ISSUE NO. : 1
ISSUE DATE : OCTOBER 2015
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AIR VENTILATION ASSESSMENT INITIAL STUDY

FOR

PROPOSED PUBLIC RENTAL HOUSING DEVELOPMENT AT TUNG CHUNG AREA 39, LANTAU ISLAND

COMMERCIAL-IN-CONFIDENCE

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1. INTRODUCTION

Allied Environmental Consultants Limited (AEC) has been commissioned by the Hong Kong Housing Authority to conduct an Air Ventilation Assessment (AVA) Initial Study for the Proposed Public Rental Housing Development at Tung Chung Area 39, Lantau Island. The AVA Initial Study aims to assess air ventilation performance of the building design and its impacts to the surrounding development accessible by pedestrians. Computational Fluid Dynamics (CFD) simulation is employed as the assessment tool for quantitative ventilation performance evaluation in the study.

2. OBJECTIVE OF THE STUDY

In accordance with Technical Circular No.1/06 "Air Ventilation Assessments" jointly issued by Housing, Planning and Lands Bureau and Environment, Transport and Works Bureau, proponent departments, bureaux or authorities should assess the need to apply Air Ventilation Assessment (AVA) to some categories of major government Project during the planning stage. The Proposed Public Rental Housing Development at Tung Chung Area 39, Lantau Island falls under the categories of "Developments on sites of over 2 hectares and with an overall plot ratio of 5 or above" and "Development proposals with total Gross Floor Area exceeding 100,000square metres".

The objective of this AVA Initial Study is to quantitatively evaluate the likely impact of the proposed public housing development on the pedestrian wind environment within the study area. Computational Fluid Dynamics (CFD) simulation is employed as the assessment tool in this AVA Initial Study:

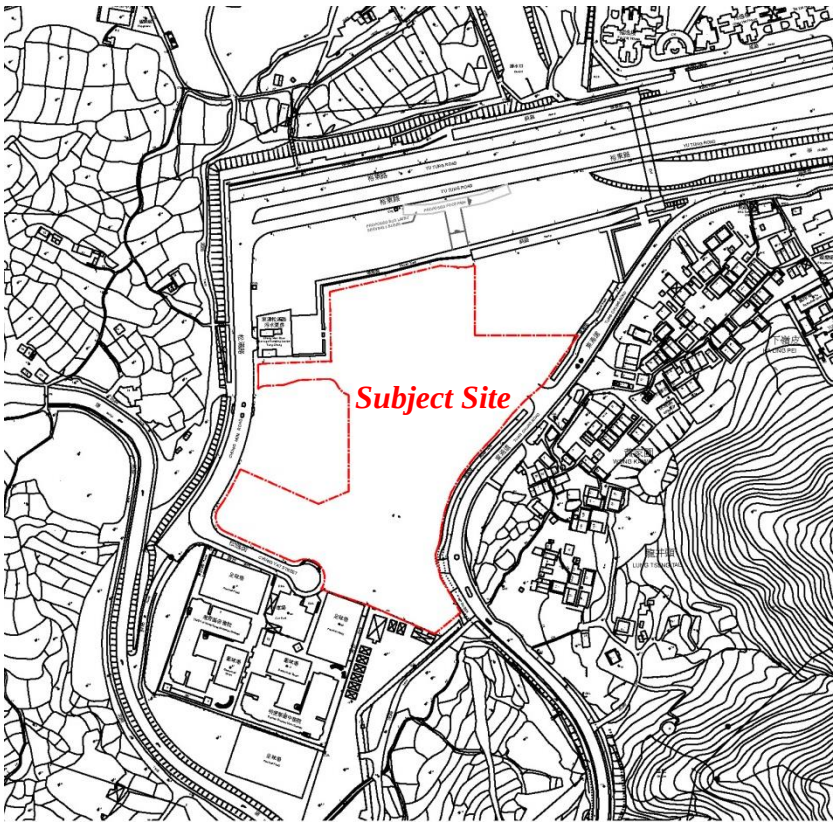
- To assess the characteristics of the wind availability ($V\infty$) of the site;
- To give a general pattern and quantitative estimate of wind performance at the pedestrian level reported using Wind Velocity Ratio (VR); and
- To further refine the wind-responsive design features and problem areas of the Expert Evaluation.

3. EXPERT EVALUATION

3.1. SUBJECT SITE

The Proposed Development is located in the western part of the Tung Chung New Town. The subject site (***Plate 1***) is bounded by Tung Chung Road to the east, Yue Tung Road to the north, Chung Mun Road to the west and Chung Yat Street to the south. The Proposed Development will consist of 4 domestic blocks and a low-rise Retail cum Welfare Block. The domestic blocks are aligned with the prevailing easterly wind direction to increase wind penetration.

Plate 1 Location of the Subject Site



3.2. SITE ENVIRONS

As shown in ***Plate 2*** below, the subject site is situated in an area with mountainous topography. Elevation increases gradually towards Lantau North (Extension) Country Park and Countryside Conservation Areas. The built-up area in the vicinity of the site comprises mainly clustered low-rise village houses with elevation ranging from 3 to 18mPD.

Plate 2 Areas Surrounding the Proposed Development (Ground Elevation)

The characteristics of the surrounding area are summarized as follows:

- Yu Tung Road separates Yat Tung Estate, a high-rise public housing development located at the mouth of Tung Chung Bay, from the subject site.
- Immediate to the south of the subject site lie YMCA of Hong Kong Christian College and Caritas Charles Vath College. Clustered villages of Shek Lau Po sit further to the southwest of the subject site.
- Planned developments within the assessment area include a proposed school and a proposed IRC site. The proposed school (+29.0mPD) which will be bounded by the subject site and the proposed IRC site (+24.0mPD) will be sited at the northeast corner of the Proposed Development.
- Further to the east of Tung Chung Road lie the village houses of Lung Tseng Tau, Wong Ka Wai, Ha Ling Pei and Sheung Ling Pei which are all built on similar elevation as the Proposed Development. Some low-rise village houses also spread across Shek Lau Po which is located to the southwest of the subject site.

3.3. SITE WIND ENVIRONMENT

With regards to the wind data from *Experimental Site Wind Availability Study for the Proposed Public Rental Housing Development at Tung Chung Area 39, Lantau Island*, prevailing winds for the site mainly come from northeast and east in non-summer whereas in summer, the south-westerly wind dominates.

Localized sea breezes from Tung Chung Bay during daytime may improve the wind environment at pedestrian level of the subject site and surrounding built-up areas.

Wind flow pattern at the subject site is expected to be substantially influenced by the local topography. Wind approaching the subject site from the east is expected to be shielded by the significant topographies of Pok To Yan, Lin Fa Shan, Yi Tung Shan, Tai Tung Shan, Nei Lak Shan and Fung Wong Shan along of Lantau Island. Eddies and re-circulations are expected at pedestrian areas leeward of the terrains.

On the local scale, Yu Tung Road lies parallel to Tung Chung Road to act as a localized ventilation corridor in the district. As the surrounding built-up areas to the east of the subject site are relatively low-rise in nature, the existing ventilation corridor is expected to extend from Tung Chung Road and Yue Tung Road to the foothills of Lantau North (Extension) Country Park and Countryside Conservation Areas, where the clustered village houses of Wong Ka Wai, Lung Tseng Tau, Ha Ling Pei and Sheung Ling Pei are located. Localized ventilation is expected to rely on this established system of road network and semi-opened space. Surrounding built-up areas such as the high-rise Tung Chung New Town located to the northeast of the subject site may also impede wind penetration from the northeast quadrant.

4. ASSESSMENT APPROACH & METHODOLOGY

4.1. GENERAL

This AVA Initial Study has adopted the Air Ventilation Assessment (AVA) methodology for Initial Study given in the *Technical Guide, "Technical Guide for Air Ventilation Assessment for Developments in Hong Kong"* published by Housing, Planning and Lands Bureau and Environment, Transport and Works Bureau in 2006.

4.2. SITE WIND AVAILABILITY

Wind availability of the site is essential information to the investigation of the effects of the Proposed Development on the surrounding pedestrian wind environment. In the *AVA Technical Guide*, it is recommended that wind data from nearby weather station(s), simulated wind data or experimental site wind data should be referenced. The study has made reference to the wind data from wind tunnel test for Tung Chung Area 39 conducted by the CLP Power Wind/Wave Tunnel Facility (WWTF) at the Hong Kong Science and Technology (HKUST).

4.3. WIND DATA FROM WIND TUNNEL TEST

A wind tunnel study was conducted with a 1:2000 scale topographical model that comprises the Outlying Islands, the New Territories, Kowloon and Hong Kong Island. Surrounding areas within a distance of up to approximately 10km from the subject site were used to model site wind availability. The wind tunnel testing techniques used are in accordance with the procedures and recommendations of the Australasian Wind Engineering Society Quality Assurance Manual, AWES QAM-1-2001 and the American Society of Civil Engineers Manual and Report on Engineering Practice No. 67 for Wind Tunnel Studies of Building and Structures. Wind data measured by Hong Kong Observatory (HKO) at Waglan Island during the period of 1953 to 2006 ware corrected for position and topographical effects to determine the probability distribution of directional mean wind speeds. Characteristics of atmospheric boundary layer flow were simulated using WWTF's boundary layer wind tunnel test sections. Mean wind speed and turbulence intensity profiles were measured at 9 different height levels with the aid of miniature dynamic pressure probes. ***Plate 3*** and ***Table 1*** below show the results of the 1:2000 scale topography study for Tung Chung Area 39. The experimental site wind data for the 8 most probable wind directions are used in this AVA Initial Study.

Plate 3 Wind Rose for Annual Non-Typhoon Winds at 500mPD

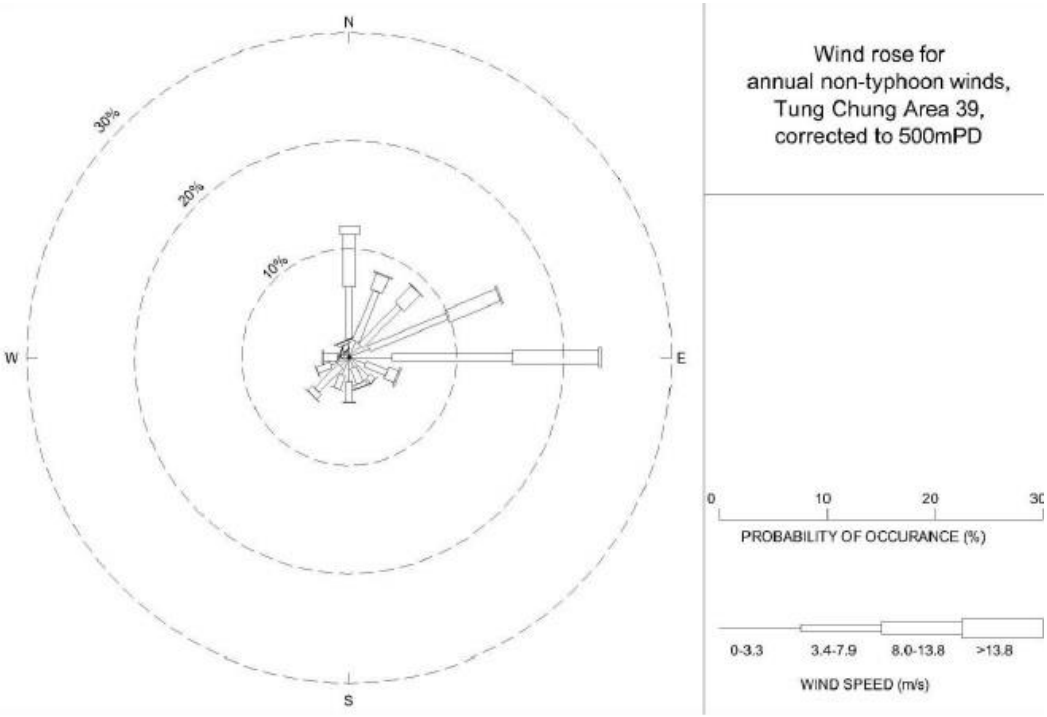


Table 1 Percentage Occurrence for Annual, Non-typhoon Directional Winds at 500mPD

Wind Angle (°)	Wind Direction	Wind Speed at 500mPD (m/s)	Percentage Occurrence
0.0 or 360.0	**N**	**8.66**	**12.1%**
22.5	**NNE**	**6.86**	**8.3%**
45.0	**NE**	**6.90**	**8.8%**
67.5	**ENE**	**6.66**	**15.1%**
90.0	**E**	**7.50**	**23.4%**
112.5	**ESE**	**6.83**	**4.9%**
135.0	SE	2.59	3.1%
157.5	SSE	5.37	3.0%
180.0	**S**	**3.84**	**4.3%**
202.5	SSW	3.46	3.1%
225.0	**SW**	**5.78**	**4.9%**
247.5	WSW	3.44	3.2%
270.0	W	4.32	2.5%
292.5	WNW	4.99	1.0%
315.0	NW	3.48	0.6%
337.5	NNW	4.46	1.5%

5. ASSESSMENT METHODOLOGY AND CRITERIA

5.1. GENERAL

The AVA Initial Study employed a computational fluid dynamics (CFD) computer simulation model, *ANSYS FLUENT*, for the assessment. *FLUENT* has been widely applied for numerous AVA research and studies worldwide. It provides complete mesh flexibility, solving flow problems with different types of unstructured meshes. Such unstructured grid technology allows grid consisting of elements in variety of shapes such as hexahedra, tetrahedral, prisms and pyramids for 3D simulation. Sophisticated numeric and a robust solver ensure accurate results.

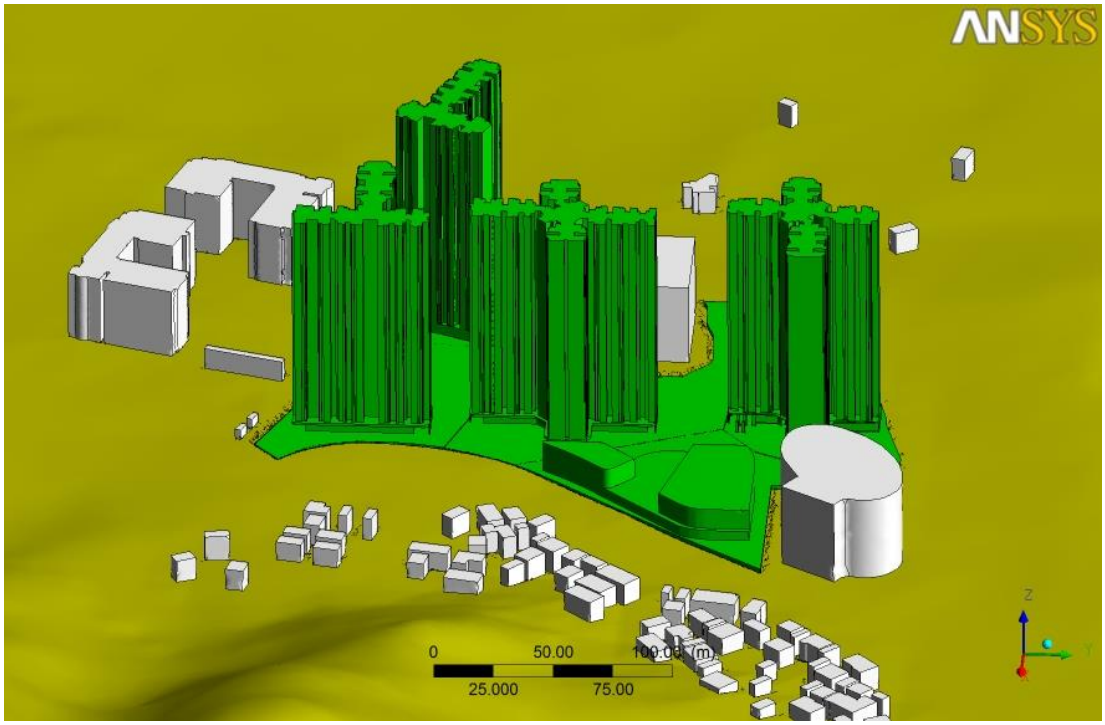
5.2. INITIAL AND IMPROVED LAYOUTS

Two schemes are investigated in the AVA Initial Study, namely the Initial Scheme and the Proposed Scheme. The layout plans of the Initial and Proposed Schemes are shown in ***Figure 1*** and ***Figure 2*** respectively.

5.2.1. Initial Layout

The Initial Layout modelled in the Initial Scheme comprises 4 residential blocks of similar height profile ranging from 108.1 to 109.3mPD. Block 1 and Block 2 are longitudinally-shaped while Block 3 and Block 4 are T-shaped and L-shaped respectively. The building orientation in the initial scheme has taken into account of the 100m-wide breezeway immediate to the east of the subject site. ***Plate 4*** shows the geometry setting of the Initial Scheme.

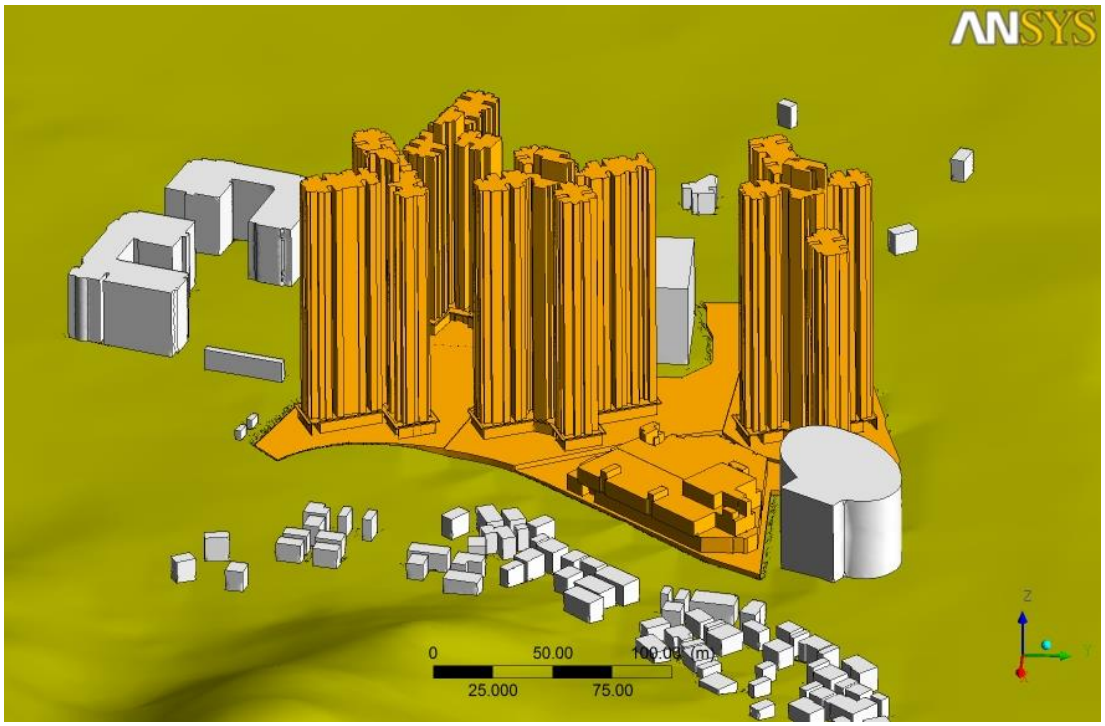
Plate 4 Geometry Setting of Initial Scheme



5.2.2. Proposed Layout

The Proposed Layout modelled in the Proposed Scheme comprises 4 residential buildings of varying height profile (28 to 40 storeys) ranging from 83.2 to 116mPD. Block 1 (+99.7mPD at low zone and +116.2mPD at high zone) and Block 2 (+116.2mPD) are longitudinally shaped while Block 3 (+113.4mPD) and Block 4 (+83.2mPD) are T-shaped. The Proposed Scheme is viewed as a better option than the Initial Scheme in terms of air ventilation performance. Residential blocks are properly aligned to facilitate flow of easterly wind. Ground floor openings are also rearranged to further enhance wind penetration across the proposed development. ***Plate 5*** shows the geometry setting of the Proposed Scheme.

Plate 5 Geometry Setting of Proposed Scheme



5.3. MODELLING TOOL AND ASSUMPTIONS

5.3.1. Domain Size & Grid Setting

In the AVA Initial Study, three-dimensional models of the site and the surrounding built environment are constructed to simulate the wind performance of the design options. Related wind speeds around the development are assessed by setting up a geometry model of the development with surrounding building structures.

It is recommended in the *Technical Guide* that the Assessment Area and Surrounding Area of the Project should include the Project's surrounding of up to a perpendicular distance *H* and 2*H* respectively from the Project boundary, while *H* being the height of the tallest building of the Proposed Development (H is assumed to be 125.9m and 116.5m in the Initial Layout and Proposed Layout respectively). However, the Assessment Area has been enlarged in the Initial Study to capture more realistic wind performance as prominent topographical features exist to the south of the site. An Assessment Area with a perpendicular distance of 500m from the Project Boundary has been adopted in the AVA Initial Study. It is calculated that the blockage ratio of the model approximates 4.0%

Top view and side view of the representation of the computational domain are shown in ***Plate 6*** and ***Plate 7*** respectively. The size of the computational domain of the 3D model is illustrated below:

x-direction (L) = 3,960m;

y-direction (W) = 3,960m; and

z-direction (H) = 1,365m

Plate 6 Top View of Domain Dimension

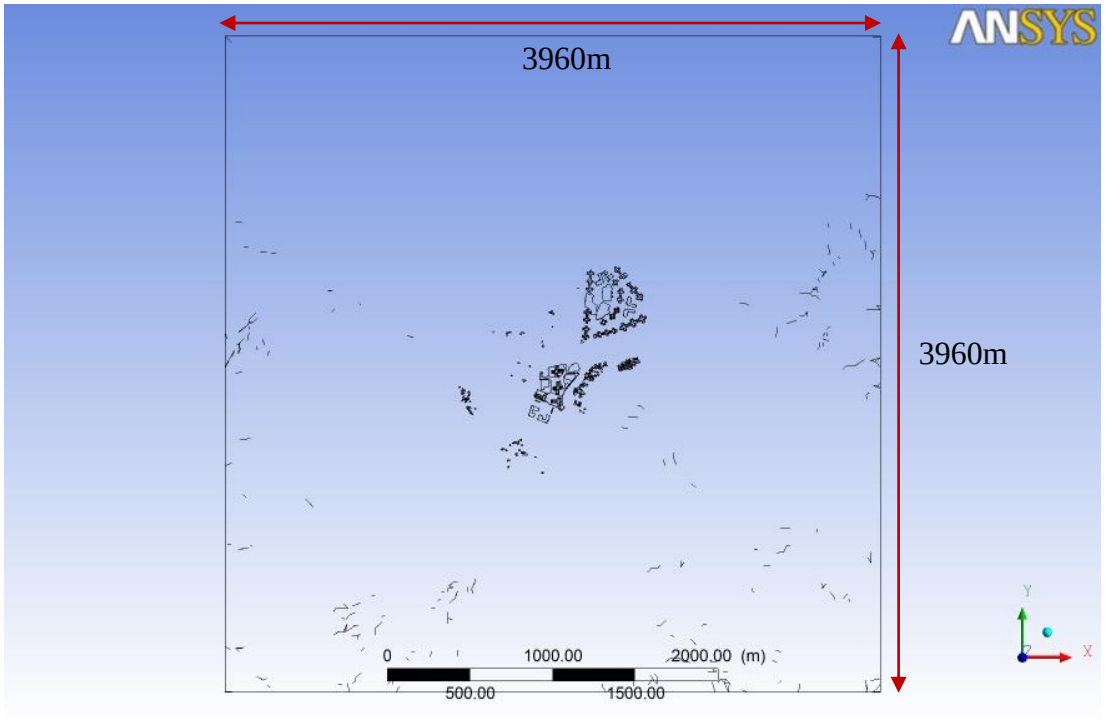
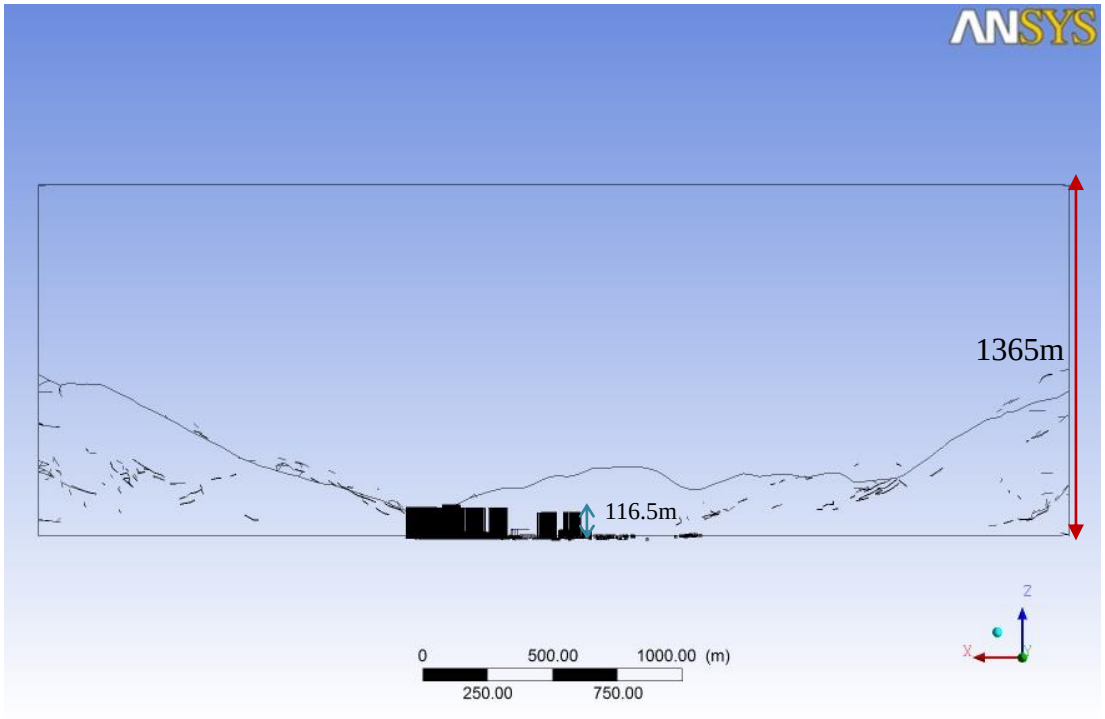


Plate 7 Side View of Domain Dimension



Unstructured grid is constructed by *ANSYS ICEM CFD* and the grid size can be manually adjusted in the aforesaid meshing tools. Within the assessment area, cells located across the *x*-axis and *y*-axis are positioned with smaller intervals than those located further from the site location in order to produce a more precise result at higher resolution where it is required.

The CFD model is developed with the combination of tetrahedral and prism cells. Approximately 16.23 million cells are constructed for the study. The grid arrangement within the assessment height of 2m above ground has been refined to facilitate the pedestrian wind environment study. In order to improve accuracy, smaller gird has been adopted in order to achieve a higher resolution at low levels of z-axis and thus capable of resolving small scale height structures and changes in topography at pedestrian level. The expansion ratio between two consecutive cells approximates 1.6. Four prism layers at prism ratio of 1.00 are created at 2m above ground to increase modelling accuracy at pedestrian level.

5.3.2. Turbulence Model

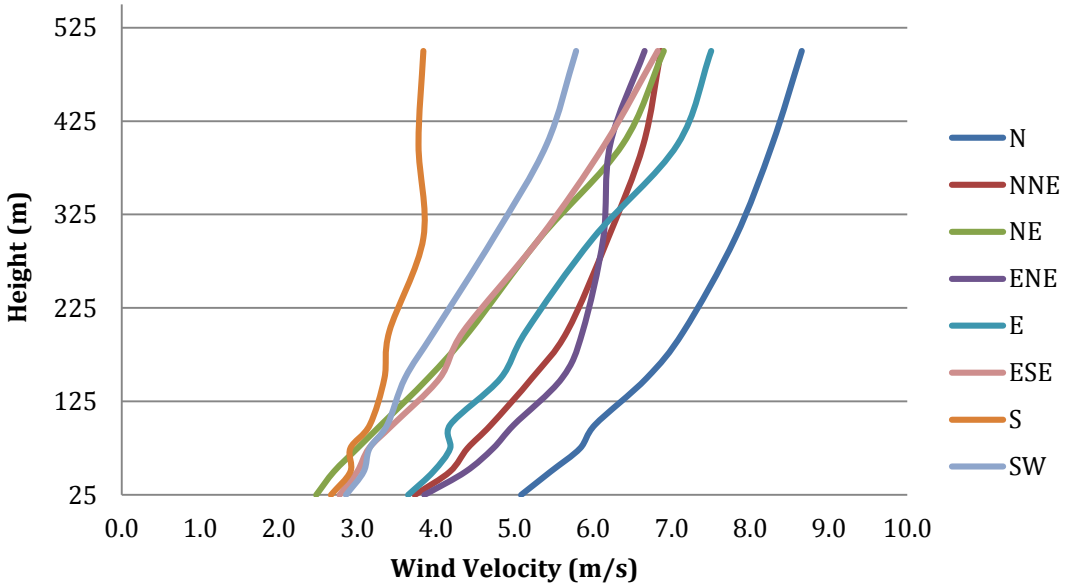
ANSYS FLUENT offers an unparalleled breadth of turbulence models such as k-epsilon turbulence model and the Reynolds stress model (RSM). In this study, the realizable k-epsilon model and a second order discretization scheme are adopted for simulation. Common computational fluid dynamics equations are also used in the analysis. A symmetry condition is prescribed at the lateral and top boundary of the 3D model. The convergence

criterion adopted being the sum of the normalized absolute residuals less than 1 x10^{-3}.

5.3.3. Wind Profile

The wind velocity at the top boundary layer has made reference to the *Experimental Site Wind Availability Study for the Proposed Public Rental Housing Development at Tung Chung Area 39, Lantau Island* conducted by the CLP Power Wind / Wave Tunnel Facility (WWTF) at the Hong Kong University of Science and Technology. ***Plate 8*** below summarizes the wind characteristics for the computational model under the 8 most probable wind directions. In the aforementioned wind tunnel study, mean wind speeds were measured at elevations equivalent to 25mPD, 50mPD, 75mPD, 100mPD, 200mPD, 300mPD, 400mPD and 500mPD in prototype scale above the subject site. The wind profile is obtained by regression analysis of the best fitting third-order polynomial regression model.

Plate 8 Wind Characteristics of the 8 Most Probable Wind Directions



5.3.4. Wind Velocity Ratio

Wind Velocity Ratio (*VR*) should be used as an indicator of wind performance for the AVA. It indicates how much of the wind availability of a location could be experienced and enjoyed by pedestrians. The higher the wind Velocity Ratio, the less likely would be the impact of the Proposed Developments on the wind availability.

Wind Velocity Ratio is defined as follows:

$$VR_w = \frac{V_p}{V_\infty}$$

where

V_p is the wind velocity at the pedestrian level (2m above ground) after taking into account the effects of buildings; and

V_∞ is the wind availability of the site, i.e. wind velocity at the top of the wind boundary layer. For each of the most probable wind direction, experimental site wind data at elevations equivalent to 500mPD is used to determine velocity at infinity level for the Project site.

The assessment on the overall wind performance of the current situation and the Proposed Development were analyzed by comparing the weighted wind Velocity Ratio (VR_w) to account for wind coming from the 8 wind directions. VR_w is the sum of the Wind Velocity Ratio of wind from direction i (VR_i) multiplied by the probability (F_i) of wind coming from that direction.

$$VRi = \frac{V_{pi}}{V_{\infty i}} \qquad VR_w = \sum_{i=1}^{16} Fi \times VRi$$

where

V_{pi} is the wind velocity at the pedestrian level (2m above ground) when wind comes from direction i; and

$V_{\infty i}$ is the wind availability of the site, when wind comes from direction i

F_i is the frequency occurrence of wind from direction i, eight wind directions are considered.

VR_w is the wind Velocity Ratio

5.3.5. Test Points

Test Points are the assessment locations where Wind Velocity Ratios (*VRs*) at 2m above ground level are reported. The criteria of choosing Test Points are stipulated in paragraph 28 of the *Technical Guide*. Perimeter Test Points and Overall Test Points were selected within the Assessment Area so as to assess the impact on the immediate vicinity and local areas respectively. All test points are elevated at 2m above ground.

Perimeter Test Points were distributed to assess the resultant wind environment that can be frequently accessed by pedestrians. Test Points in this group were selected at around 10 m to 50 m interval along the boundary of the site, and were named with prefix "P" (i.e. P-01, P-02…). Local Test Points were positioned in the open spaces, on the streets and places of the Project and Assessment Areas which are frequently accessed by pedestrians. Test points in this group are named with prefix "O" (i.e. O-01, O-02…). ***Figure 3*** and ***Figure 4*** show the selected Test Points of the Initial Scheme and the Proposed Scheme for the purpose of this AVA Initial Study.

For the Site Air Ventilation Assessment, the weighted Site Spatial Average Wind Velocity Ratio (SVR_w) is reported. SVR_w is the average of VR_w of all Perimeter Test Points. For the Local Air Ventilation Assessment, the weighted Local Spatial Average Wind Velocity Ratio (LVR_w) is reported. LVR_w is the average of VR_w of all Overall Test Points as well as Perimeter Test Points.

6. RESULTS AND ANALYSIS

6.1. GENERAL

In this AVA Initial Study, wind environment at pedestrian level (2m above ground) is simulated under the 8 most probable wind directions in both the Initial Scheme and Proposed Scheme. Wind velocity contour and vector diagrams simulated for each assessed wind direction are provided in ***Appendix I***.

Pedestrian-level wind Velocity Ratios (*VRs*) are simulated for each Test Point under the 8 most probable wind directions in both Schemes. Furthermore, the *VRs* simulated under each wind direction are averaged taking into account wind probability to determine the weighted wind velocity ratio (VR_w) of the Baseline and Proposed Scheme. The VR_w of the 28 Perimeter Test Points and 65 Overall Test Points for the Initial and the Proposed Schemes are summarized in ***Appendix II***. The detailed average *VRs* of all Test Points under each assessed wind direction are also shown in ***Appendix III***.

6.2. LOCAL AIR VENTILATION ASSESSMENT

6.2.1. Annual Prevailing Wind Condition

Local spatial average Velocity Ratios (*LVRs*) are evaluated for each wind direction by considering the average *VR* modelled at all Overall Test Points and Perimeter Test Points. Weighted Local spatial average Velocity Ratios (LVR_w) are also determined after taking into account wind probability of the 8 assessed wind directions. ***Table 2*** summarizes the *LVR* and LVR_w results for both the Initial and Proposed Schemes under the 8 most probable wind directions.

Table 2 Analysis of Average LVR between Initial Scheme and Proposed Scheme

Wind Directions	Average LVR (Initial Scheme)	Average LVR (Proposed Scheme)	Change in Average LVR between Schemes	Change in Average LVR between Schemes (%)
N (0^o or 360^o)	0.246	0.250	0.004	1.6%
NNE (22.5^o)	0.137	0.153	-0.007	11.6%
NE (45^o)	0.091	0.090	-0.001	-1.3%
ENE (67.5^o)	0.206	0.232	0.026	12.7%
E (90^o)	0.165	0.189	0.025	15.1%
ESE (112.5^o)	0.189	0.205	0.015	8.2%
S (180^o)	0.140	0.421	0.002	1.5%
SW (225^o)	0.194	0.190	0.190	-2.0%
LVR_w	**0.175**	**0.191**	**0.016**	9.0%

Comparing the Initial and Proposed Schemes, it is found that majority of the LVR values show changes in the range of -2.0% to 15.1% with the proposed scheme in place. Medium to significant increase (> 10%) in average *LVR* is found under prevailing E, ENE and NNE wind conditions, while noticeable improvement in average *LVR* (0 – 10%) is found under N, ESE and S wind conditions. Negative change in average LVR is expected under NE and SW wind condition, indicating that the wind availability within the assessment area is slightly deteriorated; however, such changes in average LVR are considered insignificant (<5%). The overall change in LVR_w is 9.0% when comparing the two Schemes. On the whole, the findings indicate a noticeable improvement in ventilation performance within the site, in its immediate vicinity and other areas accessed frequently by pedestrians with the Proposed Scheme in place.

6.3. SITE AIR VENTILATION ASSESSMENT

6.3.1. Annual Prevailing Wind Condition

Site spatial average Velocity Ratios (*SVR*) are evaluated for each wind direction by considering the average Velocity Ratio modelled at all Perimeter Test Points at podium level along the boundary of the Subject Site which are accessible by pedestrians. Weighted Site spatial average Velocity Ratios (SVR_w) are also determined after taking into account wind probability of the 8 assessed wind directions. The *SVR* and SVR_w results as well as the percentage changes for both the Initial and Proposed Schemes are summarized in ***Table 3*** below.

Table 3 Analysis of Average SVR between Initial Scheme and Proposed Scheme

Wind Directions	Average SVR (Initial Scheme)	Average SVR (Proposed Scheme)	Change in Average SVR between Schemes	Change in Average SVR between Schemes (%)
N (0^o or 360^o)	0.253	0.267	0.014	5.5%
NNE (22.5^o)	0.110	0.112	-0.024	2.1%
NE (45^o)	0.031	0.032	0.001	3.2%
ENE (67.5^o)	0.188	0.273	0.085	45.5%
E (90^o)	0.147	0.216	0.069	47.0%
ESE (112.5^o)	0.130	0.154	0.023	17.8%
S (180^o)	0.101	0.111	0.010	10.2%
SW (225^o)	0.133	0.127	-0.007	-4.9%
SVR_w	**0.150**	**0.189**	**0.039**	24.5%

As shown in ***Table 3***, the predicted *SVR* values show positive change in the range of 3.2% to 47.0% under 7 assessed wind directions, namely N, NNE, NE, ENE, E, ESE and S. A slight decrease in *SVR* (-4.9%) is also observed under SW wind condition. The weighted average SVR_w is found to be 0.150 and 0.189 in the Initial and Proposed Schemes respectively. The overall change in SVR_w is 24.5% when comparing the two Schemes. The findings indicate a significant improvement in ventilation performance within the site and in its immediate vicinity with the Proposed Scheme rather than the Initial Scheme in place.

6.4. FOCUS AREAS

The Spatial Average Velocity Ratios (SAVRs) for each focus area is summarised in ***Table 4*** below. In summary, significant air ventilation problem due to the Proposed Development is not anticipated with reference to the assessment results. The ventilation condition under the proposed scheme is slightly improved. No stagnant areas (VR_w <0.1) are identified, and ventilation performance in those areas of interest is generally maintained.

Focus areas that are of a relatively close proximity to the site, including Proposed IRC, YMCA of Hong Kong Christian College, Caritas Charles Vath College, Wong Ka Wai and Lung Tseng Tau are expected to experience slight increase in VR_w. Shek Lau Po and the Proposed School are the only two focus areas that may experience slight decrease in weighted VR_w. However, it is evidently observed from the vector and contour diagrams that the development in the Proposed Scheme is not anticipated to obstruct wind flow or deflect the prevailing wind patterns as compared to that in the Initial Scheme.

Table 4 Analysis of Weighted Average Velocity Ratio (VR_w) in Focus Areas

Focus Area		**Test Points**	**VR_w (Baseline Scheme)**	**VR_w (Proposed Scheme)**	**Change in VR_w**
Zone 1	Proposed IRC	O-01 to O-04	0.190	0.201	0.010
Zone 2	Proposed School	O-05 to O-06	0.132	0.129	-0.002
Zone 3	YMCA of Hong Kong Christian College and Caritas Charles Vath College	O-07 to O-18	0.153	0.159	0.006
Zone 4	Wong Ka Wai	O-19 to O-31	0.134	0.141	0.007
Zone 5	Lung Tseng Tau	O-32 to O-37	0.214	0.222	0.008
Zone 6	Ha Ling Pei and Sheung Ling Pei	O-38 to O-51	0.245	0.247	0.002
Zone 7	Shek Lau Po	O-52 to O-57	0.201	0.199	-0.003
Zone 8	Yat Tung Estate	O-58 to O-65	0.197	0.211	0.015

6.6. AIR VENTILATION IMPROVEMENT MEASURES

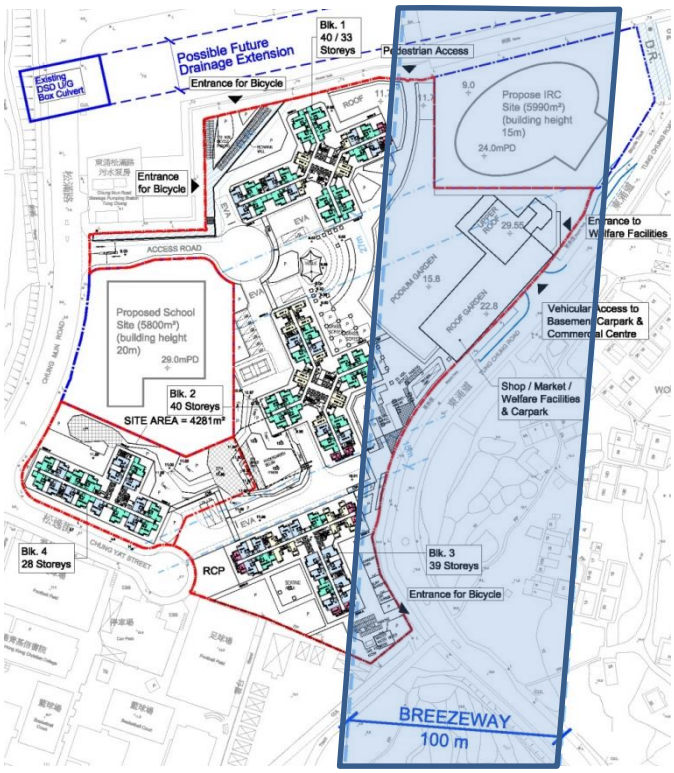
With due consideration of the prevailing wind directions and evaluation of the Initial Layout in terms of air ventilation, a series of design features have been incorporated into the layout to enhance air ventilation and wind comfort of the Proposed Development and to minimize the potential impact on the surrounding environment. These features include:

- Preservation of existing breezeway
- Ground floor openings for domestic blocks
- Building Deposition

6.6.1. Preservation of Existing Breezeway

The Proposed Development maintains an existing 100-metre-wide breezeway extending from north-northeast to south-southwest by restricting building height of the Retail cum Welfare Block to less than 30mPD and strategically locating the 4 domestic blocks to ensure that wind flow extending from the established system of road network and semi-opened space to the east of the subject site / south of Tung Chung New Town is maintained, thereby enhancing penetration of natural sea breeze from the Tung Chung Bay.

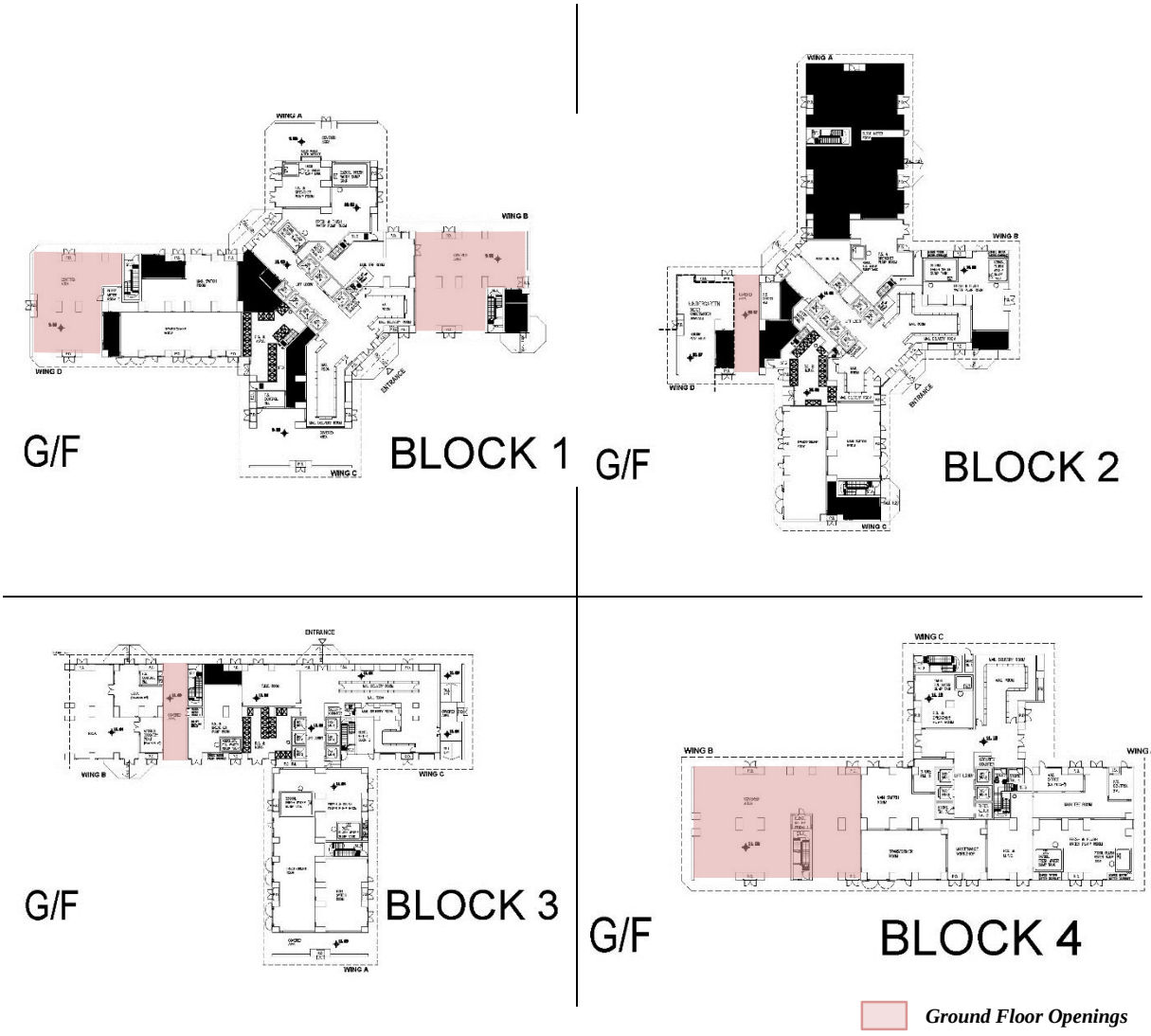
Plate 9 Existing Breezeways



6.6.2. Ground Floor Openings at Domestic Blocks

Ground floor openings would generally allow wind penetration at the pedestrian level of the site to enhance the local wind environment and facilitate air ventilation. In the Improved Layout, ground floor openings are widely incorporated in the buildings (***Plate 10***); for example, Wing B and Wing D of Block 1 have both incorporated 11-metre wide empty bays while Wing B of Block 4 is fully opened to enhance wind flow.

Plate 10 Ground Floor Plan of the Proposed Scheme



6.6.4. Building Deposition

Adequately wide gaps are provided between the 4 proposed domestic blocks to maximize wind permeability. 31-metre and 18-metre wide breezeways are maintained along the prevailing easterly wind direction between Block 1 and 2 as well as Block 2 and 3 (as shown in ***Plate 11***). The building gaps channelize wind flow within the Subject Site and improve the ventilation environment at downwind locations of the surrounding built environment.

Plate 11 Building Deposition of the Proposed Scheme

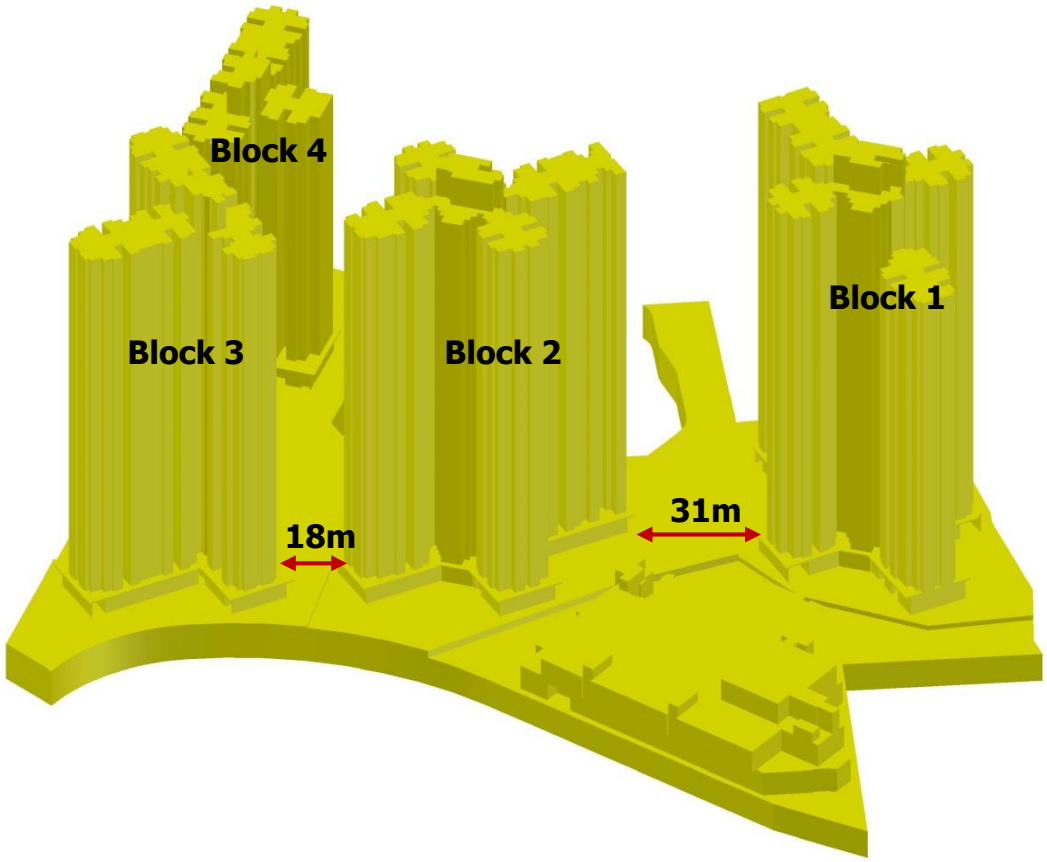
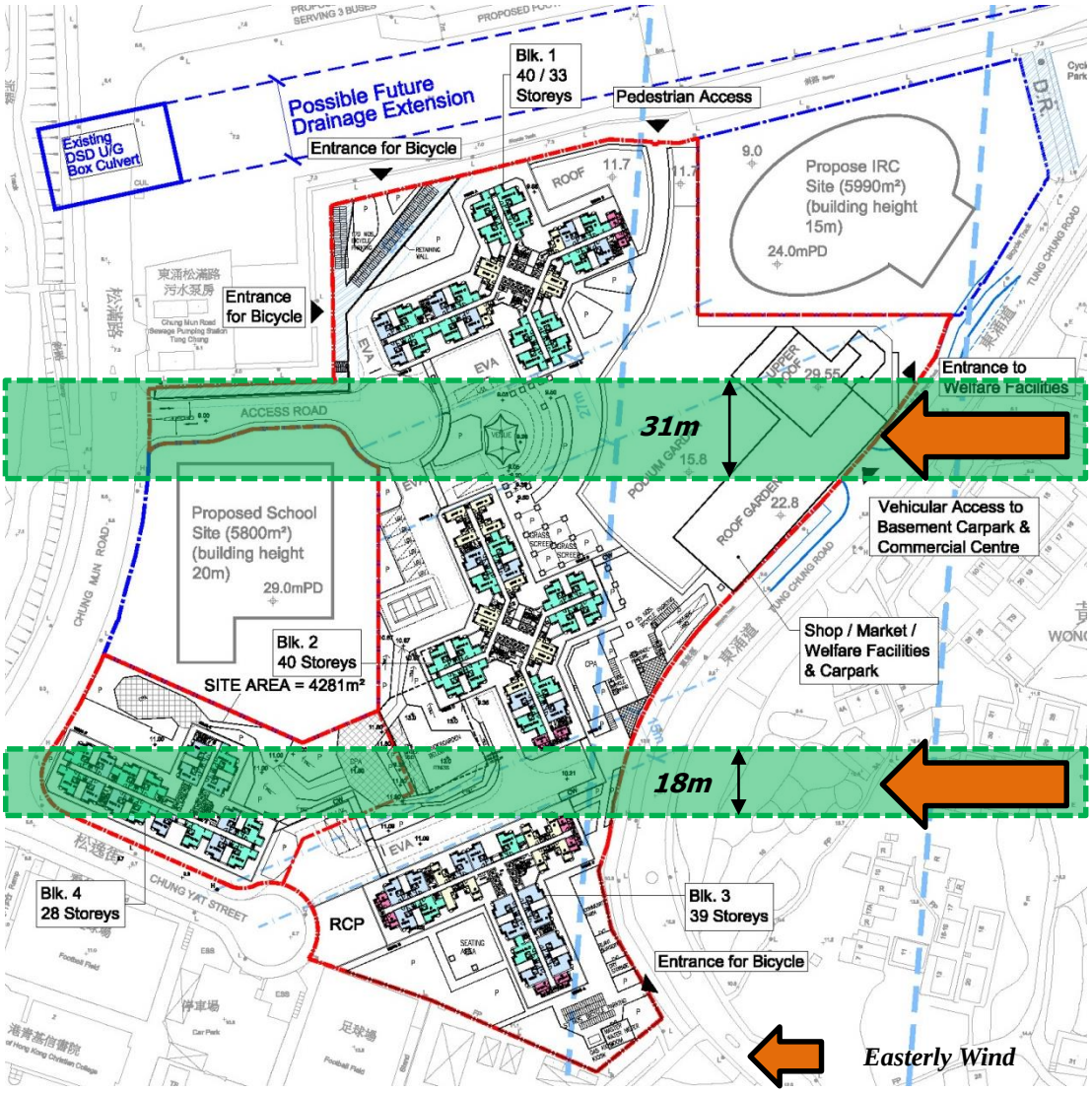


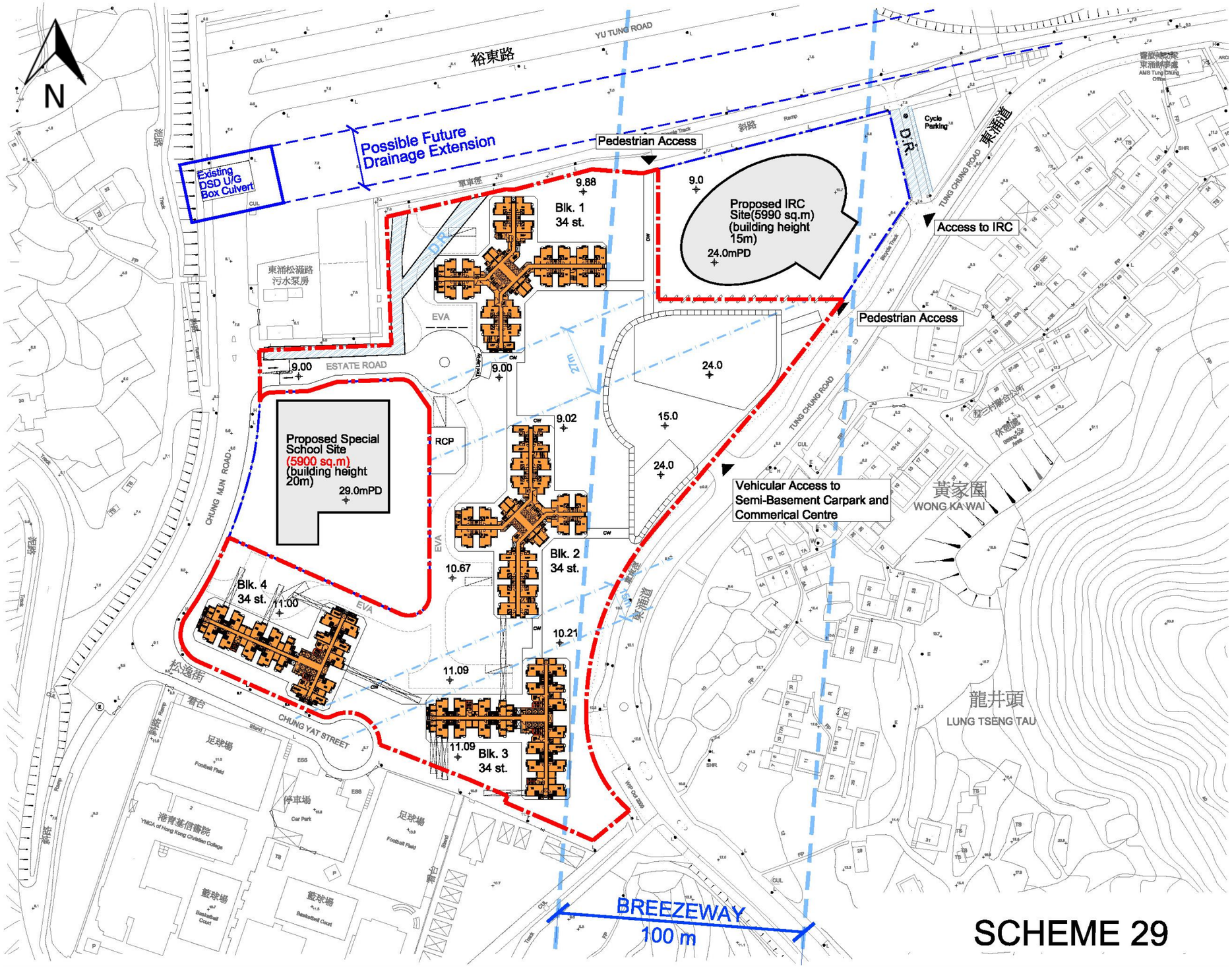
Plate 12 Diagonal Building Separation under Easterly Wind



7. CONCLUSION

Computational Fluid Dynamics (CFD) technique is utilized for the AVA Initial study of the Proposed Public Rental Housing Development at Tung Chung Area 39, Lantau Island in accordance with the Air Ventilation Assessment (AVA) methodology given in the *Technical Guide*. With reference to data from MM5 data from the Planning Department and HKO automatic weather station data, prevailing winds from the northeast quadrant are dominant in non-summer period while wind from the southwest direction are dominant in summer period within the Tung Chung area. In this AVA study, 8 wind directions which account for 81.8% occurrence of wind over a year were chosen to quantitatively air ventilation performance of the Proposed Development and its surrounding environment. The eight most frequent wind directions include North (N), North-northeast (NNE), Northeast (NE), East-northeast (ENE), East (E), East-southeast (ESE), South (S) and Southwest (SW).

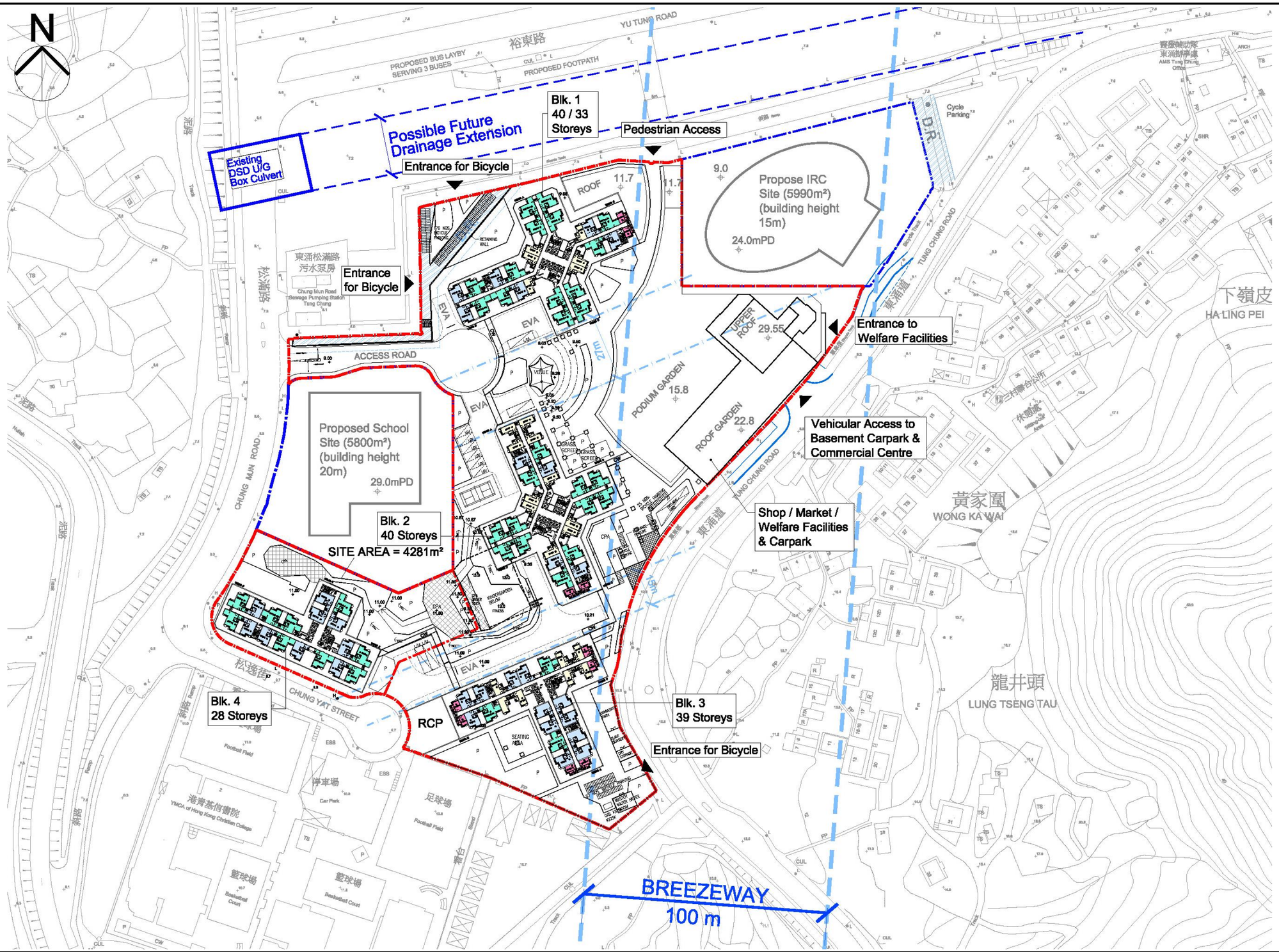
Wind Velocity Ratio (*VR*) is simulated to quantitatively evaluate the air ventilation performance of the Proposed Development and its surrounding environment. Representative assessment points, including 28 Perimeter Test Points and 65 Overall Test Points, were selected for detailed assessment. With reference to the assessment findings, no problem areas due to the Proposed Development has been identified in the AVA Initial Study, most likely due to the considerable distance between the Subject Site and surrounding development. Overall percentage changes in weighted Local spatial average Velocity Ratios (LVR_w) and weighted Site spatial average Velocity Ratios (SVR_w) were found to be 9.0% and 24.5% between the Initial Scheme and Proposed Scheme respectively. Wind performance within the Subject Site is also evaluated to study the improvement measures and good design features in the Proposed Scheme. The AVA Initial Study reveals that the wind environment in the Project and assessment area will be improved with the Proposed Layout. It is anticipated that the good design features that have been incorporated in the Proposed Layout, including the reduced number of blocks, widened gaps between the buildings and the ground floor openings, facilitate wind permeability and improve local wind environment.



PROPOSED PUBLIC RENTAL HOUSING DEVELOPMENT AT TUNG CHUNG AREA 39, LANTAU ISLAND
AIR VENTILATION ASSESSMENT

Layout Plan – Initial Scheme

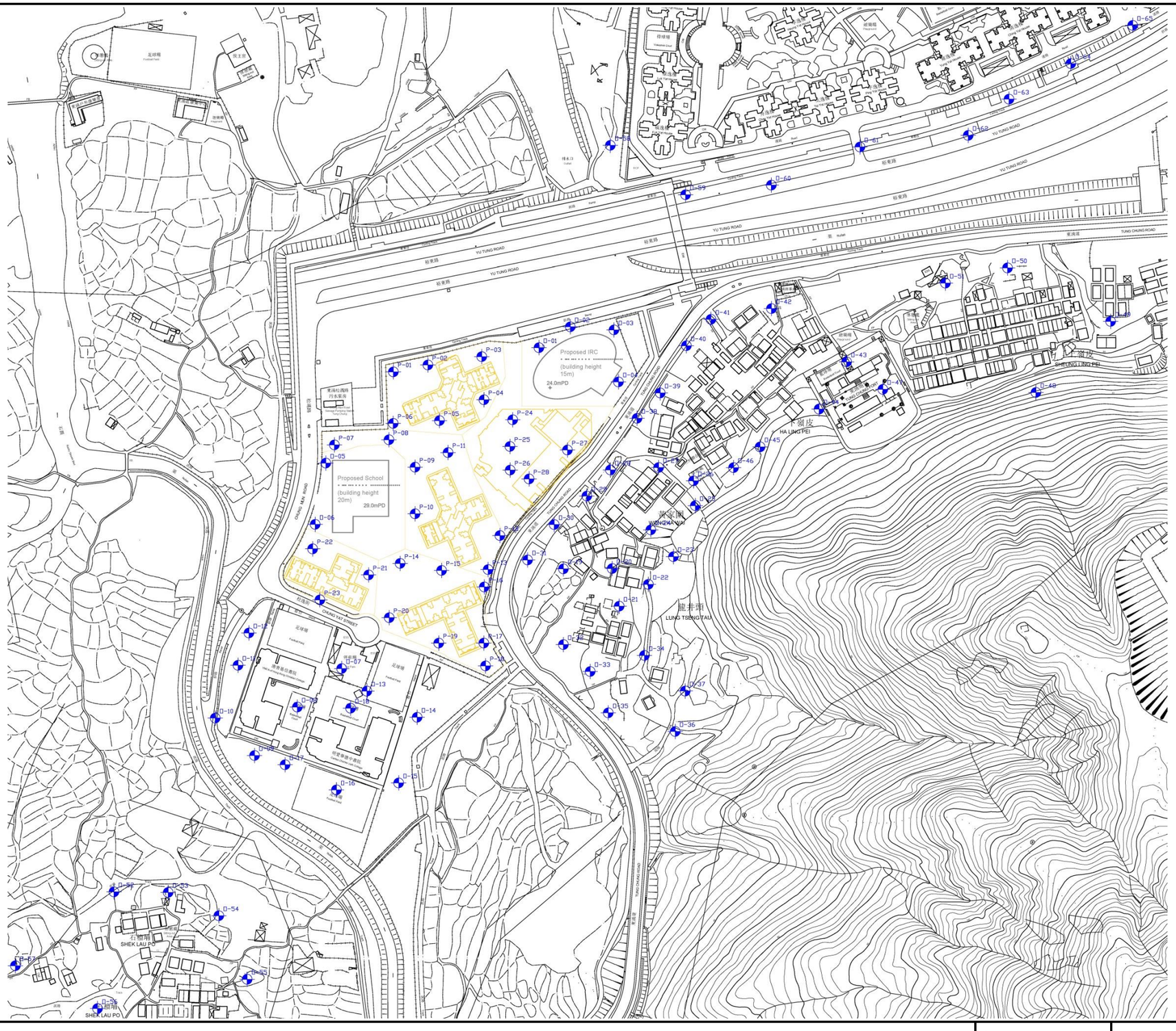
Figure No.	Rev:
1	0
Scale: NTS	Date: 06/13



PROPOSED PUBLIC RENTAL HOUSING DEVELOPMENT AT TUNG CHUNG AREA 39, LANTAU ISLAND
AIR VENTILATION ASSESSMENT

Layout Plan – Proposed Scheme

Figure No.	Rev:
2	0
Scale	**Date**
NTS	06/13

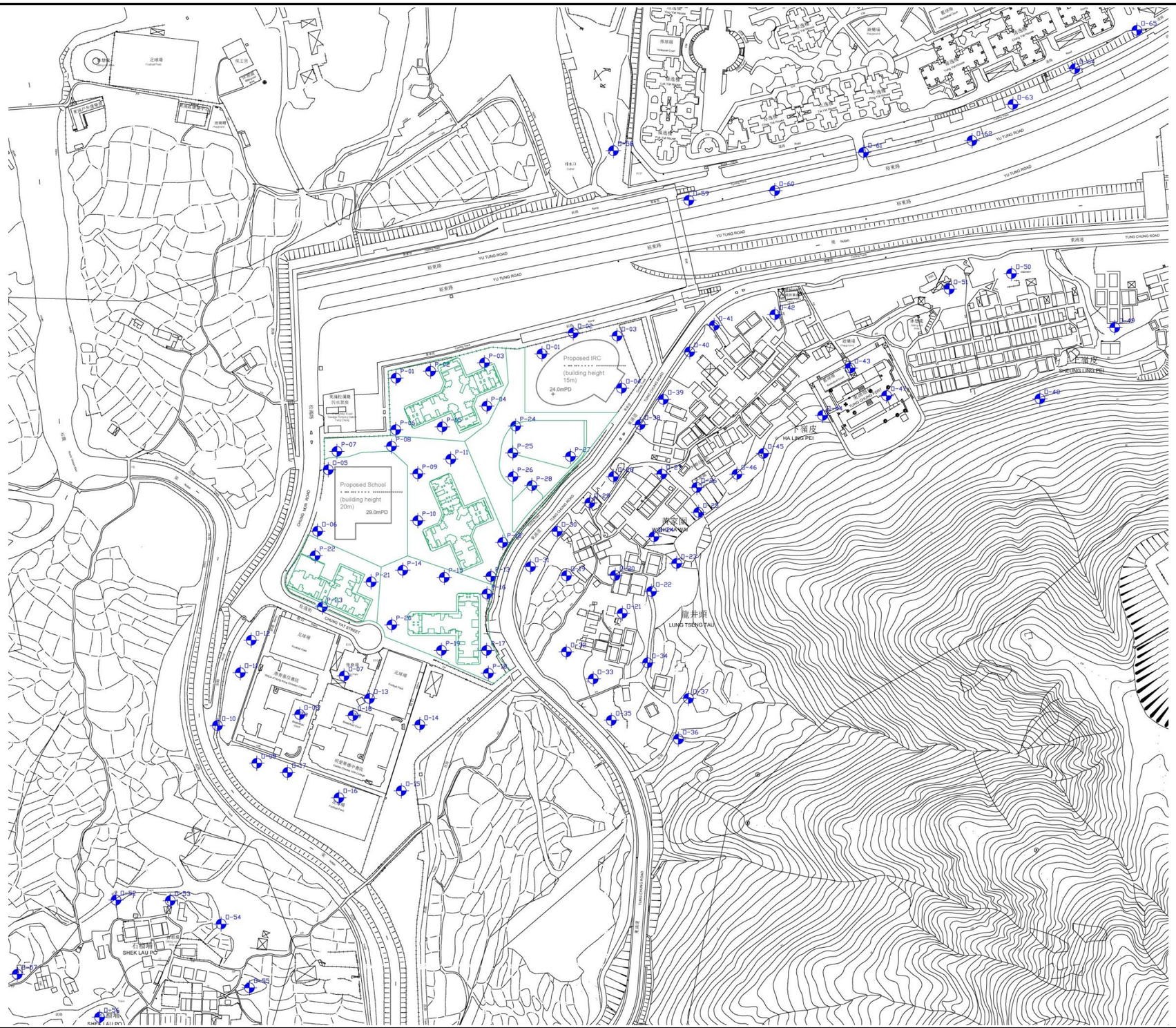


PROPOSED PUBLIC RENTAL HOUSING DEVELOPMENT AT TUNG CHUNG AREA 39, LANTAU ISLAND
AIR VENTILATION ASSESSMENT

Test Point Position – Initial Scheme

Figure No.	Rev:
3	0
Scale	Date
NTS	06/13

AEC



PROPOSED PUBLIC RENTAL HOUSING DEVELOPMENT AT TUNG CHUNG AREA 39, LANTAU ISLAND
AIR VENTILATION ASSESSMENT

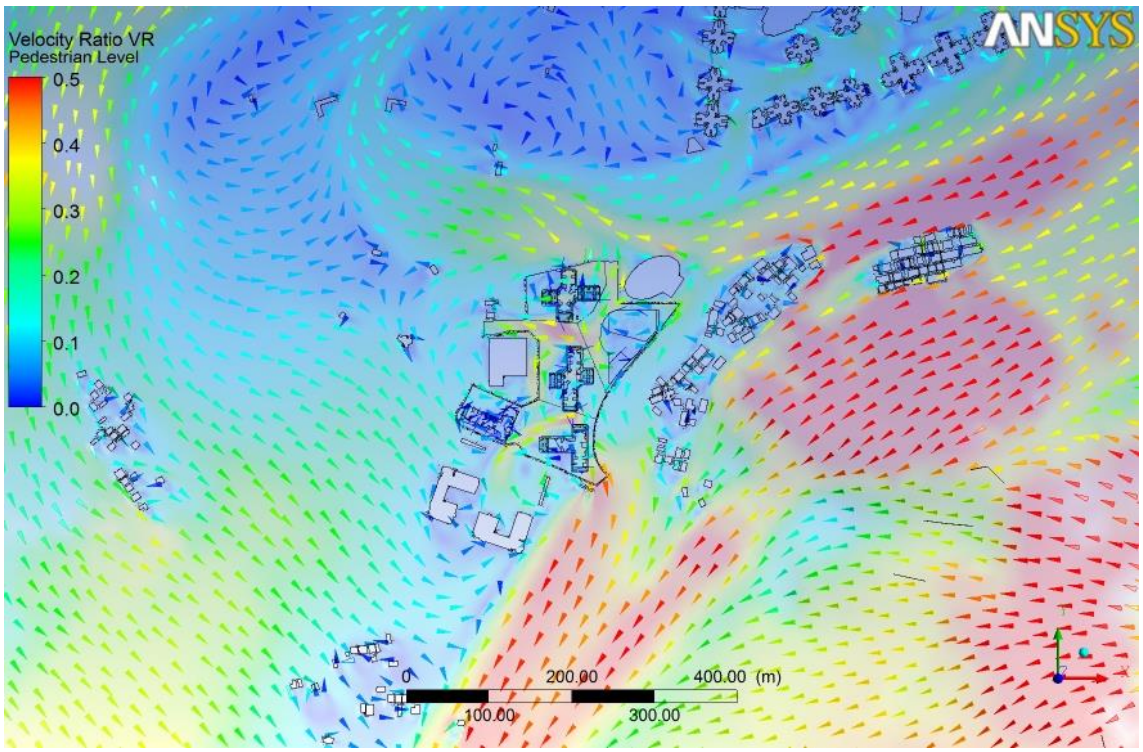
Test Point Position – Proposed Scheme

Figure No.	Rev:
4	0
Scale: NTS	Date: 06/13

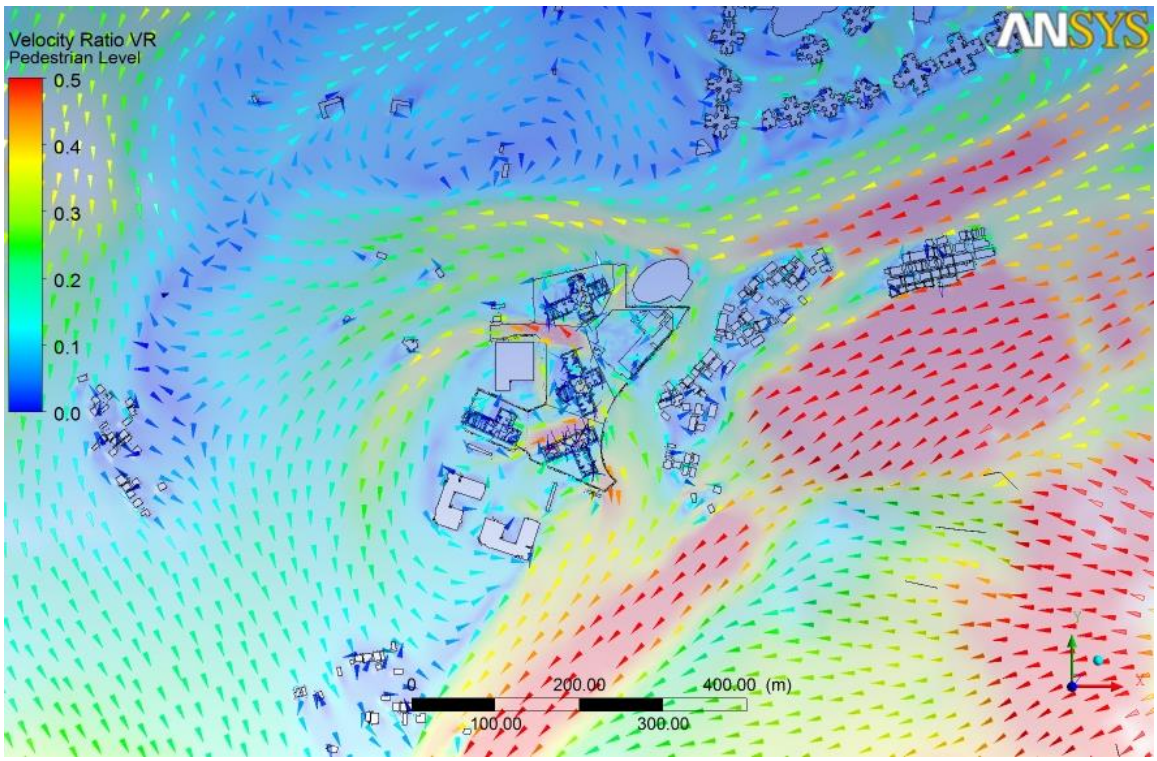
APPENDIX I: VELOCITY VECTOR, VELOCITY CONTOUR AND VELOCITY RATIO DIAGRAMS

Prevailing Wind Direction: East-Northeast (ENE)

Velocity Ratio (VR) Vector Diagram of Initial Scheme at 2m above Ground Level

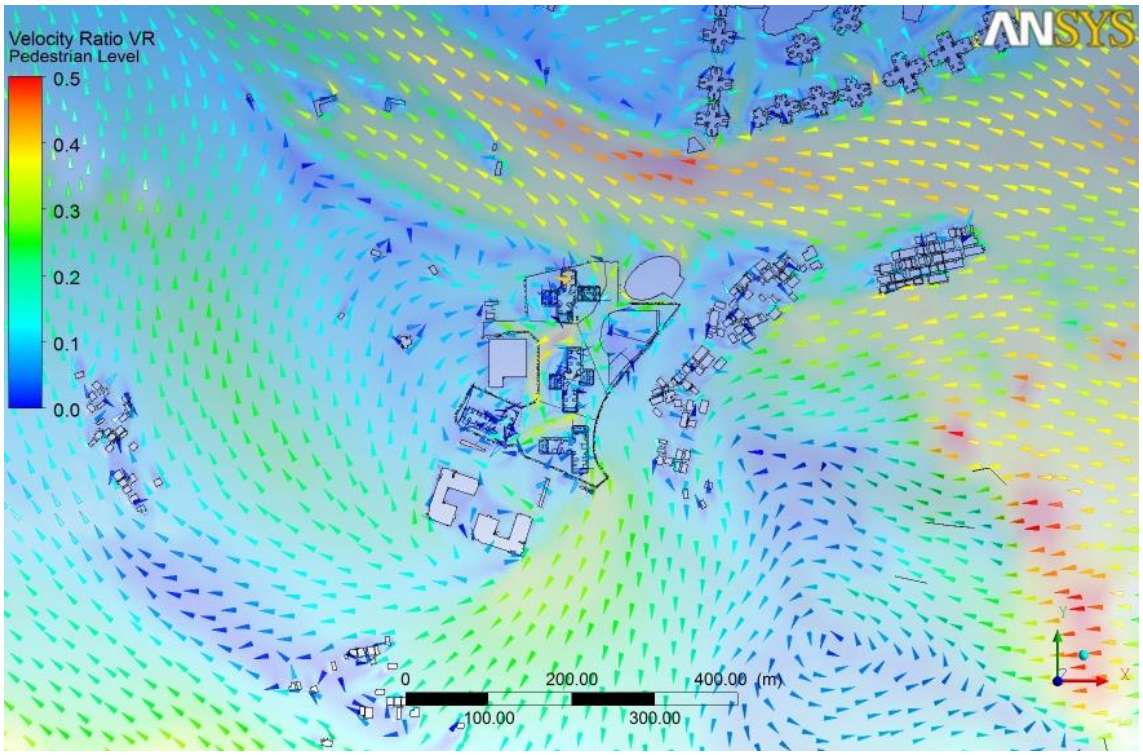


Velocity Ratio (VR) Vector Diagram of Proposed Scheme at 2m above Ground Level

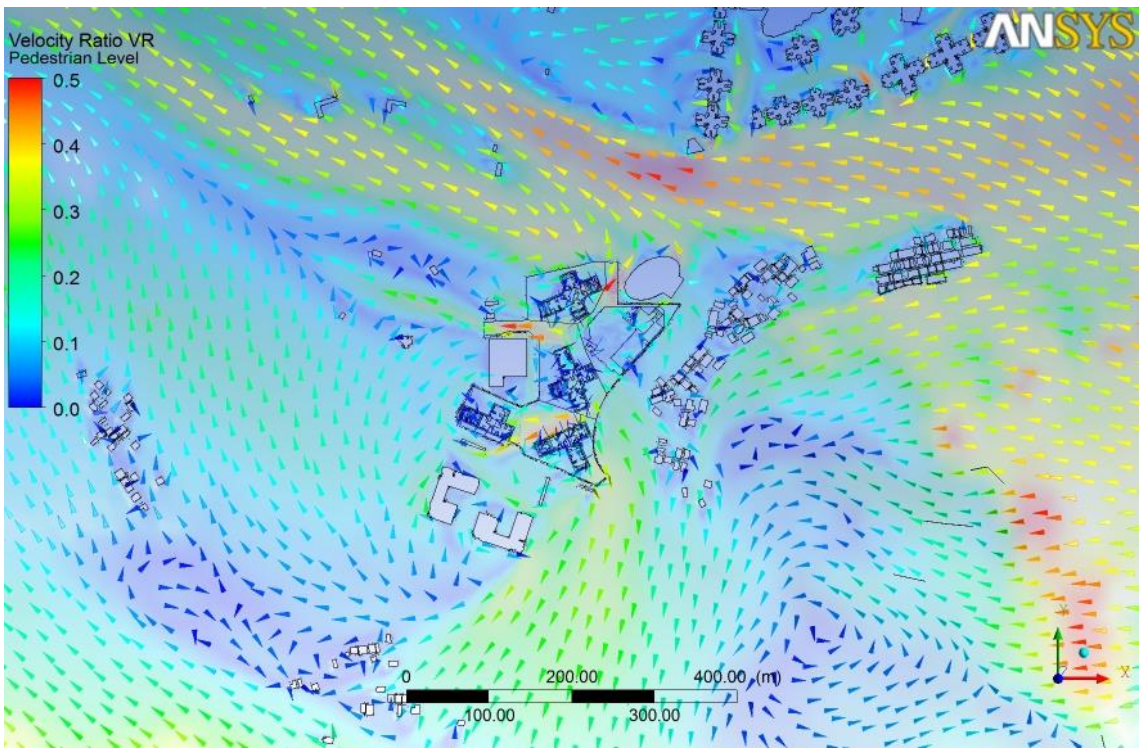


Prevailing Wind Direction: East (E)

Velocity Ratio (VR) Vector Diagram of Initial Scheme at 2m above Ground Level

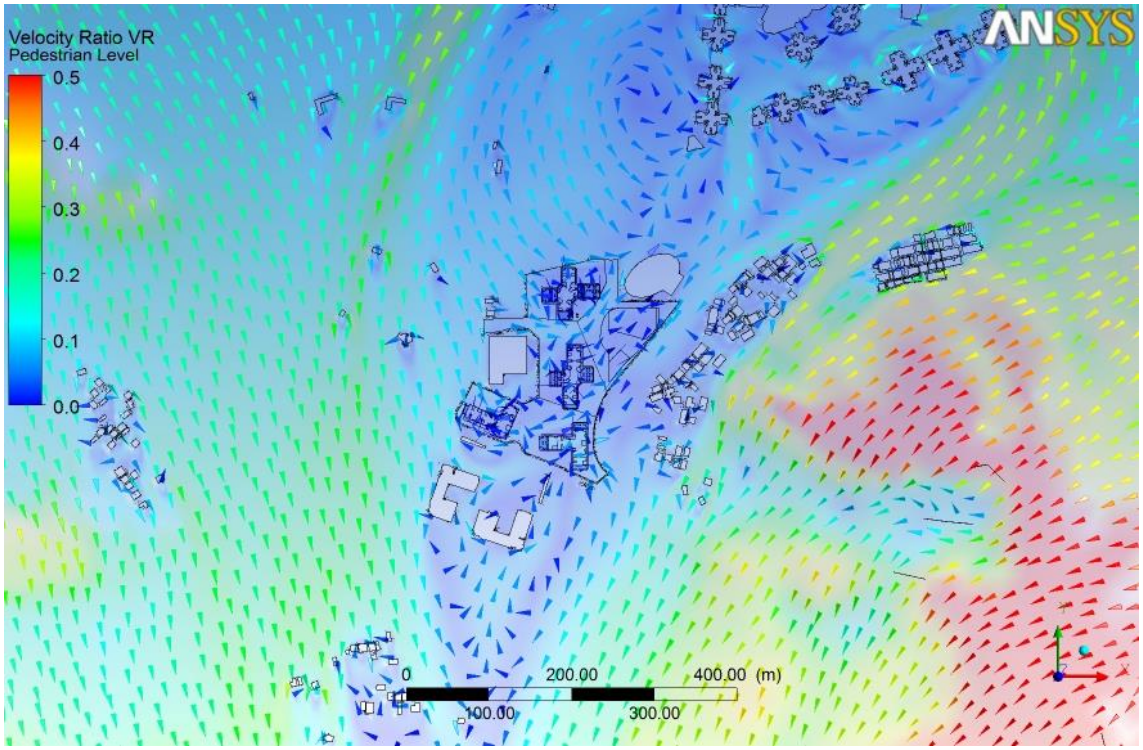


Velocity Ratio (VR) Vector Diagram of Proposed Scheme at 2m above Ground Level

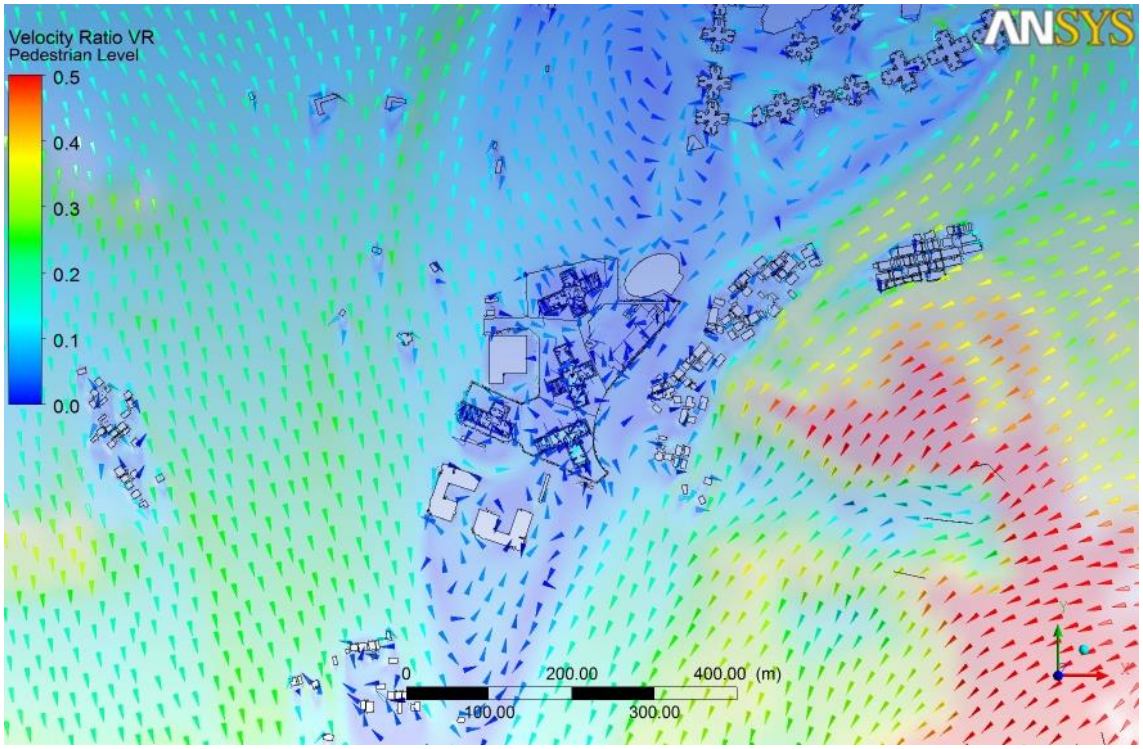


Prevailing Wind Direction: Northeast (NE)

Velocity Ratio (VR) Vector Diagram of Initial Scheme at 2m above Ground Level

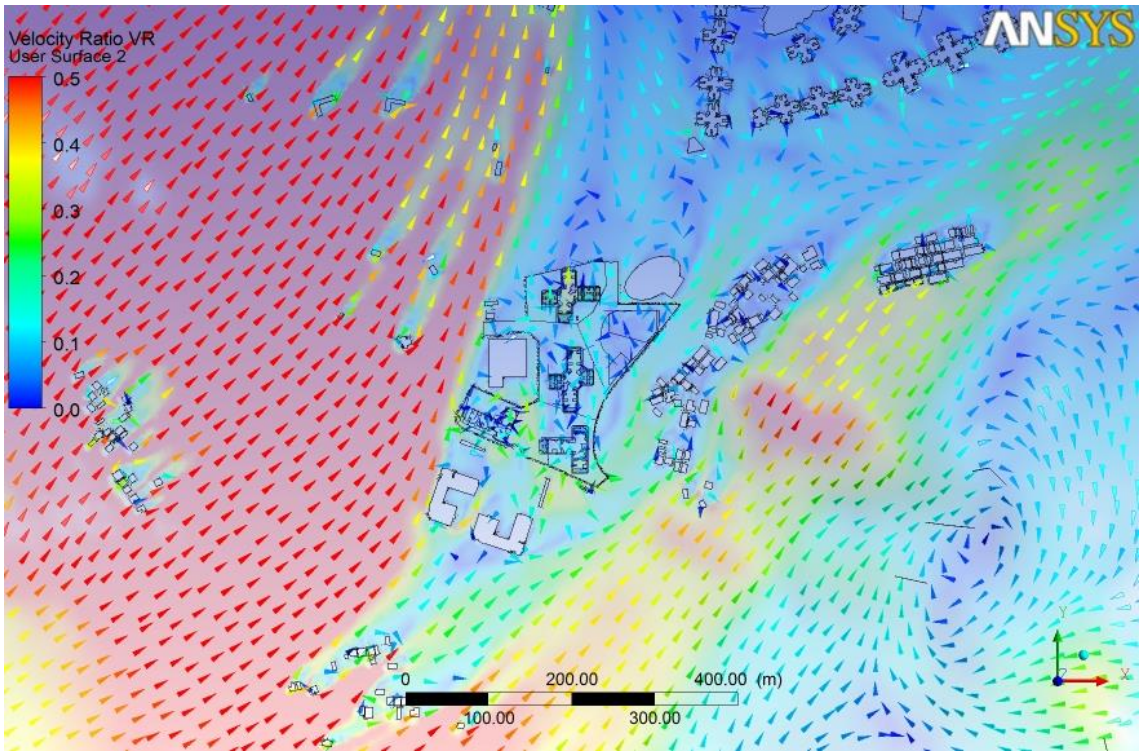


Velocity Ratio (VR) Vector Diagram of Proposed Scheme at 2m above Ground Level

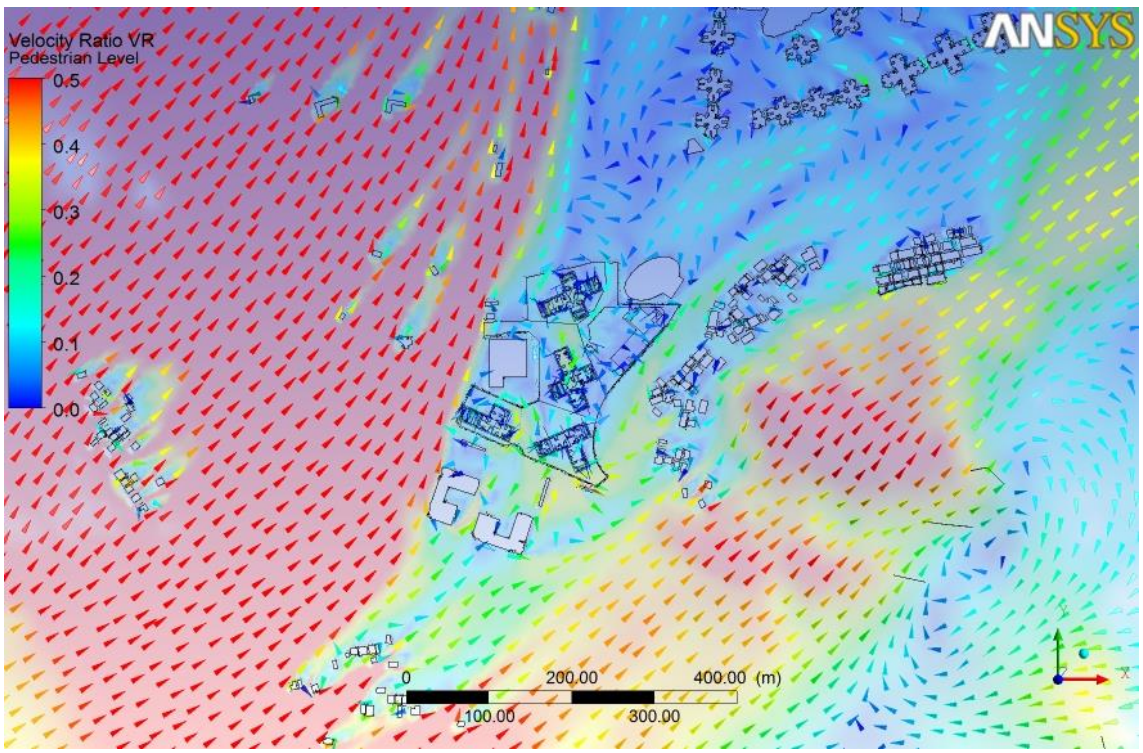


Prevailing Wind Direction: East-Southeast (ESE)

Velocity Ratio (VR) Vector Diagram of Initial Scheme at 2m above Ground Level

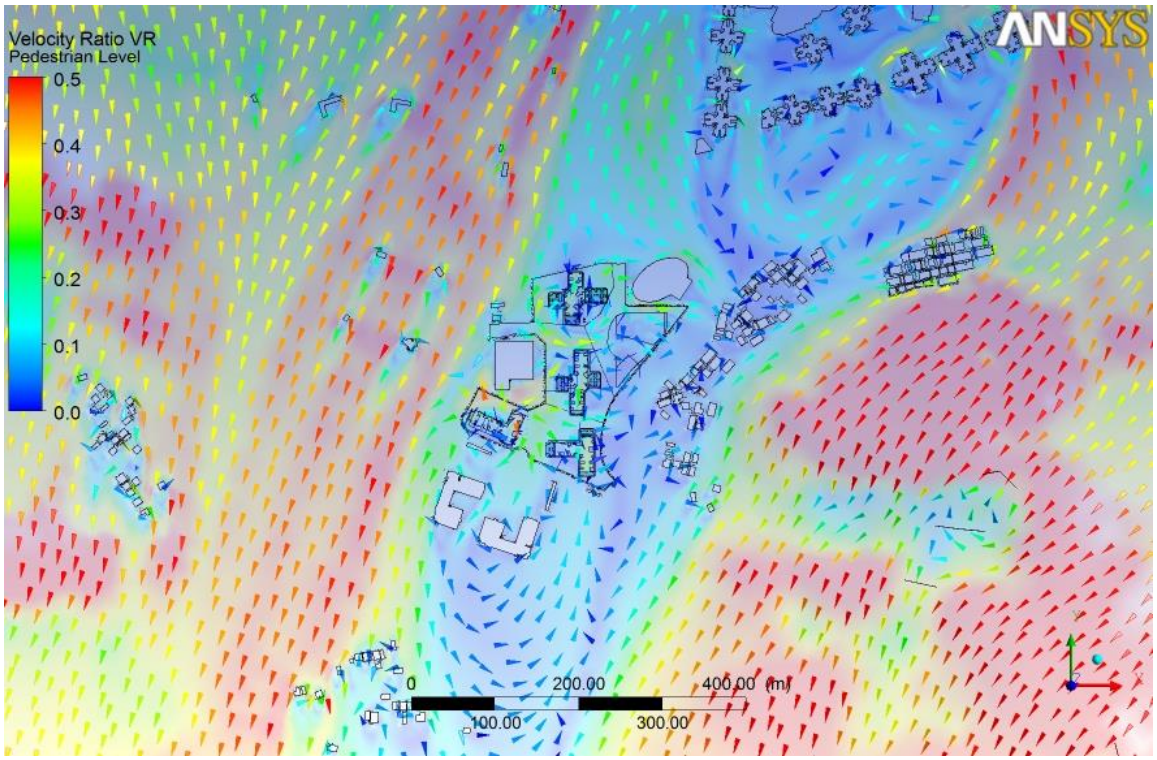


Velocity Ratio (VR) Vector Diagram of Proposed Scheme at 2m above Ground Level

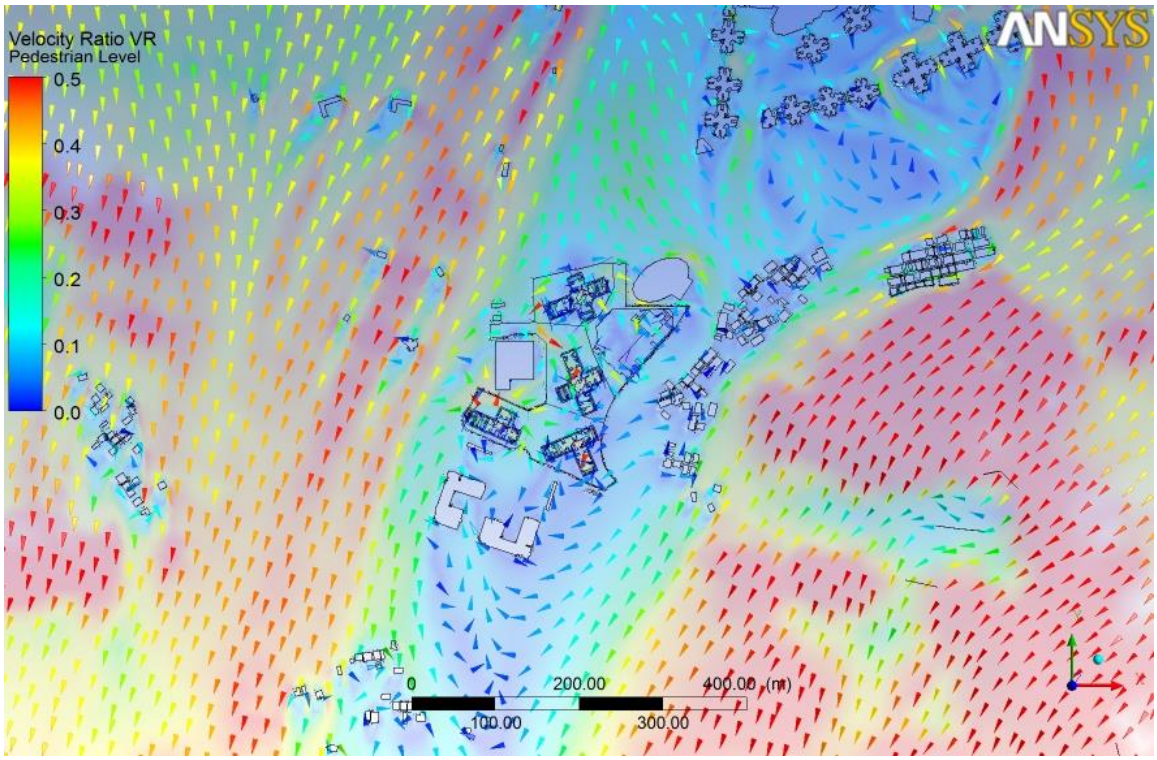


Prevailing Wind Direction: North-Northeast (NNE)

Velocity Ratio (VR) Vector Diagram of Initial Scheme at 2m above Ground Level

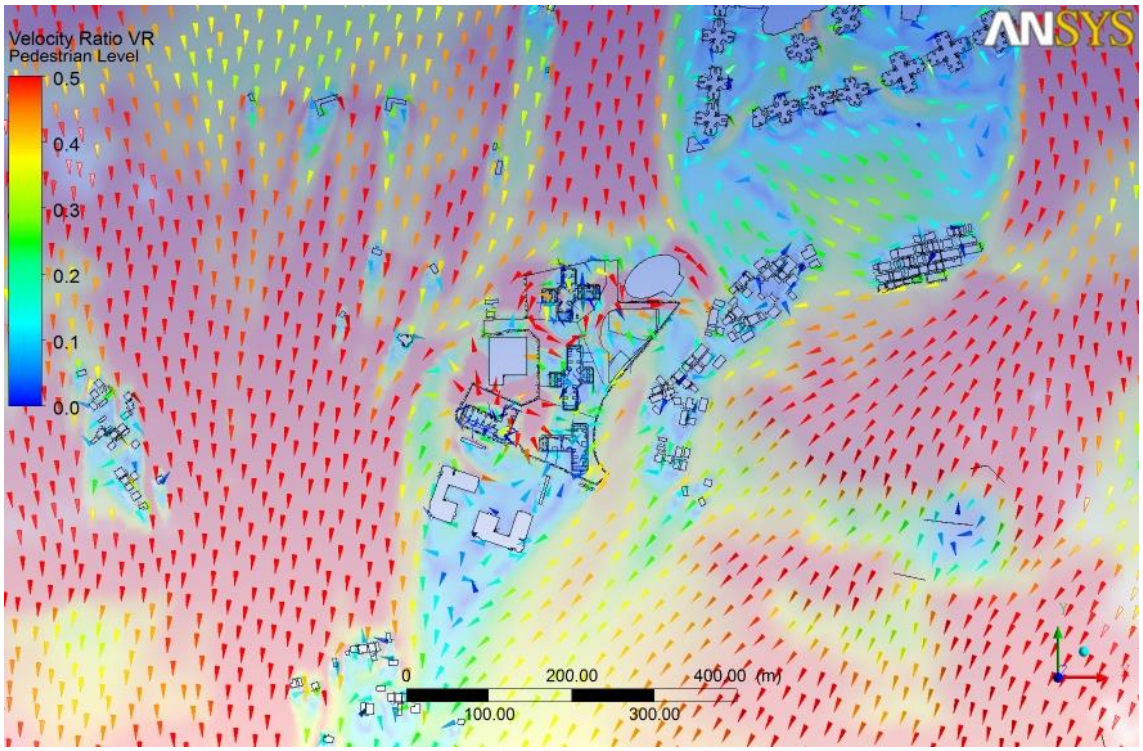


Velocity Ratio (VR) Vector Diagram of Proposed Scheme at 2m above Ground Level

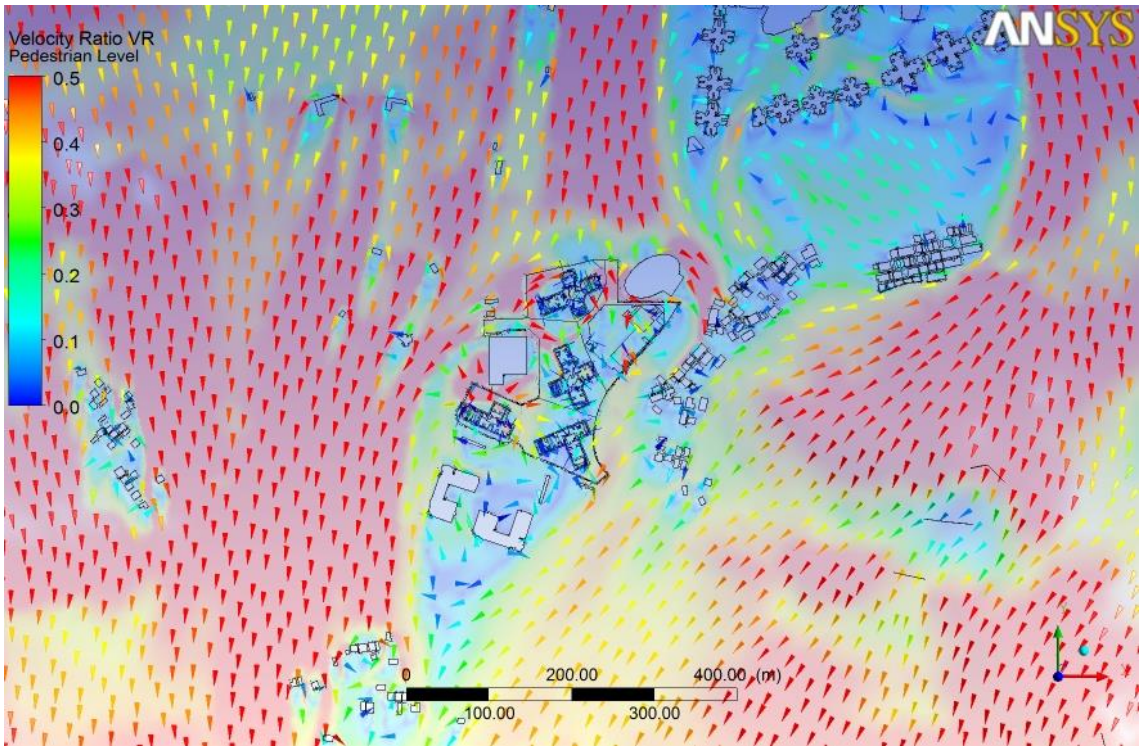


Prevailing Wind Direction: North (N)

Velocity Ratio (VR) Vector Diagram of Initial Scheme at 2m above Ground Level

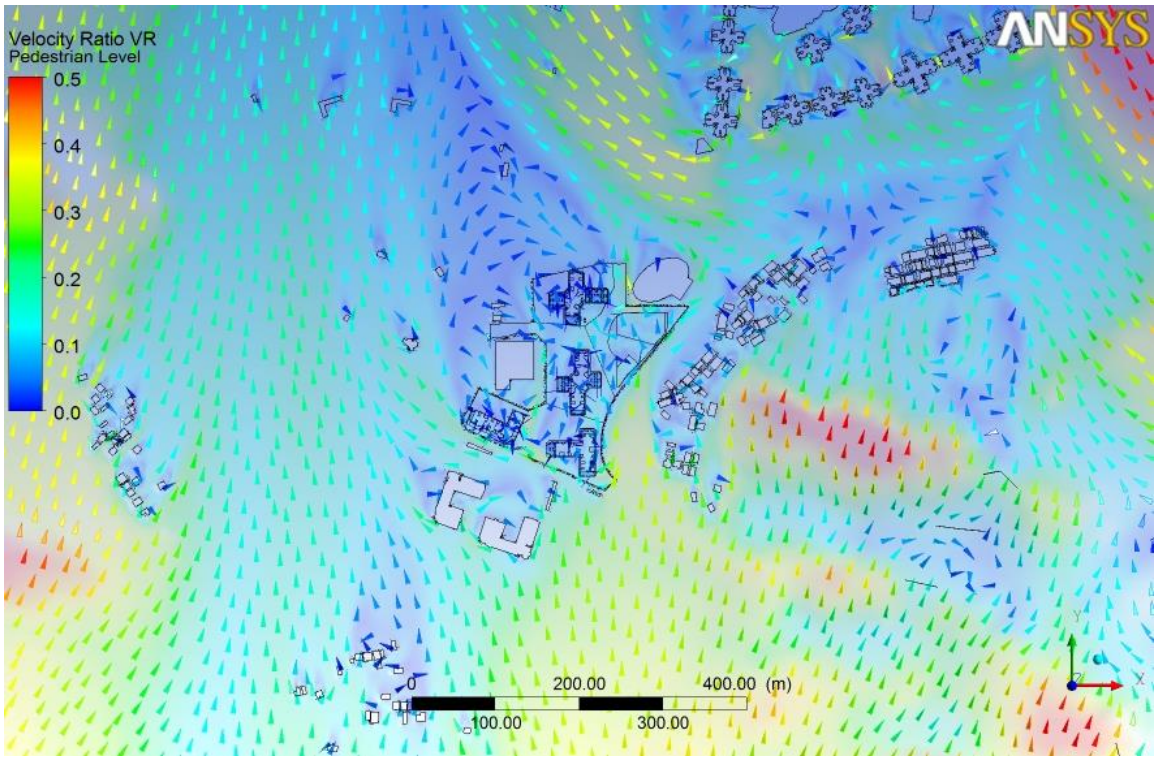


Velocity Ratio (VR) Vector Diagram of Proposed Scheme at 2m above Ground Level

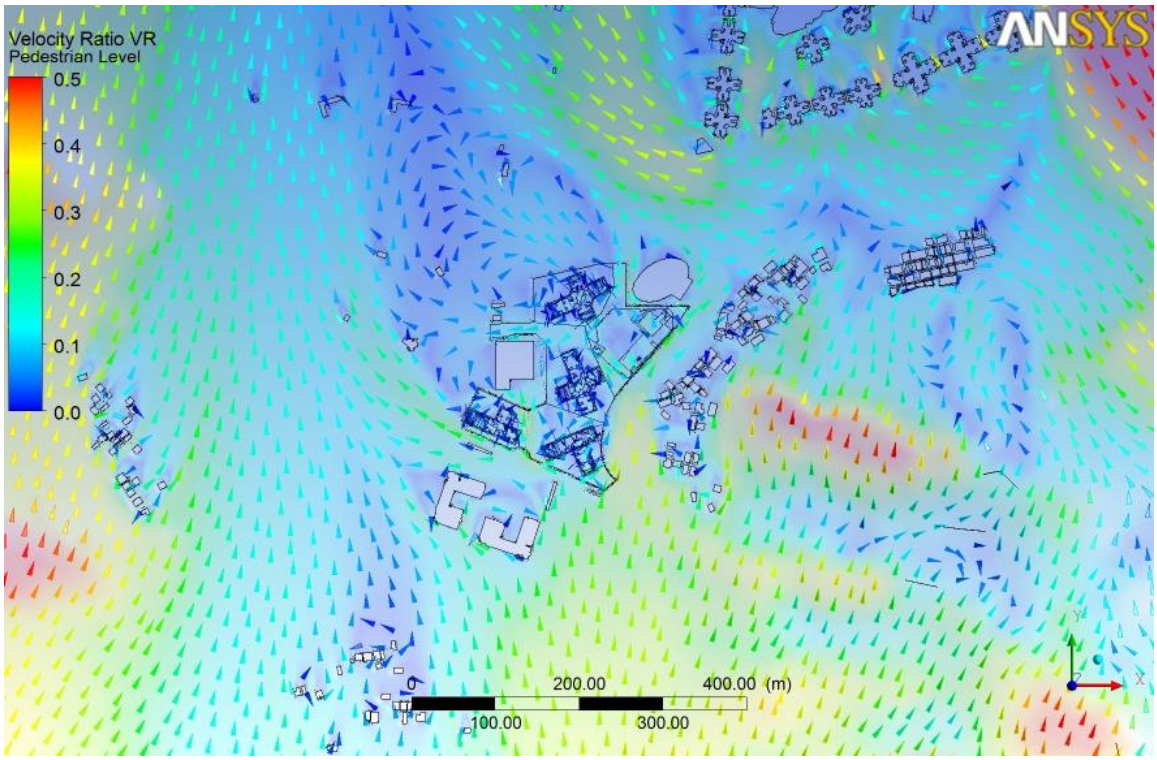


Prevailing Wind Direction: South (S)

Velocity Ratio (VR) Vector Diagram of Initial Scheme at 2m above Ground Level

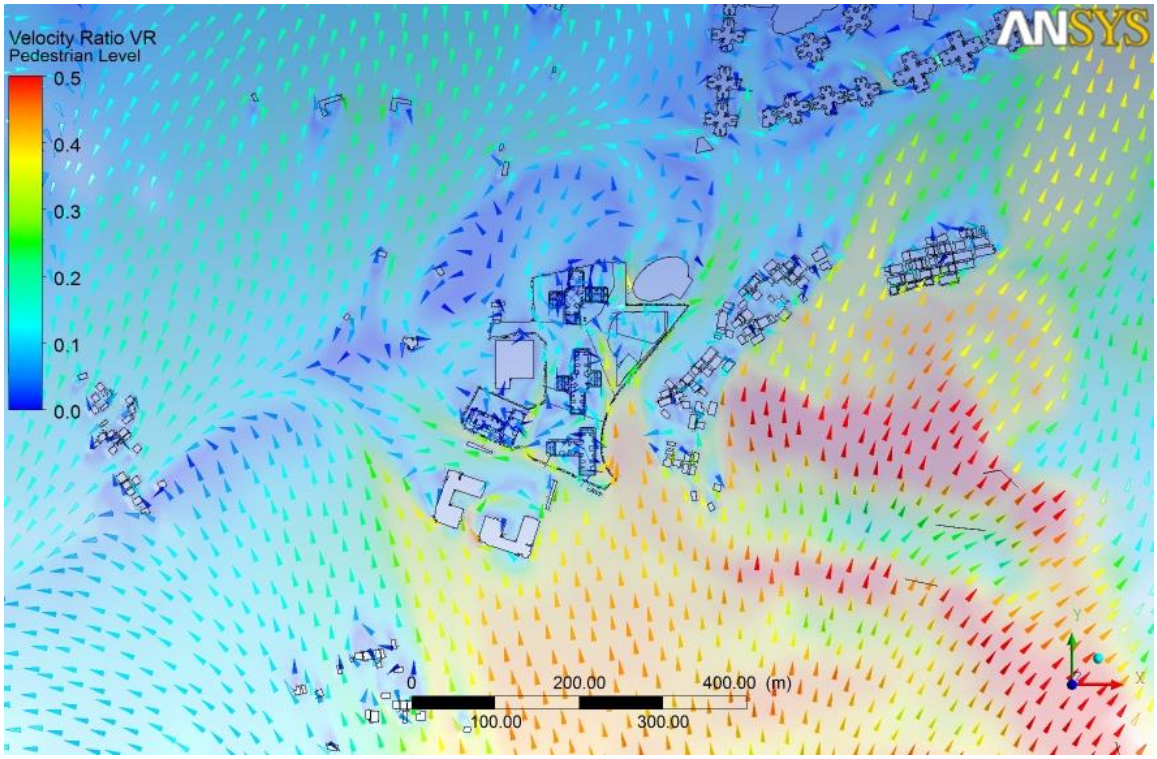


Velocity Ratio (VR) Vector Diagram of Proposed Scheme at 2m above Ground Level

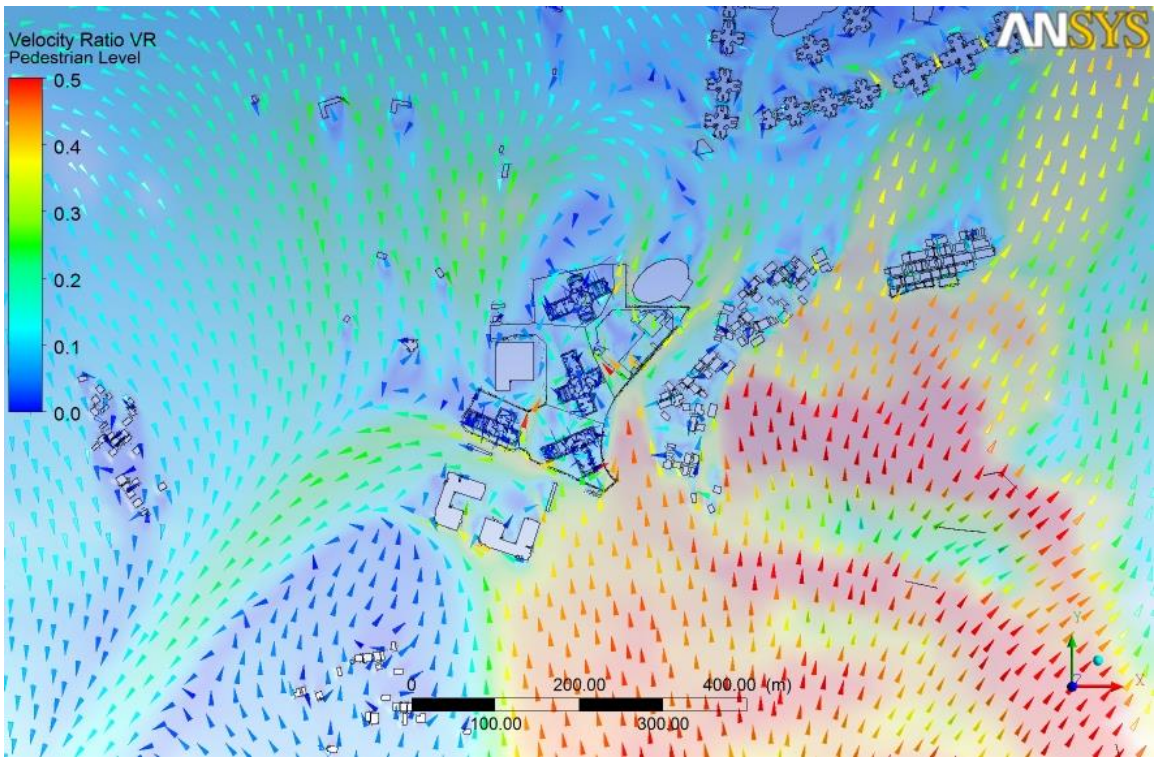


Prevailing Wind Direction: Southwest (SW)

Velocity Ratio (VR) Vector Diagram of Initial Scheme at 2m above Ground Level



Velocity Ratio (VR) Vector Diagram of Proposed Scheme at 2m above Ground Level



APPENDIX II: DETAILED VR_W RESULTS FOR ALL TEST POINTS

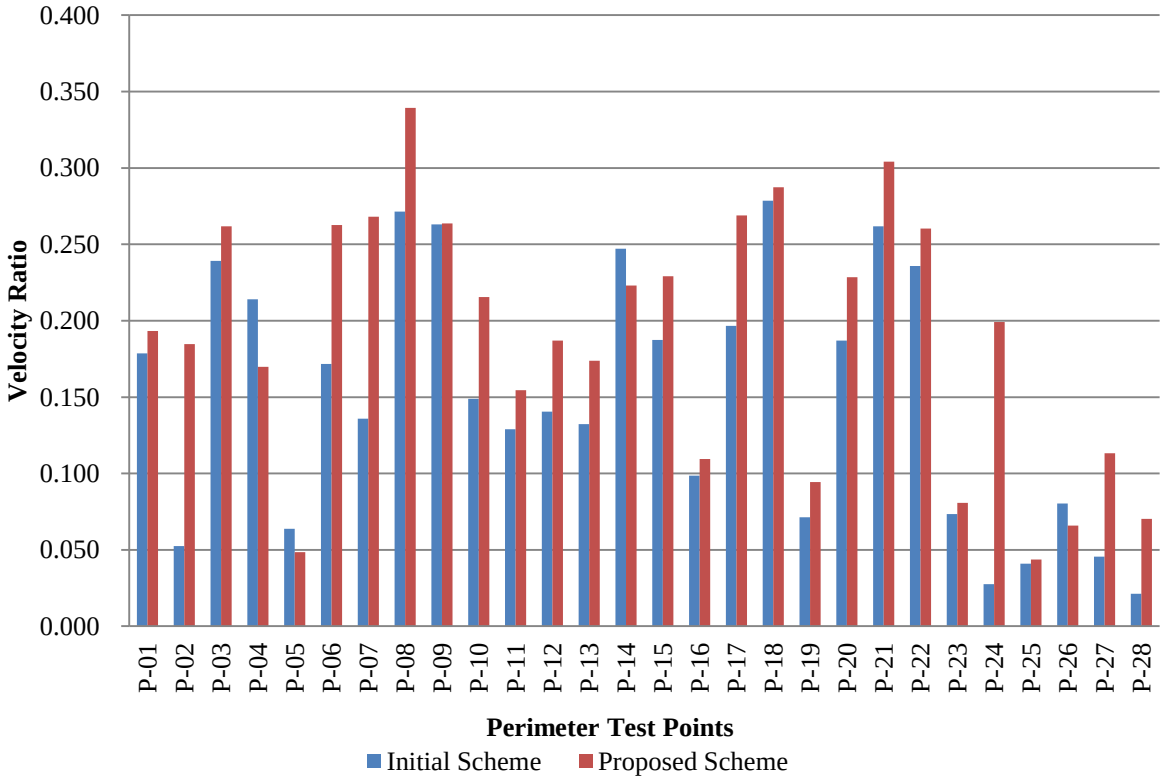
Weighted Velocity Ratio (VRw)

Test Point No.	VR_w for Initial Scheme	VR_w for Proposed Scheme	Difference in VR_w between Initial and Proposed Scheme
Perimeter Test Points			
P-01	0.179	0.193	0.015
P-02	0.052	0.185	0.132
P-03	0.239	0.262	0.023
P-04	0.214	0.170	-0.044
P-05	0.064	0.048	-0.015
P-06	0.172	0.263	0.091
P-07	0.136	0.268	0.132
P-08	0.271	0.339	0.068
P-09	0.263	0.264	0.001
P-10	0.149	0.215	0.067
P-11	0.129	0.155	0.026
P-12	0.140	0.187	0.047
P-13	0.132	0.174	0.041
P-14	0.247	0.223	-0.024
P-15	0.187	0.229	0.042
P-16	0.099	0.109	0.011
P-17	0.197	0.269	0.072
P-18	0.279	0.287	0.009
P-19	0.071	0.094	0.023
P-20	0.187	0.229	0.042
P-21	0.262	0.304	0.042
P-22	0.236	0.260	0.024
P-23	0.073	0.081	0.007
P-24	0.027	0.199	0.172
P-25	0.041	0.044	0.003
P-26	0.080	0.066	-0.015
P-27	0.046	0.113	0.068
P-28	0.021	0.070	0.049

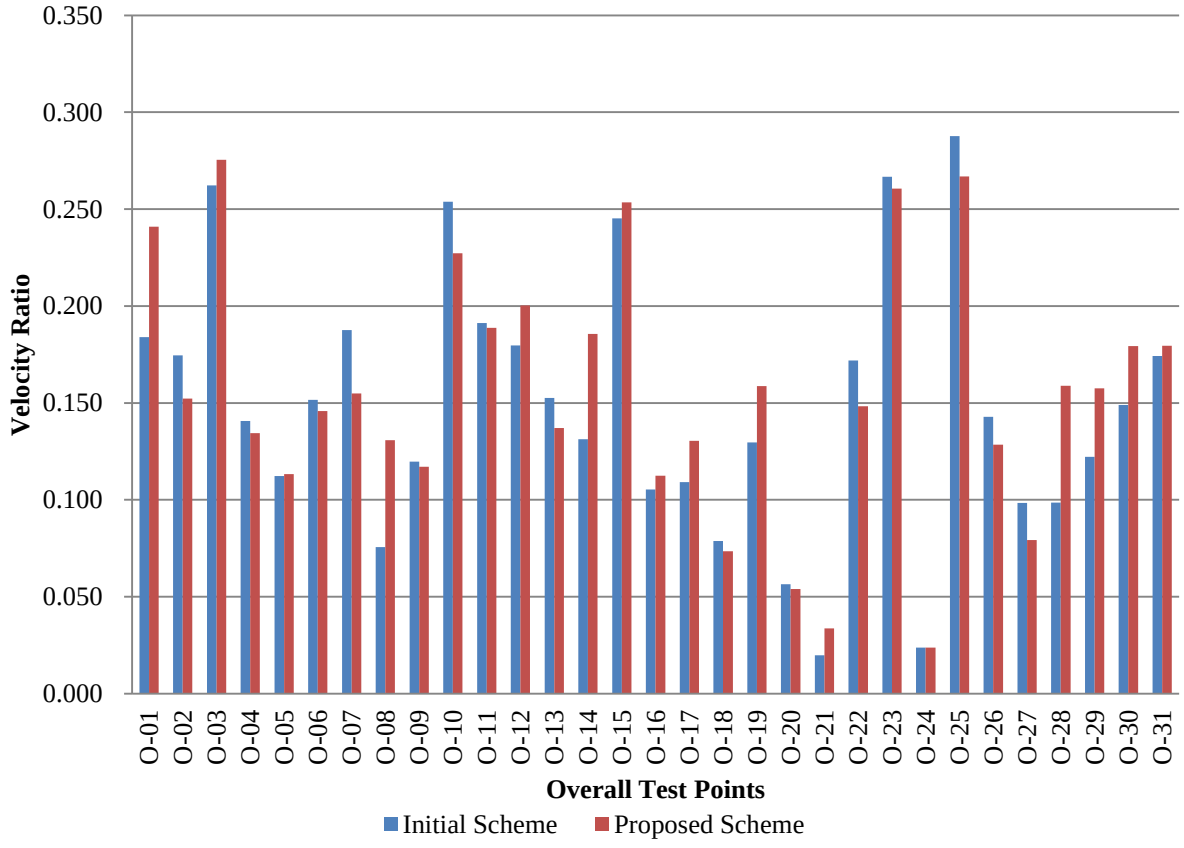
Test Point No.	VR_w for Initial Scheme	VR_w for Proposed Scheme	Difference in VR_w between Initial and Proposed Scheme
Overall Test Points			
O-01	0.184	0.241	0.057
O-02	0.174	0.152	-0.022
O-03	0.262	0.275	0.013
O-04	0.141	0.134	-0.006
O-05	0.112	0.113	0.001
O-06	0.152	0.146	-0.006
O-07	0.188	0.155	-0.033
O-08	0.076	0.131	0.055
O-09	0.120	0.117	-0.003
O-10	0.254	0.227	-0.027
O-11	0.191	0.189	-0.003
O-12	0.180	0.200	0.021
O-13	0.153	0.137	-0.015
O-14	0.131	0.186	0.054
O-15	0.245	0.254	0.008
O-16	0.105	0.112	0.007
O-17	0.109	0.130	0.021
O-18	0.079	0.073	-0.005
O-19	0.130	0.159	0.029
O-20	0.056	0.054	-0.002
O-21	0.020	0.034	0.014
O-22	0.172	0.148	-0.024
O-23	0.267	0.261	-0.006
O-24	0.024	0.024	0.000
O-25	0.288	0.267	-0.021
O-26	0.143	0.129	-0.014
O-27	0.098	0.079	-0.019
O-28	0.099	0.159	0.060
O-29	0.122	0.158	0.035
O-30	0.149	0.179	0.030
O-31	0.174	0.180	0.005
O-32	0.190	0.188	-0.001
O-33	0.125	0.128	0.003
O-34	0.239	0.269	0.030
O-35	0.172	0.161	-0.011
O-36	0.302	0.319	0.017
O-37	0.255	0.267	0.012
O-38	0.172	0.195	0.023
O-39	0.172	0.209	0.037
O-40	0.158	0.167	0.008
O-41	0.203	0.235	0.031
O-42	0.199	0.209	0.010
O-43	0.200	0.202	0.001
O-44	0.312	0.282	-0.031
O-45	0.319	0.291	-0.027
O-46	0.271	0.244	-0.027
O-47	0.067	0.064	-0.003
O-48	0.394	0.415	0.022
O-49	0.345	0.363	0.018
O-50	0.328	0.298	-0.030
O-51	0.296	0.290	-0.005
O-52	0.232	0.226	-0.006
O-53	0.186	0.151	-0.035
O-54	0.196	0.221	0.025
O-55	0.164	0.179	0.015

Test Point No.	VR_w for Initial Scheme	VR_w for Proposed Scheme	Difference in VR_w between Initial and Proposed Scheme
O-56	0.186	0.188	0.002
O-57	0.244	0.228	-0.016
O-58	0.129	0.129	0.000
O-59	0.215	0.252	0.038
O-60	0.183	0.212	0.029
O-61	0.167	0.178	0.011
O-62	0.214	0.230	0.016
O-63	0.197	0.204	0.007
O-64	0.168	0.181	0.013
O-65	0.300	0.302	0.002

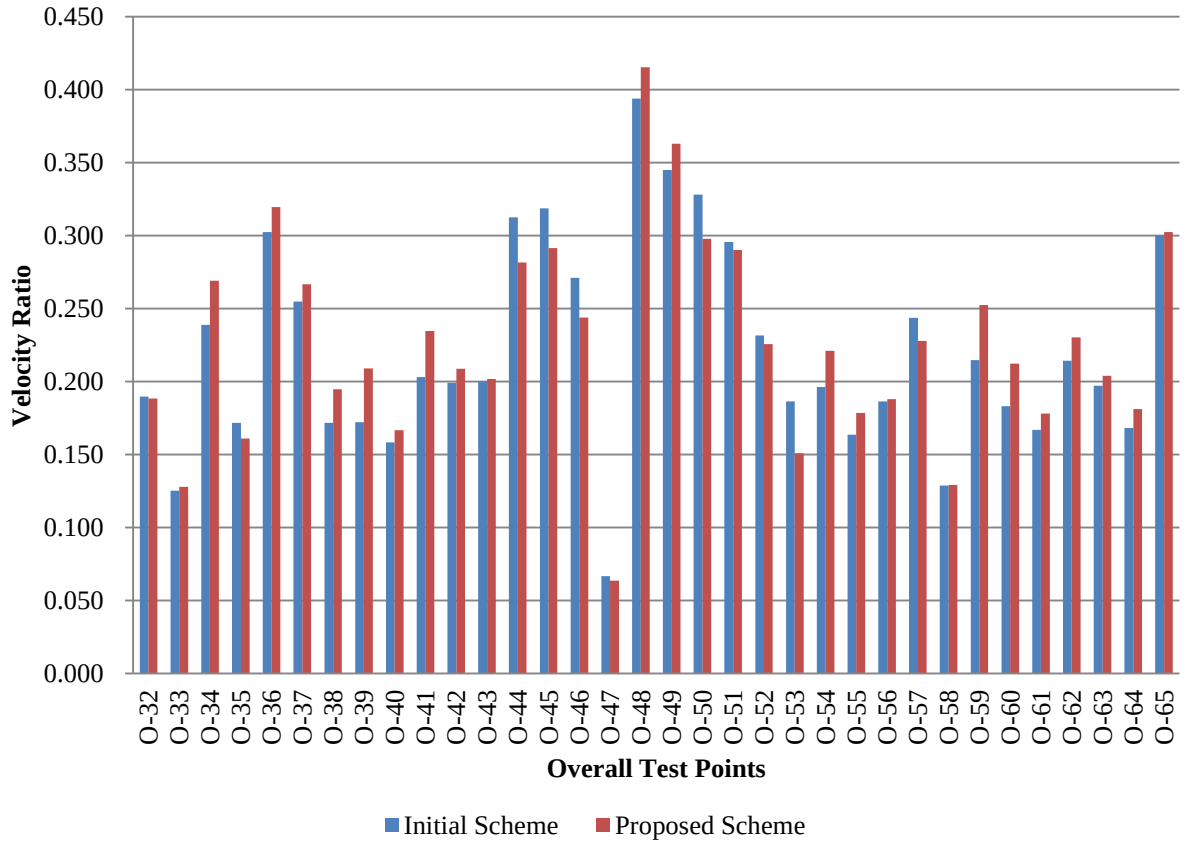
Weighted Velocity Ratios (VR_w) of Perimeter Test Points P-01 to P-28



Weighted Velocity Ratios (VR_w) of Overall Test Points O-01 to O-31



Weighted Velocity Ratios (VR_w) of Overall Test Points O-32 to O-65



APPENDIX III: DETAILED VELOCITY RATIO (VR) RESULTS FOR ALL TEST POINTS

Prevailing Wind Direction: East-Northeast (ENE)

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Perimeter Test Points			
P-01	0.072	0.250	0.178
P-02	0.039	0.153	0.114
P-03	0.352	0.342	-0.010
P-04	0.203	0.202	-0.001
P-05	0.079	0.030	-0.049
P-06	0.070	0.403	0.333
P-07	0.213	0.421	0.208
P-08	0.433	0.519	0.086
P-09	0.552	0.543	-0.009
P-10	0.145	0.409	0.263
P-11	0.245	0.261	0.016
P-12	0.207	0.293	0.086
P-13	0.170	0.338	0.167
P-14	0.190	0.147	-0.043
P-15	0.350	0.437	0.087
P-16	0.063	0.171	0.108
P-17	0.330	0.428	0.098
P-18	0.472	0.445	-0.027
P-19	0.007	0.114	0.107
P-20	0.163	0.253	0.090
P-21	0.322	0.430	0.108
P-22	0.316	0.320	0.003
P-23	0.032	0.117	0.084
P-24	0.019	0.280	0.261
P-25	0.023	0.037	0.014
P-26	0.117	0.060	-0.057
P-27	0.059	0.189	0.130
P-28	0.019	0.066	0.048

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Overall Test Points			
O-01	0.220	0.227	0.007
O-02	0.341	0.373	0.032
O-03	0.248	0.239	-0.009
O-04	0.260	0.282	0.022
O-05	0.086	0.047	-0.039
O-06	0.116	0.055	-0.061
O-07	0.275	0.140	-0.135
O-08	0.039	0.110	0.070
O-09	0.041	0.129	0.088
O-10	0.139	0.124	-0.015
O-11	0.101	0.020	-0.080
O-12	0.143	0.098	-0.045
O-13	0.202	0.264	0.062
O-14	0.042	0.292	0.250
O-15	0.324	0.368	0.044
O-16	0.103	0.142	0.038
O-17	0.043	0.127	0.085
O-18	0.169	0.147	-0.022
O-19	0.190	0.211	0.021
O-20	0.045	0.038	-0.007
O-21	0.034	0.039	0.005
O-22	0.196	0.081	-0.114
O-23	0.306	0.212	-0.094
O-24	0.013	0.022	0.008
O-25	0.391	0.249	-0.142
O-26	0.179	0.051	-0.128
O-27	0.149	0.124	-0.025
O-28	0.159	0.252	0.093
O-29	0.144	0.232	0.088
O-30	0.149	0.218	0.070
O-31	0.148	0.130	-0.018
O-32	0.306	0.274	-0.032
O-33	0.128	0.114	-0.015
O-34	0.283	0.369	0.086
O-35	0.160	0.121	-0.038
O-36	0.454	0.529	0.074
O-37	0.317	0.417	0.100
O-38	0.210	0.237	0.027
O-39	0.168	0.174	0.006
O-40	0.343	0.346	0.002
O-41	0.418	0.464	0.046
O-42	0.480	0.503	0.023
O-43	0.339	0.274	-0.066
O-44	0.398	0.289	-0.108
O-45	0.436	0.285	-0.150
O-46	0.405	0.253	-0.152
O-47	0.070	0.059	-0.011
O-48	0.461	0.543	0.082
O-49	0.379	0.407	0.028
O-50	0.585	0.476	-0.109
O-51	0.589	0.503	-0.086
O-52	0.143	0.300	0.157
O-53	0.104	0.115	0.010
O-54	0.074	0.110	0.036

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
O-55	0.091	0.221	0.130
O-56	0.023	0.093	0.070
O-57	0.189	0.164	-0.025
O-58	0.050	0.046	-0.004
O-59	0.196	0.159	-0.037
O-60	0.031	0.101	0.070
O-61	0.048	0.100	0.053
O-62	0.258	0.279	0.021
O-63	0.226	0.230	0.004
O-64	0.202	0.233	0.031
O-65	0.329	0.299	-0.030

Prevailing Wind Direction: East (E)

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Perimeter Test Points			
P-01	0.100	0.099	-0.001
P-02	0.040	0.188	0.148
P-03	0.339	0.343	0.005
P-04	0.221	0.198	-0.022
P-05	0.094	0.075	-0.019
P-06	0.064	0.153	0.088
P-07	0.053	0.331	0.278
P-08	0.262	0.424	0.162
P-09	0.370	0.316	-0.054
P-10	0.218	0.205	-0.013
P-11	0.156	0.107	-0.049
P-12	0.162	0.249	0.087
P-13	0.167	0.268	0.101
P-14	0.202	0.278	0.075
P-15	0.237	0.379	0.142
P-16	0.130	0.178	0.047
P-17	0.249	0.313	0.064
P-18	0.316	0.322	0.006
P-19	0.061	0.110	0.049
P-20	0.055	0.264	0.209
P-21	0.223	0.372	0.149
P-22	0.192	0.303	0.111
P-23	0.064	0.007	-0.057
P-24	0.045	0.280	0.236
P-25	0.013	0.027	0.014
P-26	0.034	0.047	0.013
P-27	0.036	0.125	0.089
P-28	0.013	0.091	0.077

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Overall Test Points			
O-01	0.223	0.099	-0.001
O-02	0.196	0.188	0.148
O-03	0.277	0.343	0.005
O-04	0.117	0.198	-0.022
O-05	0.048	0.075	-0.019
O-06	0.103	0.153	0.088
O-07	0.171	0.331	0.278
O-08	0.034	0.424	0.162
O-09	0.144	0.316	-0.054
O-10	0.222	0.205	-0.013
O-11	0.165	0.107	-0.049
O-12	0.096	0.249	0.087
O-13	0.211	0.268	0.101
O-14	0.191	0.278	0.075
O-15	0.283	0.379	0.142
O-16	0.069	0.178	0.047
O-17	0.131	0.313	0.064
O-18	0.022	0.322	0.006
O-19	0.148	0.110	0.049
O-20	0.033	0.264	0.209
O-21	0.023	0.372	0.149
O-22	0.127	0.303	0.111
O-23	0.151	0.007	-0.057
O-24	0.022	0.280	0.236
O-25	0.221	0.027	0.014
O-26	0.162	0.047	0.013
O-27	0.146	0.125	0.089
O-28	0.076	0.091	0.077
O-29	0.105	0.367	0.144
O-30	0.117	0.094	-0.102
O-31	0.105	0.277	0.000
O-32	0.213	0.142	0.025
O-33	0.082	0.074	0.026
O-34	0.181	0.108	0.005
O-35	0.148	0.201	0.030
O-36	0.135	0.133	0.098
O-37	0.129	0.059	-0.086
O-38	0.099	0.197	-0.025
O-39	0.053	0.219	0.054
O-40	0.075	0.166	0.070
O-41	0.164	0.226	0.014
O-42	0.143	0.232	0.040
O-43	0.132	0.283	0.000
O-44	0.298	0.110	0.040
O-45	0.298	0.067	-0.064
O-46	0.249	0.034	0.012
O-47	0.051	0.234	0.086
O-48	0.342	0.031	-0.002
O-49	0.345	0.032	0.009
O-50	0.315	0.114	-0.013
O-51	0.272	0.192	0.041
O-52	0.130	0.017	-0.006
O-53	0.159	0.222	0.000
O-54	0.201	0.138	-0.025

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
O-55	0.205	0.090	-0.056
O-56	0.085	0.152	0.076
O-57	0.014	0.143	0.037
O-58	0.100	0.123	0.005
O-59	0.411	0.143	0.038
O-60	0.421	0.248	0.035
O-61	0.376	0.049	-0.033
O-62	0.400	0.178	-0.004
O-63	0.336	0.131	-0.018
O-64	0.269	0.127	-0.008
O-65	0.213	0.085	-0.045

Prevailing Wind Direction: Northeast (NE)

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Perimeter Test Points			
P-01	0.061	0.053	-0.008
P-02	0.012	0.023	0.011
P-03	0.044	0.046	0.002
P-04	0.040	0.013	-0.026
P-05	0.012	0.010	-0.002
P-06	0.060	0.070	0.010
P-07	0.040	0.035	-0.005
P-08	0.066	0.060	-0.006
P-09	0.072	0.017	-0.056
P-10	0.002	0.021	0.019
P-11	0.032	0.016	-0.016
P-12	0.056	0.044	-0.011
P-13	0.026	0.018	-0.007
P-14	0.016	0.052	0.036
P-15	0.015	0.029	0.014
P-16	0.035	0.030	-0.005
P-17	0.029	0.049	0.020
P-18	0.061	0.044	-0.017
P-19	0.010	0.015	0.005
P-20	0.037	0.064	0.027
P-21	0.032	0.061	0.030
P-22	0.052	0.022	-0.030
P-23	0.021	0.023	0.002
P-24	0.004	0.045	0.042
P-25	0.010	0.008	-0.002
P-26	0.018	0.017	-0.001
P-27	0.008	0.012	0.005
P-28	0.002	0.002	0.000

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Overall Test Points			
O-01	0.067	0.064	-0.003
O-02	0.052	0.064	0.012
O-03	0.055	0.032	-0.023
O-04	0.066	0.036	-0.030
O-05	0.098	0.122	0.024
O-06	0.107	0.129	0.022
O-07	0.083	0.089	0.006
O-08	0.061	0.068	0.007
O-09	0.037	0.046	0.010
O-10	0.158	0.163	0.005
O-11	0.104	0.115	0.011
O-12	0.108	0.126	0.018
O-13	0.018	0.010	-0.007
O-14	0.053	0.058	0.005
O-15	0.072	0.062	-0.009
O-16	0.053	0.041	-0.012
O-17	0.054	0.062	0.008
O-18	0.005	0.011	0.006
O-19	0.011	0.014	0.003
O-20	0.026	0.013	-0.013
O-21	0.015	0.016	0.001
O-22	0.051	0.049	-0.001
O-23	0.240	0.246	0.005
O-24	0.012	0.015	0.003
O-25	0.229	0.229	0.000
O-26	0.022	0.021	-0.001
O-27	0.052	0.063	0.011
O-28	0.056	0.044	-0.012
O-29	0.045	0.022	-0.023
O-30	0.035	0.006	-0.029
O-31	0.008	0.029	0.021
O-32	0.052	0.061	0.009
O-33	0.043	0.043	0.000
O-34	0.238	0.224	-0.015
O-35	0.134	0.115	-0.019
O-36	0.196	0.186	-0.010
O-37	0.151	0.169	0.019
O-38	0.084	0.062	-0.022
O-39	0.100	0.091	-0.009
O-40	0.111	0.103	-0.008
O-41	0.088	0.082	-0.006
O-42	0.176	0.176	0.000
O-43	0.226	0.223	-0.002
O-44	0.290	0.280	-0.010
O-45	0.323	0.314	-0.009
O-46	0.190	0.176	-0.013
O-47	0.050	0.060	0.009
O-48	0.387	0.362	-0.025
O-49	0.293	0.269	-0.024
O-50	0.300	0.304	0.004
O-51	0.327	0.322	-0.005
O-52	0.205	0.197	-0.008
O-53	0.159	0.145	-0.014
O-54	0.162	0.158	-0.005

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
O-55	0.120	0.106	-0.014
O-56	0.215	0.215	0.000
O-57	0.215	0.209	-0.006
O-58	0.027	0.064	0.037
O-59	0.089	0.054	-0.035
O-60	0.060	0.017	-0.043
O-61	0.052	0.093	0.041
O-62	0.002	0.044	0.043
O-63	0.042	0.042	0.000
O-64	0.069	0.043	-0.026
O-65	0.345	0.358	0.014

Prevailing Wind Direction: East-Southeast (ESE)

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Perimeter Test Points			
P-01	0.264	0.193	-0.071
P-02	0.078	0.111	0.033
P-03	0.273	0.299	0.026
P-04	0.173	0.144	-0.029
P-05	0.023	0.034	0.010
P-06	0.283	0.286	0.003
P-07	0.140	0.150	0.010
P-08	0.239	0.227	-0.012
P-09	0.068	0.108	0.040
P-10	0.328	0.200	-0.127
P-11	0.072	0.160	0.088
P-12	0.072	0.022	-0.050
P-13	0.104	0.019	-0.085
P-14	0.335	0.185	-0.149
P-15	0.162	0.030	-0.132
P-16	0.045	0.013	-0.032
P-17	0.023	0.052	0.029
P-18	0.039	0.075	0.036
P-19	0.042	0.036	-0.007
P-20	0.274	0.160	-0.114
P-21	0.311	0.172	-0.139
P-22	0.267	0.192	-0.075
P-23	0.034	0.008	-0.026
P-24	0.014	0.098	0.084
P-25	0.019	0.019	0.000
P-26	0.071	0.051	-0.020
P-27	0.047	0.058	0.011
P-28	0.021	0.041	0.021

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Overall Test Points			
O-01	0.115	0.044	-0.071
O-02	0.090	0.083	-0.007
O-03	0.045	0.078	0.032
O-04	0.165	0.113	-0.052
O-05	0.225	0.337	0.112
O-06	0.412	0.522	0.110
O-07	0.193	0.185	-0.008
O-08	0.021	0.160	0.139
O-09	0.250	0.211	-0.039
O-10	0.464	0.449	-0.014
O-11	0.511	0.509	-0.002
O-12	0.500	0.504	0.004
O-13	0.184	0.252	0.068
O-14	0.248	0.291	0.043
O-15	0.215	0.282	0.067
O-16	0.061	0.125	0.064
O-17	0.078	0.200	0.122
O-18	0.102	0.222	0.120
O-19	0.223	0.280	0.057
O-20	0.167	0.249	0.082
O-21	0.009	0.033	0.024
O-22	0.149	0.059	-0.090
O-23	0.311	0.198	-0.113
O-24	0.014	0.024	0.011
O-25	0.263	0.282	0.019
O-26	0.118	0.195	0.077
O-27	0.063	0.040	-0.023
O-28	0.175	0.229	0.054
O-29	0.163	0.258	0.096
O-30	0.208	0.311	0.103
O-31	0.224	0.238	0.014
O-32	0.166	0.230	0.064
O-33	0.270	0.238	-0.032
O-34	0.209	0.344	0.135
O-35	0.391	0.410	0.019
O-36	0.418	0.466	0.048
O-37	0.407	0.358	-0.049
O-38	0.204	0.226	0.022
O-39	0.233	0.252	0.019
O-40	0.228	0.174	-0.053
O-41	0.198	0.147	-0.051
O-42	0.095	0.174	0.078
O-43	0.164	0.108	-0.056
O-44	0.308	0.232	-0.077
O-45	0.267	0.223	-0.043
O-46	0.193	0.188	-0.005
O-47	0.092	0.068	-0.024
O-48	0.294	0.347	0.052
O-49	0.292	0.294	0.002
O-50	0.214	0.064	-0.151
O-51	0.222	0.103	-0.119
O-52	0.498	0.442	-0.055
O-53	0.106	0.195	0.089
O-54	0.269	0.243	-0.026

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
O-55	0.080	0.105	0.025
O-56	0.612	0.591	-0.021
O-57	0.618	0.593	-0.026
O-58	0.142	0.063	-0.079
O-59	0.081	0.129	0.048
O-60	0.032	0.171	0.139
O-61	0.113	0.079	-0.034
O-62	0.115	0.055	-0.060
O-63	0.121	0.073	-0.049
O-64	0.141	0.136	-0.005
O-65	0.199	0.265	0.066

Prevailing Wind Direction: North-northeast (NNE)

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Perimeter Test Points			
P-01	0.195	0.193	-0.002
P-02	0.051	0.111	0.060
P-03	0.188	0.299	0.112
P-04	0.127	0.144	0.018
P-05	0.002	0.034	0.031
P-06	0.205	0.286	0.081
P-07	0.123	0.150	0.028
P-08	0.204	0.227	0.023
P-09	0.098	0.108	0.010
P-10	0.207	0.200	-0.007
P-11	0.034	0.160	0.126
P-12	0.042	0.022	-0.020
P-13	0.115	0.019	-0.096
P-14	0.243	0.185	-0.057
P-15	0.182	0.030	-0.152
P-16	0.054	0.013	-0.041
P-17	0.011	0.052	0.042
P-18	0.052	0.075	0.023
P-19	0.049	0.036	-0.013
P-20	0.229	0.160	-0.069
P-21	0.240	0.172	-0.068
P-22	0.220	0.192	-0.028
P-23	0.032	0.008	-0.024
P-24	0.008	0.098	0.090
P-25	0.059	0.019	-0.041
P-26	0.066	0.051	-0.015
P-27	0.031	0.058	0.027
P-28	0.012	0.041	0.030

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Overall Test Points			
O-01	0.085	0.111	0.025
O-02	0.130	0.183	0.053
O-03	0.210	0.287	0.077
O-04	0.040	0.032	-0.008
O-05	0.185	0.087	-0.098
O-06	0.128	0.052	-0.076
O-07	0.150	0.092	-0.058
O-08	0.057	0.072	0.015
O-09	0.033	0.076	0.042
O-10	0.303	0.238	-0.065
O-11	0.268	0.224	-0.044
O-12	0.250	0.218	-0.032
O-13	0.147	0.025	-0.123
O-14	0.088	0.035	-0.053
O-15	0.095	0.041	-0.054
O-16	0.051	0.052	0.001
O-17	0.053	0.115	0.062
O-18	0.107	0.034	-0.074
O-19	0.004	0.043	0.039
O-20	0.048	0.037	-0.011
O-21	0.016	0.033	0.018
O-22	0.118	0.207	0.089
O-23	0.198	0.312	0.114
O-24	0.017	0.014	-0.003
O-25	0.184	0.276	0.091
O-26	0.082	0.109	0.028
O-27	0.060	0.036	-0.024
O-28	0.058	0.077	0.019
O-29	0.068	0.117	0.049
O-30	0.089	0.159	0.071
O-31	0.084	0.117	0.032
O-32	0.027	0.025	-0.002
O-33	0.029	0.085	0.056
O-34	0.225	0.335	0.110
O-35	0.068	0.056	-0.012
O-36	0.377	0.424	0.047
O-37	0.324	0.382	0.058
O-38	0.114	0.110	-0.004
O-39	0.119	0.199	0.080
O-40	0.011	0.124	0.113
O-41	0.015	0.167	0.152
O-42	0.106	0.101	-0.005
O-43	0.077	0.207	0.130
O-44	0.180	0.276	0.096
O-45	0.176	0.263	0.087
O-46	0.164	0.236	0.072
O-47	0.066	0.090	0.024
O-48	0.483	0.517	0.034
O-49	0.356	0.398	0.042

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
O-50	0.379	0.370	-0.009
O-51	0.069	0.201	0.132
O-52	0.416	0.356	-0.060
O-53	0.294	0.237	-0.057
O-54	0.222	0.185	-0.037
O-55	0.130	0.125	-0.005
O-56	0.267	0.246	-0.021
O-57	0.452	0.425	-0.028
O-58	0.170	0.173	0.003
O-59	0.098	0.238	0.140
O-60	0.092	0.132	0.040
O-61	0.039	0.058	0.020
O-62	0.120	0.142	0.022
O-63	0.043	0.050	0.007
O-64	0.063	0.054	-0.009
O-65	0.457	0.541	0.084

Prevailing Wind Direction: Southwest (SW)

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Perimeter Test Points			
P-01	0.141	0.040	-0.100
P-02	0.016	0.129	0.113
P-03	0.018	0.022	0.004
P-04	0.149	0.103	-0.046
P-05	0.066	0.016	-0.050
P-06	0.111	0.051	-0.060
P-07	0.098	0.037	-0.062
P-08	0.102	0.046	-0.056
P-09	0.129	0.110	-0.018
P-10	0.077	0.157	0.081
P-11	0.160	0.127	-0.033
P-12	0.310	0.175	-0.136
P-13	0.230	0.079	-0.150
P-14	0.218	0.212	-0.006
P-15	0.012	0.065	0.053
P-16	0.225	0.118	-0.107
P-17	0.094	0.320	0.226
P-18	0.213	0.171	-0.042
P-19	0.191	0.137	-0.054
P-20	0.362	0.129	-0.233
P-21	0.074	0.191	0.117
P-22	0.212	0.213	0.000
P-23	0.209	0.319	0.110
P-24	0.037	0.153	0.117
P-25	0.115	0.024	-0.092
P-26	0.076	0.062	-0.014
P-27	0.054	0.178	0.123
P-28	0.034	0.164	0.130

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Overall Test Points			
O-01	0.226	0.276	0.050
O-02	0.076	0.038	-0.038
O-03	0.044	0.146	0.102
O-04	0.191	0.181	-0.010
O-05	0.081	0.073	-0.008
O-06	0.108	0.137	0.029
O-07	0.059	0.142	0.083
O-08	0.378	0.215	-0.163
O-09	0.227	0.230	0.003
O-10	0.361	0.240	-0.122
O-11	0.066	0.025	-0.041
O-12	0.199	0.223	0.023
O-13	0.200	0.006	-0.194
O-14	0.351	0.362	0.011
O-15	0.364	0.364	-0.001
O-16	0.267	0.280	0.013
O-17	0.372	0.274	-0.097
O-18	0.173	0.102	-0.071
O-19	0.107	0.130	0.023
O-20	0.081	0.098	0.017
O-21	0.007	0.012	0.004
O-22	0.267	0.307	0.040
O-23	0.460	0.499	0.039
O-24	0.027	0.029	0.002
O-25	0.407	0.429	0.022
O-26	0.275	0.321	0.045
O-27	0.106	0.055	-0.051
O-28	0.138	0.202	0.064
O-29	0.123	0.163	0.040
O-30	0.143	0.186	0.044
O-31	0.247	0.289	0.042
O-32	0.381	0.398	0.017
O-33	0.384	0.415	0.032
O-34	0.182	0.255	0.073
O-35	0.400	0.437	0.037
O-36	0.368	0.396	0.028
O-37	0.374	0.415	0.041
O-38	0.221	0.287	0.066
O-39	0.235	0.323	0.087
O-40	0.214	0.281	0.067
O-41	0.172	0.185	0.014
O-42	0.025	0.030	0.005
O-43	0.294	0.327	0.033
O-44	0.361	0.399	0.038
O-45	0.391	0.421	0.030
O-46	0.335	0.371	0.036
O-47	0.097	0.110	0.013
O-48	0.383	0.394	0.010
O-49	0.313	0.333	0.020
O-50	0.104	0.133	0.029
O-51	0.214	0.255	0.040
O-52	0.098	0.042	-0.056
O-53	0.064	0.008	-0.056
O-54	0.263	0.038	-0.225

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
O-55	0.401	0.060	-0.341
O-56	0.166	0.052	-0.114
O-57	0.109	0.055	-0.054
O-58	0.127	0.181	0.054
O-59	0.148	0.138	-0.010
O-60	0.083	0.079	-0.004
O-61	0.127	0.118	-0.009
O-62	0.256	0.268	0.012
O-63	0.233	0.237	0.003
O-64	0.247	0.256	0.009
O-65	0.363	0.359	-0.004

Prevailing Wind Direction: South (S)

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Perimeter Test Points			
P-01	0.030	0.033	0.003
P-02	0.024	0.065	0.041
P-03	0.104	0.017	-0.087
P-04	0.097	0.070	-0.027
P-05	0.052	0.025	-0.027
P-06	0.092	0.102	0.010
P-07	0.041	0.137	0.095
P-08	0.156	0.151	-0.005
P-09	0.091	0.164	0.073
P-10	0.046	0.048	0.003
P-11	0.112	0.120	0.007
P-12	0.083	0.131	0.048
P-13	0.115	0.059	-0.055
P-14	0.229	0.190	-0.039
P-15	0.016	0.024	0.007
P-16	0.078	0.069	-0.008
P-17	0.047	0.258	0.211
P-18	0.172	0.154	-0.018
P-19	0.135	0.083	-0.052
P-20	0.277	0.187	-0.090
P-21	0.186	0.212	0.026
P-22	0.151	0.190	0.039
P-23	0.174	0.212	0.038
P-24	0.048	0.086	0.038
P-25	0.124	0.018	-0.106
P-26	0.062	0.050	-0.012
P-27	0.046	0.131	0.085
P-28	0.033	0.122	0.089

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Overall Test Points			
O-01	0.088	0.151	0.063
O-02	0.062	0.081	0.019
O-03	0.229	0.170	-0.059
O-04	0.164	0.117	-0.047
O-05	0.076	0.011	-0.065
O-06	0.069	0.064	-0.005
O-07	0.030	0.065	0.036
O-08	0.176	0.160	-0.016
O-09	0.141	0.145	0.003
O-10	0.188	0.186	-0.002
O-11	0.061	0.041	-0.020
O-12	0.148	0.178	0.030
O-13	0.095	0.034	-0.060
O-14	0.228	0.223	-0.005
O-15	0.226	0.223	-0.003
O-16	0.165	0.161	-0.004
O-17	0.205	0.191	-0.014
O-18	0.112	0.107	-0.005
O-19	0.167	0.186	0.019
O-20	0.066	0.076	0.010
O-21	0.006	0.014	0.008
O-22	0.236	0.215	-0.021
O-23	0.367	0.352	-0.015
O-24	0.025	0.016	-0.009
O-25	0.295	0.291	-0.004
O-26	0.174	0.163	-0.011
O-27	0.089	0.086	-0.003
O-28	0.062	0.116	0.054
O-29	0.061	0.111	0.050
O-30	0.108	0.139	0.031
O-31	0.291	0.274	-0.017
O-32	0.282	0.273	-0.009
O-33	0.298	0.282	-0.017
O-34	0.171	0.166	-0.005
O-35	0.309	0.274	-0.035
O-36	0.259	0.245	-0.014
O-37	0.260	0.248	-0.012
O-38	0.122	0.180	0.059
O-39	0.099	0.176	0.077
O-40	0.136	0.099	-0.037
O-41	0.159	0.127	-0.033
O-42	0.093	0.096	0.003
O-43	0.031	0.088	0.057
O-44	0.112	0.168	0.056
O-45	0.242	0.233	-0.010
O-46	0.202	0.187	-0.015
O-47	0.020	0.018	-0.002
O-48	0.152	0.151	0.000
O-49	0.132	0.121	-0.010
O-50	0.097	0.131	0.034
O-51	0.089	0.110	0.021
O-52	0.098	0.063	-0.035
O-53	0.034	0.019	-0.016
O-54	0.038	0.049	0.010

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
O-55	0.165	0.143	-0.022
O-56	0.121	0.086	-0.035
O-57	0.201	0.156	-0.045
O-58	0.256	0.267	0.011
O-59	0.193	0.192	-0.001
O-60	0.202	0.177	-0.025
O-61	0.159	0.167	0.009
O-62	0.204	0.201	-0.003
O-63	0.202	0.209	0.007
O-64	0.249	0.258	0.009
O-65	0.358	0.361	0.003

Prevailing Wind Direction: North (N)

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Perimeter Test Points			
P-01	0.631	0.536	-0.095
P-02	0.150	0.482	0.331
P-03	0.274	0.379	0.105
P-04	0.502	0.326	-0.176
P-05	0.085	0.062	-0.022
P-06	0.619	0.629	0.010
P-07	0.346	0.365	0.019
P-08	0.450	0.511	0.061
P-09	0.153	0.199	0.046
P-10	0.195	0.212	0.017
P-11	0.086	0.217	0.132
P-12	0.089	0.242	0.153
P-13	0.059	0.134	0.075
P-14	0.570	0.381	-0.188
P-15	0.170	0.127	-0.043
P-16	0.102	0.035	-0.067
P-17	0.269	0.305	0.035
P-18	0.357	0.417	0.059
P-19	0.112	0.077	-0.034
P-20	0.419	0.336	-0.084
P-21	0.529	0.367	-0.163
P-22	0.393	0.337	-0.056
P-23	0.094	0.123	0.029
P-24	0.029	0.209	0.180
P-25	0.072	0.149	0.076
P-26	0.198	0.165	-0.033
P-27	0.086	0.099	0.013
P-28	0.057	0.066	0.009

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
Overall Test Points			
O-01	0.262	0.331	0.069
O-02	0.159	0.132	-0.026
O-03	0.627	0.657	0.031
O-04	0.125	0.074	-0.051
O-05	0.210	0.246	0.036
O-06	0.280	0.288	0.008
O-07	0.319	0.199	-0.120
O-08	0.089	0.182	0.093
O-09	0.187	0.201	0.015
O-10	0.390	0.374	-0.016
O-11	0.335	0.359	0.024
O-12	0.265	0.313	0.048
O-13	0.068	0.019	-0.049
O-14	0.042	0.032	-0.010
O-15	0.272	0.293	0.020
O-16	0.184	0.084	-0.100
O-17	0.099	0.209	0.110
O-18	0.052	0.048	-0.003
O-19	0.149	0.085	-0.065
O-20	0.087	0.057	-0.030
O-21	0.017	0.060	0.044
O-22	0.302	0.277	-0.025
O-23	0.375	0.326	-0.050
O-24	0.055	0.054	-0.001
O-25	0.359	0.318	-0.041
O-26	0.135	0.182	0.047
O-27	0.017	0.067	0.050
O-28	0.091	0.166	0.075
O-29	0.227	0.194	-0.033
O-30	0.328	0.339	0.010
O-31	0.431	0.363	-0.068
O-32	0.111	0.040	-0.071
O-33	0.108	0.174	0.066
O-34	0.363	0.321	-0.042
O-35	0.101	0.122	0.021
O-36	0.405	0.392	-0.013
O-37	0.335	0.332	-0.003
O-38	0.352	0.345	-0.007
O-39	0.473	0.513	0.039
O-40	0.181	0.238	0.057
O-41	0.252	0.297	0.045
O-42	0.187	0.196	0.009
O-43	0.262	0.193	-0.069
O-44	0.395	0.324	-0.071
O-45	0.326	0.290	-0.036
O-46	0.309	0.277	-0.032
O-47	0.100	0.079	-0.021
O-48	0.483	0.499	0.016
O-49	0.443	0.472	0.029
O-50	0.237	0.168	-0.069
O-51	0.244	0.186	-0.058
O-52	0.426	0.446	0.020
O-53	0.423	0.430	0.007
O-54	0.347	0.385	0.037

Test Point No.	VR for Initial Scheme	VR for Proposed Scheme	Difference in VR between Initial and Proposed Scheme
O-55	0.167	0.206	0.039
O-56	0.370	0.412	0.043
O-57	0.550	0.526	-0.024
O-58	0.278	0.275	-0.003
O-59	0.119	0.343	0.224
O-60	0.160	0.193	0.033
O-61	0.123	0.058	-0.065
O-62	0.046	0.071	0.024
O-63	0.125	0.119	-0.006
O-64	0.025	0.043	0.018
O-65	0.288	0.258	-0.030