# Interrogating Urban Renewal Scenarios Using Skyline Analysis in Fishermans Bend, Melbourne

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Abstract: Cities are often abstracted through their skylines. They reflect the interactions between historical, social, cultural, and economic forces in their societies (GASSNER 2009). As the skylines of many Australian cities continue to be shaped by urban renewal master plans, planning restrictions define the visual properties of such urban landscapes. In this paper, we take Fishermans Bend in Melbourne as a case study and propose a workflow that allows designers to test scenarios that incorporate variable bulk and height of future built forms. This is accomplished by reconstituting Google Earth 3D building information into photometric point cloud datasets, in order to measure and analyse visual and environmental impacts of future developments. We interrogated three urban renewal scenarios against existing conditions through the following skyline variations, 1) approved applications to be constructed, 2) suggested development application, and 3) future development in Fishermans Bend. Two vantage viewpoints, along the West Gate Freeway and New Quay in Docklands, respectively vehicular and pedestrian, were identified. In this scenario, we conclude that the sky factor ratio the measure visible sky, based on the unwrapped skyline diagram from the vehicular entry is reduced from 88% in the existing condition to 38 % by the planned future developments. This is a considerable change to the level of visibility and enclosure relative to the public vantage viewpoint, as the sky ratio is comparatively reduced from 75 % to 70 % by the future Fisherman Bend development. Using this method, we are able to quantify the impact of the development proposals. The unwrapped 2D diagram of skyline provided an inclusive method to study visual relationships of between existing and future building heights. In doing so, we weigh the significance of impacts of these scenarios within the realm of public spaces in order to manage the community's expectation and perception of their urban environments.

Keywords: Visual bowl, skyline analysis, visual relationship, building bulk and height

## **1** Introduction

*Fishermans Bend* in Melbourne, is at present Australia's largest urban renewal site. It is located in close proximity to the Central Business District along the bend of the Yarra River. This area plays a key role in the future growth of Melbourne which is currently ranked high on the liveable city index. The site has evolved from a popular recreational location for local communities in the early years of colonial settlement, to an industrial hub for major Australian factories. The project's vision is to transform the existing industrial part of the city into a sustainable and mixed-use urban development to accommodate 80,000 residents and 80,000 jobs by 2050 (VICTORIA GOVERNMENT 2017).

Having a distinct visual character is one of the urban design objectives envisaged for *Fishermans Bend*. This becomes possible through a clear city image created at a range of scales and by establishing reasonable densities for new developments (HODYL+CO 2017). In Melbourne, density is determined by the measure of floor area ratio (FAR) which defines the maximum amount of built form or floor area, in relation to a given physical site. This is considered in relation to FAR shapes the built form envelopes which are defined by the height and setbacks allocated to the building.

Journal of Digital Landscape Architecture, 3-2018, pp. 2-11. © Wichmann Verlag, VDE VERLAG GMBH · Berlin · Offenbach. ISBN 978-3-87907-642-0, ISSN 2367-4253, e-ISSN 2511-624X, doi:10.14627/537642001. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution license (http://creativecommons.org/licenses/by-nd/4.0/). In *Fishermans Bend*, a combination of FAR controls and discretionary height controls are considered as the most beneficial approach to achieve the vision and objectives of the project (HODYL+CO 2017). By and large, discretionary built form controls are considered more desirable to mandatory FAR requirements as it allows for varied and more interesting urban design forms, instead of uniform and repetitive outcomes. These regulations are projected for all the four precincts in *Fishermans Bend* including *Montague, Wirraway, Sandridge* and *Lorimer* which. This provides an opportunity for developers to consider a mix of built form envelopes that may be incorporated within the skyline analysis (Figure 1).



**Fig. 1:** Fishermans Bend Precincts in relationship to Melbourne CBD

Anticipated building heights in the draft planning framework range from 12 storeys upward, put the site at risk of becoming a "wall of high rises". This urban renewal project will change the shape and the visual character of Melbourne's from public spaces and its overall attributes as a whole. The fear of losing the visual amenity and character associated with high-rise buildings has become a huge concern for local councils and communities. This fear makes communities highly sensitive to high-density urban renewal proposals and could result in costly planning appeals, lengthy delays and uncertainties for all involved parties (TARA 2017).

In this paper we characterise the landscape in *Fishermans Bend* as "the landscape within the built-up area, including the buildings, the relationship between them, the different types of urban open spaces, including green spaces and the relationship between buildings and open spaces (LANDSCAPE INSTITUTE 2013)". In the assessment of new developments in urban landscape, methods and techniques of Landscape and Visual Impact Assessments (LVIA) have been widely adopted in Australia to understand the visual effects of proposed developments on the existing visual character and receptors. The LVIA is considered to be a reactive assessment and is a requirement in the preparation of environmental impact statements (EIS) or in the case of planning appeals. In response to this, we propose a proactive approach, applying LVIA at the early stages of design process instead. This provides an opportunity to mitigate potential adverse impacts of future development. Creative solutions to understanding visual impacts of new developments on existing urban environments are only possible through understanding the visual properties in greater depth (RAIA 2004).

An important consideration of LVIA in the urban context is the visual relationship of the proposed development in relation to nearby existing buildings. The visual relationship includes visual characteristics, height, setback and appearance. However, height is usually the most important consideration in the assessment of visual relationships. In planning policies, a visual relationship that is pleasing, sympathetic, supportive, harmonious or complementary is encouraged. However, these qualities require more measurable techniques to further establish and evaluate visual relationships.

Furthermore, justification of 1) bulk and height of buildings in relation to their visual relationship to existing setting and 2) evaluation of overall impacts on visual amenity and character are perhaps the least quantifiable or most open-ended aspect of these investigations. This is especially true in urban renewal proposals during the design and decision making processes. These considerations have a direct impact on everyday experience of public spaces. Key perceptual factors such as balance, proportion, scale, enclosure and built form requires more sophisticated techniques of measurement and monitoring.

To date, urban design proposals are largely based on best practices and previous experiences that solely rely on conventional bird's-eye view perspective, cross-section and photomontage. These approaches are arguably considered as increasingly limited and perceivably inept to tackle contemporary and seemingly complicated urban renewal and infill developments. Therefore, we intend to tackle this issue by proposing a repeatable and quantitative approach to analyse the above mentioned visual properties of both existing and proposed urban. In doing so, we aim to minimise potential conflicts during the post-construction stage.

We acknowledge the difficult nature of approaching this issue as proposed developments are typically compounded by considerations of scale, massing and height. This is further complicated by the distribution of varying development heights in such built up areas and the curation of open spaces informed by planning controls and regulations. These considerations have a direct effect on the visual amenity and everyday experience of public spaces. However, the effects of these factors on the existing townscape character and visual amenity of public spaces are not fully monitored existing processes and cannot be addressed solely by the existing methods. Some of the key aesthetic factors in assessing townscapes are balance, proportion, scale, enclosure and form which require more sophisticated techniques to measure and monitor.

LVIA can produce a more nuanced understanding of visual impacts brought by future change during the design process. Modeling and spatial analysis techniques through Geographic Information Systems (GIS) provide an opportunity to assess the impacts of future development have on existing urban environments (GHADIRIAN & BISHOP 2008). GIS provides sophisticated spatial analytical techniques that can be widely used in environmental sciences and urban planning (JIANG et al. 2000). GIS is also considered as a tool through which large models can be generated and manipulated in far less time compared to other available methods (APPLETON et al. 2002). It provides a more inclusive platform to assess visual impacts in planning that eliminates the misinterpretation of conventional photomontages and computer renders during the design and planning process (HUANG 2017).

In this paper, we propose a workflow that allows designers to test scenarios by reconstituting Google Earth 3D building information into a photometric point cloud dataset to measure and analyse visual and environmental impacts of future developments. The scenarios will take into consideration the existing, approved, applied and future built environment and check the

visual amenity factors that include openness, visibility ratios, building height, and bulk using skyline analysis in Geographical Information System (GIS) platforms. Floor area ratio, height limit restrictions, and building setback controls are examples of planning control variables that are taken into consideration as we test these urban renewal scenarios. This method will allow designers to test scenarios that incorporate variable bulk and height of future built forms. This demonstrates our contribution in delivering a quantifiable approach to analyse visual amenity impacts within future public spaces and townscape character assessments.

#### 2 Reconstituting the Skyline

#### 2.1 Google Earth 3D Buildings

A dense city 3D model was recovered by using the following stereo photogrammetric screen capture workflow. This process involves the estimation of three-dimensional coordinates points detected on screen captured photorealistic buildings in *Google Earth Pro (32-bit)* at overlapping oblique and orthographic positions. Since the stereo pair is not calibrated, the photogrammetry algorithm will rectify the homographies directly from point matches. The steps and software used can be summarised accordingly: 1) record a video or screen capture of the area of interest in *Google Earth Pro (32-bit)* using *Bandicam* screen recorder 2) import the set of uncalibrated screen captures into *Pix4D 4.0.25* and produce a densified point cloud, 3) geographically register the densified point cloud in *CloudCompare v2.9*, 4) export the registered densified point cloud as a .LAS dataset into *ArcMap 10.3* and 5) convert the .LAS dataset into a raster prior to performing the skyline analysis.

#### 2.2 Development Activity Model

In order to consider the potential development scenarios, building parcel footprints were downloaded and extruded manually to the nominated heights based on the open-source *City of Melbourne*, 3D Development Activity Model (3D DAM). The visualisation is underpinned by information from the City of Melbourne Planning systems. The following colour scheme represents major development activity in the *Melbourne Local Government Area*: applied (blue), approved (green), under construction (yellow), and current (grey). The 3D models are simplified interpretations of complex built forms and should not be used for planning purposes, in our case the models inform the bulk and height of future built forms. A Digital Terrain Model (DTM) was included as base to register all features in *ArcGIS 10.3*. This model is used as a basis for the skyline analysis.

#### **3** Skyline Analysis

Skyline analysis in GIS provides a measurable method to analyse visual effects of future development scenarios on public spaces at the local and citywide scales. Skyline is defined as the outline of a building or structure seen against the sky (CHALUP et al. 2009). In order to analyse the visual relationship between existing and future built forms, a new concept called *visual bowl* is developed (TARA 2017). We define the visual bowl as the extent of a visible three-dimensional space about a defined observer's viewpoint (360°). In this space, the ob-

server is able to perceive and compare the variation in height of a proposed development against existing developments (Figure 2).



Fig. 2: Visual bowl defined by skylines around an observer in 360° context

Based on modelling skyline in ArcGIS, zenith, azimuth and elevation angle values can be calculated using Skyline Graph function. Azimuth (A) is an angular measurement (degrees) in a sphere-shaped coordinate system. Zenith (z) is the angle between sightline to the skyline and vertical axis from observer point. Elevation angle (h) is the angle between the horizontal line and the viewer sightline to the skyline. The relationship of these variables to the viewer is shown in Figure 3 (Left). By calculating these variables for a selected viewpoint, it becomes possible to describe values in a 2D silhouette diagram, which is an unwrapped presentation of the visual bowl concept as described in Figure 3 (Right). This diagram accurately describes the projection of horizontal angle or silhouette of the visual bowl as visible from a selected viewpoint. The horizontal bar is 0 to 360 degrees and the vertical dimension the zenith angle. The human eye field of view (FOV), assigned with the value of 124 degrees (a third of view), shown in relation to the 360 degrees' diagram.

Skyline analysis in ArcGIS models and measures various variables from the virtual 3D environment. In this paper, it is implemented in two steps: 1) skyline function generates a line or multipath feature that includes the results of skyline or silhouette analysis. In order to run the function, an observer point and 3D features such buildings are required. The result includes the XYZ direction of light rays from the observer to the building features. The Skyline Graph function, as the subsequent function, calculates the sky visibility and the azimuth and vertical angles going from observer point to each of the vertices of the skylines multipath feature. It has further implications by calculating the sky ratio as the level of visibility of sky.

One of the urban design principles in *Fishermans Bend* is aimed to create a balance between openness (visibility of sky) and built forms to avoid the outcome of dominance in developments on public experience. It is also aimed to define well-defined edges to public spaces. Sky factor as the ratio of visible sky provides a measure of openness and skyline graph displays the edges of the visual bowl from public spaces. This function can be applied to any given viewpoint and 3D model to conduct a viewpoint based assessment of scale, massing and height of proposed developments in relation to the existing visual setting. Hence, the tailoring a geomodel to depict different variations of built form heights is the first step to conduct the skyline assessment for *Fishermans Bend*.



Fig. 3: (Left) Relationship of quantifiable variables and observer in the visual bowl. (Right) Sample 360° plot of skyline a viewpoint (unwrapped Skyline Graph).

## 4 Interrogating Urban Renewal Scenarios

#### 4.1 Defining Vantage Viewpoints

The first step of assessment started with the identification of vantage viewpoints for skyline assessment. Multiple factors were taken into account to select these viewpoints including pedestrian and vehicular accessibility to the public, potential number of viewers during daytime, viewing direction and distance. In order to understand the viewer's location and flow inside the study area, existing dataset developed by Council were used to understand the patterns. The City of Melbourne has 42 automated pedestrian counting sensors located across the city. These sensors provide pedestrian counts for the previous hour at the given location. Counts are accessible through Council website.

A feature dataset including sensor locations and average hourly pedestrian counts during daytime (7am to 7pm) over the past 52 weeks was developed in ArcGIS. A point density analysis using Kernel Density function in ArcGIS revealed the frequency of pedestrians in Melbourne's CBD. While the identified hotspot areas are mainly away from the *Fishermans bends*, a pedestrian viewpoint in *New Quay, Docklands* (3208 users) was selected as pedestrian views due to proximity and direction in relation to future developments at *Fishermans Bend* (Figure 4). *Docklands* is considered as a major public space in proximity to Fishermans Bend which will be affected by the future developments in *Fishermans Bend*. Hence, this viewpoint represents the likely views from surrounding public spaces to future developments in *Fishermans Bend*.

User distribution was further investigated by analysing the traffic volume flow across the study area. This data became available through *Victorian Government* database. Figure 4 (Right) displays the concentration of high volume flow in CBD streets and specifically along highway *West Gate Freeway* and *CityLink Bridge* as the main access corridors from the north (*Tullamarine Airport*) and west side to the CBD. Another viewpoint along West Gate Freeway was selected as additional external viewpoints for skyline analysis. This viewpoint represents the viewpoints inside Fishermans Bend development boundary which will be affected by the future growth.



Fig. 4: (Left) Distribution of pedestrian counting sensors and heatmap showing the concentration and (Right) Traffic Volume Flow and selected viewpoints

#### 4.2 Scenario Testing

Following the selection of viewpoints, skyline function was used in ArcGIS to model the future building heights visible in each visual bowl. We interrogate three skyline variations against existing conditions, namely 1) approved applications to be constructed, 2) suggested development application, and 3) future development in *Fishermans Bend*. Figure 5 displays the geomodel including modelled skyline variations from *West Gate Freeway*.

The modelled skylines are depicted as unwrapped 2D diagrams for both viewpoints (Figure 6). The skyline diagram displays the visual relationships of existing and future built forms visible in the visual bowl at 360 degrees. It depicts the proposed bulk, height and scale of developments as visible from this viewpoint. As it is evident in Figure 6 (Left), the future developments in *Fishermans Bend* result in a dramatic change compared to other options skyline options. Based on the calculated sky ratios, the sky factor as the measure of visible sky reduces to 38% which considerably changes the levels of visibility, enclosure and overbearing. Changes to the skyline are less significant from *New Quay* as a distant viewpoint. Sky ratio reduces from 75% to 70% by the future developments in *Fishermans Bend*. Future developments provide a balanced visual relationship with emerging developments in Fishermans Bend as visible from this viewpoint.



Fig. 5: Modelled skyline variations from the selected viewpoint (along West Gate Freeway)



Fig. 6: (Top) Unwrapped skyline diagram and sky factor ratio from West Gate Freeway and (Bottom) Unwrapped skyline diagram and sky factor ratio from New Quay, Docklands

## 5 Conclusion and Outlook

Results presented in this paper only includes two viewpoints, inside and outside, of the development area. The future building heights in Fishermans Bend are highly dominant and result in a dramatic change of skyline and skyfactor on the internal viewpoint (West Gate Freeway). The magnitude of visual impacts is less significant on the external viewpoint (Docklands) due to considerable distance (1.4 km). The future developments provide a harmonious scale and dominance compared to existing, approved and applied applications. Nevertheless, the skyline analysis can be repeated for more viewpoints to fully understand the visual impact of future developments on vantage public viewpoints.

Quantitative assessment of the skyline is not a new topic in landscape planning. Skyline of urban environments has previously been investigated by several types of research by STAMPS 2002, CHALUP et al. 2009 and GUNEY et al. 2012. STAMPS and CHALUP et al. calculated the fractal dimension of cityscape skylines to measure their complexity. GUNEY et al. proposed a development plan by using a geomodel created in GIS. Similar to previous research, GIS and a virtual model were used to extract skyline data from selected viewpoints to analyse building heights within each visual bowl. Creating a 360-degree skyline graph to identify height thresholds and height relationships presented in this paper, is a new method to analyse scale, height and visual relationships of built forms in urban landscapes. This provides a more rigorous and comprehensive assessment of building heights as visible from public spaces within and outside of development area compared to current conventional methods including photomontages and 3D city models. Also, this paper provides a proactive approach to evaluate the visual relationships of new proposals and the existing urban settings.

The skyline functionality in ArcGIS, presents a powerful tool to analyse visual attributes and relationships for multiple development scenarios from various viewpoints in public spaces. Quantification and measurement of bulk, height and dominance were considered significant findings for improving evaluations in visual assessments. These considerations are commonly assessed by visual amenity expert using photomontages, which is not a quantifiable method for analysing such issues. Therefore, justification of bulk, height and dominance of development in its setting is mixed with uncertainty and subjectivity. The skyline method provides a new way for evaluating these concerns with more certainty which can be integrated into current urban design practices and visual impact studies by using accurate city models including both built and natural features. Furthermore, the calculation of sky factor in urban landscapes can contribute to more quantitative and objective characterisation process in townscape character studies.

Calculation of sky ratio using skyline is another useful measurement in urban environments to calculate the level of visual openness and enclosure for any given viewpoint. Although this study does not provide any thresholds or acceptable levels for these attributes, there is a potential to measure and analyse these attributes by considering public preferences and human vision (Vertical Field of View). Identification of thresholds for acceptability of building heights and bulks would assist in better understanding of the sense of overbearing or overdevelopment which are important considerations in visual amenity conflicts, visual impact studies and urban design.

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