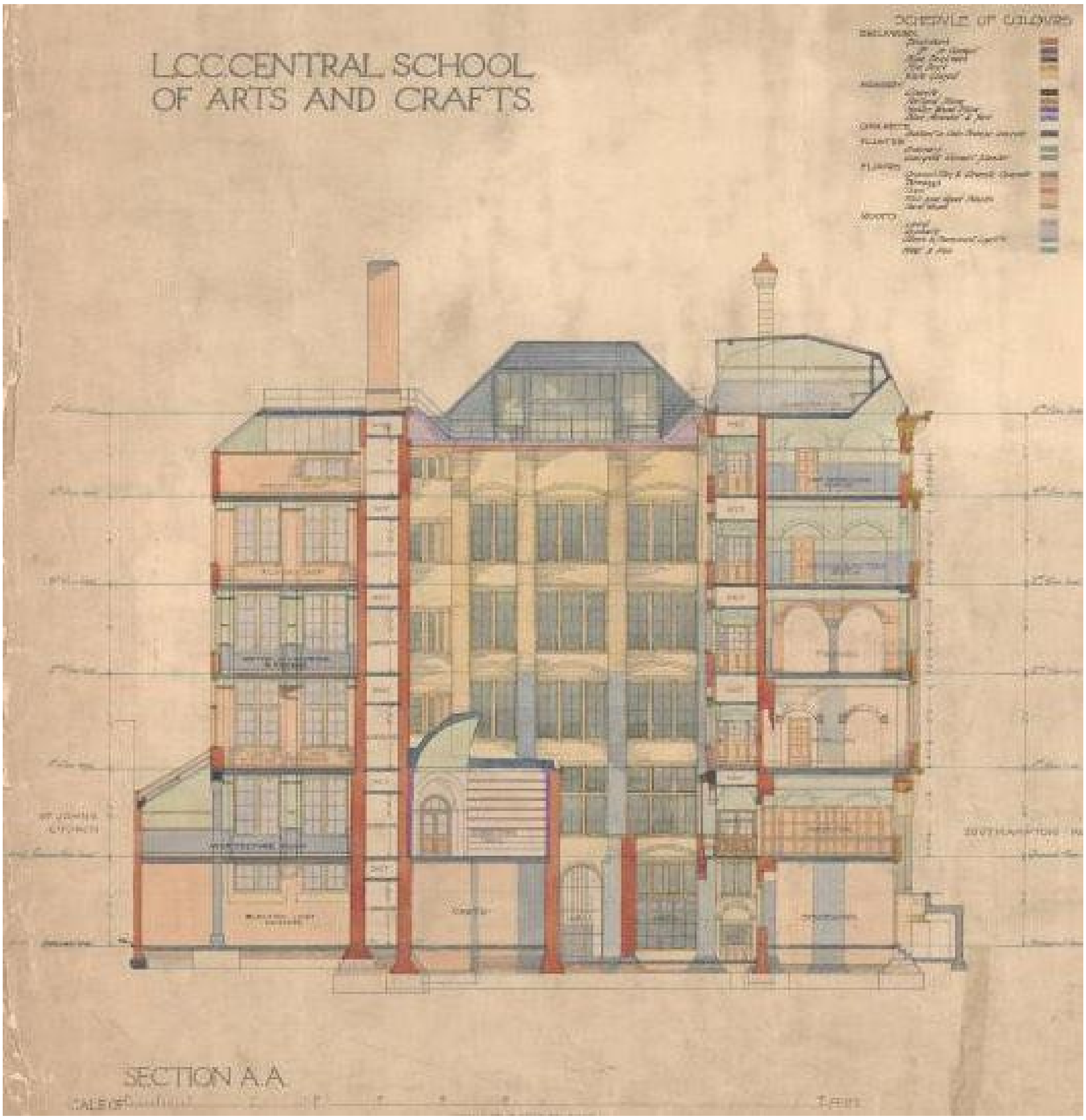
Project

Former CSM Site, Holborn

Title

Wind Comfort Computational Fluid Dynamics (CFD) Study



Intended for
Globalrange Hotels Ltd

Project Number
1620009364

Date
15 May 2020

FORMER CENTRAL ST MARTIN'S SITE
WIND COMFORT COMPUTATIONAL FLUID DYNAMICS (CFD) STUDY

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FORMER CENTRAL ST MARTIN'S SITE
WIND COMFORT COMPUTATIONAL FLUID DYNAMICS (CFD) STUDY

Project name	Former Central St Martin's Site
Description	Wind Comfort Computational Fluid Dynamics (CFD) Study
Intended for	Globalrange Hotels Ltd
Project no.	162001964
Report no.	01

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EXECUTIVE SUMMARY

Ramboll UK Ltd ('Ramboll') has been appointed by Globalrange Hotels Ltd to carry out a wind comfort computational fluid dynamics study of a proposed hotel-led development at Southampton Row in order to assess the potential wind microclimate effects.

The study assessed three scenarios: (i) existing baseline scenario of the current application site with existing surroundings; (ii) the built proposed development with existing surroundings; and (iii) the proposed development with existing surroundings plus cumulative schemes (Fisher Street building). The three scenarios have been tested for annual and the summer (calmest) and windiest (winter) seasons.

As part of a good neighbour policy, it is usual to minimise adverse changes to the wind conditions on neighbouring buildings due to the proposed development.

This report describes a quantitative computational fluid dynamics assessment of the wind comfort at locations around the application site and amended proposed development in terms of pedestrian comfort based on the LDDC wind criteria. It also considers aspects of safety of pedestrians, cyclists and vehicles.

The study concluded that the amended proposed development is unlikely to give rise to an adverse effect on the wind climate of the surrounding area. The wind microclimate within and around the amended proposed development would be suitable for activities ranging from occasional sitting to walking use during the windiest season. All areas adjacent to the amended proposed development would be rated as safe for all users.

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1. INTRODUCTION

Ramboll UK Ltd ('Ramboll') has been appointed by Globalrange Hotel Ltd to carry out a wind comfort computational fluid dynamics study of a proposed hotel-led development of the former Central St Martin's site, situated in Southampton Row in the Holborn area of the London Borough of Camden in order to assess the potential wind microclimate effects.

The existing site is a block of three buildings, formerly occupied by the Central Saint Martin's College of Arts and Design.

The three buildings which make up the site are:

- The Grade II* Listed Lethaby Building on the west of the site, adjacent to Fisher Street and Southampton Row;
- Cochrane Theatre on the north-east corner of the site, adjacent to Theobald's Road and Drake Street; and
- Red Lion Square on the east of the site, adjacent to Drake Street and Fisher Street.

The scheme proposes the refurbishment and redevelopment of Lethaby Building and the retention of the existing 1960s building concrete frame. The existing retained Red Lion Building concrete frame is extended to create a new mixed-use development. A new block (the Theobalds Road Building) is also added which contains residential and cultural use.

Planning permission is sought for the redevelopment of the site to provide a mixed-use development comprising the following key elements:

- Comprehensive refurbishment and conversion of the existing buildings, including the retention of the Lethaby Building and the provision of new extensions at the rear of the building and at roof level;
- Introduction of ground floor active/public uses, re-instatement of Orange Street and public realm enhancements; and
- Provision of a standalone Theobold's Road building at the north of the site to house affordable homes and cultural use.

2. SITE DESCRIPTION

2.1 Proposed Development

Full planning permission:

External alterations and internal refurbishment to the Grade II* Lethaby Building and the partial demolition and extensions of the existing buildings to create a new hotel facility (Use Class C1). Flexible ground floor and basements uses including retail uses (Use Class A1/A3/A4/D1), office (Use Class B1), and a range of D1 / D2 uses including exhibition hall, lecture hall, screening room, spa and swimming pool. Two restaurant spaces (Use Class A3 /A4) at first floor level and a restaurant (Use Class A3 /A4) at thirteenth and fourteenth level with access to a public terrace area. Creation of a new stand-alone block (Theobald's building) and re-instatement of former Orange Street which leads diagonally north-westwards from Red Lion Square. The Theobald's building will provide a cultural use (Use Class D1 / A1) at ground and first floor level and residential (Use Class C3) above, together with associated highway improvements, public realm, landscaping, cycling parking, bin storage and other associated works.

Listed building consent:

Listed Building Consent is sought for the following works to the Lethaby Building: Internal and external refurbishment and restoration of the Lethaby Building including externally: window repair / replacement and installation of secondary glazing, façade stone repairs, repair and reinstatement of roof form, new lift overruns and two new skylights; and internally: refurbishment and repair of stair cores, demolition of existing lift shaft, refurbishment and amends to doors and openings, installation of new mechanical ventilation and service routes, installation of new riser access, removal of modern partitions and installation of new partitions, refurbishment and waterproofing of vaults and other associated works.

The Applicant's appointed architects (ORMS Architects) supplied drawings of the proposed development together with a 3D model of the application site. Figure 2-1 shows the 3D model of the proposed development.

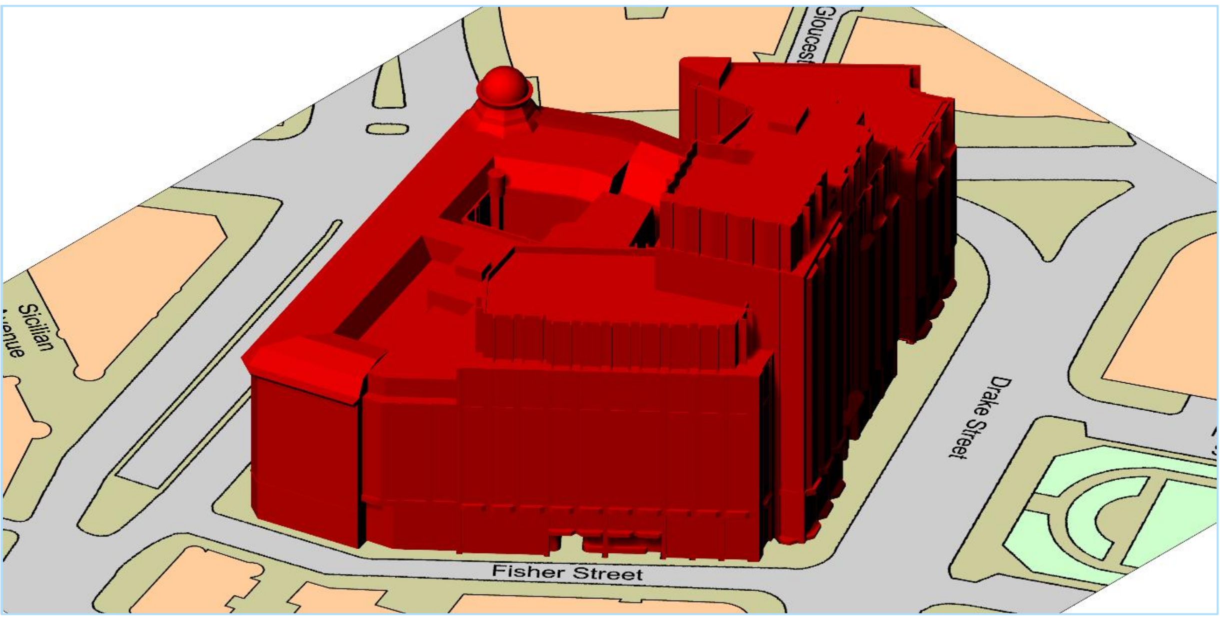

Figure 2-1. Former Central St Martin's Site - 3D model viewed from the southeast

2.2 Application Site Location

The application site, approximately 0.53 hectares, is located at Holborn in the London Borough of Camden near to the boundary with the City of Westminster to the southwest. The application site is bound by Theobald's Street to the north; Drake Street to the east; Fisher Street to the south; and Southampton Row to the west.

The surrounding land uses are predominantly commercial, retail and residential. The public Red Lion Gardens is located 50m east from the application site. Figure 2-2 shows the application site location and boundary in red colour.

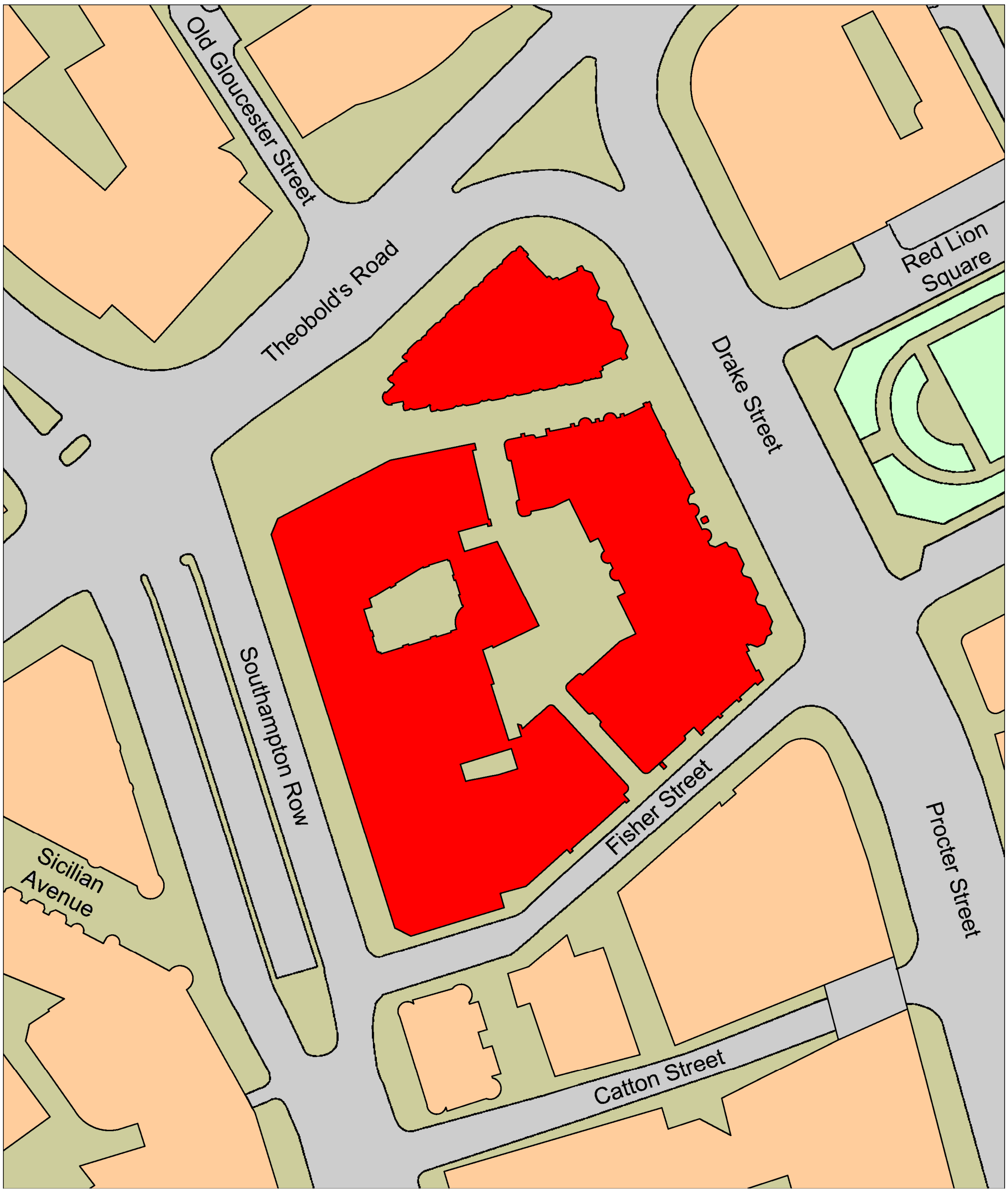

Figure 2-2. Former Central St Martin's Site location highlighted in red[1]

[1] Copyright Ordnance Survey.

2.3 Assessment Scenarios Modelled

This assessment will be aimed at predicting conditions around the proposed development for the following scenarios:

- Scenario 0: Existing Baseline
- Scenario 1: Existing Baseline + Proposed Development
- Scenario 2: Existing Baseline + Proposed Development + Cumulative Schemes

2.4 Scenario 0: Existing Baseline

The application site is a block of three buildings, formerly occupied by the Central Saint Martin's College of Arts and Design. Figure 2-3 shows the CFD model produced for the existing baseline conditions.

The green coloured building is the existing structures which occupy the application site and the grey coloured buildings are the existing surrounding buildings. The existing buildings surrounding the application have been modelled to a 400m radius from the centre of the application site, with the outer edge of the model reaching a radius of 500m.

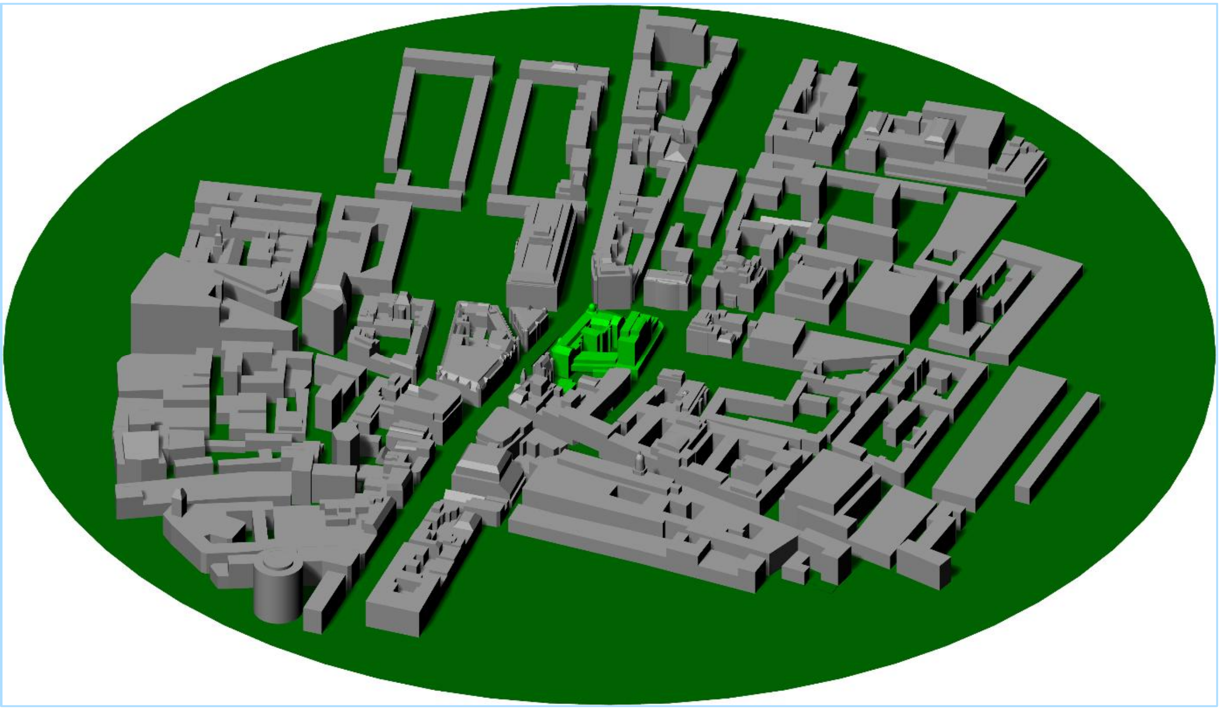

Figure 2-3. Existing Baseline Scenario- CFD model - Viewed from the southeast

2.5 Scenario 1: Existing Baseline + Proposed Development

Figure 2-4 shows the CFD model produced for the Existing Baseline + Proposed Development scenario.

The red coloured building shows the proposed development. The site immediately south is the Crossrail Headhouse building which is to be the location of a future development.

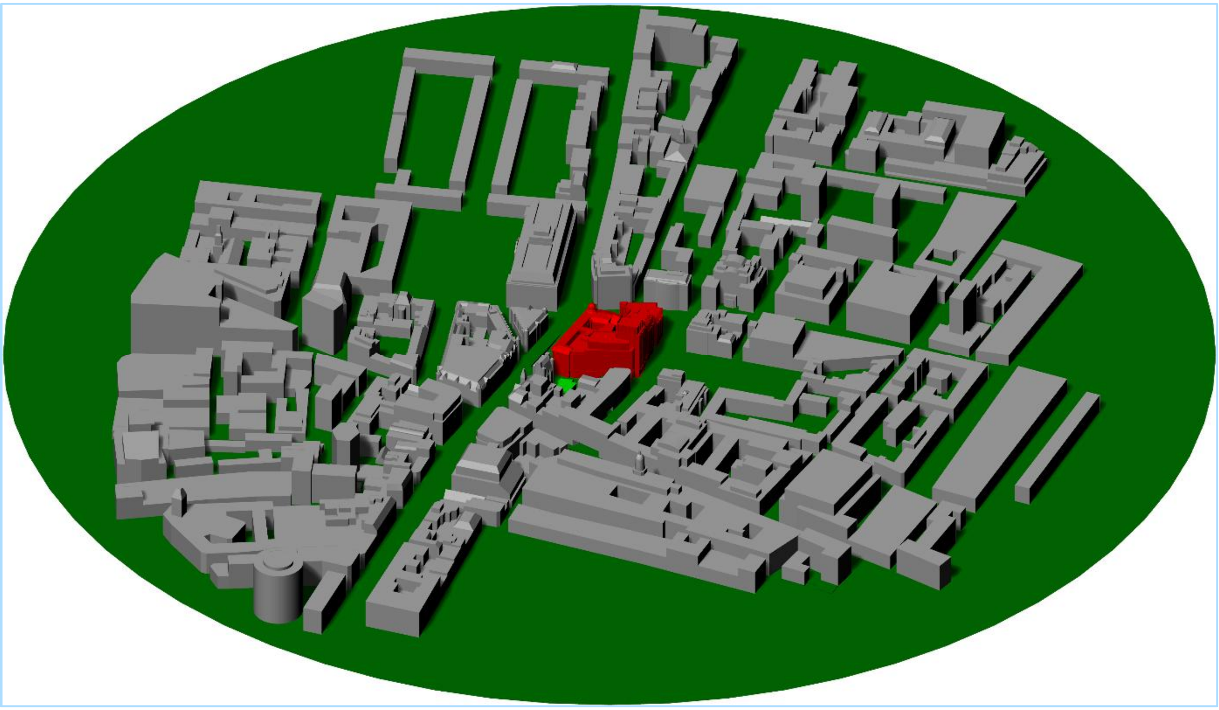

Figure 2-4. Proposed Development Scenario - CFD model - Viewed from the southeast

2.6 Scenario 2: Existing Baseline + Proposed Development + Cumulative Schemes

Figure 2-5 shows the CFD model produced for the Existing Baseline + Proposed Development + Cumulative Schemes. The blue coloured building shows the following cumulative scheme that is located within 400m of the application site:

- Crossrail over-site development, Fisher Street, London, WC1R 4AA [2013/1447/P];

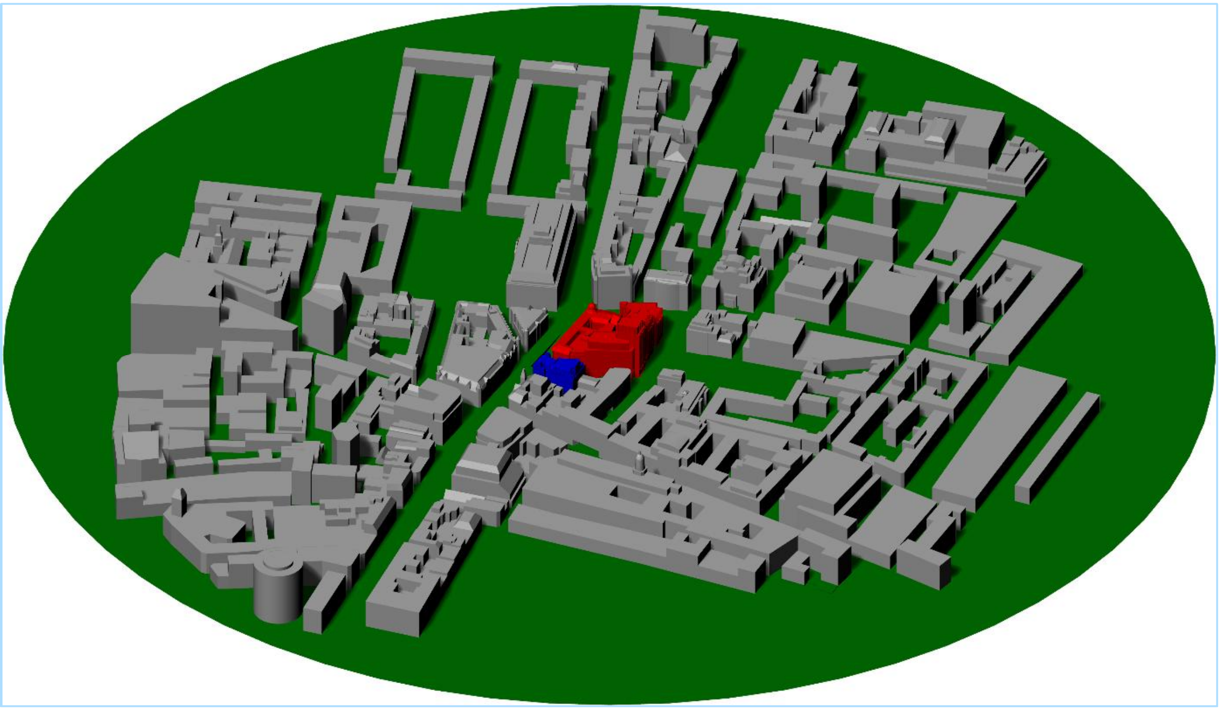

Figure 2-5. Cumulative Scenario - CFD model - Viewed from the southeast

3. ASSESSMENT CRITERIA

There is no specific national legislation or policy in the 2019 National Planning Policy Framework (NPPF)[2] dealing with microclimate. The online national Planning Practice Guidance[3] does not address these matters either. In general, there is little guidance at national level on wind effects.

Paragraph 4.1.9 of English Heritage Guidance on Tall Buildings[4] recommends that consideration be given to: "The effect on the local environment, including microclimate, overshadowing and night time appearance, vehicle movements and the environment and those in the vicinity of the building."

The London Plan[5] (and new draft London Plan[6]) contains general comments about enhancing the environment, open spaces (both public and private) and consideration of impacts on the local wind microclimate.

The London Borough of Camden (LBC) have recently published guidelines[7] for the assessment of wind microclimates for developments within the Borough. The purpose of these guidelines is to ensure that appropriate standards are met in the design of buildings and outdoor features to ensure that suitable safety and comfort levels are achieved in terms of wind and the microclimate. They also state that where poor wind conditions already exist reasonable attempts must be made to improve conditions.

Buildings proposed on exposed sites with large frontages to southwest or northeast tend to be the ones that are most sensitive to wind issues. Also, building near frequently used areas (e.g. train stations) or those that may be used by vulnerable pedestrians (e.g. hospitals and schools) require careful attention. Therefore, a degree of judgement has to be exercised, but the following general advice can provide a guideline for typical office or residential buildings. At the early stage of developing a scheme, bulk, height and massing options for the site need to be thoroughly assessed to avoid the need for retrospective mitigation measures. The Lawson Criteria known as the London Docklands Development Corporation (LDDC)[8] method is recommended to assess the wind conditions. The criteria have been developed to enable an assessment of the acceptability for particular activities in terms of comfort, as presented in Table 3-1.

The comfort criteria are based on the exceedance of the threshold mean-hourly wind speeds occurring less than 5% of the time. Gust speeds may be up to 85% greater than the mean speeds. The value of 5% has been established as giving a reasonable allowance for extreme and relatively infrequent winds, which are tolerable within each category. For example, if the wind speed exceeds 8m/s (metres per second) for more than 5% of the time but exceeds 10m/s for less than 5% of the time, then category C1, see Table 3-1, applies and the location would be considered windy but not necessarily unsafe. The acceptability of windiness is subjective and depends on a number of factors, most notably the activities to be performed.

[2] Ministry of Housing, Communities & Local Government, 2019. National Planning Policy Framework last updated 19 June 2019.
[3] Ministry of Housing, Communities & Local Government, 2019. Planning Practice Guidance [online], last updated 1 October 2019.
[4] English Heritage CABE, 2007. Guidance on Tall Buildings
[5] Mayor of London, 2016. The London Plan - The Spatial Development Strategy for London Consolidated with Alterations Since 2011. March 2016.
[6] Mayor of London, 2019. Draft London Plan, July 2019.
[7] Camden Planning Guidance, Amenity, Chapter 7. March 2018.
[8] T V Lawson. The Determination of the Wind Environment of a Building Complex before Construction. University of Bristol Department of Aerospace Engineering, Report Number TVL 9025. May 1990.

Table 3-1. Comfort assessment criteria

Comfort rating		Threshold mean-hourly wind speed exceeded for <5% of the time
C1+	Uncomfortable for all users	>10m/s
C1	Fast or business walking	10m/s
C2	Strolling or window shopping	8m/s
C3	Short periods standing or sitting	6m/s
C4	Long periods of standing or sitting	4m/s

The conditions described are the limiting criteria for comfort for the various activities. i.e. it will be more frequently comfortable to stand in an area classified as 'occasional sitting' than one classified as 'walking'. Clearly it may be comfortable to sit at times in an area classified as 'standing', but this would not be the norm. The LDDC comfort criteria are derived for open air conditions where it is expected that pedestrians will be suitably dressed for the season.

For the safety criteria, once per annum equates to a seasonal threshold exceedance of 0.025%. A mean-hourly wind speed greater than 15m/s but less than 20m/s occurring once a year is classified as unsuitable for general public which includes the elderly, cyclists and children. Able-bodied users are those determined to experience distress when the mean-hourly wind speed exceeds 20m/s once per year. Gust speeds may be up to 85% greater than the mean speeds. The criteria have therefore been developed to enable an assessment of the acceptability for particular users in terms of safety as presented in Table 3-2.

Table 3-2. Safety assessment criteria

Safety rating		Threshold mean-hourly wind speed exceeded once per annum
S1	Unsuitable for All the General Public	>20m/s
S2	Unsuitable for Frail Persons and Cyclists	>15m/s and <20m/s
S3	Safe for All the General Public	<15m/s

Such safety criteria indicate the potential for danger during normal pedestrian activity, for example, a pedestrian crossing on a busy road, where the consequences of being blown over would be very serious. Other examples include access ways to hospitals and schools where the local pedestrian population is unlikely to cope safely with extreme winds.

A significant impact that is considered to be of major significance for the purposes of this assessment are effects which impact the safety of the receptors i.e. that exceeds the safety criteria in Table 3-2. These types of impacts will require detailed and careful mitigation.

Moderate and minor impacts are not considered to cause significant effects; however, in order to reduce the impacts further and improve the comfort of receptors, mitigation measures to reduce the effects from moderate to minor have been specified as appropriate. (refer to Table 3-3)

Neutral/Negligible impacts represent the case of no or minimal impact on conditions likely to be experienced.

The criteria used to assess the magnitude of the wind impacts are as follows:

- Adverse – detrimental or negative impacts to a receptor compared with the baseline.
- Beneficial – advantageous or positive impact to a receptor compared with the baseline.

Table 3-3. Significance Criteria

Impact	Description
Major	Any impact that effects safety
Moderate	Any impact affecting pedestrian comfort where conditions change from suitable for existing activities to unsuitable for proposed activities be considered moderate and vice versa for positive impacts.
Minor	Conditions that are marginal with respect to the criteria or criteria are met during key seasons only.
Negligible	Conditions that meet the criteria during all seasons.

Sensitive receptors in respect of wind and microclimate are typically occupants and users of the site and buildings, as well as those on the adjacent public highways.

4. CFD METHODOLOGY

To identify the likely effect of the proposed development on the pedestrian level wind environment, three 3D CFD models of the proposed development and surrounding site was created. This section describes the methodology for the creation of these models and the inputs used and their solution.

4.1 Computational Fluid Dynamics (CFD)

Simulations of the microclimate were conducted using ANSYS CFX CFD software, run on a PC based multi-core HPC platform. CFD simulation of likely wind patterns requires the generation of a three-dimensional computer model of the site and surrounding buildings. A 3D model of the buildings and site was provided by the project's Architect. This was rationalised and defeatured appropriately for CFD modelling of the atmosphere, along with a 3D model of the surrounding urban area to construct a 3D model using Rhinoceros 3D geometric modelling software.

The computational process involves the solution of fundamental equations of fluid motion within the CFD software. A computational 'mesh' was created to represent the geometry by dividing the domain into a large number of cell volumes. During the simulation, the values of each variable are determined in each cell of the mesh and so a comprehensive assessment of velocity and scalar variation within the calculation domain is obtained.

The dependent variables are as follows:

- Wind velocities in the three co-ordinate directions (X, Y, Z)
- Turbulence Intensity (Iz)
- Turbulence Length Scale (Lz)

To improve the resolution of the results, the mesh was concentrated in the areas of most interest (at pedestrian level around the proposed development) and around any significant small-scale flow features. In these areas a maximum cell size of 1m was used. This ensures greater accuracy of the variables under investigation. Preliminary runs were carried out and further cells incorporated to ensure consistent results are achieved. The mesh statistics are presented in Table 4-1.

Table 4-1. Mesh Statistics

Cell Type	Scenario 0	Scenario 1	Scenario 2
Total number of Elements	16 799 489	19 403 084	19 402 484
Total number of Tetrahedrons	15 784 471	18 379 151	18 379 732
Total number of Prisms	1 013 645	1 020 770	1 019 595
Total number of Faces	1 288 440	1 572 851	1 574 092

4.2 Boundary Conditions

A 500m radius cylindrical computational domain was used for this study and 400m for surrounding development. This allows the wind direction to be altered without changing the computational mesh. Around the perimeter of the domain, a profile for the velocity and turbulence parameters was specified to consider how the wind speed changes with the height from the ground.

4.3 Wind Boundary Layer Profile

Accurate specification of the boundary layer wind profile is crucial in correctly simulating the pedestrian level wind environment. For this reason, a logarithmic profile was assumed, which creates a wind boundary layer profile based on the assumption that wind speed increases proportionally with the natural logarithm of the height from the ground. The upstream logarithmic velocity profile has been applied for the simulations. The applied velocity profiles are mean-hourly winds exceeded for less than 5% of the time, which are representative of extreme and relatively infrequent winds.

4.4 Building and Terrain Surfaces

Surfaces within the model were specified as having 'no slip'. This condition ensures that flow moving parallel to a surface is brought to rest at the point where it meets the surface. To improve the resolution of the results, the mesh was concentrated in the areas of most interest and around any significant small-scale flow features. This ensures greater accuracy of the variables under investigation. Cell inflation was used to 'grow' the cell sizes away from the ground plane with the first cell being 0.2m thick. This was to ensure that there are several cells included below the 1.5m pedestrian height plane.

The highest wind speeds experienced in England tend to occur during winter, when deciduous trees are leafless. Although the presence of a particular tree might conceivably cause an acceleration of flow in one localised region under a specific scenario, its overall effect on the pedestrian environment will be to reduce the average velocity experienced. As a result, the omission of trees from the models around the proposed buildings may be considered to be an appropriate conservative measure.

4.5 Solution Technique

The model domain was solved using the steady state Reynolds Averaged Navier-Stokes (RANS) equations. The RANS equations are primarily used to describe turbulent flows. The CFD solution technique used an iterative process to continually improve on a solution. The code then continued repeating the solution until convergence was reached. The solution is said to be converged when predicted velocity at all locations becomes steady within a predefined tolerance. The solution is a steady state approximation of the mean and turbulent flows within the model domain.

4.6 Transient Effects

Although this analysis is steady state it is possible to gain a qualitative understanding of transient turbulent effects from the results. The steady state turbulence model used calculates the turbulent kinetic energy which is a prediction of the average turbulent velocity fluctuations. The velocity fluctuations have been included in this current Lawson study as Gust Equivalent Mean (GEM) velocities calculated as GEM = Gust Velocity/1.85. The gust velocities have been calculated using the following standard formula:

$$\text{Gust Velocity} = V_m(1 + g.I)$$

Where:- V_m = Mean Wind Velocity
g = Gust Factor = 3.0
I = Turbulence Intensity

4.7 Analysis Models

Three Ansys CFX models were created for this CFD study:

- CFX00 - Scenario 0: Existing Baseline
- CFX01 - Scenario 1: Existing Baseline + Proposed Development
- CFX02 - Scenario 2: Existing Baseline + Proposed Development + Cumulative Schemes

5. SPECIFICATION OF WIND PROPERTIES

5.1 Wind characteristics

Wind environment studies require that the wind speed obtained from measurement stations is transposed to the site of interest. Statistical properties of the wind climate are typically characterized by a Weibull probability density function. A Weibull distribution was fitted to hourly wind speed data based on combined data from three London Airports (Heathrow, Gatwick and Stanstead. This data comprises hourly mean wind speed measurements between 01/01/1995 and 31/12/2019. From the Weibull Cumulative Distribution Function (CDF) the probability Pv that, for a given wind speed V, will be exceeded is given by:

$$P_v = p.e^{-(V/c)^k}$$

Where: p is the direction parameter, c is the dispersion parameter and k is the shape parameter.

These are reproduced here in Table 5-1 below.

Table 5-1. Weibull Parameters as Southampton Row

Wind direction [°]	Annual			Summer			Winter		
	p	k	c	p	k	c	p	k	c
0	0.046	2.062	2.724	0.040	2.088	2.587	0.040	2.044	2.677
22.5	0.052	2.126	2.784	0.041	2.225	2.641	0.049	2.037	2.854
45	0.054	2.203	3.133	0.044	2.357	2.836	0.052	2.137	3.442
67.5	0.052	2.066	2.960	0.043	2.168	2.740	0.046	1.905	3.121
90	0.040	2.057	2.908	0.039	2.140	2.901	0.034	1.952	2.845
112.5	0.029	2.273	3.097	0.028	2.358	3.109	0.025	2.193	2.971
135	0.033	2.373	2.945	0.027	2.455	2.768	0.032	2.326	3.012
157.5	0.041	2.188	3.052	0.032	2.266	2.852	0.044	2.087	3.313
180	0.065	2.141	3.342	0.056	2.275	3.074	0.071	2.075	3.708
202.5	0.108	2.063	3.750	0.117	2.213	3.437	0.113	2.043	4.218
225	0.137	2.115	3.873	0.157	2.276	3.526	0.149	2.100	4.399
247.5	0.101	2.074	3.785	0.113	2.286	3.405	0.108	2.070	4.324
270	0.080	1.994	3.248	0.091	2.229	3.152	0.082	1.881	3.554
292.5	0.059	1.957	2.781	0.064	2.201	2.641	0.059	1.871	3.114
315	0.055	1.929	2.556	0.060	2.098	2.456	0.051	1.833	2.799
337.5	0.048	1.979	2.595	0.047	2.097	2.445	0.044	1.897	2.715

To obtain an understanding of the general wind conditions at Southampton Row the provided data has been re-analysed to obtain the Weibull parameters which are applicable for all winds irrespective of wind direction. The fitted Weibull cumulative distribution function (CDF) together with the related probability density function (PDF) is presented in Figure 5-1 for annual winds and Figure 5-3 for summer and winter winds. The summer and winter seasons represent the calmest and windiest seasons as shown in Table 5-2.

Table 5-2. Seasonal wind speeds at Southampton Row [m/s]

Season	All Year	Summer	Winter
5% Exceedance wind speed [m/s]	5.611	5.091	6.386

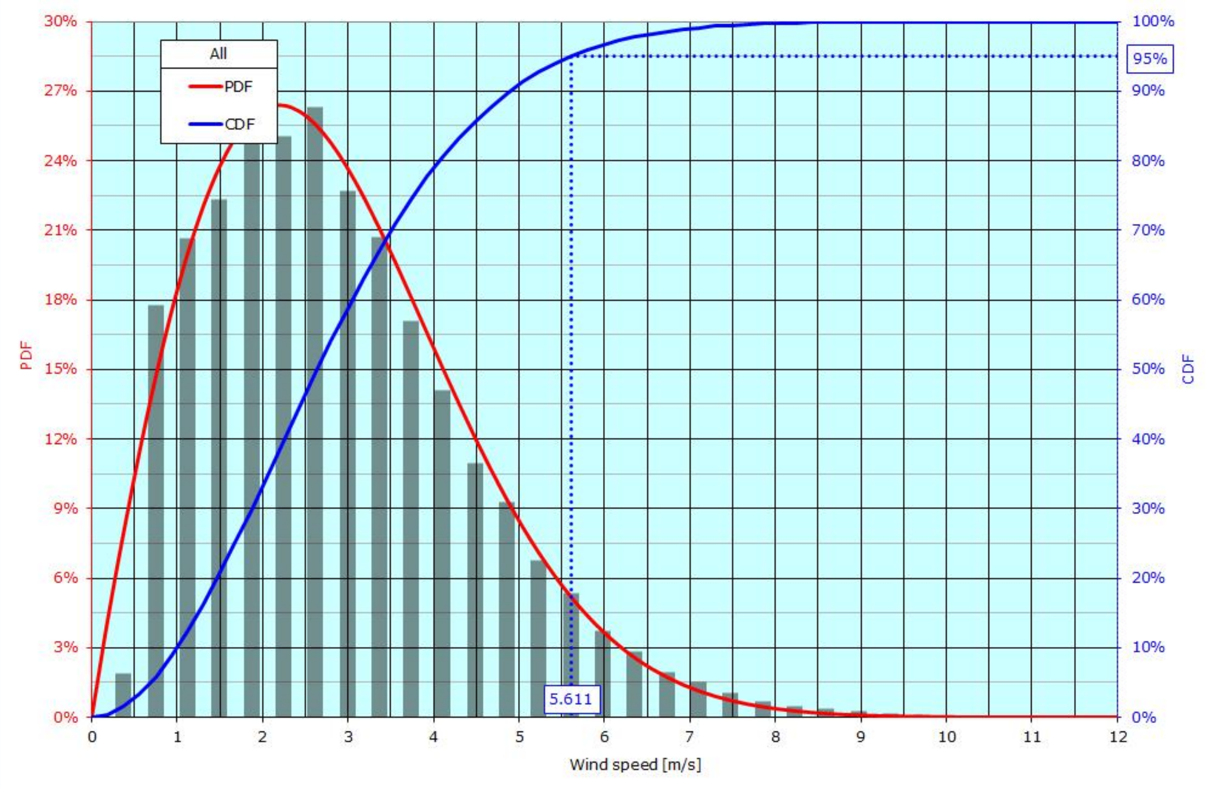

Figure 5-1. Annual wind speed probability distribution at Southampton Row [%]

Also calculated are the wind roses for Southampton Row at 30° wind segments. These are presented in Figure 5-2 for annual winds and Figure 5-4 for summer and winter winds. As can be seen the predominant wind direction is from the south-west.

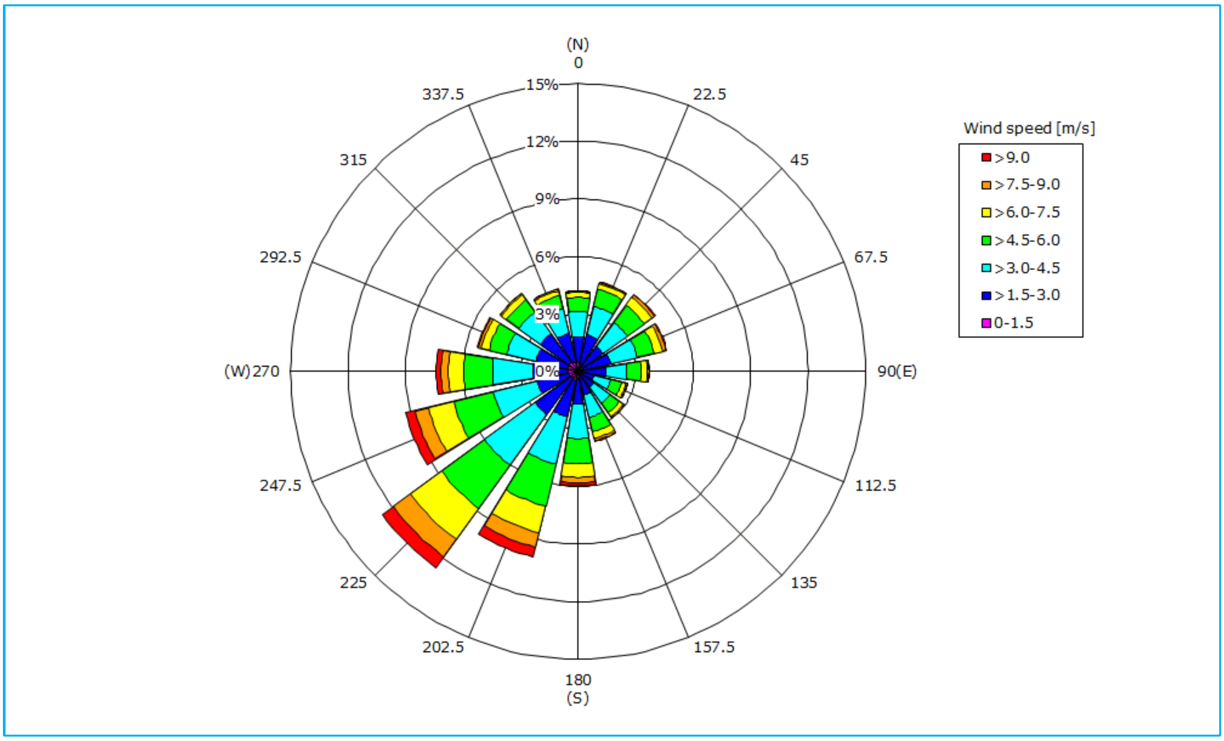

Figure 5-2. Annual wind directional probability distribution at Southampton Row [%]

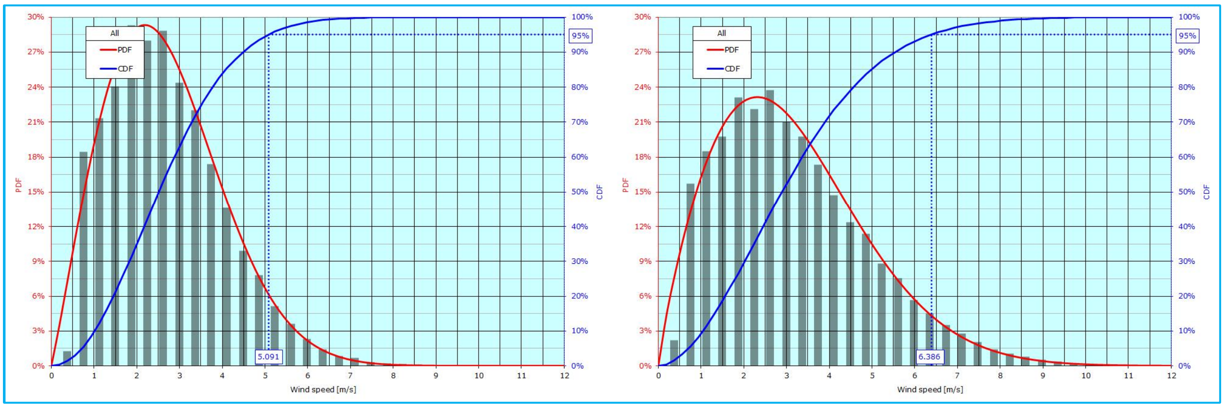

Figure 5-3. Annual wind Speed Probability. Summer (left) and winter (right) [%]

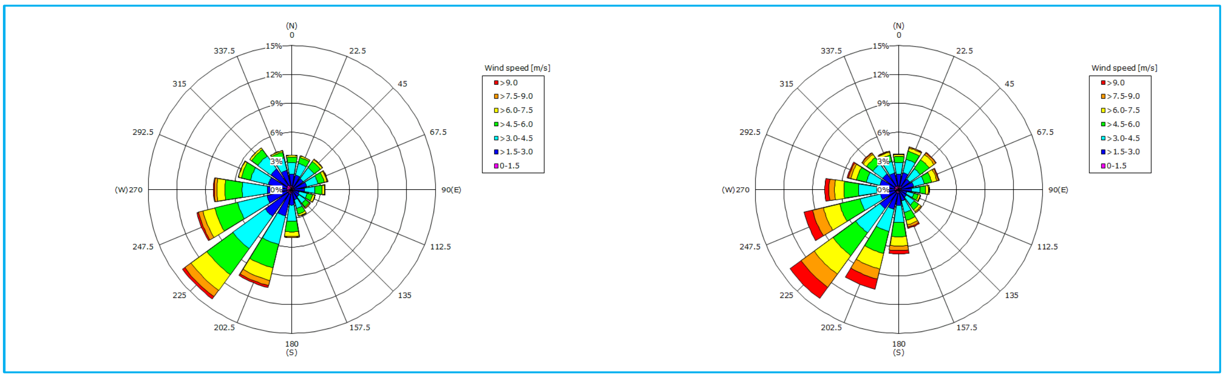

Figure 5-4. Directional probability distribution. Summer (left) and winter (right) [%]

5.2 Wind Profile

Mean wind speed profiles were calculated for 16 wind directions using industry standard descriptions of the atmospheric boundary layer in ESDU data item 01008[9]. The data item takes account of the variation of the upwind topography and terrain in each wind direction to define the wind profiles at the site. The 0° wind direction is chosen to coincide with north, with east at 90°, south at 180° and west at 270°. The wind angle denotes the direction from which the wind is blowing. The calculations were repeated for the summer (June-August) and winter (December-February).

[9] ESDU 01008. Computer program for wind speeds and turbulence properties: flat or hilly sites in terrain with roughness changes.

6. DISCUSSION

6.1 General Discussion

The strongest most frequent winds at the site for all times of the year blow from the southwest quadrant. The winds are generally warm and wet. Almost all cases of serious annoyance due to strong winds around buildings are caused by these winds. Winds from the southeast are generally light, warm in the summer, cold in the winter and are generally associated with dry conditions. These are rarely associated with annoying ground level winds and this is also the least frequent wind direction.

Winds from the northwest can be as strong as those from the southwest but are less frequent. They are relatively cold and can bring snow in winter. Conversely, northeast winds are almost as common as the southwest winds during the spring but are weaker. They are often associated with cold dry conditions and poor internal conditions, due to cold air infiltration through doors. Northeast winds may be more unpleasant than suggested by their strength due to the lower than average air temperature.

The three most common effects to understand that are reported in this type of assessment that result in accelerated wind speeds are:

- Downwash - Wind flows are induced downward to street level. A simple rectangular building will have a zone of increased wind speed at the base of its windward face, due to downwash. The taller the building, the greater the pressure difference driving the wind.
- Funnelling – Can occur when street ends are open to the prevailing winds and narrow towards the end or when the proposed buildings are more than five storeys high, more than 100 meters long, and the upstream and downstream funnels are clear of obstructions.
- Corner effects - 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 size of 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.

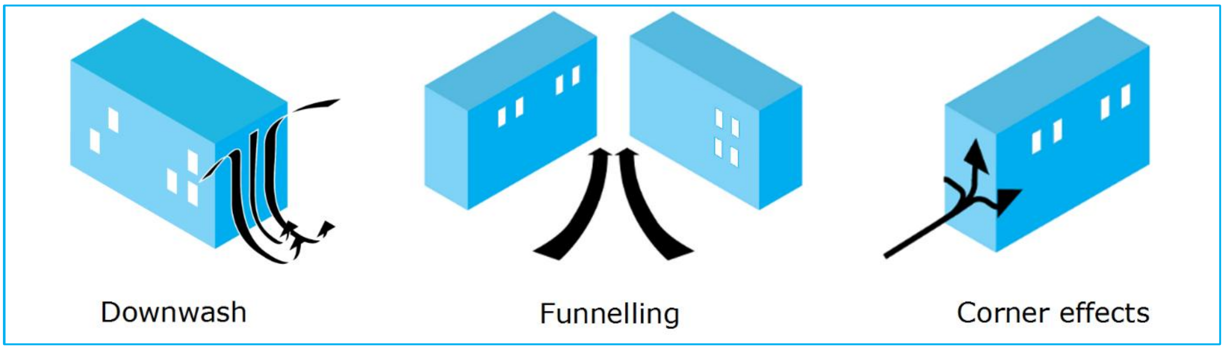

Figure 6-1. Causes of accelerated wind speeds

6.2 Wind Conditions at London

South-east England is one of the more sheltered parts of the UK, the windiest areas being in western and northern Britain, closer to the Atlantic. The strongest winds are associated with the passage of deep areas of low pressure close to or across the UK. The frequency and strength of these depressions is greatest in the winter half of the year, especially from December to February, and this is when mean speeds and gusts (short duration peak values) are strongest.

Another measure of wind exposure is the number of days when gale force is reached. If the wind reaches a mean speed of 34 knots or more over any ten consecutive minutes, then that day is classed as having a gale. Over most inland areas of the region the average is around 1-2 days per year but exposed places along the coast experience about 10 gales in an average year. Wind speed is sensitive to local topographic effects and land use. Places sheltered by hills or in extensive urban areas will have lower mean wind speeds and fewer days of gale, but can have strong gusts.

The direction of the wind is defined as the direction from which the wind is blowing. As Atlantic depressions pass the UK the wind typically starts to blow from the south or southwest, but later comes from the west or north-west as the depression moves away. The range of directions between south and north-west accounts for the majority of occasions and the strongest winds nearly always blow from this range of directions. Springtime tends to have a maximum frequency of winds from the north-east. Coastal areas experience sea breezes from late spring through the summer, caused by the temperature differential between the sea and the warmer land. These sea breezes will often reach London, originating from either the North Sea or, occasionally, the English Channel.

6.3 Priority Areas

The priority areas for this study of outdoor wind comfort are chosen to be those visited most often by people, either pedestrians and cyclists, accessing the building or using landscaped grounds. A site plan showing priority outdoor areas is presented in Figure 6-2. The priority areas are as follows:

- Main Entrances
- Main Staff Entrances
- Secondary Entrances
- Secondary Staff Entrances
- Pedestrian Movements - Through Courtyard
- Pedestrian Movements - Through Orange Street
- Pedestrian Crossings – Drake Street
- Pedestrian Crossings – Theobald's Road
- Pedestrian Crossings – Southampton Row

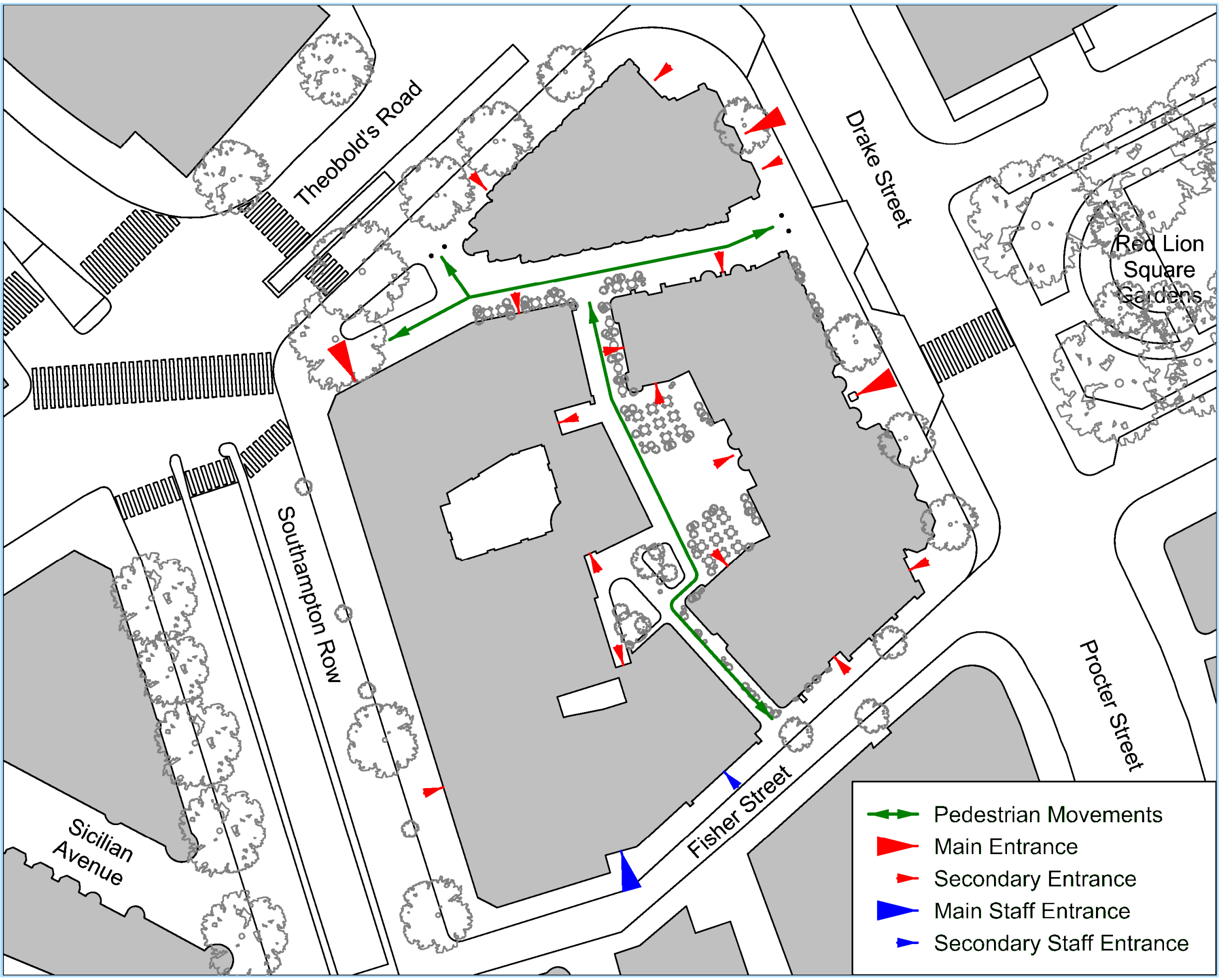

Figure 6-2. Development Site Plan – Showing site access

6.4 CFD analysis results – Existing Baseline Scenario

The baseline condition is the existing application site. The results of the CFD derived comfort ratings are presented in Figures 6-3 and 6-4.

Results are presented for the calmest season, which is typically representative of the Summer season in London (June, July and August), conditions have also been presented for the windiest season, which is typically representative of the winter season (December, January and February). This is because the majority of pedestrian activities defined by the LDDC Comfort Criteria need to be met during the windiest season (such as thoroughfares, entrances, bus stops, etc.); whereas amenity spaces are assessed for the summertime conditions when they are more frequently used.

The results of the CFD derived annual safety rating is presented in Figure 6-5.

All the ratings are derived from the maximum of hourly-mean and Gust Equivalent Mean (GEM) wind speeds. A site plan showing site access and entrances is presented in Figure 6-2. The red line denotes the development site boundary.

Figure 6-3. Existing Baseline Scenario - Summer LDDC Comfort Rating

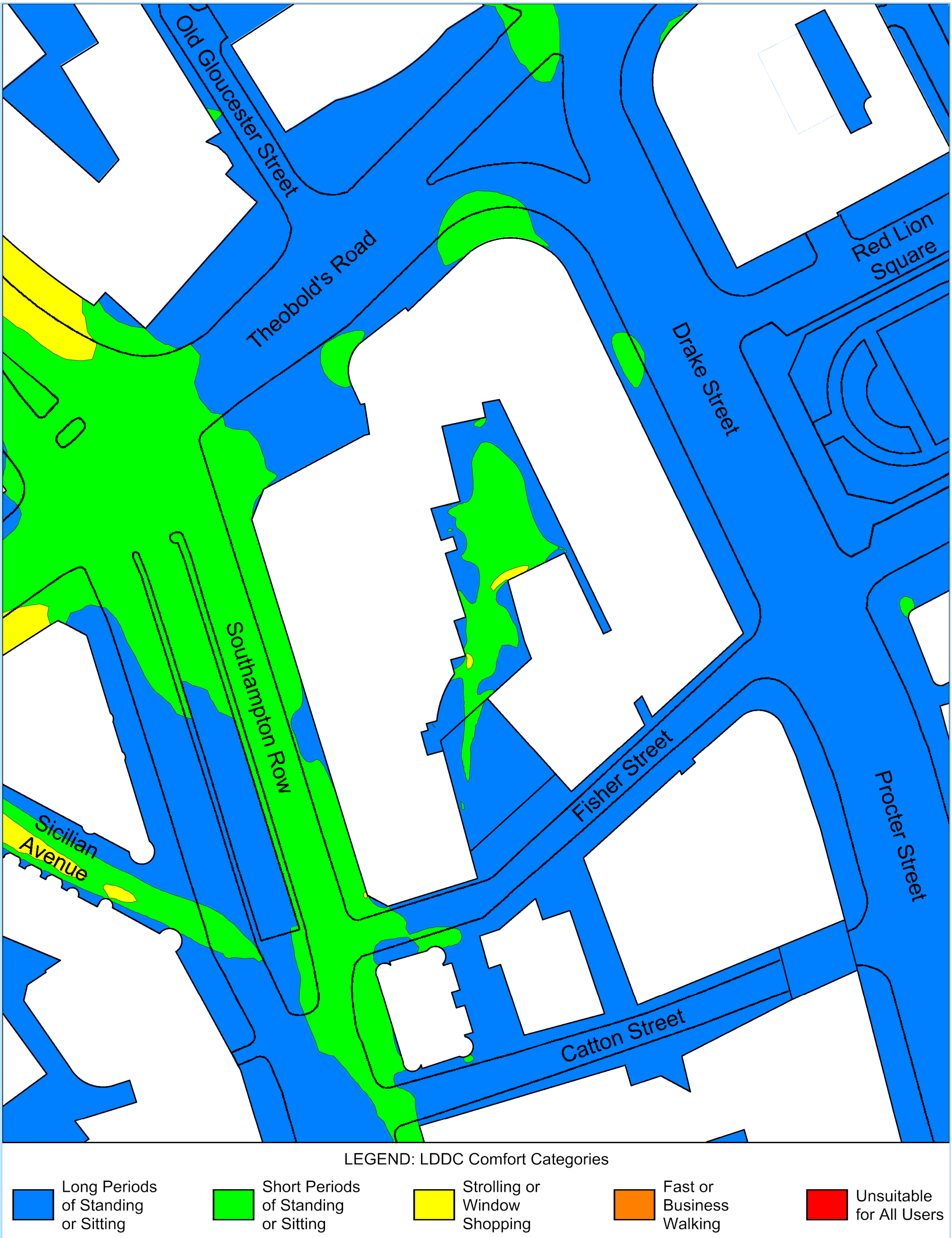

Figure 6-4. Existing Baseline Scenario - Winter LDDC Comfort Rating

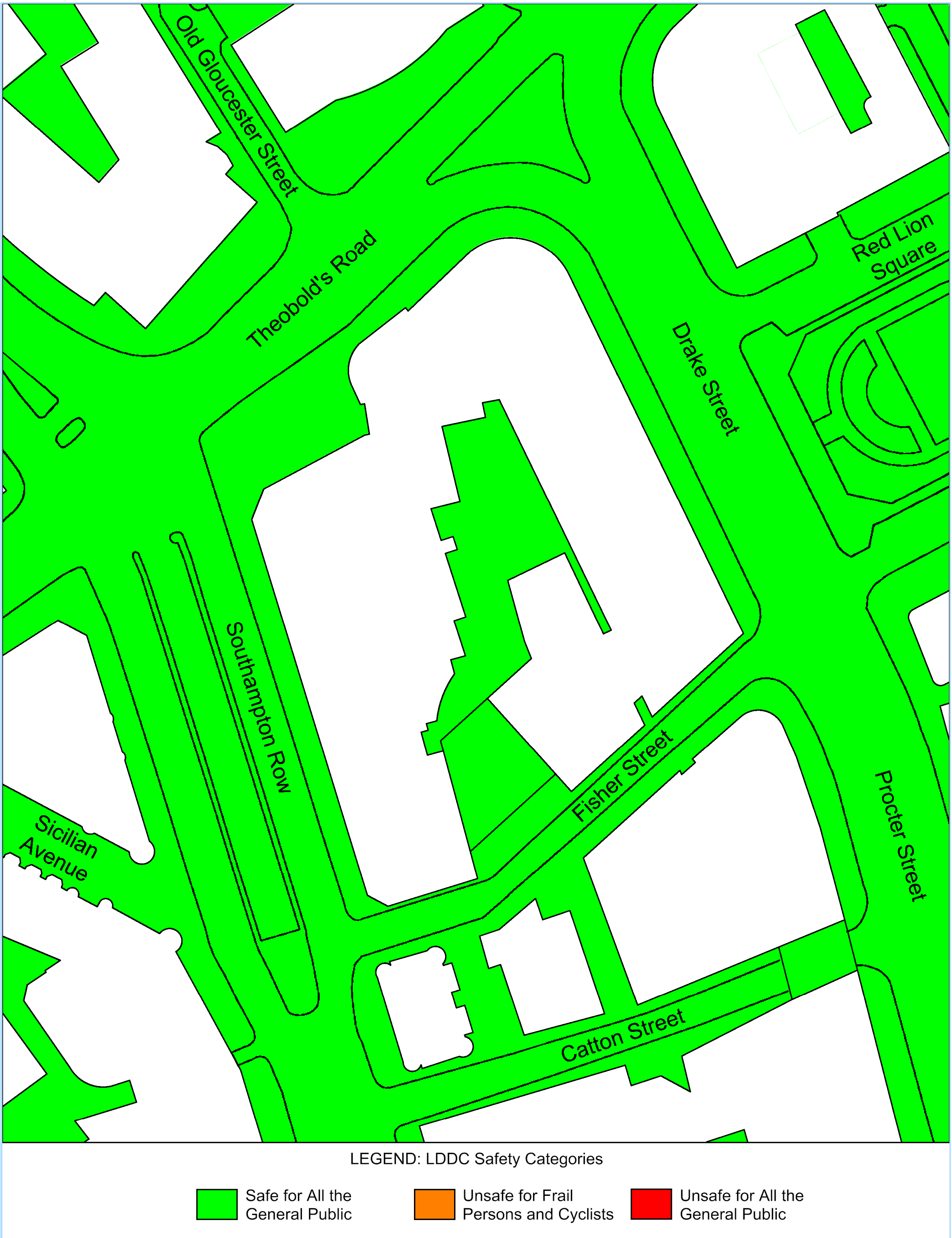

Figure 6-5. Existing Baseline Scenario - Annual LDDC Safety Rating

6.5 CFD analysis results – Proposed Development Scenario

The results of the CFD derived comfort ratings are presented in Figures 6-6 and 6-7.

Results are presented for the calmest season, which is typically representative of the Summer season in London (June, July and August), conditions have also been presented for the windiest season, which is typically representative of the winter season (December, January and February). This is because the majority of pedestrian activities defined by the LDDC Comfort Criteria need to be met during the windiest season (such as thoroughfares, entrances, bus stops, etc.); whereas amenity spaces are assessed for the summertime conditions when they are more frequently used.

The results of the CFD derived annual safety rating is presented in Figure 6-8.

All the ratings are derived from the maximum of hourly-mean and Gust Equivalent Mean (GEM) wind speeds. A site plan showing site access and entrances is presented in Figure 6-2.

Figure 6-6. Proposed Development Scenario - Summer LDDC Comfort Rating

Figure 6-7. Proposed Development Scenario - Winter LDDC Comfort Rating

Figure 6-8. Proposed Development Scenario - Annual LDDC Safety Rating

6.6 CFD analysis results – Cumulative Scenario

The results of the CFD derived comfort ratings are presented in Figures 6-9 and 6-10.

Results are presented for the calmest season, which is typically representative of the Summer season in London (June, July and August), conditions have also been presented for the windiest season, which is typically representative of the winter season (December, January and February). This is because the majority of pedestrian activities defined by the LDDC Comfort Criteria need to be met during the windiest season (such as thoroughfares, entrances, bus stops, etc.); whereas amenity spaces are assessed for the summertime conditions when they are more frequently used.

The results of the CFD derived annual safety rating is presented in Figure 6-11.

All the ratings are derived from the maximum of hourly-mean and Gust Equivalent Mean (GEM) wind speeds. A site plan showing site access and entrances is presented in Figure 6-2.

Figure 6-9. Cumulative Scenario - Summer LDDC Comfort Rating

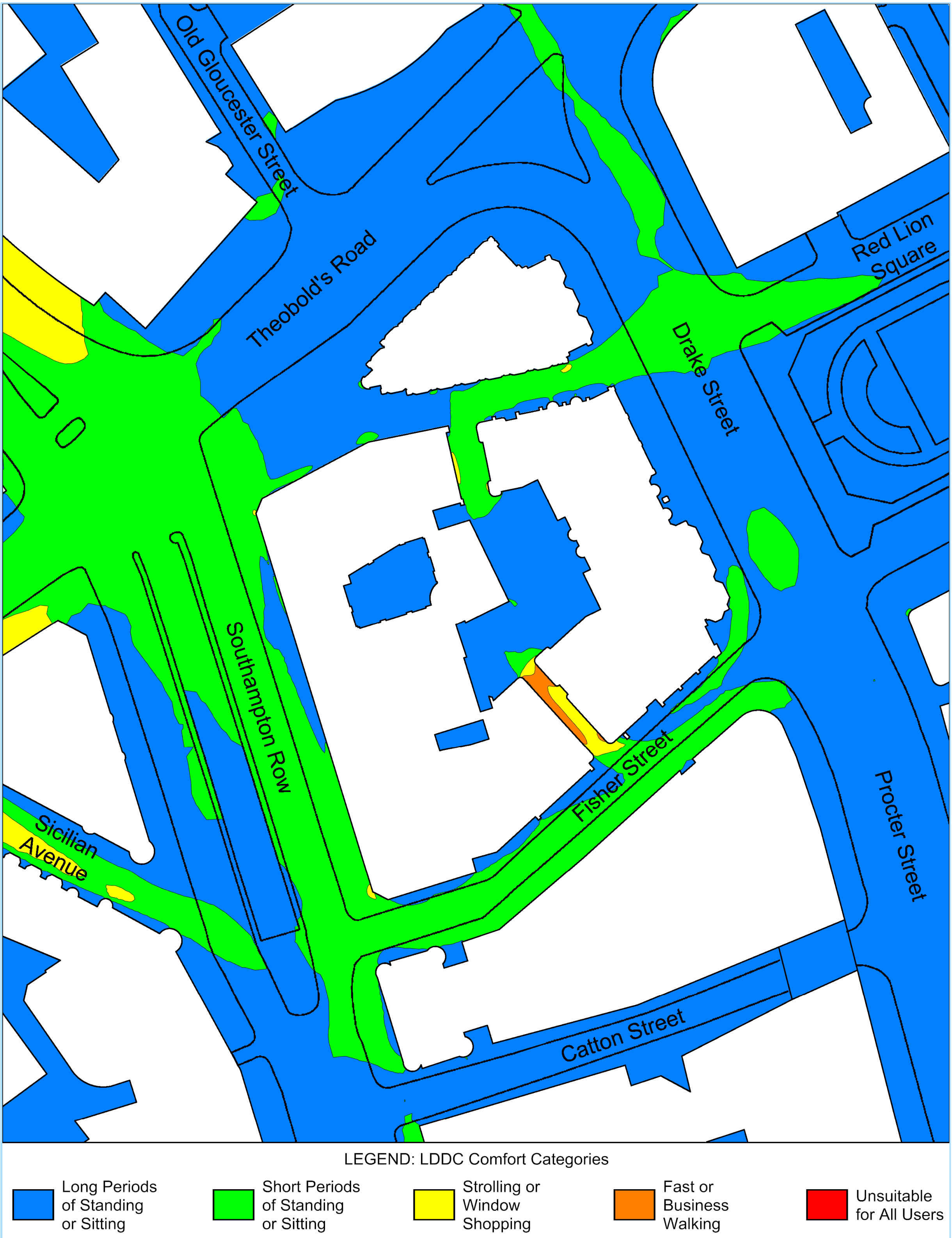

Figure 6-10. Cumulative Scenario - Winter LDDC Comfort Rating

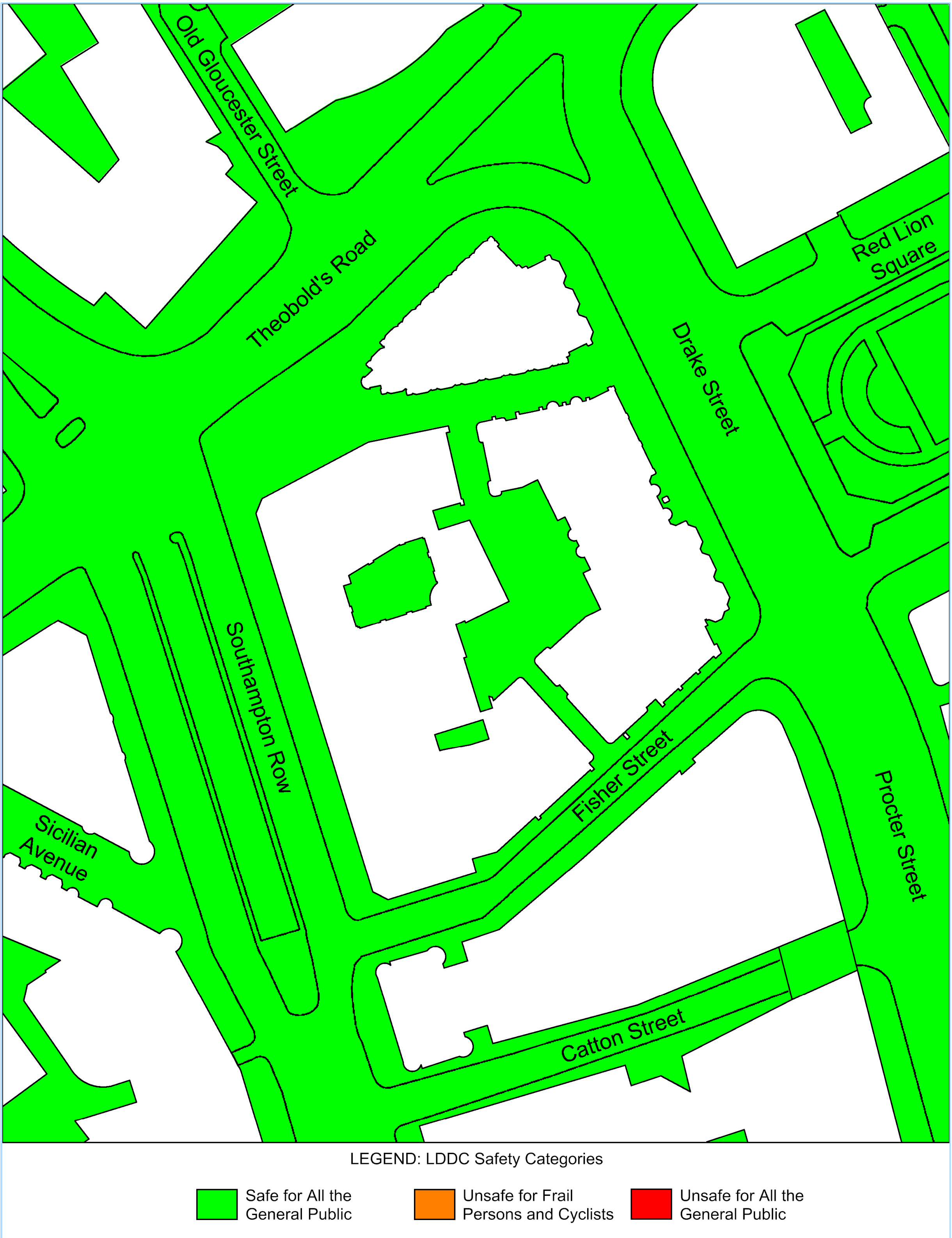

Figure 6-11. Cumulative Scenario - Annual LDDC Safety Rating

6.7 Pedestrian wind environment within the proposed development

Wind comfort will be experienced differently depending on temperature and access to the sun. There will also be individual differences in terms of how wind comfort is experienced. The outdoor areas are also used differently depending on time of day and season. Seating comfort in the outdoor areas is most important in the summer and especially in the afternoon and early evening after the end of work. The wind conditions around the entrances will be important throughout the year. When the spring sun comes it will be attractive to spend lunch time outdoors, but the temperature is still relatively low and shelter from the wind is important. A summary of the winter wind comfort in the priority outdoor areas is given in Table 6-1.

Table 6-1. Summary of winter wind comfort and safety for priority outdoor areas

Location	Comfort Rating	Safety Rating	Discussion
Main Entrances	C4	S3	Good wind comfort and safety. Conditions suitable for entrances.
Main Staff Entrances	C4	S3	Good wind comfort and safety. Conditions suitable for entrances.
Secondary Entrances	C4	S3	Good wind comfort and safety. Conditions suitable for entrances.
Secondary Staff Entrances	C4	S3	Good wind comfort and safety. Conditions suitable for entrances.
Pedestrian Movements - Through Courtyard	C4/C3 /C2	S3	Good wind comfort and safety. Conditions suitable for sitting/standing in the courtyard and covered walkway to Orange Street. Conditions suitable for passing through covered walkway to Fisher Street
Pedestrian Movements - Orange Street	C4/C3	S3	Good wind comfort and safety. Conditions suitable for sitting and standing
Pedestrian Crossings – Drake Street	C4	S3	Good wind comfort and safety. Conditions suitable for pavements/pedestrian crossings
Pedestrian Crossings – Theobald's Road	C3	S3	Good wind comfort and safety. Conditions suitable for pavements/pedestrian crossings
Pedestrian Crossings – Southampton Row	C3	S3	Good wind comfort and safety. Conditions suitable for pavements/pedestrian crossings

6.8 Site Planting

The proposed development does have some existing trees and site planting. This is shown in Figure 6-2. Planting can be effective in lifting the wind off the ground if planted in depth, or in slowing the wind if planted as windbreaks. High-crowned trees with a bare trunk to the ground will locally create increased wind under the canopy by the wind being pushed down to the ground. It is important that trees are combined with lower vegetation (shrubs and hedges) so that the wind is slowed where people are standing or sitting. Deciduous plants are only effective whilst in leaf, evergreen planting is effective all year round. Any planting can only be considered beneficial to the site conditions particularly in the covered walkway to Fisher Street.

6.9 Pedestrian wind environment adjacent to the proposed development site

As part of a good neighbour policy, it is usual to minimise adverse changes to the wind conditions on neighbouring buildings due to a development. It is the wake from an upwind tower impinging on adjacent properties that may lead to increased wind speeds for some wind directions but increased shelter for other directions. Another possible source of increased wind speeds can be due to the funnelling effect between closely spaced tall buildings.

The existing Baseline Scenario conditions are seen to vary from standing in Theobold's Road, Drake Street and Fisher Street to occasional sitting in Southampton Row and the internal courtyard.

To more easily show the effect of the Proposed Development Scenario and the Cumulative Scenario the change to the comfort wind speeds with respect to the Baseline Scenario is presented in Figure 6-12 for the Proposed Development Scenario and Figure 6-13 for the Cumulative Scenario. The blue areas show beneficial conditions whilst the red areas show adverse conditions. A change in wind speed less than 1m/s could be described as being of negligible significance whilst between 1 and 3m/s could be described as being of Minor significance. Greater than 3m/s could be described as being of moderate adverse significance and these areas will require mitigation in order for local conditions to become suitable for the intended use of the area.

The analysis reveals that at street level the conditions around the proposed development would show only a Negligible to Minor adverse effects and therefore these areas would be still be suitable for their intended use. This moderate adverse effect is located in Fisher Street and Drake Street with both the Proposed Development and Cumulative Scenarios.

6.10 Pedestrian and cyclist safety adjacent to the proposed development site

All areas adjacent to the site are rated as safe for all users.

6.11 Vehicle safety

Although the LDDC Criteria does not cover the safe passage of vehicles in strong winds the results of this study suggest that the conditions adjacent to the site will not be hazardous to vehicles.

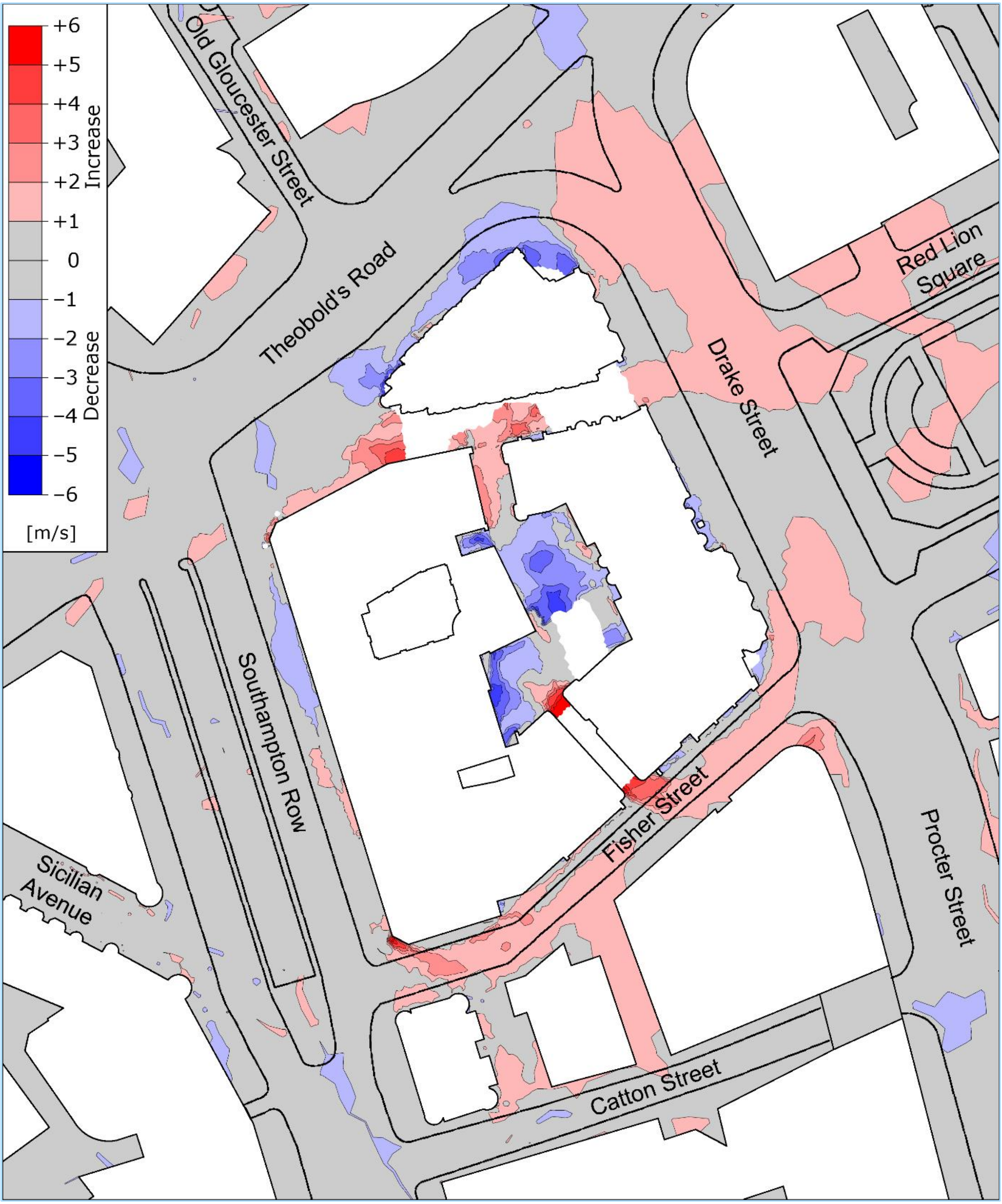

Figure 6-12. Baseline to Proposed Development change to annual comfort wind speed [m/s]

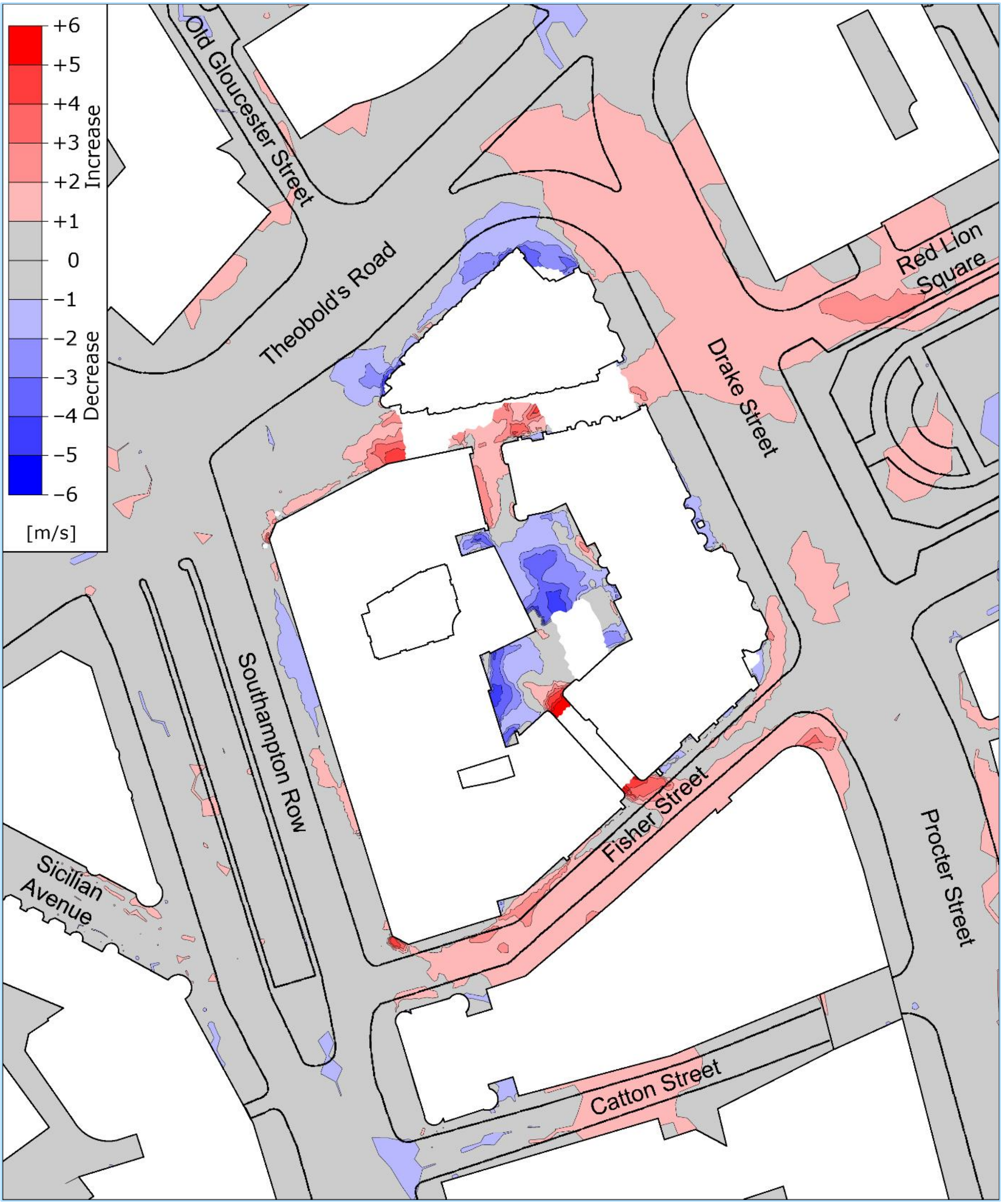

Figure 6-13. Baseline to Cumulative change to annual comfort wind speed [m/s]

7. CONCLUSIONS

A CFD study was conducted on a model of the proposed development and the nearby surrounding buildings, including cumulative schemes, in order to assess the potential wind microclimate effects arising as a result of the proposed development. The study assessed three scenarios: (i) existing baseline scenario of the current demolished application site with existing surroundings; (ii) the built proposed development with existing surroundings; and (iii) the proposed development with existing surroundings plus cumulative schemes.

The results of the wind microclimate assessment show that immediately adjacent to the proposed development at street level conditions are rated as category C4-C2 (Frequent Sitting to Standing) and would be suitable for general outdoor recreation. The application site would be windiest along the covered passageway connecting the internal courtyard with Fisher Street which has a moderate adverse effect on the wind climate of the area, as shown in Figures 6-15 and 6-16 but no mitigation is considered to be required for comfortable access through.

Table 7-1 presents the minimum comfort ratings required for various activities, and shows the proposed development to be suitable for all proposed activities. It is concluded that all areas adjacent to the application site are rated as safe for all users.

Table 7-1. Pedestrian Comfort

Comfort rating		Suitability
C1+	Uncomfortable	Not comfortable for regular pedestrian access.
C1	Walking	Acceptable for external pavements, walkways.
C2	Standing	Acceptable for entrances, bus stops, covered walkways or passageways beneath buildings.
C3	Occasional Sitting	Acceptable for occasional outdoor seating, e.g. general public outdoor spaces, balconies and terraces intended for occasional use, etc.
C4	Frequent Sitting	Acceptable for frequent outdoor sitting use, e.g. restaurant, café.