Wellington City Proposed District Plan

Appendix C - Wind Rules Evaluation

Section 42A of the Resource Management Act 1991

Project Number: 5-29P12.00

Evaluation of the Wellington District Plan Wind Rules

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Contents

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This report ('**Report**') has been prepared by WSP exclusively for Wellington City Council ('**Client**') in relation to evaluating the wind rules in the District Plan ('**Purpose**') and in accordance with the Contract for Services dated 15 January 2020. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

1 Introduction

This report summarises an evaluation of the wind provisions in the Wellington City District Plan (**the Plan**) and outlines potential changes that could be made to these provisions. It will inform a wider review of the Plan. This evaluation is undertaken within the context of Wellington City's strategy for growth, which anticipates intensification of the inner city and surrounding suburban centres. Higher developments are therefore envisaged in parts of the city, along with a greater focus on providing high quality outdoor environments for living.

The purpose of this evaluation is to establish the effectiveness of the wind related objectives, policies, rules and standards in the Plan to deliver quality new developments that minimise adverse wind effects and do not compromise public safety or comfort.

The evaluation comprises the following parts:

1 Part 1 is an assessment of how the current wind objectives, policies, rules, standards and guidance are operating in practice and what outcomes are being achieved. Two key questions are:
   - To what extent do the wind provisions limit or avoid adverse wind effects of new developments and to achieve a safe and comfortable public wind environment?
   - To what extent do the wind provisions limit or enable the efficient use of a site and enable new development?

2 Part 2 is a review of the wind rules from other cities around the world and a comparison with the Wellington approach, including both rules and guidance. It is intended to highlight current planning practice that is not reflected in the Plan provisions and identify key differences in current approaches.

3 Part 3 provides high level options for how the wind rules, standards and design guidance, could be amended to improve the public wind environment, whilst still enabling development and good design outcomes.

2 Background to Wellington's Wind Rules

Wellington is widely acknowledged as being the windiest major city in the world, with an average wind speed measured at the airport of 26 km/h. The need for planning wind rules has therefore been particularly important in Wellington. Auckland by comparison has an average wind speed measured at the airport of 18 km/h. As the wind force that people experience is proportional to the wind speed squared, this means that Wellington typically feels twice as windy as Auckland.

2.1 Wellington's First Wind Rules

The requirement to consider wind conditions during the planning of new buildings first came into effect in Wellington in 1979. Prior to that, new buildings had been developed which created notoriously bad wind conditions.

A prominent example of a building which created very bad wind conditions is 1 Willis Street, formerly known as the BNZ Centre when it was built. It was designed in the 1960s as a tall square tower which rose essentially straight up out of the ground, with an open garden area around it. Wind speeds at the corners of this building were predicted to be extremely high, and dangerous on windy days. A wind tunnel test of a building 200 m away first revealed the issue. It predicted dangerous winds for more than 50 hours a year were likely around the building at 1 Willis Street. Subsequent wind tunnel tests were used to demonstrate to the City that canopies over much of the open area adjacent to the building could mitigate the dangerous winds. The Wellington City Wind Ordinance was introduced in 1979 during the very public debate about the potential effects of this building on the wind. This building is therefore viewed as motivating the development of Wellington's original wind rules.

The 1979 Wind Ordinance applied to buildings over 4 storeys in height and required merely that a wind tunnel test be submitted. It rapidly became clear that some criteria or standards were needed to make it clear what wind speeds were acceptable.

2.2 Early Wind Tunnel Tests and Wind Criteria

The wind tunnel tests submitted under the 1979 Wind Ordinance initially followed a probabilistic presentation based on recommendations prepared by Professor W.H. Melbourne in 1978 (Melbourne, "Criteria for Environmental Wind Conditions", JWEIA, 3, pp 241-249). Professor Melbourne's work used "annual maximum 2 second gust speeds" to divide wind conditions into 5 categories: A,B,C,D,E, with Category A wind conditions being the windiest (note that the current Auckland wind rules also refer to Categories A,B,C,D,E, but in Auckland, Category E wind conditions are the windiest) The criteria recommended by Professor Melbourne are set out in Table 1 below converted to a 3 second averaging time.

Table 1 Pedestrian level gust speed criteria.

Category	Annual Maximum 3 Second Gust (m/s)	
A	21 and above	Dangerous. Completely unacceptable in a main public area.
B	14 to 21	Undesirable in a main public area.
C	Less than 14.4	Generally acceptable for walking.
D	Less than 11.7	Generally acceptable for stationary short exposure activities (e.g. window shopping, standing or sitting in plazas).
E	Less than 9	Generally acceptable for stationary long exposure activities (e.g. outdoor restaurants).

2.3 1984-85 Wind Rules

Wellington's original Wind Ordinance was modified in 1984-85 to include criteria that prescribed the required level of performance, as shown in Figure 1.

Three criteria were set because, from the few tests that had been done under the 1979 Wind Ordinance, it was clear that controls were needed to avoid a slow deterioration of the wind in the streets, in addition to avoiding dangerous wind speeds. A maximum annual 3 second gust speed of 18 m/s during daylight hours was set as the safety limit; and two lower gust speeds were set to avoid gradual deterioration in the wind conditions over time.

The initial 1984-85 wind rules applied to buildings of any height. The argument for this was that 4 storeys was an arbitrary limit, and a 2-4 storey building on the edge of the City could have as serious a wind problem as a 10 storey building in the City centre. The City returned to the 4 storey limit in the late 1980s as an economic threshold above which relatively expensive wind tunnel testing was justified. (This '4 storey' threshold was later interpreted by the WCC urban design advisers as 18.6m).

During the 1980s the planning regulations also introduced an early design option. The purpose was to incentivise use of simple flow visualisation tests early in the design process to help determine whether a full wind tunnel test would be required. The rules and guidance related to this early design option were removed in the 1990s, in an attempt to simplify the regulations.

13.1.2.11 Wind (except in the Operational Port Area)

13.1.2.11.1 New buildings or structures above 4 storeys in height shall be designed to comply with the following standards:

Existing wind speeds	Wind speeds resulting from development proposal	Requirements on developer
	If exceeding 10m/sec in any public space	Reduce to 10m/sec in the public space
Up to 15m/sec	If exceeding 15m/sec	1. Reduce to 15m/sec
		2. Although other directional speeds may be increased towards 15m/sec, overall impact is to be no worse than existing
15-18m/sec	If exceeding 15m/sec	Reduce to max 15m/sec
Above 18m/sec	If more than 18m/sec	Reduce to max 18m/sec

Figure 1 Wellington wind criteria introduced in 1984-85

The criteria introduced in 1984-85 are based on studies by Shuzo Murakami[1], who observed more than 2000 people in wind tunnel experiments and outdoors in Tokyo. Murakami's work suggested, 1) that the onset of danger in gusty wind conditions is closer to a gust speed of 15m/s; and 2) that women are more susceptible to adverse effects from wind than men.

[1] Refer Murakami S. and Deguchi K (1981) Journal of Wind Engineering and Industrial Aerodynamics, Vol.7, pages 289-309

2.4 Current Wind Provisions

The current wind provisions in the Plan are a combination of rules and standards that have been in place since the Plan was made operative plus new requirements brought in via Plan Change 48. The significant changes introduced as part of Plan Change 48 are, 1) wind speed criteria relate to all hours of the day, and 2);the criteria to avoid progressive deterioration of wind conditions are expressed in terms that might be more easily interpreted as minor or major effects in planning terms.

Relevant wind objectives, policies, rules, standards and guidance from the Plan are given in Appendix A and B.

Comprehensive wind provisions (Objective, Rules and Standards) are in place for the Central Area of Wellington, while less comprehensive wind provisions are in place for the Centres and Business Areas, where wind effects are only considered if relevant Height Standards are exceeded. The Institutional Precinct has some consideration of wind effects, but only in very specific circumstances.

2.4.1 The Central Area

The Central Area policies for wind (12.2.5.6 – 12.2.5.9) set out the general intent of the Plan to 1) minimise adverse wind effects of buildings, 2) stop the progressive degradation of wind conditions, 3) maintain comfortable wind conditions in important public parks, and 4) encourage early consideration of wind effects during design and minimise off-site mitigation.

Within the Central Area rule (13.3.8.8), developments that do not comply with the Wind Standards (13.6.3.5) become Discretionary Restricted Activities, meaning the wind effects of the development must be considered and planning approval is discretionary.

The Central Area Standards for wind (13.6.3.5.1 – 13.6.3.5.2) are triggered when a proposed building exceeds 18.6 metres in height. Buildings below 18.6 m are not assessed for wind effects in the Central Area. There are three criteria that developments must comply with.

- The first "Safety Criteria" relates to pedestrian safety and imposes a limit on the maximum gust wind speed of 20 m/s.
- The second "Cumulative Effect Criterion" is intended to stop a gradual degradation of the wind environment with successive developments. It sets limits on the change in hours per year that mean wind speeds of 2.5 m/s and 3.5 m/s are exceeded with a development (note, the average speeds of 2.5 m/s and 3.5 m/s sit at very different parts of the probability curve for wind and thus express the general windiness characteristic of breezes and strong winds). The overall change, around the whole development, is also required to be neutral or beneficial.
- The third "Comfort criteria" relates to the amenity of an area and only applies to specific parks listed in the Plan. The comfort criteria sets a limit on the absolute number of hours per year that a mean wind speed of 2.5 m/s is exceeded.

2.4.2 The Centres

The Centres policies for wind (6.2.3.10 – 6.2.3.12) set out the general intent of the Plan to 1) minimise adverse wind effects of buildings, 2) stop the progressive degradation of wind conditions, 3) encourage early consideration of wind effects during design and minimise off-site mitigation. The policies are similar to the Central Area policies for wind, except that there is no policy to maintain comfortable wind conditions in designated public parks. Another, more subtle, difference is that the Centres wind policies relates only to buildings that are greater than three storeys.

Within the Centres Rule (7.3.7.1), developments that do not comply with the Height Standard (7.6.2.11) become Discretionary Restricted Activities, at which point, the effects of the additional building height on "*the wind environment at ground level*" must be considered, and planning approval is discretionary.

There are no Centres Standards for wind.

Because there are no specific Standards for wind in the Centres area, discretion is not limited to safety and cumulative wind effects as it is in the Central Area, and consideration may also be given to pedestrian comfort.

2.4.3 The Business Area

The Business Area has no policies that relate directly to wind.

Within the Business Area Rule (34.3.9), developments that do not comply with the Height Standard (34.6.2.1) become Discretionary Restricted Activities, at which point, the effects of the "*the impact of wind from additional building height on pedestrian amenity and safety, particularly at surrounding building entries*" must be considered, and planning approval is discretionary.

There are no Business Area Standards for wind.

Because there are no specific Standards for wind in the Business Area, discretion is not limited to safety and cumulative wind effects as it is in the Central Area, and consideration must be given to pedestrian amenity and safety

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3 Assessment of the Current Situation

The current wind provisions in the Plan (objectives, policies, rules, standards and guidance) have been reviewed to assess how they are operating and what outcomes are being achieved. This assessment comprised the following elements:

- A workshop was convened to gather feedback from Wellington City Council (WCC) planners and wind consultants on their experiences of how the wind provisions in the Plan operate, what problems exist with the wind controls, and what improvements could be made to the wind provisions.
- A review of past resource consent documentation was undertaken, of developments that are believed to have responded well, or poorly, to the wind provisions in the Plan, with correspondingly good or bad outcomes for the surrounding wind environment.

Key questions that this assessment should answer are,

- To what extent do the wind provisions limit or avoid adverse wind effects of new developments and to achieve a safe and comfortable public wind environment?
- To what extent do the wind provisions limit or enable the efficient use of a site and enable new development?

3.1 Workshop

A workshop was held at Wellington City Council offices on 3 February 2020, attended by WCC's resource consent planners, members of WCC's Place Planning team, WCC's wind consultant, and wind specialists from WSP. The purpose of the workshop was to identify issues within the wind provisions in the Plan and suggest potential areas for change.

A summary of the main issues raised in the workshop are given in 3.1.1 and the workshop notes are provided in 3.1.2 – 3.1.6. The notes are intended to reflect the ideas raised and the discussions had during the workshop, but do not necessarily follow the sequence of discussions, nor accurately transcribe people's comments.

3.1.1 Summary of issues

The workshop highlighted a number of problems that people experience when dealing with wind effects in the resource consent process, and also highlighted some poor wind outcomes. Encouragingly, most of these problems have arisen from poor behaviours (and incentives) rather than any particular failing of the wind rules in the Plan.

For example, most Assessments of Environmental Effects do not contain any description of wind effects, and instead refer to specialist wind reports, which do not relate the measured wind speeds to planning effects. This lack of information/analysis in turn leads to a poor understanding of the wind effects and makes regulatory decisions difficult. Rather than reject consent applications as being incomplete, City planners attempt to interpret wind information themselves and, not surprisingly, have some difficulty understanding the technical detail. Conversely, applicants are incentivised to provide a minimum of information in their applications if their development does create adverse wind effects, provided they can ultimately gain approval. The timing of wind studies/assessments, late in the design process, can also be problematic, as wind effects may require design changes to buildings that have, to all intense purposes, been finalised. Such problems cannot be resolved by changing the wind rules, as the rules do not prescribe how and when developments are designed, nor how discretion is exercised in the resource consent process.

Some clarification of the wind rule objectives and the wind criteria is recommended to help planners and developers understand the purpose and application of the wind rules. Such clarification would be better suited as guidance rather than rule changes, as the current rules are unambiguous and achieve good wind outcomes when applied correctly.

Two policy considerations, highlighted in the workshop, are 1) should the wind rules apply to private spaces and 2) should the wind rules place greater controls on pedestrian comfort (in addition to current safety requirements). Assessing wind effects in private spaces becomes particularly difficult when such spaces are elevated (for example balconies and decks) and mitigation may be impractical where multiple private ownership interests cannot be aligned. A legal analysis is needed to properly scope potential options for introducing wind criteria for private spaces. Introducing greater comfort controls into the wind rules is discussed in Section 4 and 5.

3.1.2 Workshop notes - Policy Objectives and Outcomes

Current wind rules in the District Plan require,

- a development not increase wind speeds above the safety limit of 20 m/s.
- a development can increase wind speeds, if they remain below the safety limit, and the nett effect is that existing wind conditions are maintained or improved.

Purpose of the wind rules

High wind speeds should be mitigated to the extent that is practical, but sometimes high winds are unavoidable - District Plan could be improved to recognise this reality.

In the current wind rules pedestrian comfort and amenity, as it relates to wind, is not articulated well. There are wind rules for comfort only in designated areas in the Central Area – the list of areas is referenced from sunlight/shadow controls. Should amenity / comfort be more widely regulated?

Wind rules controls address only pedestrians. eg cycling and micro mobility are not specifically considered.

Desired outcome should be explicitly described for pedestrian safety / comfort in public / private spaces.

What is being encouraged / incentivised with height thresholds – for example, are 4-storey buildings better for the city overall than 12-storey buildings?

How are safety priorities for wind balanced amongst competing issues such as traffic and CPTED (crime prevention through environmental design)?

Private spaces

- o Do private areas / verandahs of townhouses need to be considered in an assessment of wind effects?
- o Private land/spaces can be open to the public, which could be treated differently to private land/spaces with only private occupancy.
- o A lot of planning rules are to protect property rights. Control of wind effects on private spaces are a gap in the current plan, if compared to sunlight, which is considered. Like sunlight, the expectations for wind effects could be set in policy statements, with some areas/spaces expected to have less amenity than others.
- o Should triggers/thresholds for private spaces (eg balconies) be different to public areas?
- o Should spaces promoted by developers as providing amenity be accepted if poor wind conditions mean they will, in reality, not be used?

Preserving wind design and mitigation

Past wind designs/mitigation have been (unwittingly or knowingly?) undone by alterations to existing buildings

- Example: the Social Welfare building, on the corner of The Terrace and Aurora Terrace, had chamfered corners, a large 2-storey verandah and was allowed added height in exchange for public artwork in the foyer. Recent alterations have extended building to street edge, added a building above verandah and removed chamfered corners, thereby undoing much of the mitigation.
- Many mitigating features (from past planning decisions) can be undone by redevelopments of existing buildings – not just wind.
- A potential problem is the use of carparking levels, which are porous/open to mitigate high wind speeds at ground level, being re-clad with a solid façade in future redevelopments, without considering the implications for wind effects at street level.
- Additions and alterations to buildings below a verandah are Permitted Activities (do not require resource consent), so alterations are made to buildings in ignorance of the original purpose of certain building elements. Could change the rules in the Plan to allow alterations below verandahs to be made without consent, except where existing building features are required for wind mitigation – this might at least prompt owners to check existing features before proceeding with an alteration.

Wind rules for different areas of the City

Do other areas, outside of the Central City need wind controls? The Centres areas have lower height limits than the Central Area, and wind becomes a discretionary activity once the height threshold is exceeded. Buildings that are "outliers" (i.e. relatively high) in the Centres areas should be assessed / tested for wind. However, buildings that fit within heights that are envisaged for the area shouldn't be wind tunnel tested. Assess wind effects when a development is outside particular thresholds?

What is the best way to manage wind effects at the transition from one height limit to another?

The city expects areas to develop over time and so can a system be devised so developers are not burdened with onerous wind controls/mitigation if windy areas around a development will disappear over time as surrounding sites are developed.

3.1.3 Workshop notes - Triggering the Wind Rules

Wind effects are a "discretionary activity" when a development is greater than 18.6 m in the Central Area, or greater than the height standard in the Centres areas. When planners apply this discretion is described in another part of the Plan. Reporting requirements for wind are also specified in a separate chapter of the Plan.

Situations that require wind effects to be assessed

The current rule for creating a vacant site is that it is a 'discretionary unrestricted activity' (only in the Central Area), but Council tends not to look at wind effects when assessing such applications.

Gaps between buildings can also cause wind problems, so should there also be a lower height limit to trigger wind assessment?

- the wind effects of height limits and gaps are context dependent, as illustrated by the Defence Building (now demolished) on the corner of Mulgrave and Aitken Street, which was poor in terms of adherence to the wind guide, but had a positive overall effect on wind because it blocked a large gap in the area.

The boundary between areas with higher and lower height limits can produce windy conditions.

Triggering different types of wind assessments

Is the 18.6 m height trigger for a 'discretionary activity' ok? An alternative to using a 'hard' height trigger would be to require a wind assessment/study if a development was within ± 30% (or 20%?) of height of adjoining buildings.

When is a wind assessment (i.e. expert opinion) versus a wind tunnel study needed: Developers want certainty about what is required to comply with the wind rules, so it is preferable to make it clear in the Plan when a wind assessment is required and when a wind tunnel study is required, rather than relying on a planner to make the decision. An option could be to require a specific level of reporting / evidence when a development meets certain triggering criteria, eg a wind tunnel study is required when a proposed development is outside ± 20% of the height of surrounding buildings.

Perverse outcomes

Can get poor planning outcomes when a buildings height limit is 18.6 m and developments are designed to a height less than 18.6 m high purely to avoid 'discretionary activity' status and expensive wind tunnel testing.

Lower building heights than envisaged in the Plan can occur in an area, so wind rules shouldn't ignore the potential for some "gaps" in the height of buildings to occur. For example, a site off Taranaki Street will be filled with many 3-storey townhouses, each with separate title, so they will never be consolidated into a larger taller building, which will effectively lock in a "low area" into that part of the city.

3.1.4 Workshop notes - Technical Interpretation

Incomplete information

In resource consent applications, the assessment of environmental effects typically does not describe the wind effects or provide interpretation - they simply refer to the wind report. The implications of changes in wind conditions on the safety and comfort of people need to be explained, with due consideration of different activities and amenity values of different areas in the city (eg loading zone vs busy footpath vs seated areas of a park).

Interpreting technical language and wind rules is difficult for planners who are unfamiliar with the wind rules. Numbers in the rules and the reporting needs commentary to describe the outcome / effect on people, with sufficient detail, to convey all the effects.

Is more detailed spatial/geographical information of the activities and priorities for specific areas needed, in order to describe the City's expectations for specific areas. Could include priority areas in design guidance or in the Plan.

Designating wind effects that are acceptable, or outcomes, for specific areas (outdoor dining, walking) would make it easier to judge what wind conditions are expected? This would provide a hierarchy of streets / locations within the city.

Improving information and understanding

Put diagrams in the Plan that illustrate effect of wind speeds, and diagrams to illustrate wind mitigation options.

Use of a well-known area as a comparator to describe the wind effects on comfort can be a good way to communicate wind effects, eg Midland Park is a well-known area that people can relate wind conditions to.

The Safety criterion is not described in detail in the district plan so needs better definition, eg "it is the gust that is expected to occur during the windiest hour of the worst storm each year", or "one hour once a year causes a wind speed that exceeds the limit, as a direct consequence of a development, is an unacceptable effect".

Reporting of changes in wind speeds caused by a development, particularly changes that exceed the safety threshold, need a balanced commentary and careful interpretation. If increases in gust speeds are balanced by decrease in gust speeds elsewhere, then an assessment of effects needs to consider both the relative areas that are affected and the use of the respective areas. A skilled planner is needed to understand the implications of "balancing" wind speeds in one area with another area.

In environmental wind studies, averaging wind speeds at all measurement locations does not give a good indication of the overall wind effects of a development. Reason for this include: 1) an accurate average can only be constructed if the measurement locations are spaced evenly and densely enough to capture the spatial variation in speeds: and 2) including locations further away which are unaffected by a development can effectively lower the overall change, if a simple average is taken.

"Storeys" is an ambiguous / inconsistent measure as the height of a storey is dependent on the building design. The current policy for Centres only considers wind effects for building above 3-storeys, but the Centres rules apply discretion when the height standards (expressed in metres) are exceeded – this creates an inconsistency. The 4-storey threshold was conceived as generous entrance floor (maximum ground floor height = 6.0 m) and 3 good office floors (maximum floor to floor height = 4.2 m) = 4 storeys (6.0 m + 3 x 4.2 m = 18.6 m). Often this incentivises a lower quality building because it encourages applicants to squeeze 5 storeys into an 18.6 m high building

Use a value / height rather than "storey", as it is less ambiguous / less interpretation is required.

New wind rules should ideally be easier to use, and more understandable.

Balancing wind effects against other factors

Trading off positive effects against negative effects of a development is difficult as the wind rules are currently written with definitive/quantitative criteria.

Planners have difficulty reconciling different language and views from different wind consultants, for example WSP and Michael Donn.

Cumulative hours criteria,

- o provide the relative increase / decrease in hours per year, rather than reporting on a particular wind speed level that corresponds to an acceptable level for a particular activity.
- o criteria are seen to be unnecessarily complicated, with the need for two levels (i.e. 2.5 m/s and 3.5 m/s) questioned. The Cumulative Effect criterion for 2.5 m/s (i.e. change in hours of occurrence is limited to less than 20 days) is not the same as the Comfort criterion (i.e. limit the occurrence of wind speeds greater than 2.5 m/s to no more than 73 days). Some explanation is needed for the criteria, or simplify criteria to just one number if the outcome will be the same.

3.1.5 Processing / Applying the Wind Rules

In the past, an 18.6m tall building (corresponding to the threshold height for requiring a wind tunnel test) has been treated as a "baseline" for assessing the effects of a developments against. While a recent planning law decision has determined that this approach is no longer valid, would a "baseline test" be useful in the wind rules, as a starting point (as of right) to assess wind effects against?

The scheduling of wind tunnel testing at WSP is not too lengthy at the moment and there are competitors that can also undertake the work if urgent. Giving developers certainty about what sort of report will be needed early in the process will help prevent delays to a development because of wind tunnel testing availability. CFD is also an alternative way to quantify wind effects. The Dutch Code and London wind requirements explicitly allow for CFD studies (though the London studies require cross checking against wind tunnel tests).

The current development practice is to design the building, then show compliance with the wind rules, which results in wind effects not being thought about initially in the conceptual design stages.

Would a separate chapter in the Plan for wind rules be easier to use?

Wind mitigation

Offsite mitigation is often very effective as it can be placed where it is most effective immediately adjacent to pedestrians, but it requires consent from owners of the other property (often the Council), and maintenance can also be a problem because the mitigation is not the responsibility of the owner of the building that necessitated it

When mitigation is required/recommended…

- the applicant should test a good range of options to show their effectiveness.
- at the end of a resource consent process, time may preclude testing wind mitigation options, so conditions are imposed to require testing later on.
- in many applications, the reporting of wind effects is limited and incomplete, with recommendations and suggestions in wind reports not being evidenced with tests/data. Assessments of effects should be complete and definitive.
- typically, WSP does not recommend a mitigation option in its wind reports, as the wind effects that the council will accept are not pre-defined and WSP does not want to constrain/predetermine the design that is ultimately acceptable.
- in an application, it's not always obvious which design option has been submitted for consent – a range of options are described in the wind report, but often no definitive statement is made as to which options will be incorporated into the design, that allows a planner to know which option/design has been selected.
- the number of points measured, and the distance from the site that they cover needs to be unambiguous to ensure consultants do not cut corners when they are competing for wind analysis work.

3.1.6 Workshop notes - Design Guide for Wind

Current guidance is non-statutory, so designers do not use it until there is a problem with wind. Resource consent applicants never explain how their design has responded to the Design Guide for Wind. Developers only respond to numbers / compliance problems and don't use the guidance.

A draft English translation of Gandemer's book was distributed at the workshop, which includes estimates of wind effects that are semi-quantitative. Gandemer's rules-of-thumb could be used to provide estimates of wind effects in a Design Guide, making it semi-quantitative, but the range of buildings / circumstances where the rules-of-thumb are reliable would need to be defined.

Statutory guidance

A statutory design guide for wind could include a checklist of features and things to consider in a design. The Plan could include a trigger where the Guide must be used.

If the Design Guide for Wind was "statutory guidance" then applicants would need to show they have followed it. However, a design that didn't follow the Guide could never-the-less be approved if a wind tunnel test showed it was a suitable alternative solution. This approach is analogous to the "Deemed to Satisfy" solutions in Australia.

3.2 Lessons from Previous Resource Consents

Resource consent files have been reviewed for selected developments, where good or bad outcomes for the surrounding wind environment have occurred with the development. The purpose of the reviews is to evaluate the reasons for the good or bad design outcomes and identify where improvements to the wind provisions could be made. The developments listed in Table 2 have been reviewed.

Table 2 Developments reviewed for wind outcomes

Date (SR Code)	Development	Design outcomes
approx. 1990	100 Willis Street **Majestic Centre** New high-rise office tower	The Majestic Centre has good wind outcomes. A number of substantial changes to the original design were wind tunnel tested during 1986-88, to mitigate high wind speeds at ground level. The final design included significant wind mitigation, having a rounded planform to the office tower, and a large podium and canopies at the base of the tower.
1999 (51752)	195 Lambton Quay **Hamilton Chambers (MFAT)** New high-rise commercial building	Hamilton Chambers illustrates some poor outcomes for the wind environment in the surrounding area. The development deflects winds down into the surrounding streets, and impacts pedestrian level winds some distance from the site. The mitigation measures of a porous carpark façade and canopies above the footpath are mildly effective, while the off-site planting along Panama Street footpath are ineffective.
2005 (131311)	29 Willis Street **Chews Lane Precinct** Redevelopment of existing and new mixed use buildings	The Chews Lane Precinct Development has good wind outcomes. Features of the development that limit its impact on the wind environment are, i) the orientation of the laneway (Chews Lane) that runs east-west, perpendicular to the prevailing winds, which shelters the laneway, and ii) large setback of the new apartment tower from Victoria and Willis streets iii) north-south orientation of the new apartment tower that is approximately aligned with the prevailing winds
2006 (150509)	22 Herd Street **Chauffeurs Dock Apartments** Mixed use residential / commercial redevelopment of an existing building	The Chaffers Dock Apartments highlights poor design outcomes when wind effects are ignored. The building is exposed to strong prevailing winds and sits at right angles to the prevailing wind directions increasing its effect on ground level wind flows. This is largely unavoidable given the site and the orientation of the existing building. However, the design failed in that it created a north-south opening through the ground floor of the building, which created uncomfortable wind flows through the interior ground floor space. Better orientation of the entrances would have mitigated these wind flows. This development highlights difficulties for the resource consent process dealing with spaces are privately owned, but which can have public use/access.
2006 (151582)	1 Featherston Street **Asteron Tower (IRD)**	Asteron Tower has poor design outcomes for wind. The large building sits on a site that is exposed to northly winds and has few design concessions for wind. The primary mitigation is a large canopy above the adjacent

	New high-rise commercial building	footpaths and a porous façade to the carparking levels 2 and 3. No alternative options to the slab-sided facade were evaluated/tested. Wind tunnel tests showed poor wind conditions would result from the development, and despite a recommendation to revisit the design, other considerations ultimately lead to this design being approved. The building has a notoriously bad effect on wind conditions in Featherston Street.
2015 (346546)	22 Boulcott Street Press House (Transpower) redevelopment of a mid-rise commercial building	The Press House redevelopment has good wind outcomes. The successful feature of this development is the off-site wind mitigation that is more effective than on-site measures would have been. A large screen and canopy structure, on the opposite side of Boulcott Street to Press House, shelters pedestrians on the footpath. Wind mitigation was successful in this instance because the effects where localised, and the developer was able to successfully negotiate construction of a shelter structure on someone else's land (in this case, Wellington City).
2014 (319386)	10 Waterloo Quay Site 10 (PWC) New mid-rise commercial building	The Site 10 development highlights the successful use of off-site mitigation, to provide shelter to localised areas when windy conditions are otherwise unavoidable. The Site 10 building fills what was a vacant site and consequently has a large effect on prior ground level wind flows. While the net effect on the wind environment is small, localised windy areas are unavoidable (i.e. not a function of the building design), and localised mitigation is most effective. Windy areas opposite the development on Waterloo Quay occur, and off-site mitigation (screens/canopies) has been used to minimise the impact on people waiting to cross Waterloo Quay.
2018	15 Customhouse Quay Site 9 Proposed new mid-rise commercial building that is currently being consented	The Site 9 development highlights the successful use of off-site mitigation, to provide shelter to localised areas when windy conditions are otherwise unavoidable. The proposed building fills a vacant site and consequently has a large effect on ground level wind flows. While the net effect on the wind environment is minimal, localised windy areas are unavoidable (i.e. not a function of the building design), and localised mitigation is most effective. Some of the windy areas are off-site and screens to shelter pedestrians (waiting to cross Waterloo Quay) provide effective mitigation.
2019 (448724)	1-25 Arlington Street Arlington Apartments Proposed new medium-density residential buildings complex	The Arlington Apartment development had a good design / consent process, in relation to the wind provisions. Wind mitigation (including screens, canopies and plantings) was agreed between the applicant and WCC during the consent process. The consent was granted subject to confirmation that the mitigation would achieve the desired outcomes, which allowed the development to progress without delay, waiting for landscape design and wind tunnel test results.
2019	1 Whitmore Street Proposed new commercial building that has recently been consented,	The 1 Whitmore Street development shows the relative success of the wind provisions in the Plan in mitigating poor wind conditions to a practical extent, while allowing development in a windy part of the city. The site is already windy and wind tunnel testing shows that the deterioration in wind conditions with the

		development is not a problem with the building's design. Mitigation measures to shelter pedestrians ("improvements to the adjacent 'public realm' frontage to Featherston Street") are a condition of the consent, which has enabled the development to proceed without delays waiting for detailed design.

3.2.1 Discretion is critical

The overall impression from the developments that have been reviewed, both good and bad, is that the outcome depends primarily on the parties involved in the design and consent decisions, rather than the specific details of the wind provisions in the Plan at the time. There is no documentation or indication that the wind provisions on their own prevented poor design, or lead to good wind design. Both good and bad outcomes have resulted from the same wind rules, so it is self-evident that other factors drive these outcomes.

Some discretion is necessary within the wind rules to allow sufficient flexibility in the planning controls to achieve good developments. There are no quantitative wind criteria that can be applied without discretion, that would provide good outcomes for wind, let alone the many other effects and design considerations. The planning decisions for specific developments are therefore critical in how the wind rules are applied, enforced and to the outcome that is achieved. When wind conditions around a development are marginal, the wind rules simply highlight non-compliant wind conditions. This in turn provides the City with the ability to negotiate improvements with the developer – the success of which, unsurprisingly, depends on the parties involved and the specific constraints of the development.

3.2.2 Wind mitigation can be substantial

When large adverse wind effects are generated by developments, correspondingly large changes in the bulk, form, orientation and siting of the development may be needed to significantly mitigate the effects. The Majestic Centre shows that large design changes can mitigate poor wind conditions, while the Asteron Tower shows the consequences of not making substantial design changes. Other developments show that when adverse effects are localised, then smaller mitigation, such as screens or canopies, can be sufficient.

3.3 Effectiveness of Wellington's Wind Rules

The current wind rules in the Plan set a good level of performance for development in Wellington, and provide for a safe public wind environment, if applied strictly. However, they do not affect planning outcomes. Poor wind outcomes only occur when non-compliant developments are approved, which makes the discretion and decisions in the resource consent process the most critical success factor.

Many developments (and some existing wind environments) do not comply with the wind criteria and so planning discretion is required to allow for non-compliance, if development is to occur. Improving the decisions and trade-offs in the design and planning process will have greatest effect on maintaining or improving the wind environment.

Poor information (inadequate or technically complex) and poor understanding of wind effects has been identified as problem within the planning process. Improving guidance on the objectives of the wind rules and enforcing better information on wind effects in applications is recommended. The Design Guide for Wind is rarely used, so should be amended to make it more relevant for planners by including guidance on interpreting and applying the wind rules.

The wind rules have sufficient flexibility (via planning discretion) to allow good development to occur on windy sites, but also allow poor designs to be approved. By setting performance standards (i.e. specifying what wind conditions are acceptable) rather than prescribing design features (for example set-backs, podiums and canopies) the wind rules enable efficient design and optimum use of sites. However, as noted above, the planning decisions ultimately determine success.

The current wind rules have very limited application to pedestrian comfort, so generally do not control for these outcomes. Adding more stringent comfort criteria to the Wellington wind rules would have limited effect, as many developments struggle to comply with current safety and cumulative effect criteria.

4 Comparison with Other Wind Rules

Wind rules from a number of cities around the world have been reviewed and compared to Wellington's wind rules. The purpose of this comparison is to highlight current planning practice that is not reflected in the Plan provisions and identify key differences in current approaches.

In New Zealand, Wellington and Auckland have the most thorough and specific wind rules in their district plans. Some other cities in New Zealand have district plan provisions for wind, but these are these are not specified in the same level of detail.

Wind rules from the following cities have been reviewed :

- Wellington (New Zealand)
- Auckland (New Zealand)
- Tauranga (New Zealand)
- Lower Hutt (New Zealand)
- Brisbane (Australia)
- Sydney (Australia)
- Melbourne (Australia)
- Toronto (Canada)
- Mississauga (Canada)
- Ottawa (Canada)
- Hamilton (Canada)
- San Francisco (USA)
- London (England)

These cities were selected because their wind rules can be viewed on the internet, the rules are written in English, and some of the cities are close to Wellington. This list highlights the focus on wind issues in many Canadian cities, reflecting the importance of Canada in the history of wind engineering and the prominence of Canadian companies in wind engineering activities.

4.1 Wellington

Wellington wind provisions are described in Section 2 and are transcribed in Appendix A and B. Different wind provisions apply to different parts of the city, with the Central Area having quantitative Standards that specify winds speeds and hours of occurrence that are acceptable, while other areas of Wellington do not have associated Standards, but do require a general consideration of wind effects from developments.

The following characteristics of Wellington's wind rules become apparent on close inspection, and are useful to note if minor amendments to the rules are considered:

- The Safety Criteria is a limit on the maximum gust wind speed, of 20 m/s. The gust duration and probability of occurrence also need to be specified to fully define this criterion. While, the gust speed is defined in the wind tunnel test requirements (Central Areas Appendix 8 and Centres Appendix 2), it is not defined in the reporting requirements for wind assessments.
- The rules for different areas of Wellington differ and are inconsistent in some respects.
  - Pedestrian amenity/comfort is only considered in specific parks in the Central Area, but is part of the planning discretion in the Centres and Business Areas.

- Wind Standards are prescribed for the Central Area, but are not set for the Centres and Business Areas. Of particular note, the Centres Appendix 2 specifies technical details of wind speed measurements for which there are no corresponding criteria in the Centres Rules.
- Planning discretion is triggered by a set height (18.6 m, which is less than the Height Standard) in the Central Area, but is triggered by exceeding the Height Standard in the Centres and Business Areas.

4.2 Other New Zealand wind rules

4.2.1 Auckland

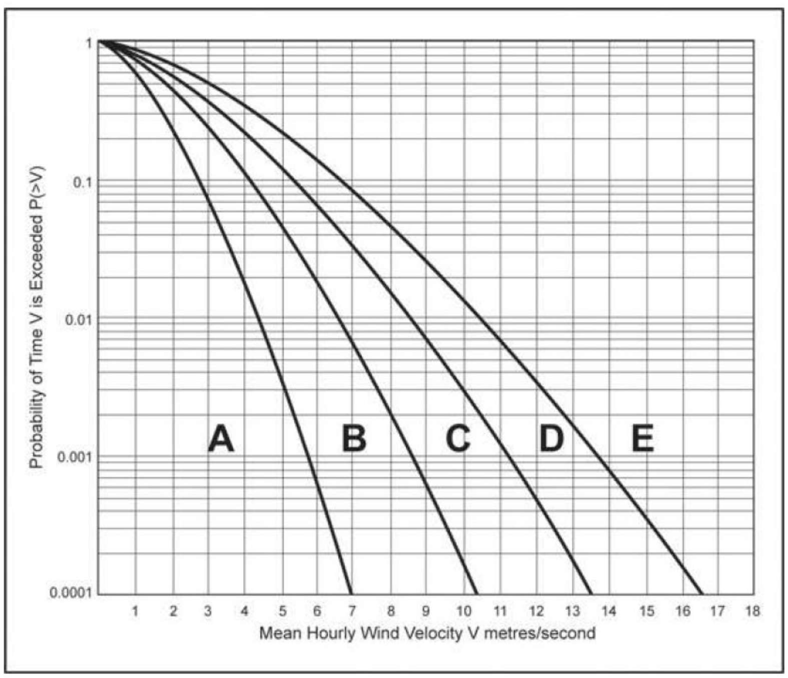
The Unitary Plan for Auckland contains wind provisions for buildings that exceed 25m height. The occurrence of mean wind speeds is used to define 5 performance categories that correspond to different pedestrian activities. There is also a safety criterion that is defined by the annual maximum 3-second gust speed. The same wind rules are set for a number of different areas in the city, so only those for the *Business – City Centre Zone* are shown below

> H8.3 Policies:
>
> (11) Require development to avoid, remedy or mitigate adverse wind and glare effects on public open spaces, including streets, and shading effects on open space zoned land.
>
> H8.6. Standards
>
> H8.6.28. Wind
>
> Purpose: mitigate the adverse wind effects generated by high-rise buildings.
>
> (1) A new building must not cause:
>
> (a) the mean wind speed around it to exceed the category for the intended use of the area as set out in Table H8.6.28.1 and Figure H8.6.28.1 Wind environment control;
>
> (b) the average annual maximum peak 3 second gust to exceed the dangerous level of 25m per second; and
>
> (c) an existing wind speed which exceeds the controls of Standard H8.6.28(1)(a) or Standard H8.6.28(1)(b) above to increase

Table H8.6.28.1 Performance categories

Cateory	Description
Category A	Areas of pedestrian use containing significant formal elements and features intended to encourage longer term recreational or relaxation use, such as. major and minor public squares, parks and other open spaces, including. Aotea Square, Queen Elizabeth Square, Albert Park, Myers Park, St Patrick's Square, and Freyberg Place
Category B	Areas of pedestrian use containing minor elements and features intended to encourage short-term recreation or relaxation, such as minor pedestrian open spaces, pleasance areas in road reserves, streets with significant groupings of landscaped seating features, including Khartoum Place, Mayoral Drive pleasance areas, and Queen Street
Category C	Areas of formed footpath or open space pedestrian linkages, used primarily for pedestrian transit and devoid of significant or repeated recreational or relaxational features, such as footpaths where not covered in categories A or B above
Category D	Areas of road, carriage way, or vehicular routes, used primarily for vehicular transit and open storage, such as roads generally where devoid of any features or form which would include the spaces in categories A - C above
Category E	Represents conditions which are dangerous to the elderly and infants and of considerable cumulative discomfort to others. Category E conditions are unacceptable and are not allocated to any physically defined areas of the city
Note: All through-site links and other private land given over to public use as bonus features, or subject to public access easements, must be subject to the wind environmental categories.	

Figure H8.6.28.1 Wind environment control



Derivation of the wind environment control graph:

The curves on the graph delineating the boundaries between the acceptable categories (A-D) and unacceptable (E) categories of wind performance are described by the Weibull expression:

$P(>V) = e^{-(v/c)^k}$

where V is a selected value on the horizontal axis, and P is the corresponding value of the vertical axis:

and where:
P(>V) = Probability of a wind speed V being exceeded;
e = The Napierian base 2.7182818285
v = the velocity selected;
k = the constant 1.5; and
c = a variable dependent on the boundary being defined:
A/B, c = 1.548
B/C, c = 2.322
C/D, c = 3.017
D/E, c = 3.715

4.2.2 Tauranga

Tauranga considers wind effects in its district plan but does not have specific wind standards or criteria. The following policies reference wind effects:

High Density Residential Zone

14E.1.1.1 Policy – Bulk and Scale of Buildings in the High Density Residential Zone – Height

By defining areas of permitted height through:

a) A High Rise Plan Area where an absolute maximum height is identified that provides an appropriate relationship of high density residential development to the outstanding natural features and landscapes and historic heritage values of Mauao and Hopukiore, and the natural landscape features of the coastal and harbour edges, while limiting the potential adverse effects of accelerated wind speed and overshadowing on adjacent residential development;

Matters of Discretion
...
The Council reserves control over density and scale, and wind effects

4.2.3 Lower Hutt

Hutt City has policies that consider wind effects of development, as below, but does not have specific wind standards or criteria in its district plan.

Central Commercial Activity Area

5A 1.2.2 Policy
....
e) Encourage buildings to be well designed to manage the adverse effects on amenity values, including visual, wind and glare.

Petone West Mixed Use Activity Area

5B 1.2.3 Area 2 Character and Building Form and Quality
...
h) Manage new buildings to be designed to manage adverse effects on amenity values, including visual, wind and glare.

4.3 Overseas wind rules

4.3.1 Brisbane

The Brisbane Centre Design Code sets Performance Criteria and Acceptable Solutions for developments for wind effects as follows:

Performance Criteria:	*The proposal must have regard to any wind generation or wind tunnel effects it may cause*
Acceptable Solutions	*A29.1 Outdoor pedestrian spaces are protected from adverse wind impacts*

The City Centre Neighbourhood Plan for Brisbane includes a requirement that developments must:

> "Achieve a high degree of pedestrian amenity that is not impacted unduly by overshadowing or adverse wind impacts."

Examination of a wind tunnel test report which has been prepared for a new building in Brisbane shows information on gust wind speed and mean wind speeds is presented, but no specific council requirements are listed.

4.3.2 Sydney

The Sydney Development Control Plan 2012 (DCP) has general wind controls, set out in clause 3.2.6, that apply to buildings above 45 metres in height.

> ***3.2.6 Wind effects***
>
> *These provisions apply to all buildings over 45m high and other development where Council requires wind effects to be considered.*
>
> *Windy conditions can cause discomfort and danger to pedestrians and downdraughts from buildings can inhibit the growth of street trees. Conversely, moderate breezes can enhance pedestrian comfort and disperse vehicle emissions and air-conditioning plant exhausts. The useability of open terraces on buildings also depends on comfortable conditions being achieved.*
>
> *The shape, location and height of buildings are to be designed to satisfy wind criteria for public safety and comfort at ground level.*
>
> ***Objective***
>
> *(a) Ensure that new developments satisfy nominated wind standards so as to maintain comfortable conditions for pedestrians and encourage the growth of street trees.*
>
> ***Provisions***
>
> *(1) A wind effects report is to be submitted with a development application for buildings higher than 45m and for other buildings at the discretion of the consent authority. The report is to be prepared by a suitably qualified engineer and is to:*
>
> *(a) be based on wind tunnel testing, which compares and analyses the current wind conditions and the wind conditions created by the proposed building;*
>
> *(b) report the impacts of wind on the pedestrian environment at the footpath level within the site and the public domain;*
>
> *(c) provide design solutions to minimise the impact of wind on the public and private domain; and*

> (d) *demonstrate that the proposed building and solutions are consistent with the provisions of this DCP.*
>
> (2) *Development must not create a ground level environment where additional generated wind speeds exceed:*
>
> (a) *10 metres per second for active frontages as shown on the Active frontages map; and*
>
> (b) *16 metres per second for all other streets.*
>
> (3) *New developments are to incorporate design features that will ameliorate existing adverse wind conditions so that the criteria above are achieved.*
>
> (4) *Building design is to minimise adverse wind effects on recreation facilities and open spaces within developments.*
>
> (5) *Balconies are to be designed to minimise wind impacts and maximise useability and comfort through recessed balconies, operable screens, pergolas and shutters.*
>
> (6) *Balconies must be recessed on building over 45m where possible.*

The DCP includes wind controls for specific areas, such as clause 5.9.4.15, which applies to the Danks Street South area in Sydney.

> *5.9.4.15 Wind testing*
>
> (1) *Development is to provide wind tunnel testing that demonstrates that all streets comply with the following wind standards:*
>
> (a) *Wind Safety Standard, being an annual maximum peak 0.5 second gust wind speed in one hour measured between 6am and 10pm Eastern Standard Time of 24 metres per second.*
>
> (b) *Wind Comfort Standard for Walking, being an hourly mean wind speed, or gust equivalent mean wind speed, whichever is greater for each wind direction, for no more than 292 hours per annum measured between 6 am and 10 pm Eastern Standard Time (i.e. 5% of those hours) of 8 metres per second.*
>
> (2) *Development is to provide wind tunnel testing that demonstrates that all non-active use areas of public open spaces comply with the following wind standard:*
>
> (a) *Wind Comfort Standard for Sitting in Parks, being an hourly mean wind speed, or gust equivalent mean wind speed, whichever is greater for each wind direction, for no more than 292 hours per annum measured between 6 am and 10 pm Eastern Standard Time of 4 metres per second.*
>
> (3) *Development is to provide wind tunnel testing that demonstrates that all active use areas of public open spaces comply with the Wind Comfort Standard for Walking (as defined in provision 1(b) above).*

The DCP includes wind controls for specific sites, such as clause 6.3.14.3, which applies to 4-6 Bligh Street, Sydney.

> *6.3.14.3 Managing Wind Impacts*
>
> (1) *A quantitative wind effects report is to be submitted with a development Application.*
>
> (2) *Development must not cause a wind speed that exceeds the Wind Safety Standard, the Wind Comfort Standard for Walking*

(3) Development must not worsen, by increasing spatial extent and/or frequency and/or speed, an existing wind speed that exceeds the Wind Safety Standard and the Wind Comfort Standard for Walking.

(4) Development must take all reasonable steps to create a comfortable wind environment that is consistent with the Wind Comfort Standards for Sitting and Standing.

(5) For the purposes of complying with Section 6.3.14.3(2) and (3):

Wind Safety Standard is an annual maximum peak 0.5 second gust wind speed in one hour measured between 6am and 10pm Eastern Standard Time of 24 metres per second.

Wind Comfort Standard for Walking is an hourly mean wind speed, or gust equivalent mean wind speed, whichever is greater for each wind direction, for no more than 292 hours per annum measured between 6 am and 10 pm Eastern Standard Time (i.e. 5% of those hours) of 8 metres per second.

Wind Comfort Standards for Sitting and Standing is hourly mean wind speed, or gust equivalent mean wind speed, whichever is greater for each wind direction, for no more than 292 hours per annum measured between 6 am and 10 pm Eastern Standard Time of 4 metres per second for sitting; and 6 metres per second for standing.

Several wind tunnel study reports for Sydney, provide information on gust wind speed effects (similar to gust information provided in Wellington wind reports). One of these reports' comments that "*It is understood that these are the once per annum gust wind speed to define pedestrian comfort based on the criterion of Melbourne (1975), however this is not explicitly stated in the DCP*."

4.3.3 Melbourne

Melbourne has wind provisions that include both safety and comfort criteria. Of note is the use of GEM (gust equivalent mean) wind speeds, which are becoming a commonly used measure worldwide when reporting comfort[2].

Several wind tunnel study reports for developments in Melbourne have been reviewed that present both mean and gust wind speed effects. One of these reports usefully summarises Melbourne City's wind criteria in the table below. The full requirements of the Melbourne Planning Scheme, for wind effects, are transcribed after this:

[2] The GEM is an adaptation of the Durgin (1990) "equivalent average" which was developed to "be able to use a single wind speed that includes the several types of windiness that can result in a given location being perceived as windy". It combines mean speed and gust speed in a single number argued to be more representative of local comfort.

Table 1: Wind Comfort and Safety Gust Criteria for Melbourne Central City	
SAFETY CRITERIA	
Annual maximum 3 second gust speed with an annual probability of exceedance of 0.01%	**Result on perceived pedestrian comfort**
>20m/s	Unsafe (frail pedestrians knocked over)
COMFORT CRITERIA	
Maximum of: **1. Hourly mean wind speed** **2. Gust equivalent mean speed (3 second gust wind speed divided by 1.85), for winds occurring 80% of the time.**	**Result on perceived pedestrian comfort**
<5 m/s	Acceptable for walking (steady steps for most pedestrians)
<4 m/s	Acceptable for standing (window shopping, vehicle drop off, queuing)
<3 m/s	Acceptable for sitting (outdoor cafés, pool area, gardens)

The Melbourne Planning Scheme (selected extracts are transcribed to show the wind provisions, as follows):

21.06 (30/07/2015) C240 BUILT ENVIRONMENT AND HERITAGE

21.06-1 (08/05/2014) C220 Urban Design

Objective 5 Ensure that the scale, bulk and quality of new development supports a high quality public realm.

Strategy 5.7 Ensure development minimises the adverse effects of wind down drafts and provides wind protection to public open spaces suitable for their role and function.

22.01 (23/11/2016) C270 URBAN DESIGN WITHIN THE CAPITAL CITY ZONE

22.01-7 (23/11/2016) C270 Wind and Weather Protection

It is policy that wind and weather protection measures are assessed against the following design standards as appropriate:

- Landscaping within the public realm should not be relied on to mitigate wind effects.
- Towers should be appropriately set back from all street frontages above the street wall or podium to assist in deflecting wind downdrafts from penetrating to street level.
- Within the tower setback, some variation in treatment may provide a transition between the podium and tower. Such treatment should be carefully checked for wind effects at street level.
- Areas designated in Schedule 4 of the Design and Development Overlay (Weather Protection) should be protected from rain and wind.
- The design, height, scale and detail of canopies, verandahs and awnings should be compatible to nearby buildings, the streetscape and the precinct character.

- Canopies, verandahs and awnings should be partly or fully transparent to allow light penetration to the footpath and views back up the building facade, and should be designed to avoid an adverse impact on street trees, allowing for future growth.
- Verandah support posts should be located at least 2 metres from tree pits.
- Weather protection does not need to be provided where it would interfere with the integrity or character of heritage buildings, heritage precincts or streetscapes and lanes.

22.17 (29/01/2015) C225 URBAN DESIGN OUTSIDE THE CAPITAL CITY ZONE

Objectives

To ensure that development promotes building forms that will minimise the adverse impacts of wind in surrounding public spaces and provide weather protection where appropriate.

Application Requirements
An application for buildings and works must be generally in accordance with the approved Comprehensive Development Plan and must include the following information, as relevant:
…
A Wind Assessment Report which addresses;
– Short term stationary wind exposure for any outdoor cafes and restaurants (should they be proposed);
– Short term wind exposure for street frontages and trafficable areas used as a thoroughfare;
– Design measures to minimise the effect of wind to streets and public open spaces and ensure that adverse wind effects over and above the conditions that are currently experienced at present are not created.

or

An application for a permit must be accompanied by a written urban context report documenting the key planning influences on the development and how it relates to its surroundings. The urban context report must identify the development opportunities and constraints, and document the effect of the development, as appropriate, in terms of:
…
Microclimate, including sunlight, daylight and wind effects on streets and other public spaces.

An application to construct a building or to construct or carry out works must be accompanied by a Wind Analysis which should show how the proposal meets the following requirements:

- Developments fronting Swanston Street or internal lanesways should be designed to be generally acceptable for stationary long term wind exposure (where the peak gust speed during the hourly average with a probability of exceedence of 0.1% in any 22.5° wind direction sector must not exceed 10 ms^{-1}).
- All other areas should be designed to be generally acceptable for short term wind exposure (where the peak gust speed during the hourly average with a probability of exceedence of 0.1% in any 22.5° wind direction sector must not exceed 13ms^{-1}). However, if it can be demonstrated that the street frontage or trafficable area is only likely to be used as a thoroughfare for the life of the development, the building interface should be designed to be generally acceptable for walking (where the peak gust speed during the hourly average with a probability of exceedance of 0.1% in any 22.5° wind direction sector must not exceed 16ms-^{1}).
- Developments should not rely on street trees for wind protection.

Decision guidelines
Before deciding on an application, in addition to the decision guidelines in Clause 65, the responsible authority must consider, as appropriate:
…
- The wind effects of the proposed development at ground level.

2.1 (13/07/2017) C311 **Definitions**

unsafe wind conditions means the hourly maximum 3 second gust which exceeds 20 metres/second from any wind direction considering at least 16 wind directions with the corresponding probability of exceedance percentage.

comfortable wind conditions means a mean wind speed from any wind direction with probability of exceedance less than 20% of the time, equal to or less than:
– 3 metres/second for sitting areas
– 4 metres/second for standing areas
– 5 metres/second for walking areas.

mean wind speed means the maximum of:
– Hourly mean wind speed, or
– Gust equivalent mean speed (3 second gust wind speed divided by 1.85).

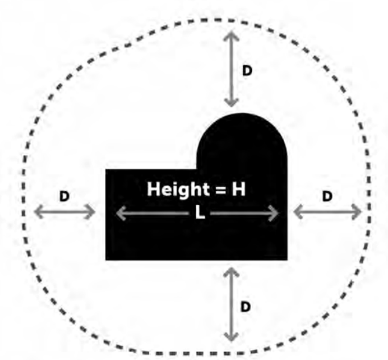
2.3 (13/07/2017) C311 **Requirements**

Wind Effects

A permit must not be granted for buildings and works with a total building height in excess of 40 metres that would cause unsafe wind conditions in publicly accessible areas within a distance equal to half the longest width of the building above 40 metres in height measured from all facades, or half the total height of the building, whichever is greater as shown in Figure 1.

A permit should not be granted for buildings and works with a total building height in excess of 40 metres that do not achieve comfortable wind conditions in publicly accessible areas within a distance equal to half the longest width of the building above 40 metres in height measured from all facades, or half the total height of the building, whichever is greater as shown in Figure 1.

Figure 1



Assessment distance D = greater of:
L/2 (Half longest width of building)
OR
H/2 (Half overall height of building)

2.5 (13/07/2017) C311 **Application Requirements**

If in the opinion of the responsible authority an application requirement listed below is not relevant to the assessment of the application, the responsible authority may waive or reduce the requirement.

…

Wind analysis report
An application for a permit for a building with a total building height in excess of 40 metres must be accompanied by a wind analysis report prepared by a suitably qualified person. The wind analysis report must:

- explain the effect of the proposed development on the wind conditions in publicly accessible areas within a distance equal to half the longest width of the building, measured from all facades, or half the total height of the building, whichever is greater.
- at a minimum, model the wind effects of the proposed development and surrounding buildings (existing and proposed) using wind tunnel testing.
- identify the principal role of each portion of the publicly accessible areas for sitting, standing or walking purposes.

- not rely on street trees or any other element such as screens, within public areas for wind mitigation.

5.0 (13/07/2017) C311 **Decision guidelines**

Before deciding on an application, in addition to the decision guidelines in Clause 65, the responsible authority must consider, as appropriate:

- Whether the cumulative effect of the proposed development in association with adjoining existing and potential development supports a high quality of pedestrian amenity in the public realm, in relation to human scale and microclimate conditions including overshadowing and wind impacts. The effect of the proposed buildings and works on solar access to existing and proposed open spaces and public places.
- The potential for increased ground-level wind gust speeds and the effect on pedestrian comfort and the amenity of public places, with allowance to exceed uncomfortable conditions only if the wind effects of the proposed development do not exceed the existing wind condition(s).

(pg 857) **Design Objective**

To promote pedestrian amenity.

To ensure built form does not increase the level of wind at ground level and that buildings are designed to minimise any adverse effect on pedestrian comfort.

Design Requirement

The design of the building should minimise the potential for ground-level wind and any adverse effect on pedestrian comfort as follows:

- In the proposed activity nodes shown on Map 1 the peak gust speed during the hourly average with a probability of exceedence of 0.1% in any 22.5° wind direction sector should not exceed 10 ms^{-1}. This speed is generally acceptable for stationary, long term exposure (>15 minutes); for instance, outdoor restaurants/cafes, theatres
- Along major pedestrian areas shown on Map 1 the peak gust speed during the hourly average with a probability of exceedence of 0.1% in any 22.5° wind direction sector should not exceed 13 ms^{-1}. This speed is generally acceptable for stationary, short term exposure (<15 minutes); for instance, window shopping, standing or sitting in plazas;
- Along all other streets the peak gust speed during the hourly average with a probability of exceedence of 0.1% in any 22.5° wind direction sector should not exceed 16 ms^{-1} (which results in half the wind pressure of a 23ms^{-1} gust) which is generally acceptable for walking in urban and suburban areas.
- Landscaping within the public realm should not be relied on to mitigate wind.

3.0 (19/07/2018) C221 **Requirements for development plan**

...

A preliminary Wind Assessment which sets criteria against which any permit applications are to be assessed which ensures that:

- Accessible areas for public or private use satisfy comfortable walking criterion of 7.5m/s for the Weekly Gust Equivalent Mean Wind Speeds, which corresponds to 16m/s for the annual maximum gust wind speeds.
- All outdoor seating areas such as café seating and short duration stays, including building entries, satisfy the short exposure criterion of 5.5m/s for the Weekly Gust Equivalent Mean Wind Speeds, which corresponds to 13m/s for the annual maximum gust wind speeds.
- All areas to be used for long duration stay activities, such as restaurant use, satisfy the long exposure criterion of 3.5m/s for the Weekly Gust Equivalent Mean Wind speeds, which corresponds to 10m/s for the annual maximum gust wind speeds.
- All areas also satisfy the Safety Limit Criterion of 23m/s for the annual maximum gust wind speeds.
- Design measures minimise the effect of wind to streets and public open spaces.

Canada: Toronto, Mississauga, Hamilton and Ottawa

These four cities are all in the province of Ontario, Canada, and have generally consistent wind rules. They use similar criteria as those described for Melbourne city, although the specified wind speeds and the % of the time are different. i.e. a higher wind speed is specified that occurs for a lower percentage of the time (note, wind rules can, and often do, specify different wind speeds and 'percentage of time', with no practical difference to the underlying effect of the rules).

4.3.4 Toronto

Toronto does not have quantitative wind rules, but the Official Plan does contain polices relating to wind effects from buildings, as follows

> New development will be massed and its exterior façade will be designed to fit harmoniously into its existing and/or planned context, and will limit its impact on neighbouring streets, parks, open spaces and properties by:
>
> ...
>
> e) adequately limiting any resulting shadowing of, and uncomfortable wind conditions on, neighbouring streets, properties and open spaces, having regard for the varied nature of such areas; and
>
> f) minimizing any additional shadowing and uncomfortable wind conditions on neighbouring parks as necessary to preserve their utility.

and

> The effects of development from adjacent properties, including additional shadows, noise, traffic and wind on parks and open spaces will be minimized as necessary to preserve their utility.

The City-Wide Tall Building Guidelines directs that tall buildings provide

> "greater tower separation, setbacks, and stepbacks proportionate to increases in tower floor plate size or height to mitigate resultant wind"(3.2.1b)

and to "Locate, orient, and design tall buildings to promote air circulation and natural ventilation, yet minimize adverse wind conditions on adjacent streets, parks and open space, at building entrances, and in public and private outdoor amenity" (4.3 Pedestrian Level Wind Effects).

The Toronto Development Guide: Site Plan Control Applications (2011), for large sites, waterfront sites and/or sites where a substantial increase in height is requested, indicates that a Preliminary Wind Study may be required in addition to the Final Wind Study.

An extensive report on city planning for Toronto was published in 2018, called: "TOcore: Building for liveability". The executive summary includes the following findings and recommendations that relate to planning controls for pedestrian level wind effects in Toronto:

01C

PEDESTRIAN LEVEL WIND

COMFORT — SAFETY

FINDINGS

- As buildings get taller, and as tall buildings are clustered in close proximity to one another, the built environment will continually impact and change how winds are experienced at the pedestrian level. The dynamic nature of wind speaks to the need to understand the cumulative impact from multiple developments in a given area.
- The Terms of Reference for Pedestrian Level Wind Studies in the City's Development Guide does not provide sufficient detail to ensure consistent information is provided through all application submissions, and does not include targets for evaluation.
- The submission of the detailed Wind Impact Assessment at the Site Plan Application stage does not allow for more substantial changes to be made to the building orientation and massing.

RECOMMENDATIONS

1. Amend the Terms of Reference in the City's Development Guide for Pedestrian Level Wind Studies to:
   - Develop comfort categories that respond to specific geographies (parks, priority retail streets) or activities (sitting, standing);
   - Require Wind Impact Assessments, rather than opinion letters, to be submitted at the early stages of the planning application review process i.e. at Zoning By-law Amendment stage, so that the evaluation of pedestrian level winds can assist to shape the development in order to reduce negative impacts;
   - Require all development applications to provide a Wind Impact Assessment that: measures Gust Equivalent Mean; applies evaluation criteria that assesses wind impacts on the pedestrian level; and uses standardized graphics and displays; and
   - Require Wind Impact Assessments to include a broad geography and existing and planned development context to evaluate the cumulative existing and future wind conditions in an accurate manner.
2. Require architectural responses such as: altering the footprint of tall building elements; increasing step-backs and separation distances; and re-orienting building footprints when the Wind Impact Assessment demonstrates negative impacts on the pedestrian environment.
3. Consider mitigation measures such as fencing, wind screens and landscaping, once other architectural responses have been exhausted.

4.3.5 Mississauga

The Mississauga Official Plan, Section 19.4.5, identifies that a Wind Study may be requested as part of a planning application. The requirements for a wind study are set out in "Urban Design Terms of Reference – Pedestrian Wind Comfort and Safety Studies – June 2014", which is attached to this report in Appendix C. These Terms of Reference provide a simple, and complete set of planning rules for wind effects. While these are less detailed/prescriptive than Wellington's rules for some aspects of wind effects, they never-the-less set a clear benchmark for what is an acceptable wind environment and the quality of information required in a planning application

The Terms of Reference include high-level quality assurance requirements for wind studies, triggers for when different types of wind studies must be submitted and criteria for assessing the wind effects against. They also included general guidance on wind mitigation strategies, but have relatively specific requirements for confirmation from a "microclimate specialist" that wind effects will be acceptable, and that any wind mitigation has been constructed in accordance with the design. There is an emphasis in these Terms of Reference on using of appropriate "microclimate specialists' and a reliance on their work/certifications.

The basic trigger for the wind rules in Mississauga is a building height of 20 metres. All developments that meet this threshold must have a "Qualitative Wind Assessment" (i.e. expert written opinion or computational fluid dynamics (CFD) study) done, but might require a "Quantitative Wind Tunnel Study" at the discretion of the City planners. A Quantitative Wind Tunnel Study is required in the following situations:

- A development > 20m high and is two times the height of surrounding buildings
- A development > 40m high
- A development has two or more buildings > 20m high
- A development > 20m high and is located south of Queen Elizabeth Way (near Lake Ontario)
- A development > 20m high and has a site area > 3 hectares

The comfort and safety wind criteria that are used in Mississauga are set out in the Table below.

Comfort Category	**GEM Speed (km/h)**	**Description**
Sitting	≤ 10	Calm or light breezes desired for outdoor restaurants and seating areas where one can read a paper without having it blown away
Standing	≤ 15	Gentle breezes suitable for main building entrances and bus stops
Walking	≤ 20	Relatively high speeds that can be tolerated if one's objective is to walk, run or cycle without lingering
Uncomfortable	> 20	Strong winds of this magnitude are considered a nuisance for most activities, and wind mitigation is typically recommended
Notes: (1) Gust Equivalent Mean (GEM) speed = *max*(mean speed, gust speed/1.85); and (2) GEM speeds listed above are based on a seasonal exceedance of 20% of the time (e.g., between 6:00 and 23:00).		
Safety Criterion	**Gust Speed (km/h)**	**Description**
Exceeded	> 90	Excessive gust speeds that can adversely affect a pedestrian's balance and footing. Wind mitigation is typically required.
Note: Based on an annual exceedance of 9 hours or 0.1% of the time for 24 hours a day.		

4.3.6 Ottawa

All planning submissions in Ottawa require a wind analysis in accordance with "Terms of Reference : Wind Analysis". which is attached to this report in Appendix D. These Terms of Reference set high-level quality assurance requirements for wind studies, describe when different types of wind studies are required (which is by agreement with City planners) must be submitted and criteria for evaluating the wind effects against.

The evaluation criteria are shown below, for comparison with other wind criteria in section 4.14:

Evaluation Criteria:

The following evaluation criteria will be used to evaluate wind speeds from the proposed development:

Wind Comfort Criteria:

Both mean wind and wind gusts will be used to measure the comfort of the wind at identified locations. There are four measuring points to evaluate the comfort of the wind speed: sitting, standing, strolling and walking. These measuring points are to be evaluated at different locations/areas on the development site and immediate adjacent area to ensure that they meet the criteria. Should a proposed development not be able to meet the comfort evaluation criteria, mitigation measures (e.g. building and / or site design measures) are required for Type 1 applications and strongly suggested for Type 2 applications.

Category	Speed (km/hr)	Where Applicable
Sitting	≤ 10	Outdoor public and private amenity spaces (e.g. restaurant patio's and seating areas)
Standing	≤ 14	Major building entrances and bus stops
Strolling	≤ 17	Sidewalks association with a mainstreet, plazas and parks
Walking	≤ 20	Sidewalks other than those associated with a mainstreet, bicycle paths and parking lots
Uncomfortable	≥ 20	Winds of this magnitude are considered a nuisance for most activities and wind mitigation measures are recommended.

NOTE: The speeds are based on a seasonal 20% exceedance factor (between 6:00am-11:00pm). In other words the criterion has been met if the wind speeds occur at least 80% of the time or four out of five days.

Wind Safety Criteria:

Wind gusts will be used to measure the safety of the wind on all test locations. Should a proposed development not be able to meet the wind safety criteria, appropriate mitigation measures (e.g. redesign of the site, reduction in height, etc.) will be required to eliminate the safety issue.

Category	Speed (km/hr)	Where Applicable
Exceeded	≥ 90	At any test location, wind speeds of this magnitude are considered a safety hazard and wind mitigation is required.

NOTE: The speeds are based on an annual exceedance of 9 hours or 0.1% of the time for a 24 hour day.

4.3.7 Hamilton (Canada)

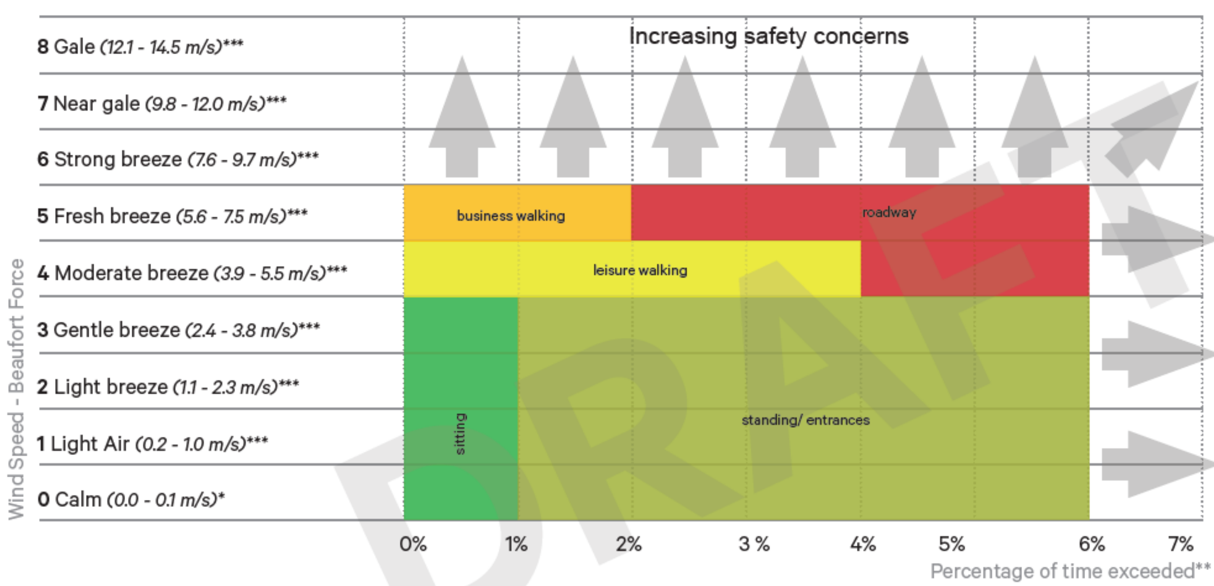
The Downtown Hamilton Tall Buildings Guidelines includes a section 5.3 on Pedestrian Weather Protection & Wind Effects. It has very high-level guidelines for wind effects, but has quantitative comfort criteria. Of note, no safety criteria or limits are set.

The Guidelines state that "Tall buildings should minimize adverse wind effects on adjacent streets, parks and open spaces, as well as at building entrances and outdoor amenity areas."

Comfort criteria for wind effects are set as follows,

> Wind targets shall meet the widely accepted Lawson Comfort Criteria. The massing of new buildings should be evaluated based on its resultant wind effects on adjacent open spaces and pedestrian areas. The combination of wind time and duration shall not exceed the standards set for the activities foreseen in each open space, based on the following thresholds:
>
> - Sitting: up to wind speed 3* if not exceeded more than 1% of the time**.
> - Standing/entrances: up to wind speed 3* if not exceeded more than 6% of the time**.
> - Leisure walking: up to wind speed 4* if not exceeded more than 4% of the time**.
> - Business walking: up to wind speed 5* if not exceeded more than 2% of the time**.
> - Roadway: up to wind speed 5* if not exceeded more than 6% of the time**.
>
> * Beaufort Force scale, see table in next page
>
> ** Percentage of time that gust wind speeds exceed the sustained gust equivalent mean (GEM) wind speed.

Thresholds for Tolerable Conditions based on Lawson Beaufort Criteria:



* Beaufort Force scale, see table in next page

** Percentage of time that gust wind speeds exceed the sustained gust equivalent mean (GEM) wind speed.

*** Wind speed measured at 1.75m height (m/s)

4.3.8 San Francisco

The San Francisco planning code requirements for wind effects (Planning Code Section 148) are reproduced below.

SAN FRANCISCO PLANNING CODE SECTION 148

Reduction of Ground-level Wind Currents in C-3 Districts

a) Requirement and Exception. In C-3 Districts, buildings and additions to existing buildings shall be shaped, or other wind-baffling measures shall be adopted, so that the developments will not cause ground-level wind currents to exceed, more than 10 percent of the time year round, between 7:00 a.m. and 6:00 p.m., the comfort level of 11 m.p.h. equivalent wind speed in areas of substantial pedestrian use and seven m.p.h. equivalent wind speed in public seating areas.

When preexisting ambient wind speeds exceed the comfort level, or when a proposed building or addition may cause ambient wind speeds to exceed the comfort level, the building shall be designed to reduce the ambient wind speeds to meet the requirements. An exception may be granted, in accordance with the provisions of Section 309, allowing the building or addition to add to the amount of time that the comfort level is exceed by the least practical amount if (1) it can be shown that a building or addition cannot be shaped and other wind-baffling measures cannot be adopted to meet the foregoing requirements without creating an unattractive and ungainly building form and without unduly restricting the development potential of the building site in question, and (2) it is concluded that, because of the limited amount by which the comfort level is exceeded, the limited location in which the comfort level is exceeded, or the limited time during which the comfort level is exceeded, the addition is insubstantial.

No exception shall be granted and no building or addition shall be permitted that causes equivalent wind speeds to reach or exceed the hazard level of 26 miles per hour for a single hour of the year.

b) Definition. The term "equivalent wind speed" shall mean an hourly mean wind speed adjusted to incorporate the effects of gustiness or turbulence on pedestrians.

c) Guidelines. Procedures and Methodologies for implementing this section shall be specified by the Office of Environmental Review of the Department of City Planning. (added by Ord. 414-85, App. 9/17/85)

4.3.9 London

The desire to improve wind conditions in the streets around new buildings has received particular focus in London in the past few years following developments that generated very poor wind conditions in the surrounding streets. A proposed 40 storey at 1 Fenchurch Street was wind tunnel tested, which showed that the building, in a city with little wind, would in two places make the wind dangerous at street level. The test also demonstrated that the dangerous winds would be resolved by the planting of trees, and low level under planting. However, planners did not recognise that the trees would only mitigate the dangerous winds, but would not stop the general wind conditions from being noticeably worse. Ultimately, the trees that were planted were inadequate and no under planting was done so the danger was not removed either.

This has resulted in a major review by wind engineering consultants RWDI and in the City of London publishing the planning guidelines, "Wind Microclimate Guidelines for Developments in the City of London". Wind is specified as an important factor in guidelines for new buildings. It is noted that other factors such as temperature, sunlight, air quality and noise also have an influence on outdoor comfort, but are not considered in the current guidelines. These factors may be included in the future.

The guidelines recommend that wind consultants should work in consultation with planning officers, to determine whether a proposed development has features that require extra care and attention.

The guidelines provide fairly high-level specifications for when wind studies are required and quality assurance requirement for wind studies and wind reports, but include quantitative criteria against which wind effects are reported.

The triggers for wind assessments are given in the following table, which use a combination of building height and height of surrounding buildings to determine the type of wind study required:

Building Height	**Recommended Approach to Wind Microclimate Studies**
Similar or lower than the average height of surrounding buildings **Up to 25m in CoL**	Wind studies are not required, unless sensitive pedestrian activities are intended (e.g. around hospitals, transport hubs, etc.) or the project is located on an exposed location (e.g. edge of Thames, near a tall building)
Up to double the average height of surrounding buildings **25m to 50m in CoL**	Computational (CFD) Simulations **OR** Wind Tunnel Testing
Up to 4 times the average height of surrounding buildings **50m to 100m for CoL**	Computational (CFD) Simulations **AND** Wind Tunnel Testing
High Rise **Above 100m**	**Early Stage Massing Optimization:** Wind Tunnel Testing OR Computational (CFD) Simulations **Detailed Design:** Wind Tunnel Testing **AND** Computational (CFD) Simulations to demonstrate the performance of the final building design

The comfort and safety wind criteria used by the City of London are set out below.

Wind comfort criteria: a modified version of the Lawson LDDC criteria referred to as the City Lawson Criteria - is to be used for all wind studies as summarized table below;

Category	Mean and GEM wind speed (5% exceedance)	Description
Frequent Sitting	2.5m/s	Acceptable for frequent outdoor sitting use, e.g. restaurant, cafe'.
Occasional Sitting	4m/s	Acceptable for occasional outdoor seating, e.g. general public outdoor spaces, balconies and terraces intended for occasional use, etc.
Standing	6m/s	Acceptable for entrances, bus stops, covered walkways or passageways beneath buildings.
Walking	8m/s	Acceptable for external pavements, walkways.
Uncomfortable	>8m/s	Not comfortable for regular pedestrian access.

The table above deviates from the original Lawson LDDC Criteria in a couple of areas,

- The 'Frequent Sitting' category is based on City of London's desire to create more active public spaces with amenable cafés/restaurant sitting areas in the future.
- The 'Uncomfortable' category is based on experience that Lawson business walking conditions often lead to complaints in the City of London. Therefore, this category is now re-named as 'uncomfortable'. This category is only suitable for areas that are not expected to receive regular public footfall, like service areas, back-of-house areas, etc.
- Discussions with City of London planning officers about the categorisation of sensitive areas would be highly recommended.

Wind safety criteria: a separate safety criteria is to be applied to ascertain the safety risks to pedestrians and cyclists as follows;

Category	Mean and GEM wind speed from any wind direction (0.022% exceedance)	Description
Pedestrian Safety Limit	15m/s	Presents a safety risk for pedestrians, especially to more vulnerable members of the public.

4.4 Summary of Different Wind Rules

Wind rules that have been reviewed vary widely, from simple high-level objective statements, which lack any detail or criteria, to detailed rules that quantify what wind conditions are acceptable, where the rules apply and provide thorough reporting and quality assurance requirements. By comparison, Wellington's wind rules are relatively detailed and well developed, making their application and interpretation unambiguous. Wellington's rules have similar characteristics to many other well-developed wind rules, but have a few unique features that are important to their current operation and effect.

Most of the wind rules that have been reviewed specifying safety wind limits using relatively infrequent gust wind speeds (for example, the annual maximum gust speed), and comfort wind criteria that use more frequent mean wind speeds (for example, hourly mean winds speeds that are exceeded 5% of the year). Figure 2 compares some of the wind criteria that have been reviewed. The magnitudes of the wind criteria are plotted against their corresponding probabilities of exceedance. In simple terms, stronger, infrequent wind speeds are plotted toward the bottom right , while calmer more frequent winds are plotted toward the top left. The black lines show boundaries between the Auckland wind categories , which increase in windiness from left to right (A – E).

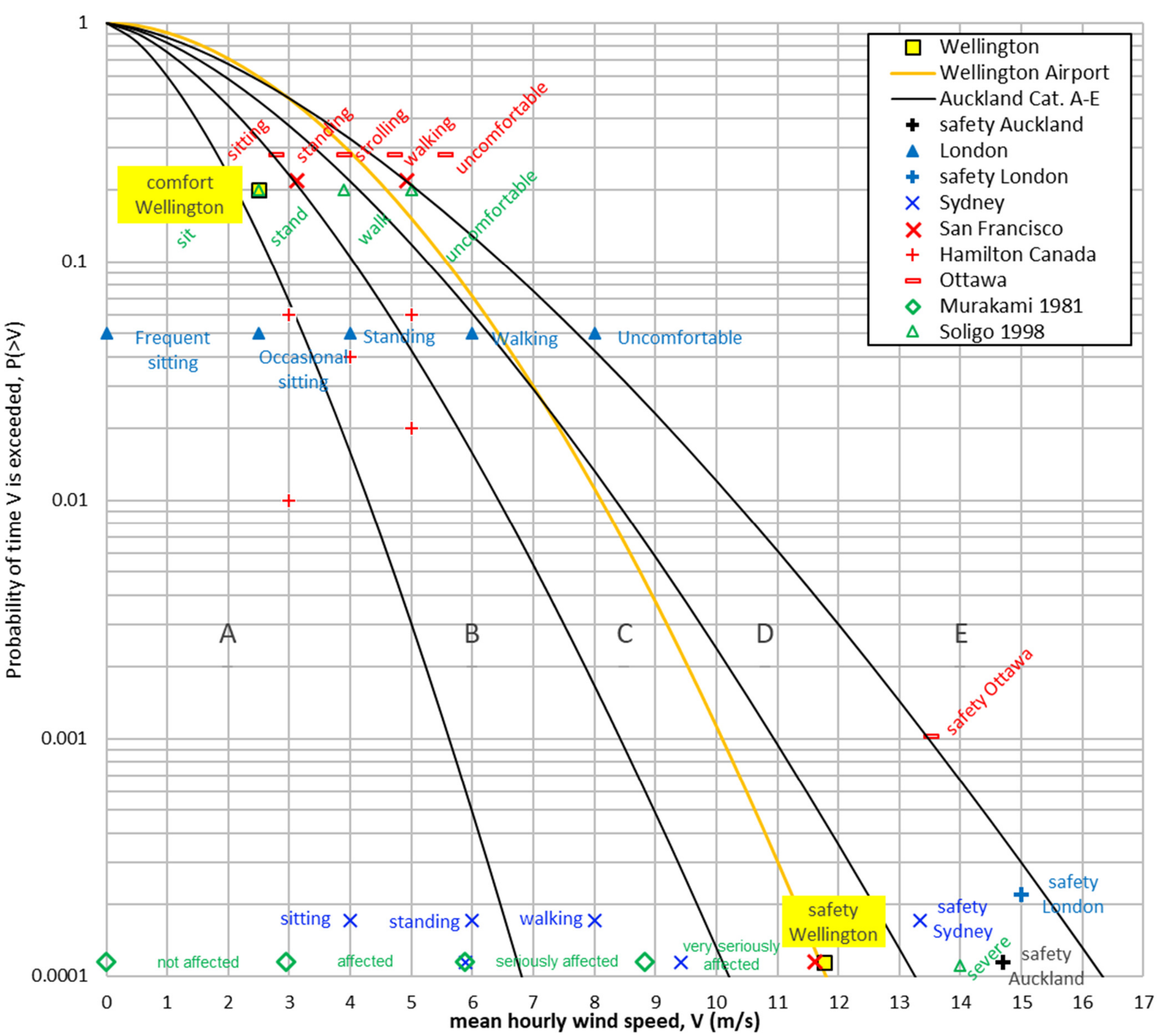


Figure 2 Comparison of safety and comfort wind criteria

4.4.1 Safety

Wind rules that specify safety limits almost always use gust wind speeds, and apply these safety criteria to all pedestrian areas. The main differences in the safety criteria are in the frequency, duration and magnitude of the wind speed that is specified as the threshold of danger. Wellington's safety criterion is consistent with many of the other safety criteria, as illustrated in Figure 2, and is almost identical to San Francisco's safety criterion (after converting the criteria to comparable units and duration).

A technical detail that is important to the definition of gust speeds is the annual probability of exceedance. Maximum gust speeds are often specified as having an annual probability of exceedance of 0.011%, or approximately one hour per year (i.e. 0.011% of 8760 total hours in a year is approximately 0.96 hours per year). In some wind rules, this has mistakenly been written as 0.1%, ten time greater than the once-per-year probability, as occurred in the American Society of Civil Engineers state of the art review "*Outdoor human comfort and its assessment*". This is noted here because caution is required when comparing some of the rules that have been reviewed, which specify probabilities of 0.1%, in relation to safety criteria that are otherwise equivalent to the original safety criteria based on annual probabilities of 0.011%.

4.4.2 Comfort

Many wind rules define comfort criteria using a graduated range of wind speeds (or "wind categories") that are suitable for different activities, such as sitting, standing, strolling and walking. The Lawson criteria are an example of commonly used comfort criteria in overseas wind rules. These comfort criteria are applied to different areas within a city using judgement and discretion of planners and designers to determine what activity, and corresponding wind conditions, are acceptable in particular areas.

The application of these types of comfort criteria are fundamentally different to Wellington's single comfort criterion, which is applied only to prescribed areas in the City. This difference between Wellington's wind rules and many other wind rules. allows Wellington's rules to be simply and consistently applied, but reduces the information that is available to determine what level of comfort will be achieved with developments in Wellington. Using comfort criteria similar to Lawsons criteria in Wellington would require additional reporting by applicants and discretion from City planners to determine appropriate criteria for specific locations.

4.4.3 Cumulative degradation

A unique feature of Wellington's wind rules are the Cumulative Effect criteria that quantify, and limit, any gradual degradation in the overall wind conditions. The two criteria limit the overall increase in moderate wind speeds (predominantly northerly in Wellington) and in strong wind speeds (predominantly southerly in Wellington) around developments. Other wind rules do not have equivalent Cumulative Effect criteria, and instead allow wind speeds to generally increase in an area until the appropriate comfort threshold has been reached. In practice, the overall changes in wind conditions can be estimated when comfort criteria/categories are reported, but this does rely on some expertise and experience to do so successfully.

While the practical effect of the two different approaches can be similar in many situations (and therefore easily confused), there is never-the-less a fundamental difference in the rules that makes Wellington's approach more transparent and aligned to policy objectives in the Plan. Wellington's Cumulative Effect criteria quantify changes in overall wind conditions, regardless of whether the existing wind conditions are calm or windy, making it easy to check compliance with the rule and also provide planning controls to stop gradual deterioration of good parts of the City. .

4.4.4 Triggers for wind controls

Wind rules are most often triggered by a building heights threshold or other site features, but other wind rules also apply wind controls at the pure discretion of planning authorities. Some wind rules are triggered using a combination of both objective measures (for example, building height thresholds) and planning discretion.

The main parameters that are used to trigger wind rules are,

- location / proximity (i.e. specific areas within a city)
- absolute building height
- building height relative to surrounding buildings
- site area

Most wind rules trigger wind controls and reporting requirements using a building height threshold in prescribed areas of a city. Further refinements to this trigger are made either using planning discretion or by applying more complex matrix of building height with surrounding buildings, site area, and proximity to street corners or areas of significant amenity or exposure.

Wellington's trigger for its wind controls uses a building height threshold for specific area of the City – 18.6 metres in the Central Area and corresponding height limits in the Centres areas, and with discretion given to corresponding reporting requirements. This is a relatively simple and unambiguous trigger, that provides clear indication of what information is required for specific developments, while allowing excessive costs to be avoided in unusual situations.

5 Options for District Plan Changes to Improve Wind

Wellington's wind rules have been in place for over 40 years and have, by-and-large, been effective in maintaining and enhancing the pedestrian wind environment. The effectiveness of the wind rules for specific developments has been dictated more by the way the rules have been applied and implemented, than by their technical make-up.

Potential amendments to the District Plan wind provisions that could improve the operation of the rules and the wind outcomes for Wellington are outlined below. The options address some of the issues that have been identified with the current wind rules in this evaluation.

5.1 Retain the Current Wind Rules

Keeping the existing wind rules, with no changes, would provide consistency for designers and planners, and would retain rules that have been carefully developed over many years. These rules have enabled good wind outcomes to be achieved in the City, with a few notable exceptions that have resulted from simply not prioritising the rules above other considerations.

There are no obvious loopholes or deficiencies in the current rules, that have allowed poorly performing developments to comply. As written, the current rules are unambiguous compared to other wind rules, and set a clear Standard for developments to comply with. This is largely because the rules have quantified safety, cumulative and comfort criteria, that are triggered by simple, clear criteria (i.e. building height) and are applied to clearly defined areas of the City.

Many of the criticisms of the current wind rules relate to the design and planning processes, and decisions, rather than the wind rules themselves. A danger therefore is that substantial rule changes will not improve wind outcomes and may add complexity to the wind rules. However, some small improvements can be made, as recommended below.

5.2 Improving safety

The existing safety criteria for wind are comparable to many other cities, as shown in section 4.4.1. There is little reason to change the current criteria, other than to explicitly define the probability, duration, and threshold more explicitly in the wind criteria, rather than in the test/reporting requirements.

5.3 Improving comfort

5.3.1 Amend Objectives and Wind Standards

The Objectives and Standards in the Plan could be amended to allow planning discretion to apply more widely to wind effects on pedestrian comfort. In particular, the Central Area Wind Standard, which currently restricts consideration of comfort to only a list of designated parks. The purpose of such a change would be to consider comfort in the planning process, and ultimately improve the wind environment in the City.

While a greater focus on comfort would align with Wellington's strategy to make the city more liveable, it may also make development more difficult, as existing wind speeds in many areas of the City do not comply with the Comfort criterion. Therefore, many developments would need to improve existing wind conditions to comply with comfort criteria, which is generally impractical. In practice, controls to limit wind speeds to comfort levels would either stop development or require planning discretion to be applied to allow non-compliant wind speeds, as very few sites or developments would be likely to comply.

Unlike any of the other wind rules that have been reviewed, the Wellington wind rules have explicit cumulative effect criteria that stop the gradual deterioration in the existing wind environment. The cumulative effect criteria are considered to be more effective at maintaining the wind environment than using comfort criteria, and set more practical (i.e. achievable) wind Standards. For these reasons, extending planning controls for comfort is not recommended.

For consistency, consideration should be given to amending the Centres, Institutional Precinct and Business Area rules to be align with the Central Area focus on safety and cumulative effects.

5.3.2 Alternative comfort criterion

The existing comfort criterion could be replaced with the criteria, or a version of those first developed by Tom Lawson in England in the mid-1970s, and adopted, to a greater of lesser extent, by many other cities, including Auckland, London, Mississauga, Ottawa, Hamilton (Canada).

The Lawson criteria are presented as categories of activity (eg sitting standing, walking) that correspond to a range of pre-defined wind conditions. The calculations involved in generating the category ratings are no less technical than mean or gust speed criteria, but the presentation of the results can be simplified to diagrams showing what areas around a development are suitable for what type of activities. This presentation of the wind environment is more easily understood by non-specialists. The City of London has specific guidance on how the wind results should be presented, as shown below.

> **Presentation of results:** the comfort conditions should be presented using a colour-coded diagram using the colour coding below. Wind safety results can be overlaid on top of the comfort results, such that any red zone indicates unacceptable or unsafe condition. Alternatively, a separate plot showing the safety conditions can be provided, in addition to the comfort plot.

Comfort Category	Colour
Frequent Sitting	Grey
Occasional Sitting	Blue
Standing	Green
Walking	Yellow
Uncomfortable and/or Unsafe	Red

5.3.3 Using Lawson's comfort criteria

To implement these comfort criteria, a designation is needed of the activities that the City envisages for every public space: classifying them as places where the City wishes them to support:

1) Long term sitting (parks, outdoor cafes?)
2) Short term sitting (street corners, exposed parks?)
3) Standing (hole in the wall cafes, pedestrian crossings?)
4) Walking (main thoroughfare pavements?)
5) Uncomfortable (alleys for car access only, secondary streets?)

Adopting Lawson criteria, or a variation of them, in Wellington's Wind Standards would add to the wind reporting requirements and complexity of wind information, but could help planners and designers better understand the wind condition that will occur around proposed developments (some caution is noted, as the Lawson criteria have not prevented poor planning decisions overseas, where wind effects of developments have been fully reported but were misunderstood by planners, resulting in poor wind environments). It would also make the rules more consistent with many other cities.

If the Lawson criteria were applied to the whole Central Area, they would be a significant increase in stringency of Wellington's wind rules. It is well-recognised they could not be applied everywhere as there are many places where the criteria are either inappropriate (e.g. the waterfront) or already exceeded significantly (e.g. Featherston Street outside the Asteron building).

There is little benefit to wind outcomes in Wellington by replacing or extending the current comfort criterion with Lawson's criteria, other than potentially improving the understanding of the expected wind conditions. The additional cost to developments, and the planning discretion required to avoid non-compliance, means this option is not recommended.

5.4 Stopping Wind Conditions from Deteriorating

The current cumulative effect criteria are unique to Wellington's wind rules, and can successfully control wind effects from developments in Wellington that would otherwise make existing wind conditions worse. The criteria are technically complex, and often misunderstood, but are effective when applied correctly. They recognise that parts of the City are already very windy, such as the waterfront where there is no shelter, or adjacent to decades old buildings that have made the local environment unsafe or uncomfortable.

5.4.1 Simplify the criteria

The cumulative effect criteria could be simplified by removing either the moderate or strong wind criterion. That is, the cumulative effect of changes in only moderate winds (i.e. represented by mean hourly wind speeds of 2.5 m/s) or only strong winds (i.e. represented by mean hourly wind speeds of 3.5 m/s) could be specified in the Wind Standard. This simplification is not expected to reduce the effectiveness of the criteria because most developments will have a similar effect on moderate winds as they have on strong winds.

Using only the "moderate" cumulative effect criterion is recommended, as opposed to using only the strong wind criterion, as the "moderate" cumulative effect criterion will pick up changes to areas with calmer existing wind conditions as well as changes to windier areas.

5.4.2 Remove any allowance for deterioration in wind conditions

The cumulative effect criteria currently allow each development to increase the occurrence of 'moderate' and 'strong' winds by 20 days per year (or 5.5% of the year). If the City wants to improve wind conditions, then a logical first step would be to remove the allowance in the cumulative effect criteria for new development to cause winds to deteriorate for 20 days per year. The change would also help to simplify the criteria by allowing Rule 13.6.3.5.2 b) and c) to be combined into a single criterion

Often, planning discretion will be needed to allow for non-compliance of wind effects when developments are well designed, but are in windy locations. It is more consistent with the wind Objectives to 'trigger' such discretion when any deterioration in the overall wind conditions occur, rather than allow a very gradual deterioration to occur without planning consideration.

5.5 Improving wind information and reporting

5.5.1 CFD

The reporting requirements reflect, to a large extent, the Wind Standards and criteria that are adopted in the Plan. However, some allowance should be made in these requirements for recent advances in wind flow modelling, where CFD (Computational Fluid Dynamics) is becoming widespread. There is nothing in principle to stop a planner accepting a CFD study today, but without appropriate quality assurance requirements, the accuracy of CFD results, particularly for evaluating safety criteria, is unknown and unreliable. A revision of the quality assurance requirements for wind tunnel studies, CFD and reporting requirements is recommended, to ensure reliable wind information is produced for resource consent applications.

5.5.2 Design Guide for Wind

The Design Guide for Wind is rarely used, and appears to only be used when wind effects have already become a problem for designers. Broadening and updating the information that is in the Guide may make it more useful for inexperienced planners, as well as those looking for solutions to problems.

Topics that have been identified in this review as needing better guidance and explanation are,

- the policy objectives of the wind rules
- the wind standards/criteria
- relating the reported wind conditions/speeds to actual effects on people in the City
- benefits of pre-design wind assessments
- potential wind effects of demolition and alterations to existing buildings

It is not surprising that the wind rules are misunderstood, or unclear to those unfamiliar with them given the technical nature of the wind criteria. Guidance is therefore recommended as described above.

5.6 Improving Wind Rule Triggers

5.6.1 Current Trigger

Under the current Plan, wind effects of developments become discretionary matters when the height of a development exceeds either 18.6 m, in the Central Area, or exceeds the Height Standard, in the Centres and Business Area.

The height of 18.6 m in the Central Area corresponds to the maximum height that a 4-storey building could reach, using the definition of “storey” in the Plan. A “four-storey” trigger was used in the previous Wind Standard and so the 18.6 m trigger simply continues the previous wind rule, but with greater clarity about when the threshold is reached.

5.6.2 Building Heights Used as a Trigger

There is no intrinsic building height that is good or bad for wind effects, but higher buildings usually create larger wind effects at ground level than lower buildings. Given the windy climate that prevails in Wellington, it is unsurprising that a lower height trigger of 18.6 m has been set compared to other less windy cities, such as Auckland and London where a 25 m height triggers consideration of wind effects, and Sydney where 40 metres is used. Mississauga is close to Wellington’s trigger height, using 20 metres.

London also adopts lower trigger heights for edges of the city: like the Thames (in Wellington, this could be the Railway Station and waterfront areas where a transition from low to high city is required).

5.6.3 Height of Surrounding Buildings

An addition to using a single height to trigger wind rules, the height of surrounding buildings can also be used, as for example, London does. This has the advantage of adjusting the trigger for specific sites and in doing so minimises unnecessary wind assessments. However, it does increase the complexity and interpretation needed to apply the wind rules, and for this reason it is not recommended as a trigger for ‘discretionary activities’ in the Plan. This would create uncertainty about when wind becomes a discretionary matter, depending on a site and surrounding buildings, and would also create the potential for the planning discretion that can be applied to a site to change as surrounding buildings are developed.

The height of surrounding buildings is an over-simplification of the shelter that a development will receive, particularly in less developed areas where large gaps can occur in the surrounding buildings. Proposed guidelines for wind in the City of Moonee Valley Ponds recognises this simplification (of the surrounding building heights), and so specifies different trigger criteria for corner sites compared to sites that lie between corner sites. The added complexity of this multi-step trigger is not recommended.

Under section 3.2.2.15A, the wind rules currently allow Council officers to accept wind assessments (expert opinions) instead of a wind tunnel test report when surrounding buildings have similar heights to a development. Guidance in 3.2.2.15A states:

> Examples of situations where a wind assessment report may be provided instead of a wind tunnel test report include:
>
> - Where the proposed building or addition is consistent with other building heights in the neighbourhood, is only a small change in scale compared to the existing building and incorporates wind mitigation measures such as verandahs, setbacks and breezeways;

It is recommended that guidance is added to the Design Guide for Wind that details appropriate rules-of-thumb to enable Council Officers to better apply the discretion in section 3.2.2.15A, and thereby trigger wind assessment reports when appropriate.

5.6.4 Triggering reporting requirements in the Centre and Business Area

For the Centres and Business Area the wind rules currently allow a wind assessment (based on expert opinion) to be submitted, unless the assessment concludes the development will, overall, degrade the surrounding wind environment, at which point a wind tunnel test report may be required. Therefore, there is no benefit in writing more sophisticated rules to avoid defaulting to wind tunnel testing, as this is avoided in the current rules.

5.7 Conclusions

The existing Wellington wind rules have successfully prevented occurrences of extreme wind conditions around new buildings, which were occurring prior to the implementation of the rules. The rules have criteria that relate to safety, cumulative effects and comfort.

The wind rules are complex and hard to understand for inexperienced people. A number of options have been provided that will simplify and improve understanding of these rules.

The current wind standards are set at a level that is comparable with those from other cites, and provide appropriate controls for Wellingtons windy environment. No relaxation of these standards is recommended, nor is an increase in their stringency needed. Simplification of the cumulative effect criteria is recommended, to clarify the rule and to reduce its complexity.

If a greater emphasis on pedestrian comfort is introduced into the District Plan, then comfort criteria that account for more environmental factors than simply wind should be adopted.

Appendix A Wind policies and rules in the District Plan

The following extracts from the Wellington District Plan do not transcribe whole Chapters, Policies Objectives or Rules. The extracts identify where wind related policies, objectives and rules currently exist.

3 District Plan General Provisions

3.2 Information to be Submitted with an Application for a Resource Consent

3.2.2 Land Use Consents

[3.2.2.15 A wind tunnel test report (or demonstrated, calibrated equivalent e.g. electronic wind tunnel) must be supplied to show compliance with the wind standards in rule 13.6.3.5.2 (unless 3.2.2.15A below applies).

The wind tunnel test study must examine the effects of the proposed building upon all areas open to the public, including roads, parks, malls, plazas, public carparks, the immediate forecourt area and entranceways to the proposed building/s. The proposed development must be tested against the existing situation except where the site is currently cleared. If the site is cleared, the proposal must be tested against any building which existed within the previous 5 years.

Details of the test requirements, and the form and content of a wind tunnel test report is outlined in Appendix 8 of Chapter 13.

3.2.2.15A A wind assessment report, which is based on the expert opinion of a qualified wind specialist, may be provided instead of a wind tunnel test report at the discretion of Council officers.

The form and content of a wind assessment report is outlined in Appendix 8 of Chapter 13. The report must conclude that the development is highly likely to comply with standard 13.6.3.5.2 before it will be accepted under standard 13.6.3.5.3.

Examples of situations where a wind assessment report may be provided instead of a wind tunnel test report include:

• Where the proposed building or addition is consistent with other building heights in the neighbourhood, is only a small change in scale compared to the existing building and incorporates wind mitigation measures such as verandahs, setbacks and breezeways;

• Where the proposed work is for a minor rooftop addition (eg. lift or ventilation room) which is setback from all sides of the building;

• Where the proposal involves a structure that will not impede wind flows, eg, aerials, masts.

3.2.2.15B For the purposes of Chapters 6 and 7 of the District Plan, a wind assessment report, which is based on the expert opinion of a qualified wind specialist, must be provided for the construction, alteration, or addition to buildings and structures that do not comply with the maximum permitted building heights in standard 7.6.2 (unless 3.2.2.15C below applies).

The form and content of a wind assessment report is outlined in Appendix 2 of Chapter 7.

The report must conclude that the overall effect of the building development will not reduce the existing pedestrian wind conditions or a wind tunnel test report may be required.

3.2.2.15C At the discretion of Council officers, a wind tunnel test report may also be required for the construction, alteration, or addition to buildings and structures that do not comply with the maximum permitted building heights in standard 7.6.2.

The wind tunnel test study must examine the effects of the proposed building upon all areas open to the public, including roads, parks, malls, plazas, public carparks, the immediate forecourt area and entranceways to the proposed building/s. The proposed development must be tested against the existing situation except where the site is currently cleared. If the site is cleared, the proposal must be tested against any building which existed within the previous 5 years.

Details of the test requirements, and the form and content of a wind tunnel test report is outlined in Appendix 2 of Chapter 7.

Examples of situations where a wind assessment report may be provided instead of a wind tunnel test report include:

- where the proposed building or addition is consistent with other building heights in the neighbourhood, is only a small change in scale compared to the existing building and incorporates wind mitigation measures such as verandahs, setbacks and breezeways;
- where the proposed work is for a minor rooftop addition (eg. lift or ventilation room) which is setback from all sides of the building; or
- where the proposal involves a structure that will not impede wind flows, eg, aerials, masts.

3.10 Definitions

The following definitions are in addition to those contained within the Act.

HEIGHT:
means in relation to a building [or structure] the vertical distance between any part of [that] building [or structure] and the ground level [immediately below,] or mean sea level where specified [in this plan. This calculation is subject to:

- where height is measured in relation to storeys, the maximum floor to floor height per storey is 4.2 metres, except that the ground floor may have a maximum height of 6 metres

PUBLIC SPACE:
means those places in public or private ownership which are available for public access (physical or visual) or leisure and that are characterised by their public patterns of use. Public spaces include, but not limited to, streets, accessways, squares, plazas, urban parks, open space and all open or covered spaces within buildings or structures that are generally available for use by the public, notwithstanding that access may be denied at certain times.

STOREY:
means a floor (full or mezzanine) or level of a building including the ground floor level. Where height is measured in relation to storeys, the maximum floor to floor height per storey is 4.2 metres, except that the ground floor may have a maximum height of 6 metres.

VERANDAH LEVEL:
means the height of a formed verandah, or where there is no formed verandah the vertical height of the ground floor storey (up to a maximum height of 4.2metres).]

6 Centres: Objectives and Policies

OBJECTIVE – BUILT DEVELOPMENT, URBAN FORM AND PUBLIC SPACE

6.2.3 To ensure that activities and developments maintain and enhance the safety and amenity values of Centres and any adjoining or nearby Residential or Open Space Areas, and actively encourage characteristics, features and areas of Centres that contribute positively to the City's distinctive physical character and sense of place.

POLICIES

To achieve this objective, Council will:

Wind

6.2.3.10 **Ensure that new buildings higher than three storeys are designed to avoid, remedy or mitigate any wind problems that they create and where existing wind conditions are dangerous, ensure new development improves the wind environment as far as reasonably practical.**

6.2.3.11 **Ensure that the cumulative effect of new buildings and building additions or alterations higher than three storeys do not progressively degrade the pedestrian wind environment.**

6.2.3.12 **Encourage the use of wind mitigation measures for buildings higher than three storeys during the early stages of building design and ensure that such measures are contained within the development site.**

METHODS

- Rules
- Design Guides (Centres Design Guide, Design Guidelines for Wind)
- Information (Advocacy)

Buildings that are significantly different in scale from their surroundings can create wind changes at ground level. This can make pedestrian activities on the ground uncomfortable, difficult and even dangerous.

The impact of a building on wind conditions will vary depending on a number of factors, including height of neighbouring buildings, height of the proposed building compared with the existing building, and features included in the building design. Wind rules seek to encourage a safe and pleasant environment by decreasing the worst effects of wind.

When resource consent to assess wind effects is required for taller buildings in Centres (particularly in Mt Cook and Johnsonville), Council will seek to ensure new developments do not make the existing wind environment dangerous or significantly worse for pedestrians, particularly at building entries in the surrounding area.

Section 3.2.2 of the Plan outlines the information requirements for land use consent applications. When developments propose a taller building, Council will require a wind assessment report to establish the likely effects of the new building at ground level. In some case a wind tunnel assessment may also be required.

Altering the design of a proposed development (ie building scale, bulk and height or other mitigation measures) can help to reduce the wind effects on pedestrians and for this reason wind effects should be considered at an early stage in the design process. Alterations may include redesigning entrance locations, entrance canopies or wind lobbies, or including larger/longer verandahs.

Council will look more favourably on mitigation measures that are contained within the development site and integrated with the building design, ie. breezeways, setbacks, verandahs. These mitigation measures will also need to be appropriate from an urban design and heritage perspective. The Council will manage concerns about the proposed siting of free-standing wind mitigation structures resulting from a private development (ie. vertical glass upstands) in Council owned public spaces through its encroachment licence process.

The environmental result will be the improvement of the pedestrian wind environment in Sub-Regional Centres and the Mt Cook Centre.

7 Centres: Rules

7.3 Discretionary Activities (Restricted)

7.3.7 The construction or alteration of, or addition to buildings and structures which would be a Permitted, Controlled or Discretionary (Restricted) Activity but that do not meet one or more of the standards specified in section 7.6.2 (buildings and structures), are Discretionary Activities (Restricted). Unless otherwise noted below, discretion is limited to the effects generated by the standard(s) not met:

7.3.7.1 height (standard 7.6.2.1), discretion is limited to the effect of the additional building height on:

...

- the wind environment at ground level

7.6 Centres Standards

7.6.2.1 Maximum building height

7.6.2.1.1 No building or structure shall exceed the building height as listed in Table 1 below:

Table 1:

Centre	Height (standard 7.6.2.1.1)	Planning Map No.
Sub-Regional Centres		
Johnsonville	See Appendix 1 for Zone boundaries	
• Zone 1	12m	23
• Zone 2	18m	23
Kilbirnie	12m	6
Town Centres		
Karori	12m	11
Miramar	12m	7
Mt Cook (Adelaide Road)	See Appendix 1 for Zone boundaries	
• Zone 1	12m	6/16
• Zone 2	18m	6/16
Newtown	12m	6

Lot 1 DP 9703 (42A Riddiford Street, Newtown), excluding the sites access leg	9m	6
Tawa	12m	6
District Centres		
Brooklyn	12m	6
Churton Park	9m	26
Crofton Downs	12m	21/15
Island Bay	12m	4
Khandallah - Dekka Street/Ganges Road and Box Hill/Baroda Street	12m	21
Newlands	12m	24/23
Neighbourhood Centres		
Aro Valley	9m	11/16
Berhampore	12m	6
Berhampore - Rintoul Street	9m	6
Hataitai	9m	6/12
Island Bay - Mersey Street	9m	4
Island Bay - Shorland Park shops	9m	4
Karori - Marsden Village	9m	11
Karori - Nottingham/Standen Street Shops	9m	11
Karori - Tringham Street shops	9m	11
Kelburn	9m	11
Kingston	9m	6
Linden	9m	31
Lyall Bay - Onepu Road	9m	4/6
Miramar • cnr Darlington Road and Camperdown Road • cnr Park Road and Brussels Street • cnr Park Road and Rex Street (east and west of Park Road) • cnr Park Road and Rotherham Terrace • cnr Para Street and Rotherham Terrace	9m	7
Newlands - Newlands Road/Salford Street	9m	23
Newtown - Constable Street/Owen Street	9m	6
Ngaio	9m	21
Ngaio - Crofton Road	9m	21
Northland	12m	11
Roseneath	9m	12
Seatoun - Dundas Street	9m	7
Strathmore - Broadway (both Strathmore Avenue and Hobart/Kauri Street Centres)	9m	7/15
Strathmore - cnr Caledonia Street, Hobart Street, and Devonshire Road	9m	7
Tawa - Oxford Street	9m	30
Thorndon	9m	18/17
Wadestown	9m	15

Centres Appendices

Appendix 2. Wind

This Appendix describes the form and content of wind assessment reports, and details the requirements for wind tunnel tests and reports, as required by Rule 7.3.7.1.

1. Form of Wind Assessment Report

A wind assessment report is not based on the results of a wind tunnel test and so ultimately relies on the expert knowledge and opinion of the qualified wind specialist. However, it must contain the following:

1.1 A description of the existing wind conditions, including sources and limitations of information used in the assessment.

1.2 A description of the likely interaction of the existing buildings with the wind that leads to the existing wind conditions.

1.3 A review of the design of the development, and its appropriateness for a windy environment. The WCC Wind Design Guide should be used as a basis for a design evaluation checklist for this review.

1.4 A description of the expected influence of the proposed development on pedestrian level wind speeds in areas open to the public. The WCC Wind Design Guide should be used as the basis for a design evaluation checklist for this review. The review should also examine the role of amelioration measures, including large setbacks of upper levels from the street façade, deep balconies and full-width verandahs.

1.5 A discussion of the building design, including the effectiveness of ameliorative measures or major design changes that are recommended. It is intended that the wind assessment should provide clear evidence that the proposed building is the best practical aerodynamic design with respect to achieving the wind standards.

1.6 A statement at the conclusion of the report that, in the professional opinion of the expert, the proposal is unlikely to result in more than minor adverse effects on the wind environment at ground level.

2. Aims of the Wind Tunnel Test

The aims of a wind tunnel test are:

2.1 to quantify the effect of a building proposal on the surrounding pedestrian level wind environment by measuring and comparing the existing and proposed wind conditions, and

2.2 where wind conditions deteriorate as a result of the proposed building, to test alternative designs to it, and

2.3 to provide documentary evidence, of the proposed building's positive effect on the wind environment, emphasising measures taken to improve the wind environment, and demonstrating, where required, that every reasonable alternative design has been explored and that the proposed building is the best practical aerodynamic design arising from the other options that have been tested.

3. Form of the Wind Tunnel Test

Wind tunnel studies must meet the following conditions:

3.1 Wind studies should comply with the requirements of Australasian Wind Engineering Society Quality Assurance Manual, Wind Engineering Studies of Buildings, AWES-QAM-1-

2001, except where the rules and requirements of the Wellington City District Plan supersede them.

3.2 The model scale used in the wind tunnel test must not produce models that are smaller than those obtained using a 1:500 scale.

3.3 The atmospheric boundary-layer simulation should be equivalent to Category 3 or Category 4 terrain, as defined in the Australia/New Zealand Loading Standard, AS/NZS 1170.2:2002.

3.4 Where there is no site wind speed data of sufficient quality, the reference wind speeds shall be derived using wind data from Wellington Airport, with the following corrections;

winds at a height of 10 m at Wellington Airport have equivalent mean speed to winds at a height of 150 m above Wellington City, and

wind directions over Wellington City are the same as those at Wellington Airport, except that the northerly wind directions (i.e. 0˚-80˚ & 280˚-360˚) are rotated to the west by 10˚ (e.g. 360˚ at the airport becomes 350˚ over the city).

3.5 Wind speeds shall be measured for the reference wind directions (degrees clockwise with respect to true North) 150˚, 170˚, 190˚, 210˚, 320˚, 340˚, 360˚ and 020˚.

3.6 3.6 The gust speeds shall be calculated as:
gust = v + 3.7σ
where v = the annual maximum hourly mean wind speed for all wind directions combined, and
σ = the corresponding standard deviation of the wind speed.
This overall gust speed will be used to assess the compliance with the safety criteria given in standard 13.6.3.5.2 (a).

3.7 All wind speeds shall be measured at a full-scale height of 2 metres.

3.8 The percentage change in hours shall be calculated by dividing the change in the number of hours by 8760 (i.e. the total hours in one year).

3.9 Flow visualisation tests that show the spatial extent of windy areas throughout public areas that surrounding the development shall be made for the existing situation and for the proposed development. Flow visualisation testing will include at least six different wind speeds, and be undertaken for at least two representative northerly wind directions and two representative southerly wind directions.

3.10 Where Council Officers consider that any effects of the proposed development will be significant in nature, additional wind tunnel testing may be required to be undertaken to quantify the effects of alternative building designs and/or modifications. Clear evidence should be gathered to show that the proposed building is the best practical aerodynamic design with respect to achieving these standards. The recording and measurement of wind speeds for this investigation of alternatives need only be for those areas around the proposed building, and for those wind directions, where problems have been identified. However, sufficient measurements must be taken to quantify all the changes with the alternative designs.

4. Form of Wind Tunnel Test Report

A wind tunnel test report must contain:

4.1 A description of the atmospheric boundary layer simulation that is used in the wind tunnel. This will include plots of the mean wind speed profile and turbulence intensity profile.

4.2 A description of the reference wind speeds that have been used to derive the wind speeds listed in the wind report. Any assumptions and limitations of the reference wind speed analysis and a description of the meteorological data used must be provided.

4.3 A calibration section, which contains images of the flow visualisation tests when applied to an isolated building model, subjected to the same wind tunnel test conditions as those used in the wind study. The building model shall be a square prism, 15 metres square in plan and 60 metres high, at the scale used in the test. Images of the flow visualisation test shall be taken for at least six different reference wind speeds. The final wind speed should correspond to an area of influence, that is identified by the flow visualisation, that is equal to 80% of a diameter of 50 metres (at the scale of the model), centred on the back face of the model. The intermediate speeds will be chosen to divide this maximum speed into equal parts.

4.4 An analysis of the errors limits and the precision that is achievable in the wind speeds and their frequency of occurrence that are listed in the body of the report. The relationship of the model (wind tunnel) to full-scale Wellington conditions, as far as it is known, should also be documented through reference to externally refereed papers or reports.

4.5 A diagram that clearly shows and identifies the locations/areas that were measured during testing

4.6 A table of the gust wind speeds for each wind direction and for each of the locations measured during testing. This will include listings for both the existing situation and for the proposed development.

4.7 A table of hours that the mean wind speeds of 2.5 m/s and 3.5 m/s are equalled or exceeded each year, for each of the locations measured during testing.

4.8 Records/diagrams of the flow visualisation tests.

4.9 A description of the effects of the proposed development on wind conditions in the surrounding area.

4.10 An analysis of the 3-dimensional wind flows around the proposed building indicating the way in which its effect on the air flow affects pedestrian-level winds. This should clarify:

4.10.1 the cause(s) of any observed problems;

4.10.2 the ways in which the problems might be avoided; and

4.10.3 the ways in which these wind problems might be mitigated.

At its simplest this might mean stating (for example):

- that the root cause is the downwash caused by the building being very much bigger in scale than its neighbours;
- that reducing the size of the proposed building would remove this root cause;
- that large canopies around the building could provide shelter from the downwash in the immediate vicinity of the entry ways, although this may result in the carparking area beyond the canopy being made uncomfortable.

4.11 Where Council Officers consider that any effects of the proposed development will be significant in nature, an assessment of alternative designs and modifications including the results of additional wind tunnel testing that quantify the wind effects may be required to be provided. Clear evidence should be provided that the proposed building is the best practical aerodynamic design with respect to achieving these standards. Existing wind speeds and hours of occurrence shall be reported only at the locations / wind directions where alternative designs have been tested.

9 Institutional Precinct Rules

9.4 Discretionary Activities (Unrestricted)

9.4.2 Buildings and structures, including pedestrian bridges, located above or over the street that exceed 25 percent of the width of the road at any point are Discretionary Activities (Unrestricted).

Assessment Criteria

In determining whether to grant consent and what conditions, if any, to impose Council will have regard to the following criteria:

....

9.4.2.4 The effect of the structure on the wind environment of the street and the extent to which sunlight levels in the street will be reduced.

12.2 Central Area Objectives and Policies

OBJECTIVE – EFFECTS OF NEW BUILDING WORKS

12.2.5	Encourage the development of new buildings within the Central Area provided that any potential adverse effects can be avoided, remedied or mitigated.

POLICIES

To achieve this objective, Council will:

…

12.2.5.2 Manage building mass to ensure that the adverse effects of new building work are able to be avoided, remedied or mitigated on site.

METHODS

- Rules
- Design Guides

Managing building mass is important in ensuring that new building works do not create adverse environmental effects. The total mass and bulk of a building on site, and the location and placement of the mass relative to adjoining buildings and structures, will determine how successfully potential adverse effects relating to wind, amenity (access to light), impacts on adjacent heritage items, viewshafts, and urban design can be managed.

For this reason the District Plan imposes standards on the total building mass (volume) that can be developed on sites in the Central Area.

…

The placement of building mass is an important tool in mitigating the effect of new building works on the amenity of the public realm. These effects can relate to the pedestrian wind environment, impact on identified viewshafts, and the loss of sunlight to public spaces. The District Plan contains specific standards for these issues in order to preserve the quality and amenity of the public environment. In some situations compliance with these standards my require building mass to be reduced to below the general mass standard specified in this plan.

…

Increases in building mass above the specified standards will be contemplated when it can be demonstrated that the additional mass will not compromise the development's ability to avoid, remedy or mitigate adverse environment effects relating to wind, preserving access to daylight, heritage and urban design. Consideration may also be given to whether the function, location and prominence of the proposed building are such that it is appropriate to utilise additional mass to help create a landmark building.

12.2.5.6 Ensure that buildings are designed to avoid, remedy or mitigate the wind problems that they create and where existing wind conditions are dangerous, ensure new development improves the wind environment as far as reasonably practical.

12.2.5.7 Ensure that the cumulative effect of new buildings or building alterations does not progressively degrade the pedestrian wind environment.

12.2.5.8 **Ensure that the wind comfort levels of important public spaces are maintained.**

12.2.5.9 **Encourage consideration of wind mitigation measures during the early stages of building design and ensure that such measures are contained within the development site.**

METHODS

- Rules
- Information (Wind design guide/Advocacy)

Buildings that are significantly different in scale than their surroundings can induce wind changes at ground level. This can make pedestrian activities on the ground uncomfortable, difficult and even dangerous.

The impact of a building on wind conditions will vary depending on a number of factors including, height of neighbouring buildings, height of the proposed building compared with the existing building, and features included in building design to mitigate adverse wind conditions.

The wind rules seek to encourage a safe and pleasant environment by decreasing the worst effects of wind. That is, a development should not make the existing wind environment dangerous or significantly worse for pedestrians.

The rules are also designed to prevent a cumulative degradation of the wind environment by a number of developments and to protect comfort levels in important public spaces.

Altering the design of a proposed development (ie building scale, bulk and height or by other mitigation measures) can help to reduce the pedestrian wind effects.

Council will look more favourably on mitigation measures that are contained within the development site and integrated with the building design, ie. breezeways, setbacks, verandahs. These mitigation measures will also need to be appropriate from an urban design and heritage perspective. The Council will manage concerns about the proposed siting of free-standing wind mitigation structures resulting from a private development (ie. vertical glass upstands) in Council-owned public spaces through its encroachment licence process.

In processing resource consent applications, consideration should also be given to the nature of the pedestrian environment affected and the degree to which the proposal represents the best practicable option after all other reasonable alternatives have been explored.

The environmental result will be the improvement of the pedestrian wind environment.

Streetscape

12.2.6.18 **Maintain and enhance the streetscape by controlling the siting and design of structures on or over roads and through continuing programmes of street improvements.**

METHODS

- Rules
- Operational activities (street improvement work)
- Encroachment licenses

When assessing an application to build over legal road Council will consider:

…

- The effect of the structure on the wind environment of the street and the extent to which sunlight levels in the street will be reduced.

12.2.8.6 **Provide for new development which adds to the waterfront character and quality of design within the area and acknowledges relationships between the city and the sea.**

METHODS

- Rules
- Design Guides (The Wellington Waterfront Framework) Operational activities (The Wellington Waterfront Framework)

...

The following matters will be considered in relation to any application for a new building or structure on the waterfront:

- *the adverse effects of the building work on wind, views, shading and sunlight on adjacent properties in the Central Area.*

13 Central Area Rules

13.3.8 **The construction or alteration of, and addition to buildings and structures which are Permitted, Controlled or Discretionary (Restricted) Activities that do not meet one or more of the following standards outlined in section 13.6.1 (Activities, Buildings and Structures) and 13.6.3 (Buildings and Structures), are Discretionary Activities (Restricted). Unless otherwise noted below, discretion is limited to the effects generated by the standard(s) not met:**

13.3.8.8 **wind (standard 13.6.3.5)**

Non-notification/ service

In respect of rule 13.3.8 applications do not need to be publicly notified and do not need to be served on affected persons in respect of:

...

- 13.3.8.8 (wind),

13.6 Central Area Standards

13.6.3.4 Sunlight Protection

13.6.3.4 All buildings and structures must be designed and located to maintain sunlight access to public spaces within the Central Area as listed below (and shown in Appendix 7).

Public Space	Time period to be calculated using New Zealand Standard Time at either of the equinoxes (i.e. 21 March or 23 September)
Pedestrian malls:	
Cuba Mall, Cuba Street	12:00 noon to 2:00pm
Manners Mall, Manners Street	1:30pmto 3:00pm
Parks and squares:	
Civic Square, Civic Centre	12 noon to 2:00pm
Midland Park, Lambton Quay	12 noon to 2:00pm
Cobblestone Park, Vivian Street	12 noon to 2:00pm
Glover Park, Ghuznee Street	12 noon to 2:00pm
Te Aro Park, Manners/Dixon Streets	12 noon to 2:00pm
'Clock Park' Southeast corner Courtenay Place/ Taranaki Street intersection	12 noon to 2:00pm
Denton Park, Bond/Lombard Streets	12 noon to 2:00pm
Lambton Harbour Area:	
Frank Kitts Park	10:00am to 4:00pm
Kumutoto Plaza, North Queens Wharf	12 noon to 2:00pm
Taranaki Street Wharf lagoon area	12 noon to 2:00pm
Post Office Square, Customhouse/Jervois Quays	12 noon to 1:30pm

13.6.3.5 Wind

13.6.3.5.1 The following wind standards apply to the Central Area, excluding buildings and structures for Operational Port Activities in the Operational Port Area.

13.6.3.5.2 New buildings, structures, or additions above 18.6 metres in height will be designed to comply with the following standards:

(a) SAFETY: The safety criteria shall apply to all public space.
The maximum gust speed shall not exceed 20 m/s. If the speed exceeds 20 m/s with the proposed development, it must be reduced to 20 m/s or below.

(b) CUMULATIVE EFFECT: The cumulative criteria shall apply to all public space. Any proposed development must meet the requirements for both of the following wind strengths, at each measurement location.

Wind strength	Change in annual days of occurrence with the development at all measurement points	Requirements on developer
Strong (mean hourly wind speed = 3.5m/s)	If days that 3.5 m/s is equalled or exceeded increase by more than 20 days/year (i.e. 5.5% of the year)	Reduce change in days to a maximum of 20 days.
Moderate (mean hourly wind speed = 2.5m/s)	If days that 2.5m/s is equalled or exceeded increase by more than 20 days/year (i.e. 5.5% of the year)	Reduce change in days to a maximum of 20 days.

(c) Under the Cumulative Effect Criterion, the overall impact of a building on the wind conditions must be neutral or beneficial.

(d) COMFORT: The comfort criteria only applies to the public spaces listed in standard 13.6.3.4

Comfort wind strength	Annual days of occurrence with the development	Requirements on developer
Mean hourly wind speed = 2.5 m/s	If days that 2.5 m/s is equalled or exceeded increase above 73 days/year (i.e. 20% of the year).	If existing building exceeds 73 days, then reduce number of days for proposed building to existing levels. If existing building is below 73 days then reduce number of days for proposed building to below 73 days.

13.6.3.5.3 To show that a development complies with these standards a wind report must be supplied that meet the requirements outlined in Appendix 8 (see also section 3.2.2.15 of the Information Requirements).

For information purposes, the effects of wind speeds, which correspond to those used in, the safety criteria, are

20 metres/second gust - Completely unacceptable for walking.

the comfort or cumulative criteria, are
3.5 metres/second mean - Corresponds to threshold of danger level.
2.5 metres/second mean - Generally the limit for comfort when sitting for lengthy periods in an open space.

Central Area Appendices

Appendix 08. WIND

This Appendix details the requirements for wind tunnel tests and describes the form and content of the wind reports, as required by standard 13.6.3.5.3.

1. Aims of the Wind Tunnel Test

The aims of a wind tunnel test are:

1.1 to quantify the effect of a building proposal on the surrounding pedestrian level wind environment by measuring and comparing the existing and proposed wind conditions, and

1.2 where wind conditions deteriorate as a result of the proposed building, to test alternative designs to it, and

1.3 to provide documentary evidence, of the proposed building's positive effect on the wind environment, emphasising measures taken to improve the wind environment, and demonstrating, where required, that every reasonable alternative design has been explored and that the proposed building is the best practical aerodynamic design arising from the other options that have been tested.

2. Form of the Wind Tunnel Test

Wind tunnel studies must meet the following conditions:

2.1 Wind studies should comply with the requirements of Australasian Wind Engineering Society Quality Assurance Manual, Wind Engineering Studies of Buildings, AWES-QAM-1-2001, except where the rules and requirements of the Wellington City District Plan supersede them.

2.2 The model scale used in the wind tunnel test must not produce models that are smaller than those obtained using a 1:500 scale.

2.3 The atmospheric boundary-layer simulation should be equivalent to Category 3 or Category 4 terrain, as defined in the Australia/New Zealand Loading Standard, AS/NZS 1170.2:2002.

2.4 Wind speeds shall be measured for the reference wind directions (degrees clockwise with respect to true North) 150˚, 170˚, 190˚, 210˚, 320˚, 340˚, 360˚ and 020˚.

2.5 The reference wind speeds for the reference wind directions are those derived from Wellington Airport wind data. These wind speeds are the equivalent annual maximum hourly mean wind speeds at a height of 150m above Wellington City. The reference mean speeds for the reference wind directions are:

150˚ 15m/s	170˚ 20m/s	190˚ 22m/s	210˚ 22m/s
320˚ 19m/s	340˚ 22m/s	360˚ 20m/s	020˚ 15m/s

2.6 The gust speeds shall be calculated at each measurement location for each wind direction:

$$\text{gust} = v + 3.7\sigma$$

where v = the annual maximum hourly mean wind speed for each wind direction, and σ = the corresponding standard deviation of the wind speed.

This overall gust speed will be used to assess the compliance with the safety criteria given in standard 13.6.3.5.2 (a).

2.7 The number of days that a 1-hour mean wind speed of 2.5 m/s and 3.5 m/s are equalled or exceeded in a year shall be calculated in order to assess compliance with creep criteria given in standard 13.6.3.5.2 (b). Where applicable, the days that a 1-hour mean wind speed of 2.5 m/s is equalled or exceeded in a year shall be calculated in order to assess compliance with comfort criteria given in standard 13.6.3.5.2 (c).

2.8 Where there is no wind speed data of sufficient quality, the days of occurrence shall be derived using wind data from Wellington Airport, with the following correction:

- winds at a height of 10m at Wellington Airport have equivalent mean speed to winds at a height of 150m above Wellington City, and
- wind directions over Wellington City are the same as those at Wellington Airport, except that the northerly wind directions (i.e. 0°-80° & 280°-360°) are rotated to the west by 10° (e.g. 360° at the airport becomes 350° over the city).

2.9 All wind speeds shall be measured at a full-scale height of 2 metres.

2.10 The percentage change in days shall be calculated by dividing the change in the number of days by 365 (i.e. the total days in one year).

2.11 Flow visualisation tests that show the spatial extent of windy areas throughout public areas that surrounding the development shall be made for the existing situation and for the proposed development. Flow visualisation testing will include at least six different wind speeds, and be undertaken for at least two representative northerly wind directions and two representative southerly wind directions.

2.12 Where the standards set in 13.6.3.5.2 are not met, additional wind tunnel testing should be undertaken to quantify the effects of alternative building designs and/or modifications. Clear evidence should be gathered to show that the development is the best practical attempt to achieve these standards. This investigation of alternatives need only be for those areas around the development, and for those wind directions, where problems have been identified. However, sufficient measurements must be taken to quantify all the changes with the alternative designs.

In situations where the standards set in 13.6.3.5.2 are not met because the wind speed criteria in the surrounding area are already exceeded with the existing situation, and cannot be practically improved by changing the design of the development (e.g. because the location is too far away to be influenced by the design), analysis of the wind tunnel data should be provided to demonstrate this.

3. Form of Wind Tunnel Test Report

A wind tunnel test report must contain:

3.1 A description of the atmospheric boundary layer simulation that is used in the wind tunnel. This will include plots of the mean wind speed profile and turbulence intensity profile.

3.2 A description of the reference wind speeds that have been used to derive the wind speeds listed in the wind report. Any assumptions and limitations of the reference wind speed analysis and a description of the meteorological data used must be provided.

3.3 A calibration section, which contains images of the flow visualisation tests when applied to an isolated building model, subjected to the same wind tunnel test conditions as those used in the wind study. The building model shall be a square prism, 15 metres square in plan and 60 metres high, at the scale used in the test. Images of the flow visualisation test shall be taken for at least six different reference wind speeds. The final wind speed should correspond to an area of influence, that is identified by the flow visualisation, that is equal to 80% of a diameter of 50 metres (at the scale of the model), centred on the back face of the model. The intermediate speeds will be chosen to divide this maximum speed into equal parts.

3.4 An analysis of the errors limits and the precision that is achievable in the wind speeds and their frequency of occurrence that are listed in the body of the report. The relationship of the model (wind tunnel) to full-scale Wellington conditions, as far as it is known, should also be documented through reference to externally refereed papers or reports.

3.5 A diagram that clearly shows and identifies the locations/areas that were measured during testing

3.6 A table of the gust wind speeds for each wind direction and for each of the locations measured during testing. This will include listings for both the existing situation and for the proposed development.

3.7 A table of hours that the mean wind speeds of 2.5 m/s and 3.5 m/s are equalled or exceeded each year, for each of the locations measured during testing.

3.8 Records/diagrams of the flow visualisation tests.

3.9 A description of the effects of the proposed development on wind conditions in the surrounding area.

3.10 An analysis of the 3-dimensional wind flows around the proposed building indicating the way in which its effect on the air flow affects pedestrian-level winds. This should clarify:

3.10.1 the cause(s) of any observed problems;
3.10.2 the ways in which the problems might be avoided; and
3.10.3 the ways in which these wind problems might be mitigated.

At its simplest this might mean stating (for example):

- that the root cause is the downwash caused by the building being very much bigger in scale than its neighbours;
- that reducing the size of the proposed building would remove this root cause;
- that large canopies around the building could provide shelter from the downwash in the immediate vicinity of the entry ways, although this may result in the carparking area beyond the canopy being made uncomfortable

3.11 Where the standards set in 13.6.3.5.2 are not met, additional wind tunnel testing should be undertaken to quantify the effects of alternative building designs and/or modifications. Clear evidence should be gathered to show that the development is the best practical attempt to achieve these standards. This investigation of alternatives need only be for those areas around the development, and for those wind directions, where problems have been identified. However, sufficient measurements must be taken to quantify all the changes with the alternative designs.

In situations where the standards set in 13.6.3.5.2 are not met because the wind speed criteria in the surrounding area are already exceeded with the existing situation, and cannot be practically improved by changing the design of the development (e.g. because the location is too far away to be influenced by the design), analysis of the wind tunnel data should be provided to demonstrate this.

4. Form of Wind Assessment Report

A wind assessment report is not based on the results of a wind tunnel test and so ultimately relies on the expert knowledge and opinion of the qualified wind specialist. However, it must contain the following:

4.1 A description of the existing wind conditions, including sources and limitations of information used in the assessment.

4.2 A description of the likely interaction of the existing buildings with the wind that leads to the existing wind conditions.

4.3 A review of the design of the development, and its appropriateness for a windy environment. The WCC Wind Design Guide should be used as a basis for a design evaluation checklist for this review.

4.4 A description of the expected influence of the proposed development on pedestrian level wind speeds in areas open to the public. The WCC Wind Design Guide should be used as the basis for a design evaluation checklist for this review. The review should also examine the role of amelioration measures, including large setbacks of upper levels from the street façade, deep balconies and full-width verandahs.

4.5 A discussion of the building design, including the effectiveness of ameliorative measures or major design changes that are recommended. It is intended that the wind assessment should provide clear evidence that the proposed building is the best practical aerodynamic design with respect to achieving the wind standards.

4.6 A statement at the conclusion of the report that, in the professional opinion of the expert, the proposal is highly likely to comply with standard 13.6.3.5.2.

34 Business Area Rules

34.3.9 The construction or alteration of, or addition to buildings and structures which would be a Permitted, Controlled or Discretionary (Restricted) Activity but that does not meet one or more of the following standards outlined in section 34.6.2 (buildings and structures), are Discretionary Activities (Restricted). Unless otherwise noted below, discretion is limited to the effects generated by the standard(s) not met:

34.3.9.1 height (standard 34.6.2.1)

...

- the impact of wind from additional building height on pedestrian amenity and safety, particularly at surrounding building entries

3 Siting, Height, Bulk and Form

G3.11 Deal with wind effects within the site boundaries and in a way that does not compromise the coherence and compositional integrity of the building.

New building work above 18.6 metres in height is assessed to ensure that it does not worsen ground level wind conditions in the vicinity. Buildings that project higher than their neighbours are most likely to cause adverse wind effects, and may require careful and sometimes substantial modelling of form to mitigate these effects. Wind effects should be dealt with by amending the massing, form and detail of the building rather than with off-site devices.

Wind mitigation measures should be coherently integrated into the building's design and should not adversely affect the heritage values of buildings.

Appendix B Wellington Design Guide for Wind

The Design Guide for Wind is non-statutory guide that is published as part of the Wellington District Plan.

Non-statutory: For Guidance Only

DESIGN GUIDE FOR WIND – TABLE OF CONTENTS

1.0 Introduction

The City of Wellington is well-known for its windy environment. This is largely due to the influence of Cook Strait which produces high winds which are more frequent than in any other lowland location in New Zealand. Gusts over 18 metres/second are experienced in Wellington on average about 150-170 days a year, compared with 90 days in Invercargill, 70 in Paraparaumu, 60 in Christchurch or 50 in Auckland.

The effects of Cook Strait and also the hills around Wellington produce prevailing winds in the City which are either northerly or southerly. The northerlies are more frequent than the southerlies, but both can produce equally severe winds. The southerlies are colder and hence more discomforting.

Some areas of the City are particularly affected by northerlies, others by southerlies. In the past, the poor design of some buildings has made this already bad situation intolerable. These buildings have created street environments where walking can be not just uncomfortable but actually dangerous.

The occasional publicity given to pedestrians being blown over, or ropes being placed along pavements for pedestrian safety, gives an indication of the seriousness but belies the extent of the problem. It is generally accepted internationally that wind gusts exceeding 15 metres/second have a very serious effect on pedestrians, and those above 23 metres/second make conditions totally unsuitable for walking. Wind gusts of 21, 22 and 23 metres/second have been recorded in the central city area.

To avoid or mitigate the adverse effects of wind, specific rules apply as conditions on permitted building development. This design guide may be read in conjunction with the rules and has the following aims:

- to help designers, developers and decision-makers to become aware of what adverse effects proposed buildings, large or small, are likely to have on wind conditions in the central area
- to give a general indication of how adverse wind effects can be reduced.

The Guide is not intended to dictate how buildings should be designed. Rather, it outlines in non-scientific terms the basics of wind effects caused by buildings and shows how particular relationships can cause or alleviate problems.

Building form and detailing can greatly affect wind-flow patterns and speeds. With an appreciation of how winds flow around buildings, designers can avoid creating high wind speeds at ground level. This is an especially important consideration for buildings proposed for exposed sites, and near significant sites such as parks.

The removal of a building from, or its introduction to, the central area may have no effect upon the wind environment, or it may reduce or increase wind conditions. A crucial factor is the building's relationship to adjacent buildings. In a complex situation such as the central city area, adequate wind reports prepared by an independent consultant are invaluable, whilst wind tunnel tests are frequently essential prerequisites to satisfactory developments.

2.0 Analysis

Safety and Comfort Aspects

Tall buildings induce changes in local ground winds. The size of these changes varies from site to site. When these wind changes happen at pedestrian level, it can make activities such as sitting, strolling, shopping, or going into a building difficult and even dangerous. In various countries it has been reported that strong pedestrian-level winds have sometimes affected the financial and operational success of new buildings. Remedial treatment for adverse winds may be necessary, and could involve substantial cost.

Safety

No matter how windy the City may be, ultimately pedestrian safety must be a major determinant of building design. The criteria for judging the acceptability of proposed development schemes should be the likelihood of danger to pedestrians - conditions at street level should not be worsened by a new building. It may be that a different building form could provide a higher degree of comfort.

Developers, designers and Council share a corporate responsibility to work towards a more sheltered urban environment. It is not sufficient merely to ensure that the streets are sheltered from winds that could knock people to the ground or blow them into the path of vehicles. The aim should be to create sheltering environments wherever possible to allow people to make the best possible use of their city, outdoors as well as indoors.

Comfort

Comfort may be considered from two aspects, wind speeds and discomfort levels.

Wind Speed

It is not the mean wind speed, but rather the peak gust wind speeds and associated changes in speed which people feel most. For some time, the concept of using peak annual three-second gusts to classify the wind environment of a site with regard to people's comfort has been used.

Although there is an obviously subjective element to a person's "comfort", and there are slight divergences of opinion amongst researchers, there is a remarkably close agreement on the general effects of winds upon people. These may be summarised as:

10 metres/second	generally the limit for comfort when standing or sitting for lengthy periods in open space
15 metres/second	generally the limit of acceptability for comfort whilst walking
18 metres/second	threshold of danger level
23 metres/second	completely unsuitable for walking

Comparative Discomfort

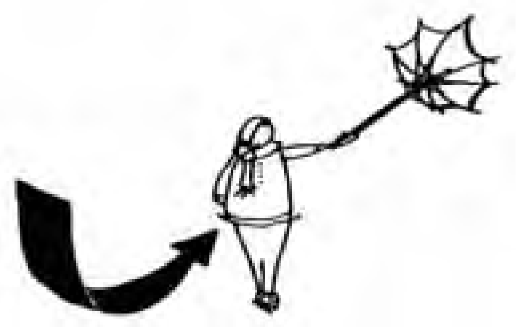
Whether people are comfortable on windy days depends upon several factors, including:

- wind speed - notably peak wind gusts
- the climate and the season
- the temperature, precipitation sunlight, shade and humidity
- what people are doing
- what people are wearing
- the age and psychological state of the individual.

To address all these aspects comprehensively is beyond the scope of this Design Guide. The Guide instead compares a person's comfort in the vicinity of a site with no buildings, to the same person's comfort in the same area with a building in place. From this comparison a percentage increase in wind speed around the building can be derived. Throughout this guide the percentage increase in wind speed is referred to as a percentage increase in discomfort.

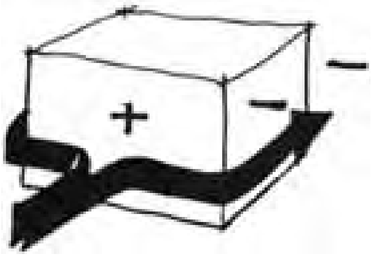
Two particular phenomena are not directly included in the measures of discomfort:

- the direction of the flow relative to pedestrians which has an especially critical effect when the flow is ascending (the "reversed umbrella" effect!)
- rapid changes in wind speed which have a showy effect on pedestrian discomfort, especially if the pedestrian is moving.

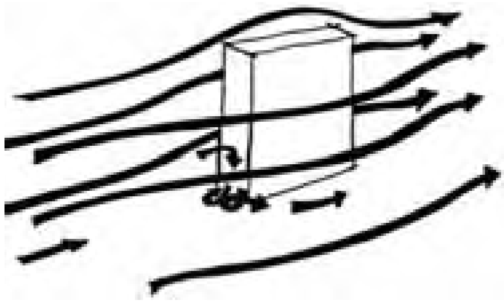


The purpose of the guide is to demonstrate clearly the degree to which a building can adversely affect the wind conditions at ground level.

The Basics of Interaction Between Buildings and Wind

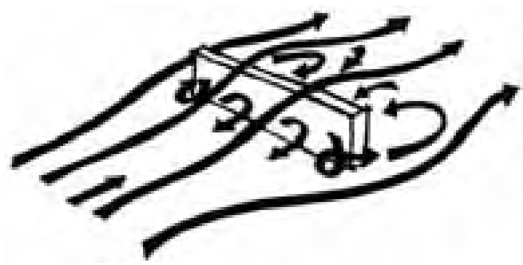


Buildings form obstacles to wind flows, causing a positive pressure zone to be formed on the windward face. At the same time, a negative pressure (which forms a suction) zone is created at the sides of the building. An increase in wind velocity occurs where the two zones meet, and the wind flows from the positive to the negative.

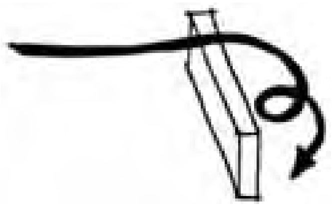


Pedestrian-level winds result from a complex reaction between the wind and the building(s), involving the building's shape, size and relationship with other buildings. Different-shaped buildings generate different wind effects.

The best approach to the problem of unpleasant pedestrian wind conditions lies in the placement and design of buildings. Buildings should not be allowed to be erected regardless of their surroundings, and tall buildings should not be built in isolation. Attention should be given to the immediate forecourt area of buildings.



One building placed to windward of another can act as a wind shield, protecting the second building. A tower block rising out of a podium, a building with substantial verandahs around it just above pedestrian height, a building which has vents through it in non-pedestrian areas to channel wind, or a building which is circular or octagonal in shape present fewer undesirable wind effects. However, even with such designs as these, it can't be assumed that further wind analysis is unnecessary, since variations of building design or the immediate environment may combine to worsen wind conditions.



It is very difficult to predict accurately the interaction between the complex and turbulent natural wind flow and a sharp-edged three-dimensional object like a building. The only currently available way to accurately predict a building's wind environment is by way of a detailed wind tunnel study. Since these are costly, the developer is often in a dilemma, undecided whether to:

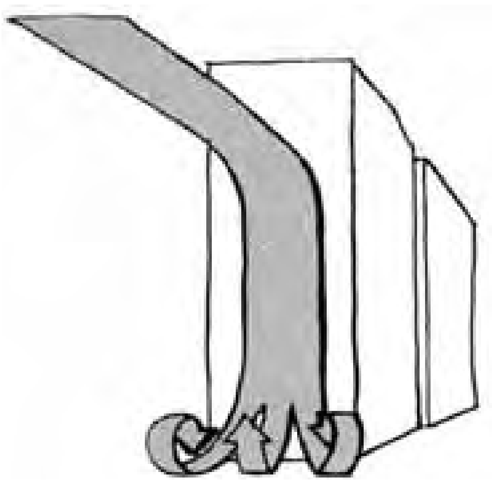
- undertake a full wind tunnel test before preparing working drawings, and risk having the wind tunnel report invalidated by subsequent design changes; or
- undertake the full wind tunnel test after the preparation of working drawings, and risk the report necessitating major changes to the working drawings.

Guidance at the initial design stage can avoid the need for time-consuming and expensive major revisions. The following paragraphs summarise the likely effects of isolated buildings of simple basic form on the ground-level wind environment in their vicinity. The diagrams, and particularly the discomfort levels which are theoretical case studies undertaken overseas, are accurate only for isolated buildings. In complicated situations, such as central Wellington, it becomes much more difficult to predict the wind effects of a new building. This makes expert advice essential.

Rectangular Towers and Slab Blocks

Because the natural wind speed increases with height, the top of a tower is exposed to wind speeds and pressures that are higher than at its base. The higher pressures at the top of a rectangular building force the air to flow down its windward face, so increasing wind speeds at pedestrian level.

Downwash



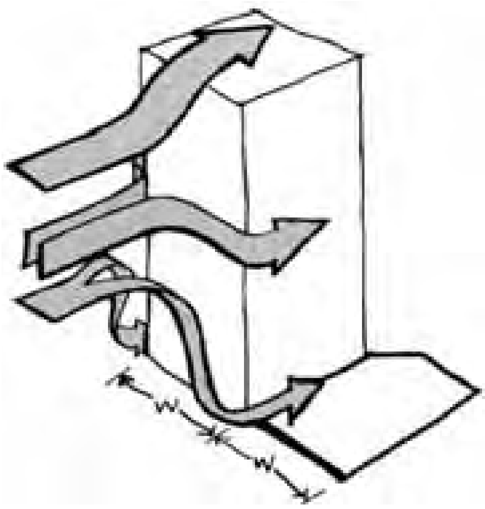
The taller the building, the greater the pressure difference driving the wind. This phenomenon is known as downwash.

A simple rectangular building will have a zone of increased wind speed at the base of its windward face, due to downwash.

Wind flows are induced downward to street level. The effects vary with the building height, typically

- a 5-storey building will cause a 20 percent increase in discomfort level
- a 16-storey building, a 50 percent increase
- a 35-storey building, a 120 percent increase.

Corner Effect



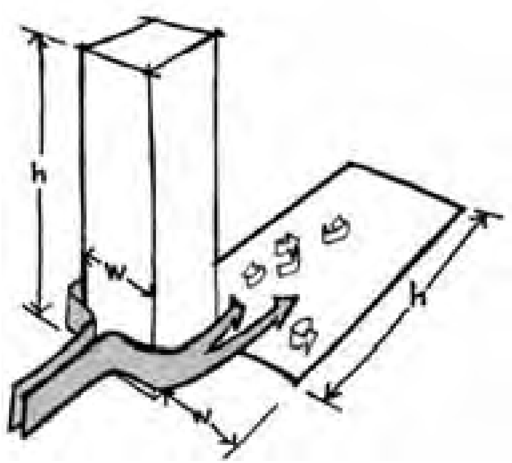
The air concentrated at the base of the windward face of a building naturally flows rapidly from there around the windward corners of the building towards its relatively more sheltered sides and rear. The transition zone between high- and low-speed wind flows at these corners is small. Pedestrians crossing this zone encounter, unexpectedly and hence in a potentially dangerous way, sudden changes in wind speed. The greatest wind speeds are generated within a distance equal to the width of the building face.

The increase in discomfort levels due to the corner effect can be similar to the range experienced from the downwash effect.

One way of decreasing the corner effect is to extend the building by adjacent structures of decreasing height, achieving a "pyramid" effect. This allows most of the wind to clear the "corner" well above pedestrian level.

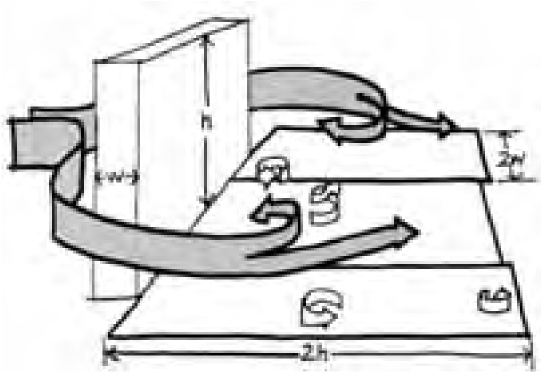
Wake Effect

Increases in wind velocities and turbulence add to the discomfort felt downwind from buildings. Much of the discomfort occurs as a result of the corner effect but it persists for a long way behind the building and can spread out, as indicated in the diagrams. Discomfort levels are worsened by increases in building height.



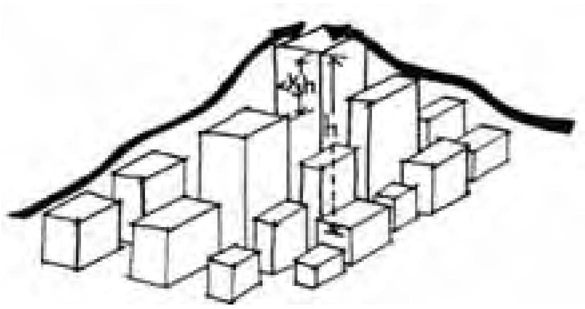
For example, an isolated 16-storey tower block building causes about a 40 percent increase in the level of discomfort, whereas a 30-storey building causes a 120 percent increase.

Each slab block is different in terms of the discomfort it creates and the area of ground it affects. A 16-storey slab block may increase the discomfort level by 60 percent.



Cumulative Effect

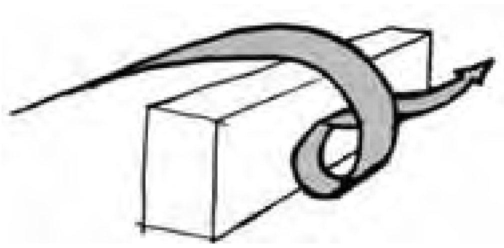
Each of the above effects is a different aspect of the same phenomenon: the interaction of a single building with the wind. When groups of buildings are being assessed, the wind effects can be cumulative.



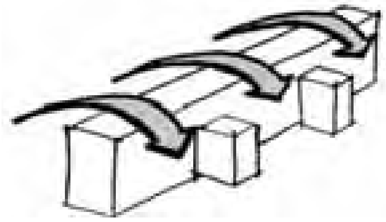
This cumulative increase in wind speed may be substantially reduced if existing or subsequent constructions nearby are of sufficient height to give a localised stepping-down effect. This may occur where the difference in height between the obtruding building and windward adjacent buildings is less than one-third the height of the dominant building.

Low Bar Buildings ("Row" Effect)

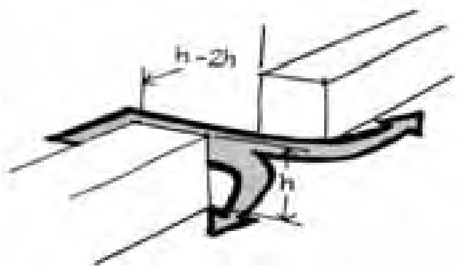
Low, "bar"-shaped buildings which present wide unshielded faces exposed to any prevailing winds cause the wind to literally trip over these bars. When a building or group of buildings is narrow, less than 10 storeys high, and its length is approximately eight or more times its height, this causes a 40 percent increase in discomfort.



One way to reduce, or even cancel, the row effect is to add one or several wings to the main block, thus localising the pedestrian wind level disturbances.

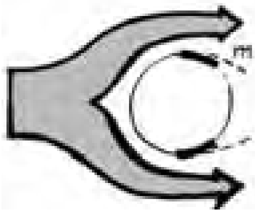


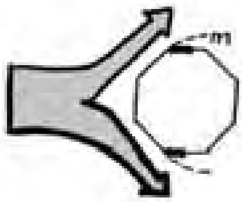
Where there are openings in the rows and the predominant wind is angled at the row, an up to 30 percent increase in discomfort level may be experienced when the width of the opening is one to two times the height of the row.



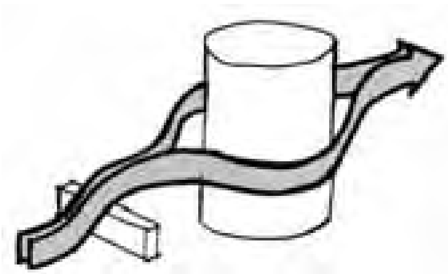
Circular Towers and Multi-sided Towers

Buildings which are circular or near-circular in plan encourage the wind to flow laterally, inducing relatively little downwards flow. Circular buildings do still induce high wind speeds at the maximum width at right angles to the wind direction (m).



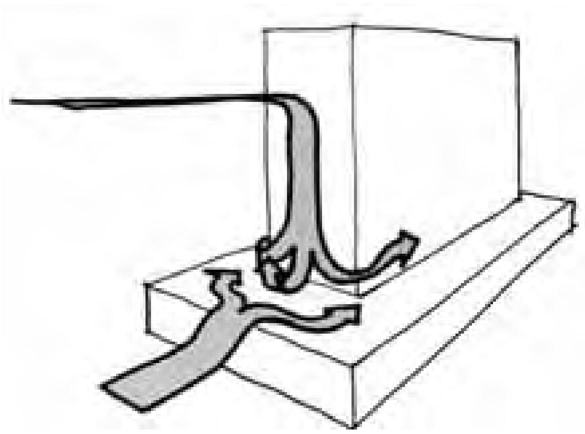


These wind speeds will be reduced even more if there are relatively low buildings upwind. This is in marked contrast to the earlier examples where the dominant building is rectangular, rather than circular.



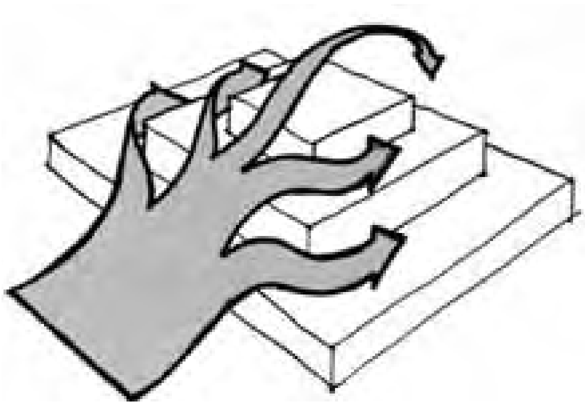
Tower Podium

Podium bases to towers, if properly designed, can be used effectively in areas where wind problems are anticipated. In this case, the podium base deflects some of the downward wind flow before it reaches ground level. Obviously the open-air podium area should not be used for general public access.



Pyramid Effect

Buildings which step up in a pyramid-like manner do not offer a great resistance to the wind. The building's irregularities (the stepped effect of the storeys and balconies) appear to dissipate a maximum of wind energy. Problems do arise in some zones such as at windward corners (where, for example, a 13-storey pyramid produces a 60 percent increase in discomfort) and on some windward balconies.



At ground level, however, it is quite sheltered. This method of construction is especially recommended, as attention can readily be given locally to the two exposure problems of windward corners and balconies.

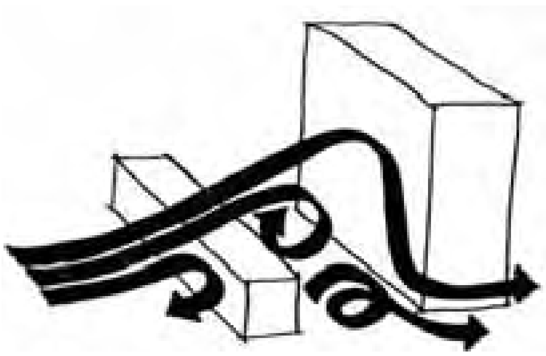
Interaction Between Groups of Buildings and Wind

As indicated, it is not possible to predict what the effect of a proposed building or open space will be on adjacent developments. Unexpected wind patterns can and do occur.

Low and High Buildings

When wind flows over rows of buildings of a similar height, as in older parts of a town, pedestrian areas are generally sheltered; usually considerably better than if there were no buildings at all.

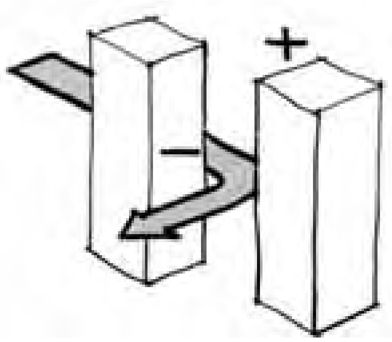
However, where a low building is upstream of a high building and the high building exceeds five storeys, there are likely to be major problems/increases in discomfort at ground level.



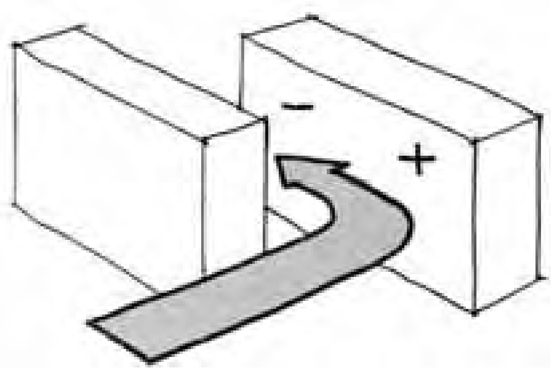
For example, downwash from a 20-storey high building with a wide windward face will cause a 50 percent increase in discomfort at its base when the building is on its own. There would be an 80 percent increase if there were a low (eg, five-storey) building on the windward side of (and located at a distance approximately equal to the low building's height from) the tall building. And there would be a 100 percent increase in discomfort in the wake of the high building.

Staggered Buildings

Adjacent buildings may protect each other from high winds, or may make their wind environment worse. The buildings in the diagram opposite show an increased wind pressure on the unsheltered area (+) and a decreased pressure at the sheltered areas (-). Consequently wind rushes from the high pressure point to the low. This effect is especially important because of:



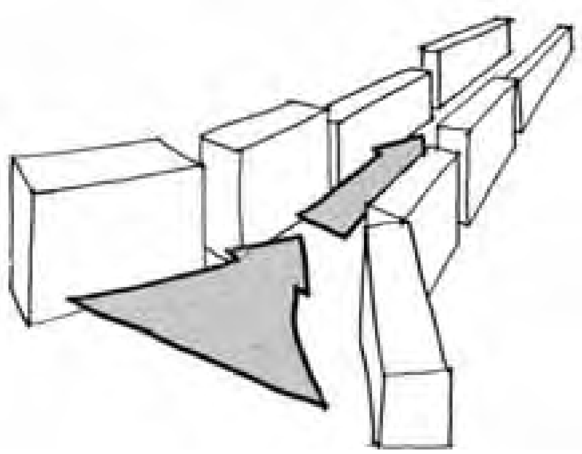
- the large area at ground level which is affected (it is related directly to the height of the buildings)
- the ways that the massing/scale of the buildings and relationship to other buildings can exacerbate the adverse wind effects. Discomfort levels are very wide-ranging, depending upon the scale and interrelationship of the staggered buildings and their neighbours.



The staggered buildings effect, especially associated with other phenomena, leads to the unexpected changes of wind direction encountered in city streets. In terms of discomfort experienced, this is a particularly bad situation.

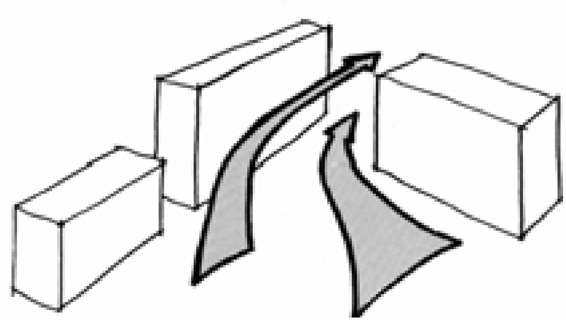
Channel Effect

A row of buildings running more or less parallel to each other forming a channel or corridor open to the sky is not in itself a cause of discomfort, but can cause discomfort when it receives some other adverse wind conditions and transmits them for the whole length of the corridor. Adverse effects are accentuated when the corridor is well-defined (such as there being few gaps and generally standard height) and is relatively narrow (when the width between rows is less than three times the buildings' height). These effects can be reduced by the introduction of sharp changes in direction.



Funnelling Effect

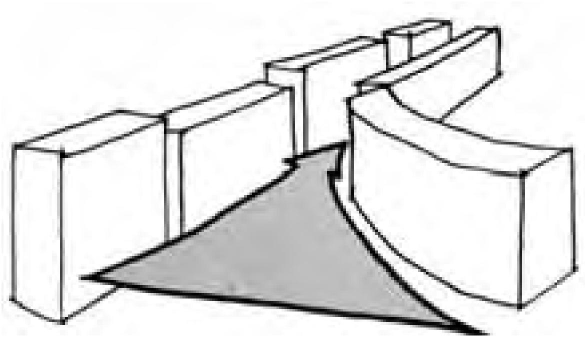
This collector, or "bottleneck", phenomenon is created by two structures with an opening between them. The axes of the two may make a right angle or an acute angle. The critical zone for comfort is at the neck.



Adverse funnelling effects occur when the relevant buildings are more than five storeys high, more than 100 metres long, and the upstream and downstream funnels are clear of obstructions.

Discomfort is worst when the width of the opening is two to three times the mean height. Buildings 8-10 storeys high cause a 30 percent increase in discomfort and buildings 18 storeys high cause a 60 percent increase.

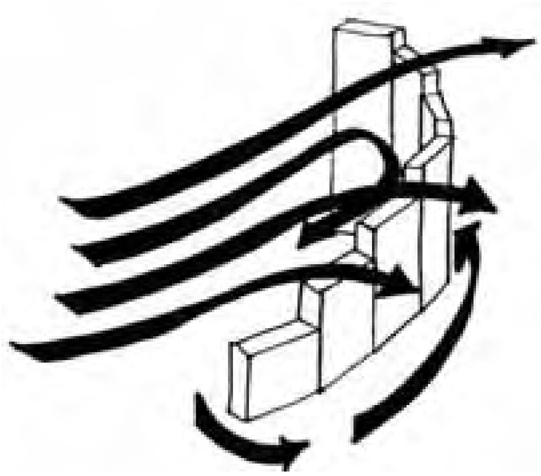
There would be a greater adverse wind reaction where the Venturi effect applies. If, after the bottleneck, the rows of buildings diverge, then an aerodynamic nozzle is formed, the wind accelerating once past the bottleneck. In this situation, building heights of about five storeys could cause a 100 percent increase in discomfort level.



If one or more of the buildings forming the acute angle is also curved in plan, a more aerodynamic situation is created and the wind problem is increased.

Stepping Effect

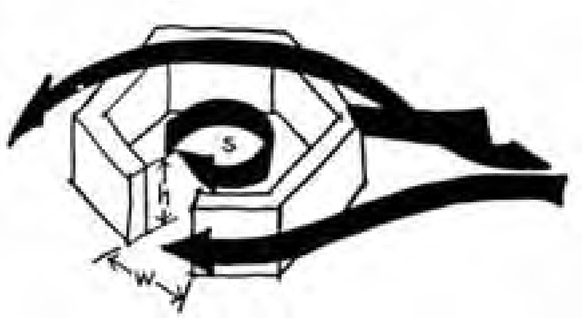
Groups of buildings which present a windward face which increases continuously in height create varying pressure zones on the lee side. Differing low-pressure zones will occur behind the different buildings. An additional wind current, often at an acute angle to the prevailing wind, will be set up between these varying low-pressure areas.



Courtyard Effect

When buildings are linked together to form an open courtyard, the wind will either jump over the courtyard, or blow down into it. Four factors determine which of the two will happen:

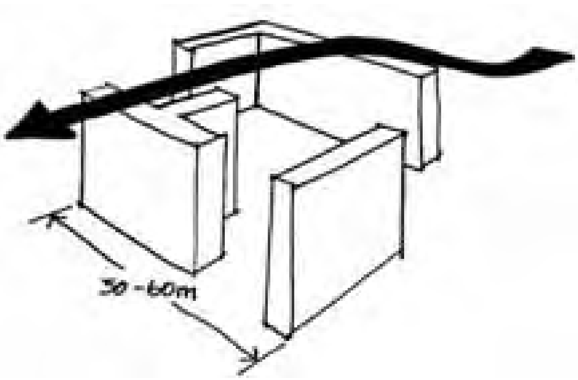
- the surface area of the courtyard *(s)*
- the mean height of the buildings forming the courtyard *(h)*
- the position of any courtyard opening with respect to the wind direction
- the width *(w)* of that opening, or total width of openings (*w* must be less than or equal to 25 percent of the total perimeter length of the linked buildings).



The protection value of the courtyard is felt when the average building height is five to eight storeys, no matter where the position of the opening is relative to the wind direction. So long as the area/height ratio (s/h^2) is no more than 10, then the courtyard area will be relatively sheltered.

When the average height of the surrounding buildings exceeds 10 storeys, the opening relative to the wind's direction plays an important part:

- when the opening is on the leeward side and the area/sheltered height ratio (s/h^2) is less than 30, the courtyard will be sheltered
- when the opening is on the windward side to within 45 degrees the air will be set into circular motion. With the opening parallel to the wind the courtyard will be sheltered.

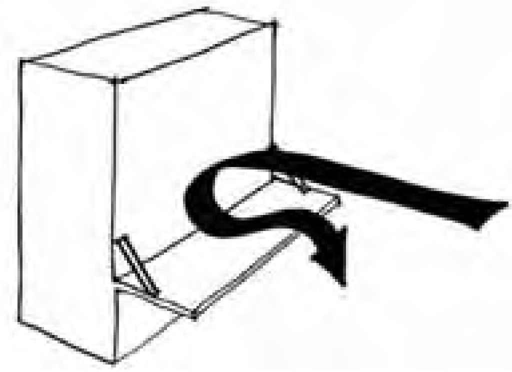


Generally if the average height of buildings exceeds four storeys, then there will be an increase in comfort within the courtyard - even in a poorly defined courtyard system - where the system measures 50 to 60 metres across.

3.0 Guidelines

Architectural Detailing

Different, complex wind pressures caused by arcades, spaces under buildings or around corners can induce very rapid local flows, which give unpleasant, sometimes violent, wind effects.

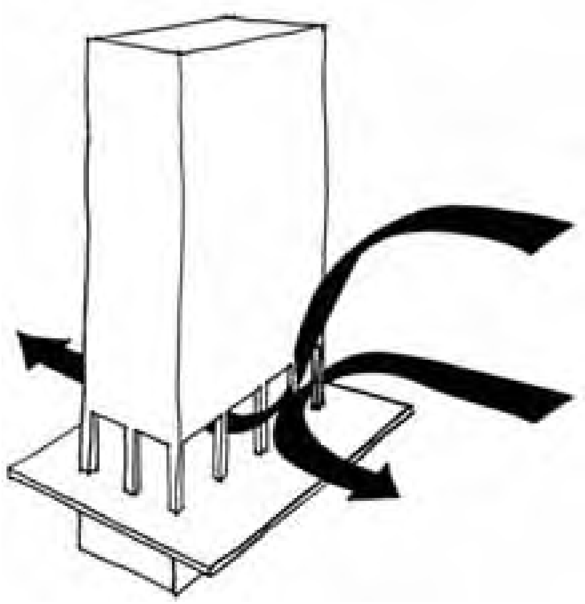


Various features such as verandahs and channels on the outside of buildings can have a marked influence on combating downwash problems.

These should not be regarded as cosmetic remedies which can be subsequently applied, if necessary, to cure pedestrian-level wind problems for developments in sensitive areas. There is no adequate substitute for the careful consideration of wind design at pre-design stage. This could well consist of testing simple block forms in a wind tunnel.

Verandahs and Canopies

Verandahs are substantial structures extending from a building to roof-in adjacent airspace, whilst canopies are minor extension covers over doorways, windows or similar.



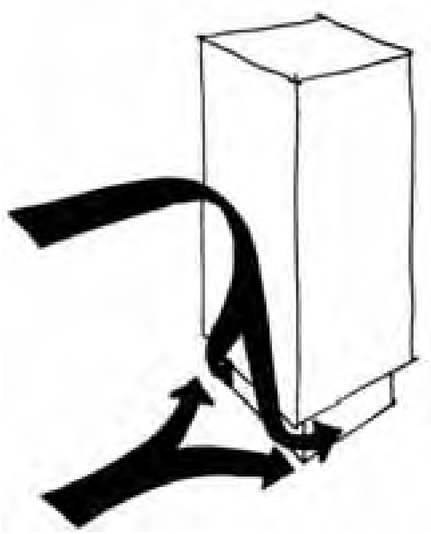
Canopies, unless extensive, do little to protect the area from high wind speeds.

G1 Verandahs should be used to deflect downwards-travelling wind flows, in effect lifting the vortex above pedestrian level.

G2 They can be used in conjunction with columns, although the associated spaces should not be open to pedestrian movement.

Verandahs are not as effective for wind flows which are parallel to the building face to which they are attached. Extra problems can arise where verandahs are not continuous and large gaps between verandahs lead to additional wind currents.

Building Setbacks



Setbacks around the building may improve the pedestrian comfort level, but usually worsen it. The effect depends on the depth and height of the setback.

Recessed entries may provide a degree of protection at pedestrian level. The degree of protection depends upon the height and depth of the recess, and the wind patterns experienced locally.

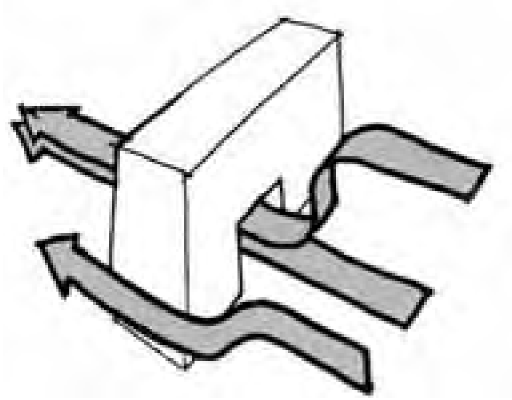
G1 Particular care should be taken when a recessed corner entrance is contemplated as these may accentuate wind effects at corners.

Arcades and Colonnades

Arcades and colonnades at the base of exposed buildings can provide openings between the higher pressures of the windward face and lower pressures at ground level through which high wind speeds would be induced.

G1 Arcades and colonnades should not be designed as main public access-ways, or as window-shopping precincts unless one is certain of adequate protection from wind.

Passageways and Slots through Buildings

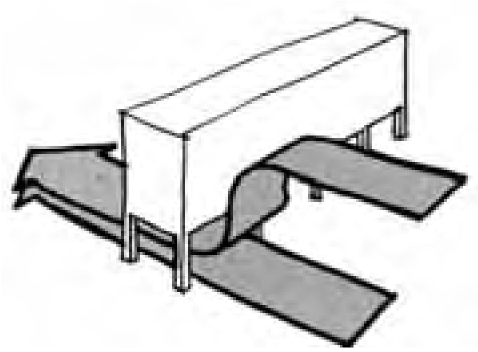


In narrow passages designed to be used specifically for vehicular access, adverse wind conditions may be accepted more readily. The more serious impact is upon pedestrians. Ground-level passageways through buildings create a level of discomfort. The higher the building, the greater the discomfort level due to the effect of the lower pressure on the lee side:

- for buildings of less than five storeys, there may be little added discomfort
- for buildings of seven storeys, a 20 percent increase may be experienced
- for buildings of 16 storeys, a 50 percent increase may occur.

G1 Unprotected passageways should not be aligned with the direction of the prevailing wind.

The zone of discomfort is not confined to the passages themselves but could extend over approximately the same area as that of the opening on the lee side, the air being released in the form of a localised jet. These "slots" under buildings make for more directional airflows than when the building has guide walls or is on columns.



If the building is on columns, the deflection of wind from its face can cause discomfort levels of up to 100 percent increase around the columns. This can increase up to 200 percent if there is a low building to windward of the tall building.

G2 Areas around columns are undesirable for pedestrian usage.

Pedestrian Corridors and Foyers

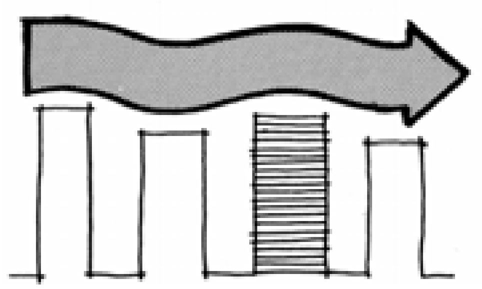
The designer's responsibility for adverse wind effects does not end once wind conditions in the street have been addressed. The entrances to buildings, foyers and pedestrian corridors can also be areas where there is pedestrian discomfort or even danger.

Discomfort can be experienced both inside and outside entrance doorways. There may be a high fluctuating wind pressure outside the doorway, which creates a high pressure upon the door itself, and given the opportunity, generates a wind flow into the building. Wind whistles through gaps, and doors bang. There are both damage and safety risks, and there can be difficulty in operating doors and lifts. In extremely bad situations, it is not unknown for lift doors to jam because of the severe local wind pressure.

Increases in wind pressure can turn stairwells and corridors into unpleasant wind tunnels, and can disrupt heating and ventilation systems. Buildings adversely affected by wind may require three to four times more heating than unaffected buildings.

G1 Entrance-ways to building foyers and pedestrian corridors should be designed or located to avoid users experiencing adverse wind conditions.

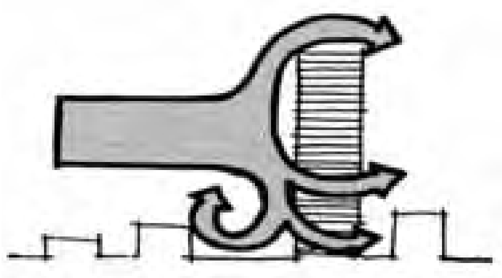
Site Exposure



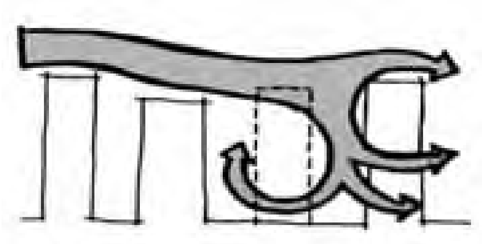
Whereas a building of similar height to its neighbours may be protected from large wind loads, and cause minimal pedestrian-level wind discomfort, this situation is lost when either:

- a building is introduced that is significantly taller than its neighbours
- a compatibly-sized building is demolished, to be replaced by either a relatively low building, or an open space. The degree of increase in discomfort depends upon the scale of the open space created.

The sites where simple form buildings have the greatest potential for creating adverse wind conditions are those which are in areas with drastic variations in building height. The greater the area of the windward face, the greater the potential problem, because of the absence of shelter from similar buildings.



A cluster of buildings of similar height will give shelter to pedestrians within the cluster.



Buildings will induce high-velocity ground-level winds if a significant part (that is, one-third the building's height or more) is clearly above the height of buildings located upwind.

G1 Where a new building is planned the design should consider:

- the wind environment created by the surrounding buildings
- the impact the building will have on the existing wind patterns
- the impact the building will have on the balance of the site.

G2 Where there is a likelihood that re-development of adjoining sites or sites within the localised wind environment may occur designers should recognise the potential for the wind patterns effecting the building to alter, by making the building as robust as possible in relation to securing pedestrian safety and comfort.

4.0 Conclusion

The design guide gives an indication of the wind effects which may be avoided - or markedly reduced - if wind design is an important consideration during the initial stages of building design.

The guide is not intended to offer a set of answers; the subject is complex, and complicated wind patterns are experienced in the Wellington central area.

Wind tunnel tests should be an early feature of the design process.

Council's reaction to development proposals is based upon the premise that a new building should not make the wind situation worse, and performance standards have therefore been included as rules in the District Plan.

Appendix 1.

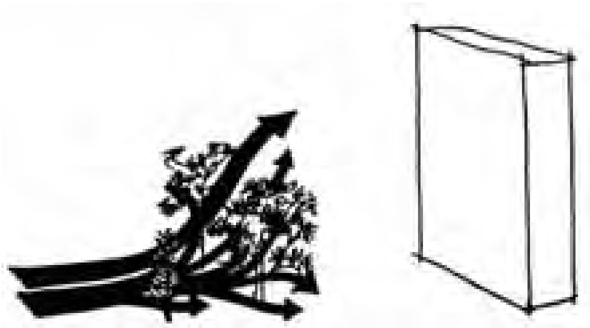
Remedial Treatment for Existing Situations

The modification of "final" drawings or subsequent alterations to existing buildings may sometimes be necessary to improve the local environment for the building's users and the general public.

Remedial treatment is never a reasonable substitute for proper consideration of wind effects at the design stage of a project.

Vegetation

The growth of trees in the area adjacent to the buildings can be prevented or distorted by the wind. However, resistant vegetation can act as a porous fence and lend a measure of protection, whereas a solid shield such as a wall or fence could encourage further pressure variations.



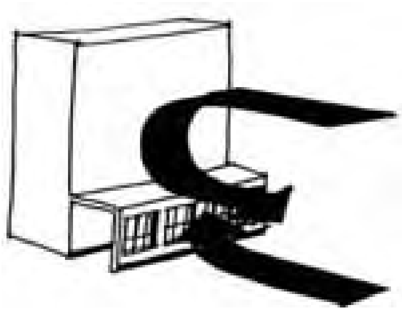
Structures

Where buildings prove to be windy after construction, various remedial works may substantially reduce the wind effects. Two approaches may be taken: people can be protected by shields, or redirected through safer areas, for example by establishing gardens and architectural features within the danger zones.

In more extreme situations, the second course is recommended.

- **Verandahs**

A substantial verandah may prevent high wind speeds descending to ground level. Care must be taken not to transfer the discomfort to another pedestrian area.

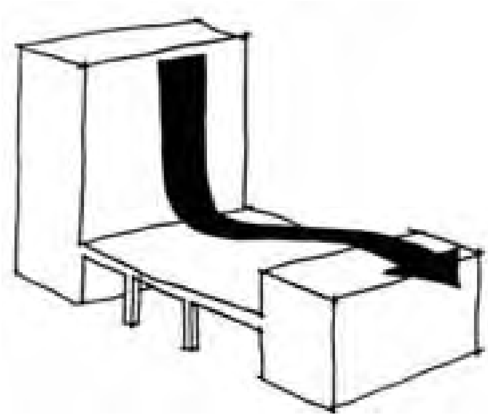


- **Enclosed Walkways**

The verandah can be extended by the addition of a side wall.

- **Roofing Over the Open Spaces**

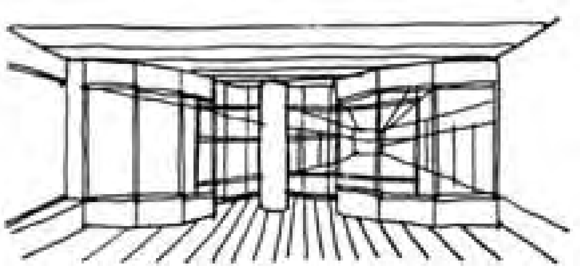
High pedestrian-usage areas such as shopping precincts can be roofed over.



- **Pedestrian Corridors and Foyers**

Although enclosing the walkways improves the situation, there may be significant discomfort from winds blowing the entire length of the enclosed walkways.

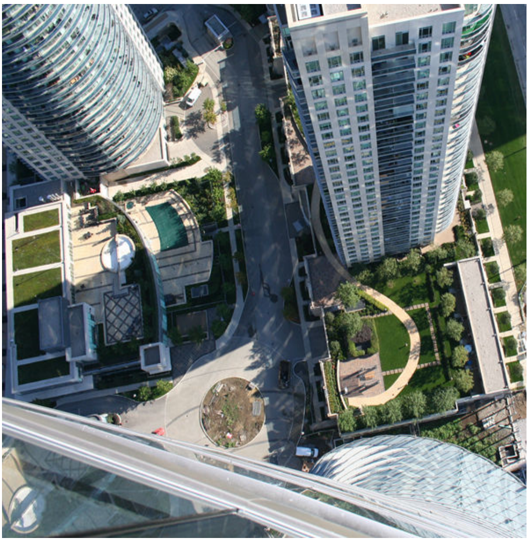
These may be reduced by putting up screens, or eradicated by building doors at the end of the walkways. Although the addition of such doors will eliminate the wind problems in the corridor, there may well be major problems at the doors - people may have trouble passing through the doors, or the doors may jam. Electronic doors often cannot operate under serious wind pressures.



Appendix C Mississauga wind rules

Urban Design Terms of Reference – Pedestrian Wind Comfort and Safety Studies, City of Mississauga, June 2014

Urban Design Terms of Reference



June 2014

Pedestrian

Wind Comfort and Safety Studies

MISSISSAUGA

Table of contents

1

Introduction

1

Introduction

1.1 Purpose

Pedestrian Wind Comfort and Safety Studies are conducted to predict, assess and where necessary, mitigate the impact of the site and building designs and development on pedestrian level wind conditions.

Mississauga Official Plan, Section 19.4.5, identifies a Wind Study as a study that staff may request as one of the requirements for a complete application.

The objective is to maintain comfortable and safe pedestrian level wind conditions that are appropriate for the season and the intended use of pedestrian areas. Pedestrian areas include sidewalks and street frontages, pathways, building entrance areas, open spaces, amenity areas, outdoor sitting areas, and accessible roof top areas among others.

Tall buildings can have major impacts on the wind conditions in their surrounding context especially when a building is considerably taller than surrounding buildings. Tall buildings tend to intercept the stronger winds that exist at high elevations and redirect them downwards towards the ground level. Winds around the base of such buildings can be accelerated up to several times the values that existed prior to the tall buildings, thus creating uncomfortable and sometimes dangerous conditions for pedestrians.

It is important to consider the potential impacts of a proposed development on the local microclimate early in the planning and design process as this allows sufficient time to consider appropriate wind control and mitigation strategies, including significant changes to site and building designs.

1.2 Who can conduct a wind study ?

Pedestrian wind comfort and safety studies are to be conducted by professionals who specialize in, and can demonstrate extensive experience in dealing with wind and microclimate issues in the built environment. The studies are to be signed and sealed by a Professional Engineer.

If the Planning and Building Department is not satisfied with the level of experience demonstrated, a peer review of the wind study will be required. The cost of the peer review is to be borne by the applicant.

1.3 Consultation with Planning and Building Department

Prior to the preparation of pedestrian wind comfort and safety studies for submission to the City, the microclimate specialist shall consult with the Planning and Building Department as follows:

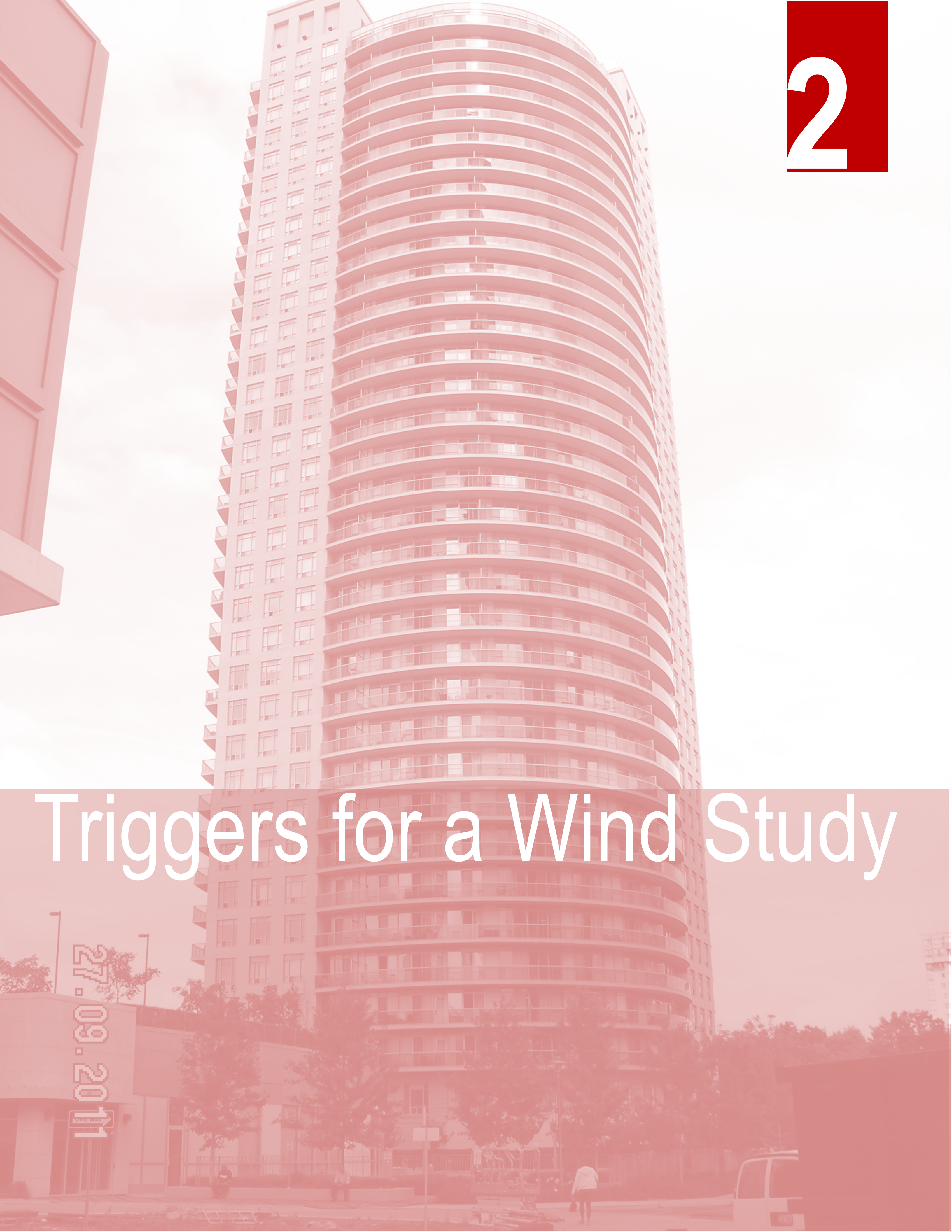
- Consult with the Development Planner and Urban Designer processing the development application, to agree upon the most appropriate approach for the wind comfort and safety study, based on the triggers described in Section 2 of this document.

- At the discretion of the City, the microclimate specialist may be asked to submit the intended test configurations and sensor locations for review by the City's Development Planner and Urban Designer prior to any wind tunnel testing.

- In the event that the proposed development is predicted to produce wind conditions that are considered unacceptable or unsafe, the City's Development Planner and Urban Designer shall be consulted to discuss potential strategies going forward.

2

Triggers for a Wind Study



2

Triggers for a Wind Study

The following factors will trigger a wind study:

2.1 Building Height

- A development proposal with a building 20 m in height or more, requires a **Qualitative Wind Assessment** as a minimum. A **Quantitative Wind Tunnel Study** may be required at the discretion of the Planning and Building Department.
- A development proposal with a building that is 20 m in height or more, and up to two times the height of surrounding buildings requires a **Quantitative Wind Tunnel Study**
- A development proposal with a building 40 m in height or more requires a **Quantitative Wind Tunnel Study**

2.2 Number of Buildings

- A development proposal with two or more buildings that are 20 m in height or more, requires a **Quantitative Wind Tunnel Study.**

2.3 Site Location

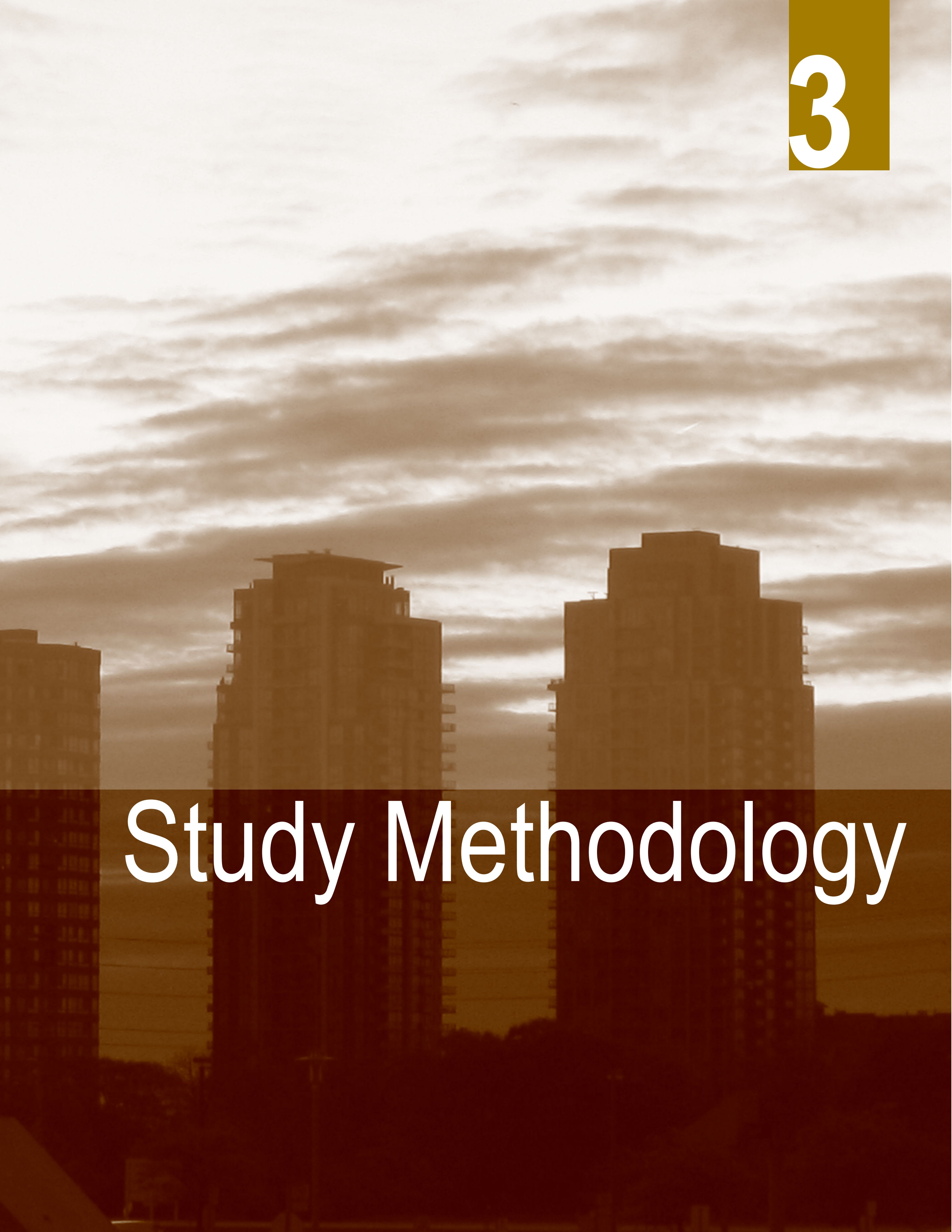
- Due to proximity to Lake Ontario, a development proposal with a building that is 20 m in height or more, and is located south of the Queen Elizabeth Way, requires a **Quantitative Wind Tunnel Study**

2.4 Site Area (Size)

- A development proposal with a site area of 3 hectares or more, and a building that is 20 m in height or more, requires a **Quantitative Wind Tunnel Study**

3

Study Methodology



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Study Methodology

The following is a description of the general methodology to be used by the microclimate specialist providing wind comfort studies:

3.1 Wind Data Collection

A minimum of 30 years of hourly wind data from Lester B. Pearson International Airport should be used for pedestrian wind comfort and safety studies in the City of Mississauga for developments north of the QEW. Data from Billy Bishop Toronto City Airport should be used for developments south of the QEW. The Data is to be presented and used on a two season basis defined as follows:

Summer: Hourly winds occurring during the period of May through October.

Winter: Hourly winds occurring during the period of November through April.

Note: Appropriate hours of pedestrian usage for a typical project (e.g., between 6:00 and 23:00) should be considered for wind comfort, while data for 24 hours should be used to assess wind safety.

3.2 Criteria

The criteria to be used for assessment of pedestrian wind conditions have been developed through research and practice. They have been widely accepted by municipal authorities as well as the international building design and city planning community. As both mean and gust wind speeds can affect pedestrian comfort, their combined effect is used as the basis of the criteria and defined as a Gust Equivalent Mean (GEM) wind speed. The GEM is defined as the maximum mean wind speed or the gust wind speed divided by 1.85.

A 20% exceedance is used in these criteria to determine the comfort category, which suggests that wind speeds would be comfortable for the corresponding activity at least 80% of the time or four out of five days.

Only gust winds are considered in the safety criterion. These are usually rare events, but deserve special attention in city planning and building design due to their potential impact on pedestrian safety.

These criteria for wind forces represent average wind tolerances. They are subjective and variable depending on thermal conditions, age, health, clothing, etc. which can all affect a person's perception of a local microclimate.

The criteria to be used are defined in Table 1.

Table1 – Pedestrian Wind Comfort and Safety Criteria

Comfort Category	GEM Speed (km/h)	Description
Sitting	≤ 10	Calm or light breezes desired for outdoor restaurants and seating areas where one can read a paper without having it blown away
Standing	≤ 15	Gentle breezes suitable for main building entrances and bus stops
Walking	≤ 20	Relatively high speeds that can be tolerated if one's objective is to walk, run or cycle without lingering
Uncomfortable	> 20	Strong winds of this magnitude are considered a nuisance for most activities, and wind mitigation is typically recommended
Notes: (1) Gust Equivalent Mean (GEM) speed = *max*(mean speed, gust speed/1.85); and (2) GEM speeds listed above are based on a seasonal exceedance of 20% of the time (e.g., between 6:00 and 23:00).		
Safety Criterion	**Gust Speed (km/h)**	**Description**
Exceeded	> 90	Excessive gust speeds that can adversely affect a pedestrian's balance and footing. Wind mitigation is typically required.
Note: Based on an annual exceedance of 9 hours or 0.1% of the time for 24 hours a day.		

Soligo, M.J., Irwin, P.A., Williams, C.J. and Schuyler, G.D. (1998). "A Comprehensive Assessment of Pedestrian Comfort Including Thermal Effects," *Journal of Wind Engineering and Industrial Aerodynamics*, Vol.77&78, pp.753-766.

Lawson, T.V. (1973). "Wind Environment of Buildings: A Logical Approach to the Establishment of Criteria", *Report No. TVL 7321*, Department of Aeronautic Engineering, University of Bristol, Bristol, England.

Durgin, F. H. (1997). "Pedestrian Level Wind Criteria Using the Equivalent average", *Journal of Wind Engineering and Industrial Aerodynamics*, Vol. 66, pp. 215-226.

3.3 Configurations

When conducting pedestrian wind comfort and safety studies, the most objective way to assess the impact of a proposed development is to compare it to the existing wind conditions. In some parts of the City it may be prudent to consider a future cumulative configuration.

The following is a description of the configurations that typically need to be considered:

- **Existing:**

Include all existing buildings, significant topographic features, and developments under construction within a 400 m radius of the site.

- **Proposed:**

Include the proposed development being studied, as well as all existing buildings, significant topographic features, and developments under construction within a 400 m radius of the subject site.

- **Future (only if warranted):**

Add any buildings that are part of a future development identified by the City, and deemed by the wind consultant to have a potential impact on winds at the subject site.

- **Mitigation:**

Where mitigation is required to achieve acceptable pedestrian wind comfort levels, evaluate the proposed configuration with all recommended mitigation measures in order to demonstrate the benefits of the mitigation strategies under the proposed and/or future configurations.

3.4 Qualitative Assessment

A Qualitative Assessment relies on professional observation and interpretation.

A Qualitative Assessment may be conducted either as a Qualitative Desk Top Assessment, or using Computational Fluid Dynamics (CFD) .

Requirements for Qualitative Desktop Assessment

- Predict and estimate the wind speeds at critical locations around the proposed development while giving consideration to the frequency of occurrence of wind speeds.
- Assessment should be based on the standard wind comfort criteria described in this document.
- Where conditions are considered to be unacceptable for the intended pedestrian usage provide mitigation concepts to improve the wind comfort to acceptable levels or suggest appropriate adjustments to pedestrian usage.

Requirements for Computational Fluid Dynamics (CFD)

- It shall be acceptable to simulate only the prevailing wind directions as a basis of assessment using CFD.
- The CFD simulation shall appropriately represent the atmospheric boundary layer for winds approaching the computational model.
- Presentation of the wind speeds shall include horizontal planes at pedestrian level (i.e. 1.5 m above local grade) and vertical slices to understand flow conditions in critical areas.
- The actual assessment of wind conditions at critical pedestrian locations must account for the probability of all wind directions that can occur based on the wind data from the appropriate airport.
- The potential wind comfort and safety categories should be assessed for areas of interest.
  If problematic wind conditions are predicted, design alternatives and wind mitigation measures shall be recommended and described in the final report.

3.5 Quantitative Wind Tunnel Study

A Quantitative Wind Tunnel Study is based on measured data from physical scale model testing.

A Quantitative Wind Tunnel Study shall be conducted in a boundary layer wind simulation facility.

Requirements for Quantitative Wind Tunnel Testing

For wind tunnel testing, the following are the key requirements:

- 36 wind directions shall be tested.
- The wind simulation facility must be capable of simulating the earth's atmospheric boundary layer and appropriate profiles for each of the wind directions tested.
- Wind speeds shall be presented in km/h.
- Wind speed sensors used to measure local wind speeds shall be omni-directional and represent the horizontal wind speed at a full scale height of approximately 1.5 m above local grade. These sensors should be capable of measuring mean wind speed and wind speed fluctuations with time, including peak gusts of three to ten second duration. Sampling time in the wind tunnel shall represent a minimum of one hour of full scale time.
- The model scale should be selected to allow representation of sufficient architectural detail on the proposed development while including the surrounding context within approximately 400 m of the centre of the proposed development site (typically scales of 1:300 or 1:400 have proven to be effective). Structures and natural features beyond the modelled surroundings shall be appropriately represented in the wind tunnel upwind of the scale model.
- Sensors shall be placed at least every 10 m along a street frontage of the study buildings and at all locations where pedestrians will travel or gather. A typical development project would require a minimum of 50 sensor locations on and around the proposed development to provide adequate coverage.
- The final results shall be presented in both tabular and graphic forms for all the test configurations, with seasonal comfort data and annual safety data.

3.6 Assessment

The pedestrian wind comfort level and safety exceedance are determined by the predicted wind speeds for respective exceeding frequencies, as specified in Table 1. The assessment will give consideration to the predicted comfort level and the intended pedestrian usage. In addition, a comparison to existing, and if appropriate future, wind conditions shall be considered.

The proposed development shall achieve wind comfort conditions that are considered appropriate for the intended usage (i.e., walking on sidewalks, standing at building entrance areas and sitting or standing in amenity areas where more passive use is anticipated). If the proposed development produces pedestrian comfort conditions that prove to be less than desirable based on the intended use or unsafe (as per the definitions in Table 1) then the developer shall propose mitigation strategies and/or investigate alternatives to the proposed design with the microclimate specialist.

Overall, any proposed development shall improve on existing wind conditions where possible, and as a minimum, shall not significantly degrade wind conditions especially when considering the safety criteria. Some allowance for degradation of wind comfort levels during the winter months may be deemed to be acceptable due to reduced pedestrian usage of outdoor spaces.

4

Mitigation Strategies

4

Mitigation Strategies

4.1 Wind Control Mitigation Strategies

In areas where wind conditions are considered to be unacceptable for the intended pedestrian use or unsafe (as defined in Table 1) and will be accessible to pedestrians, wind control mitigation strategies shall be developed and tested to demonstrate their efficacy. In more extreme cases the developer in consultation with the microclimate specialist, may need to investigate and prepare design alternatives that can achieve more acceptable wind conditions.

Wind Control Mitigation Strategies may include the following:

- Building massing changes or alternative designs that are more responsive to the local wind climate.
- Incorporating podiums, tower setbacks, notches and/or colonnades.
- Strategic use of canopies, wind screens, landscaping, planters, public art and/or other features that prove to be effective for mitigating problematic wind conditions.
- Modifications to the pedestrian usage.

The use of landscaping as part of a mitigation strategy is acceptable but must be selected and sized to be effective at the time of installation. Landscaping can only be recommended as a mitigation measure, where the wind conditions are suitable for it to thrive and for its maintenance.

High branching deciduous trees can reduce down washing wind flows in the summer months when they have full foliage. However, they generally do not provide ground level protection from horizontal wind flows. Coniferous trees can provide additional wind protection during the winter months.

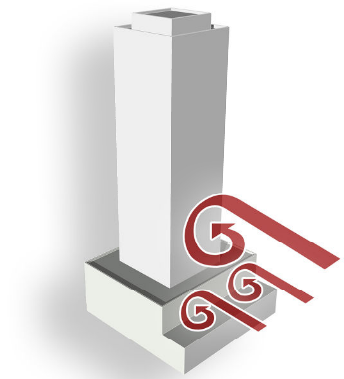
The type of trees (i.e., deciduous, coniferous or **marcescent**), approximate size and location required for wind control shall be specified in the wind study. The landscape architect shall select the species appropriate for the site and which will achieve the stated wind mitigation benefits.

Where extreme wind conditions such as safety **exceedances** are predicted, hard landscaping (e.g., architectural features, screens, etc.) is strongly recommended over soft landscaping (e.g. trees, shrubs, etc.), as trees may not be able to survive in extreme wind environments.

4.2 General Design Strategies for Wind Mitigation

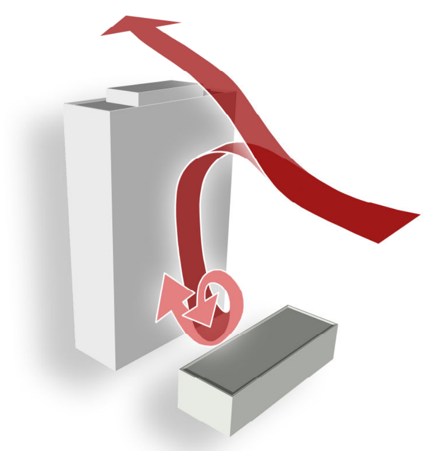
When wind hits the windward face of a tall building, the building tends to deflect the wind downwards, causing accelerated wind speeds at pedestrian level and around the windward corners of the building.

Tall and wide building facades that face the prevailing winds are generally undesirable.



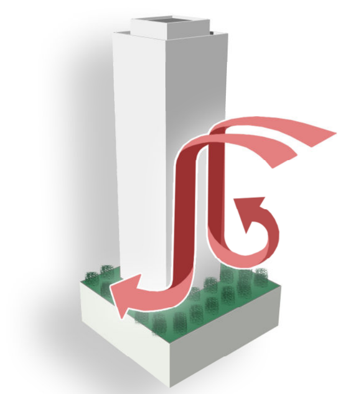
By introducing a base building or podium with a step back, and setting back a tower relative to the base building, the downward wind flow can be deflected, resulting in reduced wind speed at pedestrian level.

The proportions of the base building and tower step backs and their influence on the wind conditions is affected by the heights of surrounding buildings.



When the leeward face of a low building faces the windward face of a tall building, it causes an increase in the downward flow of wind on the windward face of the tall building.

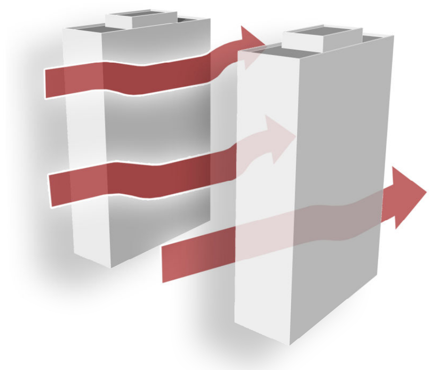
This results in accelerated winds at pedestrian level in the space between the two buildings and around the windward corners of the tall building.



By landscaping the base building roof and tower step back, wind speeds at grade can be further reduced, and wind conditions on the base building roof can improve.

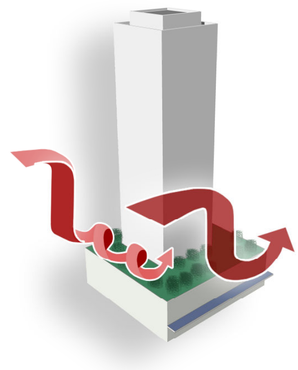
Unmitigated wind conditions on the roof of the base building, are generally undesirable for pedestrians.

4 Mitigation Strategies



Wind speed is accelerated when wind is funneled between two buildings. This is referred to as the “wind canyon effect”

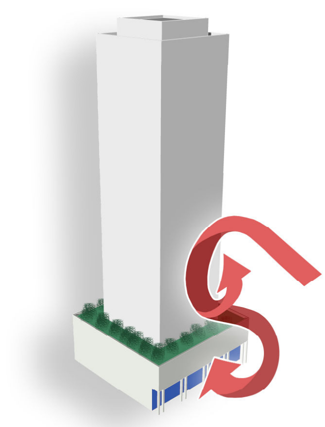
The intensity of the acceleration is influenced by the building heights, size of the facades, building separation distance and building orientation.



A horizontal canopy on the windward face of a base building can improve pedestrian level wind conditions.

Parapet walls around a canopy can make the canopy more effective.

Sloped canopies only provide partial deflection of downward wind flow.



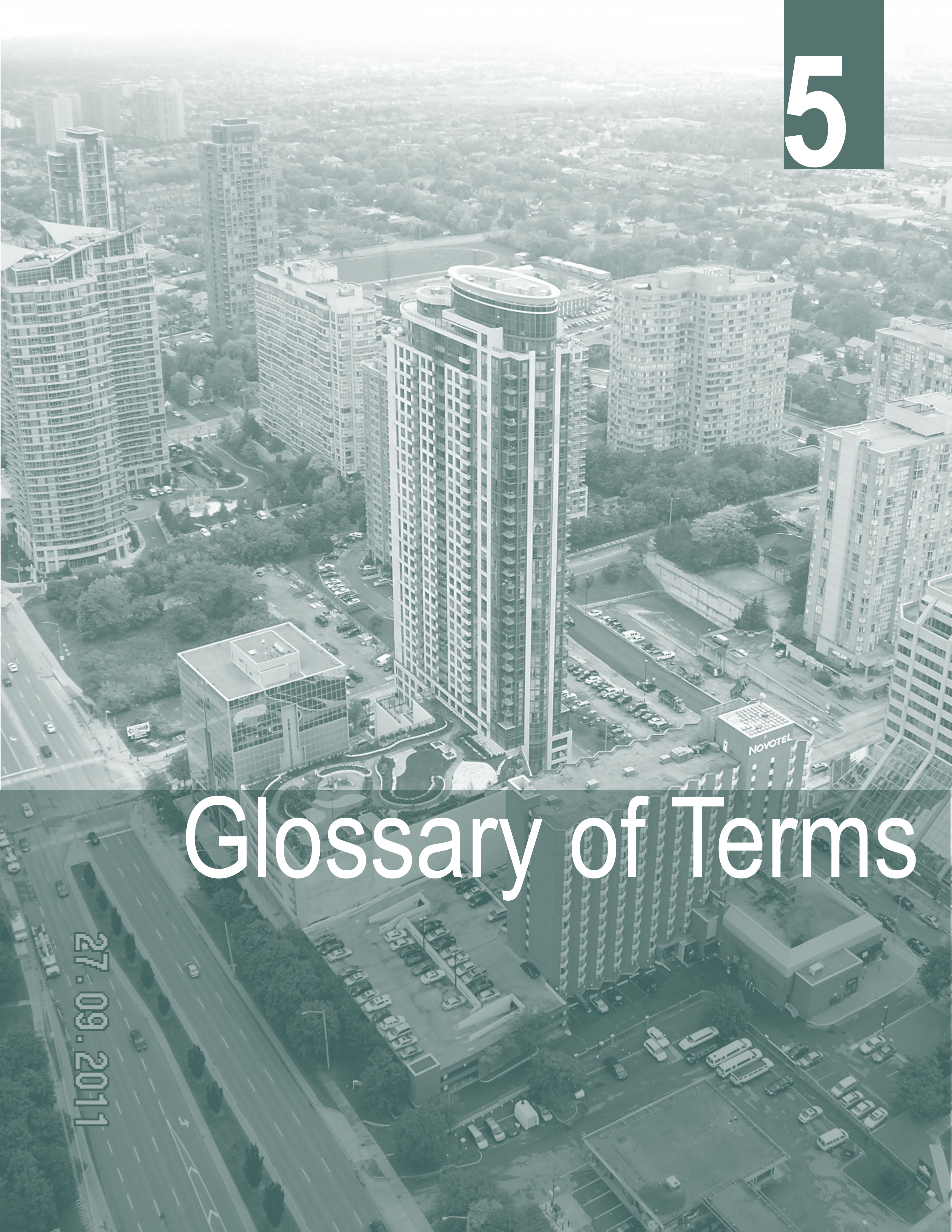
A colonnade on the windward face of a base building provides pedestrians with the option of a protected, calm walking area in the colonnade, or a breezy walk outside the colonnade.

4.3 Confirmation of Proper Implementation

Prior to Site Plan approval for any Building Permit clearance, the following clause shall be included on the Site Plan and all relevant drawings:

"The Microclimate Specialist shall confirm to the satisfaction of the Planning and Building Department that the 'as constructed' buildings and wind mitigation measures are in compliance with the recommendations of the Pedestrian Wind Comfort and Safety Studies"

Prior to the final site works inspection by the Planning and Building Department, the Microclimate Specialist shall issue a letter confirming that the wind mitigation measures have been installed in accordance with the recommendations of the Pedestrian Wind Comfort and Safety Study.



5

Glossary of Terms

5

Glossary of Terms

Colonnade
A row of evenly spaced columns supporting a roof, arches or an entablature.

Configurations
The selection and arrangement of buildings on a scale model for a wind tunnel test.

Downwind
In the direction in which the wind is blowing.

Exceedance
Beyond that which is allowed or stipulated by a set limit.

Leeward
On or towards the side that is sheltered from the wind.

Marcescent
Describes plants with leaves that wither, but remain attached to the stem without falling off.

Qualitative Assessment
Measured by its quality, rather than its quantity.

Quantitative Assessment
Measured by its quantity, rather than its quality.

Step back
The distance by which a tower or upper part of a base building is set back from the lower portion of the building (base building) on which it sits.

Upwind
Against the direction of the wind.

Windward
Facing the wind or on the side that is facing the wind.

City of Mississauga
Planning and Building Department, Development and Design Division
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MISSISSAUGA

Appendix D Ottawa wind rules

Terms of Reference: Wind Analysis, City of Ottawa, 2013

Description:

A wind analysis is a planning submission requirement, which provides a visual model and a written evaluation of how a proposed development will impact pedestrian-level wind conditions.

Preparation:

A wind analysis must be prepared, signed and stamped by an engineer who specializes in pedestrian level wind evaluation. Where a wind analysis is prepared by a company which do not have extensive experience in pedestrian level wind evaluation, an independent peer review may be required at the expense of the proponent.

When Required:

Wind studies are particularly important where a proposed development is adjacent to existing or planned low rise development, open spaces, water bodies and large public amenity areas. The requirement for and scope of a wind analysis will be determined at the formal pre-application consultation meeting. There are two types of wind studies and they will be triggered based on the following types of applications:

Type 1: Applications seeking an increase in height and/or massing which is either: a tall building(s), 10 storeys or more or a proposed building that is more than twice the height of adjacent existing buildings and is greater than five storeys in height.

Zoning Bylaw	Type 1: Preliminary Wind Analysis: will include Wind Tunnel Tests or Computational Fluid Dynamics testing to evaluate the proposed height and massing. The test will identify which areas of the site meet the City's wind evaluation criteria (as outlined on pg 4) and which areas do not. In preparation of the analysis, refer to the below "Contents for Wind Analysis".
Site Plan Control Application	Type 1: Secondary Wind Analysis: where a Preliminary Wind Analysis was submitted which exceeded the evaluation criteria or if design changes have occurred since the original submission - a Secondary Wind Analysis will be required with the Site Plan Control application. Where this applies, there are two types of Secondary Wind Studies: • *Desktop Assessment* – this applies if the design changes are minor (e.g. elimination or addition of site design measures, reduction in height, etc). • *Wind Tunnel Tests or Computational Fluid Dynamics* – this applies if the design changes are significant (e.g. increase in height, removal of a podium, building orientation change, etc). In both cases the analysis will require an overview of the final mitigation measures, which may require confirmation through the submission of a revised landscape plan, site plans and/or building elevations. A condition of Site Plan Approval will be placed to ensure that the recommendations of the Secondary Wind Analysis are fully implemented, prior to the City releasing any securities.

Type 2: Tall building applications which have not sought an increase in height or massing, and are: on the outer edge of a tall building area; or are taller than the existing development; or are immediately adjacent to a large public amenity area (e.g. park, open space, body of water, etc).

Site Plan Control Application	Type 2: Wind Analysis: will include a pedestrian level wind analysis to evaluate the building design. Detailed elements, such as anticipated building orientation, building and site design features, transitions and step backs will need to be incorporated into the evaluation. This test will identify which areas of the site meet the City's wind evaluation criteria (as outlined on pg 4) and which areas do not. In preparation of the analysis, refer to the below "Contents for Wind Analysis".

Contents for a Wind Analysis:

A wind analysis will contain and/or address the below contents for wind studies and analysis criteria. Failure to satisfy these components, may result in the application being considered incomplete.

Prior to the Application Submission:

- Where a wind tunnel test is to be completed, provide an image displaying the proposed "test locations" to the file planner for approval prior to the simulation (see *Figure 2 and 3*).

Example Pedestrian and Amenity Area Test Locations:

- Major building entrances
- Sidewalks (adjacent to the proposed building)
- Parking lots (adjacent to the proposed building)
- Public amenity spaces (e.g. parks, plazas, courtyards, trails, public pools, restaurant patios etc)
- Private amenity spaces (e.g. roof top patio's, green roofs, private pools)

The Application Submission:

- State the: type of application, municipal address and the company who has prepared the analysis.

Existing Context:

- Indicate the meteorological data used to confirm the wind conditions.
- Provide images which display the prevailing wind directions inset within the current site conditions for each required test date. Highlight the location of the proposed site (see *Figure* 3).

Effects of the Proposal:

- Provide an image which displays the existing and proposed pedestrian and amenity area(s) within the proposed development and immediate adjacent area(s). For wind tests only, inset within this image show where the final test locations were chosen (see *Figure 2 and 3*).
- Where a wind tunnel test was completed, provide the numerical findings at each sensor location on each test date. This will display the resulting wind conditions at each test location (e.g. prevailing wind directions and speeds) as a result of the proposed development.

Explanation:

- Provide a written summary of the wind impacts, which include the locations of the impact and type of wind sensitive use where the impact occurs for each test date.
- Detail the proposed mitigation measures included in the development proposal (if applicable).

Analysis Criteria:

The following wind analysis requirements outline the City's expectation for test dates and test locations.

Test Dates:

Consultants are required to use a minimum of 30 years of hourly wind data from the Ottawa International Airport on a four season basis (see *Figure 1*), as follows:

- Winter: December - February
- Spring: March - May
- Summer: June - August
- Fall: September - November

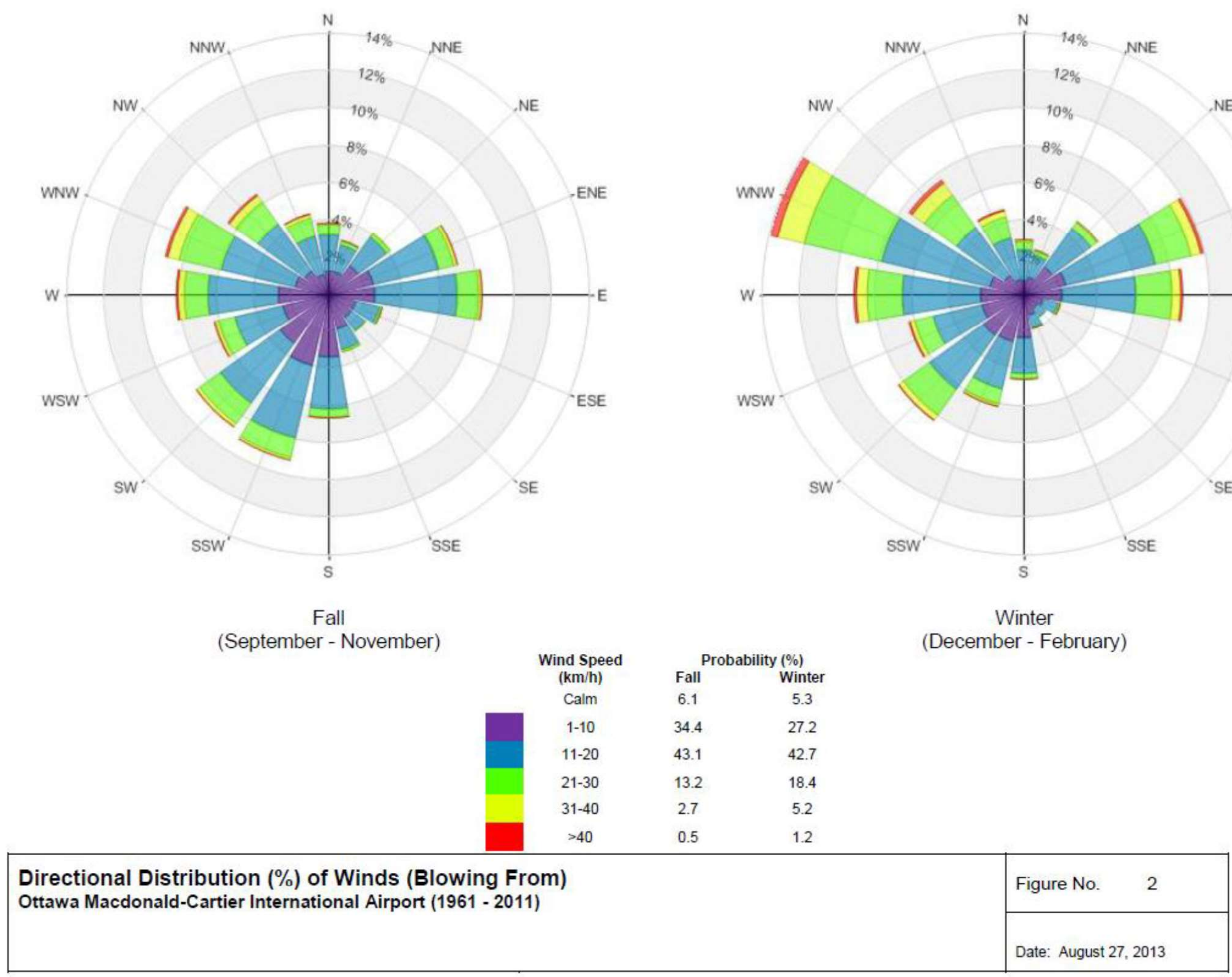


Figure 1 – Wind Data

Evaluation Criteria:

The following evaluation criteria will be used to evaluate wind speeds from the proposed development:

Wind Comfort Criteria:

Both mean wind and wind gusts will be used to measure the comfort of the wind at identified locations. There are four measuring points to evaluate the comfort of the wind speed: sitting, standing, strolling and walking. These measuring points are to be evaluated at different locations/areas on the development site and immediate adjacent area to ensure that they meet the criteria. Should a proposed development not be able to meet the comfort evaluation criteria, mitigation measures (e.g. building and / or site design measures) are required for Type 1 applications and strongly suggested for Type 2 applications.

Category	Speed (km/hr)	Where Applicable
Sitting	≤ 10	Outdoor public and private amenity spaces (e.g. restaurant patio's and seating areas)
Standing	≤ 14	Major building entrances and bus stops
Strolling	≤ 17	Sidewalks association with a mainstreet, plazas and parks
Walking	≤ 20	Sidewalks other than those associated with a mainstreet, bicycle paths and parking lots
Uncomfortable	≥ 20	Winds of this magnitude are considered a nuisance for most activities and wind mitigation measures are recommended.

NOTE: The speeds are based on a seasonal 20% exceedance factor (between 6:00am-11:00pm). In other words the criterion has been met if the wind speeds occur at least 80% of the time or four out of five days.

Wind Safety Criteria:

Wind gusts will be used to measure the safety of the wind on all test locations. Should a proposed development not be able to meet the wind safety criteria, appropriate mitigation measures (e.g. redesign of the site, reduction in height, etc.) will be required to eliminate the safety issue.

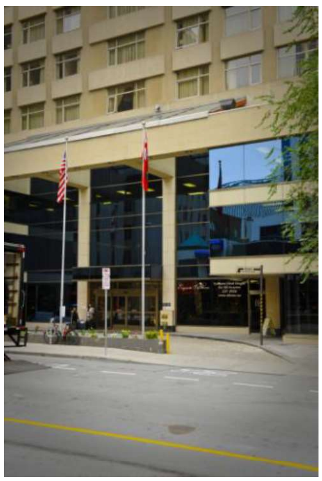
Category	Speed (km/hr)	Where Applicable
Exceeded	≥ 90	At any test location, wind speeds of this magnitude are considered a safety hazard and wind mitigation is required.

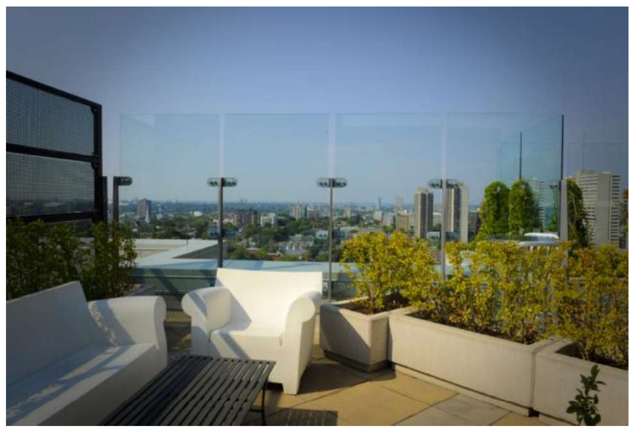
NOTE: The speeds are based on an annual exceedance of 9 hours or 0.1% of the time for a 24 hour day.

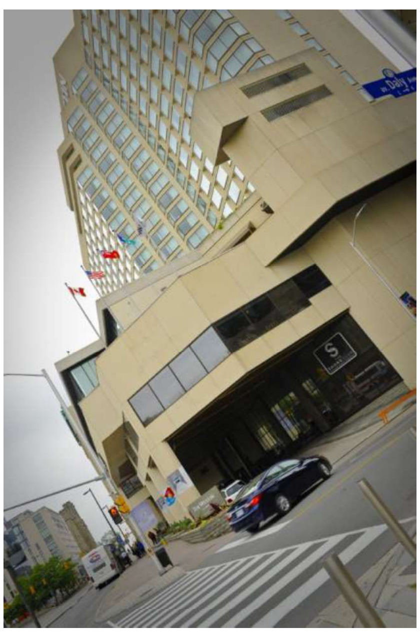
Mitigation Measures:

Building design measures can help to reduce the wind conditions that may be downwashed from buildings which are taller in height. Site design measures can help to reduce the wind conditions present at the pedestrian realm. The type and location of the mitigation measure will be determined through consultation with the development proponent and the file planner.

Building Design Measures:
- Podiums
- Balconies or terraces
- Stepped or transitioned building
- Canopies
- Parapet walls and wind screens
- Curved or stepped corners
- Entrances are away from corners
- Recess the entrance from the building façade and/or vestibules
- Overhangs



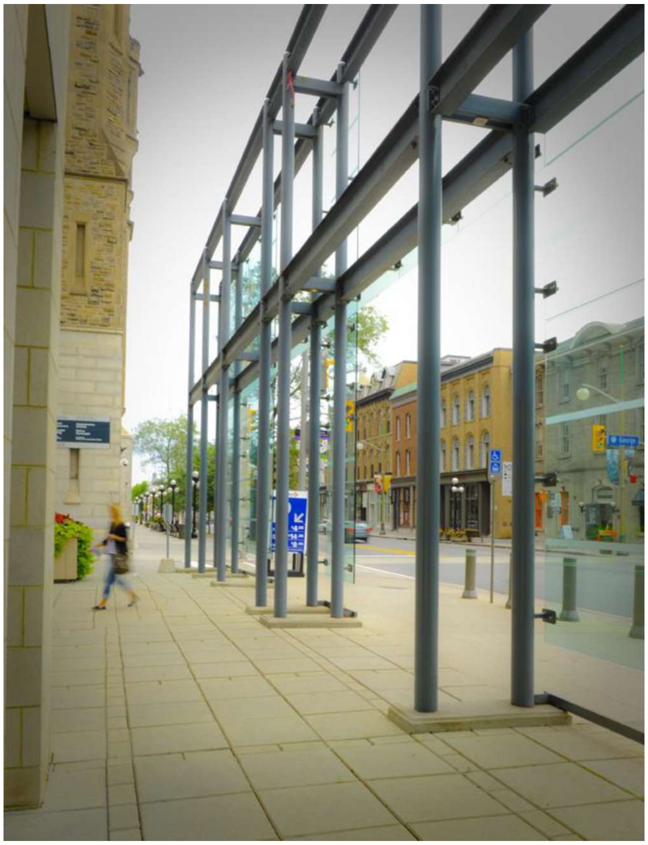


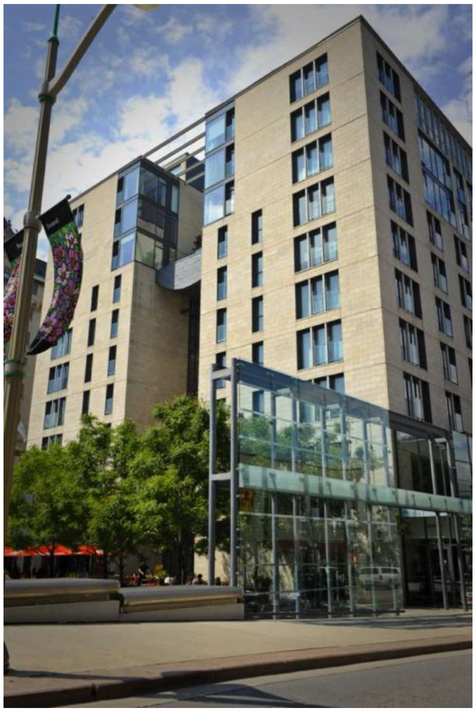


Mitigation Measures Continued:

Site Design Measures:

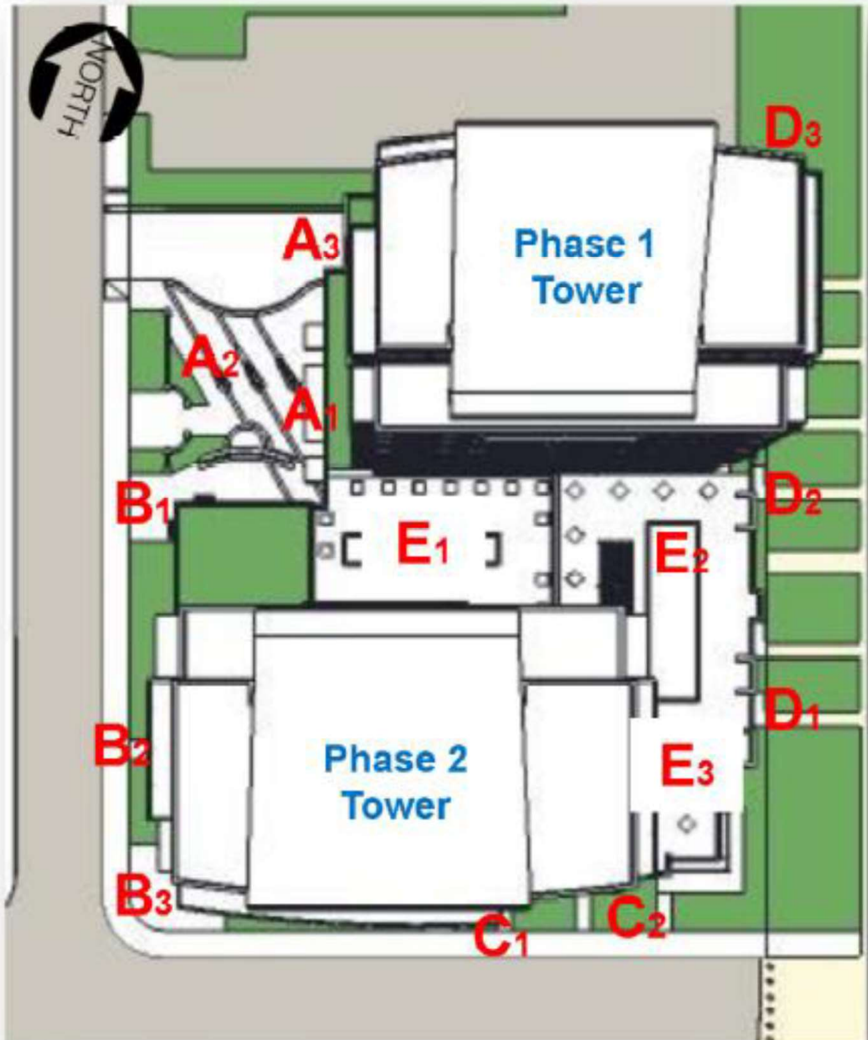
- Coniferous tree plantings near the corners of the buildings
- Landscape berms
- Large rocks
- Fences and retaining walls
- Tall obstacles (e.g. public art) at building corners in pedestrian realm
- Privacy walls and tall trellises





Submission: six hard copies and one digital copy of the wind analysis. A digital rendering (Sketch-up, AutoCAD, etc) of the proposed building(s) would also be preferred for submission; otherwise height schedules as outlined it the Shadow Analysis Terms of Reference is acceptable.

Figure 2 – Test Locations



A = PLAZA
B = SIDEWALKS
C = ENTRANCES
D = REAR YARDS
E = COMMON PEDESTRIAN AMENITY

Scale N.T.S.	August 15,2013	125 HICKORY STREET - PEDESTRIAN WIND STUDY
Test Date : Fall		FIGURE : 3
Application #		TEST LOCATIONS
Proposed Site		

Figure 3 –Surrounding Amenities Test Locations

OFF SITE MAJOR PEDESTRIAN AREAS
M1 = ROOF TOP TERRACE
M2 = ROOF TOP TERRACE
M3 = PARK
M4 = PEDESTRIAN BRIDGE

Scale N.T.S.	August 15,2013
Test Date : Fall	
Application #	

Proposed Site

125 HICKORY STREET - PEDESTRIAN WIND STUDY

FIGURE : 5
SITE LOCATION AND SURROUNDINGS
WITH WIND DIRECTIONS

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