5566 ROBINSON STREET & 6158 ALLENDALE AVENUE

NIAGARA FALLS, ON

PEDESTRIAN WIND ASSESSMENT

PROJECT #2201139

APRIL 7, 2022

SUBMITTED TO

La Pue International Inc
(c/o Pawel Fugiel)

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1. INTRODUCTION

Rowan Williams Davies & Irwin Inc. (RWDI) was retained to assess the potential wind conditions at pedestrian levels on and around the proposed 5566 Robinson Street & 6158 Allendale Avenue (also known as Niagara-77) in Niagara Falls, Ontario. The objective of this assessment is to provide an evaluation of the potential wind impact of the proposed development.

The project site is situated at southeast corner of the intersection between Robinson Street and Allendale Avenue (Image 1).

The project at 77-storey is currently planned for 680 residential and 312 hotel units. In addition, the project includes 6- storey above grade and 6-storey underground parkings (Image 2).

In addition to sidewalks, building entrances and properties near the project site, for this assessment, Level 7 amenity area are also considered in the analysis (Image 3).

Image 1: Aerial view of the existing site and surroundings
Credit: Google Maps

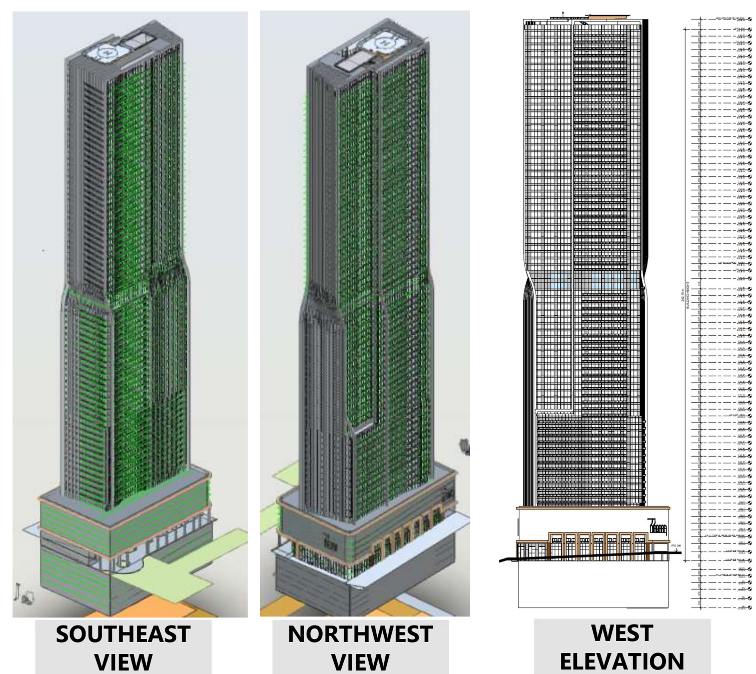


Image 2: Conceptual massing

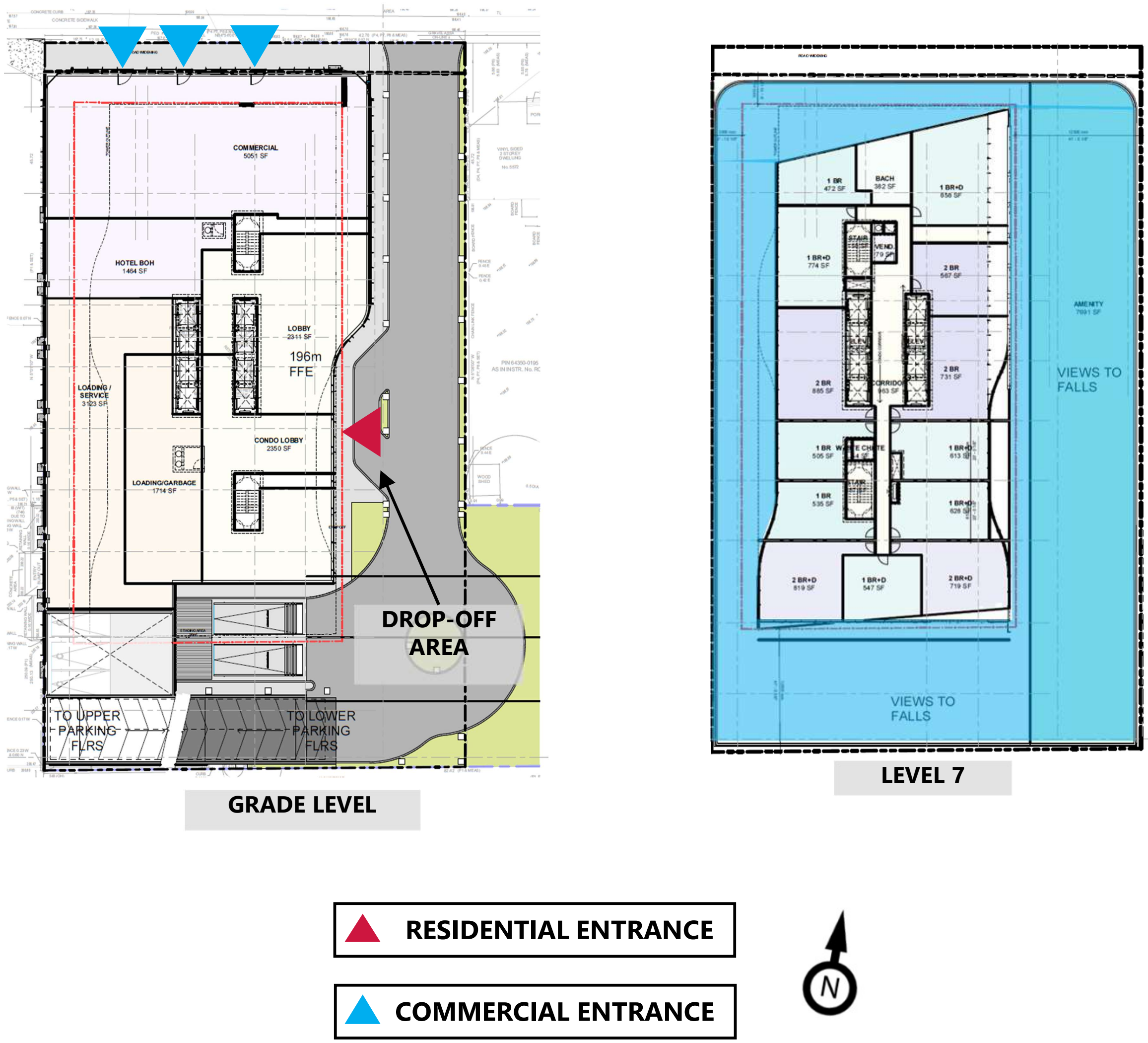


Image 3: Floor plans, received on March 7, 2022

2. METHODOLOGY

2.1 Objective

The objective of this assessment is to provide an evaluation of the potential wind impact of the proposed development on pedestrian areas around it. Our assessment is based on the following:

- A review of the regional meteorological data from St. Catharines Niagara District Airport;
- 3D e-model of the proposed project received on March 8, 2022;
- The use of Orbital Stack, an in-house computational fluid dynamics (CFD) tool, to aid in the assessment of wind comfort levels;
- The use of RWDI's proprietary tool WindEstimator[1] for estimating the potential wind conditions around generalized building forms;
- The RWDI wind comfort and safety criteria;
- Wind tunnel studies completed by RWDI for similar projects in Niagara Falls; and,
- Our engineering judgment, experience and expert knowledge of wind flows around buildings.

Note that other microclimate issues such as those relating to cladding and structural wind loads, door operability, building air quality, snow impact, noise, vibration, etc. are not part of the scope of this assessment.

2.2 CFD for Wind Simulation

CFD is a numerical modelling technique for simulating wind flow in complex environments. For urban wind modelling, CFD techniques are used to generate a virtual wind tunnel where flows around the site, surroundings and the study building are simulated at full scale. The computational domain that covers the site and surroundings are divided into millions of small cells where calculations are performed, which allows for the "mapping" of wind conditions across the entire study domain. CFD excels as a tool for urban wind modelling for providing early design advice, resolving complex flow physics, and helping diagnose problematic wind conditions. It is useful for the assessment of complex buildings and contexts and provides a good representation of general wind conditions which makes it easy to judge or compare designs and site scenarios.

Gust conditions are infrequent but deserve special attention due to their potential impact on pedestrian safety. The computational modeling method used in the current assessment does not quantify the transient behaviour of the wind, including wind gusts. The effect of gust, i.e., wind safety, is predicted qualitatively in this assessment using analytical methods and wind-tunnel-based empirical models[1]. The assessment has been conducted by experienced microclimate specialists in order to provide an accurate prediction of wind conditions. In order to quantify the transient behavior of wind and refine any conceptual mitigation measures, physical scale-model tests in a boundary-layer wind tunnel or more detailed transient computational modeling would be required.

2. METHODOLOGY

2.3 Simulation Model

Wind flows were simulated using Orbital Stack for the existing and proposed site buildings with the existing surroundings. The computer models are shown in Image 4. For the purposes of this computational study, the 3D models were simplified to include only the necessary building and terrain details that would affect the local wind flows in the area around the site. Landscaping and other smaller architectural and accessory features were not included in the computer model in order to provide more conservative wind conditions (as is the norm for this level of assessment).

The wind speed profiles in the atmospheric boundary, approaching the modelled area were simulated for 16 directions (starting at 0°, at 22.5° increments around the compass). Wind data in the form of ratios of wind speeds at approximately 1.5 m above concerned levels, to the mean wind speed at a reference height were obtained. The data was then combined with meteorological records obtained from St. Catharines Niagara District Airport to determine the wind speeds and frequencies in the simulated areas.

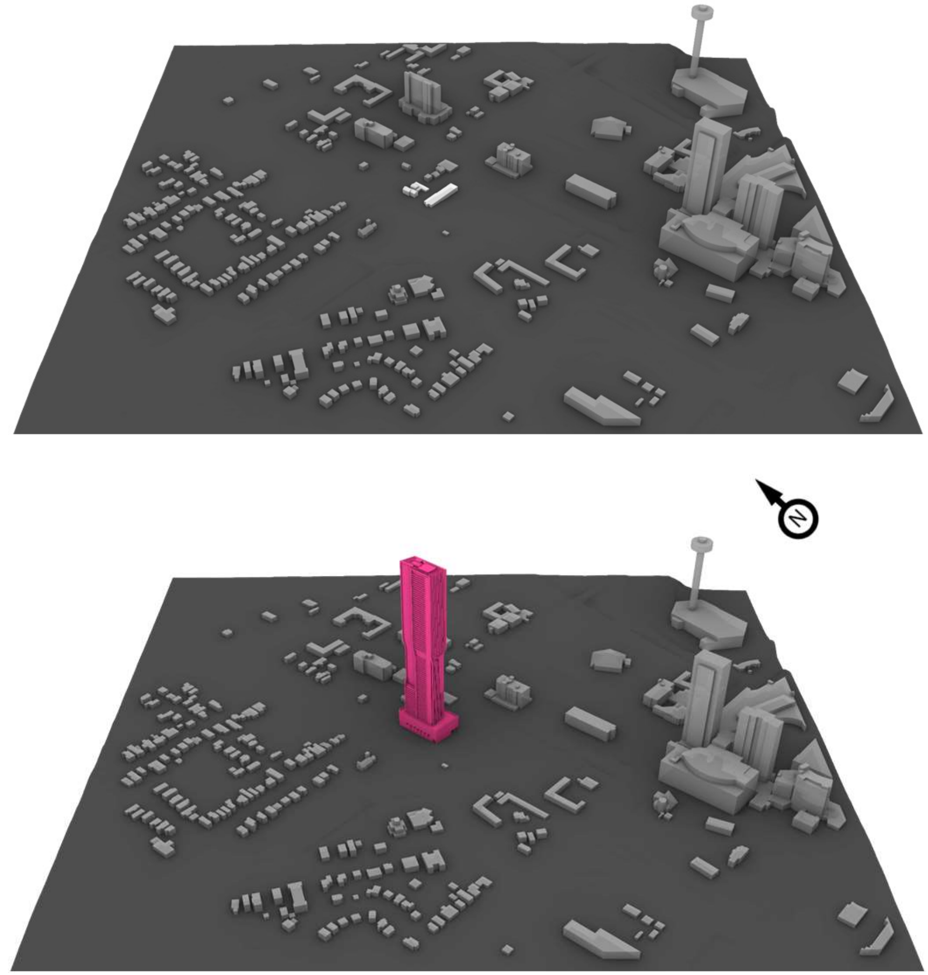


Image 4: Computer models of the existing site (top) and proposed project (bottom) with existing surroundings (southwest view)

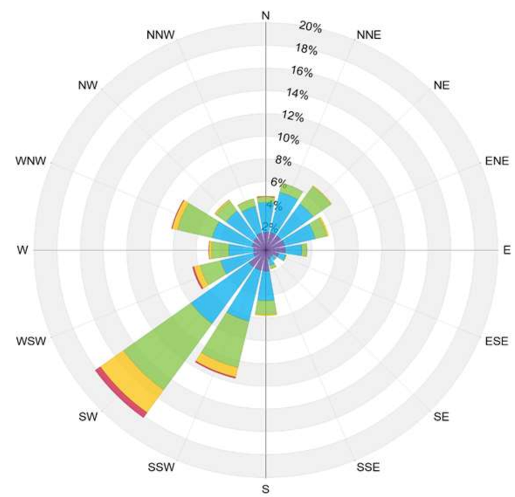
2.4 Meteorological Data

Meteorological data from St. Catharines Niagara District Airport for the period from 2012 to 2020 were used as a reference for wind directionality in the area as this is the nearest station to the site with long-term, hourly wind data. The distribution of wind frequency and directionality is shown in the wind roses in Image 5.

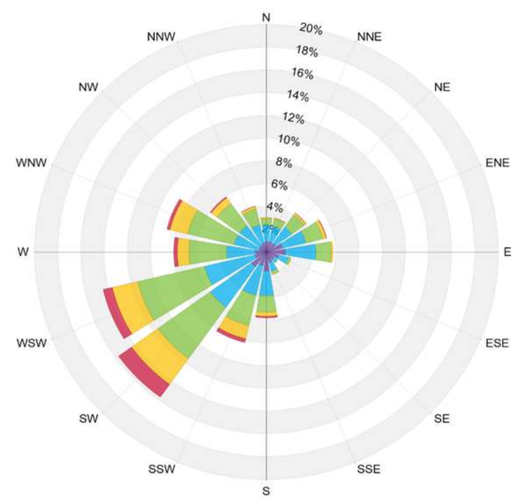
Southwesterly winds are predominant with secondary components from northeast, south and west throughout the year, as indicated by the wind roses.

Strong winds of a mean speed greater than 30 km/h measured at the airport (at an anemometer height of 10m) are from the southwest and northwest quadrants and are more frequent in the winter (red and yellow bands in Image 5). These winds potentially could be the source of uncomfortable or severe wind conditions, depending on the site exposure and development design.

Wind statistics were combined with the simulated data to predict the wind conditions at the project site and assessed against the wind criteria for pedestrian comfort.



Summer
(May through October)



Winter
(November through April)

Wind Speed (km/h)	Probability (%) Summer	Winter
Calm	3.1	2.1
1-10	22.6	17.4
11-20	42.4	33.4
21-30	25.9	32.9
31-40	5.2	10.7
>40	0.9	3.4

Image 5: Directional distribution of winds approaching St. Catharines Niagara District Airport (2012-2020)

3. WIND CRITERIA

The RWDI pedestrian wind criteria are used in the current study. These criteria have been developed by RWDI through research and consulting practice since 1974. They have also been widely accepted by municipal authorities, building designers and the city planning community. The criteria are as follows:

3.1 Pedestrian Safety Criterion

Pedestrian safety is associated with excessive gust that can adversely affect a pedestrian's balance and footing. If strong winds that can affect a person's balance (**90km/h**) occur more than **0.1%** of the time or 9 hours per year, the wind conditions are considered severe.

3.2 Pedestrian Comfort Criteria

Wind comfort is expressed in terms of typical pedestrian activities that the speeds would be conducive to:

Sitting (≤ 10 km/h): Calm or light breezes desired for outdoor seating areas where one can read a paper without having it blown away.
Standing (≤ 14 km/h): Gentle breezes suitable for main building entrances and bus stops.
Strolling (≤ 17 km/h): Moderate winds that would be appropriate for window shopping and strolling along a downtown street, plaza or park.
Walking (≤ 20 km/h): Relatively high speeds that can be tolerated if one's objective is to walk, run or cycle without lingering.
Uncomfortable: The comfort category for walking is not met.

Wind conditions are considered suitable for sitting, standing, strolling or walking if the associated mean wind speeds are expected for at least four out of five days (**80% of the time**). Wind control measures are typically required at locations where winds are rated as uncomfortable, or they exceed the wind safety criterion.

Note that these wind speeds are assessed at the pedestrian height (i.e., 1.5m above grade or the concerned floor level), typically lower than those recorded in the airport (10m height and open terrain).

These criteria for wind forces represent average wind tolerance. They are sometimes subjective and regional differences in wind climate and thermal conditions as well as variations in age, health, clothing, etc. can also affect people's perception of the wind climate.

For the current development, wind speeds comfortable for walking or strolling are appropriate for sidewalks and walkways where pedestrians are likely to be active and moving intentionally. Lower wind speeds comfortable for standing are required for building entrances and areas where people are expected to be engaged in passive. Calm wind speeds suitable for sitting are desired in areas where prolonged periods of passive activities are anticipated, such as amenity areas especially during the summer when these areas are typically in use.

3. RESULTS AND DISCUSSION

4.1 Wind Flow Around the Project

Wind generally tends to flow over buildings of uniform height, without disruption. Buildings that are taller than their surroundings tend to intercept and redirect winds around them. The mechanism in which winds are directed down the height of a building is called *Downwashing*. These flows subsequently move around exposed building corners, causing a localized increase in wind activity due to Corner Acceleration. Stepped massing, low podiums and canopies diffuse downwash and reduce the potential wind impact on the ground level. These flow patterns are illustrated in Image 6.

The proposed tower is significantly taller than the buildings that exist in the surrounding area; therefore, it is expected to redirect winds around it.

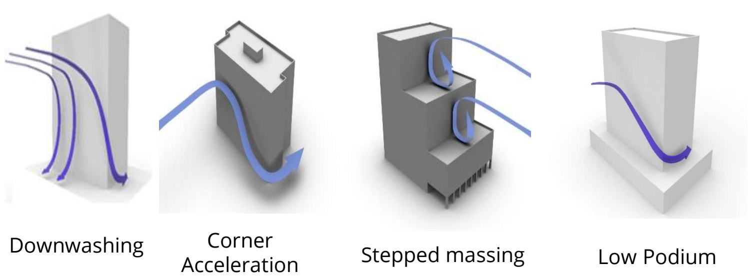


Image 6: General wind flow patterns

4.2 Simulation Results

The predicted wind comfort conditions for the existing configuration are illustrated in Images 7a an 7b for the summer and winter, respectively. Wind conditions for the proposed configuration are presented in Images 8, 9 and 10 for grade, entrances and above grade areas, respectively; each image includes the summer and winter assessments. The results are presented as colour contours of wind speeds calculated based on the wind criteria (Section 3.2). The contours represent wind speeds at a horizontal plane approximately 1.5 m above the concerned level.

The assessment against the safety criterion (Section 3.1) was done separately and multiple areas at grade and above grade are expected to exceed the wind speed safety limit.

A detailed discussion of the expected wind conditions with respect to the prescribed criteria and applicability of the results follows in Sections 4.3. and 4.4. The discussion includes recommendations for wind control to reduce the potential for high wind speeds for the design team's consideration.

3. RESULTS AND DISCUSSION

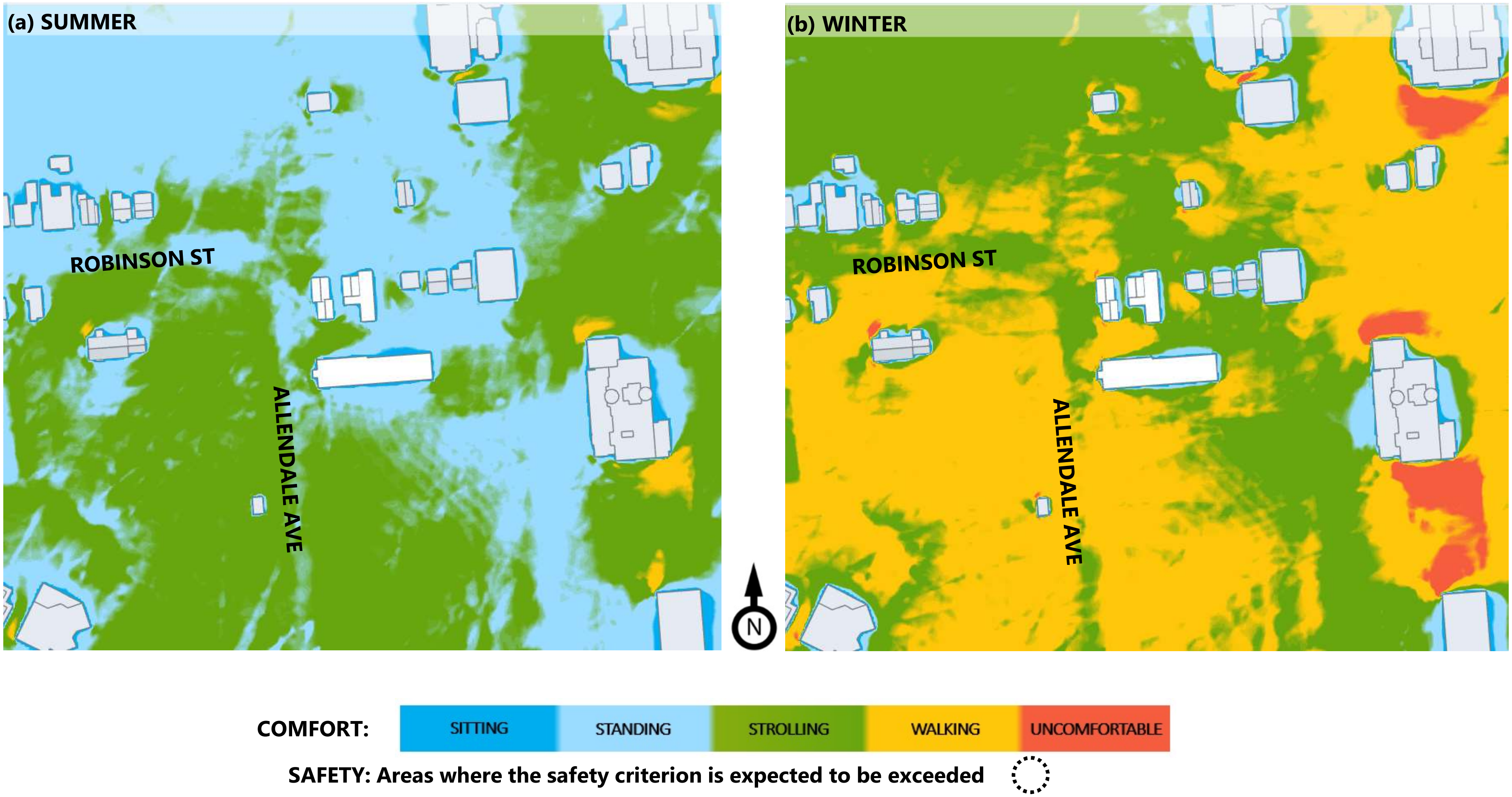


Image 7: Existing wind conditions – GROUND LEVEL

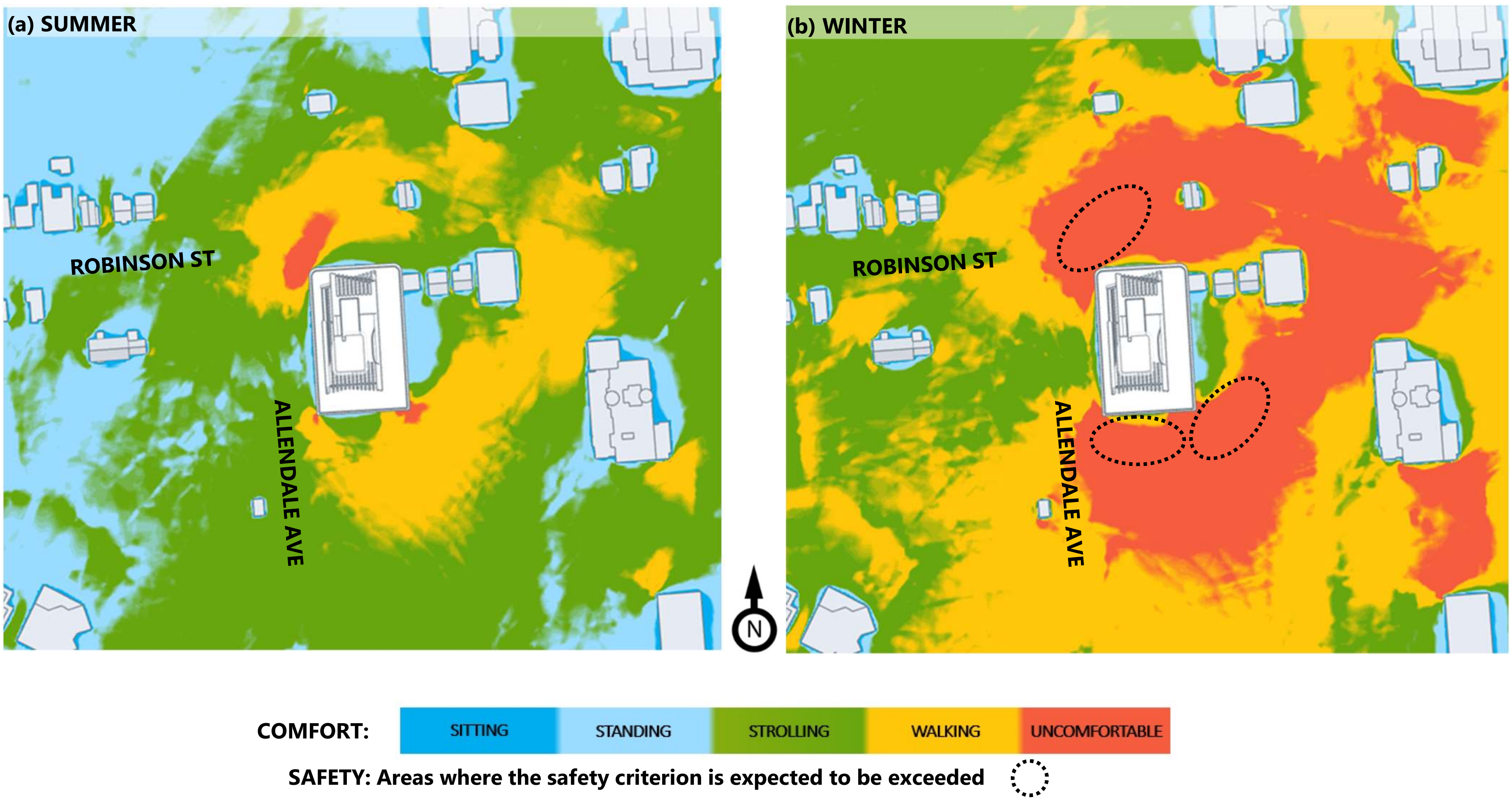


Image 8: Proposed wind conditions – GROUND LEVEL

3. RESULTS AND DISCUSSION

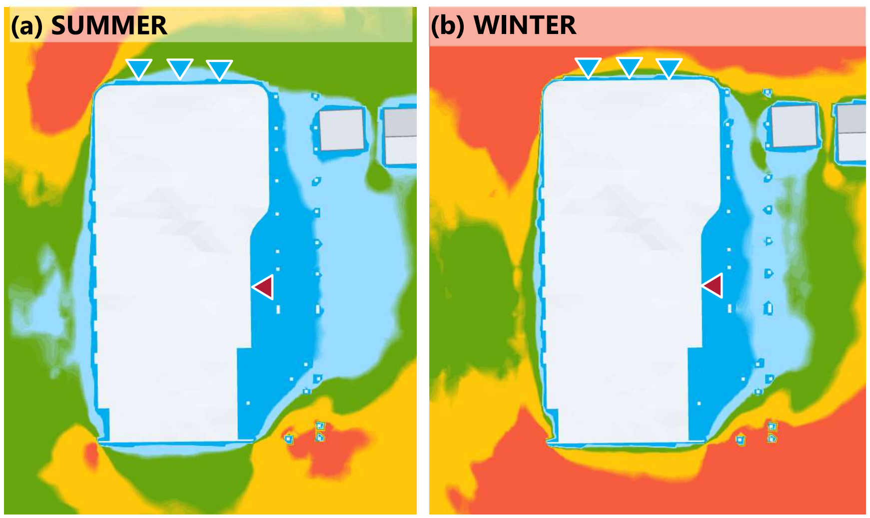


Image 9: Proposed wind conditions – GROUND LEVEL – Entrances

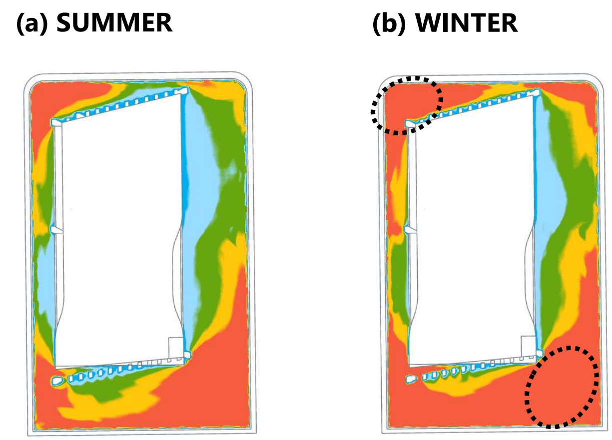


Image 10: Proposed wind conditions – LEVEL 7 – Amenity area

COMFORT: SITTING | STANDING | STROLLING | WALKING | UNCOMFORTABLE

SAFETY: Areas where the safety criterion is expected to be exceeded

4.3 Existing Scenario

The existing buildings on the site are low-rise, like the neighbouring buildings, and therefore will not redirect winds to create any notable impact. Wind conditions at most areas in the existing scenario are considered comfortable for standing in the summer (blue regions in Image 7a) and strolling/walking in the winter (green/yellow regions in Image 7b).

Wind conditions at all areas near the project site are expected to meet the safety criterion.

4.4 Proposed Scenarios

Overall, the addition of the proposed development is expected to increase the wind activity immediately around the site. During the summer, conditions are expected to become comfortable for walking and strolling, with uncomfortable conditions at the southeast and northwest corners of the proposed building (Image 8a). During the winter, wind conditions at most areas are expected to become uncomfortable, except the areas to the west and to the immediate east of the proposed tower (Image 8b).

Wind speeds in expanded areas near building corners are expected to exceed the wind safety criterion, as shown in Image 8b.

Wind control measures that could improve the wind conditions are:

- Rotating the tower to be aligned with the prevailing southwest winds.
- Incorporating multiple steps into the south and west façades to breakdown the energy of the downwashed winds before reaching the ground.
- Rounding/ tapering the edges of tower would streamline the wind flow and reduce the redirected winds toward the ground.
- Providing dense landscaping along the main sidewalks that include coniferous or marcescent species which are able to retain their foliage year-round and provide annual protection from winds.

4.4.1 Entrances

The main lobby entrance/drop-off area is located within the undercut to the east of the building which is well sheltered from the dominant winds. As a result, wind conditions comfortable for sitting are expected throughout the year, which is ideal (Images 9a and 9b).

Three commercial entrances are planned along the north façade. During the summer, wind conditions comfortable for sitting/standing are expected near this area (Image 9a). However, during the winter higher wind speeds that are comfortable for strolling/walking are predicted, which are higher than desirable for entrances. For improved wind conditions, it is recommended that entrances be recessed into the building façade. Alternatively, vertical wind screen elements (2.5 m tall and approximately 30% porous, if feasible) be positioned perpendicular to the façade at various locations to provide localized protection from horizontal winds. In addition, overhead features (such as canopies) are recommended to protect these areas from downwashed flows and other weather elements. Some examples are shown in Image 11.

4.4.2 Level 7 Amenity Area

Wind conditions on the podium at Level 7 are expected to be too windy for passive activity throughout the year with uncomfortable and potential wind safety exceedances at large areas of this level (Image 10). To improve the conditions on this level tall guardrails (2.5 - 3 m) along with planters/screens that are scattered throughout the area are recommended. Additionally, trellis/canopies are recommended near the tower base, especially at the northwest and southeast corners.

Some examples of wind control strategies for the above grade areas are illustrated in Image 12.

4. RESULTS AND DISCUSSION

Image 11: Design strategies for wind control at entrances

4. RESULTS AND DISCUSSION

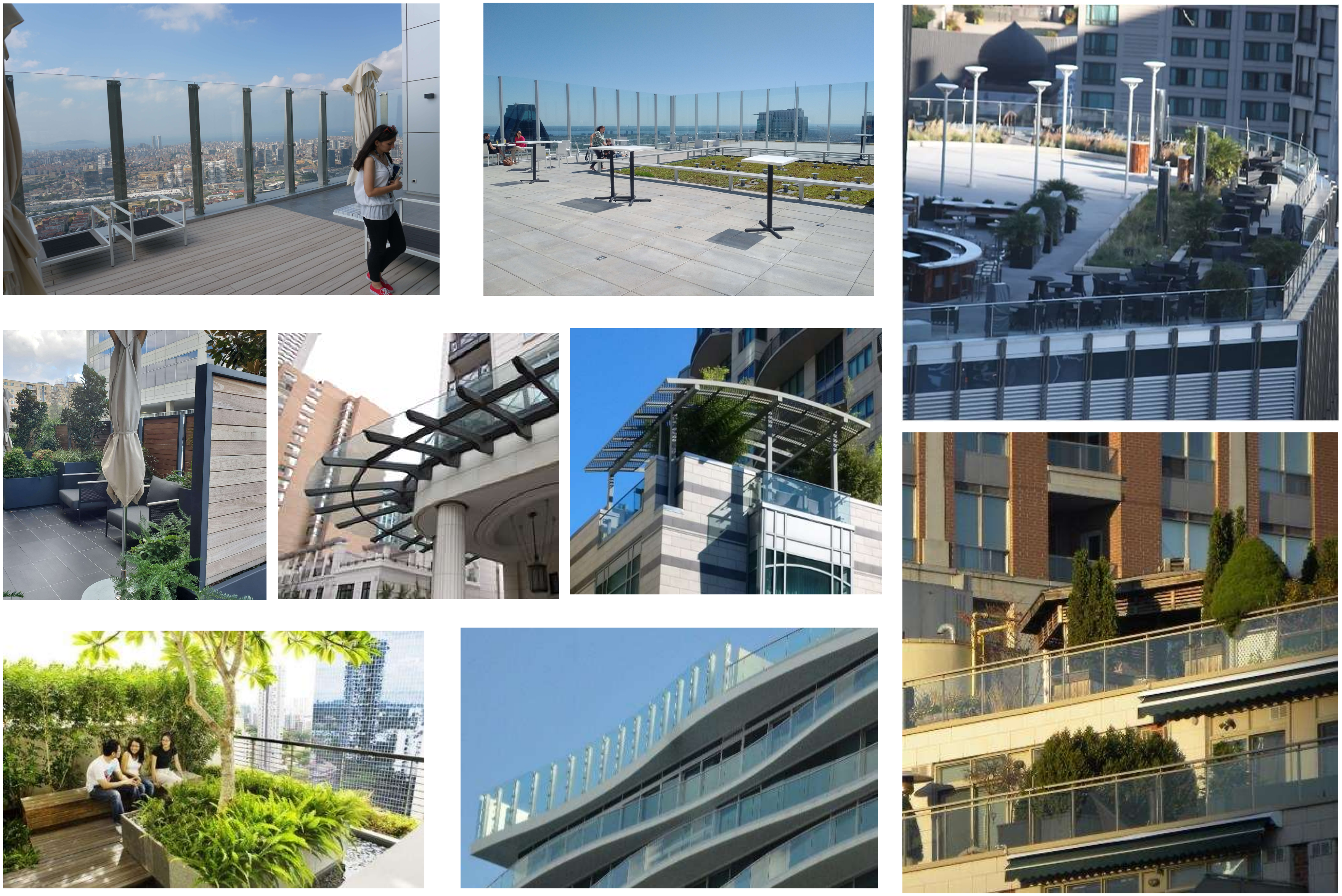


Image 12: Wind control strategies for level 7 amenity area

5. SUMMARY

RWDI was retained to provide an assessment of the potential pedestrian level wind impact of the proposed project at 5566 Robinson Street & 6158 Allendale Avenue (also known as Niagara-77) in Niagara Falls, Ontario. Our assessment was based on the local wind climate and the current design of the proposed development. Our findings are summarized as follows:

- The proposed tower is significantly taller than its surroundings, and therefore will redirect winds to ground level.
- Grade level wind conditions during the summer are expected to be comfortable for walking and strolling, with uncomfortable conditions near northwest and southeast corners of the building. During the winter, wind conditions at most locations are expected to become uncomfortable with potential wind safety exceedances.
- Positively, wind conditions near the entrance and drop-off area are expected to be suitable throughout the year due to the sheltering provided by the building and overhang. Wind speeds at the commercial entrances are suitable during the summer but higher than desired during the winter.
- Wind speeds on the Level 7 outdoor amenity area are predicted to be unsuitable for passive use in the summer. In addition, the comfort and safety limits might be exceeded at multiple areas of these outdoor amenity spaces.
- Improved wind conditions can be achieved at grade and on the above-grade areas through the use of various wind control approaches (massing modifications, hard and soft landscape elements such as trees, wind screens and trellises, etc.). RWDI can help guiding the placement of wind control features to achieve appropriate levels of wind comfort.
- Wind tunnel testing should be conducted as the design evolves to confirm the predicted wind conditions and evaluate the effectives of the recommended mitigation measures.

6. APPLICABILITY OF RESULTS

The assessment presented in this report is for the proposed project, based on the information provided by design team listed in the table below. In the event of any significant changes to the design, construction or operation of the building or addition of surroundings in the future, RWDI could provide an assessment of their impact on the pedestrian wind conditions discussed in this report. It is the responsibility of others to contact RWDI to initiate this process.

File Name	File Type	Date Received (mm/dd/yyyy)
121034 - Niagara77 - Site - revised - 2022.02.22.rvt	3D model	03/07/2022

7. REFERENCES

1. H. Wu, C.J. Williams, H.A. Baker and W.F. Waechter (2004), “Knowledge-based Desk-Top Analysis of Pedestrian Wind Conditions”, *ASCE Structure Congress 2004,* Nashville, Tennessee.

2. H. Wu and F. Kriksic (2012). “Designing for Pedestrian Comfort in Response to Local Climate”, *Journal of Wind Engineering and Industrial Aerodynamics*, vol.104-106, pp.397-407.

3. C.J. Williams, H. Wu, W.F. Waechter and H.A. Baker (1999), “Experience with Remedial Solutions to Control Pedestrian Wind Problems”, *10th International Conference on Wind Engineering*, Copenhagen, Denmark.