Cambridge Discovery Park Building 400/500
Cambridge, MA

Pedestrian Wind Assessment

RWDI # 1602140
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SUBMITTED TO

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1. Introduction

Rowan Williams Davies & Irwin Inc. (RWDI) was retained by ADD Inc. to assess the potential pedestrian wind conditions for the proposed Cambridge Discovery Park Building 400/500 Project located in Cambridge, MA (Image 1). We understand the project consists of a new 4-story bridge connecting two 6-story buildings with a roadway between them. There are concerns about the wind conditions around and under the bridge. The objective of this assessment is therefore to provide a qualitative evaluation of wind comfort conditions and recommend mitigation measures, if necessary.

This qualitative assessment is based on the following:

- a review of regional long-term meteorological data;
- our previous wind-tunnel tests on buildings in the Boston area, including many in Cambridge;
- design drawings received by RWDI on March 22, 2016;
- our engineering judgment and expert knowledge of wind flows around buildings.

This qualitative approach provides a screening-level estimation of potential wind conditions. If desired, physical scale model tests can be conducted to quantify these wind conditions and to refine wind control solutions.

Note that other wind issues, such as those related to cladding and structural loads, exhaust re-entrainment, snowdrifts, etc., are not considered in the scope of this assessment.

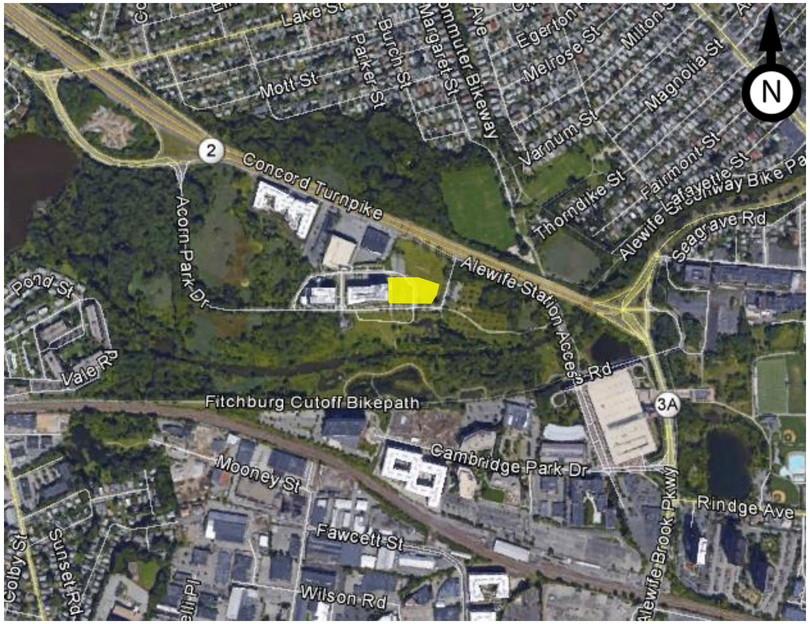


Image 1 - Aerial Photograph of Existing Site and Surroundings
(Courtesy of Google™ earth)

2. Building and Site Information

As shown in Image 1, the development site is located on the south side of Route 2 in Cambridge, MA. Building 400/500 is at the southeast corner of a campus, consisting of several office buildings and parking structures of a similar height (Image 2). These buildings shelter the study building from the prevailing northwest winds. Surroundings in the remaining directions include treed lands and roadways. Further surroundings are low residential and commercial buildings (Image 1).

The proposed bridge is 4 stories between two 6-story buildings (Image 2). It is approximately 28' above ground. The passageway between the two buildings is approximately 75' wide, running in a south-north direction.

Image 3 is a ground floor plan, showing driveways, sidewalks, building entrances and a dinning terrace under and around the proposed bridge, where the potential wind comfort conditions are of concern.

Image 2 – Site Plan

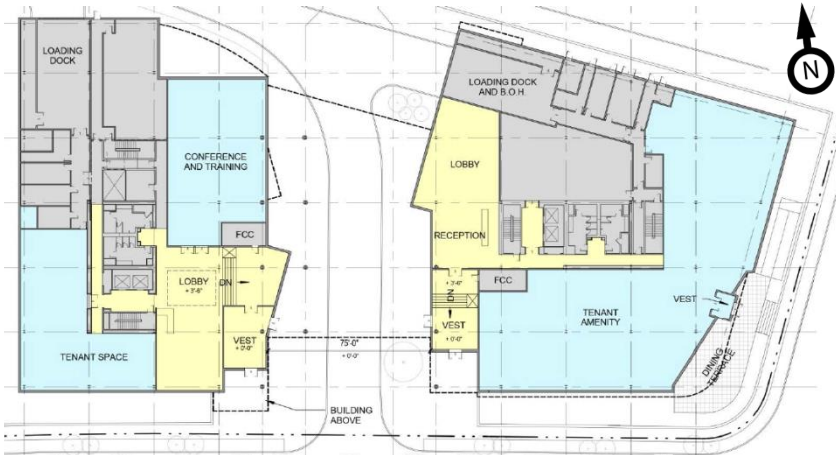


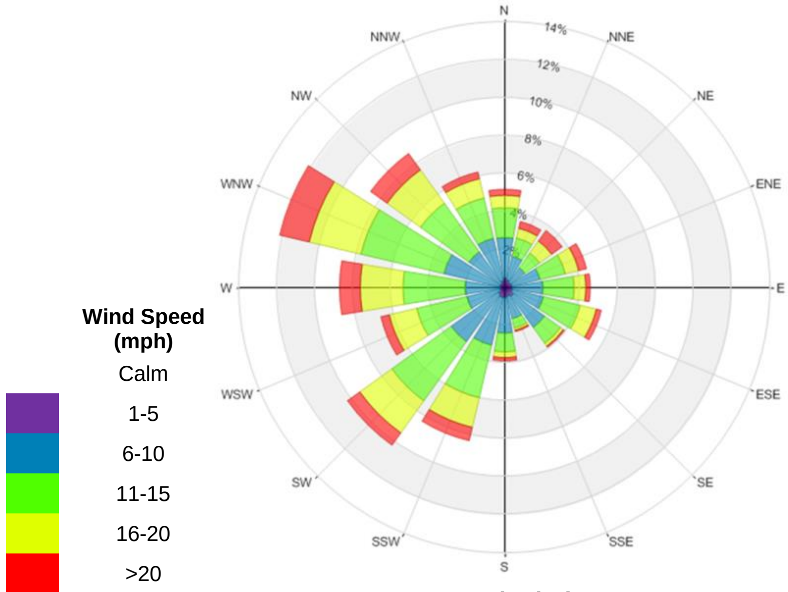
Image 3 – Ground Floor Plan for Building 400/500 and the Bridge

3. Meteorological Data

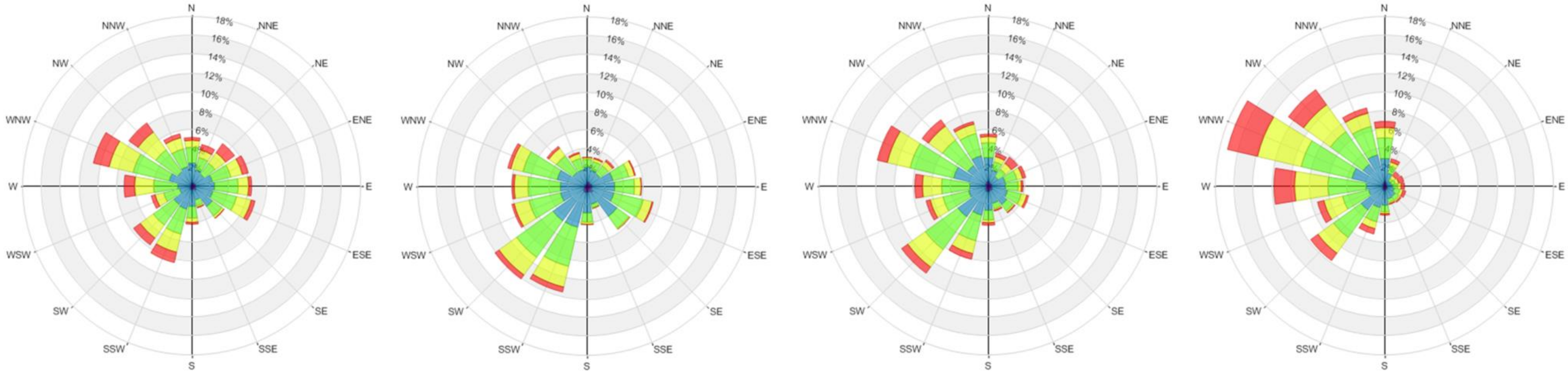
Wind statistics at Boston-Logan International Airport between 1986 and 2015 were analyzed for the spring (March to May), summer (June to August), fall (September to November) and winter (December to February) seasons. Image 4 graphically depict the distributions of wind frequency and directionality for these four seasons and for the annual period. When all winds are considered, winds from the northwest and southwest quadrants are predominant. The northeasterly winds are also frequent, especially in the spring.

Strong winds with mean speeds greater than 20 mph (red bands) measured at the airport are prevalently from the northwesterly directions throughout the year, while the southwesterly and northeasterly winds are also frequent.

Therefore, winds from the northwest, southwest and northeast directions are considered most relevant to the current study, while winds from other directions are also considered in our analysis.



Annual Winds



Spring (March to May) | Summer (June to August) | Fall (September to November) | Winter (December to February)

Image 4 - Directional Distribution (%) of Winds (Blowing From) - Boston Logan International Airport (1986 to 2015)

4. Explanation of Wind Criteria

The BRA wind comfort criteria are often used in Cambridge. They include two standards for assessing the relative wind comfort of pedestrians. The first criterion states that an effective gust velocity (hourly mean wind speed +1.5 times the root mean square wind speed) of 31 mph should not be exceeded more than one percent of the time. The second set of criteria used by the BRA to determine the acceptability of specific locations is based on the work of Melbourne[1]. This set of criteria is used to determine the relative level of pedestrian wind comfort for activities such as sitting, standing, or walking. The criteria are expressed in terms of benchmarks for the 1-hour mean wind speed exceeded 1% of the time (i.e., the 99-percentile mean wind speed). They are as follows:

Table 1: BRA Mean Wind Criteria *

Dangerous	*> 27 mph*
Uncomfortable for Walking	*> 19 and ≤ 27 mph*
Comfortable for Walking	*> 15 and ≤ 19 mph*
Comfortable for Standing	*> 12 and ≤ 15 mph*
Comfortable for Sitting	*< 12 mph*

* Applicable to the hourly mean wind speed exceeded one percent of the time.

1. Melbourne, W.H., 1978, "Criteria for Environmental Wind Conditions", *Journal of Industrial Aerodynamics*, 3 (1978) 241 - 249.

Pedestrians on sidewalks will be active and wind speeds comfortable for walking are appropriate. Lower wind speeds comfortable for standing are desired for building main entrances where people are apt to linger. For outdoor terraces, low wind speeds comfortable for sitting are desired during the summer. In other seasons, wind conditions in these areas may not be of a serious concern due to limited usage.

The wind climate found in Cambridge is generally comfortable for the pedestrian use of sidewalks and thoroughfares and meets the BRA effective gust velocity criterion of 31 mph. However, without any mitigation measures, this wind climate is likely to be frequently unsuitable for more passive activities such as sitting. These wind conditions will be altered under the proposed bridge between buildings.

5. PEDESTRIAN WIND CONDITIONS

5.1 Background

Predicting wind speeds and occurrence frequencies is complicated. It involves building geometry and orientation, position and height of surrounding buildings, upstream terrain and the local wind climate. Over the years, RWDI has conducted thousands of 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 that allows, in many situations, for a qualitative, screening-level numerical estimation of pedestrian wind conditions without wind tunnel testing.

Building 400/500 is fully exposed to winds from northeast through southeast to southwest directions. Tall buildings tend to intercept the stronger winds at higher elevations and redirect them to the ground level. Such a Downwashing Flow (Image 5a) is the main cause for increased wind activity around tall buildings at the pedestrian level. Oblique winds also cause wind accelerations around the downwind building corners (5b). Increased wind flows are expected through any passageway underneath a large building, induced by the pressure differential between the windward and leeward building facades (5c). If these building/wind combinations occur for prevailing winds, there is a greater potential for increased wind activity.

The existing surroundings to the west through north of the study building (Image 2) are expected to provide sheltering for the prevailing winds from those directions. This is a positive feature for the site. Another positive feature is the south-north orientation of the passageway, since winds are relatively infrequent from the south or north direction in Cambridge (Image 4).

Detailed discussions on the potential wind conditions are provided below with the focus on key pedestrian under and around the bridge. Wind control recommendations are provided to improve the wind conditions, where necessary.

Image 5a - Downwashing Flow

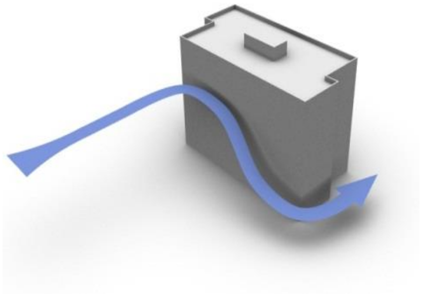


Image 5b - Corner Acceleration

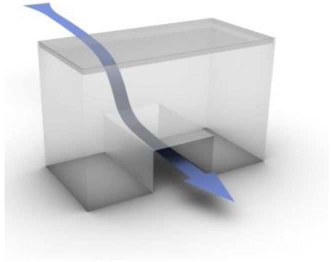


Image 5c – Channeling Effect

5.2 General Flow Patterns

As discussed previously, winds are primarily from the west-northwest, southwest and northeast directions (Image 4). While the west-northwest winds are generally reduced by the existing surroundings, they may be channeled through the space between Garage B and Building 400 (Image 6). These winds may then be re-directed into the passageway by the flat west façade of Building 500, as shown in the top diagram in Image 7.

The proposed Building 400/500 and passageway are more exposed to the southwest and northeast winds, which may cause accelerated wind flows through the passageway and around the southeast corner of the building (mid and lower diagrams in Image 7).

Note that flow patterns in Images 6 and 7 are shown in plans, but vertical wind flows are often the cause for increased wind activity at grade level. Image 8, for example, illustrates the southwesterly winds being defected down by the south façade and accelerating into the passageway.

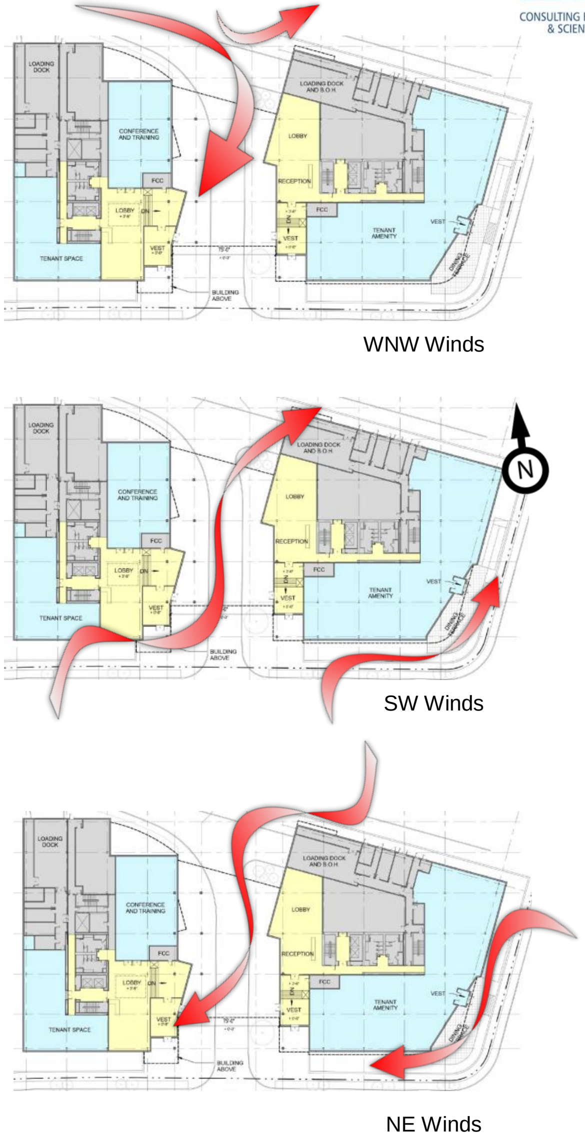


Image 7 – General Wind Flow Patterns

Image 6 – WNW Winds Channeled between Buildings and Deflected into the Passageway

Image 8 – SW Winds Downwashing into the Passageway

5.3 Potential Wind Conditions

Given the local wind climate, existing surroundings and passageway orientation, we expected the wind conditions within the passageway are generally comfortable for walking, with the potential for uncomfortable conditions at building corners during the winter and spring seasons. Lower wind activity is expected on and around the development in the summer, but it may not be suitable for sitting, especially around the exposed building corners.

Also, the effective gust criterion is expected to be met since the buildings are only 6 stories in height. The following is a more detailed discussion on the potential wind conditions in and around the passageway – use Image 9 for reference.

A. Building Entrances

The main entrances to Building 400/500 are facing south (A1 and A2 in Image 9), not directly exposed to the channeling flows along the passageway. They are largely sheltered by the building from the prevailing northwest and northeast winds, and designed with large vestibules where patrons can wait indoor on windy and cold days.

As a result, suitable wind conditions are predicted around these entrances throughout the year. If lower wind activity is desired for these areas, wind baffles (e.g., screens and planters) may be considered around the building corners - see short red lines in Image 9 for baffle locations and photos in Image 10 for examples.

The two side doors (A3 and A4) are more exposed to winds along the passageway. If they are used frequently, wind baffles are recommended on both sides of the entrances (red lines in Image 10). Alternatively, these doors may be recessed from the main façade or sliding doors may be used to reduce the risk of wind impact on doors.

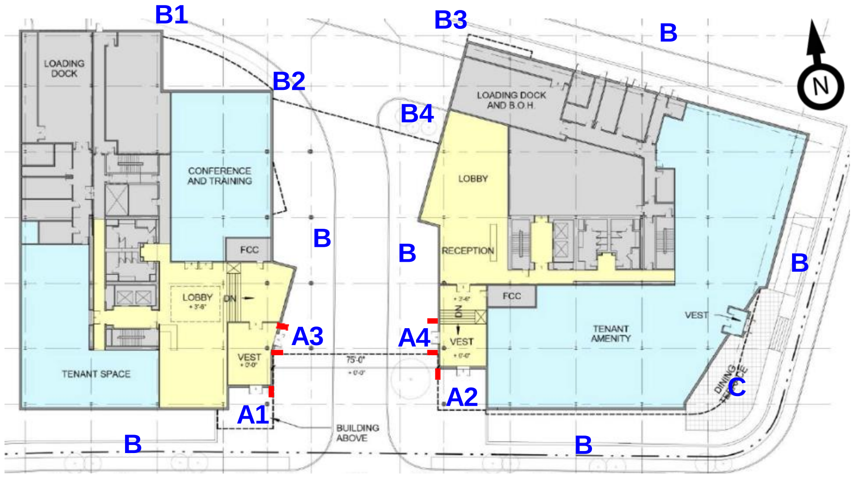


Image 9 – Ground Floor Plan

Image 10 – Wind Baffles for Building Entrances

5.3 Potential Wind Conditions (Continued)

B. Sidewalks

Pedestrians on sidewalks are typically active and wind speeds comfortable for walking are appropriate. This criterion is expected to be met on all sidewalks, including those under the bridge (Area B in Image 9). The proposed and existing landscaping around the development, including those to the east and south of the building (Image 2) will further improve the wind conditions.

Localized wind accelerations may occur around building corners, especially on the north side of the bridge (B1, B2 and B3 in Image 9). The resultant wind conditions may be uncomfortable during the winter and spring seasons. If desired, lower wind activity can be achieved by including coniferous or marcescent trees in the proposed landscaping plan, especially for the two areas highlighted in blue in Image 11, plus additional coniferous or marcescent trees in strategic locations (blue circles in Image 11), if feasible.

In particular, coniferous or marcescent trees should be considered at the northeast corner of passageway (Image 12), since this is a critical location, through which both the northwest and northeast winds may accelerate into the space under the bridge (see Images 6 and 7). Trees that keep their leaves reasonably well in the winter and spring will absorb wind energy throughout the year. Alternatively, a porous hardscaping (such as screens and trellises) may be considered for this location to reduce the winds that may accelerate into the space under the bridge (Image 12).

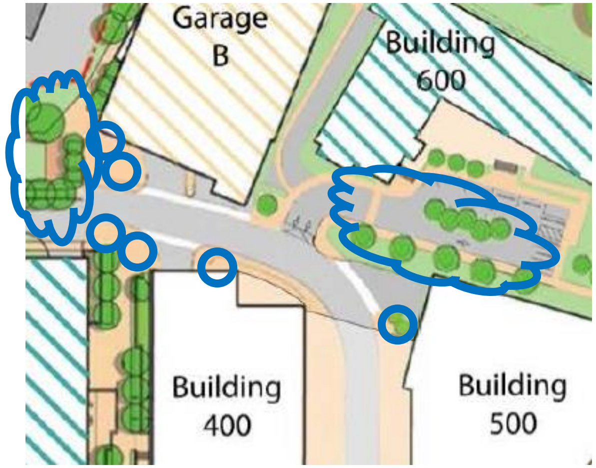


Image 11 – Additional Coniferous or Marcescent Trees

Image 12 – Coniferous/Marcescent Trees or Tall, Porous Hardscaping

5.3 Potential Wind Conditions (Continued)

C. Outdoor Dinning Terrace

This dinning area is located at the southeast corner of Building 500 (Location C in Image 9). It is sheltered by the buildings from the dominant northwest winds, but both the northeast and southwest winds will accelerate around this building corner (see flow patterns in Image 7).

To achieve a low wind speed that is comfortable for sitting in the summer, we recommend relocating the outdoor dinning terrace to the middle of south or east façade, if feasible, and developing wind control solutions for the entire seating area, especially around the southeast building corner.

If the dinning terrace has to remain around this corner, considerable wind control measures will need to be developed. They should include both horizontal and vertical elements, in the form of trellises, umbrellas, canopy-type trees, wind screens, privacy fences, hedges and so on. Photos in Image 13 provide examples for your reference.

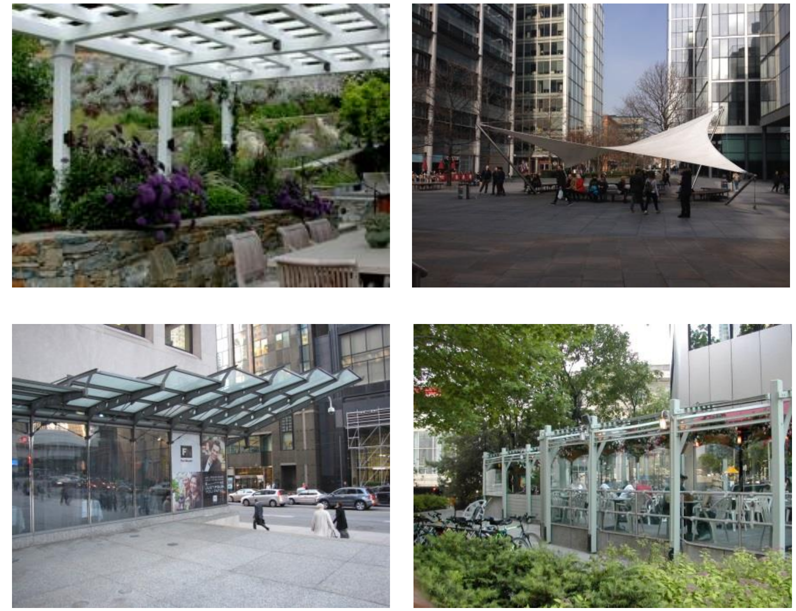


Image 13 – Wind Control Measures for Outdoor Dinning Terrace

6. SUMMARY

The proposed buildings and bridge are limited in size, the passageway under the bridge is oriented favorably and considerably wind sheltering is provided by the existing and proposed buildings and landscaping. As a result, suitable wind conditions are predicted in general for main entrances and on sidewalks.

However, uncomfortable wind conditions may occur around the exposed building corners, especially during the winter. Higher-than-desired wind speeds are also predicted around the two side doors and at the outdoor dinning terrace around the southeast corner of Building 500. Wind control measures are discussed for these areas in order to improve the wind conditions to appropriate levels.

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.