Abbey Road Area Regeneration

Wind Assessment

London Borough of Camden

8th October 2013

ATKINS

Plan Design Enable

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Executive summary

This technical note presents a "desk study" assessment of the pedestrian wind comfort at various locations of the proposed Abbey Road development.

The objective of this study is to review and assess the impact of the proposed buildings on the local wind microclimate. A semi-quantitative approach is used to estimate the frequency of wind speeds without (ambient) and with the proposed buildings in place, and to assess whether these frequencies satisfy pedestrian comfort criteria. The Lawson criteria are used as the basis for this assessment since these are considered to represent best practice by UK local authorities.

This desk study analysis can thus be broken down into three main steps:

1. Estimate the ambient conditions at the site using wind statistics from a nearby meteorological station.

2. Identify the likely wind flow patterns around the buildings. Wind sheltering or wind acceleration factors (speed up factors) are estimated at a number of chosen locations based on prior experience.

3. Calculate the wind speed frequencies at each location by combining the ambient wind frequencies and estimated “speed-up” factors. These are compared against Lawson’s criteria, taking into account people’s activities around the buildings.

The site is positioned on Abbey Road in North West London, centred on the Abbey road / Belsize Road intersection. The regeneration project includes around 250-300 new homes, a new community centre and health centre as well as shops, commercial facilities and office space. These will be housed in multiple new buildings, the most notable of which is the 14 storey tall Landmark building on the South side of the Abbey road / Belsize road intersection. A 5 storey block comes off of the South West of this, running between Belsize road and the train tracks. A 5/6 storey curved building takes up most of the section West of intersection with a row of small houses behind. Low rise buildings are also being introduced around the base of the existing tall buildings North of the intersection (Casterbridge building and Snowman house, 21 storeys high).

As discussed in Section 6, the proposed development results in a wind environment that meets the Lawson comfort criteria for the intended use for virtually all areas considered. The safety criteria are also met throughout. Compared to the ambient, the new development does not increase the impact on the wind environment significantly, since it results in a maximum change of only one Lawson wind category from ambient conditions for all locations considered. In the majority of cases, there is no change from ambient conditions, and any change from ambient can be attributed to the existing buildings (Casterbridge and Snowman house) rather than the new construction.

Given that the impact of the new development is expected to be minor (at most one-category difference in the wind classification in the Lawson Scale) and that conditions meet the ‘tolerable’ Lawson criteria for the intended use at each location, mitigation would not normally be required. Nonetheless, for completeness, Section 6, provides suggestions on mitigation measures that could be used if it is required to e.g. improve the comfort level to ‘Comfortable’ for long term sitting, for locations 4 and 8.

Section 6.6 describes the conditions within Location 6 (mews houses) and concludes that no additional mitigation is required in this region. However if improved conditions are desired, scattered tree planting within the mews courtyard will have a beneficial effect.

The effect of the new tall Landmark building on the local wind environment is not expected to be significant, especially given the orientation of its narrowest side relative to the prevailing wind, and the sheltering effect of buildings located upwind. The presence of the two pre-existing (‘baseline’) tall buildings has an effect on the wind environment, however this is acceptable at the locations considered, and the planned addition of the Phase 2 pedestal buildings (including community centre, health centre and covered court yard) will likely have a mitigating effect on the wind environment in the area between the two tall buildings.

It is also worth noting that this is a probabilistic study using annual wind data. Consideration is not given to the usage of these areas, which are expected to have a higher frequency of use in the summer months when conditions are more favourable to the winter months. This approach adds to the conservatism inherent in the predictions made herein.

1. Introduction

The scope of a wind microclimate study is to assess the wind flow conditions around buildings and their impact on pedestrian comfort and safety. A financial or amenity loss could result from people avoiding windy areas, and in the most extreme cases, people can be blown over by the wind, causing injury or even loss of life.

Any new construction will have an effect on the local wind environment. This can reduce wind speeds (sheltering) as well as increase them (localised speed-up). These effects will vary across a site depending upon the layout and massing of buildings and the characteristics of the surrounding site, and will be a function of wind direction. Tall buildings in particular are a major cause of wind problems at pedestrian level. Wind speed increases with height above the ground, and tall buildings cause faster moving flow at height to become deflected down to pedestrian level.

Unlike other wind effects, such as wind loading or pollutant dispersal, there are no national codes, standards or statutory requirements in the UK for pedestrian wind comfort. However, most regional or local planning policies include some requirements for wind microclimate. For example, in the London Plan, Policy 7.6: Architecture states that buildings should "not cause unacceptable harm to the amenity of surrounding land and buildings, particularly residential buildings, in relation to privacy, overshadowing, wind and microclimate. This is particularly important for tall buildings". Policy 7.7: Location and design of tall and large buildings states that tall buildings should not "affect adversely their surroundings in terms of microclimate, wind turbulence..."

Nonetheless, there are established criteria for assessing the comfort and safety of pedestrians, as discussed in BRE Digest DG520 (1). In the UK, most wind comfort assessments use the Lawson criteria since these are considered to represent good environmental practice and are widely accepted as appropriate methodology by UK local authorities. According to the Lawson criteria, the wind speed is considered as the main parameter for assessing pedestrian comfort. The acceptable wind speed thresholds vary with the type of pedestrian activity in each area around a building – stricter criteria apply in situations where people sit outside for a prolonged period of time (e.g. outdoor cafés) and the Lawson criteria use a range of categories to make this distinction.

An assessment based on the Lawson criteria requires the frequency of exceedence of each of the relevant wind speed thresholds to be calculated. This requires a combination of wind statistics for the site (typically based on data from a nearby Meteorological station) and a quantification of the localised sheltering and/or speed-up around the proposed buildings at chosen locations of interest. The latter is most reliably done with wind tunnel testing or Computational Fluid Dynamics (CFD) modelling. However, a simpler "desk study" approach can be used as a first step to estimate the speed up factors and to assess the impact of the buildings. If effects are judged to be significantly adverse and/or cannot be addressed with simple mitigation measures, then a more detailed wind tunnel study may be warranted.

The objective of this study has been to review and assess the impact of the proposed buildings on the local wind microclimate, using a "desk study" approach.

2. Description of the Site

The site is located on Abbey Road in North West London, centred on the Abbey road / Belsize Road intersection as shown in Figure 2.1. The existing buildings be seen in Figure 2.2 and include a large multi storey car park running along the South side of Belsize road (next to the railway line), with the Community Centre, the Hinstock building and the Emminster building on the North side of Belsize Road (South of Abbey road). Snowman House and the Casterbridge building are also included in the regeneration area; these are located on the Northern side of Belsize and Abbey Road.

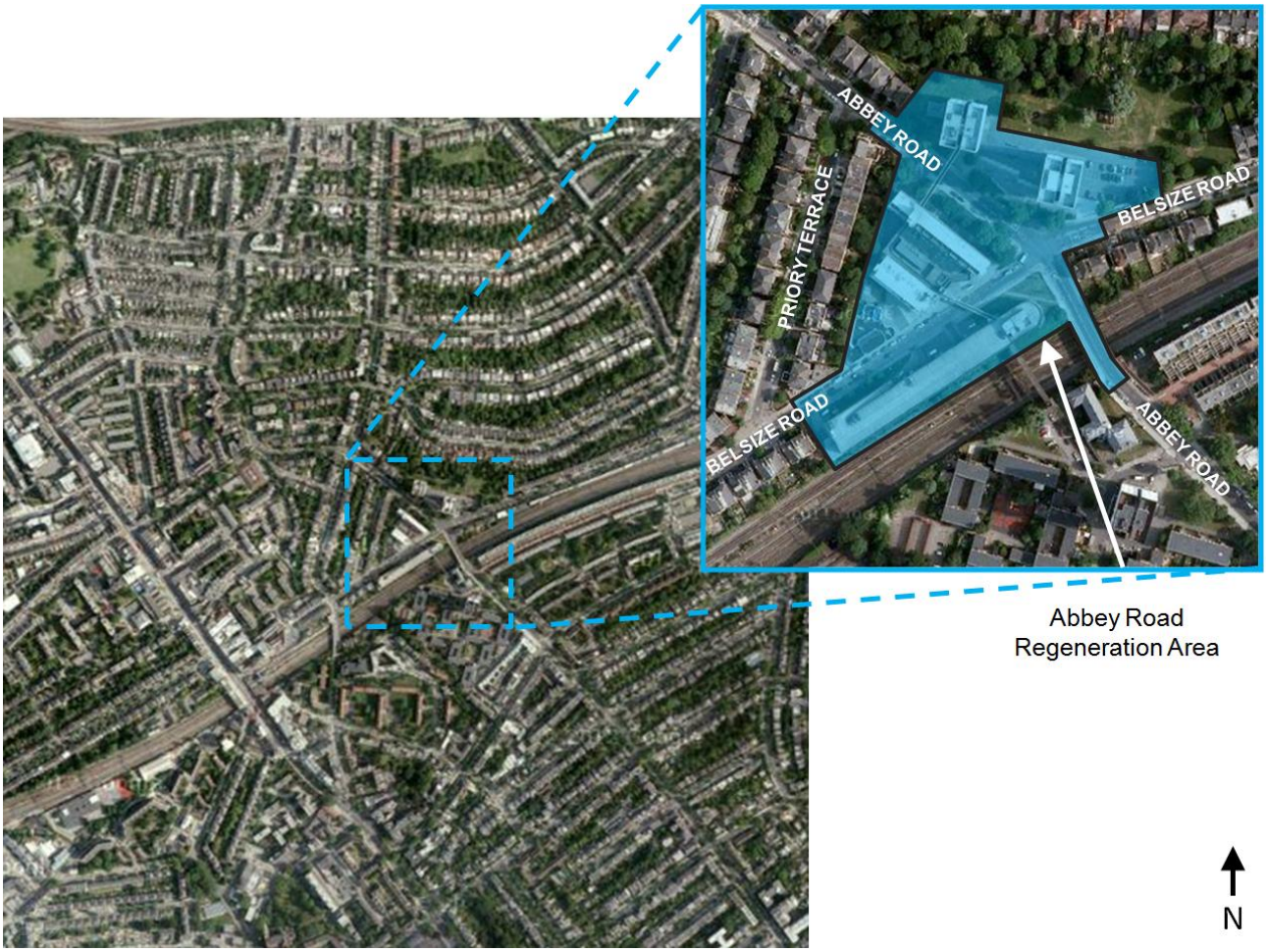

Figure 2.1 Proposed Abbey Road regeneration location.

Figure 2.2 Abbey road regeneration site, existing buildings to be removed shown in purple.

The proposed development/regeneration comprises of three Phases:

Phase 1

- Removal of the 5 storey multi-storey car park on the South side of Belsize road, West of Abbey road.
- Construction of a 150m long, 6 storey high (predominantly) residential block (with some space for retail) in its place. This runs South West in between Belsize road and the railway line.
- Construction of 'The Landmark building' (a 14 storey rhomboid tower) at the East end of this block (Abbey road / Belsize road intersection) with basement. This is the tallest new building in the regeneration project (~42m), with only the Casterbridge building and Snowman house being taller (~63m).

Phase 2

- Minor works to the site North East of the Abbey road / Belsize road intersection.
- New community centre and health centre built around the base of Snowman house and the Casterbridge building respectively. The existing buildings are 21 storeys tall, with the proposed development being ½ storeys.
- Covered courtyard within the 1 storey building in between Snowman house and Casterbridge building. This area is fully enclosed with double doors on either end.

Phase 3

- Removal of the Community Centre, the 4 storey tall residential 'Hinstock building' and the 8 storey residential 'Emmister building'. These are both orientated North-South.
- Construction of a new (predominantly) residential building closer to Abbey road, wrapping around the corner and along Belsize road. This new building is generally 6 storeys high, with an additional storey alongside Abbey road
- Construction of the 2 and 3 storey 'Mews houses' to the North West of this, parallel to priory terrace and priory road.

- These two new structures wrap the majority of the way around a communal green. A pedestrian walk way will be included through this, connecting Abbey road and Belsize road, reducing pedestrian traffic at the main intersection.

A ground level plan of the regeneration site and proposed new buildings can be seen in Figure 2.3.

Artists' impressions of the Phase 1 regeneration can be seen in Figure 2.4 to Figure 2.6, with Figure 2.7 showing the Phase 2 regeneration, and Figure 2.8 and Figure 2.9 showing the Phase 3 regeneration.

Figure 2.10 gives a rough indication of the elevation of key buildings, assuming one storey is ~3m tall. The elevation of the Phase 1 design relative to the surrounding buildings (including the Casterbridge building and Snowman house) is shown clearly in Figure 2.6.

Figure 2.3 Abbey road regeneration site, proposed new buildings shown in green.

Figure 2.4 Bird's eye view of the Abbey road Phase 1 regeneration from the North East (as indicated in key).

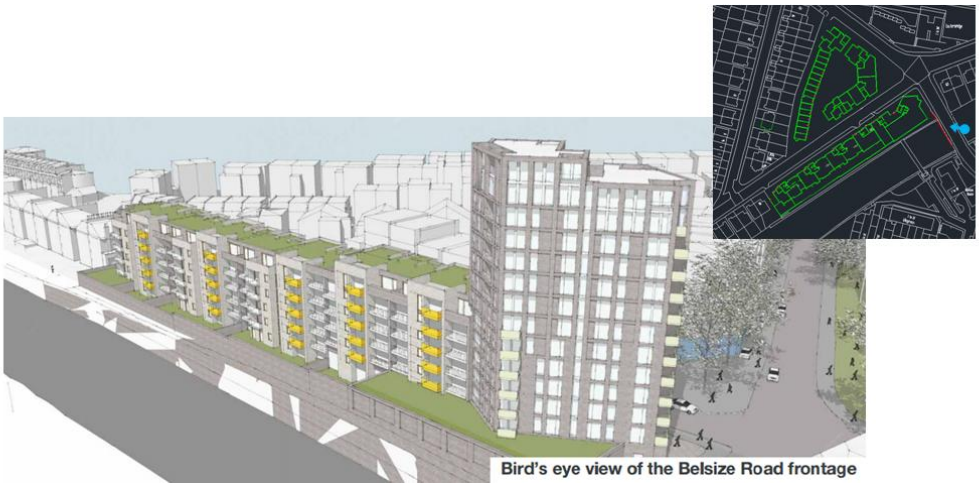

Figure 2.5 Bird's eye view of the Abbey road Phase 1 regeneration from the South East (as indicated in key).

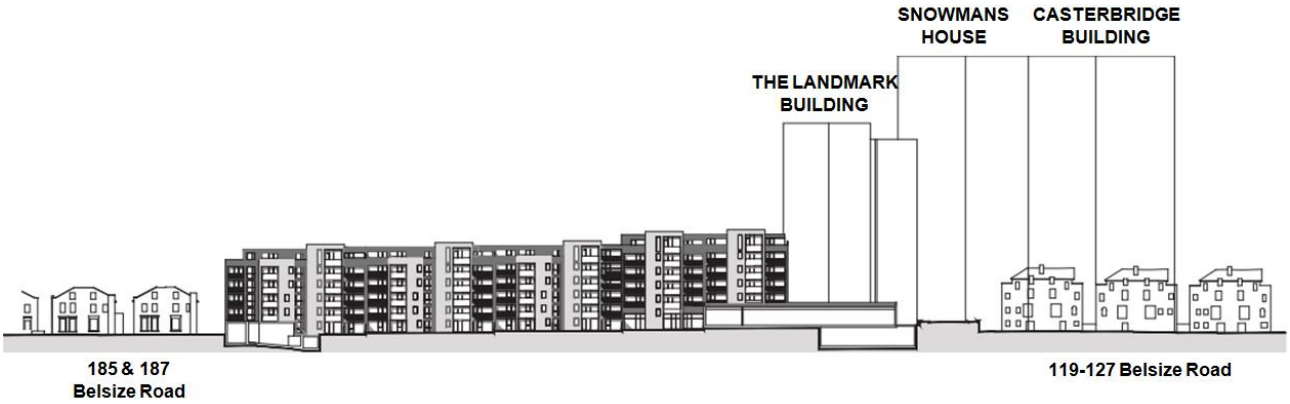

Figure 2.6 Elevation view of Abbey road Phase 1 regeneration with surrounding houses, Snowman house and the Casterbridge building superimposed.

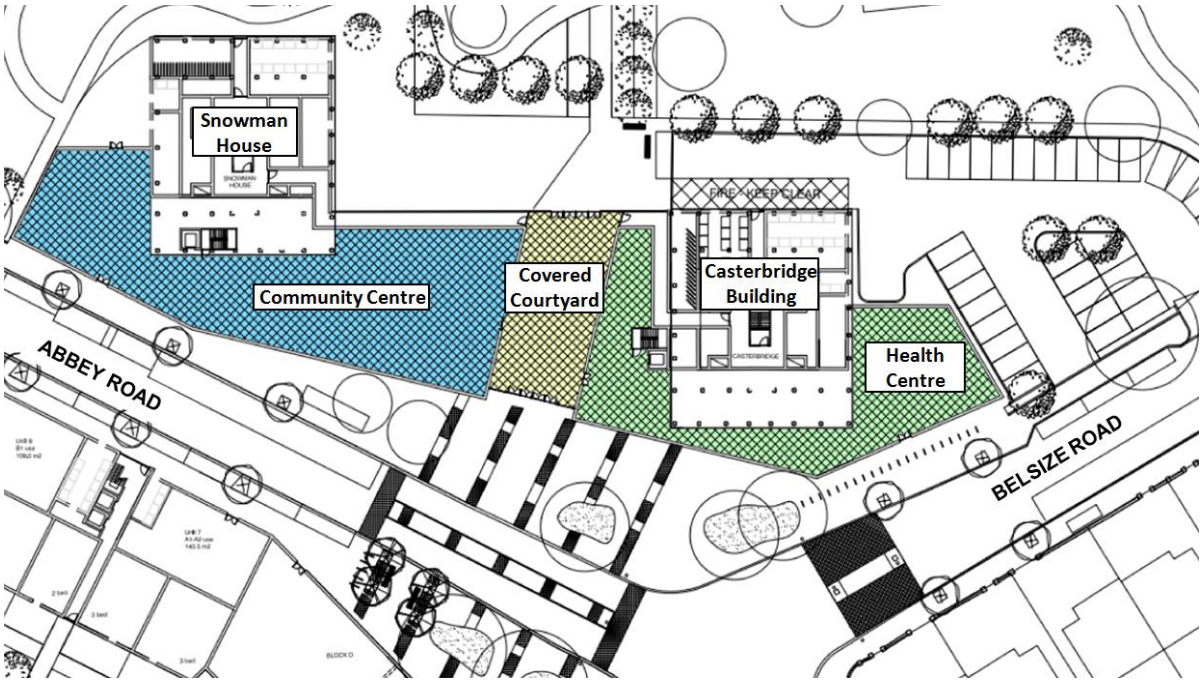

Figure 2.7 Plan view of the Abbey road Phase 2 regeneration.

Figure 2.8 Bird's eye view of the Abbey road Phase 3 regeneration from the South West.

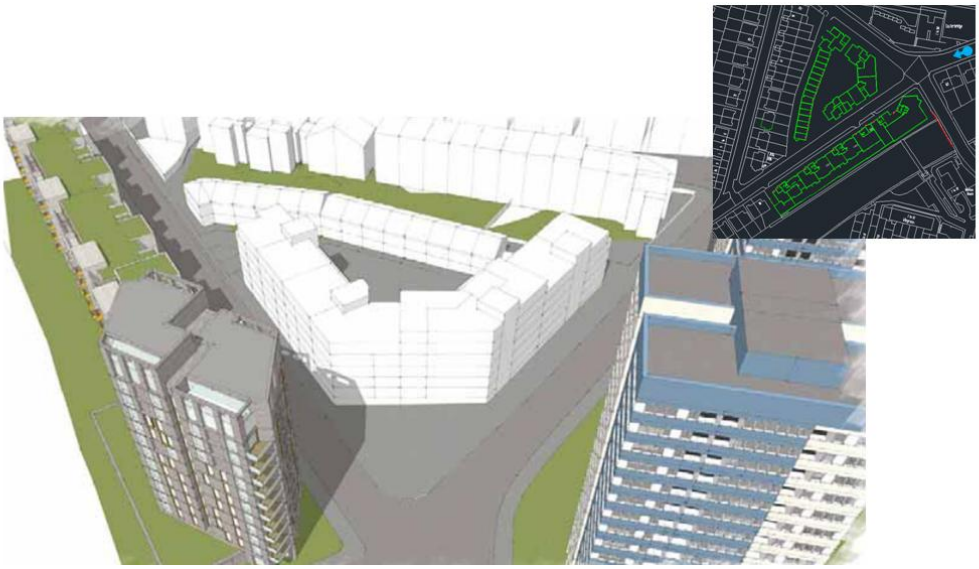

Figure 2.9 Bird's eye view of the Abbey road Phase 3 regeneration from the North East

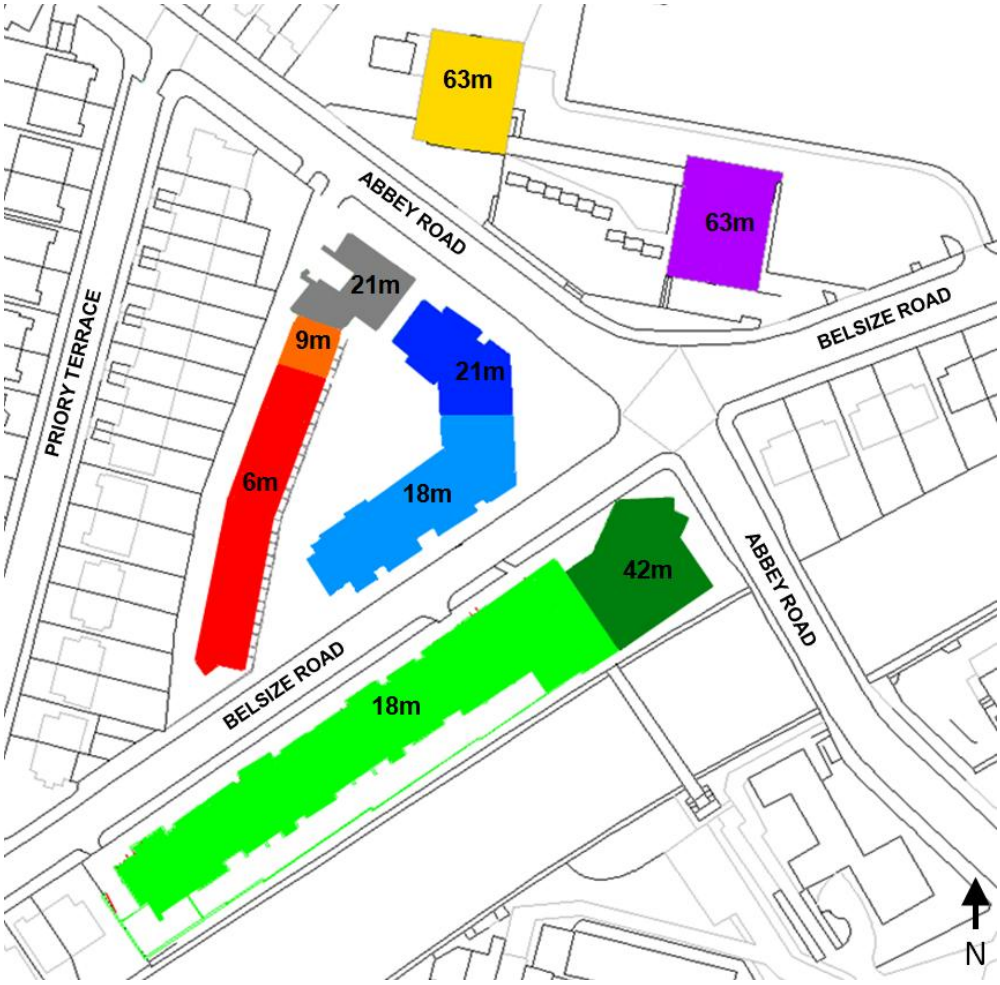

Figure 2.10 Abbey road regeneration site, proposed new buildings with elevations.

3. Assessment methodology and significance criteria

The desk study analysis can be broken down into three main steps:

1. Estimate the ambient conditions at the site using wind statistics from a nearby meteorological station.

2. Identify the likely wind flow patterns around the buildings. Wind sheltering or wind acceleration factors (speed up factors) are estimated at a number of chosen locations based on prior experience.

3. Calculate the wind speed frequencies at each location by combining the ambient wind frequencies and estimated "speed-up" factors. These are compared against Lawson's criteria, taking into account people's activities around the buildings.

This assessment focuses on pedestrian comfort and safety at pedestrian level. For the purposes of this study, a pedestrian is defined as any individual who may be walking, standing or sitting in the open within the site. Since wind speeds will vary with height, "pedestrian level" is normally defined as the wind speeds 2m above ground level.

The wind effects on a person are two-fold:

- The wind exerting a force on the person; and,
- The wind chill factor causing discomfort.

At higher wind speeds the former factor dominates, increasing with the square of the wind speed, but at lower wind speeds the thermal discomfort is usually dominant, particularly in shaded areas.

In this study the Lawson criteria (2) are used to assess pedestrian wind comfort. These cover the mechanical rather than the thermal effects of the wind [1]. Comfort levels and acceptable wind criteria depend on pedestrian activity. For example, higher wind speeds can be tolerated when walking quickly through a windy car park compared to sitting at a table outdoors for a long period of time.

The Lawson comfort criteria categorise pedestrian activities in terms of:

- Roads and car parks
- People at work
- Pedestrian strolling
- Long term sitting (more than 10mins)
- Entrance/exits
- Covered area sitting

The criteria defines wind speed exceedence thresholds below which conditions are "comfortable", "tolerable", or "unacceptable" for any given activity ("acceptable" limits).

In addition to the comfort criteria, safety criteria are also defined, to ensure that conditions never become severe enough to cause injury to pedestrians. A detailed description of the comfort and safety criteria is discussed below in section 3.1.

In order to evaluate the effect of the proposed development, the effect of the buildings in the proposed development is combined with the effect of the ambient conditions of the site. The ambient conditions account for the surrounding buildings via the use of roughness factors, giving an average wind speed across an **assumed empty site where the proposed development is to be built**. A detailed description of how the ambient condition is calculated is shown in Section 4. Note that the existing buildings which are to be

[1] It is assumed that other comfort factors, such as air temperature, can be adequately compensated by suitable clothing.

demolished have no bearing on the wind environment after construction of the proposed development and therefore they need not be considered in any quantitative way.

Site-specific wind tunnel or CFD modelling provides greater accuracy and a more precise method for proposing and testing mitigation measures, however, such studies are much more time-consuming and costly to perform. For this reason it was recommended that a desk study is carried out as a first step, with the option of a wind tunnel or CFD study considered at a later stage, if required.

3.1. Lawson Criteria

The Lawson pedestrian comfort criteria (as defined in BRE Digest 520) are a typical choice for wind assessments in the UK. They are based on three parameters:

a. Pedestrian activity,

b. Localised wind speed thresholds, and

c. An allowable frequency of exceedance.

The criteria also make the distinction between 'tolerable' and 'unacceptable' conditions. Tolerable refers to situations in which the wind will be noticed but will not prevent the area being used effectively for its designated purpose. Unacceptable corresponds to wind conditions of sufficient strength and frequency that would deter people from using the area for its designated purpose; in this case remedial measures are needed.

The wind speed threshold values (B2 to B5) correspond to the standard Beaufort scale classification (see Table 3.2). The Beaufort scale is normally defined relative to 10m, but it is assumed that the Lawson criteria refer to wind speeds at pedestrian-level height. The Beaufort wind speed thresholds used by the Lawson criteria are defined in the Table 3.1 below.

Pedestrian activity	**Relative comfort**			
	Tolerable	*Must not exceed*	**Unacceptable**	*Must not exceed*
Roads and car parks	B5	2%	B5	6%
People at work	B4	2%	B5	2%
Pedestrian strolling	B3	6%	B4	4%
Long term sitting (more than 10mins)	B2	6%	B3	6%
Entrance/exits	B2	4%	B3	6%
Covered area sitting	B2	4%	B3	1%

Table 3.1 Definition of the Lawson criteria

Beaufort scale		Wind speed thresholds	
B0	Calm	0	Smoke rises vertically
B1	Light air	0.3	Direction shown by smoke drift but not by vanes
B2	Light breeze	1.6 -3.3	Wind felt on faces, leaves rustle, wind vane moves
B3	Gentle breeze	3.4-5.4	Leaves and twigs in motion, wind extends a flag
B4	Moderate breeze	5.5 – 7.9	Raises dust and loose paper, small branches move
B5	Fresh breeze	8 - 10.7	Small trees in leaf sway
B6	Strong breeze	10.8 - 13.8	Large branches begin to move, telephone wires whistle
B7	Near gale	13.9 - 17.1	Whole trees in motion
B8	Gale	17.2 - 20.7	Twigs break off, personal progress impeded

Table 3.2 Definition of Lawson thresholds based on the Beaufort scale

For example, a region is rated as comfortable for “strolling” if the localised wind speed does not exceed B3 (upper wind threshold) more than 6% of the time. However, B4 can be exceeded up to 4% of the time before the region is deemed unacceptable for the same use.

A person outdoors does not experience a constant mean wind speed, but feels the fluctuations of the wind, called the gust wind. Lawson recommends that in wind tunnel assessments the gust speeds should also be measured and converted into to an equivalent Gust Equivalent Mean (GEM) that can be used in the same way as, and alongside, the hourly mean defined above. In the context of this desk study, the effect of turbulence is not considered.

Lawson also defines a ‘distress’ criterion, also known as the “safety” criterion, to identify situations for which pedestrians would find it difficult to walk or could even stumble and fall. For the most vulnerable pedestrians, a lower bound safety limit can be set at B6, with a probability of exceedance of 0.01% (one hourly mean exceedance a year).

A pragmatic approach commonly adopted is to compare the “acceptable” Lawson criteria exceedence categories of the proposed site to those of the ambient, empty site. A one-category difference in the wind classification in the Lawson Scale is a minor impact; a two-category difference is a moderate impact, whereas three categories or exceedence of the safety criterion represent a major impact. For regions of particular interest or significant change, results will be compared qualitatively against the baseline, as-built conditions. The baseline conditions take into account the localized flow structures caused by the existing buildings/structures. Beneficial effects are also defined based on similar considerations.

Irrespective of the difference between Site and the ambient or baseline conditions, it is recommended that mitigation measures be considered for areas in the development that exceed the “unacceptable” Lawson thresholds for a given use.

4. Ambient wind conditions

4.1. Description of site

The Abbey road regeneration site is located in North West London on Abbey road. It is surrounded by low to medium rise residential/retail areas, as illustrated in Figure 2.1. 'Ambient' wind conditions are an idealised representation of the wind conditions in the area, assuming an aerodynamic roughness representative of the surrounding buildings. It is noted that 'ambient' conditions are not the same as the 'Baseline' wind environment at the existing site, (as shown in Figure 2.2) – existing buildings will modify the ambient wind conditions creating areas of localised sheltering and/or flow acceleration. The main focus of this study is the assessment of the wind environment for the proposed regeneration site, using the 'ambient' wind conditions as the starting point.

4.2. Ambient wind assessment methodology

'Ambient' wind conditions are an idealised representation of the wind conditions in the area, upon which local speed-up factors are superposed to account for the effects of the nearby buildings. Ambient wind conditions are calculated by modifying meteorological data from a nearby measurement site.

Historical meteorological data from a nearby Met Office measurement site (London Heathrow Airport, Hounslow (51.478° N, 0.461° W) was used. The data covers 10 years of half hourly wind speed readings, for all wind direction sectors (30 degrees apart), at the standard height of 10m above ground. A wind rose representation of the data is shown in Figure 4.1. It is clear that the prevailing winds are from the south west quadrant, however this study accounts for wind from all directions, weighted for their respective frequencies.

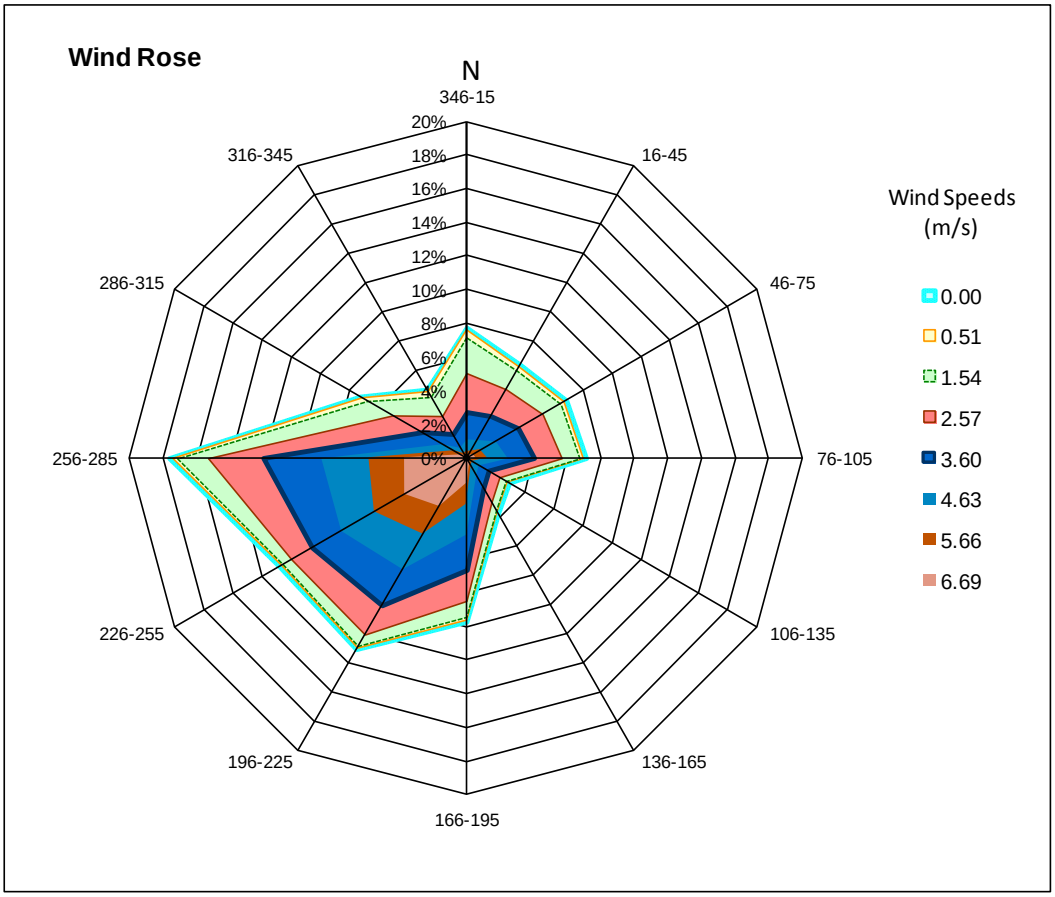

Figure 4.1 Wind rose plot of hourly mean wind speeds measured at the Heathrow Airport site for the full year (10 years of data, at reference height = 10m)

The met data were adjusted to estimate the ambient wind conditions at the Abbey Road site. Adjustments were made to:

- Account for differences in the aerodynamic roughness of the surrounding terrain at the met station and at the site.
- Scale the winds from the 10m measurement height down to pedestrian level (typically assumed to correspond to a reference height of 2m).
- Adjustment to account for differences between the ground level at the Met site and Abbey road site.

Differences in aerodynamic roughness: Ambient wind speeds are affected by the upwind aerodynamic roughness. If wind conditions are to be applied to a site other than the measurement site, the difference in aerodynamic roughness between the measurement site and the application site must be accounted for. As the aerodynamic roughness increases, the ambient wind speed decreases. It is noted that the choice of aerodynamic roughness can have a significant effect on assessing not only the ambient conditions, but also the overall impact of the development, since the frequency analysis using the Lawson criteria is often sensitive to these choices.

It is difficult to estimate roughness values with much accuracy. The values used are approximated using the guidelines stated in "The designers guide to wind loading of building structures"(3), which suggests 6 categories of aerodynamic roughness.

Aerodynamic roughness factor	Description
0.003	Large expanses of water, mudflats, snow-covered farmland, and large flat areas of tarmac.
0.01	Flat grassland, parkland or bare soil, without hedges and with very few isolated obstructions.
0.03	Meteorological standard, basic terrain roughness corresponding to typical UK farmland, nearly flat or gently undulating countryside, fields with crops, fences or low boundary hedges and few trees.
0.1	Farmland with frequent high boundary hedges, occasional small farm structures, houses or trees.
0.3	Dense woodland, domestic housing typically between 10% and 20% plan density
0.8	City centres comprising mostly four-storey buildings, or higher, typically between 30% and 50% plan-area density.

Table 4.1 Guidelines for aerodynamic roughness factors (3)

To ensure results are conservative, the lower values are used when there is uncertainty in aerodynamic drag factor. The sensitivity of the results to these values has been considered and is discussed later.

Both the met station (red) and the Abbey Road regeneration site (blue) can be seen in Figure 4.2 to help give an impression of roughness factors for all wind directions.

The larger the relative difference in roughness factor assumed between the Met site and the site of interest, the greater the adjustment to the wind data (lower wind speeds) at the site of interest. Normally meteorological sites are located in open regions with an aerodynamic roughness factor of 0.03 for all wind directions. However the Heathrow site is surrounded by built up areas and affected by its proximity to the greater London area so the use of a higher roughness factor could be justified. For this reason, a more conservative assumption of 0.1 has been used for all wind directions anticlockwise from North to South, and 0.3 for wind directions over London (North-Easterly winds, Easterly winds, and South-Easterly winds).

The Abbey Road regeneration site is surrounded by suburban areas on all sides therefore the aerodynamic roughness factor has been set to 0.3 for all directions.

The differences in elevation of the two sites have also been taken into account. The Heathrow Airport Met station is 25m above sea level, and the Abbey road site around 38m above sea level. The effect of this adjustment is minor.

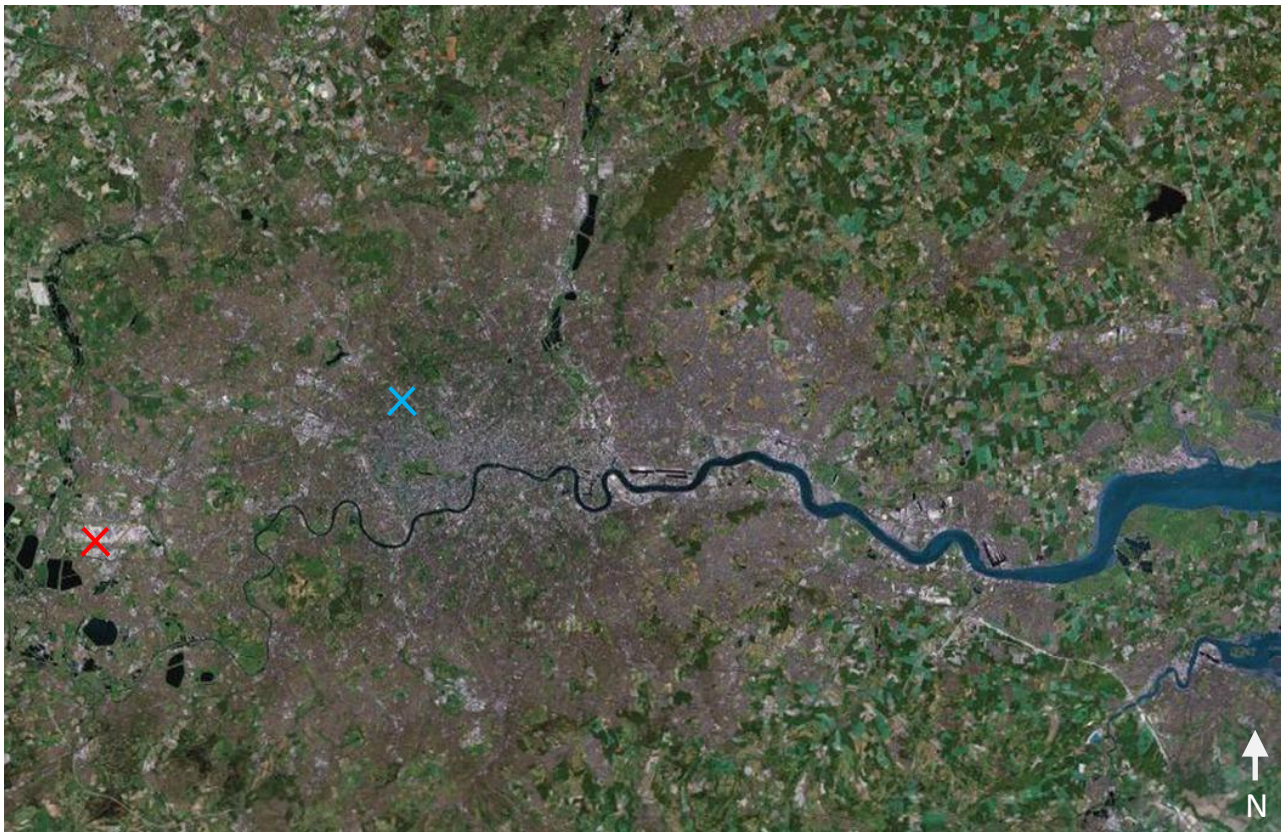

Figure 4.2 Met Station (red) and Site Location (blue)

4.3. Assessment of ambient conditions

There is a seasonal variability in the Met data, with higher wind speeds occurring in winter months. The Met data was processed in such a way as to allow yearly, 'summer' month (April to September) and 'winter' month (October to March) frequencies to be calculated, the latter giving an indication of conditions during the windier part of the year.

As expected, conditions are more favourable in the 'summer' months than the 'winter' months; there is an increased probability for the high wind speeds (>4.63m/s) and reduced probability for the low wind speeds (<2.57m/s) during the 'winter' months.

Table 4.2 shows the result of the comfort and safety assessment for the ambient case. Table 4.3 shows the degree to which these locations are exceeded.

Pedestrian Activity	Comfort Assessment
Safety (or "distress criterion")	Safe
Roads and Car Parks	Comfortable
People at work	Comfortable
Pedestrian Strolling	Comfortable
Long term sitting (more than 10mins)	Tolerable
Entrances/exits	Tolerable
Covered area sitting	Tolerable

Table 4.2 Abbey road regeneration site ambient case comfort and safety assessment.

Pedestrian Activity	Not to be exceeded (for Comfortable rating)	Location exceedence
Roads and Car Parks	B5 2%	B5 0.0%
People at work	B4 2%	B4 0.0%
Pedestrian Strolling	B3 6%	B3 0.1%
Long term sitting (more than 10mins)	B2 6%	B2 9.4%
Entrances/exits	B2 4%	B2 9.4%
Covered area sitting	B2 4%	B2 9.4%

Table 4.3 Degree of exceedence for each potential use, ambient site conditions

Conditions are tolerable for ‘long term sitting’ activities (e.g. shopping area), ‘entrances/exits’, and ‘covered area sitting’ activities (e.g. stage areas, outdoor coffee shops or benches). This implies that sheltering from neighbouring buildings or additional mitigation measures is required in order to achieve a ‘Comfortable’ assessment for any pedestrian activity deemed more stringent “Pedestrian Strolling”.

5. Impacts of development

5.1. General considerations

Introducing a building onto a site has two main effects on the wind environment; it can provide shelter in some areas, or accelerate the wind in others. The effects are strongly dependent on wind direction.

Sheltering typically occurs in the downwind wake area of a building. Flow amplification occurs around the corners of the building ("corner flow") and is strongest for tall buildings (e.g. >40m high). Channel flow occurs when wind flows past two parallel buildings that are separated by a small gap. Venturi flow occurs when wind is funnelled in between two buildings which are positioned at an angle relative to each other. All these wind amplification and sheltering mechanisms are illustrated in Figure 5.1.

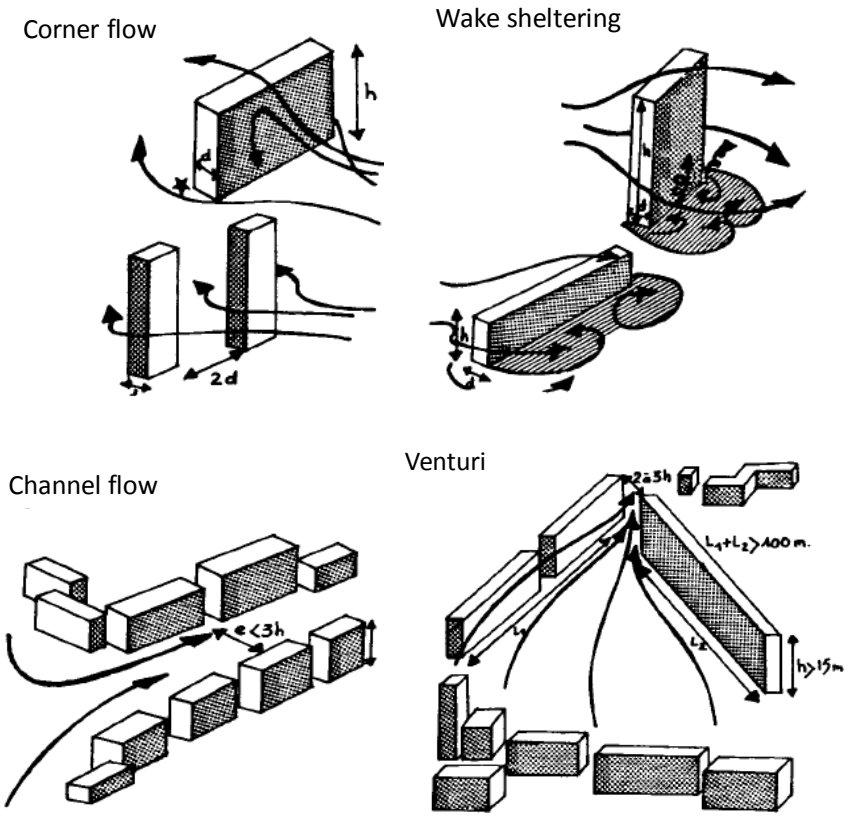

Figure 5.1 Schematic of typical wind amplification/sheltering mechanisms.

Tall buildings (i.e. >40m high) may cause pedestrian wind problems, by deflecting faster moving flow down to ground level. Wind speed increases with height above ground; it follows, therefore, that the taller a building, the stronger the wind speeds impinging on the building and deflecting downwards.

Not all tall buildings cause wind problems; what is important is the relative height of the building compared with that of neighbouring buildings. A tall building in a group of other buildings of similar height might not cause problems (due to buildings sheltering each other) whereas a mid-rise building could cause unacceptable conditions if it is adjacent to an exposed, open area.

5.2. Expected flow patterns at the proposed site

Most of the new proposed buildings are of similar heights to surroundings structures and so will not cause any significant increase to wind speed. Some wind channelling can occur along uninterrupted stretches of road, such as down Belsize road and Abbey road as well as through narrow passages between buildings. However such channelling effects are expected to be modest.

However there are high rise buildings in the area that could introduce localised regions of increased wind speed. These include the pre-existing high rise structures - Casterbridge building (21 storeys) and Snowman house (21 storeys), and the new Landmark building (14 storeys). It is expected that there will be areas of accelerated flow (corner vortices) surrounding these structures, and the location of these areas will vary with wind direction.

Speed-up factors were estimated to quantify these effects for all wind directions. A schematic impression of the expected flow structure due to the SW prevailing wind is shown in Figure 5.2. The assumed speed-up factors are based upon published data/relevant guidance, and conservative assumptions were made. It is noted that the presence of other buildings will affect the exact location and strength of corner vortices and other flow features discussed. For example, the fact that the tall landmark building is oriented with its narrower side to the prevailing wind, and the presence of sheltering buildings upwind is expected to significantly reduce the strength of corner vortices at pedestrian level. Also, the planned addition of the Phase 2 pedestal buildings (including community centre, health centre and covered court yard) surrounding the existing high rise buildings will act to mitigate the effect of the corner vortices by deflecting the flow away from pedestrian height. It is not possible to predict the exact flow patterns and speed-up/sheltering factors of such groups of buildings, however it is possible to estimate the likely magnitudes in a conservative way.

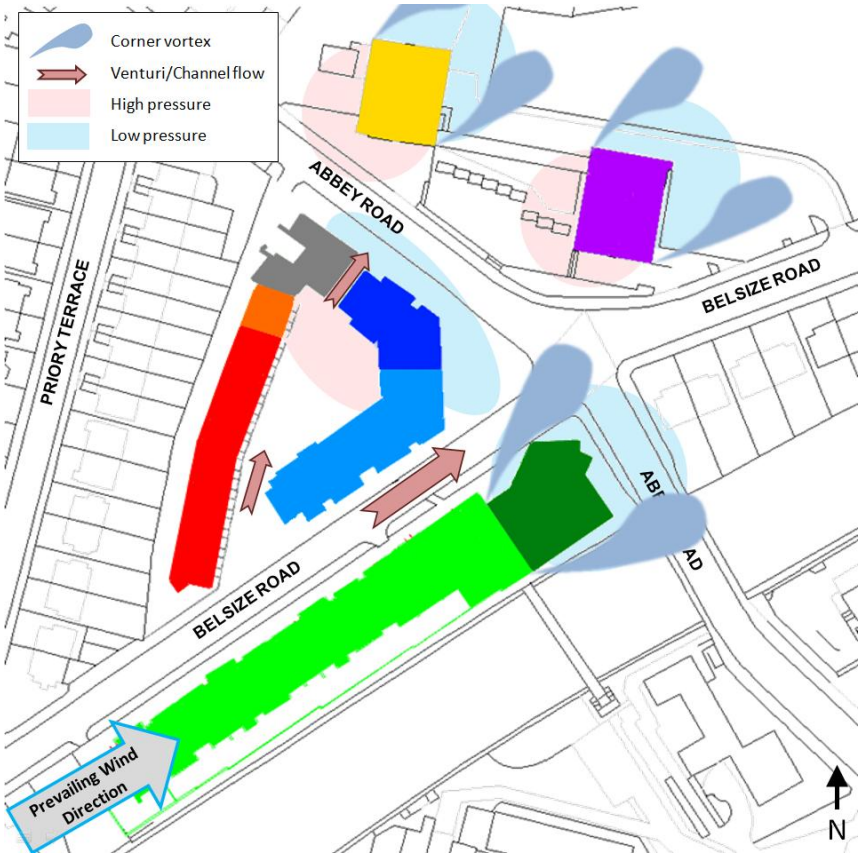

Figure 5.2 Schematic of expected flow structure from prevailing winds (from the South West) at the Abbey road regeneration site.

5.3. Locations chosen for the analysis

Based on the considerations discussed above, 7 locations were chosen around the Abbey road regeneration site near building entrances, pedestrian walk through areas and / or areas where wind effects are expected to be most pronounced. The chosen locations are summarised in Figure 5.3 and Table 5.1 below.

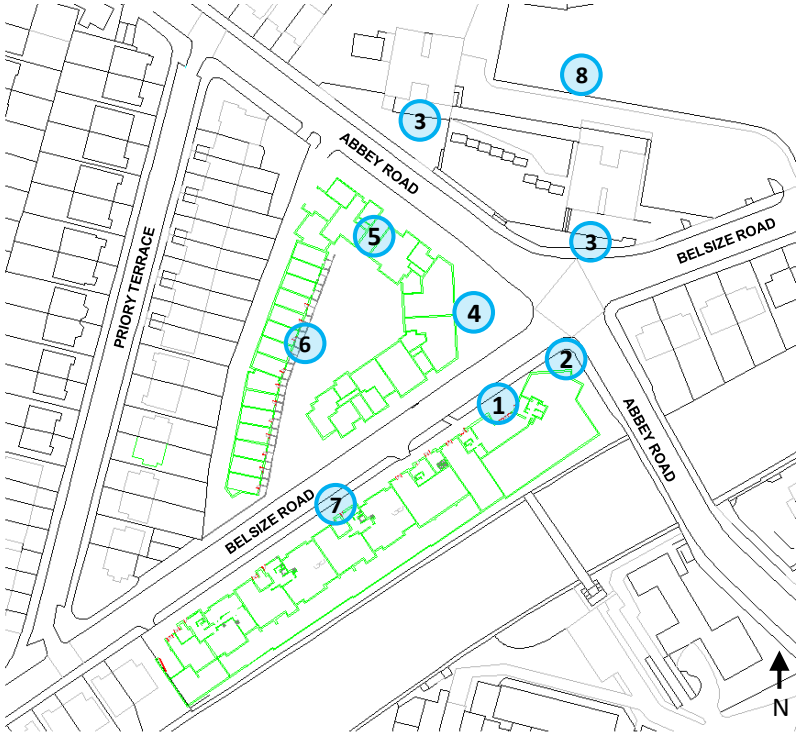

Figure 5.3 Locations of interest at Abbey road regeneration site (known building entrances indicated in red)

Location	Description
1	The entrance to the Landmark building.
2	The side of Landmark building.
3	In front of Casterbridge building and Snowman house, wind affects are assumed similar for both locations.
4	In front of Phase 3 development, next to Belsize road / Abbey road intersection.
5	Pedestrian footpath in between the Phase 3 development from Abbey road to Belsize road.
6	Entrance to Mews house, assumed representative of all entrances. Can also be used as the assumed worst conditions for the communal green.
7	Entrance to railway side housing, assumed representative of all entrances.
8	To the north west (behind) Snowman House and Casterbridge building

Table 5.1 Locations of interest at the Abbey road regeneration site.

6. Results

The wind acceleration/sheltering factors estimated at each chosen location for each wind direction, were combined with the adjusted met data (ambient wind) frequencies to calculate the frequency of exceedance of each category on the Beaufort scale. These results were compared against Lawson pedestrian comfort criteria to assess the relative comfort and safety of each location dependent on its usage. The results of this analysis are presented below for each location of interest for the all year wind conditions.

6.1. Location 1

The entrance to the Landmark building is located on the ground level within a small recess. This recess may offer some sheltering from the channelled flow down Belsize Road for the prevailing wind direction, however this may be counteracted by flow acceleration into this area from flow deflected around the corners of the Landmark building. Winds from the South East and North West are blocked by surrounding structures, however it is possible that corner vortices off Casterbridge building could cause increased wind speeds for winds from the North East sector.

The results from the desk study analysis are summarised in Table 6.1. The area meets all of the Lawson comfort and safety criteria applicable to it with the exception of the 'covered area sitting' criterion, but this area is not expected to be used in this way.

Pedestrian Activity	Comfort Assessment
Safety (or "distress criterion")	Safe
Roads and Car Parks	Comfortable
People at work	Comfortable
Pedestrian Strolling	Comfortable
Long term sitting (more than 10mins)	Tolerable
Entrances/exits	Tolerable
Covered area sitting	Unacceptable

Table 6.1 Abbey road regeneration site location 1 comfort and safety assessment – yearly wind data.

The area will not be used for 'long term sitting' but is near an 'entrance/exit', making the latter result more significant. It is suggested that mitigation measures are taken such as the addition of double doors or a revolving door at the entrance to ensure comfortable conditions throughout the year.

6.2. Location 2

Corner vortices off the Casterbridge building can cause increased wind speeds as well as channelling down Abbey road, dependent on wind direction. This site lies in the wake of the Landmark building for the prevailing wind direction. This will only provide some modest sheltering; although a reduction in mean wind speed in the wake is expected, this effect will be counteracted by increased turbulence.

This location meets all of the Lawson comfort criteria, with no activities being deemed unacceptable.

Pedestrian Activity	Comfort Assessment
Safety (or "distress criterion")	Safe
Roads and Car Parks	Comfortable
People at work	Comfortable
Pedestrian Strolling	Comfortable
Long term sitting (more than 10mins)	Tolerable
Entrances/exits	Tolerable
Covered area sitting	Tolerable

Table 6.2 Abbey road regeneration site location 2 comfort and safety assessment – yearly wind data.

6.3. Location 3

This location includes the area at the base of the pre-existing Casterbridge and Snowman house buildings and Phase 2 re-generation buildings, along Abbey road. The pre-existing tall buildings could significantly increase wind speed in some areas due to the formation of corner vortices. However this will only affect the Abbey Road frontage area for winds from the North East / North West sectors, which occur much less frequently than the prevailing wind (see Figure 4.1).

The area meets all comfort criteria except the ‘covered area sitting’ category, which does not apply.

The contribution of the Phase 2 buildings to this pre-existing wind environment is likely to be beneficial, since they are expected to deflect downwash/corner vortices away from pedestrian level (the so-called ‘pedestal’ building protective effect). It is also noted that, as part of the Phase 2 scheme, there is a covered courtyard area between the community and health centres (Figure 2.7) with entrances on Abbey Road. The conditions at these entrances should meet the Lawson criteria.

Pedestrian Activity	Comfort Assessment
Safety (or "distress criterion")	Safe
Roads and Car Parks	Comfortable
People at work	Comfortable
Pedestrian Strolling	Comfortable
Long term sitting (more than 10mins)	Tolerable
Entrances/exits	Tolerable
Covered area sitting	Unacceptable

Table 6.3 Abbey road regeneration site location 3 comfort and safety assessment – yearly wind data.

6.4. Location 4

Location 4 passes the Lawson comfort and safety criteria in a similar way to previous locations.

Overall, wind speed exceedance results are slightly elevated. This is due in part to the prevailing winds channelling down Belsize road and accelerating around the corner into the low pressure region formed behind the Phase 3 development block. It is also significantly impacted by less frequent winds from the NE and SE by corner vortices forming off the high rise buildings in the development (The Landmark building, and the pre-existing Casterbridge building or Snowman house). Table 6.4 shows the comfort assessment for this location against the range of possible uses. Atkins have assumed that the expected use for this location is ‘long term sitting (more than 10 minutes)’.

The proposed development does not change the comfort rating for its expected use when compared to the ambient condition, therefore no mitigation is normally required (refer to Section 3.1).

The criteria for ‘Comfortable’ ratings and the calculated exceedences for this location are summarised in Table 6.5. It should be noted that the ‘Comfortable’ limit on long term sitting is exceeded by a wide margin for

this location (~26% exceedence of B2 where 6% exceedence is the maximum allowed). Significant mitigation measures are therefore required in order for this location to be downgraded to 'Comfortable' from 'Tolerable' for long term sitting. Although the prevailing winds are from the SW, this location is well sheltered from the wind from this direction. It is the less frequent winds from the NE quadrant which contribute the majority of the B2 exceedence for this location. This is due to local wind speedup effects from the upwind tower blocks (corner vortices from Casterbridge and Snowman House) during northerly winds, as well as corner vortices from the landmark building in easterly/south easterly winds. The most effective mitigation measures will shelter this location from these flow features. These mitigation measures could take the form of dense planting or natural screens bordering this location to the northeast and southeast as shown by the red lines in Figure 6.1. These mitigation measures will reduce the proportion of annual exceedence however they may not result in a step change to a 'Comfortable' rating for long term sitting. It is recommended that the assumption of the expected use being 'long term sitting' be confirmed and rationalised prior to expending any further effort into wind mitigation at this location.

Pedestrian Activity	Comfort Assessment
Safety (or "distress criterion")	Safe
Roads and Car Parks	Comfortable
People at work	Comfortable
Pedestrian Strolling	Comfortable
Long term sitting (more than 10mins)	Tolerable
Entrances/exits	Tolerable
Covered area sitting	Unacceptable

Table 6.4 Abbey road regeneration site location 4 comfort and safety assessment – yearly wind data.

Pedestrian Activity	Not to be exceeded (for Comfortable rating)	Location exceedence
Roads and Car Parks	B5 2%	B5 0.0%
People at work	B4 2%	B4 0.5%
Pedestrian Strolling	B3 6%	B3 5.8%
Long term sitting (more than 10mins)	B2 6%	B2 25.7%
Entrances/exits	B2 4%	B2 25.7%
Covered area sitting	B2 4%	B2 25.7%

Table 6.5 Calculated exceedence levels for Location 4 compared with maximum exceedences for 'Comfortable' rating. Note that this location is rated Unacceptable for covered area sitting, however the details of this more stringent criterion are not shown here. Please refer to Table 3.1.

Figure 6.1 Proposed location of mitigation measures for Location 4.

6.5. Location 5

There is a narrow new pedestrian passage through the north face of the Phase 3 development. Although this is sheltered for most wind directions, accelerated flow from the corner vortices off the existing tall Casterbridge or Snowman house buildings can be directed towards it for some wind directions, and some channelling may occur for South Westerly and North Easterly winds.

The area meets the Lawson comfort criteria for all categories except 'covered area sitting', and therefore passes the comfort and safety assessment.

Pedestrian Activity	Comfort Assessment
Safety (or "distress criterion")	Safe
Roads and Car Parks	Comfortable
People at work	Comfortable
Pedestrian Strolling	Comfortable
Long term sitting (more than 10mins)	Tolerable
Entrances/exits	Tolerable
Covered area sitting	Unacceptable

Table 6.6 Abbey road regeneration site location 5 comfort and safety assessment – yearly wind data.

6.6. Location 6

This location sees some of the lowest wind speeds due to the relative height of the local buildings and the high level of sheltering. Wind speeds may be accelerated slightly due to channel flow through the south opening of the Phase 3 block, however this effect is expected to be minimal given the height of the buildings. The results show that this location passes all of the Lawson comfort assessments and could even be used for covered area sitting.

The proposed development does not change the comfort rating for its expected use when compared to the ambient condition, therefore no mitigation is normally required (refer to Section 3.1).

Table 6.8 shows the amount by which the Comfortable criteria are exceeded for this location for the range of possible uses. For long term sitting, the B2 level is exceeded roughly double the allowed amount of time required for a Comfortable rating for this use. As this is a small margin, scattered planting within the mews courtyard could improve the wind environment in this region if deemed necessary.

Pedestrian Activity	Comfort Assessment
Safety (or "distress criterion")	Safe
Roads and Car Parks	Comfortable
People at work	Comfortable
Pedestrian Strolling	Comfortable
Long term sitting (more than 10mins)	Tolerable
Entrances/exits	Tolerable
Covered area sitting	Tolerable

Table 6.7 Abbey road regeneration site location 6 comfort and safety assessment – yearly wind data.

Pedestrian Activity	Not to be exceeded (for Comfortable rating)	Location exceedence
Roads and Car Parks	B5 2%	B5 0.0%
People at work	B4 2%	B4 0.0%
Pedestrian Strolling	B3 6%	B3 0.3%
Long term sitting (more than 10mins)	B2 6%	B2 11.5%
Entrances/exits	B2 4%	B2 11.5%
Covered area sitting	B2 4%	B2 11.5%

Table 6.8 Calculated exceedence levels for Location 6 compared with maximum exceedences for 'Comfortable' rating.

6.7. Location 7

This location passes all of the Lawson comfort criteria. This is due to the two banks of near identical height buildings (both 6 storeys) resulting in high levels of sheltering due to symmetrical canyon flow for winds from the North West and South East. Winds from the North East and South West will be channelled down Belsize road, however this effect is likely to be minor.

Pedestrian Activity	Comfort Assessment
Safety (or "distress criterion")	Safe
Roads and Car Parks	Comfortable
People at work	Comfortable
Pedestrian Strolling	Comfortable
Long term sitting (more than 10mins)	Tolerable
Entrances/exits	Tolerable
Covered area sitting	Tolerable

Table 6.9 Abbey road regeneration site location 7 comfort and safety assessment – yearly wind

6.8. Location 8

This location is expected to see the highest wind speeds throughout the development, exceeding the acceptable criteria for long term sitting, entrances/exit and covered area sitting. Corner vortices off of the Casterbridge building and Snowman house are likely to impinge upon location 8 for the prevailing wind, resulting in increased wind speeds at this location.

Although this location does see high wind speeds and exceeds many of the Lawson comfort criteria, the criteria are exceeded primarily due to the pre-existing structures of Casterbridge and Snowman House. The impact of the new development on wind conditions in this location is negligible or marginally beneficial. The 1 storey development surrounding the Casterbridge building and Snowman house are expected to improve conditions directly next to the buildings due to a reduction in downwash; however this will benefit location 8 only marginally as the single storey building provides only minor sheltering in a prevailing wind.

Without mitigation this location experiences 'no' impact for the majority of expected uses and only a 'minor' impact for the most stringent use (Covered Sitting) as described in Section 3.1; however since one of the expected uses for this region is deemed Unacceptable, mitigation measures should be considered.

Table 6.11 and Table 6.12 show the extent of exceedence above the criterion for 'Comfortable' and 'Tolerable' levels for the range of expected uses for this location. It is clear that the criterion for Comfortable long term sitting is exceeded by a large margin at this location. Much of this exceedence is due to winds from the prevailing direction, and result from downwash and corner vortices from these tall buildings.

It is recommended that mitigation measures are considered to reduce the impact of downwash and corner vortices from these two tall buildings on this location. This location presents significant difficulties for mitigation due to the large margins by which the comfort criteria are exceeded. The effect of downwash and

corner vortices can be mitigated against through the installation of a canopy extending from the north and east faces of the Casterbridge building. Planting throughout location 8 may also provide some shelter from these flow features. It is not possible to determine the extent of mitigation that these measures could generate without detailed modelling or wind tunnel testing due to the complex nature of the multiple flow interactions. It is unlikely that this location could achieve Comfortable for the remainder of expected uses due to the influence of the two large tower blocks, however with the proposed mitigation it is likely that this location could be downgraded to 'tolerable' for long term sitting.

Pedestrian Activity	Comfort Assessment
Safety (or "distress criterion")	Safe
Roads and Car Parks	Comfortable
People at work	Comfortable
Pedestrian Strolling	Tolerable
Long term sitting (more than 10mins)	Unacceptable
Entrances/exits	Unacceptable
Covered area sitting	Unacceptable

Table 6.10 Abbey road regeneration site location 8 comfort and safety assessment – yearly wind

Pedestrian Activity	Not to be exceeded (for Comfortable rating)	Location exceedence
Roads and Car Parks	B5 2%	B5 0.0%
People at work	B4 2%	B4 0.9%
Pedestrian Strolling	B3 6%	B3 9.9%
Long term sitting (more than 10mins)	B2 6%	B2 36.4%
Entrances/exits	B2 4%	B2 36.4%
Covered area sitting	B2 4%	B2 36.4%

Table 6.11 Calculated exceedence levels for Location 8 compared with maximum exceedences for 'Comfortable' rating.

Pedestrian Activity	Not to be exceeded (for Tolerable rating)	Location exceedence
Roads and Car Parks	B5 6%	B5 0.0%
People at work	B5 2%	B5 0.0%
Pedestrian Strolling	B4 4%	B4 0.9%
Long term sitting (more than 10mins)	B3 6%	B3 9.9%
Entrances/exits	B3 6%	B3 9.9%
Covered area sitting	B3 1%	B3 9.9%

Table 6.12 Calculated exceedence levels for Location 8 compared with maximum exceedences for 'Tolerable' rating.

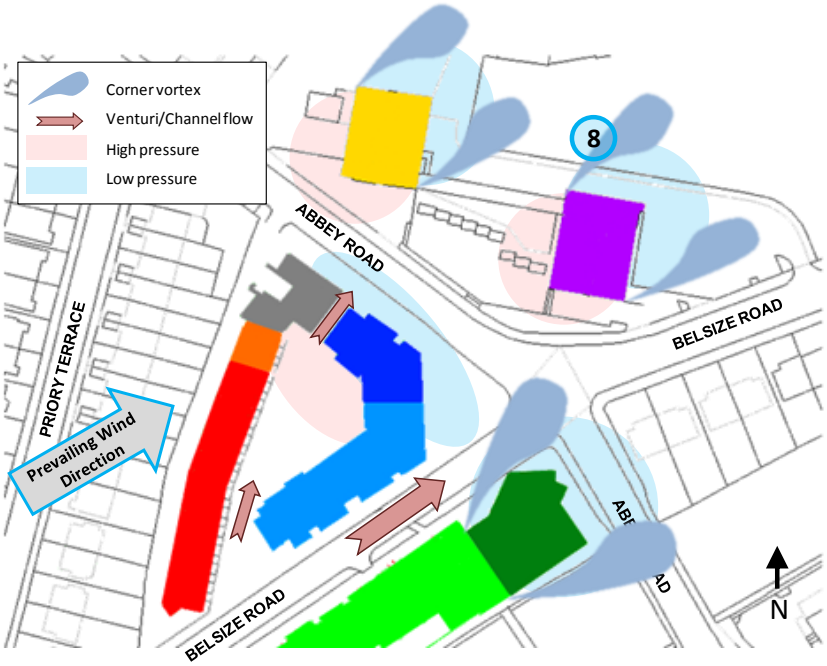

Figure 6-2 Prevailing wind condition. Corner vortices from existing tower blocks result in significant speedup within Location 8.

7. Conclusions and Recommendations

A "desk study" assessment of the pedestrian wind comfort at various locations of the proposed Abbey Road development has been carried out. The objective of this study has been to review and assess the impact of the proposed buildings on the local wind microclimate. A semi-quantitative approach was used to estimate the frequency of wind speeds without (ambient) and with the proposed buildings in place, and to assess whether these frequencies satisfy pedestrian comfort criteria at a variety of locations around the site. The Lawson criteria are used as the basis for this assessment since these are considered to represent best practice by UK local authorities.

As discussed in Section 6, the proposed development results in a wind environment that meets the Lawson comfort criteria for the intended use for virtually all areas considered. The safety criteria are also met throughout. Compared to the ambient, the new development does not increase the impact on the wind environment significantly, since it results in a maximum change of only one Lawson wind category from ambient conditions for all locations considered. In the majority of cases, there is no change from ambient conditions.

Given that the impact of the new development is expected to be minor (at most one-category difference in the wind classification in the Lawson Scale) and that conditions meet the ‘tolerable’ Lawson criteria for the intended use at each location, mitigation would not normally be required. Nonetheless, for completeness, Section 6, provides suggestions on mitigation measures that could be used if it is required to e.g. improve the comfort level to ‘Comfortable’ for long term sitting, for locations 4 and 8.

Section 6.6 describes the conditions within Location 6 (mews houses) and concludes that no additional mitigation is required in this region. However if improved conditions are desired, scattered tree planting within the mews courtyard will have this effect.

The effect of the new tall Landmark building on the local wind environment is not expected to be significant, especially given the orientation of its narrowest side relative to the prevailing wind, and the sheltering effect of buildings located upwind. The presence of the two pre-existing (‘baseline’) tall buildings has an effect on the wind environment, however this is acceptable at the locations considered, and the planned addition of the Phase 2 pedestal buildings (including community centre, health centre and covered court yard) will likely have a mitigating effect on the wind environment in the area between the two tall buildings.

It is also worth noting that this is a probabilistic study using annual wind data. Consideration is not given to the usage of these areas, which are expected to have a higher frequency of use in the summer months when conditions are more favourable to the winter months. This approach adds to the conservatism inherent in the predictions made herein.

8. References

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