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 - Mid Levels West

March 2008

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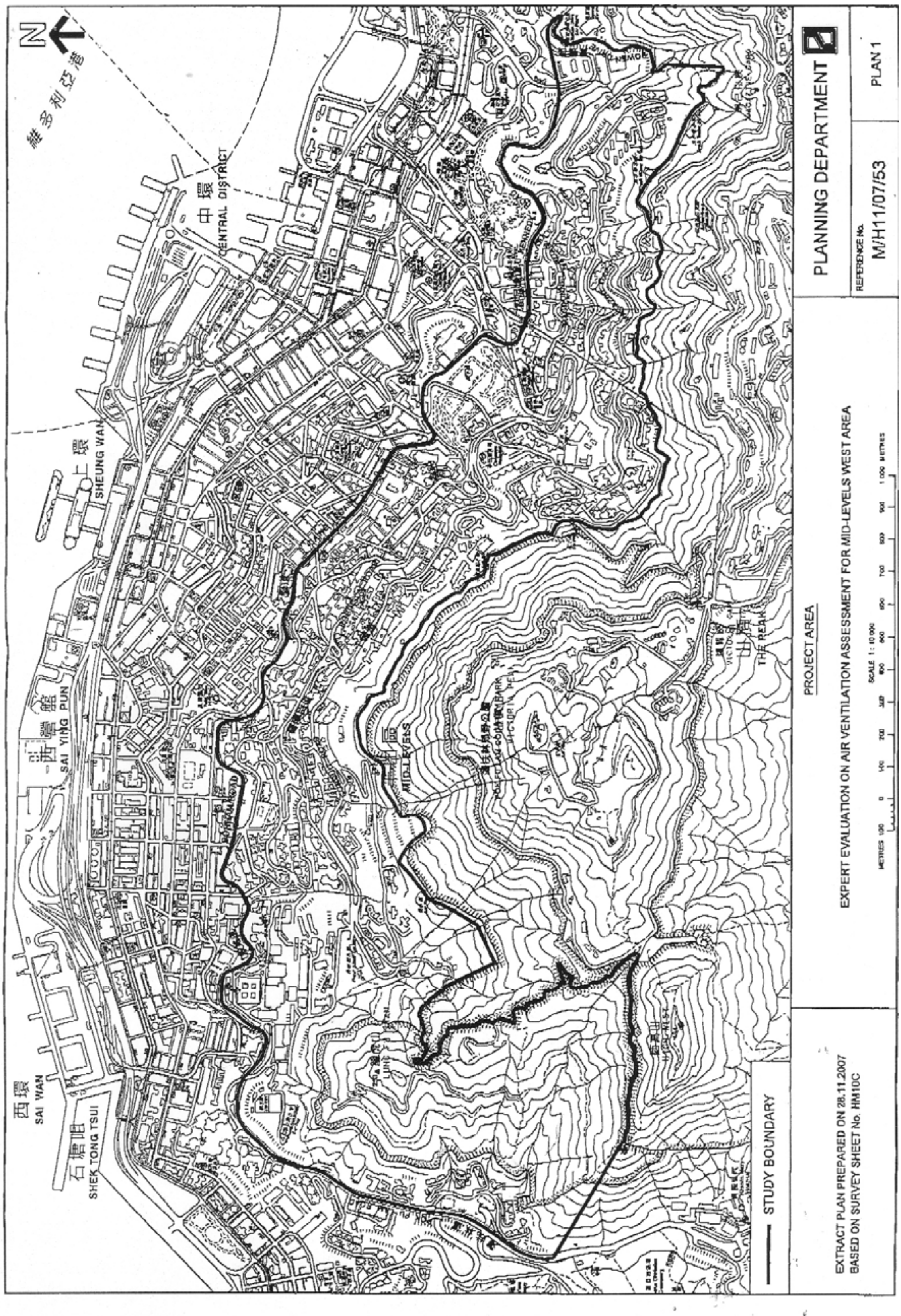
by Professor Edward Ng
Department of Architecture, CUHK, Shatin, NT, Hong Kong
T: 26096515 F:26035267
E: edwardng@cuhk.edu.hk W: www.edwardng.com

The Study Area



Expert Evaluation Report of Mid-Levels West

Executive summary

0.1 Wind Availability:

(a) The prevailing summer wind of the study area comes from the south. The prevailing annual wind of the study area comes from the East and North-East.

(c) The hills south of the study area shield and reduce the air ventilation potentials. They also complicate the wind regime of the study areas when the summer wind comes from the south.

(b) At 500m above ground, it is estimated that the site wind is on average in the order of 6 to 8 m/s; and at the top of the urban canopy layer (UCL) (about 100 to 150m), it is estimated that the site wind is on average in the order of 3-5 m/s.

(e) The north facing hill slopes is a useful local cool air production source that can benefit the study area, this source of cool air (can be 2-3 degree C cooler) can create downhill (katabatic) air ventilation in the order of 0.5 to 1.0 m/s.

0.2 Topography and Valleys:

(a) The valleys on both sides of the Peak are channels of air movement to and across the study area, especially when the important summer wind comes from the south. (i) One of the channels is over the air space of Hong Kong University (HKU), and extends north towards Sai Ying Pun. (ii) The other is from Tregunter Path, and extends north towards the Central District. They should be respected.

0.3 Vegetation and Greeneries

(a) Currently, there are a number of noticeable Vegetated Air Paths across the study area. They are useful and should be respected.

- (i) from Kotewall Road south to West End Park, through Bonham Road Government Primary School to King George V Memorial Park just north of the study area (partially obstructed);
- (ii) from the middle of Conduit Road, through Caine Road Garden on Seymour Road to Blake Garden just outside of the study area (partially obstructed);
- (iii) the Peak Tramway; and
- (iv) along Borrett Road.

0.4 Existing conditions:

(a) The areas north of Conduit Road between HKU and Hong Kong Zoological and Botanical Gardens (HKZBG) are denser with higher towers and large podiums. Air ventilation is reduced. Careful interventions with air paths and open spaces are desirable to improve the wind environment. Currently, when wind comes from the East and North-East, the streets parallel to the wind are useful air paths; wind velocity ratio (VR) of around 0.1 can be expected. When wind comes from the south, most of the streets are perpendicular to the wind, the tall buildings form deep canyons; VR of around 0.05 can be expected. That is to say, only about 5% of the available wind of the site at the top of the atmospheric boundary layer can be enjoyed by the pedestrian at 2m above ground – this is estimated to be on average in the order of 0.5m/s; hence, it is very important to find ways to improve the air ventilation performance of the area.

(b) Given that the buildings of the study area in (a) are already tall which result in high building height to street width ratios (H/W), adjusting the building heights a little bit one way or another would not make a difference to air ventilation. For example, all else being equal, a deep street canyon of H/W of 4:1 or 5:1 would have very similar air ventilation performance at pedestrian level (2m above ground). In such a circumstance, the most effective way to improve air ventilation is to introduce air paths through building gaps.

(c) Most of the other areas should not have major air ventilation issues due to their higher altitude, proximity to green areas, unobstructed aspects, and lower density. Their air ventilation implication to the neighbours will be discussed later.

0.5 <u>The Study Area's Strategic Importance</u>:

(a) The study area is strategic in that it lies on the south of the main urban fabric of Hong Kong Island from Sai Ying Pun to Admiralty. The planning of the study area must take into account its air ventilation contribution to this urban fabric. That is to say, the study area cannot be planned in isolation without a consideration of its neighbours. When the summer wind comes from the south, currently, the tall and dense buildings in the study area make it very difficult for the wind moving into the urban fabric north of the study area.

(b) To make a useful contribution to the air ventilation of the urban fabric to the north of the study area, it is very useful to have proper air paths (both by preserving existing air paths and by creating new ones); buildings of the study area must not be too high or too bulky adding roughness and blockage to the incoming winds; and given that some parts of the study area [refer to 0.4(a)] are already "over-developed", adding further building volumes is not recommended and is in general not desirable for air ventilation.

(c) As a principle, to maximize the neighbour's air ventilation, buildings of the study area should be as low as possible. However, given the same building volume, lower buildings occupy more of the site, have higher site coverage, and thus reduce air ventilation within the study area. To optimize and balance the conditions, once the heights are kept as low as possible, the lower and "fatter" buildings of the study area need to be carefully designed and positioned to maintain some air paths through their north-south direction.

0.6 <u>The Study Area with Potential Re-Developments</u>:

(a) Based on the information provided by Planning Department, a lot of sites in the study areas have development potentials. They are yet developed to their maximum permitted intensity and can be re-developed with taller, larger and bulkier buildings, and with big podiums. This will further reduce air ventilation, and is not desirable. Adding further building volumes is not recommended. Due to considerations other than air ventilation, should they be allowed, proper planning and design control are extremely important. For example, introducing air paths and building permeability are useful and beneficial strategies.

(b) To illustrate, consider a "worst case scenario" that three to four long lines of tall buildings of 30-40 storeys (or higher) with large podiums form a continuous wall like barrier between the hills and the urban fabric from Sai Ying Pun to Admiralty. Due to the layout of existing street patterns, these lines of tall buildings will be perpendicular to the critical summer wind from the south. This scenario should be avoided.

(c) If "limited" re-development could be considered, a number of strategies should be borne in mind.

- (i) The GIC, O and GB zones in the study area should be respected. They provide useful air spaces in the study area. They should not be further developed with tall buildings or re-zoned for bulkier development.
- (ii) North-south orientated air paths should be provided by designating non-building areas. It is recommended that air paths be incorporated for each development.
- (iii) The scale and size of the podium should be restricted. Permeability should be designed into the buildings. Properly perforated podiums provide useful air paths for air ventilation.
- (iv) Towers must not be designed to occupy the full frontage of the site, especially the east-west direction. Appropriate gaps between the towers, and within the towers, must be left to allow air ventilation through them.
- (v) Greeneries and landscaping should be encouraged and enhanced. Existing trees must not be disturbed.

0.7 <u>The Study Area with Height Restrictions</u>:

(a) First of all, the consultant opines that, given the congested building environment with lots of tall buildings, and the possibility of having many more taller and bulkier buildings within the study area, height restrictions may not be the most important consideration for air ventilation. The air ventilation in some denser parts of the study area is already poor, and will worsen further due to the potential re-development. Given the scenario, height restrictions on its own is NOT going to help air ventilation.

(b) As a principle, for air ventilation, a variation of building heights in close proximity is preferred.

(c) As a principle, for air ventilation, a street canyon proportion less than H/W of 2:1 would allow wind perpendicular to the canyon to flow into the streets benefiting the pedestrian level air ventilation.

(d) As a principle, for air ventilation, a tall building has a longer wind-wake. A long and slab like building has a shorter but wider wind-wake. The worst case scenario for air ventilation is therefore a tall and wide building.

(e) Due to the high building height to street width ratio (H/W) of 3:1 and more in the study area, in general, building height control is NOT the most effective planning strategy for securing good district air ventilation at pedestrian level. Designing air ventilation not from above the buildings, but from the sides is a useful, effective and practical strategy. The provision of Air Paths, Open Spaces, and Green Belts are far more effective strategies especially for air ventilation at the pedestrian levels.

(f) It is important that a proposal of height restrictions do not adversely impact the air ventilation performance. The basic understanding is that when building heights are controlled, developers may need to build buildings with higher site coverage increasing the very important ground coverage ratio, hence restricting air ventilation. In practice, the understanding above may not be entirely correct as developers typically would position their buildings to maximize the site frontage in order to maximize its harbour view. As such, a shorter building will result in an increase of the building depth. For the study area, the summer wind comes from the south, the frontage of buildings are perpendicular to the wind. Adding further depth along the N-S direction to the buildings impacts little the air ventilation.

(g) Based on the information provided by Planning Department, it seems that the proposed height restrictions are not overtly tight. That is to say, within the allowable maximum heights, building designers have some design flexibility. Hence, the proposed height restrictions do not limit the possibility of introducing building gaps and permeability to optimize air ventilation.

(h) In response to the recommendations of the AVA expert evaluation, the proposed building height restrictions under the recommended scenario (Figure 0.1) have taken the following air ventilation issues into consideration:

(i) Where there are already development restrictions (site coverage, plot ratio and building height restrictions, and so on), they are not relaxed.
(ii) The valley wind channel that leads to Tregunter Path has been considered as much as practically possible.
(iii) The 4 existing vegetated air paths across the study area have been considered as much as practically possible.
(iv) All open spaces/green area are maintained and height of G/IC facilities are restricted to the existing height.
(v) The area to east of the tram way has been kept as low as possible to maintain the low-rise character of the area and an open view to Hong Kong Park.
(vi) A lower height band has been proposed along the Caine Road / Kennedy Road. A stepped height concept with progressive increase towards uphill directions has been adopted. A smaller height band has been proposed taken the topography into consideration.
(vii) Buildings along the green corridor / air path to east of HKU has been kept as low as possible to maintain the open view and for better ventilation.

(i) The consultant's understanding of the implication of the proposed building height restrictions as above is made based on the assumption that the potential re-development will happen anyway. Based on this "the damage has been done" basis, it is unlikely that the proposed building height restrictions in itself would make any difference one way or another to the possibility of poor performance of air ventilation in the denser part of the study area. Nonetheless, the proposed building height restrictions under the recommended scenario as in Figure 0.1 have taken into account, as far as practically possible and within the limit of only considering building height itself, suggestions of the AVA expert evaluation.

0.8 Further and Key Recommendations:

(a) The study area is the "gateway" of air ventilation in the summer to the districts of its north. Hence it is strategically important. The consultant opines that many sites of the study area are already "over-developed", and air ventilation through it to the districts of its north is already restricted. Therefore, in general, further development adding taller and bulkier buildings and podiums to the study area is not desirable, and is not recommended.

(b) For air ventilation, the proposed building height restrictions may be considered a "small" step towards the goal. It is important to further the OZP with studies, guidelines and restrictions of the more important design parameters like Open Space, Air Paths, Site Coverage and Non-building Area, and so on. Without these further measures, air ventilation of the study area and its contributions to its neighbours cannot be secured.

0.9 Further Studies:

(a) Given the "damage has been done" basis when taking into account the re-development potentials of the area, the consultant opines that there would unlikely to be a lot of difference between the air ventilation performance "with" and "without" the proposed building height restrictions. Further AVA studies comparing the "with" and "without" options may not be necessary or even beneficial as it is not possible to specify the more important parameters (e.g. building geometry and block disposition within each of the building sites) in the tests.

(b) Should any further studies of AVA be needed beyond the consideration of height control restrictions and 0.8(b) above be OPTIONALLY considered, it may be useful to test parametrically at least the following:

(i) as existing; and
(ii) with potential re-developments and height restrictions, and with:
option 1: "wall" towers and 100% podiums (worse scenario)
option 2: towers with gaps and 100% podiums
option 3: towers with gaps, non building area, perforated buildings (best scenario)

The focus area should be the strip of the study area from the east of HKU to the west of HKBZG.

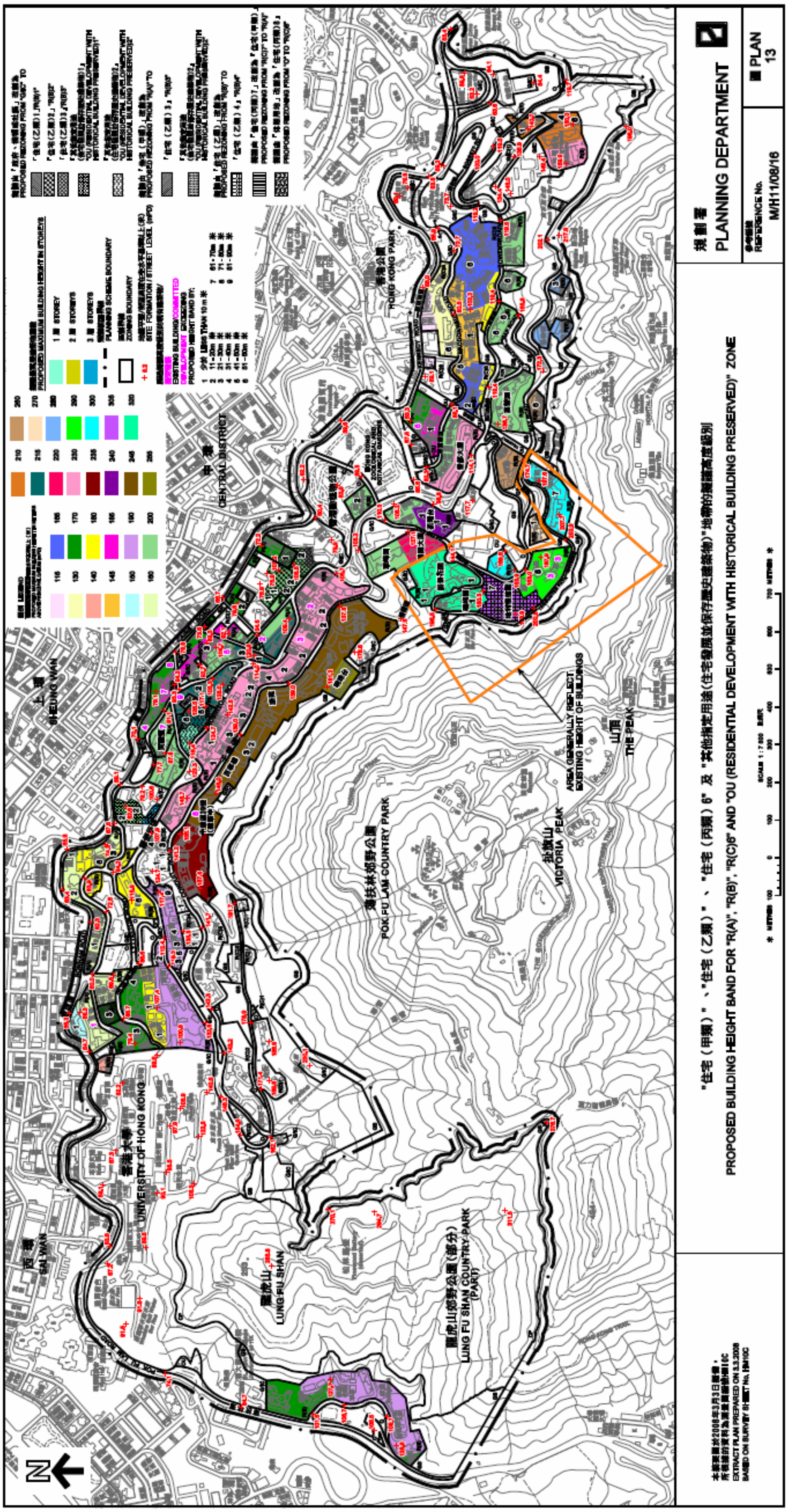


Figure 0.1 The study area with proposed building height restrictions under the Recommended Scenario.

Expert Evaluation Report of Mid Level West

1.0 The Assignment

1.1 In order to provide better planning control on the building heights upon development/redevelopment, the approved Mid-Levels West Outline Zoning plan (OZP) No. S/H11/13 is being reviewed with a view to incorporating appropriate development restrictions in the Notes for various development zones of the OZP to guide future development/redevelopment. It is necessary to conduct an expert evaluation to assess the broad Air Ventilation (AV) impacts of the proposed building height restrictions.

Apart from merely providing our views on the likely impact of air ventilation "with" and "without" the proposed building height restrictions, the consultant takes a step further to examine the study area "as it is" and "with potential re-development", and tries to recommend mitigation measures which could be useful for the study area.

1.2 This expert evaluation report is based on the materials given by Planning Department to the Consultant on 21 Dec 07 including:

- Aerial overview
- Existing building height profile (no. of storeys)
- Existing building height profile (in mPD)
- Committed developments
- Zonings with building height restrictions under OZP
- Proposed building height restrictions (in mPD)
- Existing building height (no. of storeys)
- Existing building height (in mPD)
- Existing spot height and location of potential redevelopment sites
- Site Photos

AND on 27th Dec 07 the following:

- Existing podium height (mPD)
- Building/podium height of committed developments (mPD)
- Estimated development parameters of potential redevelopment sites.

1.3 The consultant has studied the above mentioned materials, and has conducted site inspection between 22nd Dec and 25th Dec 2007. During the writing of the report, the consultant has working sessions with colleagues at Planning Department on 21st Dec 07, 27th Dec 07, and 3rd Jan 08.

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 thermal comfort.

2.2 Given Hong Kong's high density urban development, the study opined 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 the wind data as the input boundary conditions of the wind environment of the study area.
(b) Analyse the topographical features of the study areas, as well as the surrounding areas.
(c) Analyse the greenery/landscape characteristics of the study areas, as well as the surrounding areas.
(d) Analyse the land use and built form of the study areas, as well as the surrounding areas.

Based on the analyses:

(a) Estimate the characteristics of the input boundary conditions of the wind environments of the study area.
(b) 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.
(c) Estimate the need of wind for pedestrian comfort.

Based on the analyses of the EXISTING urban conditions:

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

Based on an understanding of the EXISTING urban conditions:

(a) Compare the prima facie impact, merits or demerits of the building height development restrictions as proposed by Planning Department on Air Ventilation.
(b) Highlight problem areas, if any. Recommend improvements and mitigation measures if possible.
(c) 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.

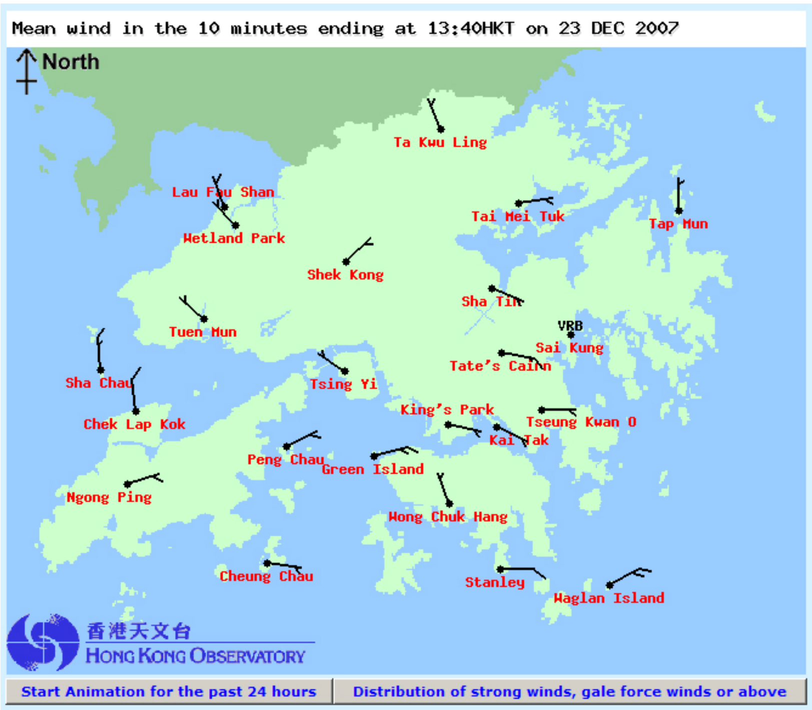
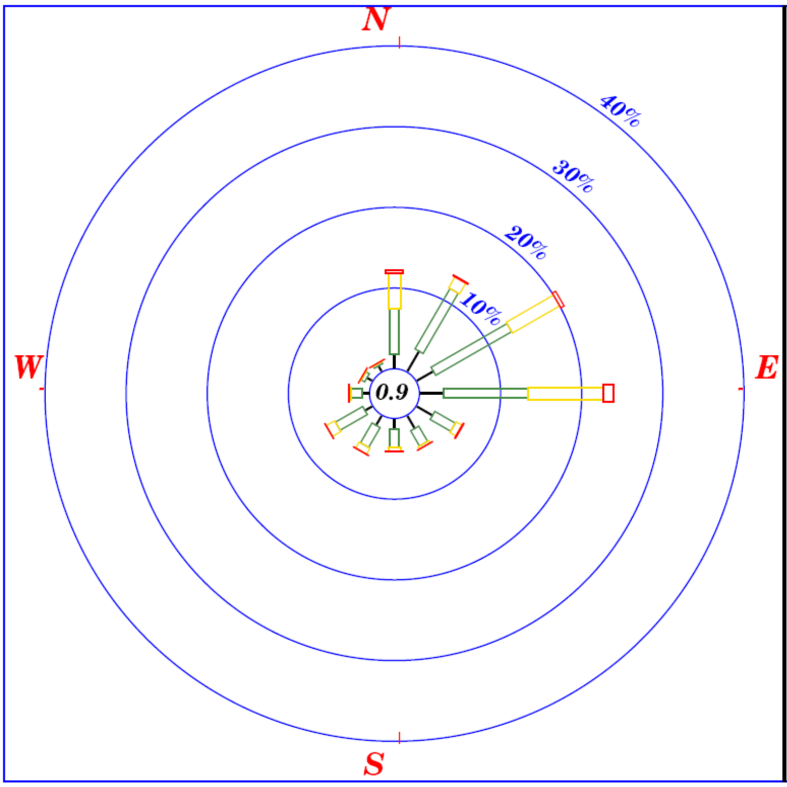


Figure 3.1 Some of the HKO stations in Hong Kong. This is a screen capture at 13:40 on 23 Dec 2007 from the HKO website. The arrows show the wind directions and speeds of the time. The case study illustrates that the local wind environment is affected by the topography, as well as the thermally induced sea breezes.

3.2 The HKO station at Waglan Island (WGL) is normally regarded by wind engineers as the reference station for wind related studies (Figure 3.2). The station has a very long measuring record, and it is unaffected by Hong Kong's complex topography [unfortunately, based on HKO's studies r508, it does not capture the thermally induced local wind circulation of some part of the Hong Kong's territory 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.

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).



	015-044	045-074	075-104	105-134	135-164	165-194
F1	2.797	2.267	2.758	2.143	1.719	1.106
F2	8.630	10.801	10.402	2.912	2.170	2.295
F3	1.545	6.729	9.355	0.842	0.322	0.452
F4	0.136	0.468	1.210	0.123	0.039	0.040
	13.108	20.265	23.725	6.019	4.251	3.893

	195-224	225-254	255-284	285-314	315-344	345-014	Total
F1	1.263	0.922	0.761	0.642	0.681	1.665	18.723
F2	2.837	3.880	1.337	0.482	0.274	5.530	51.548
F3	0.849	1.197	0.246	0.107	0.072	4.455	26.171
F4	0.049	0.047	0.015	0.017	0.019	0.426	2.590
	4.998	6.046	2.359	1.249	1.045	12.075	99.032

Figure 3.2 Wind rose of WGL 2006 (annual).

3.3 For the study, it is important to understand the wind environment seasonally or monthly (Figure 3.3 and 3.4). 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.

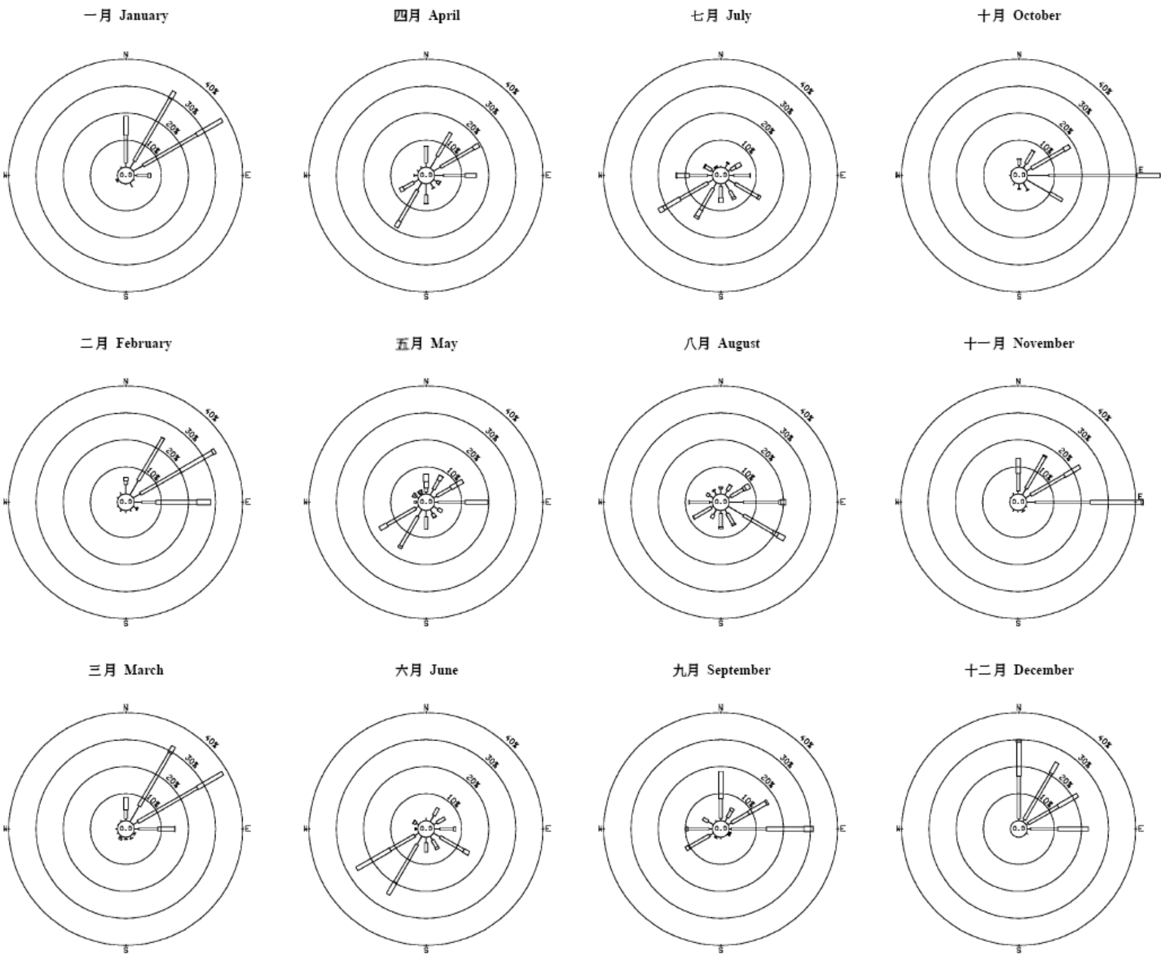


Figure 3.3 (as an example) monthly wind roses of WGL 2006.

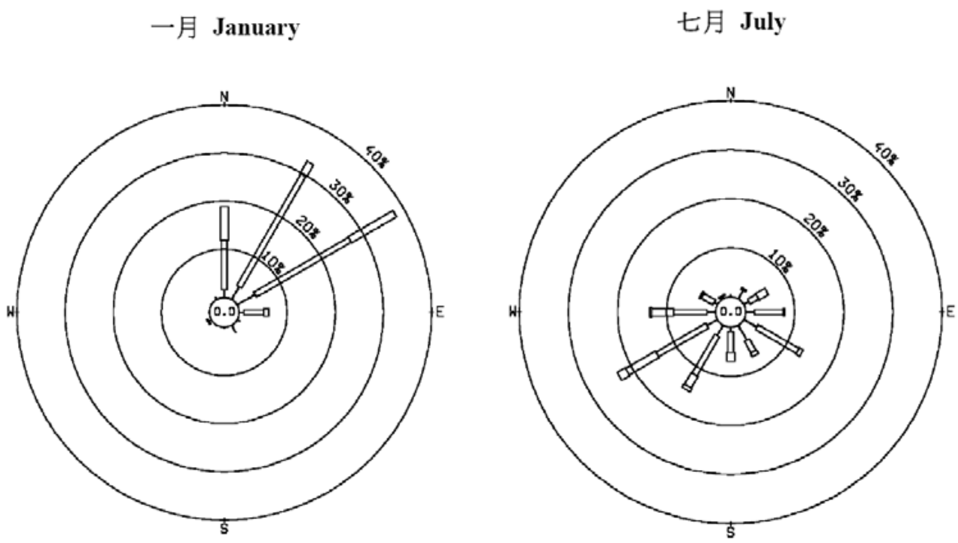


Figure 3.4 (as an example) Wind roses of WGL 2006 (Jan and July).

3.4 Hong Kong has a complicated wind regime due to its complex topography and sea breezes. It is important to look closer at the site wind availability of different locations in Hong Kong as it is very likely that they all have very different site wind. The study area is located at the western end of Hong Kong Island. The nearest HKO station is Green Island. The station's anemometer is at 107 mPD. It sits on a small hill of 88 mPD (Figure 3.5 and Figure 3.6).

Figure 3.5 Location of HKO Green Island station.

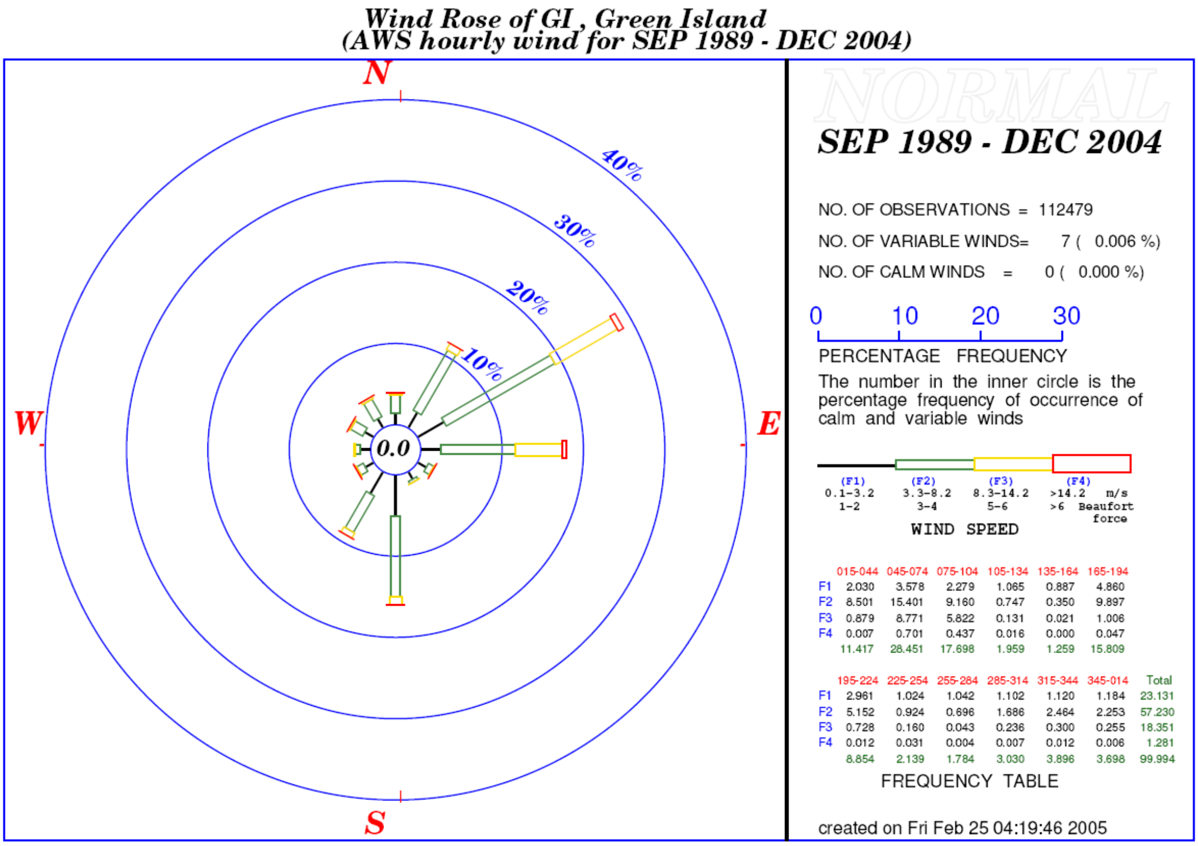


Figure 3.6 1989-2004 wind rose of Green Island.

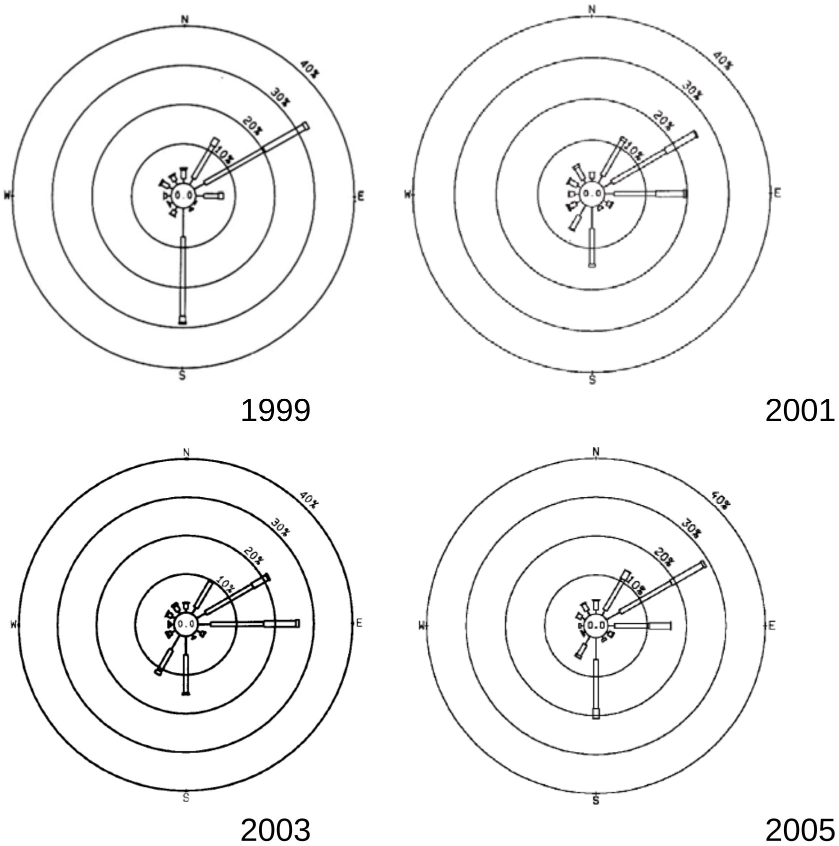


Figure 3.7 (as an example) Green Island annual wind roses (1999, 2001, 2003, 2005)

3.5 The mean wind speed measured at HKO Green Island is around 5 m/s. Referring to Figure 3.6 and Figure 3.7, Green Island's annual wind rose has a prevailing wind direction of North-East. It also has a major component from the South. Based on HKO 1989 to 2004 data, breaking down the wind directions into months (Figure 3.8), it is apparent that at Green Island the summer wind comes mainly from the South.

GI	1989 Sept 11	2004 Dec 31

Jan ... Dec

070	070	070	070	070	190	190	190	070	070	070	070

Figure 3.8 Green Island wind directions (monthly prevailing) in compass bearing. 70 means 20 degree north of east and 190 means 10 degree west of south.

3.6 With the kind assistance of Urban Renewal Authority (URA), from Oct 2005 – Oct 2006, CUHK researchers had mounted a wind mast on top of Millennium Plaza on Queen's Road Central (Figure 3.9). The anemometer is at 125 mPD. It captures the Urban Canopy Layer (UCL) wind very well. At UCL, the wind characteristics allow one to have useful information of the air mass that moves through the city fabric.

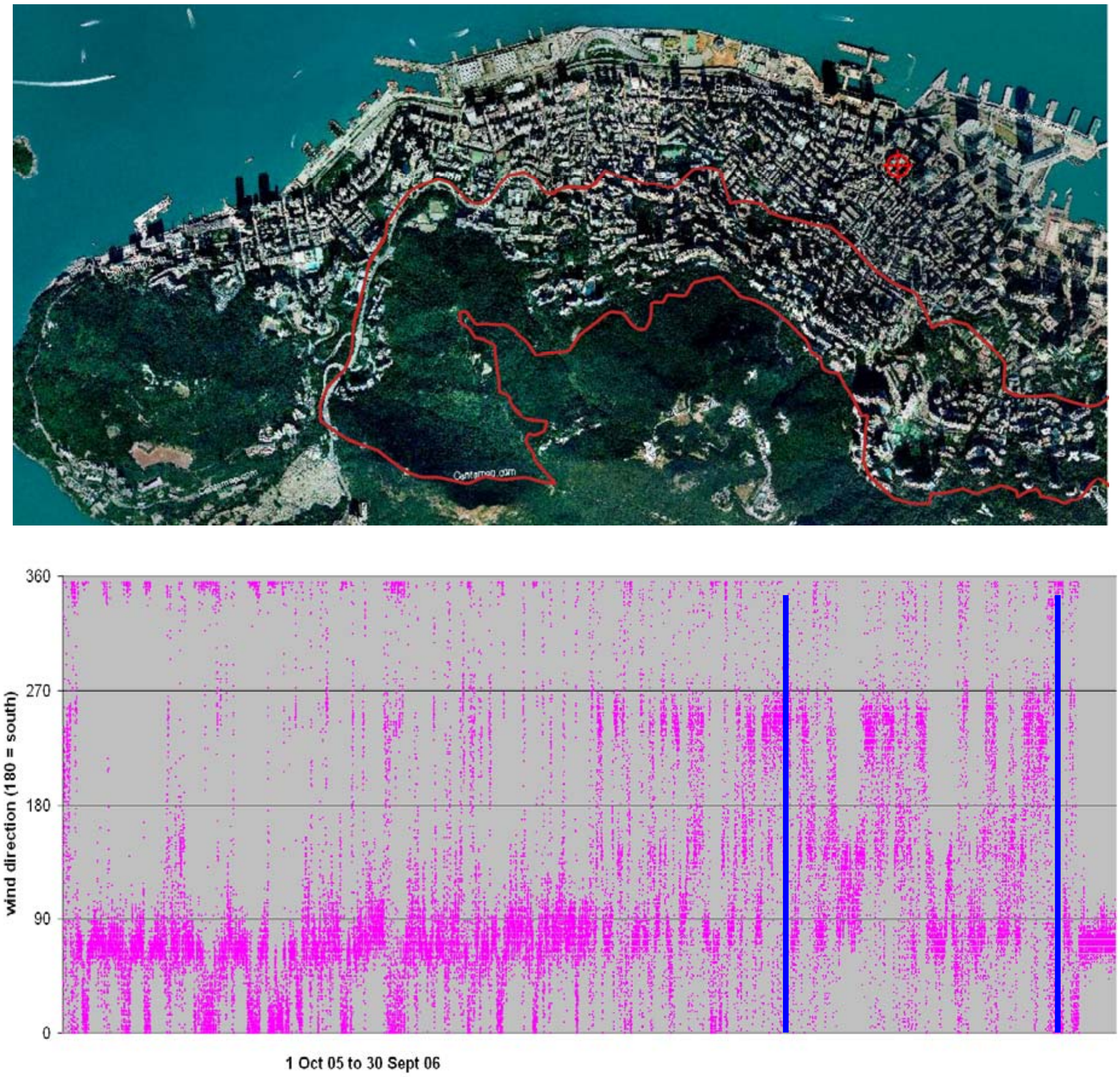


Figure 3.9 (Top) Location of CUHK's wind mast (1 Oct 2005 – 30 Sept 2006); (Bottom) Wind directions [Y axis, 0 or 360 is north, 180 is south, 90 is east,]; the period of interest is between 1 June to 31 August – between the two blue lines.

3.7 CUHK's measurement indicates that the mean wind speed at this height is around 3 m/s – which is weak. The annual prevailing direction is east (as indicated by the heavily pinked areas in Figure 3.9). However, in the summer months of June, July and August (between the two blue lines), the prevailing wind directions oscillate between south-east and south-west.

3.8 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 above ground (Figures 3.10, 3.11, 3.12, 3.13).

Figure 3.10 The three locations of MM5 extracted data, around Hong Kong University, Caine Street/Aberdeen Street and Bowen Road.

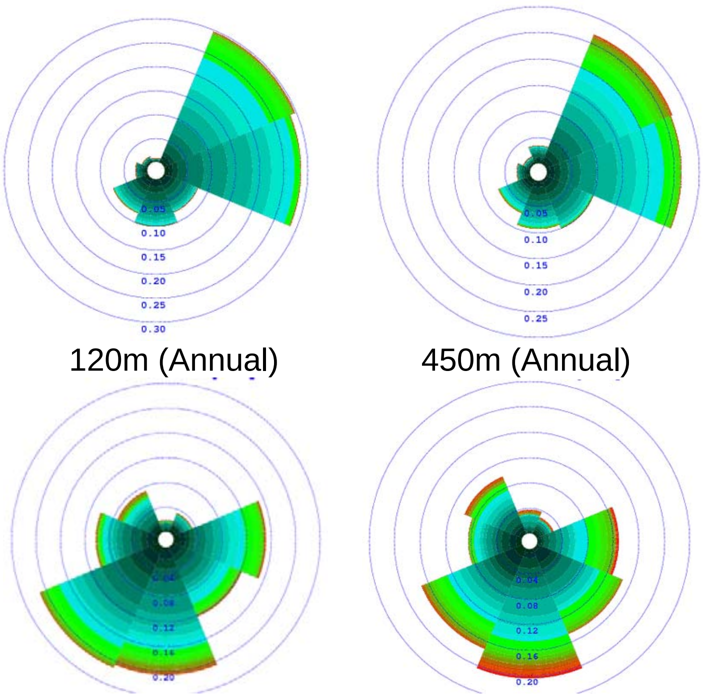
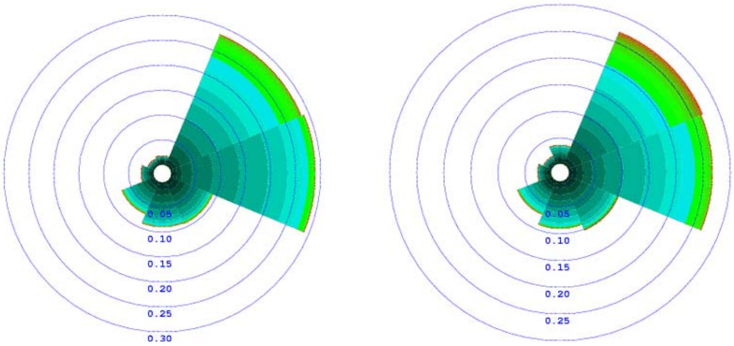
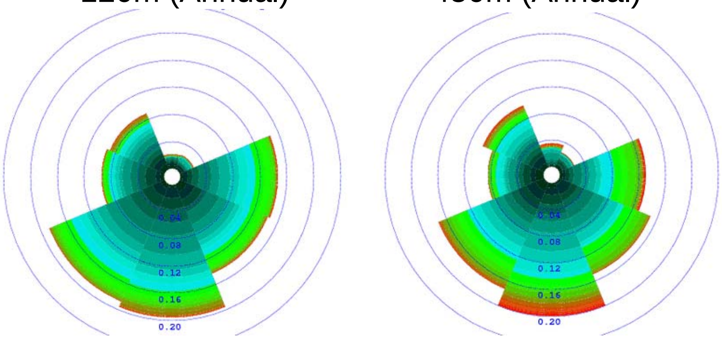


Figure 3.11 Wind roses at Hong Kong University

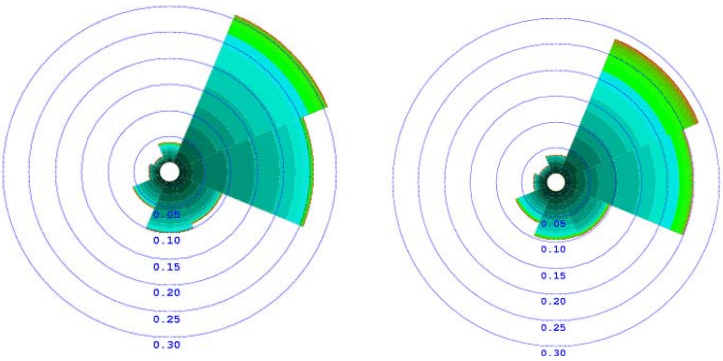


120m (Annual)　　　450m (Annual)

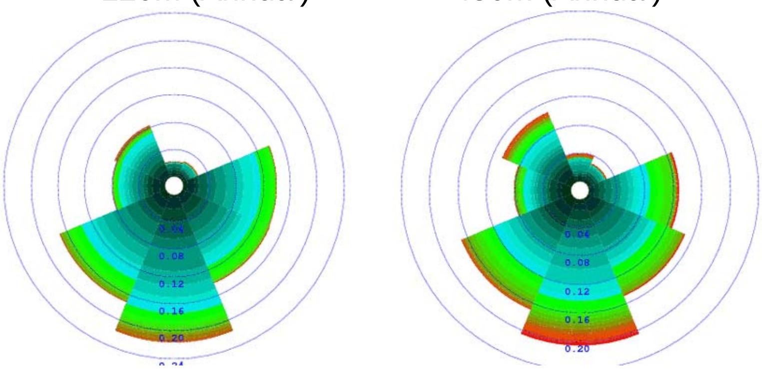


120m (Summer)　　　450m (Summer)

Figure 3.12　Wind roses at Caine Street / Aberdeen Street



120m (Annual)　　　450m (Annual)



120m (Summer)　　　450m (Summer)

Figure 3.13　Wind roses at Bowen Road

3. 9 Based on the MM5 simulated wind roses of the 3 locations extracted, one could suggest that there are little differences among them. It can be noted that the annual and summer wind roses roughly follows what has been measured by the HKO Green Island station, as well as the CUHK measurement station at Sheung Wan.

3.10 Using the simulated MM5 data, the summer and the annual prevailing wind directions of the study area and the surroundings are indicated in Figure 3.15 and 3.16. The summer prevailing wind direction of HKO Green Island station is also shown.

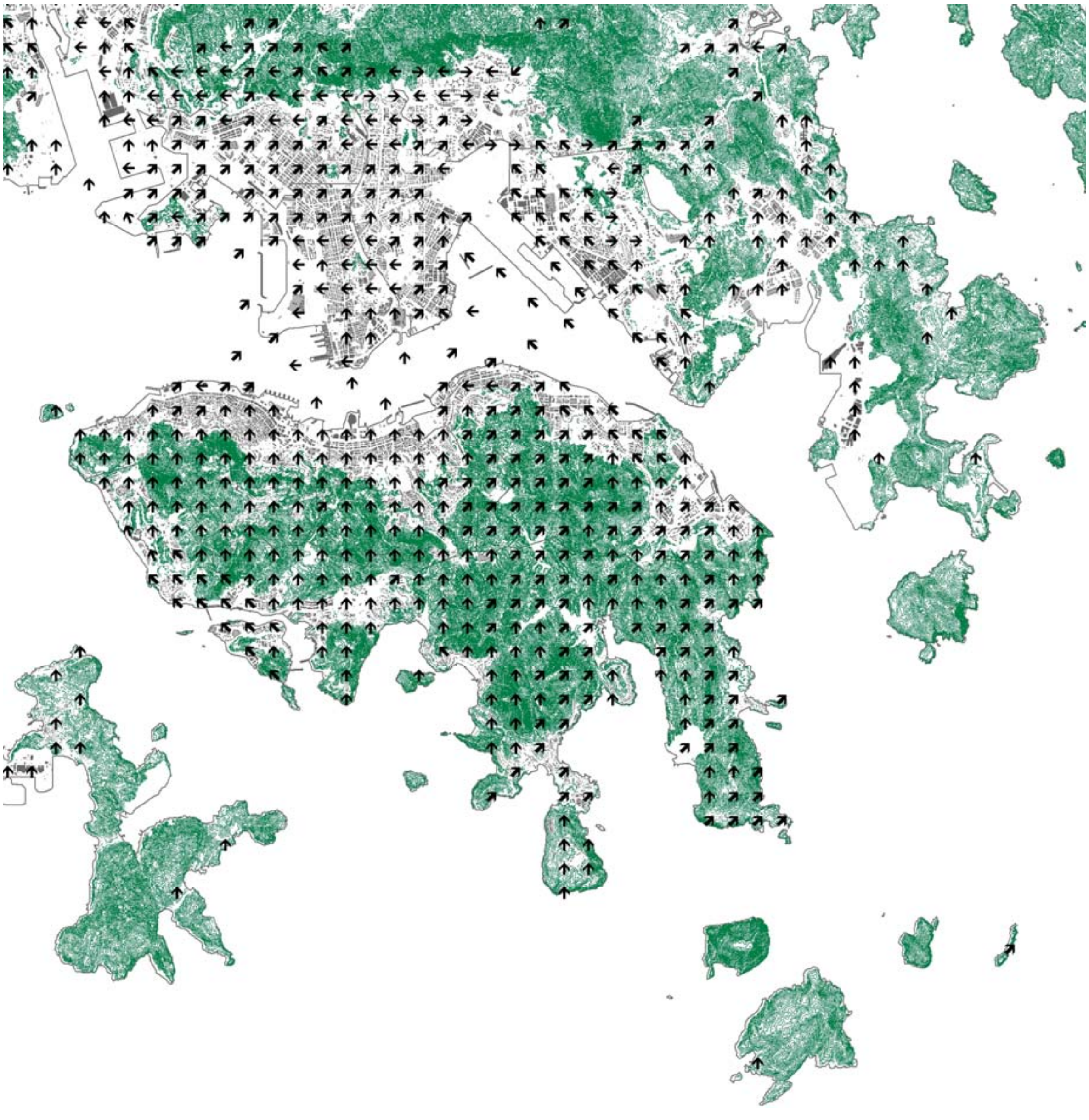


Figure 3.15 Prevailing wind directions of the summer months (Jun-Aug 2004) based on MM5.

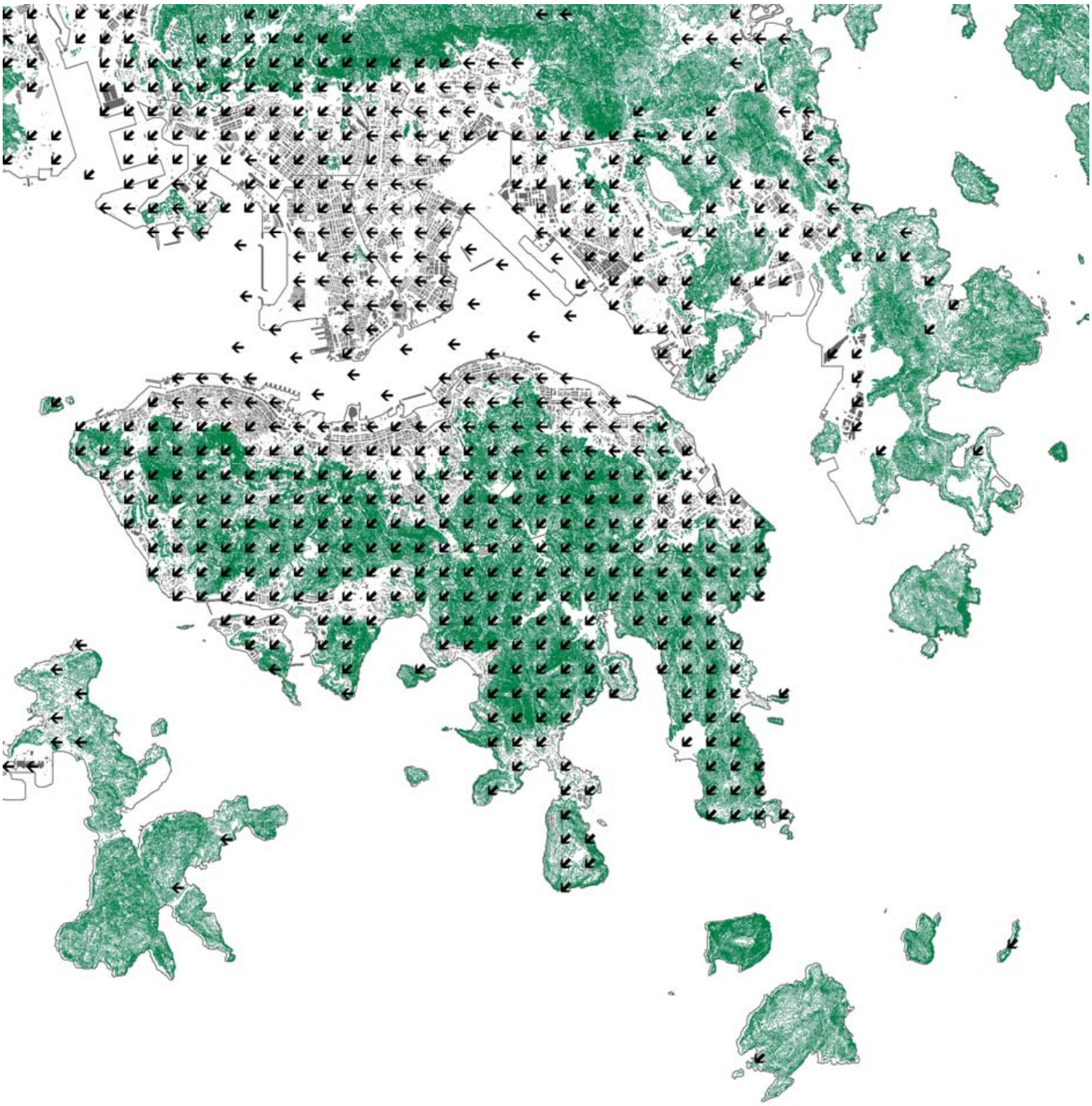


Figure 3.16 Prevailing wind directions (annual 2004) based on MM5.

3.11 The MM5 data predicts that at 450m, the annual mean wind speed is about 8 m/s. The predicted mean wind speed in the summer at 450m is about 7 m/s.

3.12 The MM5 data at 120m largely collate with the HKO measured data at Green Island at 107 mPD.

3.13 In summary, based on the available wind data from the HKO and HKUST-MM5, one may conclude that the annual wind of the study area is mainly from the

East and North-East. The summer wind is mainly coming from the South and South-West.

3.14 In terms of the mean wind speed, HKO's data in the open area suggests a mean wind speed at Urban Canopy Layer of around 5 m/s. The HKUST MM5 data agrees. However, the CUHK data is lower at about 3 m/s. Prudently speaking, one may assume that an average wind speed of around 3-4 m/s at the Urban Canopy Layer level is a reasonable understanding for the study area. At the top of the boundary layer (500m), it is estimated that the site wind is on average in the order of 6 to 8 m/s. Theoretically speaking, this means for example at the sea front on an unobstructed open ground, when wind comes from the sea, the available wind at the pedestrian level can be around 2 to 3 m/s. This is not high. In addition, due to the buildings and high ground roughness, wind reduces when it moves inland; thus it is very important that the city is designed to capitalize this available wind realistically.

3.15 In addition to the wind characteristics (direction and speed), it is also important that the locally induced thermal wind is estimated and considered. This is particularly important for Mid-Levels West as there is a large area of northerly-slope of dense vegetation immediately south of the study area. This "cool air" production area is extremely beneficial to the air ventilation of the study area.

3.16 For example, when there is no background wind (i.e. when WGL and GI both record calm or no wind), the temperature difference between the city fabric and the vegetated slopes will thermally induce a local circulation. The slightly cooler and denser air generated by the north facing vegetated slopes, also known as "Katabatic Wind", will sink towards the city. The cooler air not only reduces the air temperature of the city, it flushes the streets as it moves downwards. It is important that the study area be also planned to try to capture and benefit from the Katabatic air ventilation of the vegetated hills.

3.17 The strength of this Katabatic air ventilation movement depends mainly on the air temperature differences between the city fabric and the vegetated slopes. This in turn depends on the time of the day and the magnitude of the solar radiation. Researchers at CUHK have done some measurements previously. The data indicates that on a sunny day in summer of Hong Kong, it is in the order of 0.5 to 1 m/s and at a temperature of around 2 ºC -3 ºC lower than the air temperature of the city. That is to say, referring to 3.16 above, this air ventilation can be extremely useful when it is not obstructed and can pass through the urban fabric.

4.0 Topography

4.1 For wind coming from the North-East over the Victoria Harbor, taking the topography into account; the hills south of the study area reduce the air space and slow down the incoming wind. Some northeast wind will climb the valley, and some wind will be diverted to the west around the Victoria peak. The urban fabric north east of the study area and its high roughness also slows the wind.

4.2 For wind coming from the East, taking the topography into account, the land mass and buildings east of the study area will generally slow down the wind due to the roughness. The hills south of the study area (Victoria Peak) promote some channeling of the east wind to its north and south. This channeled wind is normally slightly stronger than the same wind in the free stream. The channeled wind converges after passing Mount Davis.

4.3 For wind coming from the South, taking the topography into account, the hills south of the study areas shield the incoming wind (Figure 4.1). A key section across the study area from the peak is shown in Figure 4.2. The 3 dimensional flow patterns 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.

4.4 The south wind accelerates when it climbs and passes the hills; and decelerates when it descends towards the study area. On the whole the wind velocity reaching the site will be reduced. Some eddies and re-circulations are expected as the wind descends the hills. Some wind will be diverted and channeled around Victoria Peak along the two valleys on both sides of the Peak; this will converge and re-circulate behind the hills. The re-circulation can oscillate a bit causing east-west air ventilation movements (vortex shedding). The high roughness of the urban fabric damps the oscillations, and creates turbulence.

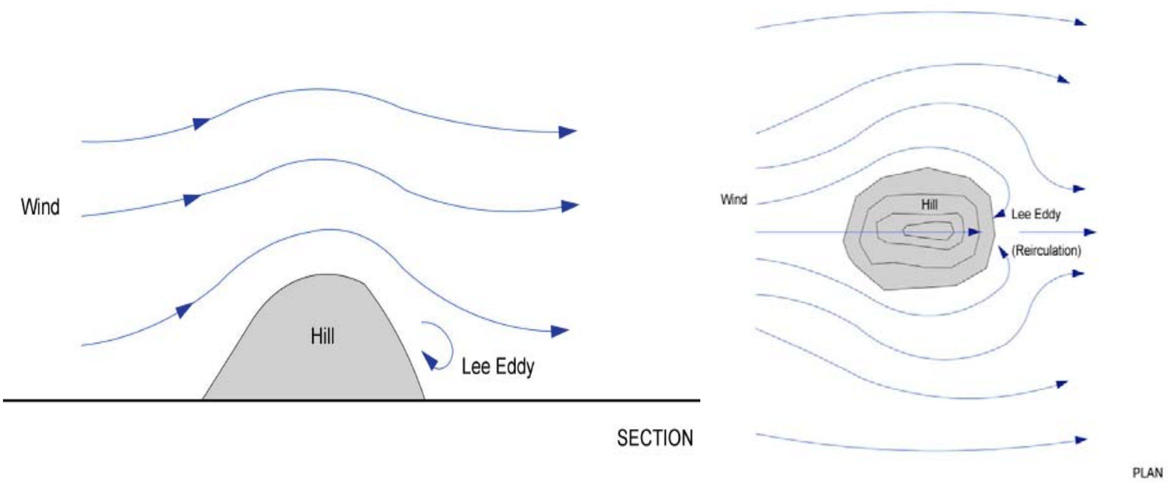


Figure 4.1 An example of wind flow across hills under moderate wind.

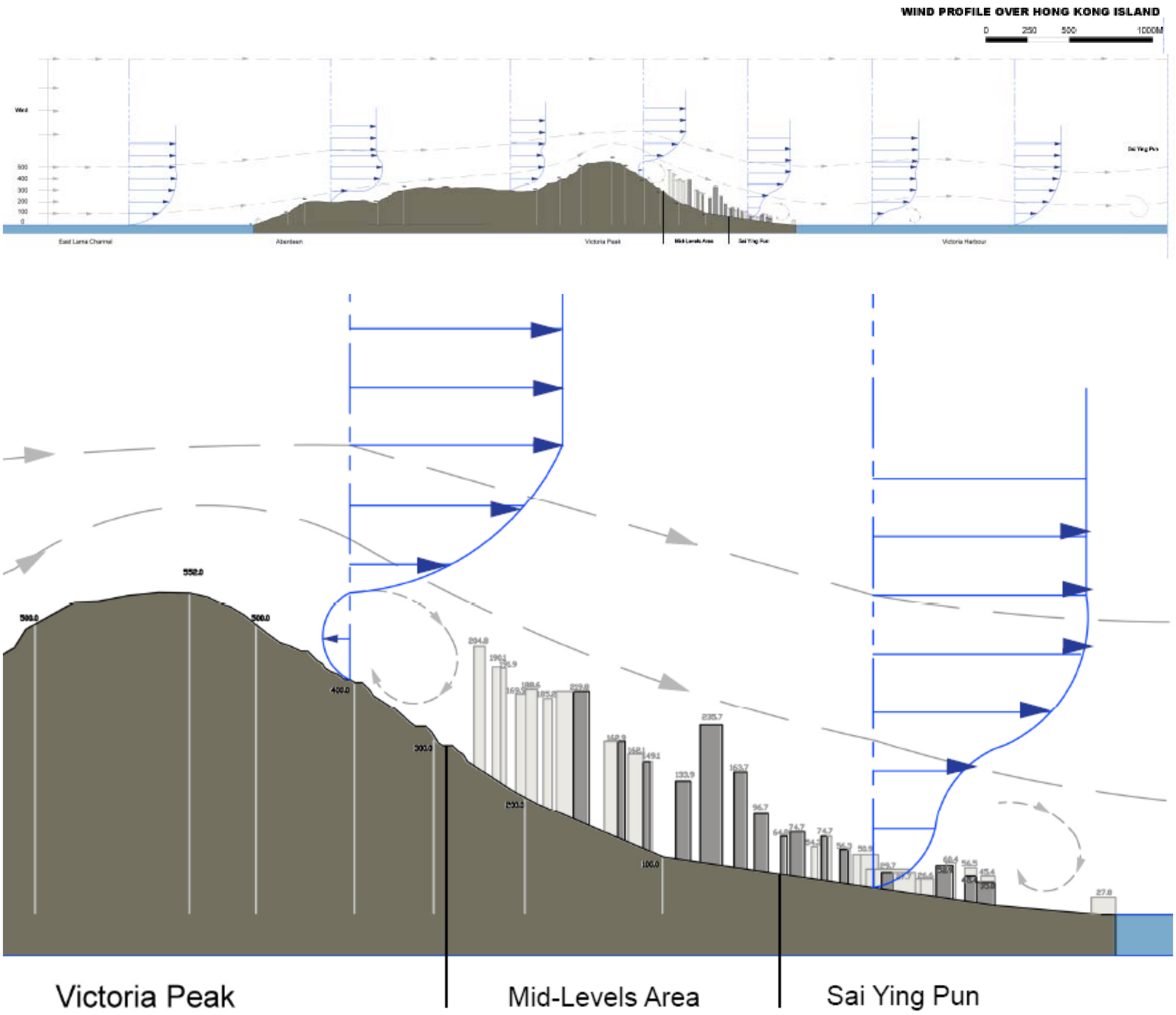


Figure 4.2 A possible (simplified) wind flow pattern across the site when the incoming "moderate wind" is from the south (left). The study area can experience eddies, re-circulations and fluctuations.

4.5 The MM5 data should have largely taken into account the topographical effects when the data is simulated. What is important is to examine if there is further smaller scale channeling and valley situations especially immediately south of the study area. Figure 4.3 shows a relief map of the study area. Two major and 2 minor valley conditions can be noted (Figure 4.3). For AV, the minor valley may not be that important. The major valleys can be useful as the cooler downhill air movement follows the valleys. Air movements along the valleys are stronger and can penetrate deeper into the urban fabric.

4.6 One of the major valleys leads to the Hong Kong University. The valley air movement will generally benefit the areas of the university. Due to the gentler slopes and the buildings in the way, the area north of HKU will benefit less, but some benefits are still possible especially when the cooler downhill wind is assisted by the background wind from the south in the summer months. It is useful that buildings around Kotewall Road are not too bulky to stop the air ventilation from going further too soon.

4.7 Another valley leads to Tregunter Path. The valley air movement will generally benefit the areas around May Road, the Government House, and so on. Again, the background summer wind from the south will penetrate further along the valley. It is useful that buildings along the valley are not too bulky as to prevent too quickly the air ventilation from going further. The width of the valley extends from Raimondi College on one side to Garden Road on the other as shown in Figure 6.2.

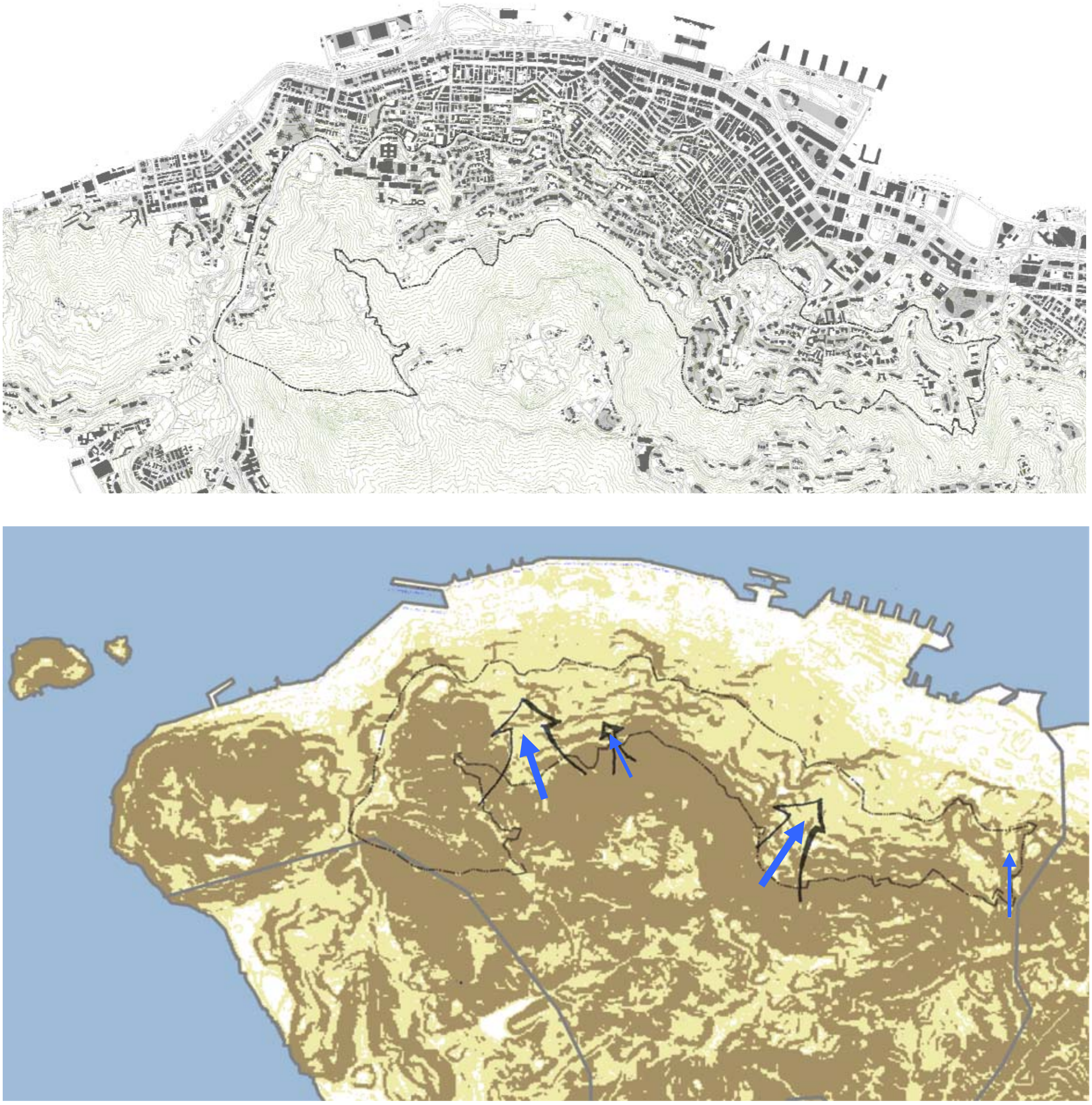


Figure 4.3 Valleys that air ventilation, especially the cooler katabatic air movement will follow.

4.8 Other than the valleys, as mentioned earlier (section 4.6 and 4.7), the steeply sloped green belt south of the study area provides useful air ventilation in general (i.e. the cooler katabatic wind).

4.9 Just outside the study area, there is another valley along Bowen Drive (blue arrow on the far right, Figure 4.3). This valley basically channels the wind around the Victoria Peak providing useful air ventilation to Central / Admiralty. Although not within the scope of this study, the consultant opines that buildings on both sides of this valley should be carefully controlled.

5.0 The Shape of Study Area and the Air Ventilation Environment

5.1 Based on an understanding of the critical summer wind from the south, and the shape of the site is “thin”, the south wind has only a few hundred metres to travel.

5.2 Given that the study area is at the windward side of Sai Wan, Sheung Wan and the Central District when the summer wind is approaching from the south, it is very important that the planning of the study area tries to make a contribution to the wind environment in these urban areas. Disregarding this principle and trying to add another layer of densely built urban fabric to the south of the existing urban areas is not recommended. Should additional buildings be allowed in the study area, it is important to compensate by designating “air paths” and non-building areas, thus ensuring the site permeability. The site coverage and ground coverage ratio (as described later) should not be increased.

6.0 Greenery, Open Spaces and Landscaping

6.1 The area west of Hong Kong University (HKU), and including HKU, is largely vegetated. Within the study area, this vegetated belt extends eastwards along the southern boundary to Hong Kong Zoological and Botanic Gardens (HKZBG). It then further extends eastwards to the eastern end of the study area (Figures 6.1 and 6.2).

6.2 Vegetated belt, extending across the study area from south to north, if possible, is beneficial, especially during the summer months when wind comes from the South. Between HKU and HKZBG (Figure 6.2), the vegetated belt spans N-S through the study area at a number of points. Firstly, from Kotewall Road south to West end Park, through Bonham Road Government Primary School to King George V Memorial Park just north of the study area. Unfortunately the path is partially obstructed by a number of buildings along its route. However, this penetration is still useful especially for the urban fabric north of the study area. Secondly, there is another vegetated belt starting from the middle of Conduit Road linking up a garden on Seymour Road to Blake Garden just outside the study area. The buildings between Robinson Road and Seymour Road, notably Caine Road Garden are partially obstructing the path. Fortunately an air space above Ying Wa Girls’ School assists a bit.

6.3 Between HKZBG and the eastern end of the study area, the Peak Tramway provides a continuous linear open area. In addition, there is another vegetated belt found in the eastern end of the study area starting from the area along Borrett Road to Hong Kong Park in the west and Harcourt Garden in the east. However, the bulky Pacific Place and the two hotel buildings and large podium partially obstruct the path leading towards Admiralty.

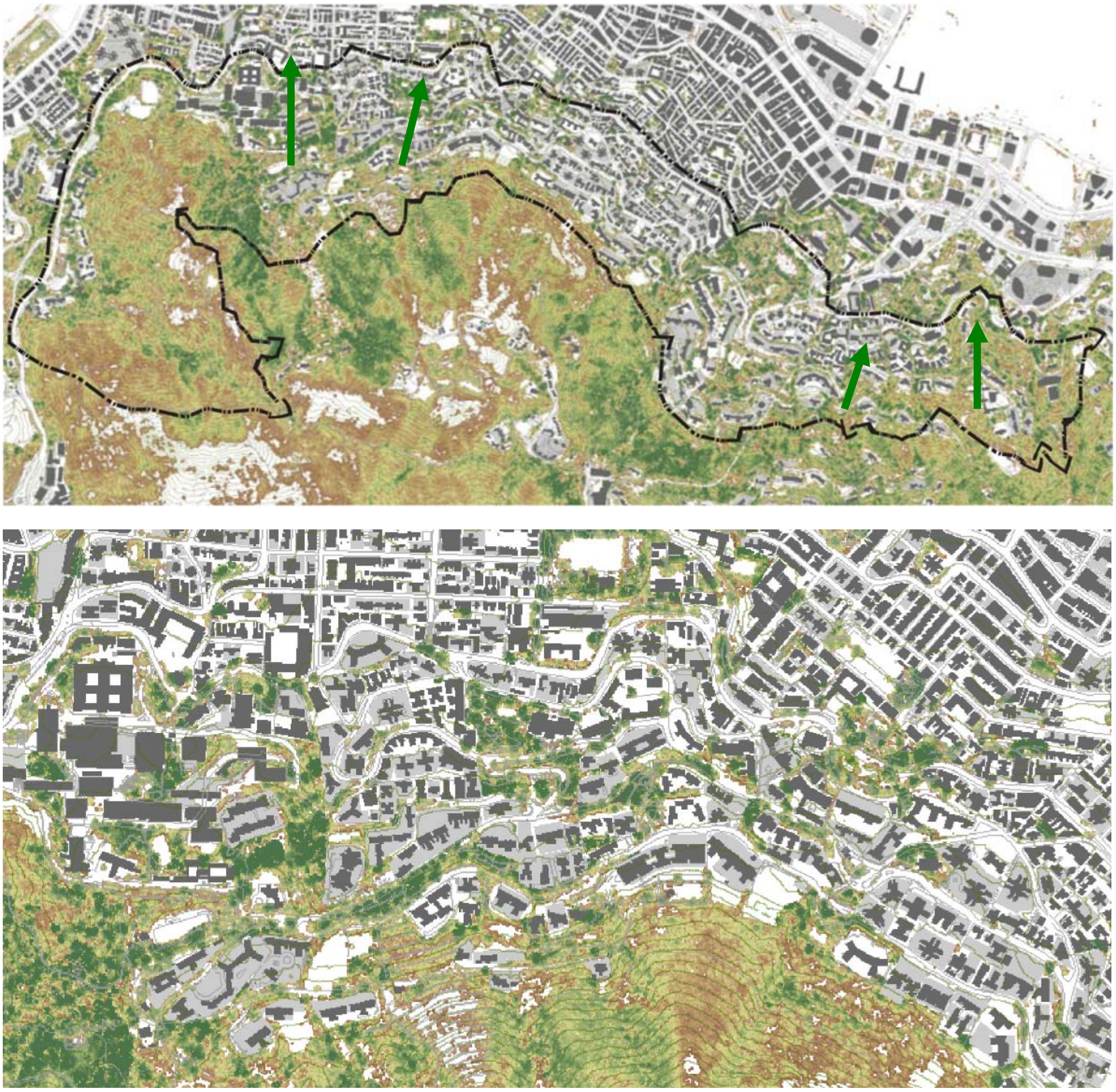


Figure 6.1 Vegetation of the study area based on LiDAR data provided by PlanD.

6.4 Taking into consideration the topography, the consultant opines that the vegetated belt and air path over HKU and the other one over HKZBG are very important existing air paths. Four other possible vegetated air paths as identified earlier in the report, summarized below, can be useful and should be enhanced or respected (Figure 6.2).

(A) From Kotewall Road south to West end Park, through Bonham Road; Government Primary School to King George V Memorial Park just north of the study area (partially obstructed);
(B) from the middle of Conduit Road, through a garden on Seymour Road to Blake Garden just outside of the study area (partially obstructed);
(C) the Peak Tramway
(D) area along Borrett Road to Hong Kong Park.

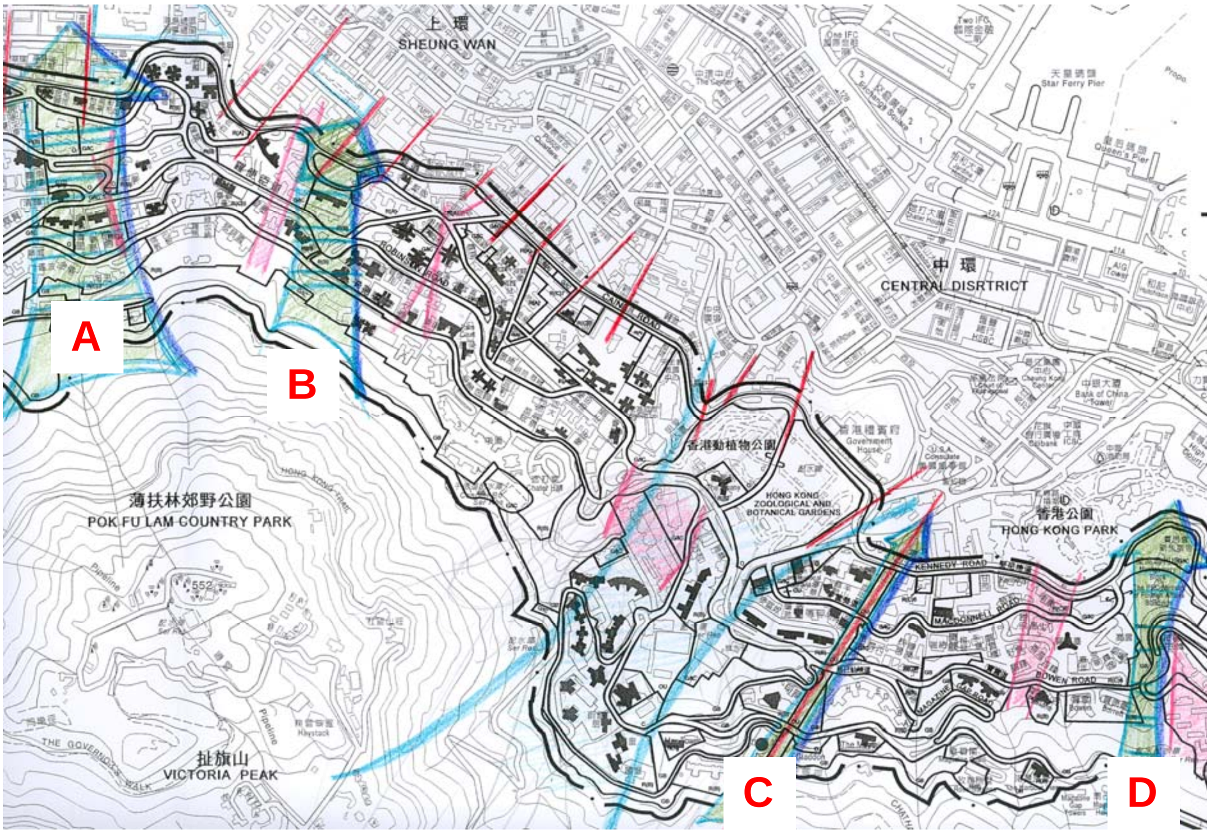


Figure 6.2 The four existing vegetation belts (Green arrows) through the study area. Red lines indicate that all of the streets leading to the northern boundary of the study area are NOT through air path. The two areas between the Blue lines indicate the main valley air paths through the study area. The pink zones indicate clusters of low buildings that could provide air ventilation over their roofs (pseudo air paths).

6.5 Unfortunately none of the streets or roads leading into the study area from the northern boundary (red lines in Figure 6.2) could extend across the whole study area to the southern boundary. This means the study area does not contribute to these air paths. This is due to the fact that the main roads and streets of the study area are mostly running east-west.

6.6 Some buildings in the study areas are still low rise, together they form clusters of air spaces and air channels above their low buildings. A few of these cases can be detected (pink zones in Figure 6.2). They can be useful pseudo-air paths through the study area.

7.0 Existing Street Grids

7.1 The east west orientated streets and roads are parallel to the east wind. Hence they can be useful air paths when wind comes from the east. However, the streets and roads are not wide. Given the tall buildings and podiums on both sides, and the high roughness they generate, these air paths have reduced ventilation potentials. Wind velocity ratios (VR) in the order of 0.1 can be expected.

7.2 When wind comes from the north-east, the thick urban fabric on the north and the north east of the study area generate high turbulence. The air path concept of the streets and roads may not be applicable.

7.3 Most of the streets and roads of the study area are east-west with buildings on both sides; they may not be too effective to take advantage of the critical summer wind from the south. The tall buildings on both sides of the streets and roads form deep canyons and significantly reduce the ventilation potentials. Wind velocity ratio in the order of 0.05 to 0.1, or less, can be expected.

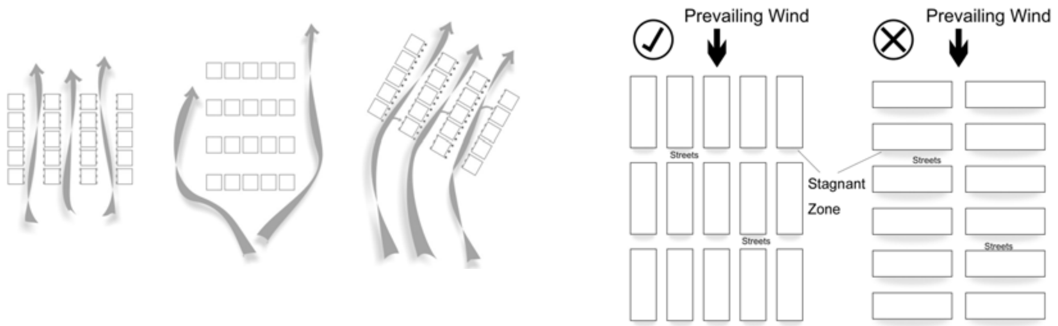
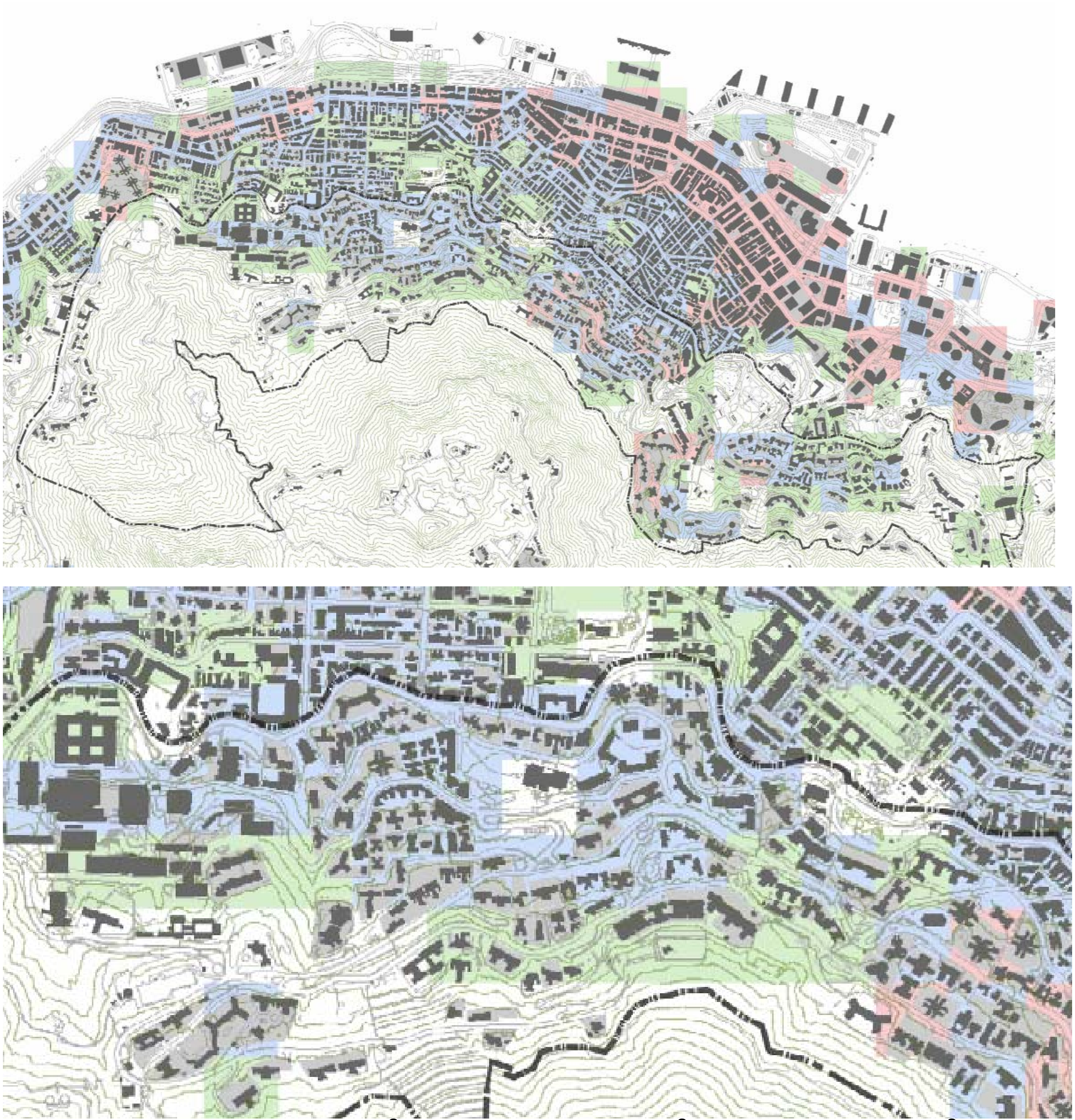


Figure 7.1 Streets parallel to the incoming wind are useful wind paths. VR in the order of 0.1 and better can be expected. Streets perpendicular to the incoming wind have stagnant zones within its canyons. VR in the order of 0.05 or less can be expected.

7.4 There is no street or road that connects all the way from the south of the study area to the north. Hence there is no direct air path parallel to the incoming south wind. Wind velocity ratio in the order of less than 0.05 is expected in streets within the deep canyons when wind travels perpendicular to the streets. It is vitally important to find ways to create south-north air paths. This can be done by leaving gaps between buildings (non building area). One way to do it is to identify the streets that lead into the study area from the north, and try to align the air paths using building gaps along them.

8.0 Land use and Urban Morphology



Green 60K-120K m^3, Blue 121K-240K m^3, Red over 241K m^3

Figure 8.1 Building volume density map of the study area, resolved to 100m x 100m grid. For example, lower BVD (blue area) can be observed along Conduit Road, Higher BVD (pink area) can be observed around Bonham Road.

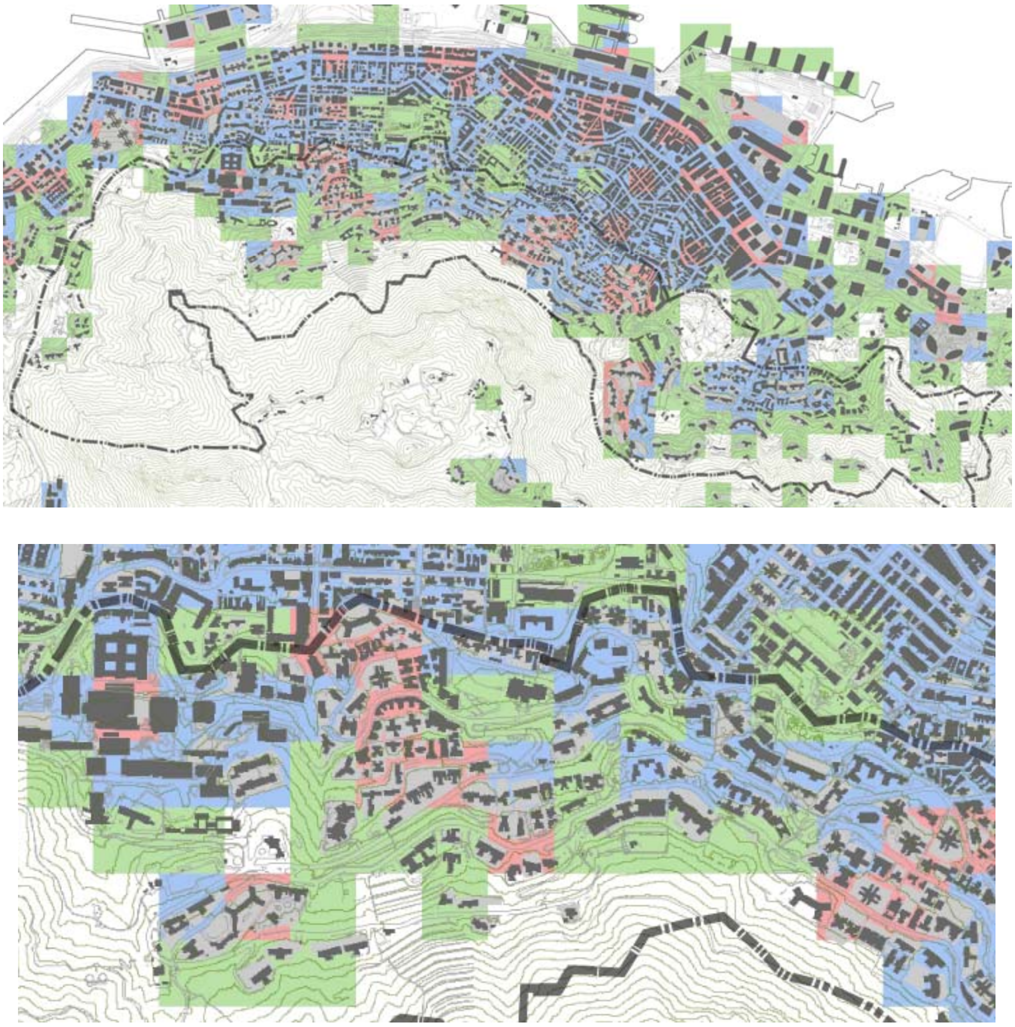
8.1 The study area has a mixture of different residential zones – mostly R(B) and R(C), and with a number of R(A) zones. It also has a good number of GIC, O and GB zones providing air space relieves.

8.2 Higher building volume increases the thermal capability. This creates higher thermal stress in the summer months and the need for higher air ventilation to mitigate the negative thermal effects. Building Volume Density (BVD) [building volume in m^3 of a 100m x 100m grid of land] – On the whole the building volume density of the study area is not high– when compare to the urban fabric to its north

(Figure 8.1). [For a site that occupies 100m x 100m, with a plot ratio of say 5, the BVD of the site will be about 150,000m^3].

8.3 Along Conduit Road, BVD is between 50,000 to 180,000 with an average of around 100,000m^3. North of Conduit Road and south of Bonham Road, BVD is around 120,000 to 180,000 with an average of around 140,000m^3. In all these cases, air ventilation is still needed to assure pedestrian thermal comfort given an average summer air temperature of 28 ºC in Hong Kong.

8.4 Ground Coverage Ratio [the ratio of total ground area (include roads and open spaces) and ground area covered by buildings and podiums in a 100m x 100m grid] – On the whole the ground coverage ratio of the study area is not high – when compare to the city fabric to its north (Figure 8.2); or say Mongkok or Causeway Bay. Along Conduit Road, the site coverage ratio is around 30-40%. Higher ground coverage of the study area is at the north of Robinson Road (40 to 60%) and also at the north of Magazine Gap Road.



Green 10-35%, Blue 36-55%, Red over 56%

Figure 8.2 Ground Coverage Ratio map of the study area, resolved to 100m x 100m grid.

8.5 Based on previous research works of CUHK, higher ground coverage in a city means lower air ventilation permeability on the whole. In these cases, roughly speaking, deep canyons perpendicular to the wind can only capture around 5 to 10% of the available site wind. Fortunately, at the moment, there are still many gaps between building towers, and many sites are without podiums. However, one must guard against increasing the site coverage, thus increase the ground coverage ratio. It is useful to specify non-building areas parallel to the critical summer wind.

8.6 Sections across the study area are shown in Figure 8.3, 8.4, 8.5 and 8.6. The deep canyons of buildings with narrow streets are obvious.

8.7 With wind from directions perpendicular to the canyons, downwashes due to differential building heights is unlikely. It is known that for long and deep canyons with an H/W ratio of 2 and above, a double vortex phenomenon will be observed (see Figure 9.1). For long and deep canyons with an H/W ratio of 5 and above, there will be little or no air ventilation at the pedestrian level due to winds moving above the urban canopy. In these cases, air ventilation will only pass through building gaps, streets parallel to the wind, and open spaces. Otherwise, air mass exchange will only be due to the local thermal differentials and diffusions, and buoyancy effects; they provide weak air ventilation to the otherwise stagnant zones near the ground.

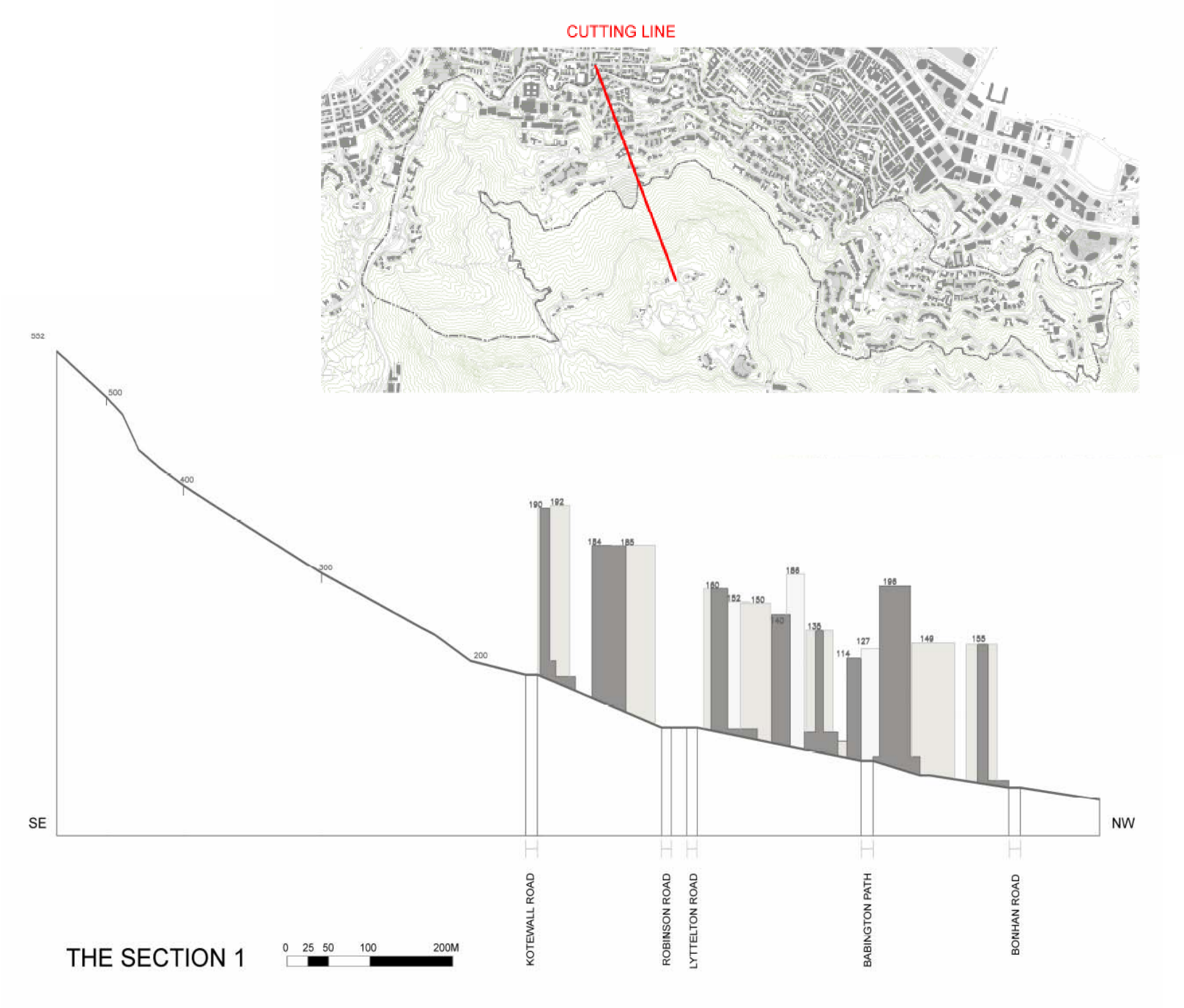


Figure 8.3 Section across t he study area.

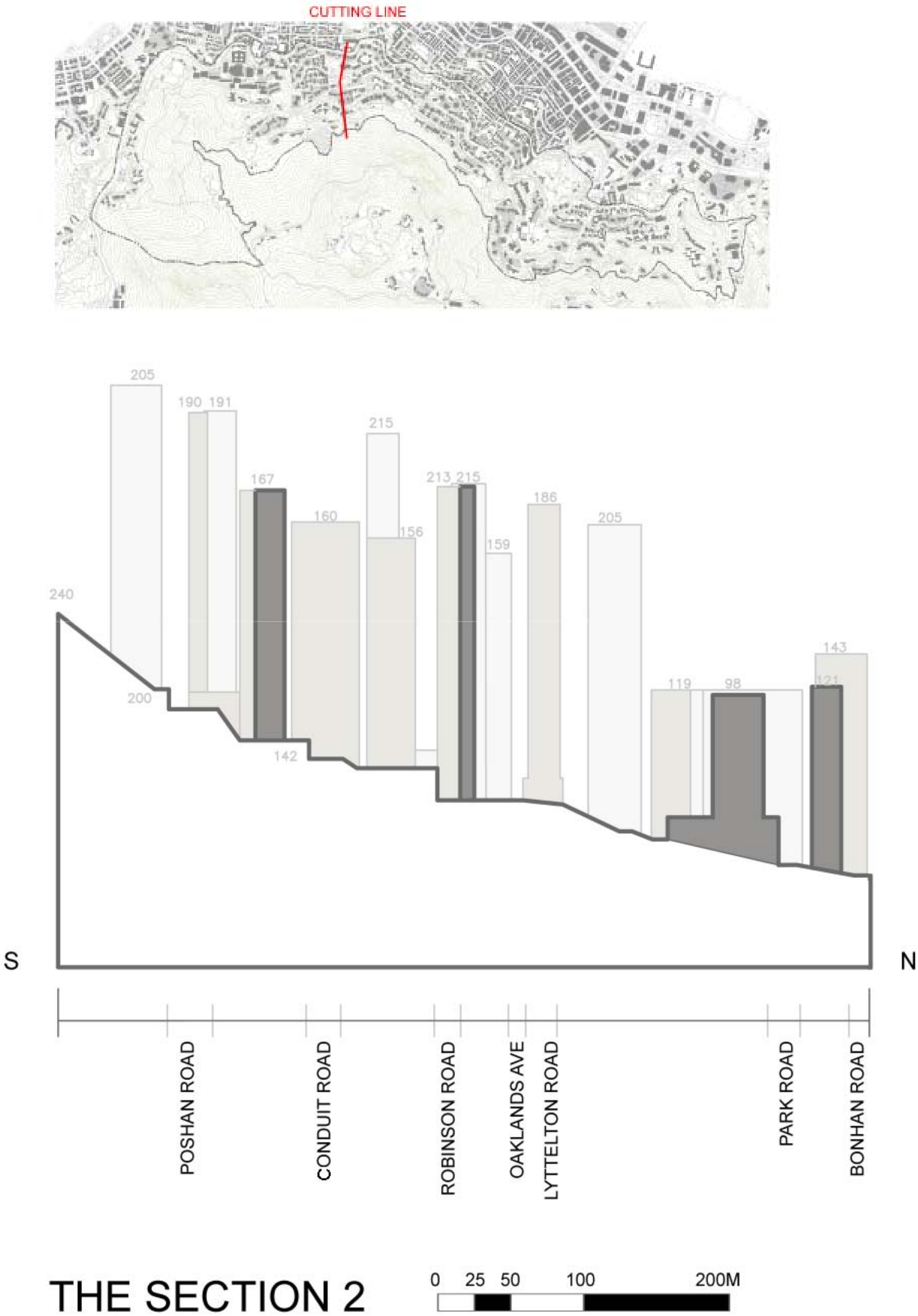


Figure 8.4 Section across the study area.

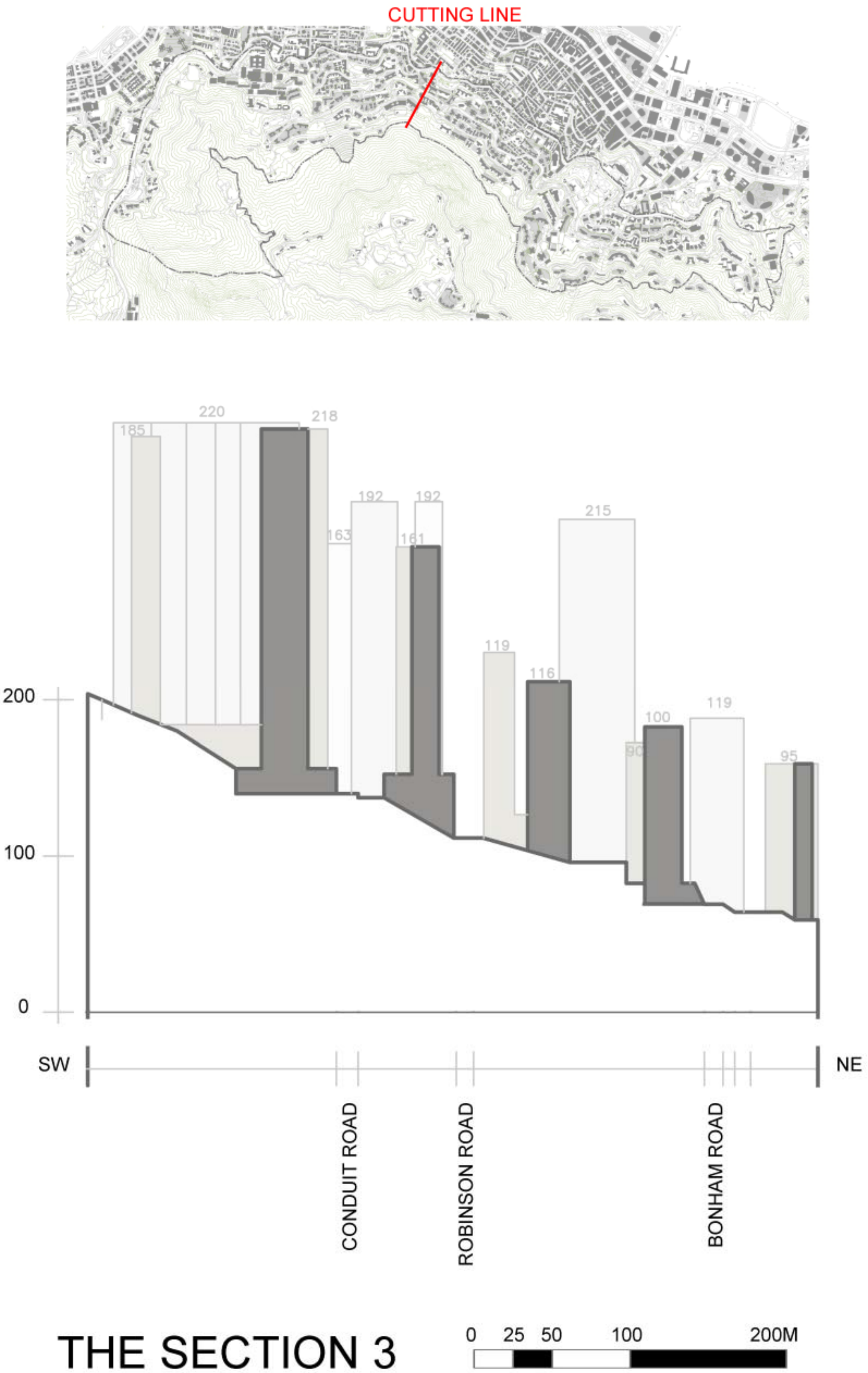


Figure 8.5 Section across the study area.

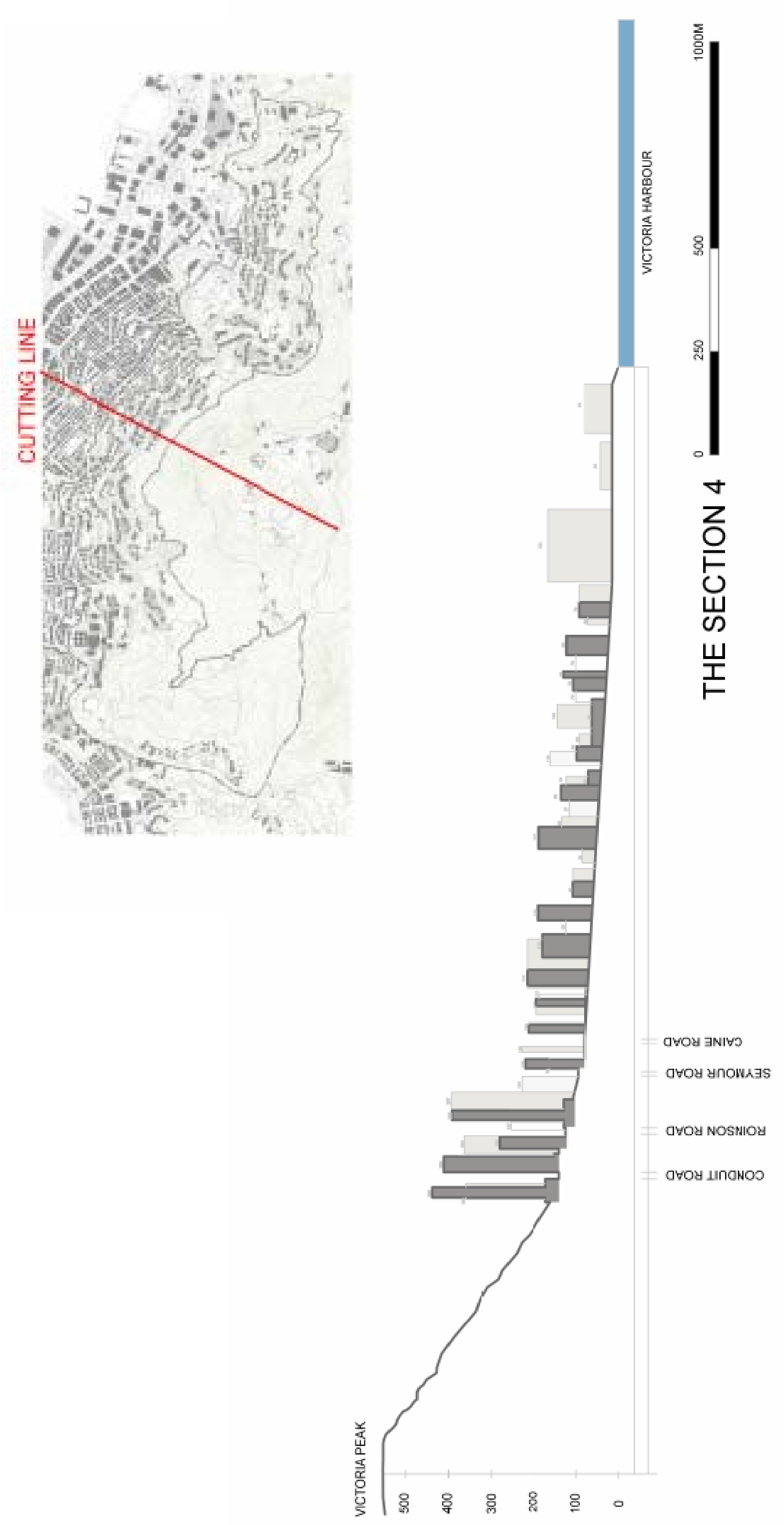


Figure 8.6 Section across the study area.

9.0 An Evaluation of the Existing AV conditions

9.1 There should be little, if any, critical AV issues at HKU and the areas west of it. The same can be said of the areas east of Borrett Road. These two areas have no tall buildings, and in general existing buildings are well spaced; and the ground well landscaped.

9.2 The air space over HKU provides useful air ventilation to the urban fabric to its north.

9.3 The vegetated hill slopes towards Sai Wan from Lung Fu Shan is useful to be respected. Buildings along Pok Fu lam Road needs to be well designed to allow permeability of the South-East to North-West air ventilation movements.

9.4 The areas east of HKU, south of Conduit Road and west of HKZBG should have little, if any, critical AV issues "themselves". This is due to their proximity to the greeneries on its south, in uphill area, and their lower density and spaced out building blocks. However, the areas at southern edge of the study area intercept the important summer and katabatic wind from the south. It is very important to ensure that buildings in these areas do not obstruct the wind too much. For example, a continuous "wall" of high rise buildings of say 200mPD will have a critical effect on AV of the urban fabric to its north. The consultant opines that the area is already "over-developed", adding further, tall and bulky buildings is not recommended. Should new developments of tall towers be considered in this area, the towers, being at the front and windward of the critical summer wind, should be well spaced. Podium should be restricted in coverage. Ground level should also be properly designed and landscaped to link up with the vegetation belt of the hills.

9.5 The areas east of HKU, north of Conduit Road and west of HKZBG are denser. The elevation of the areas descends from around 150mPD to around 50mPD. Air ventilation reduces as it moves towards Sheung Wan and Sai Ying Pun. The areas may have some AV issues. Currently, buildings in these areas are tall and most of them have limited gaps and spaces around them. There are tall towers. Some of them are over 40 storey high which cause an increase of the H/W ratio to 7:1 or even worse; thus creating very deep street canyons with poor air ventilation.

9.6 Currently, when wind comes from the East and North-East, the streets parallel to the wind are useful air paths; wind velocity ratio (VR) of around 0.1 can be expected. When wind comes from the south, most of the streets are perpendicular to the wind, the tall buildings form canyons; VR of around 0.05 can be expected. That is to say, only about 5% of the available wind of the site at the top of the boundary layer can be enjoyed by the pedestrian at 2m above ground – this is estimated to be on average in the order of 0.5m/s; hence, it is important to improve the air ventilation performance.

9.7 Like the areas mentioned in 9.4 above, the areas east of HKU, north of Conduit Road and west of HKZBG intercept the important summer and katabatic wind from the south. It is very important to ensure that buildings in these areas do not obstruct the wind too much as it moves towards Sheung Wan and Sai Ying Pun. Similar to the observation in 9.4, should new development of tall towers be considered in this area, the towers should be well separated. The ground should also be properly designed and landscaped with a view to linking up the vegetation belt of the hills. In general, it is not that advisable to increase the building bulk adding thermal capacity to the areas.

9.8 Given that the buildings in these areas are already tall, the street canyons are already deep, changing building heights a little bit one way or another would not matter that much – as, so to speak, "the damage is already there". For example, all else being equal, a street canyon of H/W of 3:1, 4:1 or 5:1 would have very similar air ventilation performance at ground level. In this case, the most effective way to improve air ventilation is to introduce building gaps.

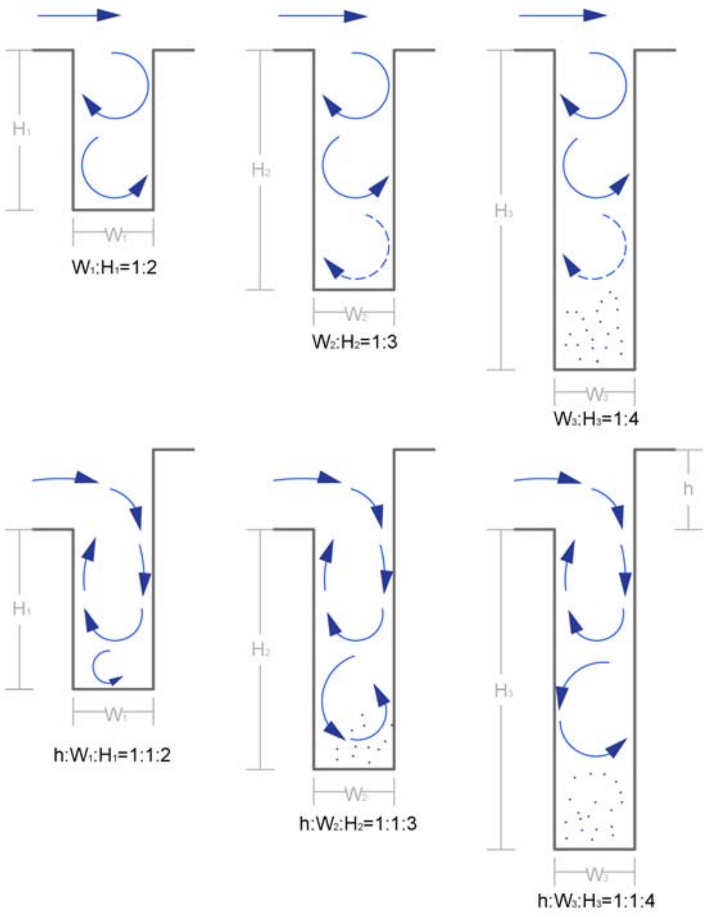


Figure 9.1 Wind regimes in canyons, and canyons with downwashes. Beyond a H/W ratio of 2:1, the ground level of canyons, even with the so call downwash effects, will have very weak eddies and air ventilation. *[Reference: A. KOVAR-PANSKUS, P. LOUKA, J.-F. SINI, E. SAVORY, M. CZECH, A. ABDELQARI, P. G. MESTAYER and N. TOY, INFLUENCE OF GEOMETRY ON THE MEAN FLOWWITHIN URBAN STREET CANYONS – A COMPARISON OFWIND TUNNEL EXPERIMENTS AND NUMERICAL SIMULATIONS, Water, Air, and Soil Pollution: Focus 2: 365–380, 2002, Kluwer Academic Publishers.]*

9.9 The two vegetated belts as identified in Figure 6.2 provides useful relieves to the area and the city fabric to the north. To capture the benefits, it is useful to keep and enhance them. There are unfortunately already a number of tall buildings in their ways.

9.10 The areas from Tregunter Path to HKZBG has little AV issues by themselves as the buildings are in general well spaced. As identified in paragraph 4.7, the area is a valley. Despite some tall buildings to its south, it provides a useful channel of air ventilation over the study area to Central District. Adding further bulky buildings parallel to the contours in the valley is not recommended. The existing air space above Canossa Hospital, Pacific Heights, Pine Court is a useful air path between the hills and HKZBG and must be respected. The open space surrounded by Old Peak Road, May Road and Brewin Path is a useful air path of the valley; this however has been compromised with tall buildings to its south; adding further buildings are not recommended.

9.11 The area east of HKZBG has in general mid-rise buildings. It should have little AV issues by themselves. The Tramway is a useful air ventilation channel. The air path along Borrett Road joins up with Hong Kong Park; it is useful. There are two noticeable air path connections over the low rise buildings on both sides of the Borret Road air path (refer to Figure 6.2, on both sides of D). The area where the EMSD building now stands is in a small valley. This small valley starts just outside the study area and continues towards Pacific Place; together with the air paths over the low buildings on the west of Borret Road, and the Borrett Road air path, they provide useful air ventilation to Pacific Place and Admiralty Transport Interchange.

9.12 All in all, it must be highlighted once again that the study area is between the vegetated hills to its south and the bulk of the urban fabric to its north. Its permeability linking the two is extremely important. The consultant opines that any planning decision has to respect this issue extremely carefully. Allowing further developments to this area may not be that problematic to each of the development's immediate AV, but collectively they would have a significant impact to the rest of the city. Due to the tall and dense buildings in the study area, it is already very difficult for the summer wind coming from the south moving into the urban fabric north of the study area.

9.13 To make a useful contribution to the air ventilation of the urban fabric to the north of the study area, it is very useful to have proper air paths; buildings of the study area must not be too high or too bulky adding roughness to the incoming winds; and given that some parts of the study area [refer to 0.4(a)] are already "over-developed", adding further buildings is not recommended and not desirable for air ventilation.

10.0 An Evaluation of AV conditions with "Potential Re-developments" and WITHOUT "proposed Building Height Restrictions"

10.1 A detailed AV assessment requires information beyond density, building heights and plot ratios. The information on building heights can provide only some general feeling. That is to say, high density city and tall buildings obviously will increase the roughness and reduce AV, but designing and positioning the buildings one way or another could either reduce the impact or worsen it – and the difference could be great. As such, building shapes, building disposition and position, gaps and permeability, are more important design parameters to optimize the AV performance.

10.2 Based on the information provided by Planning Department, it is anticipated that many sites in the study area will be re-developed up to the permitted intensity in the next 10 years or so with taller, larger and bulkier buildings, and with big podiums. The Building Volume Density as well as the site coverage will be increased. There is no precise project information, hence the exact AV impact is difficult to predict.

10.3 Suffice to suggest that referring to Figure 8.1, many "Green" coloured areas of BVD of 60-120K will be increased to "Blue" or even "Red". In addition, referring to Figure 8.2, a lot of low coverage "Green" areas will become high coverage "Red" areas. Furthermore, due to higher buildings, the Sky View will be reduced, the street canyons will be increased and existing gaps between buildings may be closed. All these changes will have an effect on pedestrian level thermal comfort and air ventilation permeability.

10.4 Based on the plan titled: Information on developments in R(C)6 zone of HKPA 11, and the summary of site coverage, the key area of focus is east of the Tramway. Buildings that are currently low rise (1-10 storeys) would be increased to around 20 storeys. As such, it is possible that the H/W ratio along McDonnell Road would be in the order of 4:1 or more (an increase from a comfortable – for AV – H/W of 1.5 or 2:1). A H/W ratio of 4:1 is a very deep canyon indeed. It is also very likely that the existing gaps between buildings would be fully obstructed by the podiums, hence most of the air paths between buildings would be gone, and AV potential at pedestrian levels is expected to be reduced.

10.5 Based on the plan titled: Information on developments in R(B) zone in H11, and the summary of site coverage, the key area of focus is the area east of HKU and west of Old Peak Road/Albany Road. A few isolated sites are around the Tramway. Many building that are currently a few storeys to 20 storeys could be re-developed. Based on the plot ratio of 5, they are expected to be increased to around 20 to 35 storeys. Buildings of around 80-90m high are expected. Given that the few roads, e.g. Lyttelton Road, Robinson Road and Conduit Road are narrow streets, a H/W ratio of 6:1 and more would be formed. A H/W ratio of 6:1 is a very deep canyon indeed. It is also very likely that the existing gaps between buildings would be fully obstructed by the podiums, hence most of the air paths between the existing buildings would be gone, and AV potential at pedestrian levels is expected to be seriously reduced.

10.6 Based on the plan titled: Information on developments in R(A) zone of HKPA11, and the summary of site coverage, the key area of focus is along Seymour Road. Many buildings that are currently a few storeys to 20 storeys could be re-developed. Based on the plot ratio of 8, they are expected to be increased to around 25 to 40 storeys. Buildings of around 100m or higher are expected. Given that Seymour Road is narrow, a H/W ratio of 8:1 and more would be formed. A H/W ratio of 8:1 is an extremely deep canyon indeed. It is also very likely that the existing gaps between buildings would be fully obstructed by the podiums, hence most of the air paths between the existing buildings would be gone, and AV potential at pedestrian levels is expected to be critically reduced.

10.7 Referring to the understanding above, a scenario with potential re-development fully executed could paint a pessimistic picture of the “to be air ventilation environment” of the study area. The consultant opines that the study area is already over-developed. Adding further buildings of the order described will add to the criticality of the problem, and is not recommended. If for some considerations other than air ventilation that they are allowed, proper planning and design control is extremely important.

10.8 To illustrate, consider a “worst case scenario” that three to four long lines of tall buildings of 30-40 storeys (or higher) with large podiums form a continuous wall like barrier between the hills and the urban fabric from Sai Ying Pun to Admiralty. Due to the layout of existing street patterns, these lines of tall buildings will be perpendicular to the critical summer wind from the south. These long lines of buildings would form very deep street canyons, even wind parallel to these deep canyons will find it difficult to pass through them and benefit the pedestrian levels. Furthermore, the buildings adds to the roughness, increase the thermal capacity, and block the wind. The probability of such a scenario should be avoided.

10.9 If “limited” re-development could be considered, a number of strategies should be borne in mind.

(i) The GIC, O and GB zones in the study area should be respected. They provide useful pockets of air spaces in the study area. They should not be further developed with tall buildings or re-zoned for bulkier development.
(ii) North-south orientated air paths should be provided by designating non-building areas. It is recommended that air paths be incorporated for each development.
(iii) The scale and size of the podium should be restricted. Permeability from ground to say 30m should be designed into the buildings. Properly perforated podiums provide useful air paths for air ventilation.
(iv) Towers must not be designed to occupy the full frontage of the site, especially the north-south direction. Appropriate gaps between the towers, and within the towers, must be provided to allow air ventilation through them.
(v) Greeneries and landscaping should be encouraged and enhanced. Existing trees must not be disturbed.

11.0 Evaluation of AV conditions with "Potential Re-developments" and WITH "Proposed Building Height Restrictions"

11.1 First of all, the consultant opines that, given the existing conditions of tall buildings, and the possibility of more taller and bulkier buildings of the study area, height restrictions may not be the most important consideration for air ventilation. The air ventilation in some denser part of the study area is already poor and will worsen still more due to the potential re-development, height restrictions itself is not the most effective measure to improve the air ventilation of the area.

11.2 As a principle, for air ventilation, a variation of building heights in close proximity is preferred as it can create pressure differences; and they can also encourage some downwashes, diffusions and mixing of air. The proposed height restrictions could take the above into consideration. Careful mixing of buildings with different heights in close proximity would allow that.

11.3 As a principle, for air ventilation, a tall building has a longer wind-wake (area behind the building that has lower air ventilation). The length of the wind-wake is normally taken as a few times (generally regarded to be around 1 to 4 times. Some researchers put it at 15 times) the height of the building. That is to say, a tall building affects more and further of its neighbours. On the other hand, a long and slab like building has a shorter but wider wind-wake. It affects very much its immediate neighbours. The worst case scenario for air ventilation is therefore a tall and wide building.

11.4 In general, given that there are developments of a certain density and building volume, for air ventilation, it is strategically advisable:

(a) to allow as much air space as possible for the development to maneuver flexibly. The result may be that some buildings will be taller, and others will be shorter and fatter;

(b) to designate non building areas parallel to the incoming prevailing winds, thus forming air paths. In general, setting aside 30% of the site width for non-building area is a good starting point;

(c) to perforate the building towers and the podium, especially at the lower level (say ground to 30m), so that useful AV could be optimized at the pedestrian level; and

(d) to maximize greeneries.

11.5 With and without the building height control, it is anticipated that developers will still build their podiums. The lower portion of the development typically impacts more on the pedestrian level AV performance – it is actually more important to control this.

11.6 Stringent height control could adversely result in lower but fatter slab like building. More of the ground floor space would be occupied hence increasing the site coverage, which is an important indicator of air ventilation performance. It is important that a proposal of height restrictions do not adversely impact the air ventilation performance. The basic understanding is that when building heights are controlled, developers may need to build buildings that occupy more of the ground increasing the very important site coverage. In practice, the understanding above may not be entirely correct as developers typically would position their buildings to maximize the site frontage anyway. A shorter and larger building will only add to the depth of the buildings (Figure 11.1). For the study area, the summer wind comes from the south, the frontage of buildings are perpendicular to the wind. Adding further depth to the buildings does not impact too much the air ventilation.

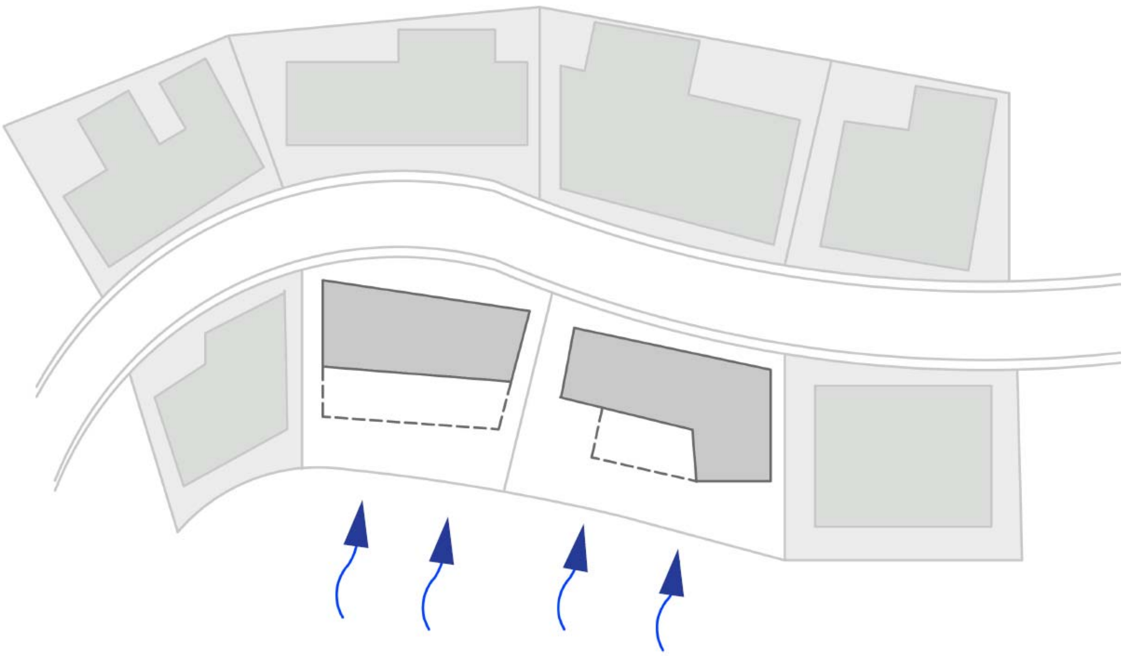


Figure 11.1 With wind coming perpendicular to the street, adding further depth (dotted lines) to a building occupying the full frontage of the street does not impact too much the AV performance.

11.7 Due to the high building height to street width ratio (H/W) of 3:1 and more in the study area, in general, building height control is NOT the most effective planning strategy for securing good city air ventilation at pedestrian level. [For it to be effective, the H/W ratio of less than 2:1 is a pre-requisite.] Designing air ventilation not from above the buildings, but from the sides is a useful strategy. The provision of connected Air Paths, Open Spaces, and Green Belts is far more effective strategy to improve air ventilation at the pedestrian levels.

12.0 Assessment of Wind Performance for Proposed Height Restrictions under the Recommended Scenario

12.1 In response to the recommendations of the AVA expert evaluation, the proposed building height restrictions (Figure 11.2) under the Recommended Scenario have taken the following air ventilation issues into consideration:

(i) Where there are already development restrictions (site coverage, plot ratio and building height restrictions, and so on), they are not relaxed.

(ii) The valley air path that leads to Tregunter Path has been considered as much as practically possible.

(iii) The 4 existing vegetated belts across the study area have been considered as much as practically possible.

(iv) All open spaces/green area are maintained and height of G/IC facilities are restricted to the existing height.

(v) The area to east of the tram way has been kept as low as possible to maintain the low-rise character of the area and an open view to Hong Kong Park.

(vi) A lower height band has been proposed along the Caine Road /Kennedy Road. A stepped height concept with progressive increase towards uphill directions has been adopted. A narrower height band has been proposed taken the topography into consideration

(vii) Buildings along the green corridor to east of HKU has been kept as low as possible to maintain the open view and for better ventilation

12.2 It seems that the proposed height restrictions are not overtly tight. That is to say, within the allowable maximum heights, building designers have some design flexibility. Hence, the proposed height restrictions do not limit the possibility of introducing building gaps and permeability to optimize air ventilation.

12.3 The consultant's understanding of the implication of the proposed building height restrictions as above is made based on the assumption that the potential re-development will happen anyway. Based on this "the damage has been done" basis, it is unlikely that the proposed building restrictions in itself would make any difference one way or another to the possibility of poor performance of air ventilation in the denser part of the study area. Nonetheless, the proposed building height restrictions under the Recommended Scenario as in Figure 12.1 have taken into account, as far as practically possible and within the limit of only considering building height itself, suggestions of the AVA expert evaluation.

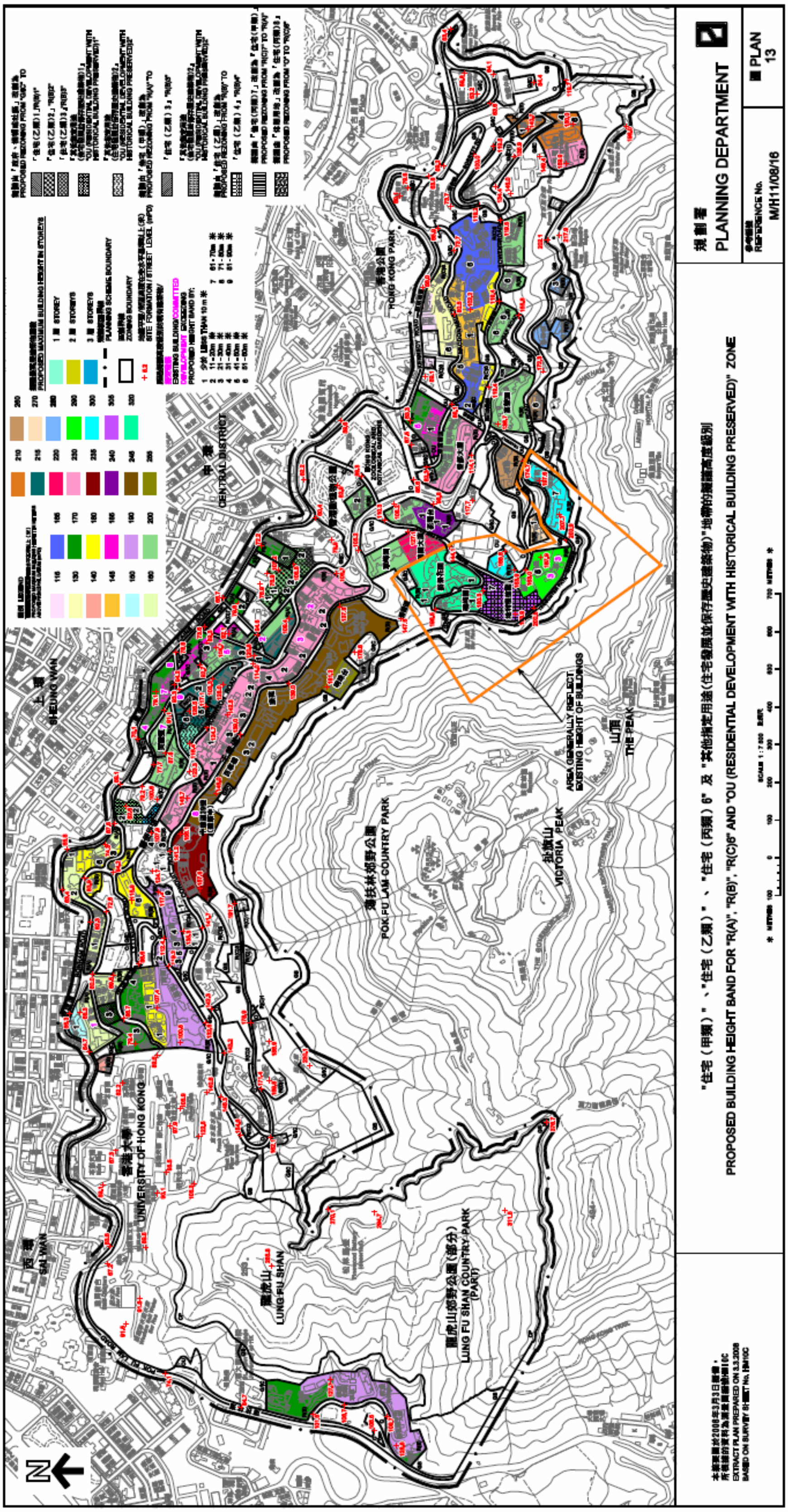


Figure 12.1 The study area with proposed building height restrictions under the Recommended Scenario.

13.0 Further and Key Recommendations

13.1 The study area is the "gateway" of air ventilation in the summer to the city of its north. Hence it is strategically important. The consultant opines that many sites of the study area are already "over-developed", and air ventilation through it to the city of its north is already restricted. Therefore, in general, further development adding taller and bulkier buildings and podiums to the study area is not desirable.

13.2 For air ventilation, the proposed building height restrictions may be considered a "small" step towards the goal. It is important to further carry out studies with a view to establishing guidelines and stipulating restrictions on the more important design parameters like Open Space, Air Paths, Site Coverage and Non-building Area, and so on. Without these further measures, air ventilation of the study area and its contributions to its neighbours cannot be secured.

13.3 An understanding of the concept of canyon may help designers making some design decisions as to the position of the towers. This understanding is particularly useful for lots for say on Conduit Road. To optimize air ventilation, the H/W ratio of 2:1 is a useful rule of thumb. Referring to Figure 12.1, designer of the lot on the left has the option of position his tower (at A or at B) in his lot to retain the H/W ratio and to adjust the building height of the tower accordingly. This understanding is more difficult for lots with streets on both sides.

14.0 Focus Areas and Further Studies

14.1 Given the "damage has been done" basis when taking into account the re-development potentials, the consultant opines that there would unlikely to be a lot of difference between the air ventilation performance "with" and "without" the proposed building height restrictions. Further AVA studies comparing the "with" and "without" options may not be necessary or even beneficial as it is not possible to specify the more important parameters (e.g. building geometry and block disposition within each of the building sites) in the tests.

14.2 Should any further studies of AVA be needed beyond the consideration of height control restrictions and 12.2 above be OPTIONALLY considered, it may be useful to test parametrically at least the following:

(i) as existing; and

(ii) with potential re-developments and height restrictions, and with:

option 1: "wall-like" towers and 100% podiums (worse case scenario)

option 2: towers with gaps and 100% podiums (optimum scenario) option 3: towers with gaps, no building area, perforated buildings (best scenario)

The focus area should be the strip of the study area from the east of HKU to the west of HKBZG.

Option 1 and option 3 should be tested first to establish the scales. Option 2 could then be meaningfully and realistically designed, and then tested.

The key methodology of HPLB and ETWB Technical Circular no. 1/06 for Initial Studies and Detail Studies could be followed.

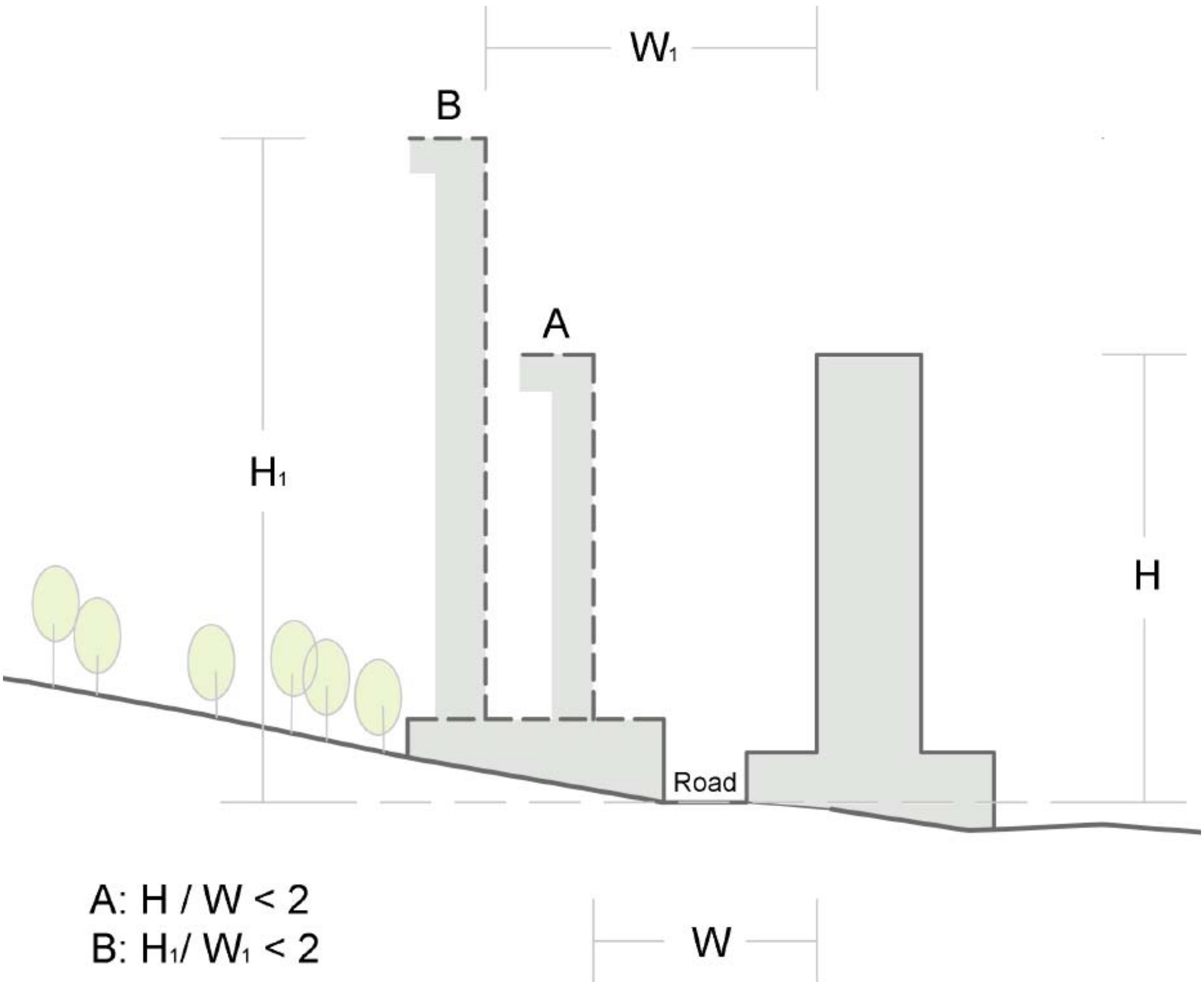


Figure 12.1 An understanding of canyon geometry, position of tower and tower height. The H_1/W_1 arrangement is particularly beneficial when wind is from Right to Left.

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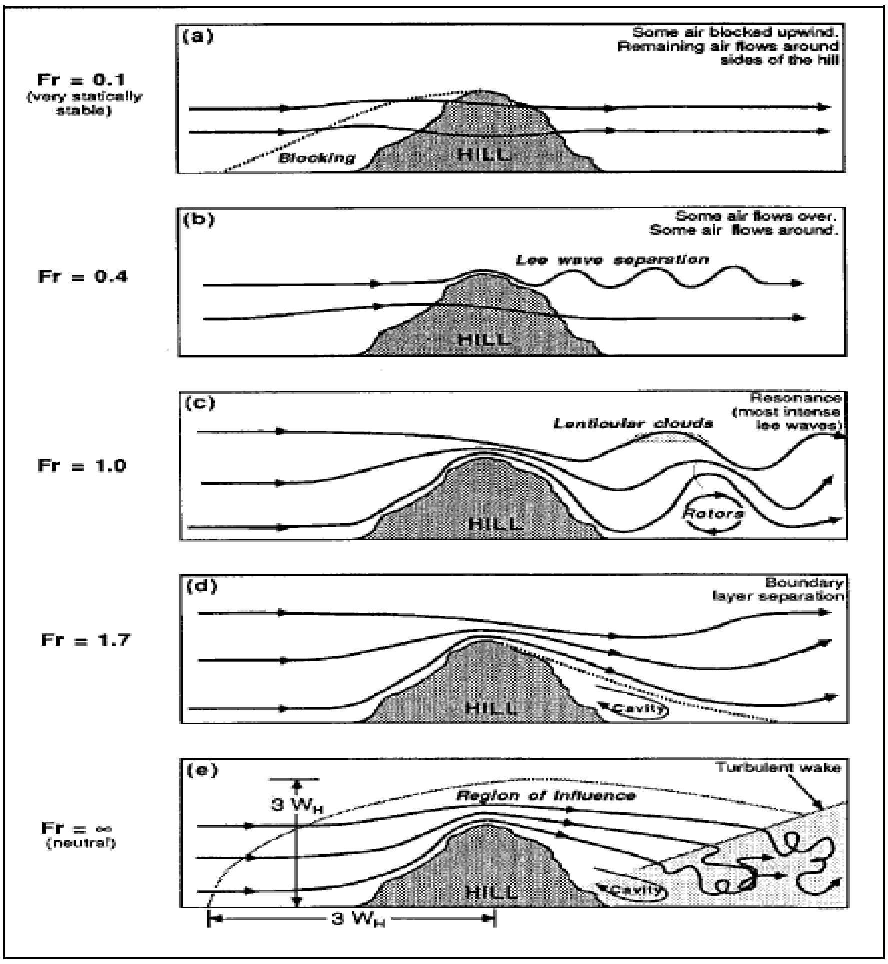
Professor Edward Ng
On behalf of technical experts in the term consultant term

Department of Architecture, CUHK,
Shatin, NT, Hong Kong
T: 26096515 F:26035267
E: edwardng@cuhk.edu.hk

Consultant team

	Expertise
Professor Edward Ng (Coordinator) CUHK, Hong Kong	Architect, Environmental and sustainable studies
Miss Betty Ho	Planner,
Mr K S Wong	Architect,
Professor Jimmy Chi-Hung Fung HKUST, Hong Kong	Mathematician, Meso-scale wind field modeling, CFD

Appendix A: Wind over a small 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) $$F_r^2 = \frac{\text{Inertial forces}}{\text{Bouyant forces}} \qquad F_r^2 = \frac{\bar{u}_0^2/W_h}{g\Delta\theta/\theta_0}$$

The inertial forces (order $\bar{u}_0^2/W_h$) act in the horizontal direction along the wind flow, and the buoyant forces (order $g\frac{\Delta\theta}{\theta_0}$ where $\Delta\theta$ 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.]