

**Vinci Construction**

# New Victoria Residential Development, Manchester

## Wind Environment

Reference: 273988

Issue | 15 May 2023

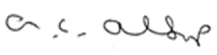
This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 273988

**Ove Arup & Partners International Limited**  
8 Fitzroy Street  
London  
W1T 4BJ  
United Kingdom  
[arup.com](https://www.arup.com)

# Document Verification

**Project title** New Victoria Residential Development, Manchester  
**Document title** Wind Environment  
**Job number** 273988-03  
**Document ref** 273988-03  
**File reference**

| Revision | Date                        | Filename    | 20230428_New Victoria Residential Development Wind Environment                      |                                                                                       |                                                                                       |
|----------|-----------------------------|-------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Rev 1    | 28 <sup>th</sup> April 2023 | Description | Wind Environment                                                                    |                                                                                       |                                                                                       |
|          |                             |             | Prepared by                                                                         | Checked by                                                                            | Approved by                                                                           |
|          |                             | Name        | Giulia Matteoni                                                                     | Andrew Allsop                                                                         | Andrew Allsop                                                                         |
|          |                             | Signature   |    |    |                                                                                       |
| Rev 2    | 15 <sup>th</sup> May 2023   | Filename    | 20230428_New Victoria Residential Development Wind Environment                      |                                                                                       |                                                                                       |
|          |                             | Description | Amendments aligned with design team comments on context for the application         |                                                                                       |                                                                                       |
|          |                             |             | Prepared by                                                                         | Checked by                                                                            | Approved by                                                                           |
|          |                             | Name        | Giulia Matteoni/ Chris Lonergan                                                     | Matthew Holden                                                                        | Matthew Holden                                                                        |
|          |                             | Signature   |  |  |  |
|          |                             | Filename    |                                                                                     |                                                                                       |                                                                                       |
|          |                             | Description |                                                                                     |                                                                                       |                                                                                       |
|          |                             |             | Prepared by                                                                         | Checked by                                                                            | Approved by                                                                           |
|          |                             | Name        |                                                                                     |                                                                                       |                                                                                       |
|          |                             | Signature   |                                                                                     |                                                                                       |                                                                                       |

Issue Document Verification with Document



# Contents

---

|    |                                                                                         |   |
|----|-----------------------------------------------------------------------------------------|---|
| 1. | Introduction                                                                            | 1 |
| 2. | Proposed variations to the Approved Scheme Details                                      | 1 |
| 3. | Likely impact of the proposed variations to Approved Scheme Details on wind environment | 5 |

## Tables

No table of figures entries found.

## Figures

|                                                                                                                                                                                     |   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| Figure 1: Plan view of the Proposed Development with currently proposed wind screens (2023)                                                                                         | 3 |
| Figure 2: Photographs of wind mitigation measures as tested in the wind tunnel and presented in the 2016 ES. Reproduced from Figure 10.15 of the 2016 Environmental Wind ES Chapter | 4 |

## Drawings

No table of figures entries found.

## Pictures

No table of figures entries found.

## Photographs

No table of figures entries found.

## Attachments

No table of figures entries found.

## Appendices

No table of contents entries found.

# 1. Introduction

## Summary

In 2016, Muse Developments Ltd was granted permission for ‘*two residential buildings of a maximum 21 and 26 storeys*’ and ‘*one office building of maximum eight storeys*’ [ref. 111777/FO/2016/C1] (The 2016 Scheme). This scheme was developed further with the addition of an amenity link bridge in 2020, which was approved under planning permission 128667/JO/2020. This note has been produced to support the Non-material Amendment (NMA) application to the 2020 permission, providing commentary on the wind environment associated with proposed changes to the landscaping.

Arup was responsible for an environmental wind assessment for the 2016 Scheme and for preparing the environmental wind chapter of the Environmental Statement (ES) for that application which is included as Appendix A of this document. The 2020 application scoped out further wind analysis as it was not anticipated that the revised link bridge would significantly impact the findings of the previous report.

This note seeks to respond to the proposed amendments, which are the subject of this NMA. The proposed amendments include changes to the proposed planting (when compared to the scheme tested in the 2016 approved ES chapter) and the wind mitigation panels. The proposed amendments are considered in more detail below.

## Background

This note provides commentary on the impact of the NMA changes to the 2020 application in comparison with the 2016 Environmental Statement as this is an established benchmark for wind conditions for the project.

Wind tunnel testing was undertaken at RWDI Anemos in Milton Keynes in November 2015 to quantify the effects of the 2016 Scheme on the local wind environment. Wind tunnel testing is currently the most reliable method of assessing windiness in cases where strong winds may occur around wind-exposed buildings and enables rapid evaluation of the benefits of mitigation measures.

The criteria used to describe windiness levels in this study were those of TV Lawson, extracted from ‘The evaluation of the windiness of a building complex before construction’, TV Lawson, London Docklands Development Corporation (LDDC); these are used widely in the UK and around the world.

Since 2016, the following changes to the scheme include.

- As above, the introduction of the amenity link bridge (approved in 2020)
- As above, proposed amendments subject to this NMA application of the 2020 permission

Additionally, cumulative developments as modelled in the 2016 wind tunnel study are now built out, with exception of 2-3 Angel Square which has received planning permission but is not yet under construction. An additional development located immediately to the north-east of the site (4 Angel Square) which was not modelled in the 2016 wind tunnel study is nearly completed. The approved office building forming part of the approved New Victoria development application has also been taken over by another developer and is on a different development programme.

Given the above, professional judgment based upon the findings from the 2016 wind tunnel test, has been used to assess the proposed amendments within the NMA.

## 2. Proposed variations to the Approved Scheme Details

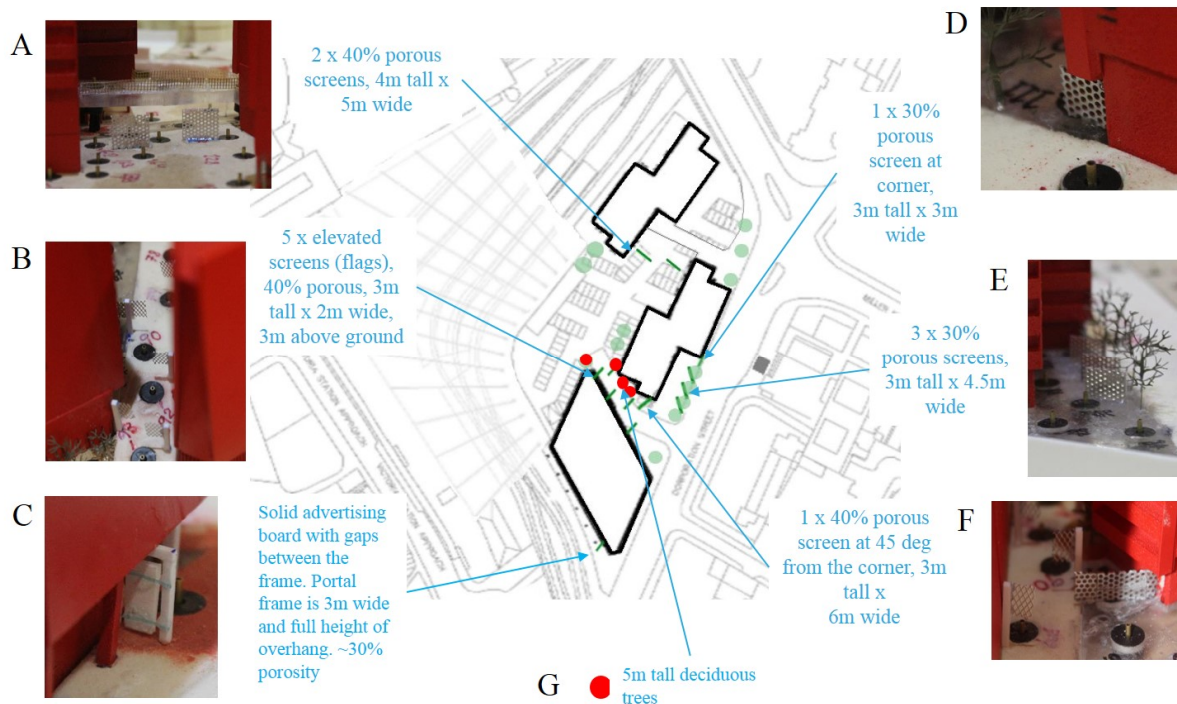
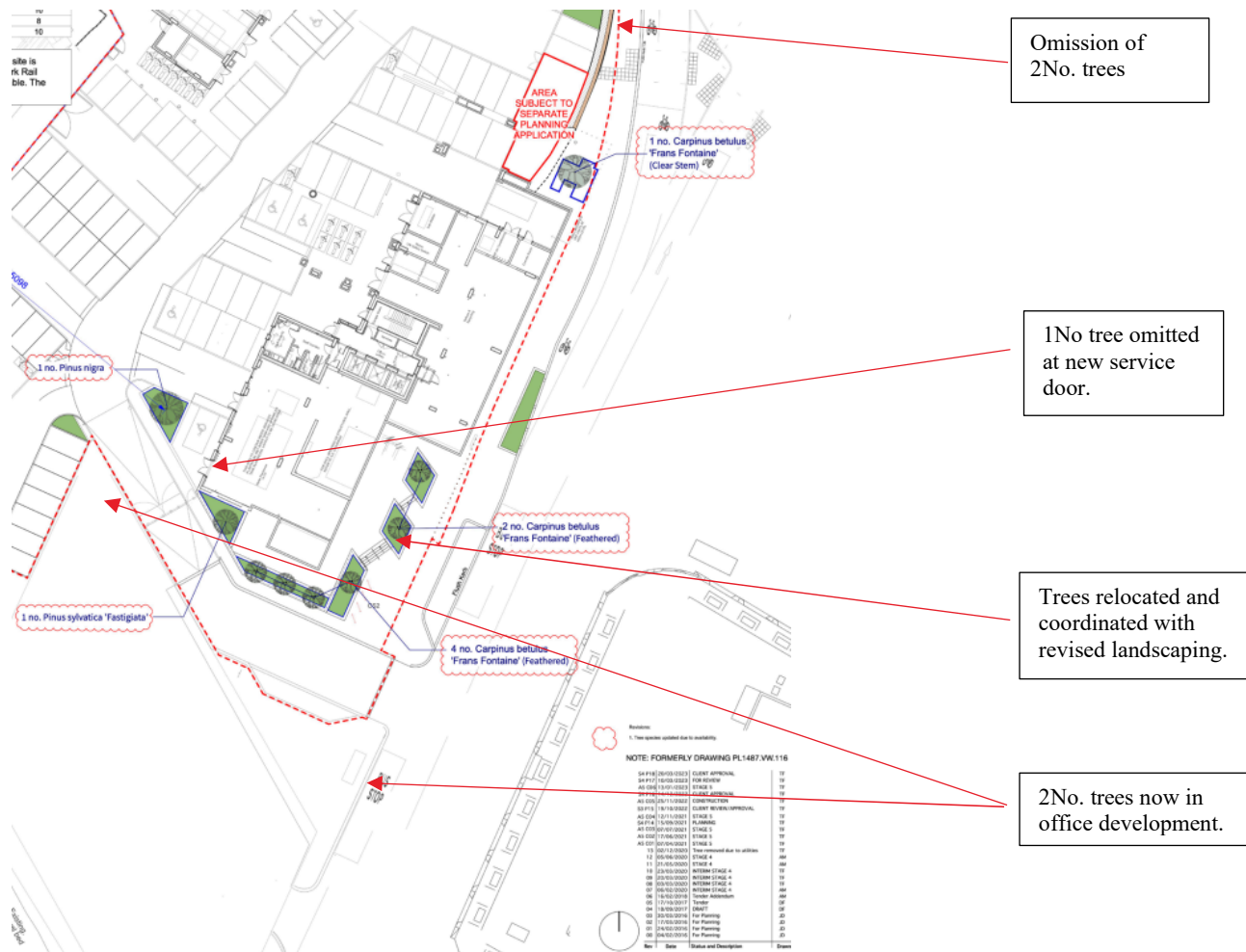
Following the 2016 ES submission, the following variations have been approved and proposed (as identified below):

- The footbridge connecting the residential towers has been replaced with an “amenity link bridge” which includes an extra floor and is positioned further south (as approved under planning permission 128667/JO/2020).
- Both wind mitigation screens labelled as “A” in Figure 1 in have been reduced in width from 4.5m to 3.3m (subject to the forthcoming NMA).
- Both wind mitigation screens labelled as “B” in Figure 1 in have been reduced in width, from 3m to 1.5m and from 6m to 1.5m; one of the two screens has also been re-oriented in plan (subject to the forthcoming NMA).
- The wind mitigation screens labelled as “C” in Figure 1 extend in height from ground level to the “amenity link bridge” soffit (subject to the forthcoming NMA).
- The wind mitigation screen labelled as “D” in Figure 1 in has been reduced in width from 4.5m to 2.2m and have been repositioned in plan (subject to the forthcoming NMA).
- The proposed perforation for all screens remains similar to that tested in the wind tunnel (subject to the forthcoming NMA).
- Amendments to planting as shown in Figure 2 (subject to the forthcoming NMA).

For reference, photographs of the wind mitigation measures as tested in the wind tunnel and presented in the 2016 ES are reproduced in Figure 3.



**Figure 1: Indicative plan view of the Proposed Development with currently proposed wind screens (2023)**



### 3. Likely impact of the proposed NMA on the wind environment

As part of the amenity link bridge S.73 application, approved under planning permission 128667/JO/2020, consideration was given to the potential wind impacts. The likely impact of the proposed variations within the NMA to this application have been assessed in March 2023 via professional judgement. The assessment was based on a review of architectural and landscape drawings provided by Vinci Construction and Planit - IE Limited in February 2023, and our previous experience of wind tunnel testing for the 2016 Scheme.

Key conclusions are described below.

The proposed variations within the Non-Material Amendment (including modifications to screens and landscaping) are not likely to impact conditions on Corporation Street; the local windiness is likely to remain similar to levels reported in the 2016 ES, due to additional sheltering from the prevailing winds, as provided by surrounding buildings that have been built out since 2016.

Noting the proposed modifications to the wind mitigation screens (labelled as “C” in Figure 1) and considering the effect of the current surrounding buildings, whilst wind accelerations below the Amenity Link bridge may be increased compared to those identified in the 2016 ES, windiness levels within the car parking areas are likely to remain similar to levels reported in the 2016 ES, or locally increased to some extent. It is thus recommended that the windiness in this location is monitored with provision for management of pedestrian routes made in line with the recommendations of the 2016 ES.

# Appendix A

## Environmental Wind Chapter of the 2016 ES

# 10 Wind Microclimate

## Introduction

- 1.1 This Chapter of the ES prepared by Arup assesses the effects of the Proposed Development on pedestrian wind comfort and safety. It also describes the methods used to assess the effects; the baseline conditions on the Site and in the surrounding area; measures required to prevent, reduce or offset any significant negative effects; and the likely residual effects after these measures have been adopted. The effects resulting from possible earlier completion of the residential part of the Development, and of future planning approved development is also considered.

## Legislation and Policy Context

### National Planning Policy

- 1.2 The **National Planning Policy Framework (NPPF)** came into force in March 2012. The NPPF does not contain any planning policies directly relating to wind microclimate issues. However, the benefits of a high quality built environment are emphasised in the NPPF. For example, paragraph 58 states development should use: "...streetscapes and buildings to create attractive and comfortable places to live, work and visit..." and paragraph 110 states "In preparing plans to meet development needs, the aim should be to minimise pollution and other adverse effects on the local and natural environment."
- 1.3 **The Guidance on Tall Buildings (CABE and EH, 2007)** sets out how the Commission for Architectural and Built Environment (CABE) and English Heritage (EH) evaluate proposals for tall buildings. Paragraph 4.4.9 under the criteria for evaluation states that applicants seeking planning permission should ensure that the following criteria are addressed, *"The effect on the local environment, including microclimate, overshadowing, night-time appearance, vehicle movement and the environment and amenity of those in the vicinity of the building..."*

### Local Planning Policy

- 1.4 **The Manchester Core Strategy Development Plan**, adopted in July 2012, places great importance on the creation and maintenance of a high quality environment for Manchester. Policy EN2 states: *"By their very size tall buildings can have a significant impact on the local environment and its microclimate. It is therefore expected that this impact be modelled and that submissions for tall buildings also include appropriate measures to create an attractive, pedestrian friendly environment."*
- 1.5 Section 12.13 states: *"Tall buildings by their very nature can dominate the street scene and be visible over long distances. They can also have an impact on the micro-climatic conditions, for example, by creating wind tunnels. It is for these reasons that it is considered particularly important that they are designed to the highest quality, both in terms of appearance and their impact on the functioning of the surrounding space."* Wind microclimate is therefore an important factor in achieving the desired planning policy objective.
- 1.6 In addition to the above, consideration of pedestrian comfort has been referenced in the **Guide to Development in Manchester Supplementary Planning Document and Planning Guidance**, adopted in 2007. Section 2.4 states: *"Where the public realm includes hard landscaped areas, its design should reflect the level and nature of their use, and should consider issues such as overshadowing, prevailing winds and rain, and the potential to sustainable urban drainage. The opportunity will be taken to improve the quality of existing areas of public realm and to ensure that areas of public realm in new developments, are designed so that they can be enjoyed by residents and users, rather than being simply functional."*

- 1.7 Section 12.8 states: *“Schemes will be considered on an individual basis, by reference to their appearance, their impact on the immediate area and the effect on the City’s skyline. Key questions will be the quality and interest of the roofline; the design of lower floors; the relationship to the surrounding streets; the impact of servicing and parking requirements; the microclimate, including overshadowing and air turbulence effects, created by the relationship of the building to those adjacent; and the quality and usability of the spaces surrounding the building.”*

## Assessment Methodology and Significance Criteria

- 1.8 Wind tunnel testing was undertaken to quantify the effects of the proposed development on the local wind conditions at pedestrian level on and around the site. It is currently the most reliable method of assessing windiness in cases where strong winds may occur around wind exposed buildings, and enables rapid evaluation of the benefits of mitigation measures.

## Wind Tunnel Testing

### Overview

- 1.9 Two environmental wind tunnel workshops were organised by Arup and held at RWDI’s wind tunnel in Milton Keynes on November 3 and 10, 2015. Sheppard Robson (SR) Architects provided massing information on the Proposed Development for the wind tunnel model and attended the workshop.
- 1.10 A 1:300 scale model of the Proposed Development and its surroundings was constructed and tested in the RWDI boundary layer wind tunnel. The model represented all surrounding buildings within approximately 350m of the Proposed Development, which is considered sufficient for the assessment of local wind effects in urban areas. A general view of the wind tunnel model with existing surroundings is shown in Figure 10.1.
- 1.11 The wind tunnel workshop, carried out in the presence of Sheppard Robson Architects served to develop a set of wind mitigation measures to improve wind conditions around the Proposed Development. Both the completion and intermediate development phases were tested with existing surroundings.

### Simulation of atmospheric winds

- 1.12 The characteristics of the oncoming wind speed and turbulence are generated by using uniformly distributed roughness elements and spires upwind of the wind tunnel model (see Figure 10.2). These elements create a boundary layer wind speed profile and a natural variation of wind turbulence that vary with height.
- 1.13 The arrangement of the roughness blocks and spires in the wind tunnel is chosen to reproduce the Harris and Deaves boundary layer profile prediction for the Site obtained using the ESDU (Engineering Science Data Unit) model. This model is the basis for the wind profiles used in the UK National Annex to the Eurocode for Wind Loading, EN1991-1-4. The ESDU analysis of boundary profiles takes into account the variation in upwind terrain characteristics (e.g. effective surface roughness) for different directions.

### Measurement technique

- 1.14 Gust and mean wind speed ratios were measured using up to 227 Irwin probe anemometers placed around the site, depending on test configuration. The probes measure wind speeds at an effective height of 1.5m above ground, which is the standard height used for assessing wind effects on pedestrians, compared to wind speeds above the Site at a height unaffected by buildings.
- 1.15 Measurements were taken at frequently used locations (e.g. entrances, retail frontages, walking zones) and in other areas expected to experience high wind speeds. For each test configuration, wind speeds were measured for sixteen equal angle increments to cover all wind directions.

- 1.16 The measured wind speed ratios were combined with the long-term wind statistics for Manchester (see next section) to calculate the windiness for each season of the year based on the Lawson 'comfort' and 'distress' criteria described in the section following the wind climate description.

## **Wind Climate**

- 1.17 Historical wind data (wind speed and direction) recorded at Manchester Airport during the years 2001 to 2015 were analysed and adjusted to site exposure using the ESDU method as described in section 1.13 above.
- 1.18 Strength and directionality of the winds are fundamental aspects of the environmental wind assessment. The directionality of winds in the region of Manchester is affected by the Welsh Mountains to the south-west. While in the rest of the UK the most frequent and strongest winds are from the south-west, the most frequent winds in Manchester are slightly shifted in the direction to the south and the strongest winds are from the west. The annual wind rose shown in Figure 10.2 and 10.3 illustrates the directionality and strength of the prevailing winds at Manchester Airport for all times of the day and seasons.
- 1.19 Other characteristics of the wind climate in Manchester are summarized below.
- The south and west winds are the most frequent and strongest in Manchester at all times of the year. These winds are relatively warm and wet. Most cases of serious annoyance due to strong winds around buildings are caused by these winds.
  - Northeast winds are almost as common as the west winds during spring but are weaker. They are often associated with cold, dry conditions. These winds can be more unpleasant than their strength suggests due to the lower-than-average air temperature.
  - Northwest winds are less frequent than the south and west winds. They are relatively cold.
  - Finally, southeast winds are generally warm and light and are rarely associated with problematic ground level winds.

## **Significance Criteria**

- 1.20 The significance of windiness at a given location is assessed for the intended pedestrian activities at that location. Lawson's comfort criteria (see

1.21 Table **10.1** and Table 10.2 ) are used to evaluate the appropriateness of windiness for everyday use.

1.22 An effect may be described as:

- **Beneficial:** the likely windiness is lower than needed for the intended or existing-and-continued use;
- **Adverse:** the likely windiness is higher than needed for the intended or existing-and-continued use; or
- **Negligible:** any changes in windiness have a negligible effect on the intended or existing-and-continued use.

1.23 An effect is categorised according to the following table:

**Table 10.1 - Categorisation of effects**

| Magnitude of Effect        | Criteria for Assessment                                                                                                                                                                                                                 | Lawson Description                                                                                                                                                                 |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Major adverse effect       | Levels of windiness with expected effect on future wind 'safety', particularly in areas of frequent everyday use, such as main public access routes and main building entrances.                                                        | Exceedance of Lawson's distress criteria in areas used regularly by the Public<br><br>Exceedance of 'Standing' conditions at major entrances                                       |
| Moderate adverse effect    | Levels of windiness, with expected moderate effect on wind 'comfort' and 'safety'. This includes any important adverse changes to existing usage categorisation.                                                                        | Exceedance of acceptable conditions in areas of less critical use, which may affect usage at times                                                                                 |
| Minor adverse effect       | Levels of windiness with minor effect on future usage, e.g. changes in areas that are normally used only in suitable weather conditions.                                                                                                | Marginal exceedance of acceptable conditions or exceedance in rarely used areas                                                                                                    |
| Negligible effect          | Levels of windiness that have a negligible effect on the future usage of the Development, and in the surrounding areas.<br><br>This includes areas where appropriately described wind mitigation has been incorporated into the scheme. | Acceptable conditions                                                                                                                                                              |
| Minor beneficial effect    | Levels of windiness that contribute to future usage of the Development and surrounding areas.                                                                                                                                           | Conditions are one-category calmer than acceptable in areas of significant usage.                                                                                                  |
| Moderate beneficial effect | Levels of windiness with expected benefit for both wind 'comfort' and 'safety' in areas of less critical use.                                                                                                                           | Conditions are calmer than acceptable limits in areas that previously exceeded the relevant Lawson 'comfort' and 'safety' criteria.                                                |
| Major beneficial effect    | Existing wind 'safety' exceedance in areas of everyday use, such as public access routes and major building entrances is improved to acceptable levels.                                                                                 | No longer any exceedance of Lawson's distress criteria in areas used regularly by the Public<br><br>Conditions at major entrances are improved to the acceptable 'Standing' limit. |

## LDDC Lawson Assessment Criteria

- 1.24 The acceptability of windiness is subjective and depends on a number of important factors, particularly the type of activity being performed.
- 1.25 Lawson's comfort criteria are used to describe frequent wind conditions and specify tolerable limits for various activities. The discrete categories, in order of increasing windiness, are described in Table 10.1. These conditions are limiting thresholds for comfort. For ideal conditions, it would be desirable to achieve a category better than the comfort categories described below.
- 1.26 The terms 'Sitting', 'Standing', 'Strolling' and business 'Walking' are used in the text to describe the comfort levels of windiness as described in Table 10.2. The coloured dots are used to indicate the windiness on the referenced figures, eg Figure 10.5, which also show the measurement locations.

**Table 10.2 : Lawson Comfort Criteria**

| Comfort Criteria                   |                                                                                     | Description                                       |
|------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------|
| Long Term 'Sitting'                |    | Reading a newspaper, eating and drinking          |
| 'Standing' or short term 'Sitting' |    | Bus stops, window shopping and building entrances |
| Walking or 'Strolling'             |    | General areas of walking and sightseeing          |
| Business 'Walking'                 |  | Areas where people are not expected to linger     |

- 1.27 There are also distress (or safety) criteria used to describe less frequent levels of windiness, to be exceeded less often than once a year. These are described in Table 10.3.
- 1.28 The distress limit for 'General Public Access' corresponds to an equivalent mean speed of 15 m/s and gust speed of 28 m/s. Exceeding this limit signifies a safety hazard for less able-bodied members of the public (e.g. elderly and cyclists). In such instances, the wind tunnel results would display a single red ring around the outside of the coloured dot as shown in Table 10.3.
- 1.29 There is a further limiting distress criterion above which 'Able-bodied' individuals may find themselves in difficulties at times. This corresponds to a mean speed of 20 m/s and a gust speed of 37 m/s. Aerodynamic forces beyond this limit approach the body weight and it rapidly becomes impossible to remain standing. If these conditions are exceeded, then the wind tunnel results would display a double red ring around the outside of the dot as shown in Table 10.3. Such winds may also affect safety of some road vehicles.

**Table 10.3: Lawson Distress Criteria**

| Distress Criteria       |                                                                                     | Description                                                                                |
|-------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| 'General Public Access' |  | Above which the less able and cyclists may at times find conditions physically difficult   |
| 'Able Bodied Access'    |  | Above which it may become impossible at times for an able bodied person to remain standing |

## Assumptions and Limitations

During the modelling and analysis of the pedestrian level winds around the proposed development, the following limitations were identified and the corresponding assumptions were made:

- There is little information about future developments in the area to the north-east of the site, the space was considered and tested as open. Future developments in this area as part the masterplan or otherwise could affect the wind conditions around the proposed development.
- The Irwin probes used for the wind tunnel test give readings at a single point on the model. Care was needed to place the probes at points of interest and where high wind speeds in pedestrian areas were expected to occur. Areas in between are likely to have intermediate conditions.
- The wind data used for modelling the conditions around the site is based on previous wind speeds gathered from Manchester airport and corrected for the site. There is no reliable methodology for assessing future variations in wind due to climate change.

## Baseline Conditions

- 1.30 The baseline configuration is for the Site with existing surroundings (Figure 10.4). The Site is partially sheltered from the westerly winds by Victoria station and the newly constructed roof extension, and from the easterly winds from the buildings along the eastern side of Corporation Street. However, the Site is exposed to the southerly and north-easterly winds, which are unobstructed by relatively large open plots.
- 1.31 The 'worst season' (normally winter) wind conditions around the Site (with existing surrounding) are shown in Figure 10.5, and are summarised below:
- 'Standing' conditions along Corporation Street, Cheetham Hill Road Railway Bridge, and tram tracks to the south of the Site. Conditions are acceptable for general access use;
  - 'Strolling' conditions to the north-east of the site along Corporation Street, including an exceedance of the distress conditions for general public access. These conditions are likely to be windy for normal uses, but note that these conditions have been measured considering the whole area to the north-east of the Site (Ducie Bridge, Angel Square and Plot L) vacant, as shown in Figure 10.4.
  - Mainly 'Sitting' to 'Standing' at all measured locations within the site.
  - 'Sitting' conditions at all measured points underneath the new Victoria Station roof.
- 1.32 Wind conditions are therefore acceptable for the current use at all locations of measurement.

## Identification and Evaluation of Significant Effects

### Overview

- 1.33 The Proposed Development includes an office building and two residential buildings connected by a footbridge. A view of the wind tunnel model of the Proposed Development with existing surroundings is shown in Figure 10.6.
- 1.34 The office building, 8 storeys tall, fits in the south corner of the Site (Plot 3), and is bounded by the southern end of Corporation Street and the tram tracks to the west. Details of the office building and the main entrance to the south-east are shown in Figure 10.7.
- 1.35 The residential building in Plot 1 is at the north-west corner of the site and is 25 storeys tall. The residential building in Plot 2 is along the north-east side of Corporation Street and is 20 storeys tall. Both residential

buildings have private balconies along the entire height of the north and south facing facades, as shown in Figure 10.8.

1.36 Figure 10.9 shows the landscaping plan, that included 12 trees placed as follows:

- 2 x 8m tall trees to the south-west of the residential building in Plot 1;
- 3 x 8m tall trees to the north of the residential building in Plot 2 along Corporation Street;
- 4 x 8m tall trees to the east of the residential building in Plot 2 along Corporation Street;
- 2 x 8m tall trees to the west of the residential building in Plot 2 towards the car park;
- 1 x 8m tall tree at the northeast corner of the office building.

1.37 The wind tunnel workshop, carried out in the presence of SR Architects served to develop a set of wind mitigation measures to improve wind conditions around the Proposed Development. Both the completion and intermediate development phases were tested with existing surroundings.

## **Proposed Development at Completion with Existing Surroundings**

1.38 Wind conditions around the Proposed Development at completion, and in the context of existing surroundings, (Figure 10.6) and with the mitigation described below, are shown in Figures 10.10 and 10.11, for worst season and summer season, respectively. The results are assessed relative to the proposed pedestrian activities. (Note that some of the conditions described below improve when other planning approved developments are included in the surroundings as described later in this document.)

## **Mitigation**

1.39 The mitigation measures developed through the wind tunnel tests have reduced the windiness at and around the proposed development to what are considered satisfactory levels. This demonstrates that there is a wind mitigation solution that can be successfully implemented. The wind mitigation measures and their integration with the masterplan will be developed further during the detailed design phase with further wind testing to optimise the solution's integration with the masterplan scheme.

1.40 The main entrance to the office building is exposed to the south-westerly and westerly winds and without mitigation windiness exceeds all acceptability limits. With the addition of a 3m wide, full height solid advertising board with gaps between the frame and the board (equivalent to about 30% porous) to the south west of the entrance, lower 'Strolling' is achieved, but this condition still exceeds the acceptable 'Standing' limit for entrances. A picture of the mitigation as tested is shown in Figure 10.15.C. Note that wind pressure in this location may affect infiltration and door operation.

1.41 Westerly and north-westerly winds are channelled through the passage between the office building and the south side of the residential building in Plot 2. Proposed mitigation includes 5 staggered elevated vertical fins (3m tall, 2m wide, 40% porous) later described as 'flags' along the ramp to the car park and 4 x 5m tall trees, two in the 'triangle' of land on the northern side of the ramp and two at the opposite sides of the lower exit of the ramp as indicated in Figure 10.15B/G. Note that the 'flags' may need to be articulated to allow passage of large lorries. With mitigation in place, conditions in the passage are generally in the 'Standing' to 'Strolling' range and suitable for pedestrian access. Such protection is needed because this area is expected to be frequently accessed by pedestrians.

1.42 Westerly and easterly winds are accelerated under the foot bridge. The addition of two 40% porous screens (4m tall and 5m wide) within the car park, close to the bridge on the southern side helps to reduce this acceleration from the west but does not eliminates the local distress. Pedestrian routes which avoid the areas of highest windiness should be indicated on site. Conditions in the areas close to the residential buildings on either side are 'Standing' to 'Strolling' and acceptable for pedestrian access. A detail of the mitigation is shown in Figure 10.15A.

- 1.43 Wind conditions along the northern part of Corporation Street on the northwest corner of Old Bank are in the 'Standing' to 'Strolling' range. The addition of 3 screens (4.5m wide, 3m tall, 30% porous) placed diagonally between the trees along Corporation Street to the east of the residential building in Plot 2 helps reduce windiness along the east building frontage. A detail of the mitigation is shown in Figure 10.15E.
- 1.44 Two screens are placed at the south-east corners of the residential building in Plot 2 to reduce the effect of the wind acceleration around the corners.
- 1.45 One, 40% porous screen, 6m long and 3m tall, extending to the south-west from the south-east corner of the central block of the residential building in Plot 2. This screen reduces the wind conditions to within the 'Standing' range, suitable for good weather outdoor sitting conditions. A detail of the mitigation is shown in Figure 10.15F.
- 1.46 One, 30% porous screen, 3m tall and 4.5m wide at the south-east corner of the easternmost block of the residential building in Plot 2, along and parallel to Corporation Street. This screen reduces the wind conditions along Corporation Street to the 'Walking' range and suitable for 'general public' access. A detail of the mitigation is shown in Figure 10.15D.

### **Intermediate development phase (without the office building)**

- 1.47 Figure 10.12 shows the Proposed Development without the office and in the context of existing surroundings. This includes the two residential buildings and a 5m tall, solid hoarding, placed around the perimeter of the office building site. Consultation with Manchester City Council following the wind tunnel test indicated their preference away from hoarding in the interim phase. Therefore, an alternative acceptable intermediate wind mitigation solution will be developed during the detailed design stage with further wind tunnel testing.
- 1.48 The residential buildings are significantly taller than immediate surrounding buildings and are exposed to all winds that accelerate at the corners creating areas of windiness. In addition, being orientated south-west to north-east, the residential buildings channel the prevailing winds in the gap between them.
- 1.49 Figure 10.13 and 10.14 illustrate the wind conditions in the context of existing surroundings in the worst season and summer respectively with the mitigation described below. The results are assessed relative to the proposed pedestrian activities.

### **Mitigation**

- 1.50 The mitigation measures developed through the wind tunnel tests have reduced the windiness at and around the proposed development to what are considered satisfactory levels. This demonstrates that there is a wind mitigation solution that can be successfully implemented. The wind mitigation measures and their integration with the masterplan will be developed further during the detailed design phase with further wind testing to optimise the solution's integration with the masterplan scheme.
- 1.51 Overall, the wind conditions are worse than at completion. However, the mitigation proposed in the previous section is effective to improve windiness at ground level and achieve tolerable conditions. In particular:
- The 40% porous screen (6m long by 3m tall) near the south-east corner of the central block of the residential building in Plot 2 lowers conditions in the passage to mostly lower 'Strolling', with areas of 'Standing' near the south-east corner of the residential building (Figure 10.15F).
  - The 3 screens (4.5m wide, 3m tall, 30% porous) placed diagonally between the trees along Corporation Street to the east of the residential building in Plot 2 help reduce windiness along the east building frontage and across the street. A detail of the mitigation is shown in Figure 10.15E.

- The 30% porous screen (3m tall by 4.5m wide) at the south-east corner of the easternmost block of the residential building in Plot 2 also helps reduce down drafted winds accelerating around this corner to the 'Walking' range and suitable for 'general public' access (Figure 10.15D).
  - Two 40% porous screens (4m tall and 5m wide) within the car park, close to the food bridge on the southern side are useful to achieve similar conditions as at completion (Figure 10.15A).
- 1.52 Wind conditions along Corporation Street are worse than at completion. There is a marginal exceedance of the distress criteria along the north-east side of Corporation Street (15.09m/s and 15.59m/s and the limit is 15m/s). The existing bus shelter is important to provide protection before the office building is complete.

## **Proposed Development at Completion with Future Surroundings**

- 1.53 The future developments included in the cumulative analysis are listed below and are identified in figure 10.16
- City Buildings Hotel
  - Plot L Angel Gardens
  - 2/3 Angel Square
- 1.54 Windiness around the buildings improved in the context of future surroundings. Figure 10.17 and 10.18 illustrate the wind conditions around the development with all the previously agreed mitigations (described above) for the worst season and summer respectively. The following results are assessed relative to the proposed pedestrian activities.
- Wind conditions around the office building improve to 'Standing' or 'Sitting' which is acceptable for entrances and pedestrian access.
  - The conditions within the passage between the office building and the residential building in Plot 2 are similar to those measured with existing surroundings. Mostly 'Standing' is achieved with few areas of 'Strolling' making it safe for pedestrian access.
  - The area around and under the footbridge improves to 'Standing' with no distress, making it safe for pedestrians to access all areas beneath the bridge.
  - Conditions along Corporation Street improve to mostly 'Standing' and small zones of 'Strolling' which is acceptable for entrances and window shopping.
- 1.55 Conditions in all areas improve and are within acceptable limits for the intended activities at all measured locations.

## **Mitigation Measures**

- 1.56 The minimum agreed mitigation measures are summarized in Figure 10.15 and described in the previous sections.
- 1.57 Possible additional mitigations are described below which will improve conditions in and around the development during phasing and while existing surroundings are in place.
- Moving the main entrance of the office building to the south-east side, where 'Sitting' or 'Standing' conditions are measured, would achieve satisfactory conditions for access and also for door operation.
  - During the intermediate development phase, additional mitigation might be considered for the short term near the bus stop in Corporation Street.

1.58 It should be noted that neither of the mitigations described in 1.57 are needed once the future surroundings tested, as described in 1.53 are in place.

## Residual Effects

1.59 Table 10.4 below identifies the residual effects of the proposed development and the agreed mitigation on the pedestrian wind environment both on and off site. The significance for pedestrians is described using the terminology and criteria defined in Table 10.1.

**Table 10.4 – Summary of residual effects**

| Pedestrian Level Wind Condition                                                                                                                   | Pre-mitigation Significance                                                 | Agreed Mitigation                                                                                                                     | Residual Significance                                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Completion Phase</b>                                                                                                                           |                                                                             |                                                                                                                                       |                                                                                                                                           |
| High wind accelerations around southeast corner of the residential building in Plot 2 and exceedance of the distress criteria.                    | <b>Major adverse effect</b>                                                 | Addition of porous screens at corners and 'flags' along the passage between Office building and residential building in Plot 2.       | <b>Negligible effect</b>                                                                                                                  |
| 'Business Walking' and exceedance of the distress criteria under foot bridge.                                                                     | <b>Major adverse effect</b><br>(distress speed = 18.59m/s) mostly from West | Addition of two porous screens in the lower level parking lot, just south of the foot bridge and indicate safe pedestrian route.      | <b>Negligible effect</b><br>(With the porous screens present, conditions become acceptable with cumulative developments in place)         |
| 'Strolling' conditions and possible suction at the corner Entrance to the Office building.                                                        | <b>Major adverse effect</b>                                                 | Solid screen to the south west of the entrance.                                                                                       | <b>Negligible effect</b><br>(Conditions become acceptable with the solid screen and with cumulative developments in place)                |
| High 'Business Walking' and exceedance of the distress criteria along the passage between Office building and the residential building in Plot 2. | <b>Major adverse effect</b>                                                 | Additional trees to the lower level exit and northern side of the car park ramp and alternating, raised, porous 'flags' along passage | <b>Negligible effect</b>                                                                                                                  |
| <b>Intermediate development Phase</b>                                                                                                             |                                                                             |                                                                                                                                       |                                                                                                                                           |
| 'Business Walking' and exceedance of the distress criteria along the northern part of Corporation Street.                                         | <b>Major adverse effect</b>                                                 | Additional trees and porous screens along the western edge of Corporation Street and temporary mitigation near the bus stop.          | <b>Negligible effect</b><br>(Conditions become acceptable with the proposed protection and when the cumulative developments are in place. |

## Non-Technical Summary

- 1.60 Wind tunnel workshops were carried out in the presence of SR Architects to develop a set of wind mitigation to improve wind conditions around the Proposed Development during its intermediate development and at completion with existing and cumulative surroundings.
- 1.61 Tests were carried out in the atmospheric boundary layer wind tunnel at RWDI Anemos Ltd using a 1:300 reduced-scale model of the Proposed Development and surroundings within 350m.
- 1.62 The baseline used was of the Site and existing surroundings. A point in the intermediate development phase was tested with existing surroundings, where the two residential buildings are complete and a hoarding is placed around the perimeter of the office footprint. The complete Proposed Development was tested with existing and cumulative surroundings.
- 1.63 Lawson's Assessment Criteria were used to assess the wind conditions according to pedestrian activities and associated comfort and safety levels.
- 1.64 The results of these tests showed windiness to increase compared with the baseline. However, with mitigation, acceptable conditions for the anticipated pedestrian use of the areas around the Proposed Development may be achieved. Implementing mitigation that is less effective than those tested, could lead to unacceptable conditions.
- 1.65 Key mitigations identified include:
- Planting 12x8m tall and 5x12m tall deciduous trees within the site at key areas to help disperse high winds,
  - Installing a solid screen to the southwest of the Office entrance or moving the office entrance to a more sheltered location on the east side of the building,
  - Installing 5No. elevated, porous screens or 'flags' along alternate sides of the road between the office building and the residential building in Plot 2,
  - Installing two large porous screens in the car park to the south of the footbridge,
  - Incorporating three porous screens between the 8m tall deciduous trees along Corporation Street and next to the residential building in Plot 2,
  - Installing two screens at the south-east corners of Residential Building No. 2.
- 1.66 It should be noted that the tests were carried out with model trees intended to represent deciduous trees in winter and of current or intended size. Further growth would be expected to improve the conditions.
- 1.67 With the proposed mitigation in place, the Proposed Development, in the existing surroundings will have a minor adverse impact along part of Corporation Street. This improves when future cumulative surroundings are built to the north-east and south.



Figure 10.1: 1:300 scale model of the Proposed Development with existing surroundings (view from the south)

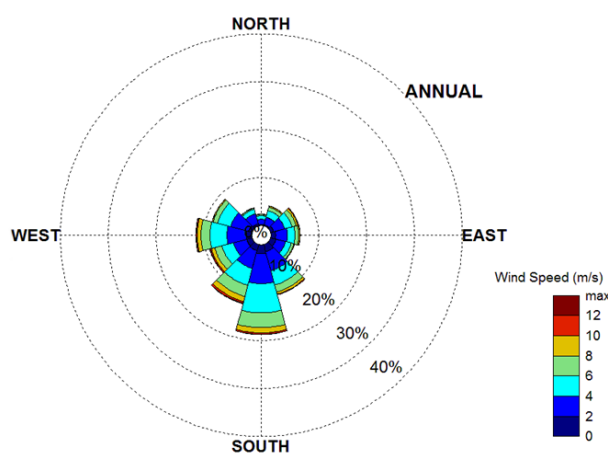


Figure 10.2: Annual wind rose obtained from the wind data recorded at Manchester Airport (10m height) during the years 1991 to 2015.

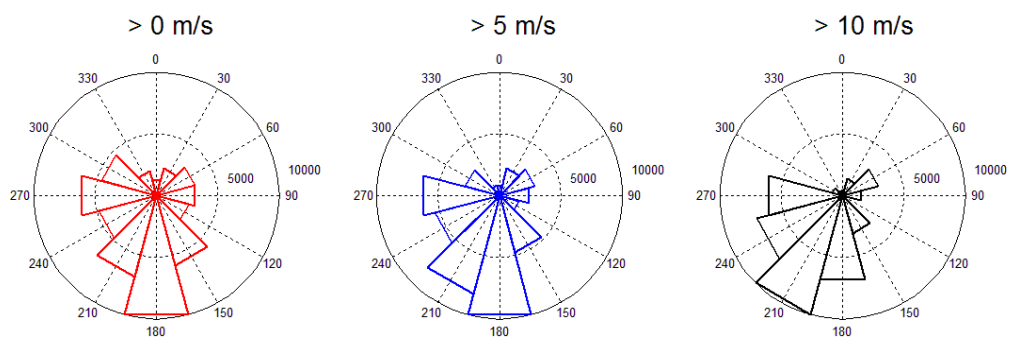


Figure 10.3: Probability of exceedance of wind speeds from Manchester Airport obtained from the wind data recorded during the years 1991 to 2015.

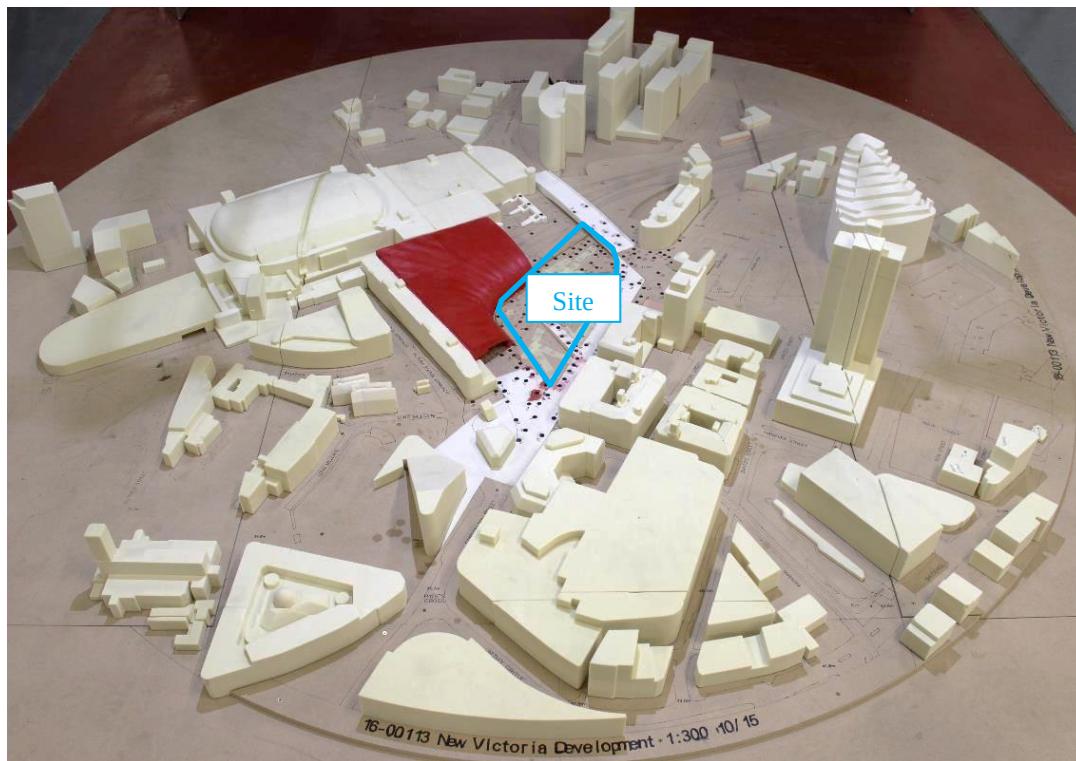


Figure 10.4: Baseline model of the Site with existing surroundings (view from the South)

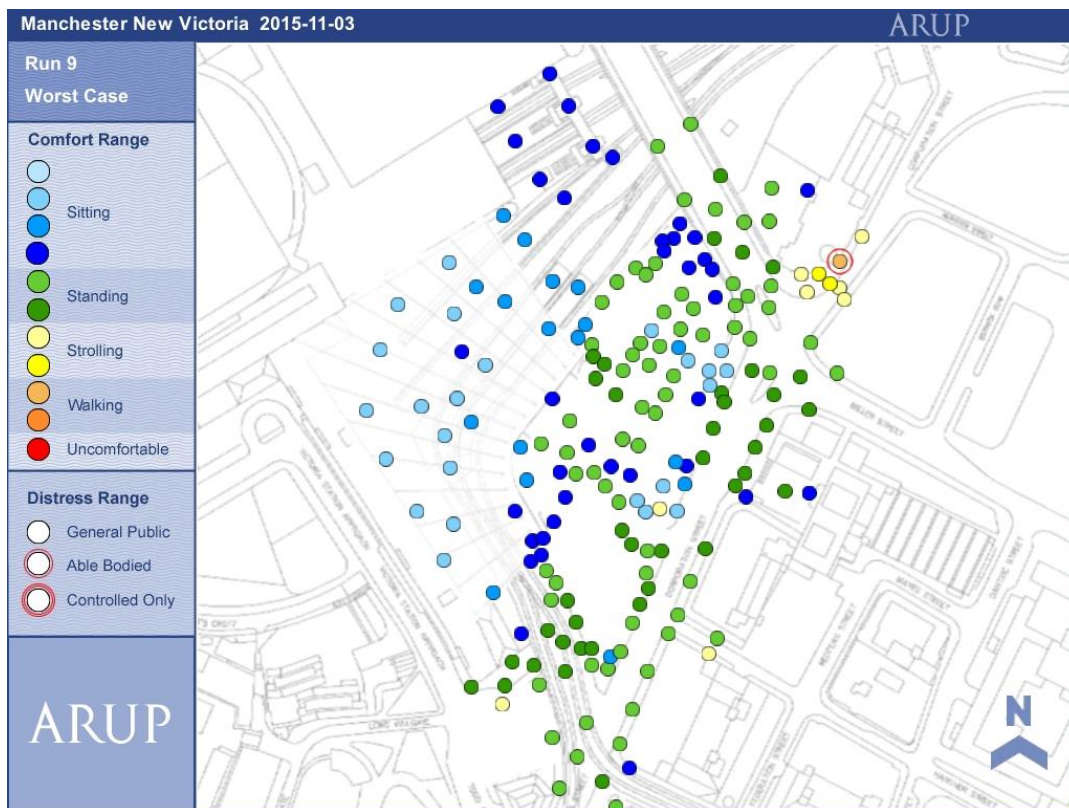


Figure 10.5: Worst season wind conditions for the baseline configuration (Site with existing surroundings).

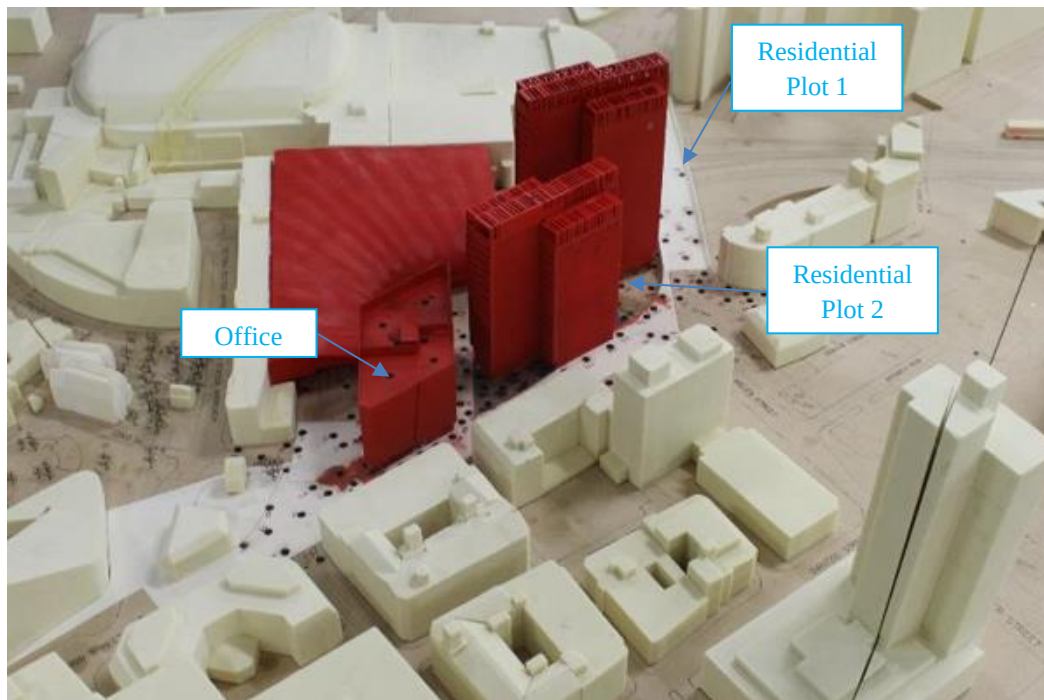


Figure 10.6: Proposed Development with existing surroundings (view from the East).

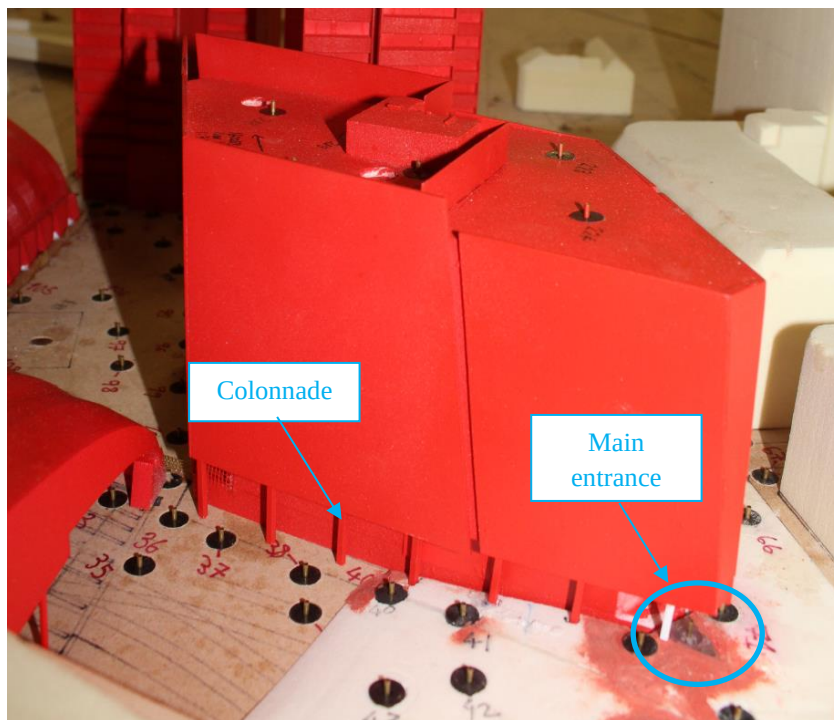
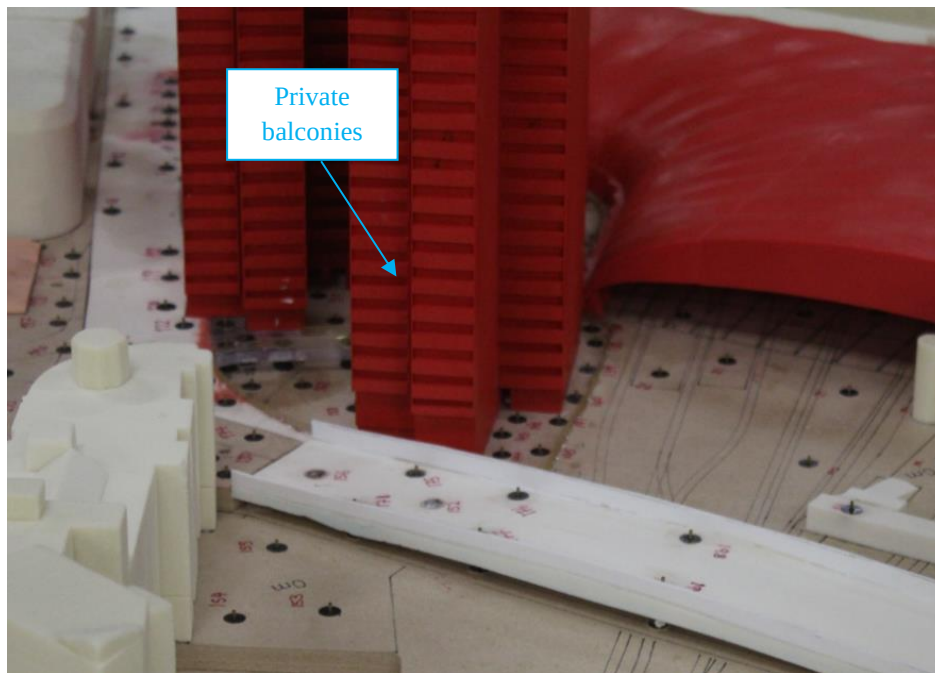


Figure 10.7: Detail of the southern facade of the office building and main entrance (view from the South).



**Figure 10.8: Detail of the northern side of the residential buildings and private balconies (view from the North).**



**Figure 10.9: Summary of tree locations tested (all 8m tall)**

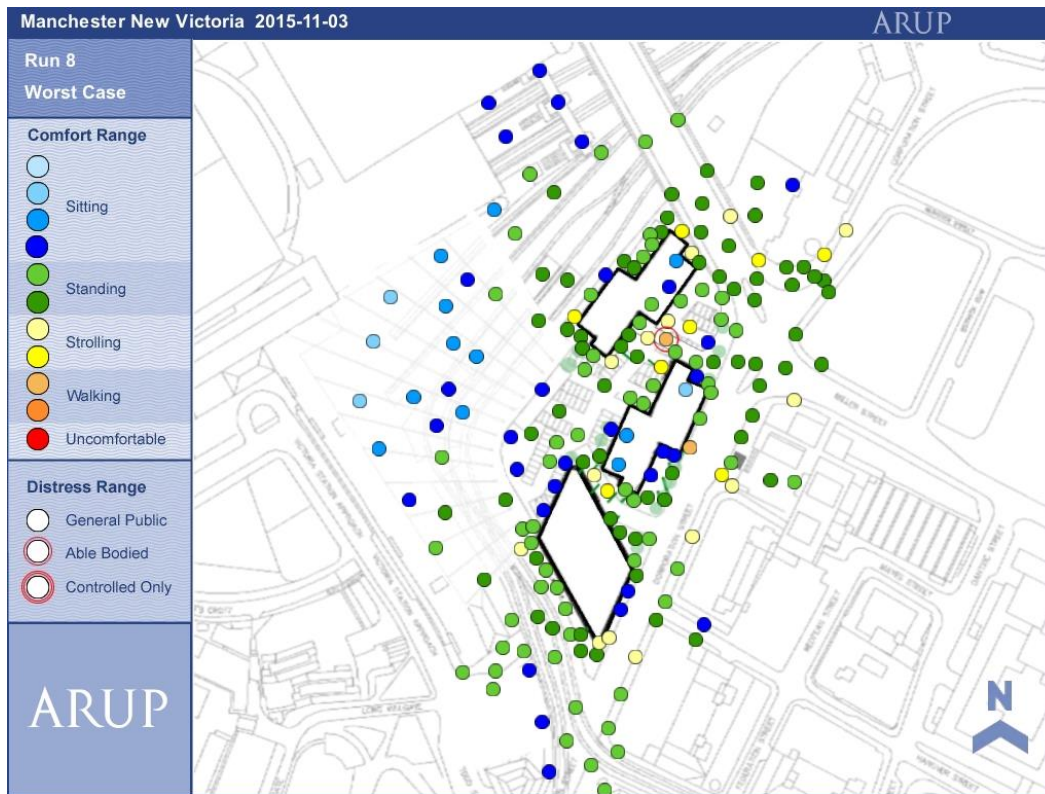


Figure 10.10: Worst season conditions around the Proposed Development (existing surroundings) with wind mitigation as tested.

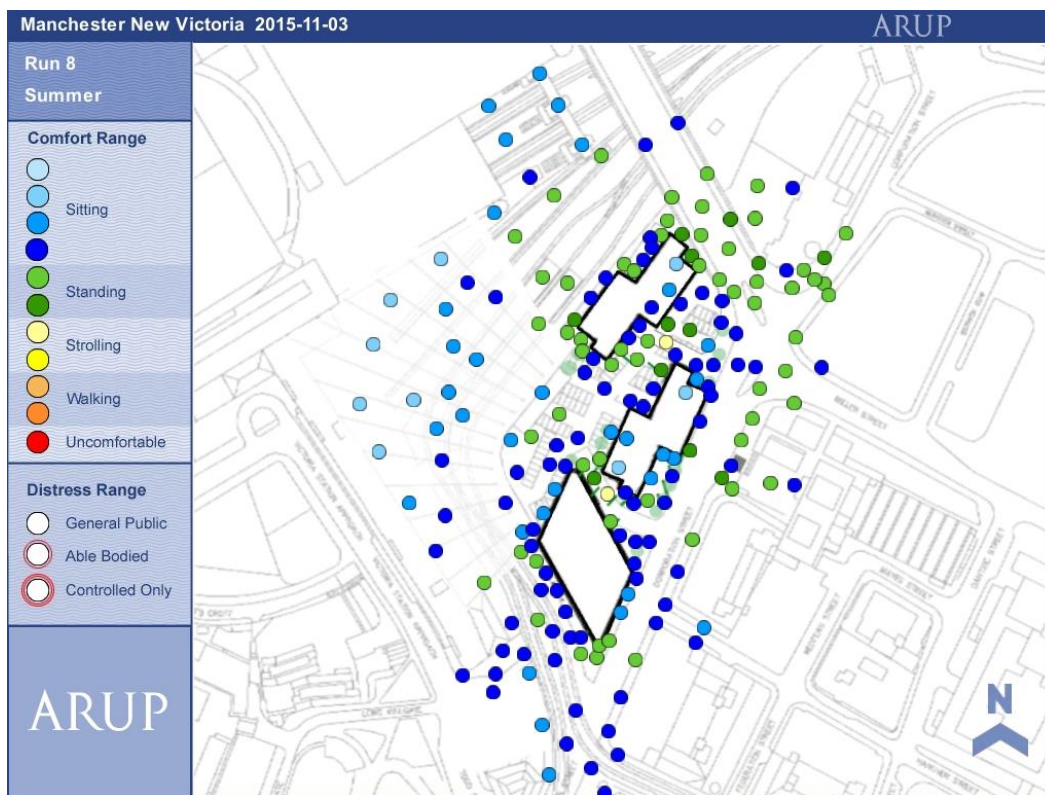


Figure 10.11: Summer conditions around the Proposed Development (existing surroundings) with wind mitigation as tested.

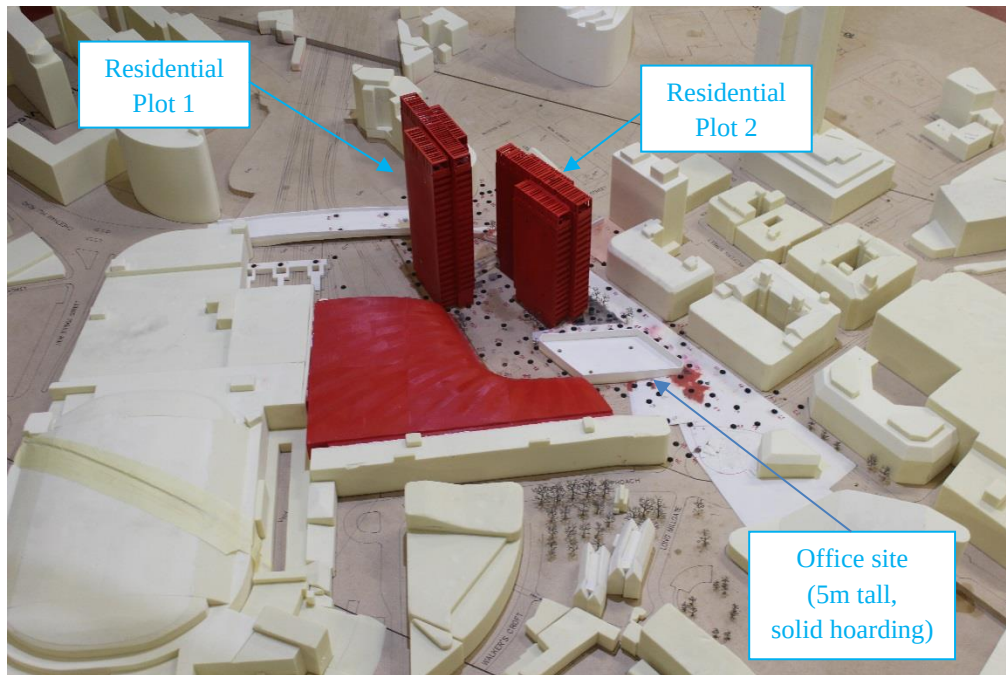


Figure 10.12: Proposed Development during construction with existing surroundings (view from the southwest).

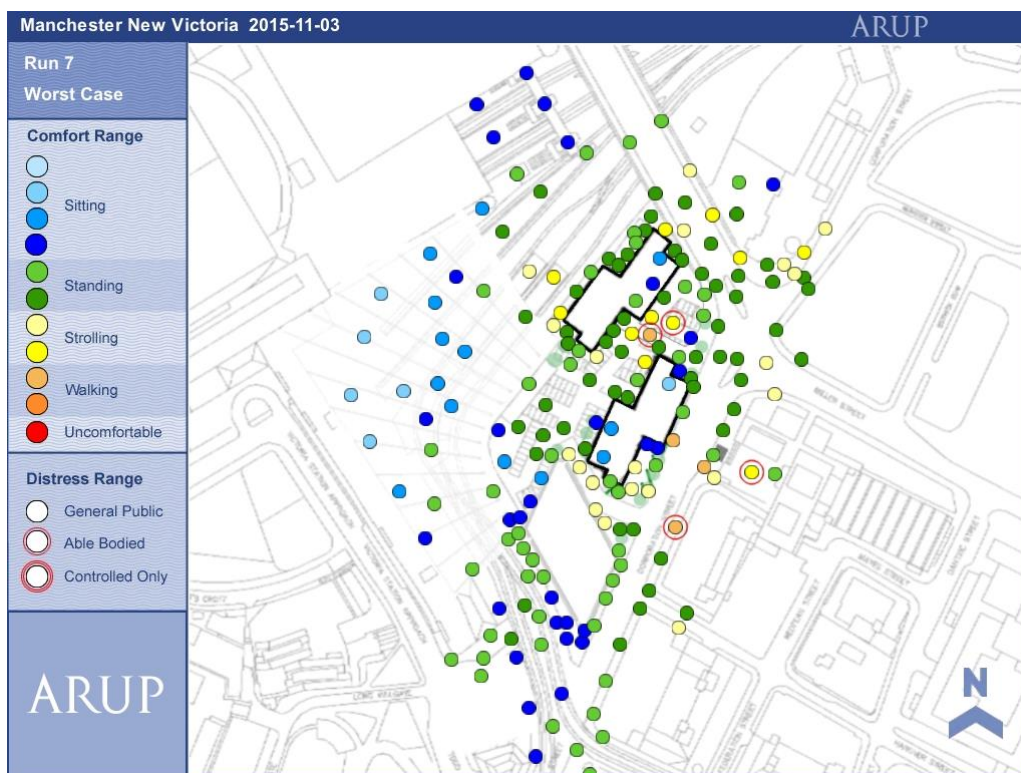


Figure 10.13: Worst season conditions around the Proposed Development during construction (existing surroundings) with wind mitigation as tested.

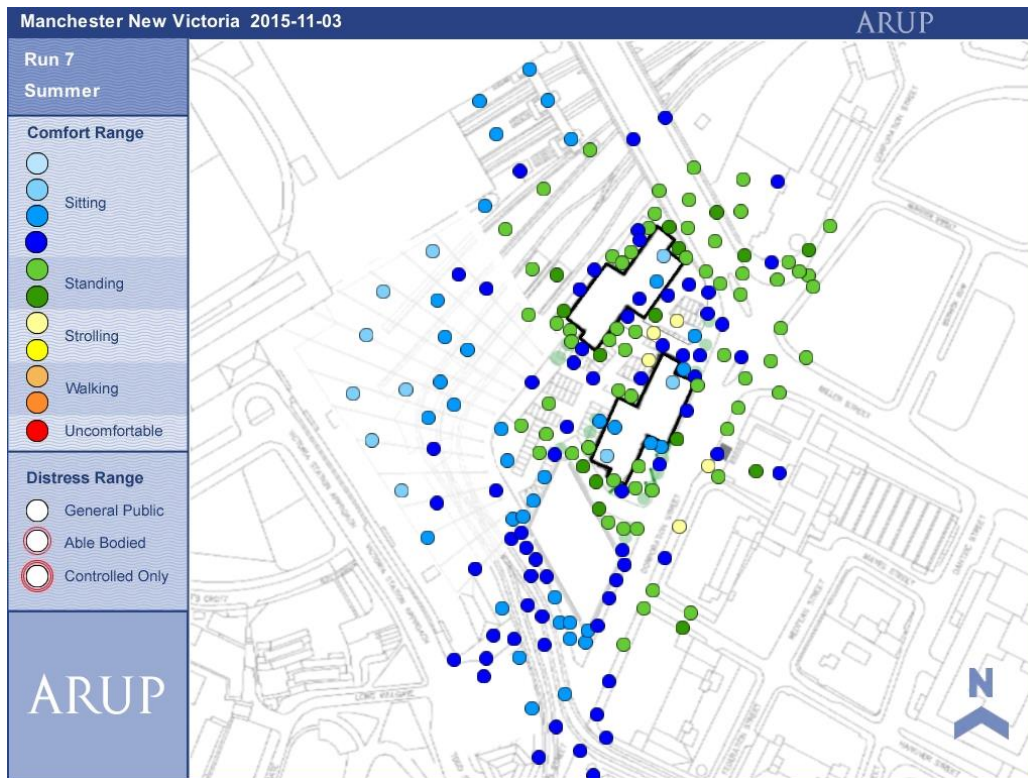


Figure 10.14: Summer conditions around the Proposed Development during construction (existing surroundings) with wind mitigation as tested.

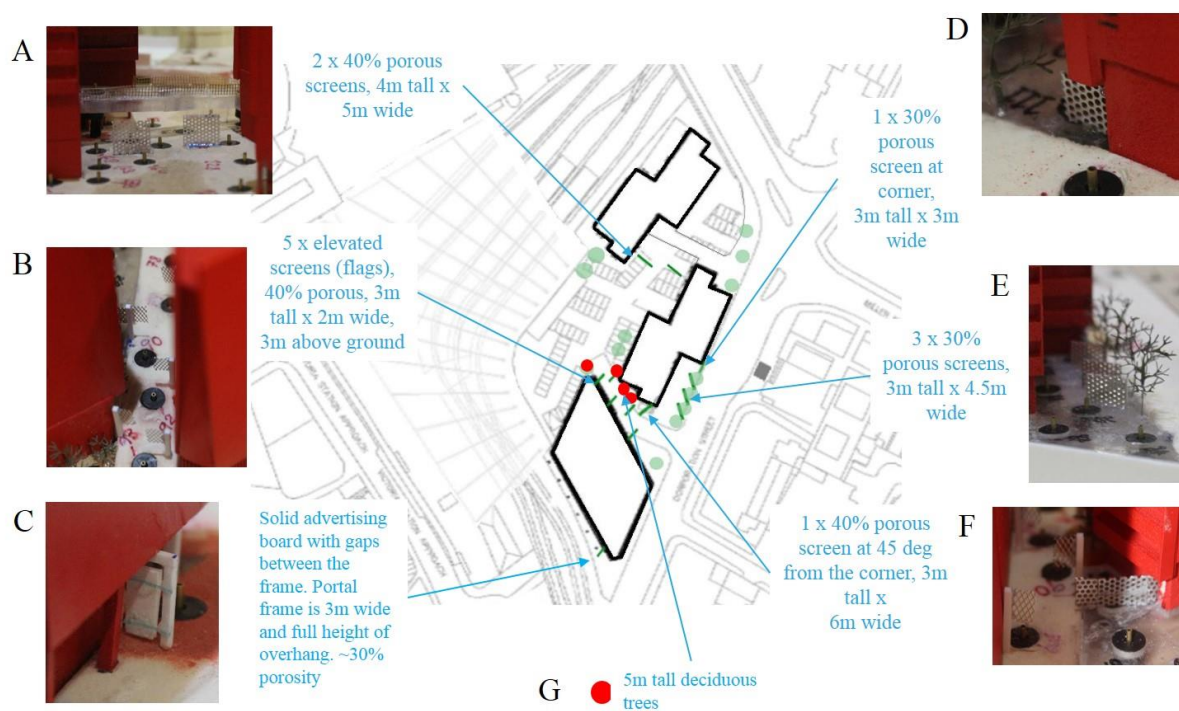


Figure 10.15: Summary of the mitigation as tested.



Figure 10.16: Proposed Development during construction with proposed surroundings (view from the east).

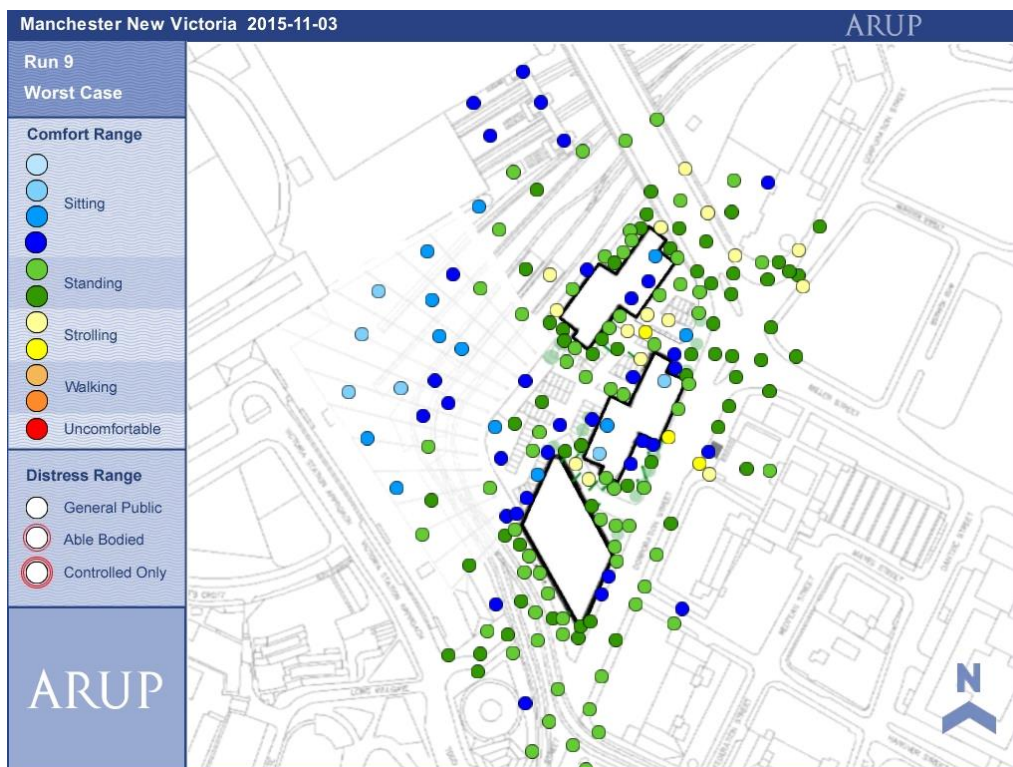
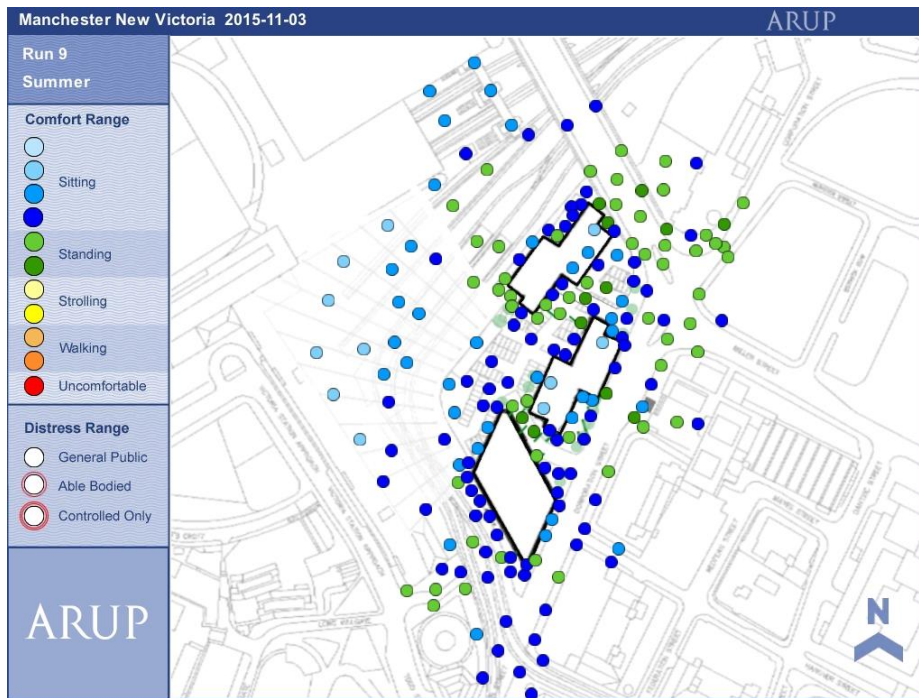


Figure 10.17: Worst season conditions around the Proposed Development with proposed surroundings with wind mitigation as tested.



**Figure 10.18: Summer conditions around the Proposed Development with proposed surroundings with wind mitigation as tested.**