PHILLIP BOYLE & Associates

Punt Road Public Acquisition Overlay Advisory Committee

Expert Witness Report commissioned by City of Melbourne

2 February 2016

Expert Witness Report Particulars

1. This expert evidence has been commissioned by the City of Melbourne to assist the advisory committee investigate issues surrounding the public acquisition overlay (PAO) in Punt Road. This expert evidence report focuses on:
   - Broad consensus regarding metropolitan strategy that articulates what type of city Melburnians want to live in
   - Transport planning principles and proven theorems
   - Impacts of various demands within the corridor
   - Issues likely to arise from the concepts being considered
2. This section of the report provides the basic information required the Guide to Expert Evidence.

Name and address of the expert

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The expert's qualifications and experience

3. See appendix 1

A statement identifying the expert's area of expertise to make the report

4. See Appendix 1.

A statement identifying any other significant contributors to the report and where necessary outlining their expertise;

5. Not Applicable

All instructions that define the scope of the report (original and supplementary and whether in writing or oral)

	INSTRUCTIONS FROM CITY OF MELBOURNE WERE TO ANSWER THE FOLLOWING
1	What principles are important to consider in planning for the ongoing use and functioning of Punt Road?
2	Comment briefly on the concepts proposed by VicRoads as set out in the Arup Report (taking into account the material set out in the submission to the Advisory Committee on behalf of VicRoads and PTC - Part A) and relevant planning and transport policies, and in particular please comment on: a. the provision of a clearway as an appropriate measure? b. whether the reduction of speed along Punt Road is appropriate setting out the reasons for your opinion.
3	Comment on the impact of each concepts on the surrounding road networks and identify any constraints on assessing the impact of each option.
4	What is the likely impact of urban growth on and around Punt Road on the surrounding road network?
5	Are there any other matters you consider relevant to the advisory committee's consideration of the submission made on behalf of the City of Melbourne?

The identity of the person who carried out any tests or experiments upon which the expert has relied on and the qualifications of that person.

6. Not Applicable

Summary of Opinion

7. Melbourne has been founded on principles of the *city beautiful* and *city functional*. At the highest level these should continue to be our aims as we develop the city further.

8. Victorians have come to expert a high level of urban amenity from public spaces including roads, and desire to see more 'grand boulevards' created. This has been supported in successive metropolitan planning strategies.

9. Punt Road is currently not performing adequately for many road user groups (including pedestrians, cyclists, public transport users, freight forwarders and private vehicle users). Of all these it is probably catering for private vehicle users better than others.

10. Principles that formally guide transport planning in Melbourne are found in the Transport Integration Act.

11. Principles that guide best practice approaches to integrated transport planning include:
    - Understand what the community wants
    - Use robust evidence to help the community understand the current situation and how we can meet the vision for the area
    - Apply world's best practice and proven transport theorems to gain a deep appreciation of how various improvement concepts will impact on the whole urban system (triple bottom line analysis) not just outcomes for transport or for one specific mode.

12. With regard to Clearways they should only be introduced at times when congestion is occurring, based on robust evidence and analysis of the situation. Where clearways are applied, traffic speeds tend to increase, and safety for other road users (particularly pedestrians and cyclists) is typically be reduced. The safety impacts can be mitigated through allocation of lower speed limits.

13. Clearways on tram corridors have significant safety impacts on tram passengers at tram stops.

14. A reduced speed limit for Punt Road would be appropriate – particularly in the section between Alexandra Avenue and Toorak Road.

15. The are a number of constraints to assessing the concepts related to the lack of data and clarity of information provided.

16. Currently there are significant deficiencies in the Punt Road corridor related to bus and pedestrian faculties. Some of these are dangerous and do not meet legislative requirements.

17. A high level assessment of the Concepts seems to suggest that Concept 3 provides the best short term outcome. It should be noted that some aspects of this Concept might not be supported once I am able to review data for all modes.

18. This high level assessment also seems to suggest that Concept 6 provides the best long term outcome. This takes into account the overall road width and balancing the needs of all modes, including people crossing the corridor by car, tram, bus, cycle or foot.

19. There are many other options that could be considered (across a wide geographic area) to reduce the level of traffic congestion in the Punt Road corridor. This is partly due to the fact that Punt Road is one of very few north-south arterial connections, and public transport corridors.

20. Urban growth in the corridor will increase local traffic congestion if it includes car parking.

21. The City of Melbourne's submission is a logical assessment and is supported.

Contents

List of Figures

List of Tables

1. Introduction

22. A Public Acquisition Overlay (PAO) affecting land on the east side of Punt Road between Alexandra Avenue and Union Street within the City of Stonnington has been in existence since 1954.

23. An Advisory Committee has been appointed under Section 151 of the Planning and Environment Act 1987, to report and recommend on whether to modify or remove the Public Acquisition Overlay affecting Punt Road within the City of Stonnington.

24. A Concept Options Report contains a series of potential design concepts for the broad corridor. While the PAO is located wholly within the City of Stonnington, the design concepts presented impact the broader corridor and introduce impacts on the City of Melbourne which range from minor to significant.

25. This expert evidence is informed by policy documents and strategies endorsed by the Victorian State Government including:
    - Transport Integration Act 2010
    - Plan Melbourne
    - MANAGING MELBOURNE: Review of Melbourne Metropolitan Strategic Planning
    - Investing in Transport – East West Link Needs Assessment
    - Network Development Plan – Metropolitan Rail
    - Melbourne Metro Concept of Operations
    - Lower Yarra River – Future Directions Plan

26. And a range of documents endorsed by the City of Melbourne:
    - Transport Strategy 2012
    - Open Space Strategy 2012
    - Heritage Strategy 2013
    - Road Safety Plan 2013-17
    - Walking Plan 2014-17
    - Bicycle Plan (draft) 2016 - 2020
    - City Road Draft Master Plan

1.1. CONSTRAINTS ON PREPARATION OF EVIDENCE

27. Due to the fast-tracked timeframe for the preparation for this expert evidence and the lack of relevant data available this statement is preliminary (much like the VicRoads background report).

28. The Term of Reference make specific reference to current and projected data related to the pedestrian, cyclist and public transport activity in the Punt Road corridor. The information that has been provided in the Background Report is for a single weekday AM & PM peak hour (it is not clear whether it is the vehicle peak or the pedestrian/cyclist peak) and is focussed on activity at intersections (rather than mid-block).

29. Discussion of cyclist, pedestrian and public transport data in the background report lacks the basic information required to substantiate its efficacy (it is often for the peak period only), most data is in a format (and resolution) that is too difficult to analyse and various elements are not provided (such as bus passengers and pedestrians walking along Punt Road or crossing Punt Road mid block).

30. The amount and type of data provided is insufficient for a robust analysis of total user activity, current needs or future demand within and across the corridor. For example it seems that around 1,900 pedestrians (the exact number is unclear due to the digital resolution of the data provided) crossing Punt Road in the AM peak hour. This number may actually be higher than the peak hour one-way capacity of Punt Road (which Austroads advises would be around 900 vehicles per lane per hour in free flow conditions (Ogden & Taylor, 2003).

31. With regard to the various improvement concepts considered, expert analysis of these from the perspective of all system users and the integrated transport planning principles is impeded by a lack of adequate information regarding the total number of people currently using the road reserve (not just those in cars). Information that would have been useful to the analysis includes:

- Pedestrians count of those walking along the corridor and crossing Punt Road at mid-block locations
- Average weekday and weekend pedestrian counts across the entire day by time of day (hourly)
- Proportion of pedestrians crossing illegally compared with legally
- Signal settings and phase time for pedestrians for all pedestrian crossings in the corridor
- Average weekday and weekend cyclist counts across the entire day by time of day (hourly)
- Proportion of cyclists cycling on the footpath compared to on road (including approximate age to determine legality of the cycling on footpath)
- Average weekday and weekend public transport counts across the entire day by time of day (hourly)
- Public transport passenger origin-destination survey for passengers transferring between services and passengers on bus Route 246
- Run time data for bus Route 246 from first to last stop by service across a six month period (this data is available and relatively easy to analyse with the correct tools)
- Understanding of the relative importance of passenger transfer between bus Route 246 and other public transport services (including the 30 other bus routes that Route 246 provides connection to).
- Longitudinal data related to all transport modes showing rate of change in use over the last decade for services in the local area.

2. What principles are important to consider in planning for the ongoing use and functioning of Punt Road?

32. The formal principles in Victoria are those in the Transport Integration Act. These have been listed in various documents already provided to the Advisory Committee. It is noted that each of these *principles* and the *transport system objectives* require some interpretation and could be dealt with to varying degrees of detail. Each agency is entitled to interpret the principles and transport system objectives as they see fit.

33. Beyond these formal (legally required) principles there are various types of principles that should also be applied. Decision makers should:

- Base any analysis on evidence and facts that are able to be interrogated by all.
- Understand the type of city that the Victorian taxpayers would like us to create.
- Endeavour to understand the likely future scenarios (resulting from various changes to technology, climate, social and economic conditions).
- Use worlds' best practice and proven theorems to assess the likely impact of various interventions is critical.

34. *The Economist* has ranked Melbourne as the world's most liveable city for the past five years (2011-2015). Decision makers should seek to understand why this is the case and how we can apply the positive lessons from the past while seeking to resolve the many remaining issues that plague our city.

35. Robert Hoddle is attributed with the design of Melbourne, Williamstown and Geelong. His plans show a desire to merge two urban-planning movements of his day, the *city functional* with the *city beautiful*. While it is difficult to speculate as to his motives, the discussion over road widths with Governor Sir Richard Bourke is well documented. It highlights an approach that reduces congestion of movement, has the potential for grand vistas along boulevards to monuments and creates spaces for communities to enjoy.

36. Once having commenced on anything so elaborate as building a city, it would seem folly to change the guiding principles without good reason. However, in Melbourne we did and thus several grand boulevards ended at (ironically) Hoddle Street to then become much narrower roads (for example Victoria Parade, Melbourne leading into Victoria Street, Richmond).

37. I place significant value in Hoddle's legacy and believe that it continues to influence the way we think about future city improvements. In part this is reflected by successive metropolitan strategies all seeking to achieve the same goals of economic functionality and improved liveability[1]. These documents, completed over six decades tend to highlight the benefits of more wide boulevards, along which liveable streets and local communities can be created.

38. Long term planning is one particular principle of transport planning I think has served the Victorian public very well. I believe that very early government reservations of land for freeways, railways (such a reserve still exists in the Eastern Freeway despite decades of congestion) or even

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[1] *Looking back at the previous plans for Melbourne it is clear that the basic aims have been constant, though expressed somewhat differently, as each plan adopted the language of its time. All plans set out to:*

- *improve the efficient operation of the city,*
- *improve what we would now call its liveability, and*
- *preserve valued environmental areas.*

Source: Managing Melbourne: Review Of Melbourne Metropolitan Strategic Planning

airplane flight paths is something that protects the values of our current and future population and economy.

39. To quote *Managing Melbourne: Review Of Melbourne Metropolitan Strategic Planning*

> *"A long term plan based around maintaining opportunities for future transport projects, that can be realised when needed, can have great success"*

40. For example, Melbourne has the only major airport in the country that has no curfew, thanks in part to long term planning of the areas around Melbourne Airport, including limiting land development within the flight paths.

41. This approach to long term planning and use of the precautionary principle (knowing that we can always plant more trees if we have too much space) is one of the critical transport planning principles that leads Melbourne to be the most liveable city in the world.

42. It is fair to say that other cities are putting significant effort into catching-up. There are many cities around the world that are converting spaces like Punt Road into transit corridors or building active and public transport only links such as the Tilikum Crossing in Portland (below). This $US135m bridge caters for bus, light rail, streetcar (separate system), bicycles and pedestrians (active transport on both sides), but no cars.

Figure 1 –Tilikum Crossing in Portland, Oregon, USA

43. The ban on private vehicles using the Tilikum Crossing was considered essential to reduce road traffic congestion, giving transit riders and active transport a competitive advantage and maintain community liveability in nearby neighbourhoods. It also reduced the overall project cost.

44. Perhaps more comparable with Punt Road is the conversion of arterial lane space in suburban areas of Paris (tram lines), London (bus, tram and cycle ways), New York (bus and cycle ways), Los Angeles (bus and light rail lines), Sydney (busways), Brisbane (busways) and Adelaide (bus and tram ways) for public transport lanes.

45. By comparison Melbourne's transport planners have been slow to recognise that in many cases lane space needs to be reallocated (rather than making public transport wait until new lane space can be created). This principle of better balancing the existing lane space should be applied to

planning the ongoing and future use of Punt Road (for example by restricting use of the left lane to high occupancy vehicles.

46. As a principle, transport planning professionals should consider world's best practice approaches and base decisions on transparent robust information that includes all transport modes in equal measure.

2.1. CORE TRANSOPRT PLANNING PRINCIPLES

47. Beyond the community's vision for the corridor, there are several transport planning principles that should be considered (and explained to the public) when assessing what transport improvements (including what modes) might be appropriate for the Punt Road corridor. These include:
    - Braess Paradox – a proven theorem
    - The Principle of triple convergence
    - Marchetti's Constant & Travel Time Budgets
    - Integrated Transport Planning

48. These concepts are briefly described in Appendix 2.

49. Integrated planning as described in Appendix 2 is a significant planning principle for the Punt Road corridor because it is a critical urban connector and barrier surrounded by some of Victoria's highest value real estate and highest quality office precincts. The effectiveness of movement across and along Punt Road and in particular the walkability of the corridor will be critical to stitching together (and making the most of) the economic activities in Melbourne CBD, Richmond, South Yarra and St Kilda Road.

50. To improve its contribution to the Victorian economy, the future Punt Road corridor cannot just 'steal' trips away from other corridors (although that would relieve Chapel Street and others). Rather Punt Road needs to be a walkable urban corridor in its own right that attracts investment and people into a liveable space and makes the most of the many high capacity transport concepts that exist in the corridor.

51. There are many destinations already along the entire Hoddle Highway corridor but these are connected with a traffic artery that currently lacks liveability, travel mode choices and basic amenities for some users (particularly those with a disability or using active modes).

52. The principle of integrated transport planning including a deep understanding of the broad community's vision for the space, wider economic forces and optimal land development outcomes and must be applied in order to comply with the Transport Integration Act.

53. The principle of approaching transport planning by considering the most efficient modes first (such as active modes that make us healthier), then high capacity modes such as public transport and freight is also worth considering given the highly urbanised nature of land use in the corridor. It is highly likely that with the growth in development of residential and commercial property in Richmond, South Yarra and St Kilda Road the future dominant mode (if it is not already) will be pedestrians. To maximise the economic productivity of the corridor pedestrian amenity and safety will need to be significantly improved and therefore planning adequate facilities for this mode first would be a reasonable principle to apply.

54. With greater time to consider these wider aspects the Hoddle Street-Punt Road investigation should result in a significantly improved urban environment and astounding economic outcome for Victoria (particularly given the central importance of people movements across and along the corridor) to our State economy.

A note about congestion

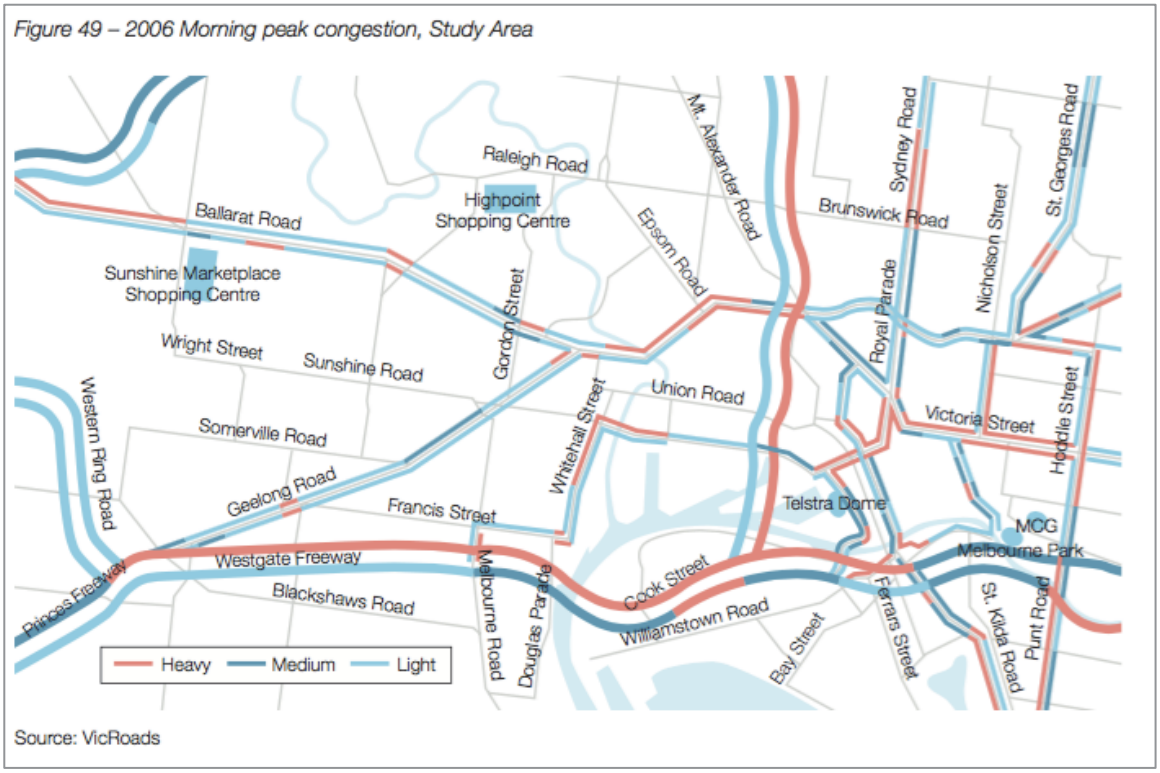
55. Often it is unclear what is meant by 'congestion'. There is no universally accepted definition of traffic congestion (Downs, 2004, Aftabuzzaman, 2007). I have prepared this expert witness report on the basis that (minor) congestion occurs when any car delays another. Severe congestion (considered to be a concern) occurs when a driver needs to wait through more than one complete cycle of traffic signals before being able to cross an intersection. It is recognised that congestion can occur without a traffic signal, but the distribution of traffic signals along the Punt Road corridor make this definition applicable in this instance.

56. It should be noted that some level of minor congestion is good and even severe congestion (in certain circumstances) can improve pedestrian safety. Two cars in one lane are more likely to adhere to road safety rules than one lone driver. Up to a certain level congestion is bearable and not a problem in terms of network efficiency. In fact congestion is a sign that the community has not wasted resources on road space that does not get used (as they have in Detroit).

57. There is a point at which congestion frustrates 80% of drivers. It is assumed that in Melbourne this occurs when a driver at a standard traffic signal is delayed for more than one cycle of that traffic signal (as per the definition above).

58. I am unclear about what level of congestion is occurring through what time period of the day and week (as it does not seem to be addressed in the background documents). The most recent public information I can easily find is in the East West Link Needs Assessment as shown below.

Figure 2 – Congestion in Hoddle Street-Punt Road (left side of figure)



Source: Eddington, 2008

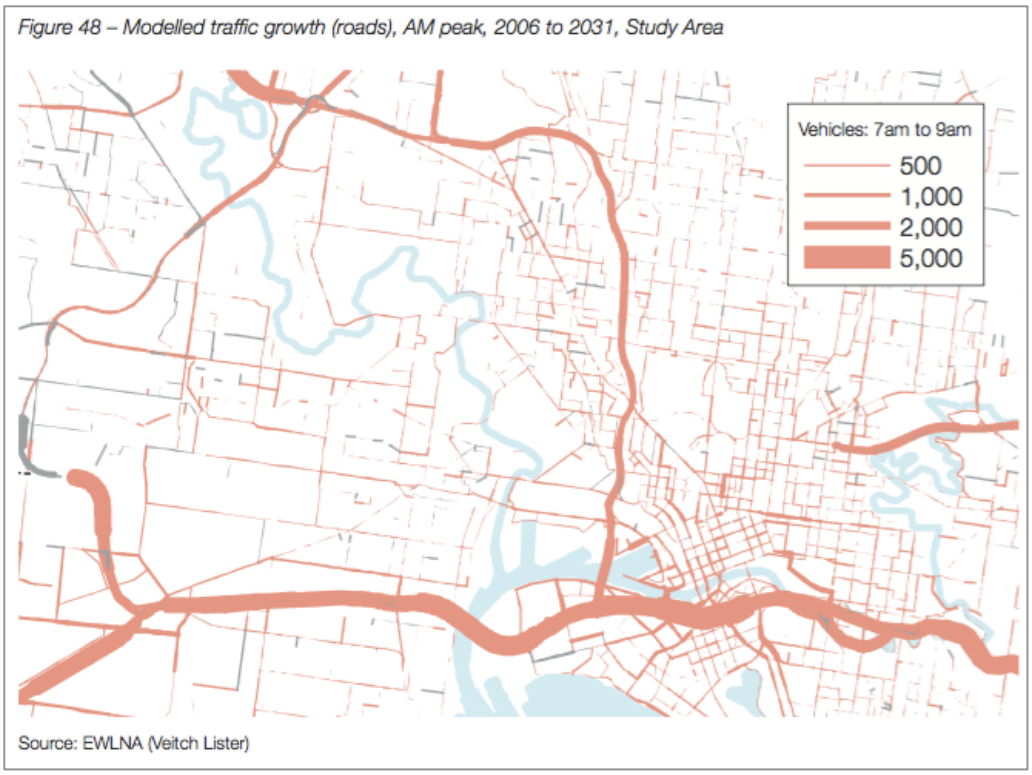
59. Clarification of how congestion should be defined generally across the network (and specifically in the Punt Road corridor) would assist me to consider the concepts. In considering this it should be noted that the level of service (LOS) indicators for intersections are a measure of delay and only a

proxy for congestion (it is possible to be delayed without being in congestion). Importantly, nor do LOS indicators consider all road users (public transport passengers, cyclists or pedestrians).

60. If delay is going to be the proxy for congestion, then we surely should include delay for public transport passengers (not vehicles) and pedestrians (including those crossing mid block). This is the only way in which we can get a true picture of the transport needs in the corridor.

61. Congestion changes over time will depend on the amount of traffic growth on Punt Road. The anticipated growth data I could find publicly available for the corridor shows some growth on Punt Road – mainly north of the Yarra River.

Figure 3 – Modelled Growth in Traffic



Source: *Eddington, 2008*

62. The difference between a congested road and a saturated road (while somewhat dependant on definitions) is estimated to be around 8-10% of the traffic volume. This means that to fix todays congestion we only need to divert 10% of the existing users to alternative modes. The spectacular growth in public transport patronage over the last decade shows that this is achievable. Indeed the initial growth in public transport patronage (largely as a result of petrol price increases from 2005-08) removed significant congestion from Melbourne's arterial road network.

2.2. SUMMARY

63. Melbourne was founded on principles of *city functional* and *city beautiful* with 30m wide streets and 60m wide boulevards. These attributes have been very successful and most metropolitan strategies have sought to reinforce these network design principles – most recently with Initiative 4.6.2 in Plan Melbourne to "*Develop Melbourne's Network of Boulevards*".

64. The support for long term, evidence-based planning is critical to protecting long term community value and economic prosperity.

65. The transport network should give all residents and visitors real choice about how they move around the city. These choices need to be competitively convenient and the transport system should be developed in such a manner that if a high capacity mode is not competitive because of congestion (either on the mode or in the corridor) then a holistic suite of improvement concepts (across all modes) should be considered to help resolve the imbalance in the system.

66. Regardless of what mode people chose to use they should be safe (and feel relatively safe).

67. Growth forecasts mean that the only way to accommodate future travel demands in inner Melbourne will be through significant shift to active and public transport modes. This means significant improvements private car transport are unlikely to meet future residents' needs, as they are very expensive when compared to transporting the same number of people using active and public transport.

68. Around the world many cities are bypassing the discussion about increasing inner city traffic lane capacity with the knowledge that even a 100% increase in capacity will not be enough. Therefore the only sensible alternative in highly urbanised areas is to make the pedestrian, cycling and public transport networks much more attractive and effective at meeting people's daily transport needs.

3. Comment briefly on the concepts proposed by VicRoads

The full text of instructions to the author reads:

> *Comment briefly on the concepts proposed by VicRoads as set out in the Arup Report (taking into account the material set out in the submission to the Advisory Committee on behalf of VicRoads and PTC - Part A) and relevant planning and transport policies, and in particular please comment on:*
>
> *a. the provision of a clearway as an appropriate measure?*
>
> *b. whether the reduction of speed along Punt Road is appropriate setting out the reasons for your opinion.*

3.1. BROAD DISCUSSION OF THE CONCEPTS

69. The concepts are generally focussed on throughput and speed of private vehicles and local freight.

70. No concepts consider how land-use concepts could influence or affect a solution, apart from providing additional car parking.

71. There is clear international evidence that providing more car parking leads to higher car ownership and car use, thus exacerbating local congestion.

72. Some of the discussion refers to 'compensating' local land owners for the loss of on-street parking. The author is not aware of any land owners having a 'right' to on street parking – even the space outside their property. Compensating for any lost on-street parking with more parking will only serve to encourage the types of land use and development that need to be discouraged from the corridor.

73. The types of land use that should be encouraged in the corridor are high intensity developments that will activate the street and locate residents and jobs within walking distance of the existing high capacity active and public transport networks through and around the corridor.

74. Few of the concepts pay attention to significant deficiencies in the current Punt Road corridor such as bus stops that are poorly (even unsafely) located and pedestrian facilities that are not compliant with the Disability Discrimination Act 1992.

Example of Bus Issues

75. The example in Figure 4 below shows a bus at the exact location that each bus needs to stop in order for passengers to alight and board 'safely' at Alexandra Avenue. This location is so precise due to the arrangement of traffic lanes to the west of the bus. The image clearly shows that it is not compliant with the Disability Discrimination Act, nor with the Road Safety Act given that the rear of the bus is overhanging into the Alexandra Avenue through lanes.

Figure 4 – Example of Bus Stop location

76. The example above should not be occurring and can be easily fixed (particularly given there are only peak period clearways in this segment of Punt Road). It only occurs due to carriageway geometry that seems to make provision for a triangular vehicle to pull into the kerb south of Alexandra Avenue as shown in Figure 5 below. If a full size bus comes any further forward than that shown in Figure 4 then the front of the bus will stick out into the left hand traffic lane.

77. The bus has come from the left hand traffic lane (as there are only two southbound lanes on Hoddle Bridge). It should also be stopping in the left hand traffic lane. There are two simple concepts to fix this safety problem. Either extend the kerb to where is should be and have the bus stop in the left hand traffic lane or move the bus stop about 20 metres south (to be fully within the left hand traffic lane).

Figure 5 – Aerial View of Punt Road at Alexandra Road

78. It is noted that other bus stops in Hoddle Street-Punt Road are all in the left hand traffic lane except where they are at a queue jump facility prior to traffic signals.

79. This example is just one of several issues related to safety, disability compliance, location and passenger facilities at bus stops in the section of Punt Road under consideration. Further time would enable a deeper analysis and improvement concepts for each to be developed.

80. Fixing the minor issues with bus stops alone would generate more bus patronage, and reduce car use in the corridor to some small extent.

81. Re-branding bus Route 246 as a SMARTBUS was found likely to increase awareness and perceptions of service while also reducing perceived waiting times. Bus Route 246 is the second most frequent public transport service in Stonnington (behind the Frankston Railway Line). Research shows that rebranding alone would generate around 5% patronage growth (King, 2001) from increased awareness amongst non-passengers. This growth (an additional 250 passengers per weekday) would come mainly from private car driver diverting to the bus service.

82. Without re-branding the bus route will continue to operate at a very high level of service (every 10 minutes) and be a wasted opportunity given the spare capacity that some existing car drivers could occupy on the bus. Adding bus lanes in some segments of the route will also make the services and travel times more reliable.

83. PTV data confirmed by research from Monash University also shows that a full SMARTBUS treatment of bus lanes and signal priority to make travel times more reliable would likely increase patronage in the order of 30% over a 24 month period. Again much of this increased patronage (1,500 passengers) would divert from being car drivers in the Punt Road corridor. This mode shift would significantly reduce congestion levels, but not enough to offset the removal of a traffic lane.

Example of Pedestrian Issues

84. The northern end of Punt Road has very narrow (in some cases no) footpaths. In every case this is because lane width for private vehicles has been considered to be more important than adequate space for pedestrians. An example from the south western side of the intersection of Domain Road and Punt Road is shown in below. This footpath does not meet the minimum standard endorsed by the City of Melbourne and is likely to be non-compliant with the Disability Discrimination Act.

Figure 6 – Footpath on the western side of Punt Road, south of Domain Road

85. As the intensity of residential development, commercial activity and schools in the surrounding area increases the demands on the footpath space across the whole area are increasing. In particular there is significant need for residents on the western side of Punt Road to cross the road for their daily shopping needs and residents on the eastern side of the road often need to cross in order to access education and recreation facilities (Fawkner Park and Botanic Gardens in particular).

86. These crossings of Punt Road can occur in a vehicle (bus, car or tram), on a bicycle or on foot. Given the amenity of the pedestrian environment and the signal timing for pedestrians (particularly at Alexandra Avenue intersection) it seems logical that some people are currently driving very short distances to access education, recreation and retail facilities that they might otherwise walk to.

87. I am aware of examples of this through the monitoring of residential car parking permit use. Multiple investigations have found several cars being driven very short distances from South Yarra to St Kilda Road each day and back again each night. While these trips were not crossing Punt Road they highlight that the pedestrian routes need to be very attractive and safe in order to reduce local residents dependence on cars for short trips.

88. The issue of short trips being made by car is discussed in the background report but does not seem to have significantly influenced the concepts. The discussion of the impact of each concept lacks detail regarding the impact on pedestrians and cyclists. Without significant increases in amenity for these user groups, 35% of people will continue to use their car for short trips when a better outcome for everyone would be for them to get more exercise in a high amenity walkable urban precinct.

Concept 1 – 24 Hour Clearways

89. This concept is a relatively blunt instrument (being applied at all times) and is not targeted at fixing the specific issue. As such it could easily negatively impact on the community and produce unintended consequences.

90. Extending the clearways on Punt Road to operate through the interpeak period of the day seems logical. However there is insufficient data available to analyse the impact it would have on pedestrians using or crossing Punt Road.

91. Extending clearways along the arterial roads crossing Punt Road would have a detrimental impact on tram passengers in terms of safety. This professional opinion is based on knowledge of 25 years worth of crash data related to passengers boarding and alighting trams across Melbourne's network (however the report is an internal Department document and has not been published). Mitigation for the increased safety risk would be likely to require kerb extension platform stops – which would reduce the width of each arterial to just the tram lane anyway.

92. Concept 1 does not help achieve the overall objectives of making Punt Road a more attractive and safe. However it does assist to ease traffic congestion and provide more reliable bus travel times in the corridor.

3.2. DISCUSSION OF CLEARWAYS

93. It is understood that the Minister for Roads made an announcement about Punt Road clearways on Sunday 31 January 2016. The announcement indicated that Concept 1 for a 24 hour, 7 day/week clearway was being formally proposed in accordance with the Code of Practice for Clearways on Declared Arterial Roads.

94. It would be illogical to plan a major road capacity expansion (such as additional lanes) before concepts regarding clearways were fully explored and tested. It goes without saying that a parked car has very little economic value to society (particularly when alternative parking concepts abound in the nearby area). Therefore why would society provide space for such an activity on what is described as one of the most sought after movement corridors in the arterial road network.

95. It is thus very sensible to extend the clearway to the hours of the day and week in which significant congestion is occurring. The data available to the author does not provide detail regarding the times that congestion occurs on Punt Road. However from personal experience there seems to be many times of the day and week during which free flow conditions exist despite cars being parked in the left lane.

96. At times when congestion is not occurring there does not seem to be any need for clearway controls to apply. A principle of transport planning is to balance the needs of all users (including local residents) to achieve the most efficient use of the public resource. If congestion is regularly occurring for 24 hours everyday then such controls would be warranted. If there is minimal congestion occurring at some times of the day/week (for example between 1am and 5am), then the controls need only apply outside those times (in the example for 20 hours per day).

97. The clearway controls should be flexible (over years) and responsive to changes such as increased or reduced demand, seasonal requirements (such as providing for Games Family Lanes during the Commonwealth Games) or changes to the space required for various modes or urban treatments (such as street trees). Examples of clearways responding to changing needs include "Special Event Routes" in Sydney and "Snow Routes" that apply in many North American cities.

98. Clearways and any parking control (such as paid parking) should not be applied like an 'on/off' switch. Rather they should be applied like a thermostat, being gradually 'tuned' to meet the circumstances and needs of the corridor. The negative impact on local communities can be significant and unintended.

99. Unnecessary application of clearways is not world's best practice. Applying unnecessary controls can erode broad community 'faith' in the competence of decision makers to manage public assets for the benefit of all members of the community.

100. As briefly mentioned above, clearways have particular negative outcomes for tram passengers in the form of increased risk of serious injury. The application of clearways on the intersecting streets for 100 metres before and after Punt Road will reduce safety at tram stops. The likely result is more near misses and crashes between cars and passengers boarding or (twice as likely) alighting from trams.

101. I have researched the safety impacts of clearways around kerbside tram stops as part of project work for the Department of Transport. Given various factors including the stop location, patronage and demographics of passengers using trams that cross Punt Road this should be flagged as a significant issue in the multi-criteria assessment of any concept that includes clearways along tram corridors[2].

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[2] *Only if the tram stops are developed into accessible kerb extension platform stops will that safety issue be adequately resolved. This is because there is not yet enough empirical research to confirm that the alternative design of kerb access stops (those that allow cars to travel*

102. Permanent clearways in Punt Road would also negatively impact on safety of pedestrians both walking along the footpath and seeking to cross Punt Road.

103. Analysis of SmartBus lanes found that significant safety improvements resulted from restricting private vehicles from using the left lane at the normal speed limit. The reasons relate to the proximity of cars to the pedestrians and the greater impact that results from a loss of horizontal control of the vehicle when the car is close to the kerb (Goh et al, 2014).

104. The optimum transport planning outcome for Punt Road if any clearway is introduced would be for the left lane to be paved in a 'red-carpet' bus lane. As suggested in one of the concepts the lane could start as a 'high occupancy vehicle lane' until such time as the buses are operating every 5 minutes and high occupancy vehicles are congesting the lane too much.

105. Just like the clearway controls themselves, the high occupancy lane could be tweaked like a thermostat depending on demand, and be restricted to two person vehicles at the start, and once too congested it could be restricted to 3+ or 4+ vehicles, or vehicles of a specific type such as freight.

106. Research shows that all drivers tend to drive at higher speeds on roads with wider carriageways. Parking a car on the street, is shown to be effective at narrowing the carriageway such that drivers then operate vehicles more slowly. Clearways will lead to higher free flow travel speeds in the Punt Road corridor – and increased risk (both in terms of crash likelihood and severity) for other road users.

107. On site observations found a significant number of people crossing Punt Road at mid-block locations (a movement type that is not recorded/shown in the background report). These people benefit from parked cars in the inter-peak period as they only need to observe and negotiate one lane of traffic in each direction. Effectively a parked car on each side of the street can halve the distance that they need to cross without 'protection'. This negative impact is not recorded in the multi-criteria analysis.

108. Importantly, these people can potentially be caught unawares when conditions on the road change and drivers adopt higher speeds. A risk mitigation strategy may identify some appropriate measures to reduce the likelihood and severity of future pedestrian crashes if clearways are introduced over a longer period of the day/night.

3.3. DISCUSSION OF SPEED LIMITS

109. It is sensible to consider a lower speed limit for the Punt Road corridor at least from Alexandra Avenue to High Street.

110. This is due to the range of factors at play, including the extent of congestion, lack of space to protect pedestrians and cyclists and diversity of dense land uses abutting the road (and within the wider corridor).

111. The number and location of schools along Punt Road leads to a 40km/h speed limit being in place during some peak periods on some segments while a 60km/h limit is currently in place between Alexandra Avenue and Toorak Road.

112. This situation is not safe for other road users as the segment between Alexandra Avenue and Toorak Road has a steep hill that cyclists are slower on, and narrower footpaths for pedestrians

over the raised tram platform) adequately resolve the issue of passenger safety. Such an infrastructure commitment would require the cars in most of the east-west arterials to share the tram lane as they travel past the tram stop.

and bus passengers. In some locations there is literally not enough footpath width for two people to comfortably pass each other (or a wheelchair to pass a pedestrian).

113. Lower speed limits may also increase capacity of the road (under certain circumstances) because the headway between each vehicle will be reduced. Lower speed limits may have very little impact on the overall travel time in the corridor (particularly in peak congestion) as the key limiting factor is the intersections (particularly at Alexandra Avenue and Swan Street).

114. The objective of any improvement to Punt Road should be to get closer to the communities vision for what boulevards in Melbourne should look like. A secondary consideration should be maximising the ability for people to travel in the corridor and providing them with a choice of modes all of which are safe and efficient. The mean speed of private vehicles in the corridor may be a worthy consideration but not ahead of the other two (and potentially behind the mean speed of public transport vehicles or mean delay to people (in cars or not) crossing the corridor).

115. A deep analysis of the impact of lower speed limits in the Punt Road corridor has not been possible due to time and resource constraints. On face value (with due regard to the existing mean travel speeds in the corridor) it seems like a concept that is worth considering and may fit within the safety risk mitigation related to expanded clearways.

Concept 2 – 4 lanes + Central Right Turn Lane

116. This concept has a total of five lanes.

117. Concept 2 strives to maximise the potential turning movements across oncoming traffic flows and thus has a high potential of invoking Braess Paradox.

118. The addition of a central turning lane comes mainly at the expense of pedestrians travelling along the Punt Road footpath and seeking to cross the road.

119. Signal time to enable the turning movements comes at the expense of through traffic and people crossing Punt Road from east-west (some in vehicles some not).

120. This concept does not meet the basic principles of achieving a more functional and efficient road network (for all users) nor does it achieve a higher amenity boulevard that contributes positively to the sense of place and community in the area.

121. It should be noted that modelling may suggest this concept provides an overall better outcome than would actually occur because the model is not seeking to identify occurrences of Braess Paradox. It is understood that modelling has not been undertaken with the right hand turns completely removed (concept 3 includes jug handle turns and thus retains the right turn traffic volumes). It may be worthwhile testing a scenario with no right turns (even jug handle turns) to understand the impacts of such an option. Most likely traffic will divert to alternative routes and some will rely on left hand turns.

122. Another alternative that retains right hand turns but it yet to be considered in detail is providing for hook turns at the arterial road intersections. The effectiveness of hook-turns had been questioned for some time, until a study by Currie and Reynolds in 2011. This peer reviewed study found that hook-turns not only improve performance of on-road public transport, they also reduce congestion for all vehicles (particularly through traffic) and improve safety for all road users.

123. Given the type of travel being accommodated in Punt Road the application of hook turns to some intersections (such as Domain Road and Greville Street) could be a very logical way of catering for a small number of vehicles without causing significant delay within the standard traffic signal cycle.

Concept 3 – 4 lanes + Central Median

124. This concept provides for an improvement to traffic flow, urban amenity and pedestrian safety with the introduction of a central median and ban on right hand turns at all intersections.

125. Of the concepts that minimise need for road widening this one seems to offer the most benefits for other road users (in addition to benefits identified in the report for car drivers). The reduction in turning choices significantly streamlines the traffic flow and consistent application along the entire corridor makes it simple for all road users to understand. They will thus be able to plan their journeys knowing with confidence what movements are allowed.

126. Weaknesses of this concept could be the lack of footpath width in some parts of the corridor and the increased number of left turn movements impacting on cyclists and pedestrians in the corridor. In this regard it should be noted that the users that are least expected are often those most in danger (because they are not expected by drivers either). Therefore particular attention should be given to pedestrian treatments at intersections with low pedestrian volumes and cyclist treatments (at least stop line storage boxes) along the entire corridor.

Concept 4 – 4 lanes + Central Reversible Lane

127. This concept has a total of five lanes.

128. Given that Concept 4 has been determined to be unfeasible by VicRoads, I have not assessed its merit. The discussion in the VicRoads/PTV submission related to the lack of feasibility is logical.

Concept 5 – 5 lanes + 2 Lanes at Arterial Intersections

129. This concept has five lanes arranged as in Concept 2 plus additional lanes at arterial road intersections.

130. This concept for a widening to six lanes at each intersection relies on road users to weave before and after every intersection to maximise the capacity of the road. This introduces safety issues and can have a negative impact on bus services unless the additional lane is a queue jump facility for buses and high capacity vehicles.

131. Depending on the model parameters this concept may struggle to realise the full benefits that the model predicts because it relies on human behaviour seeking the shortest queue when approaching each intersection. Many drivers do not like having to remerge into the traffic stream (some consider it impolite) and therefore, often an additional left lane may only cater for a small number of vehicles in each signal cycle.

132. During the green phase under free flow conditions the additional capacity provided by the third lane almost all relates to storing left-turning vehicles whilst the driver awaits pedestrian movements to clear. At intersections or times of low pedestrian movement or low number of left turning movements the third lane will have minimal impact on vehicle throughput.

133. The widening of intersections does however have a significant impact on pedestrians trying to cross the intersection. Analysis of the additional pedestrian phase time and the signal cycle phases envisaged would be necessary in order to determine the magnitude of the impacts for each pedestrian movement.

134. Given the impact on surrounding properties, potential for negative impact on other road users and the limited benefits this concept seems like a poor outcome for the local community and the Victorian economy.

Concept 6 – 6 Lanes + Central Median

135. This Concept has six lanes plus a central median and right turning lanes in the median at selected arterial road intersections.

136. This concept seems to best cater for the long term movement needs in the corridor provide that the third lane in each direction can be dedicated for high occupancy vehicles at an appropriate time in the future.

137. The uniform total carriageway width will be beneficial in terms of safety, amenity and providing the typical boulevard treatment that Melbourne is famous for. The three simple lanes and reduced turning movements will provide clarity for all users and reduce the amount of weaving necessary.

138. The ability to accommodate cyclist facilities is a key benefit of this option, particularly given the density of education, employment, retail and recreation facilities in the area. The bicycle facilities could link to the Capital City trail over the widened Hoddle Bridge. The outcome could be a very attractive north-south bicycle corridor that links key origins and destinations and invigorates mode shift for regional trips in the Punt Road corridor.

139. If the left lane is used as a bus lane, the Hoddle Bridge widening could be avoided (or reduced to a new bridge for the bicycle facility). This is because the northbound bus would only need a queue jump lane and bus priority signal (which it already has) in order to be the first vehicle onto the two northbound lanes of Hoddle Bridge.

140. The northbound left turn from Hoddle Bridge into Alexandra Avenue could also accommodate a bus queue jump facility similar to many other locations in Melbourne. Thus meaning the current Hoddle Bridge width would accommodate the traffic movements in this concept (if the concept is modified to have bus lanes as the new left lane).

Concept 7 – 6 Lanes + 2 Bus Lanes

141. This Concept has a total of eight lanes at intersections and six lanes mid-block.

142. This long term concept introduces complexity on top of Concept 6 by adding additional storage at each intersection. It is unlikely that this concept would be required until the long-term future.

143. The lane configuration of this concept has higher capacity for vehicles travelling along Punt Road, but it also has an almost equally detrimental impact on pedestrian access across the what becomes an eight lane highway. At the intersections pedestrians would experience this concept like they currently experience in City Road, Southbank, with long crossing times and a very hostile environment that pedestrians will be reluctant to cross.

144. The interchange between public transport services would become more difficult as a result of the time taken to complete the walking transfer. This would reduce the attractiveness of public transport services unless they are placed in the middle of the roadway.

145. If this width of road pavement was seriously entertained, consideration could be given to providing two medians and transit priority in the middle of the road (similar to St Kilda Road). There are a range of other design concepts for these types of transit corridors most recently published by the National Association of City Transportation Officials (NACTO) in the USA.

146. It would be difficult to design this concept in such a manner that achieves all the Transport Integration Act objectives to result in a walkable urban precinct that contributes significantly to the economic prosperity of Victoria.

4. Comment on the impact of each concepts on the surrounding networks and identify any constraints on assessing the impact of each option

147. The impact of the concepts on surrounding networks has been discussed broadly, but there is insufficient data available for robust conclusions to be made. In particular the scope of the concepts seems very narrow given the region that the problem is suggested to affect.

148. The background documents refer to Punt Road as the only north south corridor through a wide band of metropolitan Melbourne. If so, surely the improvement concepts would need to consider a corridor wider than a few hundred metres either side of Punt Road.

149. For example, there are no direct public transport services that cross from the City of Stonnington to the Cities of Darebin or Banyule (although Route 246 formerly performed this connection). These municipalities roughly equate to the 4km corridor that Punt Road is providing for to the east). These north south public transport connections were considered in the Metropolitan Bus Service Reviews (Booz & Company, 2010a & 2010b) and recommendations were made to increase transport concepts for people needing to travel across the Yarra River. None of these improvements have yet been implemented.

150. The Chandler Road crossing of the Yarra River in Fairfield is proceeding and will alleviate congestion in the surrounding area. The concepts for someone wanting to travel in this corridor from Kew to Toorak by public transport consist of bus Route 609 operating six times per day in each direction (none of the trips going the full distance). Getting to Hawthorn still requires three transfers onto tram Routes. It is therefore no wonder that someone living in Fairfield and working in Toorak would travel into Hoddle Street and south to Punt Road before then heading outbound on Alexandra Avenue or Toorak Road.

151. Another recommendation of the Bus Service Reviews (Booz & Company, 2010a & 2010b) is to extend bus routes from Stonnington north into the City of Yarra (and potentially the City of Boroondara). This has not occurred as yet and therefore someone living in Kew and working in South Yarra has two main car based travel concepts – and no reasonably competitive public transport concept with fewer than two transfers.

152. It can be concluded that there are many improvement concepts yet to be considered in the hinterland of the Punt Road corridor that would give people more transport choice and reduce their need to travel along Hoddle Street-Punt Road at all. Each of these services or improvements to modes in alternative corridors could have a significant impact not just on Punt Road but also on their more local arterial road corridor.

5. What is the likely impact of urban growth on and around Punt Road on the surrounding road network?

153. The impact that urban growth will have on the surrounding road network is highly dependent on a wide range of factors including the nature of that growth, the amount of car parking and car storage is provided, the walkability of the urban environment and the level of pubic transport services provided.

154. Highest levels of growth will have the most positive impacts (in terms of reducing vehicle kilometres travelled per capita per annum) and low density development with car parking will generate the most negative impacts on the road network.

155. In the City of Melbourne for example the high density of development and walkable urban precincts has resulted in a motorisation rate of 31 cars per 100 residents. This is compared with Metropolitan average of 65 cars per 100 residents. If the area around Punt Road can transition to become a highly walkable urban precinct (as Forrest Hill, South Yarra is doing) then the motorisation rate of this area will also reduce to a rate similar to the City of Melbourne.

156. Such a reduction in local car ownership will assist greatly in reducing demand for short car journeys along and across the Punt Road corridor.

157. If however a walkable urban precinct is not created and residents feel they must rely on owning a car, then a higher motorisation rate will result and more space will be required for car storage, parking and movement.

158. The level of car ownership is directly dependant on the amount of car parking and storage provided in that local area. The rate of car ownership directly influences car use and local traffic congestion.

159. To reduce the impact on congestion on Punt Road (by both restricting car ownership and limiting driveway access points) no new developments along the corridor should be allowed to have any car parking. However they should be able to intensify as much the Planning Scheme controls (such as the Design and Development Overlays) allow. This will maximise the efficiency of each building to focus use on those residents and employers who want lower car ownership and cheaper travel concepts.

160. The intensity will increase demand for public transport in the corridor and provide more affordable housing concepts in the area – as each car space costs in an apartment about $50,000 for the developer to construct (including the cost of finance and risk that the car space will not be sold).

6. Are there any other matters you consider relevant to the advisory committee's consideration of the submission made on behalf of the City of Melbourne?

161. The City of Melbourne's submission is a solid piece of analysis related to integrated transport planning in the Punt Road corridor.

162. The request to be more closely involved in developing improvement concepts is supported and seems to link directly to requirements of the Transport Integration Act.

163. Any significant loss of recreation space along the Yarra River seems to be inconsistent with State documents such as the Lower Yarra River Future Directions Plan.

164. Data relating to the number of bicycles using the Capital City Trail and Yarra River trail (on the north and south banks of the river) over time could be helpful in identifying potential demand for Punt Road cyclist movements if adequate infrastructure is provided.

Figure 7 – Punt Road at the Yarra River c.1856

Source: Royal Historical Society of Victoria

7. Conclusion

165. The formal statements required by the Guide to Expert Evidence are provided below.

Table 1 – Formal Statements required by the Guide to Expert Evidence

	STATEMENTS
List any questions falling outside the expert's expertise	N/A
Is the report incomplete or inaccurate in any respect	No

166. I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.

8. References

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Appendix 1

The expert's qualifications and experience

QUALIFICATION	INSTITUTION
Bachelor of Urban & Regional Planning	University of New England
Master of Transport	Monash University
Public Transport Planning Short Course (4 days)	Monash University
Certificate IV in workplace training	AGSM

MEMBERSHIPS	SPECIFIC DISCIPLINES & ROLES	
United States Transportation Research Board	1 of 25 Members on the Transport and Land Development Committee Assistant to the Chair of the Parking Management Subcommittee	
Planning Institute of Australia	Urban Planning Social Planning Transport Planning	Former National Board Member Chair of Transport Planning Chapter
Institute of Transportation Engineers	Transportation Planning	
Australian Institute of Traffic Planning and Management	Integration of Land Use and Transportation Planning	
Australian Education City – Advisory Board	Transportation Planning	1 of 5 Members of the Advisory Board
Melbourne High School Old Boys' Association	Green, Maroon and Black Patrons' Club	Secretary of Executive Committee

The expert's area of expertise to make the report

167. I have over 20 years' experience on strategic planning and transport integration projects for public sector organisations and government departments. I work collaboratively with clients and stakeholders to achieve my vision of developing integrated, efficient and sustainable transport solutions. In my eleven years as a consultant, and previous ten years in local government, I have led multidisciplinary teams on complex projects:

- Researching and producing integrated transport plans, strategic frameworks, business cases and concepts assessments
- Evaluating transport networks including financial and economic modelling
- Developing transport network improvement strategies focussed on delivering enhanced customer value to the wider community.

168. My expertise has been recognised in Australia and the United States where I sit on multiple senior transport industry boards including professional and research associations.

169. Specific project experience relevant to the topics being considered by the Advisory Committee are highlighted below.

PHILLIP BOYLE & Associates

SELECTED PROFESSIONAL EXPERIENCE	
Outcomes: Provided course work and assessment of undergraduate and masters level students in Transport & Mobility *Tasks*: Prepare and present transport and mobility course	**La Trobe University** Sessional Lecturer 2015-2016
Outcomes: Prepare business case for up to $60m worth of new infrastructure in Mebourne CBD *Tasks*: Analysis of existing tram stops, road space environment and scenarios; identification of benefit streams; preparation of concepts assessment and business case	**Public Transport Victoria, CBD Tram Stop Upgrade – Business Case** Project Manager 2014
Outcomes: Definition of a range of governance models in line with government objectives and strengths and weaknesses of models *Tasks*: Investigation of best-practice governance models and divergent stakeholder views, through a series of workshops and engagement sessions; review of available evidence to identify common ground and reach consensus on complex issues	**Department of Planning & Community Development (Vic.), Melbourne Metropolitan Planning Authority Governance Model Study** Project Manager 2013
Outcomes: Video analysis of congested areas; concept plans with recommended short- and long-term improvements and priorities for improvement *Tasks*: Investigation of pedestrian congestion around specific locations such as railway stations and busy tram stops	**City of Melbourne, Pedestrian Congestion Study** Project Manager 2013
Outcomes: Quantified improvements to pedestrian amenity and safety from changes to traffic signals across Inner Melbourne *Tasks*: Evaluation and quantification of improvements; collaboration with four local government authorities, Department & VicRoads to analyse existing data and test the behavioural response to pedestrian signal timing changes for 20 locations	**City of Yarra (Vic.), Project Greenlight – Pedestrian Signal Analysis** Expert Advisor 2011
Outcomes: Alternative Ultimate SmartBus networks based on network planning principles developed through workshops *Tasks*: Strategic advice; evaluation of previous planning work; development of two alternative networks	**Department of Transport (Vic.), Ultimate SmartBus Network Strategic Review** Project Manager 2010
Outcomes: A range of safety improvements (blackspot and en masse) to address infrastructure, vehicle and road user safety issues *Tasks*: Oversight of project delivery; investigation into 23 years of crash history across the tram network; categorisation of tram stop types; development of improvement concepts	**Department of Transport (Vic.), Kerbside Tram Stop Safety Strategy** Project Manager 2010
Outcomes: 75 public workshops and 100 stakeholder consultation meetings; ten separate projects, which totalled 75% of Melbourne's network *Tasks*: Oversight of project delivery; extensive stakeholder and community engagement; evaluation of travel patterns, future demographics to ensure the network responds to these needs; development of service recommendations	**Department of Transport (Vic.), Melbourne Bus Service Reviews (for Melbourne, Port Phillip, Stonnington & Yarra)** Project Manager 2010

Outcomes: Strategy that identified improvements to parking management in the Melbourne CBD *Tasks*: Coordination of workshops; baseline reporting; identification and development of concepts; development of holistic parking management strategy	**City of Melbourne (Vic.), CBD and Docklands Parking Strategy** Lead Author 2008
Outcomes: Options Assessment (PRC2 Report) for upgrading tram infrastructure along St Kilda Road, Melbourne *Tasks*: Oversight of project delivery; developing Options Assessment, including assessment of DDA-compliant infrastructure and impact of the infrastructure on the surrounding environment	**Department of Infrastructure (Vic.), St Kilda Road Tram Upgrade Project** Project Manager 2006

PUBLICATIONS

Currie, G & Tivendale, K 2010, 'Inclusive planning process for citywide bus network restructuring', *Transportation Research Record*, Journal of the Transportation Research Board, Transportation Research Board of the National Academies, Volume 2145 / 2010 Transit 2010, Vol. 3, www.trb.org/Main/Blurbs/163893.aspx

Currie, G, Scott, R & Tivendale, K 2013, *Experience with Value-for-Money Urban Public Transport System Enhancements*, NZ Transport Agency Research Report 531

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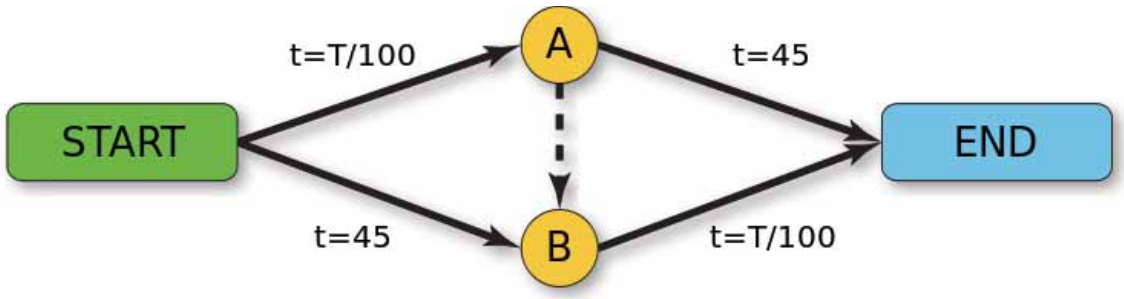
Appendix 2

Explanation of Braess Paradox

170. In 1968 German mathematician Dietrich Braess noticed that adding a road to a congested road traffic network could increase overall journey time. The theorem of Braess' Paradox has since been mathematically proven many times and witnessed in practice in cities all around the world (including Melbourne). The cities to have studied the impact of various high profile road closures and empirically proven the theorem include Seoul, Korea (2003-05) and New York (2009-10).

171. Consider a road network as shown in the diagram below. Solid lines are existing roads and the dotted line is a very fast new connection (with a travel time of around zero minutes). It could be a new lane that takes minimal time to merge into.

Figure 8 – Braess Paradox Example



172. Now consider 4,000 drivers who all wish to travel from point Start to End in the peak period. The travel time in minutes on the Start-A road is the number of travellers (T) divided by 100, and on Start-B is a constant 45 minutes (likewise with the roads across from them).

173. If the dashed road does not exist (so the traffic network has 4 roads in total), the time needed to drive Start-A-End route with A drivers would be (A/100) + 45 minutes. The time needed to drive the Start-B-End route with B drivers would be (B/100) + 45 minutes. If either route were shorter, it would not be a Nash equilibrium: all rational drivers would switch routes from the longer route to the shorter route.

174. As there are 4000 drivers, the fact that A+B=4,000 can be used to derive that when the system is balanced (at equilibrium) A=B=2,000. Therefore, each route takes (2000/100)+45 = 65 minutes.

175. Now suppose the dashed line is a road with an extremely short travel time of approximately 0 minutes. In this situation, all drivers will choose the Start-A route rather than the Start-B route, because Start-A will only take 4,000/100 = 40 minutes at its worst, whereas Start-B is guaranteed to take 45 minutes.

176. Once at point A, every rational driver will elect to take the "free" road to B and from there continue to End, because once again A-End is guaranteed to take 45 minutes while A-B-End will take at most 0+(4,000/100) = 40 minutes.

177. Each driver's travel time therefore becomes (4,000/100) + (4,000/100) = 80 minutes, which is an increase from the 65 minutes required when the fast A-B road did not exist.

178. No driver has an incentive to switch, as the two original routes (Start-A-End and Start-B-End) are both now 85 minutes. If every driver were to agree not to use the A-B path, every driver would

benefit by reducing their travel time by 15 minutes. However, because any single driver will always benefit by taking the A-B path, the socially optimal distribution is not stable and so Braess' paradox occurs.

179. This proven theorem is very important when planning new road links and considering how to get the most capacity from our existing road networks. It partly explains why rat-running occurs and how the rat-running not only affects local amenity, but also reduces the efficiency of the wider road network.

180. Most of our road network was designed prior to the theorem being proven in 1968. The street network in Richmond and South Yarra was also designed before current technology (like the automobile) was invented. They therefore typically have too many intersections and concepts to meet Hoddle's vision of functional efficiency. Just by existing (or being available to car drivers) these intersections and links make the overall network less efficient.

181. To achieve the maximum functional efficiency of the road network we need to close some of the links to cars – particularly the links likely to be causing a Braess Paradox. This has already been done on some Punt Road links (probably for safety reasons) as shown in Figure 9 below.

Figure 9 – Examples of links that have been closed and thus prevent Braess Paradox

182. As an example of how minor changes can help to avoid Braess Paradox occurring, Clowes Street could be fully closed at Punt Road. This would result in slightly less traffic queuing in the northbound lanes at the Alexandra Avenue intersection and require drivers to find an alternative path into Clowes Street (from Anderson Street). The reduction in vehicles on Punt Road would be equal to (or slightly more than) the number of drivers inconvenienced by the change.

183. In this example, the inconvenience to drivers going to Clowes Street is difficult to determine (and may not be significant), because of the different value they attribute to the 'frustration' of current arrangements. Currently they must travel north of Domain Road before that 'know' that there is no congestion at the Alexandra Avenue intersection. Such congestion could result in their overall travel time being greater than it would have been if they drove via Anderson Street.

The Principle of Triple Convergence

184. The principle of "triple convergence", formulated by Anthony Downs in 1992 explains the difficulty of removing peak-hour congestion from highways. In response to a capacity addition three immediate effects occur:

- Drivers using alternative routes begin to use the expanded highway
- Drivers previously traveling at off-peak times shift to the peak
- New drivers shift from using other modes (notably public transport) to driving.

185. These effects are important because in all three cases there the economic benefit associated with the "new" trips being made on the highway is minimal – because all these people have an viable alternative. The 'rule of one half' would need to be applied when valuing the benefit to all such users to account for a standard distribution of benefit across the new user cohort.

186. Most road upgrade projects are founded on the economic principles that
    - Existing drivers will gain travel time savings for a long period of time
    - Some people not currently making a trip will be able to do so (and be more economically productive as a result)

187. In a New Zealand Transport Agency Research Report the principle of triple convergence (induced demand) was found to soak up 60-90% the benefits from new road construction over the longer term (Wallis et al 2012).

188. Anthony Downs also notes that even if the improvements are soaked up by induced demand there is still some economic benefit related to the change in travel behaviour (otherwise people would not change their behaviour).

189. However the overall point is that decision makers should be careful not to over-estimate the benefits as they may be related to economic activities that would have occurred anyway (without the new infrastructure).

190. These transport planning principles can have significant flow on impacts for public transport services and other elements of the transport system (parking availability, travel costs per household). In addition a lack of understanding these principles may lead decision makers to believe (incorrectly) that people must drive in the peak to achieve their economic objectives. In reality very few people want to only use one mode for all their trips over a year, most people seek to maximise their utility by using the mode that most suits their needs given their specific needs at the time.

191. It follows that the principle of creating a balanced transport system will best suit the broad community needs. Such as system is one in which all modes and links are moderately congested at all times of the day (and week) rather than one that that has links or vehicles only heavily used for an hour or so each morning and afternoon. The same can be said for all public infrastructure, for example a hospital that is only full for 10% of the year might be considered to be an inefficient allocation of resources.

Explanation of Marchetti's Constant & Travel time budgets

192. Marchetti's constant is an unproven theory regarding the average amount of time spent commuting each day, which Marchetti's Constant suggests is approximately one hour. Venetian physicist Cesare Marchetti, posits that although forms of urban planning and transport may change, and although some live in villages and others in cities, people gradually adjust their lives to their conditions (including location of their homes relative to their workplace) such that theie average travel time stays approximately constant.

193. Marchetti's constant has been researched and supported by many transport professionals however is yet to be conclusively proven. A related theory, that of 'travel time budgets' is also yet to be proven although several studies (notably in Europe and the United States) consider and establish reliable travel time budgets for residents of various cities and towns. Empirical data

seems to suggest that the economic theory related to mis-behaviour (whereby people who make savings waste those savings on related less worthy items) is at play in urban transport networks.

194. If these two concepts (Marchetti's Constant and Travel Time Budgets) are at play, then improvements to congested transport networks will make life seem easier (and in the case of a road project, drivers may find this equates to liveability). However, the investment may not generate a significant long-term increase economic productivity (because the economic interactions would have occurred anyway).

Integrated Transport Planning

195. 2012 research from George Washington University shows that economic growth is shifting into agglomerated urban areas that are highly walkable. These offer the greatest chance for interaction and sharing of ideas to generate innovation in the knowledge economy. Evidence of this is that a growing percentage of office development in the United States is occurring in Walkable Urban Precincts rather than office parks (Leinberger, 2014).

196. These Walkable Urban Precincts already account for a large proportion of the US national economy and are expected to be the fastest growing in the coming decades. Similar analysis by the Grattan Institute shows that over 80% of Australia's Gross Domestic Product (GDP) is produced in just 0.2% of our land mass and a significant portion of that is in walkable urban precincts. For example 15% of the national GDP is produced in just 7.1 square kilometres of central Melbourne and Sydney.

197. Putting US and Australian research together shows that the metropolitan areas that transform quickest to having multiple inter-connected walkable urban precincts will attract investment and employment from others that are slower to make the same shift to a more liveable urban form.