AECOM Water & Urban Development

Air Ventilation Assessment Report (Final)

Mar 2014

土木工程拓展署
CEDD Civil Engineering and Development Department

Agreement No. NTE 06/2013

Technical Assessments to Support Section 16 Application under the Town Planning Ordinance for CDA(3) Site at Whitehead, Ma On Shan

土木工程拓展署
New Territories East Development Office
Civil Engineering and Development Department

Agreement No. NTE 06/2013

Technical Assessments to Support Section 16 Application under the Town Planning Ordinance for CDA(3) Site at Whitehead, Ma On Shan

Air Ventilation Assessment Report (Final) (Ref.F-02)

March 2014

Reviewed:	Anna Chung	11 March 2014
Approved for Issue:	Stephen Lai	11 March 2014

AECOM ASIA COMPANY LIMITED

TABLE OF CONTENTS

List of Tables

FIGURES

APPENIDIX

1 INTRODUCTION

1.1 Background

1.1.1 A site located at the southern part of Whitehead headland in Ma On Shan has been designated as a land sale site by the Government for private housing development. The site is currently zoned "Comprehensive Development Area(3)" ("CDA(3)") under the Approved Ma On Shan Outline Zoning Plan (OZP) No. S/MOS/18 and is subject to a maximum gross floor area (GFA) of 30,000m^2 and building height restriction of 50mPD.

1.1.2 In order to increase flat supply to meet housing needs of the community, it is proposed to explore the possibility of enhancing the GFA and the number of flats to be accommodated on the site. As required, a proposed scenario with an increase of GFA by 20% to 36,000m^2 together with a reduction of average flat size and an appropriate building height for the site is studied. The development parameters of Base Scheme and Proposed Scheme are compared as follows:

Table 1.1 Development Parameters of "Comprehensive Development Area(3)" Site at Whitehead, Ma On Shan

	Base Scheme	Proposed Scheme
Maximum GFA	30,000m^2	36,000m^2
Building Height Restriction	50mPD	58mPD
Assumed Flat Number (Average Flat Size)	231 (130m^2)	550 (65m^2)
Population	698	1,650

1.1.3 The difference between the Base Scheme and the Proposed Scheme is the heights of the development increasing from 50mPD to 58mPD so as to increase the flat numbers. The other design parameters such as the layout plan, the locations of the breezeways (15m in width) and good design features for improvement air ventilation performance are similar in both schemes. The proposed development layout and the cross-section drawings of both development schemes are shown in **Figures 1.1, 1.2 and 1.3**.

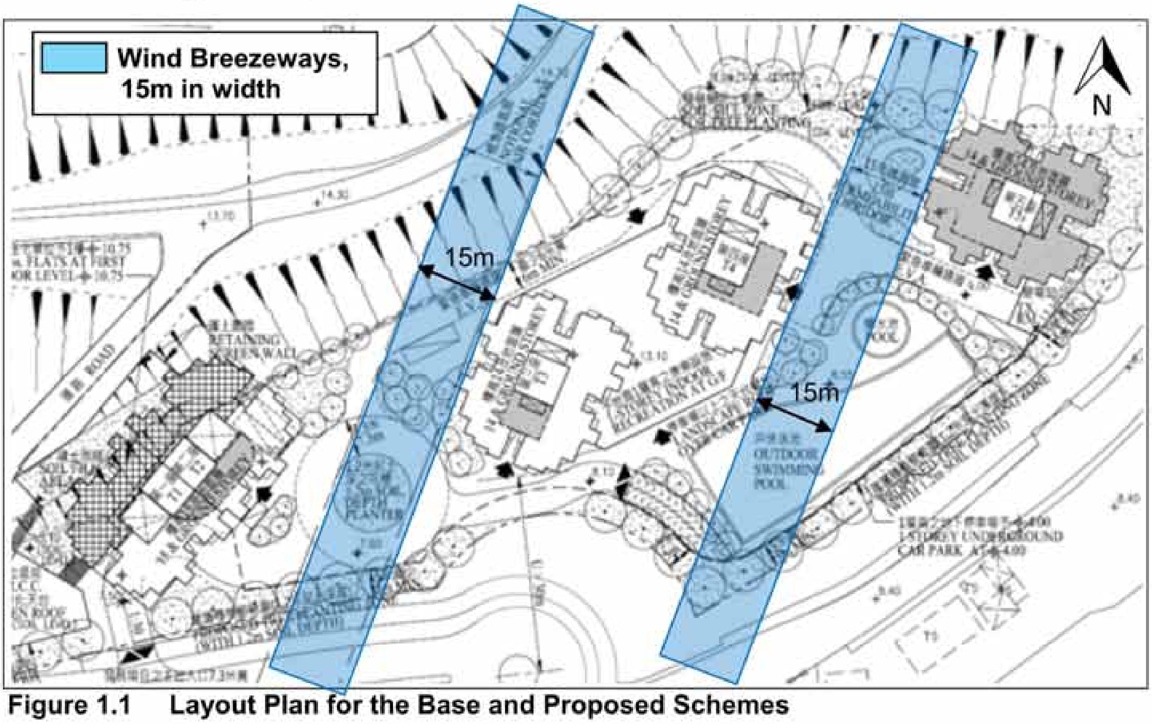


Figure 1.1 Layout Plan for the Base and Proposed Schemes

Figure 1.2 Cross Section of the Base Scheme

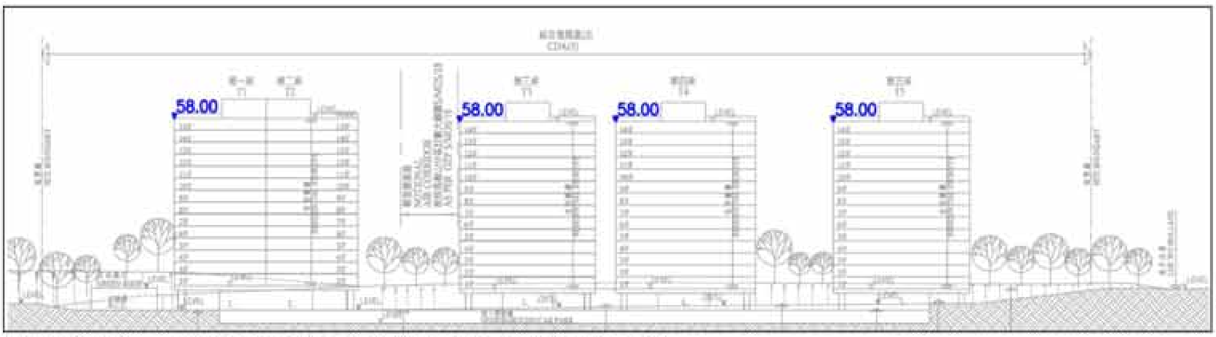


Figure 1.3 Cross Section of the Proposed Scheme

1.2 Objectives

1.2.1 The AVA Study for the CDA(3) Site at Whitehead, Ma On Shan (i.e. the Study Area) has been conducted in accordance with the methodology outlined in the Technical Guide for AVA for Developments in Hong Kong (the Technical Guide) annexed in HPLB and ETWB TC No. 1/06. The main purposes of this AVA Study are:

- To assess the characteristics of the wind availability (V_∞) of the site;
- To give a general pattern and a rough quantitative estimate of wind performance at the pedestrian level reported using Wind Velocity Ratio (VR); and
- To quantitatively assess the air ventilation performance in the neighbourhood of the proposed development after the increasing in building heights.

1.3 Content of this Report

1.3.1 Section 1 is the introduction section. The remainder of the report is organized as follows:

- Section 2 on expert evaluation;
- Section 3 on assessment methodology;
- Section 4 on key findings of AVA study; and
- Section 5 with a summary and conclusion.

2 EXPERT EVALUATION

2.1 Wind Availability

2.1.1 The Study Area, CDA(3) Site at Whitehead, is located in Ma On Shan District, to the north of the Wu Kai Sha Station. The Site falls within the Approved Ma On Shan (MOS) Outline Zoning Plan (OZP) No.S/MOS/18. **Figure 2.1** shows the location of the Subject Site.

Figure 2.1 Location of the Study Area – CDA(3) Site at Whitehead, Ma On Shan

2.1.2 The natural wind availability is crucial to investigate the wind ventilation performance of the Study Area. The Hong Kong Planning Department (PlanD) has released a set of wind availability data of different locations in Hong Kong using MM5 mesoscale model for AVA studies. The set wind availability data can be obtained at the official website of Planning Department (http://www.pland.gov.hk/pland_en/misc/MM5/index.html).

2.1.3 For the Study Area in the current study, the data from grid (32, 35) as shown in **Figure 2.2,** is used as the site wind availability data for wind analysis. Table 2.1 summarizes the annual wind frequencies from MM5 model (Grid 32, 35).

2.1.4 According to PlanD website, wind rose (32,35) as shown in **Figure 2.2**, wind environment surrounding the Study Area was simulated using CFD under the 8 most prevailing wind directions (which represent occurrence of more than 75% of time) to illustrate the change in microclimate due to the proposed development. They are NE, ENE, E, ESE, NNE, SE, SSW, and SW with ENE wind being the most predominant wind, contributing 13.7% of time in a year. The occurrence for the 8 prevailing simulated wind directions (NE, ENE, E, ESE, NNE, SE, SSW, and SW) has a cumulative percentage value of 78.6%.

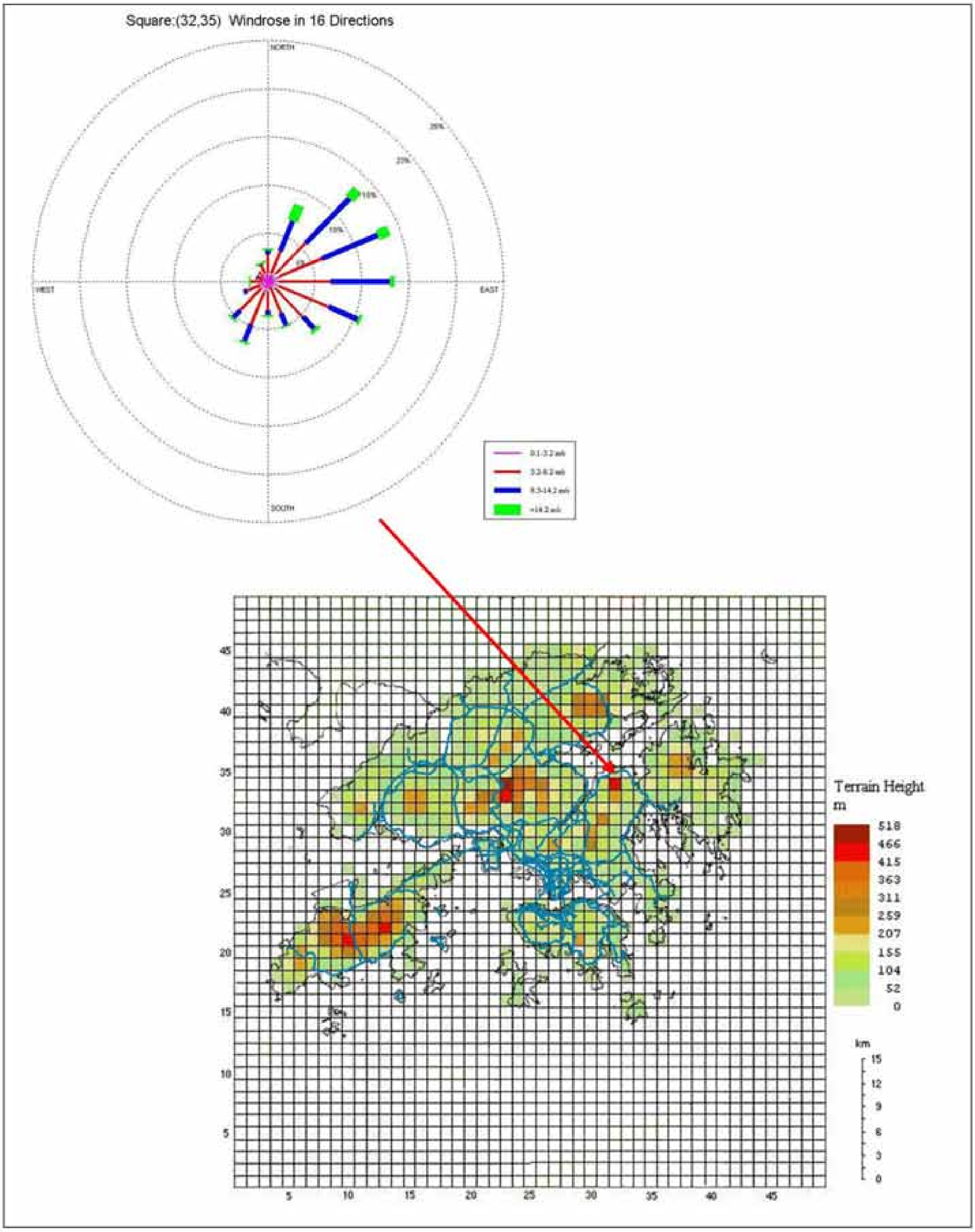
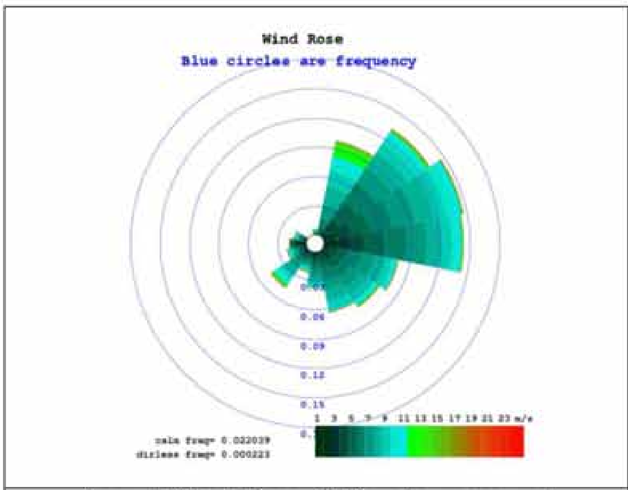
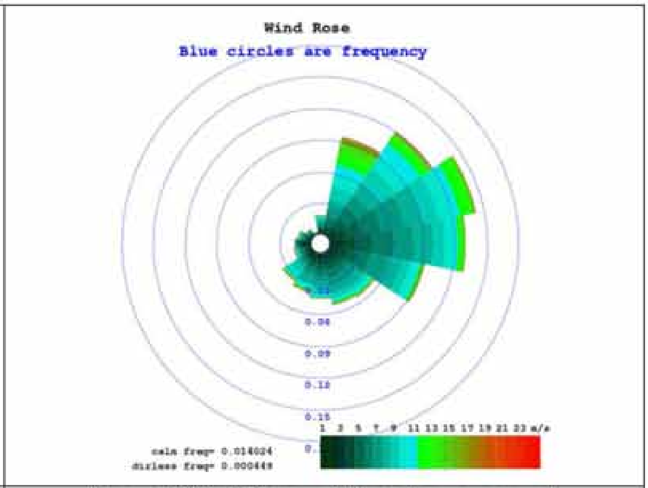


Figure 2.2 Wind Rose from PlanD Website obtained from MM5 Model (Grid 32, 35)

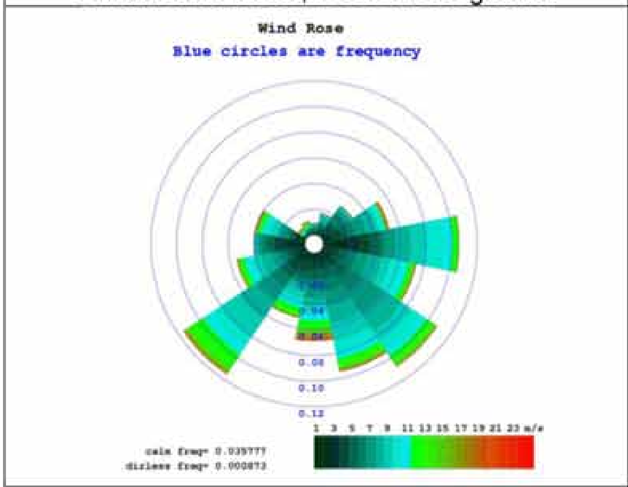
2.1.5 Apart from the wind availability data obtained at Planning Department, the researchers from Hong Kong University of Science and Technology (HKUST) have also simulated a set of wind data using MM5 model, details can be found in the Section 3.6 of Cat. A1– Term Consultancy for Expert Evaluation and Advisory Services on Air Ventilation Assessment (PLNQ 37/2007), Final Report – Ma On Shan Area. Based on the dataset obtained from HKUST, the annual and summer wind roses (120m and 450m above ground) at the location near Wu Kai Sha MTR station are presented in **Figure 2.3**, while the location of the extracted wind data is presented in **Figure 2.4**.



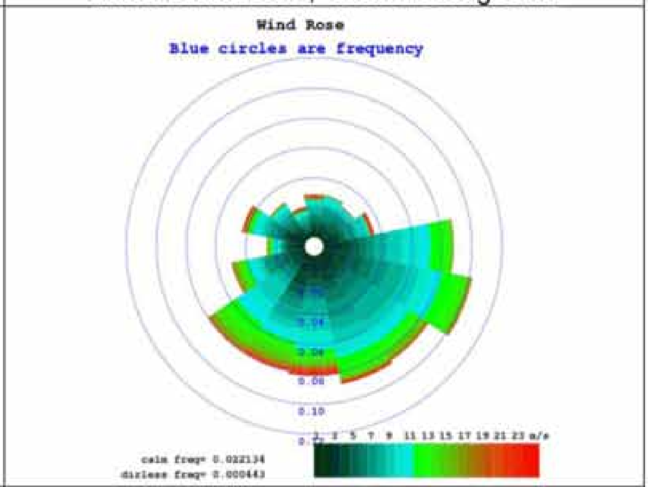
Annual Wind Rose, 120m above ground



Annual Wind Rose, 450m above ground



Summer Wind Rose, 120m above ground



Summer Wind Rose, 450m above ground

Figure 2.3 Wind Rose from HKUST obtained from MM5 model at Location A near Wu Kai Sha Station

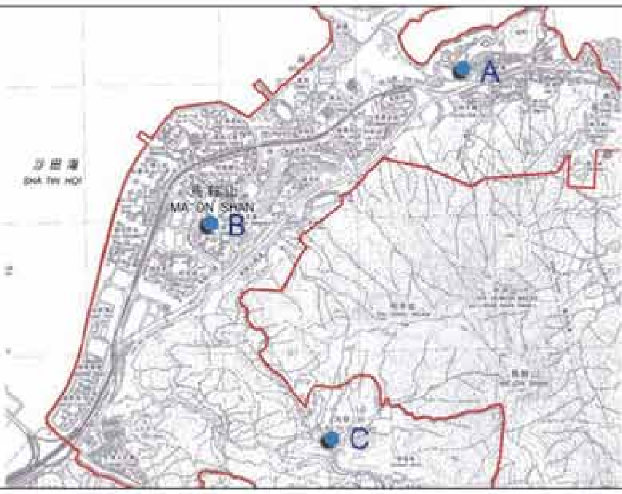


Figure 2.4 Locations of extraction for HKUST MM5 model data

2.1.6 Other than MM5 data, the annual wind roses during 2008 to 2012 from the Sha Tin automatic weather station are presented and shown in **Figure 2.5**. The relative location for the Sha Tin automatic weather station and the Study Area are indicated in **Figure 2.6**

Table 2.1 Annual Wind Frequencies from MM5 model (Grid 32, 35)

Wind Direction	% of Annual Occurrence^
0º (N)	3.40%
22.5º (NNE)	**8.50%**
45º (NE)	**13.3%**
67.5º (ENE)	**13.7%**
90º (E)	**13.3%**
112.5º (ESE)	**10.5%**
135º (SE)	**7.10%**
157.5º (SSE)	5.00%
180º (S)	3.80%
202.5º (SSW)	**6.80%**
225º (SW)	**5.40%**
247.5º (WSW)	2.80%
270º (W)	1.90%
292.5º (WNW)	1.30%
315º (NW)	1.40%
337.5º (NNW)	2.00%

^ Percentage of occurrence directly extracted from wind probability table

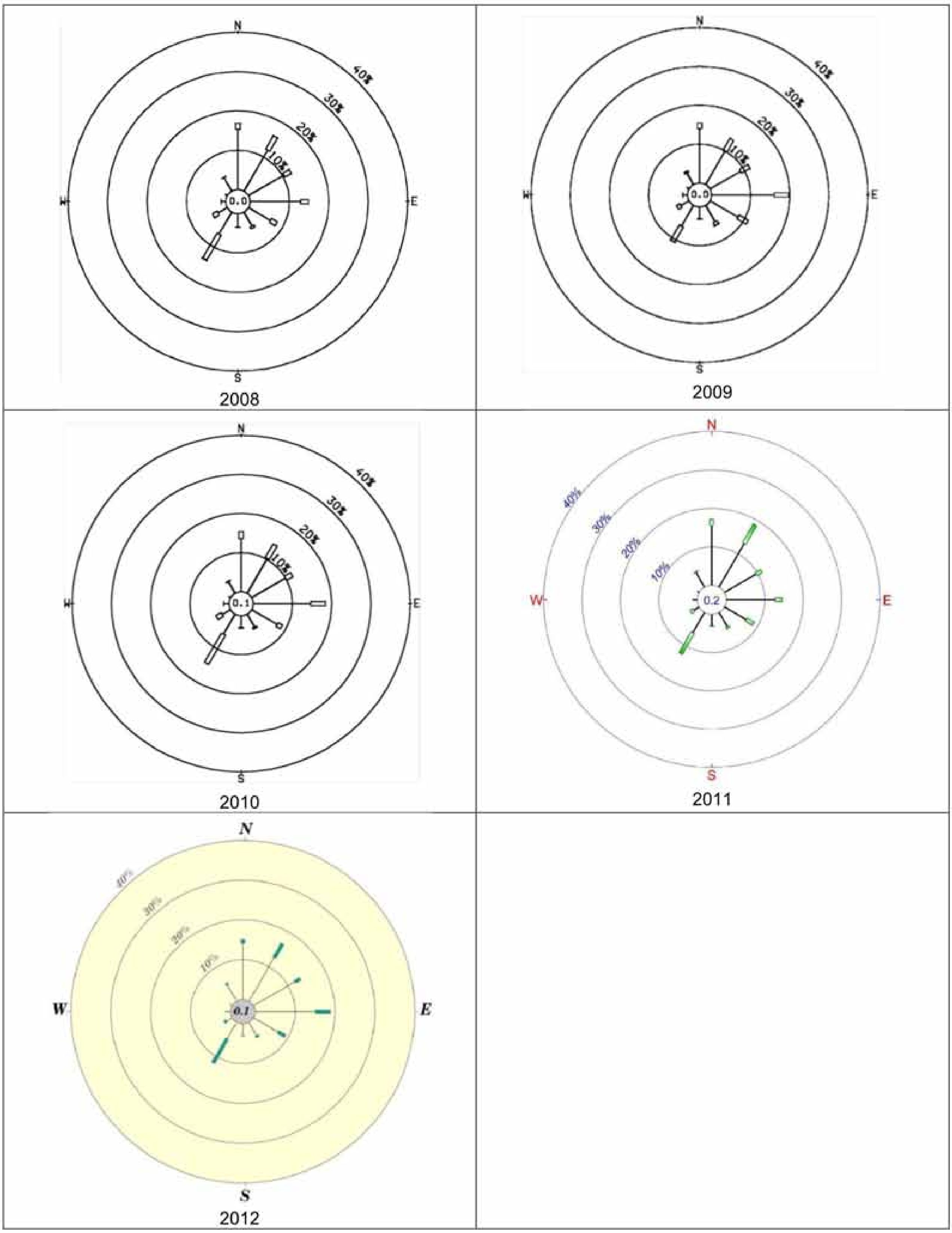


Figure 2.5 Annual Wind Roses from Sha Tin Automatic Weather Station, 2008 to 2012

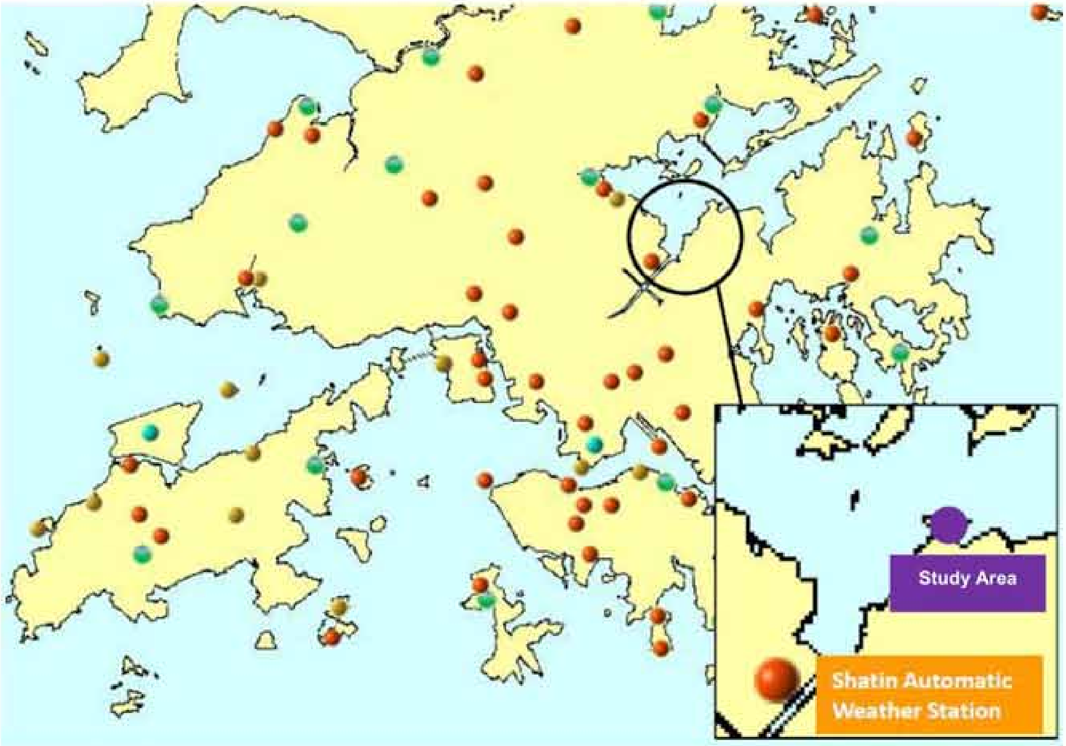


Figure 2.6 Locations of the Weather Stations and the Study Area

2.1.7 The MM5 natural wind availability data (obtained from Planning Department and HKUST) and the HKO data are compared in this report in order to identify the annual and summer prevailing wind directions for analysis on the existing wind environment of Whitehead Area.

2.1.8 From the wind rose obtained from the Planning Department's website (see **Table 2.1**), it is noted that the occurrence of wind from North eastern quadrant (which including NNE, NE, ENE and E) directions occupy 48.8% of the annual wind direction. According to the wind probability table (**Table 2.1**) provided together with the wind rose analysis result shown in **Figure 2.2**, the winds from the E, NE and ENE directions are considered to be the most predominant winds in the area with contributions over 13% per wind of the time in a year.

2.2 Topography and Building Morphology within Study Area and Surroundings

2.2.1 **Figure 2.7(a)** shows land use of the Study Area and its surroundings while **Figure 2.7(b)** is the aerial photo of the study area and the surroundings.

Figure 2.7(a) Land Use of the Study Area and its Surrounding Area

2.2.2 The Study Area, CDA(3) Site at Whitehead area, is located in Ma On Shan District. The Wu Kai Sha MTR Station is located to the south of the Study Area. The terrain in the vicinity of the Subject Site to the north and west is flat, with some GIC(Government , Institution or Community) and leisure facilities as well as open spaces and sea, while there is a very small, low rise hilly terrain as well as sea in its east. The terrain from the southern boundary of the Study Area to Wu Kai Sha is also relatively flat, and huge hilly terrain only occurs further south to Wu Kai Sha. The Project Area of this study falls within the Approved Ma On Shan (MOS) Outline Zoning Plan (OZP) No. S/MOS/18.

1.	Study Area (CDA (3)) (~60mPD)	2.	Whitehead Golf Driving Range	3.	Stadium (25mPD)	4.	CDA (2) (50mPD)
5.	To Tau Village (12.5mPD)	6.	Student Hostel /511-514 in CDA (1) (93mPD)	7.	Double Cove (127mPD)	8.	Wu Kai Sha MTR Station
9.	Lake Silver (173mPD)	10.	Monte Vista (110mPD)	11.	Kam Lung Court, Lee On Estate and Ma On Shan Lee On Community Service Complex (~130mPD)	12.	Chinese YMCA of Hong Kong Wu Kai Sha Youth Village (23mPD)
13.	Villa Concertro Symphony Bay (42mPD)	14.	Villa Rhapsody Symphony Bay (62mPD)	15.	Li Po Chun United World College (34mPD)	16.	Holiday Centre for the Elderly (26mPD)

Figure 2.7(b) Location of the Study Area and its Surrounding Area

2.2.3 The Study Area circled with the red line as shown in the **Figure 2.7(b)** is bounded by Yiu Sha Road and the northern portion of Lok Wo Sha Lane. This CDA is intended for comprehensive private residential development.

2.2.4 To the north and west of the Study Area, there is Whitehead Club Golf Driving Range, CDA(2) developments, and the To Tau Village. The building morphology in these areas are mainly open spaces with separated mid rise buildings.

2.2.5 To the south of the Study Area, there are existing residential developments including CDA(1) developments, Double Cove, Lake Silver, Lee On Estate, Kam Lung Court and Saddle Ridge Garden. The building morphology in this direction is mainly mid to high-rise clusters in mid density. In addition, Ma On Shan New Town Centre is located to the southwest of those residential buildings.

2.2.6 There are seven blocks (forming 3 clusters) in the region of CDA(2), all with height of around 50mPD with around 35m width between the clusters. The CDA(1) development contains 3 blocks with maximum height of 93mPD.

2.2.7 From the above paragraphs, the buildings morphology in the area surrounding the Study Area are mostly low density low to mid-rise buildings and open sea to the north, east, and far west. The high-rise clusters of residential buildings are mainly located south and south southwest to the development area.

2.3 Wind Environment of Existing Scenario

2.3.1 In accordance with the wind availability data, the Study Area relies on easterly, north easterly and east north easterly winds for ventilation during the year. Summer prevailing wind is coming from the easterly, south easterly, southern and south westerly directions. Therefore, any blockage to the prevailing winds mentioned above should be avoided as far as possible.

2.3.2 Yiu Sha Road acts as wind breezeways under the north easterly annual wind direction, and Lok Wo Sha Lane acts as wind breezeways under the south easterly wind directions. Apart from these two major roads, Wu Kai Sha Road and Sai Sha Road located at the south of Subject Site are also considered as wind breezeways. Major wind breezeways are marked in **Figure 2.9** as purple arrows which include but not limited to Yiu Sha Road, Lok Wo Sha Lane, Wu Kai Sha Road, Sai Sha Road. These wind breezeways will enhance and promote ventilation performance at the surrounding areas of the Study Area.

2.3.3 To the vicinity of the Study Area, there are large open areas including the Whitehead Club Golf Driving Range and sea to the north, far west, and immediate east side of subject site which are expected not to create blockages to the wind from the north, west, and east quadrant and will not lead to significant ventilation issues towards the Study Area.

2.3.4 Existing residential buildings such as Double Cove Club House and Lake Silver located at the south direction of the Study Area are high-rise clusters. These clusters will likely to create blockage against the Study Area and weaken the incoming SSW and SW direction winds.

2.3.5 It should be noted that the mid-rise developments at the west of the Study Area (i.e. CDA(2)) incorporate a major wind corridor (around 35m in width) aligning in the southeast-northwest direction, and this corridor is elongate by the separation gap between blocks of CDA(1) to link up the wind breezeway , which aligning in the same direction, between the clusters of the Double Cove as shown in **Figure 2.8** below. This measure will enhance the wind permeability, thus no server wind environment is expected.

2.3.6 It is also noticed that the elongated SE-NW direction wind breezeways mentioned in paragraph 2.3.5 have crossing with the mid portion of Yiu Sha Road (which serve as the major wind corridor aligning in the ENE-WSW direction). Meanwhile, the two wind breezeways each of width 15m within CDA(3) in both Base and Proposed Schemes, which are marked in **Figure 1.1** and **Figure 2.8**, will also reach Yiu Sha Road from the north-north easterly directions. Such wind corridor network as shown in **Figure 2.8** penetrating the building clusters in Whitehead area would be expected to further enhance the wind permeability, and reducing the negative impact in terms of air ventilation issues caused by the (CDA(1), CDA(2) and CDA(3)) developments.

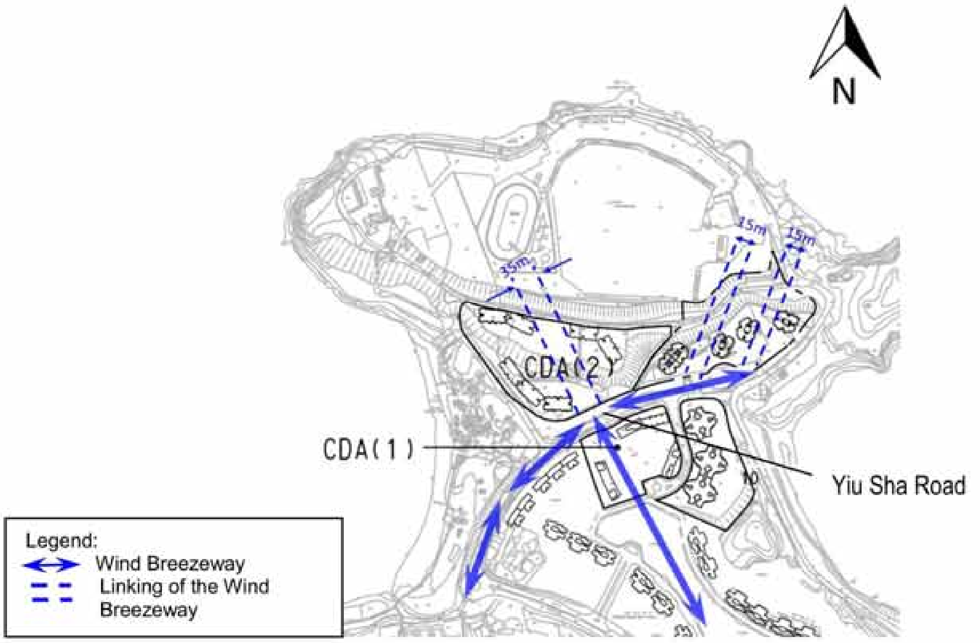
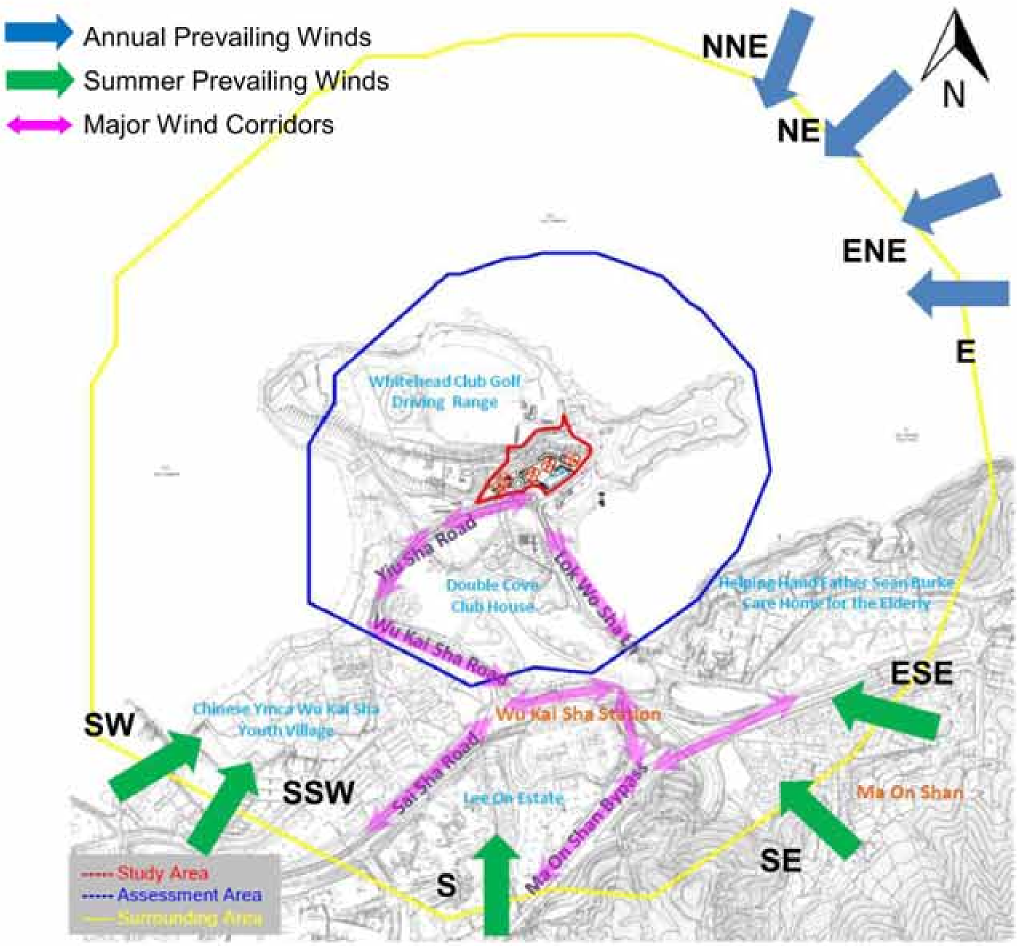


Figure 2.8 Illustration of wind breezeway networks in CDA(1), CDA(2) and CDA(3)



Notes: Width and Length of arrows do not relate to strength of wind. Arrows are just for illustration purpose.

Figure 2.9 Major breezeways movement within the Surrounding Area

3 ASSESSMENT METHODOLOGY

3.1 General

3.1.1 This AVA study is carried out in accordance with the guidelines stipulated in the Technical Guide for AVA for Developments in Hong Kong with regard to Computational Fluid Dynamics (CFD) modelling. Reference is also made to the "Recommendations on the use of CFD in Predicting Pedestrian Wind Environment" issued by a working group of the COST action C14 "Impact of Wind and Storms on City Life and Built Environment" (COST stands for the European Cooperation in the field of Scientific and Technical Research). COST action C14 is developed by European Laboratories/Institutes dealing with wind and/or structural engineering, whose cumulative skills, expertise and facilities have an internationally leading position. Thus, it is considered that the COST action C14 is a valid and good reference for CFD modelling in AVA study.

3.2 Modelling Tool and Model Setup

3.2.1 Assessment is conducted by means of 3-dimensional CFD model. The well-recognised commercial CFD package FLUENT is used in this exercise. FLUENT model had been widely applied for various AVA research and studies worldwide. The accuracy level of the FLUENT model was very much accepted by the industry for AVA application.

3.2.2 Wind Directions: In the CFD model, the average wind speed of individual prevailing wind directions identified for the Study Area is adopted for simulation of air ventilation performance for each direction (**Table 2.1** refers). Wind environment surrounding the Project Area is simulated using CFD under the 8 most prevailing wind directions (which represent occurrence of more than 75% of time in a year) to illustrate the change in microclimate due to the proposed development. They are NNE, NE, ENE, E, ESE, SE, SSW and SW, with ENE wind being the most predominant wind and contribute 13.7% of time in a year. The occurrence for the 8 prevailing simulated wind directions (NNE, NE, ENE, E, ESE, SE, SSW and SW) has a cumulative percentage value of 78.6%.

3.2.3 Vertical Wind Profile: Wind environment under different wind directions will be defined in the CFD environment. According to the Technical Guide, wind profile for the site could be appropriated from the V∞ data developed from MM5 and with reference to the Power Law or Log Law using coefficients appropriate to the site conditions. In this assessment, vertical wind profile condition is determined using the Log Law:

$$\text{Log Law} \quad U_z = \frac{u^*}{\sigma} \ln\left(\frac{Z}{Z_0}\right)$$

where U_Z : wind speed at height z from ground

u^* : friction velocity

σ : von Karman constant

Z : height z from ground

Z_o : roughness length

Table 3.1 Simulated Wind Directions and their corresponding percentage occurrence, Velocity at 596m and Roughness Length

Wind Direction	% of Annual Occurrence	Average V at infinity, m/s	Roughness Length (Z_o)
22.5° (NNE)	8.5%	9.30	1
45° (NE)	13.3%	8.83	1
67.5° (ENE)	13.7%	13.23	1
90° (E)	13.3%	8.04	1

Wind Direction	% of Annual Occurrence	Average V at infinity, m/s	Roughness Length (Z_o)
112.5º (ESE)	10.5%	6.57	3
135º (SE)	7.1%	6.87	3
202.5º (SSW)	6.8%	6.50	3
225º (SW)	5.4%	5.80	3

3.2.4 Turbulence Model: As recommended in COST action C14, realizable K-epsilon turbulence model is adopted in the CFD model to simulate the real life problem. Common computational fluid dynamics equations are adopted in the analysis.

3.2.5 Variables including fluid velocities and fluid static pressure are calculated throughout the domain. The CFD code captures, simulates and determines the air flow inside the domain under study based on viscous fluid turbulence model. Solutions are obtained by iterations.

3.2.6 Computational Domain: A 3-dimensional CFD model including major topographical features and building morphology which would likely affect the wind flow was constructed. The methodology described in the Technical Guide is adopted for this assessment. According to the Technical Guide, the Assessment Area should include the project's surrounding up to a perpendicular distance of at least 1H while the Surrounding Area should at least include the project's surrounding up to a perpendicular distance of 2H calculating from the project boundary, H being the height of the tallest building on site. In this study, the assessment area is from the project area with a distance of 8H and the surrounding area is of 16H in which H approximately equals 60m, and the blockage ratio is not greater than 3%.

3.2.7 The inflow face of the computational domain is set as the velocity inlet condition and the outflow face is set as the zero gradient condition. For the two lateral and top faces, symmetric boundary condition is used. Lastly for the ground and building walls, no slip condition is employed.

3.2.8 In the CFD model, the horizontal and vertical grid size employed in the CFD model in the vicinity of the Project Area is taken as a global minimum size of 2m and is increased for the grid cells further away from the Project Area at a growth expansion ratio of at most 1.2 with a maximum cell size of approximately 50 meters. Four layers of prism cells (each layer of 0.5m thick) are employed above the terrain. In the CFD model, the pedestrian level test points are all located at 2m above ground level at the fourth cell away from the terrain to ensure a better resolution of flow close to the ground as per the recommendation of COST action C14.

3.2.9 The advection terms of the momentum and viscous terms are resolved with the second order numerical schemes. The scaled residuals are converged to an order of magnitude of at least 1×10^{-4} as recommended in COST action C14.

3.2.10 The total number of cells inside the computational domain is around 6,000,000 to 7,000,000 for the CFD models. The size of the domain is approximately 6000m x 4500m x 2000m (L x W x H).

3.2.11 **Figure 3.1** shows the boundaries of the Study Area, Surrounding Area and Assessment Area that are examined in this AVA. **Figure 3.2** shows the extent of the computational domain that is adopted in the CFD model. Images of the general model setup and grid cell setup in the CFD model are shown in **Figure 3.3** and **Figure 3.4** respectively.

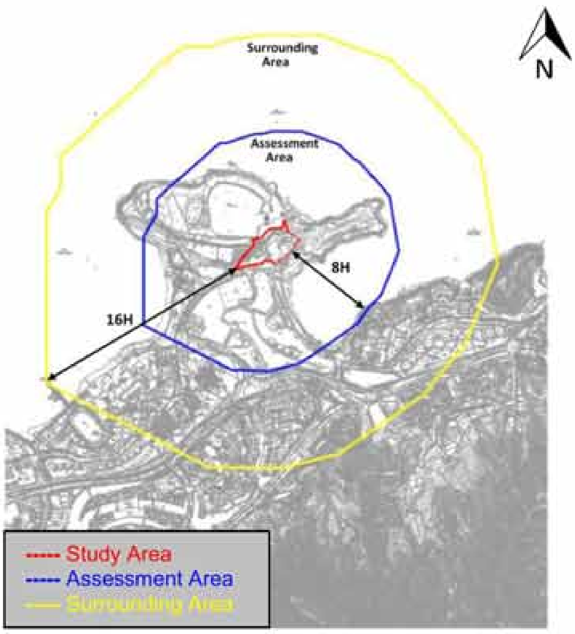
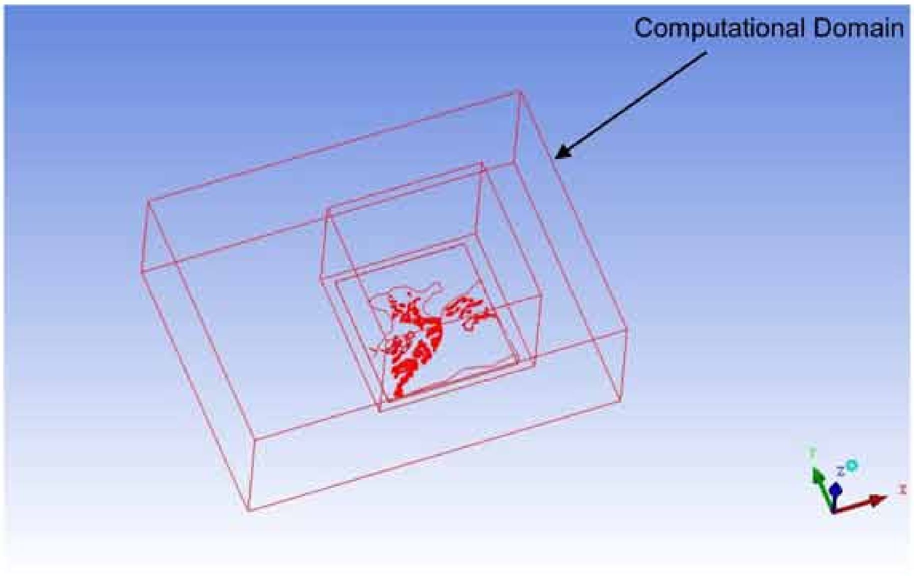


Figure 3.1 Boundaries of Study Area, Assessment Area and Surrounding Area



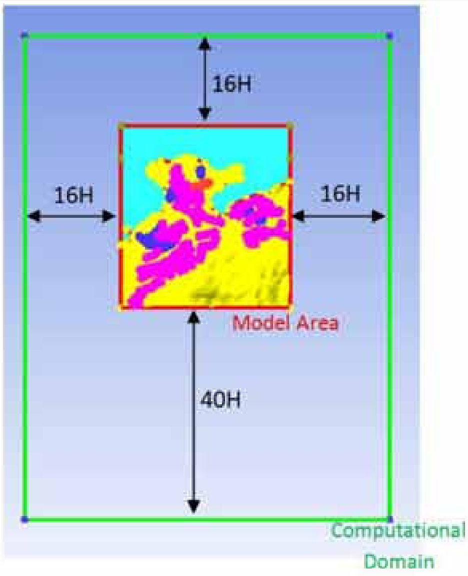


Figure 3.2 **Extent of Computational Domain for CFD Model**

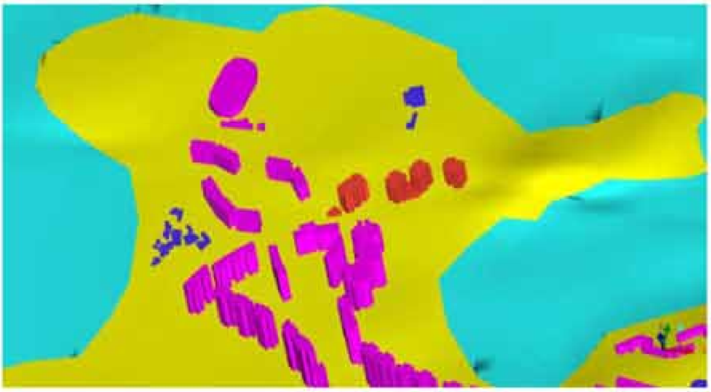


Figure 3.3 **Image of 3D CFD Model (Proposed Scenario)**

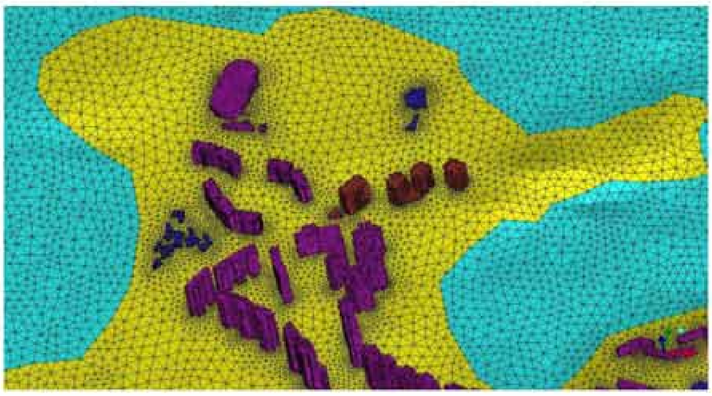


Figure 3.4(a) **Image of Mesh Cells Setup in the CFD Model (Proposed Scenario)**

Figure 3.4(b) 4 layers of Prism Mesh Cells Setup in the CFD Model

3.2.12 Test Points: Perimeter test points and overall test points are selected within the Assessment Area in order to assess the impact on the immediate surroundings and local areas respectively. Perimeter test points are selected along the boundary of the Project Area with separation distance of about 30m to 50m. Overall test points are evenly distributed over surrounding open spaces, streets, landscape deck, podium and other parts of the Assessment Area where pedestrian can or will mostly access. All test points are elevated at 2m above ground level.

3.2.13 The selected overall test points are grouped based on the land use / sensitive receivers as shown in **Figure 3.5** and summarized in **Table 3.2** for ease of discussion. There are 32 perimeter test points (with prefix "P") and 92 overall test points (with prefix "T") selected for the purpose of this AVA study.

Table 3.2 Grouping of the Test Points

Group	Description	Test Points
G1	Test points located inside the Study Area (CDA(3) site).	T1 to T15
G2	Test points located south west to the study area, covering CDA(1), Sai Sha Road and To Tau Estate	T16 to T36
G3	Test points located to the study area, covering Double Cove as well as its surrounding.	T36 to T48
G4	Test points located east to the study area, the northern portion of Lok Wo Sha Lane. covering	T49 to T69
G5	Test points located north west to the study area, covering Whitehead Golf Club Driving Range	T70 to T80
G6	Test points located west to the Study Area, covering CDA(2) and its surroundings .	T81 to T92

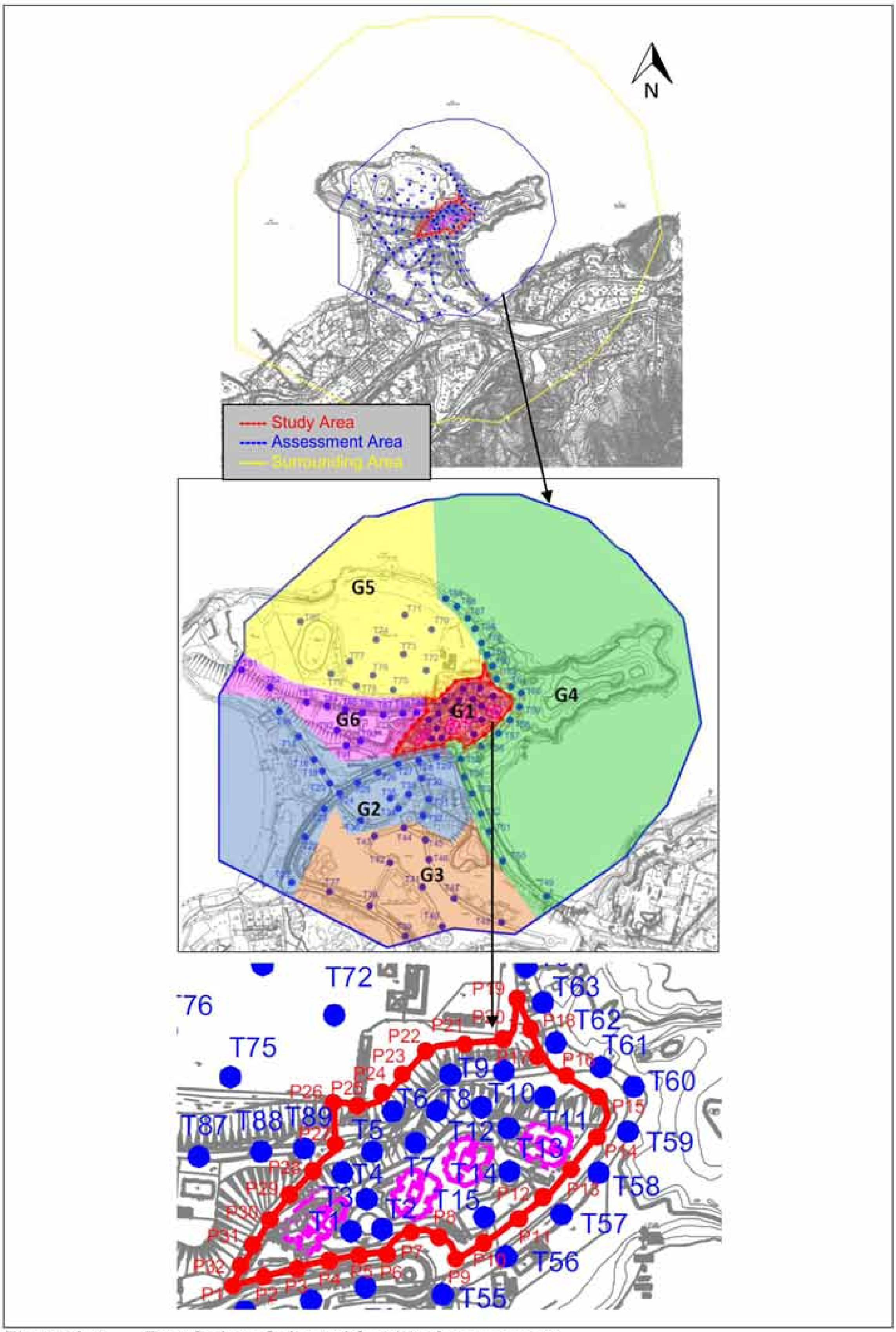


Figure 3.5 Test Points Selected for this Assessment

3.3 Wind Velocity Ratio

3.3.1 Wind velocity ratio (VR) indicates how much of the wind availability is experienced by pedestrians on the ground which is a relatively simple indicator to reflect the wind environment of the study site. VR is defined as VR = V_P / V_{INF} where V_{INF} is the wind velocity at the top of the wind boundary layer (greater than 500m in height) would not be affected by the ground roughness and local site features and V_P is the wind velocity at the 2m pedestrian level.

3.3.2 VR_W is the frequency weighted wind velocity ratio calculated based on the frequency of occurrence of all the 16 wind directions for the purpose of comparison.

3.3.3 For Site Air Ventilation Assessment, the Site Spatial Average Wind Velocity Ratio (SVR_W) and individual VR_W of all perimeter test points are reported. SVR_W is the average of VR_W of all perimeter test points.

3.3.4 For Local Air Ventilation Assessment, the Local Spatial Average Wind Velocity Ratio (LVR_W) of all overall test points and perimeter test points, and individual VR_W of the overall test points are reported. LVR_W is the average of all overall test points and perimeter test points.

3.3.5 The SVR_W and LVR_W are worked out so as to understand the overall impact of air ventilation on the immediate and further surroundings of the Project Area due to the proposed development.

4 KEY FINDINGS OF AVA STUDY

4.1 Local Situation

4.1.1 The local situation including the site environs, site wind environment, and site wind availability of the Study Area are described in **Section 2** above.

4.2 Mitigation Measures and Wind Breezeway within Study Area

4.2.1 There are two major wind breezeways incorporated in both the Base Scheme and the Proposed Scheme. As shown in **Figure 4.1**, the west breezeway (15m in width) is situated between Block T1/T2 and Block T3, while the east breezeway (15m in width) is located between Block T4 and Block T5. These wind corridors provided linkage between the open area north to the Study Area and the major breezeway (Yiu Sha Road) to the south. Furthermore, the blocks are aligned in the direction of the wind breezeways, which would reduce blockage of the wind and as a result enhance wind permeability (especially under the winds coming from northern and north eastern quadrant) within the Study Area.

4.2.2 In additional to the breezeways, both schemes are free of podiums which will reduce wind blockage at pedestrian level.

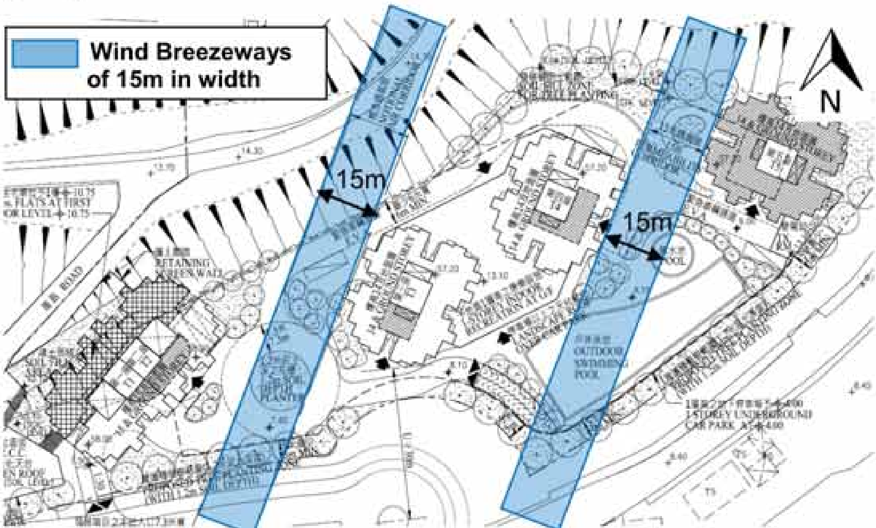


Figure 4.1 Layout Plan for the Development Scheme

4.3 Air Ventilation Issues

4.3.1 In accordance with the wind availability data, Whitehead area relies heavily on easterly, north easterly and east north easterly winds for ventilation during most time (total percentage occurrence is approximately 40%) in a year. Therefore, any blockage to these prevailing winds should be avoided as far as possible.

4.3.2 There exist open sea, large open spaces and a low-rise stadium situated in the northern quadrant direction to the Study Area, there is minor blockage to the study area for the winds coming from the above directions. Furthermore, the hilly terrain located east to the study area is 25mPD in height (meanwhile the ground level of Study Area is approximately 12mPD) and would slightly weaken the winds from the east. These situations would enhance the air ventilation performance to the subject area under the east, north east and south east prevailing wind directions.

4.3.3 There are mid to high-rise clusters namely the CDA (1) development, Double Cove and Lake Silver situated south to the Study Area. Thus, it is expected that the Study Area will have better wind environment under the North eastern quadrant prevailing winds than that under the South western quadrant winds.

4.4 Wind Velocity Ratio Results

4.4.1 A summary of the predicted wind velocity ratios for the Perimeter Test Points and the Overall Test Points as well as the SVR_W and LVR_W are presented in **Table 4.2** below. Details of the predicted wind velocity ratios are presented in **Appendix B**.

Table 4.1 Summary of Wind Velocity Ratio for Subject Site

	Wind Velocity Ratios	
	Base Scheme	Proposed Scheme
SVR_W	0.289	0.294
LVR_W	0.263	0.265

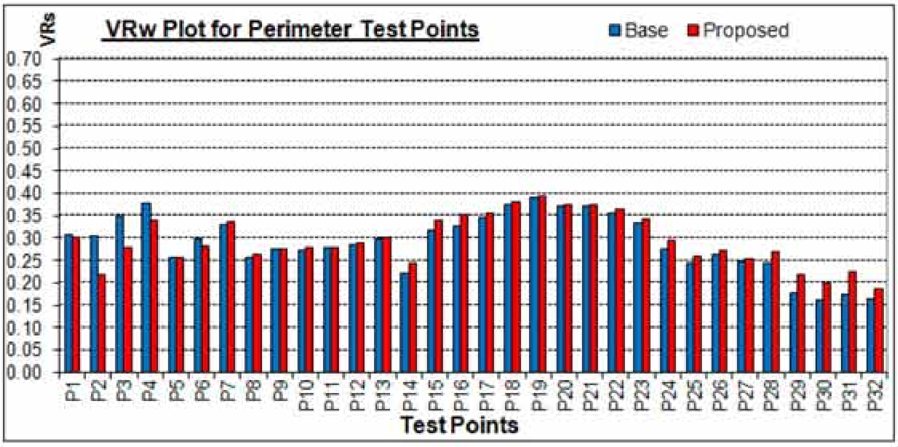
4.4.2 The results of VR_W for different groups of test points are summarized in **Table 4.2** below.

Table 4.2 Summary of Wind Velocity Ratio for Different Test Point Groups

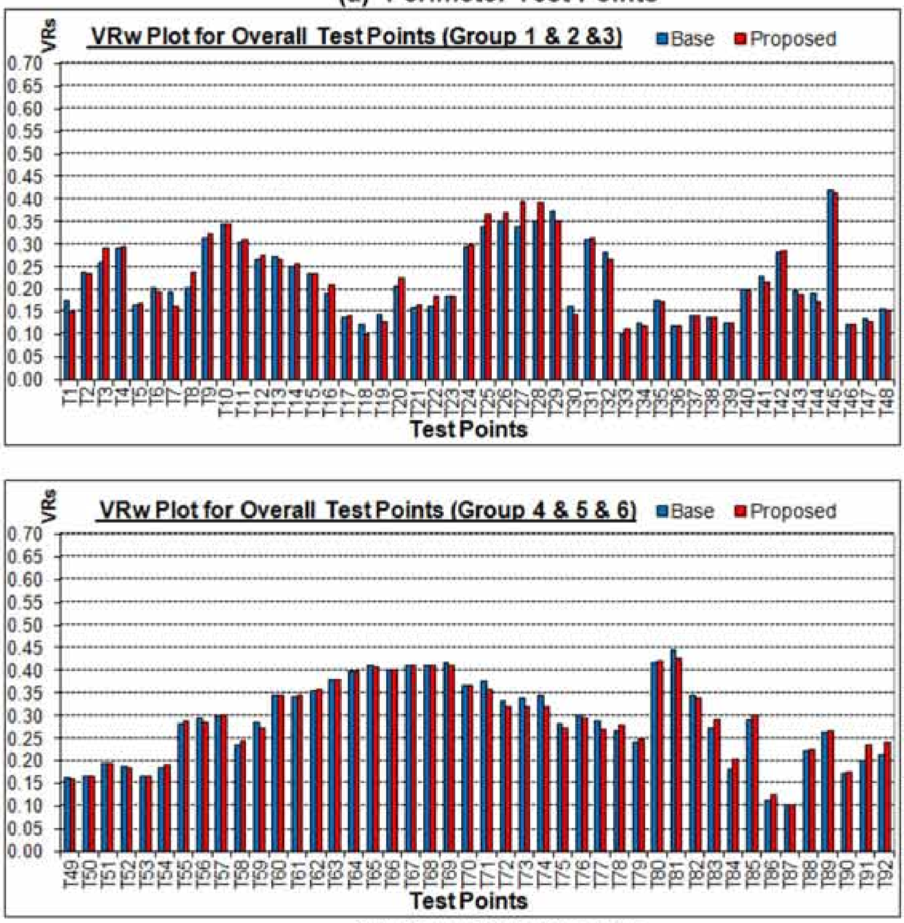
Group	Description	Test Points	Average VR_w Base Scheme	Average VR_w Proposed Scheme
G1	Test points located inside the Study Area (CDA(3) site).	T1– T15	0.247	0.249
G2	Test points located south west to the study area, covering CDA(1), Sai Sha Road and To Tau Estate	T16 – T36	0.220	0.226
G3	Test points located east to the study area, covering the northern portion of Lok Wo Sha Lane.	T37– T48	0.193	0.189
G4	Test points located north west to the study area, covering Whitehead Golf Club Driving Range and CDA(2).	T49 – T69	0.301	0.301
G5	Test points located north west to the study area, covering Whitehead Golf Club Driving Range	T70 – T80	0.322	0.314
G6	Test points located west to the Study Area, covering CDA(2) and its surroundings.	T81– T92	0.235	0.244

4.4.3 The averaged VR_W result for individual test points and test point groups are also presented in the form of bar chart as shown in **Figure 4.2**. Calculation of averaged VR_w within each test group would help to get a clear picture of wind environment within each area group. The averaged VR_W result for individual test points and test points groups in the form of bar chart under the 8 wind directions are shown in **Appendix C**.

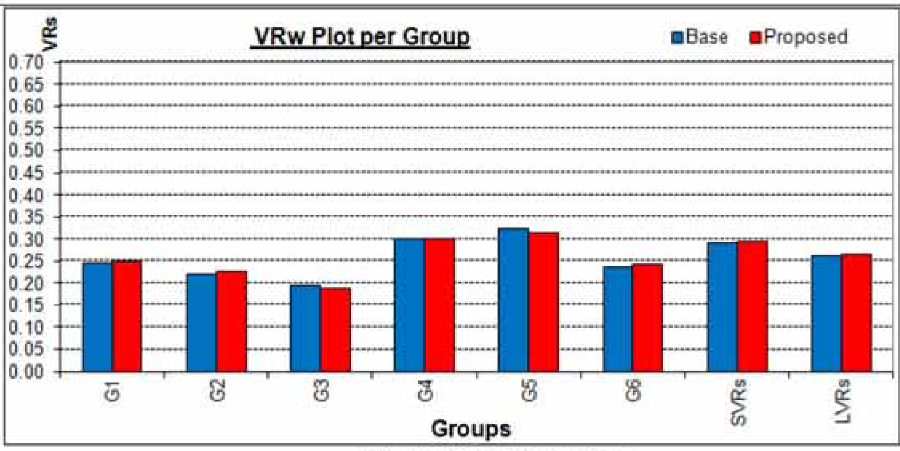
4.4.4 Contour plots of wind velocity ratio and wind velocity vector plots at 2m above the pedestrian level of assessment area under the 8 wind directions are shown in **Appendix D** and **Appendix E** respectively.



(a) Perimeter Test Points



(b) Overall Test Points



(c) Test Point Groups

Figure 4.2 Averaged VRw Result

4.5 Site Ventilation Assessment

4.5.1 It should be noted that the layout of the Base Scheme and Proposed Scheme are similar, and the major difference between them is that the proposed developments in Proposed Scheme is approximately 8m higher than that in the Base Scheme. Meanwhile, both schemes maintain two wind corridors (around 15m in width), which are identical for both schemes, penetrating the Study Area, which would greatly enhance the wind environment in its vicinity.

4.5.2 The SVR_w indicates how the lower portion of the buildings within the Study Area may affect the wind environment of its immediate vicinity. The predicted SVR_w for the Base Scheme is around 0.289, while the Proposed Scheme maintains the SVR_w of 0.294. The result indicates that the Proposed Scheme can be considered slightly better than the Base Scheme in terms of air ventilation issues.

4.5.3 Under the North eastern quadrant prevailing winds (which include NNE, NE, ENE, E directions), the Base Scheme and Proposed Scheme both maintains the average SVR value of over 0.33. This result indicates that the wind comfort at pedestrian level surrounding the Study Area has not declined due to the increment in height of the blocks in the Proposed Scheme under North eastern direction winds.

4.5.4 Under the South eastern quadrant prevailing winds (ESE and SE directions), the Base Scheme and Proposed Scheme maintains the average SVR of 0.282 and 0.288 respectively. While under the South western winds (SSW and SW directions), the two schemes both maintains SVR value over 0.113. Compare to the SVR under the North eastern quadrant wind, these decline in the South western directional winds is due to fact that there are more blockages of wind in South western direction than that of the North eastern directions. To conclude, after the increment of height of buildings in the Proposed Scheme, the pedestrian wind environment surrounding the Study Area can still be maintained.

4.6 Local Air Ventilation Assessment

4.6.1 The design of the two development schemes contain five mid-rise blocks and incorporate separation distances in between, while the area surrounding it contained large open areas. These measures would enhance the wind penetration, and the LVR_W for the Base Scheme and Proposed Scheme is 0.263 and 0.265 respectively.

4.6.2 The averaged wind velocity ratio of Group 1 test points reflects the wind environment within the Study Area (CDA (3)), which contains the proposed developing 5-blocks-cluster. The averaged VR_w for Group 1 test points is 0.247 and 0.249 for the Base Scheme and the Proposed Scheme respectively, this result reflects that the two schemes are comparable in terms of air ventilation within the Study Area since there are separation gaps to allow wind penetration through the building clusters in the Study Area.

4.6.3 There are two wind breezeways incorporated in both development schemes in the Study Area, namely the west corridor and the east corridor. These two corridors maintain even better wind environment compare to the average among the Study Area, in the west corridor (test point T2 to T4), the VR_w could reach 0.263 and 0.273 in the Base Scheme and Proposed Scheme respectively; while in the east corridor (T13 and T14), the VR_w maintains 0.261 and 0.262 for Base Scheme and Proposed Scheme respectively. The VR values at the breezeways mentioned above are relatively higher than the VR values for other test points within the Study Area (Group 1 test points), this indicates that the Wind breezeways are effective in providing wind ventilation within the Study Area.

4.6.4 The average wind velocity ratio of Group 2 and Group 3 test points reflects the wind environment of the area to the south west of the Study Area. As the averaged VR_w for Group 2 test points is 0.220 and 0.226 for the Base Scheme and the Proposed Scheme respectively, while in Group 3 area, there are slight changes in averaged VR_w compared to the Base Scheme after the proposed developments in which the VR value maintain around 0.190 which is comparable for both the two schemes. These minor changes are expected to be insignificant to pedestrian level wind environment and thus are unlikely to affect the human activities.

4.6.5 The VR values maintained in Group 2 and Group 3 are relatively lower than that maintained by Group 1 area, since the buildings in this area are higher in height (ranging from 50mPD to 130mPD for the residential clusters, while those in the Group 1 area are only 60mPD in height) and more densely located than the buildings of Group 1 area.

4.6.6 It is noticed that the northern portion of Yiu Sha Road (test points T23 to T29), which serves as a wind corridor under south western quadrant prevailing winds, has good wind performance. Averaged Wind Velocity Ratios of these test points have values over 0.3 for both the Base Scheme and the Proposed Scheme. While under the South western quadrant winds (SSW and SW), the averaged VR value could even reach 0.39 for the two development scheme. On the contrary, the area surrounded by the three blocks west to the CDA (1) (test points T33 to T35) has relatively low VR values (which are 0.132 and 0.134 for Base Scheme and Proposed Scheme respectively) as the three blocks form an air trapping zone.

4.6.7 The area between the two clusters of the Double Cove (covered by test points T40 to T42, and T46 to T48) serves as a major Southeast - Northwest wind corridor in the Assessment Area, and the VRw value in this area maintains over 0.183 for the two development schemes. However, under the SE prevailing wind, the averaged VR value in this corridor could reach 0.375 and 0.377 for the Base Scheme and Proposed Scheme respectively. This comparatively higher VR value is due to the wind corridor mentioned above penetrating the high-rise clusters.

4.6.8 The average wind velocity ratio of Group 4 test points reflects the wind environment of the area to the east of the Study Area, mainly the northern portion of Lok Wo Sha Lane, which is a major wind corridor passing through the east boundary of the Study Area. The difference in air ventilation performance between the Base Scheme and the Proposed Scheme is considered insignificant in this region since the VR_w maintain 0.301 for both Base Scheme and Proposed Scheme. This area maintains the highest average VR_w value in the Assessment Area, since there are very few buildings to east side of this area, thus provided minor blockage to the wind directed to this region.

4.6.9 The average wind velocity ratio of Group 5 and Group 6 test points reflects the air ventilation performance of the area to the north west of the Study Area, and the averaged VR_w for the region covered by Group 5 is maintained over 0.314 in both Base Scheme and Proposed Scheme. While Group 6 test points maintains 0.235 and 0.244 for Base Scheme and Proposed Scheme respectively. The CDA(2) area (test points T90 to T92) located within Group 6 area has relatively low VR_w value, which are 0.194 and 0.218 for Base Scheme and Proposed Scheme respectively, because this area is located in the trapping zone formed by the blocks of the CDA(2).

4.6.10 As Group 5 area contains mainly large open area and very few obstacles, which will not provide blockage against north eastern quadrant prevailing winds (i.e. NNE, NE, ENE and E winds), which contribute almost 49% occurrence of wind in a year, therefore it is noticed that the result in Group 5 area is higher than that maintained by Group 1 area. However, the average VR value of the Proposed Scheme has a minor decline of 2% comparing to the Base Scheme in this open area, this decline is due to the increase of height in the proposed development that would create more shelter for the wind.

4.6.11 It is observed to have slight changes in VR values at the north side and northwest to the Study Area between the Base Scheme and Proposed Scheme under ENE, ESE, NE, SE and SW wind directions. These changes are due to the slight difference in height of the buildings between the two schemes.

4.6.12 Under the North eastern quadrant prevailing winds (which include NNE, NE, ENE, E directions), the Base Scheme and Proposed Scheme both maintains the average LVR value of over 0.296. Under the South eastern quadrant prevailing winds (i.e. ESE and SE directions), the Base Scheme and Proposed Scheme maintains the average LVR of 0.226 and 0.230 respectively. While under the South western winds (SSW and SW directions), the two schemes both maintains average LVR value over 0.17. The decline of the LVR value under the South western prevailing winds is due to the fact that there are more blockages in south and south western directions.

4.6.13 To conclude, the LVR values maintained by the Base Scheme and Proposed Scheme are comparable in all six test point group regions. The result of this study reflected that the 8m increment in height of the development in the Proposed Scheme does not have significant impact upon its surrounding areas in terms of air ventilation issues.

4.6.14 In addition, it is noticed that the proposed developments of both Base and Proposed Schemes would shelter a part of "CDA(2)" Site under E and ESE winds as well as a part of "CDA(1)" Site under NNE wind. Therefore, future developers need to take this issue into consideration. Mitigation measures include but not limited to setting back the development buildings in the north eastern direction may reduce the negative effects caused by the shelter zone of the proposed development to CDA(1) and CDA(2) sites.

5 SUMMARY AND CONCLUSION

5.1 This AVA Study Report aims at assessing the characteristics of the wind availability of the site, providing a general pattern and a quantitative estimate of wind performance at the pedestrian level under different wind directions and investigating the effectiveness of ventilation for two developments namely the Base Scheme and the Proposed Scheme for the Whitehead CDA(3) area.

5.2 From the finding of this AVA Study, the SVR for Base Scheme ranges from 0.161 to 0.391 under the NNE, NE, ENE, E, ESE, SE, SSW and SW winds which amount to about 78% of the whole time in a year, while that of the Proposed Scheme range from 0.186 to 0.394. Generally, the SVR_w of the Base Scheme and Proposed Scheme can be maintained at 0.289 and 0.294 respectively. The Proposed Scheme performs slightly better than the Base Scheme in terms of air ventilation performance.

5.3 The LVR for the Base Scheme ranges from 0.098 to 0.420 under the same 8 wind directions stated above, while that of the Proposed Scheme ranges from 0.099 to 0.414. Since the LVR_W for the Base Scheme and Proposed Scheme is 0.263 and 0.265 respectively, it is concluded that the Proposed Scheme and the Base Scheme are comparable in terms of air ventilation performance.

5.4 To conclude, the two development schemes both have incorporated a number of ventilation improvement measures during the scheme design stage and the CFD modelling results show that it is able to maintain a relatively good wind performance at the pedestrian level within the Study Area and around its immediate vicinity.

Appendix A

Appendix A - Wind Probability Table (obtained from Planning Department)

Square (32,35)		Wind direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
V Infinity (m/s)	Avg. V, m/s	Sum	0.034	0.085	0.133	0.137	0.133	0.105	0.071	0.05	0.036	0.068	0.054	0.028	0.019	0.013	0.014	0.02
0_to_1	0.5	0.019	0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0	0.002	0.002	0.002
1_to_2	1.5	0.051	0.003	0.003	0.002	0.003	0.003	0.004	0.003	0.003	0.003	0.005	0.004	0.003	0.004	0.003	0.003	0.002
2_to_3	2.5	0.071	0.004	0.004	0.007	0.007	0.006	0.006	0.004	0.005	0.005	0.005	0.005	0.004	0.002	0.002	0.003	0.005
3_to_4	3.5	0.083	0.006	0.005	0.007	0.009	0.007	0.009	0.007	0.005	0.005	0.007	0.004	0.002	0.003	0.001	0.003	0.005
4_to_5	4.5	0.091	0.007	0.005	0.007	0.009	0.01	0.01	0.007	0.004	0.004	0.006	0.005	0.004	0.003	0.001	0.001	0.005
5_to_6	5.5	0.093	0.004	0.005	0.011	0.009	0.012	0.01	0.009	0.004	0.004	0.007	0.009	0.004	0.003	0.001	0.001	0
6_to_7	6.5	0.094	0.002	0.005	0.009	0.01	0.014	0.014	0.01	0.005	0.005	0.008	0.007	0.004	0.002	0	0.001	0
7_to_8	7.5	0.086	0.001	0.005	0.01	0.009	0.011	0.012	0.011	0.003	0.003	0.008	0.006	0.002	0.002	0.001	0	0
8_to_9	8.5	0.081	0.001	0.005	0.01	0.013	0.013	0.014	0.005	0.003	0.003	0.006	0.004	0.002	0.001	0	0	0
9_to_10	9.5	0.08	0.001	0.008	0.012	0.01	0.015	0.012	0.005	0.001	0.001	0.005	0.004	0.001	0	0	0	0
10_to_11	10.5	0.062	0.001	0.007	0.015	0.01	0.013	0.006	0.002	0.001	0.001	0.003	0.002	0	0	0	0	0
11_to_12	11.5	0.057	0.001	0.005	0.014	0.013	0.012	0.003	0.003	0	0	0.003	0.001	0	0	0	0	0
12_to_13	12.5	0.041	0	0.003	0.01	0.011	0.008	0.002	0.002	0	0	0.002	0.001	0	0	0	0	0
13_to_14	13.5	0.028	0.001	0.005	0.006	0.01	0.004	0	0.001	0	0	0.001	0	0	0	0	0	0
14_to_15	14.5	0.017	0	0.003	0.004	0.003	0.003	0	0.001	0	0	0	0	0	0	0	0	0
15_to_16	15.5	0.011	0	0.003	0.001	0.004	0.001	0	0	0	0	0	0	0	0	0	0	0
16_to_17	16.5	0.01	0	0.004	0.002	0.001	0	0	0	0	0	0.001	0	0	0	0	0	0
17_to_18	17.5	0.008	0	0.003	0.002	0.001	0	0	0	0	0	0	0	0	0	0	0	0
18_to_19	18.5	0.005	0	0.003	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0
19_to_20	19.5	0.004	0	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0
20_to_21	20.5	0.003	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	0
21_to_22	21.5	0.002	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0
22_to_23	22.5	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23_to_24	23.5	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Average Wind Speed at 596m, m/s			4.79	9.30	8.83	8.68	8.04	6.57	6.87	3.51	4.88	6.50	5.80	4.64	4.63	2.42	2.86	2.83

Appendix B

Appendix B - Details of the Predicted Wind Velocity Ratio (VR_W)

	Base								
Test Point	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSW**	**SW**	
Wind speed at infinity	**9.300**	**8.830**	**8.680**	**8.040**	**6.570**	**6.870**	**6.500**	**5.800**	**VR_w**
Wind probability	**0.085**	**0.133**	**0.137**	**0.133**	**0.105**	**0.071**	**0.068**	**0.054**	**0.786**
P1	0.309	0.327	0.402	0.378	0.299	0.138	0.167	0.299	0.309
P2	0.129	0.248	0.426	0.452	0.386	0.315	0.052	0.209	0.305
P3	0.199	0.316	0.511	0.529	0.417	0.361	0.044	0.068	0.350
P4	0.310	0.348	0.533	0.535	0.434	0.394	0.046	0.082	0.378
P5	0.242	0.247	0.360	0.313	0.286	0.248	0.064	0.094	0.256
P6	0.153	0.209	0.427	0.428	0.389	0.371	0.058	0.126	0.297
P7	0.115	0.116	0.497	0.539	0.509	0.463	0.091	0.057	0.331
P8	0.066	0.183	0.380	0.383	0.356	0.278	0.097	0.121	0.258
P9	0.129	0.271	0.343	0.364	0.331	0.332	0.080	0.217	0.277
P10	0.195	0.289	0.335	0.334	0.311	0.311	0.084	0.171	0.273
P11	0.238	0.300	0.358	0.328	0.313	0.313	0.082	0.112	0.279
P12	0.118	0.346	0.409	0.360	0.342	0.307	0.077	0.052	0.287
P13	0.122	0.403	0.463	0.397	0.333	0.201	0.047	0.037	0.298
P14	0.405	0.266	0.157	0.157	0.276	0.401	0.026	0.068	0.222
P15	0.341	0.305	0.310	0.370	0.429	0.471	0.046	0.128	0.317
P16	0.297	0.326	0.360	0.420	0.450	0.343	0.055	0.149	0.327
P17	0.346	0.391	0.415	0.451	0.447	0.202	0.057	0.185	0.347
P18	0.385	0.422	0.442	0.470	0.455	0.257	0.063	0.221	0.374
P19	0.406	0.439	0.462	0.485	0.469	0.273	0.077	0.247	0.391
P20	0.370	0.415	0.443	0.475	0.460	0.258	0.063	0.219	0.372
P21	0.373	0.419	0.453	0.488	0.447	0.195	0.067	0.229	0.371
P22	0.369	0.415	0.452	0.487	0.403	0.097	0.073	0.237	0.356
P23	0.337	0.400	0.447	0.449	0.306	0.147	0.080	0.224	0.334
P24	0.319	0.388	0.422	0.308	0.150	0.111	0.093	0.198	0.277
P25	0.316	0.387	0.378	0.199	0.076	0.156	0.106	0.182	0.245
P26	0.321	0.390	0.385	0.179	0.098	0.326	0.108	0.186	0.262
P27	0.270	0.372	0.226	0.196	0.256	0.329	0.116	0.125	0.247
P28	0.280	0.393	0.295	0.310	0.156	0.068	0.135	0.073	0.244
P29	0.358	0.343	0.174	0.063	0.113	0.072	0.153	0.079	0.178
P30	0.366	0.254	0.185	0.081	0.096	0.073	0.097	0.081	0.161
P31	0.357	0.254	0.193	0.116	0.109	0.080	0.116	0.114	0.174
P32	0.338	0.229	0.199	0.119	0.102	0.131	0.045	0.062	0.163
Average SVR	**0.277**	**0.325**	**0.370**	**0.349**	**0.313**	**0.251**	**0.080**	**0.145**	**0.289**
P_{Min}	0.066	0.116	0.157	0.063	0.076	0.068	0.026	0.037	0.161
P_{Max}	0.406	0.439	0.533	0.539	0.509	0.471	0.167	0.299	0.391

Appendix B - Details of the Predicted Wind Velocity Ratio (VR_W)

Test Point	Base								
	NNE	NE	ENE	E	ESE	SE	SSW	SW	
Wind speed at infinity	**9.300**	**8.830**	**8.680**	**8.040**	**6.570**	**6.870**	**6.500**	**5.800**	**VR_w**
Wind probability	**0.085**	**0.133**	**0.137**	**0.133**	**0.105**	**0.071**	**0.068**	**0.054**	**0.786**
T1	0.335	0.198	0.186	0.160	0.158	0.126	0.084	0.065	0.174
T2	0.289	0.133	0.311	0.304	0.308	0.314	0.065	0.063	0.239
T3	0.304	0.131	0.218	0.376	0.375	0.455	0.065	0.079	0.259
T4	0.236	0.148	0.280	0.445	0.431	0.499	0.104	0.042	0.290
T5	0.304	0.341	0.052	0.110	0.118	0.178	0.124	0.082	0.167
T6	0.314	0.388	0.219	0.147	0.120	0.057	0.108	0.136	0.203
T7	0.324	0.409	0.128	0.128	0.112	0.146	0.114	0.088	0.193
T8	0.325	0.416	0.205	0.151	0.086	0.095	0.091	0.130	0.204
T9	0.305	0.378	0.430	0.413	0.293	0.136	0.069	0.184	0.312
T10	0.316	0.391	0.428	0.457	0.361	0.273	0.059	0.178	0.343
T11	0.203	0.367	0.419	0.459	0.367	0.095	0.045	0.118	0.305
T12	0.217	0.336	0.336	0.354	0.319	0.115	0.062	0.126	0.267
T13	0.324	0.312	0.106	0.309	0.404	0.540	0.071	0.065	0.273
T14	0.413	0.256	0.207	0.262	0.271	0.335	0.113	0.056	0.249
T15	0.138	0.227	0.336	0.297	0.275	0.229	0.106	0.061	0.234
T16	0.300	0.199	0.150	0.102	0.009	0.110	0.449	0.442	0.190
T17	0.119	0.096	0.114	0.065	0.053	0.065	0.422	0.408	0.138
T18	0.211	0.060	0.130	0.129	0.057	0.117	0.168	0.168	0.122
T19	0.287	0.134	0.057	0.198	0.045	0.084	0.189	0.227	0.143
T20	0.319	0.284	0.068	0.271	0.034	0.187	0.291	0.280	0.206
T21	0.311	0.106	0.041	0.140	0.063	0.229	0.338	0.274	0.160
T22	0.279	0.088	0.058	0.055	0.025	0.185	0.499	0.493	0.162
T23	0.123	0.110	0.308	0.079	0.023	0.103	0.448	0.475	0.183
T24	0.389	0.462	0.432	0.078	0.061	0.100	0.412	0.447	0.293
T25	0.428	0.480	0.426	0.259	0.044	0.183	0.429	0.460	0.337
T26	0.393	0.491	0.494	0.281	0.096	0.127	0.415	0.455	0.351
T27	0.237	0.454	0.506	0.385	0.106	0.045	0.374	0.440	0.337
T28	0.230	0.465	0.515	0.417	0.196	0.128	0.285	0.361	0.351
T29	0.229	0.437	0.495	0.474	0.334	0.257	0.234	0.295	0.374
T30	0.215	0.234	0.109	0.191	0.138	0.146	0.070	0.128	0.161
T31	0.324	0.446	0.393	0.384	0.239	0.068	0.101	0.274	0.310
T32	0.326	0.370	0.340	0.282	0.155	0.205	0.153	0.359	0.282
T33	0.081	0.112	0.139	0.112	0.070	0.075	0.059	0.073	0.098
T34	0.119	0.255	0.128	0.068	0.093	0.086	0.086	0.118	0.126
T35	0.111	0.309	0.166	0.150	0.134	0.073	0.188	0.213	0.174
T36	0.074	0.212	0.028	0.083	0.102	0.128	0.171	0.191	0.117
T37	0.131	0.056	0.215	0.086	0.068	0.152	0.296	0.219	0.140
T38	0.350	0.052	0.113	0.055	0.040	0.232	0.264	0.171	0.137
T39	0.109	0.113	0.095	0.096	0.043	0.241	0.207	0.234	0.125
T40	0.366	0.319	0.134	0.239	0.095	0.164	0.068	0.126	0.200
T41	0.133	0.147	0.174	0.323	0.294	0.571	0.075	0.085	0.228
T42	0.363	0.307	0.160	0.232	0.182	0.435	0.303	0.508	0.283
T43	0.222	0.087	0.313	0.291	0.197	0.146	0.081	0.104	0.197
T44	0.196	0.178	0.270	0.249	0.214	0.036	0.127	0.107	0.191
T45	0.451	0.541	0.501	0.485	0.322	0.185	0.269	0.385	0.420
T46	0.228	0.168	0.110	0.074	0.039	0.107	0.136	0.114	0.120
T47	0.115	0.110	0.090	0.135	0.060	0.316	0.133	0.251	0.135
T48	0.145	0.075	0.117	0.072	0.135	0.660	0.102	0.105	0.155
T49	0.120	0.126	0.112	0.230	0.240	0.209	0.123	0.100	0.162
T50	0.178	0.159	0.227	0.130	0.209	0.153	0.106	0.076	0.164
T51	0.233	0.205	0.248	0.136	0.178	0.176	0.146	0.197	0.193
T52	0.255	0.208	0.199	0.194	0.150	0.158	0.130	0.188	0.189
T53	0.157	0.126	0.158	0.229	0.190	0.202	0.134	0.060	0.164
T54	0.064	0.127	0.213	0.294	0.244	0.265	0.088	0.055	0.184
T55	0.136	0.253	0.335	0.394	0.329	0.351	0.170	0.112	0.281
T56	0.210	0.323	0.338	0.361	0.323	0.361	0.068	0.190	0.293
T57	0.261	0.354	0.359	0.357	0.332	0.340	0.054	0.061	0.296
T58	0.374	0.315	0.256	0.201	0.222	0.304	0.016	0.051	0.235
T59	0.395	0.332	0.286	0.289	0.344	0.373	0.014	0.086	0.285
T60	0.439	0.418	0.375	0.382	0.390	0.380	0.017	0.115	0.344
T61	0.382	0.385	0.367	0.401	0.401	0.402	0.033	0.141	0.341
T62	0.359	0.403	0.410	0.452	0.434	0.274	0.050	0.187	0.355
T63	0.385	0.425	0.433	0.465	0.445	0.317	0.065	0.229	0.378
T64	0.404	0.442	0.454	0.481	0.471	0.339	0.089	0.262	0.399
T65	0.410	0.449	0.461	0.488	0.486	0.342	0.119	0.286	0.409
T66	0.396	0.433	0.443	0.478	0.479	0.338	0.154	0.277	0.402
T67	0.390	0.434	0.443	0.484	0.482	0.334	0.204	0.328	0.410
T68	0.387	0.434	0.437	0.479	0.474	0.324	0.260	0.356	0.412
T69	0.393	0.439	0.435	0.477	0.469	0.314	0.287	0.379	0.416
T70	0.413	0.452	0.444	0.418	0.297	0.147	0.242	0.328	0.366
T71	0.392	0.423	0.409	0.450	0.418	0.164	0.225	0.370	0.377
T72	0.333	0.374	0.385	0.452	0.346	0.159	0.114	0.247	0.331
T73	0.378	0.404	0.370	0.416	0.362	0.151	0.175	0.254	0.339
T74	0.386	0.414	0.407	0.413	0.383	0.134	0.090	0.279	0.343
T75	0.341	0.360	0.409	0.319	0.170	0.115	0.136	0.212	0.283
T76	0.354	0.388	0.389	0.399	0.195	0.123	0.118	0.217	0.302
T77	0.367	0.387	0.356	0.368	0.231	0.154	0.055	0.131	0.289

Appendix B - Details of the Predicted Wind Velocity Ratio (VR_W)

Test Point	Base								
	NNE	NE	ENE	E	ESE	SE	SSW	SW	
Wind speed at infinity	**9.300**	**8.830**	**8.680**	**8.040**	**6.570**	**6.870**	**6.500**	**5.800**	**VR_w**
Wind probability	**0.085**	**0.133**	**0.137**	**0.133**	**0.105**	**0.071**	**0.068**	**0.054**	**0.786**
T78	0.322	0.366	0.377	0.329	0.150	0.067	0.075	0.231	0.267
T79	0.339	0.358	0.313	0.281	0.195	0.030	0.068	0.105	0.242
T80	0.471	0.538	0.506	0.476	0.153	0.132	0.433	0.500	0.416
T81	0.520	0.584	0.576	0.279	0.251	0.235	0.564	0.566	0.446
T82	0.371	0.389	0.325	0.362	0.209	0.118	0.528	0.539	0.346
T83	0.240	0.366	0.406	0.312	0.167	0.049	0.221	0.191	0.271
T84	0.104	0.221	0.278	0.212	0.152	0.041	0.176	0.135	0.182
T85	0.474	0.461	0.370	0.258	0.092	0.101	0.174	0.228	0.290
T86	0.162	0.199	0.150	0.117	0.032	0.036	0.052	0.040	0.113
T87	0.133	0.101	0.097	0.113	0.097	0.088	0.070	0.126	0.104
T88	0.287	0.320	0.232	0.269	0.111	0.160	0.120	0.161	0.222
T89	0.298	0.410	0.288	0.327	0.209	0.106	0.123	0.126	0.264
T90	0.189	0.094	0.154	0.132	0.138	0.123	0.334	0.412	0.173
T91	0.269	0.246	0.219	0.077	0.126	0.074	0.360	0.335	0.200
T92	0.288	0.165	0.195	0.139	0.091	0.061	0.479	0.533	0.213
Average LVR	**0.281**	**0.303**	**0.304**	**0.293**	**0.239**	**0.213**	**0.153**	**0.203**	**0.263**
T_{Min}	0.074	0.052	0.028	0.055	0.009	0.036	0.045	0.042	0.098
T_{Max}	0.451	0.541	0.515	0.485	0.431	0.660	0.499	0.508	0.420

Appendix B - Details of the Predicted Wind Velocity Ratio (VR_W)

Test Point	proposed								
	NNE	NE	ENE	E	ESE	SE	SSW	SW	
Wind speed at infinity	9.300	8.830	8.680	8.040	6.570	6.870	6.500	5.800	VR_w
Wind probability	0.085	0.133	0.137	0.133	0.105	0.071	0.068	0.054	0.786
P1	0.335	0.333	0.338	0.294	0.272	0.275	0.205	0.311	0.302
P2	0.071	0.168	0.231	0.279	0.303	0.384	0.065	0.210	0.219
P3	0.074	0.253	0.366	0.426	0.343	0.364	0.080	0.078	0.278
P4	0.265	0.311	0.457	0.465	0.388	0.385	0.059	0.141	0.341
P5	0.306	0.250	0.323	0.304	0.277	0.245	0.072	0.134	0.258
P6	0.139	0.158	0.402	0.421	0.386	0.355	0.063	0.135	0.282
P7	0.128	0.048	0.513	0.573	0.534	0.463	0.100	0.069	0.335
P8	0.054	0.166	0.381	0.393	0.358	0.266	0.117	0.176	0.262
P9	0.129	0.261	0.344	0.367	0.328	0.310	0.101	0.213	0.276
P10	0.214	0.274	0.345	0.340	0.310	0.295	0.101	0.202	0.278
P11	0.247	0.266	0.365	0.330	0.306	0.288	0.100	0.163	0.278
P12	0.125	0.305	0.426	0.377	0.348	0.277	0.101	0.081	0.290
P13	0.127	0.395	0.462	0.411	0.340	0.186	0.067	0.049	0.302
P14	0.406	0.269	0.148	0.213	0.327	0.442	0.045	0.050	0.243
P15	0.346	0.330	0.341	0.405	0.454	0.481	0.076	0.089	0.339
P16	0.308	0.340	0.384	0.450	0.479	0.417	0.088	0.117	0.352
P17	0.326	0.385	0.420	0.466	0.460	0.257	0.090	0.161	0.357
P18	0.367	0.418	0.441	0.476	0.464	0.289	0.098	0.211	0.380
P19	0.386	0.433	0.456	0.485	0.470	0.303	0.114	0.244	0.394
P20	0.348	0.410	0.446	0.487	0.463	0.256	0.098	0.204	0.375
P21	0.356	0.419	0.460	0.499	0.451	0.193	0.100	0.217	0.376
P22	0.360	0.419	0.460	0.498	0.423	0.099	0.104	0.230	0.365
P23	0.326	0.402	0.451	0.460	0.331	0.158	0.102	0.205	0.342
P24	0.320	0.406	0.437	0.357	0.167	0.126	0.107	0.176	0.295
P25	0.315	0.407	0.381	0.231	0.080	0.213	0.109	0.151	0.259
P26	0.309	0.402	0.396	0.249	0.135	0.247	0.098	0.157	0.273
P27	0.278	0.398	0.273	0.229	0.250	0.259	0.096	0.089	0.255
P28	0.301	0.404	0.383	0.336	0.170	0.094	0.110	0.052	0.269
P29	0.398	0.411	0.275	0.098	0.136	0.079	0.124	0.073	0.219
P30	0.414	0.353	0.249	0.094	0.111	0.112	0.078	0.059	0.200
P31	0.383	0.315	0.246	0.168	0.133	0.112	0.203	0.205	0.226
P32	0.352	0.268	0.226	0.148	0.096	0.122	0.070	0.108	0.186
Average SVR	**0.275**	**0.324**	**0.370**	**0.354**	**0.315**	**0.261**	**0.098**	**0.149**	**0.294**
P_{Min}	0.054	0.048	0.148	0.094	0.080	0.079	0.045	0.049	0.186
P_{Max}	0.414	0.433	0.513	0.573	0.534	0.481	0.205	0.311	0.394

Appendix B - Details of the Predicted Wind Velocity Ratio (VR_W)

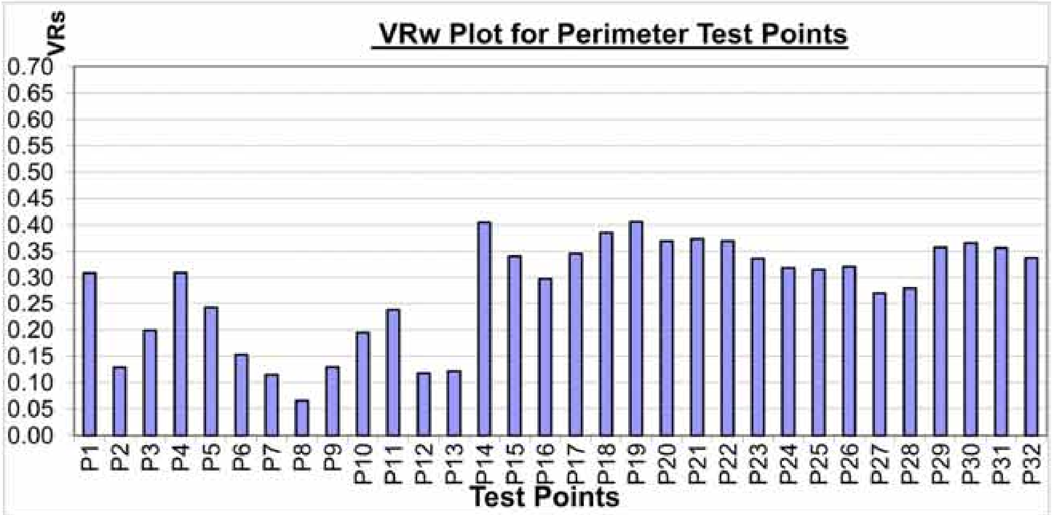
Test Point	proposed								
	NNE	NE	ENE	E	ESE	SE	SSW	SW	
Wind speed at infinity	9.300	8.830	8.680	8.040	6.570	6.870	6.500	5.800	VR_w
Wind probability	0.085	0.133	0.137	0.133	0.105	0.071	0.068	0.054	0.786
T1	0.308	0.164	0.147	0.130	0.141	0.122	0.074	0.072	0.150
T2	0.385	0.149	0.267	0.275	0.286	0.278	0.070	0.069	0.234
T3	0.378	0.175	0.281	0.403	0.384	0.433	0.067	0.082	0.290
T4	0.223	0.105	0.348	0.472	0.440	0.453	0.100	0.054	0.295
T5	0.315	0.326	0.105	0.096	0.080	0.225	0.119	0.061	0.170
T6	0.315	0.400	0.238	0.103	0.041	0.105	0.110	0.102	0.193
T7	0.334	0.366	0.115	0.077	0.070	0.069	0.118	0.063	0.162
T8	0.326	0.421	0.294	0.209	0.093	0.180	0.103	0.100	0.238
T9	0.295	0.374	0.436	0.433	0.322	0.168	0.089	0.154	0.321
T10	0.295	0.379	0.437	0.464	0.396	0.249	0.085	0.150	0.344
T11	0.212	0.367	0.430	0.466	0.382	0.092	0.066	0.063	0.309
T12	0.218	0.341	0.366	0.373	0.328	0.119	0.073	0.076	0.275
T13	0.337	0.324	0.122	0.300	0.372	0.501	0.073	0.020	0.266
T14	0.414	0.280	0.157	0.286	0.316	0.358	0.121	0.063	0.258
T15	0.136	0.212	0.338	0.293	0.271	0.212	0.125	0.115	0.234
T16	0.323	0.230	0.167	0.146	0.017	0.101	0.447	0.432	0.208
T17	0.123	0.102	0.102	0.075	0.051	0.061	0.437	0.403	0.139
T18	0.145	0.082	0.116	0.037	0.055	0.100	0.162	0.174	0.099
T19	0.254	0.124	0.050	0.185	0.032	0.051	0.178	0.201	0.127
T20	0.296	0.261	0.095	0.318	0.097	0.211	0.309	0.287	0.226
T21	0.285	0.126	0.060	0.123	0.075	0.257	0.337	0.276	0.165
T22	0.276	0.116	0.084	0.113	0.024	0.221	0.501	0.485	0.184
T23	0.131	0.118	0.267	0.079	0.048	0.117	0.457	0.464	0.183
T24	0.414	0.491	0.389	0.130	0.023	0.095	0.431	0.447	0.298
T25	0.441	0.506	0.402	0.361	0.079	0.200	0.454	0.464	0.365
T26	0.403	0.481	0.476	0.416	0.111	0.094	0.427	0.440	0.369
T27	0.247	0.457	0.516	0.497	0.314	0.102	0.401	0.436	0.394
T28	0.266	0.481	0.531	0.484	0.318	0.214	0.264	0.328	0.392
T29	0.161	0.423	0.470	0.444	0.329	0.260	0.213	0.270	0.351
T30	0.206	0.174	0.091	0.178	0.144	0.134	0.054	0.114	0.142
T31	0.316	0.437	0.403	0.394	0.256	0.071	0.080	0.275	0.312
T32	0.298	0.332	0.333	0.262	0.151	0.196	0.126	0.360	0.265
T33	0.090	0.141	0.148	0.111	0.076	0.076	0.090	0.112	0.111
T34	0.137	0.218	0.157	0.041	0.080	0.095	0.070	0.102	0.119
T35	0.113	0.265	0.192	0.150	0.129	0.076	0.181	0.208	0.171
T36	0.059	0.232	0.052	0.065	0.112	0.136	0.162	0.159	0.119
T37	0.141	0.054	0.181	0.105	0.078	0.151	0.299	0.214	0.139
T38	0.302	0.069	0.102	0.071	0.045	0.223	0.272	0.170	0.136
T39	0.083	0.108	0.093	0.095	0.069	0.246	0.210	0.242	0.126
T40	0.365	0.314	0.137	0.225	0.092	0.157	0.068	0.124	0.196
T41	0.108	0.135	0.151	0.313	0.283	0.581	0.080	0.073	0.217
T42	0.353	0.294	0.148	0.231	0.196	0.477	0.298	0.526	0.284
T43	0.219	0.086	0.240	0.281	0.192	0.194	0.095	0.119	0.188
T44	0.183	0.177	0.185	0.230	0.199	0.046	0.122	0.117	0.171
T45	0.425	0.518	0.524	0.476	0.320	0.190	0.262	0.374	0.414
T46	0.243	0.199	0.084	0.055	0.046	0.083	0.158	0.119	0.120
T47	0.080	0.089	0.098	0.137	0.062	0.301	0.092	0.274	0.127
T48	0.132	0.087	0.123	0.091	0.088	0.660	0.100	0.102	0.153
T49	0.112	0.135	0.124	0.230	0.235	0.187	0.108	0.077	0.159
T50	0.163	0.157	0.225	0.142	0.197	0.162	0.123	0.074	0.165
T51	0.227	0.205	0.254	0.147	0.182	0.188	0.150	0.170	0.195
T52	0.244	0.207	0.203	0.183	0.156	0.157	0.141	0.140	0.185
T53	0.149	0.122	0.166	0.226	0.196	0.199	0.148	0.075	0.167
T54	0.099	0.124	0.223	0.290	0.247	0.260	0.106	0.072	0.191
T55	0.146	0.269	0.347	0.396	0.333	0.344	0.184	0.086	0.287
T56	0.224	0.318	0.334	0.346	0.314	0.327	0.083	0.163	0.285
T57	0.256	0.374	0.374	0.357	0.327	0.302	0.074	0.106	0.302
T58	0.389	0.328	0.264	0.210	0.227	0.326	0.038	0.035	0.245
T59	0.381	0.307	0.264	0.276	0.344	0.375	0.023	0.056	0.272
T60	0.432	0.410	0.372	0.390	0.407	0.385	0.032	0.091	0.346
T61	0.365	0.367	0.368	0.409	0.425	0.419	0.068	0.116	0.344
T62	0.342	0.389	0.411	0.452	0.448	0.305	0.085	0.172	0.358
T63	0.371	0.413	0.432	0.459	0.449	0.327	0.102	0.227	0.378
T64	0.390	0.428	0.450	0.472	0.470	0.344	0.128	0.265	0.397
T65	0.399	0.437	0.462	0.478	0.482	0.346	0.156	0.280	0.408
T66	0.390	0.430	0.449	0.469	0.477	0.339	0.182	0.278	0.402
T67	0.385	0.433	0.453	0.477	0.480	0.336	0.230	0.332	0.412
T68	0.383	0.429	0.441	0.464	0.462	0.318	0.287	0.354	0.409
T69	0.383	0.432	0.438	0.463	0.455	0.309	0.313	0.368	0.411
T70	0.397	0.440	0.447	0.409	0.317	0.142	0.262	0.324	0.365
T71	0.365	0.393	0.390	0.416	0.401	0.161	0.239	0.328	0.356
T72	0.309	0.355	0.384	0.434	0.353	0.117	0.125	0.241	0.319
T73	0.347	0.370	0.369	0.391	0.349	0.094	0.193	0.255	0.320
T74	0.354	0.381	0.385	0.388	0.362	0.095	0.105	0.229	0.318
T75	0.309	0.333	0.391	0.336	0.179	0.069	0.135	0.203	0.271
T76	0.329	0.358	0.378	0.381	0.235	0.088	0.142	0.239	0.295
T77	0.335	0.354	0.334	0.329	0.258	0.157	0.035	0.103	0.269

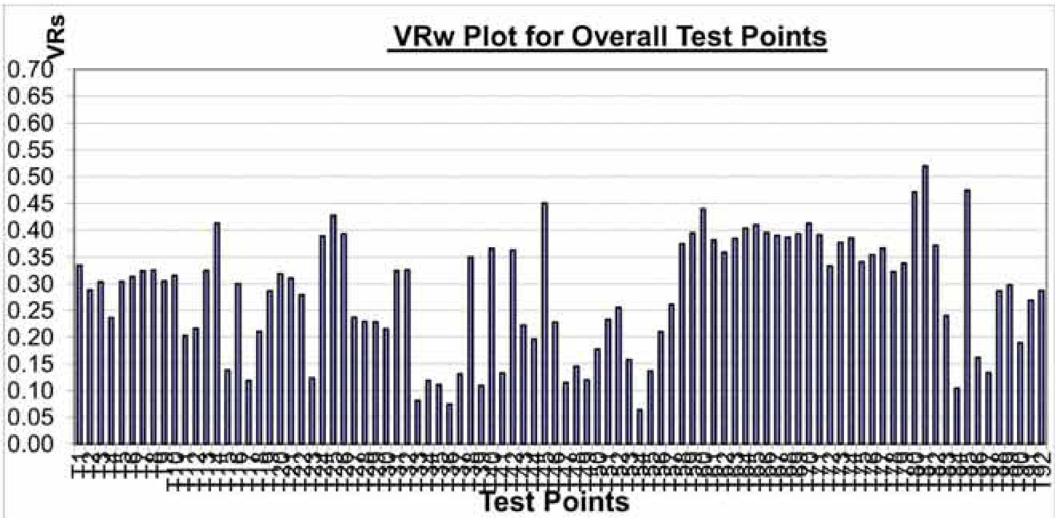
Appendix B - Details of the Predicted Wind Velocity Ratio (VR_W)

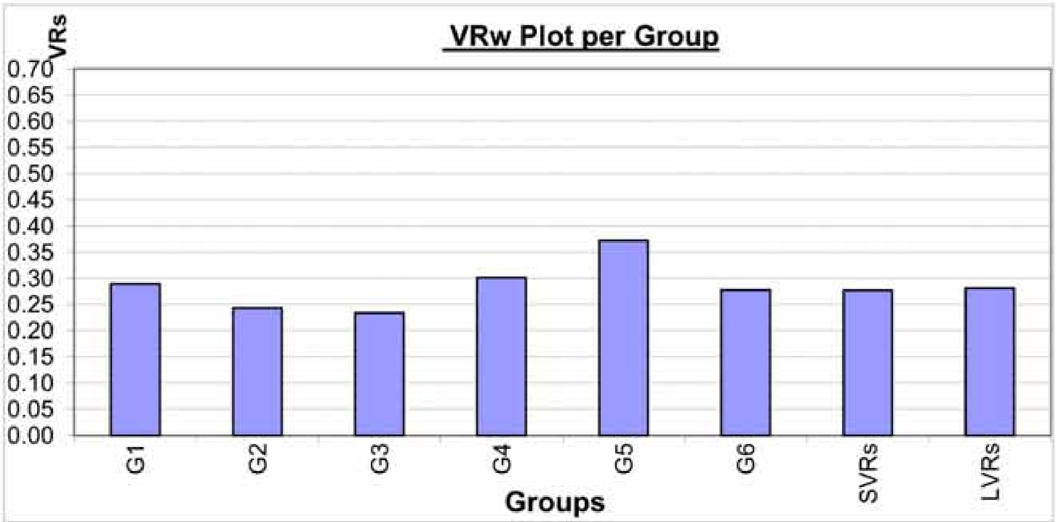
Test Point	proposed								
	NNE	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSW**	**SW**	
Wind speed at infinity	**9.300**	**8.830**	**8.680**	**8.040**	**6.570**	**6.870**	**6.500**	**5.800**	**VR_w**
Wind probability	**0.085**	**0.133**	**0.137**	**0.133**	**0.105**	**0.071**	**0.068**	**0.054**	**0.786**
T78	0.316	0.354	0.376	0.349	0.169	0.095	0.113	0.272	**0.279**
T79	0.339	0.358	0.315	0.272	0.224	0.035	0.074	0.117	0.246
T80	0.461	0.525	0.495	0.464	0.215	0.128	0.459	0.528	0.420
T81	0.488	0.551	0.538	0.289	0.240	0.237	0.532	0.537	0.425
T82	0.372	0.389	0.331	0.354	0.200	0.107	0.505	0.508	0.339
T83	0.237	0.395	0.457	0.361	0.160	0.043	0.230	0.160	0.290
T84	0.112	0.249	0.314	0.246	0.140	0.063	0.180	0.167	0.203
T85	0.483	0.455	0.393	0.297	0.078	0.101	0.199	0.245	0.302
T86	0.167	0.211	0.190	0.143	0.019	0.058	0.017	0.046	0.124
T87	0.132	0.113	0.113	0.107	0.104	0.058	0.079	0.062	0.102
T88	0.276	0.316	0.279	0.268	0.137	0.158	0.112	0.089	0.226
T89	0.295	0.409	0.341	0.330	0.207	0.104	0.087	0.067	0.266
T90	0.219	0.141	0.209	0.059	0.067	0.151	0.351	0.403	0.175
T91	0.264	0.287	0.286	0.158	0.155	0.108	0.357	0.304	0.236
T92	0.324	0.198	0.243	0.239	0.057	0.095	0.463	0.491	0.242
Average LVR	**0.277**	**0.301**	**0.307**	**0.298**	**0.243**	**0.216**	**0.162**	**0.196**	**0.265**
T_{Min}	0.059	0.054	0.050	0.037	0.017	0.046	0.054	0.020	0.099
T_{Max}	0.441	0.518	0.531	0.497	0.440	0.660	0.501	0.526	0.414

Appendix C

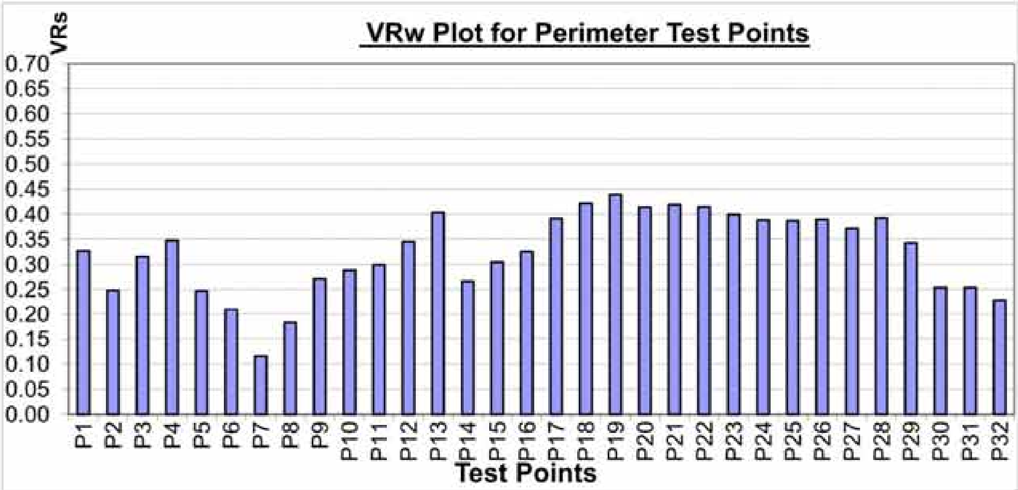
Appendix C - VRs Plot at 2m above Ground in NNE Wind Direction (Base)

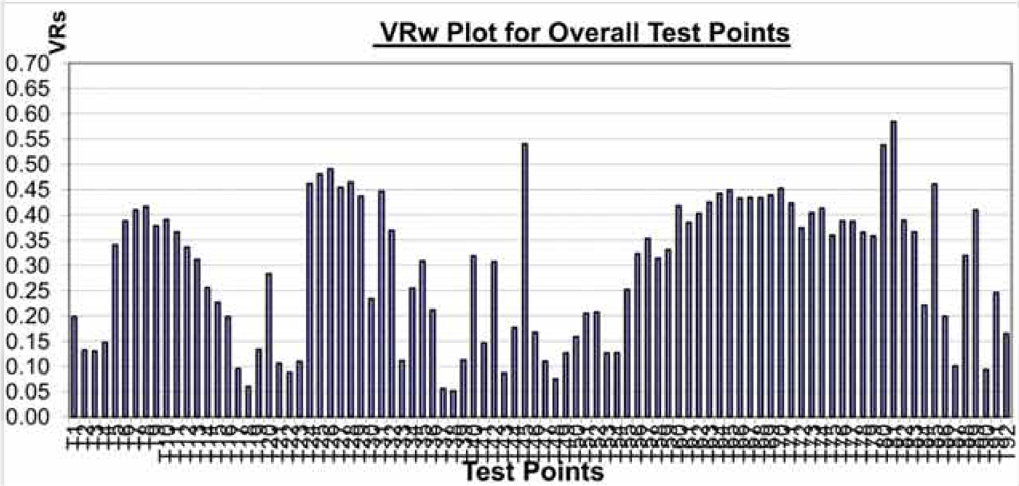


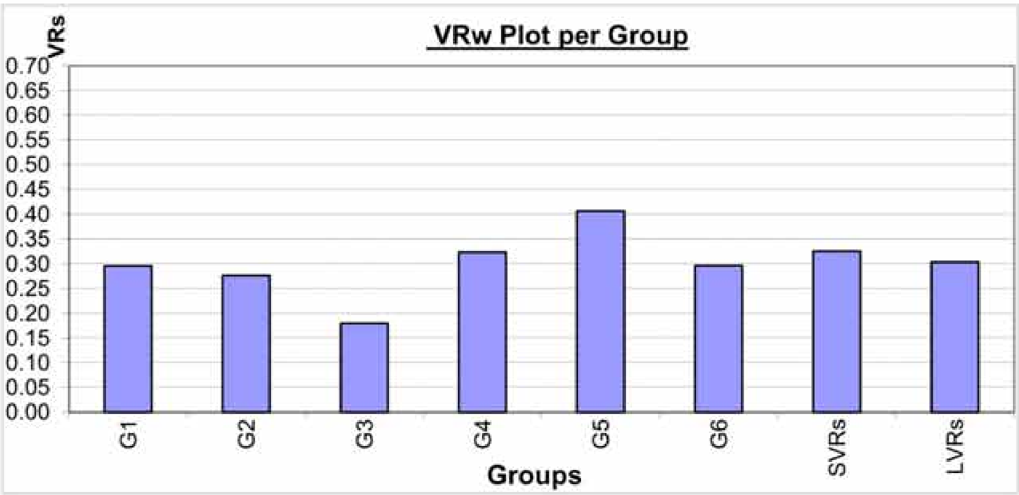




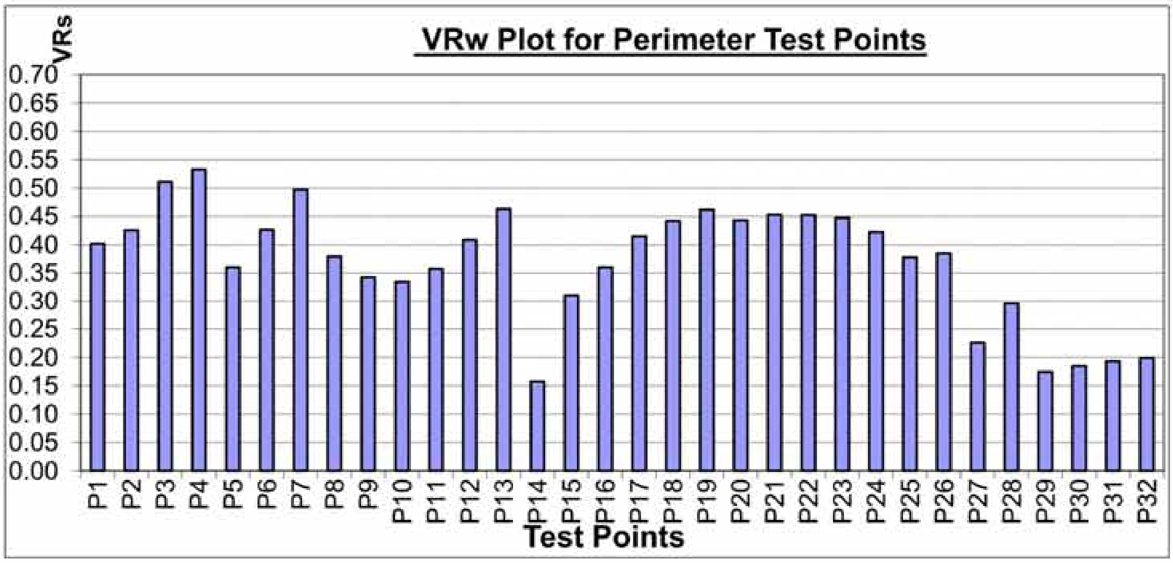
Appendix C - VRs Plot at 2m above Ground in NE Wind Direction (Base)

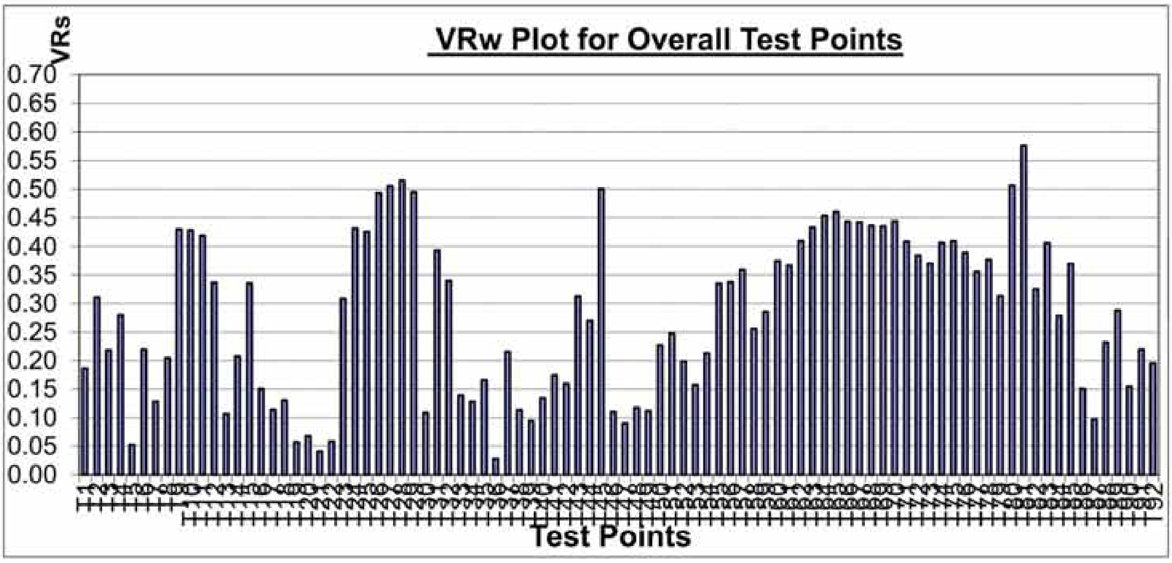


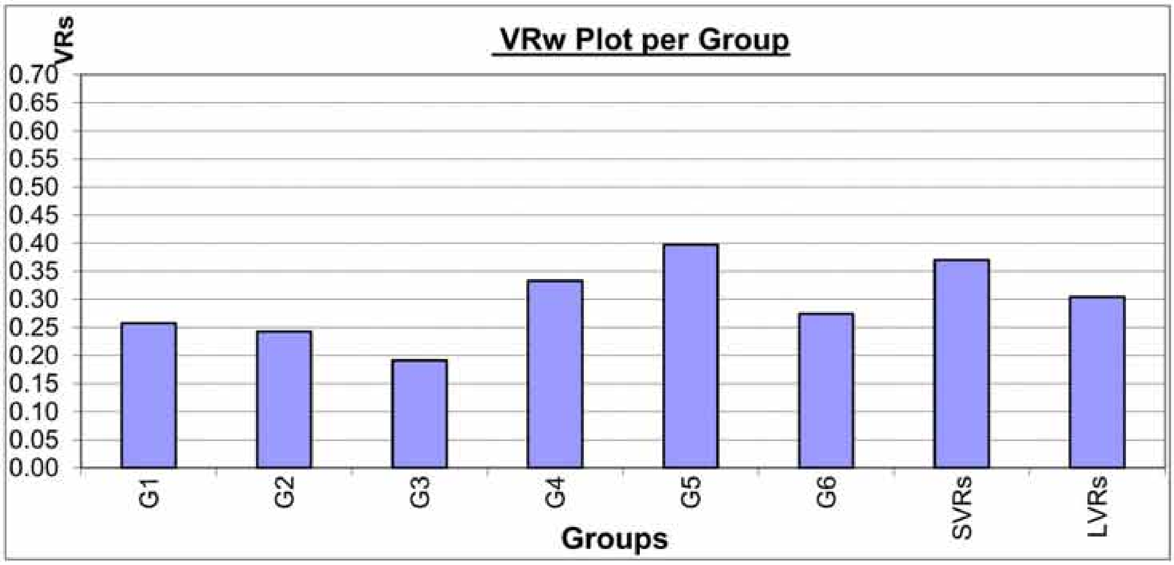




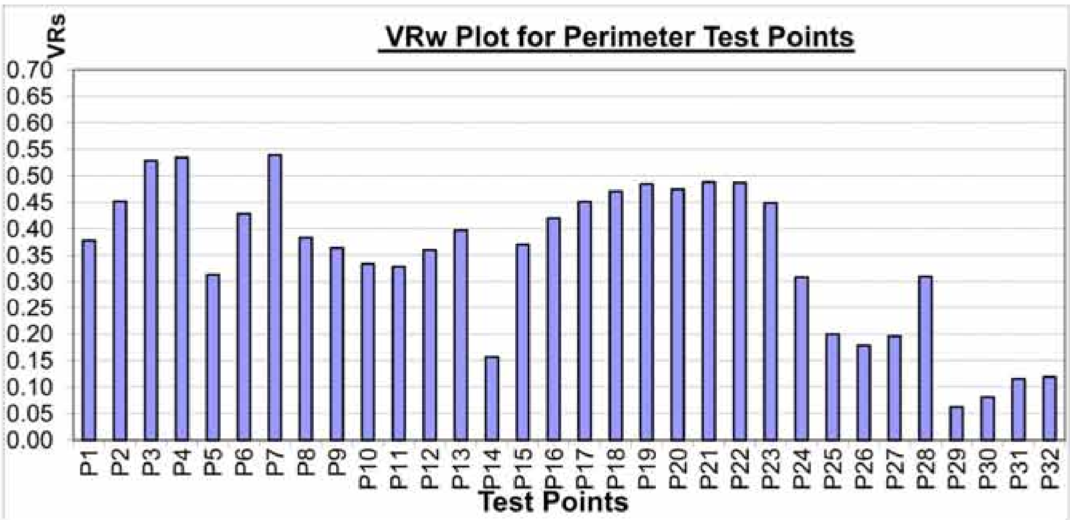
Appendix C - VRs Plot at 2m above Ground in ENE Wind Direction (Base)

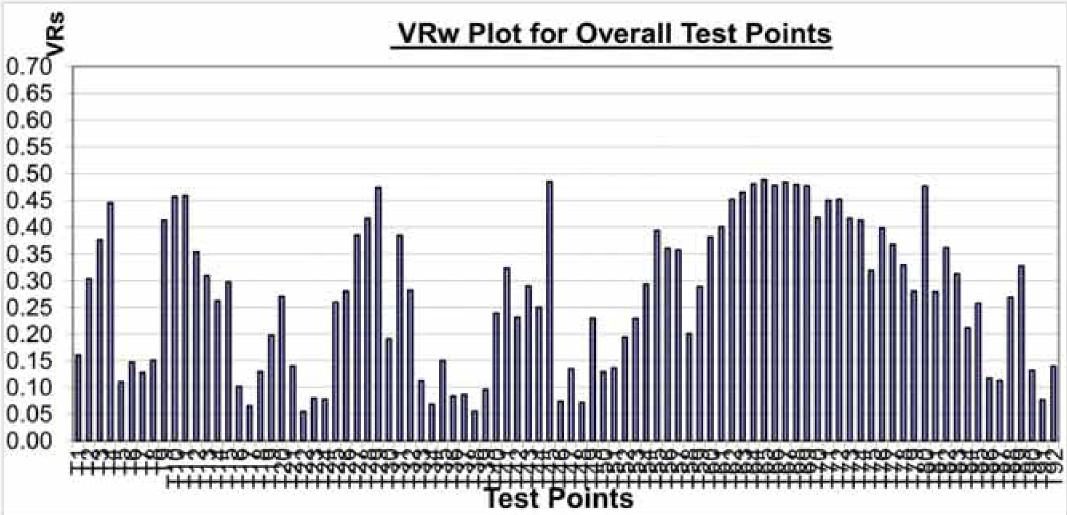


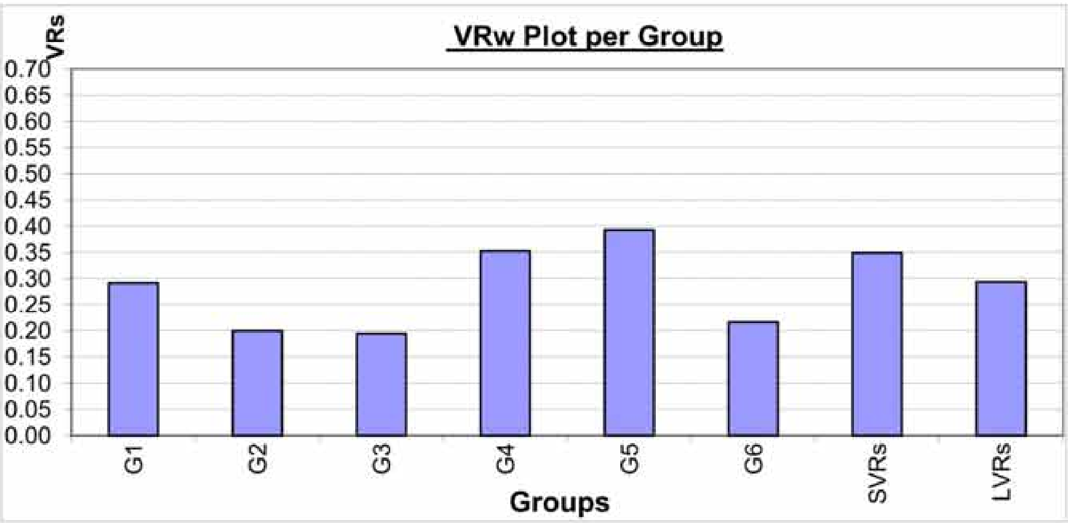




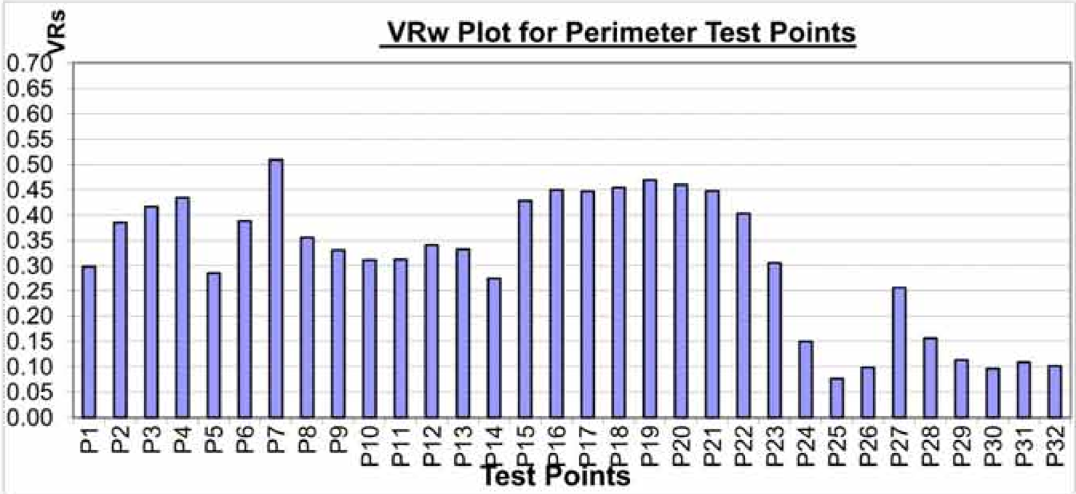
Appendix C - VRs Plot at 2m above Ground in E Wind Direction (Base)

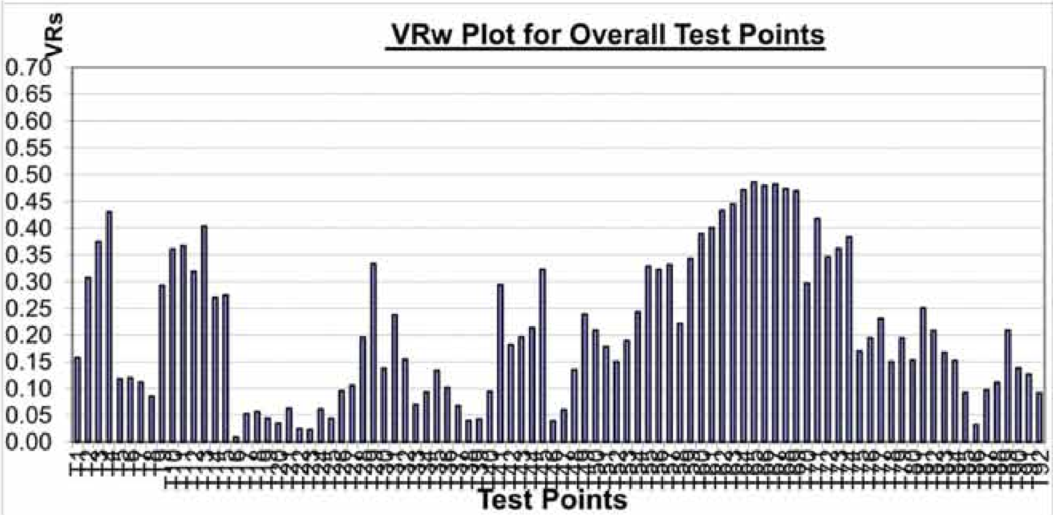


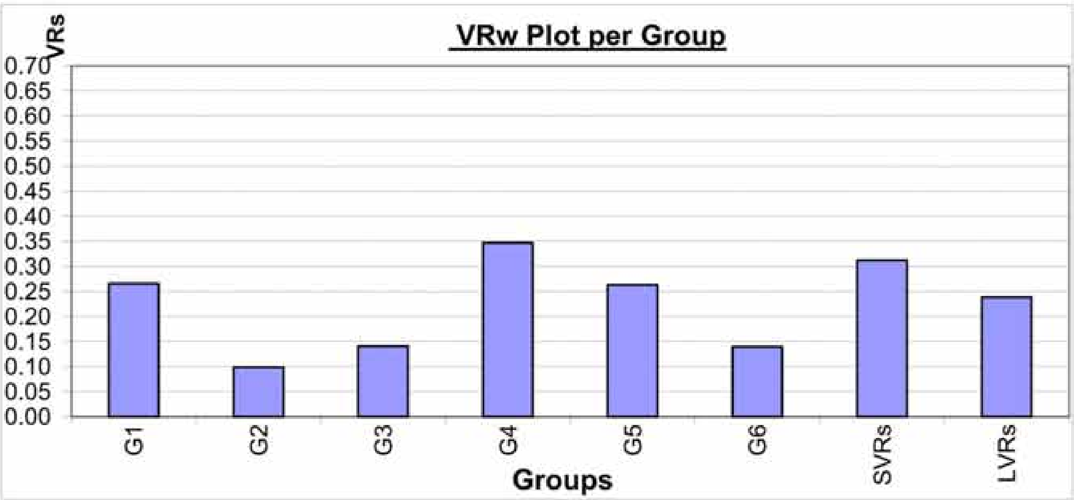




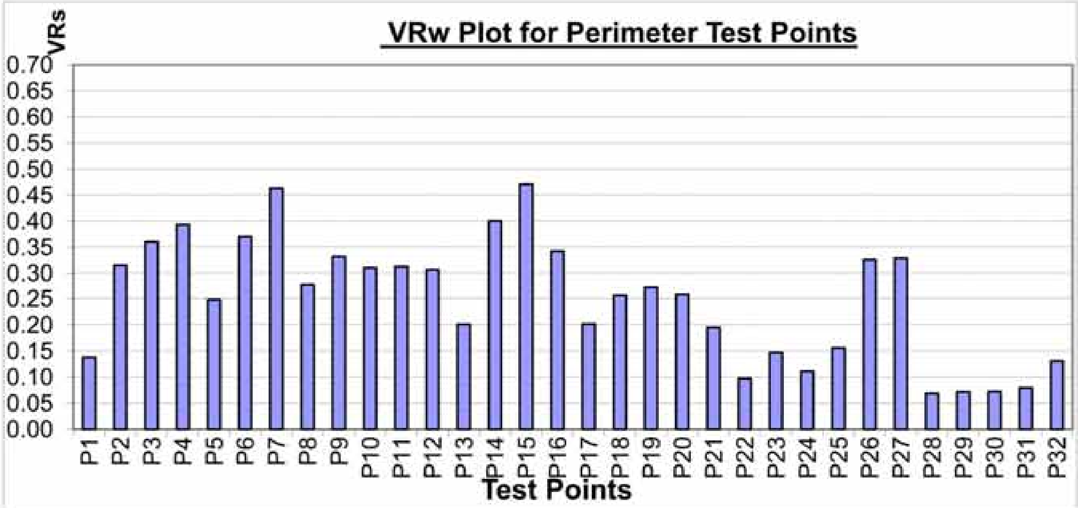
Appendix C - VRs Plot at 2m above Ground in ESE Wind Direction (Base)

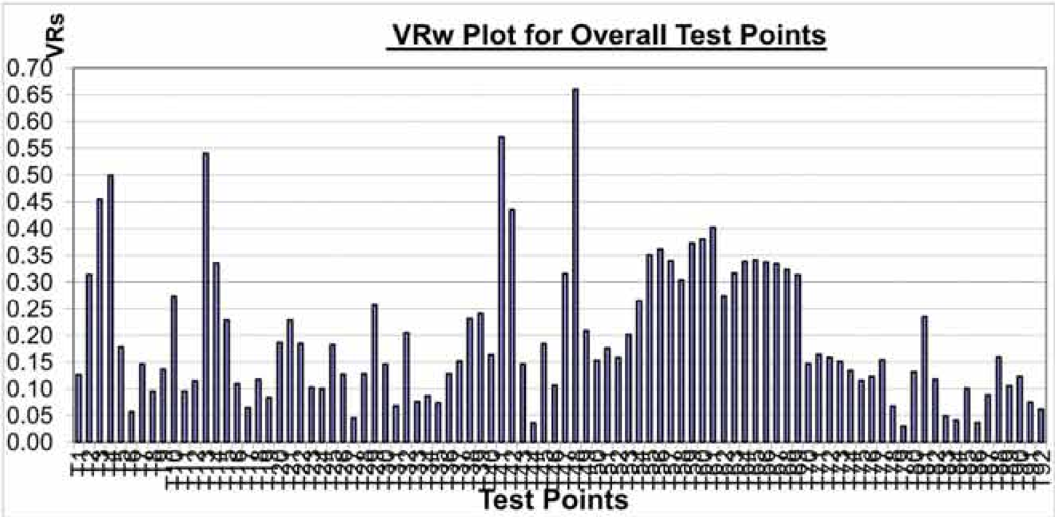


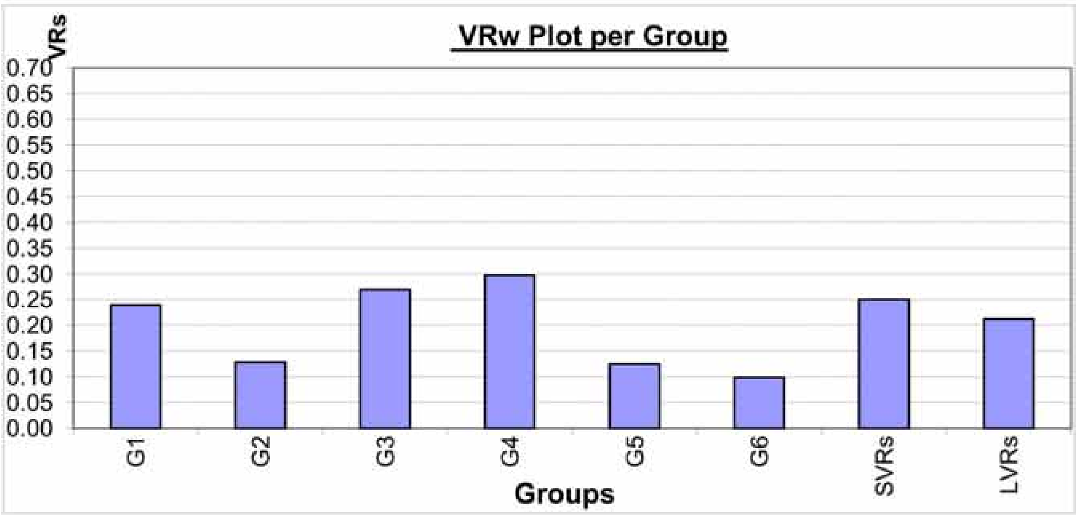




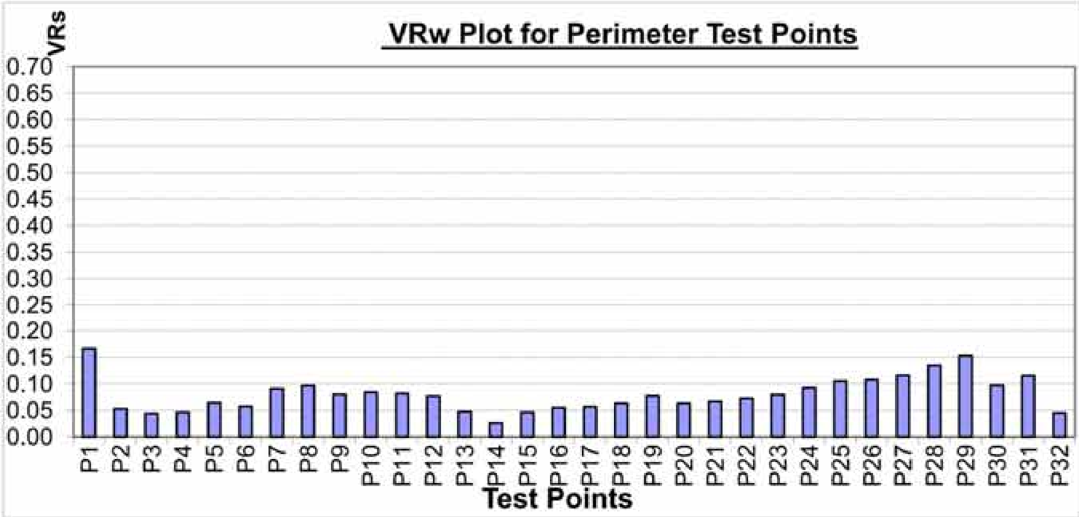
Appendix C - VRs Plot at 2m above Ground in SE Wind Direction (Base)

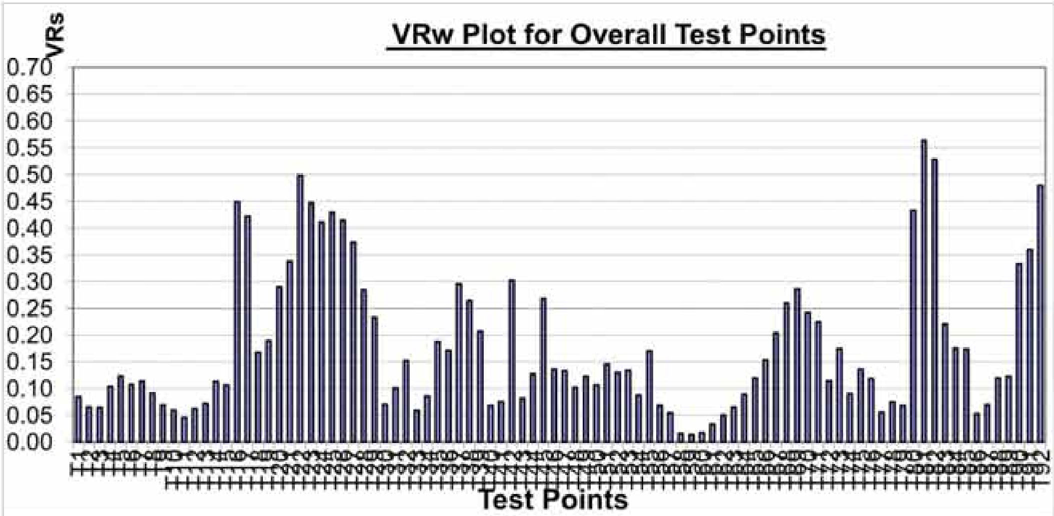


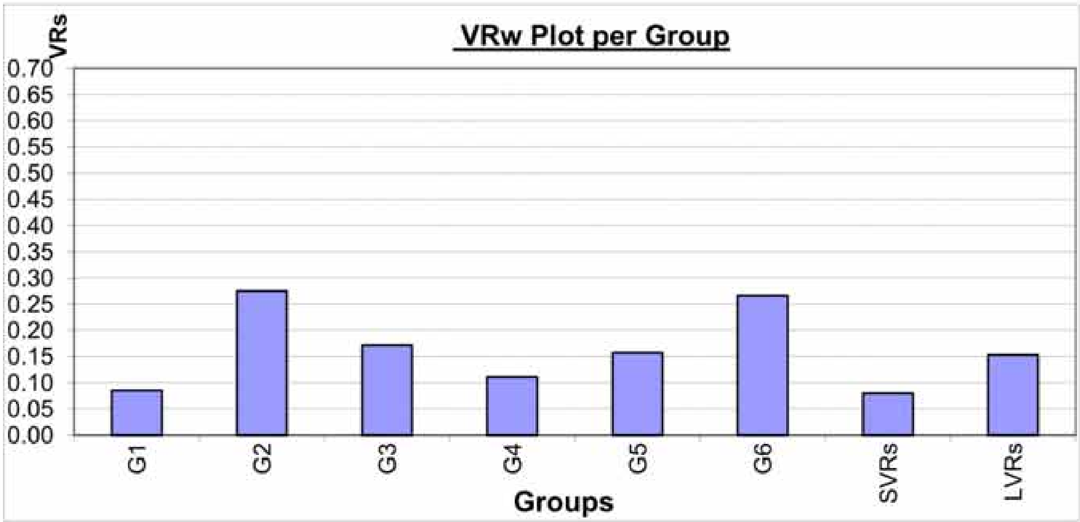




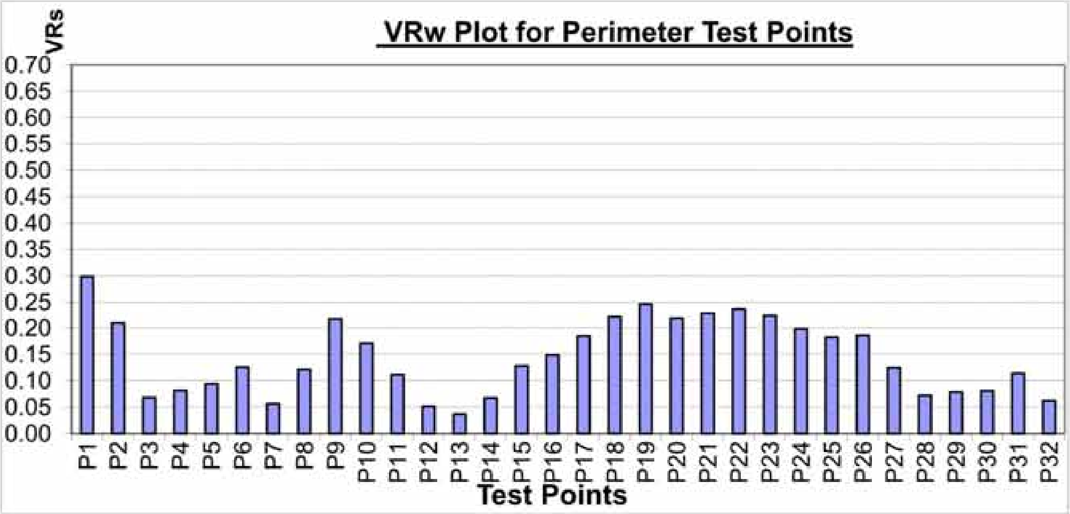
Appendix C - VRs Plot at 2m above Ground in SSW Wind Direction (Base)

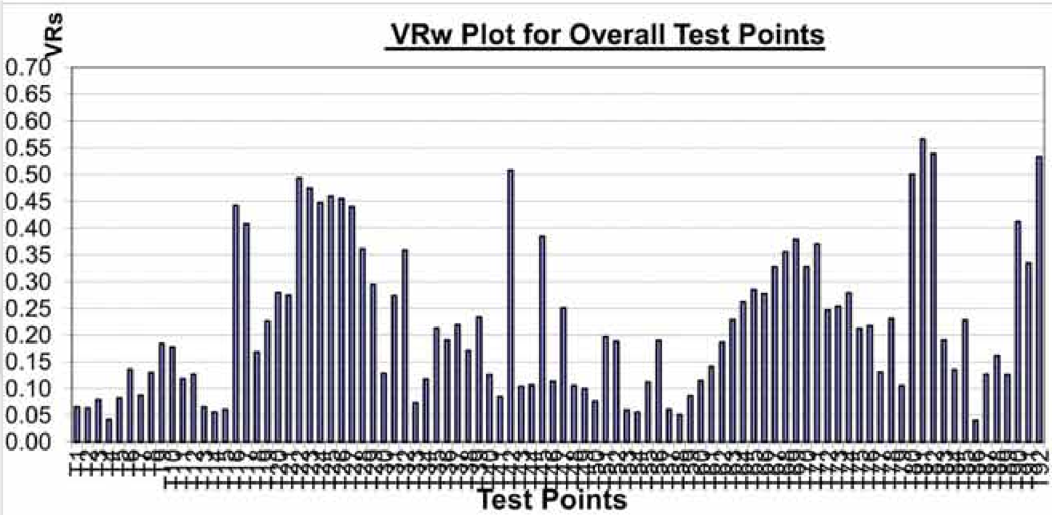


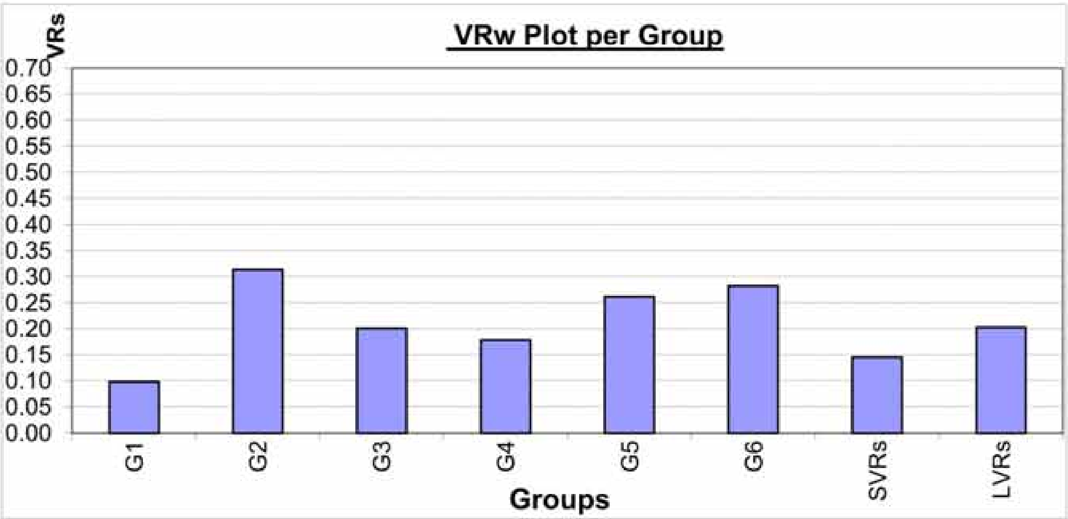




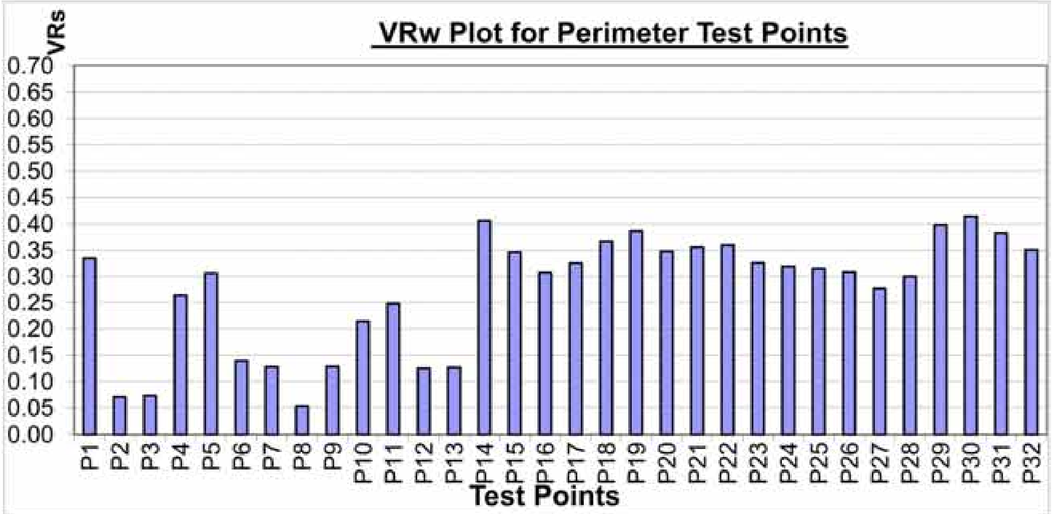
Appendix C - VRs Plot at 2m above Ground in SW Wind Direction (Base)

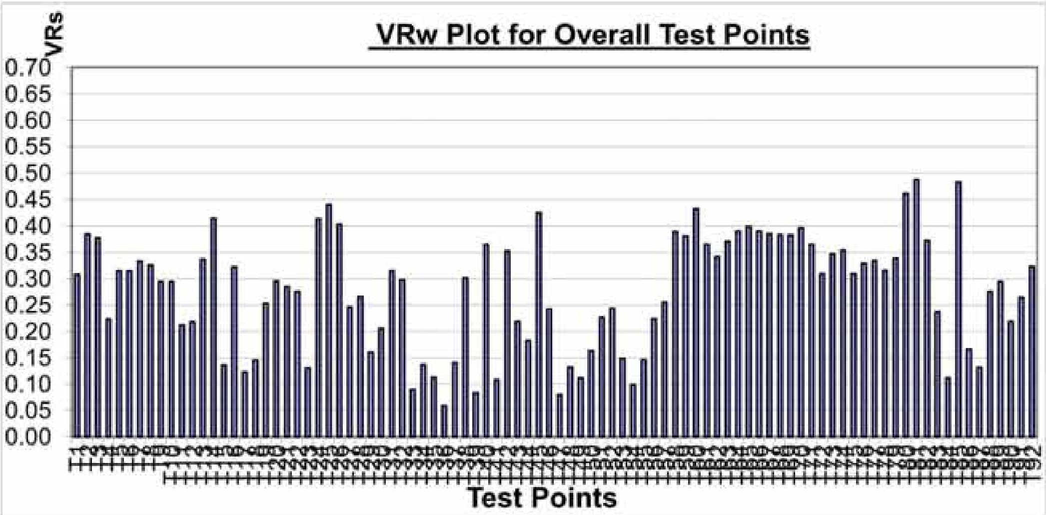


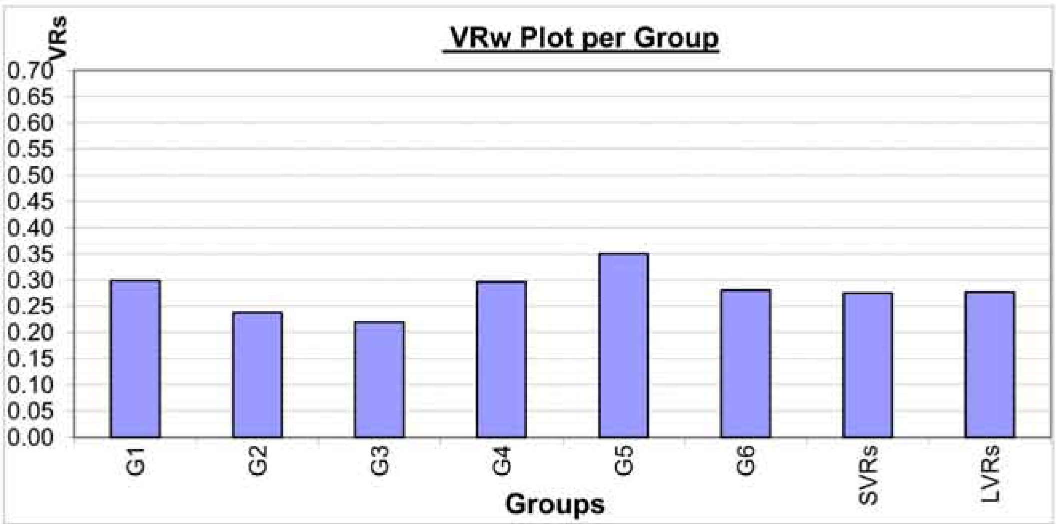




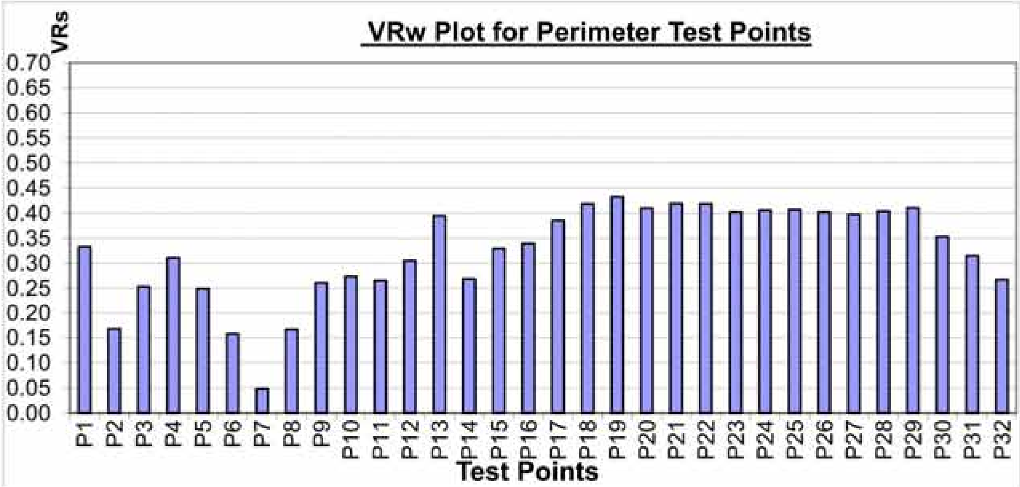
Appendix C - VRs Plot at 2m above Ground in NNE Wind Direction (Proposed)

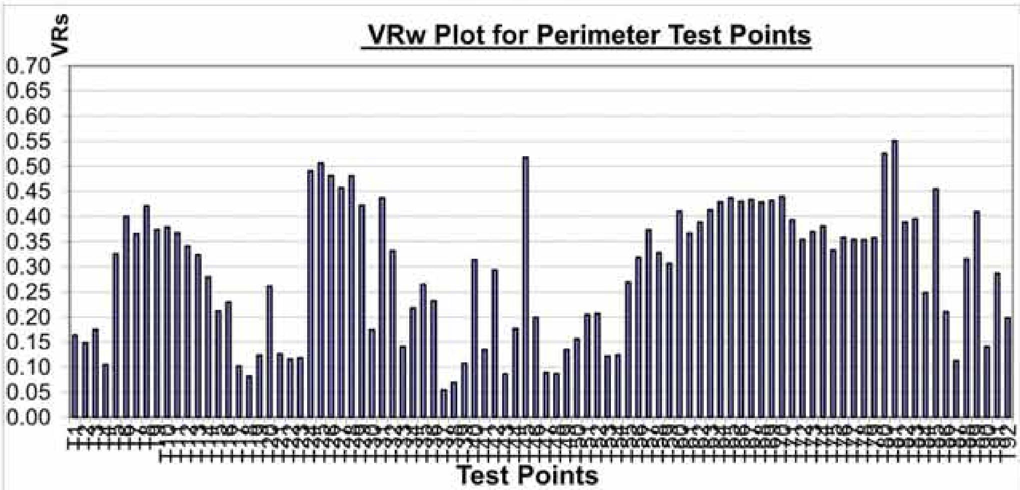


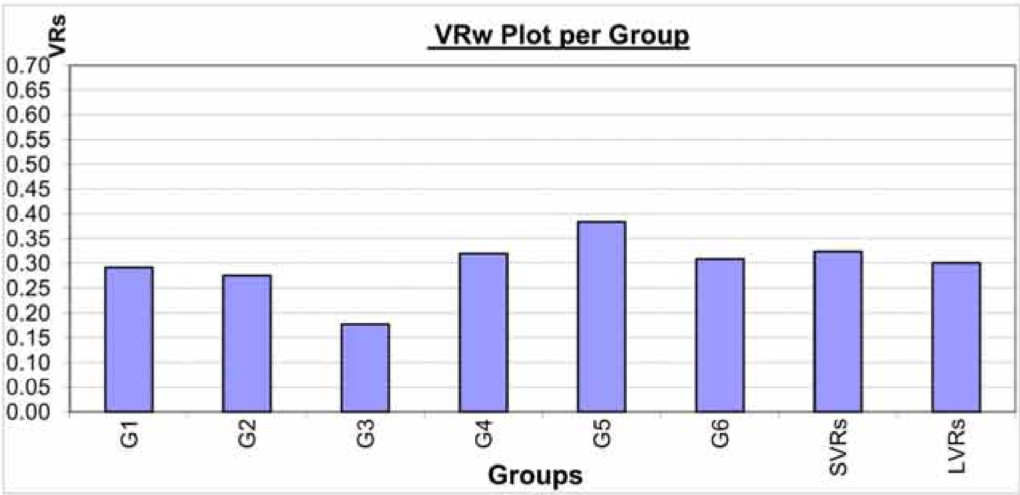




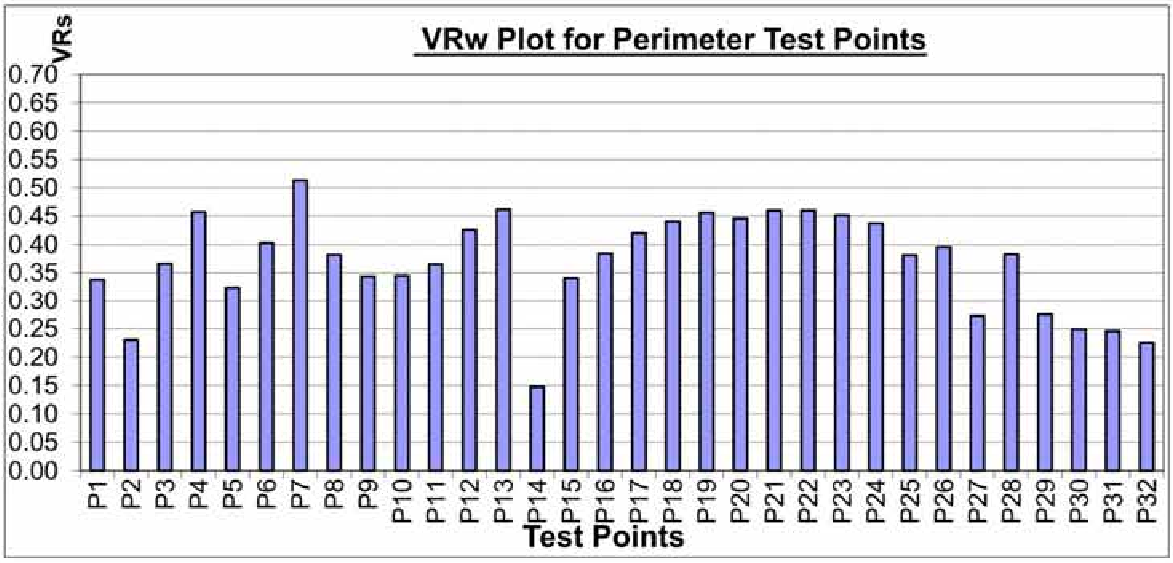
Appendix C - VRs Plot at 2m above Ground in NE Wind Direction (Proposed)

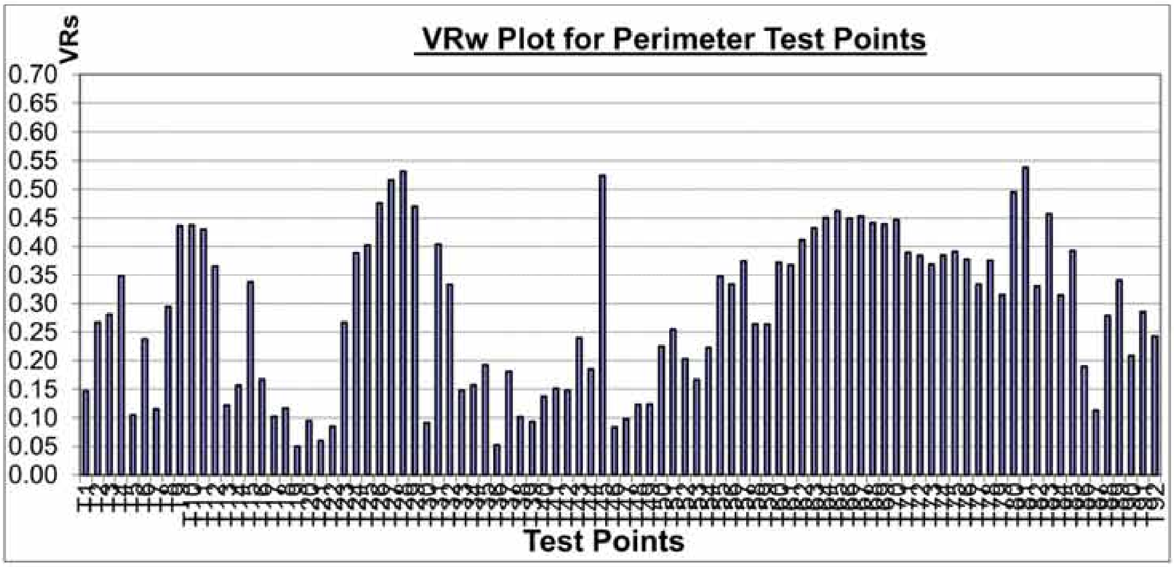


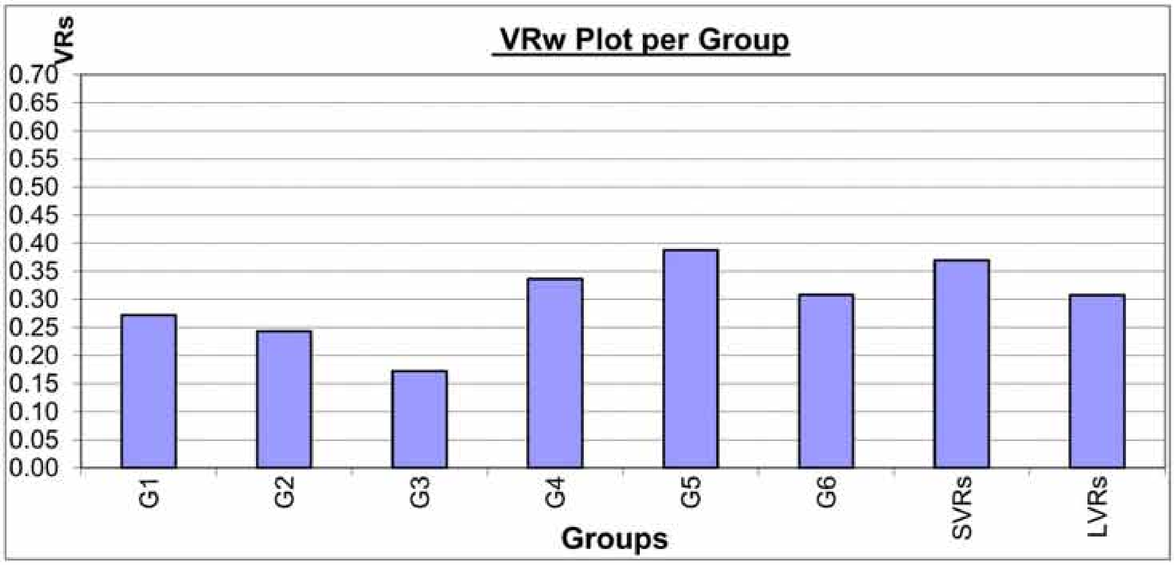




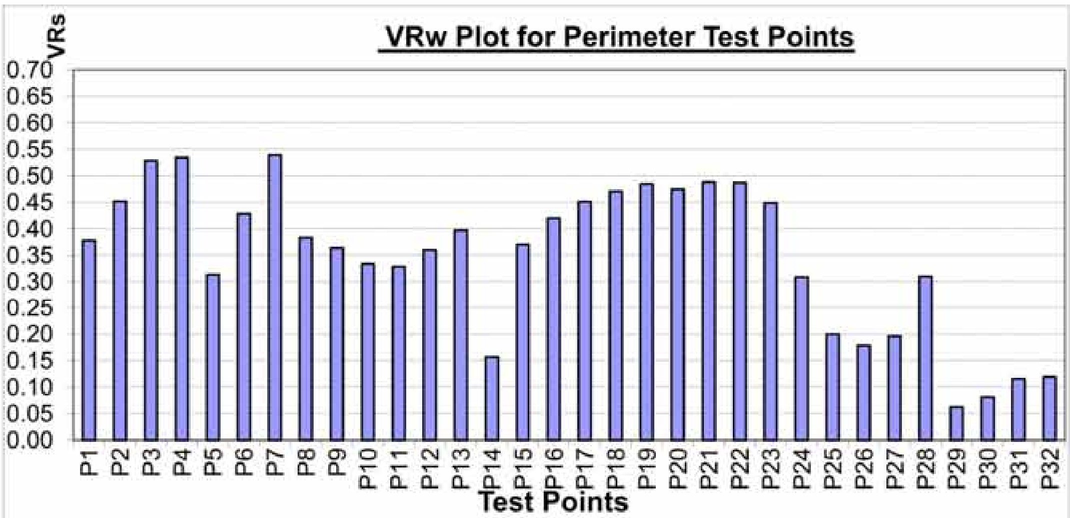
Appendix C - VRs Plot at 2m above Ground in ENE Wind Direction (Proposed)

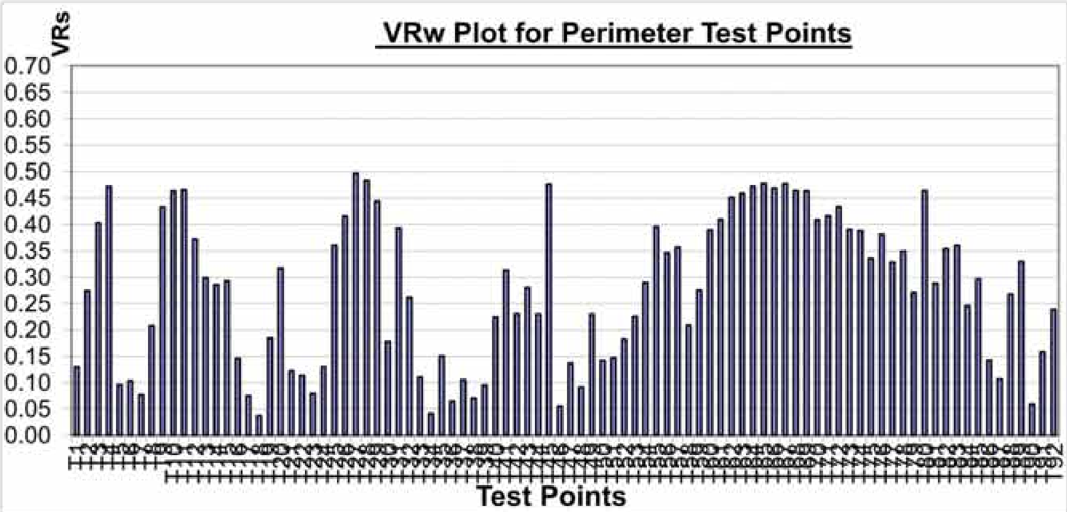


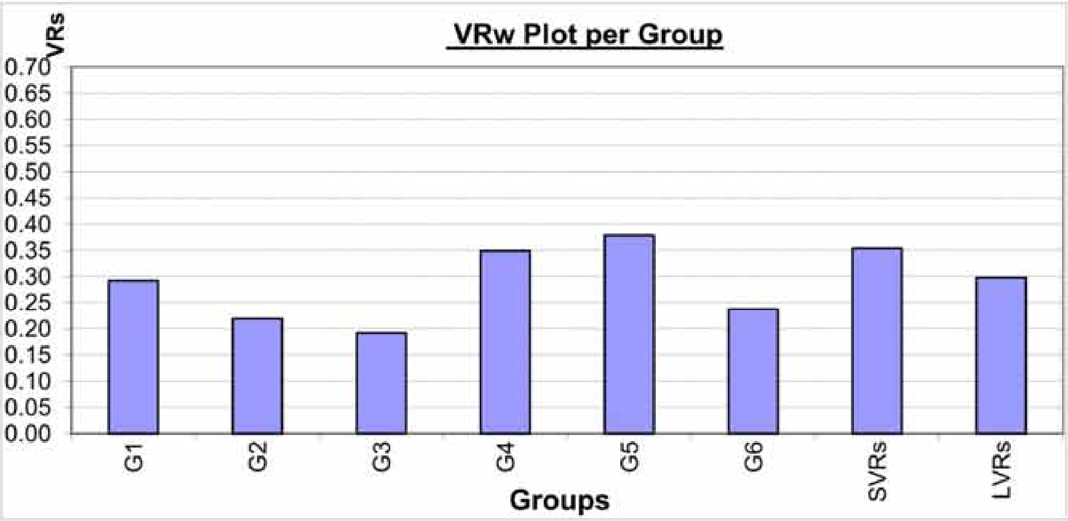




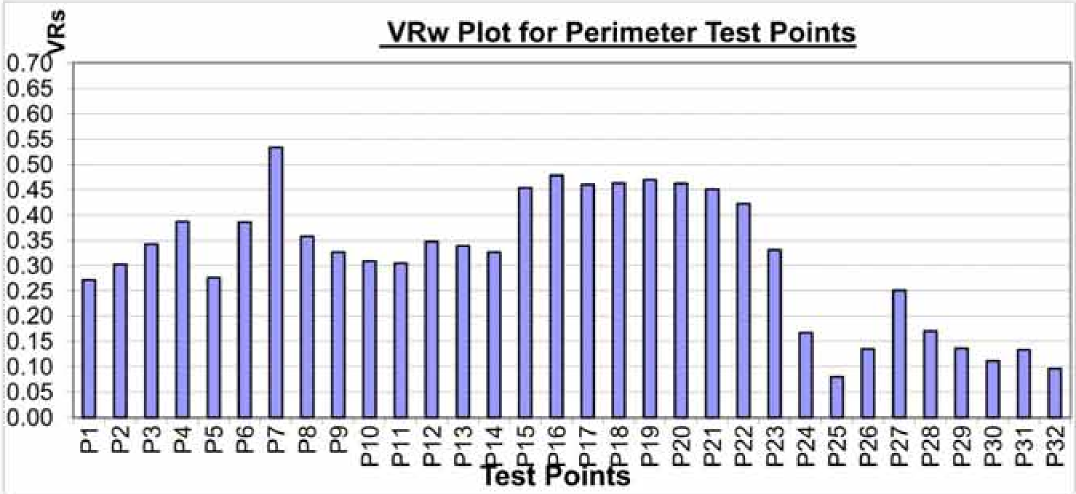
Appendix C - VRs Plot at 2m above Ground in E Wind Direction (Proposed)

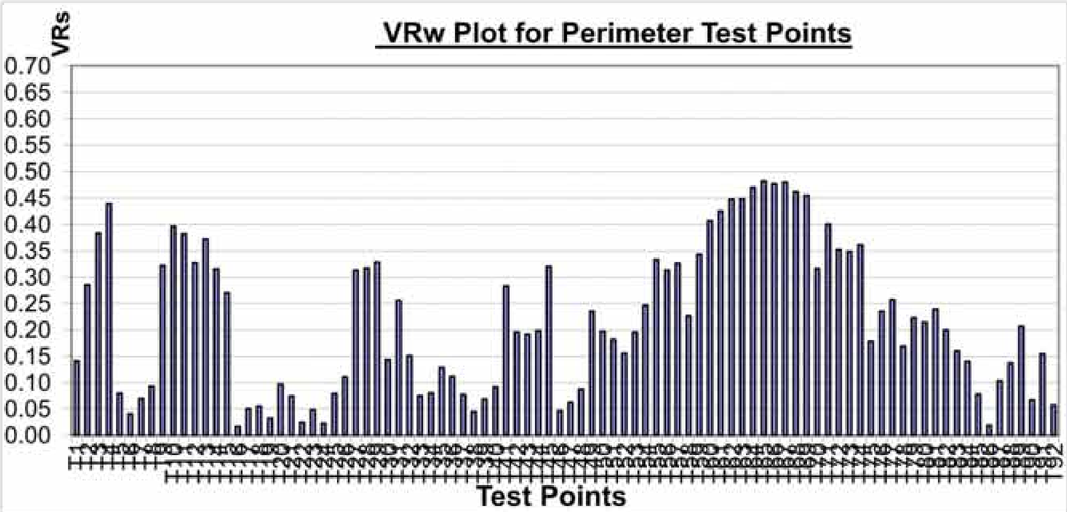


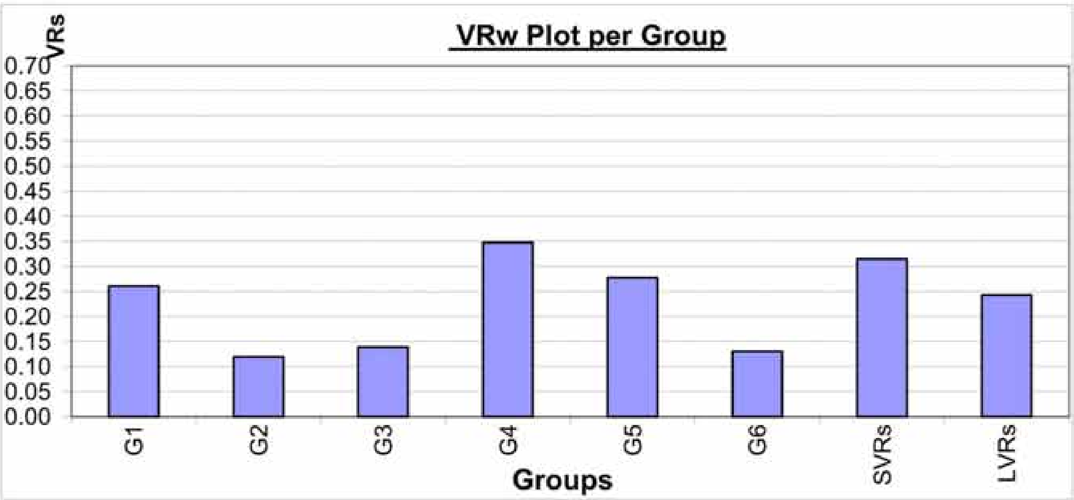




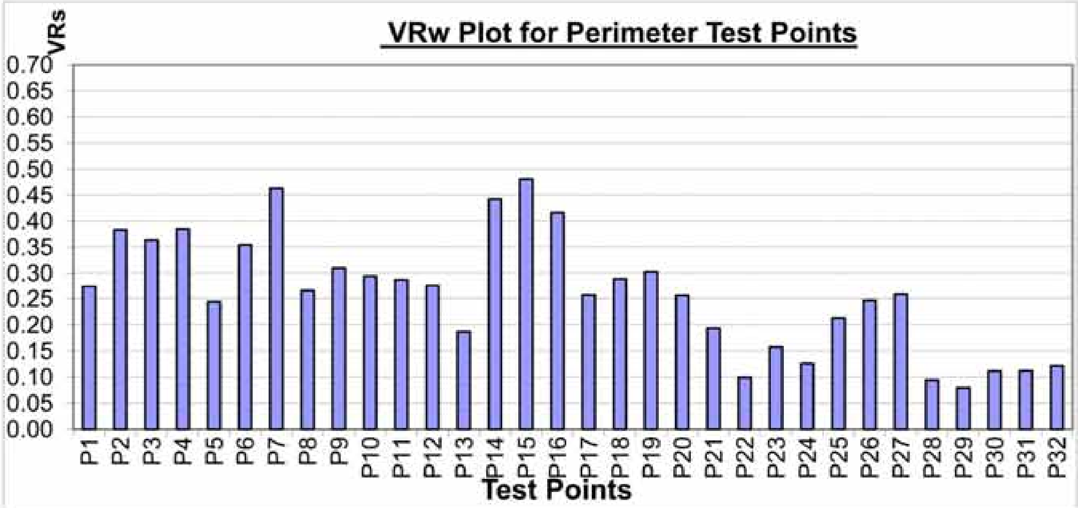
Appendix C - VRs Plot at 2m above Ground in ESE Wind Direction (Proposed)

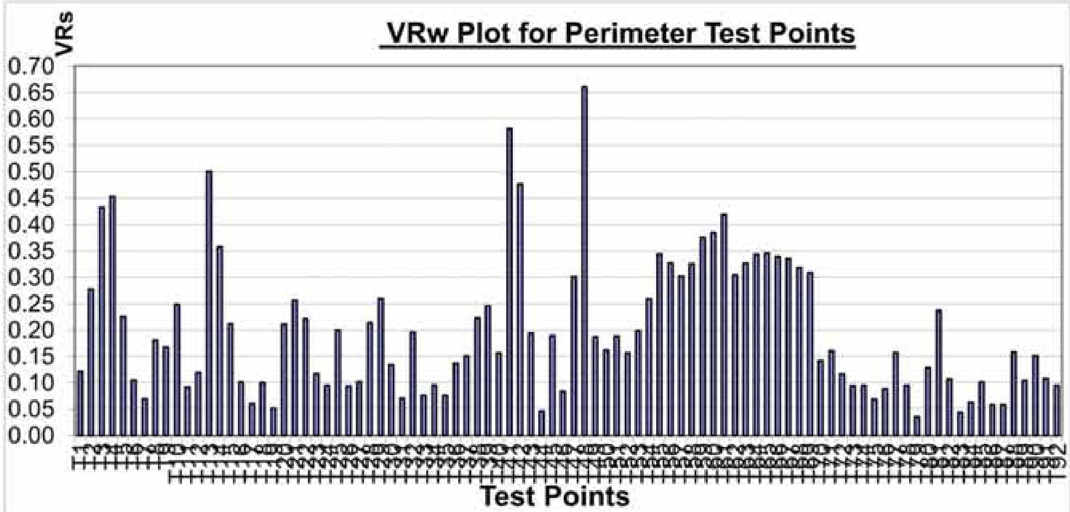


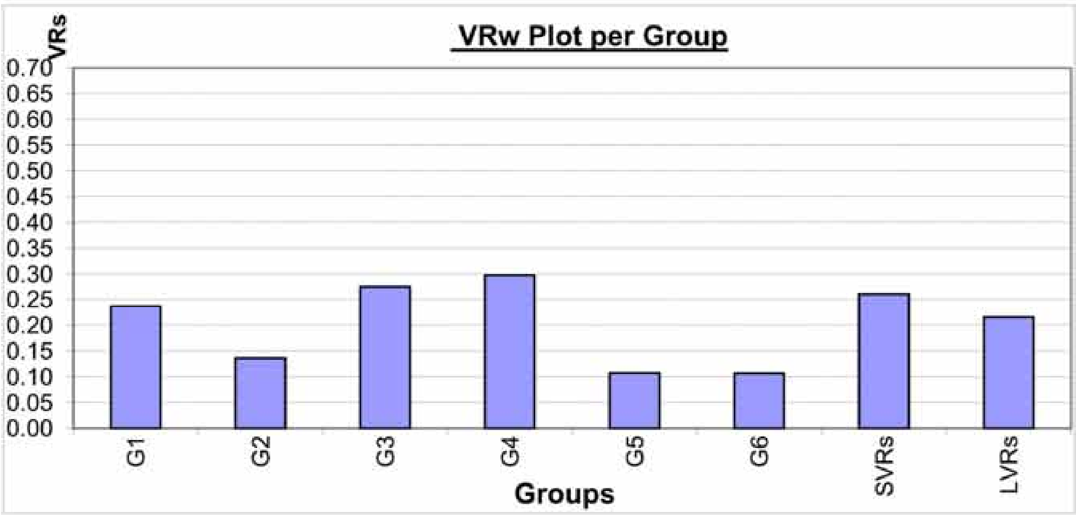




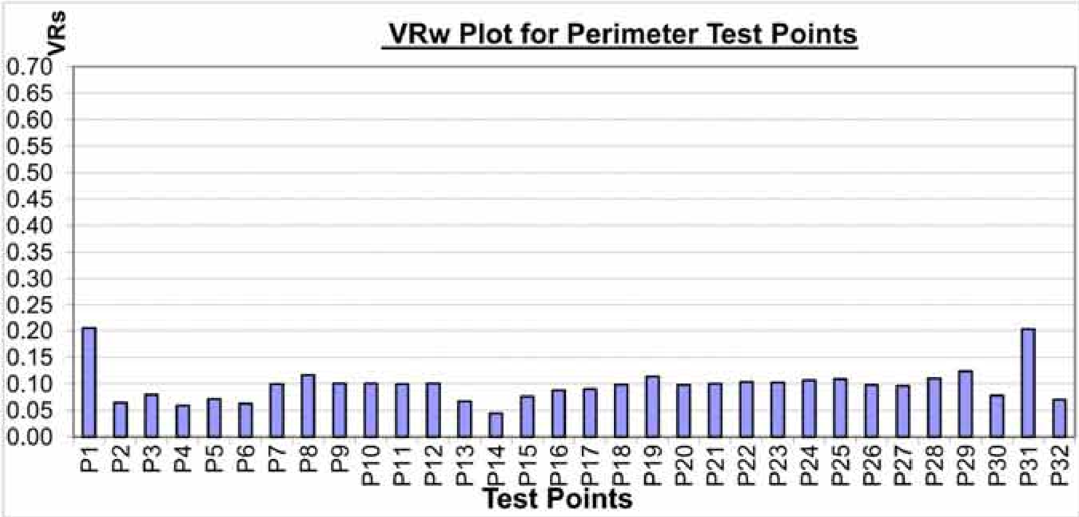
Appendix C - VRs Plot at 2m above Ground in SE Wind Direction (Proposed)

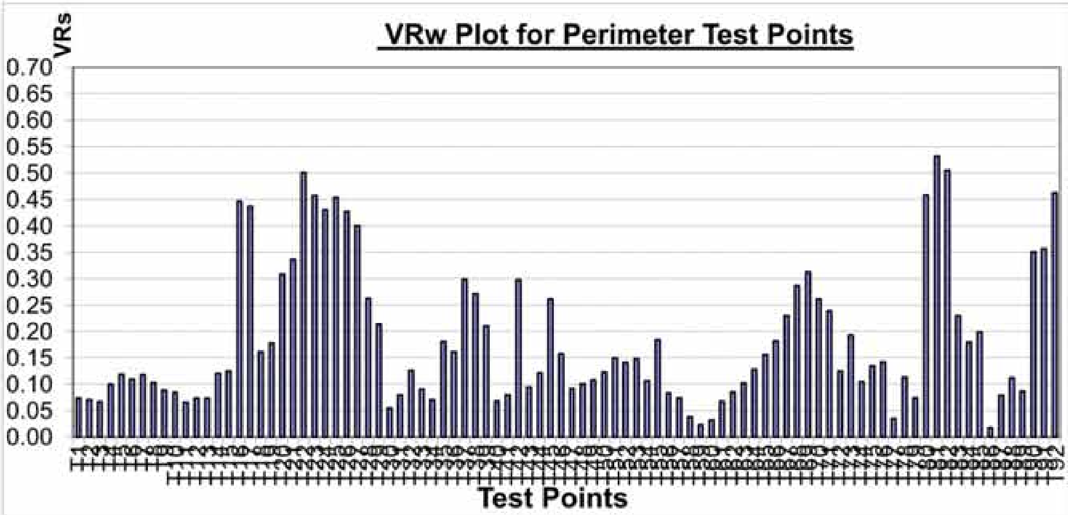


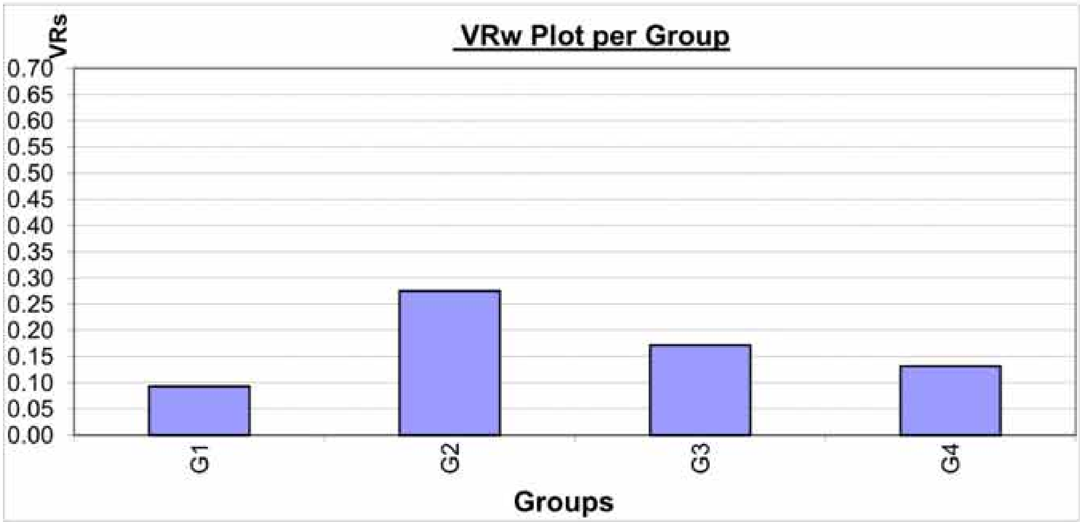




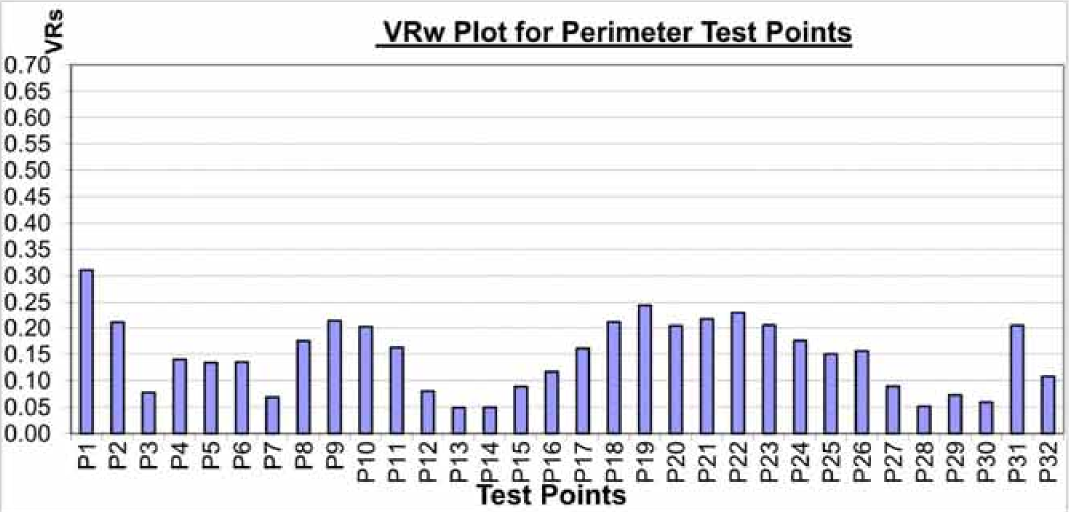
Appendix C - VRs Plot at 2m above Ground in SSW Wind Direction (Proposed)

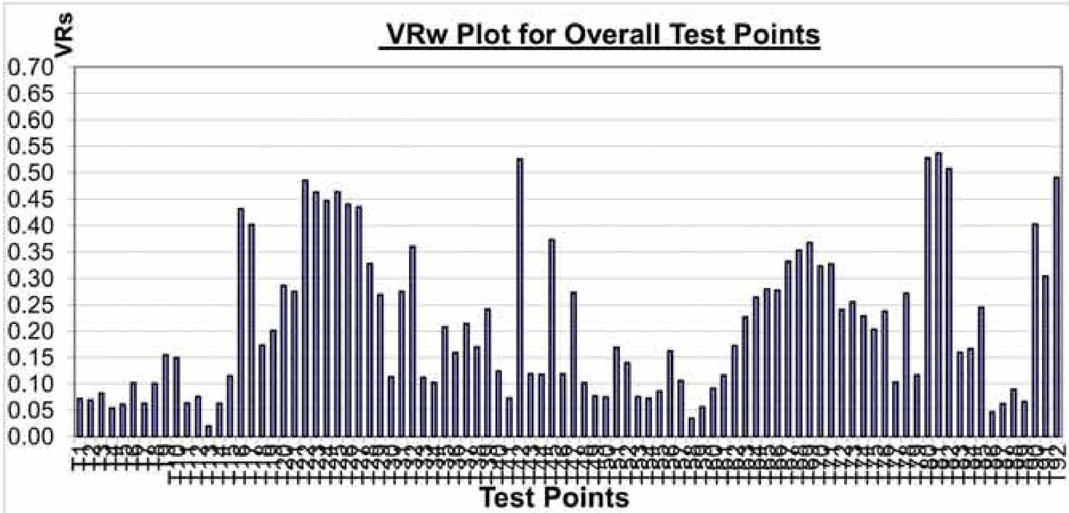


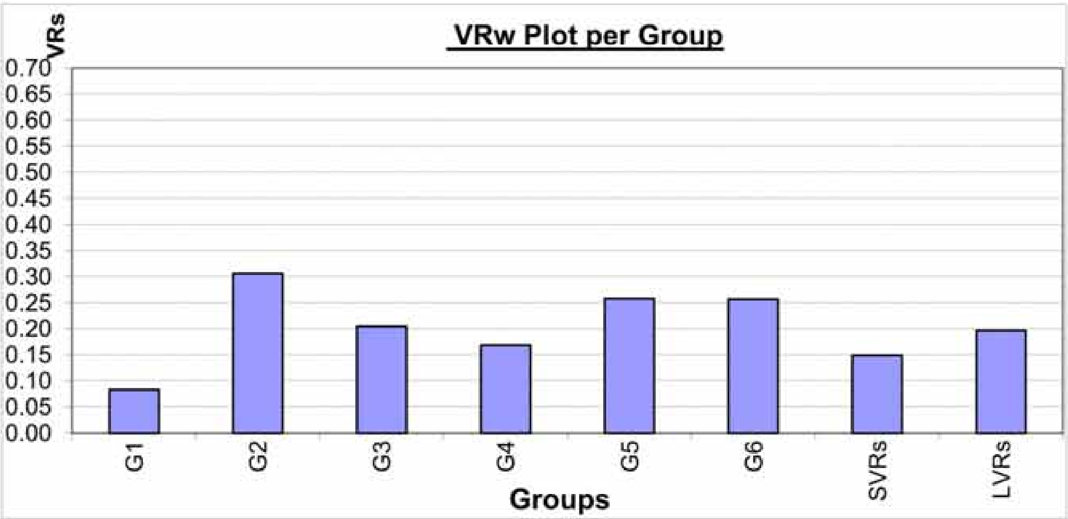




Appendix C - VRs Plot at 2m above Ground in SW Wind Direction (Proposed)



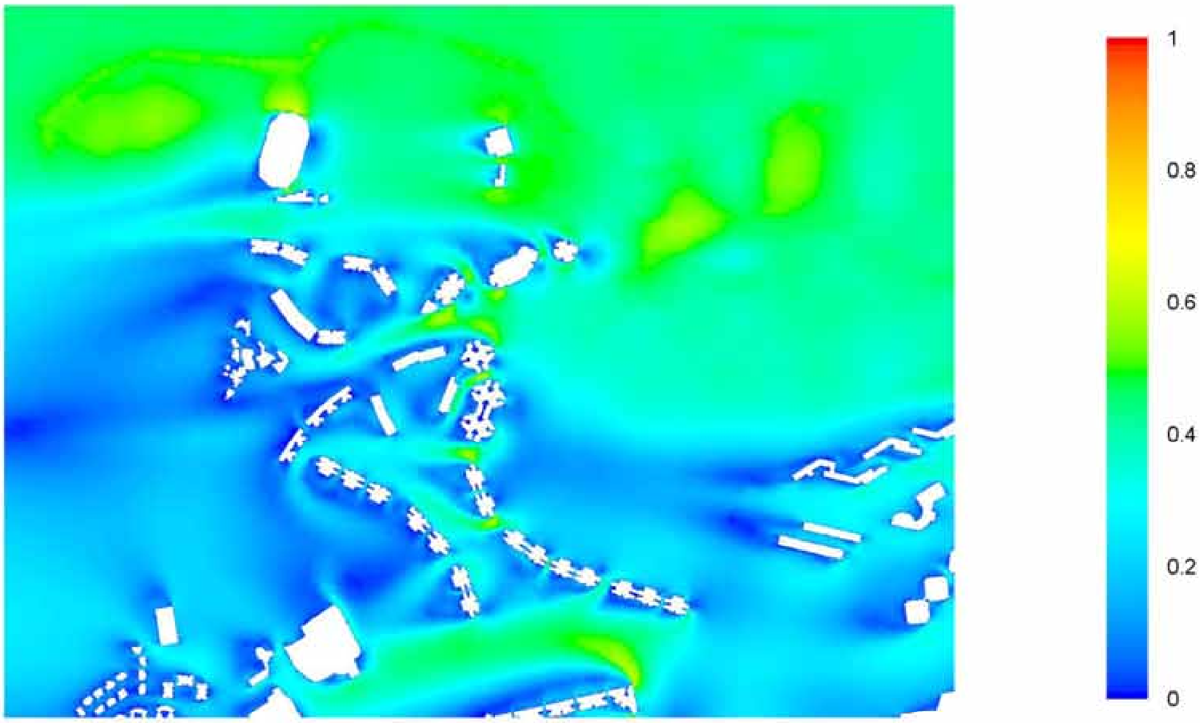




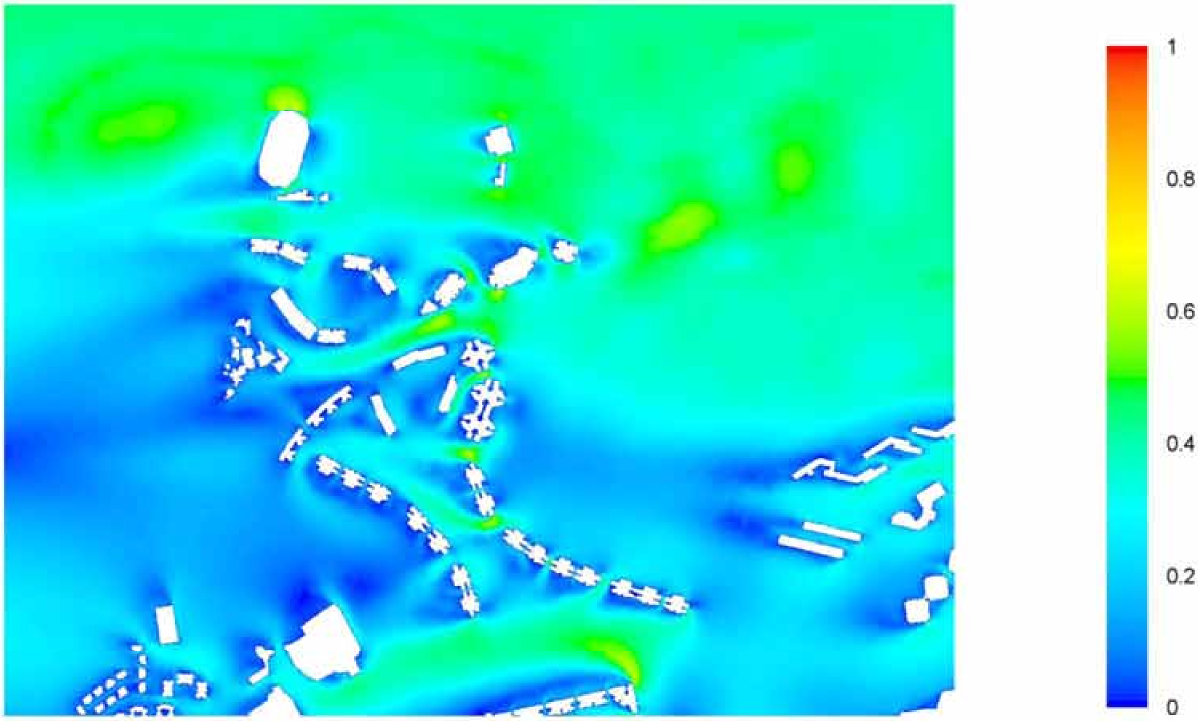
Appendix D

Appendix D – Wind Velocity Ratio Contour Plots

E at 2mAG (base scheme)

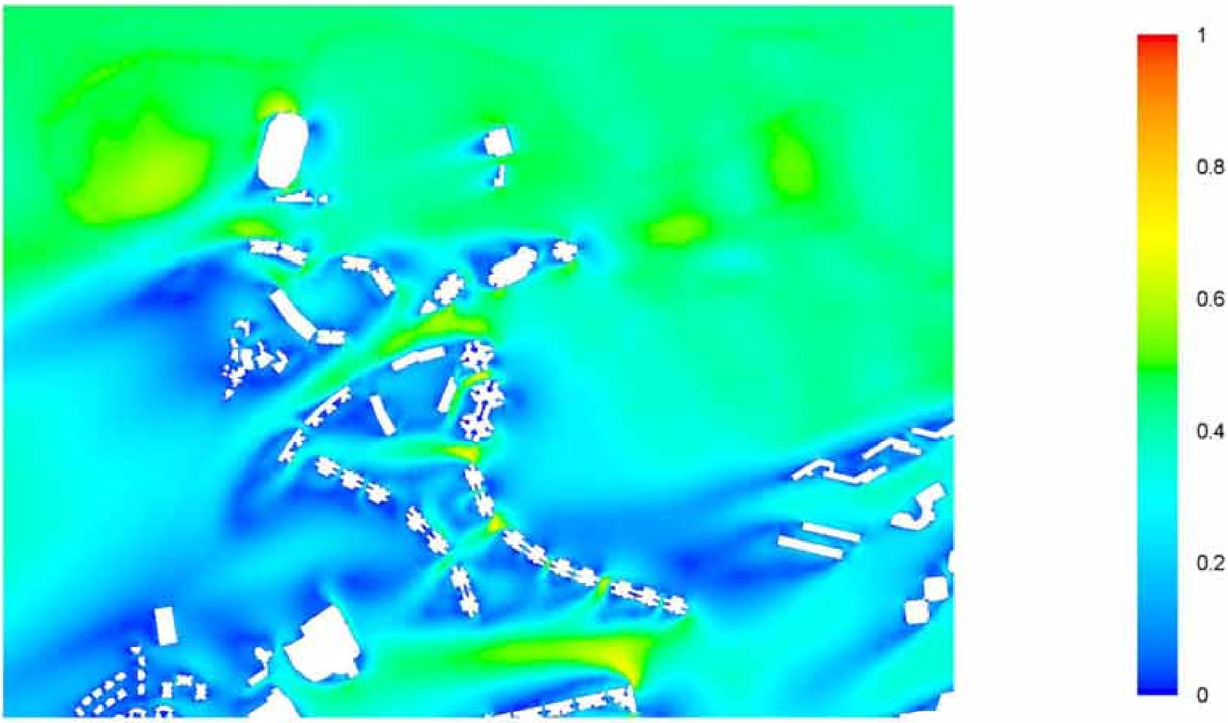


E at 2mAG (Proposed Scheme)

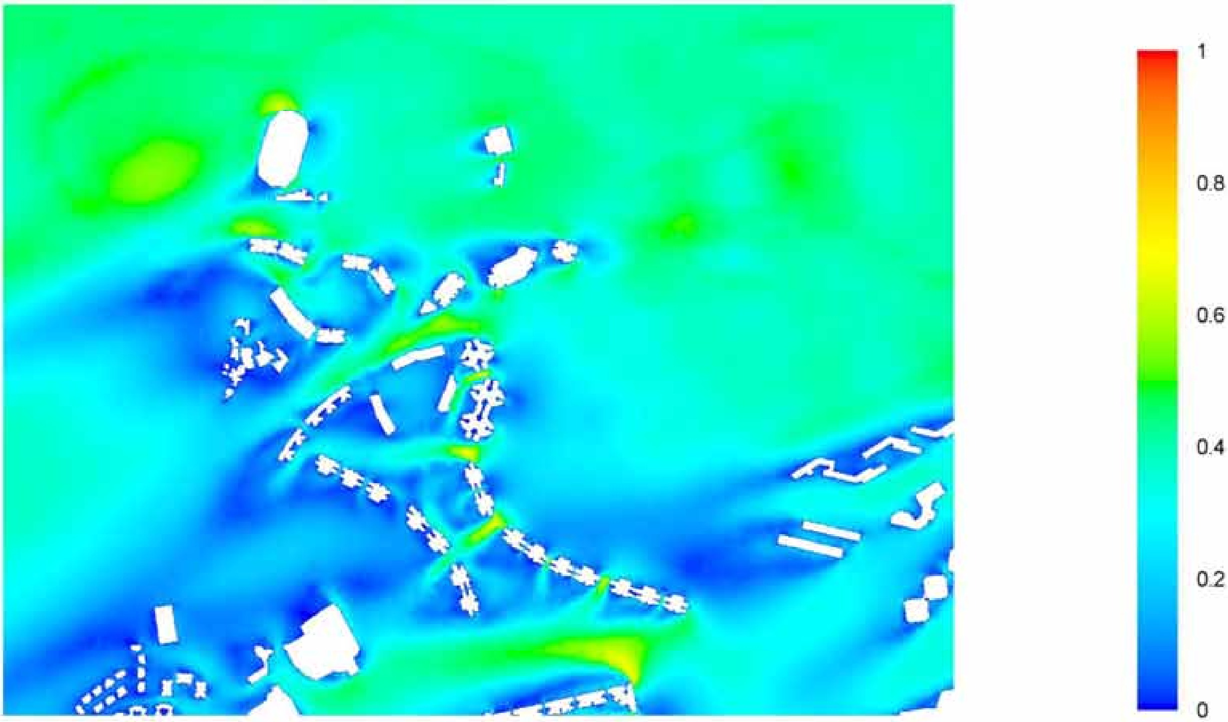


Appendix D – Wind Velocity Ratio Contour Plots

ENE at 2mAG (Base scheme)

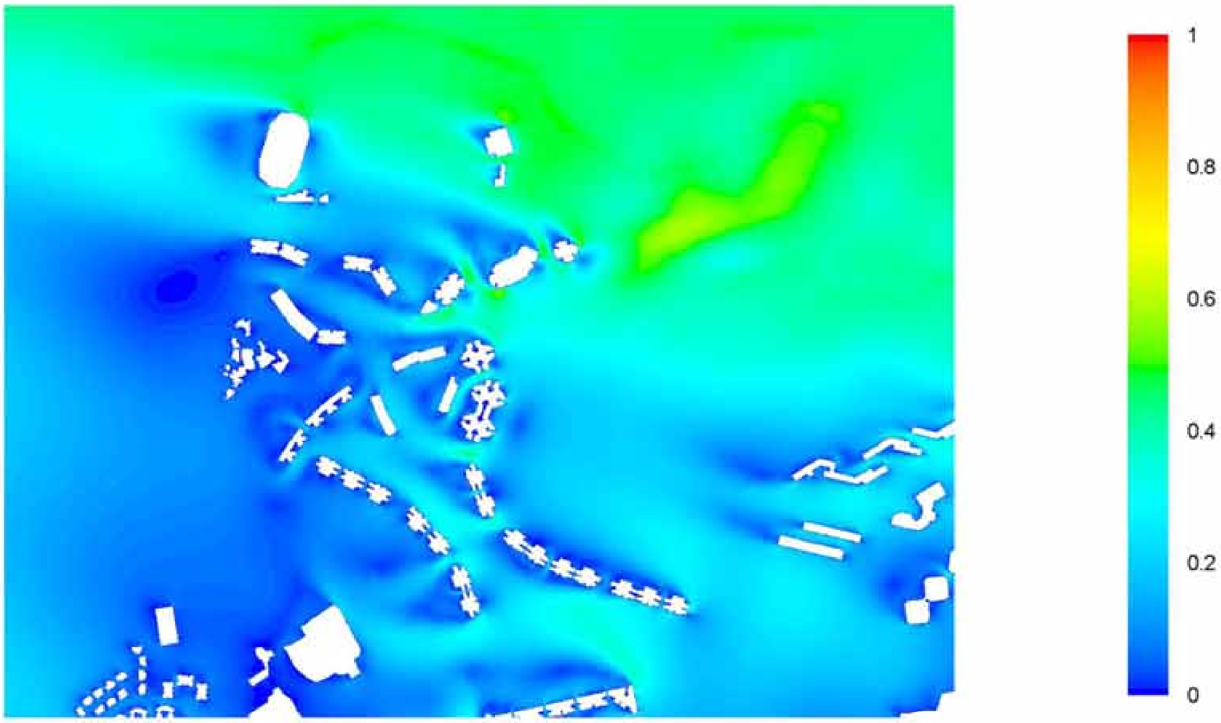


ENE at 2mAG (Proposed Scheme)

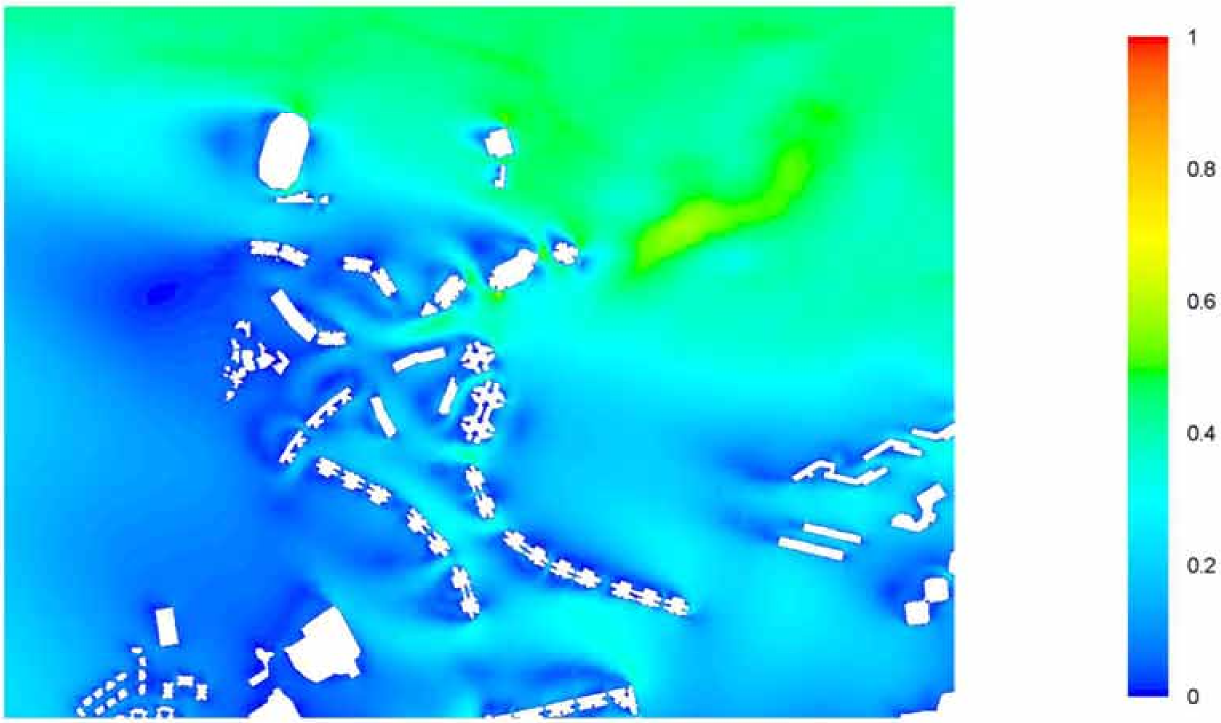


Appendix D – Wind Velocity Ratio Contour Plots

ESE at 2mAG (Base scheme)

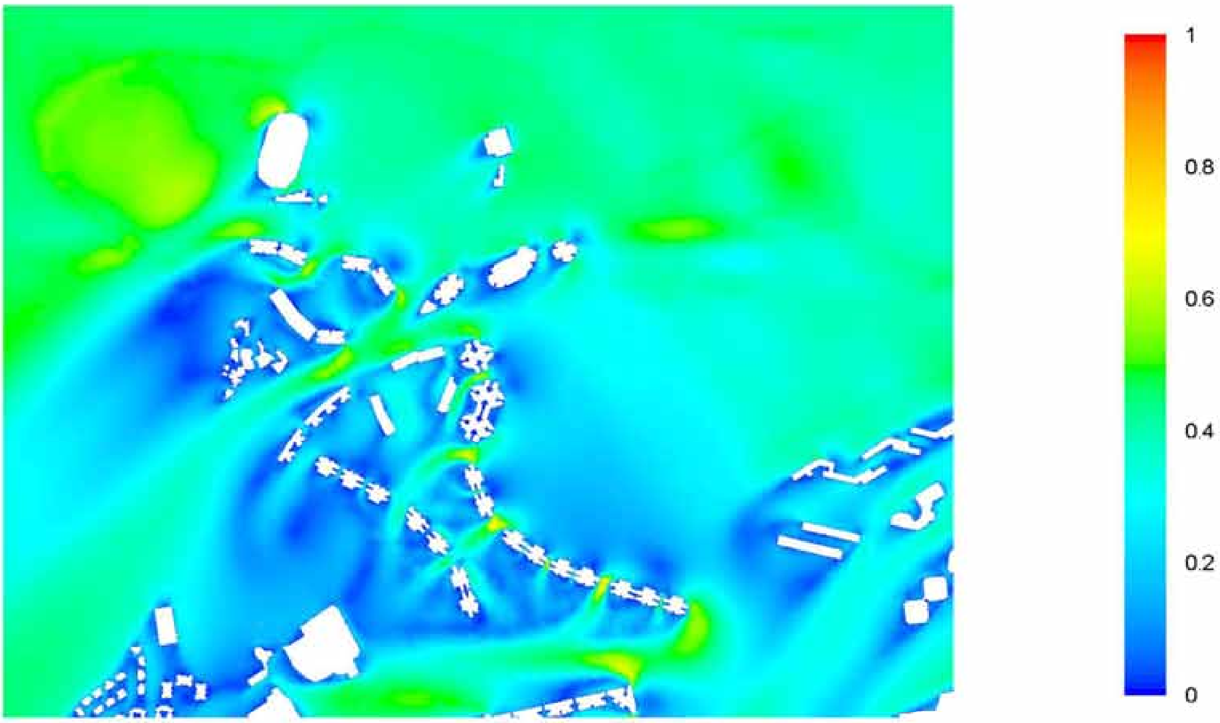


ESE at 2mAG (Proposed Scheme)

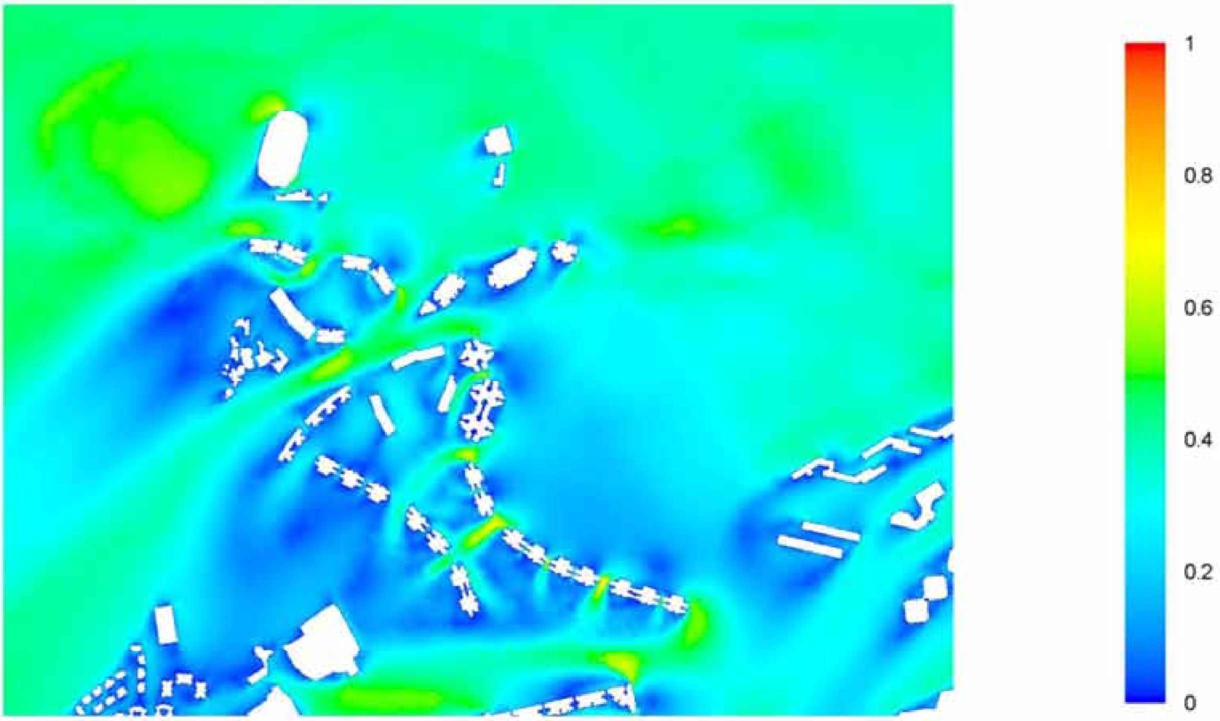


Appendix D – Wind Velocity Ratio Contour Plots

NE at 2mAG (Base scheme)

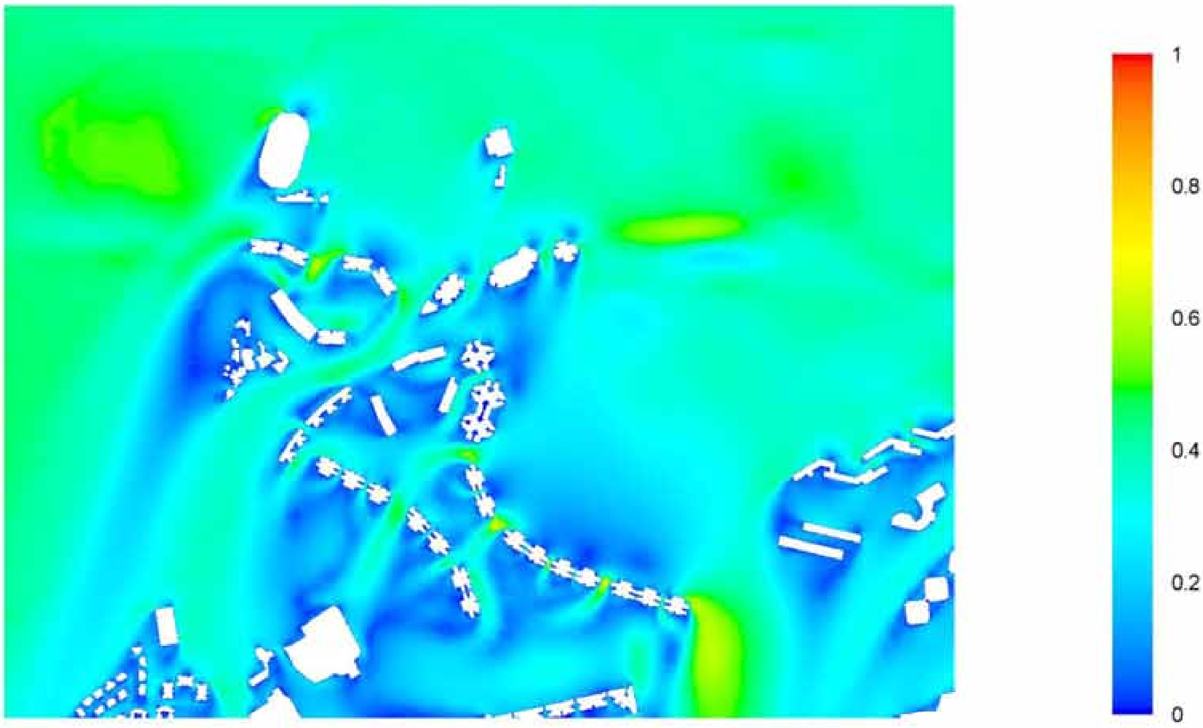


NE at 2mAG (Proposed Scheme)

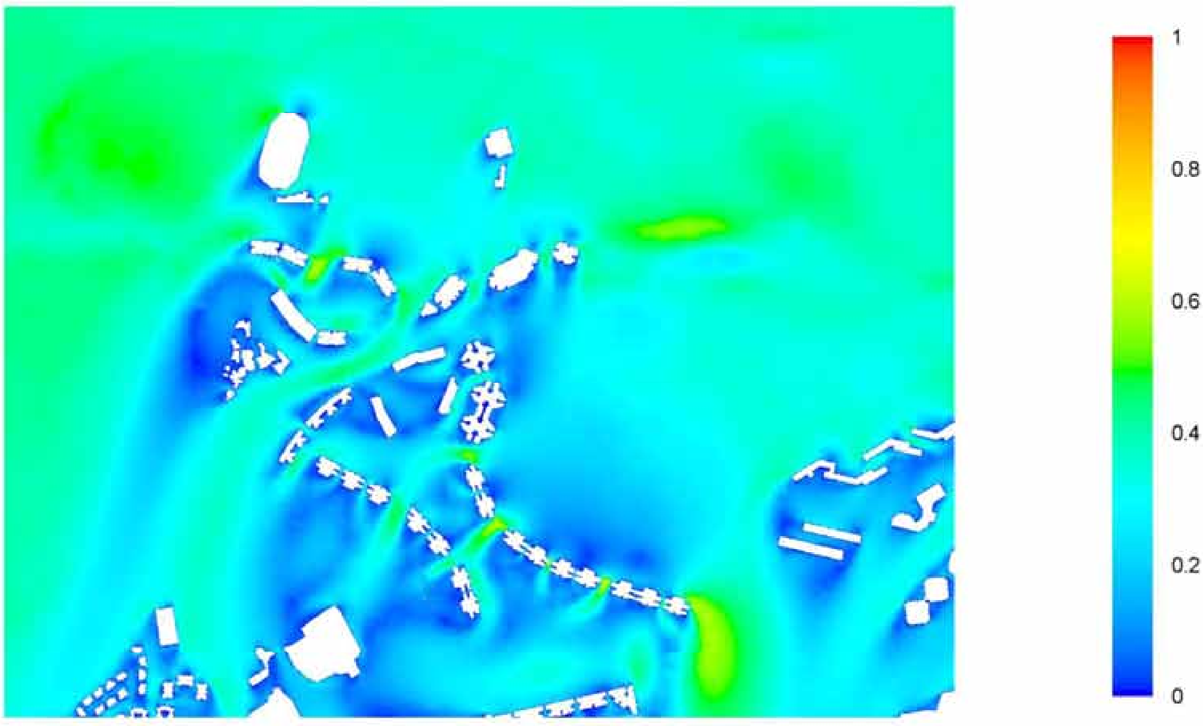


Appendix D – Wind Velocity Ratio Contour Plots

NNE at 2mAG (Base scheme)

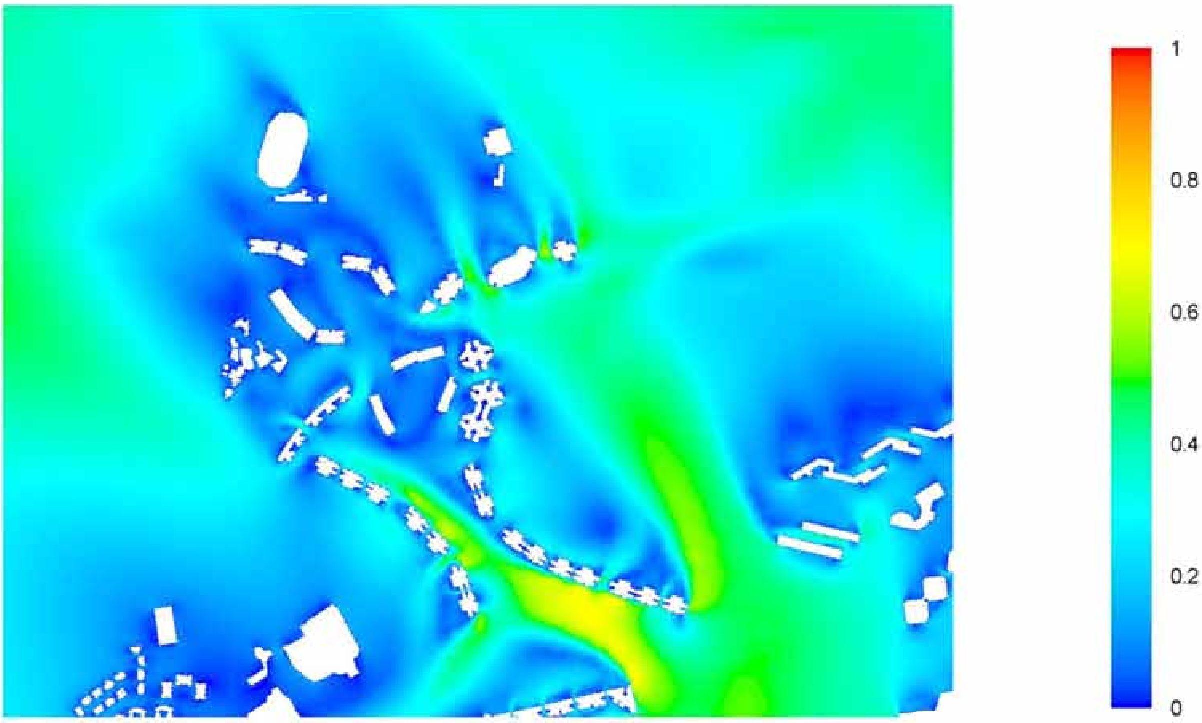


NNE at 2mAG (Proposed Scheme)

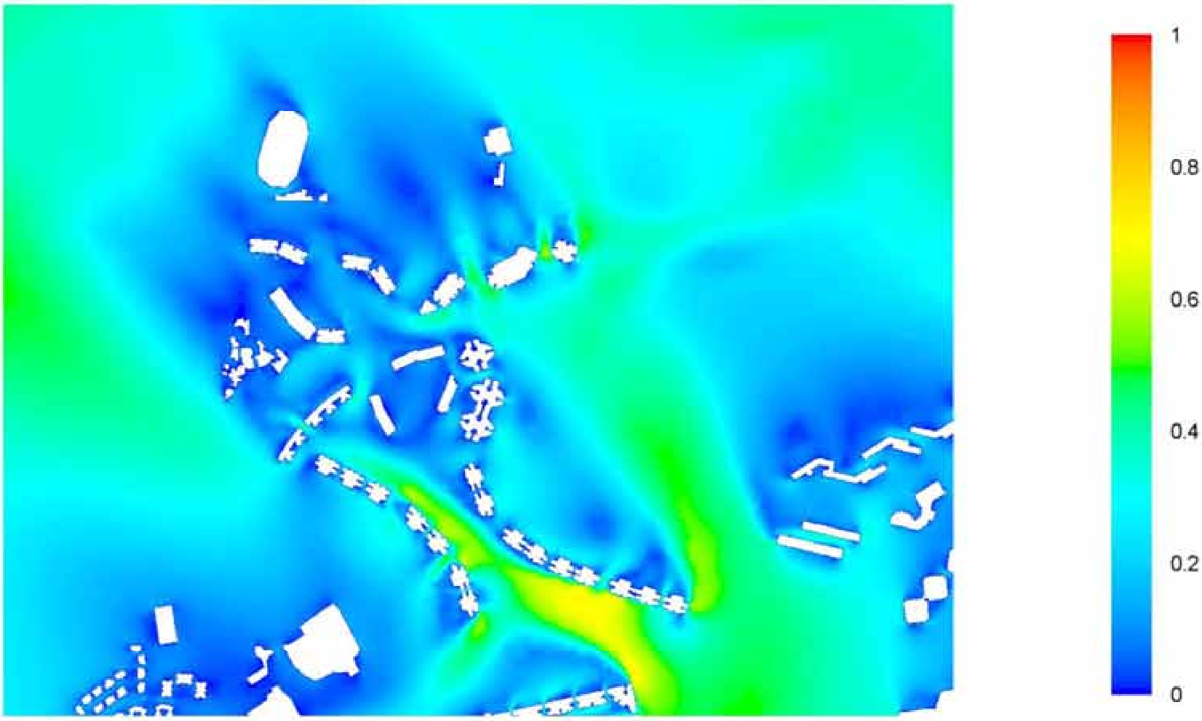


Appendix D – Wind Velocity Ratio Contour Plots

SE at 2mAG (Base scheme)

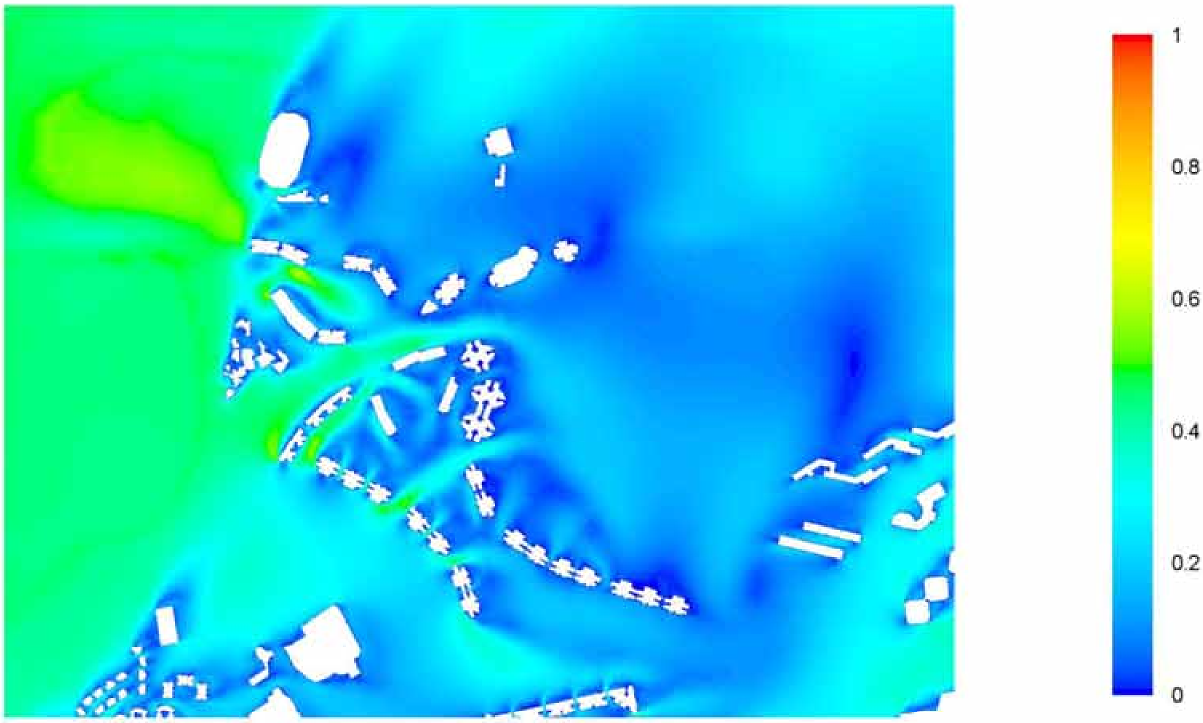


SE at 2mAG (Proposed Scheme)

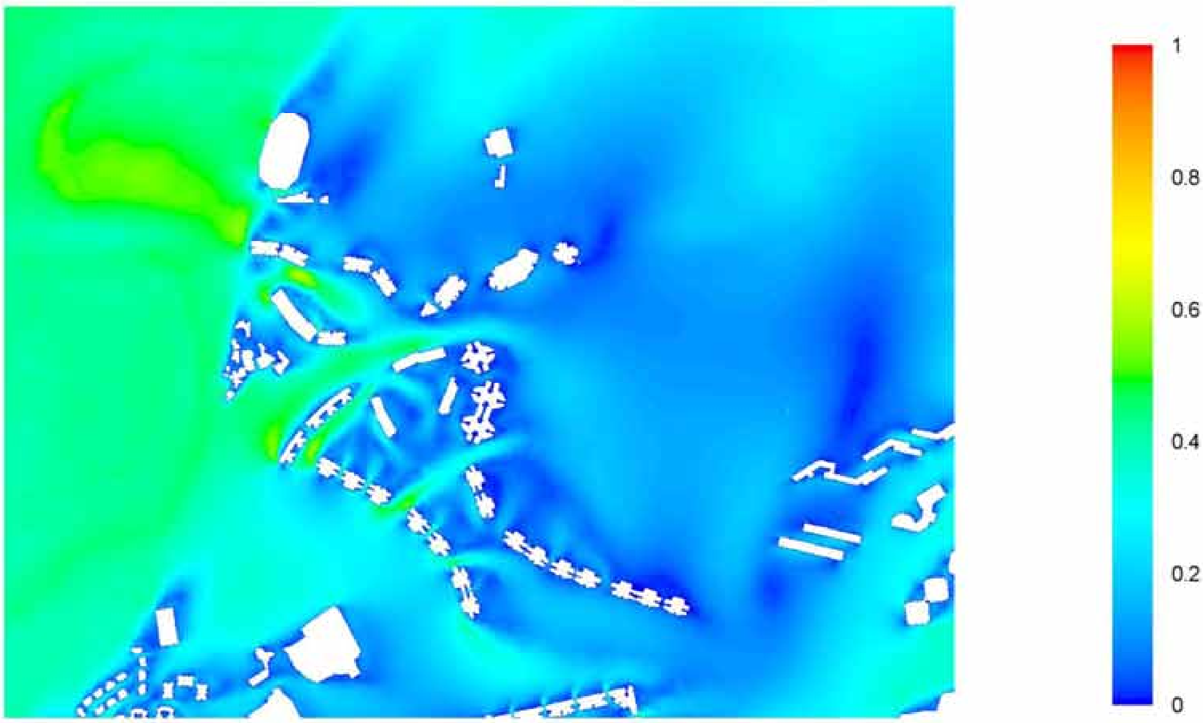


Appendix D – Wind Velocity Ratio Contour Plots

SSW at 2mAG (Base scheme)

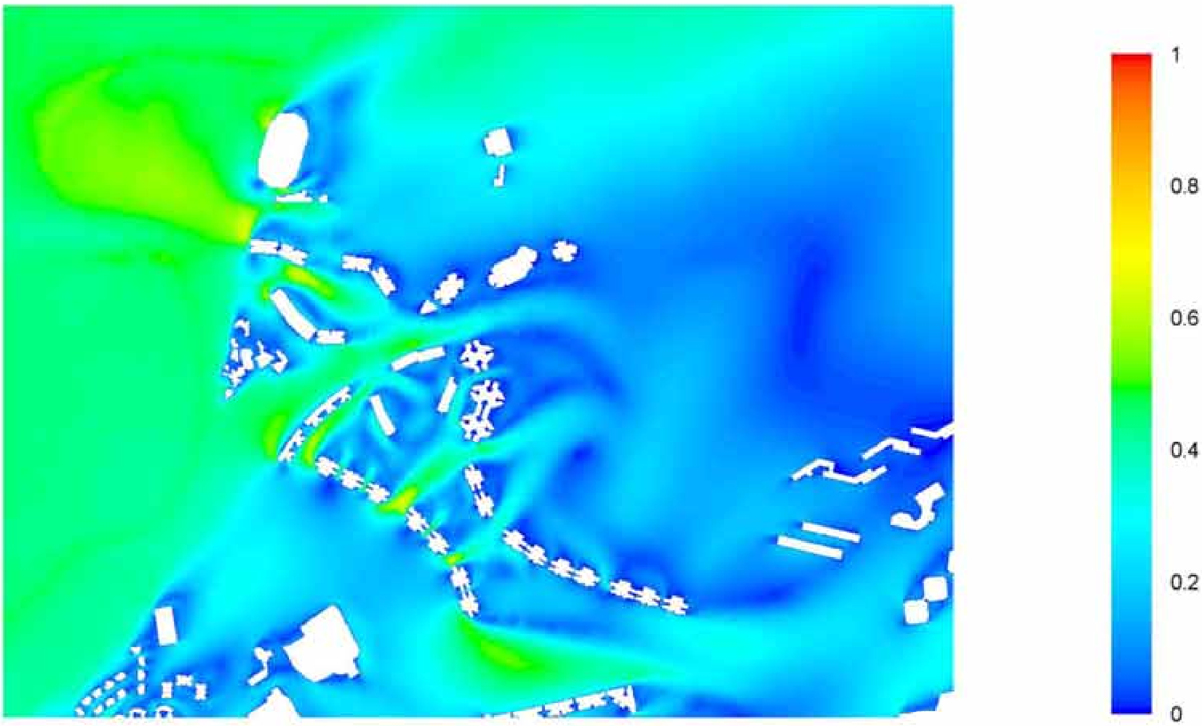


SSW at 2mAG (Proposed Scheme)

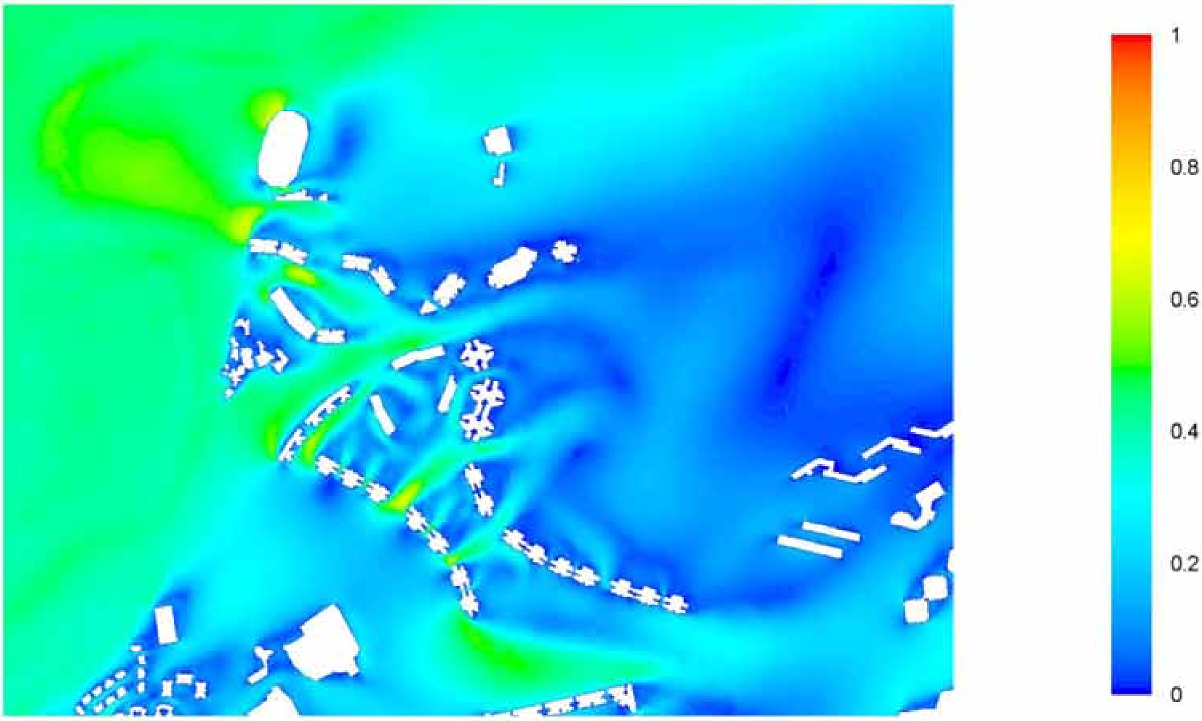


Appendix D – Wind Velocity Ratio Contour Plots

SW at 2mAG (Base scheme)



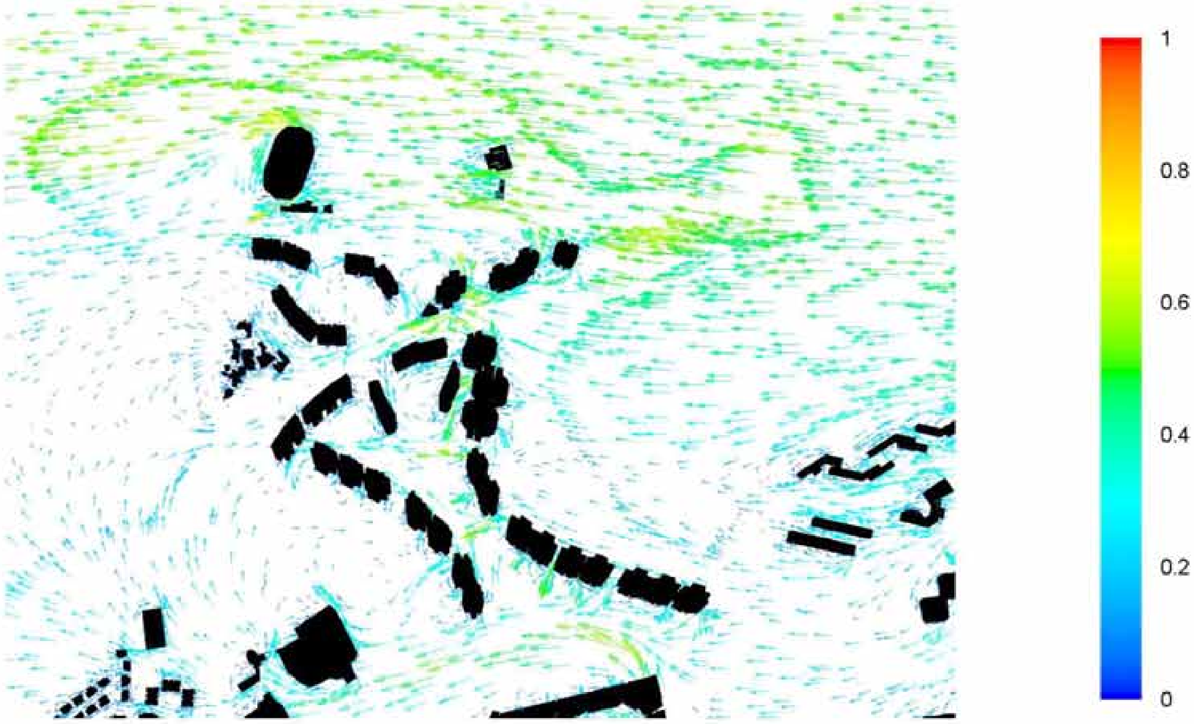
SW at 2mAG (Proposed Scheme)



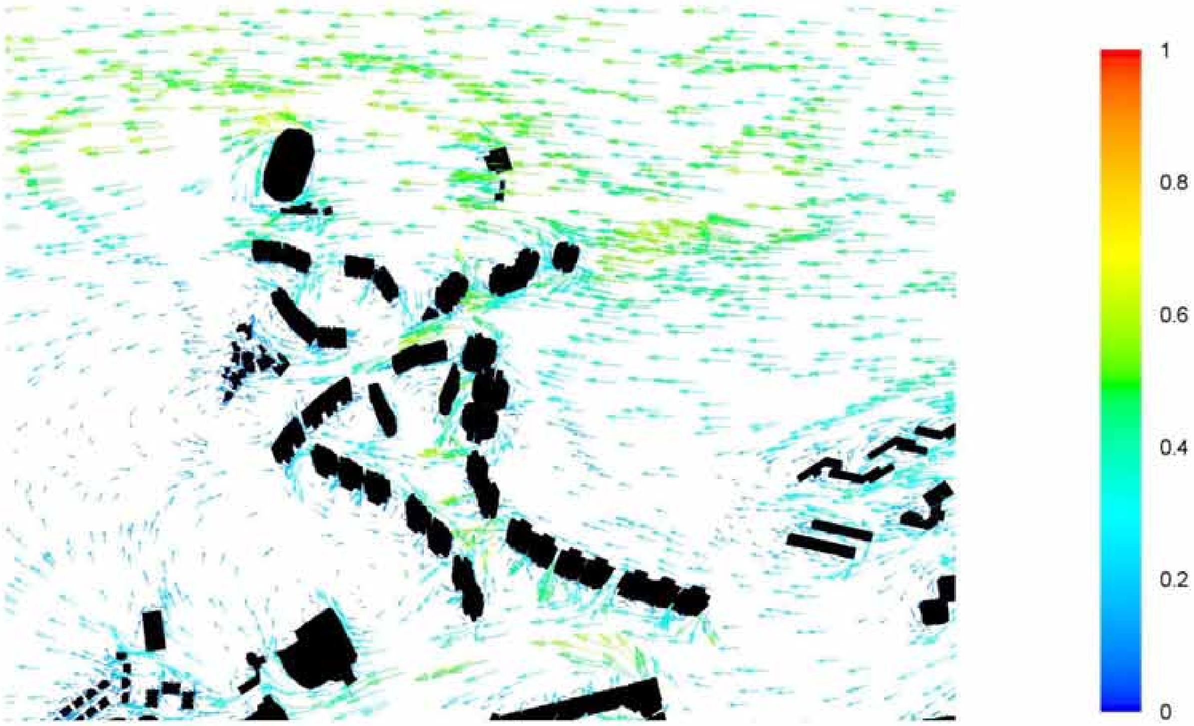
Appendix E

Appendix E – Wind Velocity Ratio Vector Plots

E at 2mAG (base scheme)

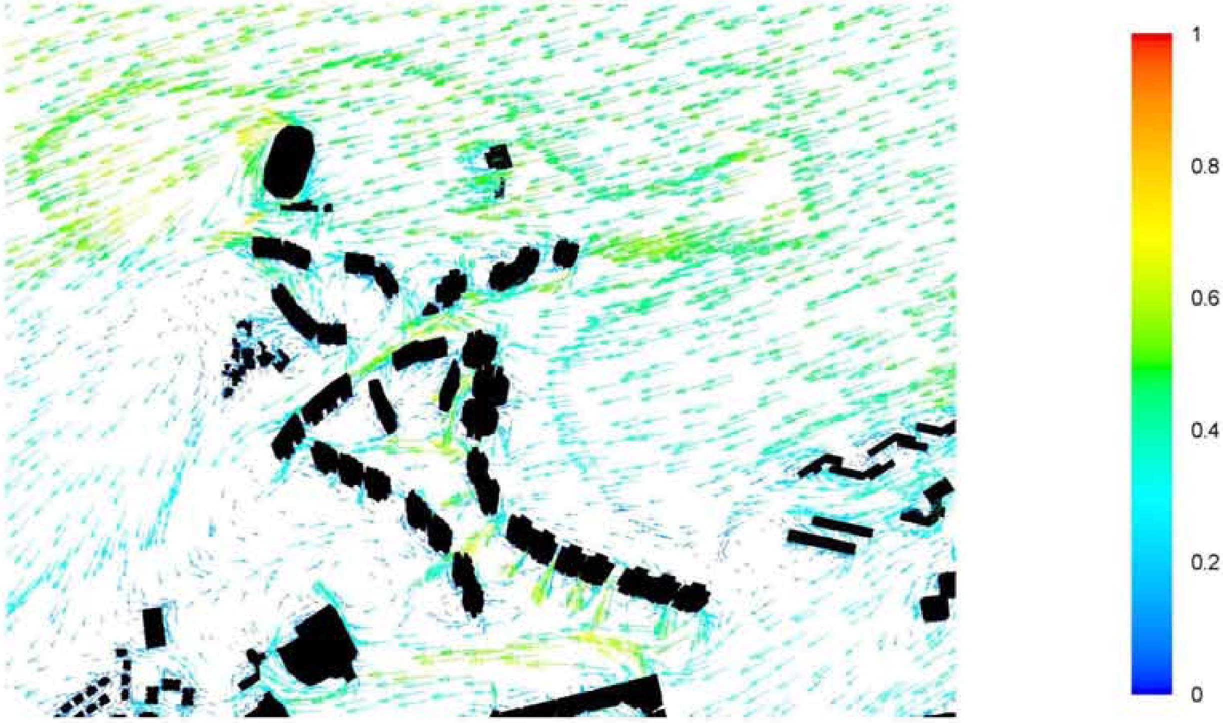


E at 2mAG (Proposed Scheme)

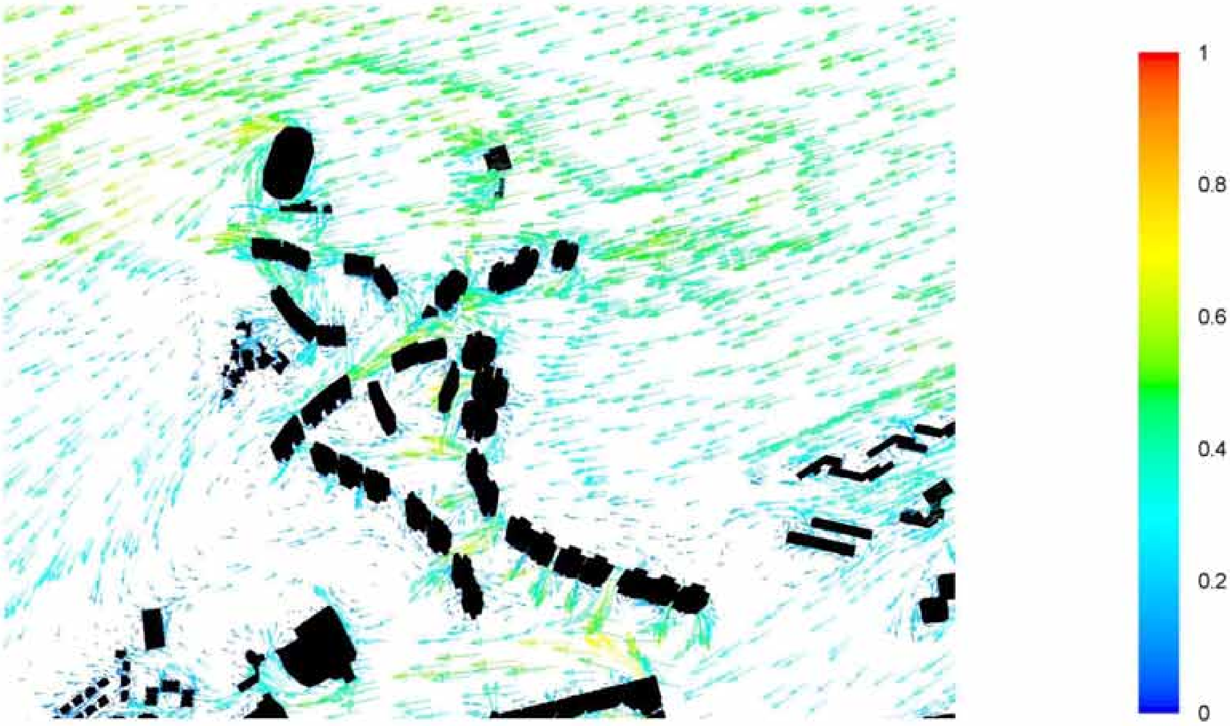


Appendix E – Wind Velocity Ratio Vector Plots

ENE at 2mAG (Base scheme)

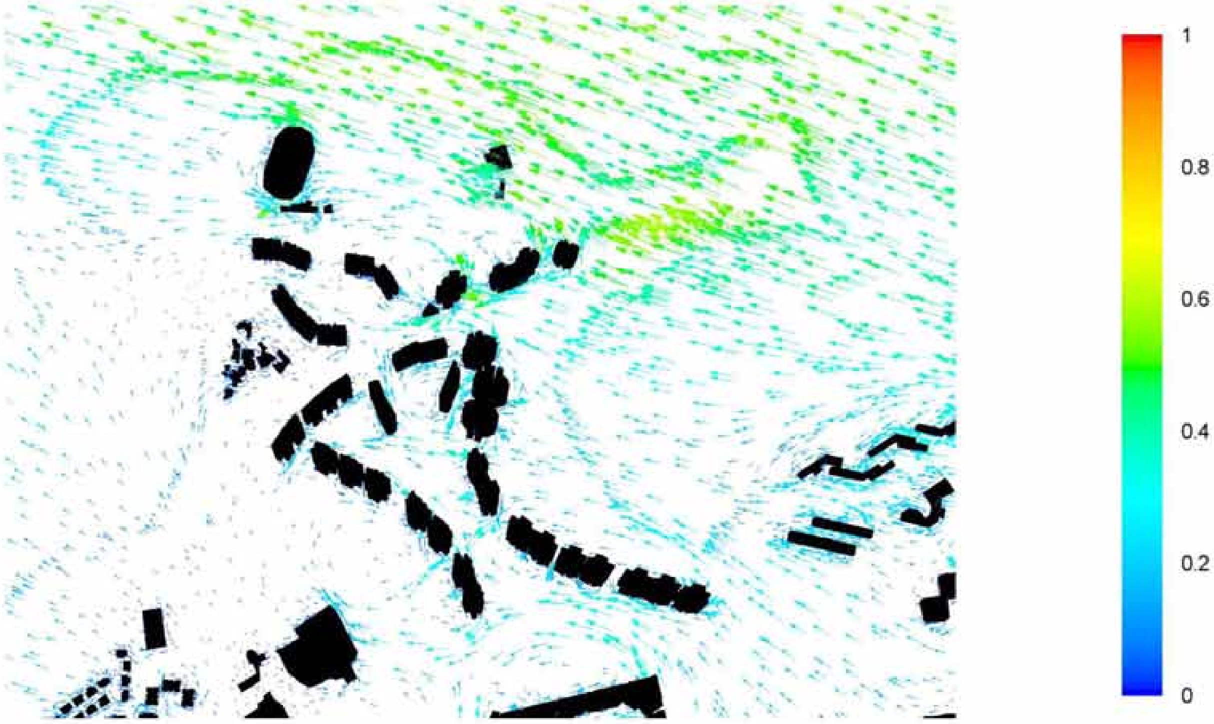


ENE at 2mAG (Proposed Scheme)

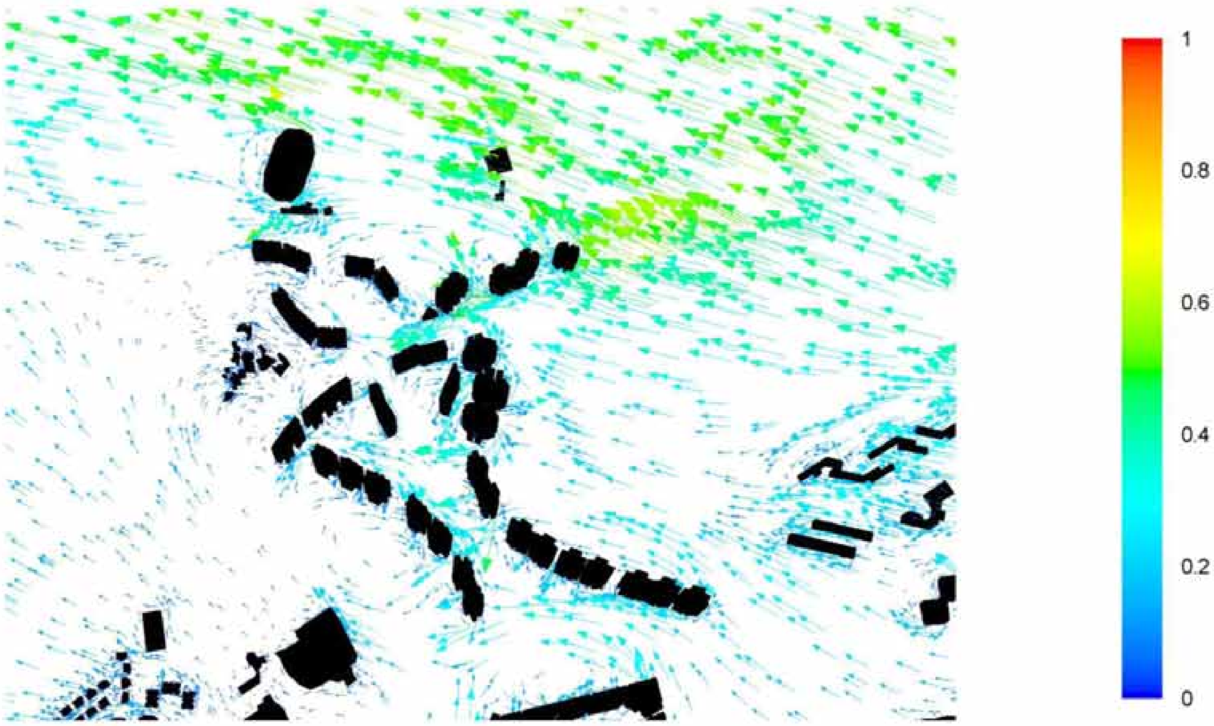


Appendix E – Wind Velocity Ratio Vector Plots

ESE at 2mAG (Base scheme)

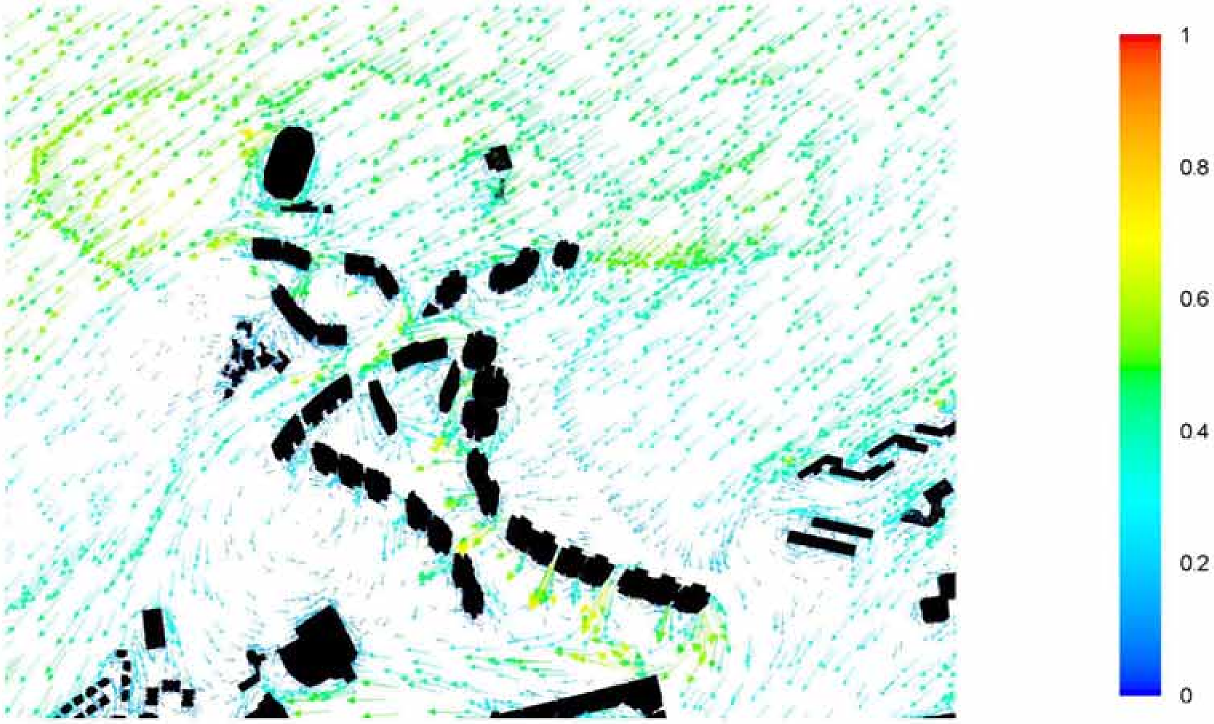


ESE at 2mAG (Proposed Scheme)

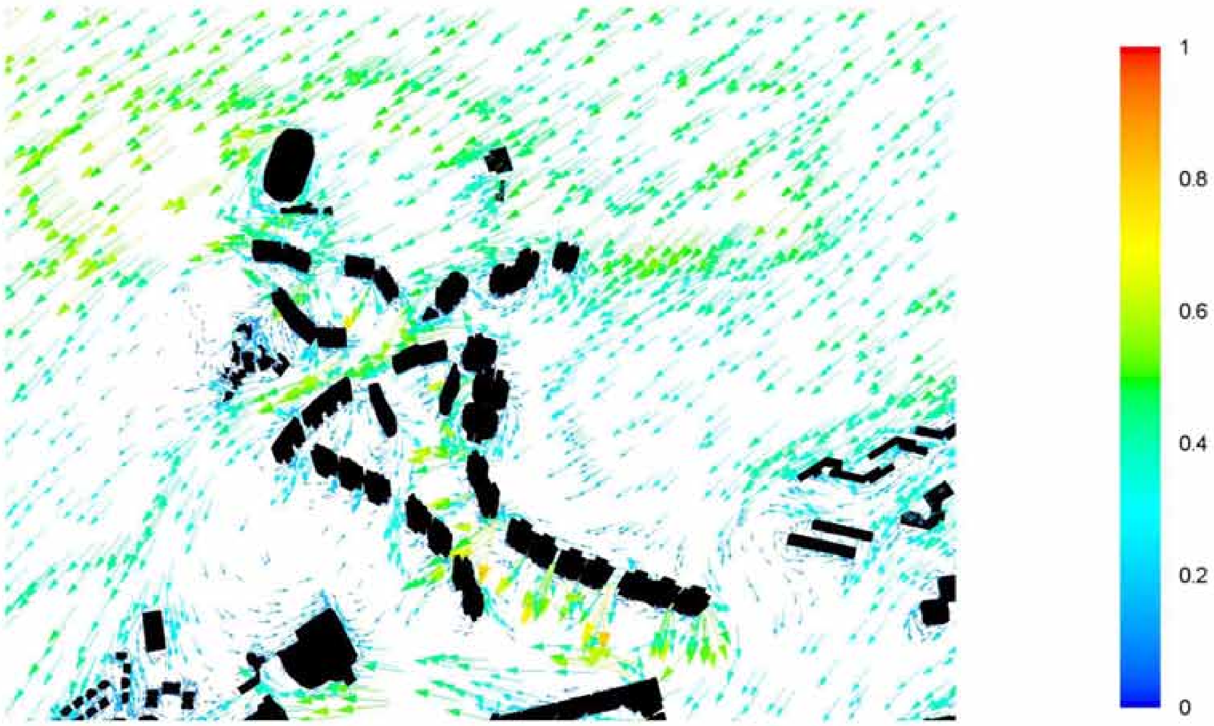


Appendix E – Wind Velocity Ratio Vector Plots

NE at 2mAG (Base scheme)

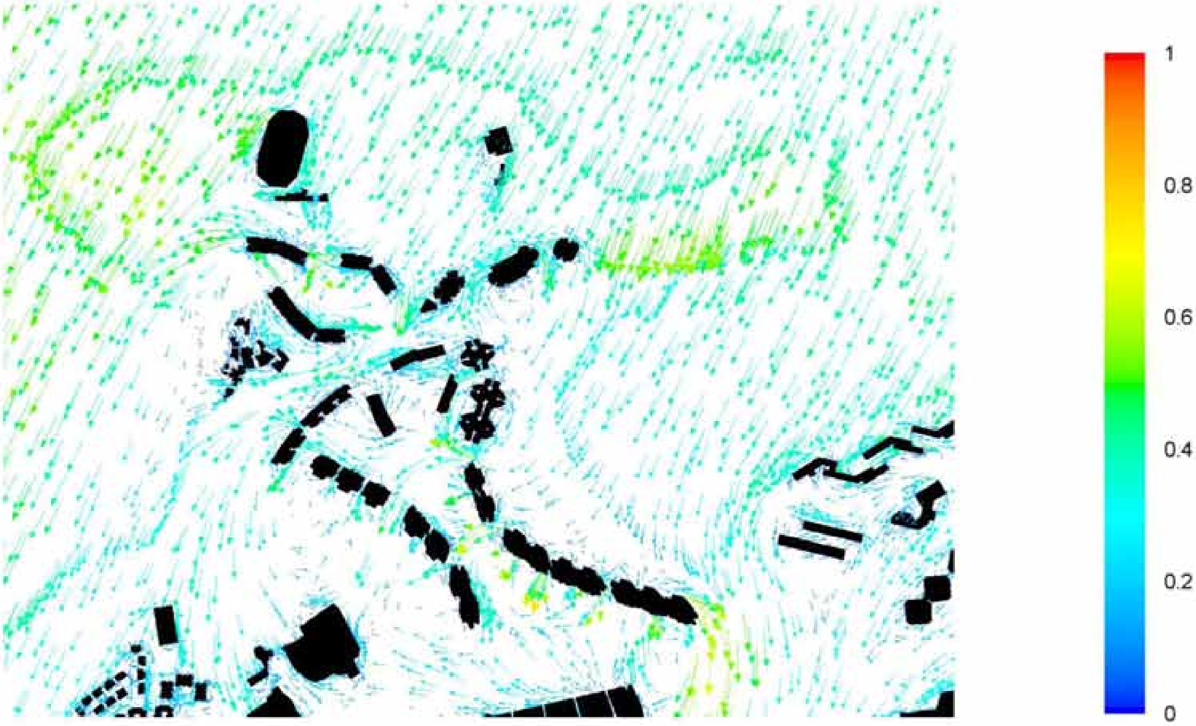


NE at 2mAG (Proposed Scheme)

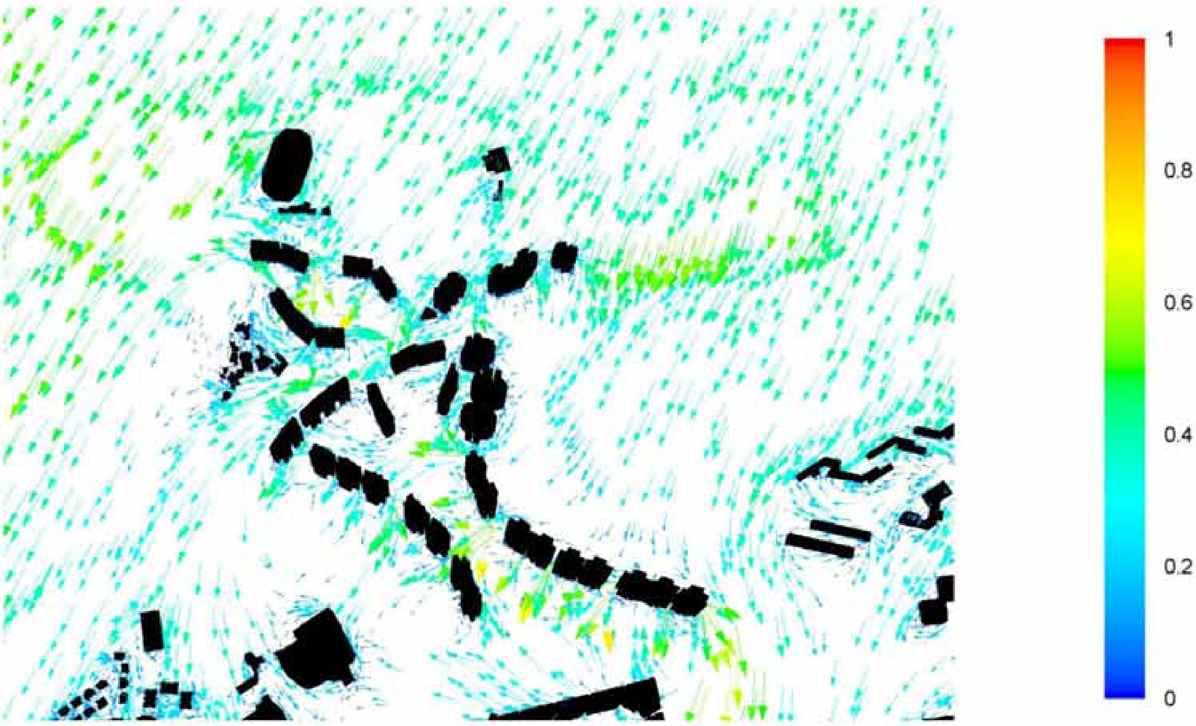


Appendix E – Wind Velocity Ratio Vector Plots

NNE at 2mAG (Base scheme)

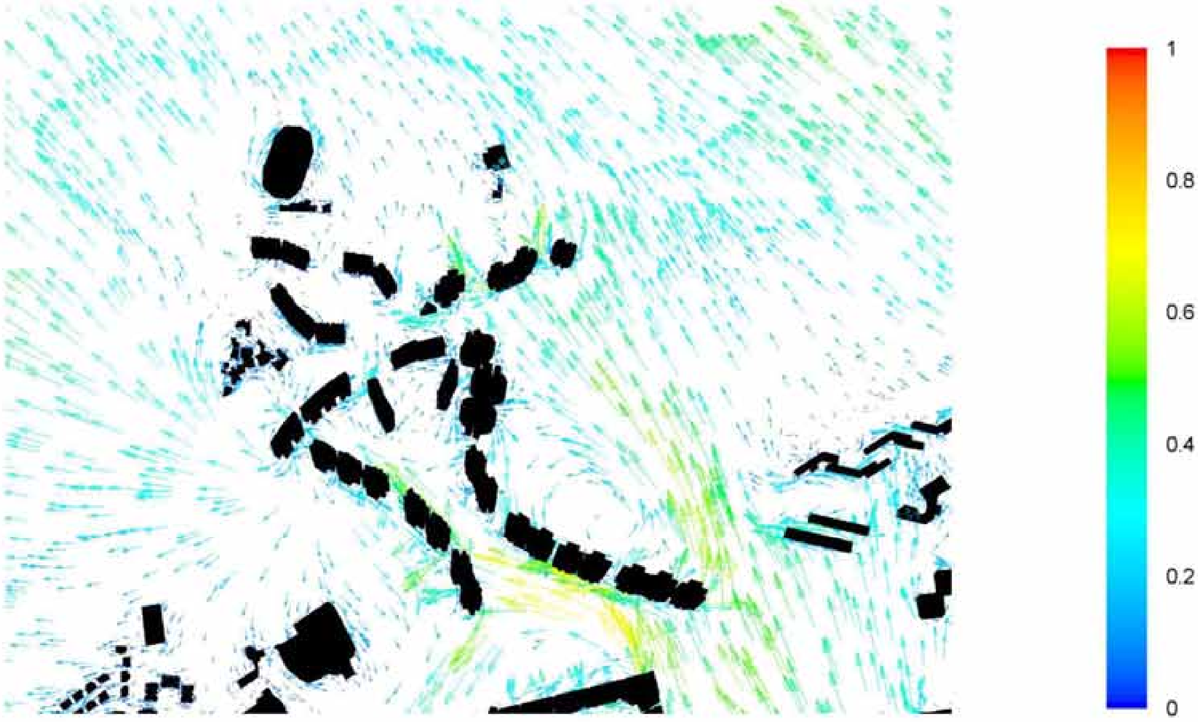


NNE at 2mAG (Proposed Scheme)

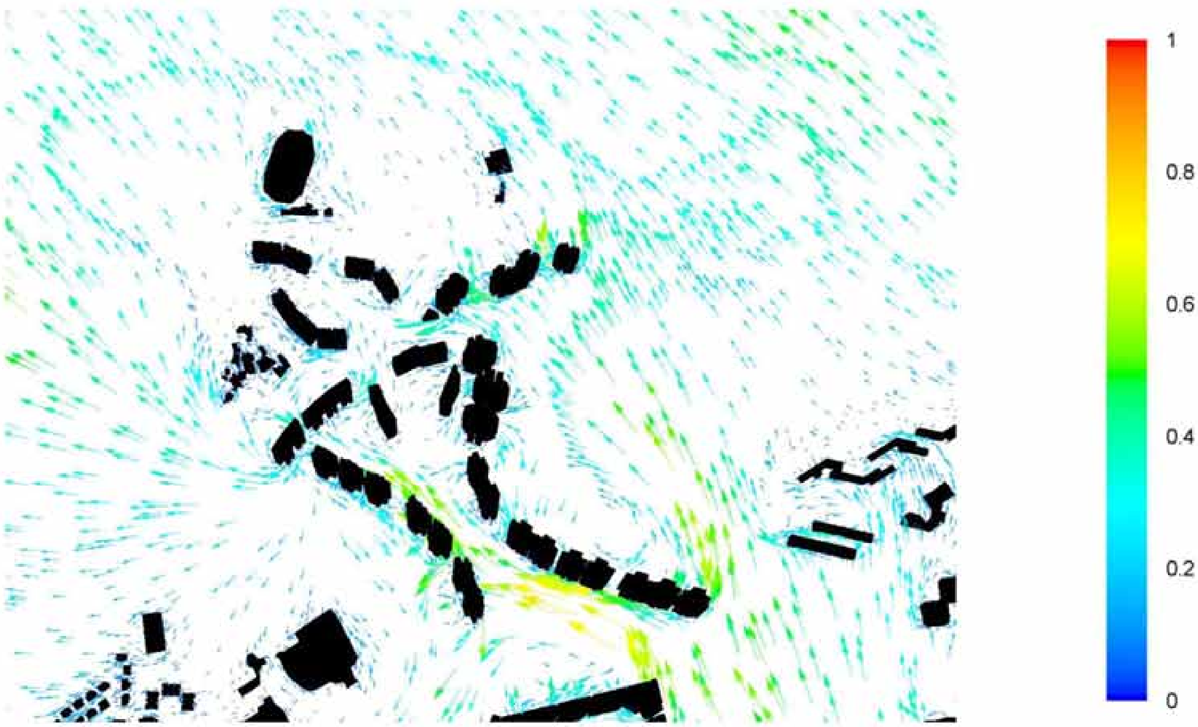


Appendix E – Wind Velocity Ratio Vector Plots

SE at 2mAG (Base scheme)

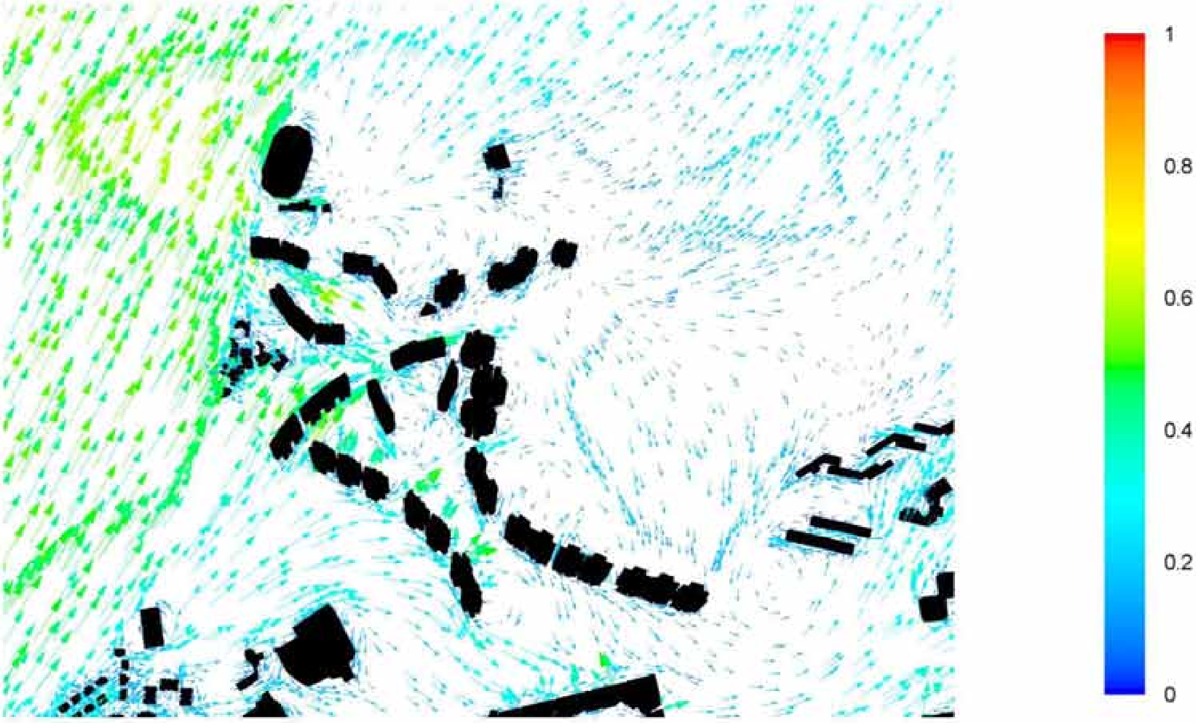


SE at 2mAG (Proposed Scheme)

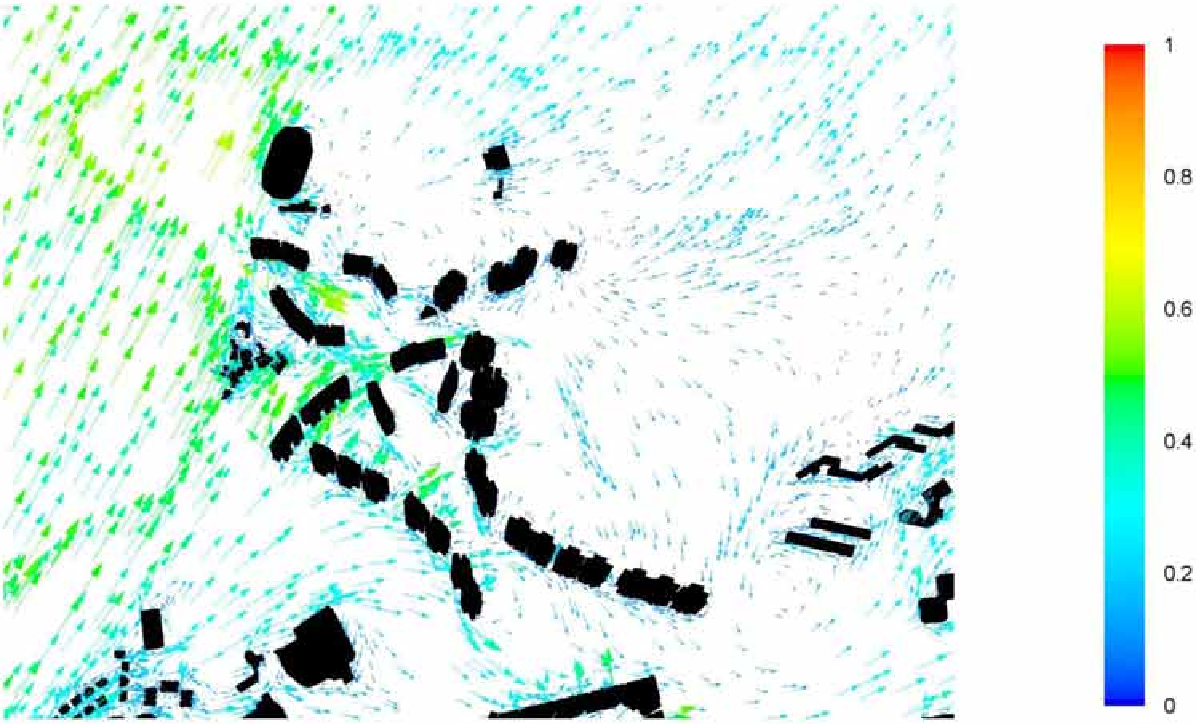


Appendix E – Wind Velocity Ratio Vector Plots

SSW at 2mAG (Base scheme)

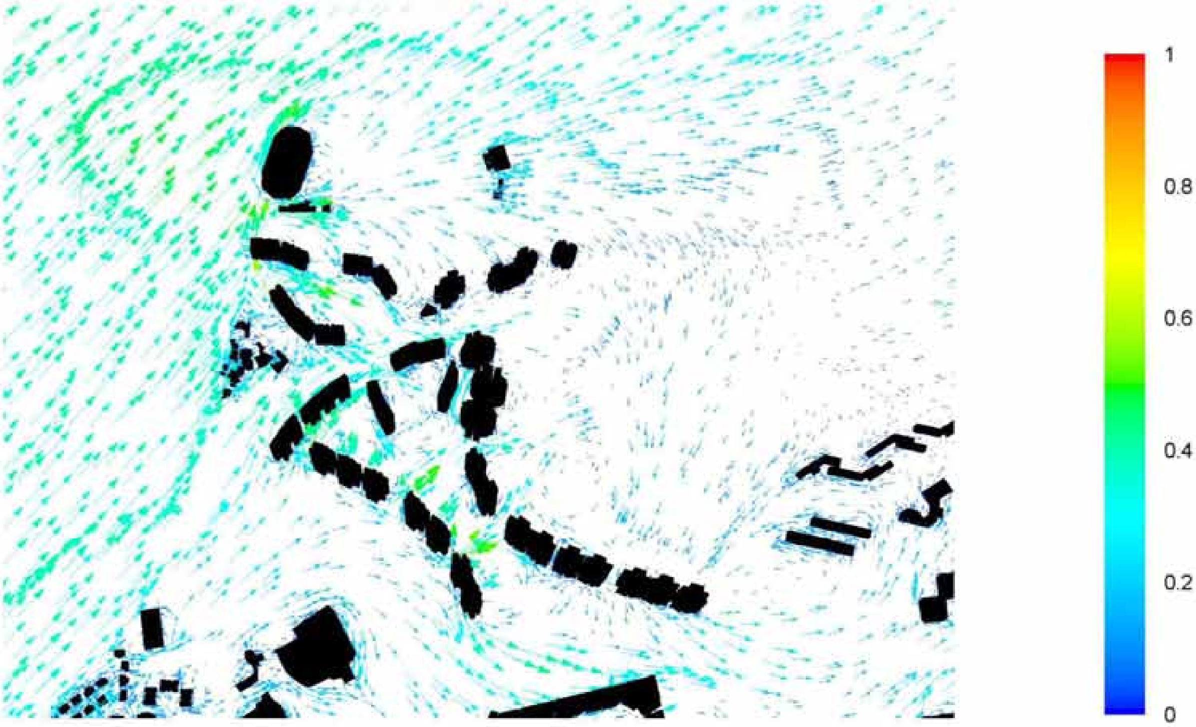


SSW at 2mAG (Proposed Scheme)



Appendix E – Wind Velocity Ratio Vector Plots

SW at 2mAG (Base scheme)



SW at 2mAG (Proposed Scheme)