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By e-mail
17 October 2022

NSW DPE
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Our ref 286355

Bays West Precinct Development – Environmental Wind Assessment Review

Dear Lachlan,

Arup has prepared this qualitative environmental wind assessment review of the Bays West, White Bay Power Station (Metro) and Roberts Street Sub-Precincts Masterplan (herein referred to 'Bays West precinct') on behalf of NSW Department of Planning and Environment (DPE) detailing the expected impact of the proposed development on the wind conditions in and around the site.

At this stage of the planning process, a qualitative review of the Master Plan and Rezoning for the White Bay Power precinct – Proof of Concept prepared by Cox (19 July 2022) has been undertaken to determine if the precinct could support residential development in relation to the environmental wind conditions. As the wind conditions are only dependent on the building geometry, this report is applicable to any building. The proposed building massing across the would be considered suitable for residential or commercial development from a wind comfort and safety perspective.

Project overview

The Bays West Precinct is located to the west of Sydney Central Business District (CBD), situated north to the ANZAC bridge, east of Victoria Road, and west of Glebe Island and White Bay Ports, Figure 1. The proposed Masterplan includes a range of commercial, retail, recreational, and cultural uses as shown in Figure 2 with the residential area highlight in red.

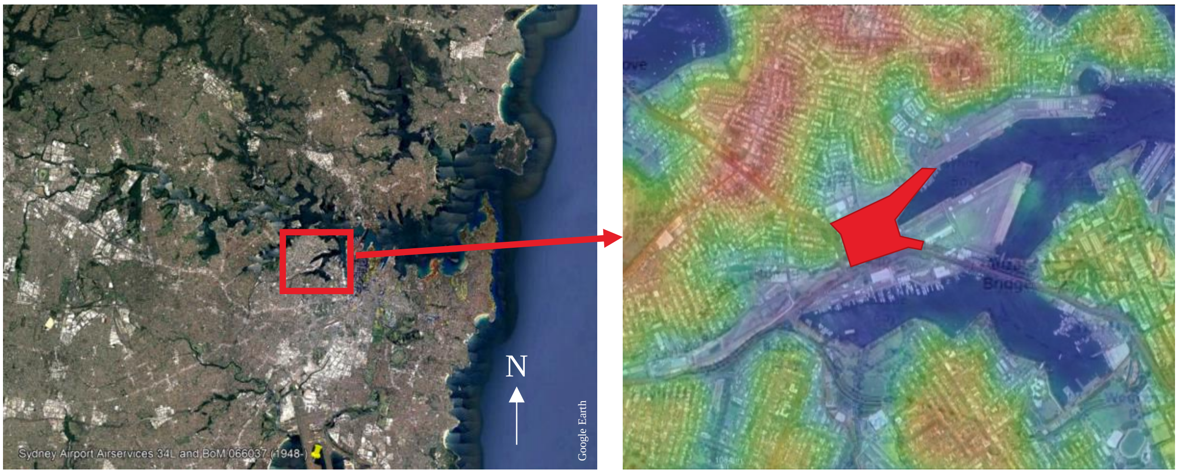

Figure 1: Site location showing local topography

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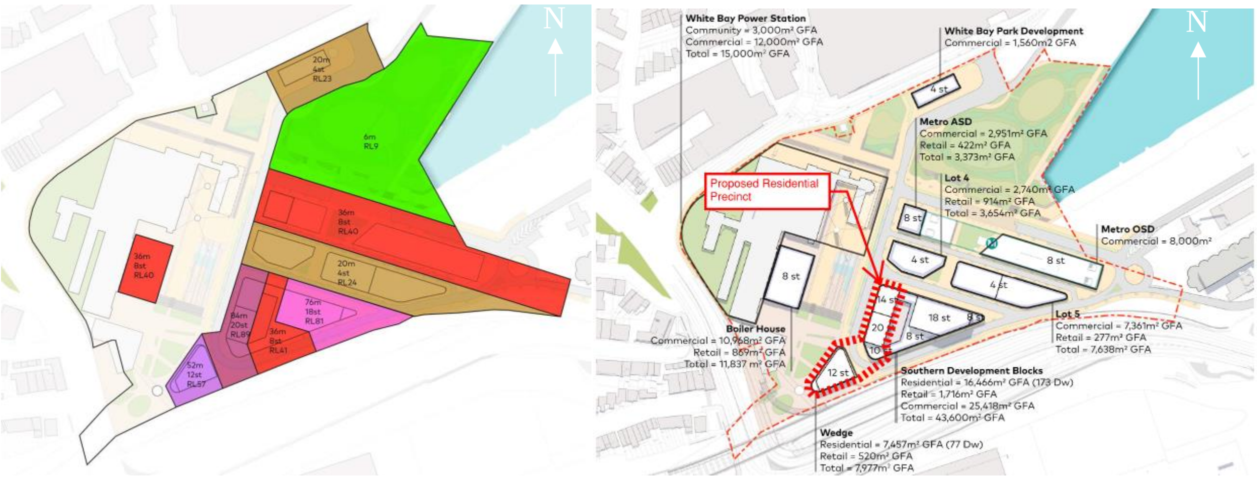

Figure 2: Building height zoning (L) and potential layout with proposed location of residential usage (R)

Wind climate

The wind frequency and direction information measured by the Bureau of Meteorology anemometer at a standard height of 10 m at Sydney Airport from 1995 to 2020 is presented in Figure 3. The arms of the wind rose point in the direction from where the wind is coming from. The anemometer is located about 10 km to the south of the site, Figure 1. The directional wind speeds measured here are considered more representative of the incident wind conditions at the site compared with closer anemometers that are significantly affected by surrounding buildings.

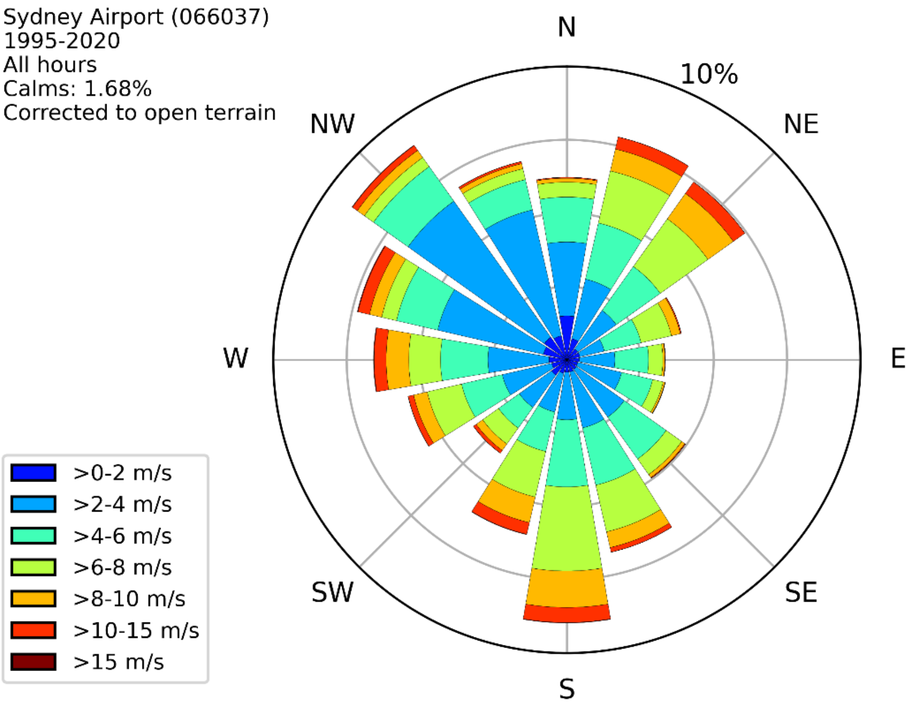

Figure 3: Wind rose showing probability of time of wind direction and speed

It is evident from Figure 3 that strong prevailing winds are organised into three main groups which centre at about the north-east, south, and west quadrants. These wind directions are important for safety considerations.

Strong summer winds occur mainly from the south and north-east quadrants. Winds from the south are associated with large synoptic frontal systems and generally provide the strongest gusts during summer. Moderate intensity winds from the north-east tend to bring cooling relief on hot summer afternoons typically lasting from noon to dusk. These are small-scale temperature driven effects; the larger the temperature differential between land and sea, the stronger the wind.

Winter and early spring strong winds typically occur from the south-west and west quadrants. West quadrant winds provide the strongest winds affecting the area throughout the year and tend to be associated with large scale synoptic events that can be hot or cold depending on inland conditions.

The local Balmain peninsula topography, Figure 1, channels winds from the north-east through White Bay, while offering some protection to winds from the west. Winds from the south are relatively unaffected by topography, with a slight funnelling of wind between the Glebe and Annandale ridges.

Basic Flow Principles

A summary of wind flow mechanisms is presented in Appendix 1. To minimise wind issues for any isolated major development it is preferable to sculpt the skylike like a rounded hill from the prevailing wind directions, rather than construct tall buildings on the perimeter of the site, which then act as a cliff accelerating the flow down and around the windward corners. For an exposed compact and linear site in a mixed wind climate, this can be problematic and an appreciation of the relationship between expected outdoor microclimate and the intended use of the ground plane in and around the site is necessary to develop a fit for purpose development.

Skewing the street alignment with prevailing wind directions is a benefit to avoid channelled flow.

Wind assessment

Pedestrian safety is the main priority during the initial design of any development, local comfort can generally be improved during detailed design with appropriate local amelioration. The proposed Masterplan showing the building height layout is presented in Figure 2. The design excellence and sustainability bonuses allow for an additional 5-storey in height to the towers in the south-west precinct, Figure 4. Generally, the taller the buildings, the greater the impact on the ground plane wind conditions, with a 5-storey increase in height introducing a measurable impact. The intended use of the space across the development is illustrated in Figure 5.

The building axis layout is generally offset from the prevailing strong wind direction, which is a benefit for the design to reduce the amount of channelled flow.

In terms of pedestrian safety, the low-rise buildings are of less concern as any downwash or accelerated flow along the length of a building, or group of buildings, can be more readily ameliorated with local treatments during detailed design. The area of taller buildings to the south-west has a greater impact on the local wind environment. It is considered possible to develop a building massing layout satisfying wind safety considerations by keeping the taller buildings away from pedestrian thoroughfares and rounding the exterior corners of the buildings. The taller the buildings, the more wind engineering treatments would be required to ensure a safe and comfortable environment.

Figure 4: Additional height allowance with design excellence and sustainability bonuses

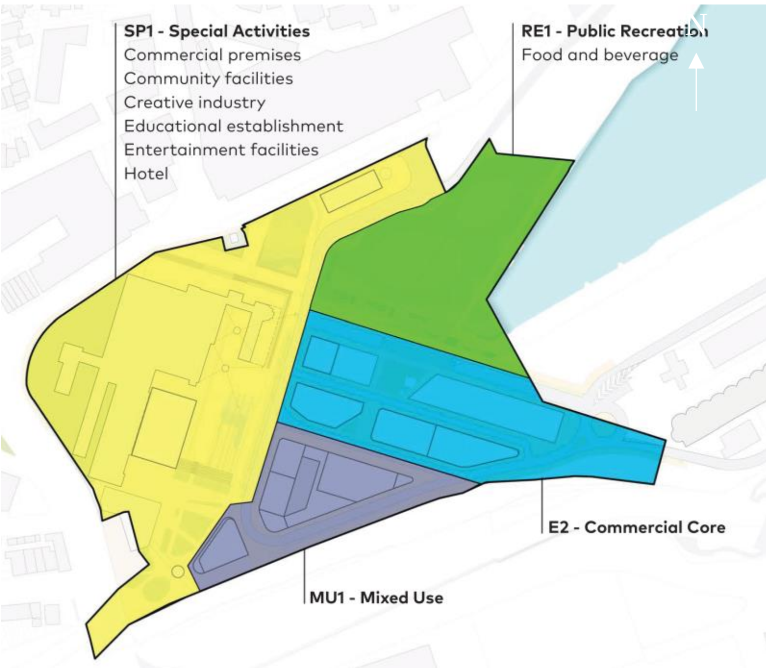

Figure 5: Public domain usage

The following sections discuss the wind conditions around the potential building layout proposed in Figure 2(R)

Winds from the north-east

Winds from the north-east are channelled across White Bay impinging on the north façade of the commercial 8-storey buildings. The flow would be directed to the north-west, through the open space adjacent to the Metro station, and over the roofs of the adjacent 4-storey buildings. The misalignment of wind direction to the building orientation, and sunken nature of the precinct to this incident wind direction, would encourage more flow over the roofs. The flow would therefore be encouraged to lift over the taller buildings to the south of the site rather than induce downwash. The taller the buildings, the greater the amount of downwash that would be directed to ground level. The orientation of the taller buildings is beneficial with the façade skewed to the prevailing wind, which would encourage the flow to pass horizontally around the tower rather than inducing downwash. The back-pressure from these tall buildings would be expected to create relatively calm conditions to the north-east and reduce the speed of flow between the 4-storey buildings. Ideally the rows of 4- and 8-storey buildings would be switched with the lower buildings on the fringe of the precinct. However it is noted that the location of the 8-storey buildings is dictated by the future metro station.

Winds from the south

Winds from the south are uninterrupted on reaching the site and would impinge on the south face of the taller buildings. The stepped nature of the buildings, with the lower heights on the corner of the block is a good design feature to reduce the amount of downwash reaching ground level. Windy conditions would be expected around the southern corners of the taller buildings and between the 12-storey satellite building to the west. Generally, the taller the buildings, the faster the ground level wind conditions. The use of the southern area around the taller buildings in the south-west precinct would be more suited to transient rather than sedentary activities.

Winds from the west

The local topography and existing White Bay Power station offer some wind protection to the site particularly in the open north-east quadrant. The taller group of buildings to the south are skewed to the incident flow thereby encouraging horizontal flow rather than downwash. Regardless, tall buildings without a podium setback will induce a component of downwash, particularly for flow more normal to the façade. Windy conditions can be expected around the western corners of the taller south-west block.

Summary

With appropriate architectural design of the buildings with the prevailing wind conditions in mind, such as orientation of buildings, tapering the buildings with height and/or rounding the outer corners perimeter buildings. The wind conditions around the site massing would be expected to produce suitable wind conditions for the proposed intended use of the space across the precinct. Stronger conditions would be expected around building corners with calmer conditions towards the middle of the building faces.

Future wind methodology

As the design progresses, it would be recommended to conduct physical or numerical modelling to quantify the impact of the proposed development on the wind environment and to assist in guiding the building layout and orientation in the zoning envelopes, and to target the design requirements in the public realm.

The wind conditions for pedestrian comfort and safety should be compared against suitable criteria. It would be recommended to adopt similar criteria to those used by the City of Sydney as outlined in Table 1: where the wind climate should be assessed between 6 am and 10 pm local time, and the gust equivalent mean (GEM) is equal to the 3 s gust wind speed divided by 1.85.

Table 1 Pedestrian comfort criteria for various activities

Comfort (max. of hourly mean or GEM wind speed exceeded 5% of the time)	
<2 m/s	Dining
2-4 m/s	Sitting
4-6 m/s	Standing
6-8 m/s	Walking
8-10 m/s	Waterfront
>10 m/s	Unacceptable
Safety (max. 0.5 s gust wind speed in an hour, for 0.0171% of the time)	
<28 m/s	Pass
>28 m/s	Fail

I hope this is of assistance, please do not hesitate to contact me on numbers below if you have any questions regarding any aspect of this report.

Yours sincerely

Graeme Wood
Associate Principal

Appendix 1: Wind flow mechanisms

An urban environment generates a complex wind flow pattern around closely spaced structures, hence it is exceptionally difficult to generalise the flow mechanisms and impact of specific buildings as the flow is generated by the entire surrounds. However, it is best to start with an understanding of the basic flow mechanisms around an isolated structure.

Isolated building

When the wind hits an isolated building, the wind is decelerated on the windward face generating an area of high pressure, Figure 6, with the highest pressure at the stagnation point at about two thirds of the height of the building. The higher pressure bubble extends a distance from the building face of about half the building height or width, whichever is lower. The flow is then accelerated down and around the windward corners to areas of lower pressure, Figure 6. This flow mechanism is called **downwash** and causes the windiest conditions at ground level on the windward corners and along the sides of the building.

Rounding the building corners or chamfering the edges reduces downwash by encouraging the flow to go around the building at higher levels. However, concave curving of the windward face can increase the amount of downwash. Depending on the orientation and isolation of the building, uncomfortable downwash can be experienced on buildings of greater than about 6-storeys.

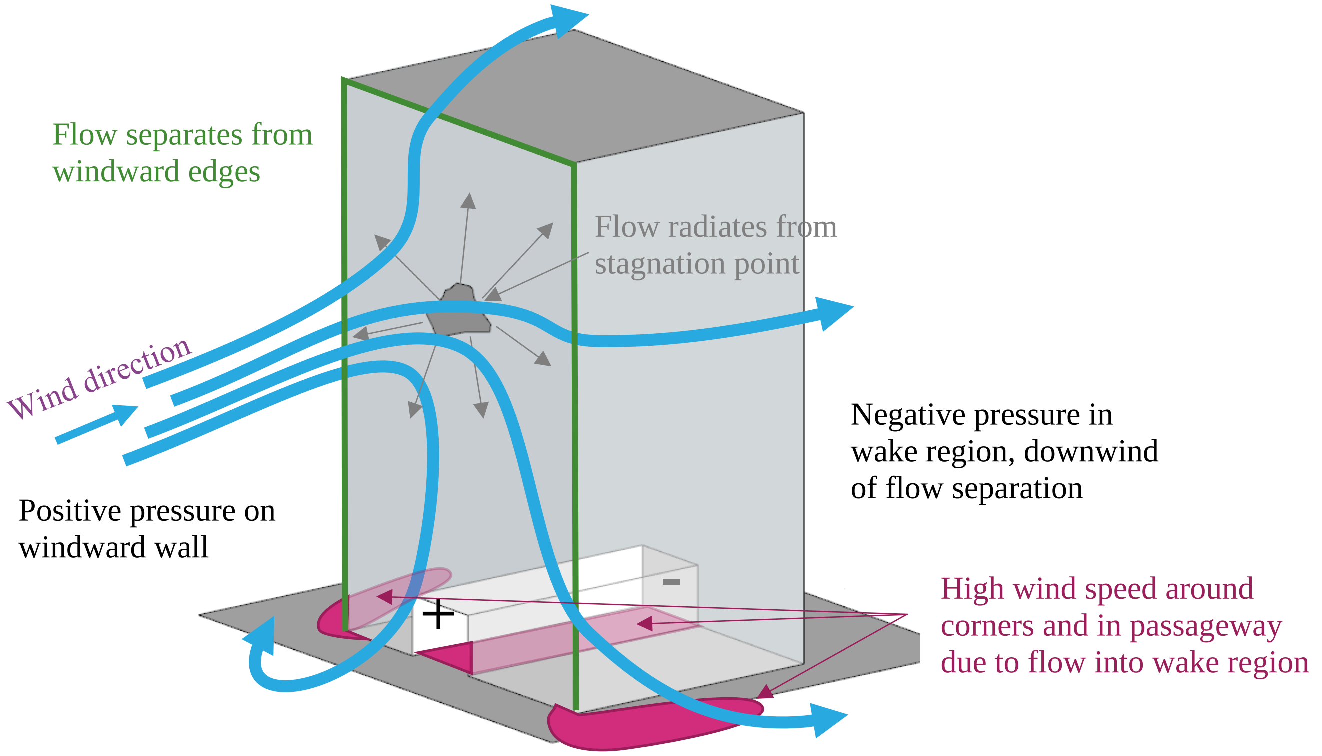

Figure 6 Schematic wind flow around tall isolated building

Techniques to mitigate the effects of downwash winds at ground level include the provision of horizontal elements, the most effective being a podium to divert the downward flow away from pavements and building entrances, however this will generate windy conditions on the podium roof, Figure 7. Generally, the lower the podium roof and greater the tower setback from the podium edge improves the ground level wind conditions. The provision of an 8 m setback on an isolated building is generally sufficient to improve ground level conditions, but is highly dependent on the building isolation, orientation to prevailing wind directions, shape and width of the building, and any plan form changes at higher level.

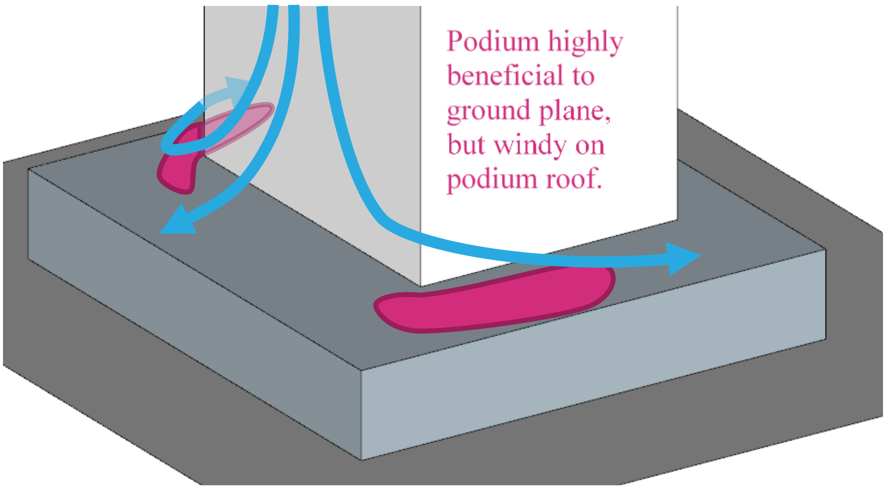

Figure 7 Schematic flow pattern around building with podium

Awnings along street frontages perform a similar function as a podium, and generally the larger the horizontal projection from the façade, the more effective it will be in diverting downwash flow, Figure 8. Awnings become less effective if they are not continuous along the entire façade, or on wide buildings as the positive pressure bubble extends beyond the awning resulting in horizontal flow under the awning.

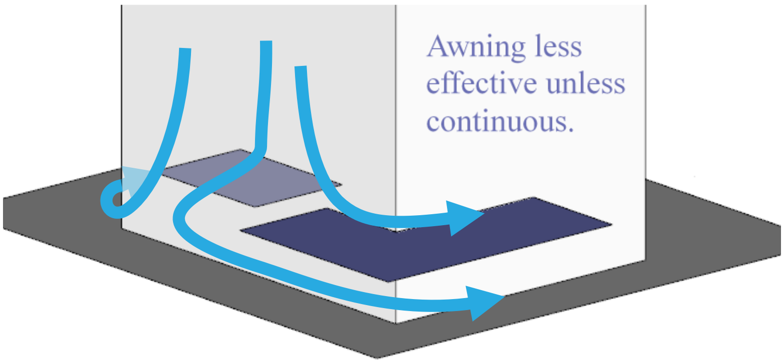

Figure 8 Schematic flow pattern around building with awning

It should be noted that colonnades at the base of a building with no podium generally create augmented windy conditions at the corners due to an increase in the pressure differential, Figure 9. Similarly, open through-site links through a building cause wind issues as the environment tries to equilibrate the pressure generated at the entrances to the link, Figure 6. If the link is blocked, wind conditions will be calm unless there is a flow path through the building, Figure 10. This area is in a region of high pressure and therefore the is the potential for internal flow issues. A ground level recessed corner has a similar effect as an undercroft, resulting in windier conditions, Figure 10.

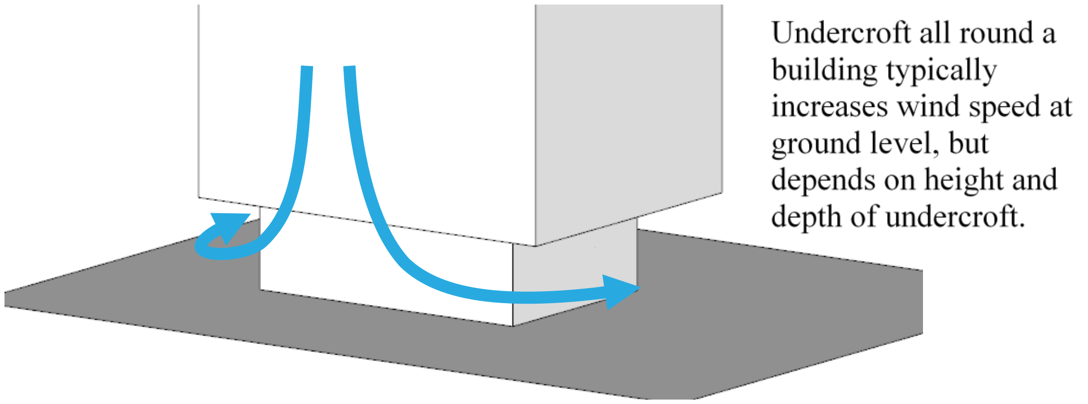

Figure 9 Schematic of flow patterns around isolated building with undercroft

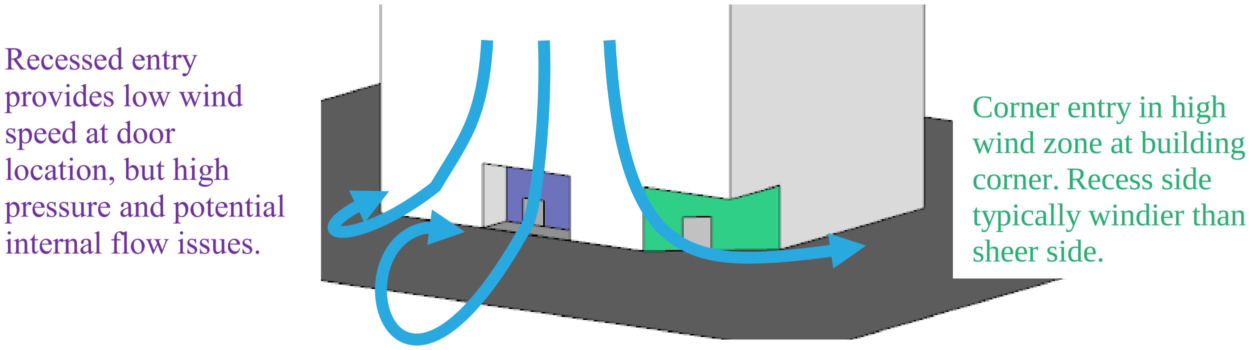

Figure 10 Schematic of flow patterns around isolated building with ground articulation

Multiple buildings

When a building is located in a city environment, depending on upwind buildings, the interference effects may be positive or negative, Figure 11. If the building is taller, more of the wind impacting on the exposed section of the building is likely to be drawn to ground level by the increase in height of the stagnation point, and the additional negative pressure induced at the base. If the upwind buildings are of similar height then the pressure around the building will be more uniform hence downwash is typically reduced with the flow passing over the buildings.

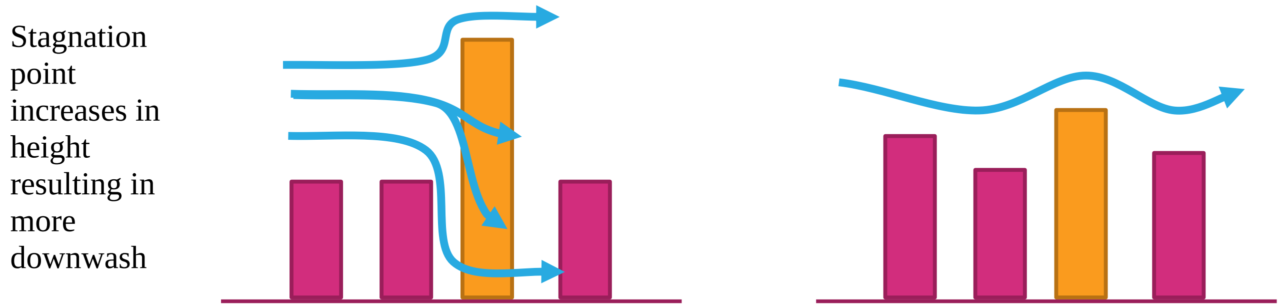

Figure 11 Schematic of flow pattern interference from surrounding buildings

The above discussion becomes more complex when three-dimensional effects are considered, both with orientation and staggering of buildings, and incident wind direction, Figure 12.

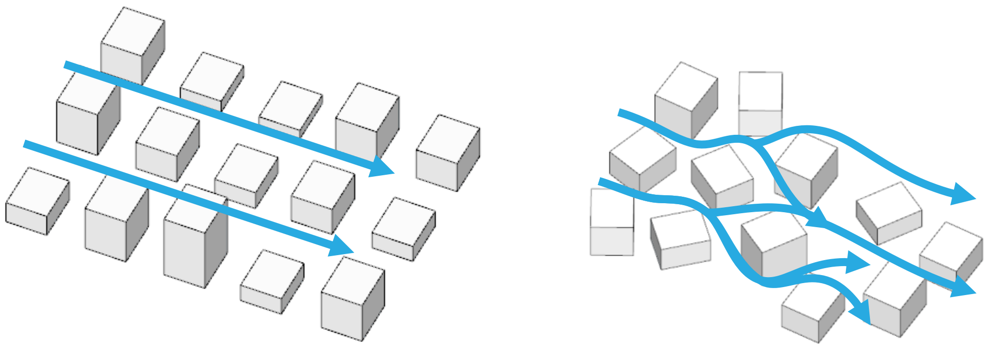

Figure 12 Schematic of flow patterns through a grid and random street layout

Channelling occurs when the wind is accelerated between two buildings, or along straight streets with buildings on either side, Figure 12(L), particularly on the edge of built-up areas where the approaching flow is diverted around the city massing and channelled along the fringe by a relatively continuous wall of building facades. This is generally the primary mechanism driving the wind conditions for this perimeter of a built-up area, particularly on corners, which are exposed to multiple wind directions. The perimeter edge zone in a built-up area is typically about two blocks deep. Downwash is more important flow mechanism for the edge zone of a built-up area with buildings of similar height.

As the city expands, the central section of the city typically becomes calmer, particularly if the grid pattern of the streets is discontinued, Figure 12(R). When buildings are located on the corner of a central city block, the geometry becomes slightly more important with respect to the local wind environment.

The general flow pattern around an isolated line of buildings is presented in Figure 13, showing wind accelerated down and around the windward corners of the overall compound shape. This flow mechanism is called downwash. With a wall of tall buildings, pressure driven flow is generated between the buildings and is generally horizontal with a smaller component of downwash close to the windward end of the opening. The vertical component in pressure driven flow is lower than downwash flow.

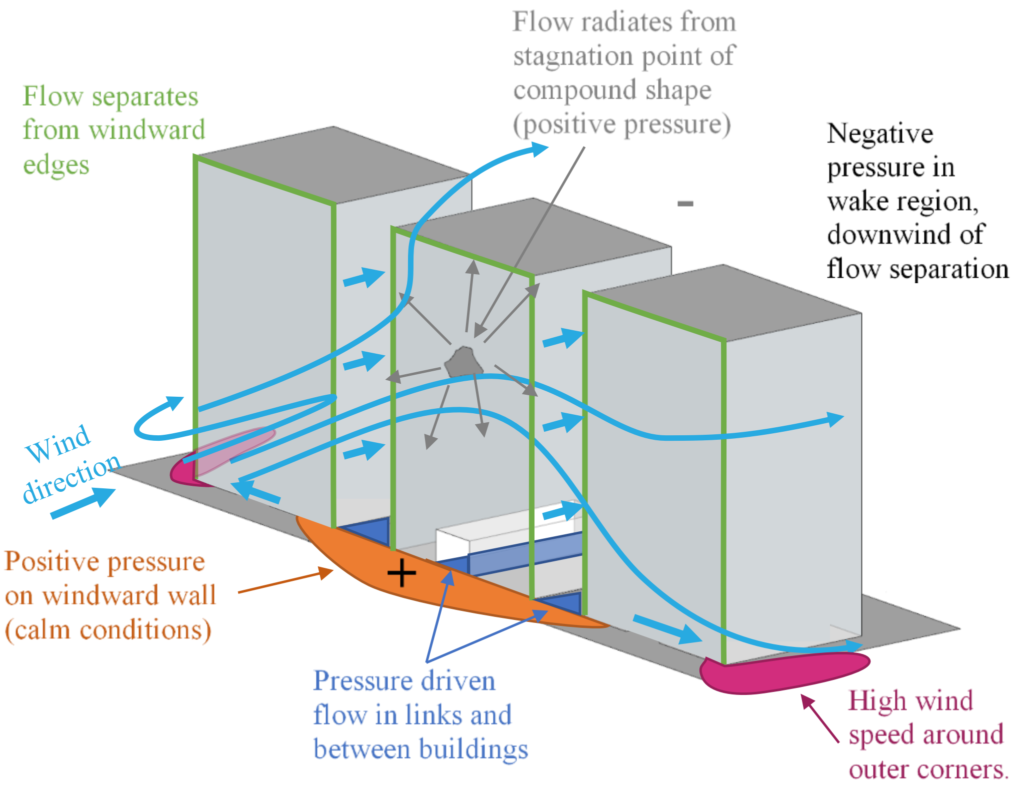

Figure 13: General flow pattern around multiple buildings