AECOM

Hong Kong Housing Authority

CB20210520

Proposed Public Housing Development at Kam Sheung Road Site 6 (Phase 1 and 2), Yuen Long

Air Ventilation Assessment – Initial Study (AVA-IS)

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Table of Content

Page

1 INTRODUCTION 3

Background 3
Objectives 3
Content of This Report 3

2 SITE CHARACTERISTICS 4

Site and Its Surrounding Area 4

3 ASSESSMENT METHODOLOGY 6

Modelling Tool and Model Setup 6
Computational Domain 6
Assessment and Surrounding Areas 7
Studied Schemes 8
Baseline Scheme 8
Proposed Scheme 9
Wind Environment 15
Vertical Wind Profiles 16
Mesh Setup 17
Turbulence Model 18
Calculation Method and Boundary Condition 18

4 ASSESSMENT CRITERIA AND TEST POINTS LOCATION 18

Wind Velocity Ratio (VR) 18
Test Points 19

5 KEY FINDINGS OF AVA STUDY 20

Good design features 20
Wind Velocity Ratio Results 22
Site Air Ventilation Assessment 23
Local Air Ventilation Assessment 23

6 DIRECTIONAL ANALYSIS 25

NE: (Annual: 9.6%) 25
ENE: (Annual: 12.2%) 28
E: (Annual: 15.4%) 31
ESE: (Annual: 9.6%, Summer: 8.8%) 34
SE: (Annual: 8.6%, Summer: 7.5%) 37
SSE: (Annual: 6.6%, Summer: 9.2%) 40
S: (Annual: 6.7%, Summer: 13.3%) 43
SSW: (Annual: 7.7%, Summer: 16.7%) 46
SW: (Summer: 13.3%) 49
WSW: (Summer: 6.2%) 52
Overall Annual Frequency Weighted VR (76.4%) 55
Overall Summer Frequency Weighted VR (81.7%) 56

7 SUMMARY AND CONCLUSIONS 57

List of Tables

Table 3.1	Simulated Wind Directions and their corresponding percentage occurrence, at 500m height
Table 3.2	Roughness Length for Determining Vertical Wind Profiles under Different Wind Directions
Table 4.1	Test Point Groups and respective represented locations
Table 5.1	Summary of Wind Velocity Ratio
Table 5.2	Summary of Wind Velocity Ratio for Different Test Point Groups

List of Figures

Figure 2.1	Overview of the Project Area and its Surroundings (Source: GeoInfo Map)
Figure 2.2	Land Use of the Project Area and its Surroundings in Draft OZP (Source: Statutory Planning Portal 2)
Figure 3.1	Geometry of Computational Model
Figure 3.2	Boundaries of the Project Area, Assessment Area and Surrounding Area
Figure 3.3	Indicative Plan of Baseline Scheme (Master Layout)
Figure 3.4	Proposed Scheme – Master Layout Plan
Figure 3.5	Proposed Scheme – Ground Floor Layout
Figure 3.6	Proposed Scheme – First Floor Layout for Block A and Upper Ground Floor Layout for Block B, C, D & E
Figure 3.7	Proposed Scheme – Second Floor Layout for Block A and First Floor Layout for Block B, C, D & E
Figure 3.8	Proposed Scheme –Typical Floor Layout for Block A, B, D & E and Block C (1-4/F)
Figure 3.9	Proposed Scheme – Typical Floor Layout for Block C (5/F)
Figure 3.10	Proposed Scheme – Typical Floor Layout for Block C (6-15/F)
Figure 3.11	Model Geometry under East and South view
Figure 3.12	Model Geometry under West and North views
Figure 3.13	Location of data extraction in RAMS model
Figure 3.14	Wind Rose at Grid (X058, Y067) (500m height)
Figure 3.15	Mesh of the simulation domain
Figure 3.16	Prism layers near ground
Figure 4.1	Distribution of Test Points
Figure 5.1	Good Design Features in Baseline Scheme
Figure 5.2	Good Design Features in Proposed Scheme

Appendices

Appendix A	Wind Probability Table (obtained from Planning Department)
Appendix B	Wind Velocity Ratios (Simulation Results)

1 INTRODUCTION

Background

1.1 AECOM Asia Co. Ltd. has been commissioned by the Hong Kong Housing Authority (HKHA) to undertake an Air Ventilation Assessment (AVA) Study – Initial Study (IS) for the Public Housing Development located at Kam Sheung Road Site 6 (Phases 1 & 2), Yuen Long to examine the air ventilation impact of the proposed building design quantitatively and formulate effective and practicable measures enhancing the air ventilation as part of the continuous design improvement process.

Objectives

1.2 The purpose of this study is to fulfil the requirement in planning brief that a quantitative Air Ventilation Assessment (AVA) - Initial Study to be conducted at the detailed design stage. The AVA Study for the proposed public housing development at the Project 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, echoing the Technical Guide, are:

- To assess the characteristics of the wind availability (V_∞) of the Project Area;
- To give a general pattern and a rough quantitative estimate of wind performance at the pedestrian level reported using Wind Velocity Ratio (VR);
- To quantitatively assess the air ventilation performance in the neighbourhood of the Proposed Development; and
- To compare two studied schemes in terms of air ventilation performance aspect.

Content of This Report

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

- Section 2 on site characteristics;
- Section 3 on assessment methodology;
- Section 4 on assessment criteria;
- Section 5 on key findings of AVA study;
- Section 6 on directional analysis; and
- Section 7 with a summary and conclusion.

2 SITE CHARACTERISTICS

Site and Its Surrounding Area

2.1 The Project Area with a gross area of about 2.6 hectares (ha) is located at the southern portion of Kam Sheung Road MTR Station in the vicinity of Yuen Long region. The Project Area is bounded by Kam Ho Road/MTRC Railway in the north to east and Tsing Long Highway in the west. The Project Area and its immediate vicinity are located in the inland areas of New Territories. The topography features to the near east, northeast, southeast and northwest directions of the Project Area are relatively flat, with generally 10mPD in height. There is the foothill of Tai Lam Country Park (200mPD in height) to the southwest of the Project Area.

2.2 According to the "Approved Kam Tin South Outline Zoning Plan (OZP) No. S/YL-KTS/15", the Project Area falls within the "Residential Group (A)" ("R(A)") zone with maximum building height restriction (BHR) of 69mPD and plot ratio of 3.0.

2.3 The current heights of the developments surrounding the Project Area are generally low to mid-rise owing to the building height restriction of the Shek Kong Airfield. To the immediate east of the Project Area is the G/IC zone for the proposed school site, where currently an open space. The regions to the east, northeast, west and far north of Project Areas are currently occupied by low-rise village type developments, while the potential developments located at the immediate north, northeast, east, southeast, as well as south to the Project Area are mostly designed as mid-rise residential buildings (with building height restriction of the Shek Kong Airfield) such as Grand Mayfair I & II. Proposed PRH Site 4a and Site 1 are located at east side of Project Area.

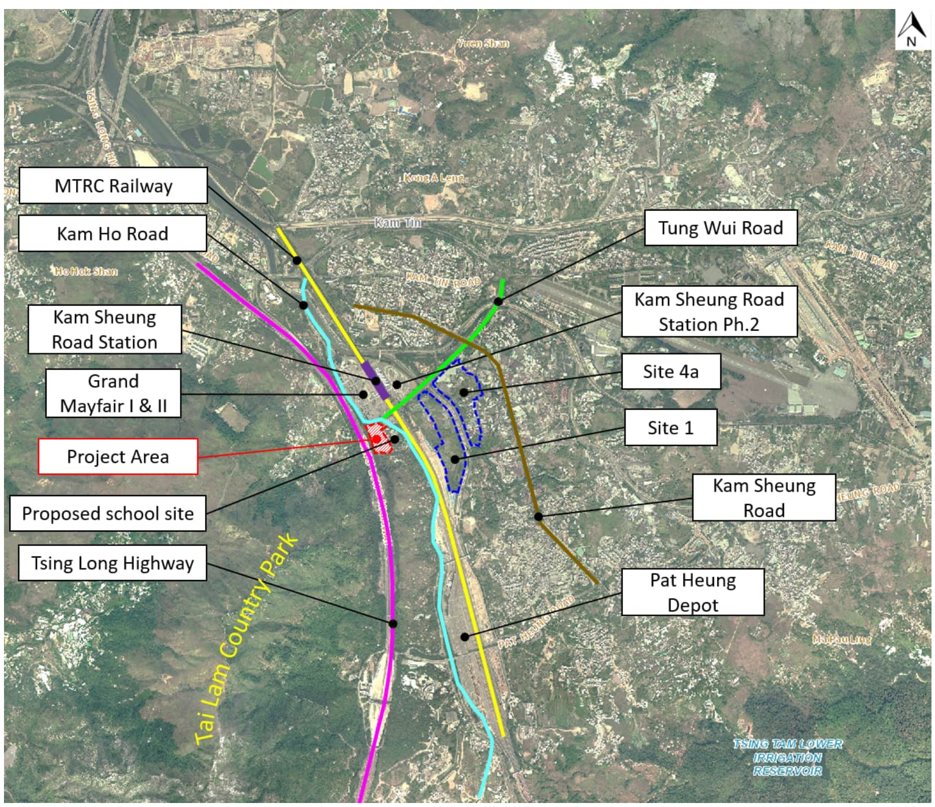


Figure 2.1 Overview of the Project Area and its Surroundings (Source: GeoInfo Map)

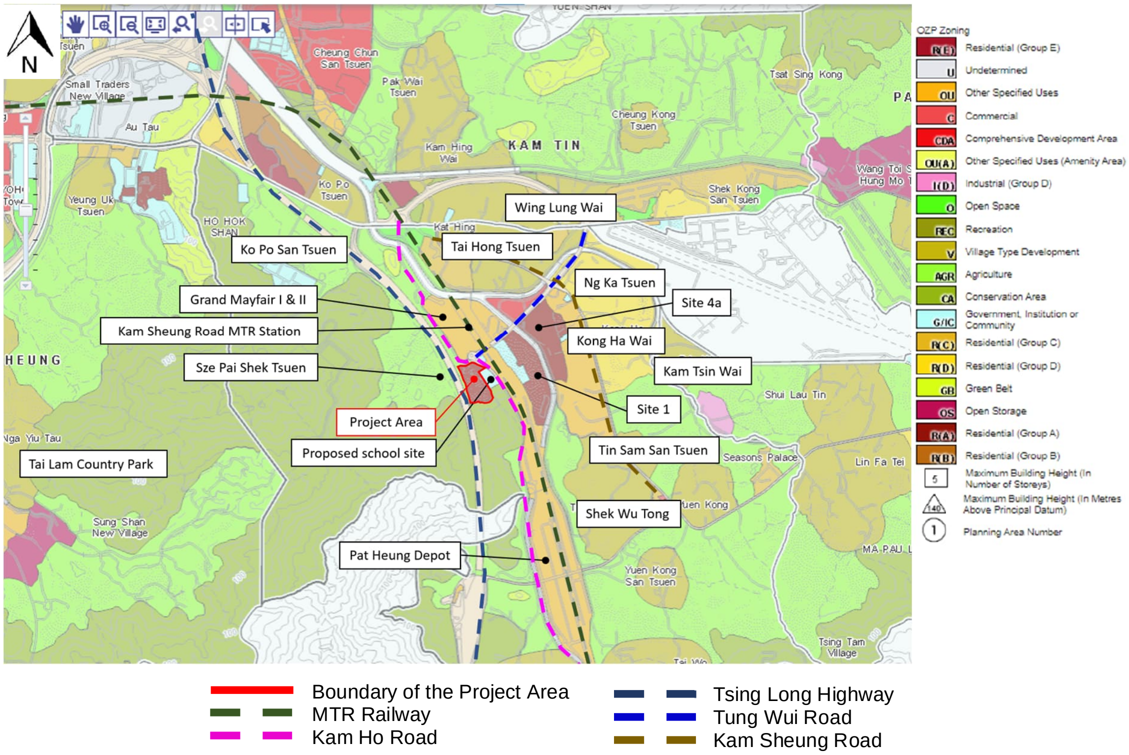


Figure 2.2 Land Use of the Project Area and its Surroundings in Draft OZP (Source: Statutory Planning Portal 2)

3 ASSESSMENT METHODOLOGY

3.1 This AVA study was 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 was 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 the AVA study.

Modelling Tool and Model Setup

3.2 Assessment was conducted by means of a 3-dimensional CFD model. The well-recognised commercial CFD package FLUENT was used in this exercise. FLUENT model has 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 applications.

Computational Domain

3.3 A 3D 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 was adopted for this assessment. According to the Technical Guide, the Assessment Area should include the project's surrounding up to a perpendicular distance of 1H while the Surrounding Area (marked in blue) should at least include the project's surrounding up to a perpendicular distance of 2H calculated from the project boundary, H being the height of the tallest building within Surrounding Area or 100m away from the project site, whichever is larger. In this study, the tallest building within Surrounding Area is 71.2m, such that 100 meters is adopted for 1H. The computational domain size of around 2500m x 2500m x 1000m. In addition, the grid expansion ratio and the blockage ratio should not exceed 1.3 and 3% respectively. The ground of the computational domain should include topography.

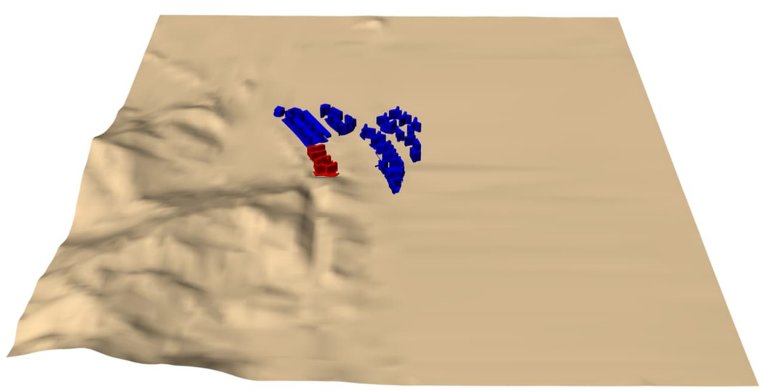


Figure 3.1 Geometry of Computational Model

Assessment and Surrounding Areas

3.4 Both the Baseline Scheme and Proposed Scheme are assessed under annual and summer wind conditions. A 3D model will be built according to the GIS information obtained from the Lands Department to include all existing, planned and committed development, if any, within the Surrounding Area. All other major elevated structures including the elevated railway tracks, and noise barriers, if any, within the Surrounding Area are also included in the model. The Assessment Area (marked in Green) and Surrounding Area (marked in Blue) have also been incorporated into the simulation model for Air Ventilation Assessment as shown in **Figure 3.2**.

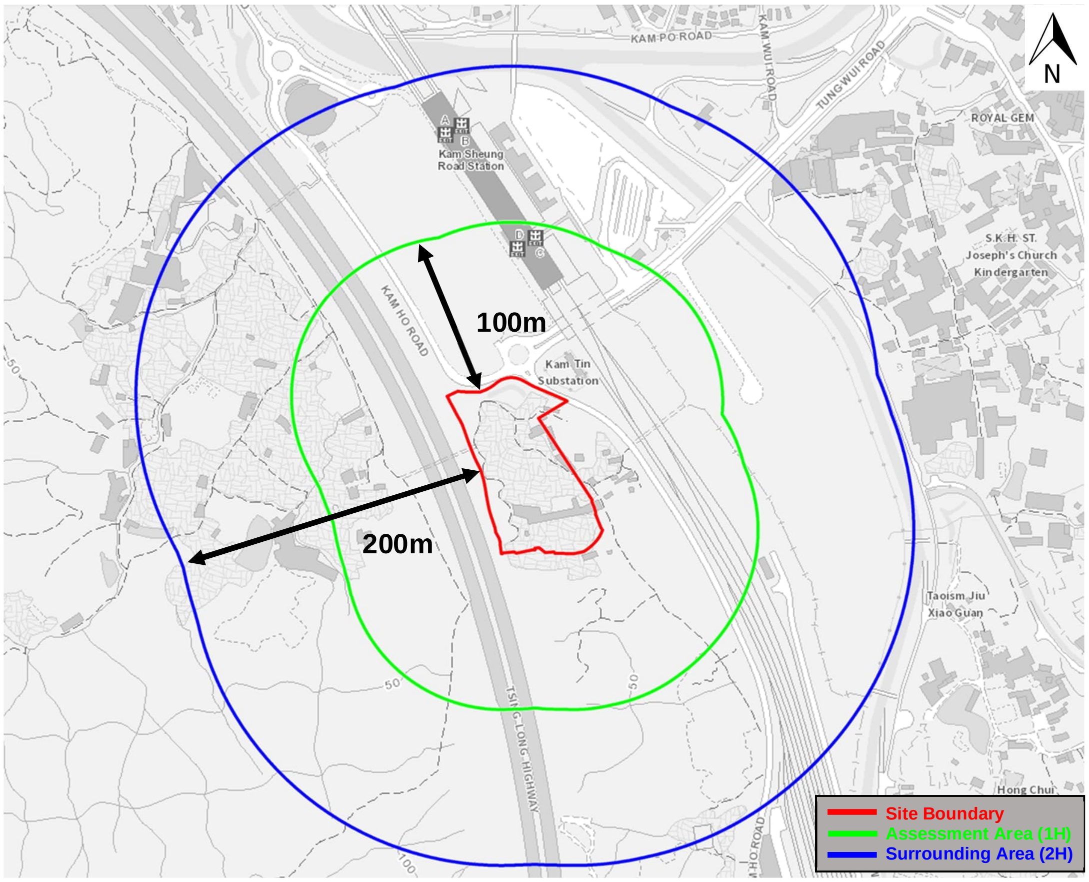


Figure 3.2 Boundaries of the Project Area, Assessment Area and Surrounding Area

Studied Schemes

3.5 **Figure 3.11** and **Figure 3.12** demonstrated model geometry of the Baseline Scheme and the Proposed Scheme in the simulation.

Baseline Scheme

3.6 The Baseline Scheme comprises 4 blocks of 17 to 18 domestic storeys, with a 1-storey podium carpark with landscape area on top as well as a non-domestic block with 3-storeys podium of welfare facilities and ancillary facilities on ground floor. Main domestic lift lobbies are located on the ground floor as shown in **Figure 3.3**.

3.7 The good design measures of the Baseline Scheme are the podium free design to reduce bulkiness, a 30m width Eco-corridor maintained between Block 1 and Block 3 in the Baseline Scheme which aligns in the ENE-WSW direction, and building setback from the site boundary and nearby major roads is considered to reduce wind impact.

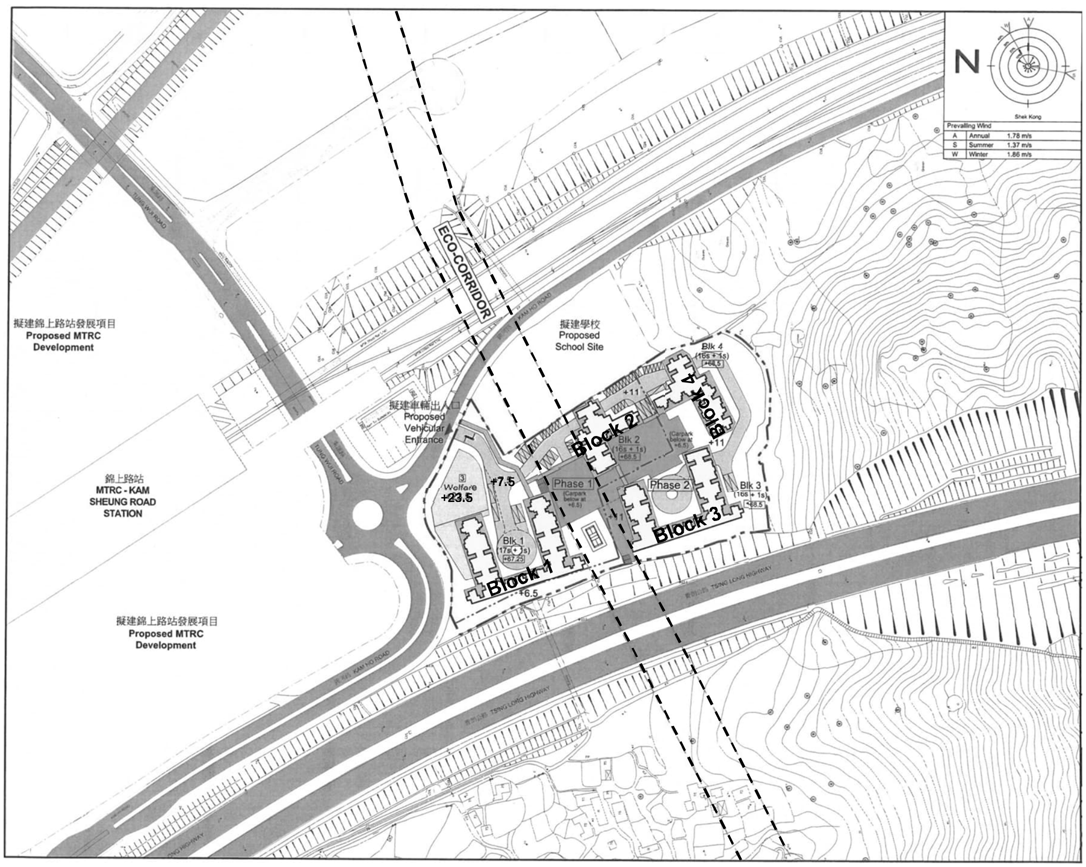


Figure 3.3 **Indicative Plan of Baseline Scheme (Master Layout)**

Proposed Scheme

3.8 The Proposed Scheme comprises 5 blocks of 14 to 15 domestic storeys, sitting on 2 to 3-storey podiums with welfare facilities and carpark. Landscape, open space, main domestic lift lobbies, and other ancillary facilities are located on the G/F and UG/F as shown in **Figure 3.5 to Figure 3.10**. The proposed good design features includes the air permeable spaces under the residential blocks at podium levels, a 30m width Eco-corridor maintained between residential Block B and Block C which aligns in the ENE-WSW direction, 15m width building gap between each building blocks, building setback from the site boundary and nearby major roads is considered to reduce wind impact, and the truncated design under Block C to improve air permeability.

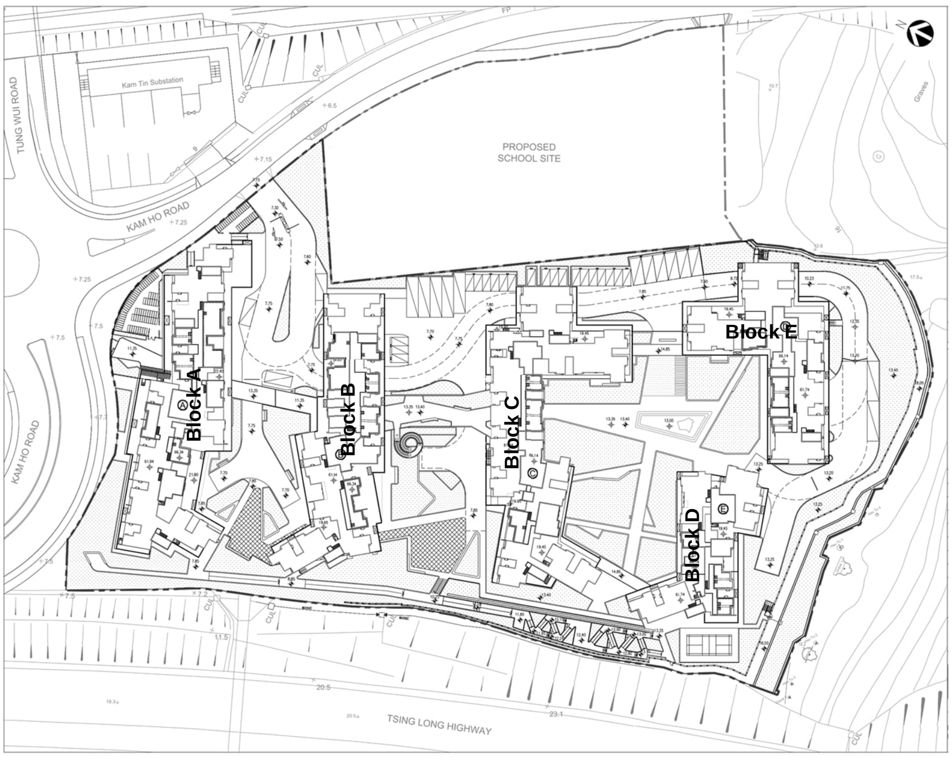


Figure 3.4 Proposed Scheme – Master Layout Plan

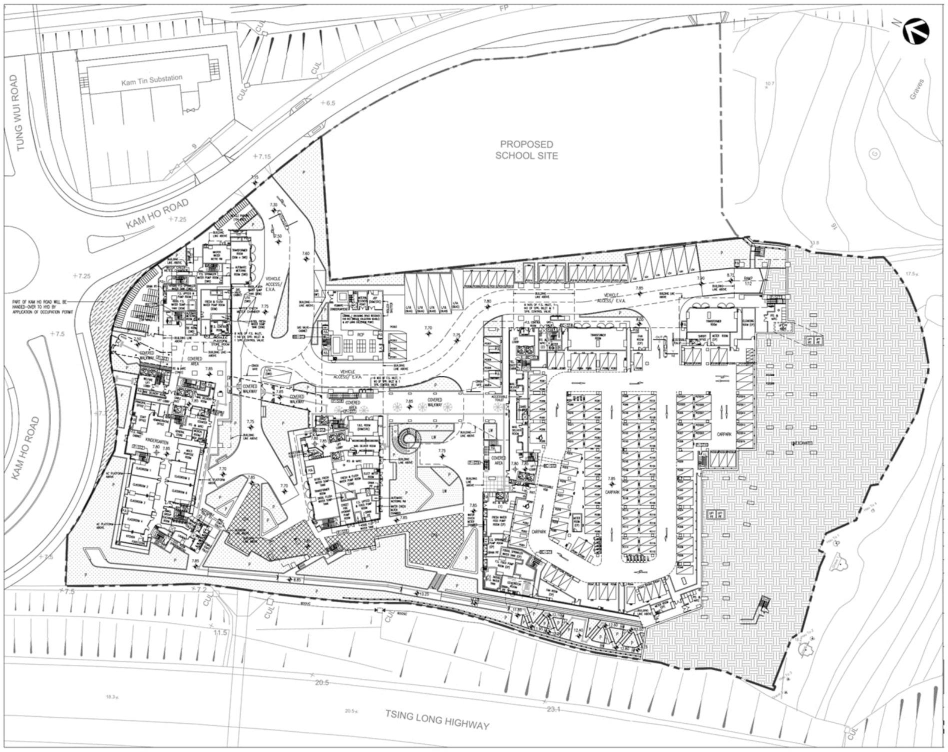


Figure 3.5 Proposed Scheme – Ground Floor Layout

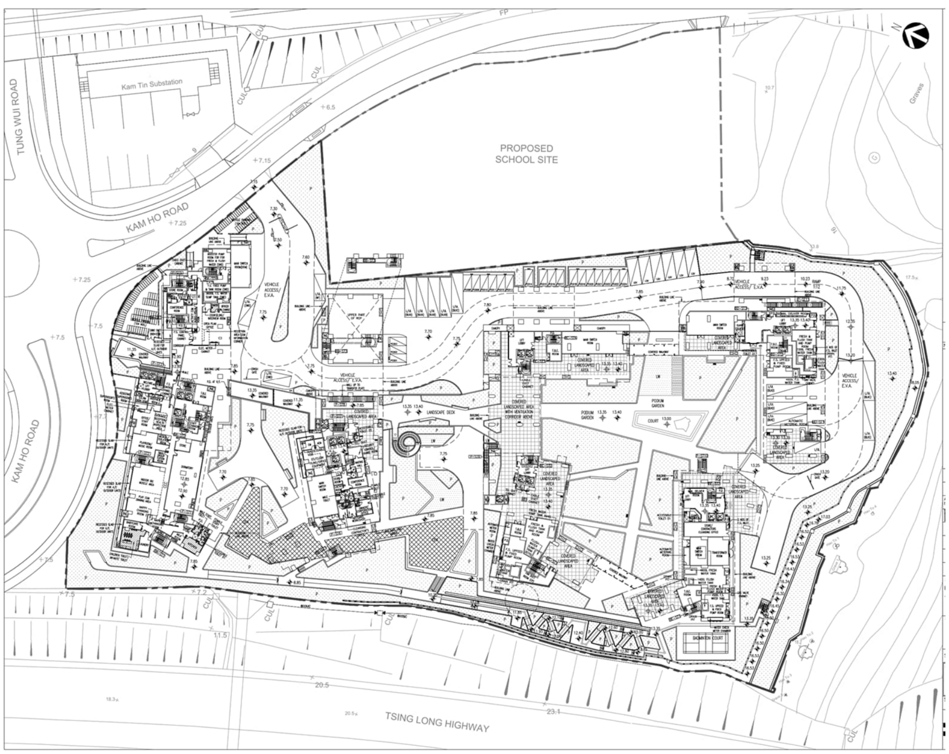


Figure 3.6 Proposed Scheme – First Floor Layout for Block A and Upper Ground Floor Layout for Block B, C, D & E

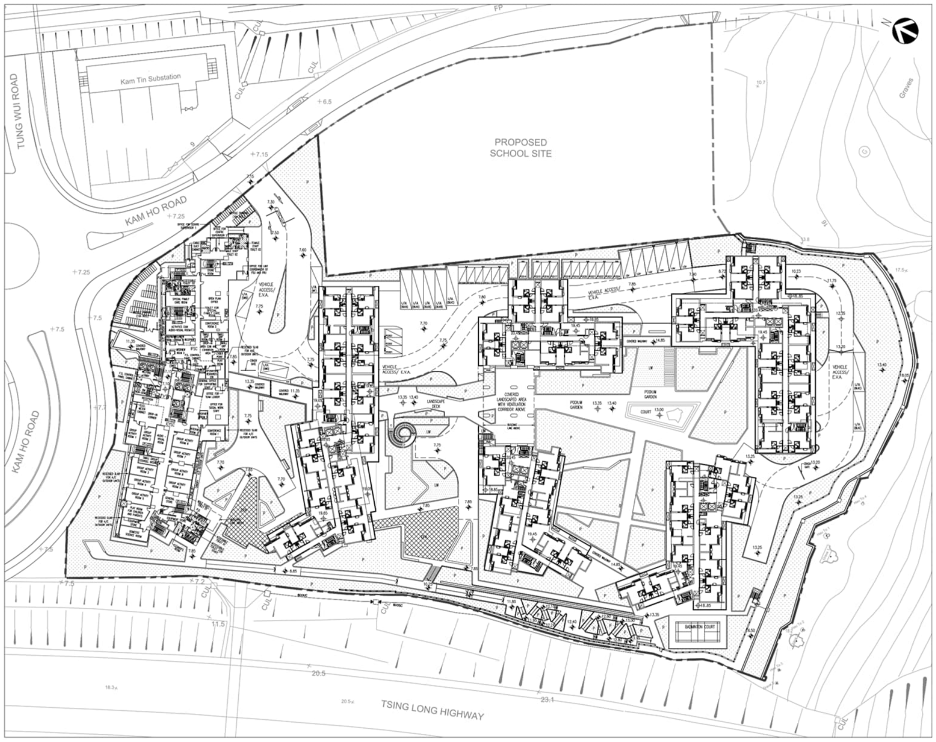


Figure 3.7 **Proposed Scheme – Second Floor Layout for Block A and First Floor Layout for Block B, C, D & E**

Figure 3.8 **Proposed Scheme –Typical Floor Layout for Block A, B, D & E and Block C (1-4/F)**

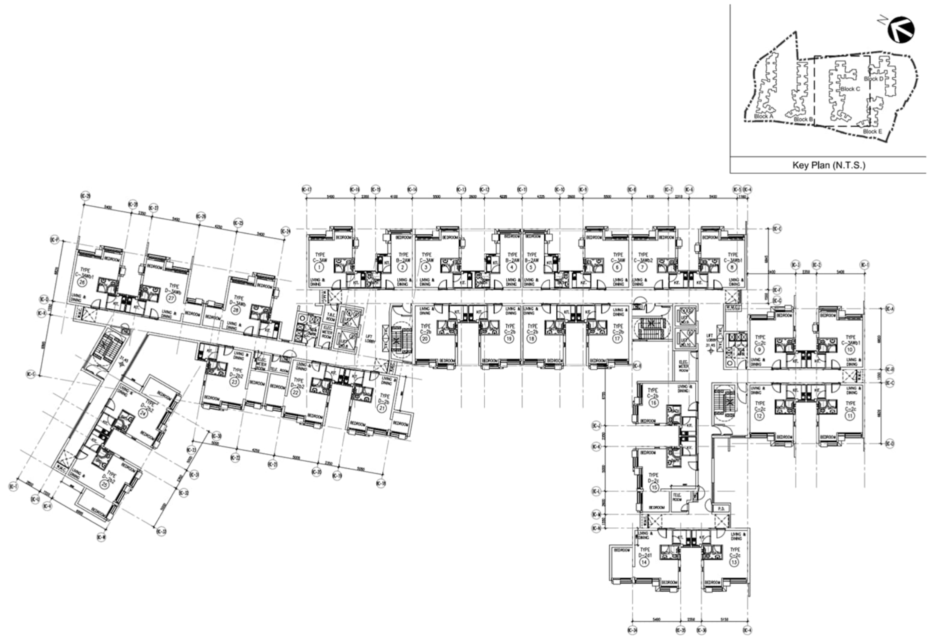


Figure 3.9 Proposed Scheme – Typical Floor Layout for Block C (5/F)

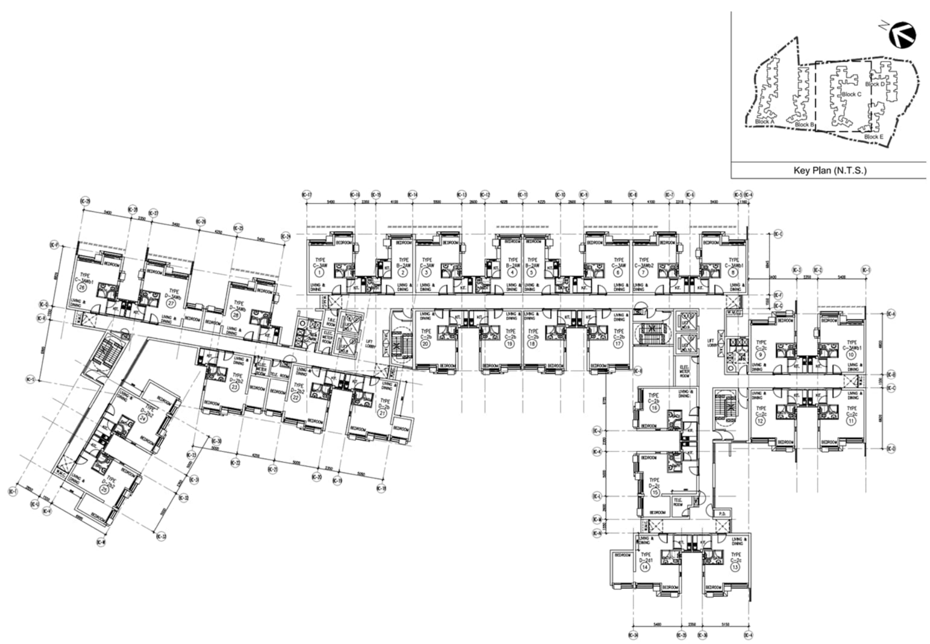
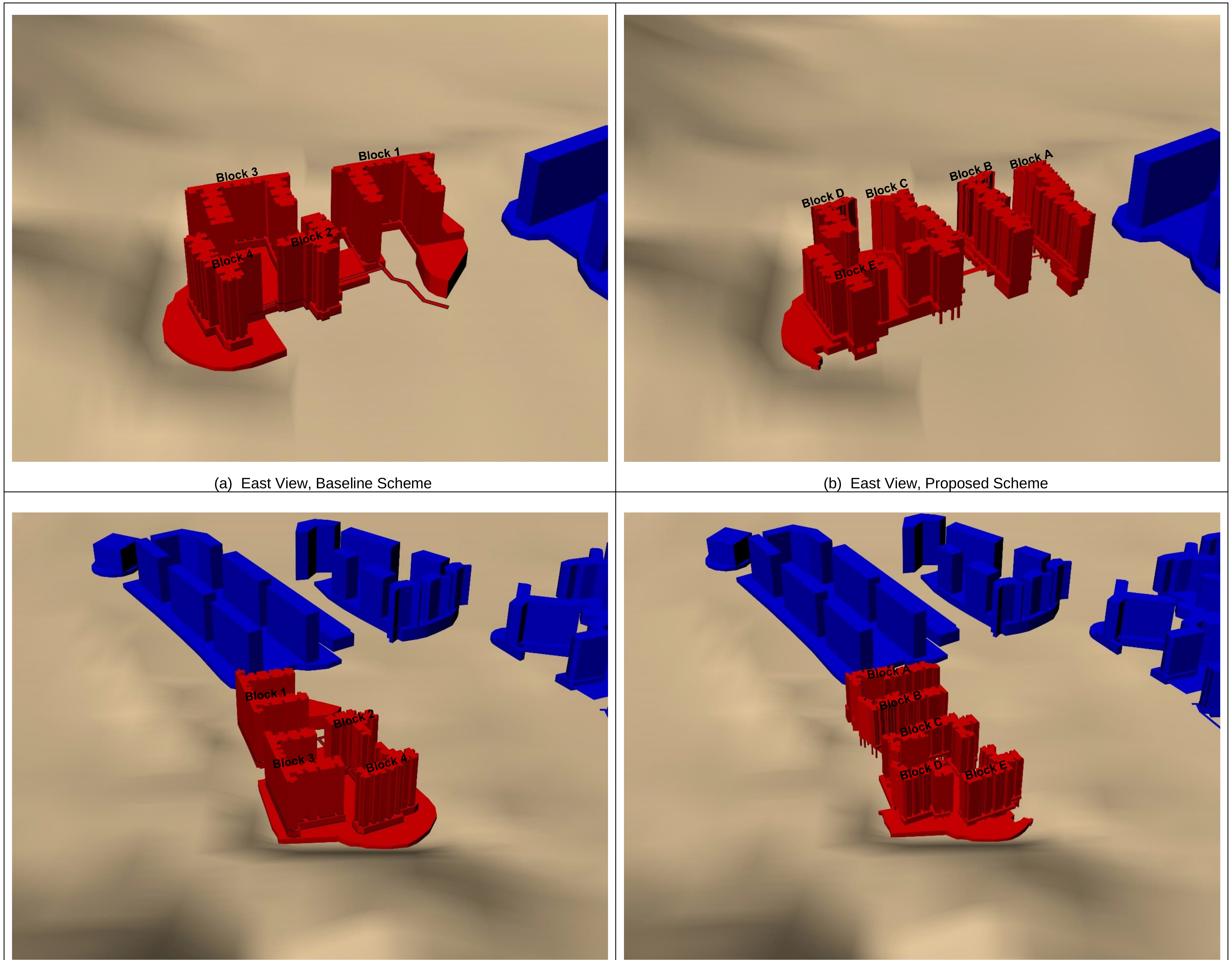


Figure 3.10 Proposed Scheme – Typical Floor Layout for Block C (6-15/F)



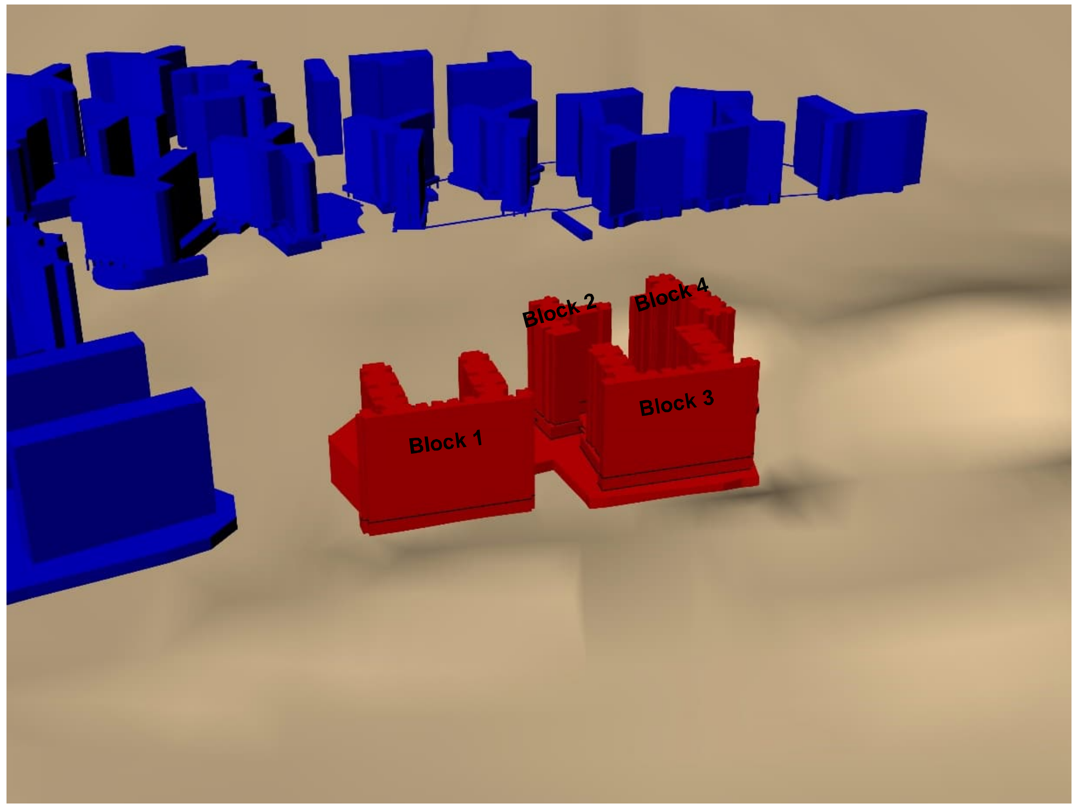
(a) East View, Baseline Scheme

(b) East View, Proposed Scheme

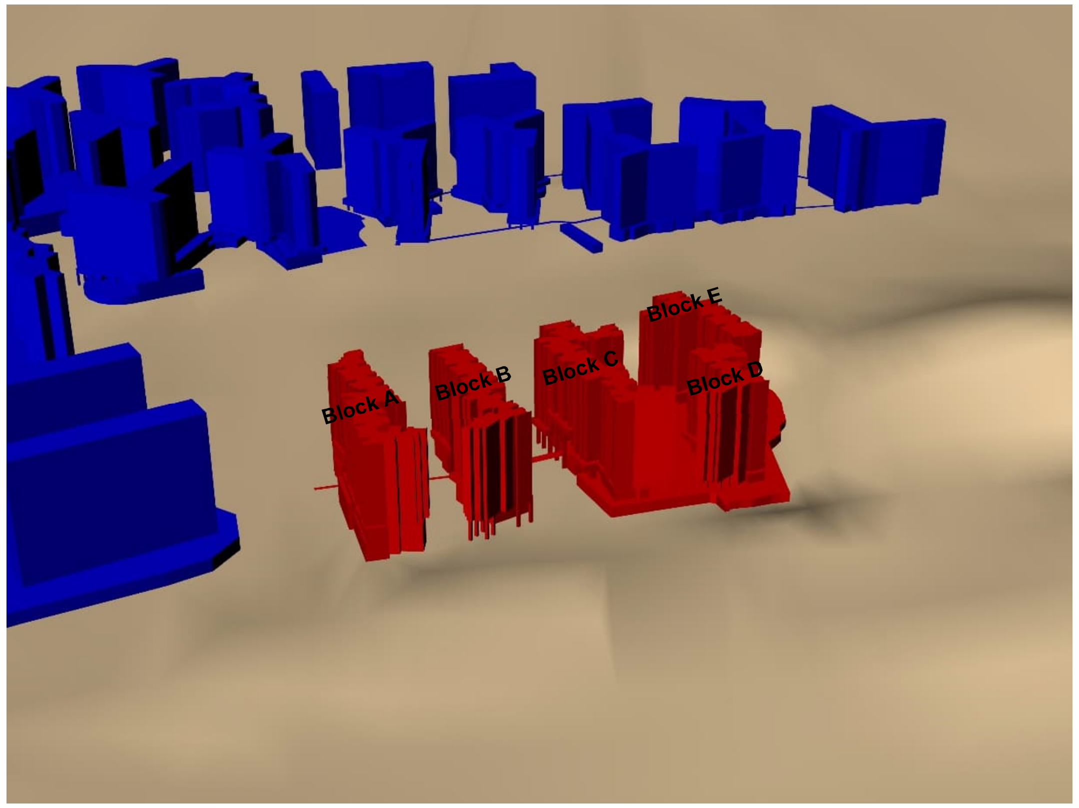
(c) South View, Baseline Scheme

(d) South View, Proposed Scheme

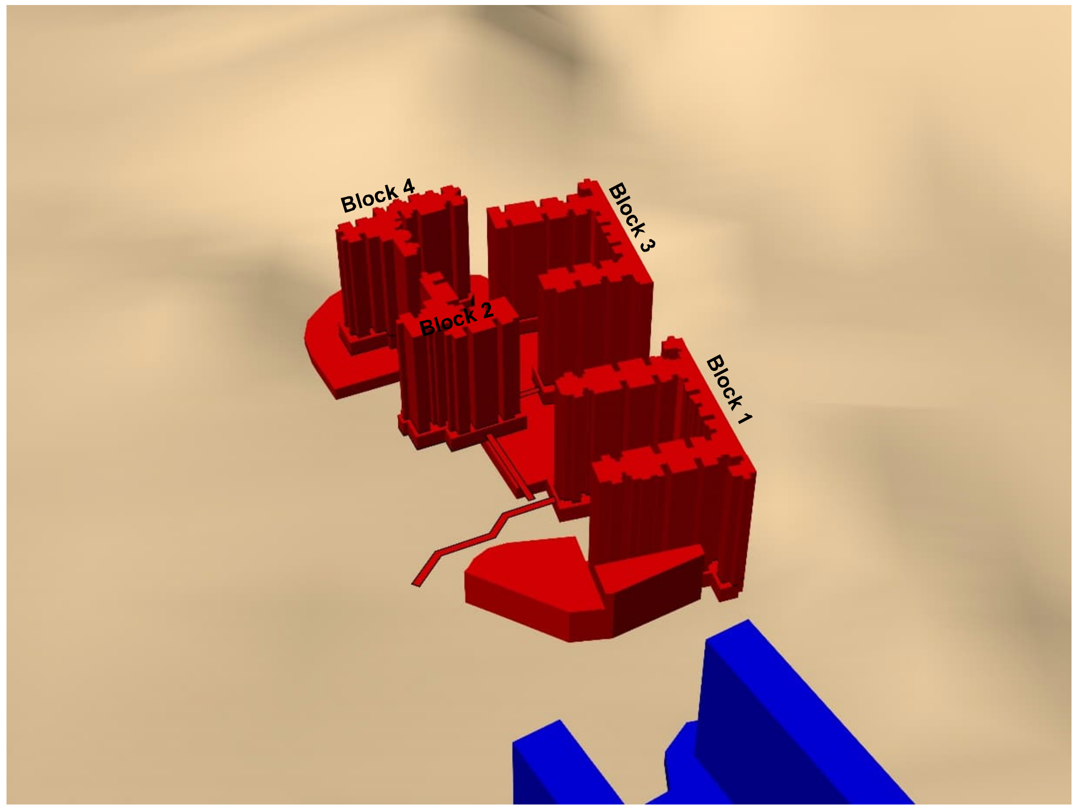
Figure 3.11 Model Geometry under East and South view



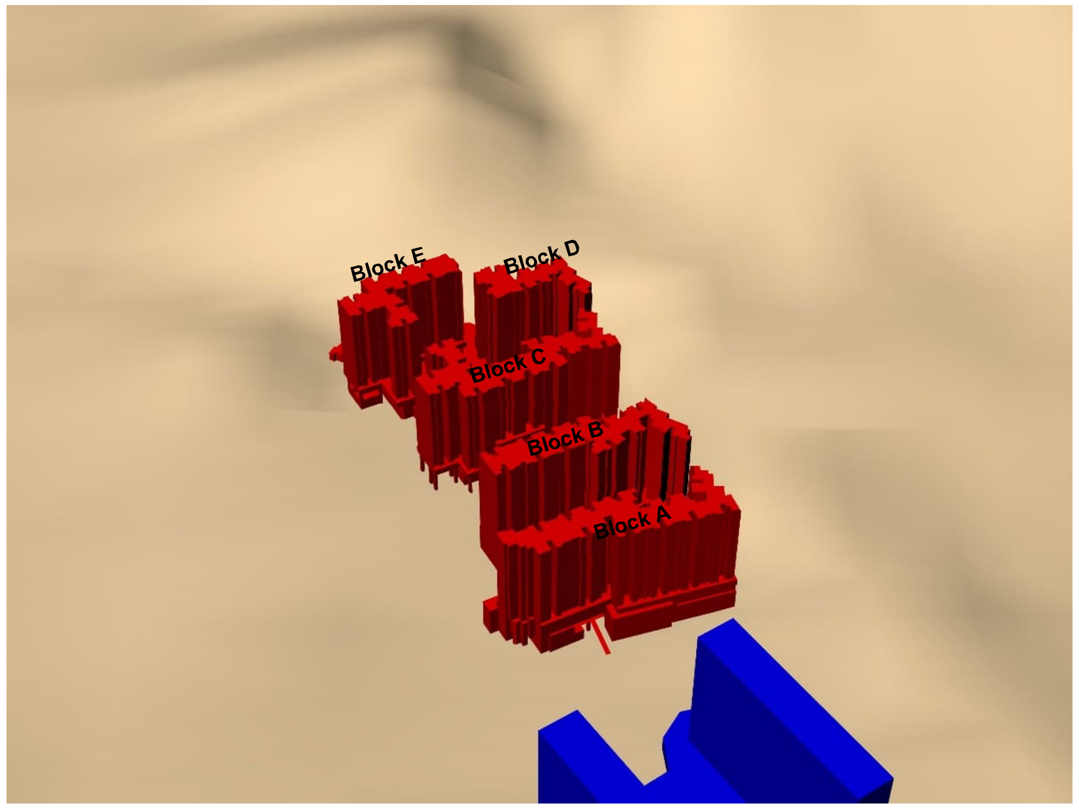
(a) West View, Baseline Scheme



(b) West View, Proposed Scheme



(c) North View, Baseline Scheme



(d) North View, Proposed Scheme

Figure 3.12 Model Geometry under West and North views

Wind Environment

3.9 The site wind availability of the Project Area will be simulated under at least 8 probable prevailing wind directions (which would represent the occurrence of more than 75% of time) under both annual and summer conditions to illustrate the change in local wind conditions due to the Proposed Development. These prevailing wind directions are determined based on the wind availability simulation result of the Regional Atmospheric Modelling System (RAMS) model published by the Planning Department (PlanD from hereafter).

3.10 **Figure 3.13** shows the location of relevant wind data extraction while the wind roses representing annual and summer winds at the Project Area of this study are presented in **Figure 3.14** below. Furthermore, the summarized chosen prevailing wind directions and their related occurrence probability are listed in **Table 3.1**. Details of the wind probability table are presented in **Appendix A**.

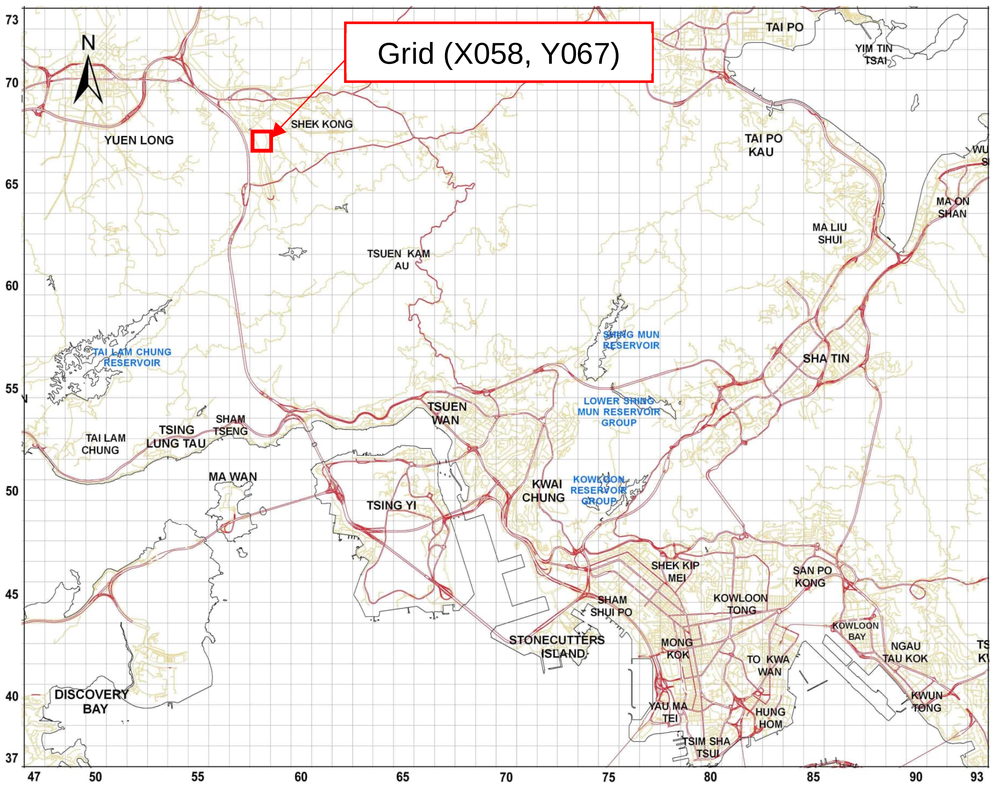
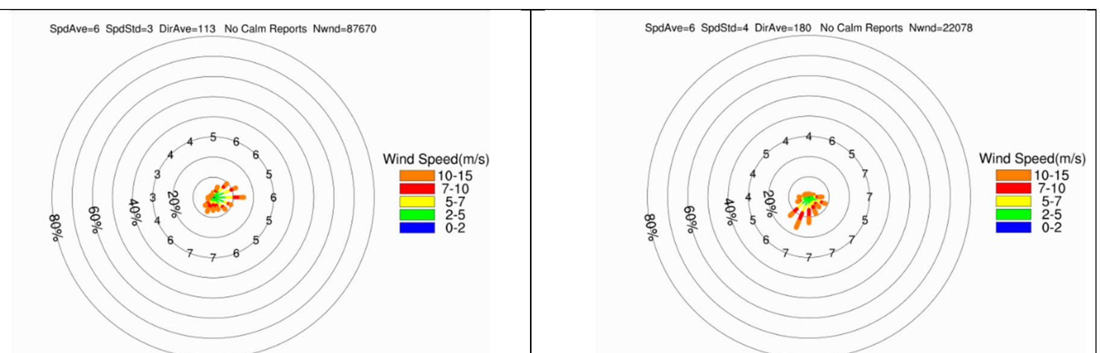


Figure 3.13 Location of data extraction in RAMS model



(a) Annual Wind Rose (b) Summer Wind Rose

Figure 3.14 Wind Rose at Grid (X058, Y067) (500m height)

Table 3.1 Simulated Wind Directions and their corresponding percentage occurrence, at 500m height

Annual Wind Direction	% of Annual Occurrence	Summer Wind Direction	% of Summer Occurrence
E	15.4%	SSW	16.7%
ENE	12.2%	S	13.3%
NE	9.6%	SW	13.3%
ESE	9.6%	SSE	9.2%
SE	8.6%	ESE	8.8%
SSW	7.7%	SE	7.5%
S	6.7%	E	6.7%
SSE	6.6%	WSW	6.2%
Total occurrence	**76.4%**	**Total occurrence**	**81.7%**

Vertical Wind Profiles

3.11 Wind environment under different wind directions will be defined in the CFD environment. According to the Technical Guide (HPLB and ETWB, 2006) per Para 20, wind profile for the Project Area could be appropriated from the V∞ data developed from RAMS and with reference to the Power Law or Log Law using coefficients appropriate to the site conditions. In this assessment, vertical wind profile condition below 20mPD is determined using the Log Law while the wind speed above 20mPD is adopted from the RAMS wind and wind profile in PlanD's website.

3.12 Vertical wind profile and roughness lengths are determined accordingly as follows:

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

Where
U_Z : wind speed at height z from ground
u^* : friction velocity
σ : von Karman constant = 0.4 for fully rough surface
Z : height z from ground
Z_0 : roughness length.

3.13 The roughness length for determining vertical wind profiles under different wind direction is tabulated in **Table 3.2**. In this study, the land further away from the surrounding area are urban areas with mid to high-rise developments, as a result, a roughness length with Z_0=3 is adopted for the inflow wind profiles.

Table 3.2 Roughness Length for Determining Vertical Wind Profiles under Different Wind Directions

Land Type of Upwind Area(1)	Roughness Length(2), Z_O
Urban area with mid and high-rise developments	3
Sea or open space	0.1

Notes:
(1) The land type refers to the area upwind of the model domain further away from the Surrounding Area
(2) With reference to Feasibility Study for Establishment of Air Ventilation Assessment System (CUHK, 2005)

Mesh Setup

3.14 The total number of cells for this study is about 12,000,000 cells in tetrahedral mesh. Polyhedral mesh cell counts can often be much smaller than comparable tetrahedral meshes with equivalent accuracy as well as improve mesh quality and manner of convergence (Franklyn, 2006). Grids may be converted to polyhedral mesh, if necessary. The horizontal grid size employed in the CFD model in the vicinity of the Project Area will be taken as a global minimum size of about 2m (a smaller grid size was also employed for specific fine details) and increased for the grid cells further away from the Project Area. The maximum mesh size within the whole computational domain will be about 200m. Besides, six layers of prism cells (each layer of 0.5m thick) were employed above the terrain. The blockage ratio and grid expansion ratio of this computational model are 1.2 and 3% respectively.

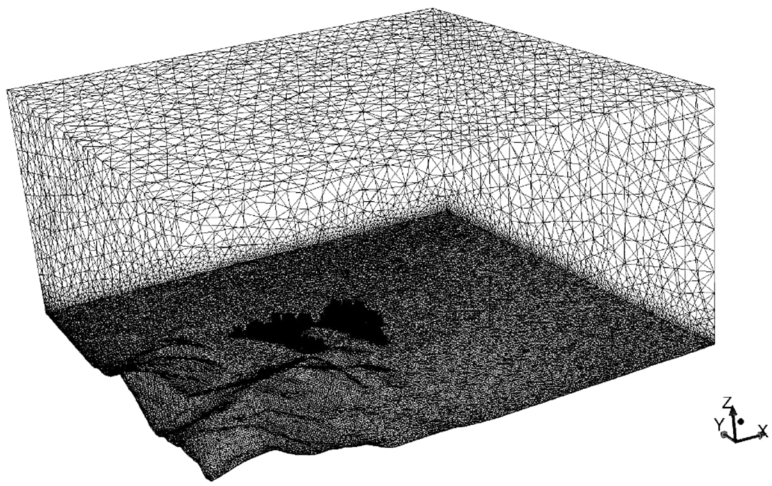


Figure 3.15 Mesh of the simulation domain

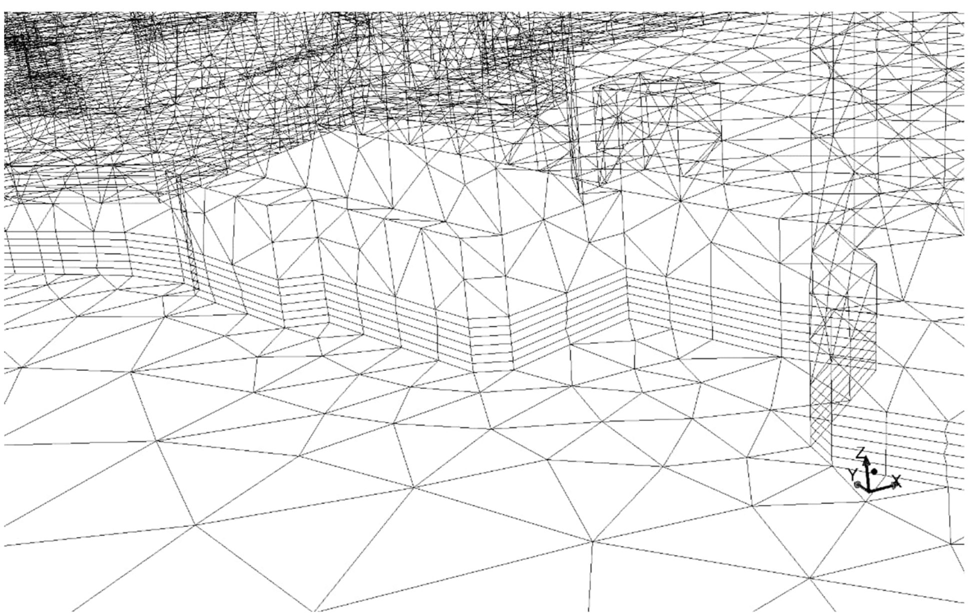


Figure 3.16 Prism layers near ground

Turbulence Model

3.15 As recommended in COST action C14, a realizable K-epsilon turbulence model was adopted in the CFD model to simulate the real-life problem. Common computational fluid dynamics equations were adopted in the analysis.

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

Calculation Method and Boundary Condition

3.17 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.

3.18 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, a symmetric boundary condition is used. Lastly, for the ground and building walls, no slip condition is employed.

4 ASSESSMENT CRITERIA AND TEST POINTS LOCATION

Wind Velocity Ratio (VR)

4.1 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 $VR = Vp / V_{INF}$ where V_{INF} is the wind velocity at the top of the wind boundary layer (greater than 500m in height) that would not be affected by the ground roughness and local site features and Vp is the wind velocity at the 2m pedestrian level.

4.2 VRw is the frequency weighted wind velocity ratio calculated based on the frequency of occurrence of 8 selected wind directions for annual and summer respectively for the purpose of comparison.

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

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

4.5 The SVRw and LVRw 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.

Test Points

4.6 Both perimeter test points and overall test points will be selected within the Assessment Area in order to assess the impact on the immediate surroundings and local areas respectively. Overall test points will be evenly distributed over surrounding open spaces, streets and other parts of the Assessment Area which pedestrians can or will mostly access. There will be 36 Perimeter Test Points and 72 Overall Test Points. Preliminary locations of perimeter and overall test points are illustrated in **Figure 4.1**.

4.7 The Test Points are further divided into 8 groups in order to analyse the respective localized wind environment performances. The coverage of the Test Points Groups is shown in **Figure 4.1** while the description of the major covering regions of each group is summarized in **Table 4.1.**

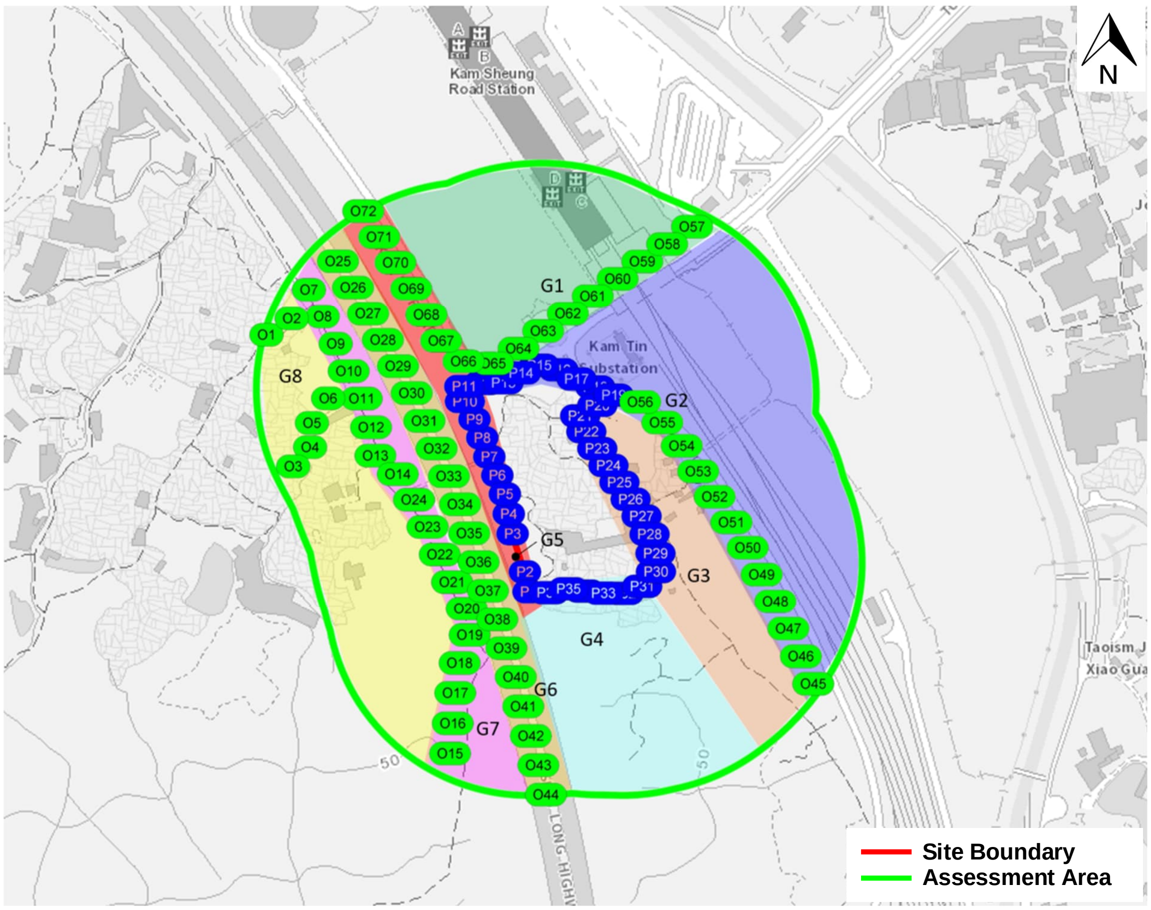


Figure 4.1 Distribution of Test Points

Table 4.1 Test Point Groups and respective represented locations

Test Point Groups	Test Point Numbers	Major location covered
G1	O57-O65	Tung Wui Road
G2	P12-P19, O45-56	Kam Ho Road
G3	P20-P30	Site Perimeter (eastern)
G4	P31-P36	Site Perimeter (southern)
G5	P1-P11, O66-O72	Site Perimeter (western) / Kam Ho Road
G6	O25-O44	Tsing Long Highway
G7	O7-O24	Hiking Trail
G8	O1-O6	Sze Pai Shek Tsuen

5 KEY FINDINGS OF AVA STUDY

Good design features

5.1 Good design features in the **Proposed Scheme** inherited from the **Baseline Scheme** include:

- The 30m width Eco-corridor between residential Block B and Block C creates the ENE-WSW wind corridors for the wind to penetrate through the Project Area and facilitate the wind availability downstream.
- The building setback from the site boundary and nearby major roads is considered, which would reduce the extent of wind influence regions to the vicinity areas and along the main corridors.

5.2 Additional good design features for improving the air ventilation performance of the **Proposed Scheme** include:

- Widening of building gap between residential blocks, the building gaps between residential blocks are at least 15m which can further improve the wind permeability.
- Empty bays under domestic blocks at podium levels favour wind penetration at the pedestrian level.
- Truncated design under Block C to improve air permeability.

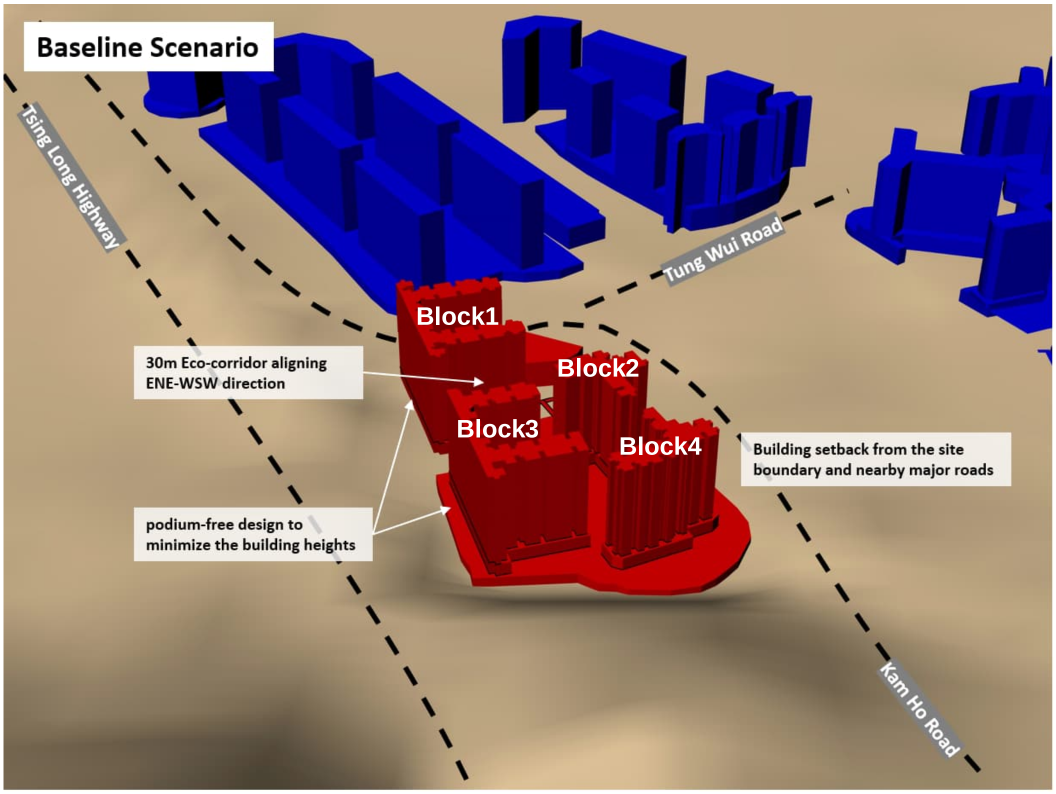


Figure 5.1 Good Design Features in Baseline Scheme

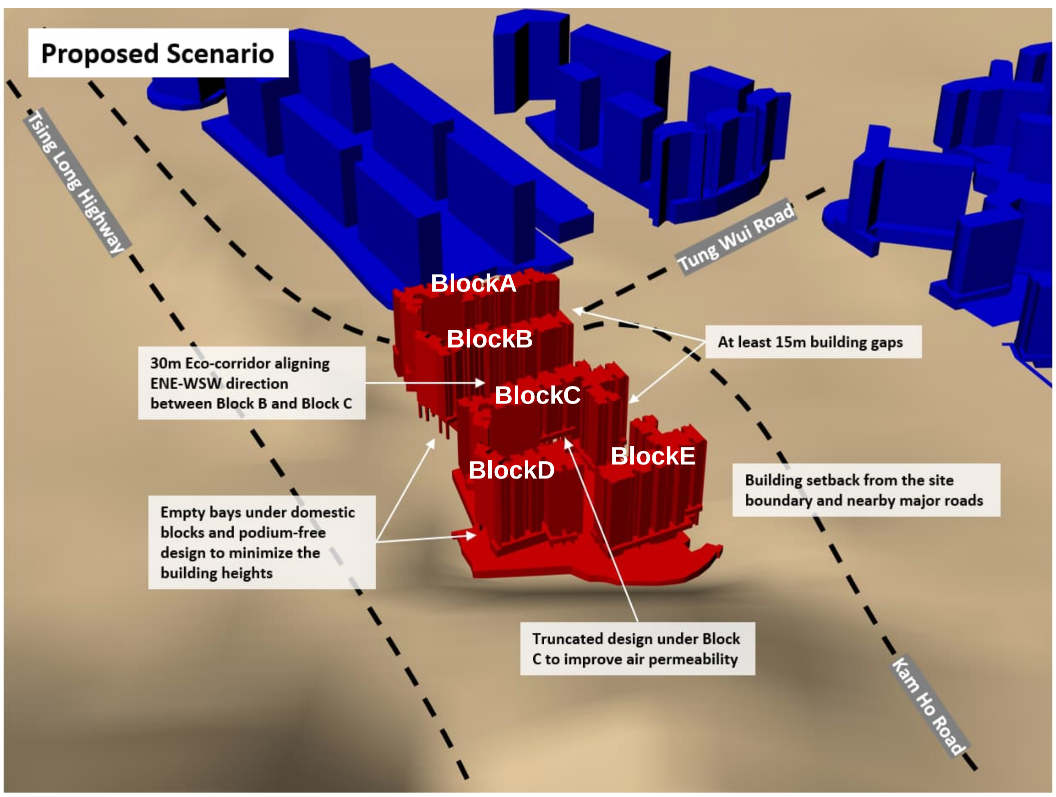


Figure 5.2 Good Design Features in Proposed Scheme

Wind Velocity Ratio Results

5.3 A summary of the predicted wind velocity ratios for the Perimeter Test Points and the Overall Test Points i.e. SVR_W and LVR_W under both annual and summer prevailing winds are presented in **Table 5.1** below. Details of the predicted wind velocity ratios are presented in **Appendix B**.

Table 5.1 Summary of Wind Velocity Ratio

	Annual Winds		Summer Winds	
	Baseline Scheme	Proposed Scheme	Baseline Scheme	Proposed Scheme
SVR_W	0.12	0.14	0.19	0.18
LVR_W	0.16	0.17	0.22	0.22

5.4 The results of VRw for different groups of test points are summarized in **Table 5.2** below.

Table 5.2 Summary of Wind Velocity Ratio for Different Test Point Groups

Group	**Description**	**Test Points**	**Average VR_w (Annual Winds)**		**Average VR_w (Summer Winds)**	
			Baseline Scheme	**Proposed Scheme**	**Baseline Scheme**	**Proposed Scheme**
G1	O57-O65	Tung Wui Road	0.16	0.16	0.26	0.25
G2	P12-P19, O45-56	Kam Ho Road	0.15	0.16	0.21	0.20
G3	P20-P30	Site Perimeter (eastern)	0.13	0.15	0.16	0.16
G4	P31-P36	Site Perimeter (southern)	0.19	0.17	0.29	0.25
G5	P1-P11, O66-O72	Site Perimeter (western) / Kam Ho Road	0.10	0.12	0.18	0.16
G6	O25-O44	Tsing Long Highway	0.18	0.19	0.24	0.24
G7	O7-O24	Hiking Trail	0.21	0.22	0.24	0.26
G8	O1-O6	Sze Pai Shek Tsuen	0.16	0.15	0.24	0.23

5.5 Contour plots of wind velocity ratio at 2m above the pedestrian level of the assessment area under prevailing wind directions are shown in directional analysis in **Section 6**.

Site Air Ventilation Assessment

5.6 The layouts of the Proposed Scheme and the Baseline Scheme consist of 5 and 4 residential blocks respectively. However, the Proposed Scheme stands out by incorporating empty bays at the podium level and implementing a truncated design under Block C. Furthermore, the widened building gaps between residential blocks in the Proposed Scheme effectively reduce the impact on air ventilation at the site perimeter when compared to the Baseline Scheme.

5.7 The SVRw indicates how the lower portion of the buildings within the Project Area affects the wind environment of its immediate vicinity. Under annual winds, the average predicted SVRw for the Proposed Scheme increases from 0.12 to 0.14 compared to the Baseline Scheme. This indicates that the Proposed Scheme demonstrates superior air ventilation performance due to its wider building gaps and the incorporation of empty spaces at the podium level within the Project Area, which promote wind penetration. However, during summer, the SVRw slightly decreases from 0.19 to 0.18 for the Proposed Scheme in comparison to the Baseline Scheme. This suggests that the Baseline Scheme would experience slightly higher velocity ratios within the Project Area under summer winds. This is attributed to the longer frontage of Block 1 and Block 3 in the Baseline Scheme, which induces a stronger downwash effect towards the western site perimeter of the Project Area.

Local Air Ventilation Assessment

5.8 The LVRw evaluates the overall wind environment within the Assessment Area for both schemes under annual and summer winds. The LVRw for the Proposed Scheme shows a slight increase from 0.16 to 0.17 compared to the Baseline Scheme under annual prevailing winds. However, during the summer seasons, the LVRw remains constant at 0.22 for both the Baseline Scheme and the Proposed Scheme. These results suggest that the Proposed Scheme exhibits a slight improvement in the pedestrian wind environment compared to the Baseline Scheme at the site boundary and throughout the Assessment Area.

5.9 The averaged wind velocity ratio of Group 1 test points provides an assessment of the wind environment along Tung Wui Road. Both the Proposed Scheme and the Baseline Scheme exhibit a similar air ventilation performance under both annual and summer winds. This is evident from the averaged VRw in Group 1 Test Points, which is 0.16 annually for both schemes, with a slight decrease from 0.21 to 0.20 during summer. It should be noted that the frontage of Block A and Block B in the Proposed Scheme is longer than that of the Baseline Scheme, resulting in a minor reduction in ventilation performance along Tung Wui Road during summer wind directions.

5.10 Group 2 Test Points are evenly spaced along the southern section of Kam Ho Road, covering the northeast and southeast quadrants of the Project Area. The results demonstrate a slight enhancement in the wind environment under annual scenarios. Under annual conditions, the VRw increases from 0.15 in the Baseline Scheme to 0.16 in the Proposed Scheme. For summer conditions, the VRw value slightly decreases from 0.21 in the Baseline Scheme to 0.20 in the Proposed Scheme. This implies a similar air ventilation performance within this region. It should be noted that a section of Kam Ho Road is situated upstream of the Project Area, and the wind influence induced by the proposed development is not significant.

5.11 Group 3 Test Points cover the eastern site perimeter. It is observed that the Proposed Scheme would have an improvement in air ventilation when compared to the Baseline Scheme with the VRw increased from 0.13 to 0.15 during annual condition for the Proposed Scheme compared to the Baseline Scheme, while remained as 0.16 during summer condition. It indicates that the a slightly stronger downwash effect in the Proposed Scheme would benefit the wind environment in the upstream area under annual conditions.

5.12 Group 4 Test Points are situated along the southern site perimeter, and the VRw measurements obtained serve as indicators of the pedestrian wind environment in that specific area. It is noteworthy that the averaged velocity ratio obtained for the Proposed Scheme is inferior to that of the Baseline Scheme in this particular area. This disparity can be attributed to the absence of empty bays, which typically induce a relatively stronger downwash effect that contributes to an increased velocity ratio. The annual VRw decreases from 0.19 in the Baseline Scheme to 0.17 in the Proposed Scheme, while the summer VRw decreases from 0.29 to 0.25. Nevertheless, it is important to acknowledge that the velocity ratio in this area remains relatively high.

5.13 The VRw values of Group 5 Test Points indicate the air ventilation performance of the western site perimeter to the west to northwest of the Project Area. The results reveal an improved wind environment under annual conditions, while a deteriorated wind environment is observed during summer. As previously mentioned, the longer frontage of Block 1 and Block 3 in the Baseline Scheme induces a stronger downwash effect towards the western site perimeter of the Project Area under summer wind directions. Meanwhile, under annual wind directions, the presence of empty bays and widened building gaps in the Proposed Scheme benefits air permeability, resulting in a higher VR compared to the Baseline Scheme. Specifically, the VRw values are 0.10 and 0.12 annually, and 0.18 and 0.16 during summer for the Proposed and Baseline Scheme respectively.

5.14 The ventilation performance along the Tsing Long Highway to the west of the Project Area is assessed by Group 6 Test Points. Similar VRw are obtained on this monitoring region for the Proposed Scheme and Baseline Scheme. The VRw of the Baseline Scheme and Proposed Scheme are 0.18 and 0.19 respectively under annual conditions, while remained as 0.24 for both schemes in summer.

5.15 Group 7 Test Points are evenly distributed along the hiking trail to the west of the Project Area. Under annual winds, the VRw increases from 0.21 in the Baseline Scheme to 0.22 in the Proposed Scheme. Similarly, when comparing the Proposed Scheme to the Baseline Scheme, the VRw slightly increases from 0.24 to 0.26. This improvement is attributed to the wider building gaps in the Proposed Scheme, which obstruct less incoming wind than the Baseline Scheme. Consequently, the wind environment in this specific region experiences enhancement.

5.16 Group 8 Test Points monitor a specific portion of Sze Pai Shek Tsuen situated in the northwest quadrant of the Project Area. Under annual winds, the VRw in this area experiences a slight reduction from 0.16 in the Baseline Scheme to 0.15 in the Proposed Scheme. Similarly, under summer winds, the air ventilation performance is also diminished, with the VRw slightly decreasing from 0.24 to 0.23. These observations illustrate that the larger building blocks of the proposed development, specifically Block A and Block B in the Proposed Scheme, may slightly obstruct more incoming wind in this higher elevation area.

6 DIRECTIONAL ANALYSIS

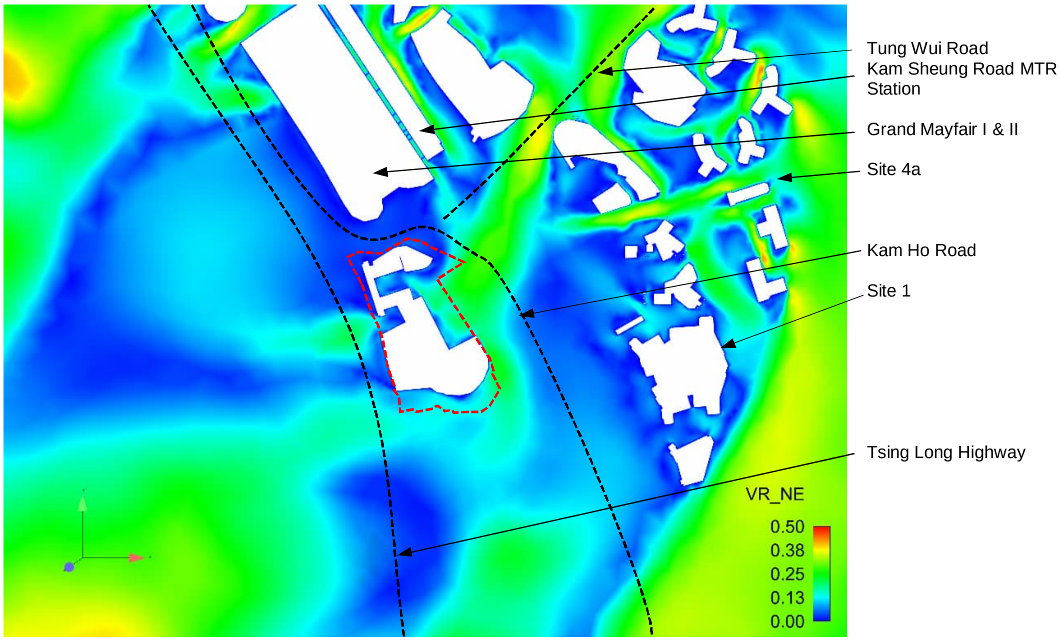
NE: (Annual: 9.6%)

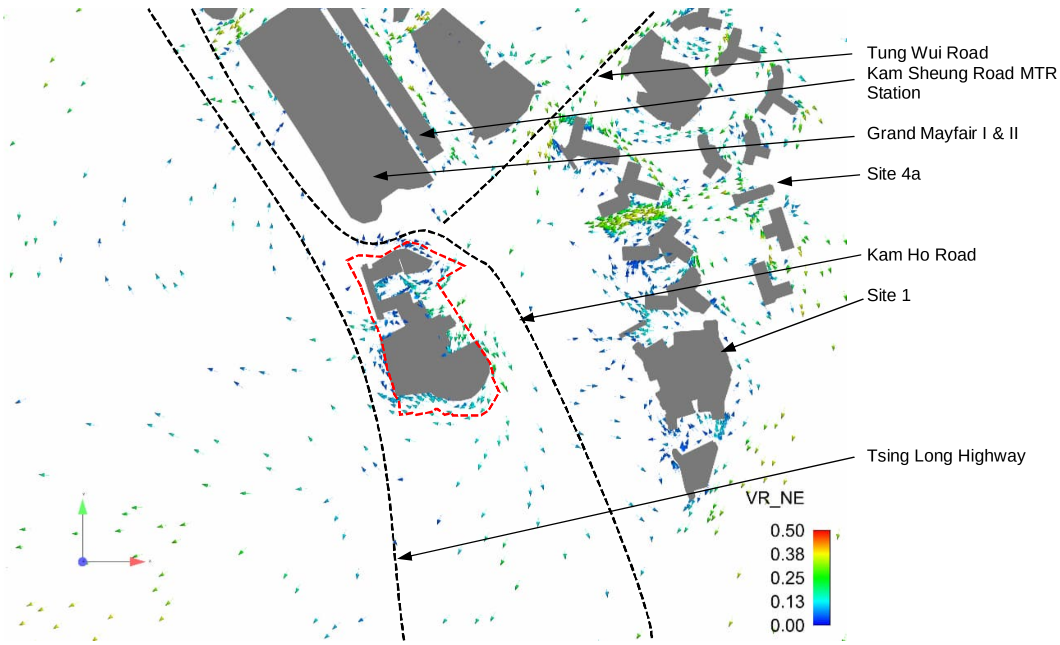
6.1 Under NE wind conditions, it has been observed that the incoming wind passes through the low-rise villages of Ng Ka Tsuen (appro. 17mPD) and Kong Ha Wai (appro. 16mPD). The presence of these low-rise developments in the upwind direction does not significantly influence wind flow towards the Project Area, as the incoming wind can skim over these developments without obstruction. However, a small portion of the incoming wind may encounter slight obstruction due to the proposed public housing development at Site 1 and Site 4a. Nonetheless, the incoming wind can gradually flow through the building gaps and reserved air permeability spaces between the residential towers at Site 1 and Site 4a, enabling it to reach the Project Area. Furthermore, another portion of the incoming wind utilizes Tung Wui Road as a primary wind corridor, as it aligns in the NE-SW direction, facilitating the incoming flow of NE incoming wind towards the Project Area. Therefore, the site's wind availability is determined to be satisfactory.

6.2 Under the Baseline Scenario, it is observed that the incoming wind is impeded by the proposed mid-rise residential development (68.5mPD). At lower levels, the extended frontage of the podium structure is found to capture a portion of the incoming wind, leading to limited wind penetration within the Project Area. Consequently, a stagnant zone characterized by low wind flow can be identified in the downstream area. At higher levels, the architectural design of Block 1 and Block 3 in the Baseline Scheme captures the incoming wind that originates from Tsing Long Highway and the western hiking trail adjacent to the Project Area. Despite not aligning perfectly with the NE wind direction, the incoming wind is able to penetrate the Project Area through a 30m wide Eco- corridor that aligns in the ENE-WSW direction between Block 1 and Block 3 in the Baseline Scheme. This configuration allows a portion of the NE wind to enter the building gaps, thereby reducing the zone in which wind influences are prominent in the immediate downstream area.

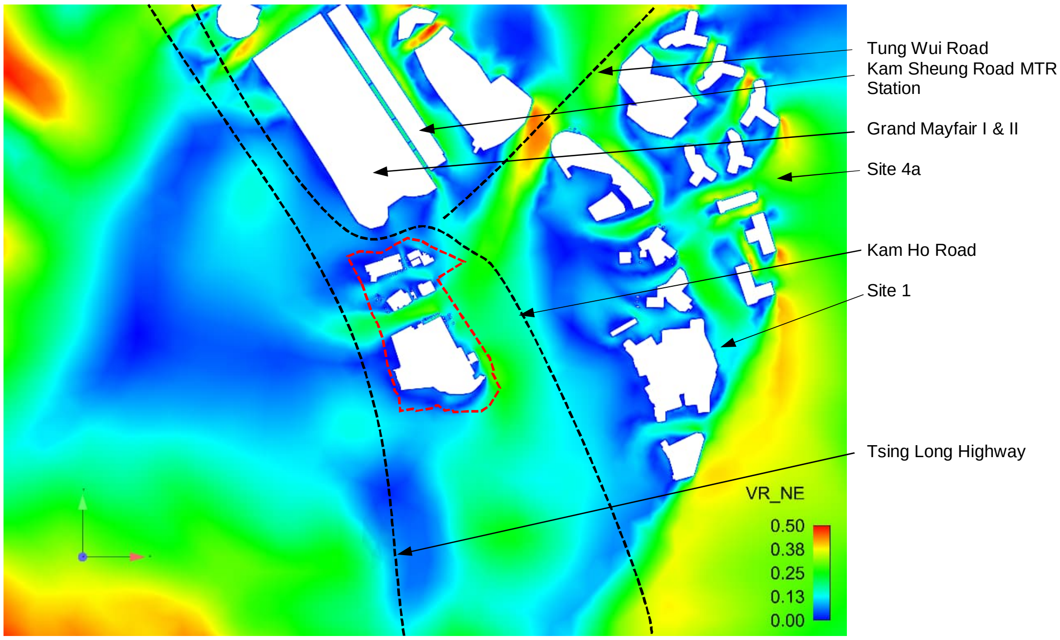
6.3 In the Proposed Scenario, it is observed that the proposed mid-rise residential developments (62.24mPD) have a reduced air ventilation impact on the immediate downstream area compared to the Baseline Scenario. This is due to the unobstructed entry of incoming wind from Tung Wui Road, allowing it to freely enter the Project Area and flow through each empty bay at the pedestrian level. Consequently, an improved Velocity Ratio (VR) is observed at the western site boundary of the Project Area. At higher levels, in addition to the 30m wide Eco-corridor between Block B and Block C in the Proposed Scheme, the wider building gaps of at least 15m between the residential blocks further facilitate the penetration of NE winds. This results in a smaller wind stagnant zone in the central portion of the Project Area compared to the Baseline Scenario. Furthermore, the increased air movement resulting from better wind penetration redirects the incoming wind towards Grand Mayfair I & II (69mPD) and Sze Pai Shek Tsuen. As a result, a higher velocity ratio is observed in this area compared to the Baseline Scenario. Ultimately, the prevailing wind is expected to flow freely towards Tai Lam Country Park after passing through the Project Area. Consequently, no significant wind influences are anticipated to affect the surrounding developments.

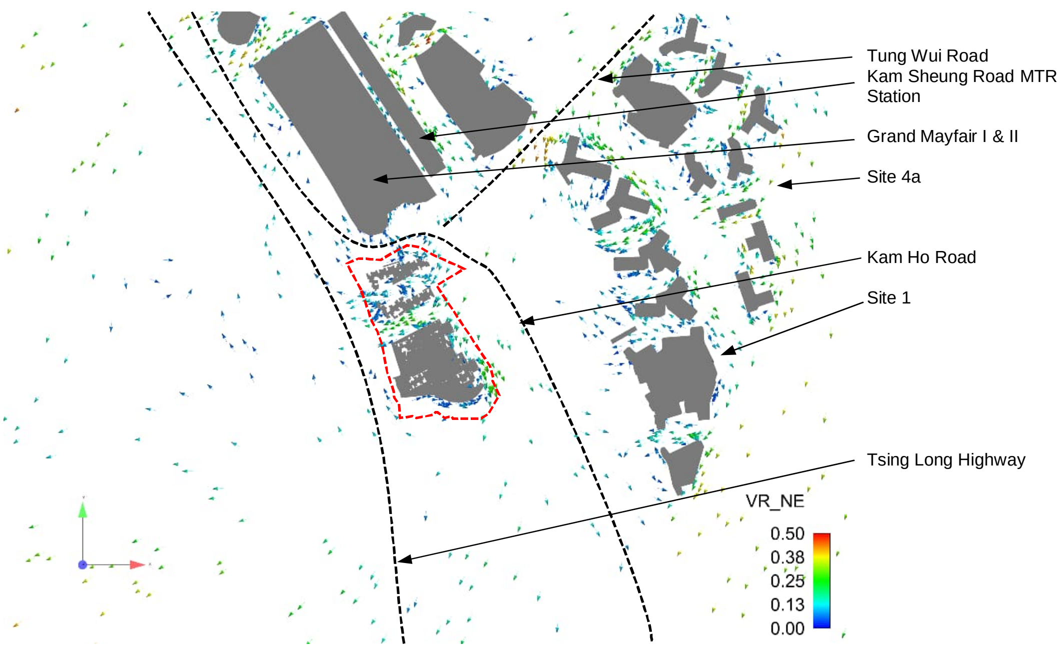
Baseline Scheme





Proposed Scheme





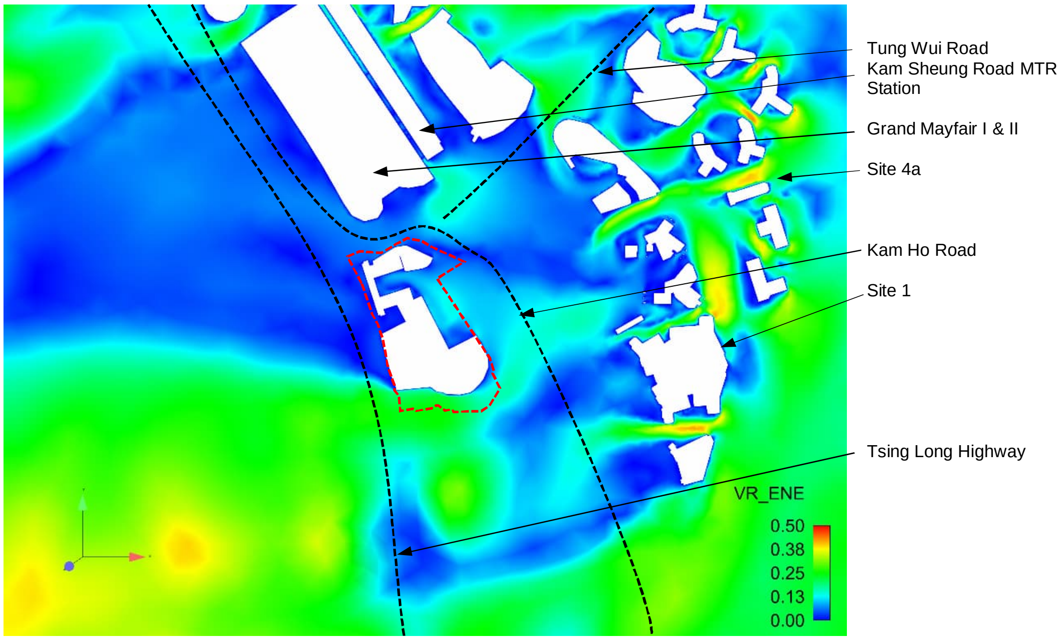
ENE: (Annual: 12.2%)

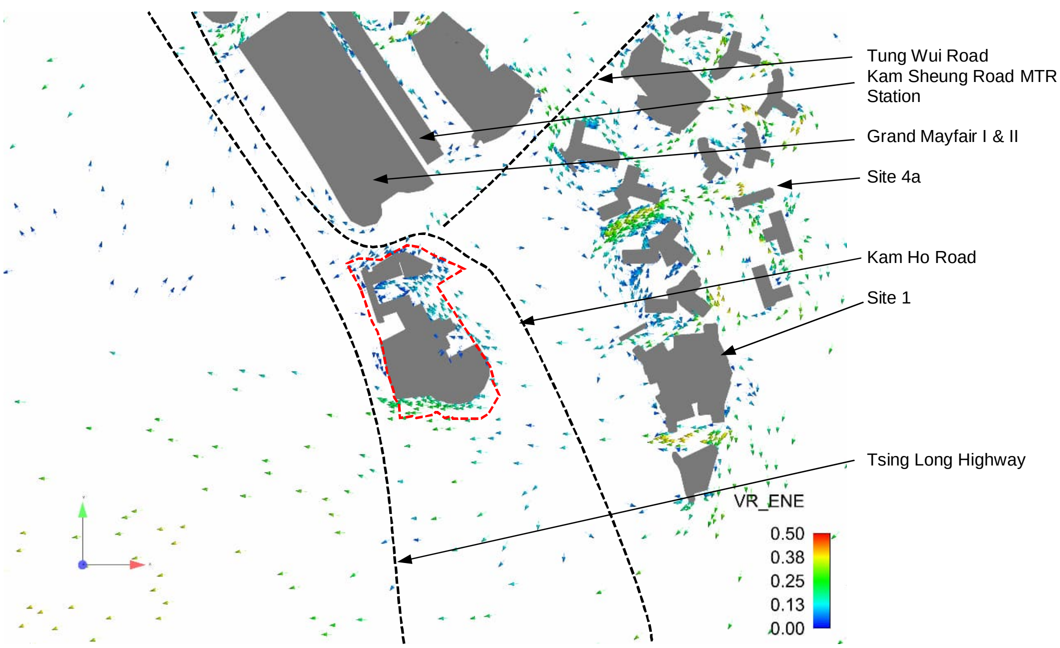
6.4 Similar to NE wind, it is observed that the incoming ENE wind would pass through the low-rise villages including Ng Ka Tsuen (17mPD appx.) and Kong Ha Wai (16mPD appx.). The low-rise villages would not induce wind influences against the Project Area as the ENE winds could skim over the low-rise developments. Then, the proposed public housing development Site 1 and Site 4a in the immediate east to northeast would slightly weaken the wind environment, which the Project Area lies in the wind influencing zone of Site 4a. On the other hand, Tung Wui Road aligns in the NE-SW direction, which is less effective under ENE wind. Thus, the ENE wind is observed to only travel a section of Tung Wui Road and gradually flow towards Kam Sheung Road MTR Station (30mPD appx.).

6.5 Under the Baseline Scenario, it is observed that the already weakened wind flow from Site 1 and Site 4a is further diminished by the proposed mid-rise developments (68.5mPD). The extended frontage of the podium structure acts as a barrier, impeding a portion of the incoming wind at the pedestrian level. Consequently, there is a reduction in wind penetration, resulting in the creation of a wind influencing zone in the immediate downstream area. This extensive area exhibits a lower Velocity Ratio (VR). However, at higher levels, the designated 30m wide Eco-corridor between Block 1 and Block 3 in the Baseline Scheme, aligned in the ENE-WSW direction, enhances wind penetration and decreases the wind stagnant area. On the other hand, the incoming wind is observed to freely travel along the southern site perimeter due to the reserved building setback from the site boundary.

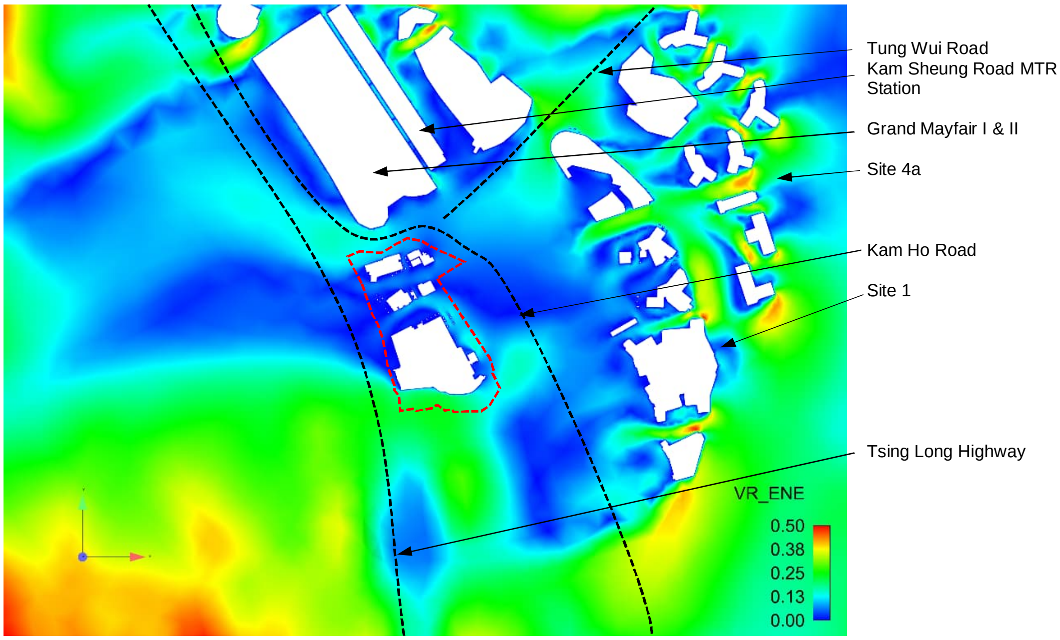
6.6 In the Proposed Scenario, it is observed that the proposed mid-rise residential developments (62.24mPD) have a less significant air ventilation impact on the immediate downstream area compared to the Baseline Scenario. The incoming wind is able to penetrate the Project Area more effectively with fewer obstructions from the proposed developments at the pedestrian level, thanks to the reserved empty bays beneath the domestic blocks. At higher levels, the widened building gaps allow the incoming wind to gradually flow through, effectively reducing the wind stagnant area in the immediate downstream. Consequently, the velocity ratio is enhanced along the northern section of Kam Ho Road, Tsing Long Highway, the hiking trail, as well as Sze Pai Shek Tsuen, in contrast to the Baseline Scenario.

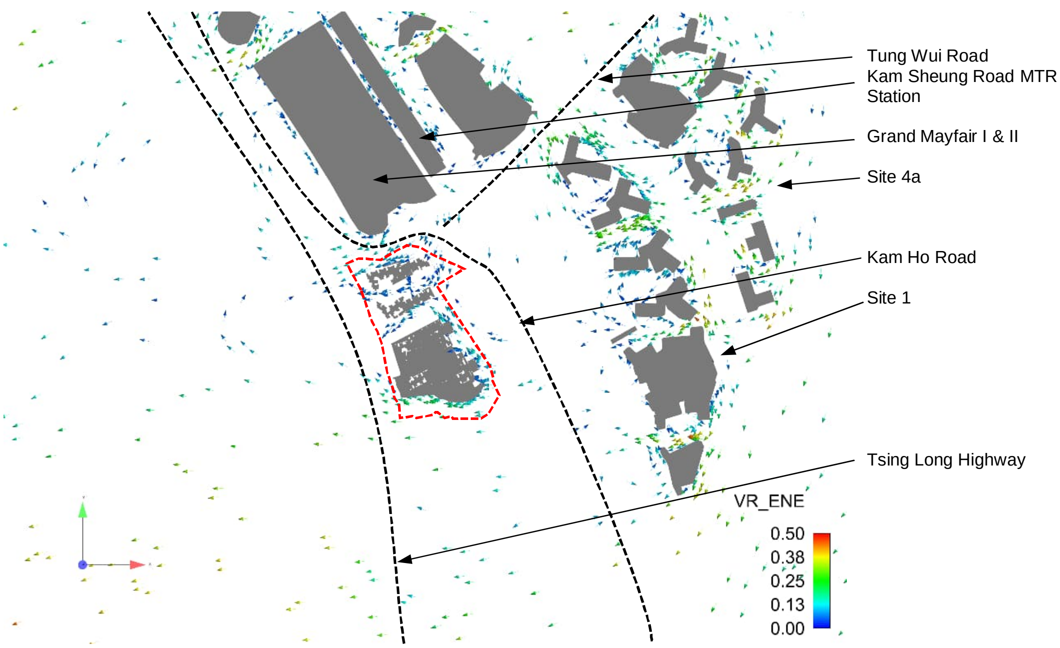
Baseline Scheme





Proposed Scheme





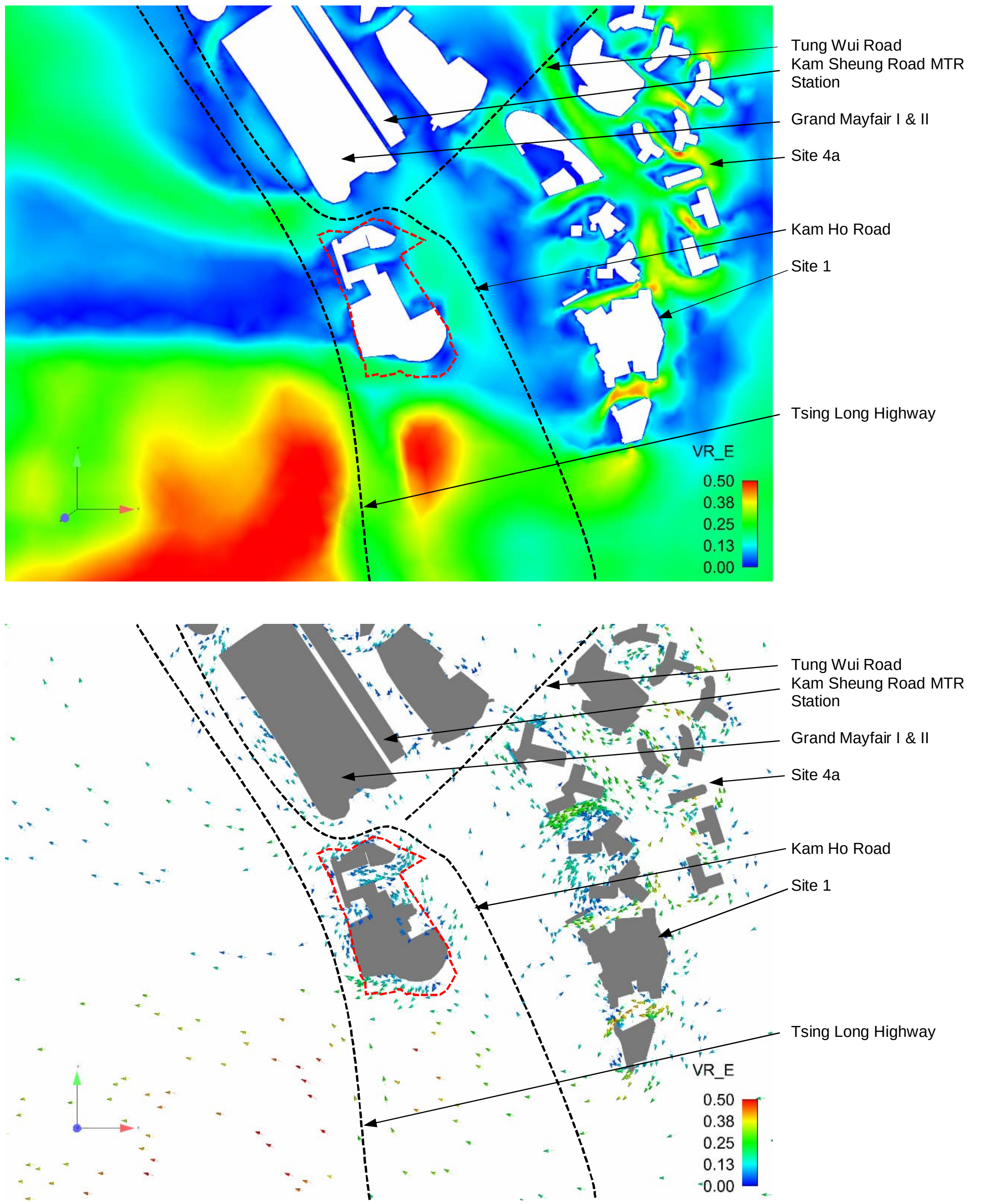
E: (Annual: 15.4%)

6.7 The easterly (E) wind is observed to flow over the Village type development ("V") area, including Kong Ha Wai (16mPD), before reaching the Project Area. The incoming easterly wind can skim over the low-rise developments and gradually reach the Project Area through the building gaps and empty bays of the proposed public housing development at Site 1 and Site 4a. Consequently, the wind availability on the site is deemed satisfactory.

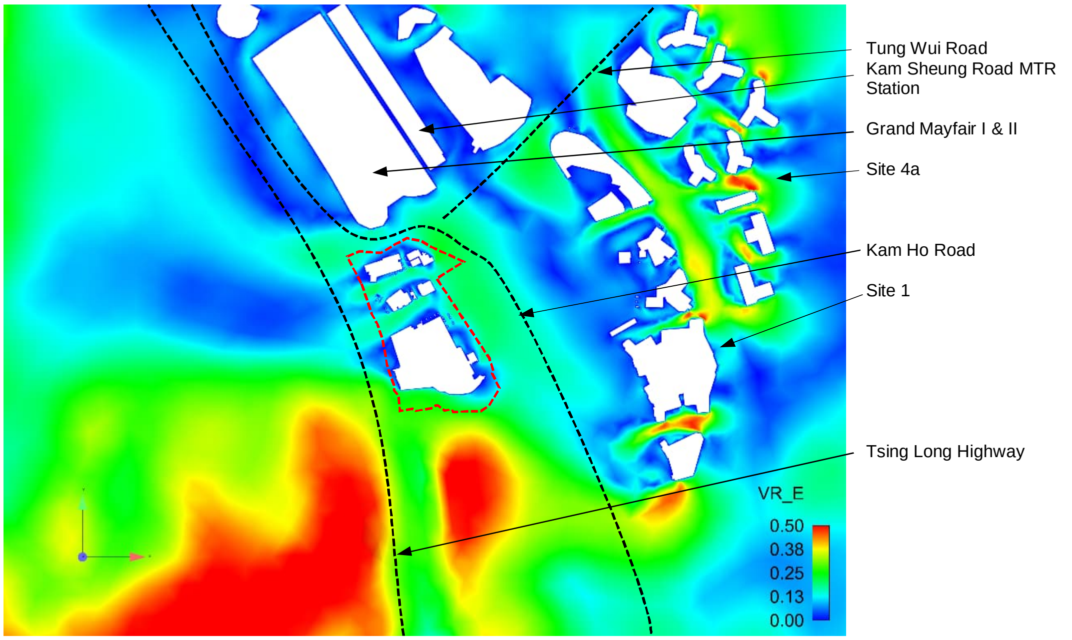
6.8 Under the Baseline Scenario, the incoming easterly wind flowing from the low-rise developments is found to be shielded by the proposed mid-rise developments (68.5mPD), creating a wind shadow in the downstream of the Project Area due to the long frontage of the podium. This results in decreased air ventilation performance in the immediate surroundings. An extensive area of wind stagnation with lower VR is observed to the west of the Project Area, covering the agriculture ("AGR") zone. However, at higher levels, the wind environment improves with the presence of a 30m wide Eco-corridor, which facilitates some penetration of the easterly wind and helps to reduce the wake area in the immediate downstream.

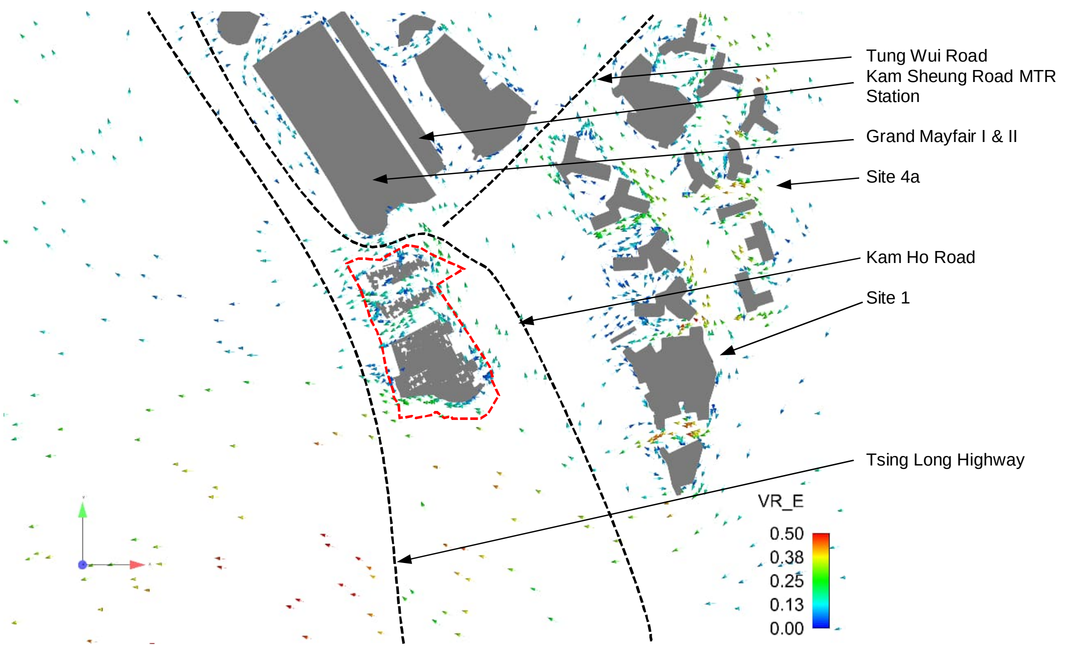
6.9 Under the Proposed Scenario, the proposed mid-rise residential developments (62.24mPD) are observed to alleviate the air ventilation impact on the immediate downstream compared to the Baseline Scenario. It is observed that the wind shadow in the downstream of the Project Area is significantly reduced compared to the Baseline Scenario. This reduction is due to the presence of air-permeable space in the podium and widened building gaps, which allow the incoming wind to freely penetrate the Project Area. Additionally, with a less bulky podium under Block A in the Proposed Scheme, a portion of the incoming wind effectively flows along a section of Kam Ho Road and reaches the downstream area. Therefore, an increased VR is observed in the western portion of the Project Area.

Baseline Scheme



Proposed Scheme





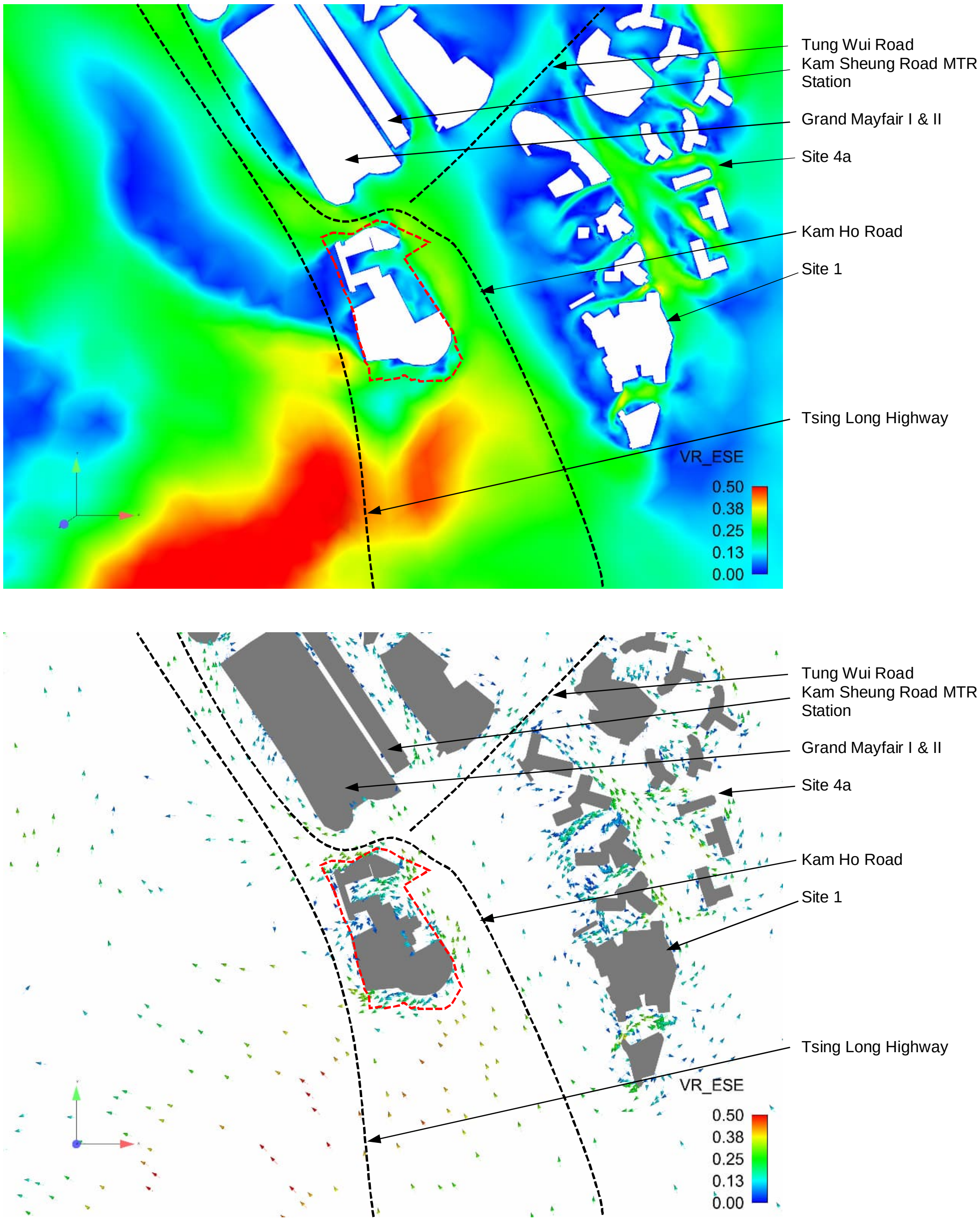
ESE: (Annual: 9.6%, Summer: 8.8%)

6.10 The incoming ESE wind under annual and summer conditions would flow along the extensive Agriculture (“AGR”) and Village type development (“V”) area including Kong Ha Wai (16mPD appx.) before reaching the Project Area. Then the incoming wind would then slightly divert by the proposed public housing development Site 4a to enter the Project Area with a satisfactory site wind availability.

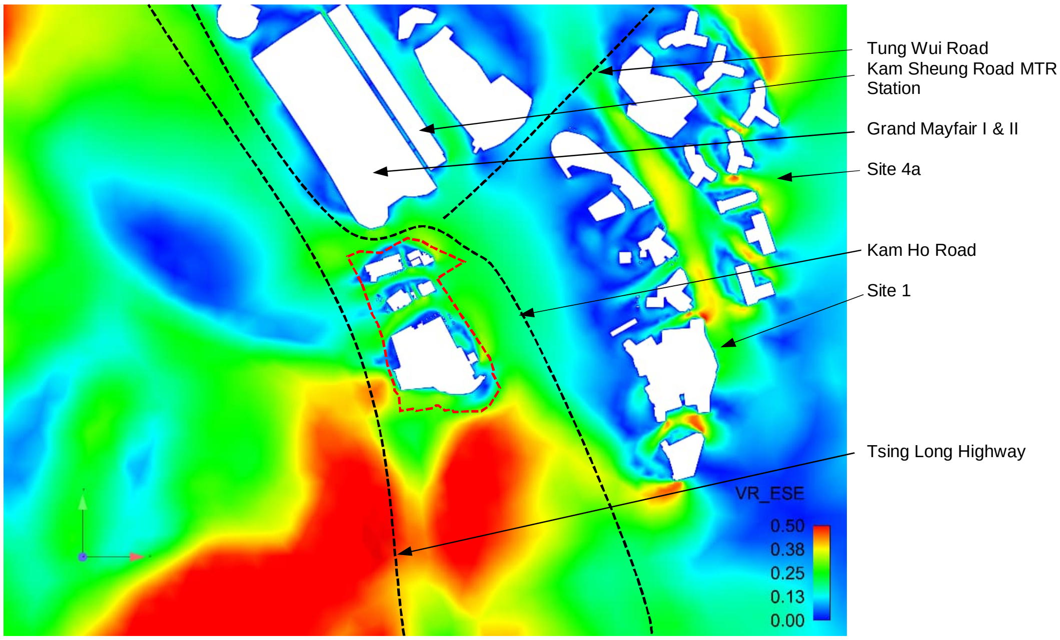
6.11 In the Baseline Scenario, a portion of the incoming ESE wind is observed to be captured by the proposed mid-rise developments (68.5mPD) due to the long frontage of the podium. Another portion of the incoming wind is redirected northward, flowing towards Kam Sheung Road MTR Station (appx. 30mPD) and the proposed residential development, Grand Mayfair I & II (apprx.69mPD), while a light breeze diverts along Tung Wui Road. The proposed developments induce a stagnant zone of wind in the downstream area, leading to a slightly weakened air ventilation performance in the agricultural area to the west and northwest of the Project Area.

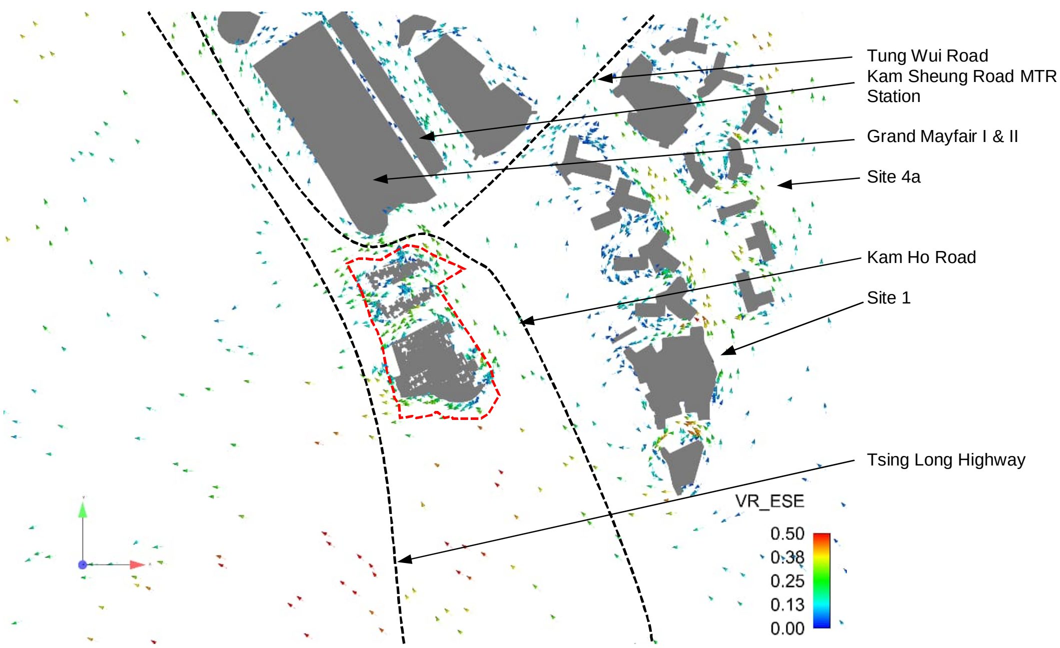
6.12 In the Proposed Scenario, the proposed mid-rise residential developments (62.24mPD) are observed to enhance the air ventilation performance in the immediate downstream compared to the Baseline Scenario. At lower elevations, it is observed that the incoming wind can pass through the air-permeable spaces in the podium, reaching the western site perimeter and Tsing Long Highway without obstruction. Although a wind stagnant zone can still be identified, its extent is greatly reduced. The VR in the immediate vicinity is found to be relatively high. Moreover, the incoming wind can freely traverse the reserved building setback from the site boundary, creating a satisfactory wind environment.

Baseline Scheme



Proposed Scheme





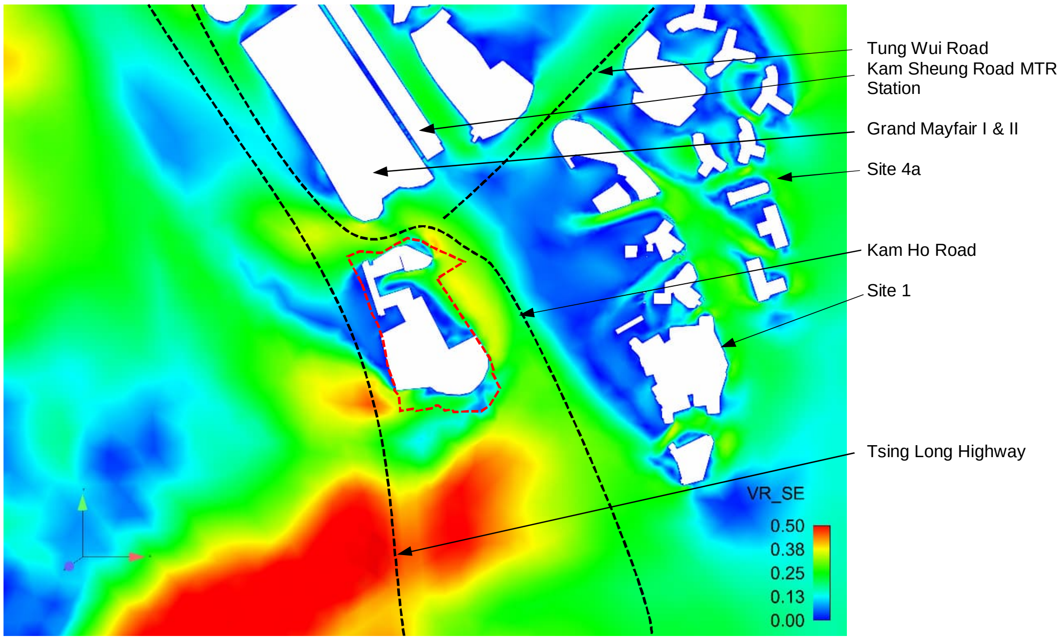
SE: (Annual: 8.6%, Summer: 7.5%)

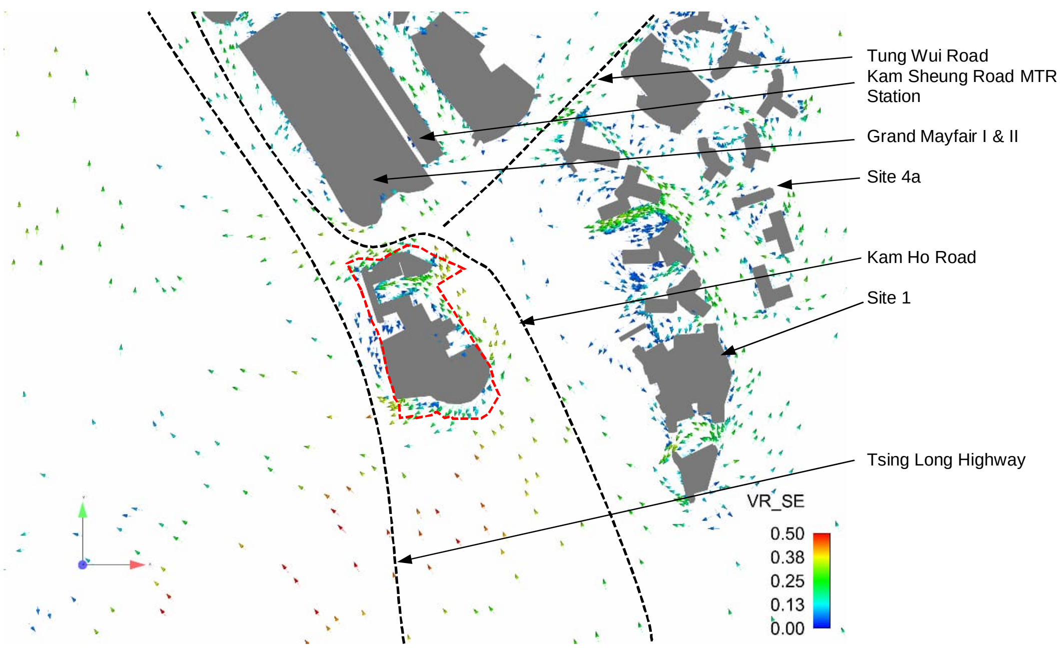
6.13 SE wind would pass through the Agriculture (“AGR”) and Village Type Development (“V”) area including Tin Sam San Tsuen before ventilating the Project Area. The incoming wind would be slightly diverted by the southern portion of the proposed public housing development Site 4a, which would not induce wind influences against the Project Area. The wind availability at the Project Area is satisfactory.

6.14 In the Baseline Scenario, the proposed mid-rise residential developments (68.5mPD) would impede the incoming wind to the immediate west, affecting the western site perimeter, a small section of Tsing Long Highway, and the hiking trail. It is observed that the incoming wind divides into two streams due to the presence of Block 4 in the Baseline Scheme. One stream flow along the eastern site perimeter towards Kam Sheung Road MTR Station (30mPD) and the Grand Mayfair I & II (69mPD). The other stream is directed westward through the southern site perimeter, merging with Tsing Long Highway. The overall wind environment is satisfactory, although it is noted that the building morphology of Block 1 in the Baseline Scheme tends to obstruct a portion of the incoming wind. A localized area with lower Velocity Ratio (VR) can be observed downstream of Block 1.

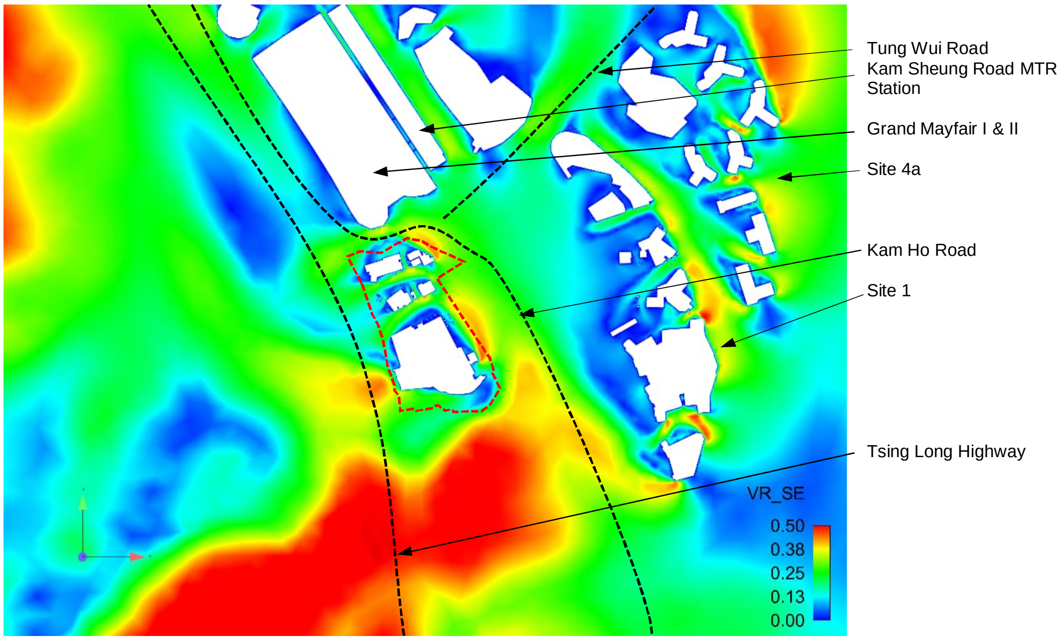
6.15 In the Proposed Scenario, the proposed mid-rise residential developments (62.24mPD) are anticipated to have a reduced air ventilation impact on the immediate downstream compared to the Baseline Scenario, owing to the enhanced air permeability. With widened building gaps and empty bays, rather than trapping the incoming wind, the wind can freely pass through each building gap. An increased VR is observed in the western portion of the Project Area due to the reduced wind shadow.

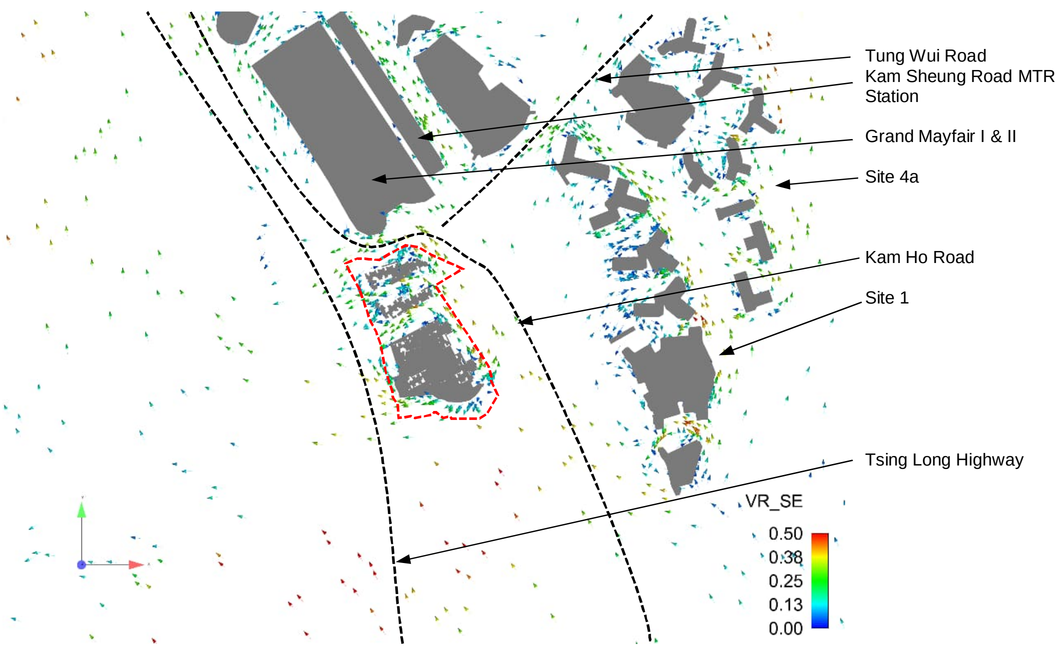
Baseline Scheme





Proposed Scheme





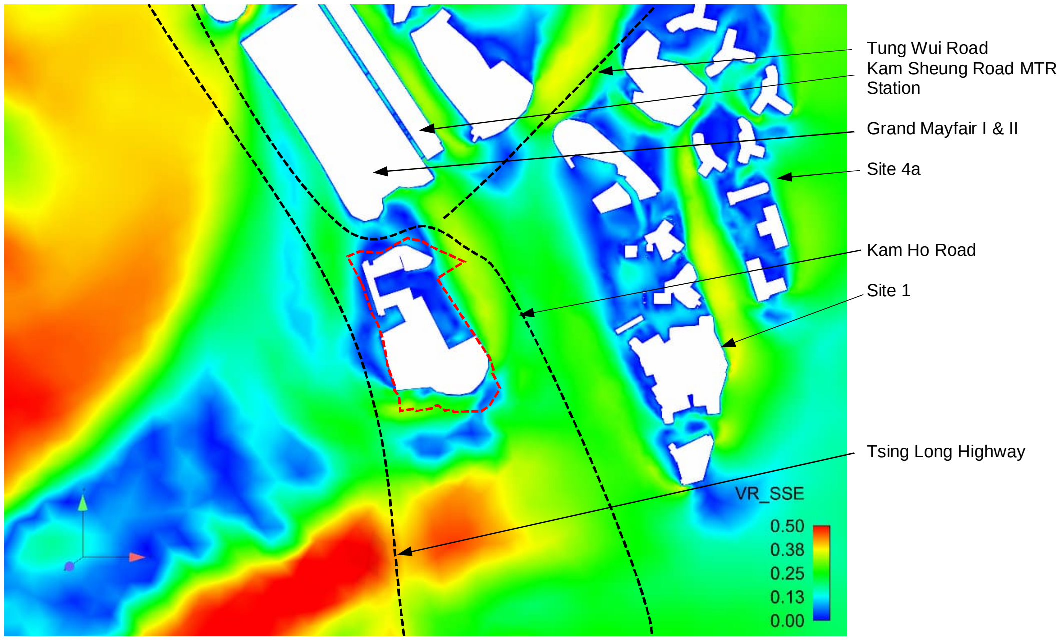
SSE: (Annual: 6.6%, Summer: 9.2%)

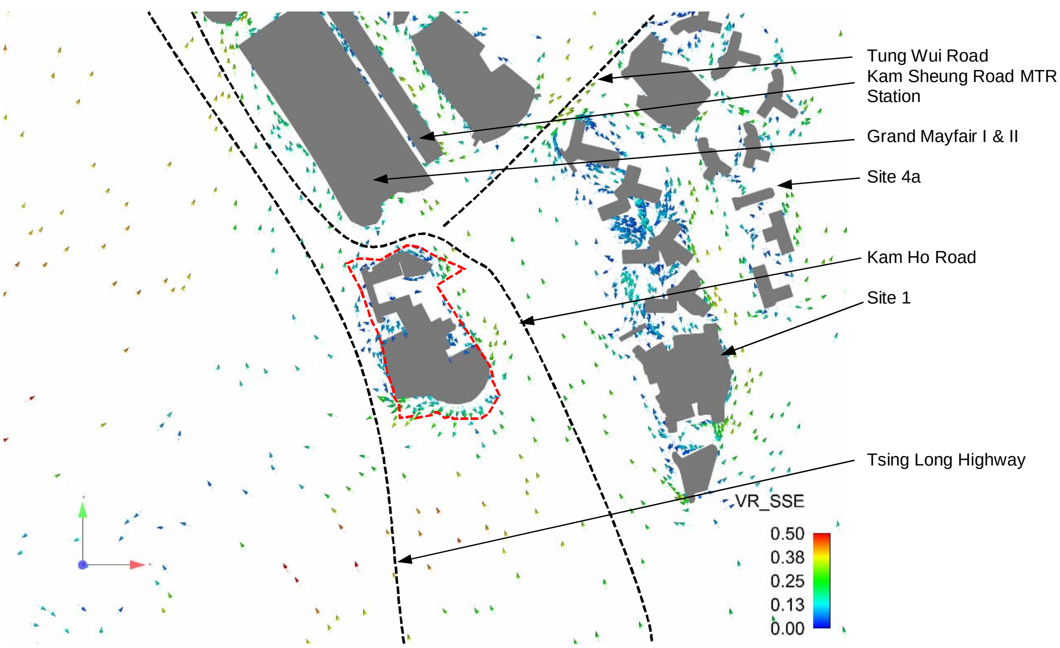
6.16 The incoming wind from SSE under annual and summer conditions is expected to pass through Pat Heung Depot before reaching the Project Area. The low-rise development would not induce wind impact on the Project Area. The site wind availability mainly relies on Tsing Long Highway and Kam Ho Road, which serve effective wind corridors for the incoming wind to penetrate the Project Area. The site wind availability is observed to be satisfactory.

6.17 In the Baseline Scenario, the short frontage of the proposed mid-rise residential developments (68.5mPD) in the Project Area would create a localized wind influence zone, leading to a reduction in air ventilation performance along the northern site boundary and a section of Kam Po Road to the immediate north. Due to the absence of empty bays and air permeability space between Block 3 and Block 4 in the Baseline Scheme, it is expected that a portion of the incoming wind will be captured, split, and diverted westward, merging with Tsing Long Highway.

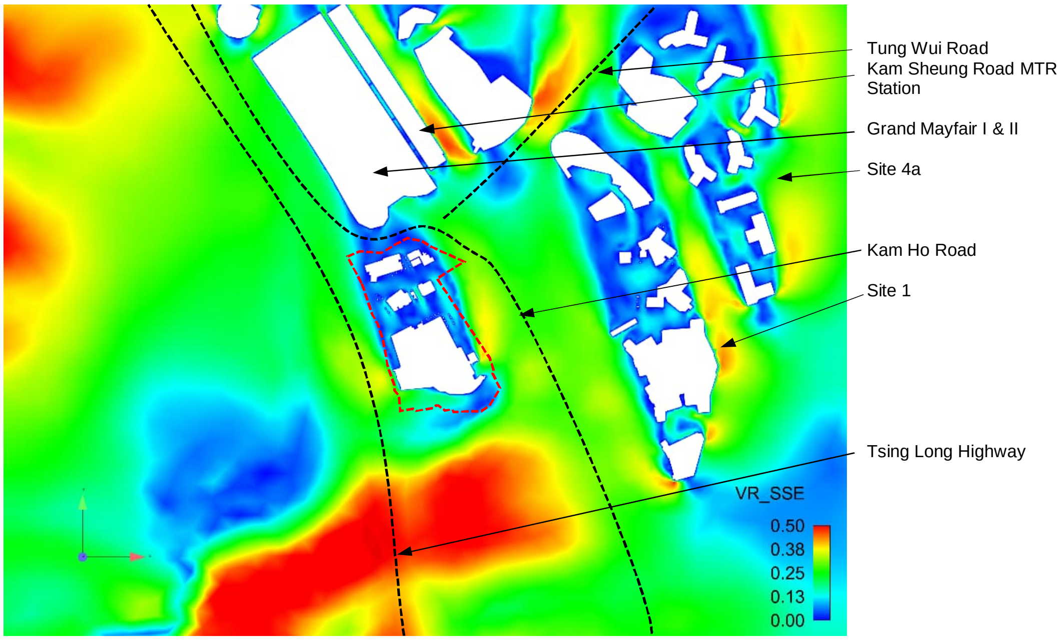
6.18 In the Proposed Scenario, it is observed that the presence of empty bays and building gaps between the proposed mid-rise residential developments (62.24mPD) facilitates air movement. Additionally, the truncated design of Block C in the Proposed Scheme, featuring a high ceiling covered area in the lower zone, aligns in the south-southeast (SSE) direction. Consequently, the incoming wind is found to pass through the central courtyard of the Project Area, resulting in an enhancement of the wind environment in the immediate downstream area. The wind influence zone is reduced, and a higher Velocity Ratio (VR) is observed.

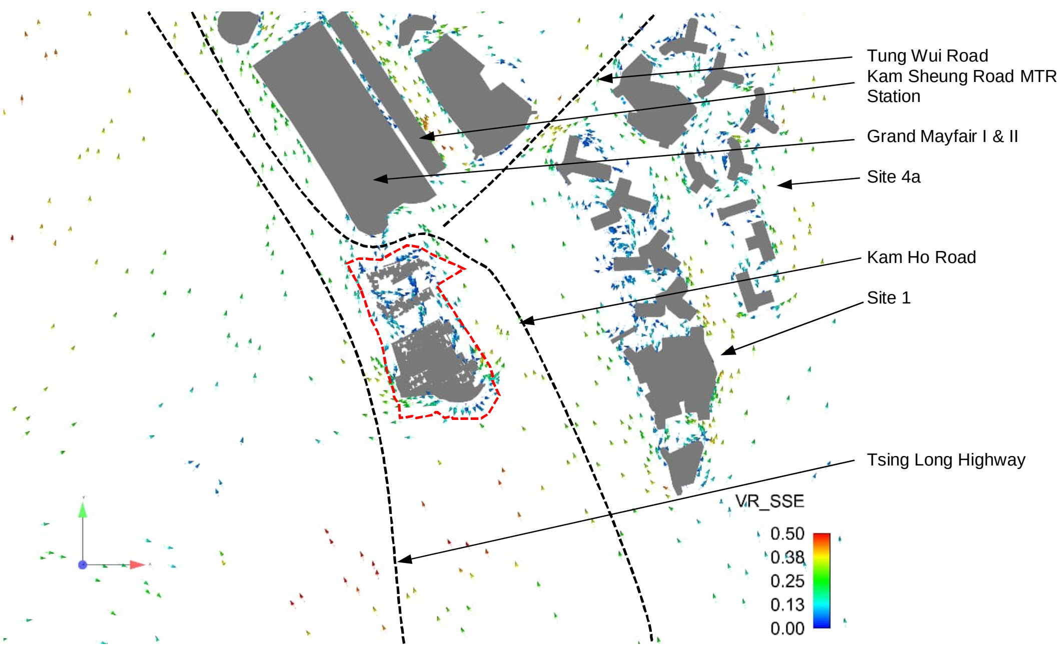
Baseline Scheme





Proposed Scheme





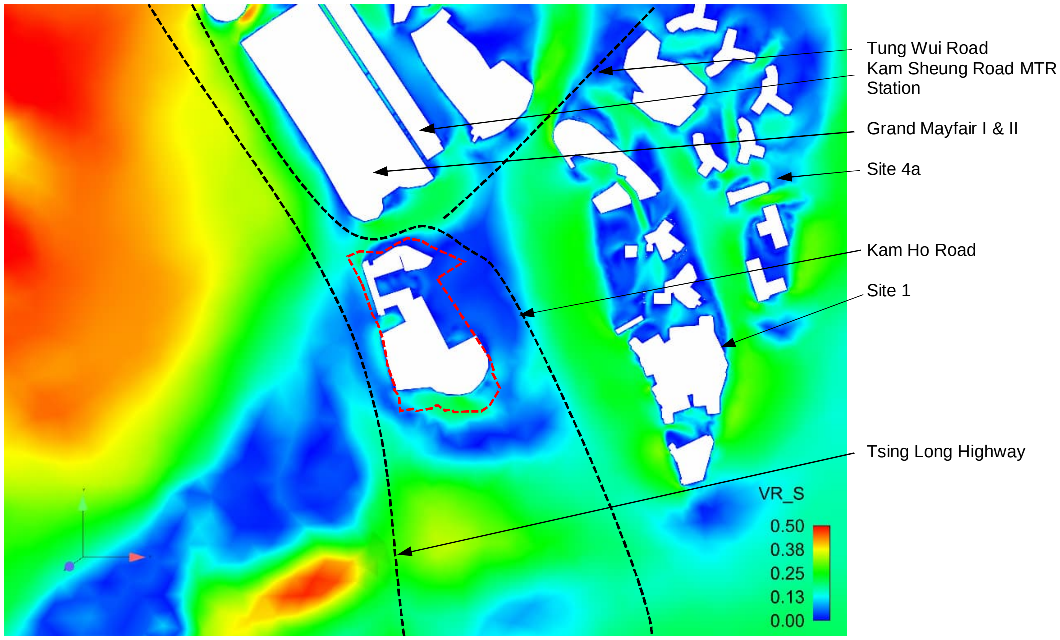
S: (Annual: 6.7%, Summer: 13.3%)

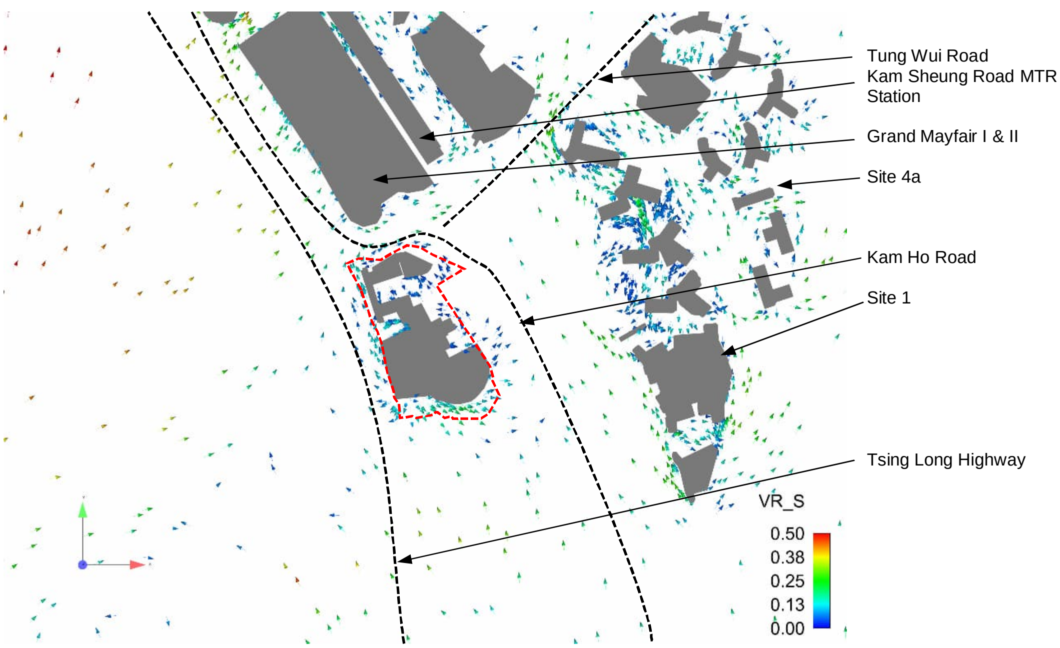
6.19 S wind under annual and summer conditions is expected to pass through Pat Heung Depot before reaching the Project Area, similar to the SSE wind flow pattern. The low-rise development would not induce wind impact on the Project Area. Tsing Long Highway and Kam Ho Road align in the NNW-SSE direction which serves as wind corridors facilitating the S winds to penetrate the Project Area. The wind availability is expected to be satisfactory.

6.20 Under the Baseline Scenario, the proposed mid-rise residential developments (68.5mPD) in the Project Area would obstruct the incoming wind flowing along the western site boundary. The relatively low wind permeability is found to limit the incoming wind to skim over the central portion of the Project Area. As a result, the incoming wind would tend to reattach along Tung Wui Road and flow further downstream. A localized wind stagnant is observed in the immediate downstream.

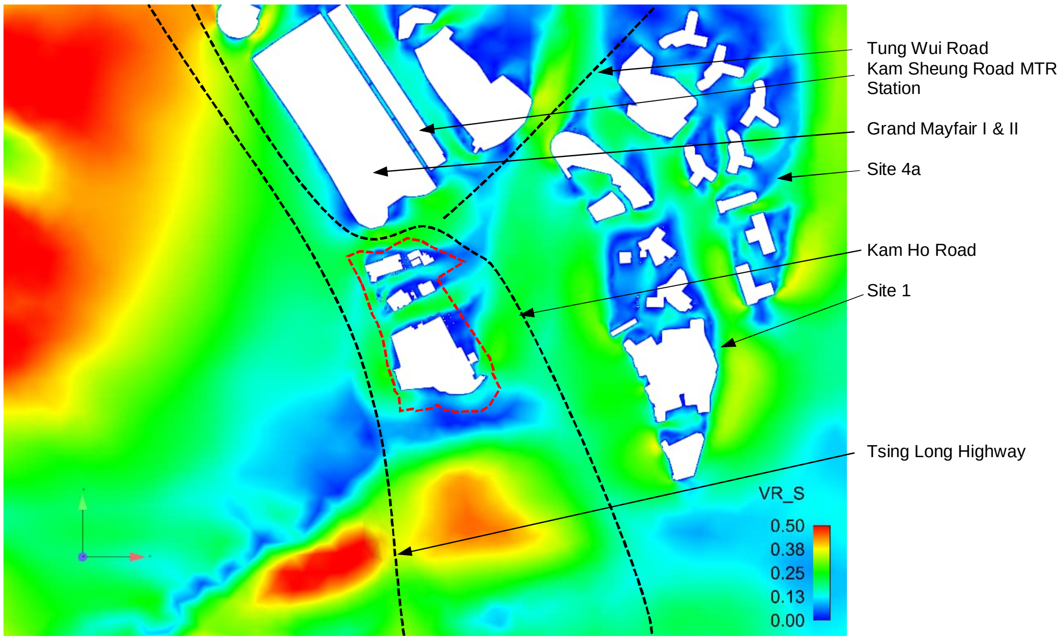
6.21 Under the Proposed Scenario, it is observed that the empty bays and the truncated design with a high ceiling covered area in the low zone of Block C in the proposed mid-rise residential developments (62.24mPD) would greatly enhance the air permeability. It is noticed that the localized wind stagnant is reduced as the incoming wind flowing along the western site perimeter could circulate and ventilate around the Project Area and improve the air ventilation performance in the immediate surrounding. Therefore, a notably higher average wind velocity is observed compared to the Baseline Scheme.

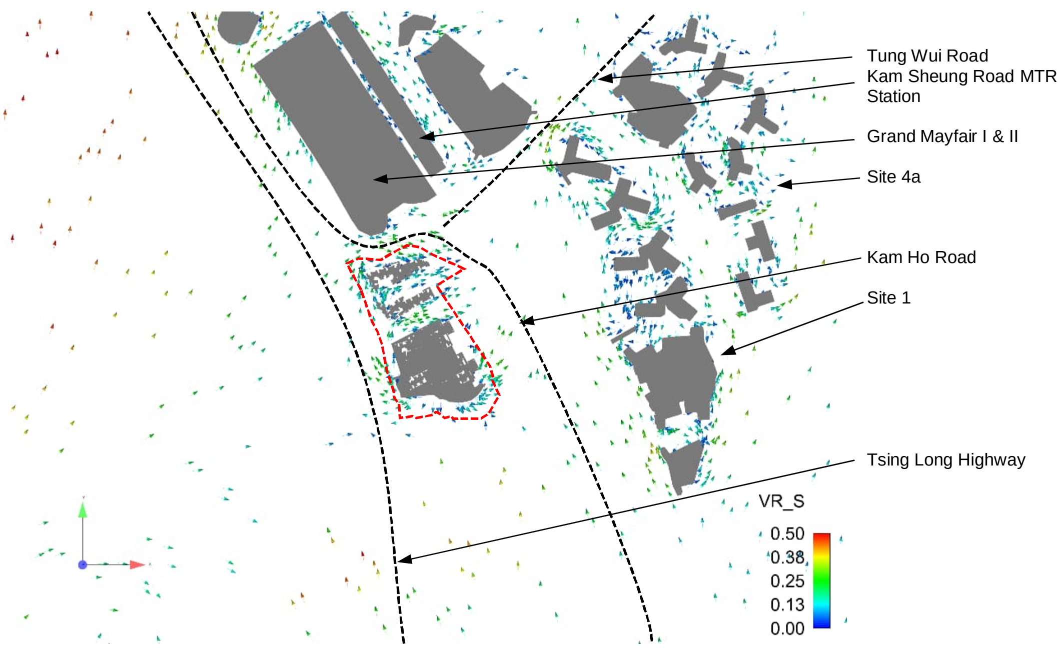
Baseline Scheme





Proposed Scheme





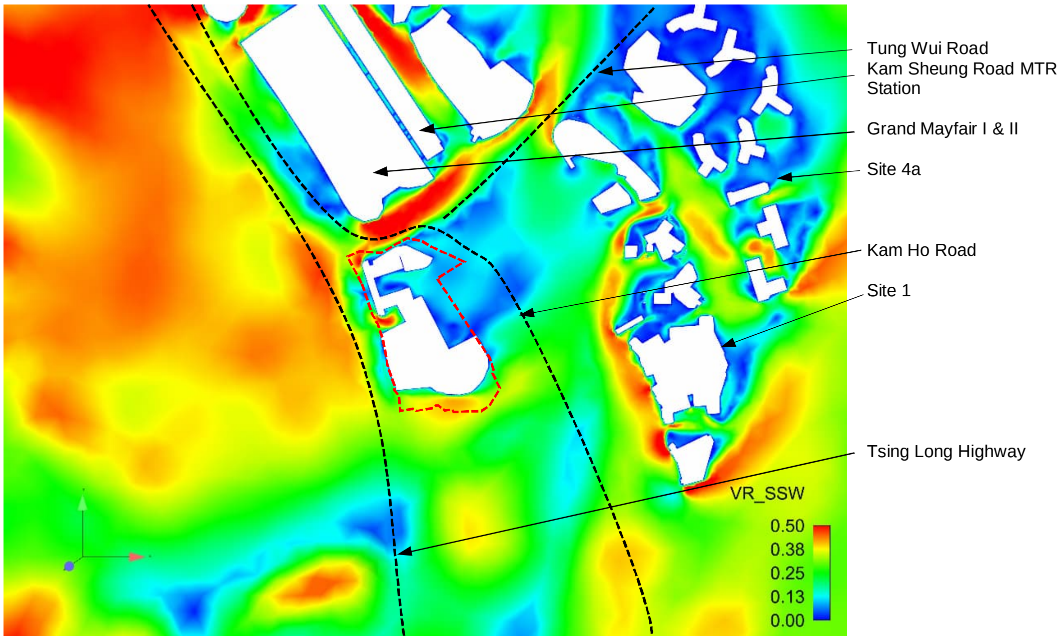
SSW: (Annual: 7.7%, Summer: 16.7%)

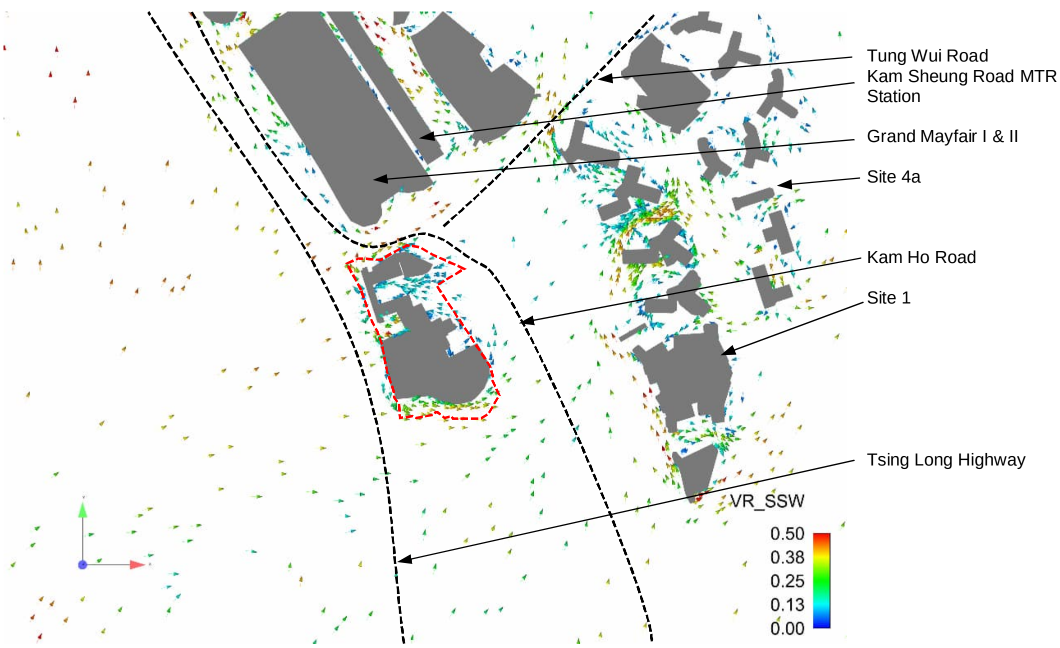
6.22 The incoming wind from SSW under annual and summer conditions is expected to pass through Tai Lam Country Park (200mPD) before reaching the Project Area. As the Tai Lam Country Park is located in the southwest of the Project Area, the hilly terrain will weaken the incoming SSW prevailing winds. High-level winds are expected to mostly flow over the hilly terrain. While the katabatic winds may flow towards the Project Area and maintain a satisfactory wind environment.

6.23 In the Baseline Scenario, the incoming wind flows along the hiking trail and Tsing Long Highway to reach the southern and western site perimeter of the Project Area. A portion of the incoming wind encounters the short frontage of Block 3 and Block 4 in the Baseline Scheme that located in the southern portion of the Project Area, leading to the proposed development inducing a strong downwash wind. As a result, a relatively high VR is observed at the southern site boundary. Another portion of the incoming wind flows along the western site boundary. Due to the absence of air permeable space and empty bays in the podium, the incoming wind is unable to effectively penetrate the Project Area and instead continues along Tung Wui Road. Consequently, a wind shadow is present in the immediate downstream area, resulting in a lower VR.

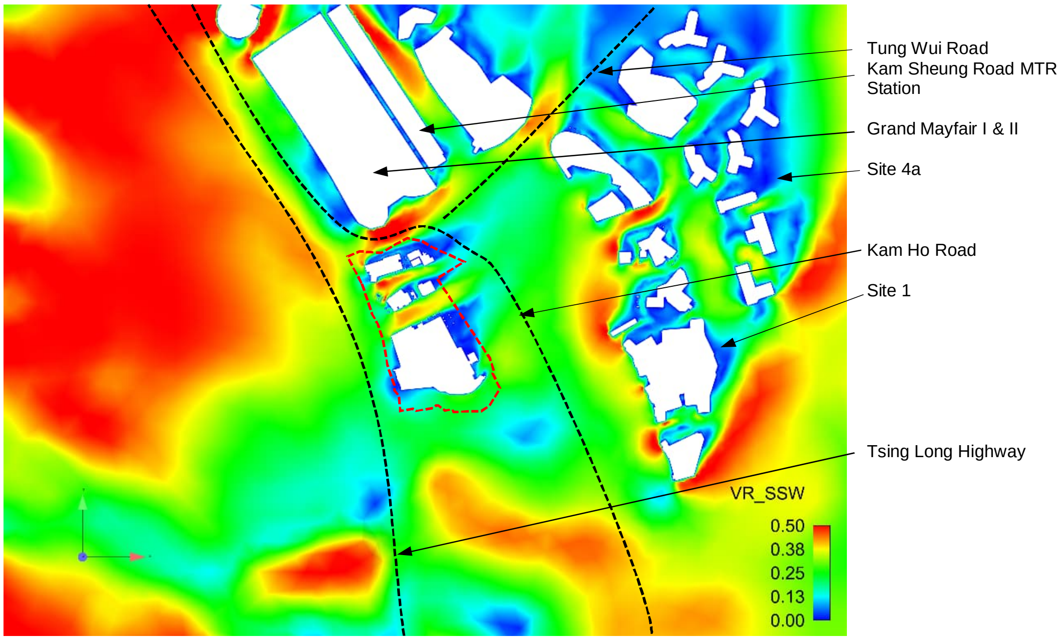
6.24 In the Proposed Scenario, although the wind corridors are not aligned with SSW direction, the incoming could enter the Project Area through the reserved empty bays. Additionally, the incoming wind would divert eastward and accelerate between the air permeable space between the proposed developments. As the incoming wind could penetrate the Project Area, the wind shadow is observed to be significantly reduced, the wind impact to the surrounding developments to be limited.

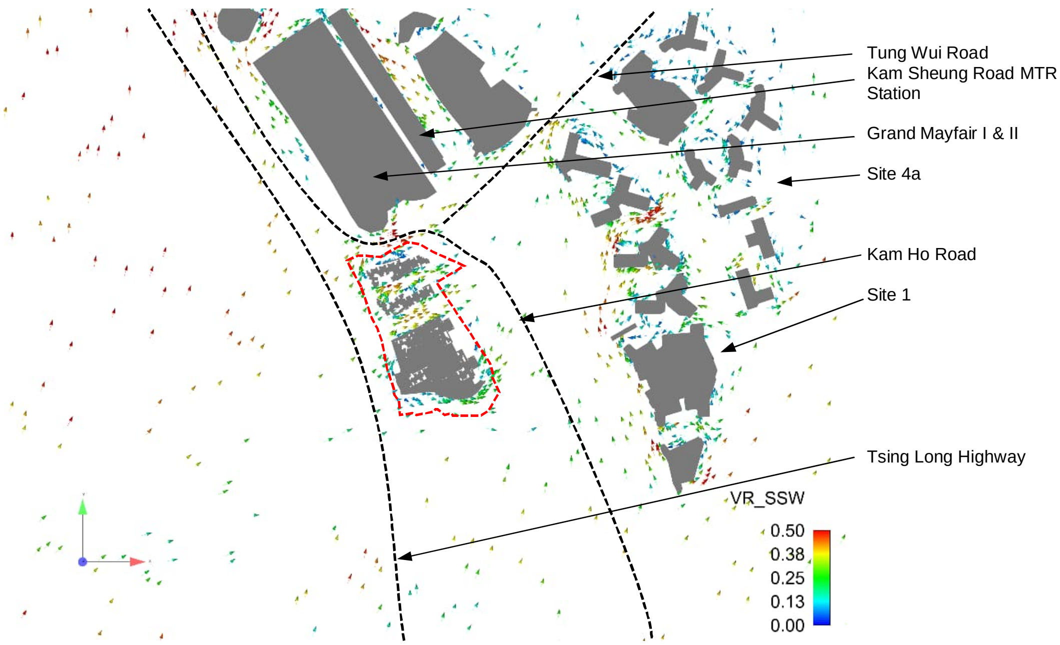
Baseline Scheme





Proposed Scheme





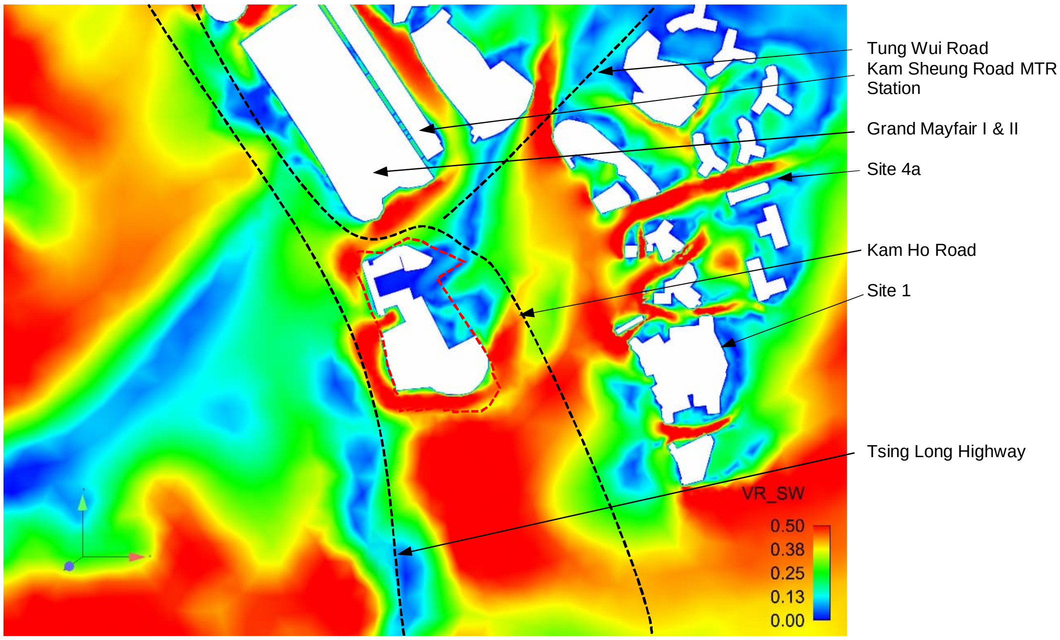
SW: (Summer: 13.3%)

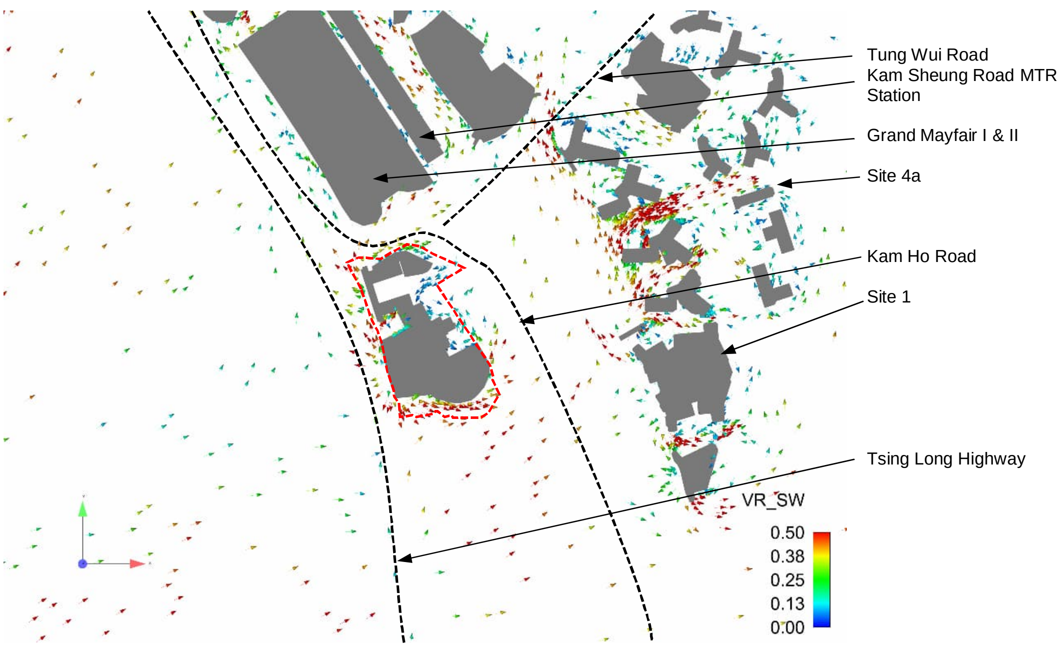
6.25 Similar to the SSW wind, the incoming SW wind is found to pass through Tai Lam Country Park (200mPD) and flow along the valley before reaching the Project Area with a satisfactory site wind availability.

6.26 In the Baseline Scenario, the incoming wind in lower level would be shielded by the long frontage of the podium. While with a relatively high wind availability, the SW wind would split and flow along the northern and southern site perimeters to ventilate downstream. Without air permeable space in the central portion of the Project Area, a small wind shadow is observed. On the other hand, in higher level, the reserved 30m width Eco-corridor aligning ENE-WSW direction between Block 1 and Block 3 in the Baseline Scheme could guide the incoming wind towards the downstream area to alleviate the wind impact.

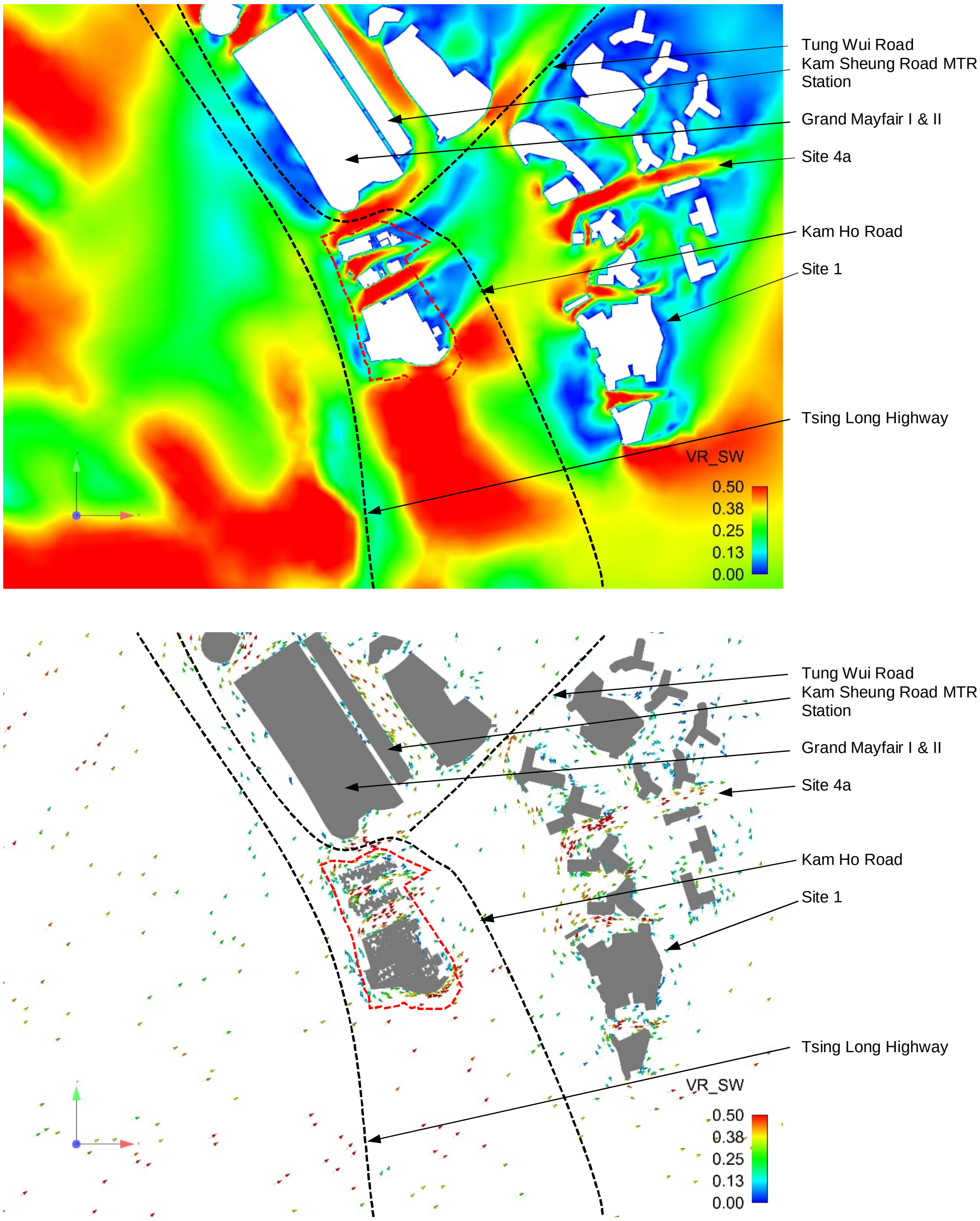
6.27 In the Proposed Scenario, with the inclusion of more air permeable space and widened building gaps, the incoming wind could penetrate the Project Area more effectively and evenly. In addition, it is found that the proposed development would not induce severe wind impact towards the proposed public housing development Site 1 and Site 4a in the downstream area.

Baseline Scheme





Proposed Scheme



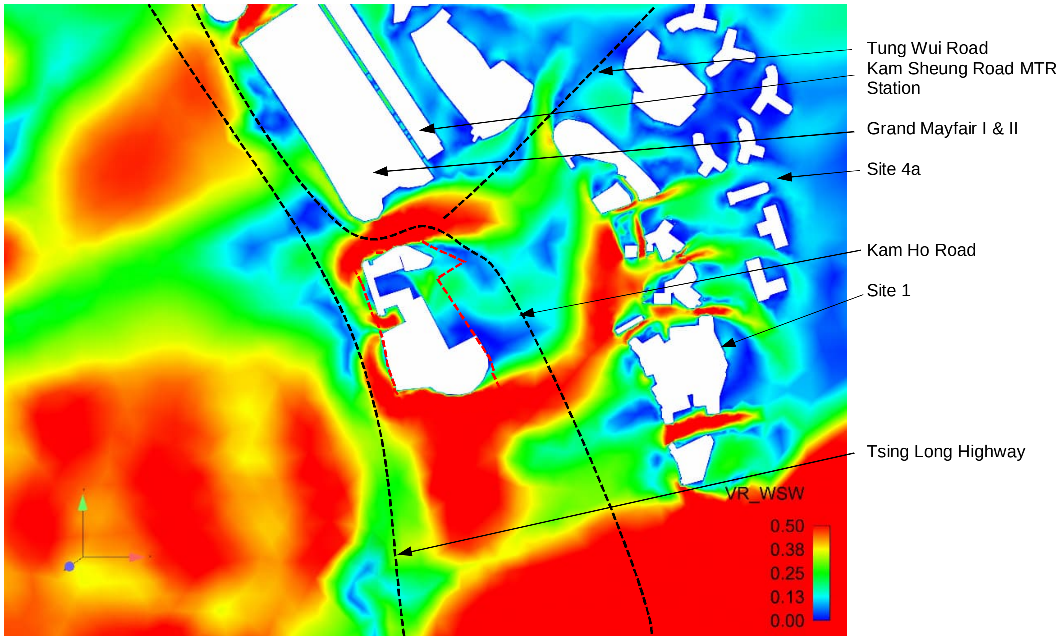
WSW: (Summer: 6.2%)

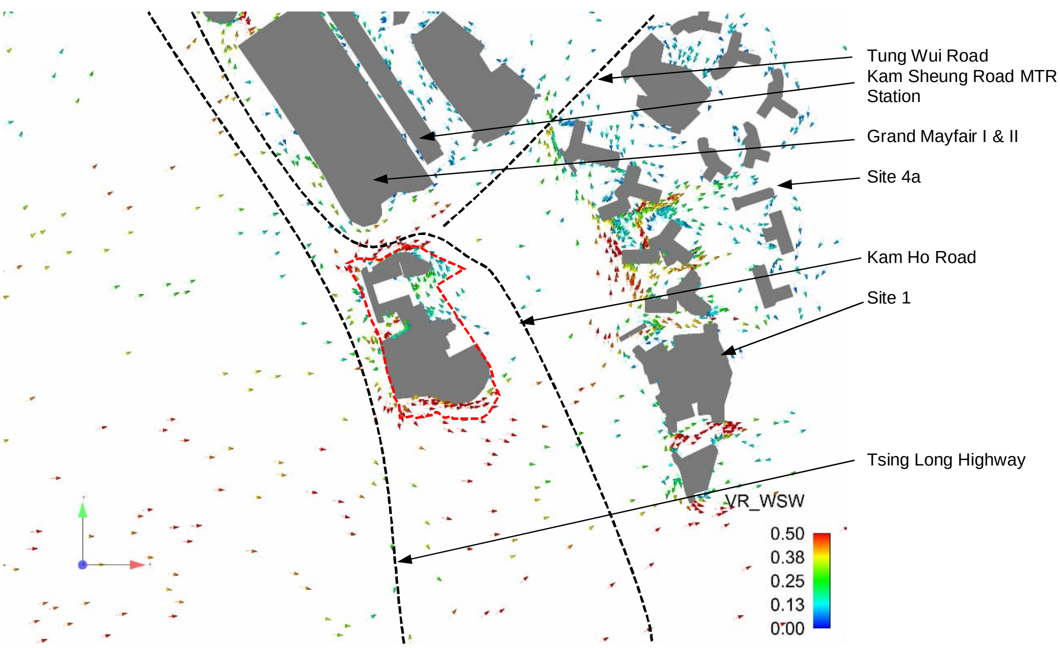
6.29 A comparable wind flow pattern can be noticed in WSW wind when compared to the SSW wind, the incoming WSW wind is found to pass through Tai Lam Country Park (200mPD) and flow along the valley before reaching the Project Area with a satisfactory site wind availability.

6.30 In the Baseline Scenario, the velocity ratio of the Project Area and the immediate surroundings are generally high as the major wind corridors including Tung Wui Road and the reserved 30m width Eco-corridor between Block 1 and Block 3 in the Baseline Scheme are effective in WSW direction. As mentioned, the incoming wind would split and flow along the northern and southern site perimeters to ventilate downstream.

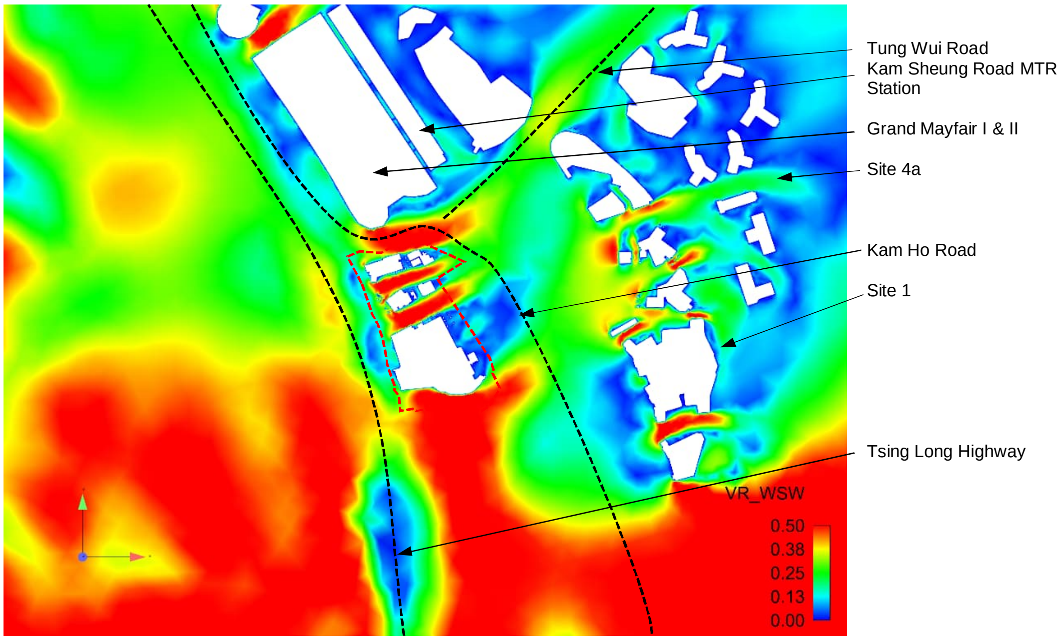
6.31 In the Proposed Scenario, a slightly lower Velocity Ratio (VR) is observed at the northern and southern site perimeters, but it remains satisfactory. This is attributed to the presence of empty bays and wider building gaps, which allow the incoming wind to penetrate the Project Area more effectively. As a result, the incoming wind diffuses into each air permeable space, providing more even ventilation to the downstream area, including the proposed public housing developments at Site 1 and Site 4a. This contributes to an overall higher VR in the downstream area.

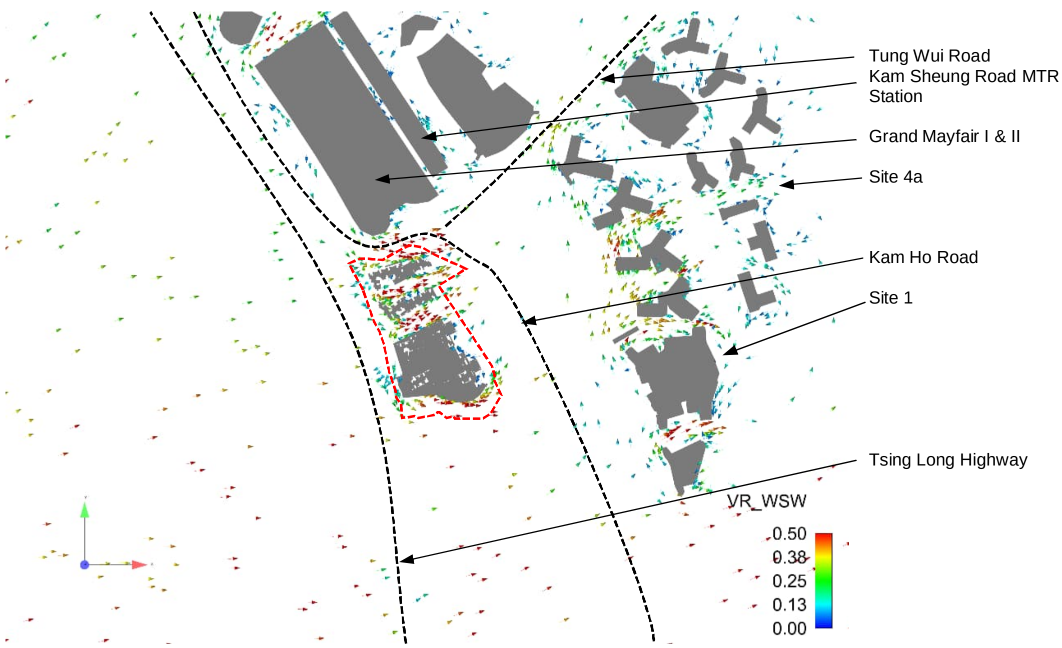
Baseline Scheme





Proposed Scheme

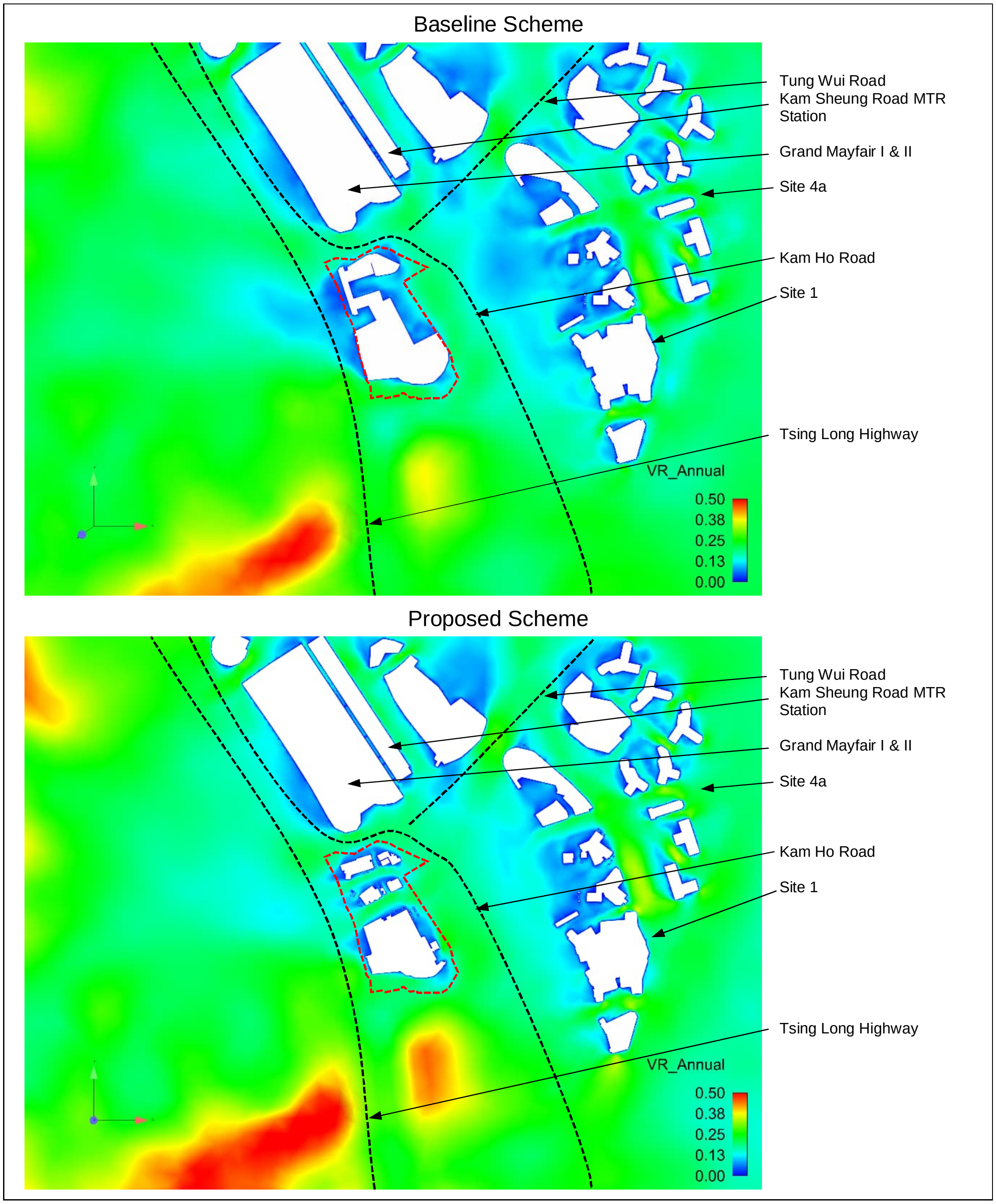




Overall Annual Frequency Weighted VR (76.4%)

6.32 According to the overall annual frequency weighted VR plot, observable air ventilation enhancements and drawbacks are summarized as follows:

- Observable improvement of air ventilation performance within the Project Area
- A slightly smaller wind stagnant zone in the west of the Project Area

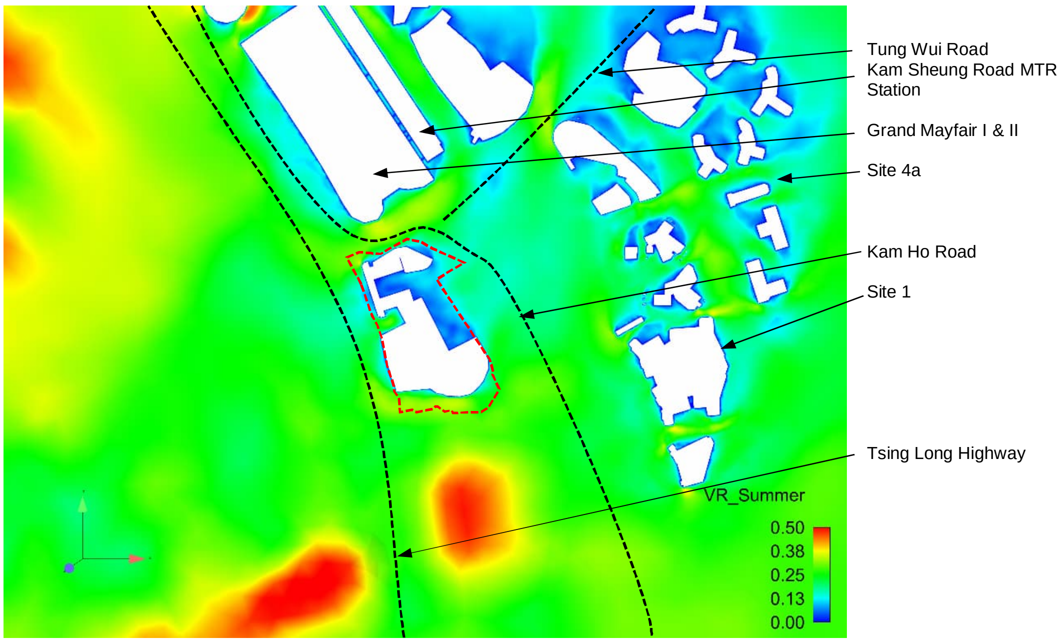


Overall Summer Frequency Weighted VR (81.7%)

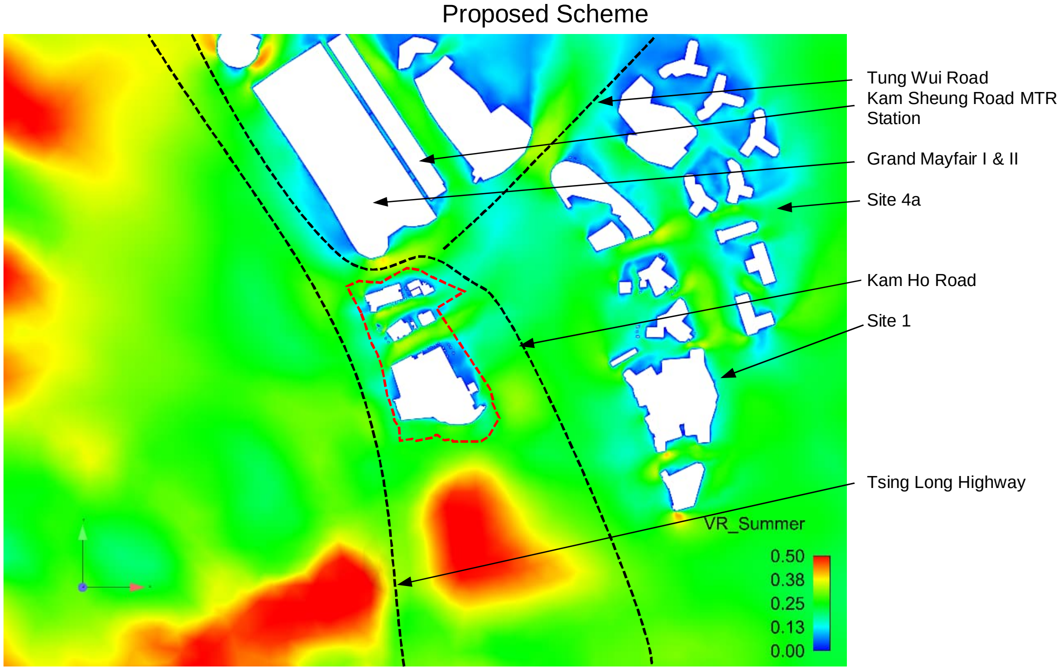
6.33 According to the overall summer frequency weighted VR plot, observable air ventilation enhancements and drawbacks are summarized as follows:

- Observable improvement of air ventilation performance within the Project Area
- Slightly better wind environment at the eastern portion of the Project Area

Baseline Scheme



Proposed Scheme



7 SUMMARY AND CONCLUSIONS

7.1 The Kam Sheung Road Site 6 of this study is situated at Kam Tin South Area, Yuen Long in the New Territories. It is noticed that the Project Area is generally flat except for natural slopes from mild gradient to hilly towards Tseng Hang Shan (237mPD) in the Tai Lam Country Park to the southwest of the Project Area.

7.2 The existing developments in the vicinity of the Project Area are residential, village and open storage buildings varying in building height and density, which will cause observable impact upon the wind environment under different prevailing winds.

7.3 There are abundant low-rise buildings that allow prevailing winds to skim over in the vicinity of the Project Area. These air paths contribute to maintaining the air ventilation performance within the Project Area and their surrounding areas.

7.4 Kam Sheung Road Site 6 is located at the southeast portion of Kam Sheung Road MTR Station, near a large cluster of low-rise villages. The indicative layout of Kam Sheung Road Site 6 incorporated more than 15m building gaps and air permeable spaces at the podium levels which would alleviate the possible wind influence by enhancing the wind permeability of the Project Area.

7.5 This AVA Study Report aims to assess the characteristics of the wind availability of the Project Area, providing a general pattern and a quantitative estimate of wind performance at the pedestrian level under the annual and summer wind directions with the highest occurrence and investigating the effectiveness of ventilation for the scheme designs for the Proposed Public Housing Development at Kam Sheung Road Site 6, namely the Baseline Scheme and the Proposed Scheme.

7.6 To mitigate the potential air ventilation impact on site perimeter by the Proposed Development, several good design features were considered in the Proposed Scheme, such as providing wide building gaps and empty bays to allow the penetration of prevailing wind, reserving building setback from the site boundary and nearby major roads to enhance air ventilation performance of the Project Area, as well as having a truncated design under Block C to improve air permeability, such that the wind environment in the immediate vicinity could be enhanced.

7.7 From the finding of this AVA Initial Study, the SVRw for the Proposed Scheme is increased from 0.12 to 0.14 compared to the Baseline Scheme under the annual prevailing wind from NE, ENE, E, ESE, SE, SSE, SE, and SSW directions which amount to about 76.4% of the whole time in a year. Thus, an improvement in air ventilation performance is observed in the vicinity of the Proposed Scheme under annual prevailing winds. This is due to the fact that air gaps and air spaces in the Proposed Scheme help mitigate the air ventilation impact of the compact residential blocks to allow wind penetration to reach the pedestrian level around the site perimeter.

7.8 The LVRw for the Proposed Scheme is increased from 0.16 to 0.17 compared to the Baseline Scheme under the annual wind directions stated above. It can be concluded that the Proposed Scheme would have a better overall air ventilation performance compared to the Baseline Scheme under the major annual winds.

7.9 Under the summer prevailing wind from E, ESE, SE, SSE, S, SSW, SW and WSW directions which amount to about 81.7% of the whole time in a year, the SVRw for the Proposed Scheme is slightly decreased from 0.19 to 0.18 compared to the Baseline Scheme, which implies a slight decline on the wind environment of the Proposed Scheme when compared to the Baseline Scheme.

7.10 The LVRw for the Proposed Scheme maintained as 0.22 compared to the Baseline Scheme under summer wind conditions. It can be concluded that the Proposed Scheme would have a similar wind environment in the Proposed Scheme when compared to the Baseline Scheme.

7.11 In addition to the good design features identified, the following are some general recommendations that would be adopted as far as practical in the detailed design stage of the Proposed Development to facilitate wind penetration:

- Adopt building permeability equivalent to 20% to 33.3% whenever possible with reference to PNAP APP-152.
- Avoid long continuous façades and face shorter frontages to the prevailing wind directions; and
- Reference to the recommendations of design measures in the Sustainable Building Design Guideline (SBDG) and Hong Kong Planning Standards and Guidelines (HKPSG).

7.12 To conclude, according to the simulation results in **Table 5.1**, improved SVR and LVR are achieved by the Proposed Scheme when compared with the Baseline Scheme under annual and summer wind conditions. No significant impact is anticipated on the surrounding pedestrian wind environment due to the Proposed Scheme.

Appendix A

Wind Probability Table

Tabulated Results – Percentage Occurrence of Directional Winds
Annual – 500m

e_00294	Wind direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
V infinity (m/s)	Sum	0.024	0.056	0.096	0.122	0.154	0.096	0.086	0.066	0.067	0.077	0.057	0.027	0.026	0.016	0.014	0.014
00_to_01	0.029	0.001	0.001	0.002	0.002	0.004	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.003	0.001	0.001	0.001
01_to_02	0.081	0.003	0.004	0.005	0.007	0.010	0.011	0.008	0.005	0.004	0.004	0.004	0.003	0.005	0.003	0.002	0.002
02_to_03	0.120	0.003	0.006	0.010	0.013	0.015	0.016	0.011	0.007	0.007	0.006	0.006	0.005	0.006	0.004	0.003	0.003
03_to_04	0.135	0.004	0.007	0.013	0.018	0.018	0.017	0.012	0.007	0.006	0.007	0.006	0.005	0.005	0.004	0.003	0.003
04_to_05	0.134	0.003	0.007	0.016	0.021	0.020	0.015	0.012	0.007	0.006	0.008	0.007	0.003	0.003	0.002	0.002	0.002
05_to_06	0.124	0.003	0.005	0.015	0.020	0.020	0.012	0.011	0.008	0.006	0.009	0.008	0.003	0.002	0.001	0.001	0.001
06_to_07	0.104	0.002	0.005	0.012	0.016	0.018	0.008	0.009	0.007	0.007	0.008	0.007	0.002	0.001	0.001	0.001	0.001
07_to_08	0.082	0.002	0.005	0.008	0.010	0.015	0.005	0.006	0.006	0.007	0.009	0.005	0.002	0.000	0.000	0.000	0.000
08_to_09	0.062	0.001	0.004	0.006	0.006	0.012	0.003	0.004	0.005	0.007	0.007	0.005	0.001	0.000	0.000	0.000	0.000
09_to_10	0.044	0.001	0.003	0.004	0.004	0.008	0.002	0.003	0.004	0.006	0.006	0.004	0.001	0.000	0.000	0.000	0.000
10_to_11	0.029	0.000	0.003	0.002	0.002	0.004	0.001	0.001	0.002	0.004	0.005	0.002	0.001	0.000	0.000	0.000	0.000
11_to_12	0.019	0.000	0.002	0.001	0.001	0.003	0.001	0.001	0.001	0.002	0.004	0.001	0.000	0.000	0.000	0.000	0.000
12_to_13	0.013	0.000	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.002	0.001	0.000	0.000	0.000	0.000	0.000
13_to_14	0.008	0.000	0.001	0.001	0.000	0.001	0.000	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
14_to_15	0.005	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
15_to_16	0.003	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16_to_17	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17_to_18	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18_to_19	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19_to_20	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20_to_21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21_to_22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22_to_23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23_to_24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Tabulated Results – Percentage Occurrence of Directional Winds Summer – 500m

e_00294	Wind direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
V infinity (m/s)	Sum	0.014	0.016	0.015	0.027	0.067	0.088	0.075	0.092	0.133	0.167	0.133	0.062	0.050	0.025	0.021	0.015
00_to_01	0.027	0.001	0.001	0.001	0.002	0.003	0.001	0.002	0.002	0.002	0.002	0.002	0.001	0.003	0.001	0.001	0.001
01_to_02	0.073	0.002	0.002	0.002	0.004	0.005	0.007	0.006	0.006	0.005	0.006	0.007	0.007	0.009	0.003	0.002	0.002
02_to_03	0.108	0.002	0.003	0.003	0.003	0.006	0.011	0.007	0.009	0.012	0.011	0.012	0.011	0.009	0.004	0.003	0.003
03_to_04	0.117	0.002	0.002	0.002	0.002	0.007	0.013	0.007	0.008	0.011	0.015	0.016	0.010	0.010	0.006	0.004	0.003
04_to_05	0.115	0.001	0.002	0.001	0.002	0.008	0.015	0.010	0.008	0.011	0.018	0.016	0.008	0.006	0.004	0.003	0.002
05_to_06	0.107	0.001	0.001	0.001	0.002	0.006	0.012	0.009	0.010	0.011	0.017	0.017	0.007	0.004	0.003	0.003	0.002
06_to_07	0.095	0.001	0.000	0.001	0.002	0.005	0.009	0.006	0.010	0.014	0.018	0.016	0.005	0.002	0.002	0.002	0.001
07_to_08	0.078	0.001	0.001	0.001	0.001	0.004	0.006	0.005	0.009	0.013	0.018	0.011	0.004	0.001	0.001	0.001	0.001
08_to_09	0.068	0.001	0.001	0.001	0.001	0.004	0.004	0.003	0.007	0.014	0.016	0.010	0.002	0.001	0.001	0.001	0.000
09_to_10	0.061	0.000	0.001	0.000	0.001	0.003	0.004	0.004	0.007	0.014	0.013	0.009	0.002	0.001	0.001	0.000	0.000
10_to_11	0.045	0.000	0.001	0.000	0.001	0.003	0.002	0.003	0.005	0.010	0.012	0.006	0.002	0.001	0.000	0.000	0.000
11_to_12	0.034	0.000	0.000	0.000	0.001	0.003	0.001	0.003	0.003	0.006	0.009	0.004	0.002	0.001	0.000	0.000	0.000
12_to_13	0.022	0.000	0.000	0.000	0.001	0.002	0.001	0.002	0.003	0.003	0.005	0.003	0.001	0.000	0.000	0.000	0.000
13_to_14	0.016	0.000	0.000	0.000	0.001	0.002	0.001	0.001	0.003	0.002	0.003	0.002	0.000	0.000	0.000	0.000	0.000
14_to_15	0.011	0.000	0.000	0.000	0.001	0.002	0.000	0.002	0.002	0.001	0.002	0.001	0.000	0.000	0.000	0.000	0.000
15_to_16	0.006	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
16_to_17	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
17_to_18	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18_to_19	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19_to_20	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20_to_21	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21_to_22	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22_to_23	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23_to_24	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Appendix B

Velocity Ratio

Wind Velocity Ratio – Baseline Scheme

	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Overall Annual	Overall Summer
Annual	**9.6%**	**12.2%**	**15.4%**	**9.6%**	**8.6%**	**6.6%**	**6.7%**	**7.7%**			**76.4%**	
Summer			**6.7%**	**8.8%**	**7.5%**	**9.2%**	**13.3%**	**16.7%**	**13.3%**	**6.2%**		**81.7%**
O1	0.11	0.06	0.20	0.09	0.16	0.36	0.36	0.40	0.37	0.30	0.20	0.31
O2	0.10	0.06	0.14	0.15	0.18	0.31	0.35	0.40	0.35	0.31	0.19	0.30
O3	0.11	0.04	0.05	0.05	0.23	0.20	0.32	0.40	0.11	0.25	0.15	0.22
O4	0.11	0.05	0.05	0.04	0.19	0.19	0.31	0.38	0.13	0.21	0.14	0.21
O5	0.10	0.05	0.08	0.06	0.14	0.20	0.32	0.38	0.11	0.15	0.14	0.21
O6	0.10	0.04	0.14	0.09	0.15	0.20	0.32	0.36	0.14	0.09	0.16	0.21
O7	0.09	0.06	0.03	0.20	0.17	0.29	0.35	0.40	0.39	0.36	0.17	0.30
O8	0.10	0.06	0.09	0.20	0.23	0.24	0.35	0.40	0.26	0.27	0.18	0.28
O9	0.10	0.05	0.19	0.19	0.28	0.20	0.34	0.36	0.14	0.12	0.20	0.25
O10	0.09	0.02	0.20	0.15	0.26	0.18	0.32	0.36	0.18	0.08	0.19	0.24
O11	0.08	0.03	0.15	0.13	0.22	0.14	0.28	0.36	0.23	0.13	0.16	0.23
O12	0.08	0.05	0.07	0.10	0.13	0.13	0.24	0.37	0.25	0.14	0.13	0.21
O13	0.08	0.04	0.03	0.08	0.08	0.12	0.20	0.39	0.22	0.14	0.11	0.19
O14	0.08	0.04	0.02	0.07	0.06	0.11	0.15	0.41	0.21	0.16	0.10	0.18
O15	0.11	0.32	0.58	0.56	0.54	0.38	0.05	0.13	0.26	0.52	0.36	0.32
O16	0.07	0.29	0.52	0.49	0.44	0.25	0.04	0.18	0.20	0.51	0.31	0.28
O17	0.09	0.25	0.44	0.42	0.35	0.18	0.04	0.27	0.20	0.46	0.28	0.26
O18	0.14	0.23	0.40	0.38	0.32	0.22	0.05	0.31	0.11	0.40	0.27	0.25
O19	0.16	0.25	0.35	0.34	0.34	0.25	0.13	0.34	0.14	0.34	0.28	0.26
O20	0.15	0.26	0.27	0.37	0.40	0.22	0.12	0.37	0.08	0.27	0.27	0.25
O21	0.10	0.20	0.19	0.37	0.39	0.18	0.10	0.39	0.04	0.24	0.24	0.23
O22	0.08	0.11	0.11	0.33	0.35	0.15	0.08	0.40	0.07	0.24	0.19	0.22
O23	0.15	0.05	0.05	0.17	0.26	0.14	0.08	0.42	0.16	0.28	0.15	0.21
O24	0.14	0.03	0.01	0.07	0.15	0.13	0.11	0.41	0.19	0.22	0.11	0.19
O25	0.07	0.05	0.07	0.22	0.14	0.22	0.32	0.33	0.37	0.37	0.16	0.28
O26	0.07	0.06	0.06	0.25	0.18	0.19	0.33	0.38	0.24	0.30	0.17	0.26
O27	0.08	0.07	0.07	0.26	0.24	0.15	0.32	0.37	0.19	0.18	0.17	0.25
O28	0.08	0.06	0.17	0.26	0.30	0.14	0.29	0.40	0.24	0.11	0.20	0.26
O29	0.07	0.04	0.24	0.26	0.34	0.14	0.26	0.44	0.30	0.14	0.21	0.29
O30	0.06	0.02	0.19	0.21	0.29	0.19	0.21	0.47	0.32	0.23	0.19	0.28
O31	0.04	0.03	0.12	0.18	0.22	0.21	0.16	0.48	0.30	0.15	0.16	0.26
O32	0.04	0.05	0.06	0.08	0.15	0.22	0.12	0.46	0.24	0.11	0.13	0.21
O33	0.12	0.04	0.03	0.04	0.09	0.19	0.09	0.42	0.22	0.06	0.11	0.18
O34	0.21	0.01	0.07	0.03	0.05	0.13	0.07	0.42	0.34	0.08	0.11	0.19
O35	0.12	0.01	0.06	0.15	0.24	0.09	0.09	0.41	0.35	0.15	0.13	0.22
O36	0.05	0.10	0.13	0.33	0.36	0.15	0.10	0.38	0.23	0.26	0.19	0.25
O37	0.13	0.25	0.23	0.40	0.43	0.23	0.14	0.37	0.17	0.30	0.27	0.28
O38	0.15	0.26	0.23	0.30	0.37	0.23	0.15	0.35	0.17	0.33	0.26	0.26
O39	0.14	0.21	0.29	0.28	0.27	0.20	0.16	0.30	0.12	0.33	0.24	0.23
O40	0.08	0.15	0.30	0.30	0.26	0.20	0.16	0.25	0.19	0.30	0.22	0.23
O41	0.01	0.07	0.16	0.17	0.16	0.13	0.09	0.10	0.14	0.12	0.11	0.13
O42	0.02	0.08	0.31	0.37	0.36	0.30	0.22	0.11	0.28	0.25	0.22	0.26
O43	0.03	0.04	0.31	0.40	0.40	0.35	0.26	0.06	0.21	0.31	0.23	0.26
O44	0.03	0.04	0.26	0.37	0.38	0.34	0.25	0.10	0.10	0.32	0.21	0.24
O45	0.10	0.11	0.13	0.29	0.30	0.28	0.17	0.21	0.28	0.28	0.19	0.24
O46	0.10	0.16	0.08	0.30	0.30	0.26	0.15	0.13	0.35	0.19	0.17	0.22
O47	0.09	0.11	0.09	0.29	0.30	0.25	0.15	0.13	0.41	0.26	0.16	0.23
O48	0.07	0.03	0.10	0.26	0.27	0.24	0.14	0.20	0.46	0.43	0.15	0.26
O49	0.06	0.03	0.11	0.24	0.27	0.23	0.14	0.27	0.51	0.52	0.16	0.29
O50	0.06	0.09	0.10	0.23	0.26	0.24	0.16	0.30	0.45	0.41	0.17	0.28
O51	0.06	0.14	0.11	0.21	0.24	0.22	0.14	0.26	0.33	0.16	0.17	0.22
O52	0.06	0.14	0.13	0.21	0.23	0.20	0.09	0.22	0.37	0.06	0.16	0.20
O53	0.09	0.12	0.15	0.22	0.23	0.24	0.05	0.12	0.41	0.15	0.15	0.20
O54	0.16	0.10	0.15	0.25	0.26	0.28	0.05	0.06	0.22	0.16	0.16	0.16
O55	0.26	0.08	0.15	0.28	0.29	0.31	0.03	0.10	0.20	0.07	0.18	0.17

O56	0.27	0.06	0.15	0.29	0.31	0.33	0.03	0.12	0.20	0.06	0.19	0.18
O57	0.20	0.04	0.07	0.13	0.17	0.09	0.06	0.32	0.22	0.14	0.13	0.17
O58	0.09	0.06	0.09	0.10	0.15	0.11	0.09	0.32	0.07	0.15	0.12	0.15
O59	0.09	0.10	0.01	0.16	0.12	0.19	0.11	0.38	0.19	0.12	0.13	0.18
O60	0.05	0.15	0.11	0.21	0.09	0.21	0.18	0.46	0.37	0.14	0.17	0.26
O61	0.12	0.13	0.12	0.22	0.16	0.27	0.21	0.52	0.46	0.30	0.20	0.32
O62	0.02	0.08	0.09	0.22	0.22	0.27	0.20	0.51	0.46	0.44	0.18	0.33
O63	0.03	0.05	0.08	0.23	0.29	0.02	0.19	0.54	0.50	0.53	0.16	0.32
O64	0.04	0.06	0.09	0.20	0.26	0.11	0.23	0.57	0.51	0.59	0.17	0.35
O65	0.04	0.07	0.14	0.29	0.33	0.07	0.20	0.45	0.43	0.52	0.19	0.31
O66	0.04	0.06	0.16	0.29	0.33	0.17	0.12	0.27	0.36	0.31	0.17	0.25
O67	0.03	0.07	0.18	0.30	0.30	0.21	0.11	0.14	0.20	0.06	0.16	0.18
O68	0.03	0.07	0.06	0.24	0.17	0.20	0.17	0.06	0.19	0.12	0.12	0.15
O69	0.03	0.05	0.10	0.14	0.06	0.17	0.20	0.08	0.21	0.25	0.10	0.15
O70	0.03	0.03	0.10	0.09	0.08	0.14	0.20	0.09	0.11	0.29	0.09	0.13
O71	0.02	0.01	0.11	0.09	0.11	0.13	0.19	0.11	0.16	0.17	0.09	0.14
O72	0.04	0.03	0.10	0.10	0.12	0.15	0.20	0.22	0.06	0.04	0.11	0.14
P1	0.08	0.20	0.20	0.31	0.35	0.22	0.11	0.27	0.50	0.49	0.22	0.30
P2	0.03	0.01	0.04	0.03	0.03	0.06	0.04	0.19	0.32	0.41	0.05	0.14
P3	0.07	0.04	0.05	0.03	0.02	0.10	0.11	0.10	0.27	0.15	0.06	0.11
P4	0.05	0.02	0.04	0.01	0.02	0.06	0.07	0.08	0.28	0.23	0.04	0.10
P5	0.09	0.03	0.11	0.12	0.05	0.09	0.13	0.27	0.49	0.31	0.11	0.22
P6	0.09	0.02	0.05	0.08	0.05	0.04	0.05	0.35	0.29	0.44	0.08	0.18
P7	0.02	0.01	0.03	0.04	0.05	0.02	0.09	0.14	0.27	0.20	0.05	0.11
P8	0.02	0.03	0.04	0.04	0.02	0.04	0.10	0.12	0.33	0.21	0.05	0.12
P9	0.03	0.03	0.03	0.03	0.04	0.09	0.12	0.29	0.44	0.39	0.07	0.20
P10	0.03	0.04	0.14	0.23	0.24	0.15	0.13	0.34	0.53	0.57	0.15	0.30
P11	0.03	0.05	0.16	0.26	0.27	0.16	0.15	0.34	0.50	0.55	0.17	0.30
P12	0.03	0.06	0.14	0.27	0.26	0.05	0.17	0.44	0.44	0.56	0.17	0.30
P13	0.04	0.07	0.11	0.29	0.27	0.03	0.02	0.27	0.30	0.48	0.14	0.21
P14	0.04	0.08	0.11	0.33	0.31	0.05	0.03	0.35	0.34	0.62	0.16	0.26
P15	0.04	0.06	0.09	0.25	0.24	0.10	0.06	0.33	0.34	0.66	0.14	0.25
P16	0.05	0.05	0.07	0.15	0.11	0.07	0.04	0.09	0.28	0.54	0.08	0.15
P17	0.04	0.04	0.06	0.14	0.20	0.04	0.04	0.11	0.09	0.11	0.08	0.10
P18	0.02	0.04	0.12	0.31	0.36	0.23	0.02	0.11	0.04	0.11	0.15	0.14
P19	0.16	0.04	0.16	0.30	0.34	0.33	0.04	0.10	0.11	0.08	0.18	0.17
P20	0.08	0.06	0.12	0.26	0.33	0.20	0.04	0.08	0.10	0.12	0.14	0.14
P21	0.03	0.07	0.09	0.15	0.25	0.02	0.03	0.10	0.08	0.25	0.09	0.11
P22	0.14	0.11	0.04	0.17	0.27	0.03	0.04	0.11	0.03	0.20	0.11	0.10
P23	0.19	0.13	0.11	0.12	0.25	0.05	0.04	0.11	0.09	0.19	0.13	0.11
P24	0.15	0.14	0.14	0.09	0.23	0.06	0.04	0.11	0.14	0.12	0.13	0.11
P25	0.21	0.11	0.11	0.08	0.20	0.07	0.05	0.09	0.13	0.04	0.12	0.09
P26	0.14	0.05	0.04	0.09	0.03	0.07	0.05	0.06	0.12	0.01	0.07	0.07
P27	0.15	0.07	0.03	0.14	0.11	0.11	0.07	0.17	0.28	0.27	0.10	0.15
P28	0.11	0.14	0.05	0.06	0.12	0.08	0.12	0.27	0.46	0.57	0.11	0.22
P29	0.04	0.20	0.12	0.17	0.18	0.18	0.22	0.39	0.53	0.66	0.17	0.32
P30	0.11	0.23	0.15	0.21	0.21	0.20	0.19	0.39	0.56	0.65	0.20	0.33
P31	0.12	0.23	0.15	0.18	0.17	0.22	0.18	0.34	0.49	0.59	0.19	0.30
P32	0.11	0.21	0.15	0.08	0.12	0.10	0.16	0.29	0.46	0.60	0.15	0.25
P33	0.09	0.22	0.21	0.24	0.29	0.25	0.13	0.35	0.53	0.54	0.22	0.32

Wind Velocity Ratio – Proposed Scheme

	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Overall Annual	Overall Summer
Annual	**9.6%**	**12.2%**	**15.4%**	**9.6%**	**8.6%**	**6.6%**	**6.7%**	**7.7%**			**76.4%**	
Summer			**6.7%**	**8.8%**	**7.5%**	**9.2%**	**13.3%**	**16.7%**	**13.3%**	**6.2%**		**81.7%**
O1	0.12	0.11	0.13	0.10	0.08	0.27	0.31	0.45	0.17	0.29	0.18	0.25
O2	0.13	0.13	0.11	0.14	0.02	0.27	0.28	0.44	0.17	0.29	0.17	0.24
O3	0.07	0.05	0.04	0.08	0.25	0.22	0.23	0.44	0.18	0.27	0.15	0.24
O4	0.09	0.05	0.05	0.10	0.19	0.22	0.22	0.42	0.16	0.23	0.14	0.22
O5	0.10	0.04	0.07	0.11	0.13	0.23	0.23	0.41	0.15	0.21	0.14	0.22
O6	0.11	0.04	0.11	0.13	0.06	0.23	0.23	0.40	0.16	0.20	0.15	0.21
O7	0.14	0.13	0.05	0.18	0.07	0.28	0.27	0.44	0.17	0.29	0.17	0.24
O8	0.13	0.13	0.07	0.16	0.06	0.27	0.26	0.43	0.20	0.27	0.17	0.24
O9	0.12	0.12	0.11	0.15	0.06	0.24	0.24	0.40	0.20	0.23	0.16	0.23
O10	0.11	0.10	0.14	0.16	0.06	0.23	0.22	0.41	0.23	0.24	0.17	0.24
O11	0.10	0.05	0.13	0.18	0.13	0.21	0.21	0.39	0.22	0.24	0.16	0.23
O12	0.10	0.04	0.09	0.18	0.16	0.20	0.20	0.37	0.22	0.25	0.15	0.23
O13	0.10	0.04	0.06	0.14	0.14	0.20	0.18	0.37	0.24	0.26	0.13	0.22
O14	0.11	0.04	0.06	0.12	0.12	0.24	0.17	0.35	0.28	0.32	0.13	0.23
O15	0.13	0.33	0.56	0.62	0.56	0.44	0.20	0.14	0.34	0.53	0.39	0.37
O16	0.10	0.30	0.53	0.57	0.47	0.32	0.06	0.14	0.24	0.50	0.34	0.30
O17	0.10	0.27	0.46	0.50	0.40	0.25	0.06	0.14	0.24	0.47	0.30	0.27
O18	0.12	0.26	0.42	0.45	0.35	0.22	0.08	0.16	0.21	0.42	0.28	0.25
O19	0.13	0.25	0.37	0.39	0.34	0.23	0.06	0.18	0.27	0.40	0.26	0.25
O20	0.12	0.24	0.33	0.39	0.37	0.27	0.06	0.22	0.33	0.43	0.26	0.28
O21	0.10	0.21	0.29	0.38	0.39	0.28	0.09	0.26	0.35	0.41	0.25	0.29
O22	0.07	0.15	0.20	0.31	0.36	0.31	0.14	0.30	0.37	0.40	0.22	0.29
O23	0.07	0.09	0.14	0.19	0.27	0.31	0.16	0.33	0.36	0.38	0.18	0.27
O24	0.12	0.04	0.10	0.12	0.13	0.28	0.17	0.34	0.32	0.35	0.14	0.24
O25	0.13	0.09	0.04	0.17	0.15	0.26	0.24	0.36	0.10	0.21	0.16	0.21
O26	0.11	0.11	0.04	0.17	0.14	0.26	0.23	0.39	0.16	0.23	0.16	0.22
O27	0.10	0.13	0.03	0.18	0.11	0.24	0.22	0.40	0.19	0.21	0.15	0.22
O28	0.09	0.14	0.09	0.21	0.13	0.24	0.22	0.42	0.25	0.27	0.18	0.25
O29	0.09	0.14	0.18	0.26	0.21	0.27	0.22	0.44	0.31	0.34	0.21	0.29
O30	0.08	0.12	0.18	0.27	0.29	0.26	0.22	0.43	0.35	0.38	0.22	0.31
O31	0.05	0.04	0.13	0.21	0.25	0.25	0.21	0.41	0.35	0.37	0.17	0.29
O32	0.07	0.05	0.09	0.16	0.22	0.27	0.19	0.38	0.35	0.40	0.16	0.27
O33	0.15	0.03	0.11	0.14	0.15	0.27	0.16	0.34	0.30	0.36	0.15	0.24
O34	0.16	0.02	0.15	0.21	0.15	0.31	0.16	0.31	0.30	0.29	0.17	0.24
O35	0.05	0.06	0.11	0.21	0.21	0.33	0.18	0.29	0.30	0.27	0.16	0.25
O36	0.07	0.15	0.22	0.36	0.39	0.35	0.20	0.26	0.32	0.32	0.24	0.29
O37	0.10	0.23	0.32	0.45	0.42	0.34	0.19	0.22	0.36	0.42	0.28	0.32
O38	0.12	0.24	0.32	0.36	0.34	0.26	0.12	0.21	0.31	0.40	0.25	0.27
O39	0.12	0.21	0.30	0.30	0.27	0.20	0.09	0.20	0.32	0.36	0.22	0.24
O40	0.08	0.18	0.29	0.31	0.26	0.21	0.10	0.17	0.31	0.25	0.21	0.23
O41	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01
O42	0.01	0.04	0.12	0.16	0.15	0.14	0.11	0.06	0.10	0.04	0.10	0.11
O43	0.04	0.08	0.28	0.42	0.44	0.42	0.32	0.21	0.20	0.08	0.26	0.29
O44	0.05	0.06	0.25	0.38	0.41	0.39	0.31	0.21	0.15	0.08	0.24	0.27
O45	0.12	0.07	0.13	0.34	0.39	0.31	0.20	0.28	0.21	0.18	0.21	0.26
O46	0.12	0.04	0.11	0.30	0.40	0.29	0.19	0.23	0.19	0.15	0.19	0.23
O47	0.12	0.06	0.12	0.24	0.39	0.28	0.19	0.21	0.25	0.15	0.18	0.23
O48	0.12	0.07	0.13	0.20	0.35	0.28	0.18	0.20	0.32	0.18	0.18	0.23
O49	0.12	0.07	0.15	0.16	0.34	0.29	0.18	0.22	0.39	0.23	0.18	0.25
O50	0.14	0.11	0.16	0.16	0.34	0.32	0.18	0.25	0.42	0.30	0.20	0.27
O51	0.16	0.13	0.16	0.17	0.33	0.30	0.18	0.28	0.44	0.30	0.20	0.28
O52	0.16	0.09	0.16	0.18	0.30	0.28	0.22	0.29	0.40	0.17	0.20	0.27
O53	0.17	0.02	0.17	0.20	0.29	0.28	0.24	0.27	0.23	0.04	0.19	0.23
O54	0.18	0.02	0.18	0.21	0.27	0.31	0.22	0.20	0.08	0.04	0.18	0.19
O55	0.23	0.03	0.19	0.22	0.27	0.32	0.15	0.17	0.12	0.19	0.19	0.19

O56	0.25	0.05	0.20	0.22	0.27	0.31	0.11	0.22	0.29	0.26	0.20	0.23
O57	0.22	0.04	0.11	0.10	0.17	0.14	0.06	0.34	0.30	0.19	0.14	0.19
O58	0.03	0.02	0.11	0.06	0.02	0.06	0.09	0.28	0.21	0.14	0.08	0.14
O59	0.08	0.02	0.05	0.12	0.16	0.20	0.06	0.28	0.24	0.10	0.11	0.17
O60	0.05	0.06	0.10	0.17	0.22	0.17	0.17	0.34	0.36	0.08	0.15	0.23
O61	0.14	0.09	0.14	0.17	0.21	0.18	0.25	0.41	0.43	0.06	0.18	0.27
O62	0.02	0.07	0.16	0.19	0.22	0.19	0.24	0.41	0.44	0.10	0.17	0.28
O63	0.07	0.08	0.15	0.26	0.32	0.12	0.20	0.49	0.53	0.35	0.20	0.33
O64	0.08	0.11	0.13	0.26	0.25	0.05	0.25	0.54	0.58	0.52	0.20	0.35
O65	0.06	0.13	0.15	0.26	0.15	0.07	0.26	0.46	0.53	0.47	0.18	0.32
O66	0.08	0.14	0.16	0.27	0.27	0.10	0.19	0.29	0.25	0.32	0.18	0.23
O67	0.09	0.15	0.12	0.23	0.15	0.17	0.10	0.11	0.07	0.24	0.14	0.14
O68	0.07	0.09	0.05	0.09	0.08	0.20	0.12	0.08	0.04	0.16	0.09	0.10
O69	0.05	0.03	0.08	0.04	0.08	0.22	0.14	0.11	0.06	0.14	0.08	0.11
O70	0.05	0.01	0.08	0.08	0.10	0.22	0.16	0.10	0.03	0.16	0.09	0.11
O71	0.06	0.03	0.10	0.12	0.12	0.22	0.18	0.15	0.04	0.11	0.11	0.13
O72	0.07	0.03	0.10	0.14	0.13	0.23	0.20	0.23	0.08	0.06	0.13	0.16
P1	0.03	0.19	0.24	0.31	0.33	0.27	0.20	0.08	0.19	0.30	0.21	0.22
P2	0.03	0.02	0.04	0.15	0.17	0.15	0.11	0.02	0.10	0.19	0.08	0.11
P3	0.00	0.01	0.07	0.06	0.13	0.06	0.17	0.15	0.13	0.15	0.07	0.12
P4	0.01	0.01	0.01	0.14	0.18	0.05	0.18	0.20	0.27	0.18	0.08	0.17
P5	0.16	0.05	0.16	0.27	0.26	0.04	0.19	0.28	0.37	0.22	0.17	0.24
P6	0.21	0.01	0.15	0.17	0.14	0.05	0.14	0.20	0.21	0.20	0.13	0.16
P7	0.06	0.01	0.09	0.14	0.13	0.06	0.19	0.21	0.22	0.19	0.10	0.16
P8	0.13	0.04	0.19	0.26	0.25	0.06	0.21	0.25	0.27	0.19	0.17	0.22
P9	0.02	0.04	0.06	0.06	0.06	0.05	0.16	0.08	0.11	0.20	0.06	0.10
P10	0.03	0.07	0.13	0.21	0.17	0.10	0.20	0.29	0.34	0.17	0.14	0.22
P11	0.02	0.12	0.16	0.26	0.22	0.11	0.23	0.36	0.41	0.18	0.18	0.26
P12	0.03	0.11	0.12	0.18	0.03	0.04	0.05	0.25	0.41	0.34	0.11	0.19
P13	0.04	0.11	0.04	0.08	0.16	0.02	0.11	0.07	0.17	0.34	0.08	0.12
P14	0.03	0.09	0.04	0.06	0.15	0.06	0.10	0.06	0.33	0.50	0.07	0.15
P15	0.08	0.08	0.09	0.15	0.08	0.03	0.24	0.13	0.35	0.55	0.11	0.20
P16	0.12	0.05	0.11	0.22	0.26	0.04	0.16	0.03	0.04	0.48	0.12	0.14
P17	0.05	0.03	0.15	0.29	0.37	0.04	0.01	0.03	0.06	0.07	0.13	0.11
P18	0.12	0.07	0.22	0.27	0.32	0.18	0.06	0.16	0.05	0.31	0.18	0.17
P19	0.17	0.06	0.21	0.23	0.29	0.26	0.08	0.13	0.14	0.23	0.18	0.18
P20	0.13	0.05	0.19	0.22	0.28	0.08	0.10	0.11	0.14	0.25	0.15	0.15
P21	0.09	0.04	0.17	0.24	0.31	0.13	0.07	0.04	0.04	0.15	0.14	0.12
P22	0.15	0.02	0.14	0.16	0.21	0.13	0.11	0.25	0.40	0.26	0.14	0.21
P23	0.19	0.09	0.16	0.24	0.33	0.13	0.23	0.37	0.45	0.50	0.21	0.31
P24	0.14	0.11	0.18	0.24	0.35	0.13	0.05	0.01	0.09	0.02	0.16	0.12
P25	0.20	0.10	0.13	0.13	0.32	0.06	0.02	0.02	0.05	0.03	0.13	0.08
P26	0.17	0.13	0.09	0.10	0.32	0.13	0.06	0.04	0.16	0.17	0.13	0.12
P27	0.20	0.14	0.13	0.19	0.38	0.27	0.11	0.08	0.05	0.07	0.18	0.14
P28	0.26	0.10	0.16	0.32	0.42	0.36	0.23	0.23	0.10	0.04	0.24	0.23
P29	0.22	0.06	0.06	0.13	0.18	0.20	0.19	0.11	0.17	0.04	0.13	0.14
P30	0.06	0.08	0.04	0.04	0.05	0.08	0.12	0.23	0.42	0.29	0.08	0.18
P31	0.04	0.13	0.08	0.10	0.09	0.06	0.13	0.25	0.47	0.47	0.11	0.22
P32	0.08	0.18	0.16	0.19	0.16	0.12	0.12	0.27	0.51	0.58	0.16	0.26
P33	0.09	0.21	0.21	0.28	0.23	0.16	0.08	0.26	0.49	0.61	0.20	0.28
P34	0.04	0.22	0.24	0.31	0.26	0.19	0.07	0.20	0.37	0.58	0.20	0.25
P35	0.05	0.21	0.24	0.26	0.22	0.18	0.08	0.15	0.33	0.55	0.18	0.23
P36	0.02	0.21	0.25	0.29	0.28	0.23	0.17	0.12	0.28	0.45	0.20	0.24