AECOM

Planning Department

Agreement No. PLNQ 56/2012

Category B - Term Consultancy for Air Ventilation Assessment by Computational Fluid Dynamics

Container Terminals No.1 to 9

Air Ventilation Assessment Executive Summary

April 2015

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1 INTRODUCTION

1.1 AECOM Asia Company Ltd. was commissioned by the Planning Department (PlanD) to undertake an air ventilation assessment (AVA) for the Development of Container Terminals (CTs) No.1 to 9 under Agreement No. PLNQ 56/2012 Category B - Term Consultancy for Air Ventilation Assessments by Computational Fluid Dynamics (CFD) in February 2013.

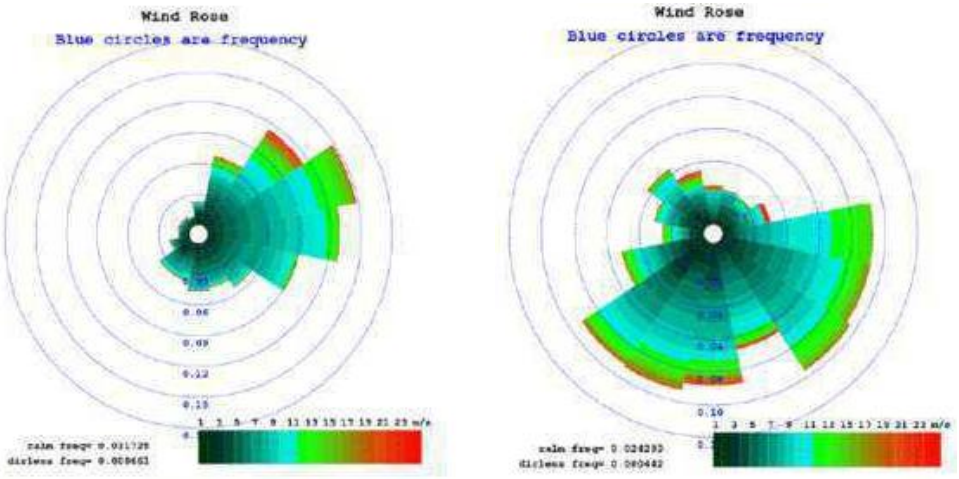
1.2 The AVA study aims to carry out an initial study by conducting a quantitative assessment on the likely air ventilation impact under different building height restrictions (BHR) scenarios for the entire Kwai Tsing container port at CTs No.1 to 9.

1.3 The assessment presents the simulation results of the Baseline Scenario and three different options of development schemes (namely Scenario A, Scenario B and Scenario C) provided by PlanD, findings and proposed potential improvement works/mitigation measures. A further revised Scenario C provided by CT operators has also been assessed qualitatively.

2 WIND AVAILABILITY

2.1 Based on the annual wind rose from the MM5 wind data at Kwai Chung obtained from HKUST, the sum of the frequencies of occurrence of wind from ENE, E, NE, ESE, NNE, SE, SSE and S exceeds 75% of the time in the reference year. These 8 wind directions have been selected as the annual prevailing winds for this AVA assessment.

2.2 Based on the summer wind rose from the MM5 wind data at Kwai Chung obtained from HKUST, a total of 9 wind directions including E, ESE, SE, SSE, S, SSW, SW, WSW and NW which account for over 75% of summer occurrence have been selected as the summer prevailing winds for this AVA simulation. Annual and summer prevailing wind roses are shown in **Figure 2.1**.



Annual Prevailing Wind Rose at 450m Elevation

Source: MM5 wind data at Kwai Chung obtained from HKUST

Summer Prevailing Wind Rose at 450m Elevation

Source: MM5 wind data at Kwai Chung obtained from HKUST

Figure 2.1 Annual and Summer Prevailing Wind Rose at 450m Elevation

3 EXISTING SITE CONDITIONS

3.1 The subject site of this AVA initial study is defined by the existing locations of Container Terminals (CTs) No.1 to 9 which span over Kwai Chung, Stonecutters Island and Tsing Yi.

3.2 The Project Area covers 3 Outline Zoning Plans (OZPs): the draft Kwai Chung OZP No.S/KC/26, the approved Stonecutters Island OZP No.S/SC/10 and the approved Tsing Yi OZP No.S/TY/24. It measures approximately 2.5km from east to west and 3.5km from north to south, with a total area of 279ha. A total of 32 potential Focus Areas are identified. They are demarcated based on the homogeneity of land use within each area and road pattern.

3.3 The Project Area is located at Kwai Tsing, occupying the waterfront on both sides of Rambler Channel. The topography for CT1-9 is predominantly flat land. The terrain in the immediate vicinity of the Project Area is rather flat with a hilly terrain (i.e. Lai King area) at about 200m to the east of the Project Area. Other major topographical features include future Kwai Chung Park (+40mPD) situated to the north of the CT No.5, the hill in Tsing Yi (+334mPD) to the west of CT No.9 and the hill in Stonecutters Island (+68 mPD) to the south. The area to the north-east of the Project Area possesses higher topographical feature as Golden Hill (+369 mPD) whereas the area to the south of the Project Area is comprised of low-lying water front area.

3.4 The CTs No.1 to 5 fall within the draft Kwai Chung OZP No.S/KC/26, CTs No.6 to 8 within the approved Stonecutters Island OZP No.S/SC10, and CT No. 9 within the approved Tsing Yi OZP No. S/TY/24. All CTs are zoned “Other Specified Used” (“OU”) annotated “Container Terminals”, except the northern portion of CT No.9 which is zoned “OU” annotated “Container Relaters Uses” and “Cargo handling Area”, on their respective OZPs.

3.5 The demarcation of the Project Area, Assessment Area, Surrounding Area, Computational Area and prevailing wind directions are shown in **Figure 3.1**.

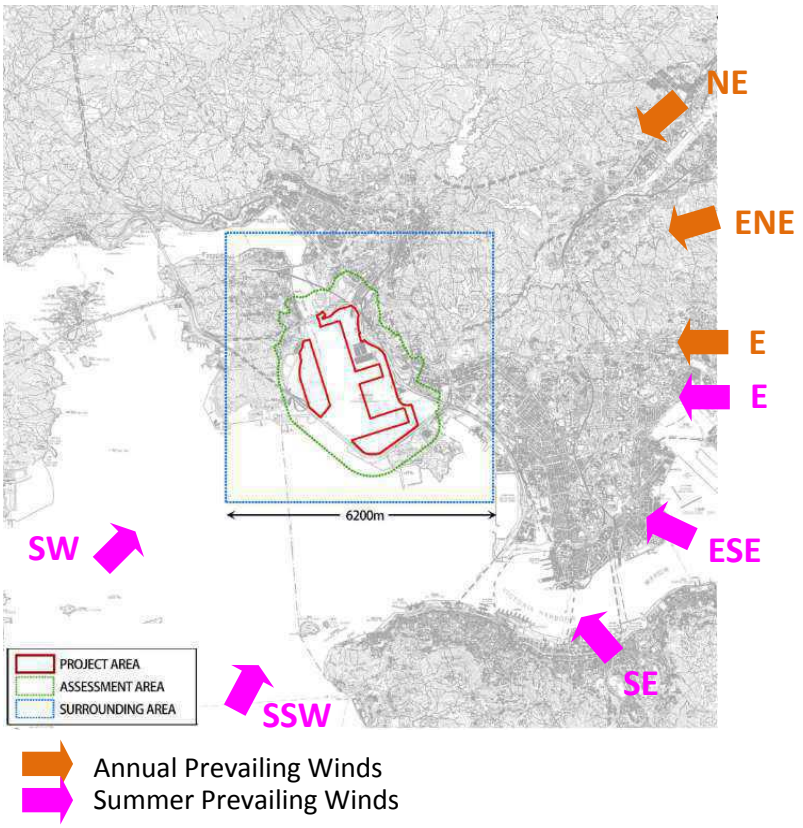


Figure 3.1 Project Area, Assessment Area, Surrounding Area and Prevailing wind directions

3.6 Just outside the Project Area is the Assessment Area delineated in green (**Figure 3.1**). The Assessment Area is usually defined as an area 1H from the Project Area based on the Housing, Planning and Lands Bureau Technical Circular (TC) No.1/06 (2006) and Environment, Transport and Works Bureau TC No. 1/06 (2006) on Air Ventilation Assessment (the Technical Guide) where H is the maximum height of the proposed development inside the Project Area. For this site, the proposed maximum building height is 250mPD. Because of the extensive lateral dimensions of the Project Area (2.7-3.4km), the common value of 1H is considered insufficient to account for the potential cumulative impacts of the proposed development within the Project Area. For prudence, an area of at least 2H i.e. 500m from the Project Area should be adopted as the Assessment Area, with modification to include the whole of a site (e.g. open space, residential site, etc.) if a site is severed during the delineation process.

3.7 The Surrounding Area is an important area that conditions the approach wind flow into the Project Area. It is normally taken as an area 2H from the Project Area according to the Technical Guide. Having reviewed the surrounding topography, buildings and characteristic lengths of the CTs No.1-9 (2.7-3.4km), a square of 6.2km is considered to be adequate (**Figure 3.1**). Buildings and topographical features are modelled within the Surrounding and Assessment Areas.

4 ASSESSMENT METHODOLOGY AND TESTPOINTS LOCATIONS

4.1 This AVA study is carried out in accordance with the guidelines stipulated in the Housing, Planning and Lands Bureau Technical Circular (TC) No.1/06 (2006) and Environment, Transport and Works Bureau TC No. 1/06 (2006) on Air Ventilation Assessment (Technical Guide) for AVA for Developments in Hong Kong with regards to Computational Fluid Dynamics (CFD) modelling. Reference is also made to the "Recommendations on the use of CFD in Predicting Pedestrian Wind Environment" issued by a working group of the COST action C14. Thus, it is considered that the COST action C14 is a valid and good reference for CFD modelling in AVA study. There is no internationally recognised guideline or standard for using CFD in outdoor urban scale studies. The onus is on the assessor to demonstrate that the tool used is 'fit for the purpose'.

4.2 Wind Velocity Ratios (VRs)[1] will be adopted as the indicator of the wind performance at pedestrian level, taking into account of surrounding buildings, topography and the project site. Per the velocity ratio method (CUHK, 2008), the analyzed CFD results will determine the extent to which the proposed development impacts over the wind environment of its immediately vicinity and local areas.

4.3 Both Perimeter test points (180 points in total) and Overall test points (392 points in total) are identified within the Assessment Area in order to assess the impact on the immediate surroundings and local areas respectively. Overall test points are evenly distributed over surrounding open spaces, streets, landscape deck, podium and other parts of the Assessment Area with pedestrian frequent access. Site Velocity Ratio (SVRw)[2] and Local Velocity Ratio (LVRw)[3], as an indicator for air ventilation performance, are calculated in all the Scenarios and compared with each other.

4.4 In this study, special test points are proposed to be positioned in areas outside the Assessment Area where potential localised problems may arise further downwind due to the large site area of the CTs No.1-9. However, these special test points will not be included in the usual Site and Local Air Ventilation Assessments in order not to distort the average VRs in the usual near field downwind of the Project Area although their significance and importance of the average VRs in these Focus Areas are no less than the test points inside the Assessment Area in terms of determining the potential air ventilation impacts.

4.5 All test points are elevated at 2m above ground, or at landscape deck or podium level where appropriate.

Note:

1 VRs, per aforesaid technical circular (HPLB and ETWB, 2006), are defined as VR = VP/VINF where VINF is the MM5 modeled wind velocity at the top of the wind boundary layer and it would not be affected by the ground roughness and local site features and VP is the wind velocity at the 2m pedestrian level.

2 SVRw gives an idea of how the lower portion of the buildings on the project site may affect the immediate surroundings. When problems are detected, it is likely that design changes may be needed for the lower portion of the development.

3 LVRw gives an idea of how the upper portion of the buildings on the project site may affect the immediate surroundings. When problems are detected, it is likely that design changes may be needed for the upper portion of the development.

5 DEVELOPMENT SCENARIOS

5.1 There are a total of four scenarios for the CTs No. 1 to 9 considered in the assessment quantitatively. They are the **Baseline Scenario** which is the existing condition of CTs No. 1 to 9 (with site coverage of about 7.4%); **Scenario A** which has building height restrictions (BHRs) of 70mPD and 110mPD for CTs No. 1 to 9 (with maximum site coverage of 60%); **Scenario B** has building height restrictions (BHRs) of 180 to 250 mPD and 70mPD for CTs No. 1 to 9 (with maximum site coverage of 60%) and **Scenario C** which is developed based on the findings of Scenarios A and B. They are tested by CFD simulations.

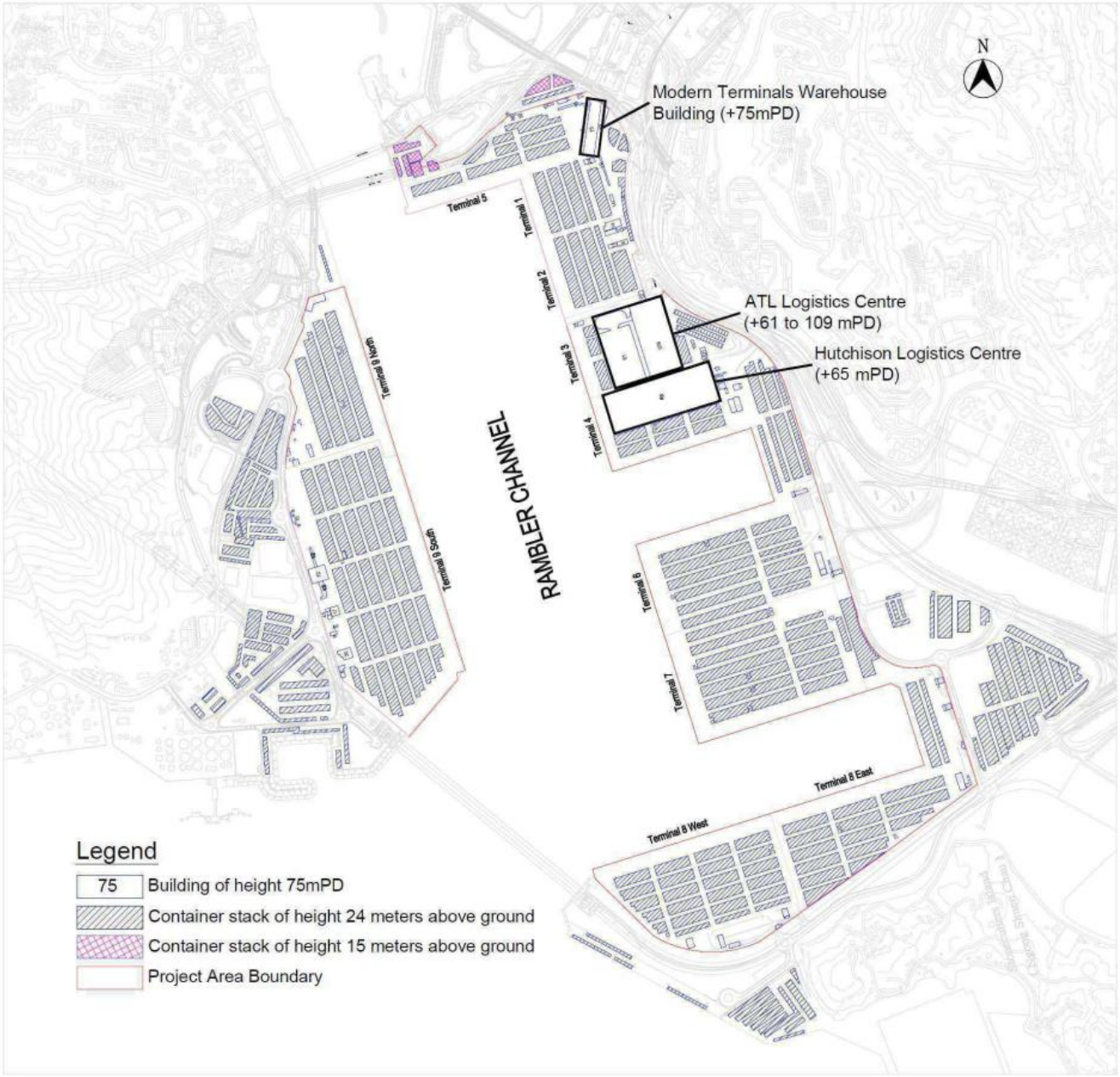


Figure 5.1 Layout Plan for Baseline Scenario

Figure 5.2 Layout Plan for Scenario A

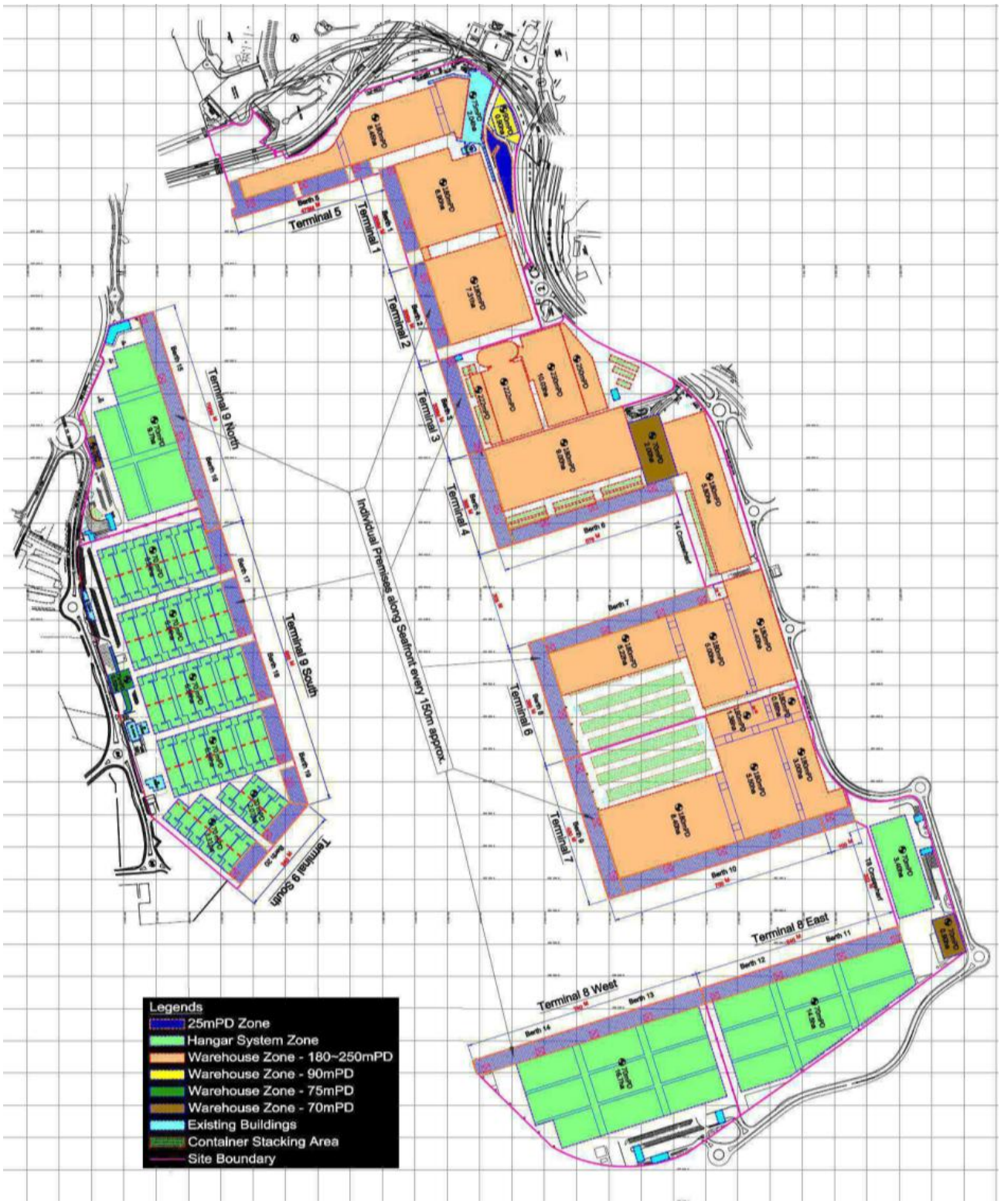


Figure 5.3 Layout Plan for Scenario B

5.2 There are multiple areas identified under Scenario A and B which have major air ventilation concerns. These areas include the north eastern portion of Tsing Yi under SE wind; Cheung Ching Estate under E wind; proposed Kwai Chung Park and industrial area to its north under southern quadrant winds; the hospitals and neighbouring residential area at Lai King under south western quadrant winds; and the Lai Chi Kok Park under south western quadrant winds. In regard to the potential air ventilation impacts that may arise at the aforementioned areas, a further Scenario C with mitigation measures such as reduction of building height, and the incorporation of NBAs has been developed. The detailed information of the mitigation measures are listed below and illustrated in **Figure 5.4**.

Item A The buildings within Terminal 5 West are lowered to 30mPD, compared to those of 110mPD and 180mPD in Scenarios A and B respectively, for facilitating wind penetration mainly from SE quadrant to benefit its downstream areas including the Proposed Kwai Chung Park and northern part of Tsing Yi.

Item B A Non-Building-Area (NBA) of 60m in width, aligning in approximately ENE to WSW direction is incorporated between Terminals 5 and 1, for facilitating wind penetration mainly from SW quadrant to benefit its downstream areas including inland area of Ha Kwai Chung.

Item C A NBA of 60m in width, aligning in approximately ENE to WSW direction is incorporated between Terminals 1 and 2, for facilitating wind penetration mainly from SW quadrant to benefit its downstream areas including Cho Yiu Chuen and Lai King Estate.

Item D A NBA of 60m in width, aligning in approximately ENE to WSW direction is incorporated between Terminals 2 and 3. Such NBA aims to provide similar improvement as the proposed NBA between Terminals 1 and 2.

Item E The eastern-most buildings in Terminal Crosswharf 4 are reduced to a building height of 30mPD, compared to 110mPD and 180mPD in Scenarios A and B respectively, for facilitating wind penetration mainly from SW quadrant to benefit its downstream areas including Kwai Chung Hospital, Princess Margaret Hospital and residential developments around Lai King Hill Road.

Item F A NBA of 60m in width, aligning in approximately ENE to WSW direction is incorporated between Terminals 6 and 7, for facilitating wind penetration mainly comes from SW quadrant to benefit its downstream areas including Lai Chi Kok Park and Mei Foo Sun Chuen.

Item G A NBA of 60m in width, aligning in approximately NE to SW direction is incorporated between Terminals 7 to 8, for facilitating wind penetration mainly comes from SW quadrant to benefit its downstream areas including Lai Chi Kok Park.

Item H The buildings within Terminal 8 West are lowered to possess a building height of 30mPD, compared to 70mPD in both Scenarios A and B, for facilitating wind penetration mainly throughout the N-S direction to benefit its downstream areas under S wind and Stonecutters Island under N wind.

Item I Not used.

Item J The buildings within Terminal 9 North are lowered to a building height of 30mPD, compared to 70mPD in both Scenarios A and B, for facilitating wind penetration mainly from NE, SE and SW quadrants to benefit its downstream areas including south eastern part of Tsing Yi under NE quadrant wind, Rambler Crest under SE quadrant wind and area around eastern shore of the Project Site under winds coming from SW quadrant.

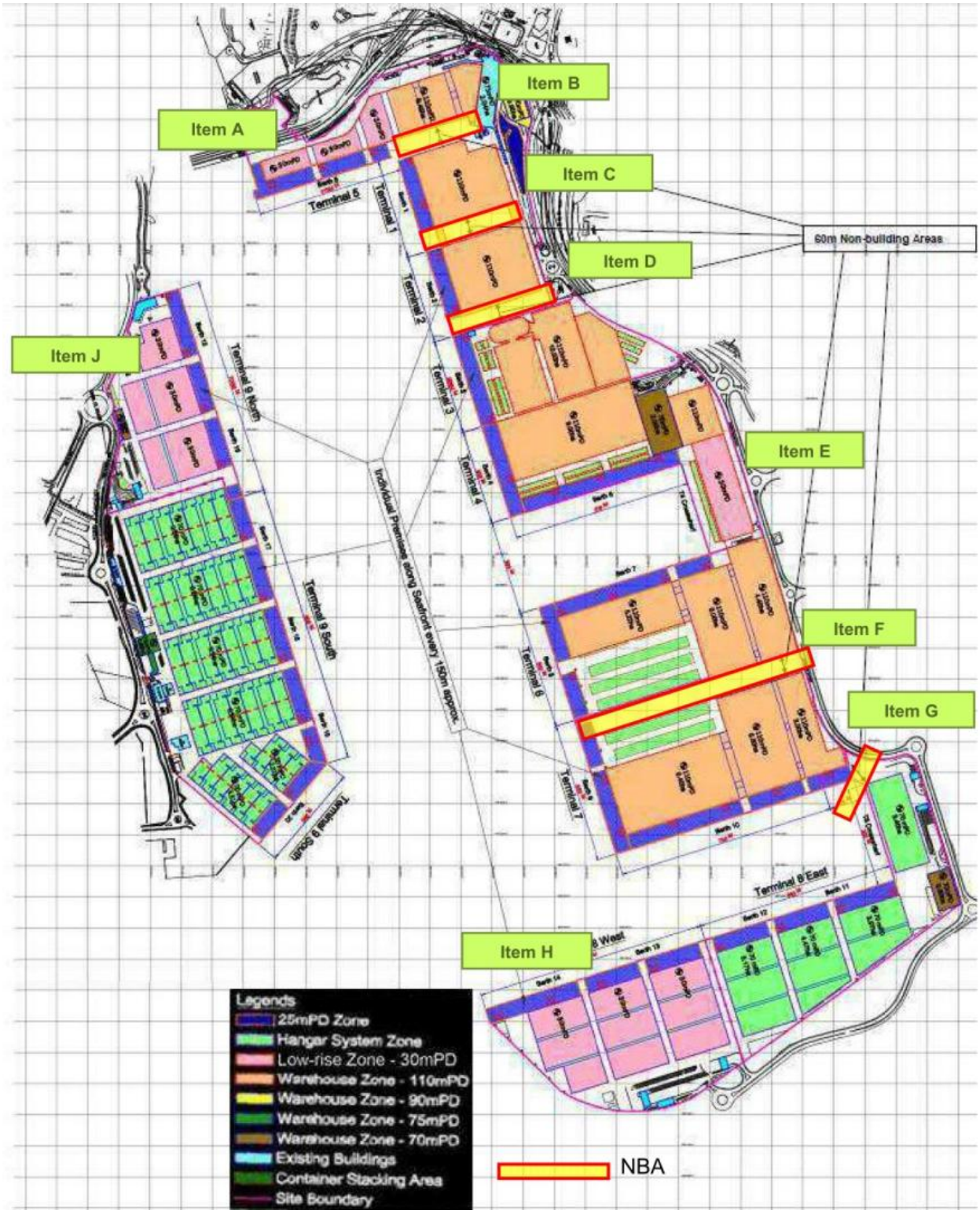


Figure 5.4 Layout Plan for Scenario C

5.3 There is a further revised Scenario C (provided by the CT operators due to operational and engineering constraints) which differs from Scenario C with the following changes:

- Building height of CT 5 increased from 30mPD to 70mPD
- NBAs reduced from 60m to 40m in width
- Partial increase in building height from 30mPD to 110mPD at CT 4
- Building height of CT 8 West and CT 9 North increased from 30mPD to 70mPD

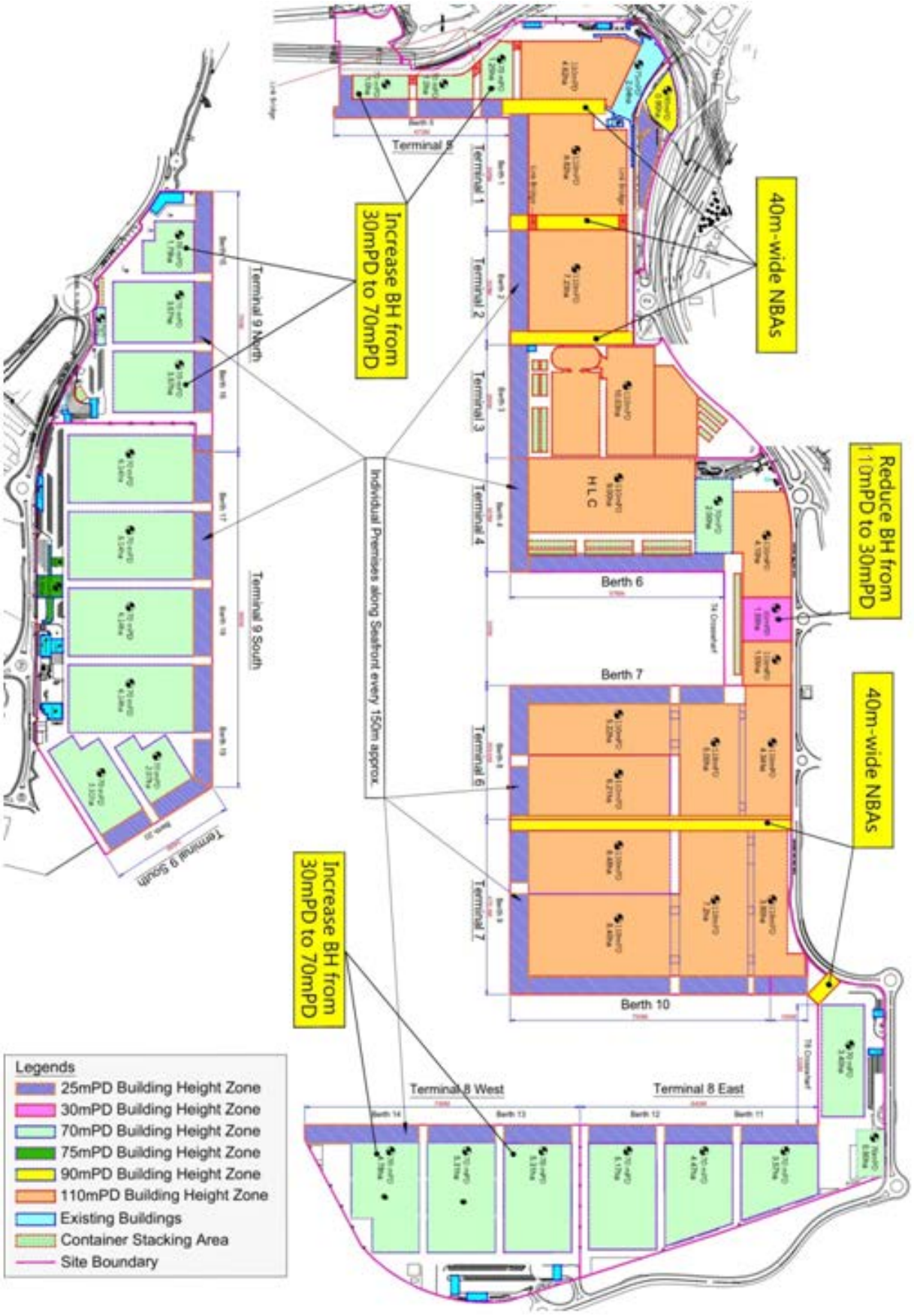


Figure 5.5 Planning Features incorporated in Revised Scenario C

6 KEY FINDINGS OF AVA STUDY

Overall Performance

6.1 According to the simulation results as presented in **Figures 6.1** and **6.2**, **Tables 6.1** and **6.2**, the SVRw for the Baseline Scenario under annual and summer wind directions are 0.24 and 0.28 respectively; the SVRw for Scenario A under annual and summer wind directions are 0.21 and 0.23 respectively; the SVRw for Scenario B under annual and summer wind directions are 0.21 and 0.23 respectively. The Baseline Scenario has the highest SVRw among the three scenarios under both annual and summer wind directions, while the SVRw of both Scenario A and Scenario B are comparable. Both scenarios significantly reduce SVRw in the immediate neighbourhood of the container terminals. The value of the SVRw indicates the effect of the lower portion of the project site to the immediate surroundings. Compared to the Baseline Scenario, reduction in the SVRw value under Scenarios A and B are mainly due to the increase in site coverage. On the other hand, as the site coverage of Scenarios A and B are similar, they result in similar SVRw value under both annual and summer conditions, which suggest that a further reduction in the proposed site coverage of both Scenarios A and B would improve SVRw to get closer to baseline values.

6.2 The averaged annual and summer LVRw for the Baseline Scenario are 0.21 and 0.24 respectively. For Scenario A, the LVRw under annual and summer wind directions are 0.19 and 0.21; for Scenario B, the LVRw under annual and summer wind directions are 0.18 and 0.20 respectively. For the LVRw, in both annual and summer conditions, a descending trend is observed by comparing Scenarios A and B with the Baseline Scenario respectively. The LVRw addresses the effect of the upper portion of the buildings to the surroundings. As there are increases in building height from the Baseline Scenario to Scenario A, which further increases under Scenario B, the LVRw values decrease from the Baseline Scenario to Scenario A and then to Scenario B. As compared with Baseline Scenario, Scenario B produces more reduction in LVRw compared to Scenario A under both annual and summer winds. This suggests that a reduction in the proposed development heights is necessary in order to minimize the adverse air ventilation impacts.

6.3 The two proposed scenarios (i.e. Scenario A and Scenario B) would create certain adverse impacts on the local wind environment as compared to the Baseline Scenario and such adverse impacts are aggravated by an increase in development heights from Scenario A to Scenario B.

6.4 For Scenario C, the predicted SVRw under annual and summer wind directions are 0.21 and 0.23 and the LVRw under annual and summer wind directions are 0.19 and 0.21 respectively. Overall speaking, Scenario A and Scenario C have the same SVRs and LVRs. The annual and summer LVRw results suggest that the features studied in Scenario C is not significantly different from Scenario A in terms of air ventilation performance for the wider area of the site.

6.5 Slight enhancement is found when comparing Scenario C to Scenario A under some of the wind directions including NE, ENE, ESE, SE, SSE in the annual condition and ESE, SE, SSE, SW, NW in the summer. More wind is able to skim over the lower building of Scenario C and the NBAs allow more wind to penetrate through the site and enhance the ventilation performance of the immediate vicinity in these directions. However, it is shown that the overall SVRw remain unchanged. The annual and summer SVRw results suggest that the features considered in Scenario C are not sufficient to reduce the overall adverse impacts of Scenario A in the locality due to the cumulative air ventilation impact of the container terminals.

6.6 In general, the overall ventilation performance of the studied scenarios (Scenario A, B and C) are not comparable to the Baseline Scenario, in which Scenario B has the worst performance and the overall ventilation performance of Scenario A and Scenario C are very similar except that some localised improvement in wind performance in Scenario C, as compared to Scenario A, are identified in directional analysis..

6.7 There are 23 common sensitive areas (see Attachment for details) identified for the Baseline Scenario and Scenarios A, B and C with frequent pedestrian access under annual and summer winds. Although several improvement measures have already been incorporated in the development scheme of Scenario C, problematic areas are still identified when compared to the Baseline Scenario which is the existing condition. More improvement measures are required to enhance the overall wind performance.

Table 6.1 Summary of Wind Velocity Ratios under Annual Wind Directions

	Wind Velocity Ratios (VR)			
	Baseline Scenario	**Scenario A**	**Scenario B**	**Scenario C**
SVR	**0.24**	**0.21**	**0.21**	**0.21**
LVR	**0.21**	**0.19**	**0.18**	**0.19**

Table 6.2 Summary of Wind Velocity Ratios under Summer Wind Directions

	Wind Velocity Ratios (VR)			
	Baseline Scenario	**Scenario A**	**Scenario B**	**Scenario C**
SVR	**0.28**	**0.23**	**0.23**	**0.23**
LVR	**0.24**	**0.21**	**0.20**	**0.21**

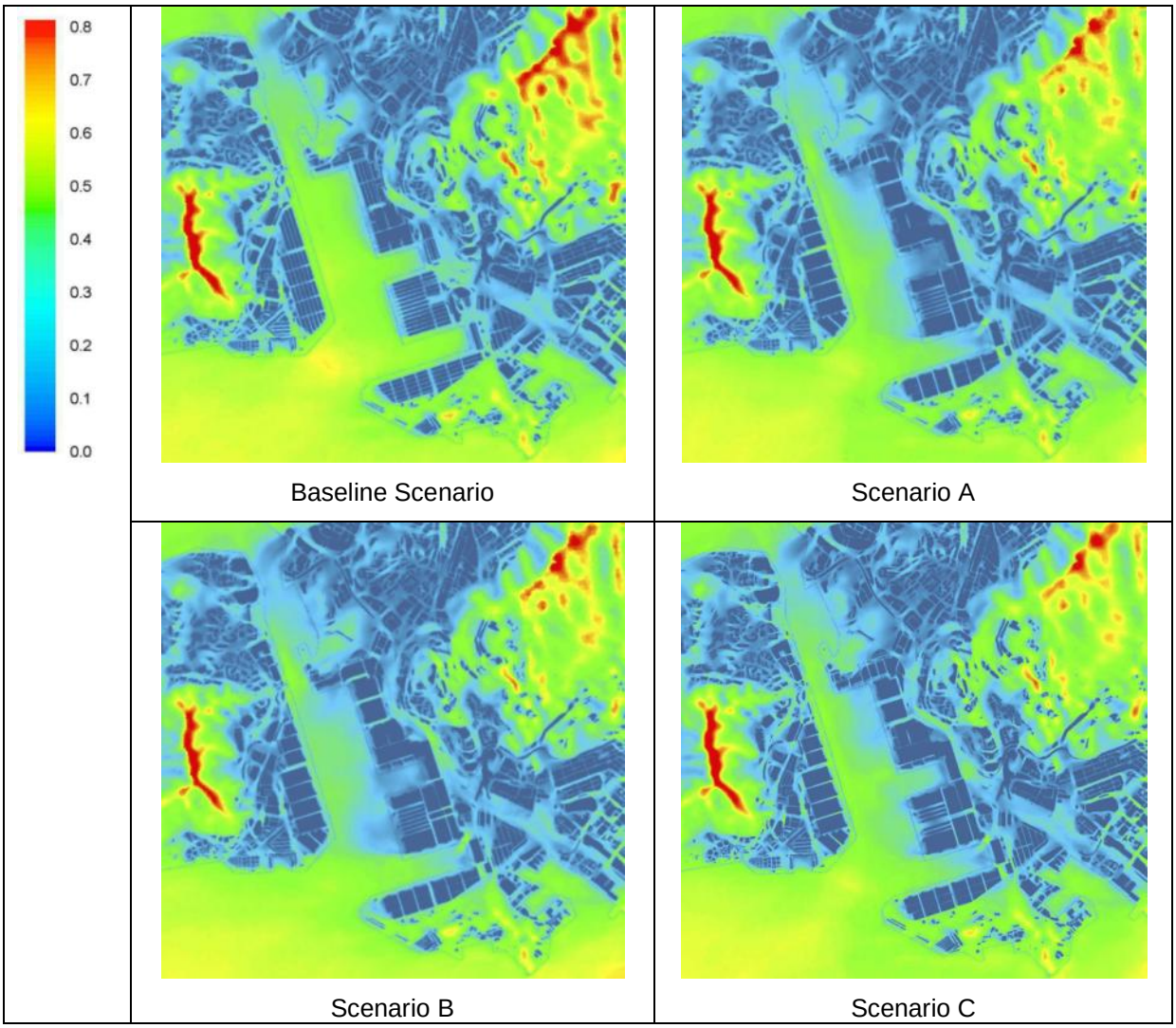


Figure 6.1 Annual Frequency Weighted Wind Velocity Ratio Contour Plot at 2m above Ground Level

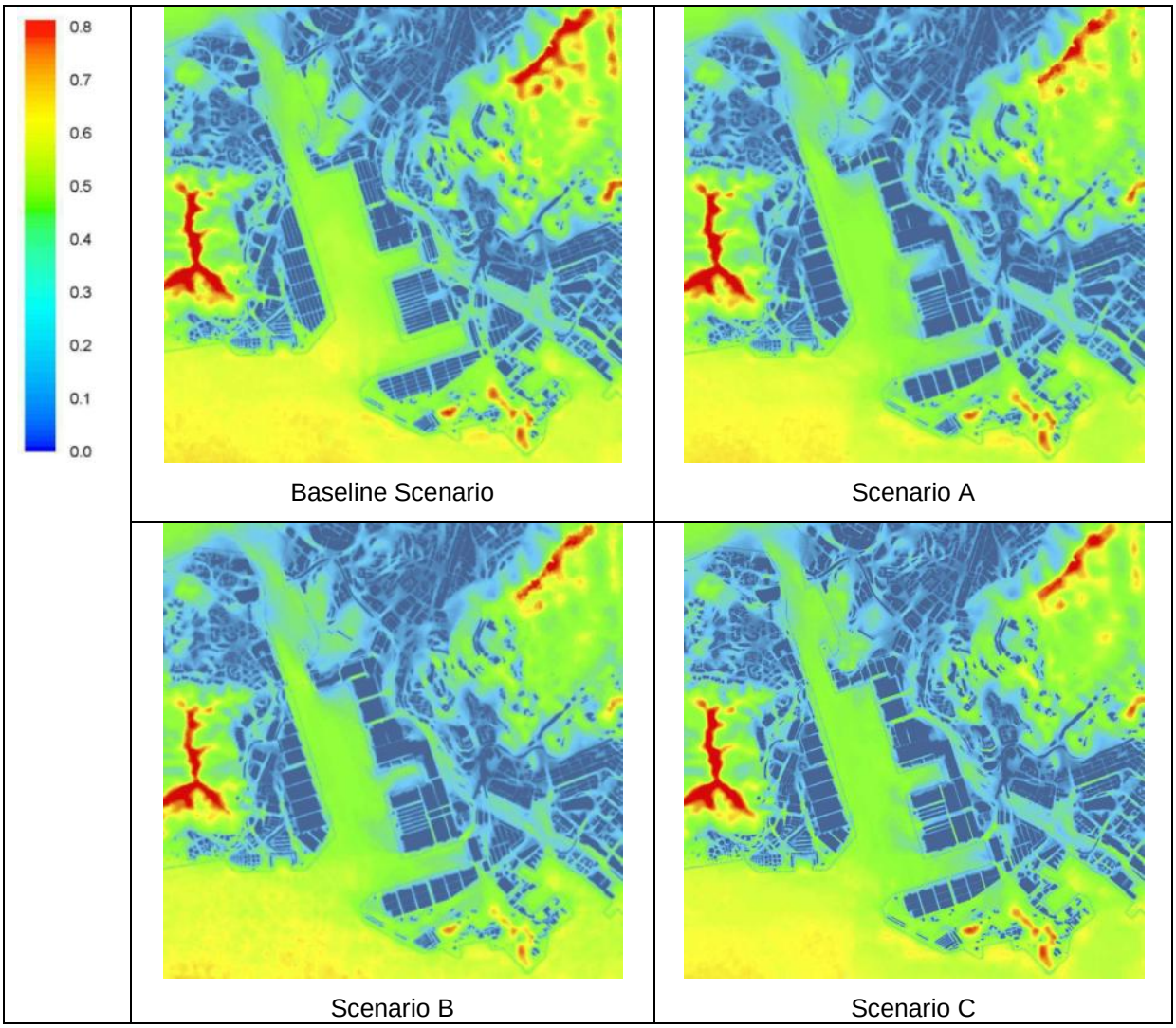


Figure 6.2 Summer Frequency Weighted Wind Velocity Ratio Contour Plot at 2m above Ground Level

Directional Analysis

6.8 The directional analysis under 4 wind directions (E, SE, S, SSW) are presented in this Executive Summary. These 4 wind directions are representative wind directions during the summer seasons and furthermore there are areas of frequent pedestrian access located at the downstream of the proposed developments under these prevailing winds. Therefore, the directional analyses under these four prevailing winds are chosen to be presented.

Directional Analysis – East Wind

6.9 When comparing Scenario A with Baseline Scenario, more areas on Tsing Yi Island are affected by the extended wake zone of the taller container terminal under the E wind, which include the areas around Cheung Fai Road Promenade, Rambler Crest, Cheung Ching Estate, Tsing Sheung Road and Tsing Yi Industrial area. Enhanced ventilation condition is found at Tsing Kwai Highway near Lai King under Scenario A when compared to the Baseline Scenario. The low-rise nature of the Baseline Scenario allows more wind to skim over and reduces the amount of wind entering that part of Tsing Kwai Highway. Under Scenario A, the relatively higher building structures limit the wind to skim over. The wind then flows along the Tsing Kwai Highway area enhancing the localized wind environment.

6.10 Under Scenarios A and B, higher VR is found near the Terminal 4 Crosswharf when compared to Baseline which changes the wind flow direction and induces acceleration around its corner. However, the taller Container Terminal 5 compared to Scenario A and Baseline Scenario casts a wind shadow on the Proposed Kwai Chung Park under Scenario B and results in a lower VR at that area.

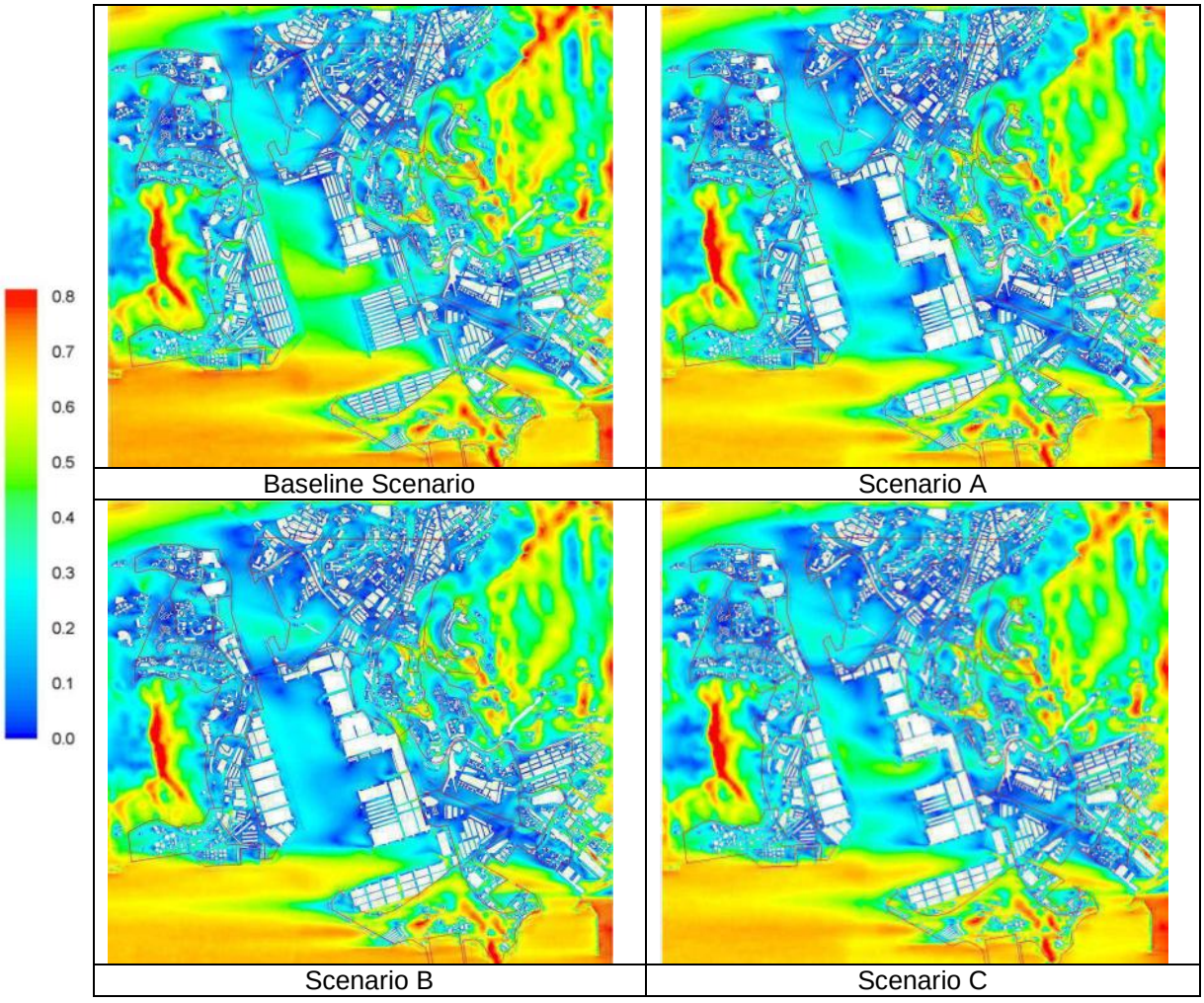


Figure 6.3 Wind Velocity Ratio Contour Plot at 2m above Ground Level (E wind)

6.11 Although incorporating several improvement measures, the tall and wide Terminals 1 to 6 in Scenario C has limited a large amount of E wind flow to the Tsing Yi Industrial Area and Cheung Ching Estate. However, significant enhancement is found in the Rambler Channel near Terminal 4 Crosswharf due to its lower building height in Scenario C, as compared to Scenario A. The enhanced wind performance at Rambler Channel in turn results in an increase in VR value at Tsing Sha Highway near Rambler Crest under Scenario C.

6.12 However, reduced VR value is found at Tsing Kwai Highway near Terminal 4 Crosswharf when comparing Scenario C to Scenario A. It is because that the low-rise nature of Terminal 4 Crosswharf under Scenario C allows the prevailing wind to skim over and hence reduces the amount of wind flow along Tsing Kwai Highway.

Directional Analysis – South Eastern Wind

6.13 Under the south eastern wind, when comparing Baseline Scenario to Scenario A, a significant reduction in VR value is found at the whole Rambler Channel area in the latter scenario. The larger building bulk and footprint of Scenario A create a larger wake region resulting in a relatively lower VR in this area. The ventilation performance of Ngau Ying Chau Street, Tsing King Road, St. Paul's Village, Tsing Yi Sports Ground, Tsing Yi Promenade, Ngau Ying Chau Garden and Proposed Kwai Chung Park are worsened under Scenario A when compared to the Baseline Scenario. The taller building height and increase in footprint, especially in Terminal 5 reduce the wind penetrating through the site and also cast a larger wake zone in its downstream area, thus affecting the surrounding ventilation performance.

6.14 Comparing Scenario A to Scenario B, a further reduction in VR value is found along the Rambler Channel due to the further increase in building volume of the container terminal especially at its eastern shore under Scenario B. Declines in ventilation performance are also observed at Tsing Yi Promenade under Scenario B when compared to Scenario A due to the increase in building bulk of the container terminal, especially in Terminal 5. Due to the tall Terminals 1 to 6 developments, the channelling effect along Tsing Kwai Highway and Kwai Chung Road in Scenarios A and B are comparable and stronger than Baseline Scenario. However, this effect does not maintain and improve wind level to pedestrian frequent areas such as the Kwai Chung Sports Ground and the Park next to Kwai Fong located further downstream of Tsing Kwai Highway under the SE wind.

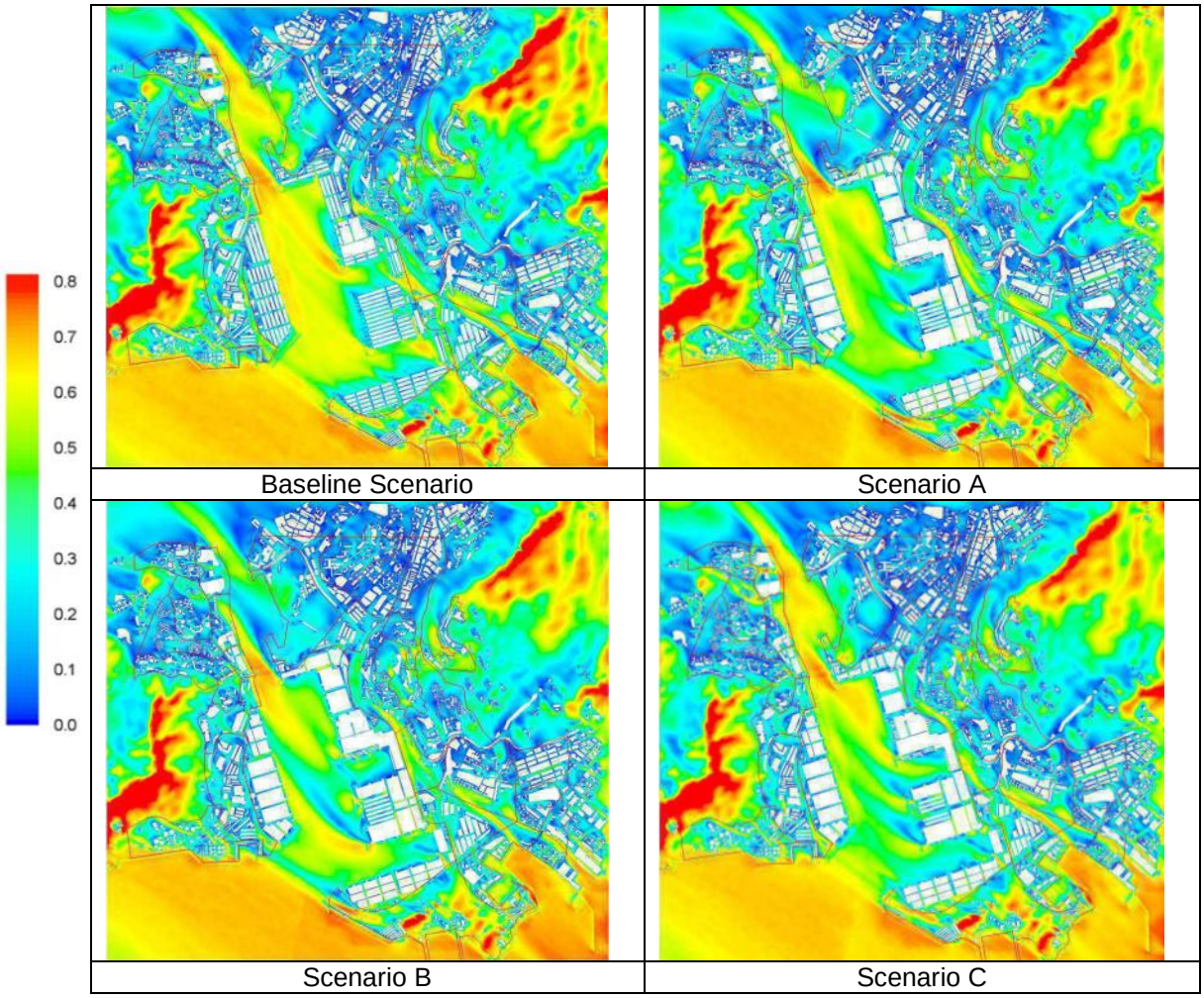


Figure 6.4 Wind Velocity Ratio Contour Plot at 2m above Ground Level (SE wind)

6.15 Under the south easterly wind, when Scenario C is compared to A, enhancements can be found at Nga Ying Chau Garden, St. Paul's Village, Tsing Yi Promenade, Tsing Yi Sports Ground, southern portion of the Proposed Kwai Chung Park and Rambler Channel area near Terminal 5 West due to lower building height of it. It reduces the wake zone in the downstream area and also allows the wind to skim over it and the localized wind environment is improved. Enhancement is also identified at the area of Rambler Channel near Terminal 4 Crosswharf because of the low-rise nature of Terminal 4 Crosswharf allowing wind to skim over under Scenario C. However, consequentially, less wind would flow along that part of Tsing Kwai Highway.

Directional Analysis – South Wind

6.16 Compared to the Baseline Scenario, a significant reduction in VR value is found in the Proposed Kwai Chung Park, Kwai Chung industrial developments under Scenario A. The larger building bulk and footprint of Scenario A create a larger wake region and result in a relatively lower VR in this area. The taller building height and increase in footprint especially in Terminal 5 reduce the wind penetration through the site and also cast a larger wake zone in its downstream area, thus affecting the surrounding ventilation performance. The ventilation performance along Kwai Chung Road and Tsing Kwai Highway are worsened under Scenario A when compared to the Baseline Scenario.

6.17 Significant decline in wind is observed in Kwai Chung Industrial Area under the S wind, when comparing Scenarios A and B to Baseline Scenario. The reason of the decline in this area is possibly that the Kwai Chung Industrial Area is influenced by the wake area downwind of Terminal 5 under this wind direction.

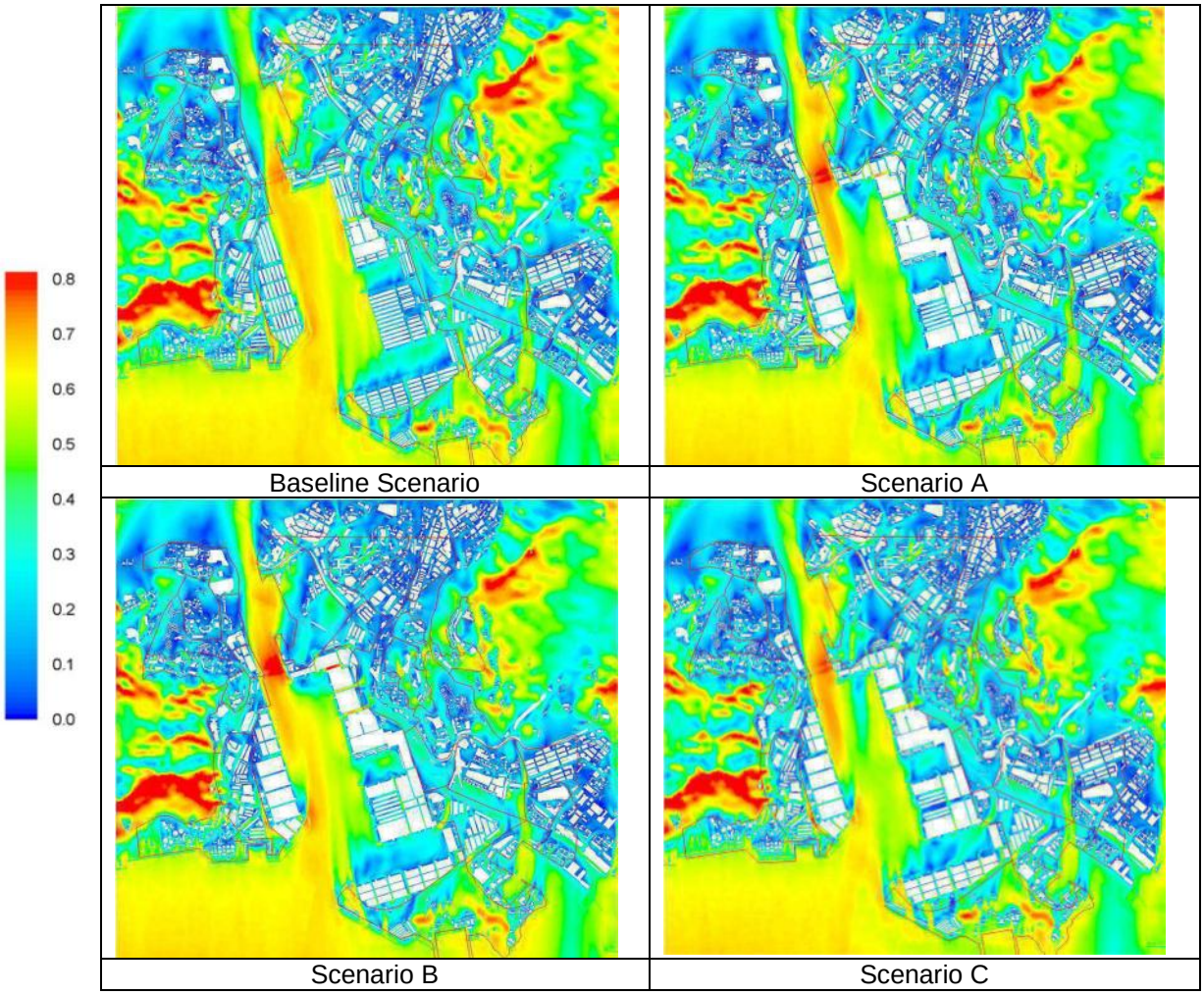


Figure 6.5 Wind Velocity Ratio Contour Plot at 2m above Ground Level (S wind)

6.18 Comparing Scenario A and Scenario B, a further reduction in VR value is found along Lai King Estate, schools (i.e. Lai King Catholic Secondary School and Lingnan Dr Chung Wing Kwong Memorial Secondary School), New Kwai Fong Gardens and the park near Kwai Fuk Road due to further increment in building volume of the container terminals especially at its eastern shore under Scenario B.

6.19 Localized enhancement is observed at the building separations among Terminals 5, 1, 2 and 3 under both Scenarios A and B. The tall Terminal 5 developments divert a portion of the southerly wind into the separations between Terminals 1, 2, 3 and 5. The even taller container terminals in Scenario B compared to Scenario A further strengthen the channel effects. The benefit however, is localized mainly along Kwai Chung Road and Tsing Kwai Highway areas, without being able to benefit further inland areas.

6.20 In comparison with Scenario A, better VR values can be found under Scenario C around southern portion of the Proposed Kwai Chung Park due to the lower building height of Terminal 5 West, which reduces the wake zone in the downstream area, allows the wind to skim over it and enhances the localized wind environment. It is also found that pedestrian wind environment around New Kwai Fong Gardens, Lai King Catholic Secondary School, Lingnan Dr. Chung Wing Kwong Memorial Secondary School have been slightly improved by lowering the building height of Terminal 4 in Scenario C. Under the S wind, the proposed 60m-wide NBAs between Terminals 2 and 3 facilitates wind penetration and enhances the localized wind environment around the south-western side of Lai King Estate to some extent.

Directional Analysis – South-Southwest (SSW) Wind

6.21 Compared to the Baseline Scenario, a significant reduction in VR value is found under Scenario A in the Proposed Kwai Chung Park, Kwai Hei Street and Kwai Tsing Road under the SSW wind. The larger building bulk and footprint of Scenario A create a larger wake region and result in a relatively lower VR in this area. The ventilation performance of Lai King Estate, Yin Lai Court, Yuet Lai Court and Cho Yiu Chuen areas is worsened under Scenario A when compared to the Baseline Scenario. Aforementioned, the taller building height and increment in footprint especially in Terminals 3, 4 and 6 reduce the wind penetration through the site and also cast a larger wake zone in its downstream area, thus affecting the surrounding ventilation performance. Even though the separations amongst Terminals 1, 2, 3 and 5 as aforementioned can allow to some extent the sea breeze to enter the inland area, the benefit cannot totally offset the impact caused by the increase in height at Terminals 3, 4 and 6.

6.22 Local high VR value is observed at the separations amongst Terminals 5, 1, 2 and 3 in Scenario A. The effect is further strengthened in Scenario B due to the increase in building height of the container terminal and enhances the localized wind environment at the Tsing Kwai Highway at the immediate vicinity. Compared to Scenario A, a further reduction in VR value is found around Lai Yiu Estate and Kwai Chung Sports Ground areas under Scenario B due to the further increase in building volume of the container terminal.

6.23 In Scenario C, slight enhancement in VR values can be found around southern portion of the Proposed Kwai Chung Park due to the lower building height of Terminal 5 West when compared to Scenario A. It reduces the wake zone in the downstream area. The combined effect together with the two proposed NBAs amongst Terminals 1, 2 and 3 and lower building height in Terminal 4 Crosswharf, it facilitates SSW entering the inland areas effectively in Scenario C. It enhances the VR in downstream area especially around Lai Chi Kok Services Reservoir and the western side of Wonderland Villas. Lower building height in Terminal 8 West in Scenario C allows more wind to skim over it, resulting in better VR along the gap between Terminal 8 West and East and less wind diverted along Tsing Sha Highway.

6.24 The proposed 60m-wide NBA between Terminals 5 and 1 in Scenario C allows penetration of SSW wind. However, such wind flow was blocked by existing buildings, limiting the effectiveness of the NBA for inland ventilation.

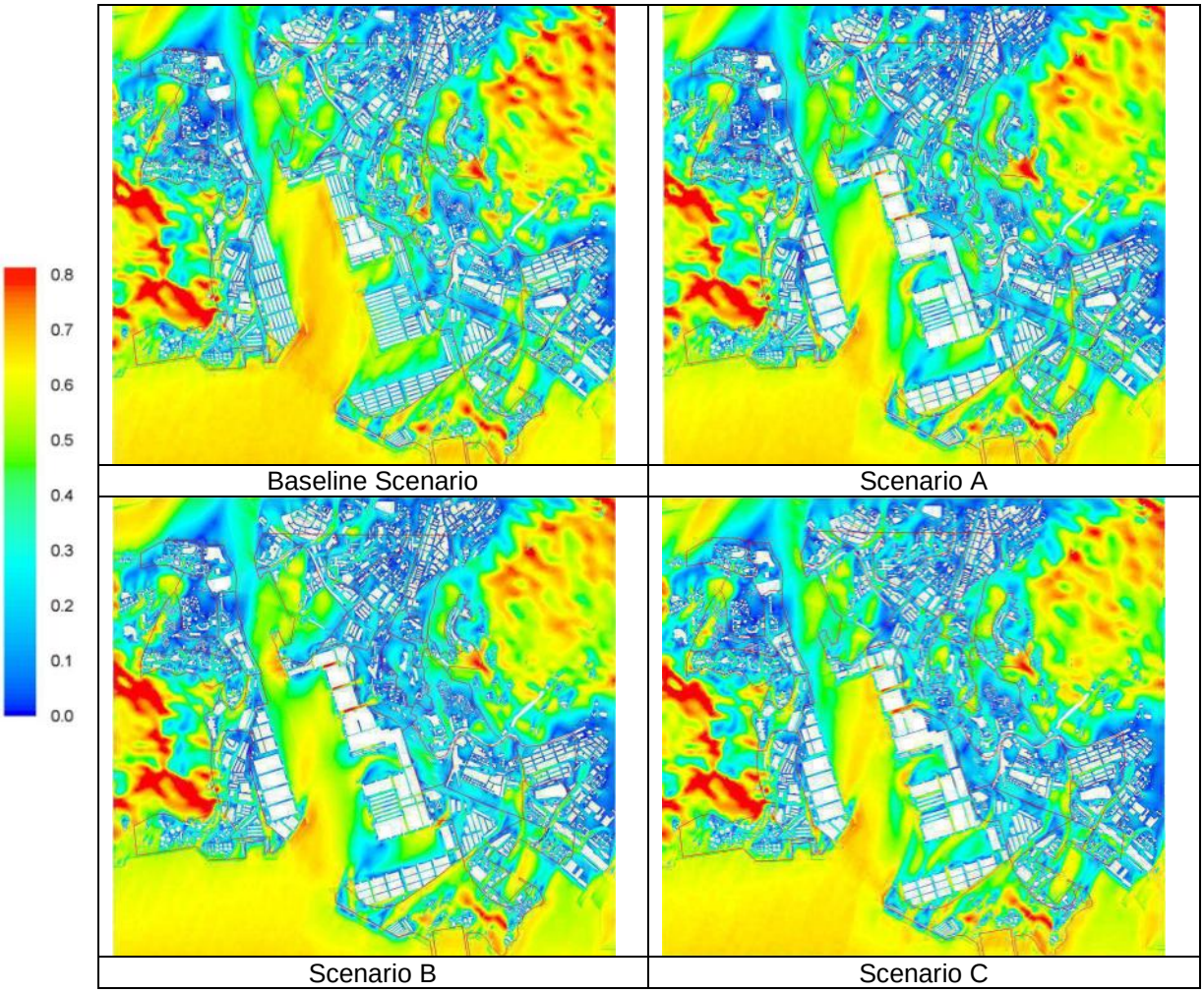
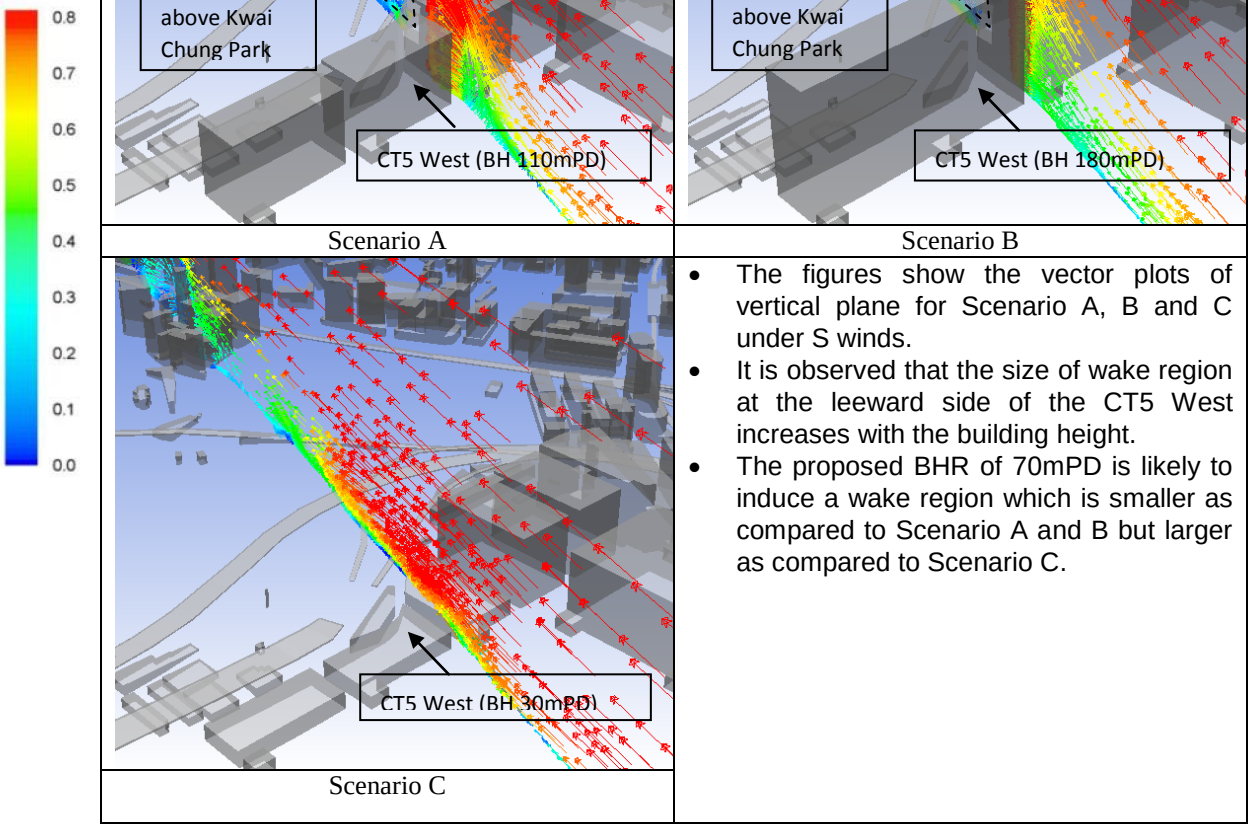


Figure 6.6 Wind Velocity Ratio Contour Plot at 2m above Ground Level (SSW wind)

7 REVISED SCENARIO C AND RELATED ASSESSMENT

CT5 West

7.1 It is observed that the taller the building height, the greater the sheltering effect for the leeward area of the building. Therefore, the proposed BHR of 70mPD applied to CT5 West in **"Revised Scenario C"** is expected to induce a less sheltering effect as compared to 110mPD of Scenario A and 180mPD of Scenario B but a greater sheltering effect as compared to 30mPD of Scenario C. Considering that the knoll (of approximately 50mPD) is located to the immediate north of CT5 west, the air ventilation impact of the Revised Scenario C and Scenario C in terms of the proposed increase in BH of CT5 is not expected to be significant.



- The figures show the vector plots of vertical plane for Scenario A, B and C under S winds.
- It is observed that the size of wake region at the leeward side of the CT5 West increases with the building height.
- The proposed BHR of 70mPD is likely to induce a wake region which is smaller as compared to Scenario A and B but larger as compared to Scenario C.

Figure 7.1 Size of Wake Regions due to Difference in Building Height under S wind

NBAs

7.2 Considering the long span/frontage of the whole Kwai Chung Container Terminals (about 2.35 km) in approximately NW to SE alignment, only very limited NBAs (i.e. 3 nos. of 40m-wide NBAs lie between CTs 1, 2, 3 and 5) have been provided in the Scenarios A and B. As such, Scenario C has adopted the widened NBAs (i.e. increase from 40m to 60m in width). However, widening of the three NBAs to 60m in Scenario C is not that effective. The difference in the air ventilation performance of the 40m-wide NBAs and 60m-wide NBAs is insignificant**.**

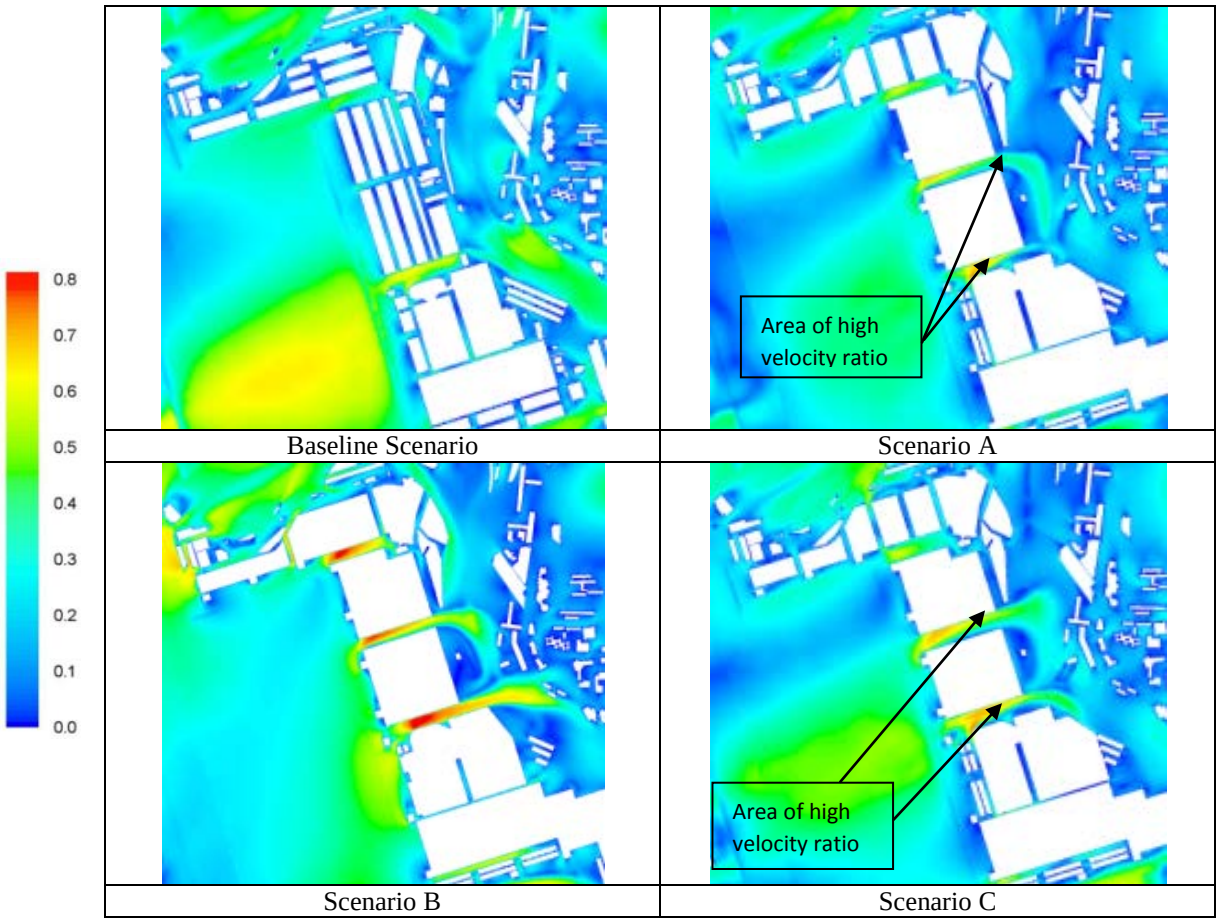


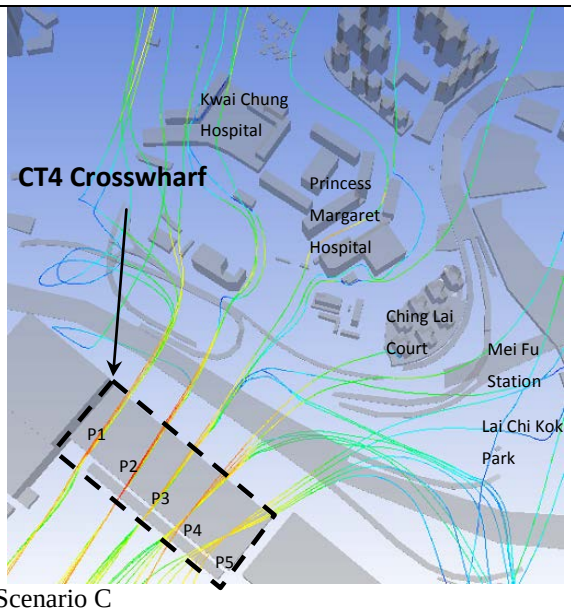
Figure 7.2 Contour Plots at 2m above ground under summer SW prevailing wind

7.3 To further improve the performance of the NBA, it is suggested that a straight linear alignment for the northern most NBA in between CT5 and CT1 should be adopted, away from the existing logistics centre and administrative building as shown in **Figure 7.3**.

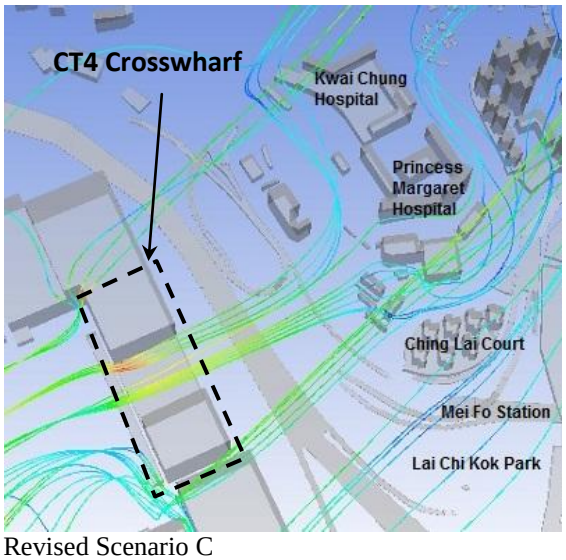
Figure 7.3 Illustrational Diagram of NBA between CT5 East and CT1

CT4 Crosswharf

7.4 The Revised Scenario C proposes to reduce the gap of BH of 30mPD from 330m wide to 110m wide at CT4 Crosswharf. Given the significant reduction in the width of the gap, the air ventilation performance of Revised Scenario C is expected to be significantly worse than Scenario C for the immediately affected areas of Princess Margaret Hospital and its vicinity for the SW quadrant winds. The narrowing in width of the gap at CT4 in "Revised Scenario C" is not recommended as it will reduce wind penetration of SSW, SW and WSW prevailing winds flowing to Kwai Chung Hospital, Princess Margaret Hospital and Ching Lai Court. The wind performance at these places is expected to be lowered in the "Revised Scenario C" as compared to Scenario C.



Scenario C



Revised Scenario C

5 sets of pathlines (P1 to P5) predicted under SW winds are illustrated in the figure on the left. The pathlines are placed at height from 35mPD to 70mPD to show the wind path above the T4 Crosswharf in Scenario C. The summary is presented in the table below:

Pathline	Area of Concern
P1	Kwai Chung Hospital
P2	Kwai Chung Hospital
P3	Princess Margaret Hospital, Ching Lai Court, Lai Chi Kok Park
P4	Ching Lai Court, Lai Chi Kok Park
P5	Lai Chi Kok Park

The revised Scenario C provided by the operators will likely block the wind path P1, P2, P4 and P5. Wind performance at Kwai Chung Hospital, Ching Lai Court and Lai Chi Kok Park would be lowered as compared to Scenario C.

Figure 7.4 Pathlines above T4 Crosswharf under summer SW wind in Scenario C

7.5 A quantitative CFD test which covers an area (2.5 km x 2.5 km) focusing on the CT4 Crosswharf and its nearby developments has been conducted in order to investigate the influence of CT4 Crosswharf (due to the difference in layout and building height) in Revised Scenario C and Scenario C on the downstream frequent pedestrian access areas (i.e. Princess Margaret Hospital, Kwai Chung Hospital and Ching Lai Court etc.). The modeling settings in CFD simulations for Baseline Scenario, Scenarios A, B and C have been adopted for the CFD test.

7.6 Referring to the contour plots in **Figure 7.5**, it is noted that the VRs at the Kwai Chung Hospital, Princess Margaret Hospital and Ching Lai Court located at the downwind side of T4 Crosswharf are lower (of 10% to 31% under SSW, SW and WSW wind directions) in the Revised Scenario C when compared with Scenario C.

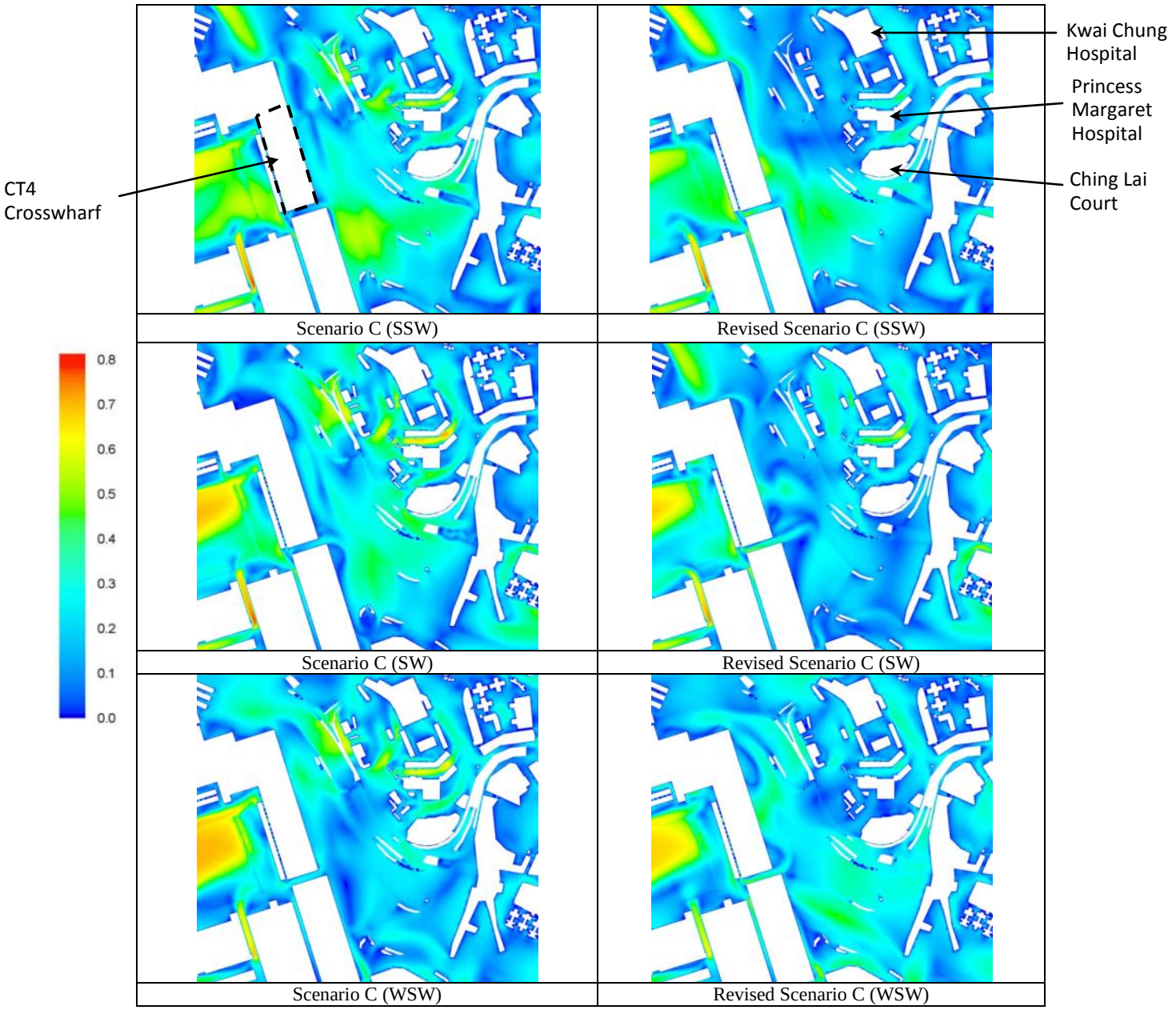


Figure 7.5 Contour Plots at 2m above ground under SW, SSW and WSW prevailing winds

A further revised building height profile of CT4 Crosswharf

7.7 After discussion between PlanD and the CT operators, a revised building height profile of CT4 Crosswharf is suggested, as shown in **Figure 7.6**. Building height of half of the CT4 Crosswharf would be increased to 70mPD, and the remaining southern part (around 110m in width) will remain at 30mPD in height as compared to Scenario C, of which a sector of 55m wide is designed as NBA.

7.8 Compared to Revised Scenario C, the reduction of northern portion of CT4 Crosswharf from 110mPD to 70mPD in Revised Scenario C (Modified) will avoid obstruction of winds towards the Kwai Chung Hospital and Princess Margaret Hospital areas. In addition, the further reduction in height of southern portion of CT4 Crosswharf and imposing a NBA will promote wind flow toward the Ching Lai Court.

7.9 The northern portion of CT4 Crosswharf, after increment in building height to 70mPD in Revised Scenario C (Modified), is not likely to create significant blockage of winds against Kwai Chung Hospital and Princess Margaret Hospital, as these hospitals are situated at the ground with 60-70mPD height. Therefore, the wind performance at Kwai Chung Hospital and Princess Margaret Hospital is expected to be similar after the increased building height in Revised Scenario C (Modified) when compared to Scenario C. Meanwhile, taking the NBA and the relatively low-rise southern part of the CT4 Crosswharf in Revised Scenario C (Modified) (same building height as compared to Scenario C), the wind impact on Ching Lai Court is likely to be similar. Generally speaking, the air ventilation performance of the further revised building height profile of CT4 Crosswharf would be similar to that of Scenario C.

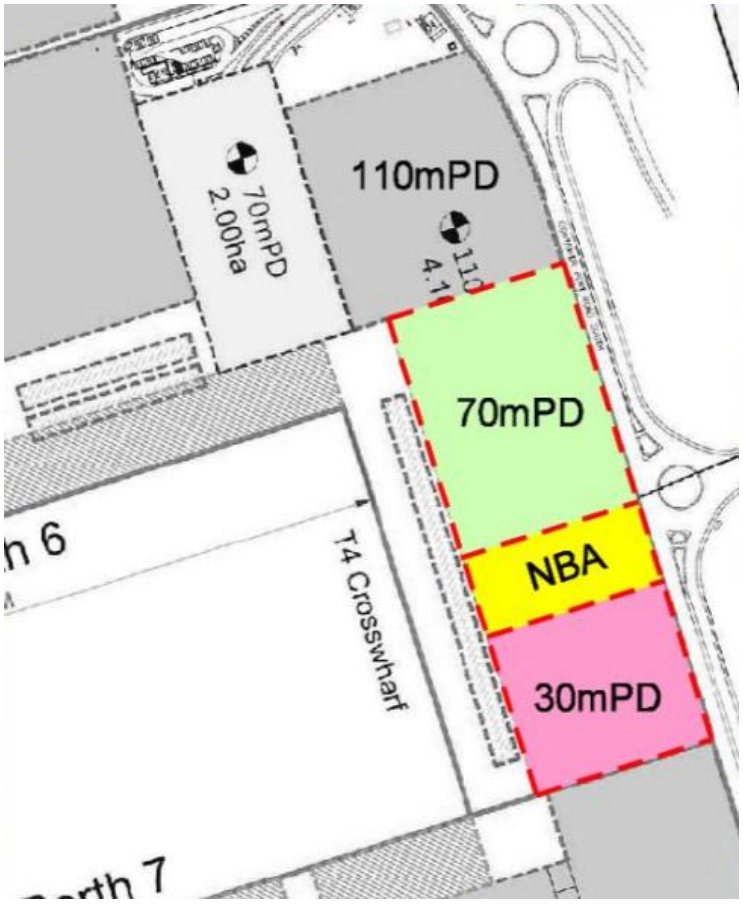


Figure 7.6 Layout Plan for Further Revised Scenario C at T4 Crosswharf

CT8

7.10 The Building Height Restriction (BHR) of 70mPD for CT8 West has been tested under Scenario A and Scenario B. No problematic area in terms of air ventilation is induced by this Building Height Restriction of CT8 West.

CT9

7.11 The BHR of 70mPD for the whole CT9 has been tested under Scenario A and Scenario B which resulted in a worsened VR when compared to Baseline Scenario under ESE and SE winds. In Scenario C, reduced building height to 30mPD is adopted for CT9 North to alleviate the adverse air ventilation impacts particularly on the residential developments (i.e. Mayfair Gardens, Mei King Playground and Cheung Ching Estates). Given that CT9 North is located in the upstream to the above-mentioned residential developments under ESE and SE winds, the CFD results have demonstrated that a building height of 70mPD in CT9 North in Scenario A and B would result in lowered VR in the above upstream areas as shown in **Figure 7.7**. A larger portion of winds from the easterly quadrant are already sheltered by CT9 before reaching the Rambler Crest. The incoming winds are further sheltered by the Rambler Crest before reaching the residents and institutes located further inland. For Scenario C, more wind flow pass CT9 north with a lower building height, resulting in stronger wind towards the residential developments (i.e. Mayfair Gardens and Cheung Ching Estates) as compared to Scenarios A and B. The proposed 70mPD for CT9 in Revised Scenario C, which is the same as the BH adopted for CT9 in Scenario A, would result in similar air ventilation performance and inferior to Scenario C.

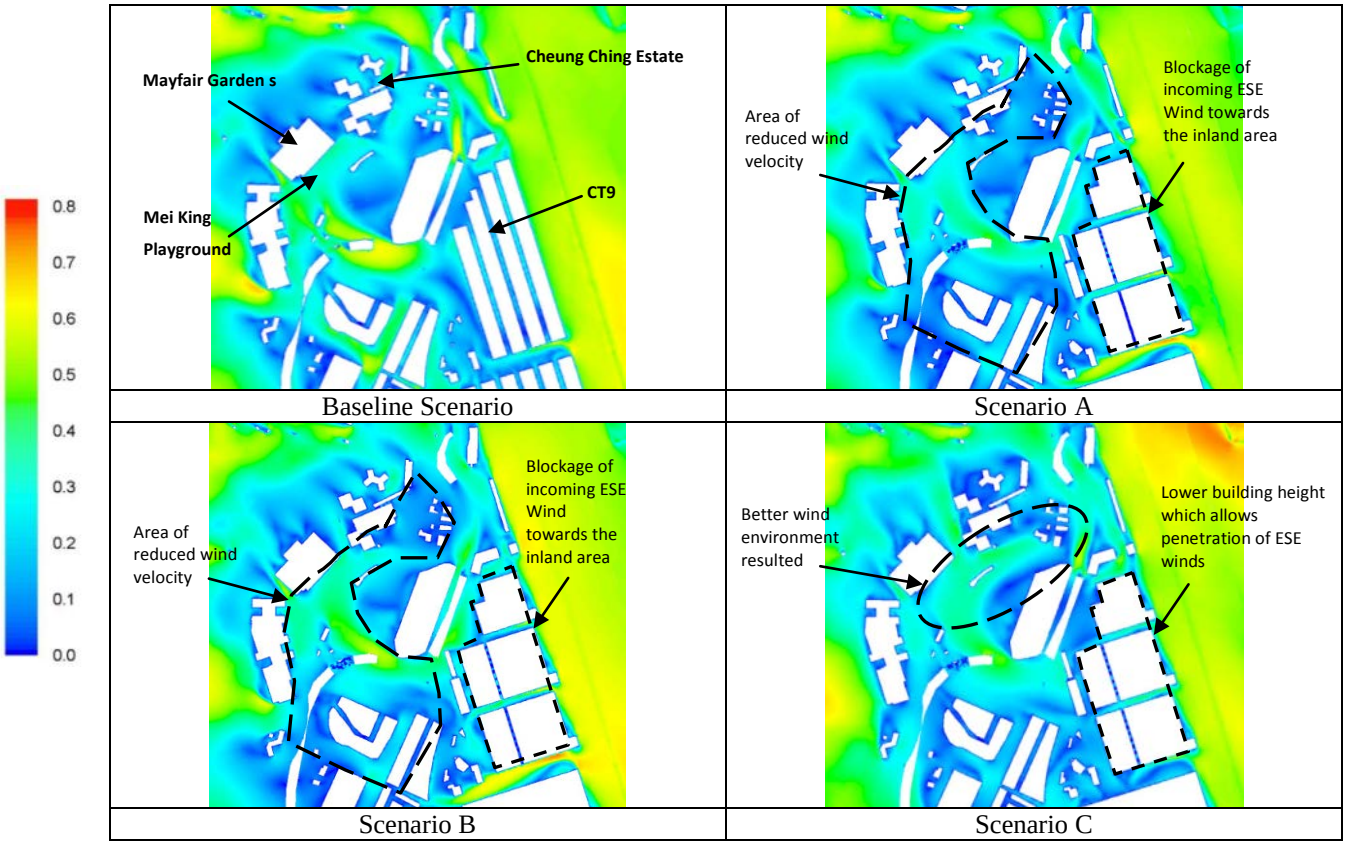


Figure 7.7 Contour Plots at 2m above ground under ESE prevailing wind

8 SUMMARY AND CONCLUSION

8.1 Quantitative air ventilation assessment by CFD simulations have been conducted on the Baseline Scenario, Scenarios A, B and C. It can be concluded that the overall air ventilation performance of Scenarios A and B as measured by SVRw have comparable pedestrian wind environment around its immediate vicinity under both annual and summer conditions, while Scenario A perform better than Scenario B in the surrounding pedestrian wind environment as measured by LVRw under both annual and summer wind conditions suggesting that an increase in development heights (in Scenario B) should be avoided if the cumulative air ventilation impact is not to be aggravated.

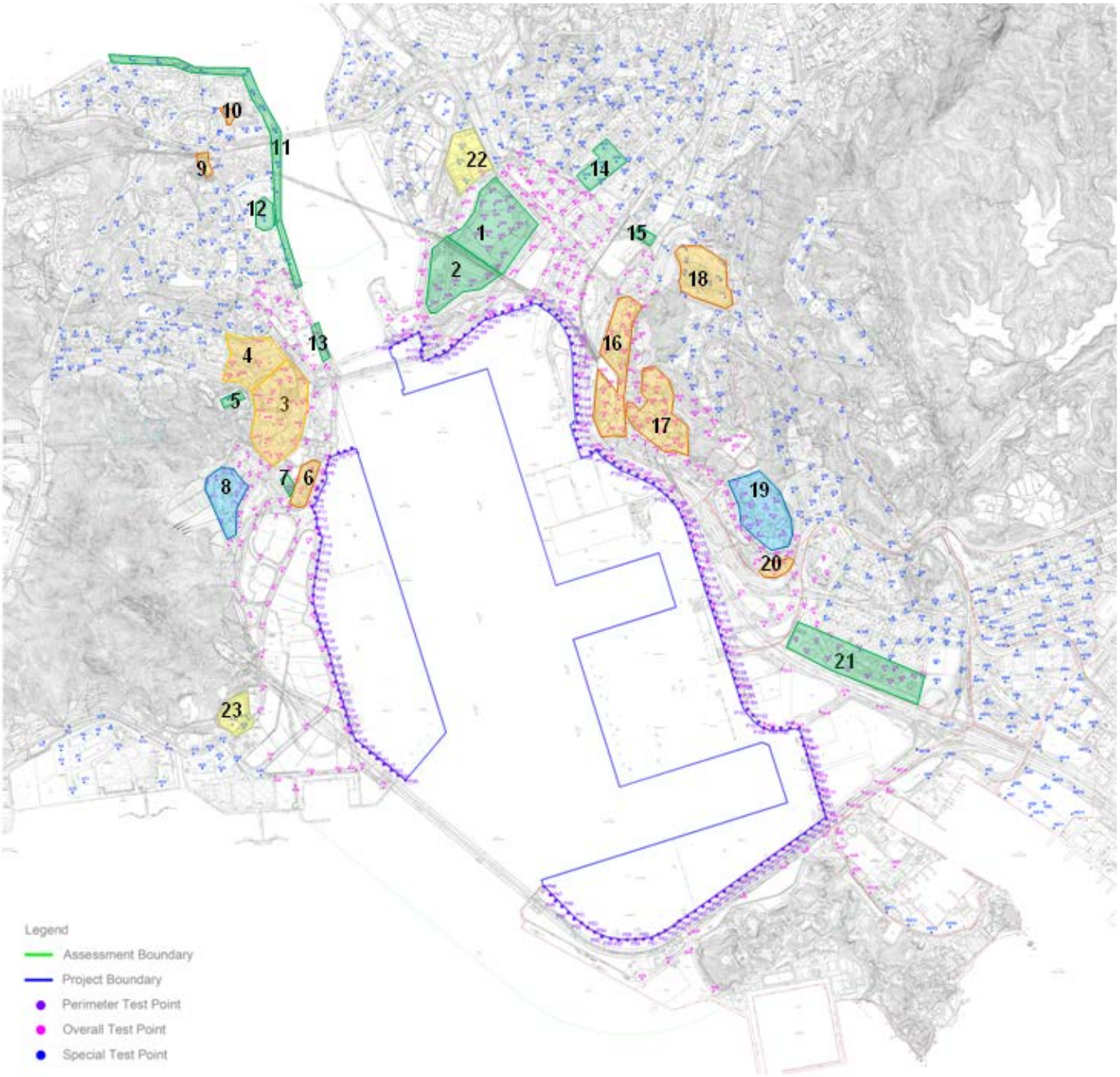
8.2 There are percentage reductions (9.5% to 17.9%) in SVR and LVR for the Proposed Scenarios compared to the Baseline Scenario. However, as the resulted SVR and LVR of Proposed Scenarios are still around 0.2, which represents an above average air ventilation performance in Hong Kong's dense urban settling. This result is not unexpected as there are wide highways in between container terminals and surrounding areas. There are 23 common sensitive areas (see Attachment for details) identified for the Baseline Scenario and Scenarios A and B with frequent pedestrian access under annual and summer winds and there are adverse on some of these areas.

8.3 Scenario C is a variation of Scenario A. It serves as a test case for evaluating the wind performance of improvement measures based on the findings of Scenarios A and B. Improvement measures include the increment of the width of existing NBAs and reduction in building heights are imposed attempting to facilitate the air flows across container terminals in Scenario C. Although these improvement measures have already been incorporated in the development scheme of Scenario C and alleviate the air ventilation impact to some extent, some residual impacts are still identified. More improvement measures could be devised to enhance the overall wind performance in the detailed design stages, following the Technical Circular and Technical Guide on Air Ventilation Assessments.

8.4 There is a Revised Scenario C (provided by the CT operators) which differs from Scenario C in building heights allowed for certain locations, taking into account CT operation constraints. In comparing the Revised Scenario C and Scenario C, their performance are largely comparable in air ventilation performance terms, except that Revised Scenario C would be inferior than Scenario C, in such a way that the proposed increase in BH of CT4 Crosswharf and CT9 would affect air penetration to the immediate surrounding areas for various wind directions, including SW quadrant and SE quadrant winds respectively. Subsequently, a Revised Scenario C (modified) incorporating a revised building profile for CT4 Crosswharf is suggested. The air ventilation performance of these revised profile would be similar to that of Scenario C.

8.5 Generally speaking, the Baseline Scenario is the existing condition of CTs No.1-9, which has low site coverage of about 7.4% and largely occupied by container stacks. It is inevitable that all four proposed development scenarios, Scenarios A, B, C and Revised Scenario C, with their significant massing, would cause adverse air ventilation impacts comparing to the Baseline Scenario on the Project Site; and due to the large project area which covers over 279ha, the cumulative impact on air ventilation is significant and extensive. Due to the extensive impact over the region and the permanent nature of the impact, more project specific mitigation measures could be devised to ensure sustainable development of the surrounding areas in the long term and to ensure that wind as a valuable public asset, is well preserved in Hong Kong in the coming quantitative AVA studies for specific development schemes.

Attachments



Sensitive Areas Common to Baseline Scenario and Scenarios A, B and C

Summary of VRw at Sensitive Areas under Annual Wind Directions

No.	Location	Average Annual Wind Velocity Ratio			
		Baseline Scenario	Scenario A	Scenario B	Scenario C
1	Proposed Kwai Chung Park North	0.22	0.21	0.23	0.19
2	Proposed Kwai Chung Park South	0.31	0.25	0.27	0.28
3	Cheung Ching Estate South	0.26	0.23	0.21	0.24
4	Cheung Ching Estate North	0.23	0.21	0.19	0.22
5	Ching Hong Road Playground	0.36	0.34	0.33	0.34
6	Rambler Crest	0.09	0.1	0.09	0.08
7	Tsing Hung Road Playground (next to Rambler Crest)	0.07	0.08	0.07	0.09
8	HKIVE (Tsing Yi)	0.14	0.14	0.13	0.13
9	St. Paul's Village	0.11	0.1	0.09	0.11
10	Nga Ying Chau Garden'	0.18	0.16	0.15	0.17
11	Tsing Yi Promenade	0.26	0.24	0.23	0.25
12	Tsing Yi Sports Ground	0.30	0.27	0.26	0.28
13	Cheung Fat Road Promenade	0.23	0.24	0.25	0.2
14	Kwai Chung Sports Ground	0.08	0.08	0.08	0.08
15	Park next to Kwai Fong Road	0.14	0.12	0.11	0.12
16	Lai King Estate and Yin Lai Court	0.13	0.12	0.11	0.12
17	Cho Yiu Chuen	0.15	0.14	0.15	0.14
18	Lai Yiu Estate	0.17	0.16	0.16	0.16
19	Princess Margaret Hospital	0.17	0.14	0.14	0.13
20	Ching Lai Court	0.14	0.09	0.09	0.08
21	Lai Chi Kok Park (Stage 3)	0.17	0.16	0.17	0.16
22	Kwai Chung Industrial Area	0.19	0.15	0.13	0.13
23	Tsing Yi Industrial Area	0.19	0.18	0.17	0.18

Summary of VRw at Sensitive Areas under Summer Wind Directions

No.	Location	Average Summer Wind Velocity Ratio			
		Baseline Scenario	Scenario A	Scenario B	Scenario C
1	Proposed Kwai Chung Park North	0.28	0.26	0.28	0.23
2	Proposed Kwai Chung Park South	0.34	0.25	0.3	0.32
3	Cheung Ching Estate South	0.23	0.2	0.2	0.21
4	Cheung Ching Estate North	0.21	0.19	0.19	0.19
5	Ching Hong Road Playground	0.40	0.4	0.4	0.38
6	Rambler Crest	0.10	0.1	0.1	0.09
7	Tsing Hung Road Playground (next to Rambler Crest)	0.20	0.19	0.18	0.21
8	HKIVE (Tsing Yi)	0.19	0.18	0.18	0.18
9	St. Paul's Village	0.23	0.21	0.21	0.23
10	Nga Ying Chau Garden'	0.21	0.18	0.15	0.17
11	Tsing Yi Promenade	0.24	0.21	0.2	0.22
12	Tsing Yi Sports Ground	0.25	0.22	0.22	0.23
13	Cheung Fat Road Promenade	0.28	0.32	0.34	0.27
14	Kwai Chung Sports Ground	0.13	0.14	0.15	0.14
15	Park next to Kwai Fong Road	0.17	0.13	0.11	0.13
16	Lai King Estate and Yin Lai Court	0.16	0.14	0.11	0.14
17	Cho Yiu Chuen	0.17	0.15	0.15	0.15
18	Lai Yiu Estate	0.17	0.16	0.15	0.16
19	Princess Margaret Hospital	0.20	0.17	0.15	0.16
20	Ching Lai Court	0.13	0.12	0.12	0.09
21	Lai Chi Kok Park (Stage 3)	0.25	0.23	0.22	0.23
22	Kwai Chung Industrial Area	0.27	0.22	0.21	0.18
23	Tsing Yi Industrial Area	0.24	0.23	0.22	0.23