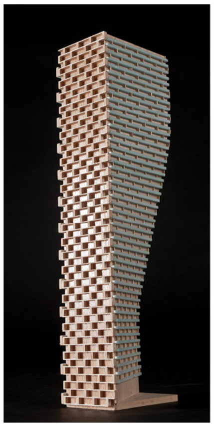
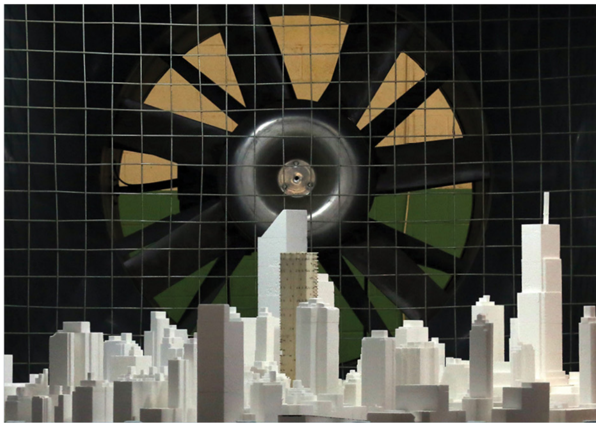
PEDESTRIAN LEVEL WIND STUDY

Ottawa Retirement Residence by Signature
Ottawa, Ontario

GRADIENT WIND REPORT: 18-176-PLW





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EXECUTIVE SUMMARY

This report describes a pedestrian level wind (PLW) study undertaken to assess wind conditions in support of a zoning by-law amendment (ZBA) submission for the Ottawa Retirement Residence by Signature development located at 412 Sparks Street in Ottawa, Ontario. The study involves simulation of wind speeds for selected wind directions in a three-dimensional (3D) computer model using the computational fluid dynamics (CFD) technique, combined with meteorological data integration, to assess pedestrian comfort and safety within and surrounding the development site. The results and recommendations derived from these considerations are summarized in the following paragraphs and detailed in the subsequent report.

Our work is based on industry standard computer simulations using the CFD technique and data analysis procedures, City of Ottawa wind criteria, architectural drawings provided by Hobin Architecture on January 16, 2019, surrounding street layouts and existing and approved future building massing information obtained from the City of Ottawa, as well as recent site imagery.

A complete summary of the predicted wind comfort conditions is provided in Section 5 of this report and illustrated in Figures 3A-6B following the main text. Wind safety is discussed in Section 5.2 and is accompanied by Figures 7A and 7B. Based on the foregoing, we conclude the following:

1) All grade-level areas within and surrounding the development site will be acceptable for the intended pedestrian uses throughout the year. More specifically, wind conditions along surrounding sidewalks and walkways, as well as at building access points, will be acceptable for the intended pedestrian uses of the areas throughout the year without the need for mitigation.

2) The only exception to item (1) concerns the northwest corner of St. Peter's Lutheran Church, where extreme winds events are predicted to occur for approximately 24 hours on an annual basis, which exceeds the City of Ottawa wind safety criterion of 9 hours. While preliminary mitigation strategies are discussed in Section 5.2, this matter could be developed to its practical conclusion in collaboration with the building and landscape architects. Additional wind simulations would be required to confirm the effectiveness of specific mitigation strategies.

3) The Level 3 AL rooftop terrace at the north side of the building will be comfortable for sitting during the summer season with solid 1.524-m tall (5') perimeter guards. Conditions during the autumn season will be mostly suitable for sitting, though standing conditions are predicted along a portion of the north perimeter. During the remaining colder seasons of spring and winter, the area adjacent to the façade and beneath the building overhang will be suitable for sitting, while the remaining exposed areas will be suitable for standing. Since conditions are suitable for sitting during the summer season, and residents are afforded a comfortable space beneath the building overhang throughout the year, the noted conditions are considered acceptable.

4) The Level 18 IL rooftop terrace on the west side of the building will be comfortable for a mix of sitting and standing during the summer season, while the colder months become windier on account of direct flow from several prominent wind directions. Mitigation will be required to ensure the area achieves the sitting criterion during the summer season and shoulder months of spring and autumn. Additional wind simulations will be performed for site plan control to confirm the effectiveness of specific mitigation strategies.

The introduction of the proposed development is expected to moderately increase wind speeds over some neighbouring areas at grade, while increasing comfort levels over other areas. Despite these changes, nearby building entrances, sidewalks, and other pedestrian areas will continue to experience wind conditions similar to those that presently exist much of the time without the proposed development in place. The only exception concerns the northwest corner of St. Peter's Lutheran Church, as noted in item (2) above).

Following the completion of the PLW study, we understand the architectural drawings for the subject site have been modified. For the purpose of our work, the general massing of the updated design is identical to the previous model. The only changes that would impact the results of the foregoing study concern the Level 18 IL rooftop terrace, which has been reduced in area and now resides within the southwest corner of the floorplan. The changes are expected to increase wind comfort conditions within the terrace throughout the year. The PLW study will be updated accordingly for the site plan control submission to quantify pedestrian wind comfort.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Reichmann Seniors Housing Development Corporation, on behalf of Cathedral Hills GP Inc., to undertake a computer-based pedestrian level wind (PLW) study for the proposed Ottawa Retirement Residence by Signature development in Ottawa, Ontario. Our mandate within this study, as outlined in Gradient Wind proposal #17-270P Wind, dated October 27, 2017, is to investigate pedestrian wind comfort and safety within and surrounding the development site, and to identify any areas where wind conditions may interfere with certain pedestrian activities so that mitigation measures may be considered, where necessary.

Our work is based on industry standard computer simulations using the CFD technique and data analysis procedures, City of Ottawa wind criteria, architectural drawings provided by Hobin Architecture and dated January 16, 2019, surrounding street layouts and existing and approved future building massing information obtained from the City of Ottawa, as well as recent site imagery.

2. TERMS OF REFERENCE

Ottawa Retirement Residence by Signature is located at 412 Sparks Street in Ottawa, Ontario. The study site is situated in the middle of a parcel of land bounded by Sparks Street to the north, Bay Street to the east, Queen Street to the south, and Bronson Avenue to the west. The study building is flanked by St. Peter’s Lutheran Church (400 Sparks Street) to the east and Christ Church Cathedral (414 Sparks Street) to the west, while three existing low-rise residential dwellings are located to the immediate south (407, 409, and 411 Queen Street).

The proposed development is an 18-storey building rising 66.3 meters (m) above grade to the top of the mechanical penthouse. The building plan form is nearly rectangular with the long axis oriented along Sparks Street. The north elevation includes a distinct segmented curve that begins at its northeast corner, creating a gradual separation from Sparks Street as it terminates at the northwest corner of the building.

The main building access points are located at the centre of the north elevation from Sparks Street and at the northwest inset, which is west-facing. Vehicle access to three levels of below-grade parking (P1 lower and upper levels; and P2) is provided at the southwest corner of the site from Queen Street, while pedestrian access is provided at the northwest corner of building from Philosopher’s Walk, a pathway extending between the proposed development and the existing Christ Church Cathedral to the west. The ground floor (Level 1) provides lobby and amenity areas, as well as building services. Level 2 contains interior administration and amenity areas, including an indoor pool at the southwest corner of the building. Level 3 steps back along the north elevation to accommodate an outdoor rooftop terrace, while the interior space contains assisted living (AL) amenities, studios, and single bedroom units. Levels 4-14 serve Independent Living (IL) single and double bedroom units, Levels 15 and 16 contain a mixture of studio, 1- and 2-bedroom apartments for seniors, while Level 17 includes a combination of apartments for seniors and several indoor amenities, including a pub/casual dining area. The 18th floor includes a common formal dining area complete with a commercial kitchen, as well as a large outdoor rooftop terrace located within the west side of the floorplan with dedicated seating areas. The single storey mechanical penthouse is located on the south side of the building, above the noted commercial kitchen, and is accessed by a stairwell. The elevator overrun reaches the noted mechanical floor, while an architectural appurtenance (extension of the roof line) creates a large canopy over the noted seating areas on Level 18.

The near-field surroundings, defined as the area within 200 m of the site, are characterized by an open exposure from the west clockwise to north, hybrid suburban-urban exposures on account of the mid-rise and mid-to-high-rise buildings from the north clockwise to east-southeast, and urban exposures for the remaining compass directions. The far-field surroundings, between a radius of 200 m and 2 kilometers (km), comprise hybrid open-suburban exposures from the southwest clockwise to north-northeast, hybrid suburban-urban exposures from the north-northeast clockwise to east-southeast, and suburban exposures for the remaining compass directions. Large expanses of green space and the open exposure created by the Ottawa River contribute to the local mean wind and turbulence intensity profiles around the subject site.

Key areas under consideration for pedestrian wind comfort include surrounding sidewalks, walkways, building access points, and the various rooftop outdoor amenity areas. Figure 1A illustrates the study site and surrounding context, while Figure 1B and 1C illustrates the rooftop outdoor amenity areas. Figures 2A and 2B illustrate the computational model used to conduct the study.

3. OBJECTIVES

The principal objectives of this study are to (i) determine pedestrian level wind comfort on a seasonal basis and wind safety conditions on an annual basis at key areas within and surrounding the development site; (ii) identify areas where wind conditions may interfere with the intended uses of outdoor spaces; and (iii) recommend suitable mitigation measures, where required.

4. METHODOLOGY

The approach followed to quantify pedestrian wind conditions over the site is based on CFD simulations of wind speeds across the study site within a virtual environment, meteorological analysis of the Ottawa area wind climate, and synthesis of computational data with City of Ottawa wind criteria[1]. The following sections describe the analysis procedures, including a discussion of the pedestrian comfort criteria.

4.1 Computer-Based Context Modelling

A computer-based PLW study was performed to determine the influence of the wind environment on pedestrian comfort and safety over the proposed development site. Pedestrian comfort predictions, based on the mechanical effects of wind, were determined by combining measured wind speed data from CFD simulations with statistical weather data obtained from Macdonald-Cartier International Airport. The general concept and approach to CFD modelling is to represent the appropriate details in the immediate vicinity of the study site on the surrounding model, and to create suitable atmospheric wind profiles at the model boundary. The wind profiles are designed to have similar mean and turbulent wind properties consistent with actual site exposures.

An industry standard practice is to omit trees, vegetation, and other existing and planned landscape elements from the model due to the difficulty of providing accurate seasonal representation of vegetation. The omission of trees and other landscaping elements produces slightly higher (i.e., windier) wind speed values.

[1] City of Ottawa Terms of References: Wind Analysis
https://documents.ottawa.ca/sites/default/files/torwindanalysis_en.pdf

4.2 Wind Speed Measurements

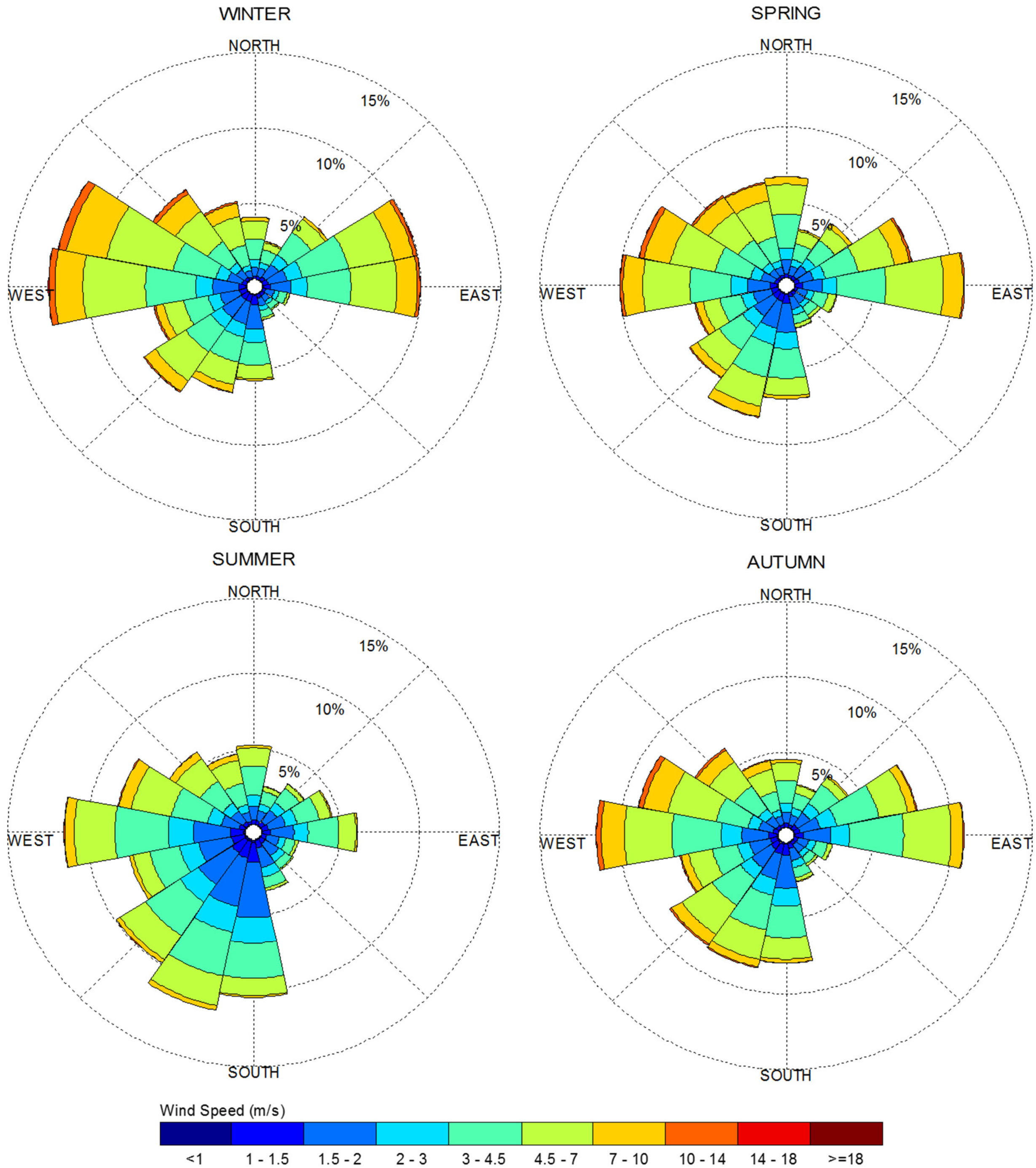
The PLW analysis was performed by simulating wind flows and gathering velocity data over a CFD model of the site for 12 wind directions. The CFD simulation model was centered on the study building, complete with surrounding massing within a diameter of approximately 840 m. Mean and peak wind speed data obtained over the study site for each wind direction were interpolated to 36 wind directions at 10° intervals, representing the full compass azimuth. Measured wind speeds approximately 1.5 m above local grade, as well as 1.5 m above the terraces at Level 3 (AL) and Level 18 (IL), were referenced to the wind speed at gradient height to generate mean and peak velocity ratios, which were used to calculate full-scale values. The gradient height represents the theoretical depth of the boundary layer of the Earth's atmosphere, above which the mean wind speed remains constant. Appendices A and B provide greater detail of the theory behind wind speed measurements.

4.3 Meteorological Data Analysis

A statistical model for winds in Ottawa was developed from approximately 40-years of hourly meteorological wind data recorded at Macdonald-Cartier International Airport and obtained from the local branch of Atmospheric Environment Services of Environment Canada. Wind speed and direction data were analyzed for each month of the year in order to determine the statistically prominent wind directions and corresponding speeds, and to characterize similarities between monthly weather patterns. Based on this portion of analysis, the four seasons are represented by grouping data from consecutive months based on similarity of weather patterns, and not according to the traditional calendar method.

The statistical model of the Ottawa area wind climate, which indicates the directional character of local winds on a seasonal basis, is illustrated on the following page. The plots illustrate seasonal distribution of measured wind speeds and directions in meters per second (m/s). Probabilities of occurrence of different wind speeds are represented as stacked polar bars in sixteen azimuth divisions. The radial direction represents the percentage of time for various wind speed ranges per wind direction during the measurement period. The preferred wind speeds and directions can be identified by the longer length of the bars. For Ottawa, the most common winds occur for westerly wind directions, followed by those from the east, while the most common wind speeds are below 10 m/s. The directional preference and relative magnitude of wind speed changes somewhat from season to season. By convention in microclimate studies, wind direction refers to the wind origin (e.g., a north wind blows from north to south).

SEASONAL DISTRIBUTION OF WINDS FOR VARIOUS PROBABILITIES
MACDONALD-CARTIER INTERNATIONAL AIRPORT, OTTAWA, ONTARIO



Notes:

1. Radial distances indicate percentage of time of wind events.
2. Wind speeds are mean hourly in m/s, measured at 10 m above the ground.
3. Apply a factor of 3.6 to convert m/s to km/h.

4.4 Pedestrian Comfort and Safety Criteria – City Ottawa

Pedestrian comfort and safety criteria are based on the mechanical effects of wind without consideration of other meteorological conditions (i.e., temperature, relative humidity). The comfort guidelines assume that pedestrians are appropriately dressed for a specified outdoor activity during any given season. Five pedestrian comfort classes are based on 80% non-exceedance mean wind speed ranges, which include (1) Sitting; (2) Standing; (3) Strolling; (4) Walking; and (5) Uncomfortable. More specifically, the comfort classes and associated mean wind speed ranges are summarized as follows:

1) **Sitting:** Mean wind speeds no greater than 10 km/h occurring at least 80% of the time. The gust equivalent mean wind speed is approximately 14 km/h.

2) **Standing:** Mean wind speeds no greater than 14 km/h occurring at least 80% of the time. The gust equivalent mean wind speed is approximately 20 km/h.

3) **Strolling:** Mean wind speeds no greater than 17 km/h occurring at least 80% of the time. The gust equivalent mean wind speed is approximately 25 km/h.

4) **Walking:** Mean wind speeds no greater than 20 km/h occurring at least 80% of the time. The gust equivalent mean wind speed is approximately 30 km/h.

5) **Uncomfortable:** Uncomfortable conditions are characterized by predicted values that fall below the 80% target for walking. Brisk walking and exercise, such as jogging, would be acceptable for moderate excesses of this criterion.

The pedestrian safety wind speed criterion is based on the approximate threshold that would cause a vulnerable member of the population to fall. A 0.1% exceedance gust wind speed of 90 km/h is classified as dangerous. The gust speeds, and equivalent mean speeds, are selected based on 'The Beaufort Scale', presented on the following page, which describes the effects of forces produced by varying wind speed levels on objects. Gust speeds are included because pedestrians tend to be more sensitive to wind gusts than to steady winds for lower wind speed ranges. For strong winds approaching dangerous levels, this effect is less important because the mean wind can also create problems for pedestrians. The mean gust speed ranges are selected based on 'The Beaufort Scale', which describes the effect of forces produced by varying wind speeds on levels on objects.

THE BEAUFORT SCALE

NUMBER	DESCRIPTION	WIND SPEED (km/h)	DESCRIPTION
2	Light Breeze	4-8	Wind felt on faces
3	Gentle Breeze	8-15	Leaves and small twigs in constant motion; Wind extends light flags
4	Moderate Breeze	15-22	Wind raises dust and loose paper; Small branches are moved
5	Fresh Breeze	22-30	Small trees in leaf begin to sway
6	Strong Breeze	30-40	Large branches in motion; Whistling heard in electrical wires; Umbrellas used with difficulty
7	Moderate Gale	40-50	Whole trees in motion; Inconvenient walking against wind
8	Gale	50-60	Breaks twigs off trees; Generally impedes progress

Experience and research on people's perception of mechanical wind effects has shown that if the wind speed levels are exceeded for more than 80% of the time, the activity level would be judged to be uncomfortable by most people. For instance, if a mean wind speed of 10 km/h (gust equivalent mean wind speed of 14 km/h) was exceeded for more than 20% of the time most pedestrians would judge that location to be too windy for sitting. Similarly, if mean wind speed of 20 km/h (gust equivalent mean wind speed of 30 km/h) at a location were exceeded for more than 20% of the time, walking or less vigorous activities would be considered uncomfortable. As most of these criteria are based on subjective reactions of a population to wind forces, their application is partly based on experience and judgment.

Once the pedestrian wind speed predictions have been established at tested locations, the assessment of pedestrian comfort involves determining the suitability of the predicted wind conditions for their associated spaces. This step involves comparing the predicted comfort class to the desired comfort class, which is dictated by the location type represented by the sensor (i.e., a sidewalk, building entrance, amenity space, or other). An overview of common pedestrian location types and their desired comfort classes are summarized on the following page.

DESIRED PEDESTRIAN COMFORT CLASSES FOR VARIOUS LOCATION TYPES

LOCATION TYPES	DESIRED COMFORT CLASSES
Major Building Entrances	Standing
Secondary Building Access Points	Walking
Primary Public Sidewalks	Strolling
Secondary Public Sidewalks / Bicycle Paths	Walking
Outdoor Amenity Spaces	Sitting / Standing / Strolling
Cafés / Patios / Benches / Gardens	Sitting
Transit Shelters	Standing
Public Parks / Plazas	Standing / Strolling
Garage / Service Entrances	Walking
Parking Lots	Strolling / Walking
Vehicular Drop-Off Zones	Standing / Strolling / Walking

5. RESULTS AND DISCUSSION

The foregoing discussion of predicted pedestrian wind conditions is accompanied by Figures 3A through 6B (following the main text) illustrating the seasonal wind conditions at grade level and within select elevated terraces serving AL and IL residents. The colour contours indicate various comfort classes predicted for certain regions. Wind conditions comfortable for sitting or more sedentary activities are represented by the colour green, standing are represented by yellow, strolling by orange, and conditions suitable for walking are represented by blue. The colour salmon magenta represents wind conditions considered uncomfortable for walking.

In addition to the common wind conditions, our analyses consider the possibility of extreme winds creating conditions dangerous to pedestrians. As noted in Section 4.4, dangerous conditions are defined to exist when wind speeds of at least 90 km/h occur for at least 0.1% of the time, or equivalently 9 hours per year based on a 24-h day). These conditions were found to exist at grade level, near the northwest corner of St. Peter's Lutheran Church (upper north half of west façade), as well as within a small area immediately adjacent to the northeast corner of the study building. The common wind events and extreme wind events are discussed in Sections 5.1 and 5.2, respectively.

5.1 Common Wind Events and Mitigation Measures

Sparks Street Sidewalk and Main Lobby Entrance (Figure 1B, Tags A-C): The sidewalk along Sparks Street (Tag A) will be mostly comfortable for sitting during the summer season, becoming suitable for standing during the spring and autumn seasons, and for a mix of standing and strolling during the winter season. The noted conditions are acceptable according to the City of Ottawa wind comfort criteria.

Conditions in the immediate vicinity of the main lobby entrance and secondary entrance to the east, both fronting Sparks Street (Tag B), will be suitable for sitting during the summer season, becoming suitable for standing during the remaining three colder seasons. The noted conditions are considered acceptable according to the City of Ottawa wind comfort criteria. Of importance, a small area immediately adjacent to the northeast corner of the study building (Tag C) is predicted to be impacted by infrequent extreme wind events, which are discussed in Section 5.2.

St. Peter's Lutheran Church Main Entrance; Private Portico / Parking Lot (Figure 1B, Tags D-G): Wind conditions in the immediate vicinity of the main entrance (Tag D) will be suitable for sitting during the summer season, becoming suitable for standing, or better, during the remaining three colder seasons. The noted conditions are acceptable according to the City of Ottawa wind comfort criteria.

The private portico (Tag E) is located at the northwest corner of the building and accommodates access from the north side (walkway) of the existing church. Wind conditions on the north side will be calmer than those on the west side. More specifically, wind conditions will be suitable for sitting during the spring, summer, and autumn seasons, while conditions during the winter season will be suitable for standing. On the west side of the portico, wind conditions will be suitable for sitting during the spring, summer, and autumn seasons, while conditions during the winter season will be suitable for standing during the summer and autumn season, strolling during the spring season, and a mix of strolling and walking during the winter season.

The area to the immediate south of the west side of the portico (Tag F) is predicted to be suitable for standing during the summer season, strolling during the spring and autumn seasons, and walking during the winter season. Of importance, the noted area is also predicted to be impacted by extreme wind events, which are discussed in Section 5.2.

The remaining area to the south (Tag G) will be suitable for a mix of sitting and standing during the summer season, standing during the autumn season, and strolling during the two remaining colder seasons of spring and winter. The noted conditions are acceptable according to the City of Ottawa wind comfort criteria.

Walkway along East Side of Proposed Development (Figure 1B, Tags H & I): Wind conditions within the northern-most two thirds of the walkway (Tag H) will be suitable for sitting during the summer and autumn seasons, becoming suitable for a mix of sitting and standing during the spring and winter seasons. The remaining walkway area to the south (Tag I) will be suitable for standing during the summer and autumn seasons, becoming suitable for strolling during the spring and winter seasons. The noted conditions are acceptable according to the City of Ottawa wind comfort criteria.

St. Peter's Lutheran Church Existing Pedestrian Pathway and Surface Parking; Rear Entrance (Figure 1B, Tags J-L): Wind conditions within the southwest corner of the existing church grounds (Tag J) will be suitable for sitting during the summer season, becoming suitable for standing during the remaining three colder seasons. Wind conditions within the corresponding surface parking area (Tag K) will be suitable for a mix of sitting and standing during the summer season, standing during the autumn season, and a mix of standing and strolling during the spring and winter seasons. The noted conditions are acceptable according to the City of Ottawa wind comfort criteria. The rear entrance to the church (Tag L) will be calm and suitable for sitting throughout the year.

Walkway East of Existing 407 Queen Street; Queen Street Sidewalk (Figure 1B, Tags M & N): The walkway area to the immediate east of the existing dwelling at 407 Queen Street (Tag M) will be suitable for sitting during the summer and autumn seasons, becoming suitable for a mix of sitting and standing during the spring and winter seasons. The noted conditions are acceptable according to the City of Ottawa wind comfort criteria.

The sidewalk along Queen Street (Tag N) will be mostly comfortable for standing during the summer and autumn seasons, a mix of standing and strolling during the spring season, becoming suitable for strolling during the winter season. The noted conditions are acceptable according to the City of Ottawa wind comfort criteria.

Walkway West of Existing 411 Queen Street and Pathway between 411 and 409 Queen Street; Pathway between 409 and 407 Queen Street (Figure 1B, Tags O & P): The walkway area to the immediate west of the existing dwelling at 411 Queen Street (Tag O) and the pathway between 411 and 409 Queen St (Tag O) will be suitable for sitting during the summer season, a mix of sitting and standing during the autumn season, and standing during the spring season. During the winter season, conditions will be suitable for a mix of sitting, standing, and strolling. The pathway between 409 and 407 Queen St (Tag P) will be calm and suitable for sitting throughout the year. The noted conditions are acceptable according to the City of Ottawa wind comfort criteria.

Pedestrian Area North of 407 Queen Street; Pedestrian Area North of 411 Queen Street, Proposed Building Secondary Access Points, Pedestrian Area Adjacent to Vehicular Parking Garage, Southeast Corner of Christ Church Cathedral (Figure 1B, Tags Q & R): The pedestrian area north of 407 Queen Street (Tag Q) will be suitable for sitting during the summer season, becoming suitable for a mix of sitting and standing during the remaining three colder seasons. The pedestrian area north of 411 Queen Street (Tag R), as well as the secondary building access points serving the proposed development along the south elevation, the pedestrian area adjacent to the vehicular parking garage, and the pedestrian area within the southeast corner of the Christ Church Cathedral, will be calm and suitable for sitting throughout the year. The noted conditions are acceptable according to the City of Ottawa wind comfort criteria.

Pedestrian Area East of Christ Church Cathedral; Christ Church Cathedral Secondary Building Access on East Elevation (Figure 1B, Tags S & T): The pedestrian area between the noted church and the proposed driveway (Tag S) will be suitable for sitting during the summer season, standing during the spring and autumn seasons, and suitable for a mix of standing and strolling during the winter season. Wind conditions in the immediate vicinity of the existing secondary entrance (Tag T), which is served by a canopy, will be suitable for sitting throughout the year. The noted conditions are acceptable according to the City of Ottawa wind comfort criteria.

Philosopher's Walk (Figure 1B, Tags U & V): The pedestrian walkway is flanked by the proposed development and the existing Christ Church Cathedral. The south end of the walkway (Tag U) will be suitable for sitting during the summer season, becoming suitable for standing during the remaining three colder seasons. The north end of the walkway (Tag V) will be windier than the south half and suitable for standing during the summer and autumn seasons, becoming suitable for strolling during the spring and winter seasons. The noted conditions are acceptable according to the City of Ottawa wind comfort criteria.

Proposed Building Access at Northwest Corner / Cathedral Parking Entrance (Figure 1B, Tag W): Wind conditions in the immediate vicinity of the noted entrance (Tag W) will be suitable for sitting throughout the year. The noted conditions are acceptable according to the City of Ottawa wind comfort criteria.

Pedestrian Areas West and Northwest of Proposed Building; Christ Church Cathedral Main Entrances (Figure 1B, Tags X & Y): The pedestrian area represented by Tag X on the north side of the site closest Sparks Street will be suitable for a mix of sitting and standing during the summer season, standing during the spring autumn seasons, and a mix of standing and strolling during the winter season. The noted conditions are acceptable according to the City of Ottawa wind comfort criteria.

Wind conditions in the immediate vicinity of the existing main entrances serving Christ Church Cathedral (Tag Y) will be suitable for sitting during the summer and autumn seasons, becoming suitable for a mix of sitting and standing during the spring and winter seasons. The noted conditions are acceptable according to the City of Ottawa wind comfort criteria.

Level 3 Assisted Living (AL) Rooftop Terrace (Tags Z, AA & AB): The simulations were performed with a solid 1.524-m tall (5’) perimeter guard. The corresponding wind conditions during the summer season are predicted to be suitable for sitting within the full area. During the autumn season, the area will be mostly suitable for sitting (Tags Z and AA), though standing conditions are predicted along a portion of the north perimeter (Tag AB). During the remaining colder seasons of spring and winter, the area adjacent to the façade and beneath the building overhang (Tag Z) will be suitable for sitting, while the remaining exposed areas will be suitable for standing (Tags AA & AB).

Level 18 Independent Living (IL) Rooftop Terrace (Tags AC & AD): The simulations were performed with a solid 1.524-m tall (5’) perimeter guard, as well as with the planned canopy that effectively extends the roof line from the mechanical level above. The corresponding wind conditions during the summer season are predicted to be suitable for sitting within the areas represented by Tag AC, and for standing within the areas represented by Tag AD. During the spring and autumn seasons, the terrace is mostly suitable for standing. During the winter season, wind conditions are predicted to be suitable for standing within the areas represented by Tag AC, and for strolling within the areas represented by Tag AD.

The noted canopy is effective in deflecting a portion of the oncoming winds away from the terrace. Without the canopy, we expect standing conditions to assume a greater percentage of the terrace area during the summer season and strolling conditions during the spring and autumn seasons. Additionally, we would also expect walking conditions would be present within the terrace during the winter season.

To achieve sitting conditions within the full area during the shoulder months of spring and autumn, we recommend that the noted canopy either be maintained or extended towards the south to increase comfort levels along the west façade of the building. Additionally, increasing the perimeters guards to a final height of at least 1.8 m above the local walking surface is also anticipated to create calmer conditions throughout the year. Additional wind simulations would be required to confirm the effectiveness of specific mitigation strategies.

5.2 Extreme Wind Events and Mitigation Measures

Figure 7A presents extreme wind events over the grade level area considered to be dangerous for the more susceptible pedestrians. Dangerous conditions were found to exist at grade level within a small area immediately adjacent to the northeast corner of the study building (Figure 1B, Tag C), and the northwest corner of St. Peter's Lutheran Church (Figure 1B, Tag E). Wind safety is illustrated in Figure 7B, which includes a safety scale on the left-hand side indicating the percentage (%) of time wind speeds of at least 90 km/h are exceeded on an annual based on a 24-h day. As noted earlier, 0.1% (dark blue) represents the cut off above which conditions are considered dangerous.

The noted areas would benefit from the introduction of clusters of dense coniferous plantings to mitigate cornering flows from prominent west clockwise to north winds. At the time of planting, the coniferous trees should achieve a minimum height of 1.8 m, which would break up the wind and therefore increase both wind safety and wind comfort levels. The noted mitigation strategy can be developed to its practical conclusion in collaboration with the building and landscape architects. Additional wind simulations will be performed for site plan control to confirm the effectiveness of specific mitigation strategies.

5.3 Existing vs Future Wind Conditions

The introduction of the proposed development is expected to moderately increase wind speeds over some neighbouring areas at grade, while increasing comfort levels over other areas. Despite these changes, nearby building entrances, sidewalks, and other pedestrian areas will continue to experience wind conditions similar to those that presently exist much of the time without the proposed development in place. The only exception concerns the northwest corner of St. Peter's Lutheran Church, where extreme winds events are predicted to occur for approximately 24 hours an annual basis. Mitigation will be confirmed for site plan control to ensure the areas are safe and comfortable throughout the year.

6. CONCLUSIONS AND RECOMMENDATIONS

This report summarizes the methodology, results, and recommendations related to a pedestrian level wind (PLW) study for the proposed Ottawa Retirement Residence by Signature development in Ottawa, Ontario. A complete summary of the predicted wind comfort conditions is provided in Section 5 of this report and illustrated in Figures 3A-6B following the main text. Wind safety is discussed in Section 5.2 and is accompanied by Figures 7A and 7B. Based on computer simulations using the CFD technique, meteorological data analysis of the Ottawa wind climate, City of Ottawa wind comfort and safety criteria, and experience with similar developments in Ottawa, we conclude the following:

1) All grade-level areas within and surrounding the development site will be acceptable for the intended pedestrian uses throughout the year. More specifically, wind conditions along surrounding sidewalks and walkways, as well as at building access points, will be acceptable for the intended pedestrian uses of the areas throughout the year without the need for mitigation.

2) The only exception to item (1) concerns the northwest corner of St. Peter's Lutheran Church, where extreme winds events are predicted to occur for approximately 24 hours on an annual basis, which exceeds the City of Ottawa wind safety criterion of 9 hours. While preliminary mitigation strategies are discussed in Section 5.2, this matter could be developed to its practical conclusion in collaboration with the building and landscape architects. Additional wind simulations would be required to confirm the effectiveness of specific mitigation strategies.

3) The Level 3 AL rooftop terrace at the north side of the building will be comfortable for sitting during the summer season with solid 1.524-m tall (5’) perimeter guards. Conditions during the autumn season will be mostly suitable for sitting, though standing conditions are predicted along a portion of the north perimeter. During the remaining colder seasons of spring and winter, the area adjacent to the façade and beneath the building overhang will be suitable for sitting, while the remaining exposed areas will be suitable for standing. Since conditions are suitable for sitting during the summer season, and residents are afforded a comfortable space beneath the building overhang throughout the year, the noted conditions are considered acceptable.

4) The Level 18 IL rooftop terrace on the west side of the building will be comfortable for a mix of sitting and standing during the summer season, while the colder months become windier on account of direct flow from several prominent wind directions. Mitigation will be required to ensure the area achieves the sitting criterion during the summer season and shoulder months of spring and autumn. Additional wind simulations will be performed for site plan control to confirm the effectiveness of specific mitigation strategies.

The introduction of the proposed development is expected to moderately increase wind speeds over some neighbouring areas at grade, while increasing comfort levels over other areas. Despite these changes, nearby building entrances, sidewalks, and other pedestrian areas will continue to experience wind conditions similar to those that presently exist much of the time without the proposed development in place. While the only exception concerns the northwest corner of St. Peter’s Lutheran Church, as noted in item (2) above), mitigation measures will be explored and confirmed for site plan control to ensure safe and comfortable use of the area throughout the year.

Following the completion of the PLW study, we understand the architectural drawings for the subject site have been modified. For the purpose of our work, the general massing of the updated design is identical to the previous model. The only changes that would impact the results of the foregoing study concern the Level 18 IL rooftop terrace, which has been reduced in area and now resides within the southwest corner of the floorplan. The changes are expected to increase wind comfort conditions within the terrace throughout the year. The PLW study will be updated accordingly for the site plan control submission to quantify pedestrian wind comfort

This concludes our pedestrian level wind study and report. Please advise the undersigned of any questions or comments.

Sincerely,

Gradient Wind Engineering Inc.

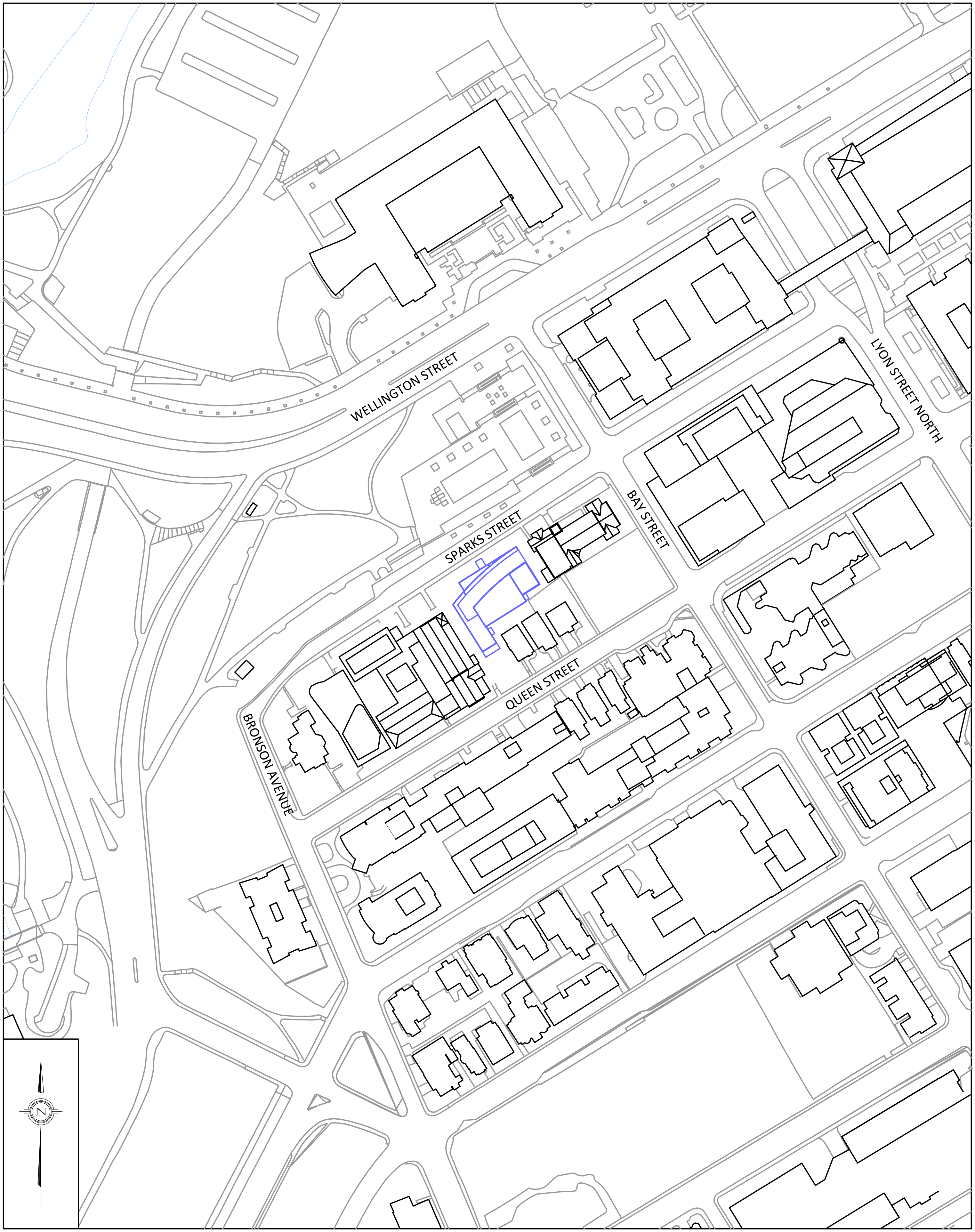
Justin Ferraro
Principal

LICENSED PROFESSIONAL ENGINEER
V. M. FERRARO
FEB 20, 2019
PROVINCE OF ONTARIO

Vincent Ferraro, M.Eng., P.Eng.
Managing Principal

Edward Urbanski, M.Eng.
Junior Wind Scientist

GWE18-176-PLW



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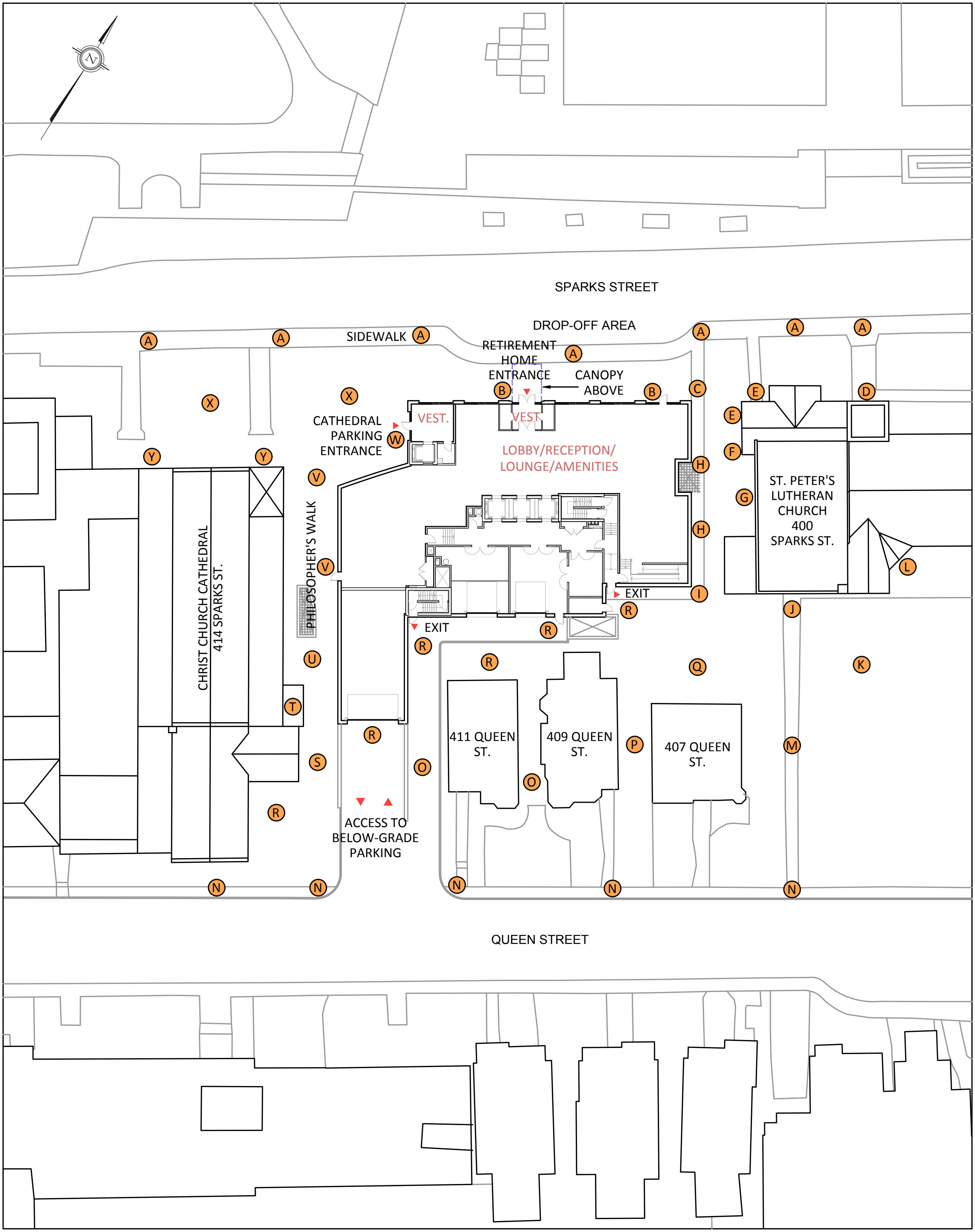
PROJECT	OTTAWA RETIREMENT RESIDENCE BY SIGNATURE PEDESTRIAN LEVEL WIND STUDY
SCALE	1:2500 (APPROX.)
DRAWING NO.	GWE18-176-PLW-1A
DATE	FEBRUARY 19, 2019
DRAWN BY	K.A.
DESCRIPTION	FIGURE 1A: SITE PLAN AND SURROUNDING CONTEXT



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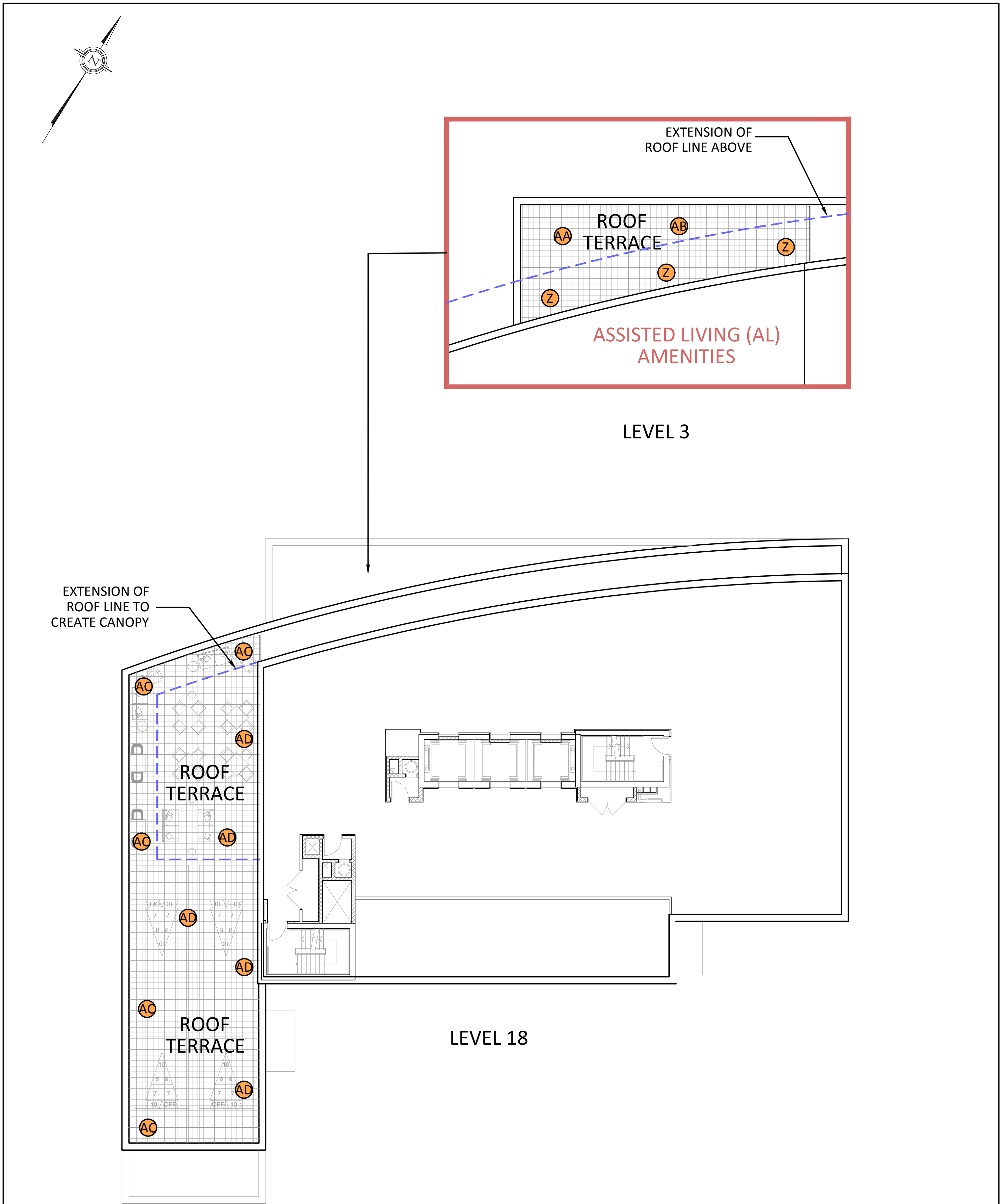
PROJECT: OTTAWA RETIREMENT RESIDENCE BY SIGNATURE
PEDESTRIAN LEVEL WIND STUDY

SCALE: 1:600 (APPROX.)
DRAWING NO.: GWE18-176-PLW-1B
DATE: FEBRUARY 19, 2019
DRAWN BY: K.A.

DESCRIPTION:
FIGURE 1B:
GROUND FLOOR PLAN
PEDESTRIAN COMFORT PREDICTIONS



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PROJECT	OTTAWA RETIREMENT RESIDENCE BY SIGNATURE PEDESTRIAN LEVEL WIND STUDY		
SCALE	1:300 (APPROX.)	DRAWING NO.	GWE18-176-PLW-1C
DATE	FEBRUARY 19, 2019	DRAWN BY	K.A.

DESCRIPTION

FIGURE 1C:
AMENITY TERRACES ON LEVELS 3 AND 18
PEDESTRIAN COMFORT PREDICTIONS

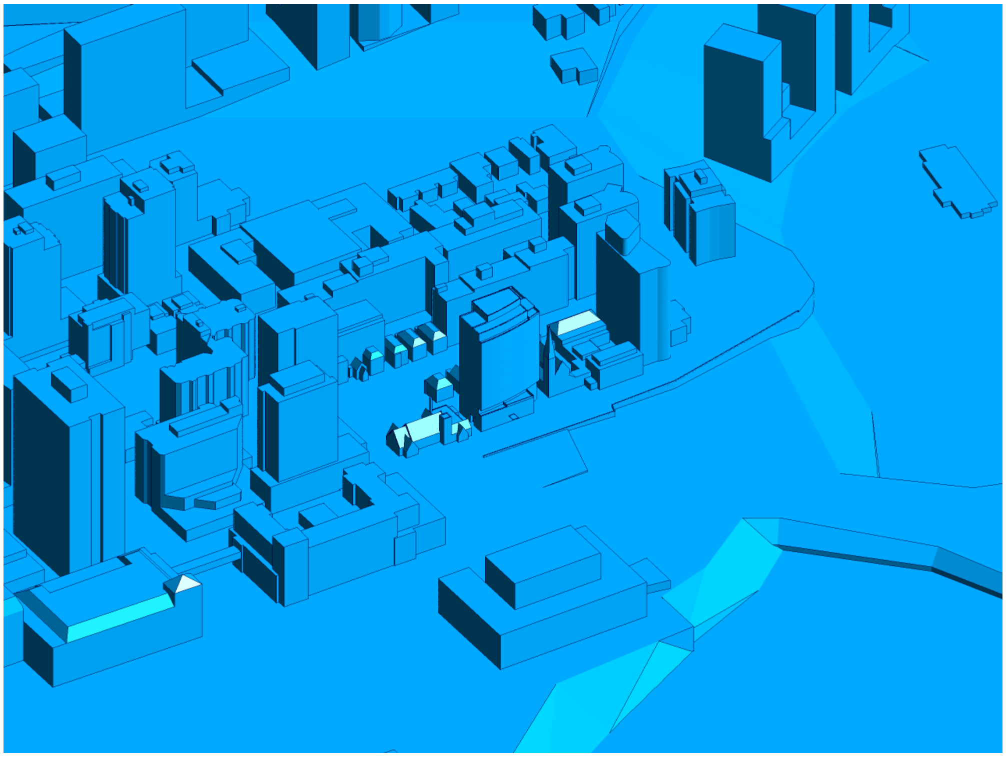


FIGURE 2A: COMPUTATIONAL MODEL, NORTH PERSPECTIVE

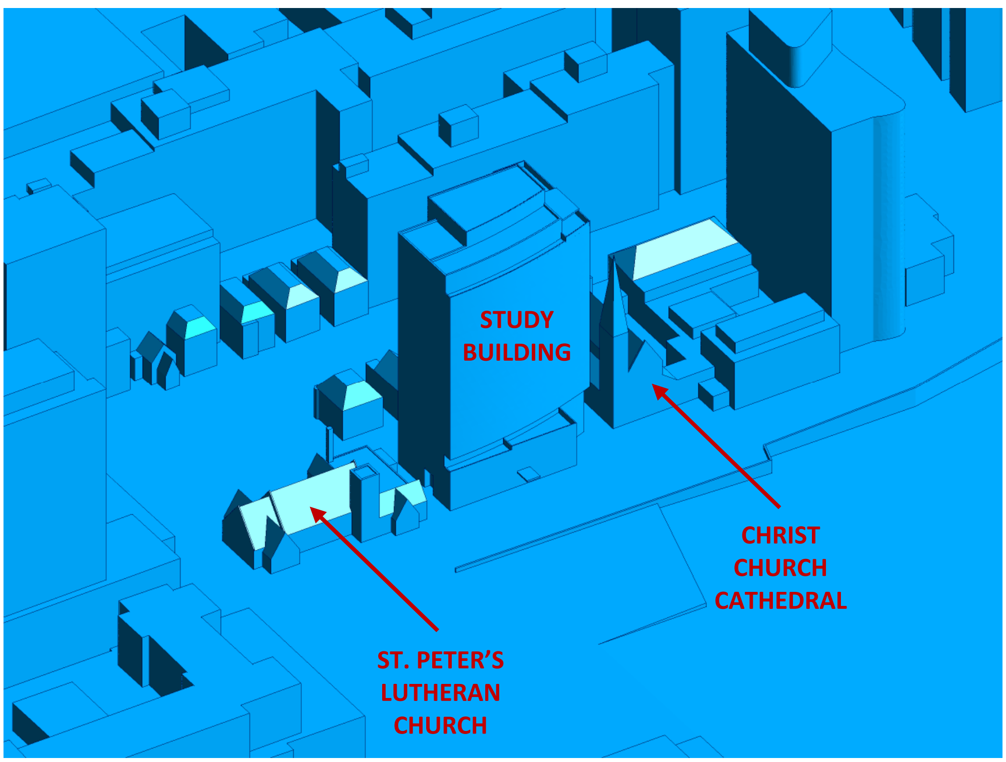


FIGURE 2B: CLOSE-UP VIEW OF FIGURE 2A

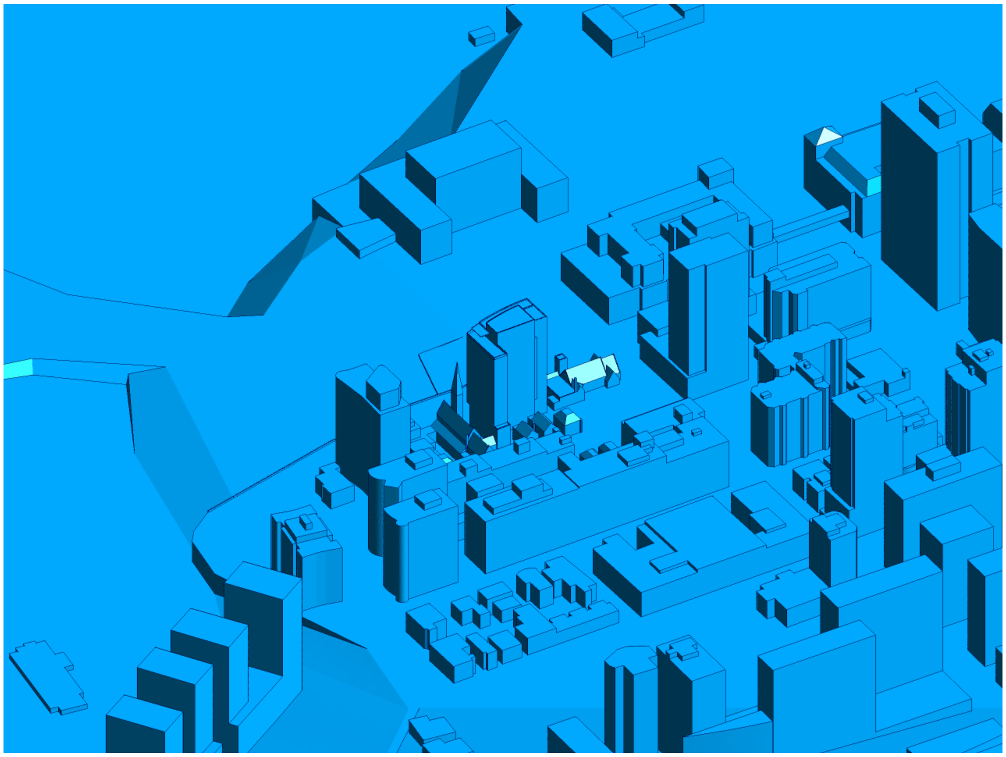


FIGURE 2C: COMPUTATIONAL MODEL, SOUTH PERSPECTIVE

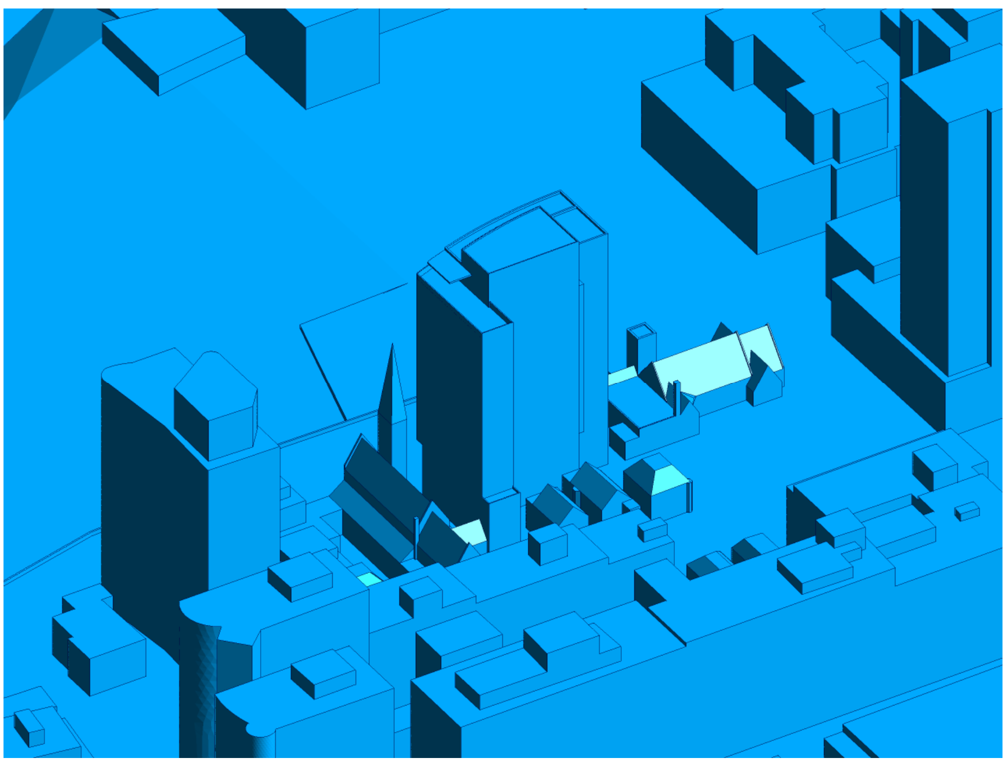


FIGURE 2D: CLOSE-UP VIEW OF FIGURE 2C

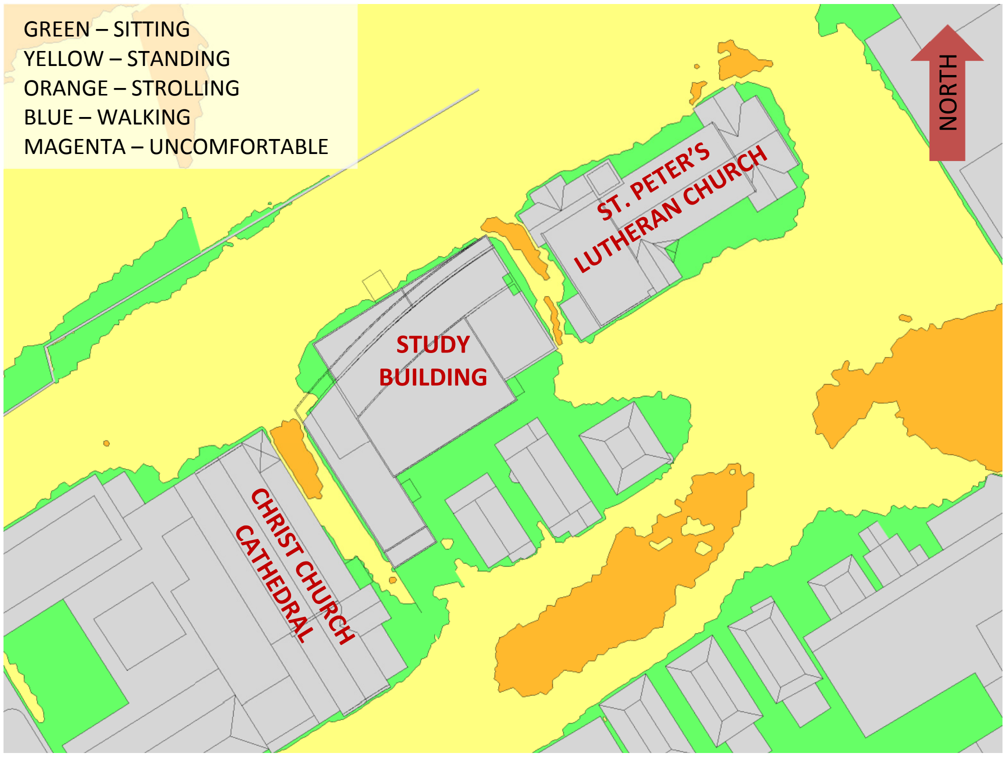


FIGURE 3A: SPRING – PEDESTRIAN WIND COMFORT AT GRADE LEVEL

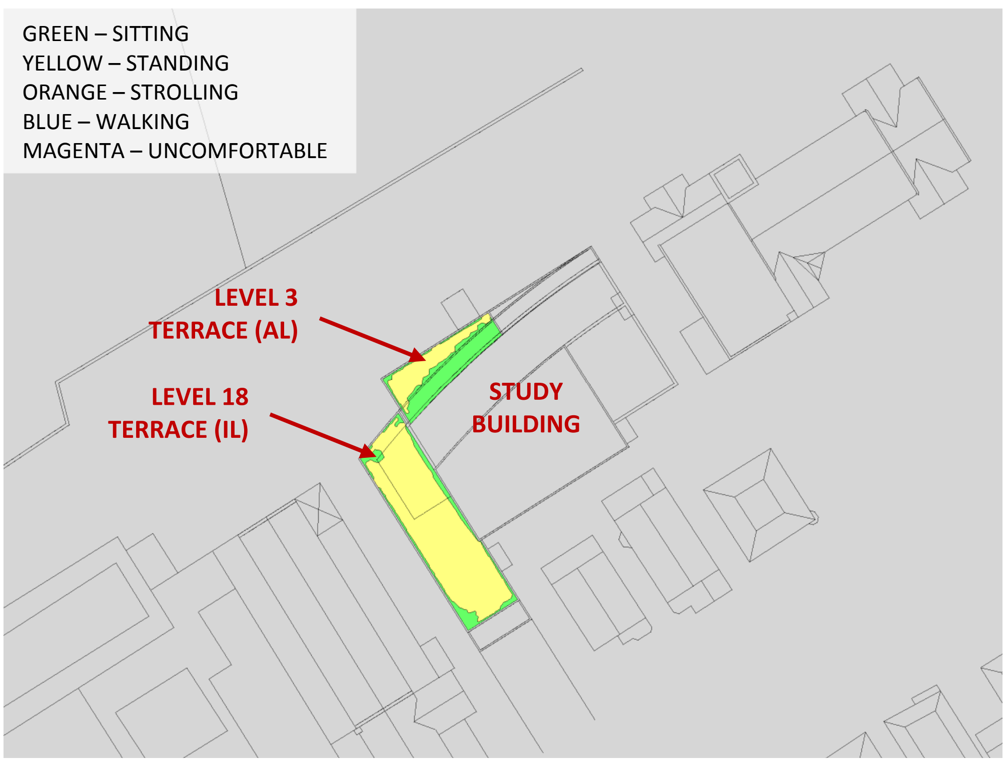


FIGURE 3B: SPRING – PEDESTRIAN WIND COMFORT WITHIN OUTDOOR TERRACES

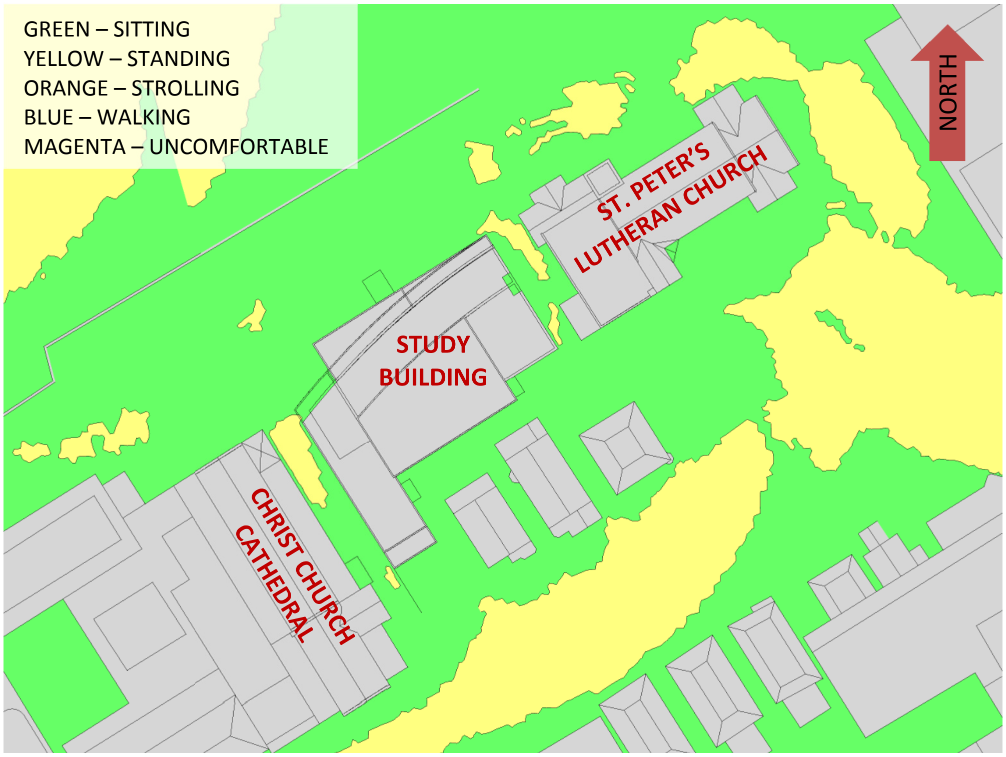


FIGURE 4A: SUMMER – PEDESTRIAN WIND COMFORT AT GRADE LEVEL

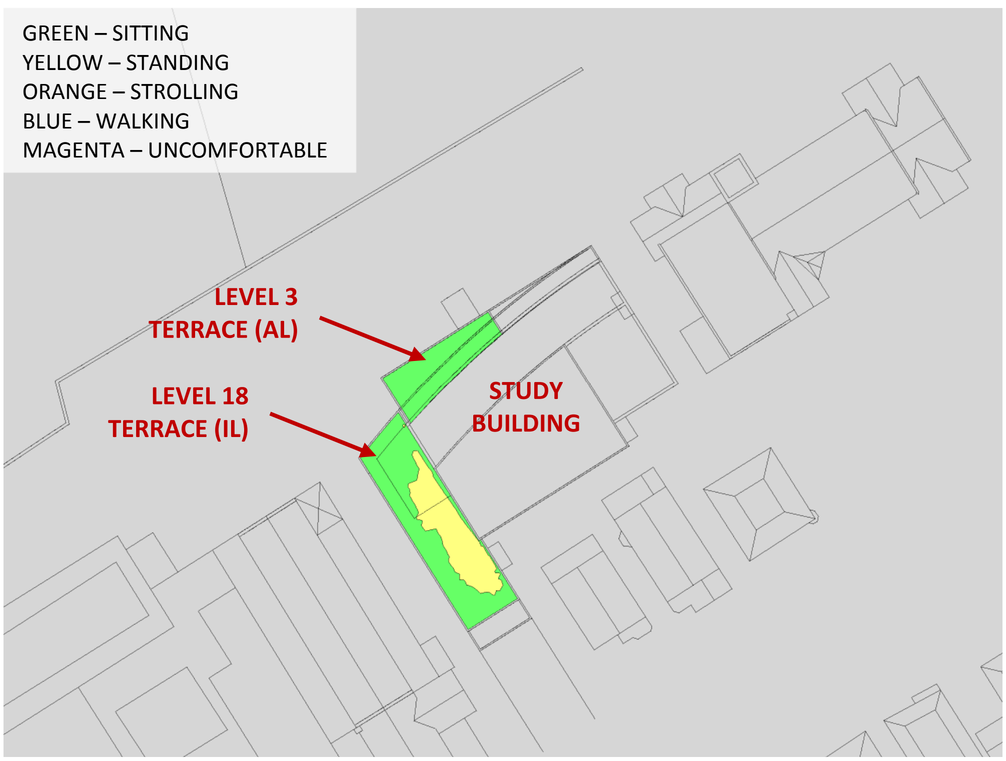


FIGURE 4B: SUMMER – PEDESTRIAN WIND COMFORT WITHIN OUTDOOR TERRACES

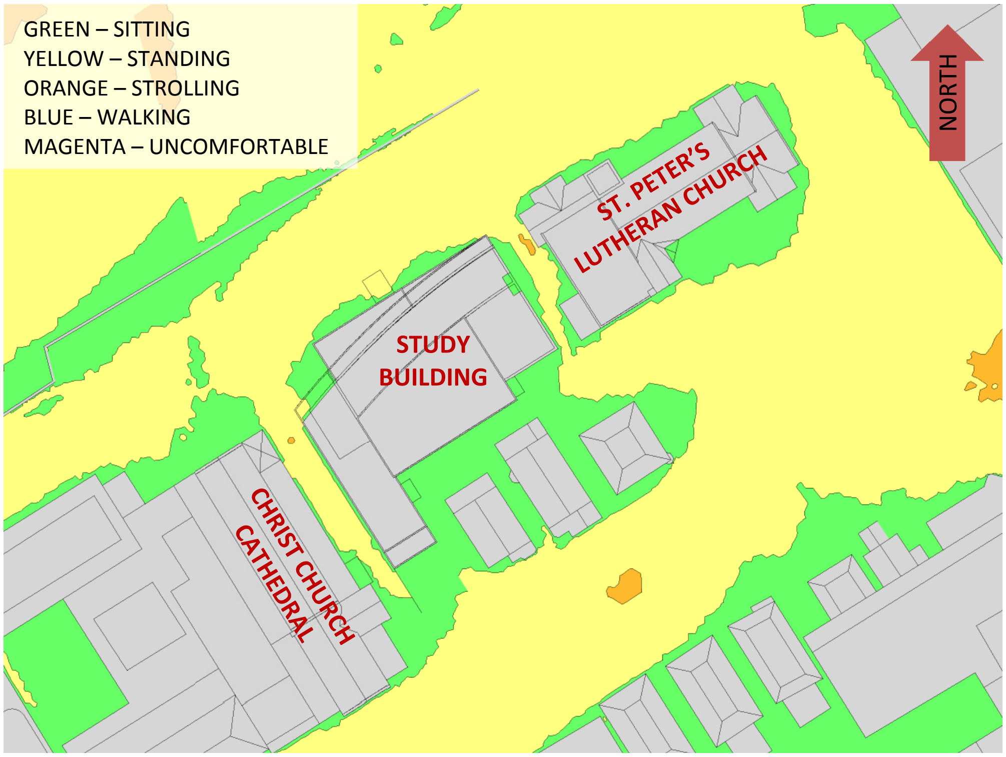


FIGURE 5A: AUTUMN – PEDESTRIAN WIND COMFORT AT GRADE LEVEL

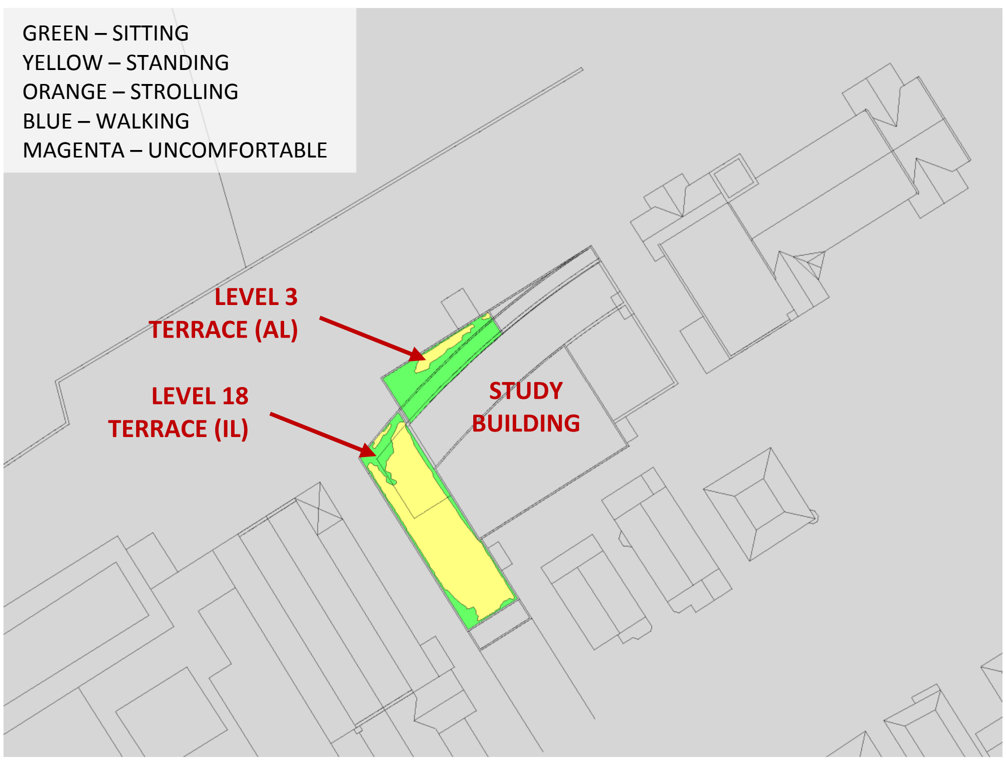


FIGURE 5B: AUTUMN – PEDESTRIAN WIND COMFORT WITHIN OUTDOOR TERRACES

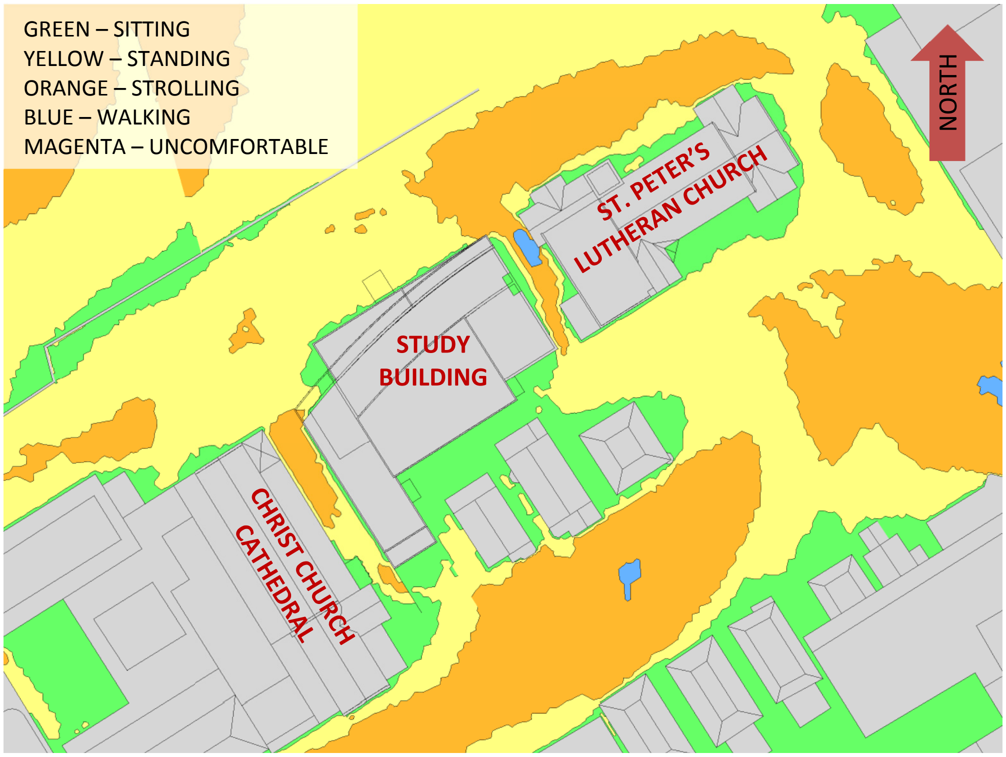


FIGURE 6A: WINTER – PEDESTRIAN WIND COMFORT AT GRADE LEVEL

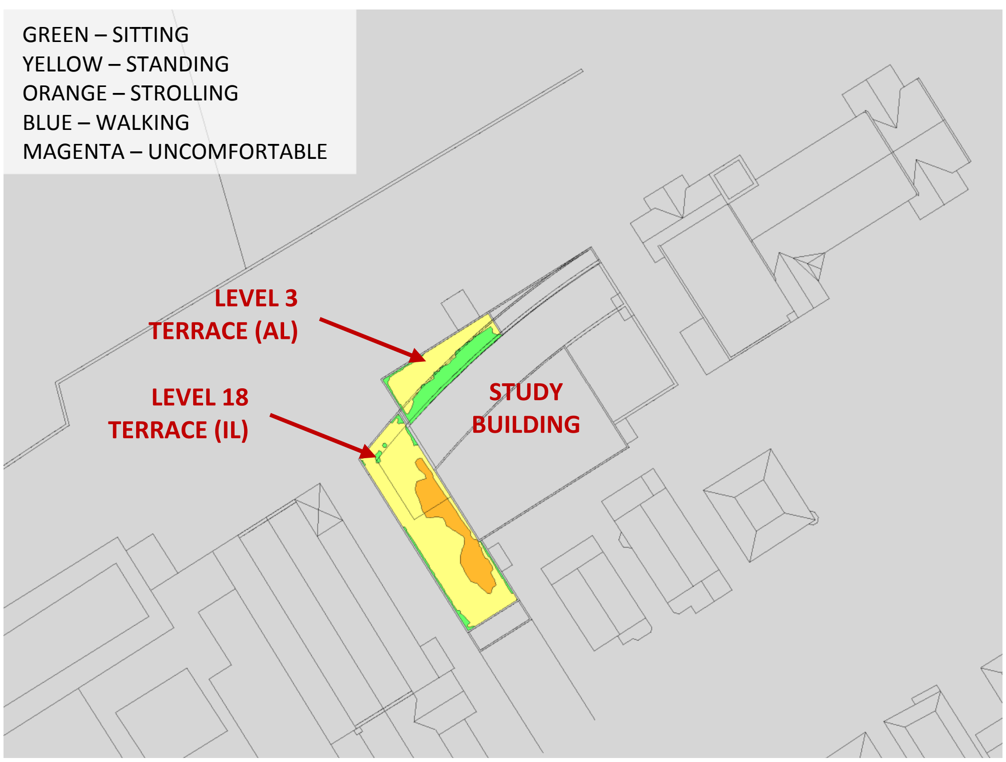


FIGURE 6B: WINTER – OUTDOOR AMENITY AREA WIND CONDITIONS

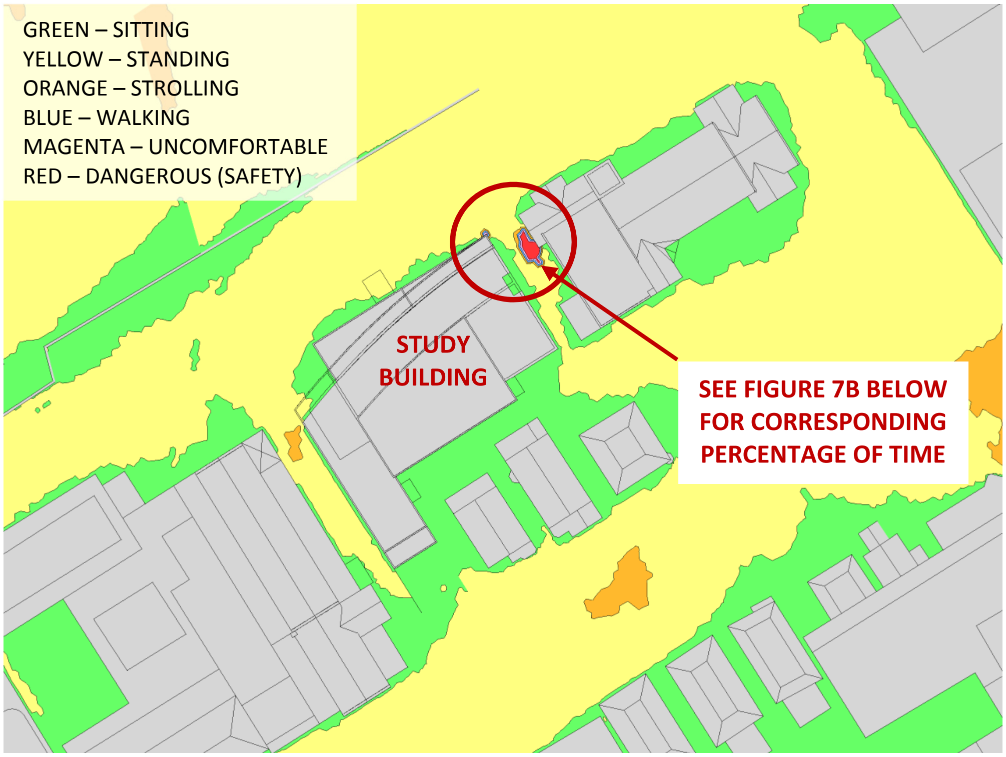


FIGURE 7A: ANNUAL – PEDESTRIAN WIND SAFETY AT GRADE LEVEL

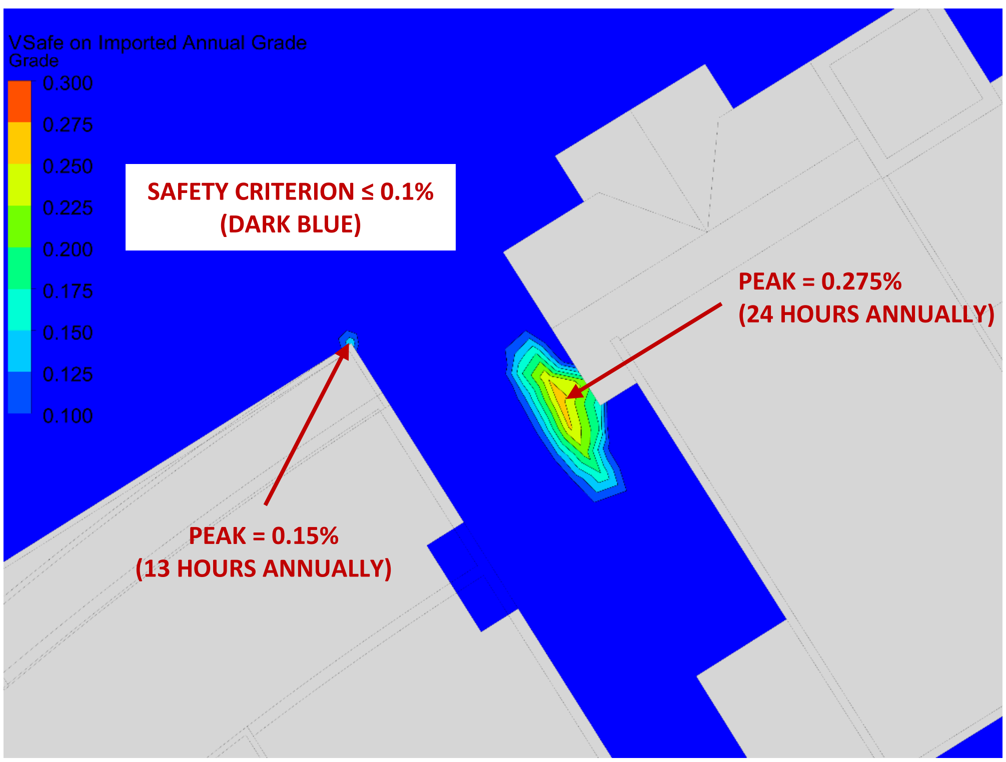
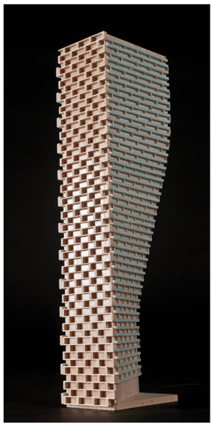
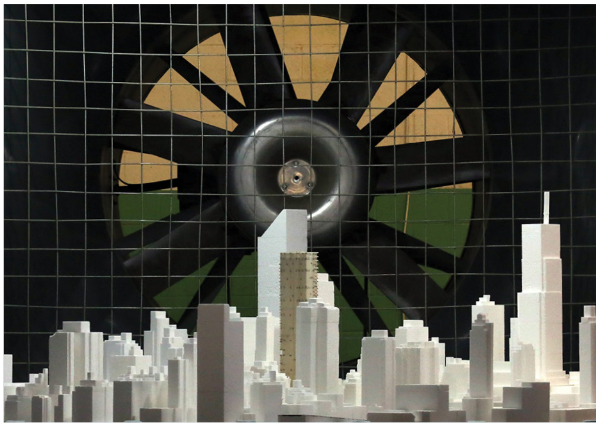


FIGURE 7B: ANNUAL – PERCENTAGE OF TIME WINDS SPEEDS EXCEED 90 km/h





APPENDIX A

WIND TUNNEL SIMULATION OF THE NATURAL WIND

WIND TUNNEL SIMULATION OF THE NATURAL WIND

Wind flowing over the surface of the earth develops a boundary layer due to the drag produced by surface features such as vegetation and man-made structures. Within this boundary layer, the mean wind speed varies from zero at the surface to the gradient wind speed at the top of the layer. The height of the top of the boundary layer is referred to as the gradient height, above which the velocity remains more-or-less constant for a given synoptic weather system. The mean wind speed is taken to be the average value over one hour. Superimposed on the mean wind speed are fluctuating (or turbulent) components in the longitudinal (i.e. along wind), vertical and lateral directions. Although turbulence varies according to the roughness of the surface, the turbulence level generally increases from nearly zero (smooth flow) at gradient height to maximum values near the ground. While for a calm ocean the maximum could be 20%, the maximum for a very rough surface such as the center of a city could be 100%, or equal to the local mean wind speed. The height of the boundary layer varies in time and over different terrain roughness within the range of 400 metres (m) to 600 m.

Simulating real wind behaviour in a wind tunnel requires simulating the variation of mean wind speed with height, simulating the turbulence intensity, and matching the typical length scales of turbulence. It is the ratio between wind tunnel turbulence length scales and turbulence scales in the atmosphere that determines the geometric scales that models can assume in a wind tunnel. Hence, when a 1:200 scale model is quoted, this implies that the turbulence scales in the wind tunnel and the atmosphere have the same ratios. Some flexibility in this requirement has been shown to produce reasonable wind tunnel predictions compared to full scale. In model scale the mean and turbulence characteristics of the wind are obtained with the use of spires at one end of the tunnel and roughness elements along the floor of the tunnel. The fan is located at the model end and wind is pulled over the spires, roughness elements and model. It has been found that, to a good approximation, the mean wind profile can be represented by a power law relation, shown below, giving height above ground versus wind speed.

$$U = U_g \left(\frac{Z}{Z_g} \right)^{\alpha}$$

Where; $\boldsymbol{U}$ = mean wind speed, $\boldsymbol{U_g}$ = gradient wind speed, $\boldsymbol{Z}$ = height above ground, $\boldsymbol{Z_g}$ = depth of the boundary layer (gradient height) and α is the power law exponent.

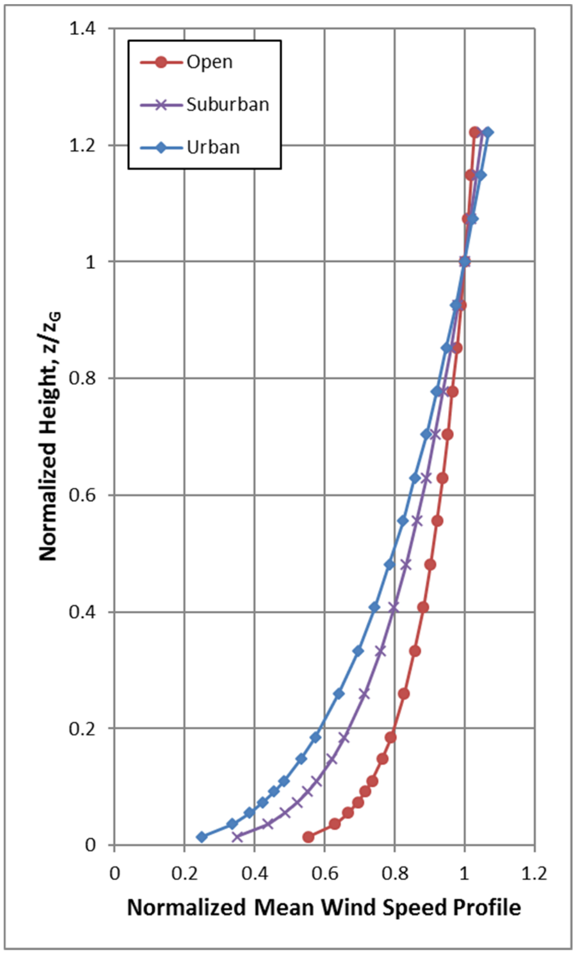
Figure B1 on the following page plots three velocity profiles for open country, and suburban and urban exposures. The exponent α varies according to the type of upwind terrain; α ranges from 0.14 for open country to 0.33 for an urban exposure. Figure B2 illustrates the theoretical variation of turbulence for open country, suburban and urban exposures.

The integral length scale of turbulence can be thought of as an average size of gust in the atmosphere. Although it varies with height and ground roughness, it has been found to generally be in the range of 100 m to 200 m in the upper half of the boundary layer. Thus, for a 1:300 scale, the model value should be between 1/3 and 2/3 of a metre. Integral length scales are derived from power spectra, which describe the energy content of wind as a function of frequency. There are several ways of determining integral length scales of turbulence. One way is by comparison of a measured power spectrum in model scale to a non-dimensional theoretical spectrum such as the Davenport spectrum of longitudinal turbulence. Using the Davenport spectrum, which agrees well with full-scale spectra, one can estimate the integral scale by plotting the theoretical spectrum with varying L until it matches as closely as possible the measured spectrum:

$$f \times S(f) = \frac{\dfrac{4(Lf)^2}{U_{10}{}^2}}{\left[1 + \dfrac{4(Lf)^2}{U_{10}{}^2}\right]^{\frac{4}{3}}}$$

Where, f is frequency, S(f) is the spectrum value at frequency f, U10 is the wind speed 10 m above ground level, and L is the characteristic length of turbulence.

Once the wind simulation is correct, the model, constructed to a suitable scale, is installed at the centre of the working section of the wind tunnel. Different wind directions are represented by rotating the model to align with the wind tunnel centre-line axis.



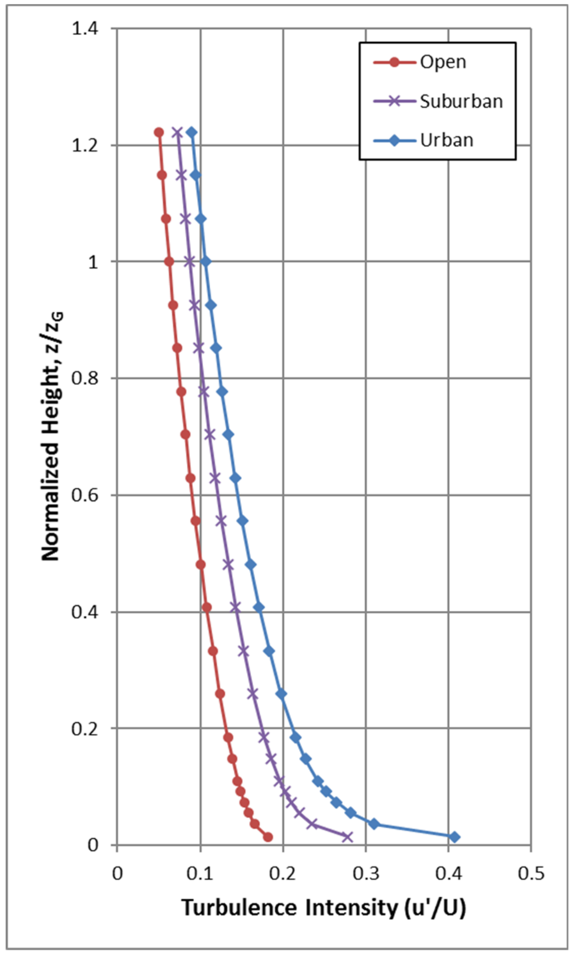


FIGURE A1 (LEFT): MEAN WIND SPEED PROFILES;
FIGURE A2 (RIGHT): TURBULENCE INTENSITY PROFILES

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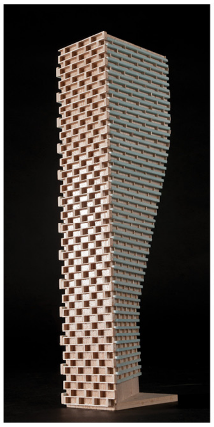

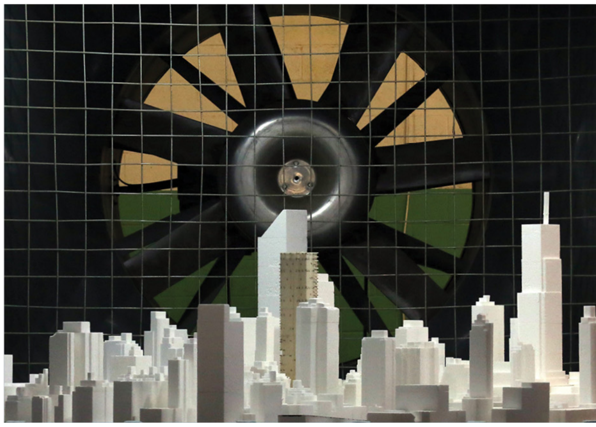

APPENDIX B

PEDESTRIAN LEVEL WIND MEASUREMENT METHODOLOGY

The information contained within this appendix is offered to provide a greater understanding of the relationship between the physical wind tunnel testing method and virtual computer-based simulations

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PEDESTRIAN LEVEL WIND MEASUREMENT METHODOLOGY

Pedestrian level wind studies are performed in a wind tunnel on a physical model of the study buildings at a suitable scale. Instantaneous wind speed measurements are recorded at a model height corresponding to 1.5 m full scale using either a hot wire anemometer or a pressure-based transducer. Measurements are performed at any number of locations on the model and usually for 36 wind directions. For each wind direction, the roughness of the upwind terrain is matched in the wind tunnel to generate the correct mean and turbulent wind profiles approaching the model.

The hot wire anemometer is an instrument consisting of a thin metallic wire conducting an electric current. It is an omni-directional device equally sensitive to wind approaching from any direction in the horizontal plane. By compensating for the cooling effect of wind flowing over the wire, the associated electronics produce an analog voltage signal that can be calibrated against velocity of the air stream. For all measurements, the wire is oriented vertically so as to be sensitive to wind approaching from all directions in a horizontal plane.

The pressure sensor is a small cylindrical device that measures instantaneous pressure differences over a small area. The sensor is connected via tubing to a transducer that translates the pressure to a voltage signal that is recorded by computer. With appropriately designed tubing, the sensor is sensitive to a suitable range of fluctuating velocities.

For a given wind direction and location on the model, a time history of the wind speed is recorded for a period of time equal to one hour in full-scale. The analog signal produced by the hot wire or pressure sensor is digitized at a rate of 400 samples per second. A sample recording for several seconds is illustrated in Figure B1. This data is analyzed to extract the mean, root-mean-square (rms) and the peak of the signal. The peak value, or gust wind speed, is formed by averaging a number of peaks obtained from sub-intervals of the sampling period. The mean and gust speeds are then normalized by the wind tunnel gradient wind speed, which is the speed at the top of the model boundary layer, to obtain mean and gust ratios. At each location, the measurements are repeated for 36 wind directions to produce normalized polar plots, which will be provided upon request.

In order to determine the duration of various wind speeds at full scale for a given measurement location the gust ratios are combined with a statistical (mathematical) model of the wind climate for the project site. This mathematical model is based on hourly wind data obtained from one or more meteorological stations (usually airports) close to the project location. The probability model used to represent the data is the Weibull distribution expressed as:

$$P\left(>U_g\right) = A_\theta \bullet \exp\left[\left(-\frac{U_g}{C_\theta}\right)^{K\theta}\right]$$

Where,

P (> U_g) is the probability, fraction of time, that the gradient wind speed ***U_g*** is exceeded; ***θ*** is the wind direction measured clockwise from true north, ***A***, ***C***, ***K*** are the Weibull coefficients, (Units: A - dimensionless, C - wind speed units [km/h] for instance, K - dimensionless). ***A_θ*** is the fraction of time wind blows from a 10° sector centered on ***θ***.

Analysis of the hourly wind data recorded for a length of time, on the order of 10 to 30 years, yields the ***A_θ, C_θ*** and ***K_θ*** values. The probability of exceeding a chosen wind speed level, say 20 km/h, at sensor *N* is given by the following expression:

$$P_N(>20) = \Sigma_\theta P\left[\frac{(>20)}{\left(\frac{U_N}{U_g}\right)}\right]$$

$$\boldsymbol{P_N (> 20) \quad = \quad \Sigma_\theta P \{ > 20/(U_N/Ug) \}}$$

Where, ***U_N/U_g*** is the gust velocity ratios, where the summation is taken over all 36 wind directions at 10° intervals.

If there are significant seasonal variations in the weather data, as determined by inspection of the $\boldsymbol{C_\theta}$ and $\boldsymbol{K_\theta}$ values, then the analysis is performed separately for two or more times corresponding to the groupings of seasonal wind data. Wind speed levels of interest for predicting pedestrian comfort are based on the comfort guidelines chosen to represent various pedestrian activity levels as discussed in the main text.

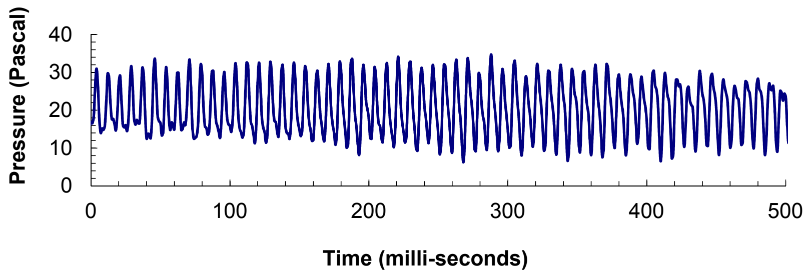

FIGURE B1: TIME VERSUS VELOCITY TRACE FOR A TYPICAL WIND SENSOR

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2. Wu, S., Bose, N., 'An *Extended Power Law Model for the Calibration of Hot-wire/Hot-film Constant Temperature Probes*', Int. J. of Heat Mass Transfer, Vol.17, No.3, pp.437-442, Pergamon Press.