2150 LAKE SHORE BOULEVARD WEST

ETOBICOKE, ONTARIO

PEDESTRIAN WIND ASSESSMENT

PROJECT #2002887
MAY 8, 2020

SUBMITTED TO

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EXECUTIVE SUMMARY

RWDI was retained to provide an assessment of the potential pedestrian level wind impact of the proposed development 2150-2194 Lake Shore Boulevard West and 23 Park Lawn Rd (2150 Lake Shore Boulevard West) in Etobicoke, Ontario. Our assessment was based on the local wind climate, the design of the proposed development as received in April 2020, the existing surrounding buildings, and computational modeling and simulation of wind conditions.

Our findings are summarized as follows:

- Wind speeds during the summer season throughout all phases of the development are generally expected to be within acceptable levels.
- During the winter season, some grade level areas are expected to experience wind speeds that are higher than desired for the intended use of the space. This is due to local geometry and orientation of buildings with the prevailing wind directions.
- Wind conditions generally improve with the addition of each subsequent phase due to the increased blockage and sheltering provided.
- The computational model was devoid of any existing and proposed trees and planting and it provided a conservative prediction of wind conditions. It is expected that the addition of any landscaping elements would further improve wind comfort conditions at grade level.
- RWDI can help guide the placement of wind control features, including landscaping, to achieve appropriate levels of wind comfort based on the programming of the various outdoor spaces. A number of potential mitigation features have been proposed.
- If the timeline of the design phase allows, small modifications to the building massings may improve localized wind conditions.

The predicted wind conditions should be quantified and confirmed through detailed studies using wind tunnel tests at an advanced design stage, which will include the existing and proposed trees and plantings.

1. INTRODUCTION

Rowan Williams Davies & Irwin Inc. (RWDI) was retained to assess the potential pedestrian wind conditions around the proposed 2150 Lake Shore Boulevard West project in Etobicoke, Ontario. The objective of this assessment is to provide a preliminary and qualitative evaluation of the potential wind impact of the proposed development.

The Master Plan includes six distinct phases, as shown in Image 2. The fundamental vision and key elements of the Master Plan remain consistent, including:

- **Residential and Commercial Buildings:** the Master Plan includes a range of built form typologies including low, mid and high-rise buildings, fifteen towers ranging in height from 22 to 71 storeys.
- **An Integrated Transit Hub:** the new Park Lawn GO station is located along the northern edge of the site, with the platform spanning the Park Lawn Road right of way and a direct interface with the redeveloped site. A TTC streetcar loop is proposed to bring streetcars into the site, integrating directly with the GO station.
- **The Relief Road:** a new relief road (Street A) is proposed along the northern edge of the site, connecting the Park Lawn Road Gardiner access ramp with the Gardiner ramp to the east.
- **New Local Street Network**: new internal streets extend from the surrounding street network, responding to the unusual shape of this large site to create a loop road (Street B) with spokes that will draw transit vehicles, cars, pedestrians and bikes into the site, and create a multi-modal transit node at the GO station.
- **Diverse Open Space Network:** a range of new interconnected open spaces are proposed across the site, including a new public park, two large squares, a covered galleria and a series of groves, largos (enlarged sidewalks), lanes and mews.
- **The Galleria:** the galleria functions as a covered pedestrian street lined with a variety of retail, services and amenities.
- **Employment, Retail Services & Entertainment**: 64,392 m^2 of employment / office gross floor area (GFA) is included in the Master Plan, creating a significant cluster of new office-type jobs at the GO Station and within the galleria.

Image 1: Aerial View of the Existing Site and Surroundings
Credit: Google Maps

1. INTRODUCTION

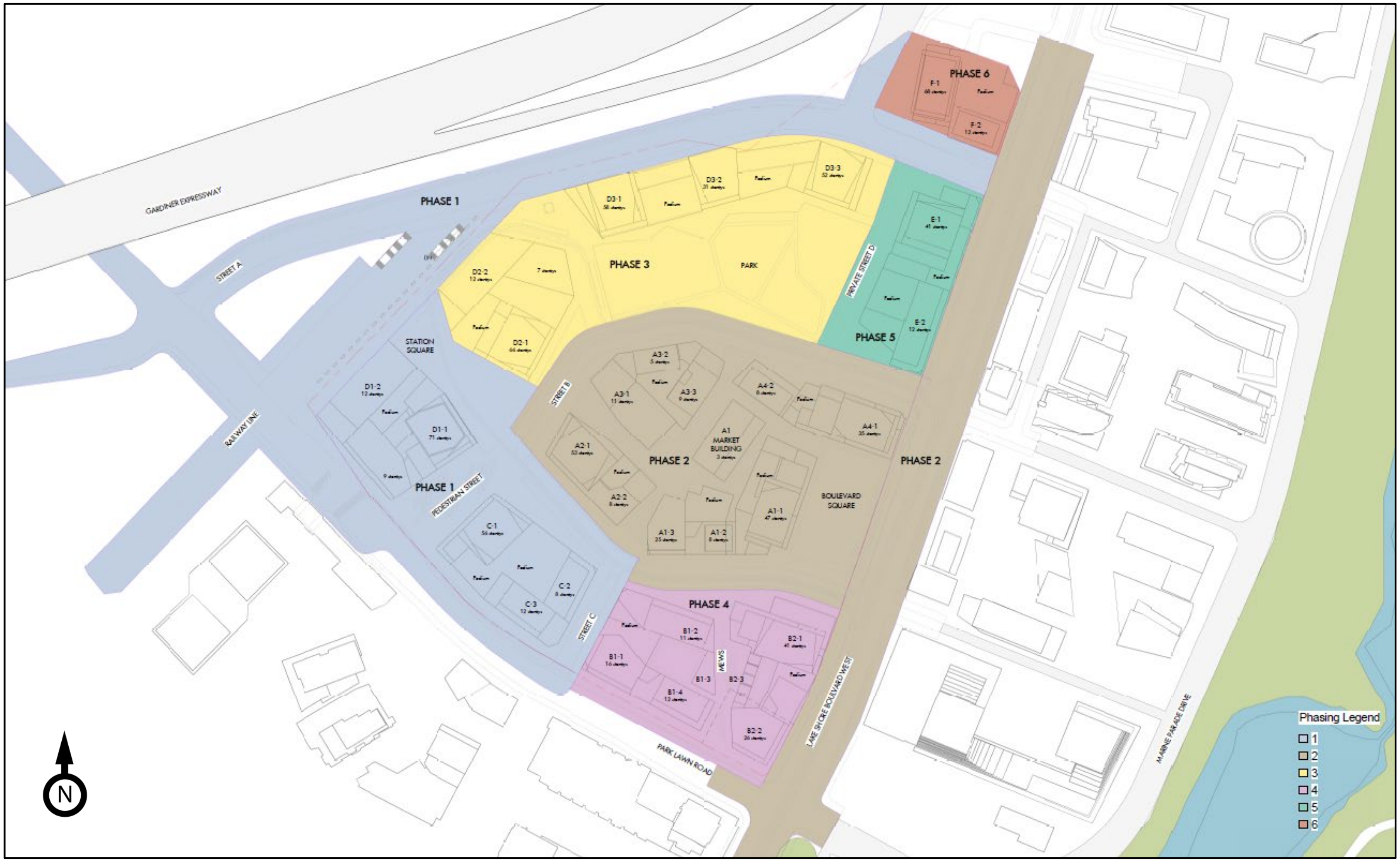

Image 2: Site Phasing Plan

2. METHODOLOGY

The objective of this assessment is to provide a preliminary and qualitative evaluation of the potential wind impact of the proposed development. The assessment is based on the following:

- A review of the regional long-term meteorological data from Billy Bishop Toronto City Airport;
- 3D e-model of the proposed project received by RWDI on April 2, 2020;
- The use of Orbital Stack, an in-house computational fluid dynamics (CFD) tool, to aid in visualization of general wind-flow patterns for a qualitative wind assessment;
- The use of RWDI's proprietary tool *WindEstimator*[2] for estimating the potential wind conditions around generalized building forms;
- Pedestrian Wind Comfort studies completed by RWDI for similar projects; and,
- Our engineering judgment, experience and expert knowledge of wind flows around buildings[1-3];

This qualitative approach provides a preliminary computational assessment of expected pedestrian wind conditions and identifies areas of accelerated or lower wind speeds. In order to confirm and quantify potential wind conditions and refine any conceptual mitigation measures, physical scale-model tests in a boundary-layer wind tunnel may be performed at a later design stage.

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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.

2. METHODOLOGY

2.1 Simulation Model

Wind flows around the proposed development and existing surroundings were simulated using *Orbital Stack*, an in-house computational fluid dynamics (CFD) tool.

The computer model of the proposed development used for the simulation is shown in Image 4. For the purposes of this computational study, the 3D model was simplified to include only the necessary building and terrain massing details that would affect the local wind flows in the area and 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 discussion of results do, however, account for the effect of landscaping, considering the significant density and extent proposed landscaping on and around the project.

The mean wind speed profile 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 mean speeds at approximately 1.5 m above ground and other concerned areas, to mean wind speed at a reference height were obtained. The data was then combined with meteorological records obtained from Billy Bishop Toronto City Airport.

As the project progresses, a wind tunnel study is suggested to quantify the effect of winds accounting for greater design detail (e.g. landscaping).

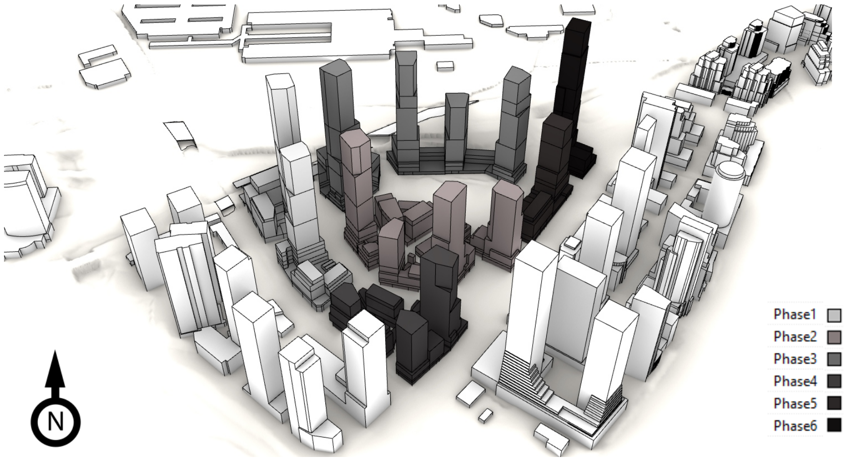


Image 3: Computer Model of the Proposed Project and Surroundings

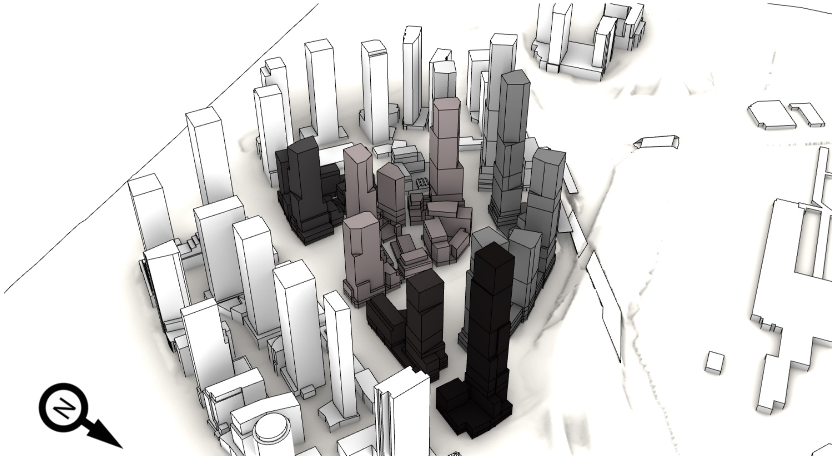
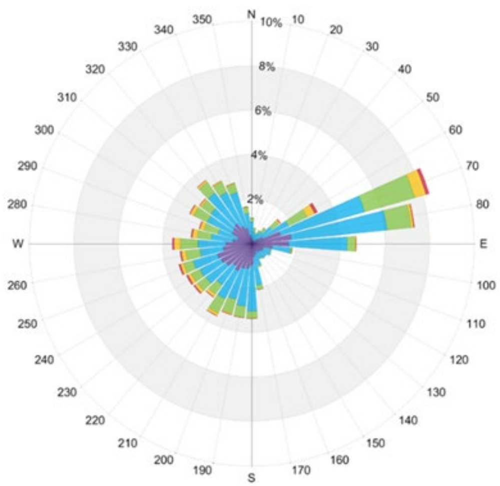


Image 4: Computer Model of the Proposed Project and Surroundings

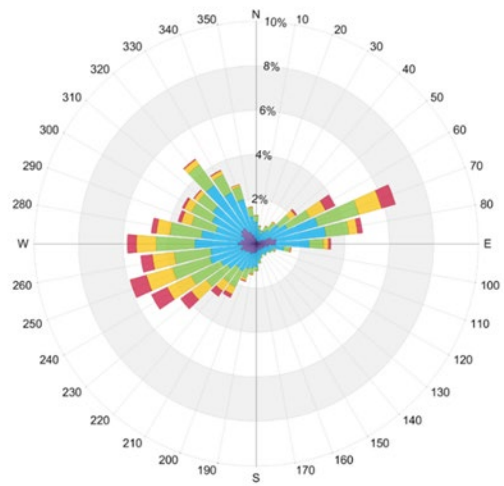
2.2 Meteorological Data

Wind statistics recorded at Billy Bishop Toronto City Airport between 1988 and 2018, inclusive, were analyzed for the Summer (May through October) and Winter (November through April) seasons. Image 3 graphically depicts the directional distributions of wind frequencies and speeds for these two seasons. Winds from the southwest and northeast directions are predominant in the summer and winter seasons 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 10 m) occur for 4.3% and 17.3% of the time during the summer and winter seasons, respectively, and they are primarily from the west-southwest and east-northeast directions.

Wind statistics were combined with the wind tunnel data to predict the frequency of occurrence of full-scale wind speeds. The full-scale wind predictions were then compared with the wind criteria for pedestrian comfort and safety.



Summer (May through October)



Winter (November through April)

Wind Speed (km/h)	Probability (%) Summer	Probability (%) Winter
Calm	5.7	2.7
1-10	30.6	17.2
11-20	43.4	38.0
21-30	16.0	25.0
31-40	3.4	11.4
>40	0.9	5.9

Image 5: Directional Distribution of Winds Approaching Billy Bishop Toronto City Airport from 1988 to 2018

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 Safety Criterion

Wind 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 (**90 km/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 can be categorized by typical pedestrian activities:

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., 1.5 m above grade or the concerned floor level), typically lower than those recorded in the airport (10 m 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.

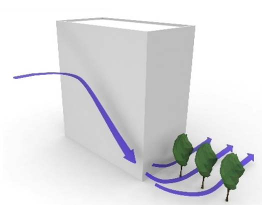
For the current development, wind speeds comfortable for walking or strolling are appropriate for sidewalks and parking areas where pedestrians are likely to be active and moving intentionally, and calm wind speeds suitable for sitting are desired in areas where prolonged periods of passive activities are anticipated, such as outdoor amenity areas.

4. RESULTS AND DISCUSSION

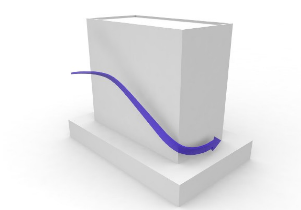
4.1 Wind Flow Around Buildings

Taller buildings can have the tendency to redirect winds downwards significantly which can cause adverse wind conditions at pedestrian areas. Particularly, in relatively open surroundings, buildings tend to intercept and redirect winds around them in this way. 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. Large groups of built structures of similar or greater height compared to the project, and dense cluster of tall trees help diffuse wind flow and shelter the site to a great extent. These flow patterns are illustrated in Image 6.

Downwashing and Corner Acceleration



Wind control effect of trees



Wind control effect of podiums

Image 6: Generalized Wind Flows

4.2 Simulation Results

The results of the simulations done without trees and landscaping, for the summer and winter season, are presented in Image 8 through 12, as still images of color contours of predicted wind speed ranges. The results correspond to a horizontal plane approximately 1.5 metres above the concerned level. These results are for the average wind condition; actual wind speeds vary with time. The conditions presented are approximate and intended for reference. The following color scale is used for representation of wind conditions against the pedestrian wind comfort criteria:

Blue regions represent low wind speed areas comfortable for sitting or standing; green indicates medium wind speeds comfortable for strolling, and yellow regions are associated with higher winds speeds comfortable for walking. The orange and red regions are associated with the highest wind speed regions that may not be suitable for pedestrian usage.

Large clusters of trees (such as in gardens), wind screens, and other tall features help reduce wind speeds around it (Image 6). It is understood that the proposed development is to be landscaped extensively with large trees. Although landscaping was not included in the simulation, the potential effect has been discussed in the discussion of results in the following sections.

4. RESULTS AND DISCUSSION

4.3 Simulation Configurations

The development was evaluated in stages consistent with the site phasing plan as shown in Image 7. A total of five configurations were assessed,

- Configuration #1 – Existing Site
- Configuration #2 – Phase 1 of the Proposed Development
- Configuration #3 - Phases 1 and 2 of the Proposed Development
- Configuration #4 – Phases 1, 2 and 3 of the Proposed Development
- Configuration #5 – Phases 1, 2, 3, 4, 5 and 6 of the Proposed Development

The above configurations are cumulative, with each phase building upon the last.

The results from these simulations are presented in Images 8 through 12 in Section 4.4, showing the comfort conditions for both the summer and winter seasons for each configuration.

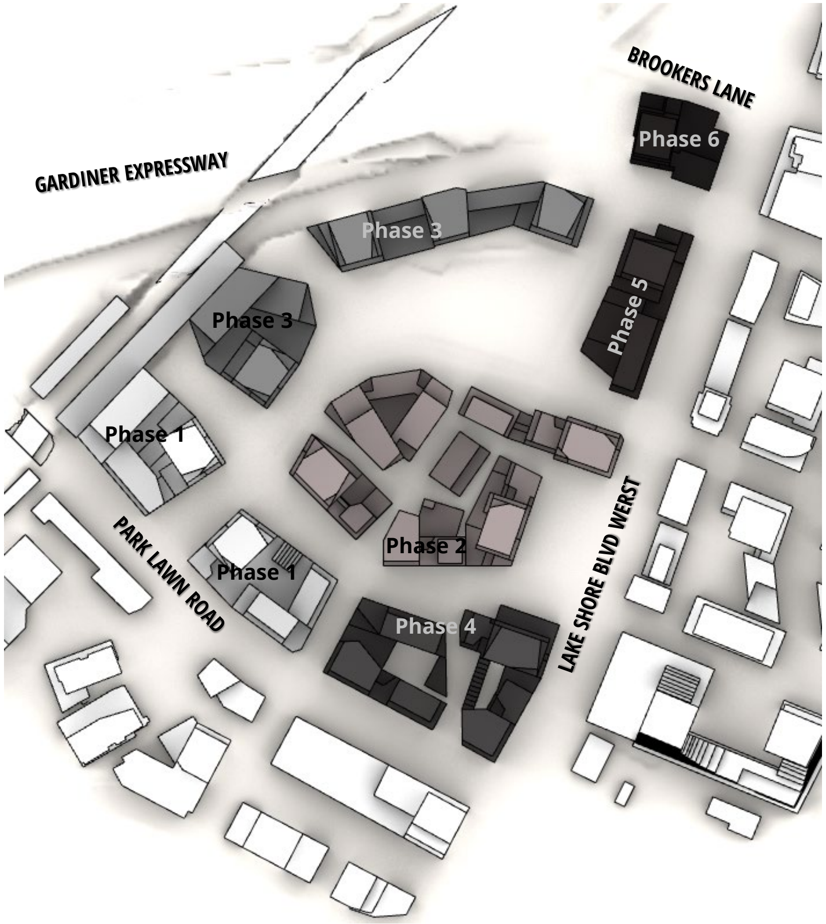


Image 7: CFD Rendering of Site Phasing Plan

4. RESULTS AND DISCUSSION

4.4 Wind Comfort and Safety Conditions

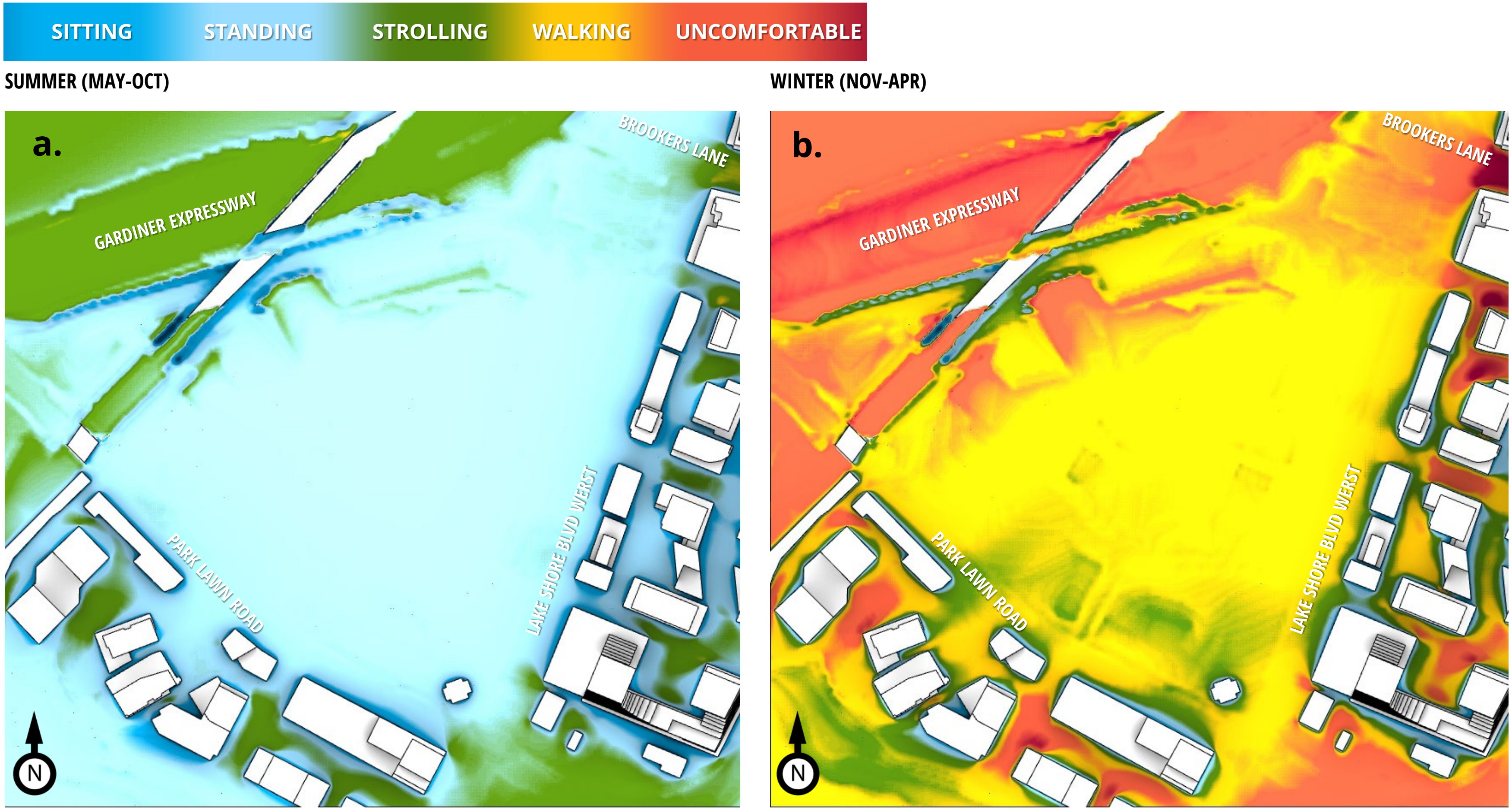


Image 8: Predicted Wind Conditions For Configuration #1 – Existing Site

4. RESULTS AND DISCUSSION

4.4 Wind Comfort and Safety Conditions

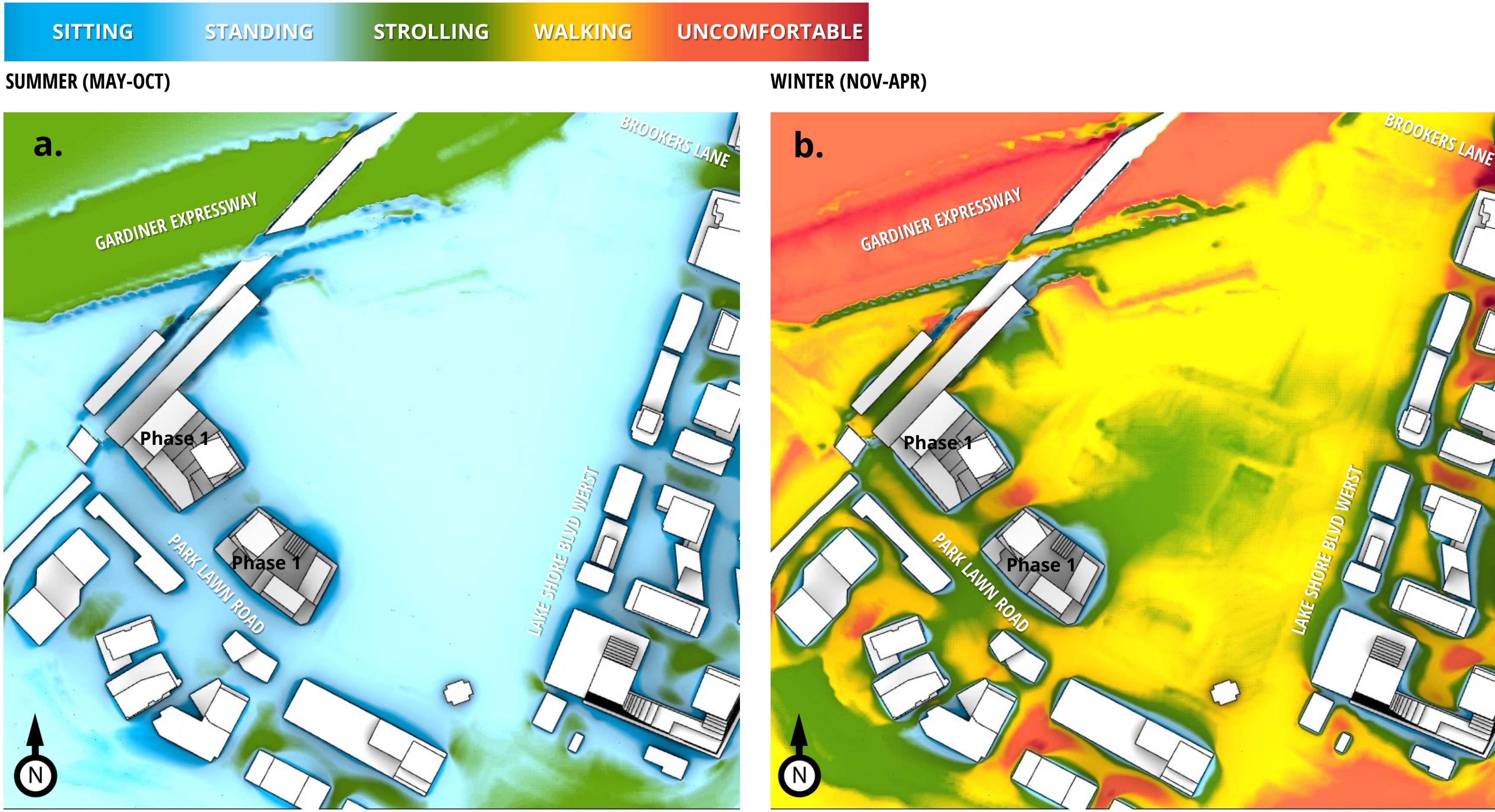


Image 9: Predicted Mean Wind Conditions For Configuration #2 – Phase 1 of the Proposed Development

4.4 Wind Comfort and Safety Conditions

SITTING STANDING STROLLING WALKING UNCOMFORTABLE

SUMMER (MAY-OCT) **WINTER (NOV-APR)**

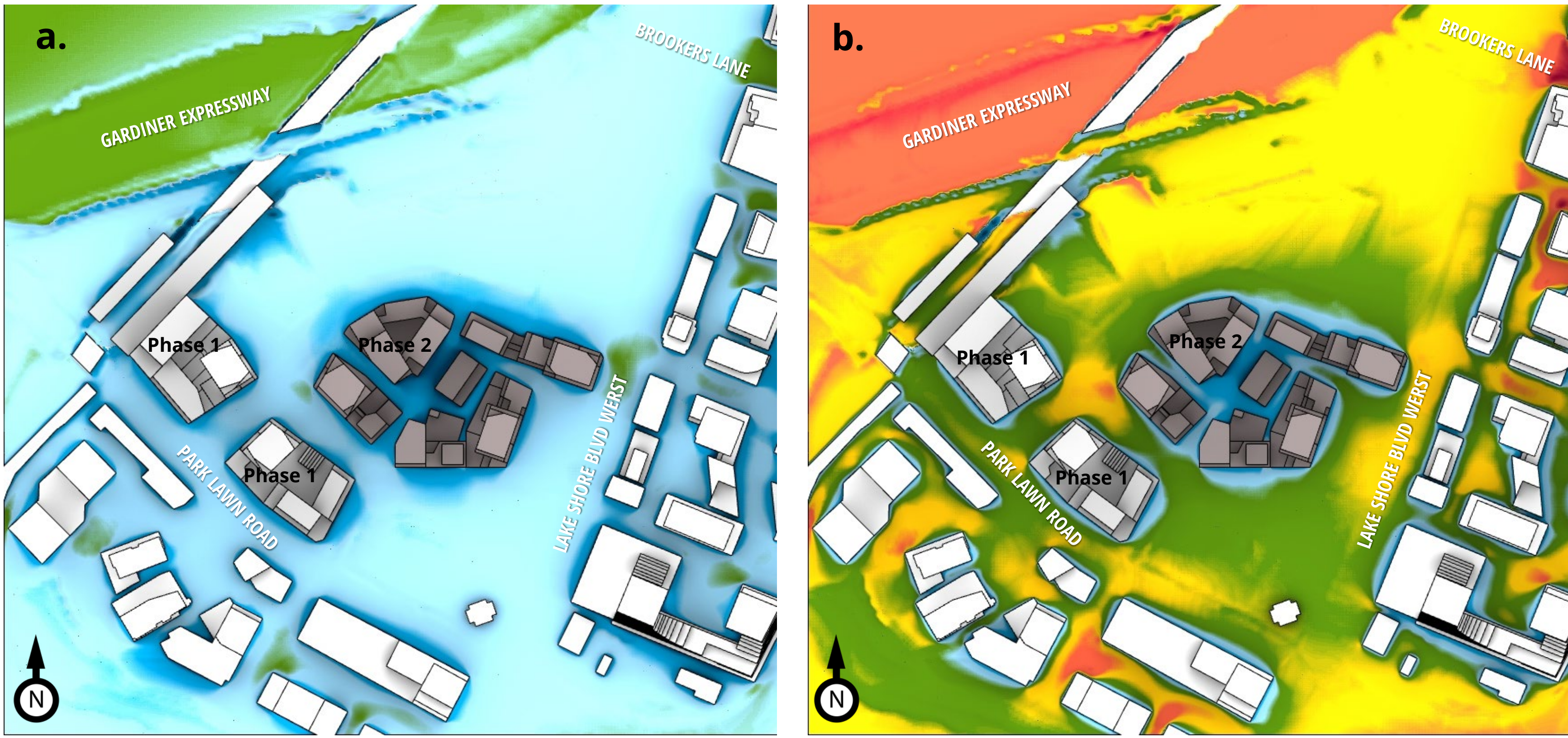


Image 10: Predicted Mean Wind Conditions For Configuration #3 - Phases 1 and 2 of the Proposed Development

4. RESULTS AND DISCUSSION

4.4 Wind Comfort and Safety Conditions

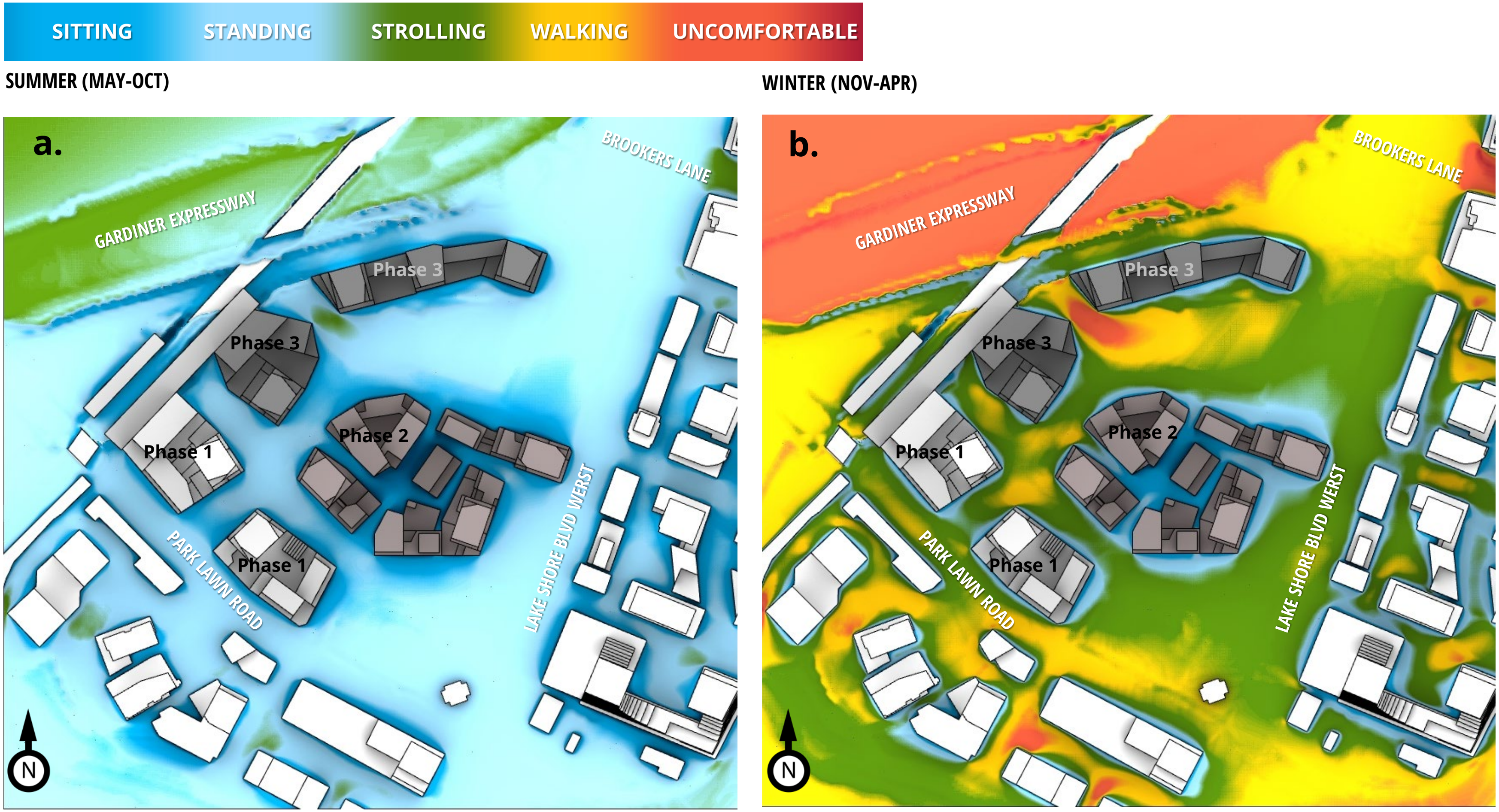


Image 11: Predicted Mean Wind Conditions For Configuration #4 – Phases 1, 2 and 3 of the Proposed Development

4. RESULTS AND DISCUSSION

4.4 Wind Comfort and Safety Conditions

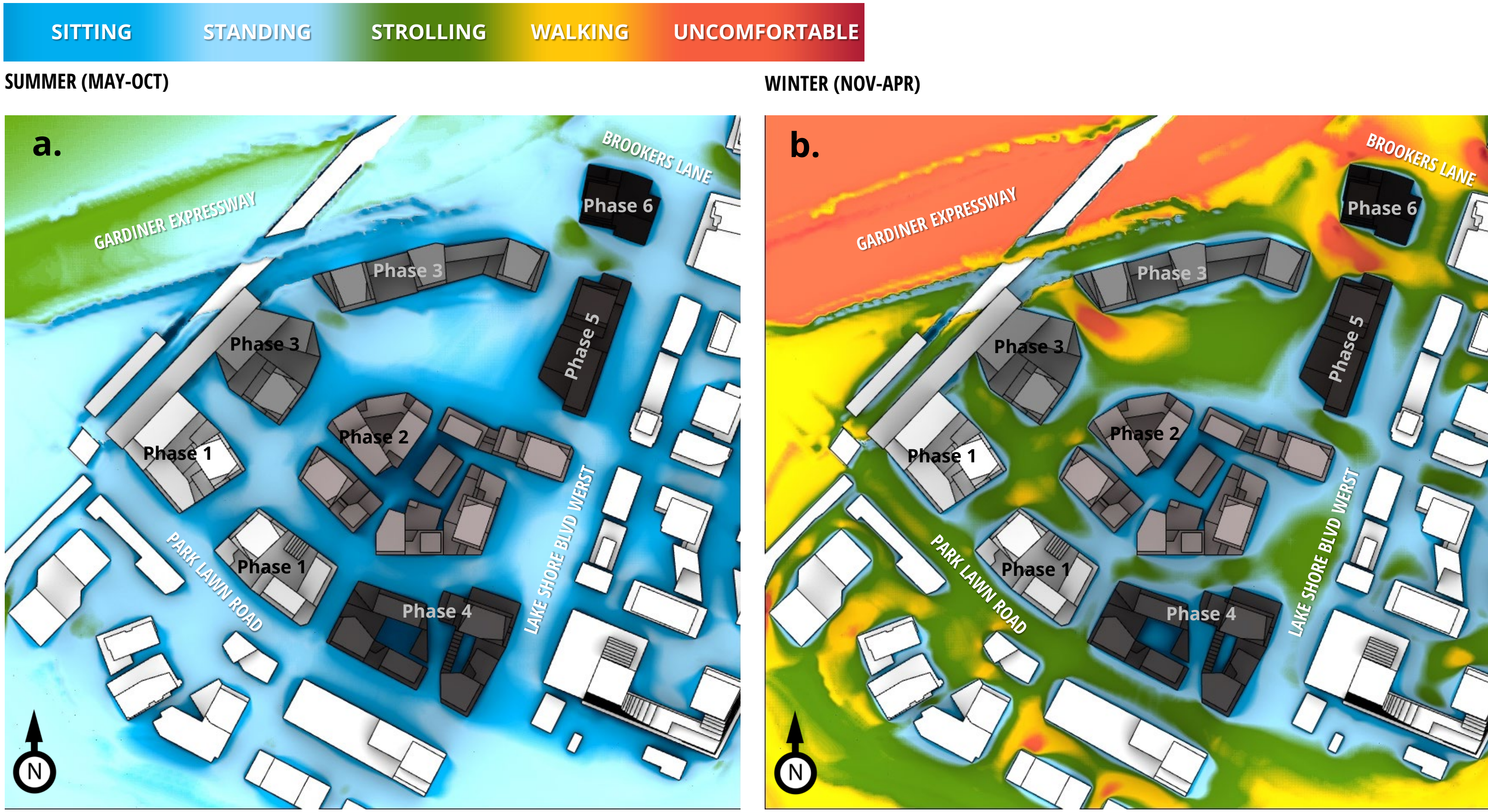


Image 12: Predicted Mean Wind Conditions For Configuration #5 – Phases 1, 2, 3, 4, 5 and 6 of the Proposed Development

4. RESULTS AND DISCUSSION

4.4 Wind Comfort and Safety Conditions

4.4.1 Existing Configuration

Due to the presence of high and mid rise surroundings which are mostly position upwind of the predominant wind directions, the existing wind conditions on site and at surrounding sidewalks along Park Lawn Road and Lake Shore Boulevard are comfortable for sitting or standing during the summer season (Image 8a). During the winter, seasonally stronger winds with slightly higher wind speeds result in conditions that are anticipated to be mostly suitable for walking (Image 8b). These wind conditions are considered appropriate for the intended use of the existing space.

4.4.2 Phase 1 Configuration

With the addition of the proposed development, wind conditions at some locations improve due to the sheltering that the development will provide from the prevailing wind directions.

With the addition of the proposed Phase 1 (buildings C-1, C-2, C-3, D1-1 and D1-2) localized areas of higher wind speeds are predicted around the towers due to a combination of downwashing and corner wrapping wind flows (Images 9a and 9b). Wind conditions during the summer season, devoid of any landscaping, are expected to be suitable for the intended use of the spaces. During the winter season, wind conditions at grade level are generally expected to increase by approximately one comfort category due to stronger seasonal winds. At the location between towers D-1 and C-1 (annotated as area A in Image 13), wind speeds may be uncomfortable and localized mitigation features should be considered, as discussed in Section 4.6.

Wind speeds that exceed the wind safety criterion may be possible between these two towers due to a combination of channeling and downwashing wind flows, and it is recommended that this area be investigated further during a wind tunnel test.

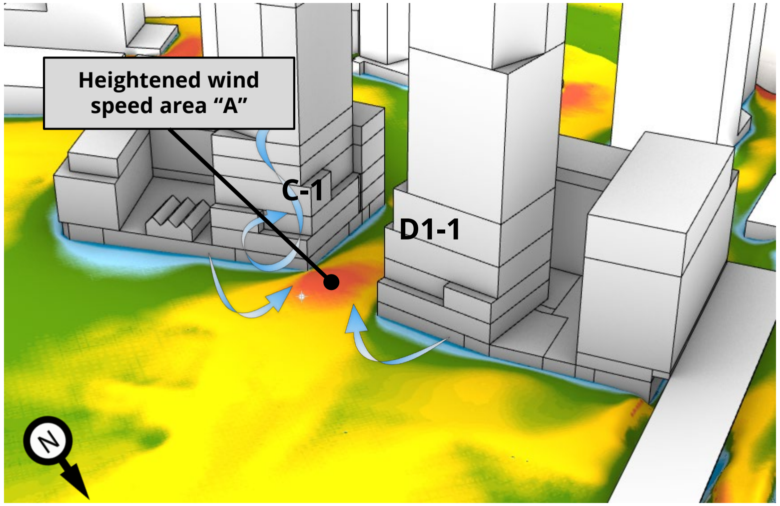


Image 13: Phase 1 Configuration (Winter Season)

4.4 Wind Comfort and Safety Conditions

4.4.3 Phase 1 + 2 Configuration

With the addition of the Phase 2 towers most grade level wind conditions are impacted minimally in the surrounding spaces, with conditions in the summer season (Image 10a) mostly suitable for standing. Sitting conditions in central courtyard spaces of Phase 2 where significant sheltering is offered is anticipated. In general, wind comfort conditions around the Phase 1 towers improve due to the sheltering provided by the presence of Phase 2. In the winter season (Image 10b), wind speeds generally increase by about one comfort category where the space is openly exposed to the prevailing winds, with most open areas expected to be comfortable for walking or strolling. Where more significant sheltering exists, such as the spaces between the Phase 2 buildings, comfort conditions are expected to be more suitable for sitting and standing. At the southwest corner of building A2-1 (annotated as area "B" in Image 14) wind conditions may be less desirable due to corner accelerating and downwashing flows, and may be uncomfortable. Conceptual mitigation features for this area are presented in Section 4.6.

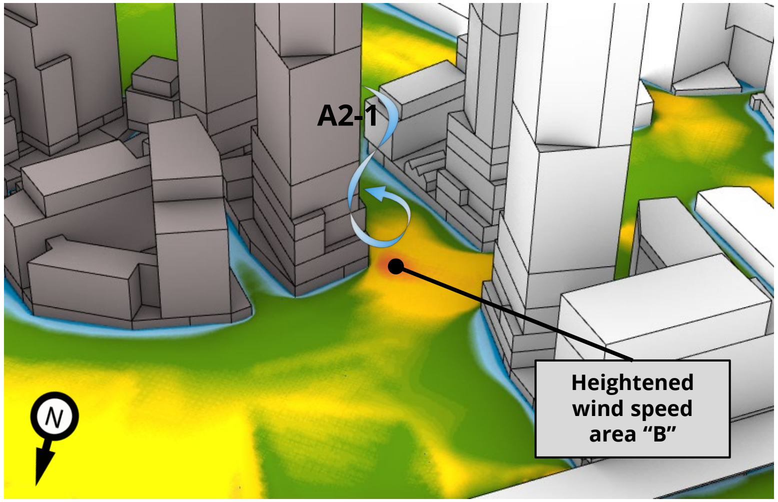


Image 14: Phase 1 + 2 Configuration (Winter Season)

4.4.4 Phase 1 + 2 + 3 Configuration

With the addition of Phase 3, wind conditions in most areas are generally similar to the Phase 2 configuration. However, one notable area of heightened wind speeds is the space between the two buildings of Phase 3 (area "C" in Image 15). Higher wind speeds at this area are the result of a strong channeling flow between the two buildings due to open exposure to the prevailing wind, and conditions are expected to be strolling during the summer and uncomfortable or potentially unsafe during the winter. Potential wind mitigation solutions are discussed in Section 4.6.

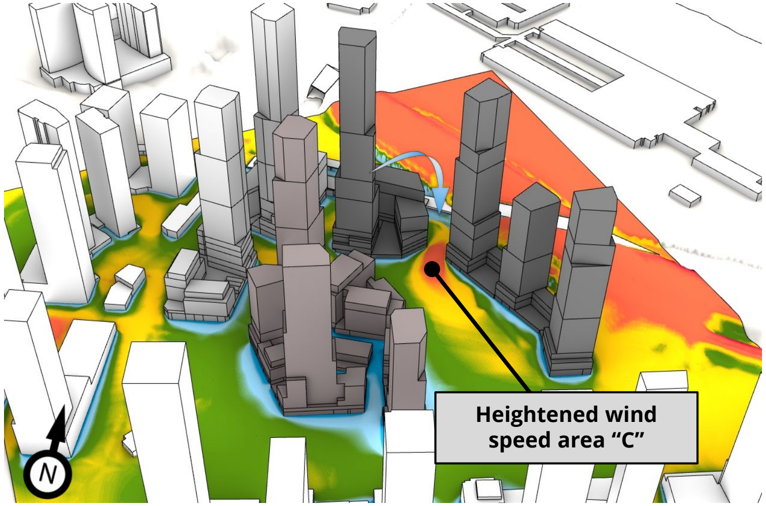


Image 15: Phase 1 + 2 + 3 Configuration (Winter Season)

4.4 Wind Comfort and Safety Conditions

4.4.5 Full Build Configuration

In general it is expected that with each additional phase of the development, wind conditions improve at most areas due to the added sheltering and blockage provided by the buildings.

With the addition of Phases 4, 5 and 6, wind conditions in the summer season are expected to be mostly suitable for sitting or standing (Image 12a). Notably, the addition of Phase 4 at the south corner of the development provides a significant blockage from prevailing winds from the southwest, resulting in calmer conditions directly adjacent to Phase 1 and Phase 2 in both seasons. The addition of Phase 4 is also expected to provide some improved conditions at off-site areas nearest to the existing development at 2183 Lake Shore Boulevard West (directly across Lake Shore Boulevard from Phase 4). Similarly, due to the increased blockage provided by Phase 5 and 6, wind conditions at the space directly southwest of Building D3-1 are expected to improve slightly.

During the winter season (Image 12b), wind speeds around the site are expected to increase resulting in wind conditions that are generally one comfort category higher, similar to the other configurations tested. As a result of exposure to the southwesterly winds, high wind speeds with uncomfortable conditions and potentially unsafe speeds are expected are the area between Phases 3, 5 and 6 buildings and to the north of Phase 6 (regions marked as “D” and “E” in Image 16). This is due to winds downwashing off the tall facades and accelerating around the corners and between the neighbouring buildings. These localized regions of higher wind speeds can be improved by making use of strategic placement of landscaping elements and other wind mitigation features (canopies, trellises, windscreens, etc.), and are detailed in Section 4.6. It is recommended that a wind tunnel study be performed, to investigate the influence of landscaping on these higher wind speed areas that could potentially be unsafe.

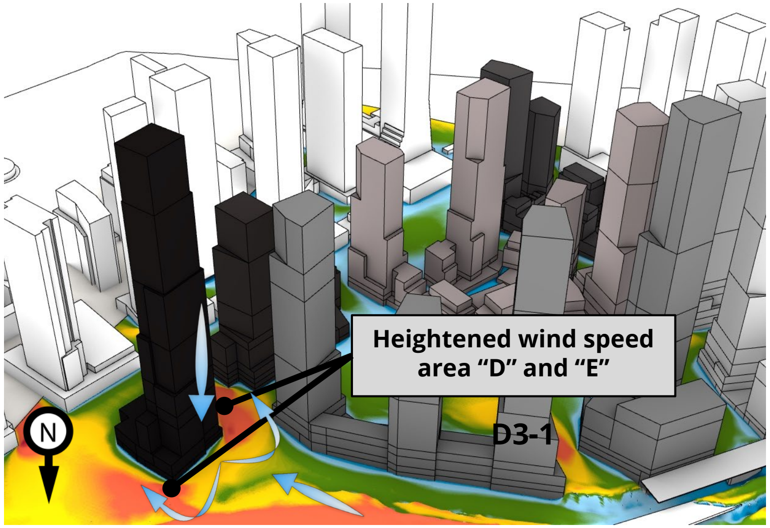


Image 16: Full Build Configuration (Winter Season)

4.5 Landscaping Features

It is RWDI's understanding that an extensive landscaping plan will be included in the master plan. This landscaping plan makes use of the placement of a number of deciduous and coniferous species trees, together with other green landscaping. This is a positive design feature from a wind condition perspective, and it is recommended to be kept in the final design.

The Computational Fluid Dynamic study was performed without landscaping features to establish a baseline condition. It is expected that a reasonable improvement in the general conditions would be made with the inclusion of the described landscaping shown in Image 17.

At some locations unique wind flows may be present, and additional more localized wind mitigation features are recommended. These features are described in Section 4.6, for heightened wind speed areas "A", "B", "C" , "D" and "E" (annotated on Image 17). Uncomfortable wind conditions typically occur during the winter months (Images 8b through 12b), and as such it is recommended that landscaping be of a coniferous species at these areas to provide most protection in that season.

As the design progresses, RWDI can help guide the placement of wind control features to ensure comfortable conditions based on the intended programming of the various spaces.

Image 17: Proposed Building Rotation

4.6 Conceptual Wind Mitigation Features

The following wind mitigation measures can be implemented to improve the conditions at areas where accelerated winds are predicted.

RWDI understands that a number of the buildings in the development include steps on the building face as well as podiums. Adding more, or including the following changes are recommended if possible;

1. Implementing a deep stepped façade as shown in Image 19 can help to deflect winds accelerating down the facades away from the ground. To be beneficial, these stepped facades should be implemented along the facades which face the prevailing wind directions described in Image 5.

2. Increasing the depth of any podium is generally beneficial in preventing downwashing winds from reaching the grade level. It is recommended that any building step near grade level be at least 10m deep.

Uncomfortable wind conditions are predicted during the winter at the area between the two buildings of Phase 1 (Region A, in the absence of other phases) and at the corner of the west tower of Phase 2 (Region B, in the absence of Phases 3, 4, 5 and 6). The following additions are recommended at these two areas If improve conditions are desired prior to completion of other phases;

1. Corner canopies should be added at the building corners of the future intersection to prevent downwashing wind flows from reaching grade. These canopies should be sufficiently high off the ground, and deep. It is recommended that wind tunnel testing be used to confirm effective dimensions. Canopy locations are shown in Image 20.

Image 18: Examples of Building Canopies

Image 19: Examples of Stepped Facades and Podiums

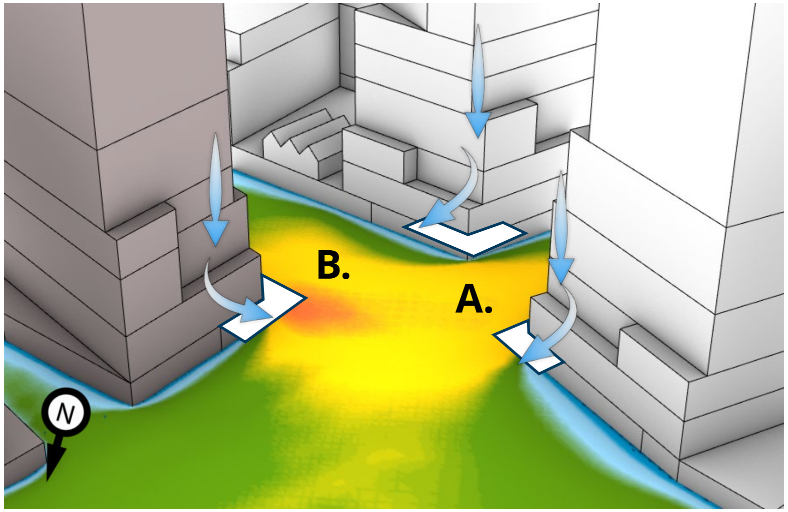


Image 20: Proposed locations for mitigation measures at locations “A” and “B”

4. RESULTS AND DISCUSSION

We recommend installing canopies at area "C"" as well increasing the building step depth at that location. Corner wrapping canopies are also recommended at location "D" and "E". Due to the open exposure to the northwest, these higher wind speeds areas are expected to persist due to lack of shelter from that direction. Such canopy elements will help to deflect winds accelerating down the tower, away from the ground. Suggested locations for canopies are shown in Image 21 and 22. Examples of canopies and building steps are shown in Image 23.

Porous wind screens can also be implemented at these building corners to provide localized blockage of corner accelerating winds. Examples of such features are shown in Image 23. If windscreens are implemented, the following recommendations should be considered;

- Windscreens should be at least 2m tall and face the direction of the prevailing winds.
- Windscreens should be at most 30% porous to provide sufficient blockage.

Similarly, grade level landscaping such as trees or large bushes can be used to provide similar sheltering from the wind, however as described previously, these green landscaping elements should be of coniferous species to provide protection throughout the year. Examples are shown in Image 23.

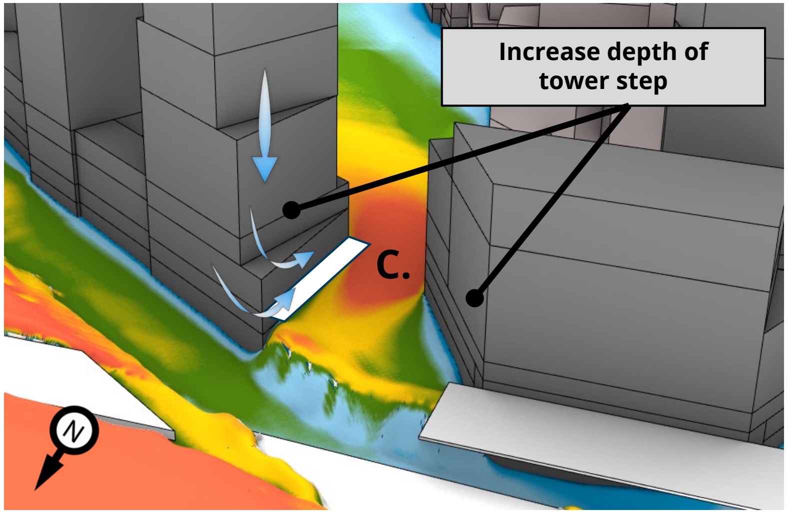


Image 21: Proposed locations for mitigation measures at location "C"

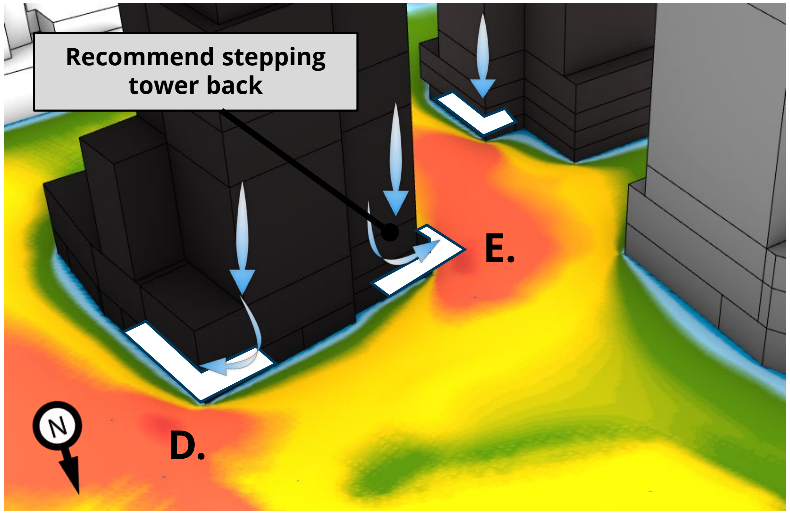


Image 22: Proposed locations for mitigation measures at locations "D" and "E"

4. RESULTS AND DISCUSSION

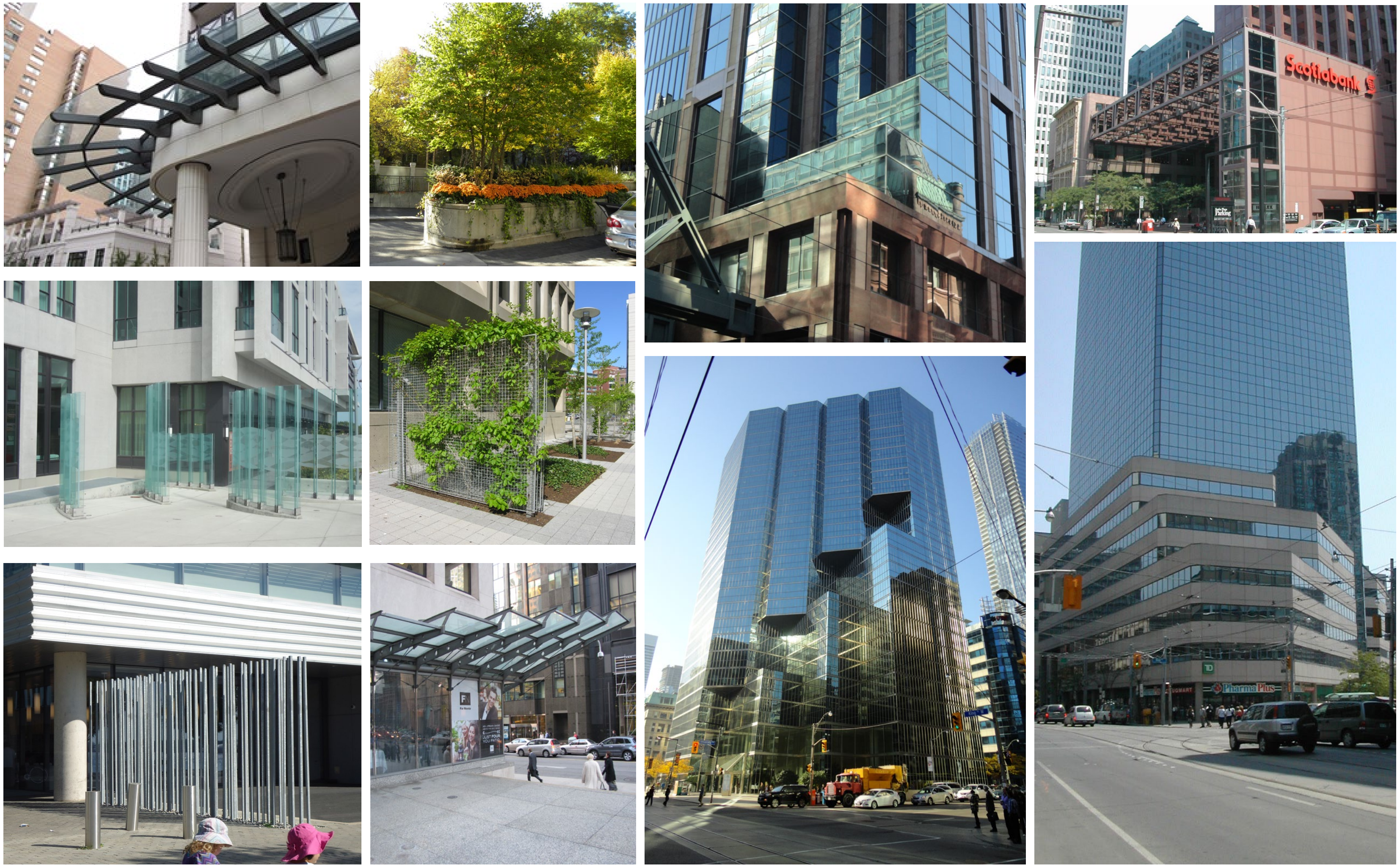


Image 23: Examples of recommended canopies at building corners, windscreens, soft landscaping and building massing steps

6. APPLICABILITY OF RESULTS

The assessment presented in this report are for the proposed 210 Lake Shore Boulevard West project based on the information provided by design team on April 2, 2020.

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.