Appleby Mall

Burlington, Ontario

Pedestrian Wind Assessment

RWDI # 1400281
November 5, 2013



SUBMITTED TO

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1. INTRODUCTION

Rowan Williams Davies & Irwin Inc. (RWDI) was retained by First Capital Realty to assess the wind comfort conditions for the proposed Appleby Mall development in Burlington, Ontario. The development consists of two residential towers at the north end of the shopping mall, as shown in the aerial photo at right.

The objective of this assessment is to provide a qualitative evaluation of pedestrian wind comfort conditions around the proposed development. Conceptual mitigation measures to improve wind comfort have been recommended, where necessary. This qualitative assessment is based on the following:

- a review of regional long-term meteorological data;
- previous wind studies undertaken by RWDI in the Burlington area;
- design drawings and renderings received by RWDI on September 9 and October 11, 2013;
- our engineering judgment and knowledge of wind flows around buildings[1-3]; and
- use of software developed by RWDI (*WindEstimator*[2]) for estimating the potential wind conditions around generalized building forms.

This qualitative approach provides a screening-level estimation of potential wind conditions. To quantify these conditions or refine any conceptual mitigation measures, physical scale model tests would typically be required.

Note that other wind issues, such as those relating to wind-induced cladding and structural loads, door pressures, stack effect, exhaust re-entrainment, snow drifting, etc. are not considered in the scope of the assessment.



Aerial Photograph of Existing Site and Surroundings
(Courtesy of Google earth™, dated August 31, 2009)

1. 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.
2. 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.
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.

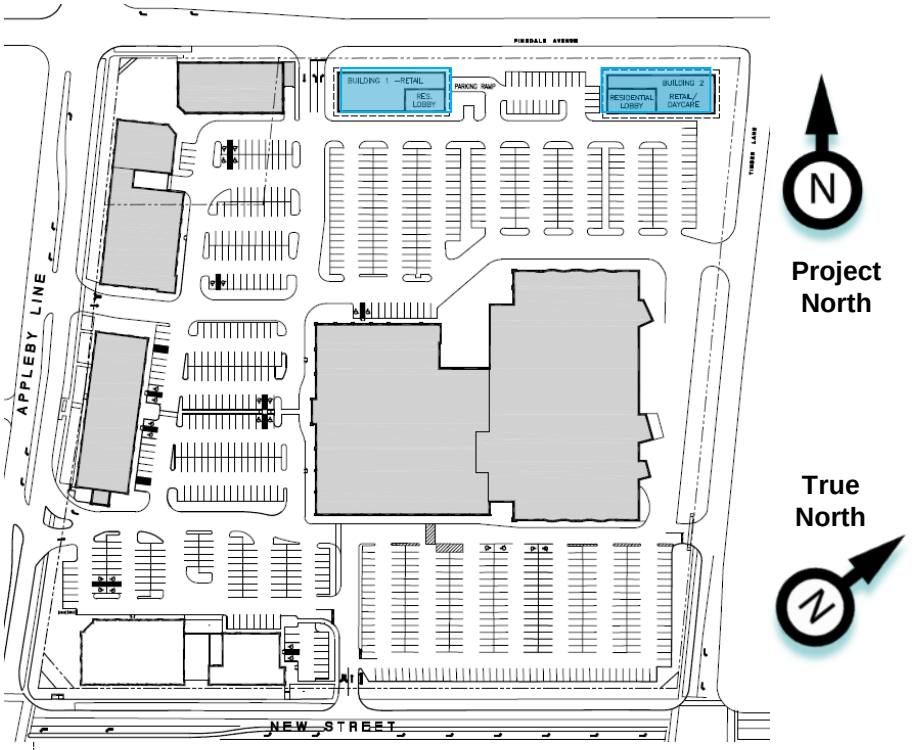
2. BUILDING AND SITE INFORMATION

In this report, orientation of buildings and streets refers to project north and wind directions are based on true north. They differ by approximately 50 degrees, as shown in the context plan at right.

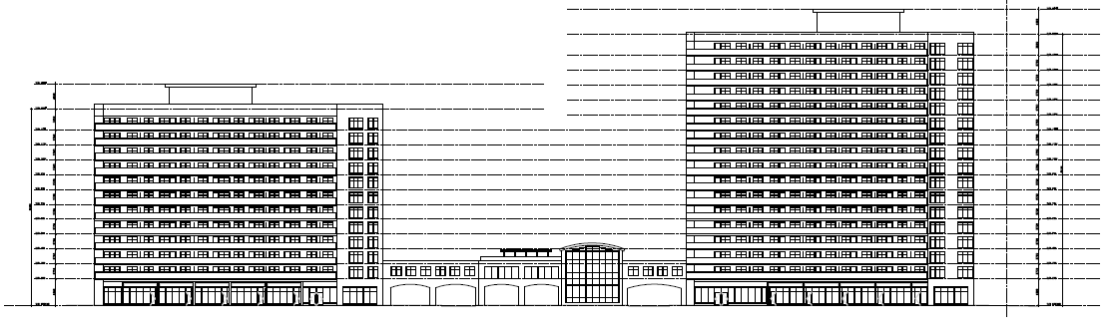
The proposed development consists of two residential towers of 12 and 17 storeys (see image below). They both have a rectangular floor plate, located along Pinedale Avenue at the north end of Appleby Mall.

Pedestrian areas on and around the development include building entrances, sidewalks and parking spaces.

The context plan shows the current and proposed buildings on the mall property, which are considerably different from those in the aerial photo dated on August 31, 2009 on the previous page. Besides these low buildings, other buildings in the surrounding areas are also low in all directions, except to the east, where high-rise buildings are located along Pinedale Avenue. Lake Ontario is located approximately 1500 m to the south and east.



Context Plan



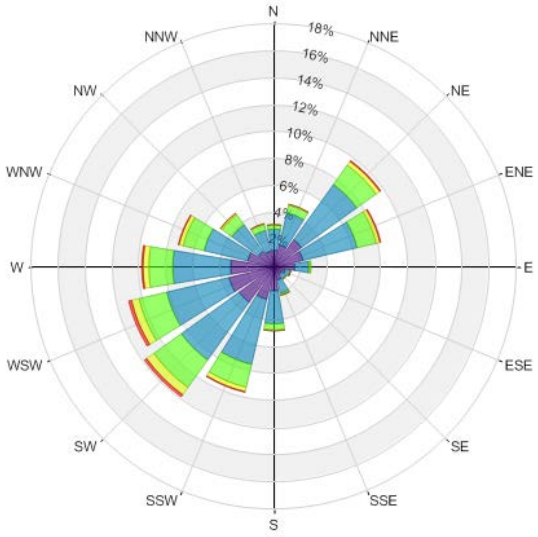
South Elevation of the Proposed Buildings

3. METEOROLOGICAL DATA

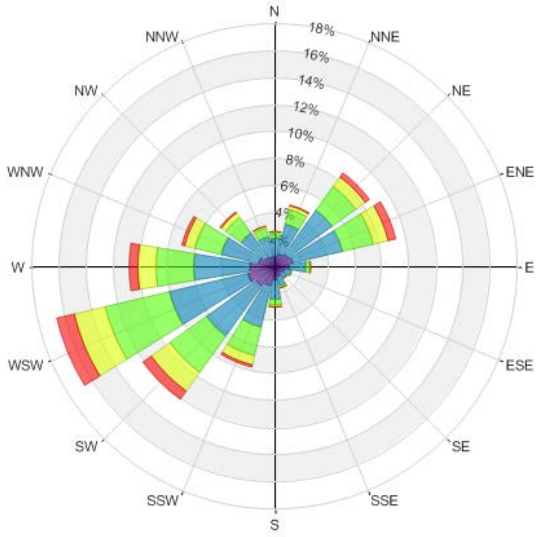
Meteorological data from Hamilton International Airport between 1970 and 2011 were used as reference for wind conditions in the region.

The distributions of wind frequency and directionality for summer (May through October) and winter (November through April) seasons are shown in the wind roses below. Winds from the south-southwest through west-northwest, northeast and east-northeast directions are predominant in the summer when all winds are considered. The right wind rose shows the winter data, indicating the predominance of winds from the southwest, west-southwest, west, northeast and east-northeast during this season.

Strong winds of a mean speed greater than 30 km/h measured at the airport occur for 4.1% and 14.3% of the time during the summer and winter seasons, respectively. The southwesterly and northeasterly winds are prevalent for both seasons, as demonstrated by the yellow and red bands in the wind roses. Winds from these directions potentially could be the source of uncomfortable or even severe wind conditions, depending upon the site exposure or development design.



Summer Winds
(May – October)



Winter Winds
(November – April)

Wind Speed (km/h)	Probability (%) Summer	Winter
Calm	4.3	2.8
1-10	30.4	18.4
11-20	45.2	40.2
21-30	16.0	24.2
31-40	3.3	10.0
>40	0.8	4.3

Directional Distribution (%) of Winds (Blowing From)
Hamilton International Airport (1970 to 2011)

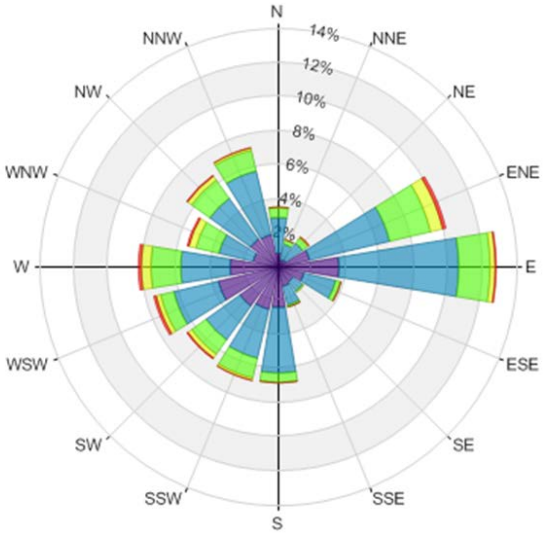
3. METEOROLOGICAL DATA

Meteorological data from Toronto Island Airport for the period from 1973 to 2012 were also used as a reference for wind conditions in the area.

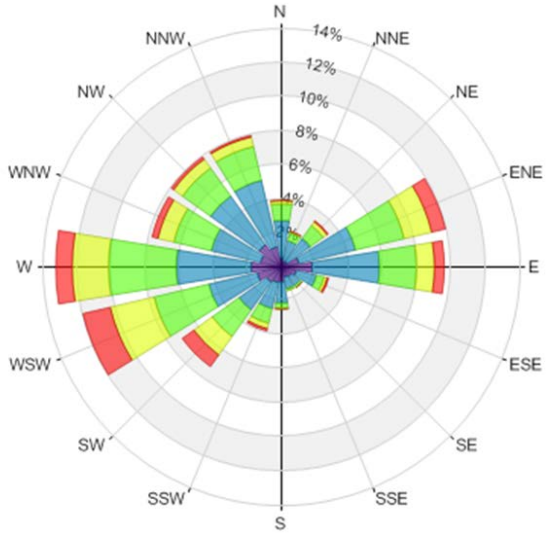
The distributions of wind frequency and directionality for the summer and winter seasons are similar to those from Hamilton International Airport. When all winds are considered, winds from the east and east-northeast directions are predominant in the summer, with frequent winds also from the south through north-northwest directions, as indicated by the left wind rose. The right wind rose shows the winter data, indicating the predominance of westerly and easterly winds, with secondary winds from the northwest quadrant.

Strong winds of a mean speed greater than 30 km/h measured at the airport (red and yellow bands) occur for 4.1% and 17.9% of the time during the summer and winter seasons, respectively. Strong easterly and westerly are prevalent throughout the year. Winds from the east, west, southwest and northwest directions potentially could be the source of uncomfortable or even unsafe wind conditions.

Overall, wind approaching from the east, northeast, southwest and west were considered most important for this assessment based on the data from the two nearby major airports.



Summer Winds
(May – October)



Winter Winds
(November – April)

(km/h)	Probability (%) Summer	Winter
Calm	6.3	2.8
1-10	30.7	16.7
11-20	43.6	37.6
21-30	15.3	25.0
31-40	3.3	12.1
>40	0.8	5.8

Directional Distribution (%) of Winds (Blowing From)
Toronto Island Airport (1973 to 2012)

4. EXPLANATION OF 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 as well as by the building design and city planning community.

- **Sitting:** Calm or light breezes desired for outdoor restaurants and seating areas where one can read a paper without having it blown away.
- **Standing:** Gentle breezes suitable for main building entrances and bus stops.
- **Strolling:** Moderate winds that would be appropriate for window shopping and strolling along a downtown street, plaza or park.
- **Walking:** Relatively high speeds that can be tolerated if one's objective is to walk, run or cycle without lingering.

Wind conditions are considered suitable for sitting, standing or walking if the wind speeds are expected for at least four out of five days (80% of the time). An **uncomfortable** designation means that the criterion for walking is not satisfied.

Safety is also considered by the criteria and is associated with excessive gust wind speeds that can adversely affect a pedestrian's balance and footing. If winds sufficient to affect a person's balance occur more than 0.1% of the time, the wind conditions are considered severe.

Wind control measures are typically required at locations where winds are rated as uncomfortable or they exceed the wind safety criterion.

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. Comparisons of wind speeds for the existing and proposed building configurations are the most objective way in assessing local pedestrian wind conditions.

5. PEDESTRIAN WIND CONDITIONS

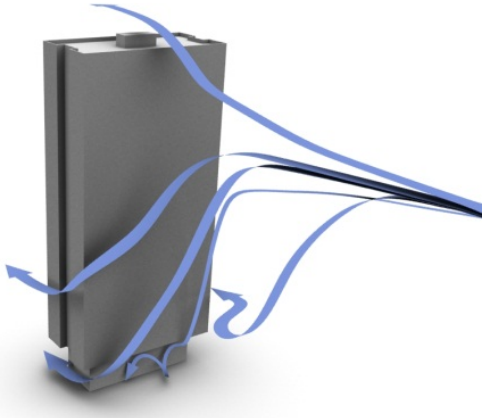
5.1 General

Generally, wind conditions comfortable for walking or strolling are appropriate for sidewalks and parking spaces; lower wind speeds comfortable for standing are preferred at major building entrances where pedestrians tend to linger.

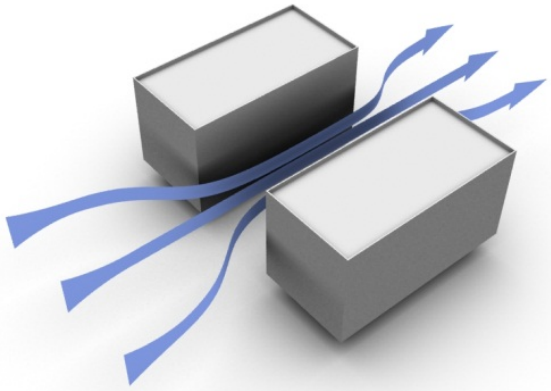
Predicting wind speeds and occurrence frequencies is complicated. It involves building geometry, orientation, position and height of surrounding buildings, upstream terrain and the local wind climate. Over the years, RWDI has conducted more than 2,000 wind tunnel model studies on pedestrian wind conditions around buildings, yielding a broad knowledge base. This knowledge has been incorporated into RWDI's proprietary software (*WindEstimator*) that allows, in many situations, for a qualitative, screening-level numerical estimation of pedestrian wind conditions without wind tunnel testing.

Tall buildings tend to intercept the stronger winds at higher elevations and redirect them to the ground level. Such a *Downwashing Flow* (see upper image to the right) is often the main cause for wind accelerations around large buildings at the pedestrian level. Also, when two buildings are situated side by side, wind flow tends to accelerate through the space between the buildings due to the *Channelling Effect* (see lower image). If these building/wind combinations occur for prevailing winds, there is a greater potential for increased wind activity.

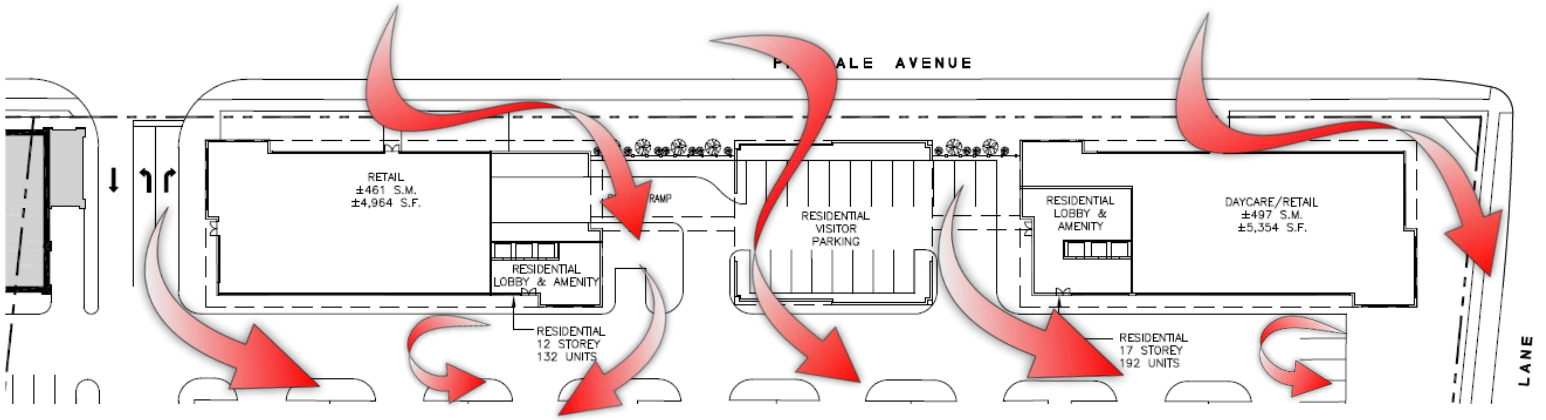
The proposed buildings have their longer axis aligned with the prevailing northeast and southwest winds, which is positive for wind control. The two images on the next page illustrate the general flow patterns for the easterly and westerly winds, that are more likely to create wind flow accelerations around the proposed buildings on the development site.



Downwashing Flow

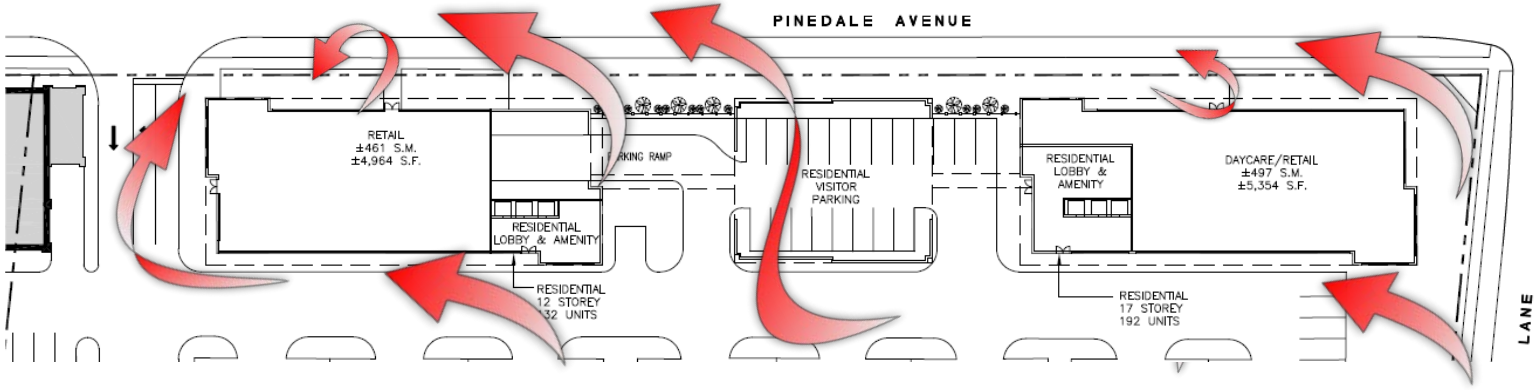


Channelling Effect



Flow Pattern of Westerly Winds



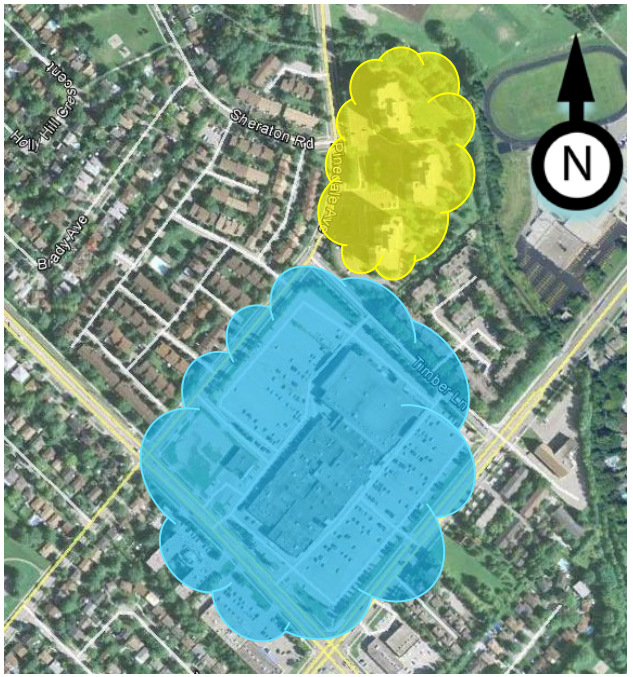


Flow Pattern of Easterly Winds

5.2 Existing Wind Conditions

The existing Appleby Mall consists of one or two storey buildings and open parking lots. It is approximately 1500 m from the lake and surrounded by dense buildings and trees of a similar height. As a result, the current wind conditions on and around the mall are expected to be comfortable for standing in the summer. Higher wind activity comfortable for strolling or walking is expected in the winter. These wind conditions are considered appropriate (blue area in the image at right).

For the existing towers along Pinedale Avenue (yellow area), uncomfortable wind conditions may occur on windy days during the winter. These high wind speeds typically occur around the exposed building corners and in the gaps between the towers. The dense landscaping, including many coniferous trees on and around the area, are effective wind control measures.



Higher Wind Activity around the Towers than at the Mall
(Aerial Photo Courtesy of Google earth™, dated August 31, 2009)

5.3 Potential Wind Conditions

The proposed two residential towers will be 12 and 17 storeys in height. They are taller than the existing buildings in the surrounding areas. As a result, winds will downwash off of the tower façade, causing wind flow accelerations around tower corners.

Both towers have their longer axis in a NE-SW direction, which reduces the potential impact of the winds from the northeasterly and southwesterly directions.

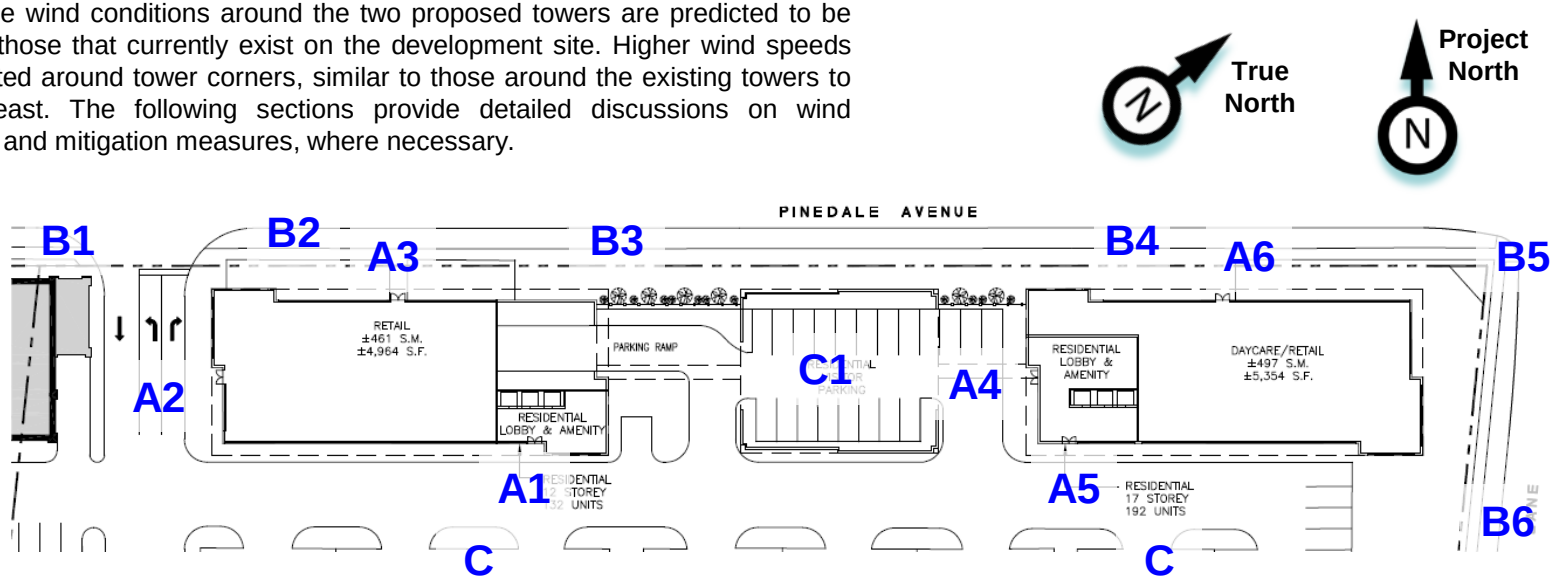
The potential channeling effect between the two towers is expected to be insignificant, due to the separation distance. The channeling effect between the 12 storey tower and the existing building to the west will not be significant either, due to the limited height of the existing building.

Overall, the wind conditions around the two proposed towers are predicted to be similar to those that currently exist on the development site. Higher wind speeds are expected around tower corners, similar to those around the existing towers to the northeast. The following sections provide detailed discussions on wind conditions and mitigation measures, where necessary.

A. Entrances

As shown in the image below, all the residential and retail entrances to the proposed towers (Locations A1 through A6) are located away from building corners. Entrances at Locations A1, A2 and A4 are recessed from the main façade. These are positive design features for wind control.

Low wind speeds comfortable for standing are desired for building entrances where pedestrians may linger. This criterion will be satisfied in the summer, but not in the winter, due to the prevailing winds downwashing off of the towers.



Site Plan

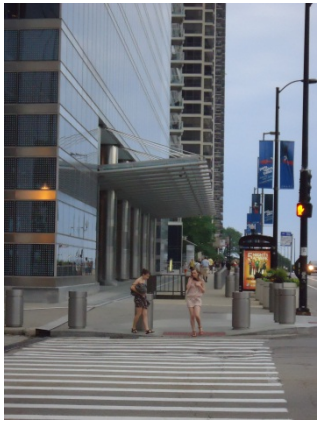
A. Entrances (continued)

The following mitigation measures may be considered to improve the wind conditions around the entrances areas. Photo examples of these measures are provided here for reference.

- Relocate Entrance A5 away from the building corner as far as feasible;
- Install a large canopy above each entrance;
- Include a vestibule for each main entrance to provide indoor waiting areas on windy days;
- Use sliding doors (rather than swing doors, which would be difficult to open on windy days or catch winds when they are open);
- Install wind screens or coniferous landscaping on both sides of the doorway; and/or
- Plant large coniferous or marcescent trees or other obstructs (e.g., street art) around the tower corners and along sidewalks.








Mitigation Examples for Entrances

B. Sidewalks

The proposed tower will alter the wind conditions along the adjacent sidewalks to various degrees. For instance, sidewalks around Locations B2 and B4 (see site plan on Page 10) will have reduced wind speeds due to sheltering offered by the towers when winds are from the easterly directions, whereas increased wind activity is expected around the exposed tower corners (Locations B3 and B5) due to downwashing and accelerations. In addition, Location B6 will be sheltered by the towers from the westerly winds.

Overall, wind conditions along the sidewalks adjacent to the proposed development are expected to be appropriate for pedestrian walking or strolling throughout the year. The existing trees along the sidewalks should be retained or enhanced by additional coniferous or marcescent trees in order to improve the wind conditions in the winter. See photos below for examples.

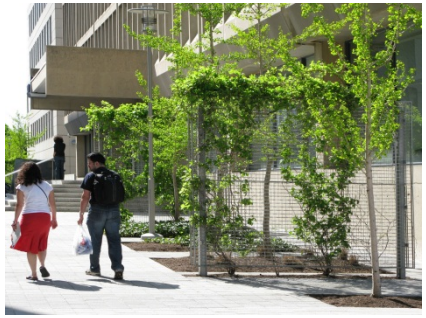
C. Parking Spaces

Any wind influence from the proposed towers is expected to be localized. The general wind conditions around the existing shopping mall and on the parking spaces (Location C in the site plan on Page 10) will not be affected by the proposed buildings.

However, there is a new parking space that will be located between the proposed towers (Location C1). Wind flow accelerations are expected in this area. From time to time in the winter, these wind speeds may become uncomfortable.

The existing link structure between the towers will offer minimal wind protection. Additional wind screens or coniferous landscaping are recommended for improving wind conditions in this parking area in the winter (see photos below for examples).





Mitigation Examples for Sidewalks and Parking Spaces

6. SUMMARY

Given the local wind climate and the proposed building massing, wind conditions on and around the proposed development are expected to be appropriate for the building entrances, sidewalks and parking spaces in general. Uncomfortable wind speeds may occur around tower corners and between the towers from time to time in the winter. Recommendations have been discussed and photo example provided to improve these wind conditions.

7. APPLICABILITY OF RESULTS

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 design considered in this report. It is the responsibility of others to contact RWDI to initiate this process.