The Strand Liverpool

Wind Microclimate Design Review
RWDI Project 1601774A
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SUBMITTED TO

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Contents

Introduction

Introduction

This report provides a qualitative review of the expected wind behaviour around the proposed The Strand, Liverpool development (referred to hereafter as the Proposed Development), with commentary on the potential impacts of the project on pedestrian comfort and safety. Mitigation measures and design alterations are suggested to help alleviate 'windy' conditions.

This review is based on:

- The architectural strategy '*LRW-7494-L(00)116 - Revised Architectural Strategy*' received by RWDI February 16, 2016;
- 3D Drawing '*7494 Strand Context Model*' received by RWDI March 02, 2016; and
- Plan drawings '*LRW-7494-L(00)03C - Ground Floor Plan*' and '*LRW-7494-L(00)124 - 18th Floor Plan*'.

Wind Climate

Wind Climate – London Wind Roses

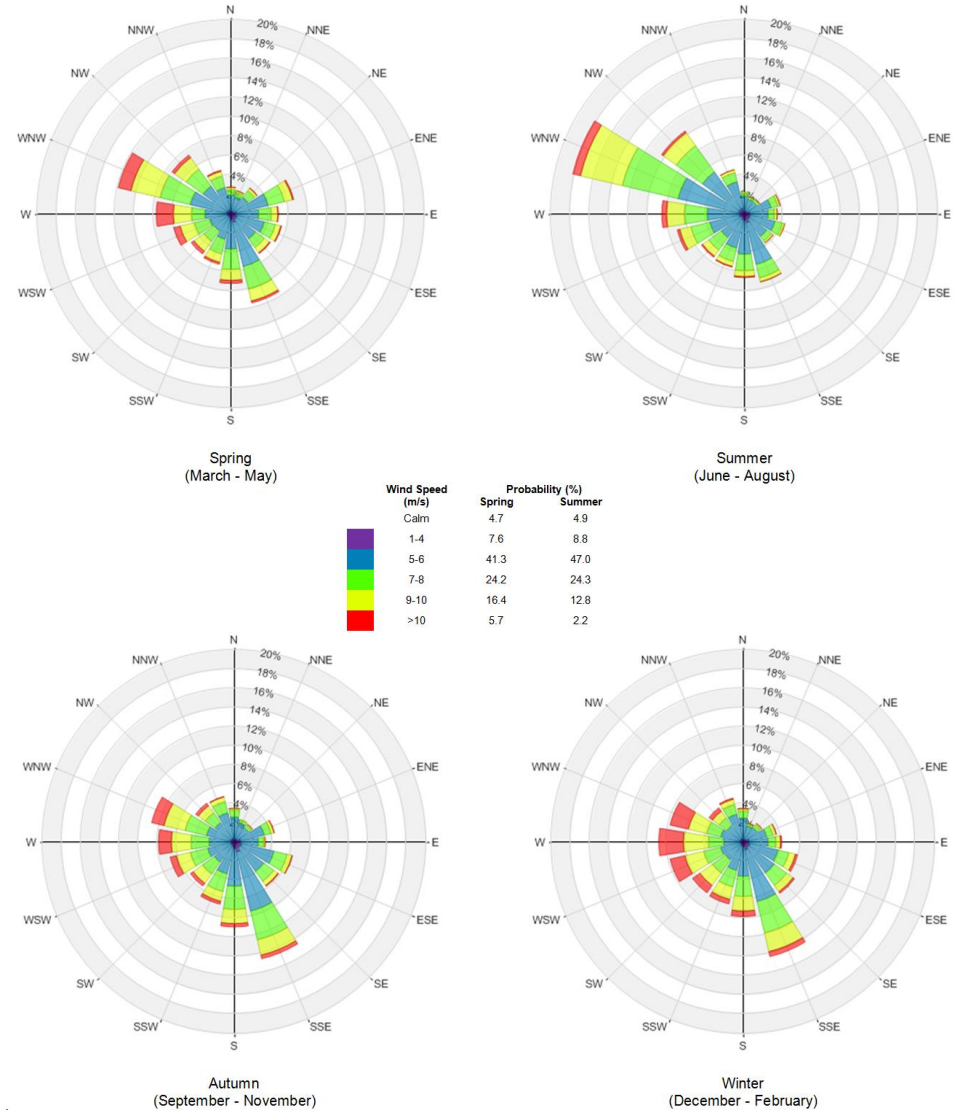
The figure to the right shows the seasonal wind roses (meteorological data) for the Liverpool area which are based on data from the Liverpool John Lennon Airport. 0° represents wind blowing from the north and 90° represents winds blowing from the east.

The prevailing winds blow from the Western quadrant (225° through to 315°) throughout the majority of the year, with the exception of winter where winds from the South-Eastern quadrant are more frequent (which is also a prevalent wind direction during the autumn). Although winds from the Western quadrant are less frequent during the winter these tend to be strongest recorded throughout the year.

The wind roses are presented for 'meteorological standard conditions' which is a height of 10m above ground level in open, countryside terrain.

The meteorological data will need to be adjusted to account for the terrain roughness surrounding the Site in order to reflect the urban exposure and account for the reduced wind speeds and additional turbulence that would occur in an urban area.

Liverpool Wind Roses



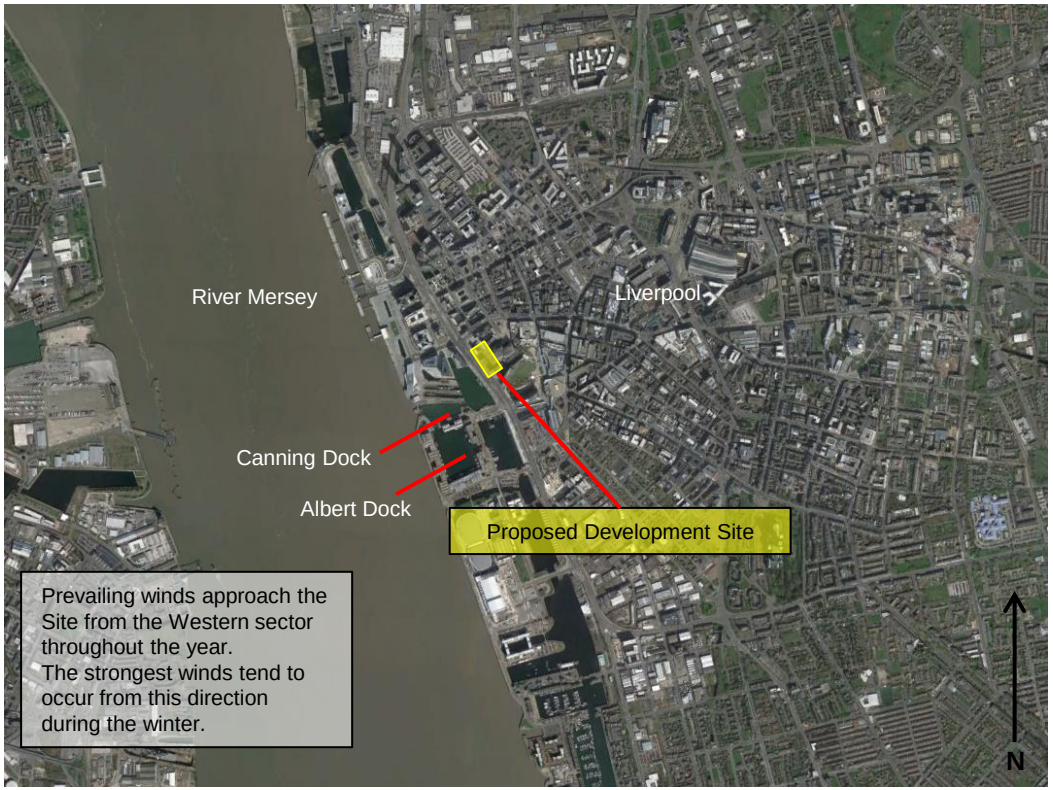
Wind Climate - Site Description

The terrain of the surrounding area, and in particular the presence of nearby large open spaces (such as the Albert Dock and River Mersey), will affect the local wind conditions at the Site.

The Proposed Development is located in Liverpool, and is bounded by Liverpool Crown Court to the North-East, 31 Strand Street to the South-East, Strand Street and Canning Dock to the South-West and Red Cross Street to the North-West.

The immediate surrounding area consists of a mixture of low to mid-rise suburban residential and commercial developments, with Canning Dock to the South-West and Albert Dock to the South, as shown in the Image to the right. As a result of these large areas of open water close to the Site winds can blow freely towards the Proposed Development from the Southern and South-West quadrants.

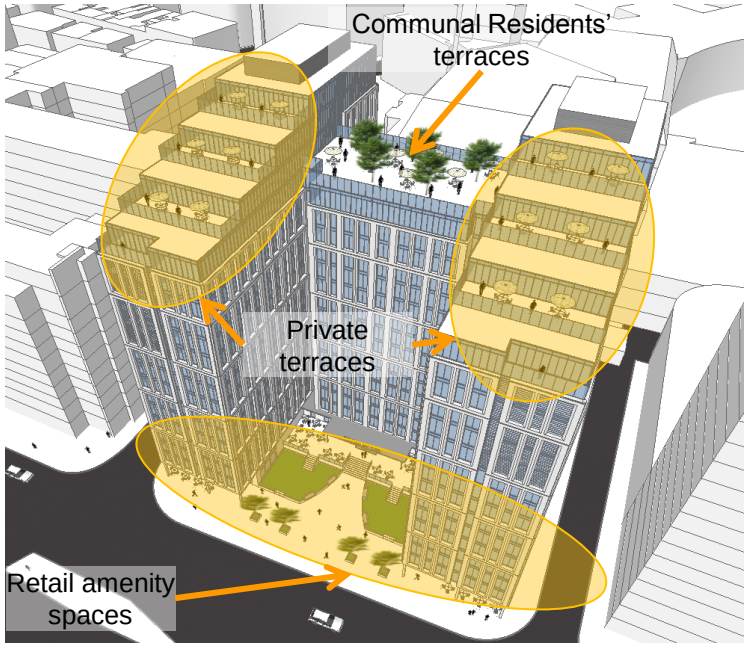
The River Mersey (which runs from the South-East direction to the North-North-West, to the West of the Site) leaves the Proposed Development relatively exposed to prevailing winds from the Western quadrant, which is expected to result in 'windy' conditions at the Site. The existing buildings to the West of the Site are expected to provide shelter to the Proposed Development, particularly from winds blowing from the Western quadrant, however the overall reduction in wind speed is expected to be minor and result in an increase in turbulent flow around the Site.



Wind Climate- Proposed Development

The figure below shows an isometric view of the Proposed Development, which will consist of an 18 storey high mixed-use tower, with private terraces provided at levels 15, 16, 17 and 18, and a communal residents' terrace at level 16.

The Western frontage of the Proposed Development provides retail spaces with exterior seating areas, with a private residents' terrace area provided to the East of the Proposed Development.



View from west-south-west

The Proposed Development is of a relatively similar height to the surrounding buildings with the exception of the more open space provided by the Canning Dock and Albert Dock to the South-West, which is likely to result in 'windy' conditions as a result of winds approaching from these directions (albeit infrequently when compared to the prevailing wind directions).

The recessed design of the main residents' entrance combined with the canopy extending from the façade over the entrance frontage is expected to reduce the effect of wind downdraughts from the façade. However as a result of the recessed design on the Western frontage, wind flows are expected to be directed through the retail amenity space (which is located on the Western Frontage). These flows may combine with downdraughts from the Western frontage and result in accelerated flows around the North-West and South-West corners of the Proposed Development (as shown in Image 1 below). This flow accelerated around the corners would then be channelled (as shown in Image 2) between the Proposed Development and neighbouring buildings.

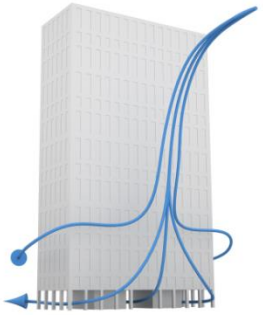


Image 1: Downdraught effect

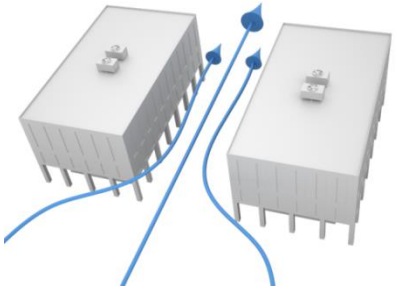


Image 2: Channelling

Wind Microclimate Criteria

Wind Microclimate Criteria - Target Wind Microclimate (Proposed Development)

Target wind conditions are based on a benchmark set of criteria (after Lawson, as described in Appendix A), which prescribe the wind speed and frequency of occurrence thresholds for a range of different pedestrian activities.

In an urban development the target wind microclimate would usually include sitting use, standing/entrance use and leisure walking use, as described below.

The **leisure walking use** conditions would represent the windiest conditions around the Site and would apply to main thoroughfares and are more likely to occur in the vicinity of building corners at ground level.

Standing/entrance use conditions would be required, even during the windiest season, at main entrances to buildings, pick-up/drop-off zones or meeting points.

The **sitting use** classification is usually applied to amenity spaces where there is café seating, benches or on roof terraces and balconies. However, we usually advise that, in the UK, this is the target during the summer season when these areas are *expected* to be usable.

If sitting conditions are achieved in the summer, the stronger winds which occur during the winter season typically produce a wind microclimate that is suitable for standing, unless there is specific additional shelter provided during the winter.

In addition to pedestrian comfort, the assessment will also address the potential for strong winds. This is based on Lawson's consideration that wind speeds in excess of Beaufort Force 6 had the potential to impede walking (as described in Appendix A).

Achieving the range of conditions outlined above usually means that the wind speed would not exceed Beaufort Force 7 or 8 on the windiest days of the year. The wind speed may exceed Beaufort Force 6, at isolated locations, but this would typically be for only a few hours per year, and could therefore be considered tolerable on a thoroughfare.

Wind Microclimate
Expected Wind Conditions

Wind Microclimate Expected Wind Conditions - Proposed Development

The following pages contain diagrams intended to illustrate the points discussed below.

The wind microclimate around both the existing Site and the Proposed Development is generated by complex interactions between the wind and the buildings. In the context of the existing surrounds, the Proposed Development is of similar size to its neighbours, which is potentially significant as winds from the directions of these buildings would be expected to have less of an impact of the ground level wind microclimate (as a result of the shelter provided).

The climate data for the Site and the proximity of large open areas (the Canning Dock, Albert Dock and the River Mersey) indicate that the Proposed Development will record 'windier' conditions than desired for the intended uses of the Site.

The primary wind issues are expected to be generated by prevailing winds from the Western sector (see Image 3, which provides an indicative view of the expected wind directionality through an overlay of meteorological data on a plan view of the Site, for winter in wind rose format), which are discussed later in this report.

Images 4-7 show that when the Proposed Development is in place, winds blowing across the Site at ground level will accelerate around the sides and become channelled around the base to the North and South of the Proposed Development.

A comprehensive landscaping scheme (including porous elements) is recommended to provide to entrances and seating areas within amenity spaces.

Entrances located in areas where significant channelling would occur (as shown in the following figures) would benefit from localised screening (which could include vertical porous or solid screens, or dense evergreen planting either side of the entranceway), which would create a 'buffer zone' for pedestrians moving from the calm interior into the relatively windy outdoor space.

Outdoor seating areas on the communal terrace would benefit from soft landscaping or localised screening (which could include shrubs in planters, planted trellises, solid or perforated screens/windbreaks), specifically placed to the West side of the seating areas to provide localised shelter and direct wind flows over the terrace.

The design of the private terraces should include balustrade heights which are of a similar height to the corresponding apartment floor to ceiling height to reduce the ingress of wind flows from the North-West and South.

Wind Microclimate Expected Wind Conditions - Proposed Development cont'd

Image 3 shows the annual meteorological data overlaid onto a plan view of the Site. This identifies that the prevailing wind directions are from the Western (with strong winds) and South-Eastern quadrants (winds from this quadrant are less likely to significantly affect the Site as shelter is provided by the neighbouring building).

Although infrequent, winds from the Southern quadrant are expected to result in an area of turbulent flow around the main residential entrance (as shown in Image 4). However, the canopy over the main entrance would be expected to provide some shelter for users to transit through this turbulent area.

Wind flows redirected from this area of turbulent flow are expected to drawn around the Proposed Development resulting in 'windy' conditions along the Western frontage.

This redirection of flow is expected to result in the retail amenity spaces recording 'windier' conditions than the desired sitting use (albeit as infrequent gust events, when this is a result of winds from the South quadrant). These accelerated wind flows are expected to be most notable around the North-West corner of the Site, as wind flows are channelled between the Proposed Development and neighbouring buildings.

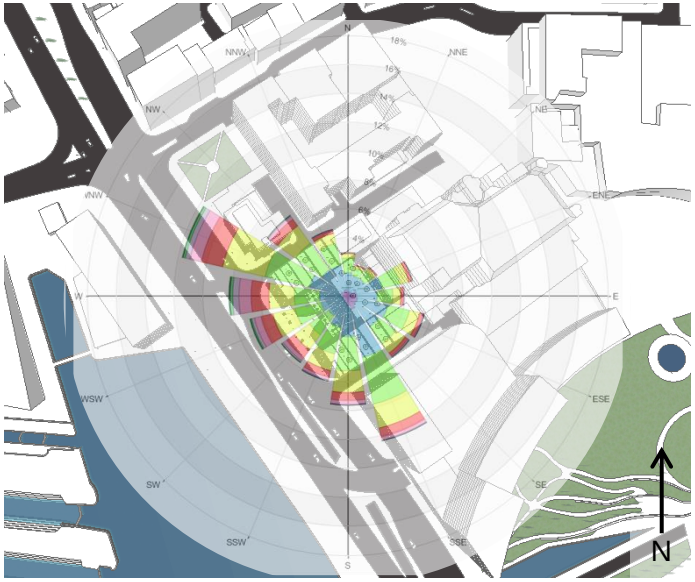


Image 3: Plan view showing winter wind rose overlay

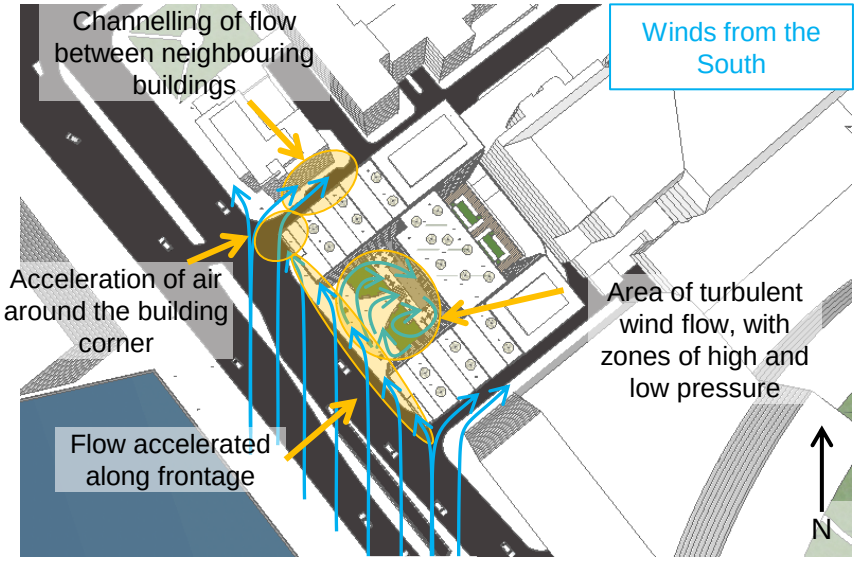


Image 4: Plan view with expected wind flow from the South

Wind Microclimate Expected Wind Conditions - Proposed Development cont'd

As with winds from the South, winds from the North-West sector are expected to generate high and low pressure zones within the area in front of the main residents entrance. This pressure difference is expected to result in wind flow being redirected along the Western frontage and around the corners of the Proposed Development (as shown in Image 5), with 'windy' conditions expected on thoroughfares and in the retail amenity areas.

As previously noted the surrounding buildings to the North-West would be expected to provide some shelter to the Site, but would increase turbulent flow around the Proposed Development.

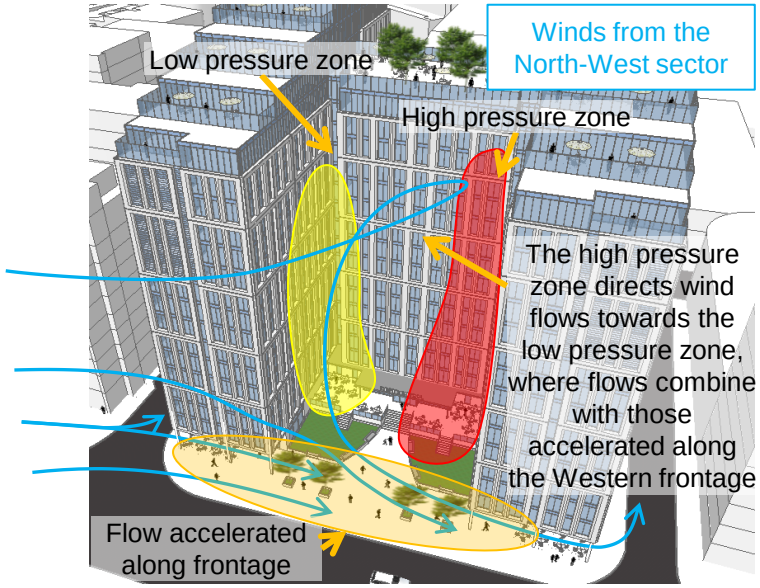


Image 5: Expected wind flow from the North-West sector

As previously discussed, the courtyard area outside of the main residential entrance is expected to record turbulent conditions as a result of the high and low pressure zones, with beneficial shelter provided by the canopy over the main residential entrance (which would provide a 'buffer' zone between the 'calm' interior and relatively 'windy' exterior conditions).

It is likely that the private residents' terrace to the East of the Site will be in a low pressure bubble (as a result of wind flows around the Proposed Development, as shown in Image 6), which may result in 'windy' conditions at the North-East and South-East corners of the Site, as air is drawn into this area of low pressure.

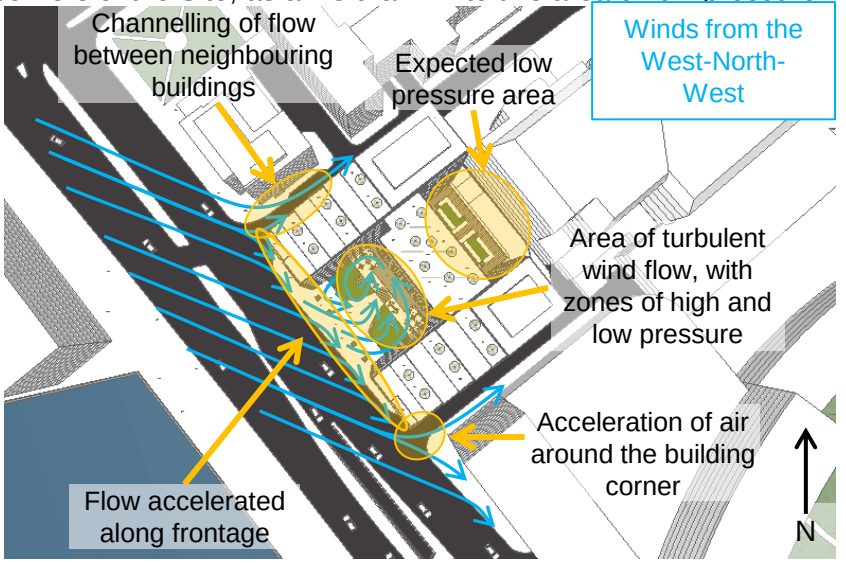


Image 6: Plan view with expected wind flow from the North-West

Wind Microclimate Expected Wind Conditions - Proposed Development cont'd

Wind flows from the South-West (whilst being infrequent) are expected to result in a high pressure area within the recess of the Proposed Development (as shown in Image 7 and Image 8). As a result of this high pressure some wind flows from the West would be directed towards the communal terrace, with the rest of this flow diverted towards ground level (which would combine with flow accelerated along the Western frontage).

This corner acceleration combined with wind channelling is expected to result in 'windy' conditions between the Proposed Development and neighbouring buildings, particularly to the South of the Proposed Development (as shown in Image 7).

As a result of the high pressure to the West of the Site (as shown in Image 8) and accelerated wind flows around the Proposed Development it is expected that the East of the development (represented by the private residents terrace) is expected to be in a low pressure zone, which as previously describe may result in 'windy' conditions around the North-East and South-East corners at ground level into this low pressure area.

It is noted that whilst less frequent than wind from the prevailing directions, winds from the South-West sector are expected to be significant due to the open spaces where winds can flow unimpeded towards the Proposed Development.

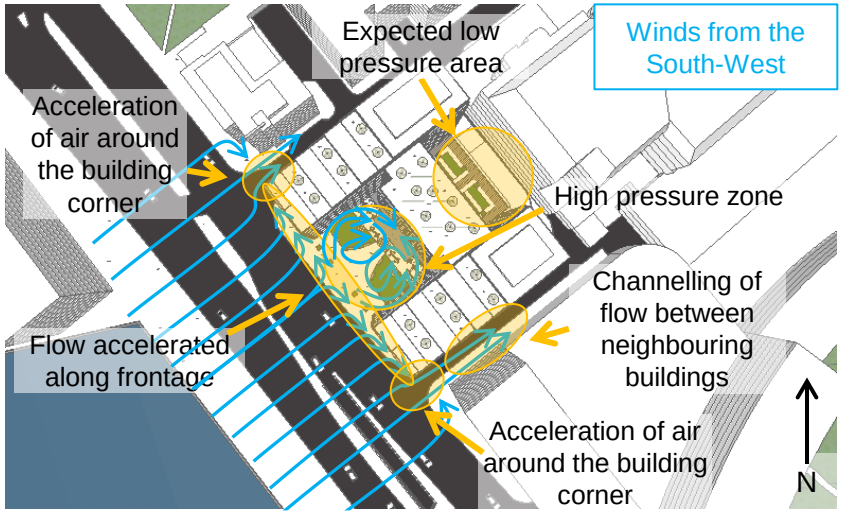


Image 7: Plan view with expected wind flow from the South-West

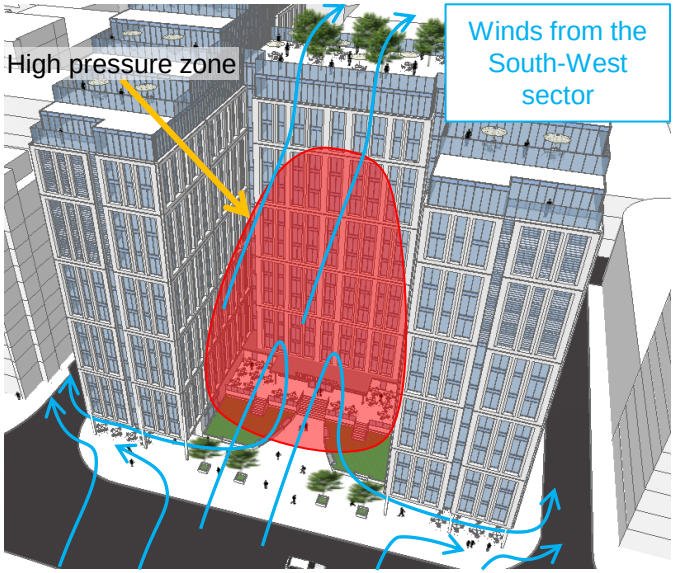


Image 8: Expected wind flow from the North-West sector

Wind Microclimate Expected Wind Conditions - Proposed Development cont'd

Winds blowing from the Western sector are expected to be channelled between the two raised sections and over the communal residential terrace (as shown in Image 9). As a result of this compression wind conditions on the residential terrace may be 'windier' than the desired sitting use, during the summer season (with occurrences of strong winds likely during the windiest season).

Winds flows (from the Western sector) around the Proposed Development, particular over the communal residents terrace are expected to generate a low pressure zone within the private residents terrace at ground level. This could be exacerbated by the recessing of the Eastern frontage, resulting in ground level wind flows being drawn into this amenity area.

Wind flows from the Western sector are generally expected to accelerate over the private terraces, as a result of the stepped design (as shown in Image 9). The height of the balustrades on the private terraces is expected to be the most important factor in reducing occurrences of 'windier' conditions than desired for amenity use (classified as sitting use, during the summer season) on these terraces, which may result from wind impacting the 'back wall' resulting in down draughts into the terraces (albeit infrequently as winds likely to cause down draughts would occur from uncommon wind directions).

Recommendations to provide shelter to occupants of terraces are discussed later in this report.

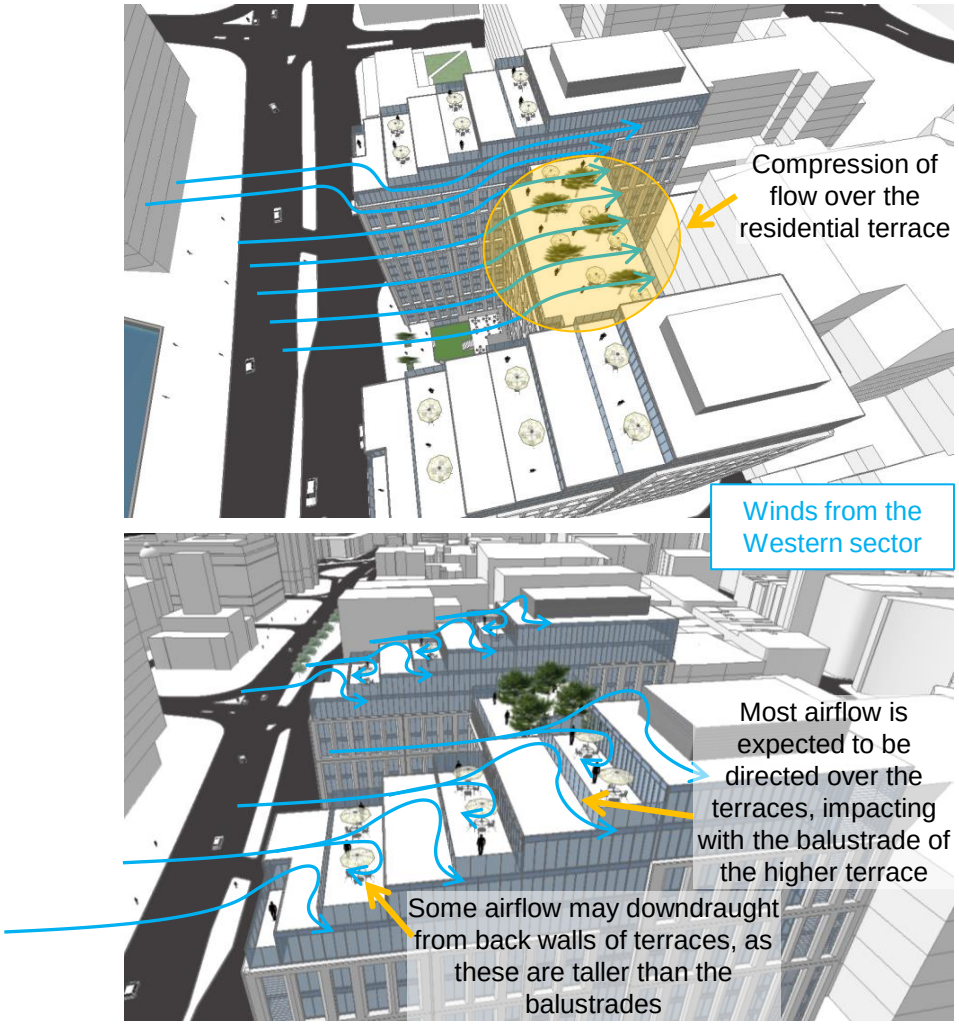


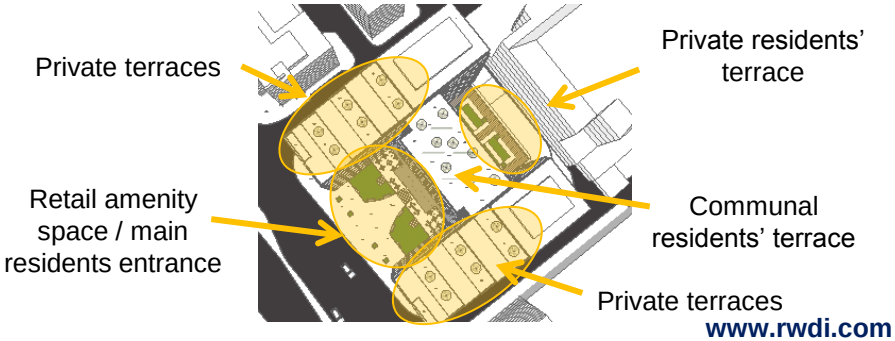
Image 9: Wind flow from the Western sector (view from the South West)

Conclusion

Conclusion

This report has identified the likely wind microclimate effects on the Proposed Development, based on an analysis of the "background" windiness of the Site, and a review of the likely interactions between the wind and the building massing. The following is a summary of the key points described in the report:

- The meteorological data for the Site indicate prevailing winds blow from the Western sector throughout the year, with the strongest winds occurring from the West during winter. Winds from other directions occur less frequently and are not typically associated with occurrences of strong winds.
- When the Proposed Development is built, it is expected that windy conditions will be induced by the wind downdraughts from the Western frontage accelerating the air flow between the Proposed Development and surrounding buildings. This acceleration is expected to generate windier conditions than desired for thoroughfare use (classified as acceptable for leisure walking).
- Prevailing winds from the Western sector are expected to result in a turbulent zone in front of the main residential entrance, with air flow expected to be directed under the colonnade when winds blow from the West-North-West and South-Westerly directions.
- Wind flows from the North-West and South-West sectors are expected to result in 'windier' conditions than desired on the private terraces, as wind flows are expected to accelerate along the 'back wall' of these terraces.
- Winds flows around the Proposed Development are expected to generate a low pressure zone within the ground level private residents terrace, resulting in ground level wind flows being drawn into this amenity area.
- Winds blowing from the Western sector are expected to be channelled over the communal residential terrace, which would be expected to record 'windier' conditions than the desired sitting use, during the summer season.
- This report provides examples of possible mitigation schemes. However, the illustrations provided are not intended to be an exact presentation and are merely to show the types of mitigation that may be required, with the exact configuration and type of mitigation open to some discussion.



Recommendations

Recommendations

The recommendation provided in this section are examples of possible mitigation schemes. However, the illustrations provided are not intended to be an exact presentation and are merely to show the types of mitigation that may be required, with the exact configuration and type of mitigation open to some discussion.

Image 10 shows possible locations for porous elements or landscaping. The recommended locations for landscaping are mainly to the North, West and South of the Site to provide shelter to the thoroughfares around the Site. Landscaping could include screens, which can be solid or porous and vary in design.

It is recommended that balustrades around ground level amenity areas are at least 1.5m in height, or are provided shelter through porous screening in the location shown in Image 10.

An examples of how 'green' porous trellises are used to provide shelter to an entrance is shown in Image 11, which act to diffuse the wind through the porous mesh during the winter and plant growth in the summer could provide additional shelter to seating areas.

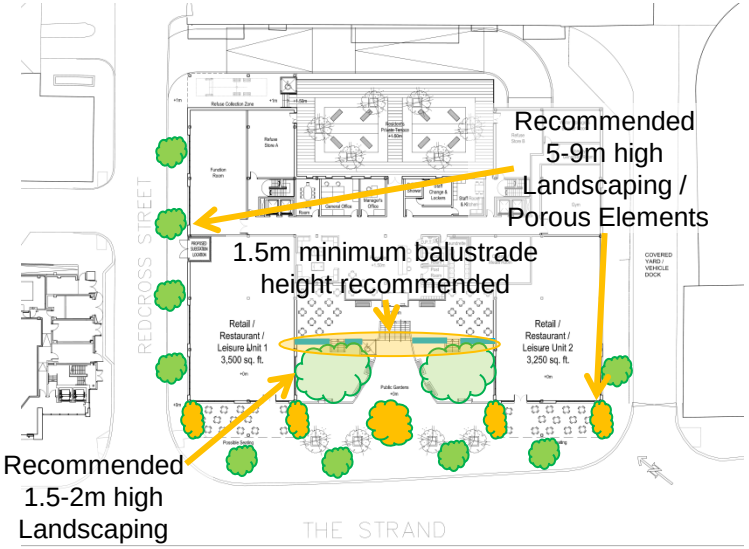


Image 10: Recommended Ground level mitigation

Image 11: Porous trellises used as screening

Recommendations cont'd

It is recommended that balustrades on the communal residents' terrace are solid / glazed and at least 2m in height, to provide localised shelter to occupants. It is noted that the 3D model reviewed by RWDI included possible locations for landscaping (as shown in Image 12), and it is recommended that this is expanded on to include dense evergreen planting or porous elements at least 1.5m in height (which would be expected to reduce the amount of wind ingress into the terrace).

The entrances onto the communal terrace may require localised screening or recessing to provide a 'buffer' zone between the 'calm' interior and comparatively 'windy' exterior conditions.

The stepped design of the private terraces is expected to provide significant shelter to occupants, although it is noted that the height of balustrades should be of a similar height to the corresponding apartment floor to ceiling height (or at least 2m in height) to reduce the 'entrapment' and encourage 'skipping' (as shown in Image 13 and 14 respectively) of wind flows from the North-West and South at these terraces.

Although 'windy' locations expected to require mitigation are limited it is recommended that wind tunnel testing is used to quantify the extent of these conditions (as the climate and location of the Site is expected to result in occurrences of strong winds). Dependent on the severity of wind conditions identified further wind tunnel tests may be required to refine an appropriate mitigation scheme where required.

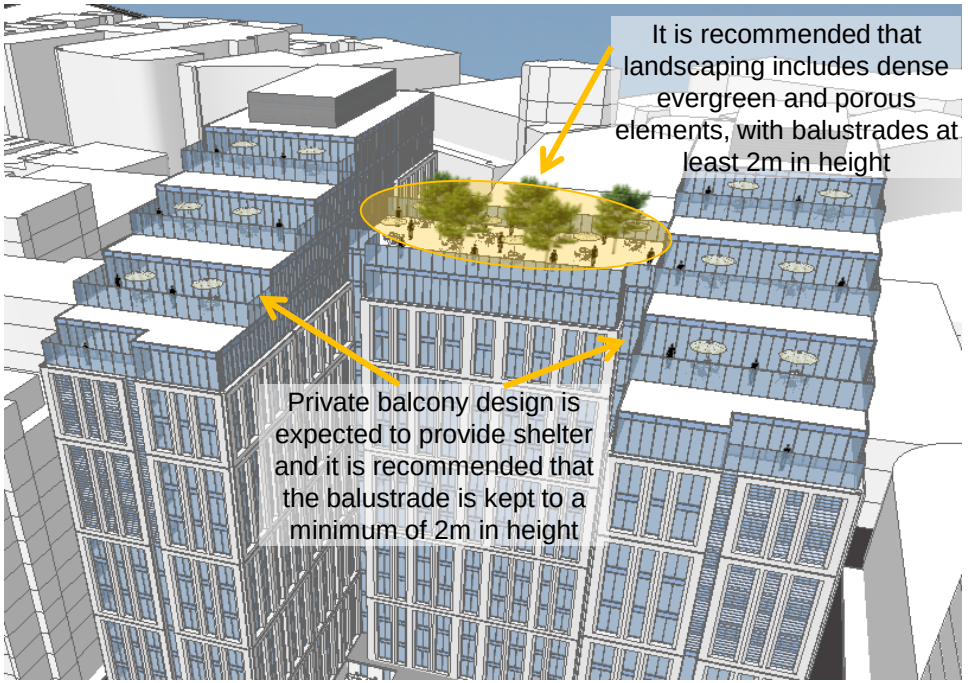


Image 12: Recommended terrace level mitigation

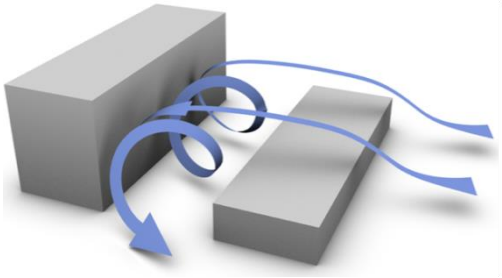


Image 13: Air entrapment

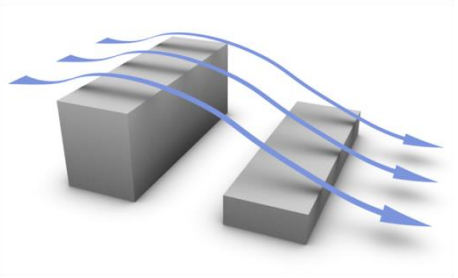


Image 14: Skipping

Appendix

Appendix A - Wind Microclimate Criteria - Lawson Comfort Criteria

There is a benchmark set of criteria (after Lawson[1]) which have been used extensively to 'quantify' the wind microclimate in the built environment.

The criteria prescribe the wind speed and frequency of occurrence thresholds for a range of different pedestrian activities. These thresholds are defined (as shown in Table 1 to the right) for sitting, standing, entering a building, leisure walking, business walking and crossing the road.

The criteria make use of the Beaufort Land Scale (as shown in Table 2) to define the wind speed. For example, if the wind speed exceeds Beaufort Force 3 (B3) for more than 6% of the time then conditions would be unsuitable for standing.

The criteria reflect our common experience that to sit comfortably outside a café requires lower wind speeds than crossing the street, for example.

Description	Threshold	Suitable Activity
Roads and Car Parks	6% > B5	open areas where pedestrians are not expected to linger
Business Walking	2% > B5	'purposeful' walking or where, in a business district, pedestrians may be more tolerant of the wind because their presence on Site is required for work
Leisure Walking	4% > B4	strolling
Pedestrian Standing	6% > B3	waiting at bus-stops, window shopping etc.
Entrance Doors	6% > B3	pedestrians entering/leaving a building
Sitting	1% > B3	long-term sitting, for example, sitting outside a café

Table 1: *Lawson Comfort Criteria*

[1]*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.*

Appendix A - Wind Microclimate Criteria - Lawson Safety Criteria

In addition to pedestrian comfort, the assessment will also address the potential for strong winds.

Lawson considered that wind speeds in excess of Beaufort Force 6 had the potential to impede walking. If such wind speeds occur then consideration should be given to the likelihood of people being at that location on the windiest days of the year.

For an urban development, wind speeds in excess of Beaufort Force 7 and 8 would require mitigation, as winds of this magnitude have implications for pedestrian safety. Wind speeds in excess of Beaufort Force 6 may be acceptable at some street locations.

Beaufort Force	Hours Average Wind Speed (m/s)	Description of Wind	Noticeable Wind Effect
0	< 0.45	Calm	Smoke rises vertically.
1	0.45 – 1.55	Light Air	Direction shown by smoke drift but not by vanes.
2	1.55 – 3.35	Gentle Breeze	Wind felt on face; leaves rustle; wind vane moves.
3	3.35 – 5.60	Light Breeze	Leaves & twigs in motion; wind extends a flag.
4	5.60 – 8.25	Moderate Breeze	Raises dust and loose paper; small branches move.
5	8.25 – 10.95	Fresh Breeze	Small trees, in leaf, sway.
6	10.95 – 14.10	Strong Breeze	Large branches begin to move; telephone wires whistle.
7	14.10 – 17.20	Near Gale	Whole trees in motion.
8	17.20 – 20.80	Gale	Twigs break off; personal progress impeded.
9	20.80 – 24.35	Strong Gale	Slight structural damage; chimney pots removed.
10	24.35 – 28.40	Storm	Trees uprooted; considerable structural damage.
11	28.40 – 32.40	Violent Storm	Damage is widespread; unusual in the U.K.
12	> 32.40	Hurricane	Countryside is devastated; only occurs in tropical countries.

Table 2: *Beaufort Land Scale*