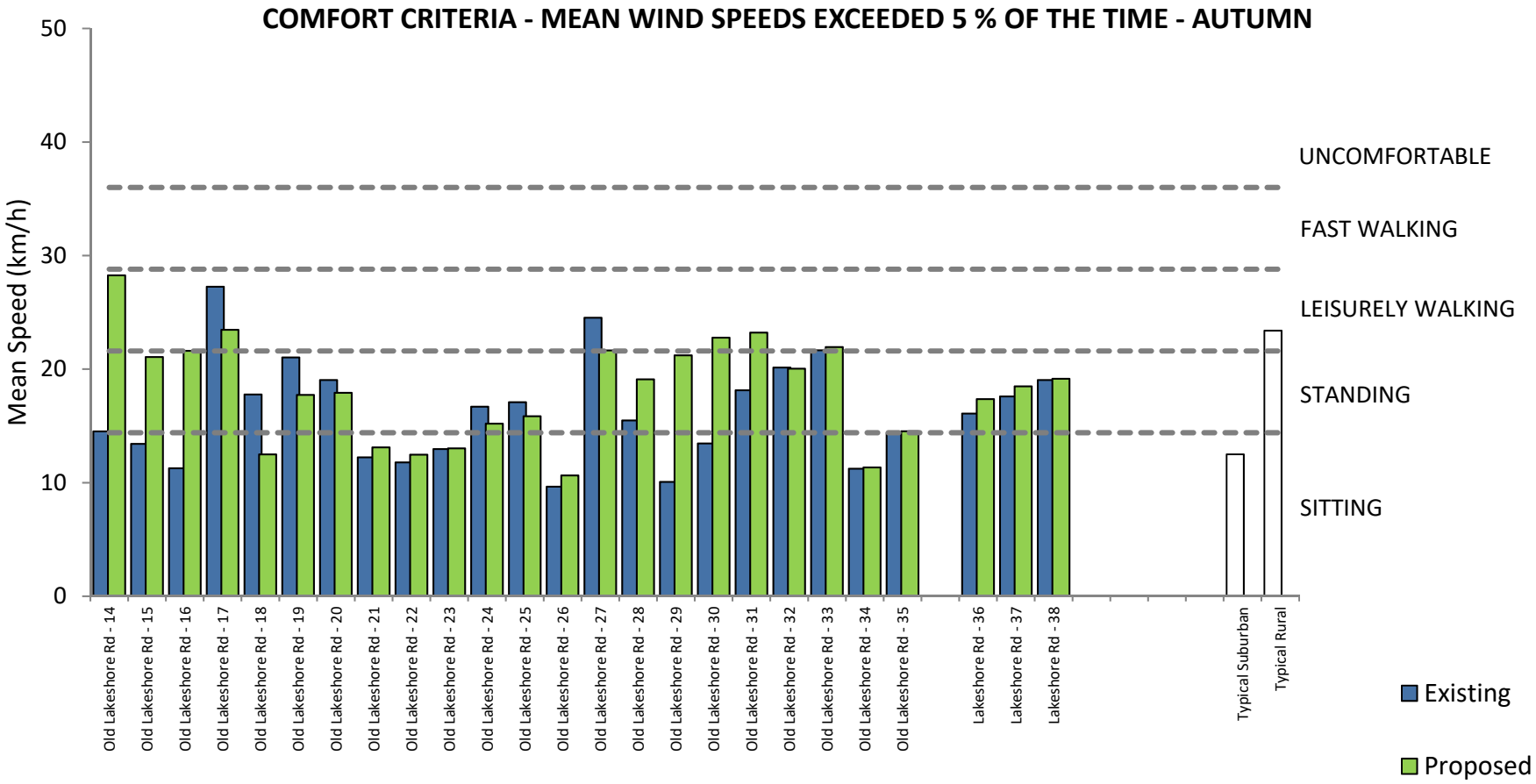


Figure B2b: Pedestrian Wind Conditions – Autumn Season – Lakeshore Road & Old Lakeshore Road

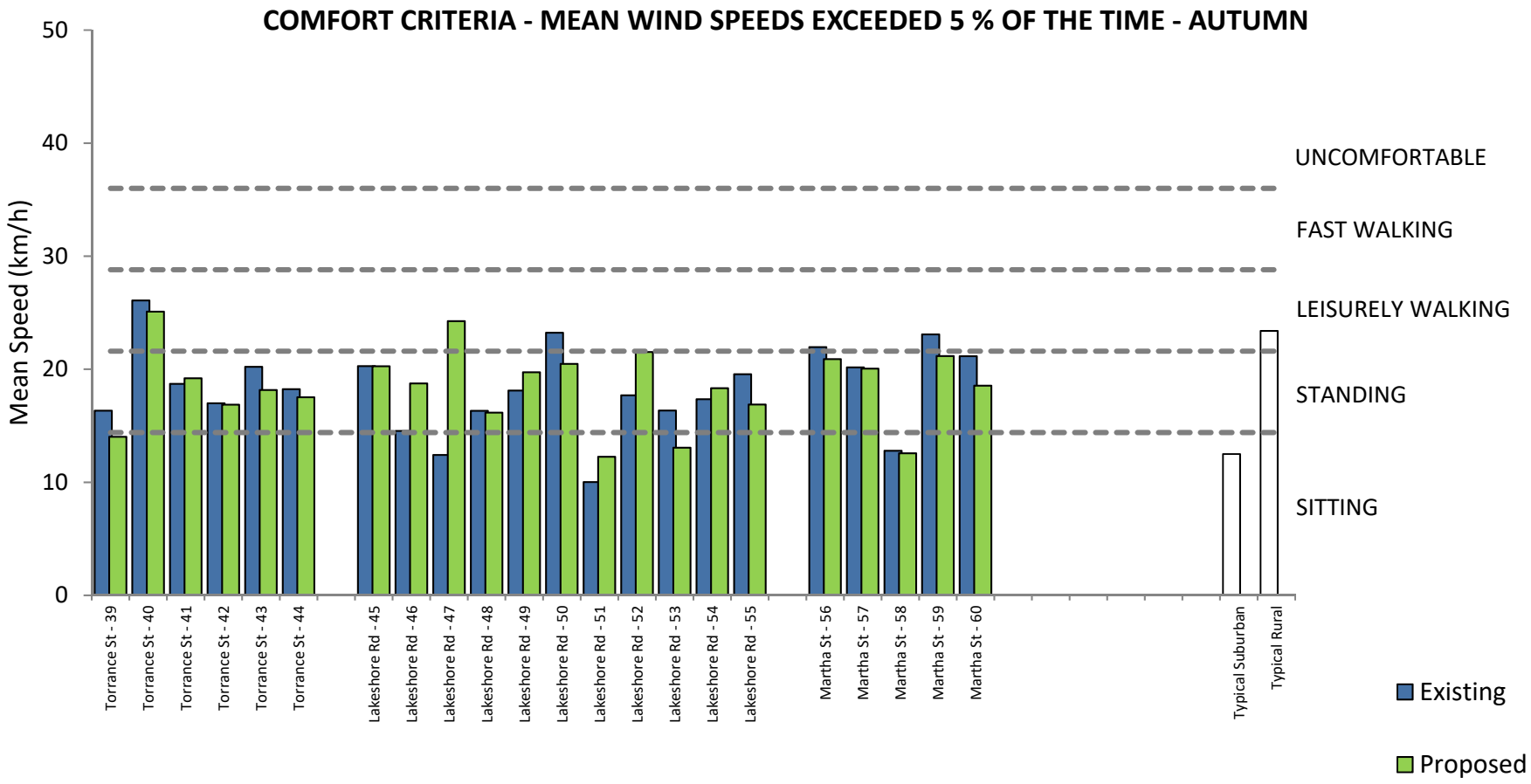


Figure B2c: Pedestrian Wind Conditions – Autumn Season – Torrance Street, Lakeshore Road & Martha Street

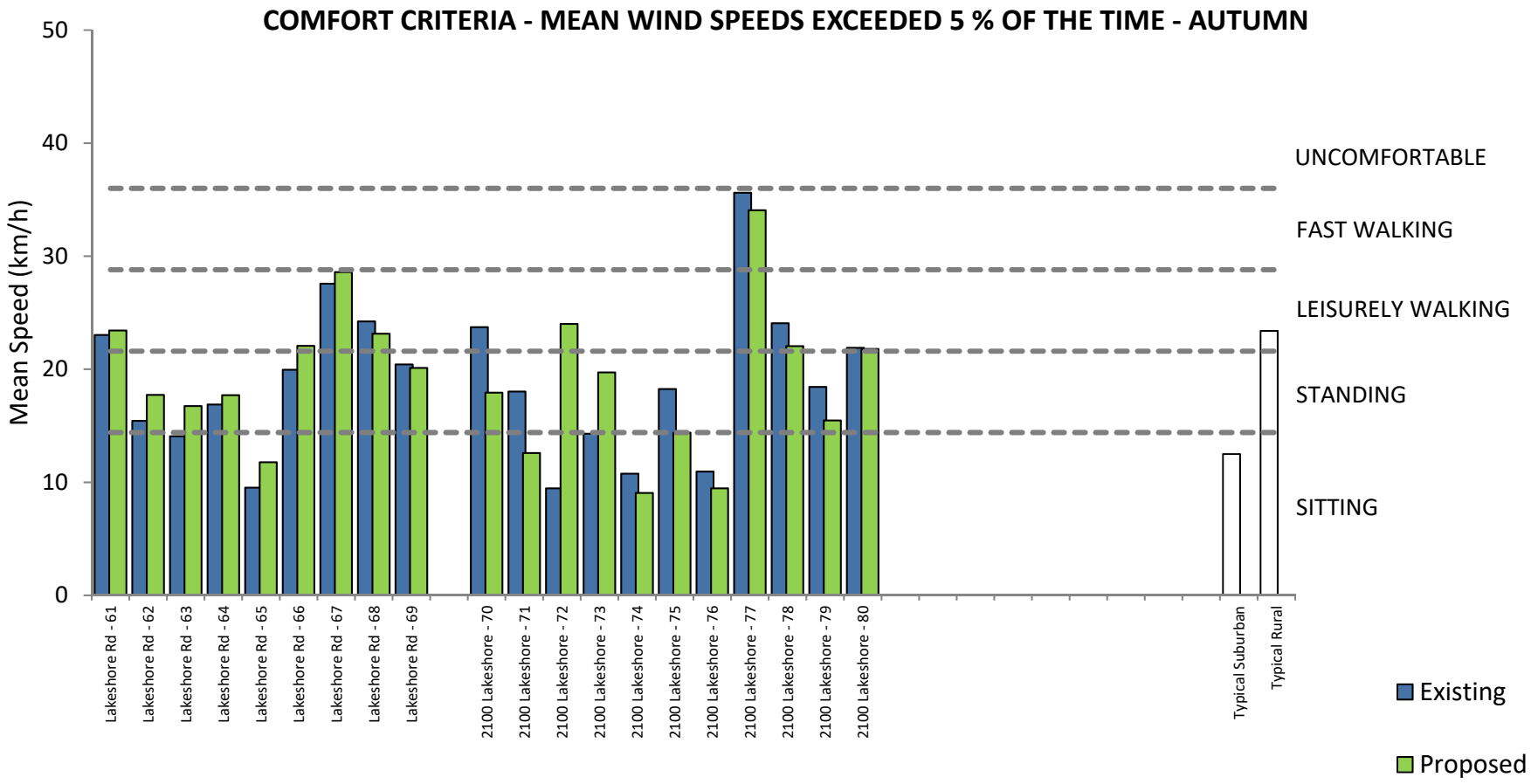


Figure B2d: Pedestrian Wind Conditions – Autumn Season – Lakeshore Road & 2100 Lakeshore

Appendix C

Pedestrian Wind Safety Results
Annual

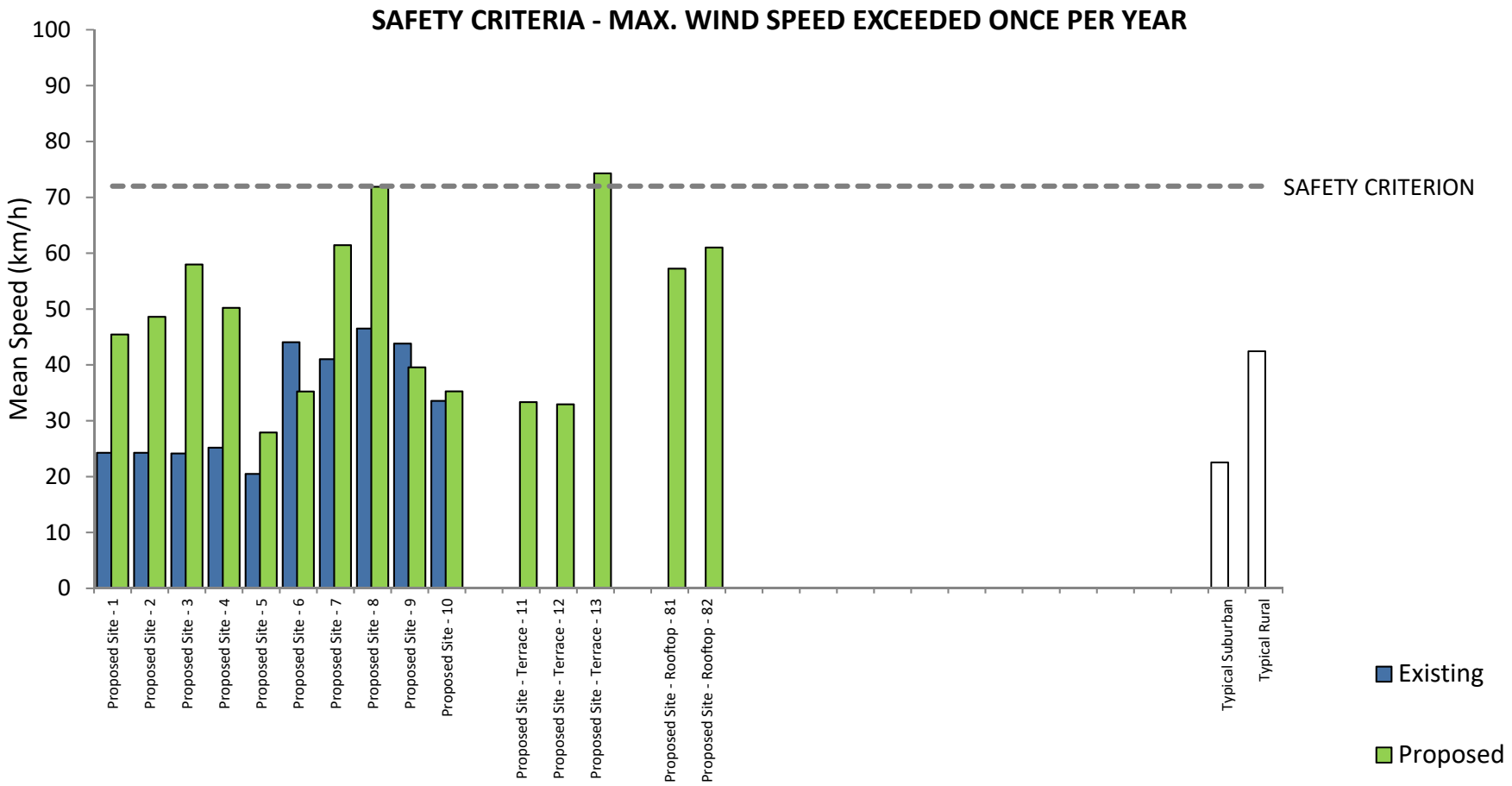


Figure C1a: Pedestrian Wind Safety – Annual – Building Entrances, Amenity, & Walkways

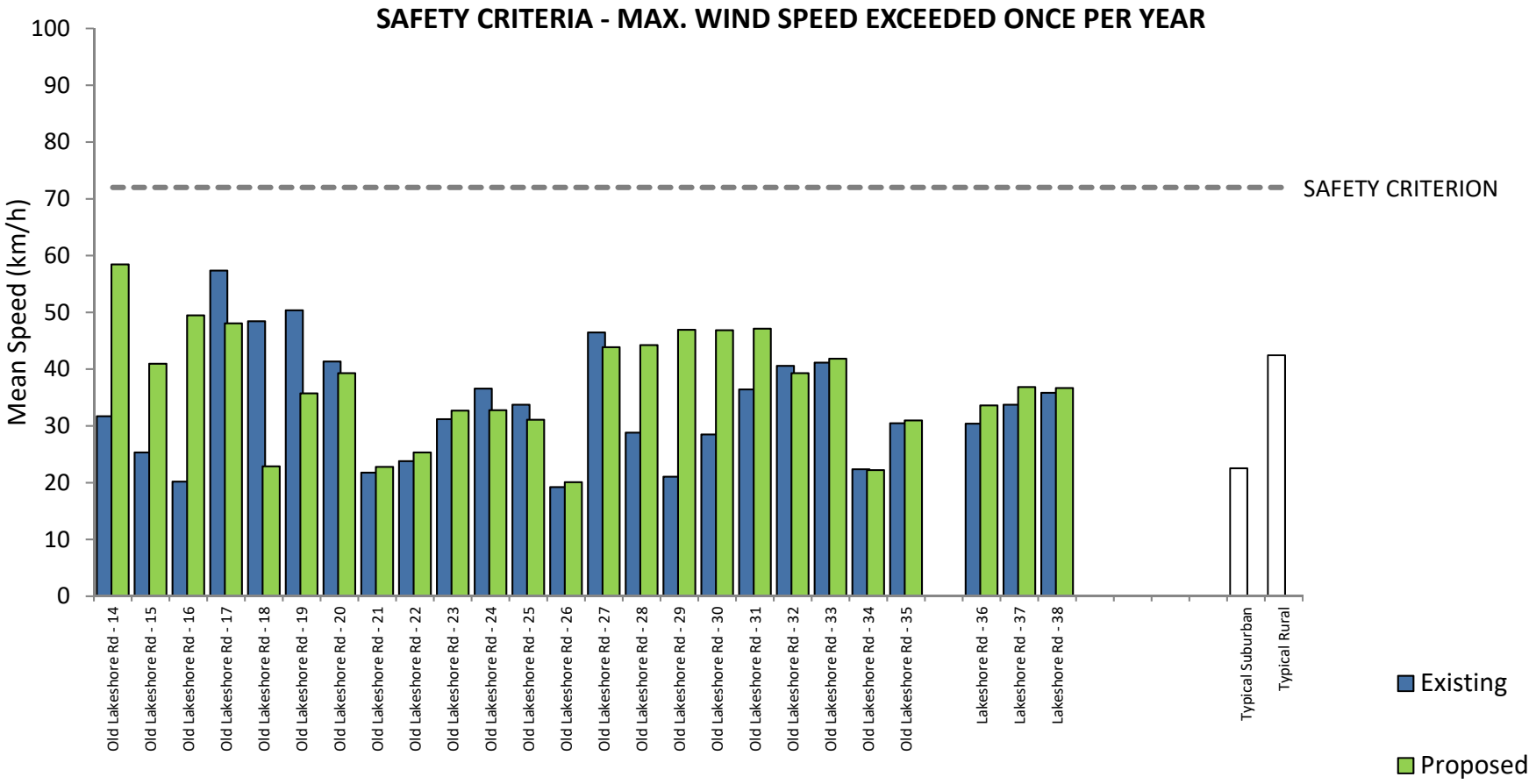


Figure C1b: Pedestrian Wind Safety – Annual – Lakeshore Road & Old Lakeshore Road

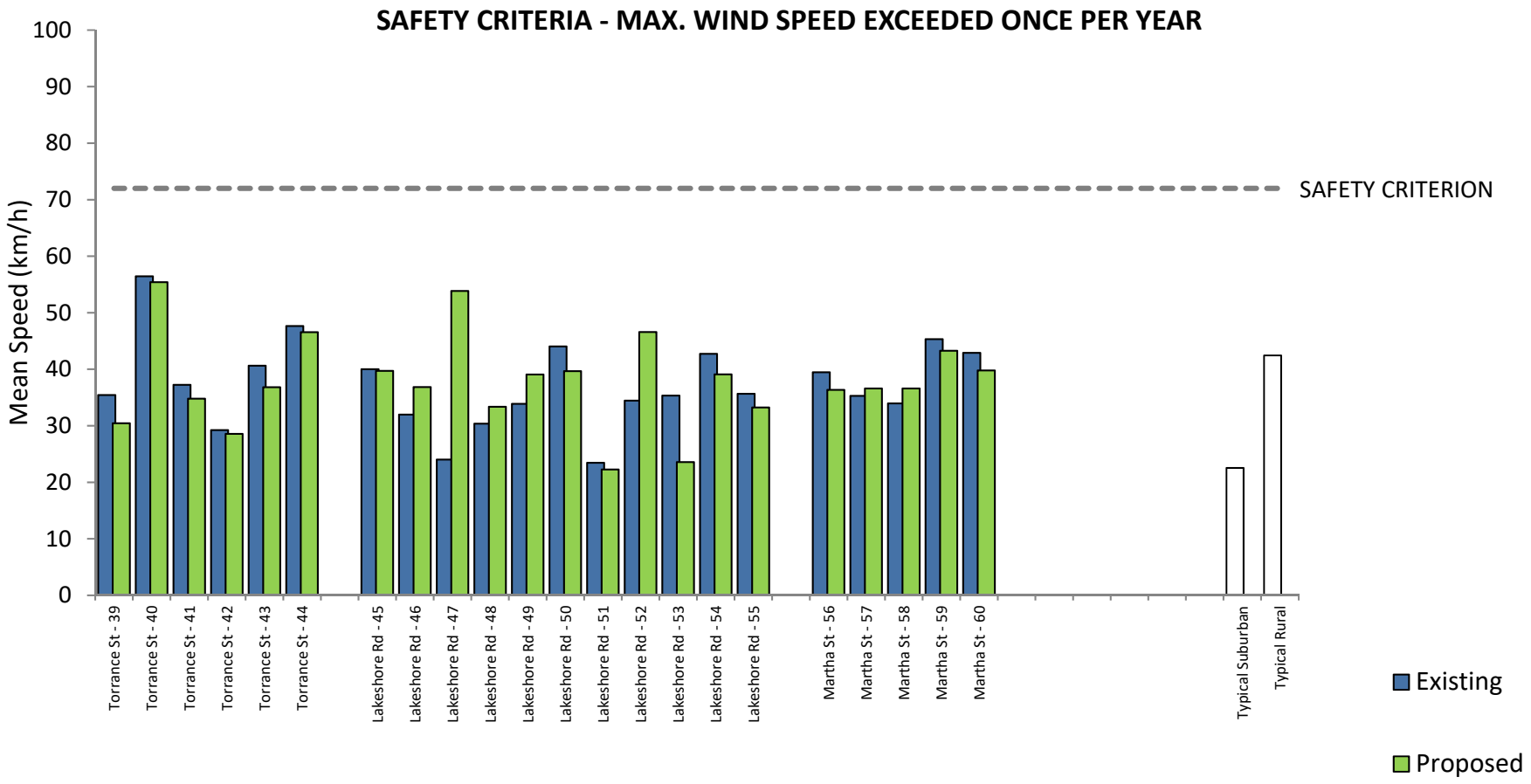


Figure C1c: Pedestrian Wind Safety – Annual – Torrance Street, Lakeshore Road & Martha Street

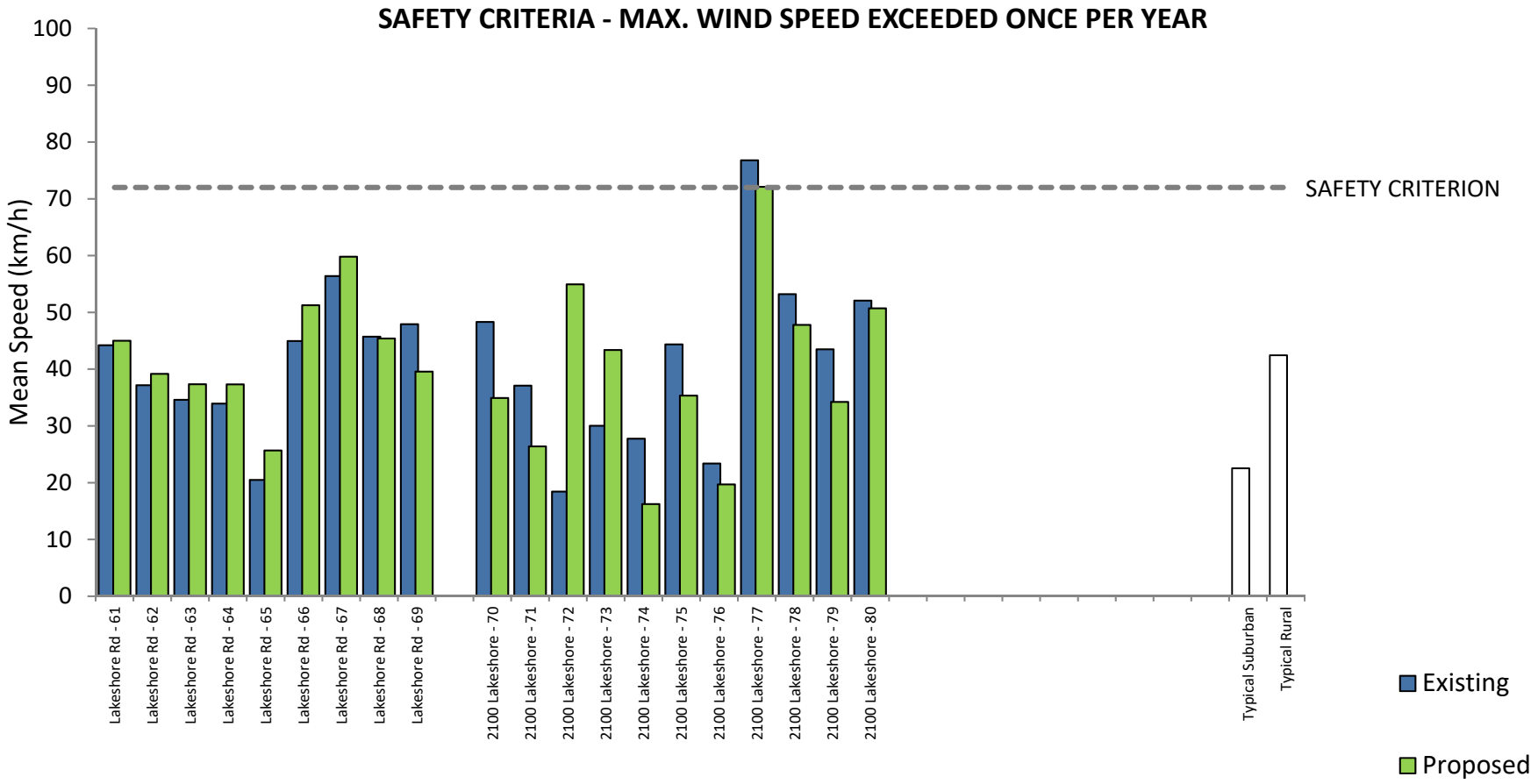


Figure C1d: Pedestrian Wind Safety – Annual – Lakeshore Road & 2100 Lakeshore