TERM CONSULTANCY FOR AIR VENTILATION ASSESSMENT SERVICES

Cat. A– Term Consultancy for Expert Evaluation and Advisory Services on Air Ventilation Assessment (PLNQ 37/2007)

Final Report– SHEK KIP MEI Area

March 2010

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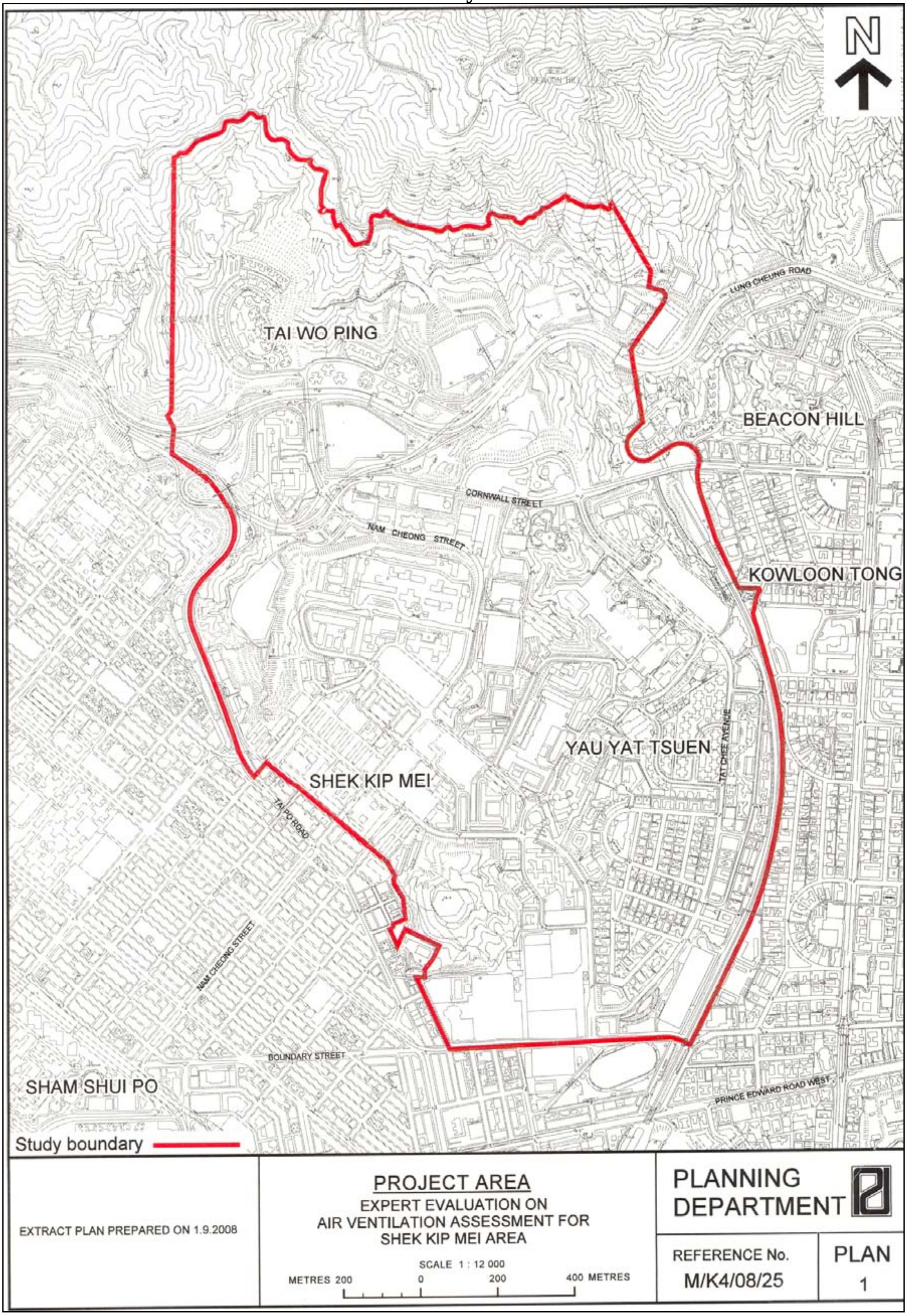
The Study Area



Expert Evaluation Report of Shek Kip Mei

Executive summary

0.1 Wind Availability:

(a) Based on the available wind data, the annual prevailing wind of the study area is mainly from the East and North-East. The summer wind is mainly coming from the East and the Southerly quarters.

(b) The study area slopes from the south (5 mPD) to the north (200+ mPD). The bulk of the urban development is on a gentle slope from 5 to 100 mPD. In general, the northerly wind arriving at the study area will be slowed and weakened by the shielding effects of the hills bordering the study area's northern boundary. This is not a problem as the important summer winds are from the East and the Southerly directions over the flatter terrain.

(c) The summer wind from the South and South-West will be slowed by the dense urban structure due to the higher ground roughness. This may have some effects to areas immediately bordering the study area's south and south-western boundaries.

0.2 The Existing Conditions:

(a) Compared to some metro areas in Hong Kong, the study area has useful greenery coverage and large open spaces including Tai Hang Tung Recreation Ground, Shek Kip Mei Park and Fa Hui Park.

(b) Except a few isolated towers in Pak Tin Estate and Shek Kip Mei Estate, in general, the study area's existing buildings are not tall, and are in the range of around 10 to 60m.

(c) On the whole, the ground coverage and the building bulk of the study area are not high.

(d) Building bulks in the eastern part of study area are mostly in low rise clusters. Air ventilation can find ways to pass through and over them.

(e) A number of streets lead into the study area from the south-west. They are useful air paths.

(f) Dense urban structures border the study area's south and south-west. Nonetheless, the existing building heights of the neighbouring areas (Sham Shui Po) are currently not tall, and are in the range of around 15m to 60m. Air ventilation can find ways to pass through and over them.

(g) All in all, the study area currently should have no major air ventilation issues.

0.3 The Study Area with Committed Re-development:

(a) The two areas on Woh Chai Street are along the south-westerly air paths. Towers on Shek Kip Mei Estate 5 are well aligned and spaced. However, a tower on Phase 2 is directly in front of an air path. Fortunately, there are buildings of lower heights both sides of it.

0.4 The Initial Planned Scenario (Figure 0.1):

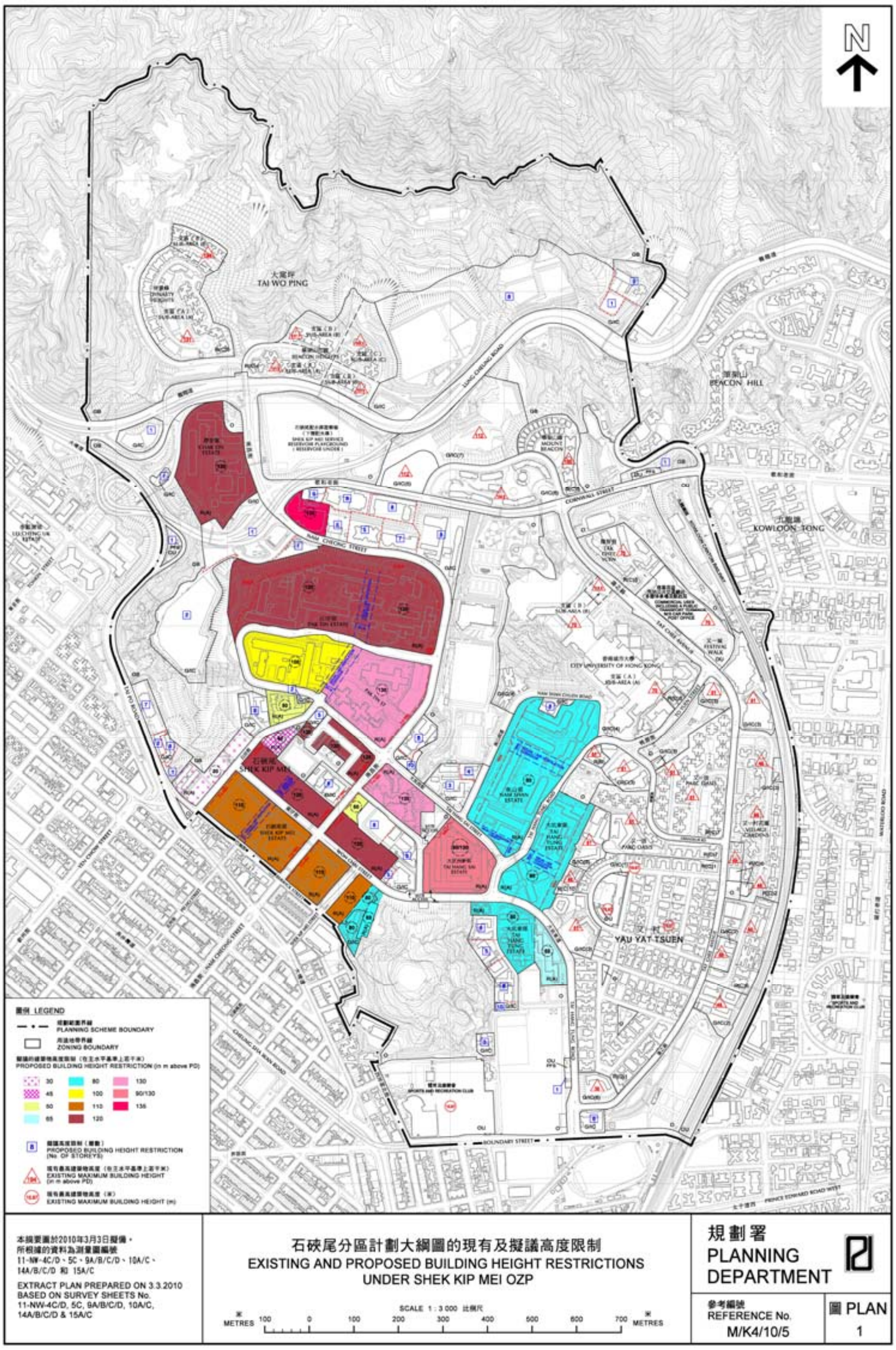


Figure 0.1 Initial planned scenario

(a) Building heights of the Public Housing Estate cluster east of Shek Kip Mei Park has been restricted to 80 mPD. Two ventilation corridors have been proposed for inclusion in Nam Shan Estate and Tai Hang Tung Estate to ensure that the easterly air ventilation is not unduly blocked.

(b) Non building areas (NBA) have been proposed along Nam Cheong Street Pak Tin Street, Nam Shan Chuen Road, in large sites at Pak Tin Estate, Shek Kip Mei Estate, Nam Shan Estate, Tai Hang Tung Estate, and partially at Tai Hang Sai Estate. Together they maintain the usefulness of the air paths leadings into the study area.

(c) Two ventilation corridors have been proposed in Pak Tin Estate and Shek Kip Mei Estate. They help extend the existing Pak Tin Street and Pei Ho Street air paths northward.

(d) All in all, except the need to incorporate the appropriate NBA in Tai Hang Sai Estate, the proposed air ventilation corridors and building set backs of the Initial Planned Scenario in forms of NBA should be able to provide optimum air ventilation passages through the study area given the building height restrictions.

0.5 Focus Areas and Further Studies:

(a) There are many Housing Department housing estates in the study area. Apart from observing paragraph 6.9 of this report, it is recommended AVA studies be carried out when these housing estates are re-developed in the future, so that air ventilation within their site boundaries are optimized.

(b) NBA as discussed in the report is important for Tai Hang Sai Estate. This should be incorporated and evaluated.

(c) Subject to paragraph (b) being respected, the study area, given the proposed building height restrictions and NBA, should have no major air ventilation issues. Further AVA studies are not needed.

Expert Evaluation Report of Shek Kip Mei

1.0 The Assignment

1.1 In order to provide better planning control on the building height and plot ratio/gross floor area (GFA)_upon development/redevelopment, the approved Shek Kip Mei Outline Zoning plan (OZP) No. S/K4/23 (the Plan) is being reviewed with a view to incorporating appropriate development restrictions into the Plan for various development zones of the OZP to guide future development/redevelopment. It is considered necessary to conduct an expert evaluation to assess the broad Air Ventilation impacts of the proposed building height restrictions.

1.2 This expert evaluation report is based on a site inspection on 11 Dec 2008 and the materials given by Planning Department to the Consultant on 10 Dec 2008 including:

- the Shek Kip Mei OZP
- Existing height profile in ranges of mPD, building height in mPD, and spot heights - committed and planned developments
- Aerial view of the study area
- concept plan and proposed building height control

AND the following information forwarded to the Consultant on 19 Dec 2008, 23 Jan 2009, 15 Dec 2009 and 03 March 2010:

m_k4_08_39_plan4_a3	superseded by M/K4/09/3 Plan 4
M/K4/09/3 Plan 4	as figure 6.1

2.0 Background

2.1 Planning Department study: "Feasibility Study for Establishment of Air Ventilation Assessment System" has recommended that it is important to allow adequate air ventilation through the built environment for pedestrian comfort.

2.2 Given Hong Kong's high density urban development, the study opines that: "more air ventilation, the better" is the useful design guideline.

2.3 The study summarises 10 qualitative guidelines for planners and designers. For the OZP level of consideration, breezeways/air paths, street grids and orientations, open spaces, non-building areas, waterfront sites, scales of podium, building heights, building dispositions, and greeneries are all important strategic considerations.

2.4 The study also suggests that Air Ventilation Assessment (AVA) be conducted in 3 stages: Expert Evaluation, Initial Studies, and Detailed Studies. The suggestion have been adopted and incorporated into HPLB and ETWB Technical Circular no. 1/06. The key purposes of Expert Evaluation are to:

(a) Identify good design features.
(b) Identify obvious problem areas and propose some mitigation measures.
(c) Define "focuses" and methodologies of the Initial and/or Detailed studies.
(d) Determine if further study should be staged into Initial Study and Detailed Study, or Detailed Study alone.

2.5 To conduct the Expert Evaluation systematically and methodologically, it is necessary to undertake the following information analyses:

(a) Analyse relevant wind data as the input conditions to understand the wind environment of the study area.
(b) Analyse the topographical features of the study area, as well as the surrounding areas.
(c) Analyse the greenery/landscape characteristics of the study area, as well as the surrounding areas.
(d) Analyse the land use and built form of the study area, as well as the surrounding areas.

Based on the analyses:

(e) Estimate the characteristics of the input wind conditions of the study area.
(f) Identify the wind paths and wind flow characteristics of the study area through slopes, open spaces, streets, gaps and non building areas between buildings, and low rise buildings; also identify stagnant/problem areas, if any.
(g) Estimate the need of wind for pedestrian comfort.

Based on the analyses of the EXISTING urban conditions:

(h) Evaluate the strategic role of the area in air ventilation term.
(i) Identify problematic areas which warrant attention.
(j) Identify existing "good features" that needs to be kept or strengthened.

Based on an understanding of the EXISTING urban conditions:

(k) Compare the prima facie impact, merits or demerits of the building height restrictions as proposed by Planning Department on Air Ventilation.
(l) Highlight problem areas, if any. Recommend improvements and mitigation measures if possible.
(m) Identify focus areas or issues that may need further studies. Recommend appropriate technical methodologies for the study if needed.

3.0 The wind environment

3.1 Hong Kong Observatory (HKO) stations provide useful and reliable data of the wind environment in Hong Kong (Figure 3.1). There are some 46 stations operated by HKO in Hong Kong. Together, they allow a very good general understanding of the wind environment especially close to ground level.

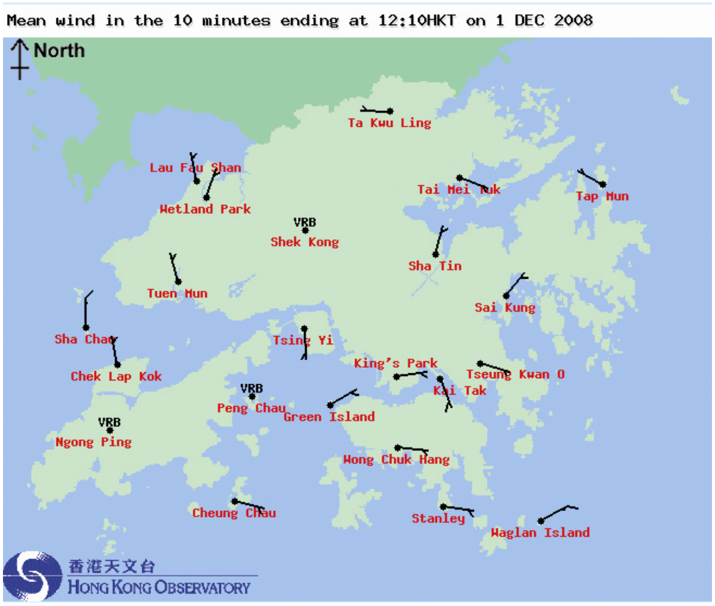


Figure 3.1 Some of the HKO stations in Hong Kong. This is a screen capture at 12:10 on 1 Dec 2008 from the HKO website. The arrows show the wind directions and speeds of the time. The case study illustrates that the local wind environment is affected by the topography, as well as the thermally induced sea breezes

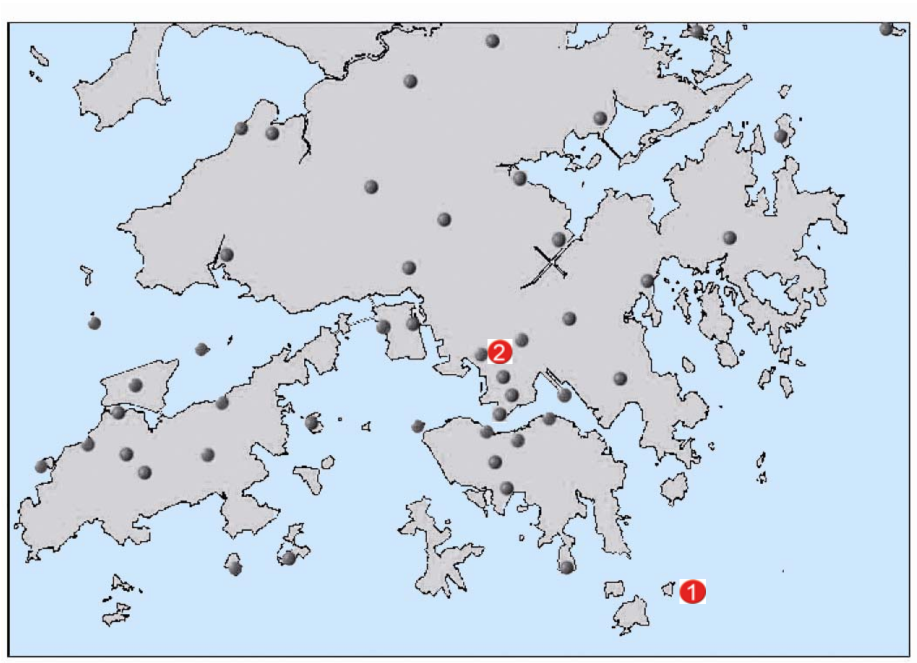
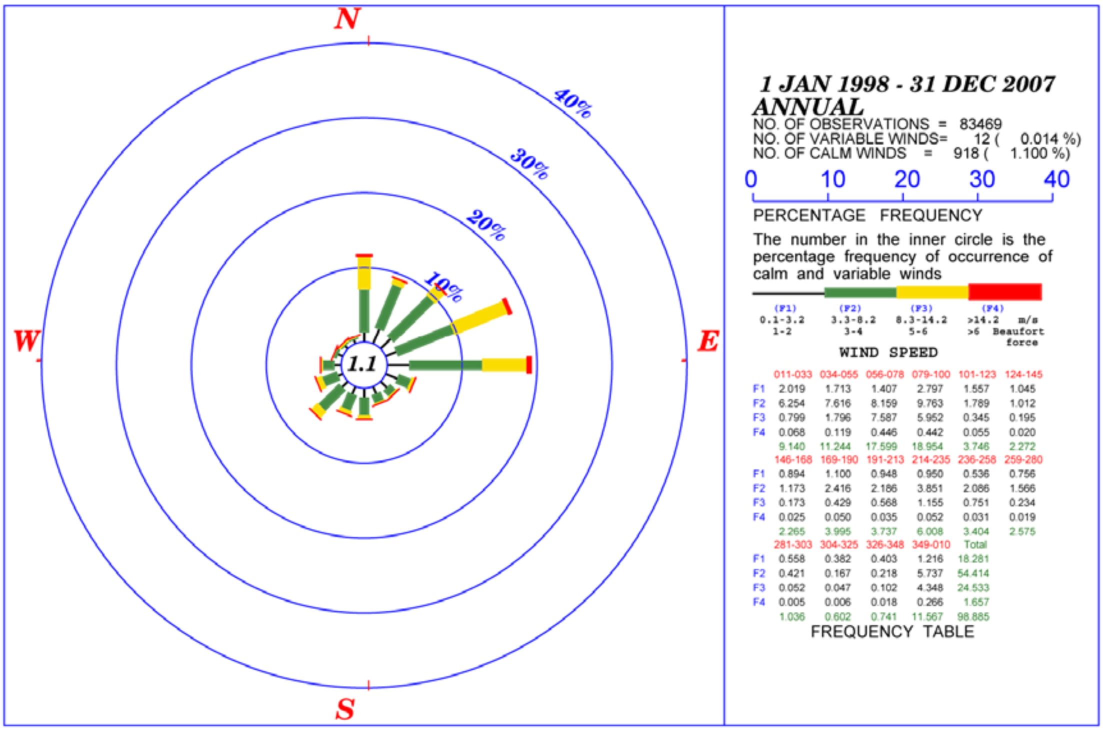


Figure 3.2 The HKO stations at 1: Waglan Island (WGL) and 2: Yau Yat Chuen (YYC)

3.2 Refer to Figure 3.2, the HKO station at Waglan Island (WGL) is normally regarded by wind engineers as the reference station for wind related studies (Figure 3.3). The station has a very long measuring record, and it is unaffected by Hong Kong's complex topography [*unfortunately, it is known not to be able to capture the thermally induced local wind circulation like sea breezes too well*]. Based on WGL wind data, studies are typically employed to estimate the site wind availability taking into account the topographical features around the site.

Wind Rose of WGL, Waglan Island
(Running 60-minute wind)



	011-033	034-055	056-078	079-100	101-123	124-145
F1	2.019	1.713	1.407	2.797	1.557	1.045
F2	6.254	7.616	8.159	9.763	1.789	1.012
F3	0.799	1.796	7.587	5.952	0.345	0.195
F4	0.068	0.119	0.446	0.442	0.055	0.020
	9.140	11.244	17.599	18.954	3.746	2.272
	146-168	169-190	191-213	214-235	236-258	259-280
F1	0.894	1.100	0.948	0.950	0.536	0.756
F2	1.173	2.416	2.186	3.851	2.086	1.566
F3	0.173	0.429	0.568	1.155	0.751	0.234
F4	0.025	0.050	0.035	0.052	0.031	0.019
	2.265	3.995	3.737	6.008	3.404	2.575
	281-303	304-325	326-348	349-010	Total	
F1	0.558	0.382	0.403	1.216	18.281	
F2	0.421	0.167	0.218	5.737	54.414	
F3	0.052	0.047	0.102	4.348	24.533	
F4	0.005	0.006	0.018	0.266	1.657	
	1.036	0.602	0.741	11.567	98.885	

Figure 3.3 Wind rose of WGL 1998-2007 (annual)

3.3 Examining the annual wind rose of WGL, it is apparent that the annual prevailing wind in Hong Kong is from the East. There is also a major component of wind coming from the North-East; and there is a minor, but nonetheless observable component from the South-West. Around 70% of the time, WGL has weak to moderate wind (0.1m/s to 8.2 m/s).

3.4 For the study, it is important to understand the wind environment seasonally or monthly (Figure 3.4 and 3.5). In the winter months of Hong Kong, the prevailing wind comes from the North-East. In the summer months, they come from the South-West. As far as AVA is concerned, in Hong Kong, the summer wind is very important and beneficial to thermal comfort. Hence, based on WGL data, it is very important to plan our city, on the one hand, to capture the annual wind characteristics, and on the other hand, to maximize the penetration of the summer winds (mainly from the South-West) into the urban fabric.

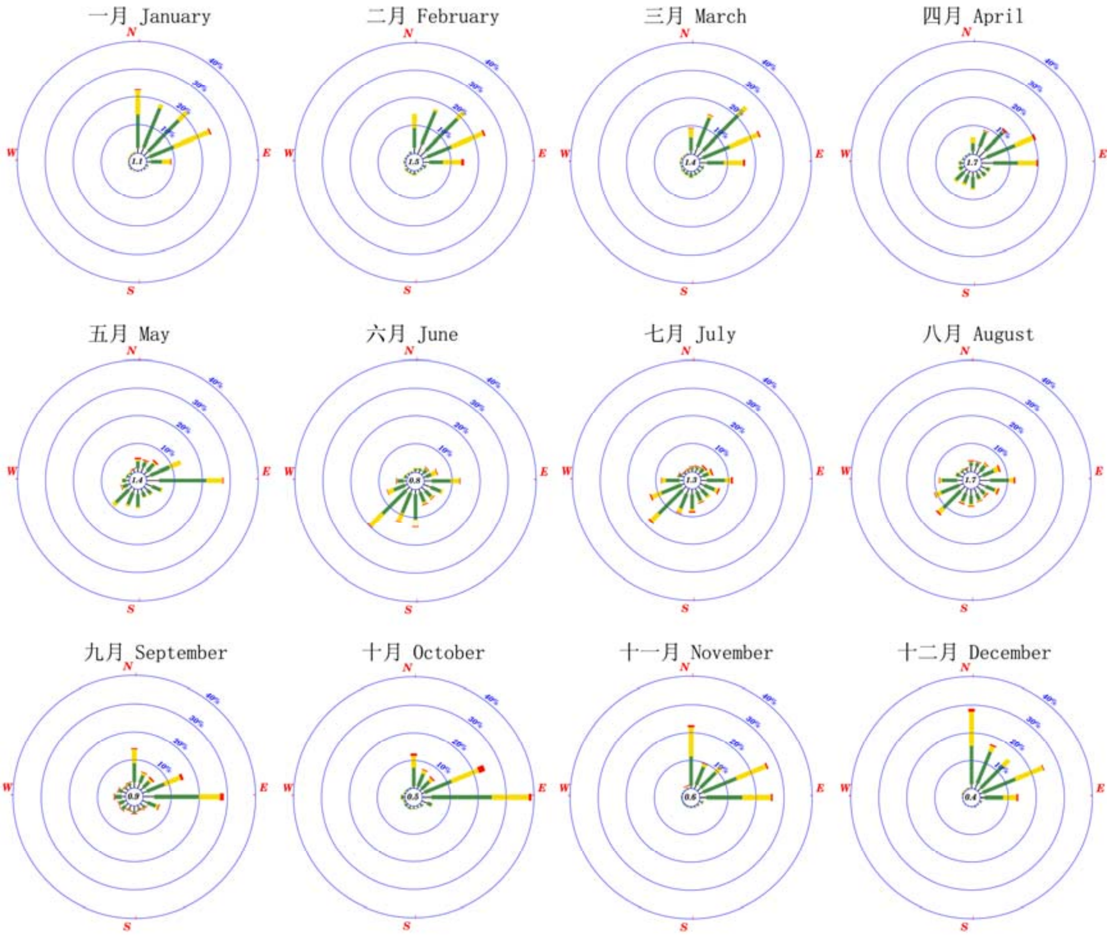


Figure 3.4 Monthly wind roses of WGL 1998-2007

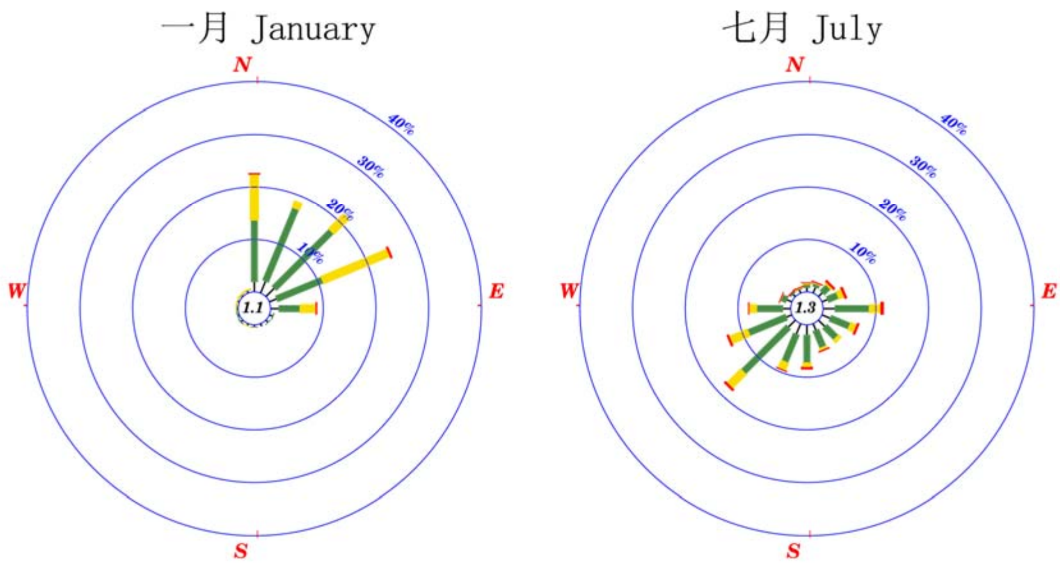


Figure 3.5 Wind roses of WGL 1998-2007 (Jan and July)

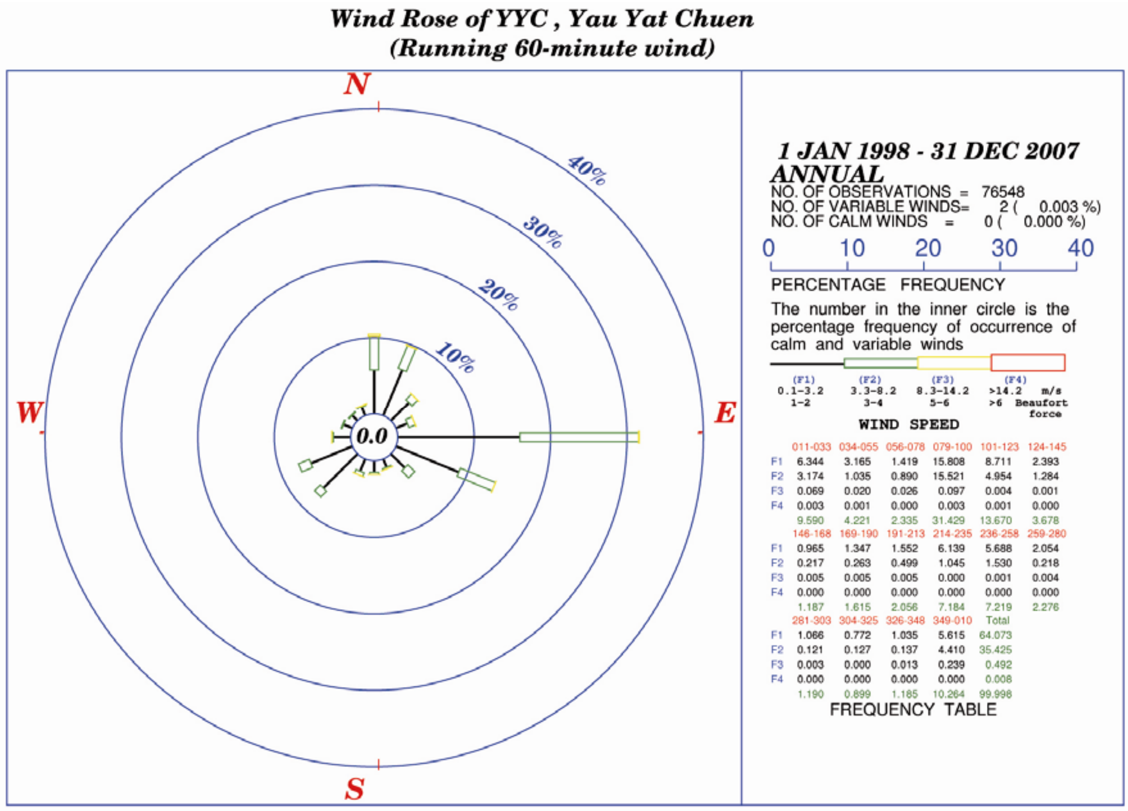


Figure 3.6 Wind rose of YYC (annual)

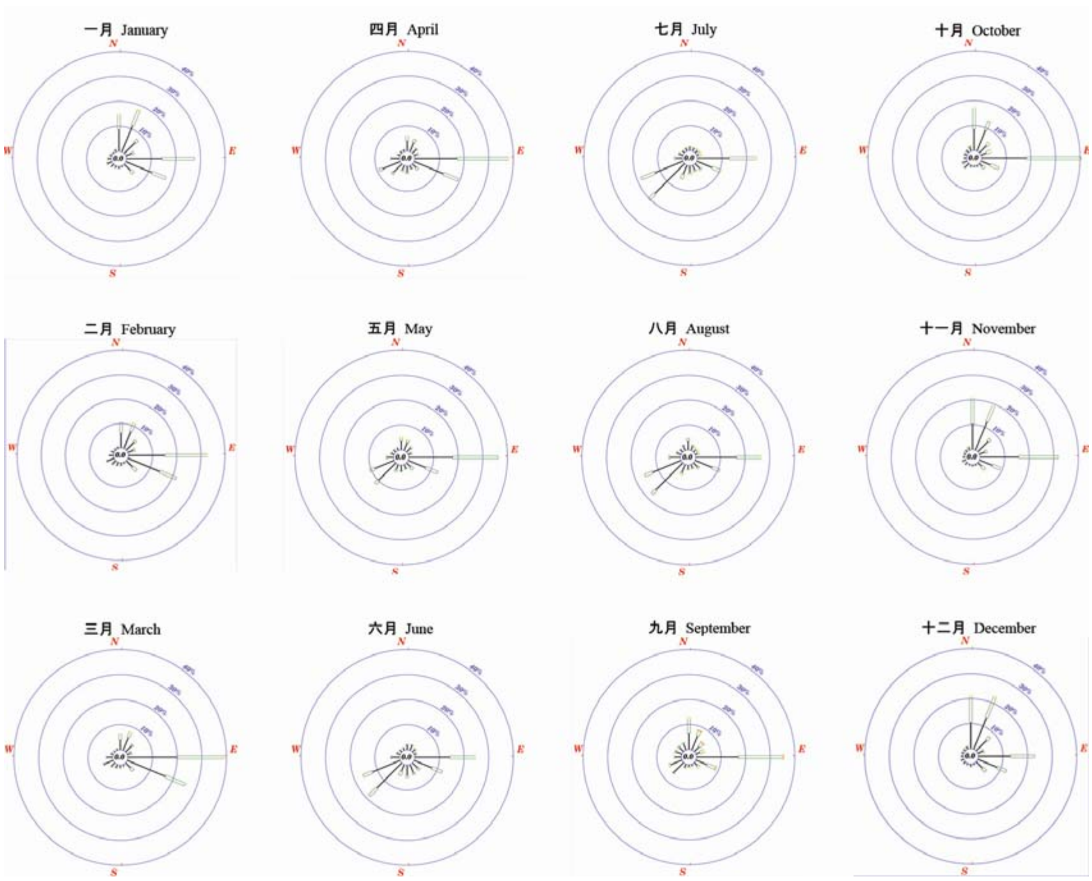


Figure 3.7 (as an example) monthly wind roses of YYC 1998-2007

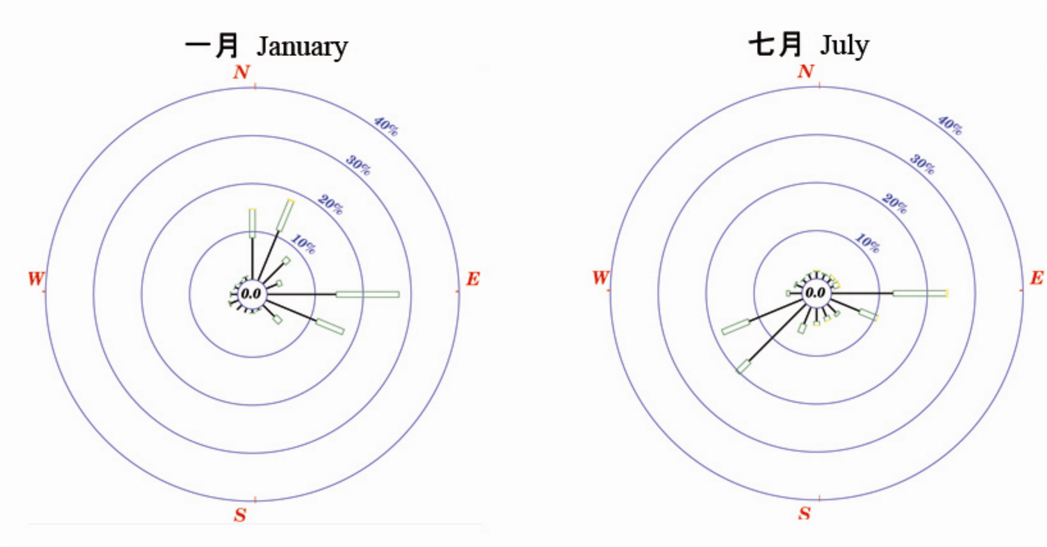


Figure 3.8 (as an example) Wind roses of YYC 1998-2007 (Jan and July)

3.5 Researchers at Hong Kong University of Science and Technology (HKUST), Prof Alexis Lau and Prof Jimmy Fung, have simulated a set of wind data using MM5. The data period cover the whole year of 2004. Based on this dataset, 3 locations of the study area are extracted at 120m and 450m (roughly at the urban canopy layer level and at the atmospheric boundary layer level respectively) above ground (see Figures 3.9 to 3.15)

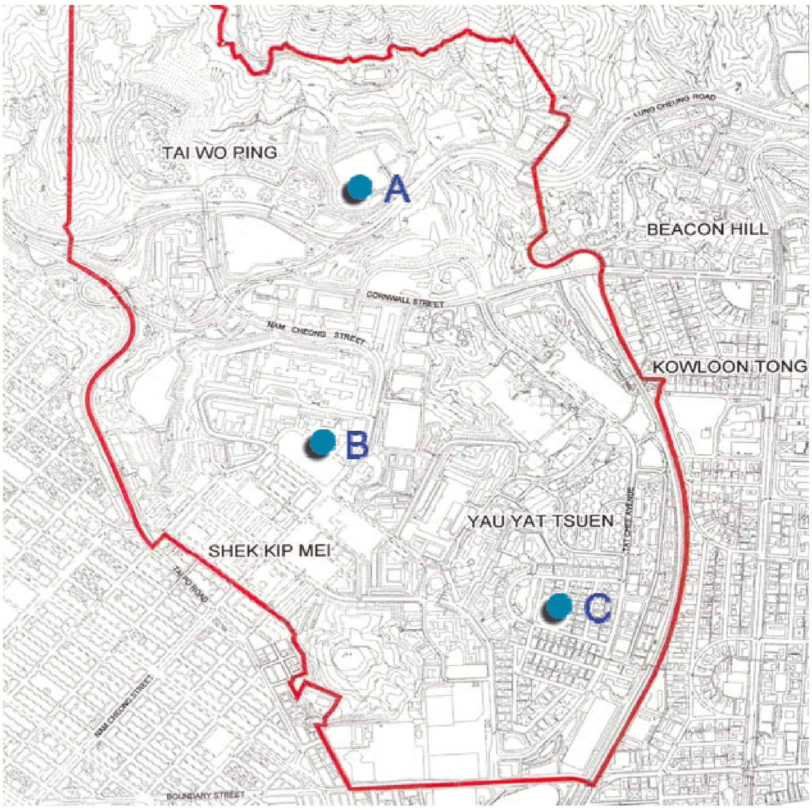
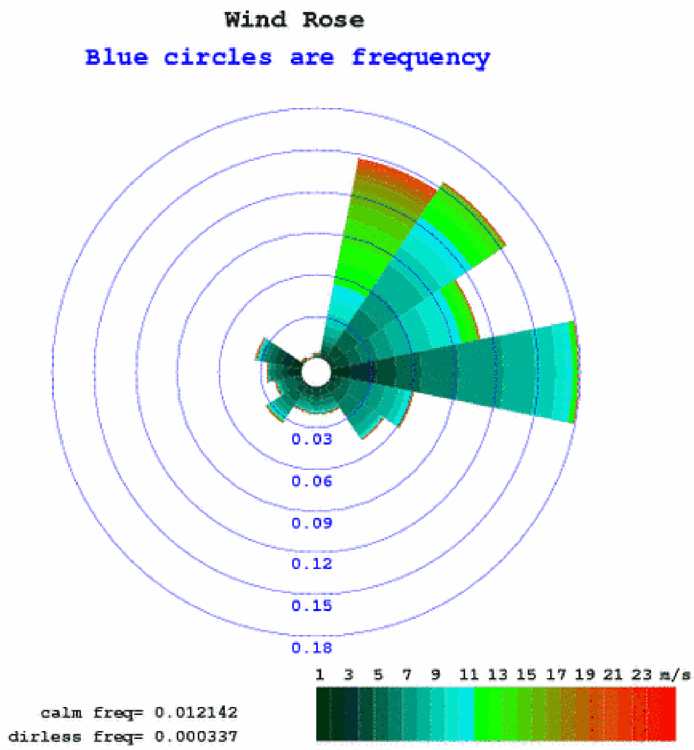


Figure 3.9 The 3 locations of MM5 extracted data



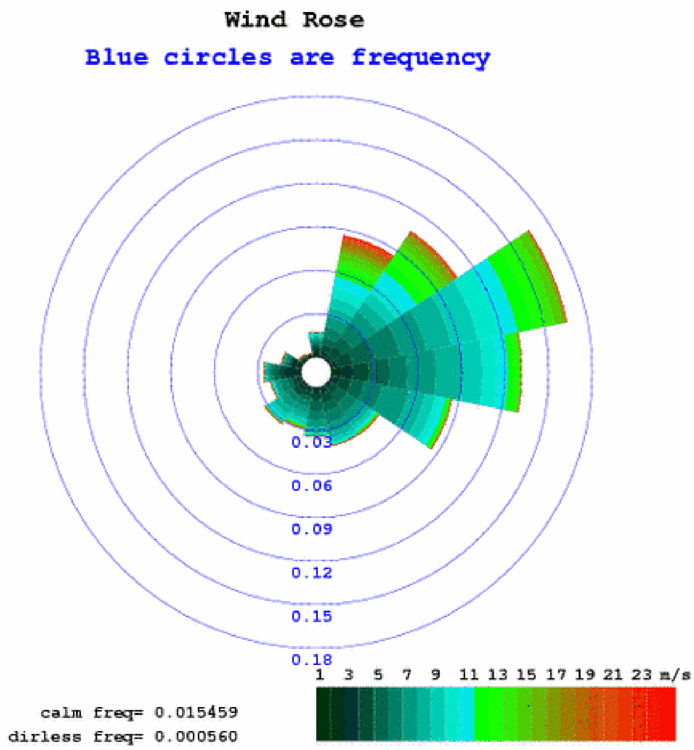
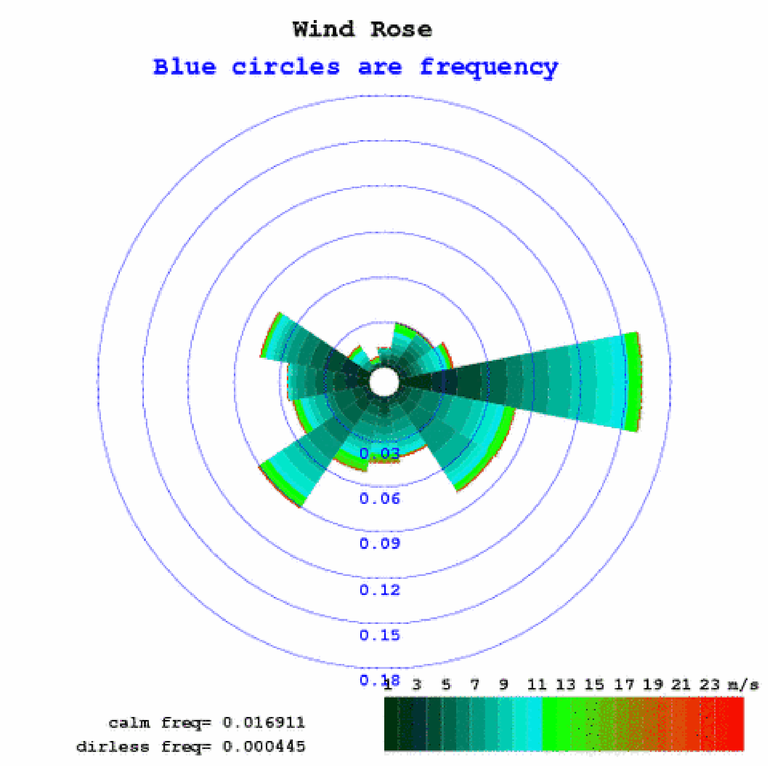


Figure 3.10 Wind roses (annual) at A (top:120m) (bottom:450m)



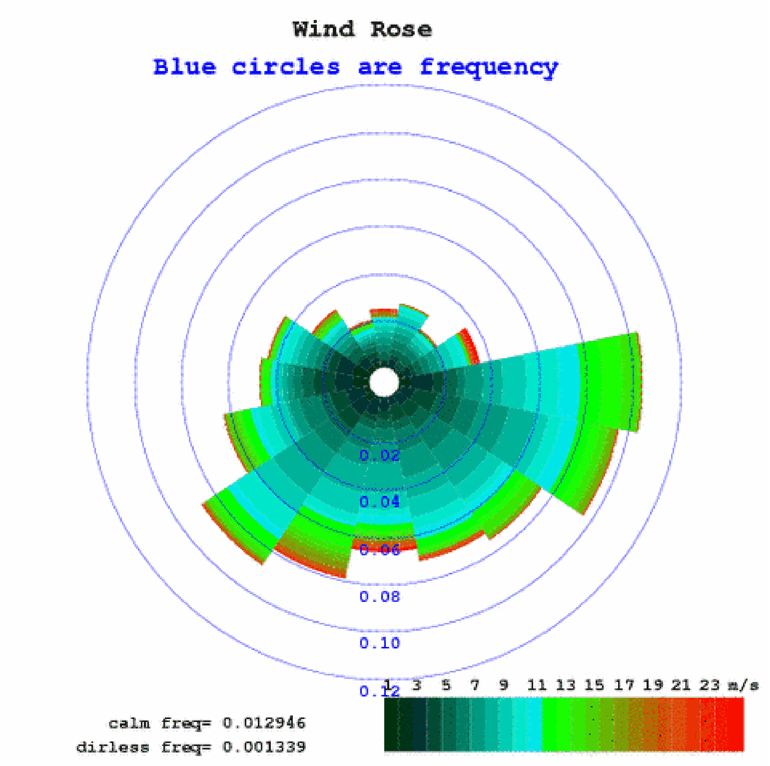
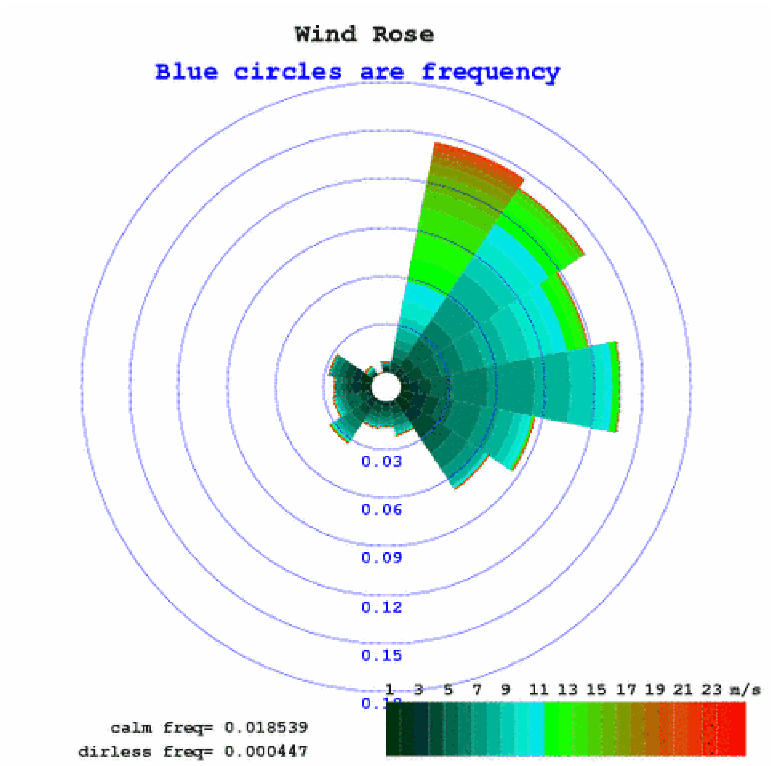


Figure 3.11 Wind roses (summer) at A (top:120m) (bottom:450m)



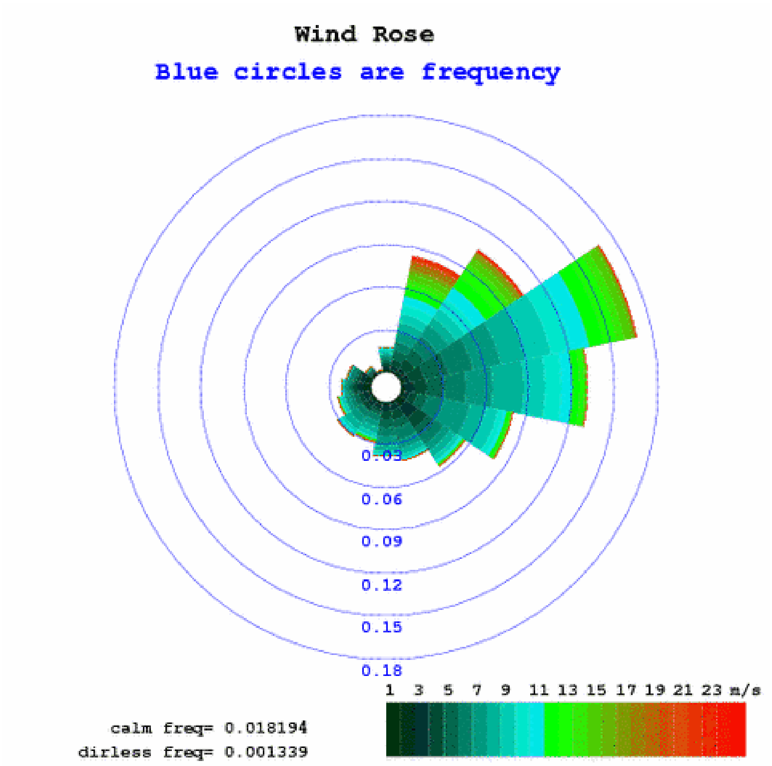


Figure 3.12 Wind roses (annual) at B (top:120m) (bottom:450m)

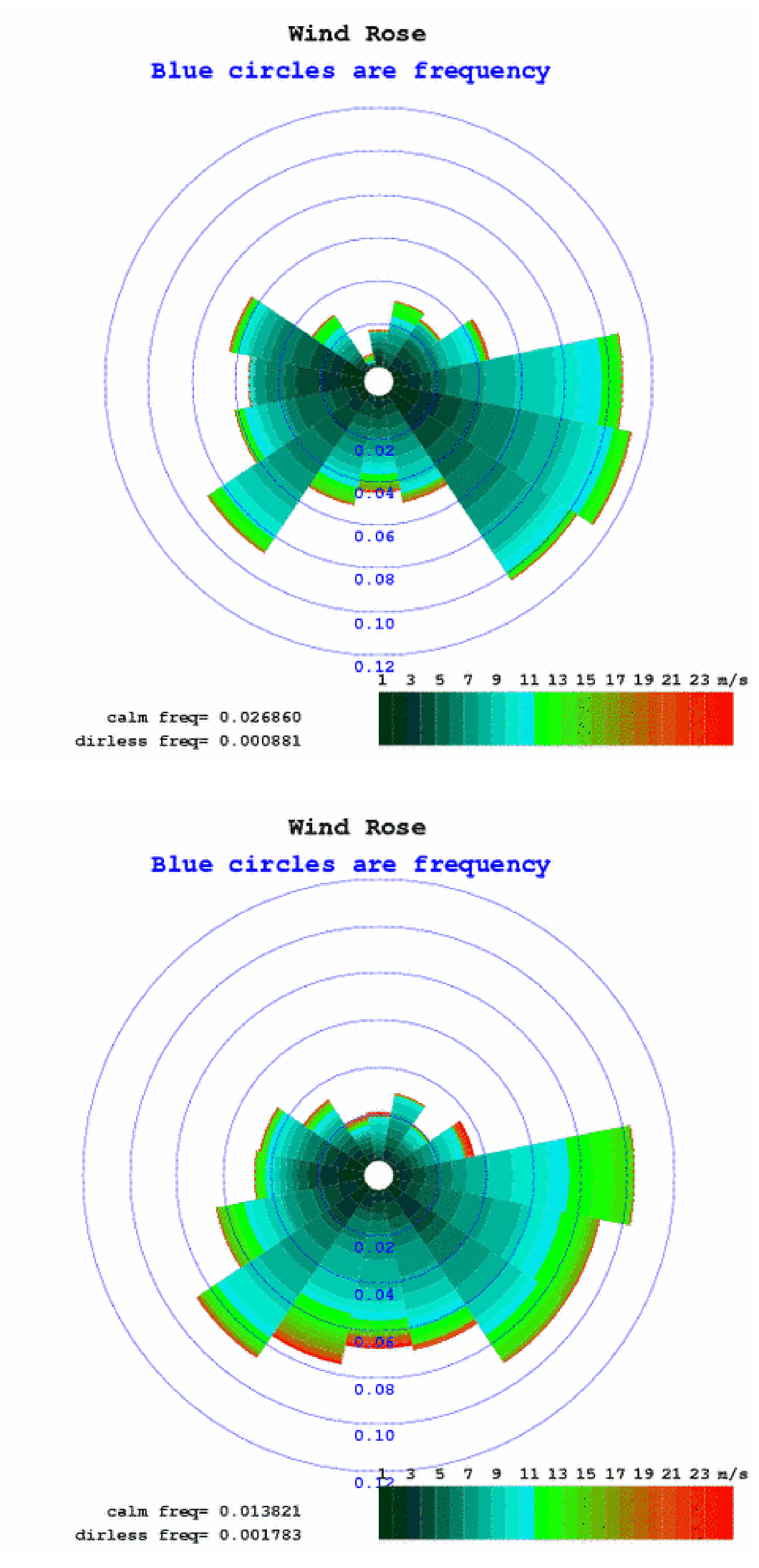
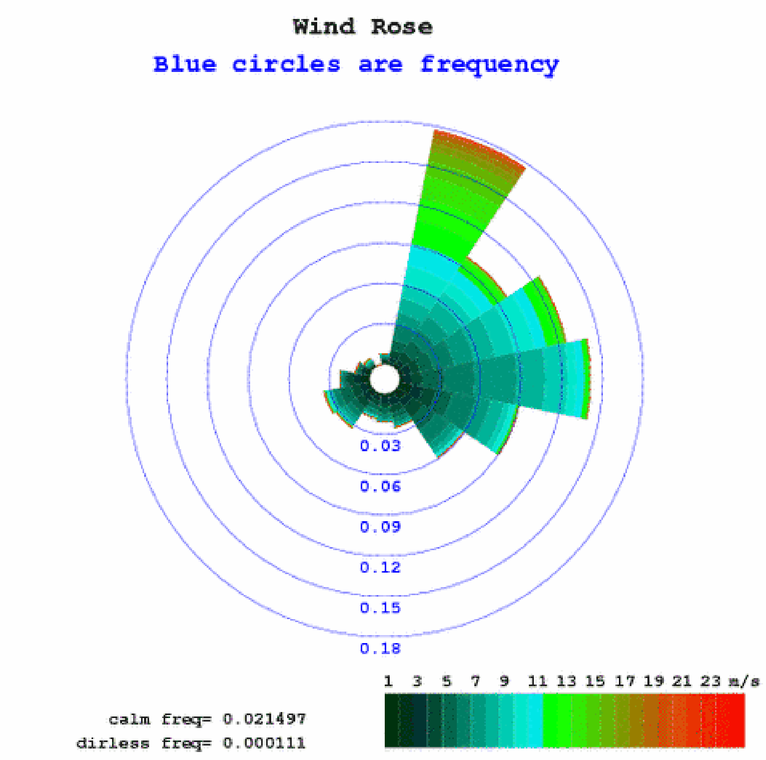


Figure 3.13 Wind roses (summer) at B (top:120m) (bottom:450m)



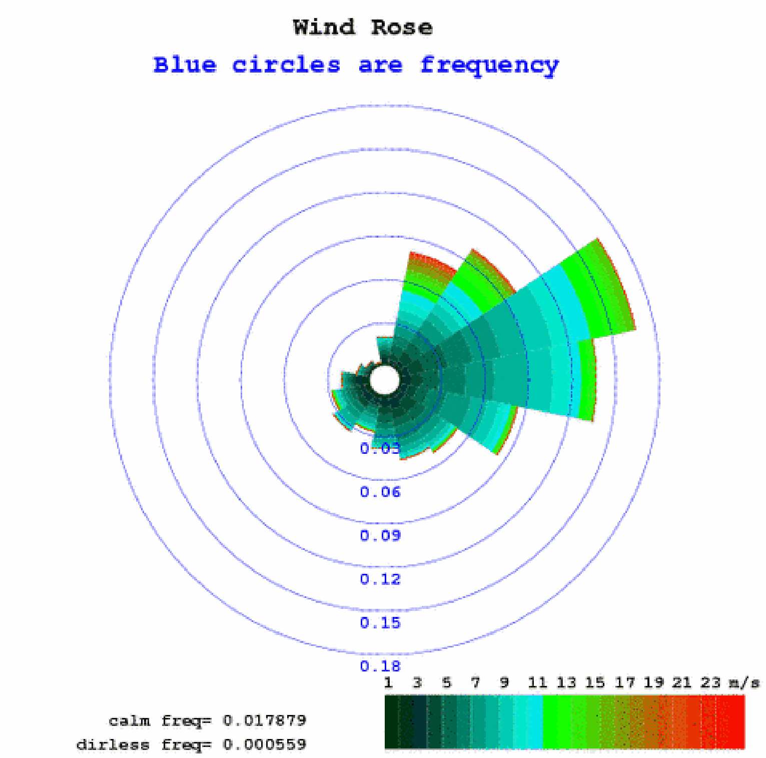
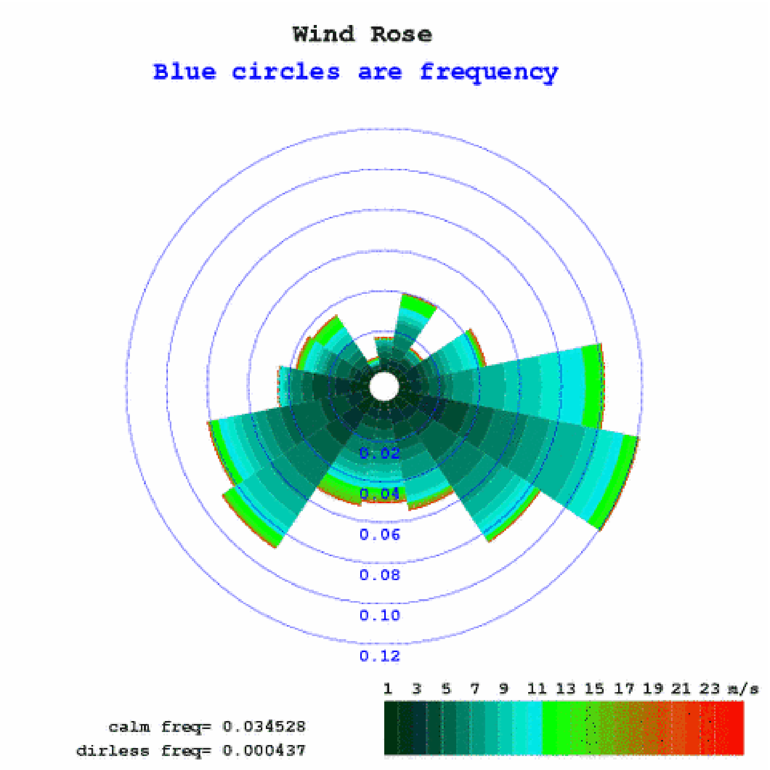


Figure 3.14 Wind roses (annual) at C (top:120m) (bottom:450m)



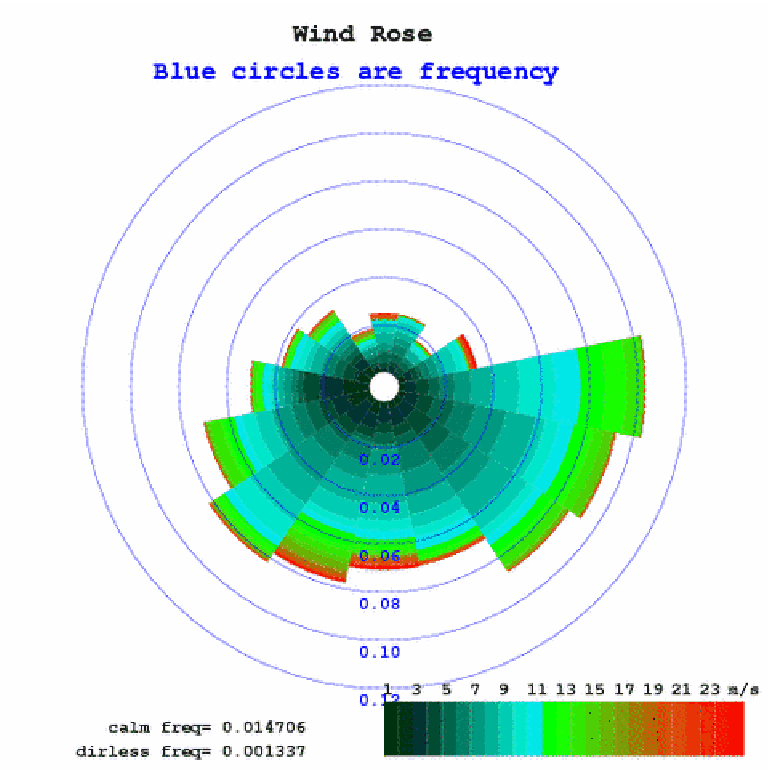


Figure 3.15 Wind roses (summer) at C (top:120m) (bottom:450m)

3.6 Using the simulated MM5 data, the summer and the annual prevailing wind directions of the study area and the surroundings can be summarized and are indicated in Figure 3.16 and 3.17.

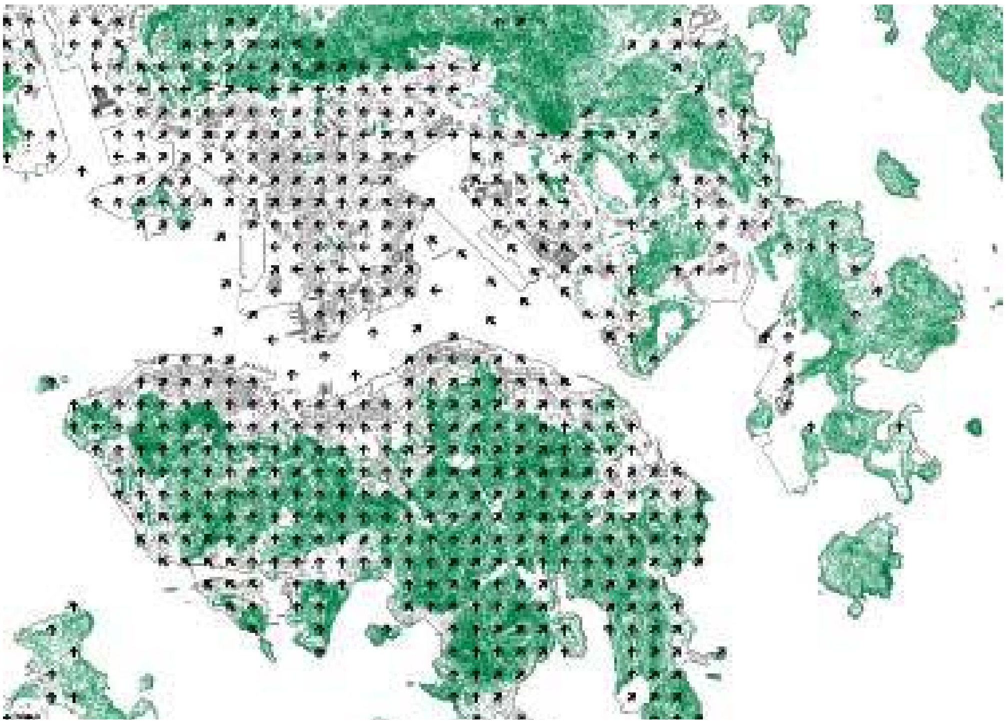


Figure 3.16 Prevailing wind directions of the summer months (Jun-Aug) based on MM5.

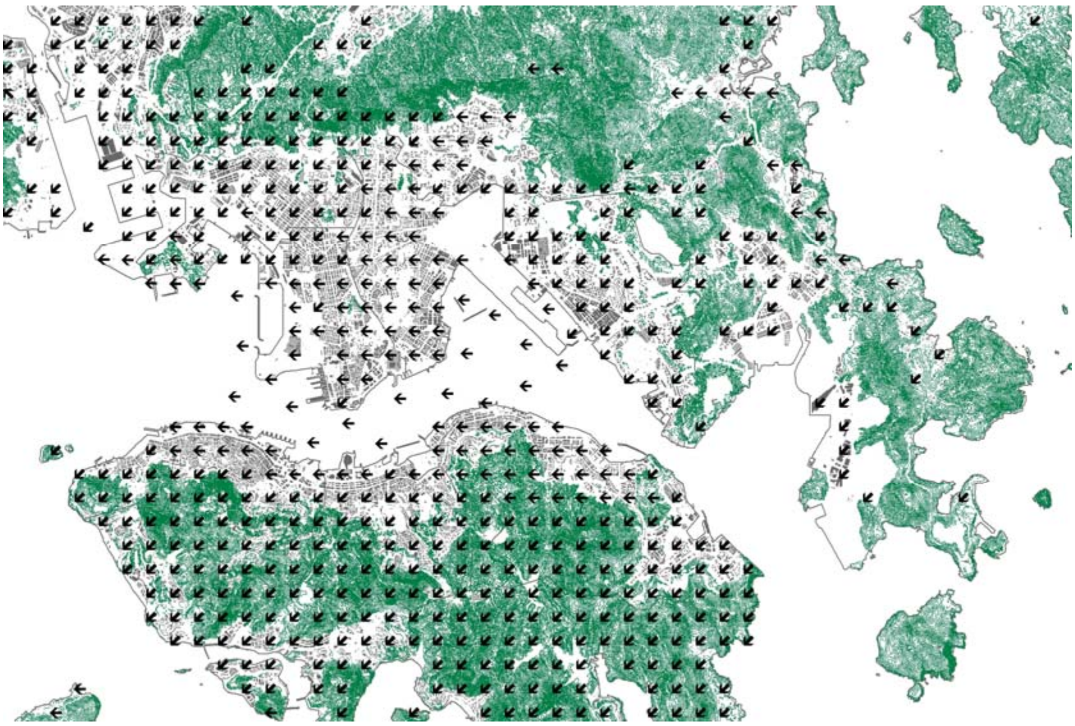


Figure 3.17 Prevailing wind directions (annual) based on MM5

3.7 In summary, based on the available wind data, one may conclude that the annual prevailing wind of the study area is mainly from the East and North-East. The summer prevailing wind is mainly coming from the East and the Southerly quarters (Figure 3.18).

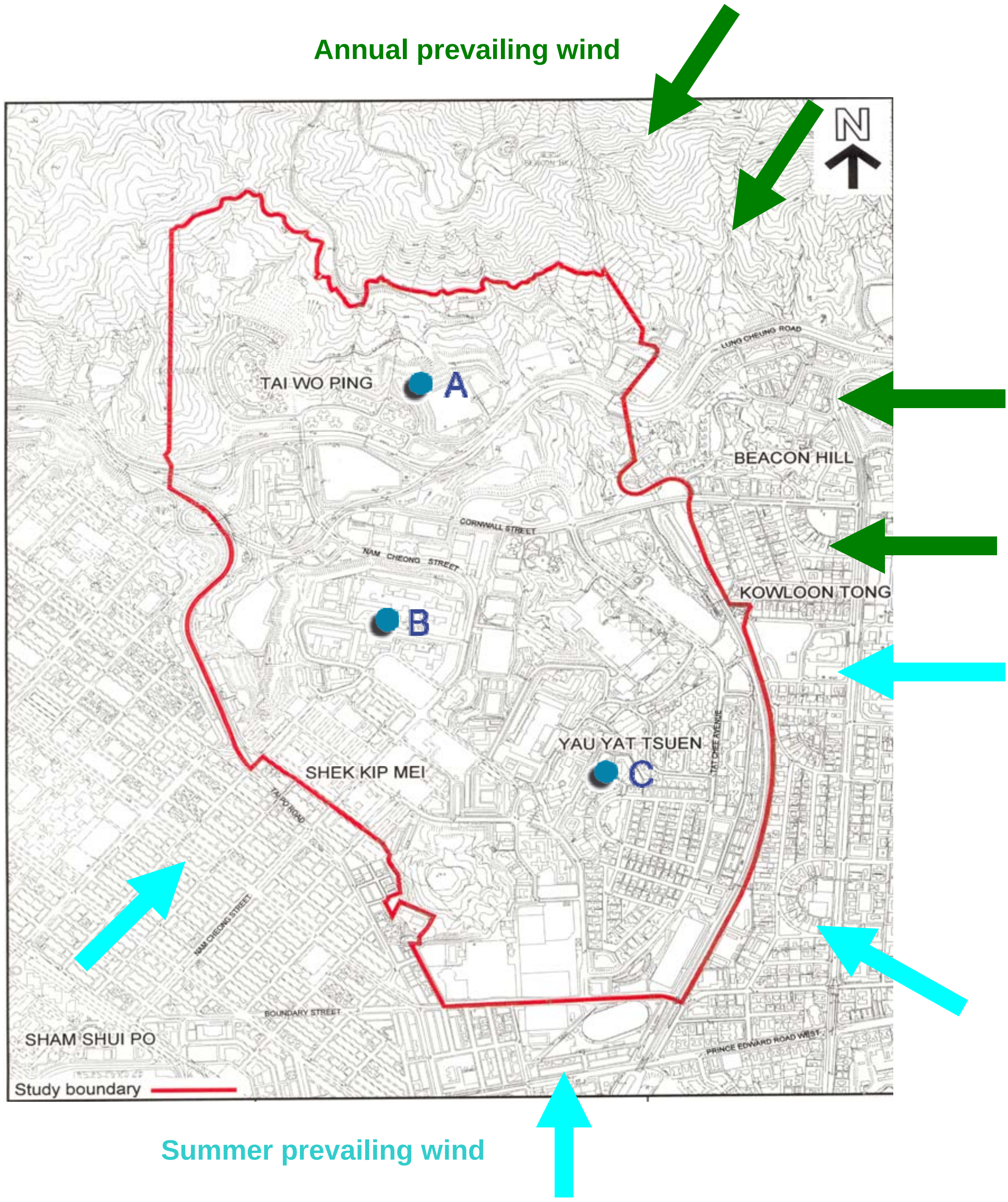


Figure 3.18 A summary of the prevailing winds of the study area

4.0 Topography and the Wind Environment

Figure 4.1 A digital elevation map of the study area

4.1 The study area slopes towards the north from around 5 mPD to about 200 mPD. A hill range of around 400 mPD borders its northern boundary.

4.2 For wind coming from the north and north east, the wind profiles and characteristics will be affected by the hills. Turbulence and re-circulation of wind when it moves downhill towards the study area is expected (Figure 4.2). In general, the northerly winds arriving at the study area will be slowed and weakened by the shielding effects of the hills.

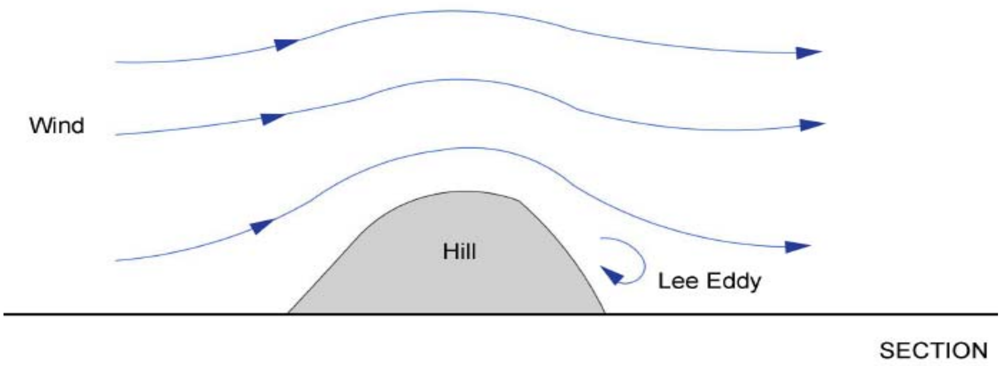


Figure 4.2 An example of wind flow across hills under moderate wind.

4.3 The 3 dimensional flow patterns of wind crossing the hills can be very complicated depending on a number of factors, e.g. the speed of the incoming wind [Appendix A]. In moderate wind conditions, it is predicted that a lee-wave will be generated, a number of eddies will form, and some re-circulation will be expected. To fully understand the wind characteristics to the study area from the hill ranges to its east and northerly directions will require a detail topographical study using wind tunnel. A more precise wind profiles and turbulence intensity profiles can then be better understood,

4.4 Based on the Digital Elevation Map in Figure 4.1, there is an increase of the ground level from the south towards the north of about 100m (from 5 to 100 mPD) over a distance of some 2 Km. The ground rises gently northwards until Cornwall Street, then it goes steeper. For the purpose of air ventilation assessment, when wind is from the south to the north, the compression of air volume due to the sloping ground is insignificant. One could assume that the ground is reasonably flat when air paths of the study area are later assessed. There are two small hills of around 80 mPD in the study area. Areas to its wakes can have marginally weaker air ventilation, but on the whole the hills are small and isolated and air ventilation can find ways to pass around it.

4.5 Notwithstanding Sections 4.2 and 4.3 above, for the purpose of air ventilation, the summer winds from the southerly quarters over the flat urban terrain are more important to consider. They are important for the area's summer air ventilation.

5.0 The Existing Scenario

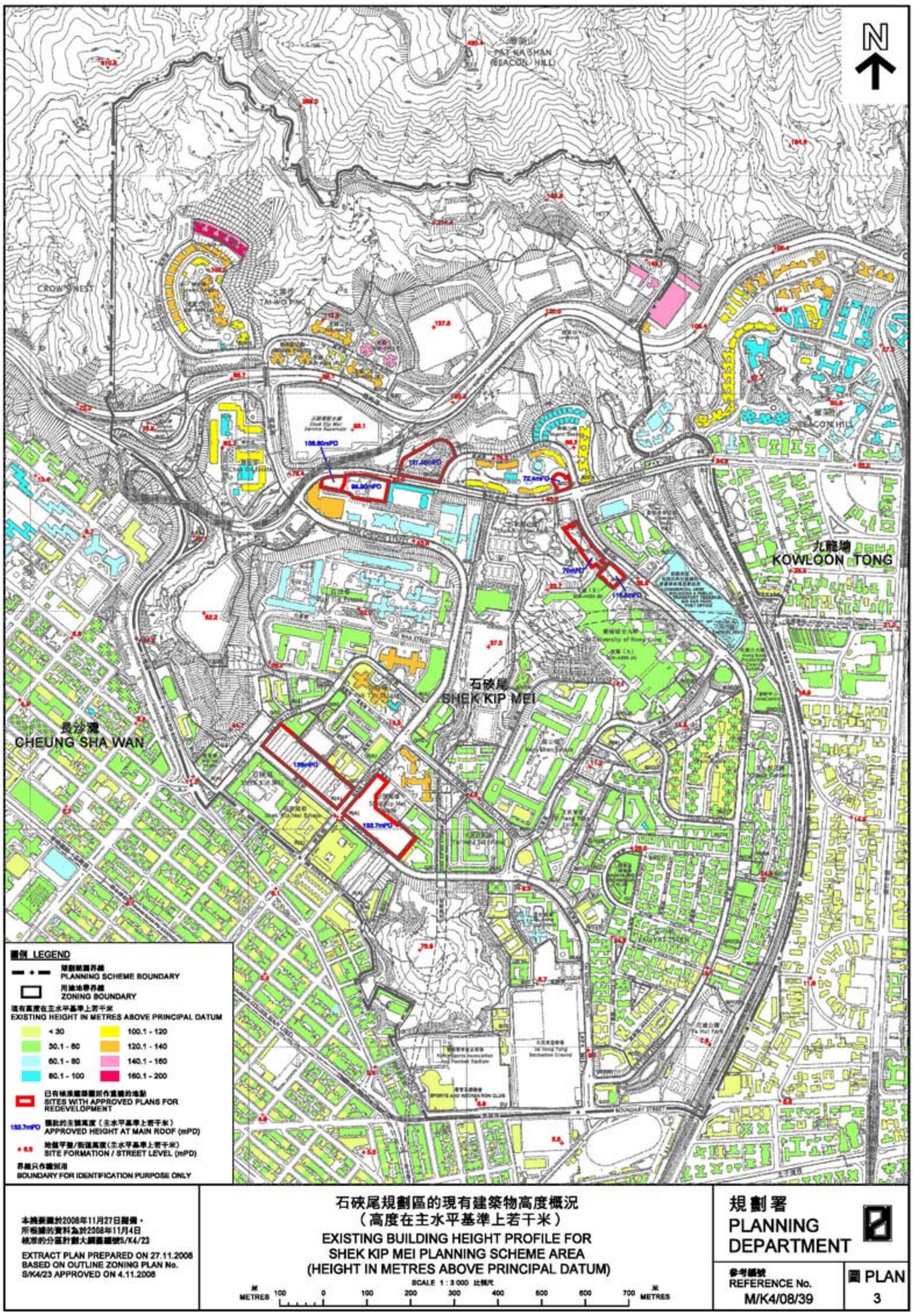


Figure 5.1 The existing condition of the study area

5.1 Greenery, Open Spaces and Landscaping

5.1.1 Based on an examination of a satellite image of the study area, it has, relatively speaking compared to some metro areas in Hong Kong, a large green coverage. The understanding has been evaluated by researchers at CUHK as shown in Figure 5.2. Vegetated areas are also well distributed but currently not linked. Linking them with designated air ventilation corridors is a useful air ventilation consideration.

Figure 5.2 A greenery map of the study area.

5.2 Land Use and Urban Morphology

5.2.1 Refer to 5.1 above, due to the fact that the greenery coverage of the study area is large; the corresponding ground coverage (as shown in Figure 5.3) is low.

5.2.2 High ground coverage reduces urban porosity at the pedestrian level and thus reduces the potentials of air ventilation. Researchers at CUHK have resolved a set of understanding on ground coverage for Hong Kong. A relevant area as is shown in Figure 5.3. Based on Figure 5.3, location A has respective array of high ground coverage cells. Isolated cells of high ground coverage (RED) are normally not a cause of concern.

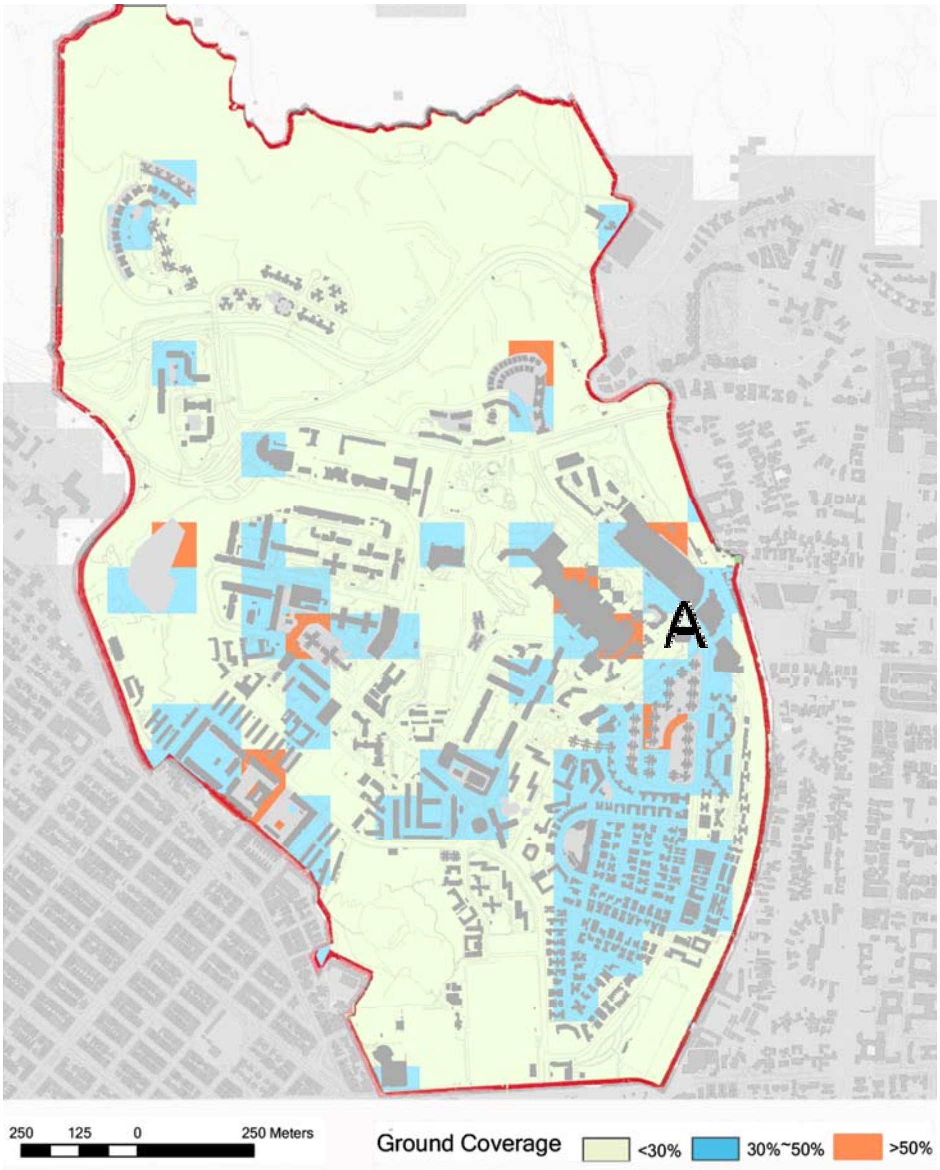


Figure 5.3 Ground Coverage Ratio map of the study area resolved to 100mx100m cell area (include roads, open spaces and ground area covered by buildings and podiums) [Ground cover ratio is the % of the ground occupied by buildings. The maximum is 100% for a 100mx100m grid fully occupied by buildings.]

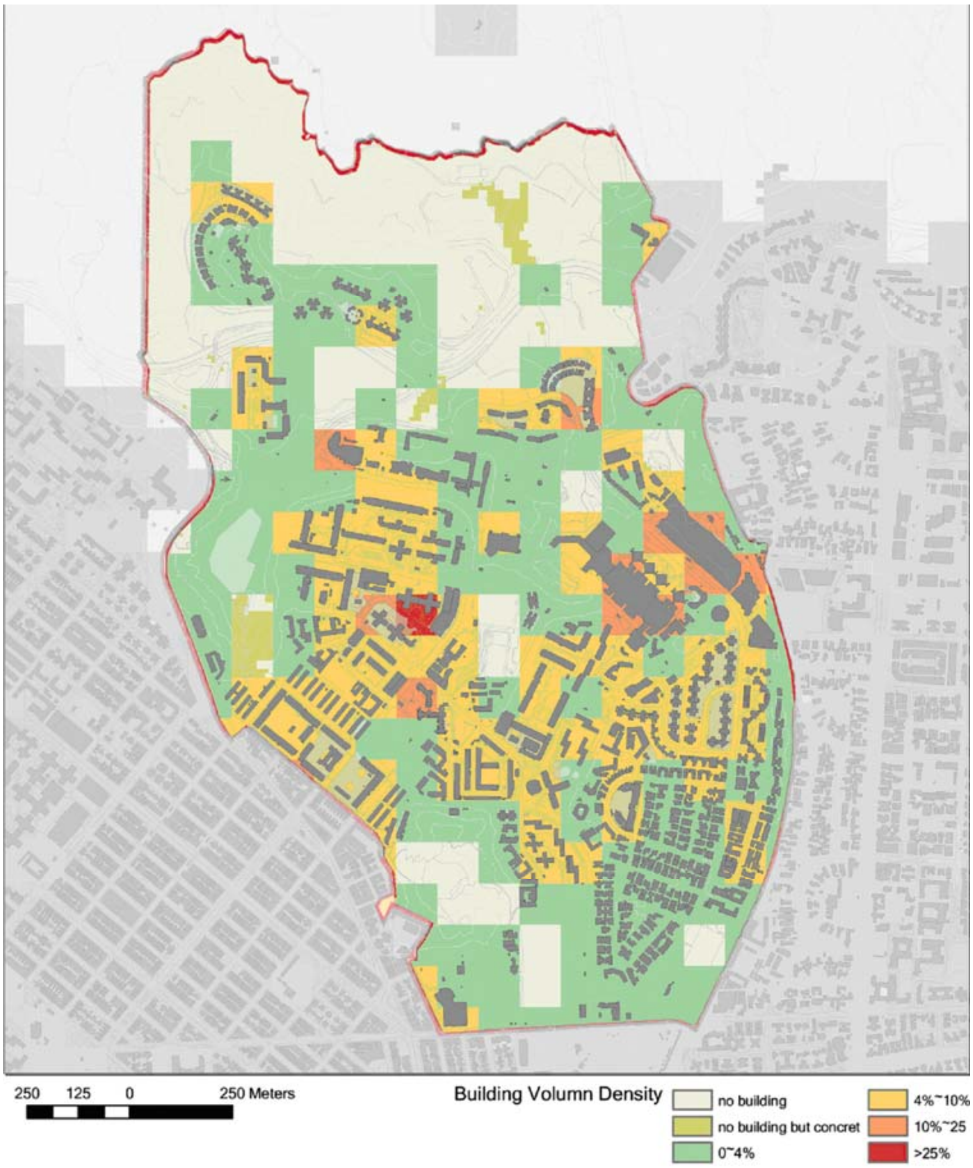


Figure 5.4 Building Volume Ratio map of the study area resolved to 100mx100m cell. [Building Volume Ratio is the ratio between the cubic volume of buildings in a 100mx100m grid and the maximum building volume in Hong Kong – currently 1.2 million m^3.]

5.2.3 High building volume increases the thermal capability and reduces urban Sky View Factor (SVF), which reduces long wave radiation back to the sky causing urban heat island. This creates higher thermal stress in the summer months and the need for air ventilation to mitigate the negative thermal effects. Researchers at CUHK have resolved a set of understanding on building volume for Hong Kong. A relevant area is as shown in Figure 5.4. On the whole the building volume density of the study area is not high. [For a building that occupies the entire 100m x 100m site, with a plot ratio of say 5, the Building Volume Density (BVD) of the site will be about 13% or 150,000m^3]. Properly and strategically located air paths (as will be described later in this report) should be able to address some of the urban thermal comfort concerns in the summer months.

5.2.4 Summarizing the analysis of Building Volume Density and the Ground Coverage Ratio of the study area as shown in Figure 5.3 and 5.4, it can be noted that there are clusters of building bulks, but they are mostly isolated and not extensive.

5.2.5 In general, building heights of existing buildings are not tall (Figure 5.1). Wind wakes are minor issues if at all.

5.2.6 The public housing estate cluster west of Shek Kip Mei Park has taller buildings of about 100m tall. Currently they are well spaced isolated towers standing on open ground. Wind wakes are minor issues if at all.

5.3 Air Paths

5.3.1 Based on an understanding of building bulks in section 5.2, and the greenery areas in section 5.1, the air paths of the study area can be evaluated (Figure 5.5).

5.3.2 Currently, neighbouring buildings that border the study area's south west are not tall. The south westerly wind can pass over them and reach the study area. In addition, there are a number of roads leading into the study area. Wider streets like Nam Cheong Street and Yen Chow Street are useful air paths. These air paths (orange colour in Figure 5.5) lead to the study area, pass aligned building gaps and open spaces, and enter the heart of the study area. Maintaining and improving the efficacy of these air paths is important for Shek Kip Mei Estate, Pak Tin Estate, and so on.

5.3.3 Nam Cheong Street in particular leads from the study area's south-west boundary into the football field, Shek Kip Mei Sport Centre and Shek Kip Mei Park. To maintain or improve this air paths, it is important to bear section 5.3.2 above in mind when the neighbouring OZP is assessed. Care should be taken to ensure that Nam Cheong Street's role as an air path is retained.

5.3.4 Building heights east of the study area are low; hence air ventilation can pass over the buildings and enter the study area (indicted by the two thick blue arrows in Figure 5.5). The concept of air path may not apply. Currently, air ventilation can pass over buildings and reach Shek Kip Mei Estate and Pak Tin Estate easily.

5.3.5 A north-south green corridor runs through the study area. From Police Sports Association and Football Stadium, the small hill north of it, Tai Hang Sai Estate, The GIC site north of it, the football field, Shek Kip Mei Park, and so on. Currently there are already built up areas along its path (the back arrows and the two circled built up areas as in Figure 5.5). Its efficacy has been slightly impaired.

Figure 5.5 Air paths of the study area

5.4 Committed Developments

5.4.1 There are a few scattered committed developments in the study area. The two areas on Woh Chai Street are along the south-westerly air paths. Towers on Shek Kip Mei Estate 5 are well aligned and spaced. However, a tower on Phase 2 is directly in front of an air path. Fortunately, there are buildings of lower heights both sides of it.

6.0 Expert Evaluation of the Initial Planned Scenario

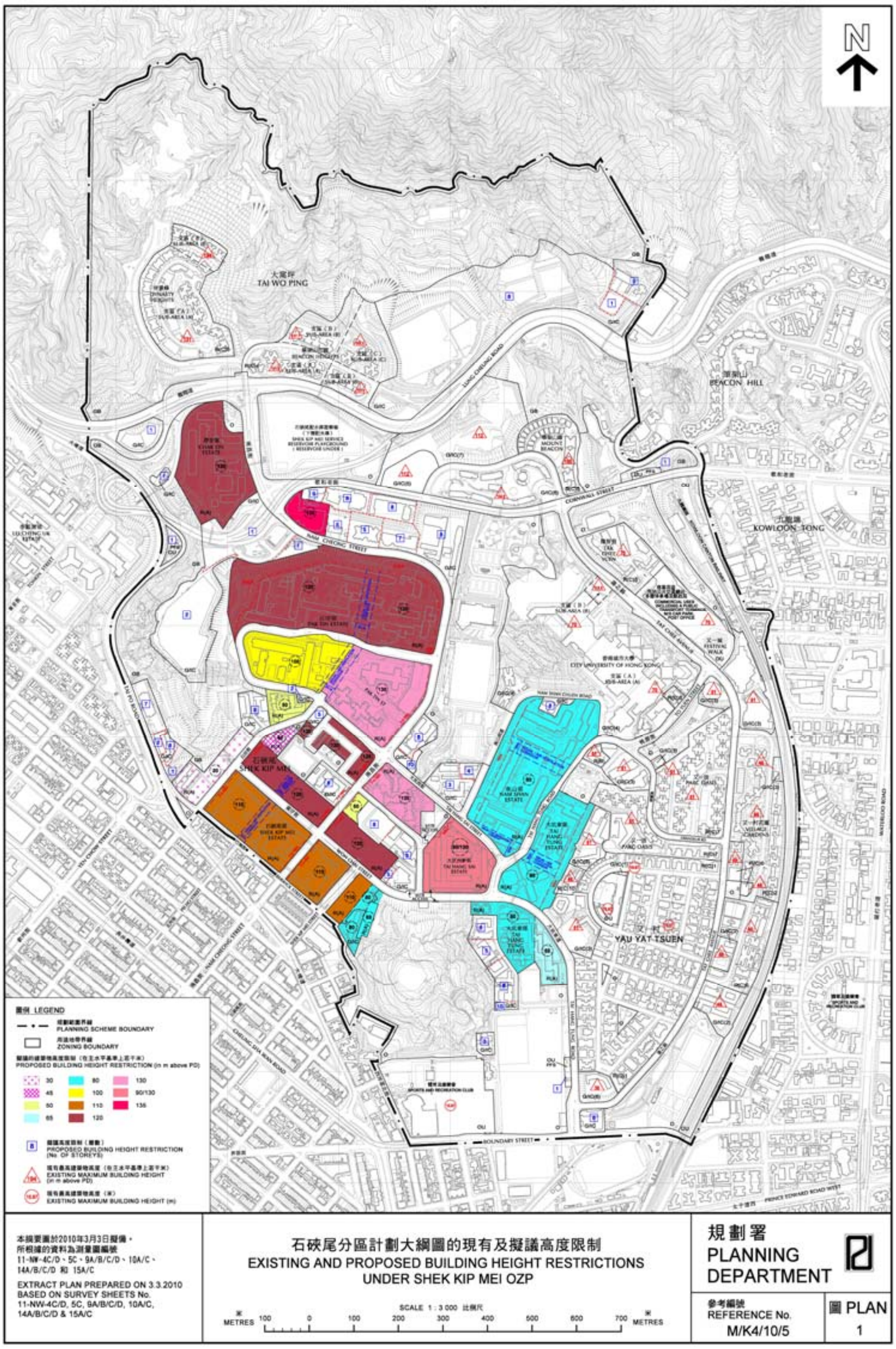


Figure 6.1 The initial planned scenario

6.1 Building heights of the Public Housing Estate cluster east of Shek Kip Mei Park has been restricted to 80 mPD. This translates to building heights of 60-70m tall. Two air ventilation corridors at 30m wide have been proposed for Nam Shan Estate/Tai Hang Tung Estate to ensure that the easterly air paths are not unduly blocked. The positions of the proposed air ventilation corridors are appropriate. The air corridor across the northern part of Nam Shan Estate aims to connect green open spaces in both east and west so as to facilitate the easterly wind to reach the central part of the study area. The air corridor across the southern parts of Nam Shan Estate and Tai Hang Tung Estate seeks to widen the Tai Hang Sai Street air path and penetrate through Tai Hang Tung Estate. Housing Department should take note of the air paths and the proposed air ventilation corridors and other air ventilation requirements in the design and disposition of buildings when planning and redeveloping these sites. Ventilation corridors should preferably be designated as NBAs, where no building structure should be allowed in the NBA. Practically, small single storey buildings could be permitted if warranted.

6.2 To further improve air ventilation to the GIC site which is on the impaired north-south corridor as shown in Figure 5.5, it is recommended that buildings in Nam Shan Estate along Nam Shan Chuen Road [as shown – orange arrow – in Figure 6.2] are well spaced to reduce the wake areas of tall towers along the site boundary when wind comes from the east, and the design of the Estate is such that air can pass between the buildings – section 7.1 of this report referred. The proposed NBA at Nam Shan Estate western boundary, consisting of an existing slope and a multi-storey car park, together with Nam Shan Chuen Road and its adjacent low-rise GIC and Shek Kip Mei Park, collectively serve as an existing north-south air corridor facilitating the summer southwesterly wind over the rooftop of the low-rise Tai Hang Sai Estate into the wider area. The slope area (including the carpark portion) should remain as an NBA for ventilation purpose. Since the slope area is below the level of Nam Shan Chuen Road, consideration could be given within the NBA to allow developments not higher than the existing road level so as to facilitate wind flow above the rooftops. Also, the NBA at Tai Hang Tung Estate, currently serving as air path for the area, should be maintained to continue its ventilation function.

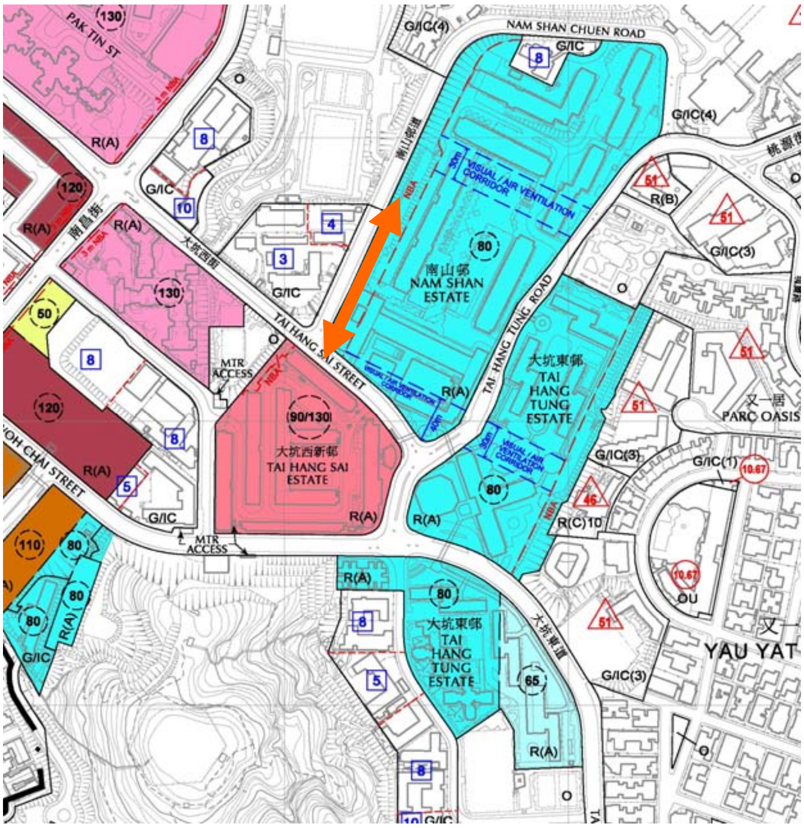


Figure 6.2 The initial planned scenario – Public Housing Estate cluster east of Shek Kip Mei Park

6.3 As shown in Figure 6.3, NBAs have been proposed in the initially planned scenario for sites along sections of Nam Cheong Street (3m until Pak Wan Street and various width along the existing slope area of Pak Tin Estate), Pak Tin Street (5m), Nam Shan Chuen Road (up to 20m along the existing slope area of western boundary of Nam Shan Estate) and in other large sites such as Tai Hang Tung Estate (up to 20m along the eastern boundary slope area). Nam Cheong Street is a useful air path. Given that there would be taller buildings upon re-development, the width of NBA on either side of Nam Cheong Street should preferably be in the order of 5m or wider to maintain a H/W ratio of no more than 3 for parallel air flow. A 3m NBA currently proposed along Nam Cheong Street is already a compromise taking into account various practical considerations such existing developments; it is still acceptable. For Pak Tin Street, a 5m NBA is proposed on the only one side because the other side has already lower building limits of 30-50mPD on a hill. Together they maintain the usefulness of the air paths leading into the study area. It may be optionally considered that the area of the orange arrow (Figure 6.3) be designated as NBA to maximize the east west air path. The width of this NBA is suggested to be the same width as Pak Wan Street east of it. No building structure should be allowed on NBA. Practically, small single storey buildings could be permitted if warranted.

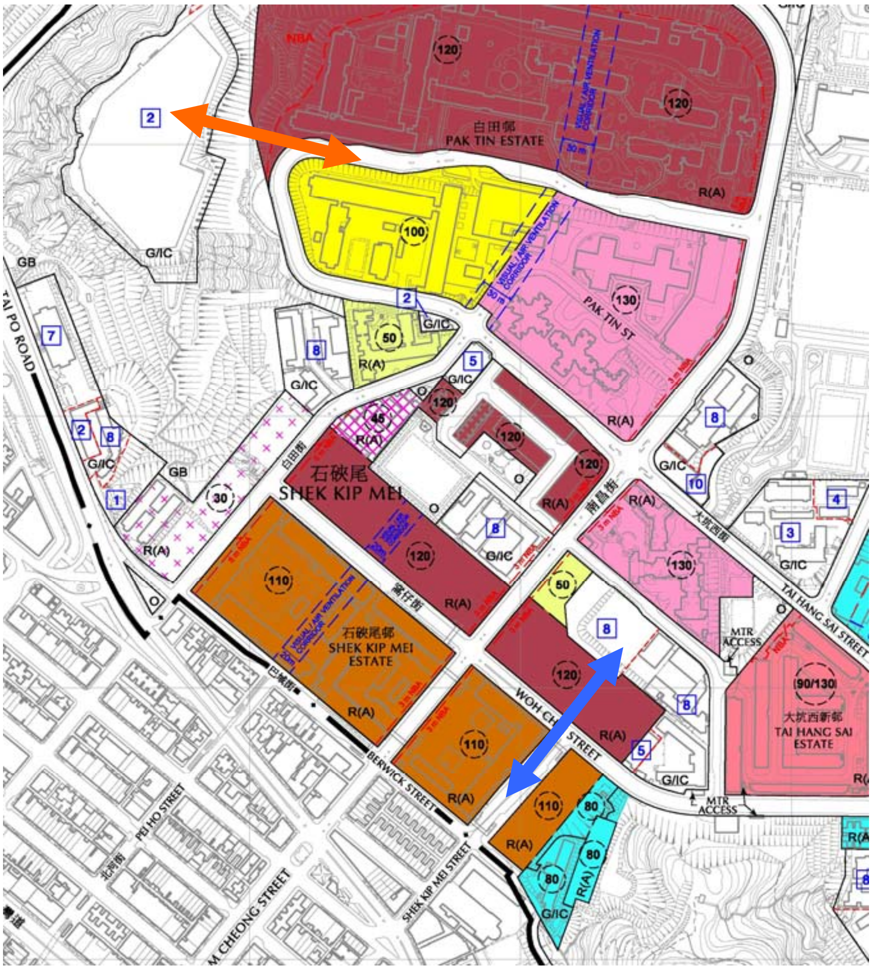


Figure 6.3 The initial planned scenario – Public Housing Estate cluster west of Shek Kip Mei Park

6.4 Two air ventilation corridors at 30m and 20m have been proposed in Pak Tin Estate and Shek Kip Mei Estate respectively. They help extend the existing Pak Tin Street and Pei Ho Street air paths northward. On the same token, no building structure should be allowed on these two air ventilation corridors. Practically, small single storey buildings could be permitted if warranted.

6.5 To extend the Shek Kip Mei Street air path, it is recommended that a NBA be positioned as shown [blue arrow] in Figure 6.3. The width of this NBA be the same as the width of open strip of space north-east of Shek Kip Mei Street. In view of advanced stage of Shek Kip Mei Estate Redevelopment Phase 2, it is understood that this recommended NBA could not be incorporated into the redevelopment. However, this should be a long term aim of the site should the site be later re-developed again for the purpose of maintaining proper air ventilation in the area.

6.6 A strip of NBA has been proposed at the north-west corner of Tai Hang Sai Estate. This is useful to align it with the GIC sites, the open space and Nam Shan Chuen Road (Fig. 6.4).

6.7 For Tai Hang Sai Estate, it is desirable to consider restricting the building heights to its existing level in consideration of the north-south air corridor as shown in Figure 5.5. Should that be not feasible, it is suggested that the north-south air corridor be partially maintained by designating a NBA as indicated by the areas between two dotted red lines in Figure 6.4. Fail that, a strip of slightly bended NBA along its west boundary to better connect Nam Shan Chuen Road and the hill south of Tai Hang Sai Estate (orange line in Figure 6.4) is still acceptable. Two different plans of NBA were firstly proposed by Planning Department in Appendix B and the bended one performs better as it connects directly to Nam Shan Chuen Road. A set back of 25m is recommended. A setback of 25m is recommended taking into account the width of Tai Hang Sai Estate, which is in the order of 80m to 130m. A permeability of 20% - 33% is considered a reasonable range [*]. The NBA of 25m, together with an array of GIC sites with low buildings and open space can partially maintain the air corridor for the summer south and south-westerly winds. This strip of NBA should ideally be landscaped with tree planting. In future, when Tai Hang Sai Estate is re-developed, it is suggested that the designer can optimize the north-south air corridor (as in Figure 5.5) with appropriate building layout and permeability within the site. It is further recommended that AVA studies be conducted to optimize the design. Also the designer should make reference to Chapter 11 of HKPSG on recommended urban design guidelines for air ventilation which cover podium design among other site level considerations. Site coverage of the podia should be reduced to allow more open space at grade. Besides, adequately wide gaps should be provided between building blocks to maximize the air permeability of the development and minimize its impact on wind capturing potential of adjacent developments. Two examples of design guidelines are illustrated in Figure 6.5 & 6.6.

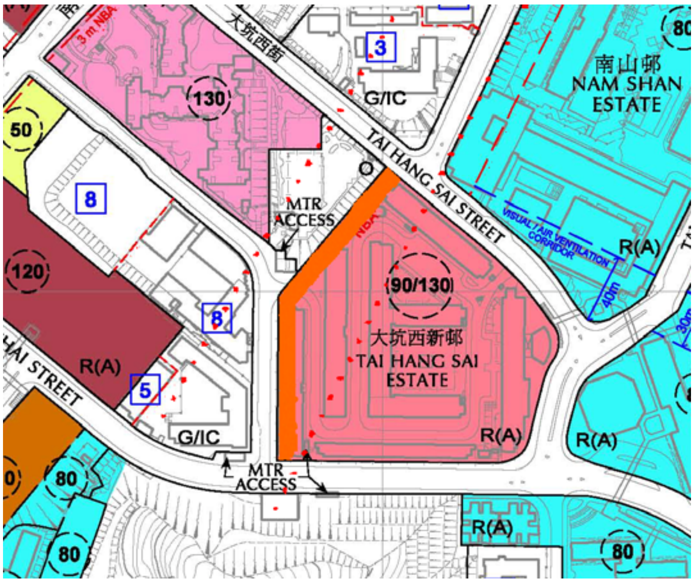


Figure 6.4 The initial planned scenario – Tai Hang Sai Estate

[*] Please refer to the guidelines on required Building Separation Distance, indicated in the section of 5.2.5, of the published "Building Design to Foster a Quality and Sustainable Built Environment" by the Council for Sustainable Development in early 2009. In the guideline, it is proposed that for site areas greater than two hectares or with continuous building width of greater than 60 meters, an intervening space equivalent to 20% - 33% of the total frontage area of the building or buildings would be required.

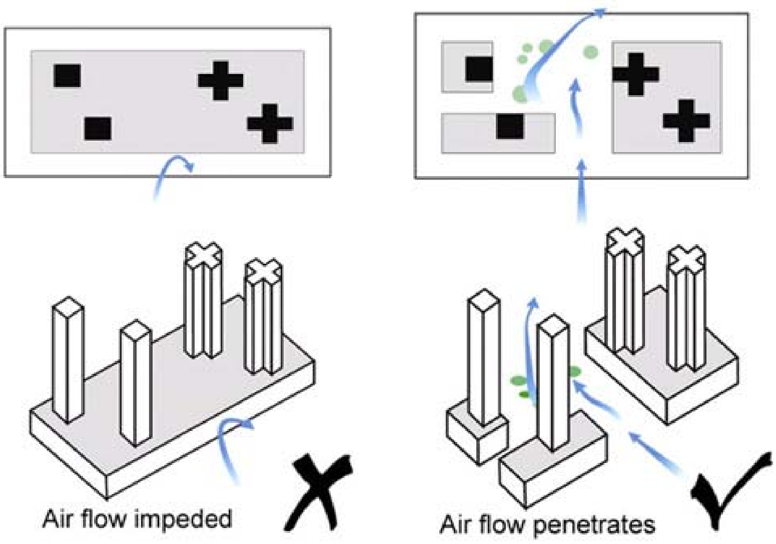


Figure 6.5 Guideline on podium design for better air ventilation

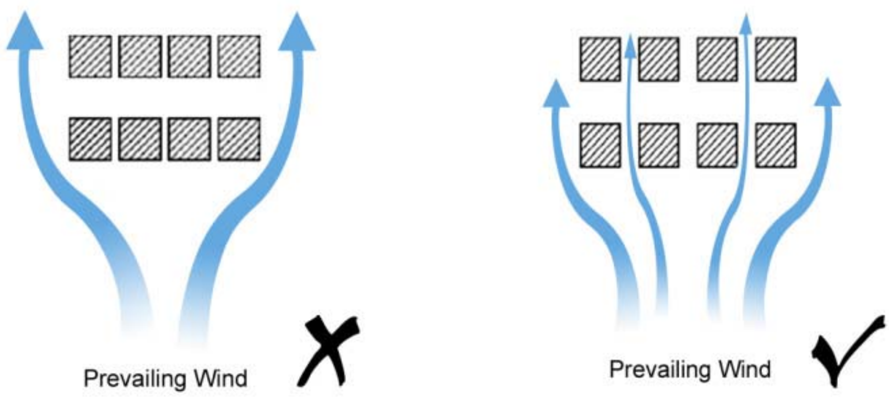


Figure 6.6 Guideline on building disposition for better air ventilation

6.8 There is a 2-tier building height profile for Tai Hang Sai Estate redevelopment, with a 130mPD height band for the west and a 90mPD height band for the east within the site. This creates a stepped building height profiles that can benefit the turbulent mixing and the vertical transport and diffusion of air. This may marginally improve ground air ventilation. However, given the already high building morphology of the site, NBA is more useful for air ventilation at the ground level. The NBA as proposed in section 6.7 should be followed. A strip of slightly bended NBA along its west boundary to better connect Nam Shan Chuen Road and the hill south of Tai Hang Sai Estate (orange line in Figure 6.4) is still acceptable. When the re-development finally takes place eventually, AVA studies should be conducted for Tai Hang Sai Estate redevelopment to ensure good ventilation to its neighbours.

6.9 It is anticipated that Housing Department will conduct AVA studies within Shek Kip Mei Estate and Pak Tin Estate, to ensure that buildings are well designed.

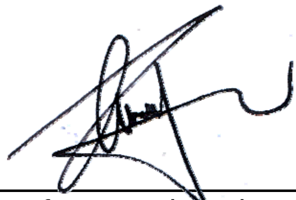
6.10 All in all, except the need to incorporate the appropriate NBA in Tai Hang Sai Estate, the proposed air ventilation corridors and building set backs of the Initial Planned Scenario in forms of NBA should be able to provide optimum air ventilation passages through the study area given the building height restrictions.

7.0 Focus Areas and Further Studies

7.1 There are many Housing Department housing estates in the study area. Apart from observing paragraph 6.9 of this report, it is recommended AVA studies be carried out when these housing estates are re-developed in the future, so that air ventilation within their site boundaries are optimized.

7.2 NBA as discussed in paragraph 6.7 & 6.8 in the report is important for Tai Hang Sai Estate. This should be incorporated and evaluated.

7.3 Subject to paragraph 7.2 being respected, the study area, given the proposed building height restrictions and NBA, should have no major air ventilation issues. Further AVA studies are not needed.



Date: 9 March 2010

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On behalf of technical experts in the term consultant term

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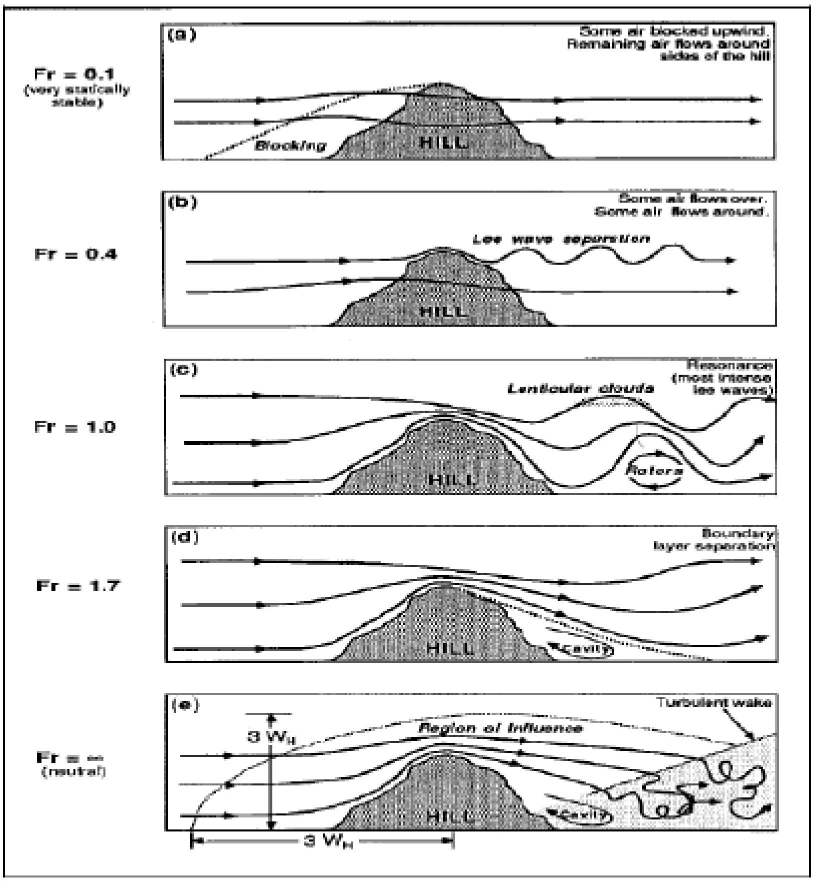
Appendix A: Wind over a hill.



For a strongly stable environments, i.e. where the buoyancy affects are strong, and Fr ≈ 1, the air flows around the hill ((a)) and a stagnant mass of air builds up before the hill. **At a slightly faster wind** (Fr ≈ 0.4) some of the air flows over the hill ((b)) while the air at lower altitudes separate to flow around the hill. The natural wavelength of the air that flows over the top is much smaller than the hill size and the flow is perturbed by the hill to form lee waves. A lee wave separation occurs from the top and flows above the air that flows around the hill. A column of air with the same height as the hill approaches the hill and a fraction of it flows above the hill. **At higher wind speeds** and Fr ≈ 1.0, the stability is weaker and the wavelength of the gravity waves (lee waves) approaches the size of the hill ((c)). A natural resonance forms the large amplitude lee waves or mountain waves. If there is sufficient moisture, lenticular clouds can form along the crests of the waves downstream of the hill. **For stronger winds** with Fr ≈ 1.7 ((d)) the natural wavelength is longer than the hill dimensions, thus causing a boundary layer separation at the lee of the hill. **Neutral stratification** ((e)) occurs for strong winds with neutral stability (no convection) and Froude number approaching infinity. The streamlines are disturbed upwind and above the hill out to a distance of about 3 times the hill length WH. Near the top of the hill the streamlines are packed closer together, causing a speed-up of the wind. Immediately downwind of the hill is often a cavity associated with boundary layer separation. This is the start of a turbulent wake behind the hill. The height of the turbulent wake is initially the same order as the size of the hill and grows in size and diminishes in turbulent intensity downwind. Eventually the turbulence decays and the wind flow returns to its undisturbed state.

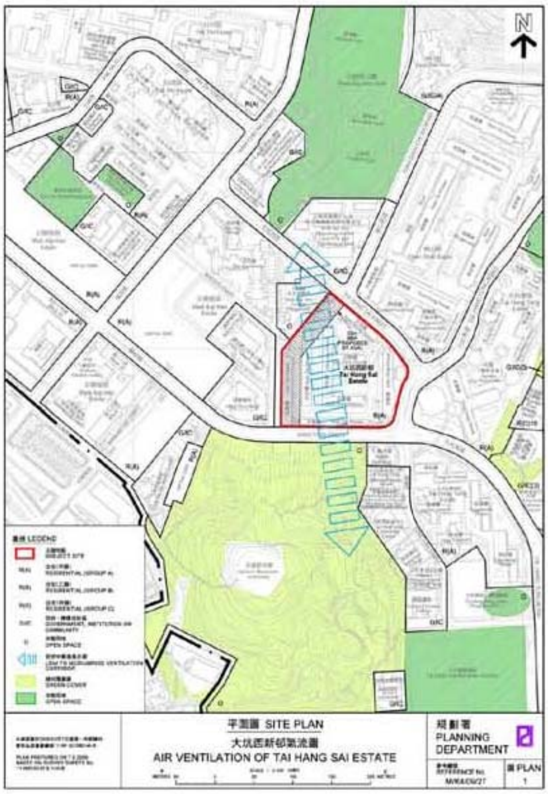
Froude number (Fr)

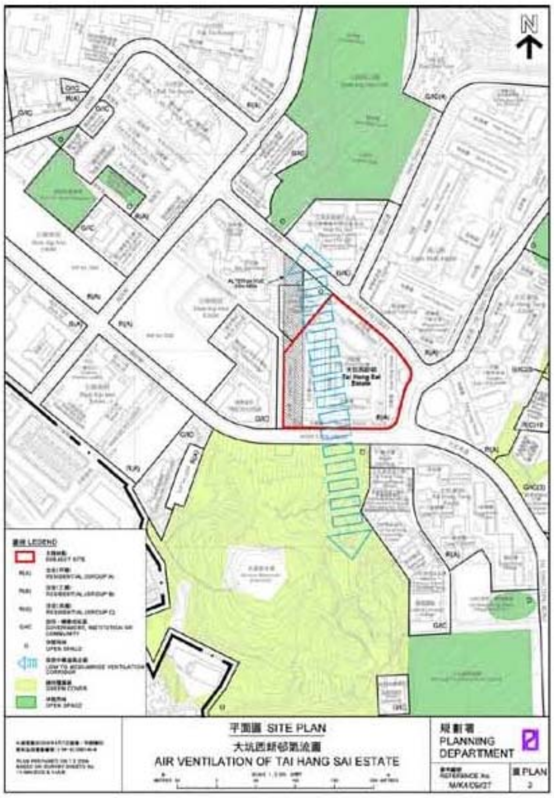
$$F_r^2 = \frac{\text{Inertial forces}}{\text{Bouyant forces}} \qquad F_r^2 = \frac{\overline{u}_0^2/W_h}{g\Delta\theta/\theta_0}$$

The inertial forces (order u_0^2/W_L) act in the horizontal direction along the wind flow, and the buoyant forces (order $g\frac{\Delta\theta}{\theta_0}$ where Δθ is a typical temperature disturbance, g is gravitational acceleration, θ_0 is potential temperature) act in the vertical. The Froude number can be more elaborately defined as

[courtesy Sykes, R.I., 1980, "An asymptotic theory of incompressible turbulent boundary-layer flow over a small hump", J. Fluid Mech.101: 647-670.]1

Appendix B





As per the email of 9th Aug 09, Plan 1 and Plan 2 as suggested by Planning Department are evaluated. It is considered that the NBA of plan 1 would perform better than plan 2 because the air path directly connect to Nam Shan Chuen Road.

It is important to read this seemingly blended NBA together with the GIC and O sites west of Tai Hang Sai Estate.

The buildings on the 2 GIC sites must be as low as possible. Slightly taller buildings are possible on these two GIC sites if they are positioned more along their western boundaries.