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Client:

CIP Property (AIP) Limited

Prepared by:

R. Elze

Date:

04/11/16

Edited by:

E. Healy

Date:

17/11/16

Authorised by:

P. Sciven

Date:

17/11/16

Issuing office:

London City

Desktop Microclimate Study

52-55 Friar Street & 12 Greyfriars Road
Reading

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EXECUTIVE SUMMARY

This desktop microclimate study was commissioned in response to a comment in Reading Borough Council's Pre-Application feedback letter (dated 07th September 2016) relating to the microclimate, namely the final sentence of the last paragraph on page 6:

".....you are also advised to consider microclimate matters (more specifically a wind assessment), in light of the proposed heights of buildings and the limited space between buildings at this point."

This desktop Computational Fluid Dynamics (CFD) study has been produced to consider the potential risk associated to the proposed development in relation to the wind microclimate.

The study provides an initial overview and insight into the potential wind microclimate around the proposed development at 52-55 Friar Street and 12 Greyfriars Road in Reading. The key areas of interest being reviewed are:

- Public Realm (Street Level)
- Public amenity (Roof Levels)

Two scenarios have been considered:

1. The first considers conditions around the development within the existing surroundings; that is all buildings other than those on the development site are unchanged from the current condition.
2. The second scenario considers conditions with the neighbouring proposed development located to the north and east of the Friar Street/Greyfriars Road development, referred to as Plot E of the Station Hill site and neighbouring Telecom House site, being in place. We understand this neighbouring development was granted outline planning permission in July 2016. This scenario is referred to as the 'Stanhope' scheme hereafter.

The main findings of the study are as follows:

Street Level

The predicted conditions in both cases ('Existing' and 'Stanhope') are favourable for the intended uses at street level. The 'Existing' configuration provides better conditions to the north of the site, and marginally better conditions on Greyfriars Road and Friar Street, while the 'Stanhope' results provide better conditions in the courtyard.

Roof-top

The study shows that the rooftops are viable amenity spaces. While mitigation measures such as localised screening and the provision of planting will be required, the garden areas are not subject to excessively windy conditions in either case.

The 'Stanhope' development does provide some additional shelter from north-east winds particularly for the higher gardens; however as the prevailing wind direction is from the south-east, mitigation will be required regardless of the surroundings.

The less favourable conditions on Garrard Street are considered to be due to downwash from the southern facade of the buildings to the north of Garrard Street within the 'Stanhope' development. It is stressed that these conditions are not hazardous or even excessively uncomfortable but are less favorable than without the Stanhope development.

From the study and associated Lawson Criteria results considered herein the proposed development at 52-55 Friar Street and 12 Greyfriars Road in Reading appears to be at little risk of unacceptable wind microclimate conditions occurring within the Lawson comfort criteria.

Recommendations

Whilst the general comfort conditions appear satisfactory for the proposed usages in and around the proposed Friar Street development, mitigation measures to localised areas would further improve the comfort levels, namely: roof top terraces. Localised screening such as a 1.8m to 2.1m high glazed fencing should prolong and enhance the area of comfort within the terraces. The actual screening/fencing height will need further investigation either with computational modelling or in a wind tunnel during the next stage of design.

The Stanhope development (outline planning missing) provides a degree of sheltering to the northern roof top terraces. As such there is a risk that in the event the Stanhope scheme does not get full planning permission or the mass and form changes in this area the proposed northern roof top terraces would become less comfortable. Therefore, it is recommended that mitigation screening/fencing is incorporated in these locations.

The analysis undertaken herein has predicted adequate comfort conditions generally across the site, while possible mitigation measures in areas with potential localised issues should be further investigated during detailed design.

Further Considerations

Although the methodology employed is based on the Lawson method the predicted results reported herein only consider a limited number of wind directions and as such may over or under predict the annual comfort conditions. Further, a full policy compliant planning submission may well require comparison of comfort conditions with existing conditions (that is before the 52-55 Friar Street and 12 Greyfriars Road development is constructed) which have not been considered in this study. However, it is considered unlikely that the results of the final study will be markedly different to the initial results reported herein.

Computer simulations have been carried out to estimate annual pedestrian comfort levels around the site taking into account variations in wind speed and direction throughout the year. To assess the predicted comfort levels industry recognised Lawson Criteria have been applied. Only criteria associated to comfort have been considered herein, the additional Lawson criteria considering 'distress' or potentially 'dangerous' conditions have not been considered

2.0 INTRODUCTION

2.1 General

This report has been produced to provide an overview and insight of the potential wind microclimate around the proposed development at Friar Street in Reading. The aim and intention of this study was to give an indication of the air flows at street level and the rooftop amenity areas for the prevailing wind direction to establish whether or not further consideration would be required to achieve pedestrian comfort.

The scheme proposals comprise three new medium rise buildings comprising new residential (private and affordable), office and retail uses. The built form would be lowest fronting onto Friar Street (8 storeys) stepping up as it progresses to the rear of the site (northwards). Towards the rear the built form would be 12 storeys.

The number of storeys in each residential block is as follows:

- Block A: 8 storeys
- Block B: 12 storeys
- Block C: 6 storeys

The neighbouring site to the east and north of the development site, referred to as Plot E of the Station Hill site and Telecom House, is understood to have been granted outline planning permission in July 2016 consisting of:

"Outline application with all matters reserved for mixed use redevelopment of Plot E of the Station Hill site and neighbouring Telecom House site (48 to 51 Friar Street & 4 to 20 Garrard Street) to comprise the demolition of existing buildings and erection of new buildings/structures to provide residential units, a range of town centre uses including retail and related uses (Use Class A1 - A5), associated infrastructure, public realm works and ancillary development."

The wider neighbouring Station Hill 3 site will provide approximately 475 residential units, circa 100,000m² of B1 office floor space, 11,400m² of commercial floor space and 1,800m² of D2 floor space.

This neighbouring development is referred to as the 'Stanhope' scheme hereafter for the purposes of presenting results.

Two scenarios have been considered:

1. The first considers conditions around the development within the existing surroundings: that is all buildings other than those on the development site are unchanged from the current condition.
2. The second scenario considers conditions with the neighbouring proposed development located to the north and east of the Friar Street/Greyfriars Road development, referred to as Plot E of the Station Hill site and neighbouring Telecom House site, being in place. We understand this neighbouring development was granted outline planning permission in July 2016. This scenario is referred to as the 'Stanhope' scheme hereafter.

It should be noted that this is not a complete wind microclimate study as only a limited number of wind directions have been considered. The computer model constructed to inform this report could be modified to carry out a more comprehensive and informative study ahead of

any formal Wind Tunnel test(s), if required as part of supporting the planning process and/or supporting submission material.

This report does not attempt to constitute a formal wind microclimate report for planning purposes or seek to replace a physical wind tunnel test, in any way. The study and reporting herein provides initial indications of any potential areas of concern and possible mitigation measures that could be considered to improve the local microclimate, ahead of a physical wind tunnel test being undertaken. As such this information will help to inform the architectural design to assist in improving the likely developed microclimate at Friar Street, Reading.

2.2 Form of Report

Section 3 of this document describes the physical situation, the computer modelling approach used to determine conditions within the room is discussed in Section 3. The simulations performed and results obtained are reported in Section 4 while conclusions and recommendations are made in Section 5.

3.0 METHODOLOGY AND COMPUTER MODEL

3.1 Site Arrangement

The location of the development site can be seen in Figure 3 this shows the existing site with no additional developments (namely Stanhope). The basic arrangement of the proposed development is shown in the 3D renders in Figure 4 and Figure 5. The renders show the site with the basic massing of the Stanhope development in place.

The development consists of two main blocks (A to the east and B to west). These are largely residential units with retail units at street level on Friar Street. The two blocks enclose a courtyard amenity area. Foot access to Block B is gained by passing through access passageways at ground floor level in Block A; so most users will enter the residential areas from Greyfriars Street.

Both blocks also include a number of rooftop gardens at varying levels.

The current study has concentrated on determining conditions at street level (for retail areas on Friar Street and for pedestrian access along Greyfriars Street and the comfort levels at the rooftop gardens to determine if they are viable amenity areas.

3.2 Wind Data

For the purposes of the desktop study representative meteorological data for the site has been obtained from the CIBSE DSY data sets. The nearest available data for this site are for London. For the final assessment local data for the Reading area are to be obtained from the Met Office; however it is not anticipated that the change in data set will have a significant impact on the findings of the study.

The hourly data from the DSY data are shown in the form of wind speed and directional frequency in Figure 1 and Figure 2.

Analysis of these data show that while the average wind speed is 3.8m/s the 50th percentile wind speed is just below 3m/s, however wind speeds of up to 12.5m/s can occur in a typical year.

The wind direction frequencies in the DSY are plotted in Figure 2. These are typical of most of the UK, with the prevailing wind blowing from the south-west. Wind blows from this quarter for 41% of the year, with winds from the north-east being the next most frequent at 25%. Winds from the south-east quarter are the least frequent at 13% of the year.

For the Lawson analyses (Section 4) the 95th percentile wind speed for each wind direction band have been calculated and used to define the boundary conditions for the simulations.

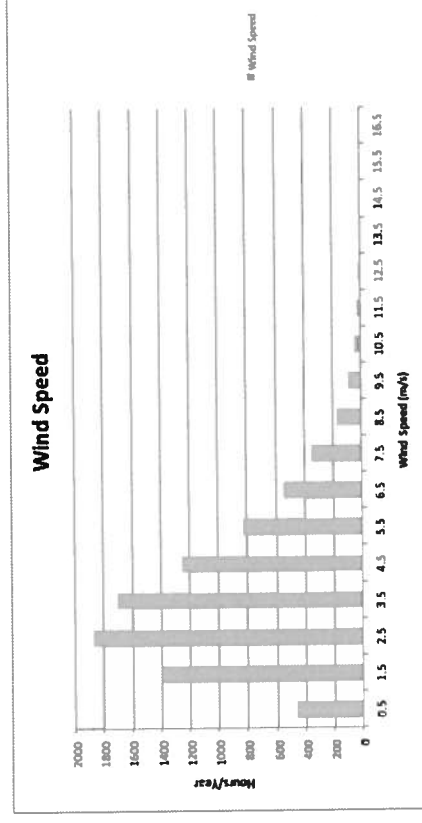


Figure 1 – Wind Speed Frequency Data

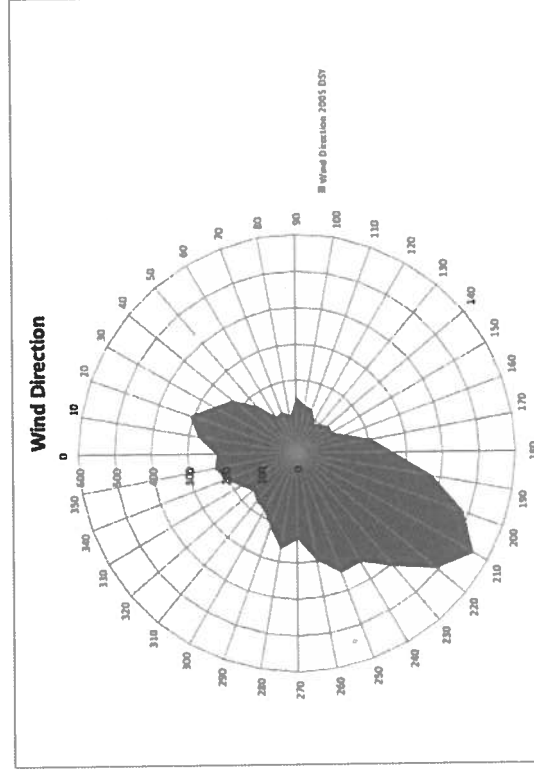


Figure 2 – Wind Direction Frequency Data

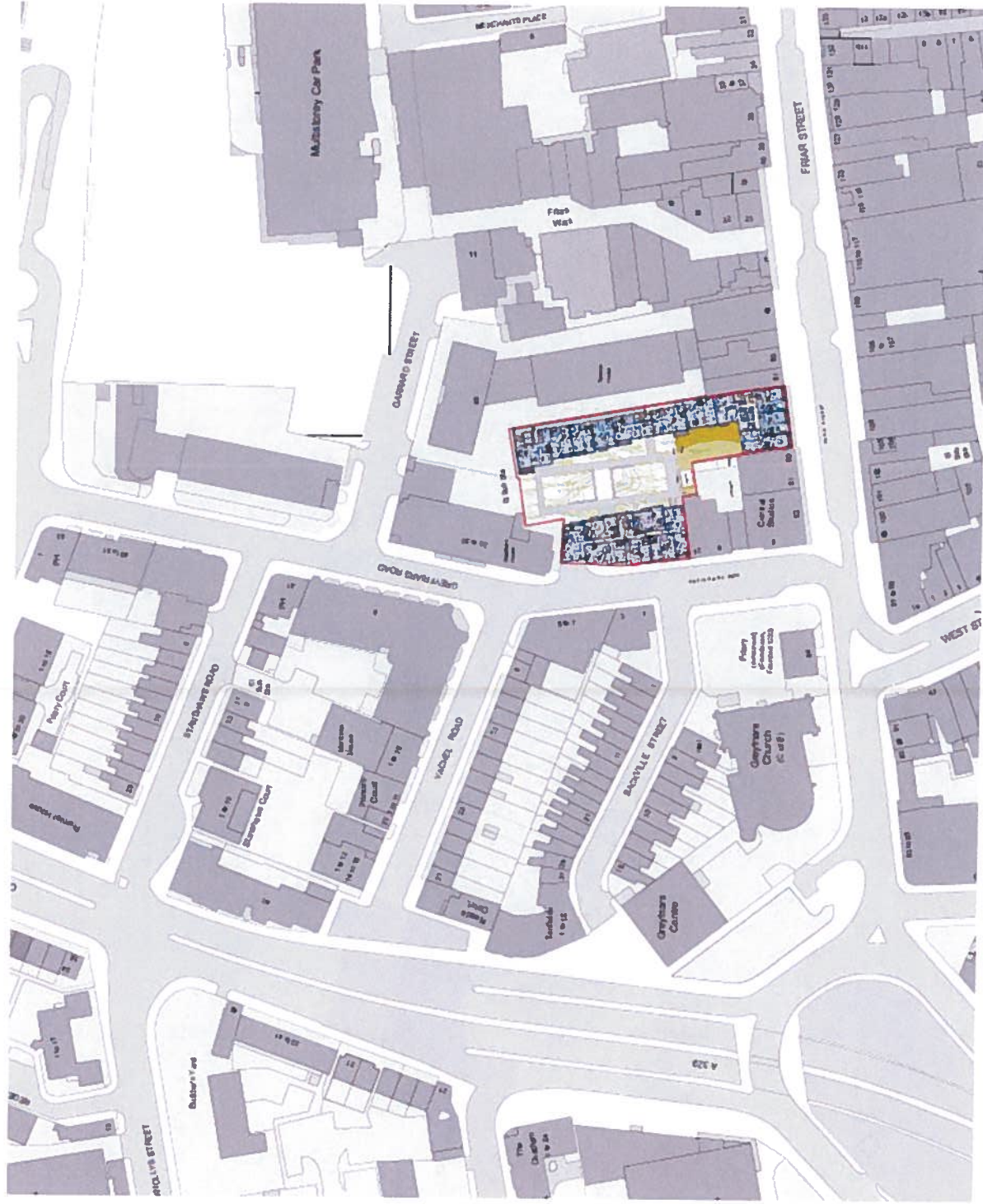


Figure 3 – Proposed Development 'Existing' Surroundings



Figure 4 – Proposed Development 3D View with 'Stanhope' Massing



Figure 5 – Proposed Development 3D View with 'Stanhope' Massing

3.3 CFD Modelling

CFD modelling involves the solution of the fundamental equations of fluid motion using numerical techniques. This is achieved by sub-dividing the region of interest into a mesh of many small volumes or cells, within which the basic (Navier-Stokes) equations are solved numerically. Typically, partial differential equations are solved for the conservation of fluid mass, momentum and energy. Closure of these equations is obtained by using a two-equation k-ε turbulence model.

The dependent variables are as follows:

- Velocities in the three co-ordinate directions (U, V, W)
- Pressure (P)
- Turbulence Kinetic Energy (k)
- Turbulence Dissipation Rate (ε)

During the simulation the values of each variable are determined in each cell and so a comprehensive assessment of velocity pressure and turbulence within the calculation domain is obtained. To improve the resolution of the results the mesh is concentrated about the areas of most interest, this ensures that gradients of velocity and pressure are modelled within reasonable accuracy.

For the purposes of the current study only steady-state simulations have been performed. The steady-state simulations assume that the wind has been blowing constantly for an extended period of time.

3.4 Computer Model

For the purposes of the current study two three-dimensional steady-state models of the development and simplified representations of the two surrounding building configurations have been constructed.

Both models use an identical representation of the 52-55 Friar Street & 12 Greyfriars Road development, in the 'existing' configuration (Figure 6 to Figure 8) the current surroundings (Figure 3) are assumed.

In the 'Stanhope' configuration the block massing of the proposed Stanhope development has been inserted into the model with appropriate buildings removed and replaced. This model can be seen in Figure 9 to Figure 11.

The model only extends a several hundred metres from the site and the local topography and buildings have only been approximately represented. The model has been constructed in this way to make a rapid initial assessment of any potential issues.

The current study is intended as a preliminary analysis before more complete computer or wind tunnel modelling is carried out. As a result the model is not as extensive or refined as would be required for a full planning submission. However, it is considered unlikely that the results of the final study will be markedly different to the initial results reported here.

3.5 Boundary Conditions

The boundary conditions applied to the models are as follows:-

Development and Other Buildings:
The buildings are represented as solid regions. All surfaces include an appropriate wall function to account for frictional losses.

Ground Surface:
This has been prescribed as a wall surface with associated frictional losses. A rough wall function has been used with a roughness height of 0.3m to represent terrain features (see below).

'Downwind':
Constant pressure boundaries have been prescribed.

Above:
A constant pressure boundary has been prescribed.

Upwind:
An inlet boundary has been defined. The profiles of velocity and turbulence for this boundary are defined as follows:

The velocity profile is assumed to be:

$$U_z = \frac{U_{10}}{\kappa} \ln \left(\frac{Z}{Z_0} \right)$$

Where:

$$\frac{\kappa U_{10}}{\ln \left(\frac{10.0 + Z_0}{Z_0} \right)}$$

And:

- U_z – Velocity at height Z (m/s)
- U₁₀ – Velocity at 10m (m/s)
- Z – Height above ground (m)
- Z₀ – Roughness height of terrain (m)
- κ – von-Karman constant

Turbulence is represented using the k-ε model. For the atmospheric boundary layer these parameters are defined as:

$$\kappa = \frac{U_{10}}{C_{\mu}^{0.5}}$$

Which is assumed to be constant as turbulent energy K does not vary significantly with height. The dissipation of energy ε does vary with height, the relationship is as below.

$$\epsilon = \frac{U_{10}^3}{\kappa(Z + Z_0)}$$

The roughness height is modified to reflect the type of terrain outside the solution domain for each wind direction. The following roughness lengths are used for each terrain category:

- Z₀ = 0.0002 (sea)
- Z₀ = 0.03 (open country)
- Z₀ = 1.0 (Regular large obstacles (suburb, forest))
- Z₀ = 2.0 (city centre with low and high rise buildings)

For the current study a value of 1.5m has been selected.

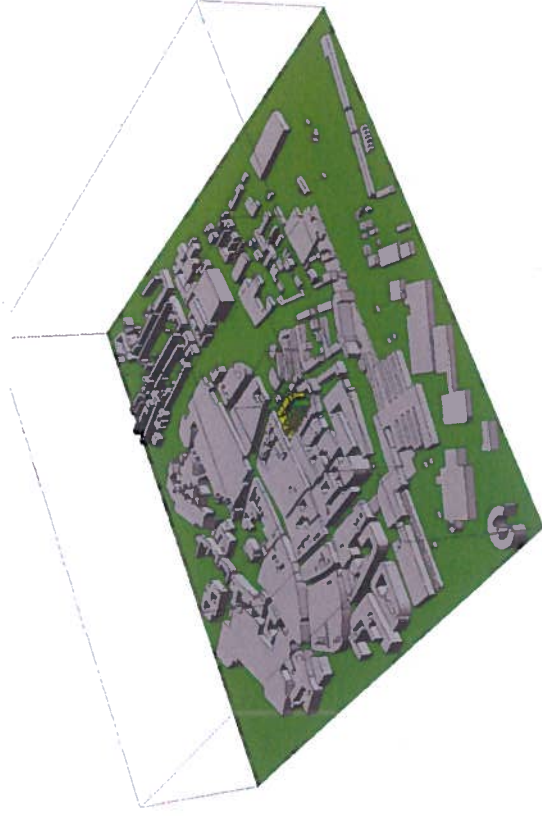
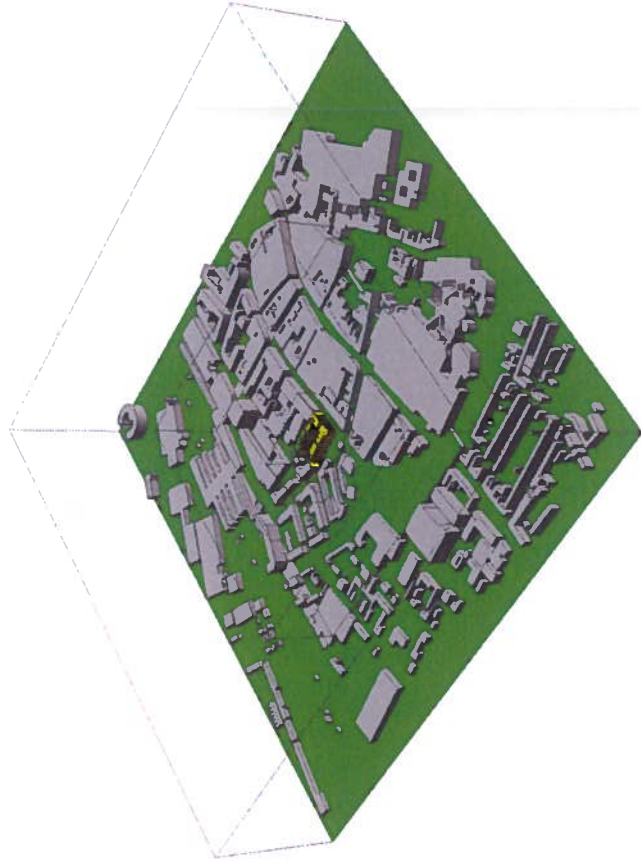


Figure 6 – CFD Model 'Existing': Surroundings

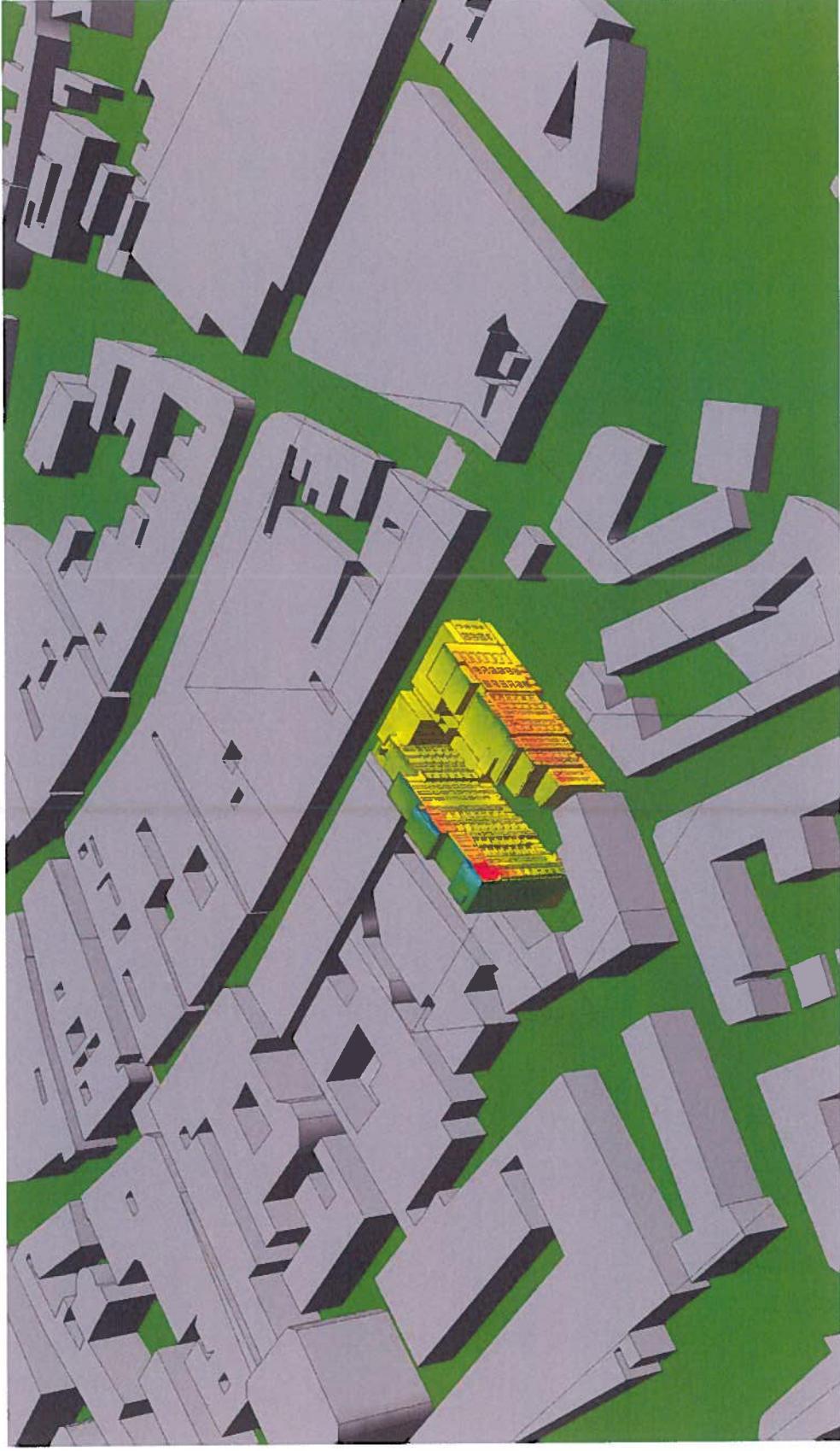


Figure 7 – CFD Model 'Existing'; Surroundings

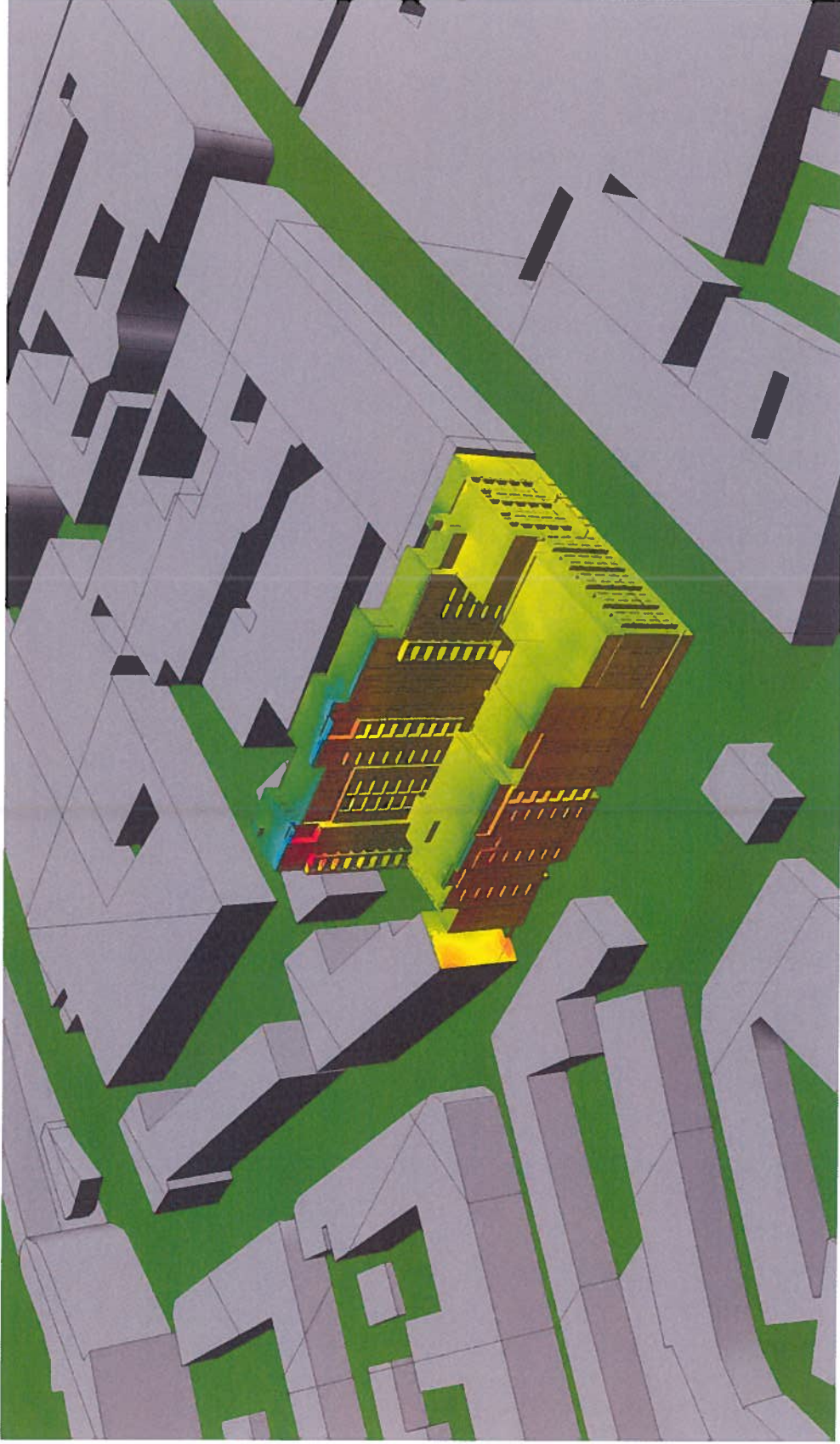


Figure 8 – CFD Model 'Existing'; Surroundings



Figure 9 – CFD Model 'Stanhope': Surroundings

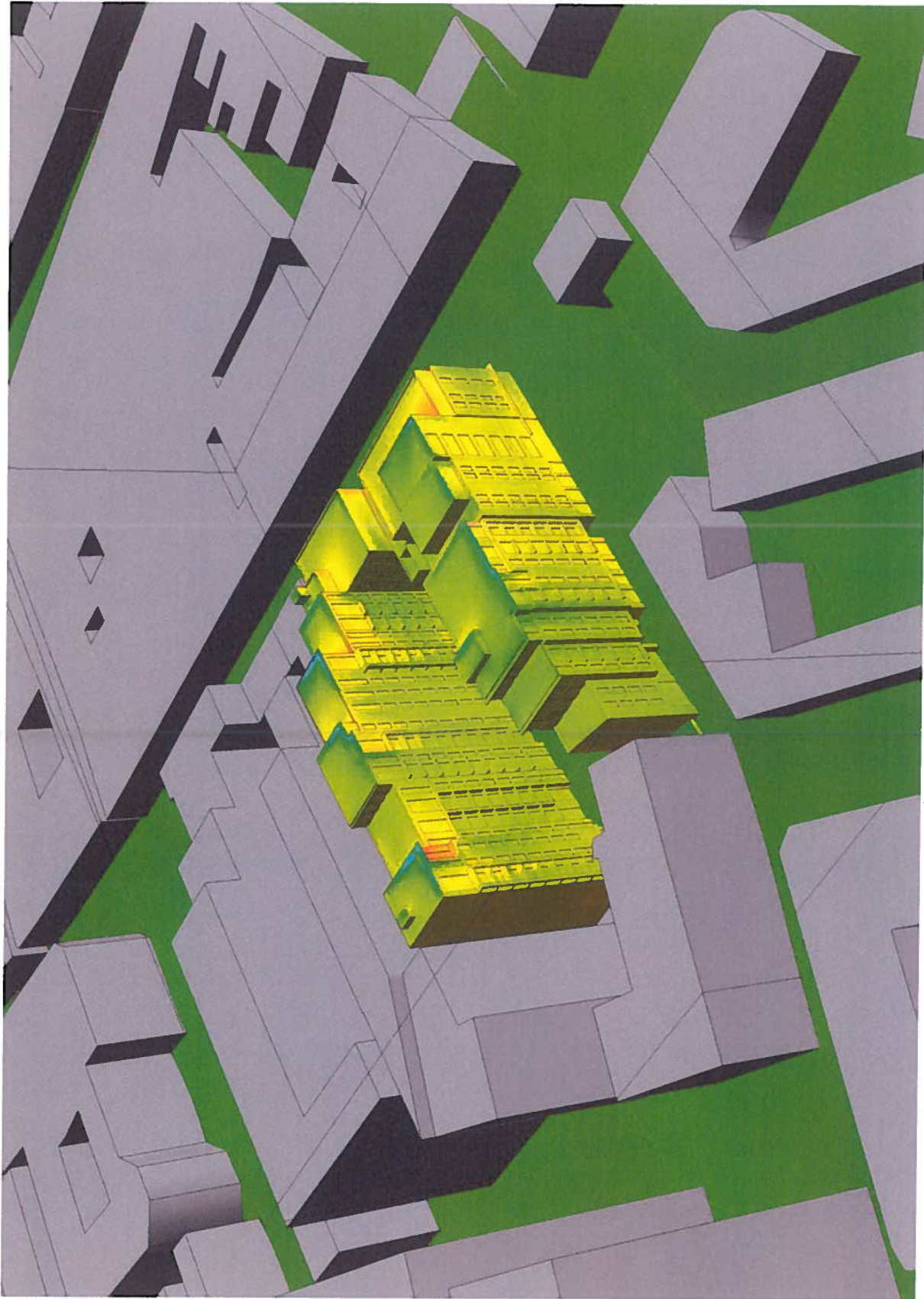


Figure 10 – CFD Model 'Stanhope'; Surroundings

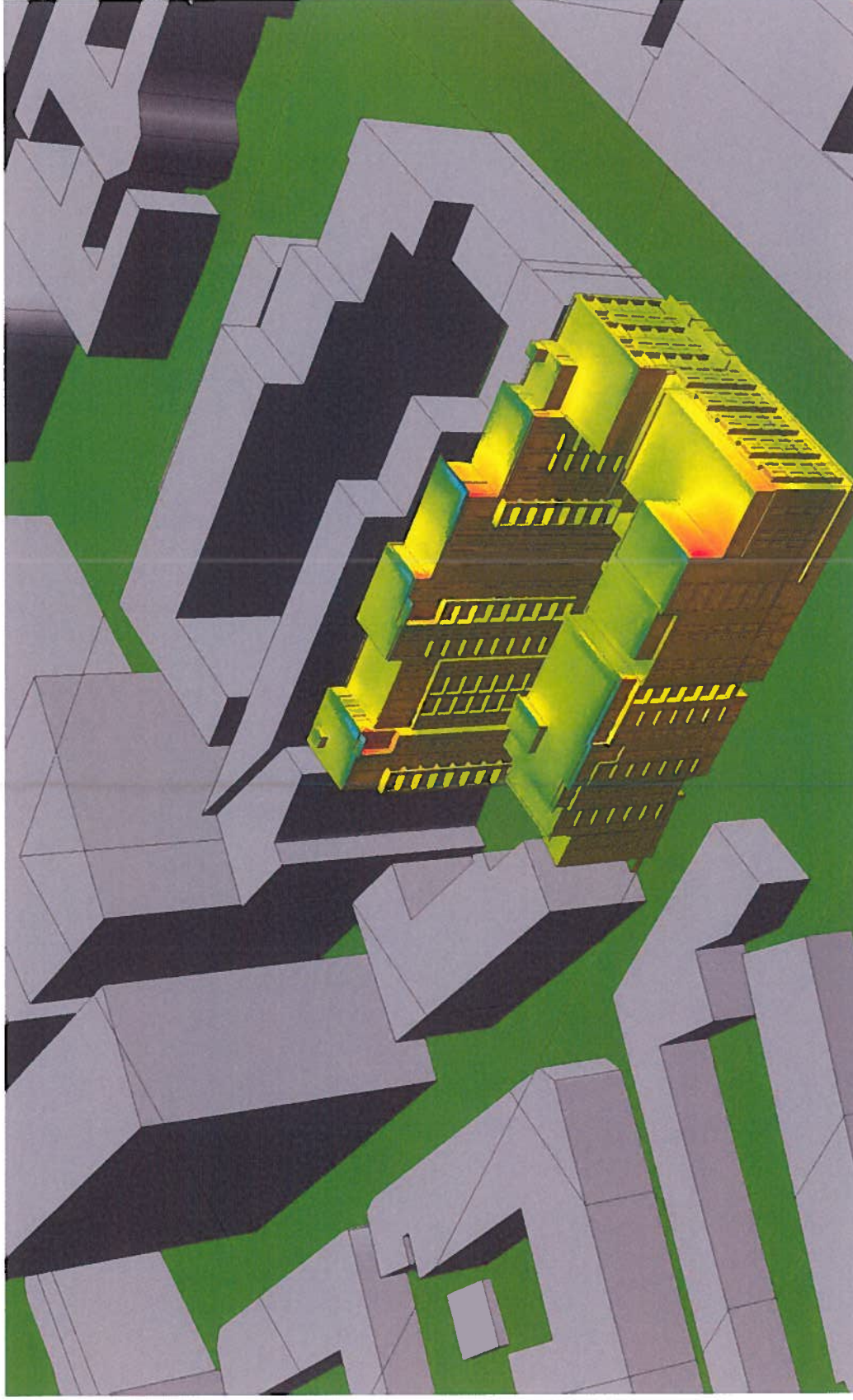


Figure 11 – CFD Model 'Sianhope'; Surroundings

4.0 SIMULATIONS PERFORMED AND RESULTS

4.1 Introduction

For the purposes of this initial study two sets of six steady-state simulations have been performed to provide an initial assessment of the proposed development for the two sets of surroundings. These simulations were intended to identify the likelihood of any potential comfort issues or possible safety concerns caused by wind around the site using the Lawson comfort criteria.

4.2 Presentation of Results

As the focus of the current study is pedestrian comfort, the results have been presented in the form of plots showing the results of a statistical analysis of the air speeds around the site across the year. These are based on the Lawson criteria and are used to determine the suitability (or otherwise) of these locations for pedestrian activities.

The locations of these horizontal plots (with the exception of the street level plots which follows the road contours at street level) are shown in Figure 12.

Some additional streamline plots (Figure 20 to Figure 23) have been included to assist in visualising some of the mechanisms generating the comfort conditions.

4.3 Statistical Assessment Criteria

While the current microclimate study is not a typical formal comprehensive analysis the standard 'Lawson' criteria have been considered when reviewing the results.

The Lawson criteria are defined in Table 1. Accordingly, the comfort criteria are dependent on activity level and are defined separately for each activity in terms of an average wind speed exceeded for no more than 5% of the time. The value of 5% has been established as giving a reasonable allowance for extreme and relatively infrequent winds that are deemed tolerable within each category. For example, if the mean hourly wind speed at a particular location is less than 4 m/s for at least 95% of the time, then that location would be classified as an 'A' wind speed category.

Table 1: Lawson Pedestrian Comfort Assessment Criteria

Wind Speed Category	Mean Wind Velocity Range	Tolerable Activity
A	0-4 m/s (0-9mph)	Pedestrian sitting for a long time and wind velocity in the vicinity of entrance doors
B	4-6 m/s (9-13mph)	Pedestrian standing or sitting for a short time
C	6-8 m/s (13-18mph)	Pedestrian walking, e.g. strolling and sight-seeing
D	8-10 m/s (18-22mph)	Business Walking (objective walking from A to B or for cycling)

Wind speeds faster than 10m/s (22mph) are considered uncomfortable but not necessarily dangerous. Lawson has defined a second group of criteria for 'distress' wind speeds. These capture wind criteria that most people would find so uncomfortable that they couldn't reasonably conduct normal outdoor activities until the wind event has passed. These have not been considered in the current study.



Figure 12 – Location of Lawson Contour Plot Planes

4.4

Comfort Contour Plots

The Lawson contour plots for the two sets of surroundings are shown in **Figure 13** to **Figure 19** below. For comparative purposes at each level the 'Existing' and 'Stanhope' plots are shown alongside one another with the 'Existing' plot on the left and the 'Stanhope' shown on the right.

Street Level

4.4.1

Figure 13 shows the comfort bands at street level. Data here have been extracted 1800mm above street level and follow the contours of the road. The air flow around the buildings for selected wind conditions is also shown in **Figure 20** to **Figure 23**.

The 3D air flow plots show some of the flow features that affect pedestrian comfort. Comparison of the first two plots (**Figure 20** and **Figure 21**) shows that for a south-west 95th percentile wind conditions on Friar Street and the south of Blocks A and B and Greyfriars Road are similar for both cases. This similarity is reflected in the comfort contours (see below). **Figure 21** also shows a tendency for air from the south-west wind to flow down into Garrard Street between two of the Stanhope buildings.

The second two 3D plots (**Figure 22** and **Figure 23**) show flow from a northerly wind for the two cases. The most important feature here is the higher velocities along the northern half of Greyfriars Road with the Stanhope development in place which results in a reduction in comfort in this area (see below).

For both the 'Existing' and the 'Stanhope' case conditions at street level the results are largely acceptable. With the exception of one small area comfort falls in bands 'A', B or 'C' indicating that for most locations the conditions are always suitable for strolling, (C) standing (B) or even sitting (A).

On Greyfriars Road conditions for both plots fall largely in Band 'B' and as such are better than might be required for normal walking or strolling. More importantly conditions at the entrances to the passageways that provide the main access to both blocks conditions are in Band 'A' which is recommended for entrance doors.

In both plots conditions along Friars Street are adequate for strolling throughout; there are extensive regions suitable for standing (B - green) or even sitting (A blue) with the best conditions occurring along the facades of the retail unit along the north side of Friar Street. Conditions on the south side of Friar Street are not quite as good but still adequate for strolling. The area (amount) of Band C in the south side of Friar Street is greater with the Stanhope development in place which results in it being marginally less pleasant for strolling.

However, the Stanhope development has a beneficial impact within the courtyard of the development which is largely subject to Band A 'sitting' conditions for the Stanhope case but existing conditions are better suited for 'standing'. Clearly the larger buildings in the Stanhope development are sheltering the courtyard from winds from north-easterly (the second most frequent wind direction).

To the north of the site and particularly along Garrard Street the Stanhope development does result in a deterioration in comfort conditions. For the 'existing' surroundings much of Garrard Street falls in Band A which is suitable for sitting. Conditions are markedly different with the Stanhope development in place where most of Garrard Street falls in either Band B (standing) or Band C (walking). While this is a deterioration, these conditions are still adequate for pedestrians. There is also a small zone of orange (Band D); here conditions are adequate for brisk walking but may be deemed uncomfortable for anyone choosing to stand in this area.

The conditions of Garrard Street are considered to be due to downwash from the southern facade of the Stanhope buildings to the north of Garrard Street. It is stressed that these conditions are not hazardous or even excessively uncomfortable but are less favourable than without the Stanhope development.

Overall conditions in both cases are favourable for the intended use at street level. In summary, the 'Existing' configuration giving better conditions to the north of the site, and marginally better conditions on Greyfriars Road and Friar Street while the 'Stanhope' results provide better conditions in the courtyard.

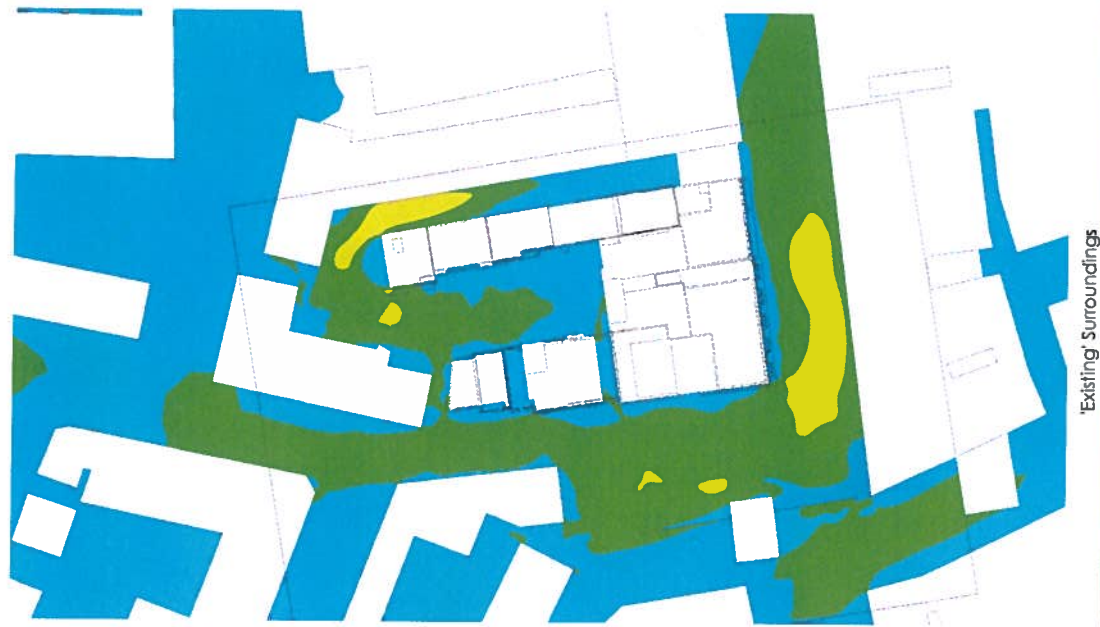
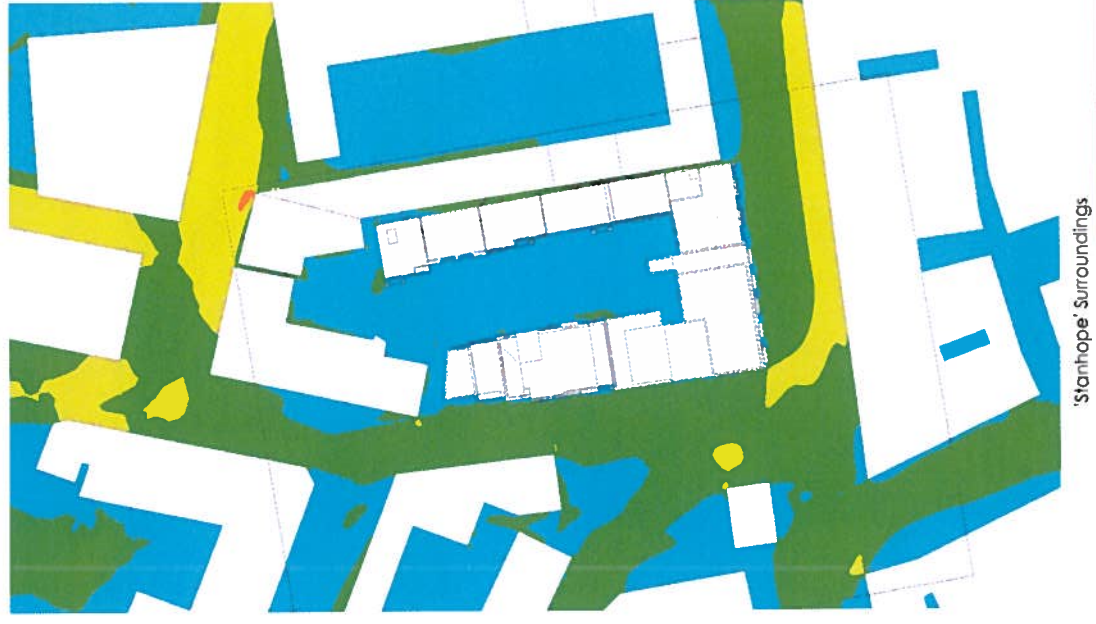
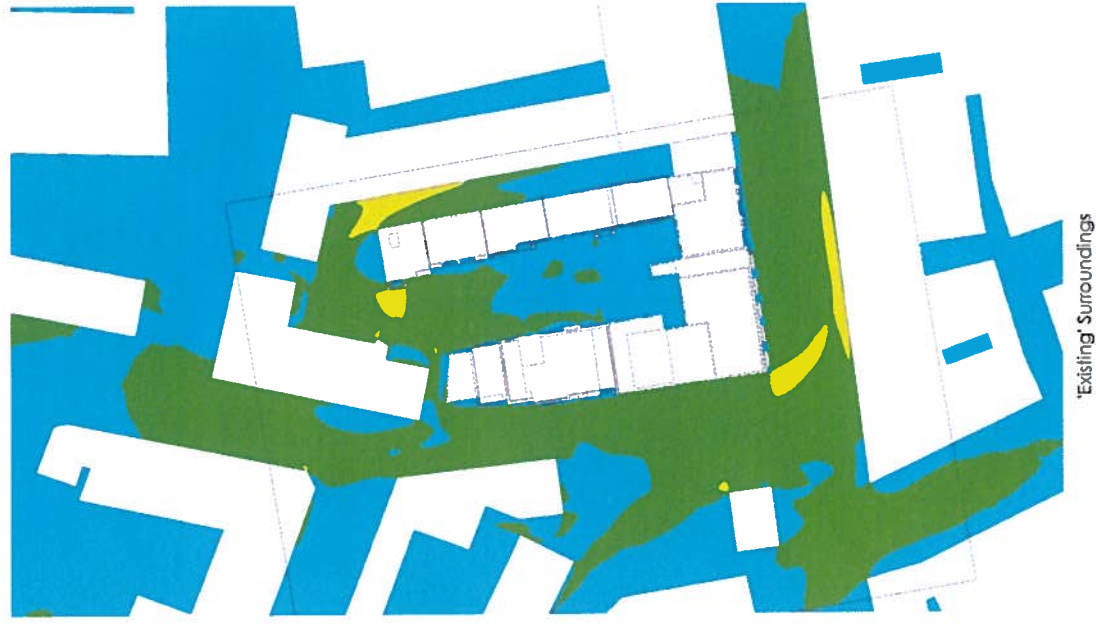


Figure 13 – Lawson Bands at 1800mm above street level (plane follows road contours)



'Existing' Surroundings

'Stanhope' Surroundings

A
Sitting

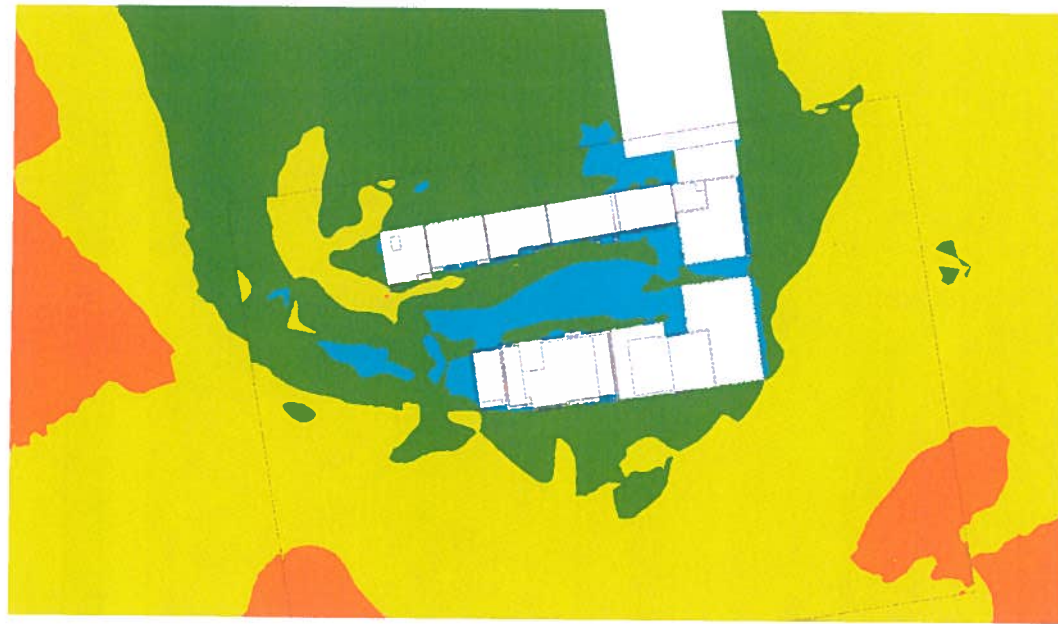
B
Standing

C
Walking

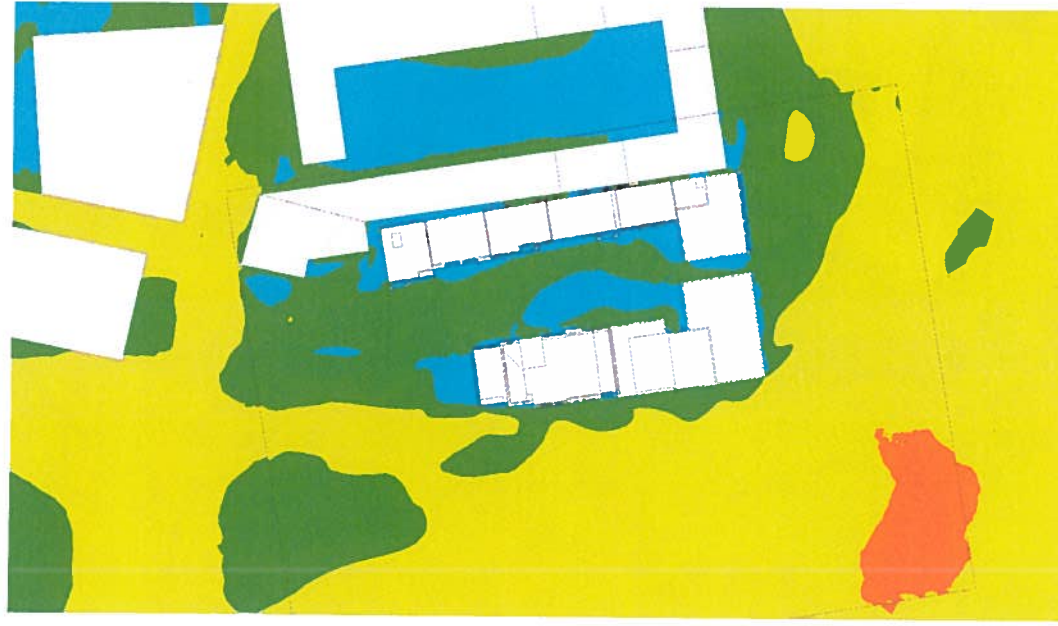
D
Brisk Walk

Above Uncomfortable

Figure 14 – Lawson Bands at 1800mm above Block B Level 1



'Existing' Surroundings



'Stanhope' Surroundings

Above Uncomfortable

D
Brisk Walk

C
Walking

B
Standing

A
Sitting

Figure 15 – Lawson Bands at 1800mm above Block A Level 5



'Existing' Surroundings



'Stanhope' Surroundings



Figure 16 – Lawson Bands at 1800mm above Block B Level 6

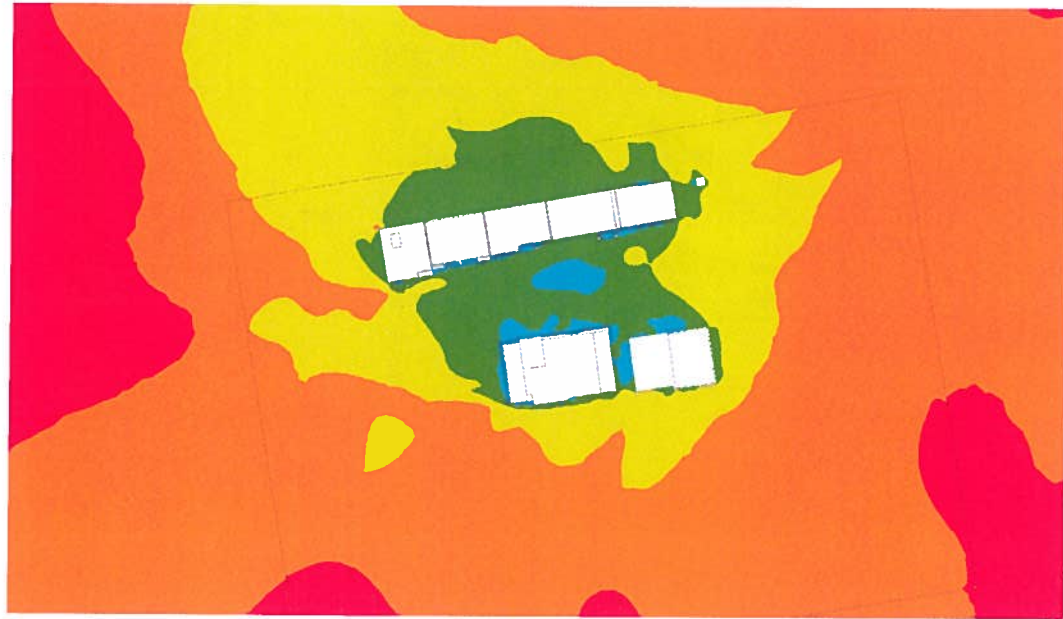


Figure 17 – Lawson Bands at 1800mm above Block A Level 7



'Existing' Surroundings

'Stanhope' Surroundings



Figure 18 – Lawson Bands at 1800mm above Block B Level 8

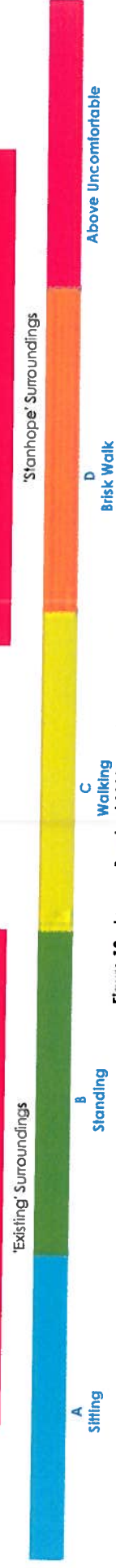


Figure 19 – Lawson Bands at 1800mm above Block B Level 10

4.4.2

Roof Areas

The comfort contours at the levels including significant amounts of rooftop garden are shown in **Figure 14** to **Figure 19**.

The proposed development includes rooftop gardens which under the 'existing' surroundings are not well sheltered by adjacent structures particularly to the south and west. The site is more sheltered to the north and east in the 'Stanhope' case as the buildings are taller than the Friar Street development.

The garden level at Level 1 of Block B (**Figure 14**) is within the courtyard and is naturally sheltered by the development itself. As a result the garden are in the south-east corner of the courtyard falls in Band A for both cases. No additional mitigation measures should be required in this region.

The next significant area of rooftop garden is at the north side of Block A on Level 5 (**Figure 15**). This garden is well sheltered for both sets of surroundings falling largely within Band A; however conditions are marginally better in the 'Stanhope' case. No major mitigation measures should be required here, although screens at the periphery might improve conditions at the north of the garden in both cases.

Conditions at Level 6 of Block B (**Figure 16**) are slightly less favourable, particularly for the 'existing' case, though these are zones of Band A (larger for the 'Stanhope' case). Mitigation measures will be required here: 1800mm or higher screens and painting should be considered to shelter the garden from south-west winds.

As the gardens on Block A Level 7 (**Figure 17**) are located to the north they are sheltered from south-west winds but are exposed to north-east winds in the 'existing' case. Here the benefit of the 'Stanhope' case are shown more clearly, the additional shelter providing a larger area in Band A. However, for both cases mitigation measures will be necessary for these cases in the form of 1800mm screens and painting.

The last two garden levels (Block B levels 8 and 10 in **Figure 18** and **Figure 19**) are higher and as such are more exposed to south-west winds (the prevailing wind direction). They are also exposed to north-east winds under 'existing' conditions while the 'Stanhope' development shelters these higher gardens and as result conditions are better in this case. However, due to the height of these gardens mitigation measures will be required.

Overall the conditions around the gardens are encouraging for both sets of surroundings and it is considered that with suitable mitigation measures these will provide a good level of amenity.

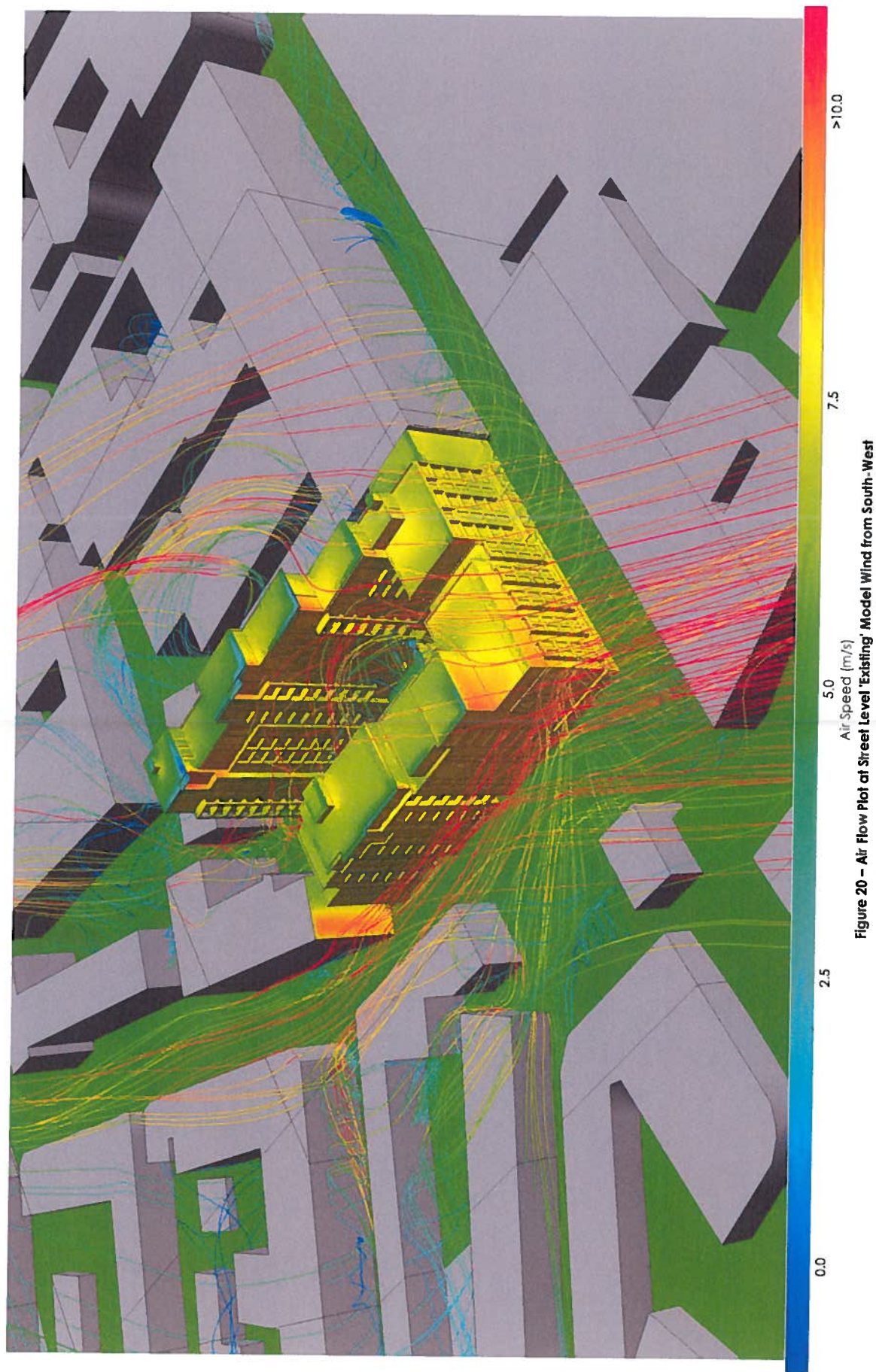


Figure 20 – Air Flow Plot at Street Level 'Existing' Model Wind from South-West

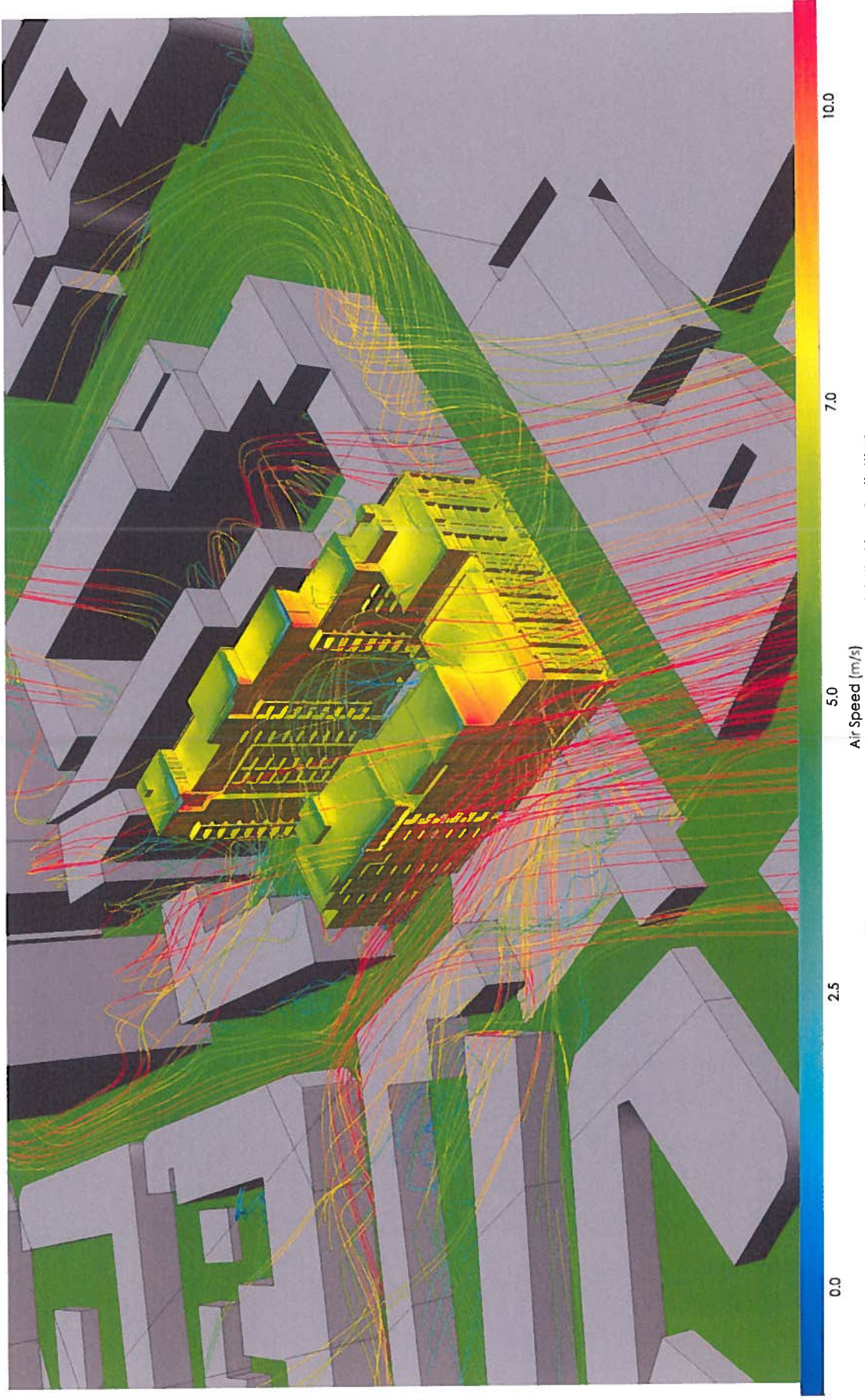


Figure 21 – Air Flow Plot at Street Level 'Stanhope' Model Wind from South- West

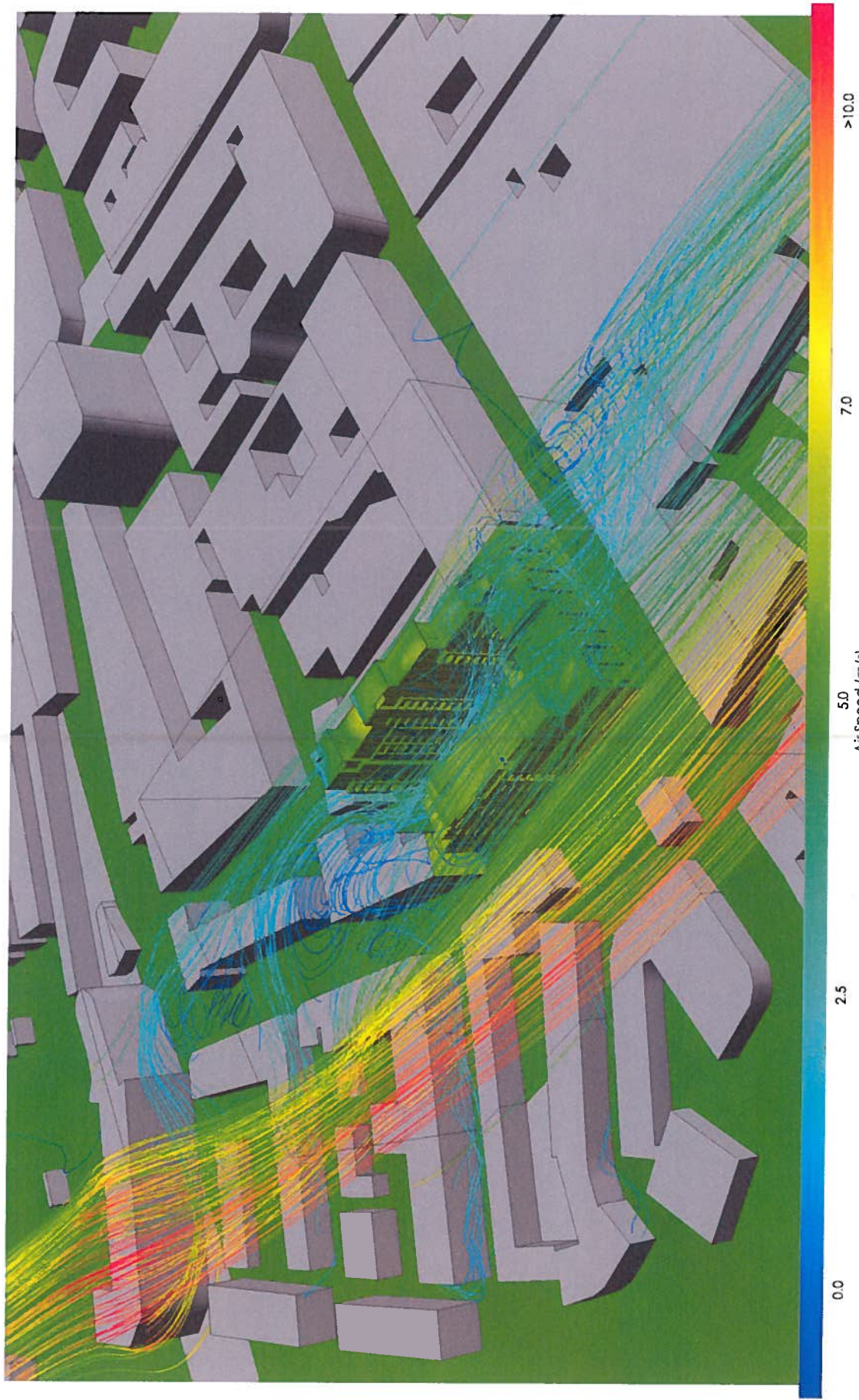


Figure 22 – Air Flow Plot at Street Level 'Existing' Model Wind from North-East

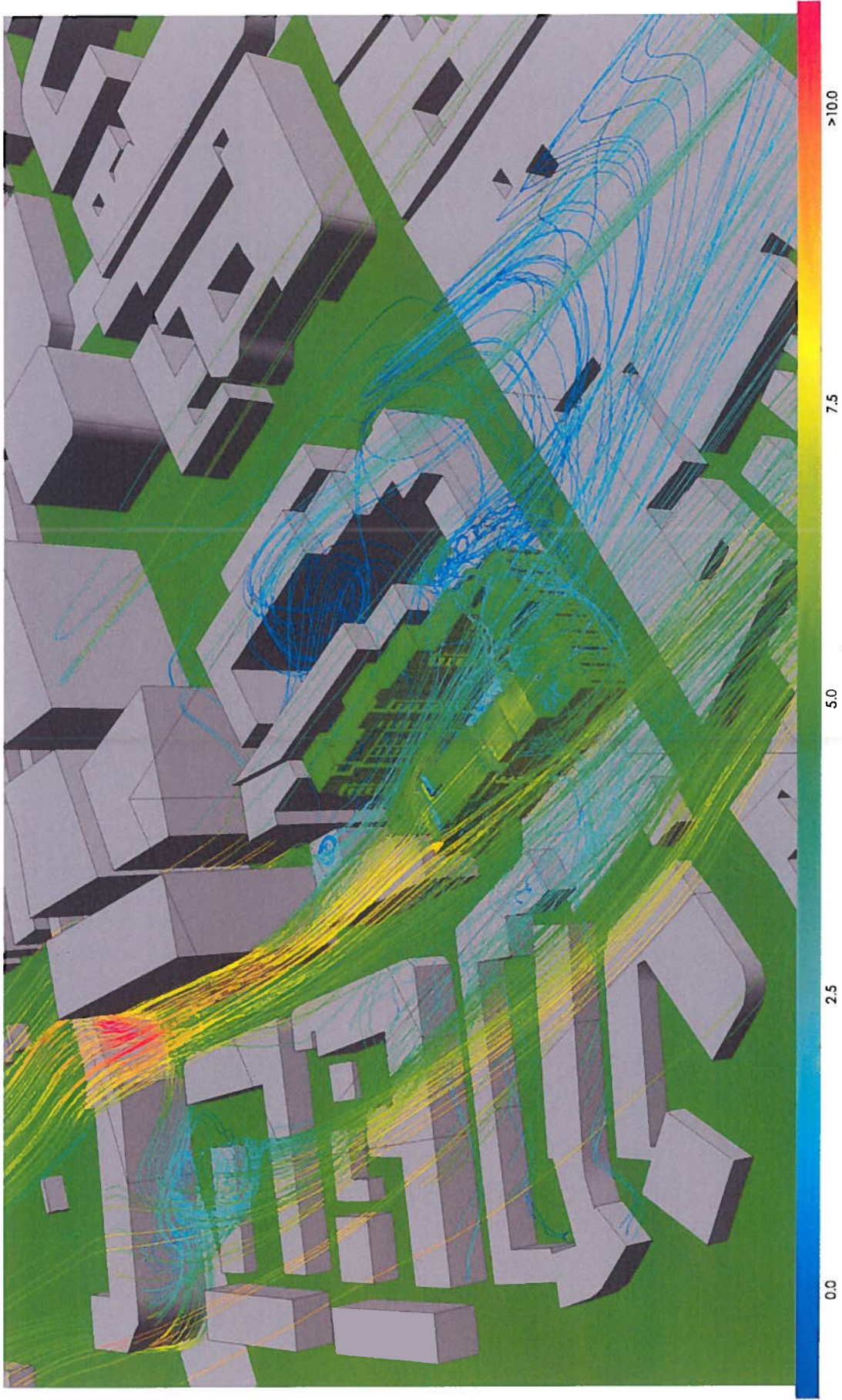


Figure 23 – Air Flow Plot at Street Level 'Sunhope' Model Wind from North

CONCLUSIONS AND RECOMMENDATIONS

A desktop study has been carried out to provide an overview of the potential wind microclimate around the proposed development at 52-55 Friar Street and 12 Greyfriars Road in Reading. The key areas reviewed were:

- Public Realm (Street Level)
- Public amenity (Roof Levels)

Two scenarios have been considered; the first considers conditions around the development within the existing surroundings; that is all buildings other than those on the development site are unchanged from the current condition. The second scenario considers conditions with the proposed Stanhope development (located to the north and east of the Friar Street/Greyfriars Road development) in place.

The main findings of the study are as follows:

Street Level

Conditions in both cases ('Existing' and 'Stanhope') are favourable for the intended uses at street level. The 'Existing' configuration provides better conditions to the north of the site, and marginally better conditions on Greyfriars Road and Friar Street while the 'Stanhope' results provide better conditions in the courtyard.

Roof Top

The study shows that the rooftops are viable amenity spaces. While mitigation measures such as localised screening and the provision of planting will be required the garden areas are not subject to excessively windy conditions in either case.

The 'Stanhope' development does provide some additional shelter from north-east winds particularly for the higher gardens; however as the prevailing wind direction is from the south-east mitigation will be required regardless of the surroundings.

Recommendations

Whilst the general comfort conditions appear satisfactory for the proposed usages in and around the proposed Friar Street development, mitigation measures to localised areas would further improve the comfort levels, namely: roof top terraces. Localised screening such as a 1.8m to 2.1m high glazed fencing should prolong and enhance the area of comfort within the terraces. The actual screening/fencing height will need further investigation either with computational modelling or in a wind tunnel during the next stage of design.

The Stanhope development (outline planning massing) provides a degree of sheltering to the northern roof top terraces. As such there is a risk that in the event the Stanhope scheme does not get full planning permission or the mass and form changes in this area the proposed northern roof top terraces would become less comfortable. Therefore, it is recommended that mitigation screening/fencing is incorporated in these locations.

The analysis undertaken herein has predicted adequate comfort conditions generally across the site, while possible mitigation measures in areas with potential localised issues should be further investigated during detailed design.

