Infrastructure Victoria

Strategy Update

Problem Definition Modelling Outcomes

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Executive Summary

In 2016, Infrastructure Victoria (IV) released Victoria's 30-year Infrastructure Strategy. Since then, the state has continued to grow at a rapid pace whilst facing new, emerging challenges. As such, IV plans to release an updated strategy in 2020 that reflects these evolving needs and priorities.

To support this update, Arup and AECOM were engaged by IV to evaluate how the Victorian transport network may perform in the future under two distinct infrastructure futures:

- *Do Minimum*: representing little funding or development in infrastructure across Victoria beyond what has currently been funded or committed to by Government.
- *Network Development Scenario (NDS)*: representing a scenario where the transport network has capacity and connectivity to cater for increasing demand from population growth[1].

These infrastructure futures were tested for the future years of 2036 and 2051 using two different transport models – the Victorian Integrated Transport Model (VITM) and the Victorian Land Use and Transport Integration (VLUTI) model. The former was used to assess network performance against the Small Area Land Use Projections (SALUP) of population and employment growth[2] whilst the latter explored how infrastructure investment and land use zoning policy might affect future land use distribution patterns.

Infrastructure Futures

The two infrastructure futures represent very different ways in which the Victorian transport network may develop into the future:

- The Do Minimum highway network incorporates 1,540 additional lane kilometres by 2051 compared to today, whilst the NDS incorporates 4,310. This large disparity is felt most heavily in metropolitan Melbourne's outer growth areas, where large increases in population are expected into the future.
- The Do Minimum public transport network provides 151,000 additional service kilometres by 2051 compared to today (571,000 km), whilst the NDS incorporates 458,000 km. The metropolitan train network differs the most significantly between these two infrastructure futures, owing to greater electrification of the broader

[1] The NDS incorporates upgrades and projects that may be needed in the coming years. This includes all the existing projects covered in the Do Minimum, projects that remain in early stages of planning and further initiatives to make the transport network function effectively in the future. It includes initiatives that are not currently Victorian Government policy commitments but represent reasonable assumptions about the development of the future transport network that aligns with existing transport planning approaches.

[2] Sourced from the SGS Economics and Planning model.

system. In addition, the NDS network includes more vehicle upgrades, increasing the overall capacity of its services.

Static Land Use Tests

The VITM was used to test each infrastructure future with the SALUP, which predicts heavy population and employment growth into the future. By 2051, the state is expected to hold an additional 4.4 million and 2.3 million people and jobs compared to today. The most intense increases in residents are expected at the fringes of metropolitan Melbourne – north, west and south of the city.

This level of growth translates into an increased quantity of trips occurring on Victoria's transport network. Compared to today, a 60% and 100% rise in daily private vehicle and public transport travel is expected by 2051 respectively across all tested scenarios. This has the following implications:

- The overall proportion of private vehicle travel that occurs in congested conditions is expected to increase compared to today. This occurs with both the Do Minimum and NDS network assumptions, although the Do Minimum network performs expectedly worse.
- The level of road congestion seen during the middle of an average weekday in 2051 is expected to exceed conditions seen during the morning peak today for both infrastructure futures.
- The Do Minimum public transport network will be critically over capacity by 2051, with 45% of all travel during the morning peak occurring under crowded conditions. By comparison, the equivalent NDS network performs significantly better than even today's conditions.

These impacts affect the overall accessibility of travelling throughout the state, with the NDS network providing universally faster travel times for all types of travel. However, despite the large differences in infrastructure provision, both infrastructure futures only minimally influence overall mode share of public transport travel.

Variable Land Use Tests

The VLUTI model was used to test each infrastructure future against a dynamic demographic input – that is, the impacts of the infrastructure provided could modify the overall distribution of population and employment throughout the state. This works in contrast to the static land use tests where the SALUP inputs remain consistent.

An additional scenario – *Density Done Well* (DDW) – was also tested with the NDS network and an alternative land use zoning policy. Compared to other scenarios, this policy allowed increased densification along principle public transport network within metropolitan Melbourne.

With the ability to influence where people were living and working throughout the state, the high-level outcomes of the variable land use tests were as follows:

- Compared to the Do Minimum network, the NDS scenario resulted in more residents living in outer and growth areas of metropolitan Melbourne – likely related to increased accessibility from infrastructure upgrades. The DDW scenario expectedly resulted in more residents and jobs within inner Melbourne compared to both the NDS scenario and the Do Minimum.
- Because the DDW scenario resulted in more population within inner areas of the city, the overall number of motorised trips was lower than that of other scenarios. Residents within these areas are more likely to use active transport as a means of travel.
- Broad trends in congestion and crowding followed that of the static land use tests, with the NDS network performing better than the Do Minimum. Network performance of the DDW scenario maintained similar performance when compared to the NDS, despite the increased density of residents and jobs accommodated towards central Melbourne.

Direct comparisons between the outcomes of the static and variable land use tests have been largely avoided throughout this report due to methodological differences. However, it is worth noting that when compared to SALUP, the VLUTI model allocates significantly less residents to growth areas of the city. This contributes to improved network performance when comparing equivalent VITM and VLUTI model scenarios, with lower levels of congestion and crowding throughout.

Summary

The infrastructure and policy decisions made for the transport network today will not only influence its performance tomorrow, but also where we live, work, study and play. Bolstering the capacity of our existing network infrastructure has an important role to play in maintaining the connectivity and accessibility Victoria expects going forward. However, this alone will be insufficient in creating a future where public transport is used more frequently and road congestion is improved from today's conditions. Combining policy mechanisms such as land use zoning policy and behaviour change programs with transport improvements represents our strongest tool in shaping a successful future.

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Model Background

1 Overview

1.1 Purpose

In 2016, Infrastructure Victoria (IV) released Victoria's 30-year Infrastructure Strategy. This was an evidence-based view of what infrastructure and planning policy would be required to support the state into the future. Such a strategy cannot remain static in time. Victoria continues to grow at a rapid pace whilst facing new, emerging challenges. IV plans to release an updated strategy in 2020 that reflects these evolving needs and priorities.

To support this update, Arup and AECOM were engaged by IV to evaluate how the Victorian transport network is likely to perform in the future. This assessment focused on the operational performance of transport infrastructure across the state, as well as the network's general capability in meeting the population's mobility needs.

Impacts of infrastructure investment and land use zoning policy on future land use were also explored. The decisions surrounding where people live and work are linked to the structure of our transport network in a continuous feedback loop. As such, these two factors shape how cities grow over time. Given this, the re-allocation of land can have an equivalent impact to an upgrade in infrastructure – making land use policy an important tool in managing future demand challenges.

This report summarises the collective outcomes of Arup and AECOM's assessments.

1.2 Approach

For this report, the performance of the Victorian transport network was tested against two distinct infrastructure futures. Details surrounding these infrastructure assumptions can be found in Section 2, and are summarised as follows:

- *Do Minimum* – representing little funding or development in infrastructure across the state. This only includes currently funded and committed projects, along with any enabling infrastructure necessary for their proper function.
- *NDS* – representing a scenario where the transport network has capacity and connectivity to cater for increasing demand from population growth.

These two infrastructure futures were simulated in the 2036 and 2051 future years using two different transport models:

- *Victorian Integrated Transport Model (VITM)* – a state-wide strategic transport model developed and maintained by DoT. This takes a static set of land use assumptions as an input that is not affected by any network performance effects.
- *Victorian Land Use and Transport Integration Model (VLUTI)* – a modified version of the VITM developed by the consultant team for IV that incorporates a land use

model developed by Victoria University (VU). This allows for land use and network performance to directly influence each other during testing, rather than the land use remaining as a static input.

Further background for both models can be found in Appendix A. The modelled years of 2036 and 2051 each correspond with the model's available simulation years whilst representing conditions approximately 15 and 30 years into the future. The VITM was employed to specifically assess network performance and accessibility using DoT's Small Area Land Use Projections (SALUP) as the basis for future population and employment throughout the state. By contrast, the VLUTI model produces its own predictions of population and employment distribution (using SALUP state-wide totals) whilst simulating network performance. This seeks to offer an alternative view to SALUP on how Victoria may grow into the future. Whilst both methodologies produce similar metrics, the outcomes are not directly comparable with each other due to differing underlying assumptions and are presented separately.

To summarise, Table 1 outlines the core scenarios tested that inform the contents of this report. In addition to the Do Minimum and NDS assumptions outlined above, a 2018 scenario representing current conditions was tested to act as a benchmark (this corresponds with the baseline year for each model). A further scenario was also tested with the VLUTI model using IV's *Density Done Well* assumptions. This represents the NDS assumptions with a modified land use zoning policy promoting more densification along Melbourne's principle public transport network.

Table 1: *Core scenario group*

Model	**Assumptions**	2018	2036	2051
VITM	Current Conditions	•		
	Do Minimum		•	•
	NDS		•	•
VLUTI	Do Minimum		•	
	NDS		•	•
	NDS – Density Done Well Zoning Policy		•	

A set of alternative growth scenarios was additionally tested using the VITM as outlined in Table 2. These were equivalent to the respective core Do Minimum tests with less or more aggressive future population and employment projections.

Table 2: *Alternate growth scenario group*

Model	Assumptions	2018	2036	2051
VITM	Do Minimum – Low Growth		•	•
	Do Minimum – High Growth		•	•

More detailed assumptions surrounding the demographic and land use zoning policy inputs of each of these scenarios can be found in Sections 3 and 4 for the VITM and VLUTI tests respectively. Outcomes of these tests can also be found in these sections.

1.3 Limitations

It is important to note that model outputs are always an approximation of what can be expected in the real/built environment. They are subject to technical limitations and the general uncertainty associated with projections. As such it is important that results from both the VITM and VLUTI are treated with caution and interpreted with an understanding of the strengths and weaknesses of these modelling tools (more detail is provided in Appendix A).

A key input to both models is future SALUP land use projections. This data and the analysis informing this report was prepared prior to the emergence of the Covid-19 situation in Victoria. Therefore, the analysis in this report does not take into consideration possible and uncertain longer-term implications of Covid-19 impacts for the Victorian economy or changes in underlying travel behaviour.

1.4 Structure

The report is structured as follows:

- Section 1 provides an overview of the study.
- Section 2 outlines and compares the Do Minimum and NDS network assumptions for 2036 and 2051. All tested scenarios use one of these two infrastructure futures as the basis for its transport network.
- Section 3 outlines assumptions and outcomes specific to the static land use scenario tests using the VITM.
- Section 4 outlines assumptions and outcomes specific to the variable land use scenario tests using the VLUTI model.
- Section 5 summarises the key messages of this report.

Appendix A provides background for the VITM and VLUTI model used to perform the assessments within this report.

1.5 Reporting Conventions

In contextualising the outcomes of each scenario test, this report refers to several different region systems and metrics to illustrate impacts across different parts of the state and elements of the transport system. For clarity, these are outlined in the subsequent sections.

1.5.1 Region Systems

When referring to specific parts of the state, unless otherwise stated, this report uses three region systems – *Functional Urban Areas* (FUA), *Functional Economic Regions* (FER) and *Local Government Areas* (LGA):

- The FUA system splits Victoria into six regions, defined by their level of centrality to Melbourne's CBD. This also accounts for potential growth opportunities in the future. Figure 1 shows the classification of these regions.
- The FER system defines distinct parts of Melbourne's geography that correspond to connected, regional economies within the city. In brief, trade, commerce, commuting and other activities occur more frequently between firms and residents within these regions than with those outside of them[3]. Figure 2 shows the classification of these regions.
- The LGA system contains the municipal boundaries of the 79 cities, shires and boroughs that make up Victoria.

[3] More information on the FER system can be found in the Melbourne Functional Economic Region Report (2019) prepared by SGS Economics and Planning for IV.

1.5.2 Metrics

The outcomes of each scenario are formalised through metrics that have precise definitions, particularly that surrounding transport network performance. Travel will often be characterised in terms of *kilometres travelled*, which is the number of people travelling via a particular means multiplied by the distance they are travelling. This seeks to capture the magnitude of a behaviour more clearly than the two components alone.

Further, this report will also refer to *congested* or *crowded* travel. This too has a precise meaning, corresponding to kilometres travelled along a road or within a public transport vehicle that has exceeded 80% of its capacity[4].

It is important to note that both the VITM and VLUTI model use a higher-order representation of the road network that does not include a representation of local streets. This must be kept in mind when interpreting figures such as lane kilometre increases.

1.5.3 Time Periods

Both the VITM and VLUTI model simulate an average non-school holiday weekday. This simulated day is split into four distinct periods to account for varying travel behaviours during these times. Reporting outcomes will often correspond to one of these time periods:

- *Morning peak*: 7am – 9am
- *Inter-peak*: 9am – 3pm
- *Evening peak*: 3pm – 6pm
- *Off-peak*: 6pm – 7am

[4] Each road in the simulation is assigned a throughput capacity based on its characteristics and lane count. Performance of a road progressively degrades as this capacity is approached and exceeded. 80% capacity for roads corresponds approximately to Level of Service D conditions – a standardised scale of quantitative and qualitative measures for determining road conditions used throughout transport assessments.

For public transport, each vehicle type has both a defined seated and standing capacity. An overall crowding capacity is defined as all seats being taken and four people per square metre of available standing space (referred to as ‘load standard’).

Figure 1: *Functional Urban Areas*

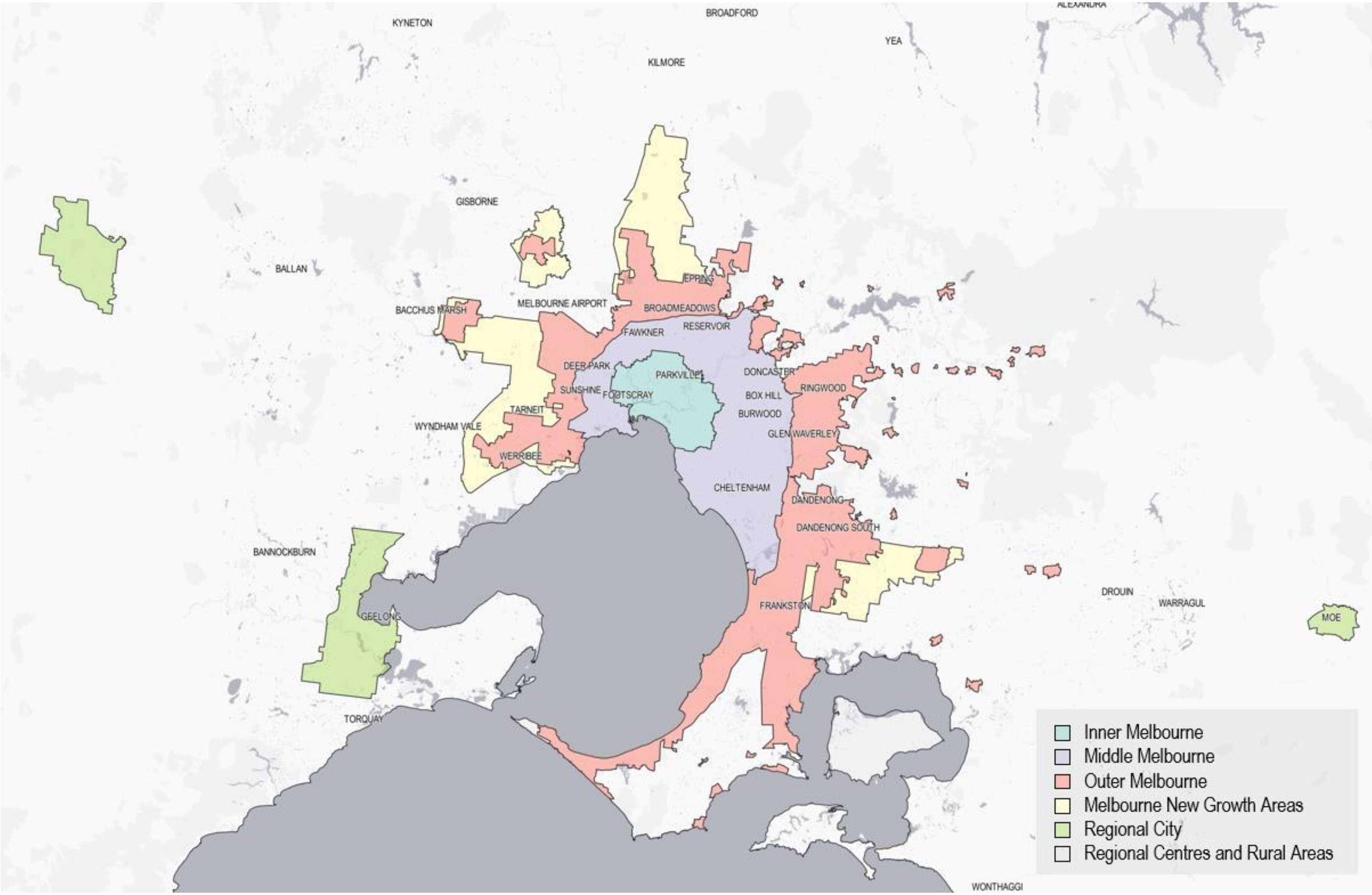
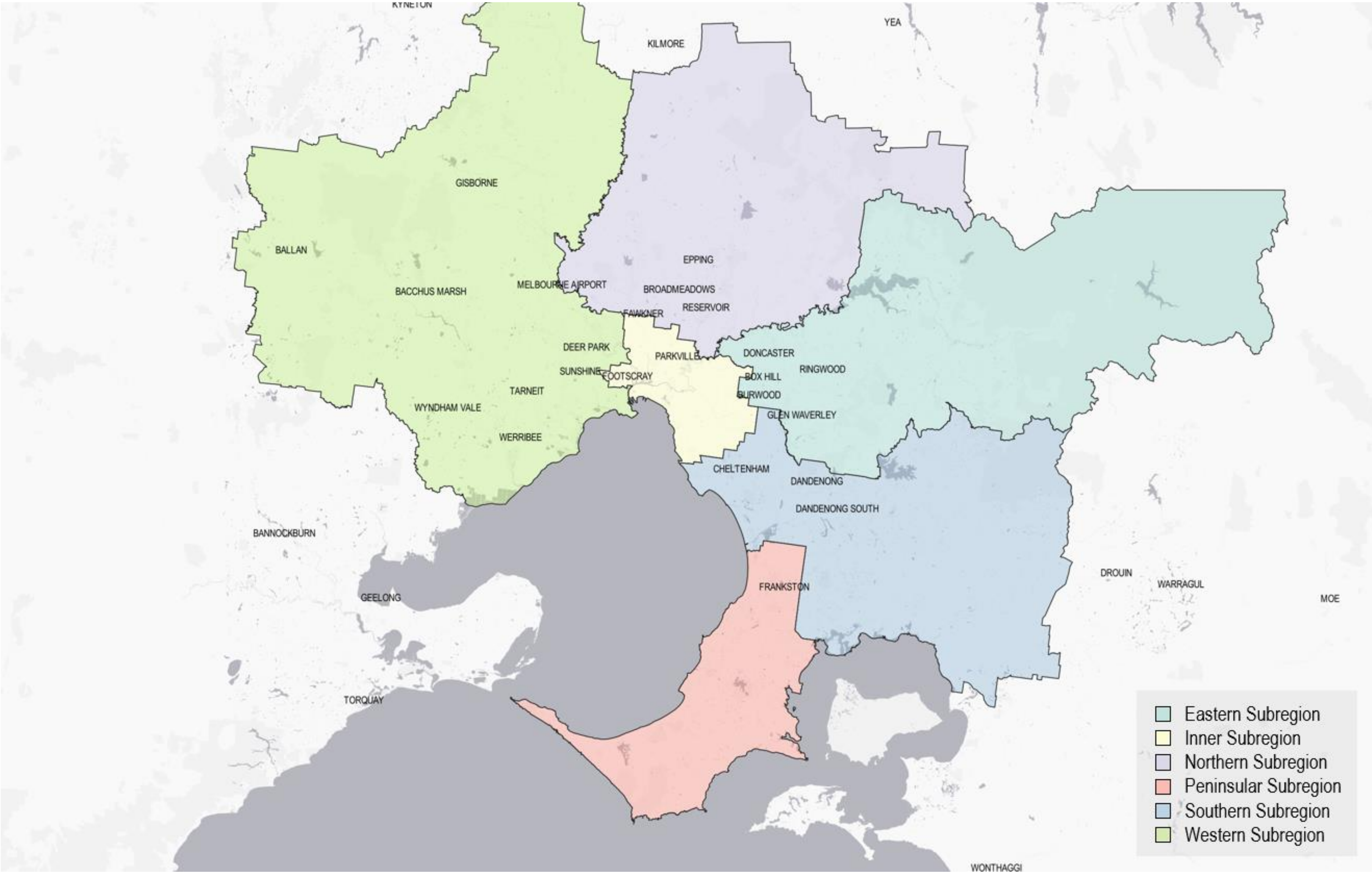


Figure 2: *Functional Economic Regions*



2 Infrastructure Assumptions

Two infrastructure futures were tested across the future years of 2036 and 2051 as outlined in Table 1 – Do Minimum and NDS. All scenarios tested as part of this work use one of these futures, except for the 2018 current conditions scenario.

These two infrastructure futures represent distinctly different scenarios in terms of how Victoria's transport network may develop into the future:

- The Do Minimum assumptions involve little further investment into the transport network beyond what Government has already funded or committed towards as of the writing of this report.

  The only additional interventions included within these assumptions are those that would logically accompany those projects once they come online in order to facilitate acceptable connectivity to the broader network. To illustrate where this is relevant, consider the Suburban Rail Loop (SRL) as an example – this major project has been committed to by the Victorian government and thus forms part of the Do Minimum infrastructure assumptions. Such a rail project would be accompanied by minor changes to the adjacent bus network to account for its presence and improve connectivity to specific stations. Whilst the main SRL project has clear Government commitment, these auxiliary changes do not. However, in reality it would be unlikely for the SRL to be constructed without these changes being implemented concurrently, as they contribute towards its proper functioning. Thus, these types of changes have been included within the Do Minimum infrastructure future.

- The NDS assumptions incorporate upgrades and projects that may be needed in the coming years. This includes all the existing projects covered in the Do Minimum, projects that remain in early stages of planning and further initiatives to make the transport network function effectively in the future. It includes initiatives that are not currently Victorian Government policy commitments but represent reasonable assumptions about the development of the future transport network that aligns with existing transport planning approaches.

More specific details regarding road and public transport assumptions underpinning these futures can be found in Sections 2.1 and 2.2.

2.1 Road Network

Table 3 and Table 4 summarise the difference in lane kilometres across each infrastructure future for 2036 and 2051. Do Minimum lane kilometres for 2051 are very similar to those in 2036.

Compared to today, a large portion of future road investment across both the Do Minimum and NDS assumptions is in Melbourne's new growth areas. This additional network is intended to support basic connectivity within these development areas to the broader city – hence the proportionally high level of estimated growth. This pattern is most heavily seen north and west of the city.

The NDS assumptions contain almost double the additional lane kilometres within outer and growth areas compared to the Do Minimum assumptions in 2036 – this is amplified further in 2051. There is also substantially more network growth in regions outside Melbourne under the NDS assumptions.

Table 3: *Lane kilometres by FUA compared to 2018*

FUA	2018 Current Cond.	2036 Do Minimum		2036 NDS		2051 Do Minimum		2051 NDS	
Inner Melbourne	2,453	+53	*+2.1%*	+53	*+2.1%*	+53	*+2.1%*	+59	*+2.4%*
Middle Melbourne	5,649	+329	*+5.8%*	+376	*+6.7%*	+329	*+5.8%*	+449	*+7.9%*
Outer Melbourne	6,232	+280	*+4.5%*	+588	*+9.4%*	+288	*+4.6%*	+1,031	*+16.5%*
Growth Areas	1,465	+679	*+46.4%*	+1,105	*+75.5%*	+711	*+48.5%*	+1,651	*+112.7%*
Regional City	4,636	+86	*+1.9%*	+233	*+5.0%*	+86	*+1.9%*	+329	*+7.1%*
Regional/Rural Areas	82,012	+74	*+0.1%*	+311	*+0.4%*	+74	*+0.1%*	+791	*+1.0%*
Total	102,447	+1,501	*+1.5%*	+2,666	*+2.6%*	+1,540	*+1.5%*	+4,310	*+4.2%*

Table 4: *Lane kilometres by FER compared to 2018*

FER	2018 Current Cond.	2036 Do Minimum		2036 NDS		2051 Do Minimum		2051 NDS	
Inner	3,930	+95	*+2.4%*	+97	*+2.5%*	+95	*+2.4%*	+105	*+2.7%*
Northern	3,164	+563	*+17.8%*	+953	*+30.1%*	+573	*+18.1%*	+1,194	*+37.7%*
Eastern	3,021	+69	*+2.3%*	+77	*+2.6%*	+69	*+2.3%*	+339	*+11.2%*
Southern	4,778	+298	*+6.2%*	+468	*+9.8%*	+299	*+6.3%*	+872	*+18.3%*
Western	4,833	+360	*+7.4%*	+736	*+15.2%*	+388	*+8.0%*	+1,276	*+26.4%*
Peninsula	1,754	+19	*+1.1%*	+35	*+2.0%*	+19	*+1.1%*	+93	*+5.3%*
Other	80,965	+97	*+0.1%*	+299	*+0.4%*	+97	*+0.1%*	+430	*+0.5%*
Total	102,447	+1,501	*+1.5%*	+2,666	*+2.6%*	+1,540	*+1.5%*	+4,310	*+4.2%*

Figure 3 and Figure 4 show the extent of these changes spatially for 2036 and 2051 respectively. The Do Minimum assumptions show new roads supporting developments out to Wallan and Melton. The NDS assumptions build on this with a greater density of upgrades across the city, particularly in the outer growth and regional areas.

Figure 3: *Road network differences in 2036 compared to 2018*

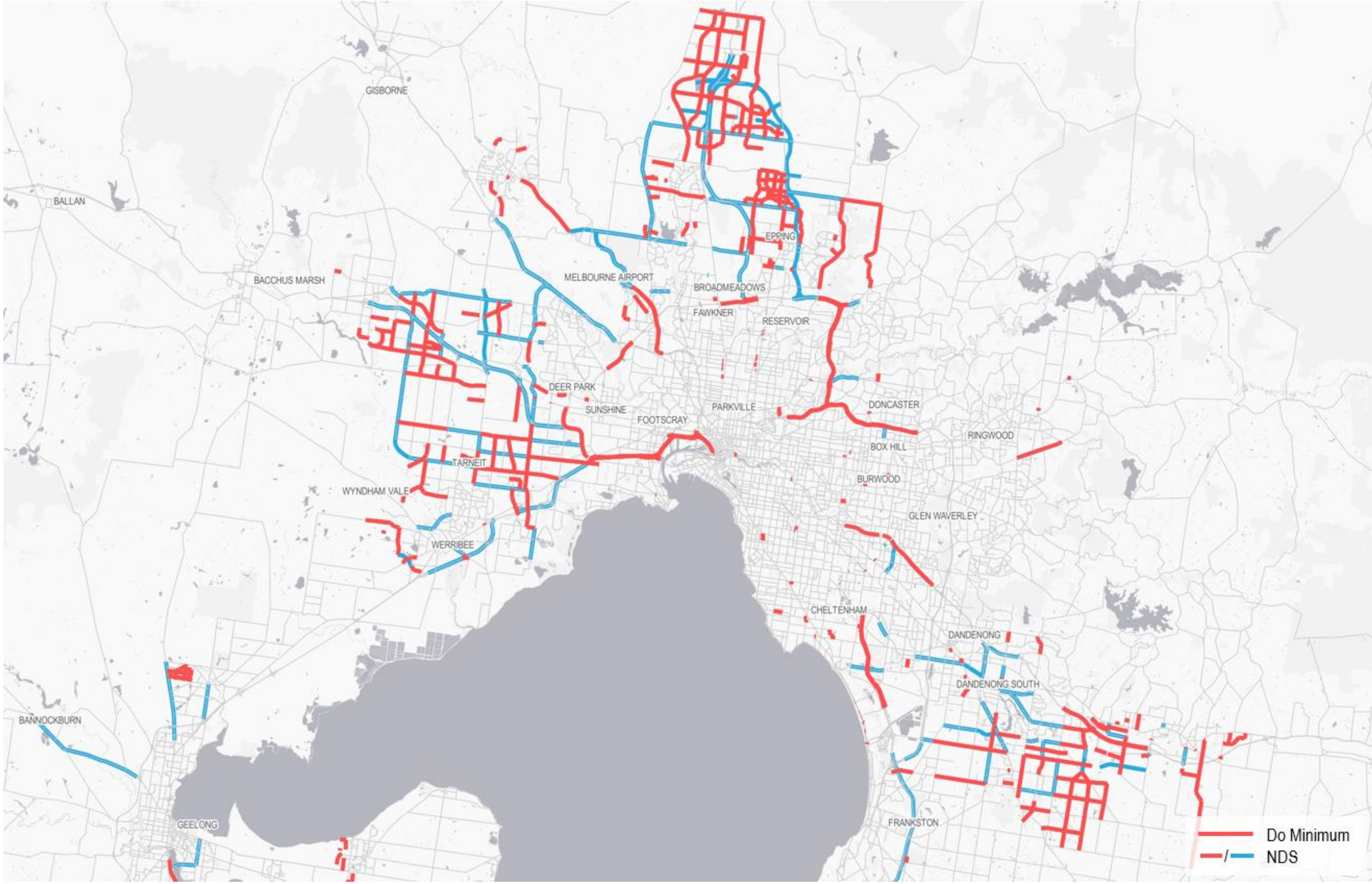
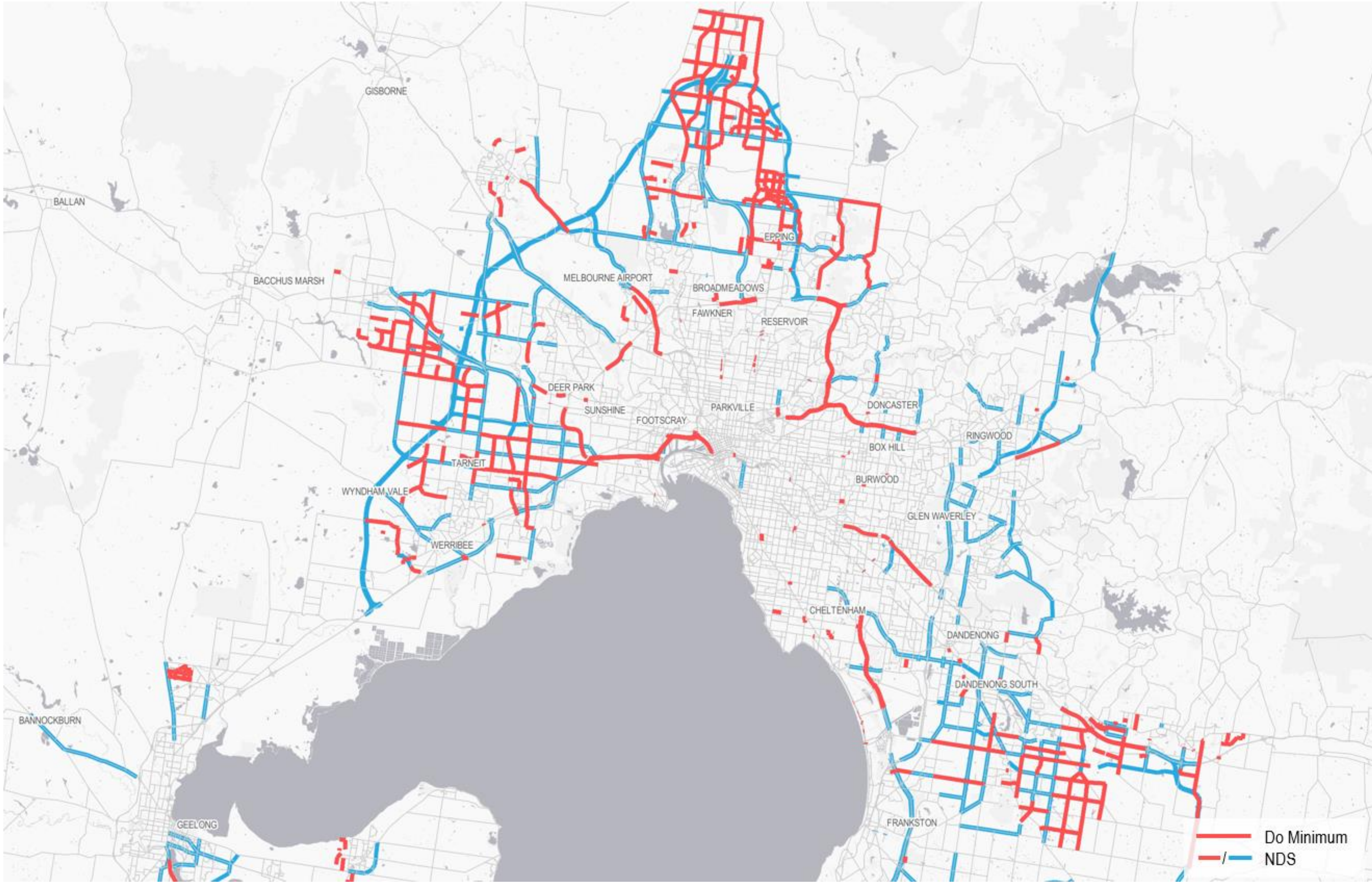


Figure 4: *Road network differences in 2051 compared to 2018*



Driving these increases in lane kilometres are several significant road projects. These are aimed at providing broad capacity uplifts across key corridors throughout Melbourne and its surrounding regions. Table 5 summarises the sequencing of these major projects across the Do Minimum and NDS assumptions for 2036 and 2051.

Table 5: *Major road project sequencing*

Project	2036 Do Minimum	2036 NDS	2051 Do Minimum	2051 NDS
Calder Freeway Upgrade	•	•	•	•
M80 Upgrades	•	•	•	•
Monash Freeway Upgrades	•	•	•	•
North East Link	•	•	•	•
Tullamarine Freeway Upgrade	•	•	•	•
West Gate Tunnel	•	•	•	•
Bayswater Bypass		•		•
Bellarine Link – Stage 1		•		•
Bulla Bypass		•		•
Dandenong Bypass Extension		•		•
E6 Corridor		•		•
Tullamarine Freeway Extension		•		•
Westall Road Extension		•		•
Bellarine Link – Stage 2				•
East-West Freeway				•
Outer Metropolitan Ring Road				•
Stud Road Extension				•
Western Port Highway Conversion				•

By 2036, the NDS includes major new roads not in the Do Minimum such as E6 transport corridor, Bulla Bypass, Westall Road extension and Dandenong Bypass extension. By 2051 these additions also cover projects such as the Outer Metropolitan Ring Road and Stud Road extension.

Overall, the NDS assumptions include an additional 1,200 and 2,800 lane kilometres throughout Victoria compared to the Do Minimum in 2036 and 2051 respectively. This covers a combination of new roads and upgraded arterials throughout the state, as well as key corridor-shaping projects.

2.2 Public Transport

Table 6 summarises the differences in daily service kilometres across each public transport mode for the Do Minimum and NDS assumptions. Substantial growth in public transport provision is included under the NDS assumptions through 2036 and 2051. This is achieved through the construction of new infrastructure and increases in frequency throughout the network. There is also the use of higher capacity vehicles that can carry more passengers, contributing to less crowding.

Table 6: *Daily public transport service kilometres compared to 2018*

FUA	2018 Current Cond.	2036 Do Minimum		2036 NDS		2051 Do Minimum		2051 NDS	
Train	71,960	+26,360	*+36.6%*	+53,290	*+74.1%*	+41,000	*+57.0%*	+123,910	*+172.2%*
Tram	72,400	-3,560*	*-4.9%**	+5,240	*+7.2%*	-3,560*	*-4.9%**	+5,240	*+7.2%*
Bus	388,540	+66,040	*+17.0%*	+268,110	*+69.0%*	+93,490	*+24.1%*	+314,320	*+80.9%*
V/Line	37,980	+20,480	*+53.9%*	+30,800	*+81.1%*	+20,480	*+53.9%*	+15,000	*+39.5%*

*At face value, it can seem that the Do Minimum tram network provides less service provision than the current 2018 tram network. This is an artefact from the modelling process due to how future off-peak tram travel is simulated. When considering just the morning and evening peaks, the 2036 Do Minimum tram network has approximately 11-12% more service kilometres than current conditions. Further refinements to the assessment will be required to draw reliable inferences for the off-peak period specifically.

2.2.1 Train

Daily train service kilometres are expected to more than double from current conditions by 2051 under NDS assumptions. In contrast, the Do Minimum train timetable is derived off the current 2020 service plan with some modifications to accommodate a small number of future committed projects (see Table 7). Figure 5 and Figure 6 show how these differences manifest in terms of service frequency spatially.

Figure 5: *Morning peak total service differences, 2036 NDS vs. 2036 Do Minimum*

Figure 6: *Morning peak total service differences, 2051 NDS vs. 2051 Do Minimum*

Table 7: *Major metropolitan rail project sequencing*

Project	2036 Do Minimum	2036 NDS	2051 Do Minimum	2051 NDS
Cranbourne Duplication	•	•	•	•
Hurstbridge Line Upgrades	•	•	•	•
Melbourne Airport Rail Link	•	•	•	•
Melbourne Metro	•	•	•	•
Suburban Rail Loop (Southland to Box Hill)	•	•	•	•
Burnley Junction Segregation		•		•
Cranbourne East/Clyde Rail Extension		•		•
Cross City Line		•		•
Geelong Rail Corridor Improvements		•		•
Mooroolbark-Lilydale Duplication		•		•
Upfield Link		•		•
Wallan Electrification		•		•
Wallan Extension from Upfield		•		•
Suburban Rail Loop (Southland to Melbourne Airport)			•	•
Geelong Electrification				•
Melbourne Metro 2 (Newport to Clifton Hill Tunnel)				•
Baxter Electrification				•

2.2.2 Tram

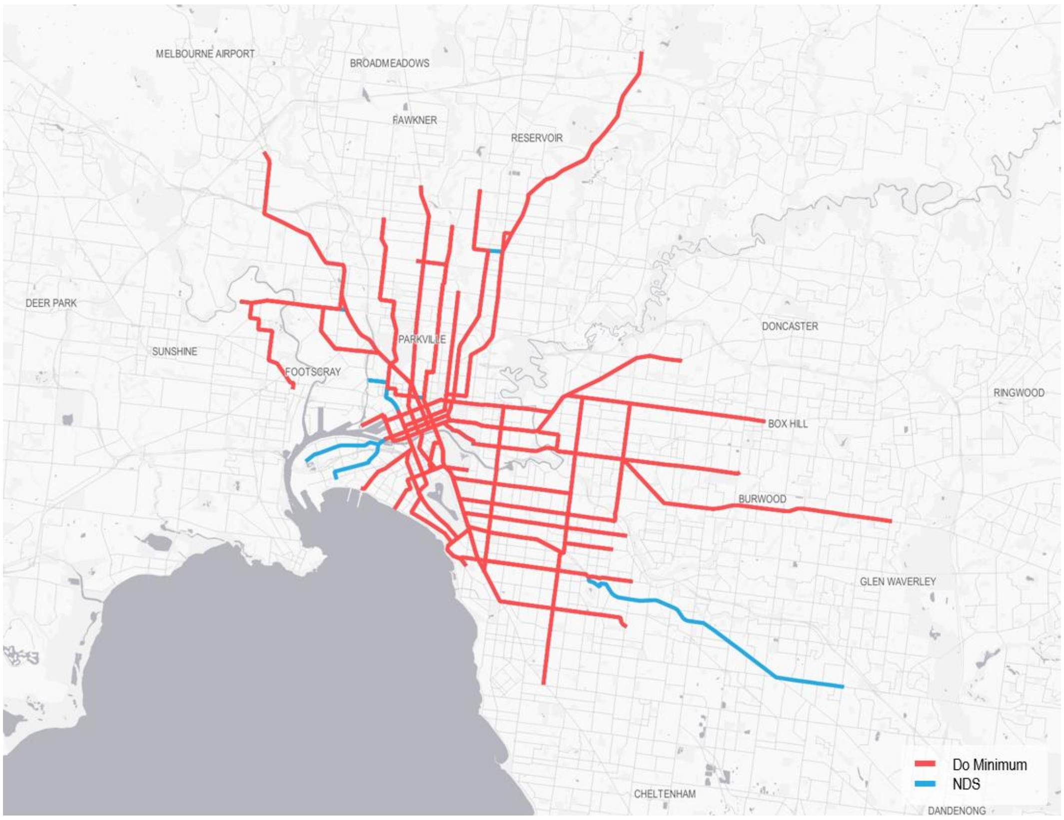
Table 8 shows the sequencing of major tram projects across the Do Minimum and NDS assumptions. The Do Minimum network only differs from the current network in accommodating for the completion of the Melbourne Metro tunnel project and the construction of the Park Street Link. Figure 7 shows the location of new tram infrastructure spatially.

Apart from these major projects, the NDS assumptions also include more frequent services across much of the network as well as the use of higher capacity vehicles in certain cases compared to the Do Minimum.

Table 8: *Major tram project sequencing*

Project	2036 Do Minimum	2036 NDS	2051 Do Minimum	2051 NDS
Melbourne Metro Configuration Changes	•	•	•	•
Park Street Link	•	•	•	•
Caulfield to Monash Route		•		•
Fishermans Bend North and South Routes		•		•
Spencer Street to Arden Route		•		•
Trunk Corridor Service Improvements		•		•

Figure 7: *Tram network coverage, 2051 Do Minimum and NDS*



2.2.3 Bus

Table 9 summarises the differences in daily service kilometres for the bus network across the Do Minimum and NDS assumptions. When compared to current conditions, the Do Minimum bus network only provides marginal improvements – most of which are confined to additional services within outer and growth areas. Other changes include:

- Additional bus connectivity to Suburban Rail Loop (SRL) services.
- The Doncaster Bus Rapid Transit (BRT) system.
- Modifications to the bus services to accommodate for the completion of the Melbourne Metro tunnel project.

In contrast, the NDS bus networks across 2036 and 2051 represent a much more comprehensive investment program throughout the city. Growth areas are assumed to receive a ten-fold increase in service kilometres by 2036, with other areas of Melbourne experiencing improvements of more than 40% in service kilometres.

Table 9: *Daily bus service kilometres by FUA compared to 2018*

FUA	2018 Current Cond.	2036 Do Minimum		2036 NDS		2051 Do Minimum		2051 NDS	
Inner Melbourne	48,840	+4,680	*+9.6%*	+19,750	*+40.4%*	+4,830	*+9.9%*	+19,600	*+40.1%*
Middle Melbourne	146,970	+11,460	*+7.8%*	+85,090	*+57.9%*	-290	*-0.2%*	+81,000	*+55.1%*
Outer Melbourne	133,550	+21,510	*+16.1%*	+96,830	*+72.5%*	+23,840	*+17.8%*	+109,140	*+81.7%*
Growth Areas	5,990	+27,540	*+460%*	+60,100	*+1009%*	+63,830	*+1066%*	+96,150	*+1606%*
Regional City	26,110	0	*0.0%*	0	*0.0%*	0	*0.0%*	0	*0.0%*
Regional/Rural Areas	27,090	+850	*+3.1%*	+6,340	*+23.4%*	+1,290	*+4.8%*	+8,430	*+31.1%*
Total	388,540	+66,040	*+17.0%*	+268,110	*+69.0%*	+93,490	*+24.1%*	+314,320	*+80.9%*

No changes to bus services are assumed across the Do Minimum and NDS assumptions for all regional cities.

2.2.4 V/Line

The 2036 Do Minimum regional rail network is based off the Regional Network Development Plan and includes a range of capacity and service frequency improvements throughout the network. The NDS assumptions follow this plan beyond 2026, incorporating further improvements.

Several metropolitan train projects outlined in Table 7 affect the coverage and operation of the V/Line network. The most significant of these assumptions are improvements to the Geelong rail corridor, which involves significant electrification of the network to Geelong by 2051. This reclassifies these services as metropolitan train services once online. There are also several other smaller electrifications planned throughout the network, including towards Wallan and Baxter.

3 Static Land Use Tests

The VITM was used to test the Do Minimum and NDS infrastructure assumptions against future demographic projections from SALUP, representing estimates of future population, households, employment and other attributes.

As outlined in Section 1.2, a set of core and alternate growth scenarios were conducted using the VITM and SALUP inputs (Table 10).

Table 10: *Static land use (VITM) scenario tests*

Group	Assumptions	2018	2036	2051
Core	Current Conditions	•		
	Do Minimum		•	•
	NDS		•	•
Alternate Growth	Do Minimum – Low Growth		•	•
	Do Minimum – High Growth		•	•

The core scenarios were used to explore network performance and resulting travel behaviour for the Do Minimum and NDS assumptions under SALUP growth predictions for the state. These outcomes are contextualised against each other and the current performance of the network using the 2018 Current Conditions scenario.

The alternate growth scenarios are intended to act as a sensitivity test, building on the outcomes of the core scenarios. These explore the differences in impact lower or higher levels of population growth will have on the transport network.

This section is structured as follows:

- Section 3.1 outlines the evolution of the SALUP demographic assumptions through the years of 2018, 2036 and 2051 that underpin the core scenario tests.
- Section 3.2 explores travel behaviour changes across the five core scenarios that have resulted from both population growth and the infrastructure future assumptions.
- Section 3.3 covers impacts to network performance associated with each combination of land use and infrastructure assumptions for the core scenarios.
- Section 3.4 summarises the changes to accessibility in travelling to and from specific destinations given changing network performance.
- Section 3.5 provides further details regarding assumptions underlying the alternate growth scenarios and their outcomes relative to the core group.

3.1 Demographic Changes

All static land use tests use demographic projections from the SALUP as inputs. This means that the Do Minimum and NDS scenarios use the same demographic assumptions for their respective years. Table 11 provides state-wide summary totals for the three modelled years.

Table 11: *State-wide demographic totals summary for SALUP compared to 2018*

Totals	2018 SALUP	2036 SALUP		2051 SALUP	
Population	6,460,000	+2,400,000	+37.1%	+4,370,000	+67.7%
Employment	3,220,000	+1,330,000	+41.5%	+2,330,000	+72.4%
Households	2,510,000	+970,000	+38.7%	+1,800,000	+71.6%
Enrolments	1,630,000	+740,000	+45.4%	+1,200,000	+73.6%

Population and employment throughout the state are projected to reach almost 11 and 5.5 million respectively by 2051 under these assumptions. Sections 3.1.1 and 3.1.2 describe the spatial distribution of this assumed growth in more detail.

3.1.1 Population Changes

By 2051, regional areas are assumed to grow in population by approximately 700,000. A remaining growth of 3.6 million people is allocated to Melbourne and its surrounding growth areas. Significant growth is forecast in the northern, southern and western regions corresponding with large sites of residential expansion at the fringe (Table 12).

Table 12: *Total population by FER for SALUP compared to 2018*

FER	2018 SALUP	2036 SALUP		2051 SALUP	
Inner	1,380,000	+510,000	+37.2%	+930,000	+67.6%
Northern	770,000	+390,000	+49.9%	+680,000	+88.1%
Eastern	700,000	+160,000	+22.5%	+310,000	+44.5%
Southern	920,000	+400,000	+42.8%	+680,000	+73.9%
Western	900,000	+550,000	+61.0%	+990,000	+110.6%
Peninsula	310,000	+70,000	+21.3%	+140,000	+44.5%
Other	1,480,000	+340,000	+22.6%	+640,000	+43.0%
Total	6,460,000	+2,400,000	+37.1%	+4,370,000	+67.7%

Figure 8 and Figure 9 show the overall distribution of this population growth spatially through 2036 and 2051 for Melbourne and its surrounds.

Figure 8: *Population increases for SALUP, 2036 vs. 2018*

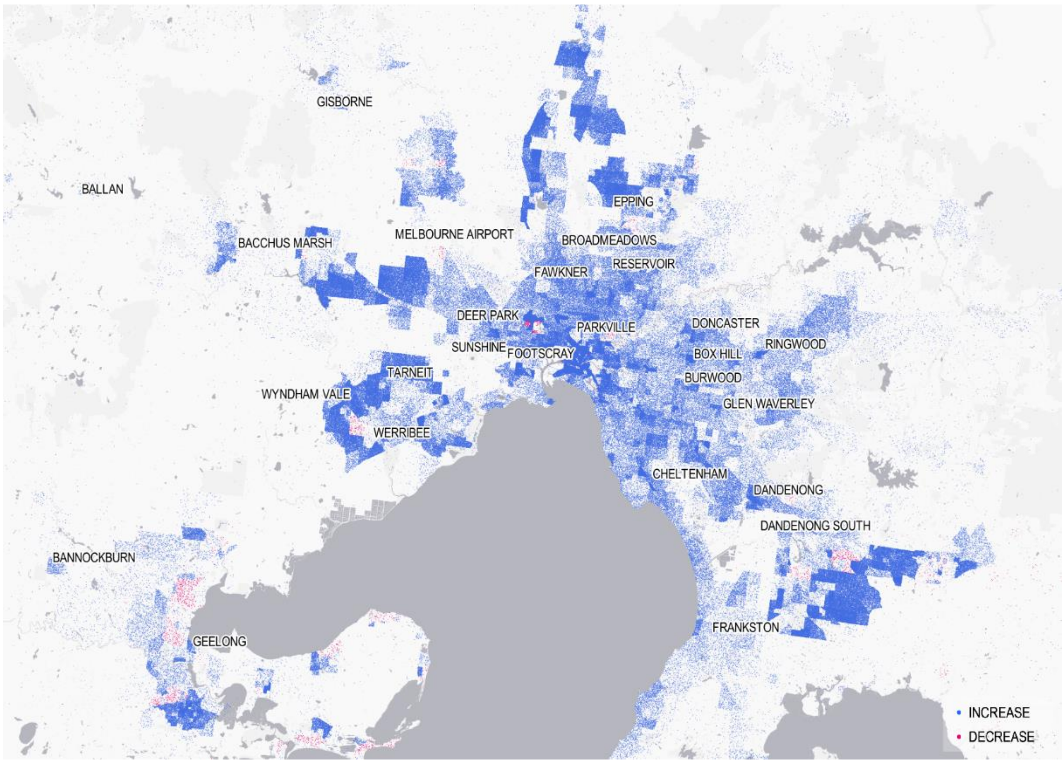
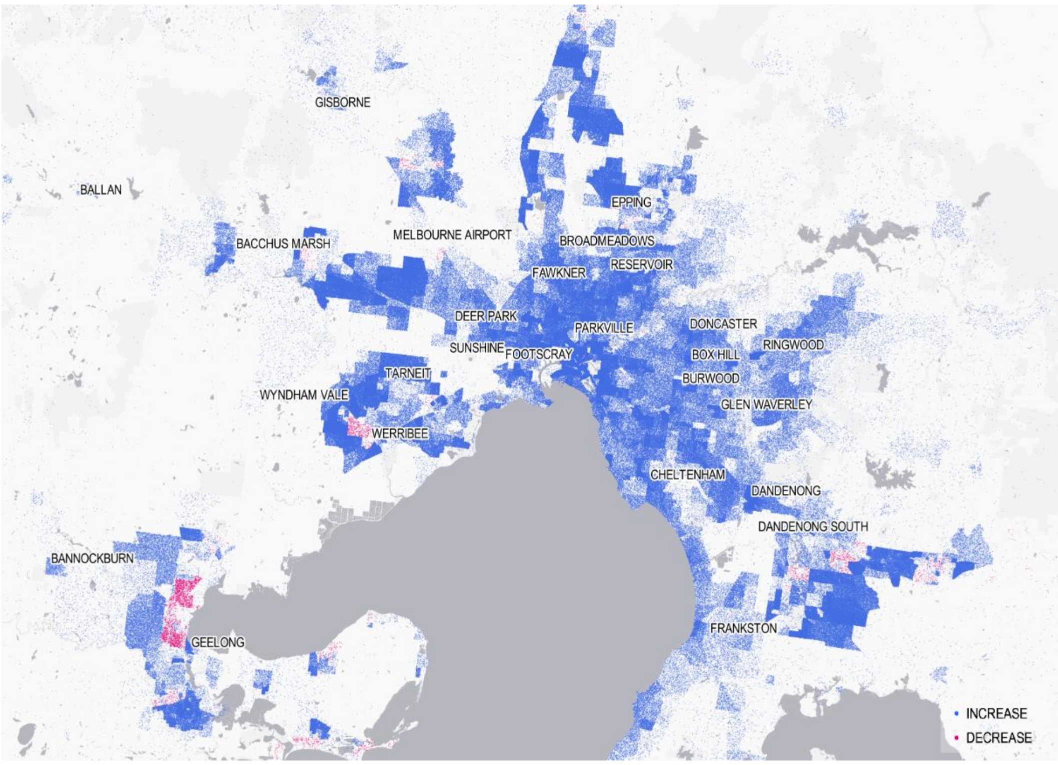


Figure 9: *Population increases for SALUP, 2051 vs. 2018*



3.1.2 Employment Changes

Throughout all future years, Melbourne remains the dominant hub of employment within Victoria. By 2051, 4.4 million jobs are assumed to consolidate within the metropolitan area, with a remaining 1.1 million spread through regional cities and other areas. Even within Melbourne itself, the assumed profile of future job density favours the city centre rather than outer or even middle Melbourne. Table 13 shows this distribution of employment by FUA. Growth areas proportionally receive the highest level of growth, but this is dwarfed by the absolute number of jobs allocated within Melbourne's more central areas.

Table 13: *Total employment by FUA for SALUP*

FUA	2018 SALUP	2036 SALUP		2051 SALUP	
Inner Melbourne	980,000	+410,000	*+42.1%*	+700,000	*+72.1%*
Middle Melbourne	710,000	+290,000	*+41.5%*	+530,000	*+75.4%*
Outer Melbourne	740,000	+340,000	*+45.6%*	+570,000	*+76.9%*
Melbourne New Growth Areas	40,000	+90,000	*+223.2%*	+160,000	*+369.4%*
Regional City	330,000	+90,000	*+27.2%*	+160,000	*+49.1%*
Regional Centres & Rural Areas	420,000	+110,000	*+25.7%*	+200,000	*+48.4%*
Total	3,220,000	+1,330,000	*+41.5%*	+2,330,000	*+72.4%*

Figure 10 and Figure 11 show the overall distribution of employment growth spatially through 2036 and 2051 for Melbourne and its surrounds.

Figure 10: *Employment increases for SALUP, 2036 vs. 2018*

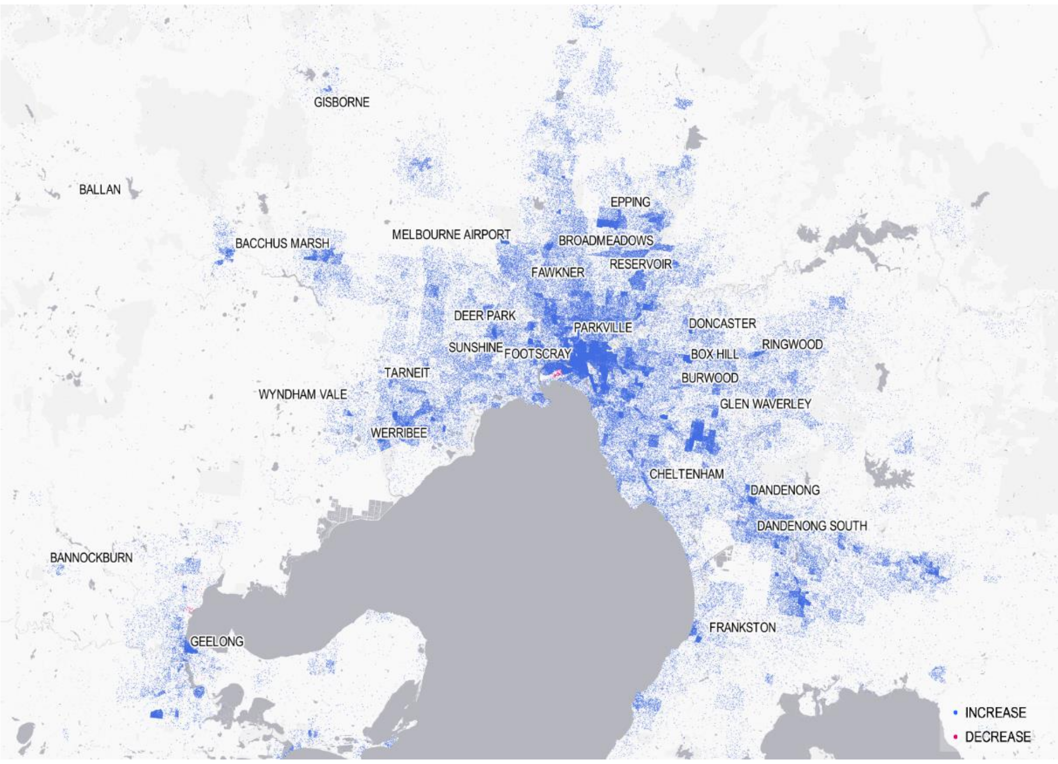
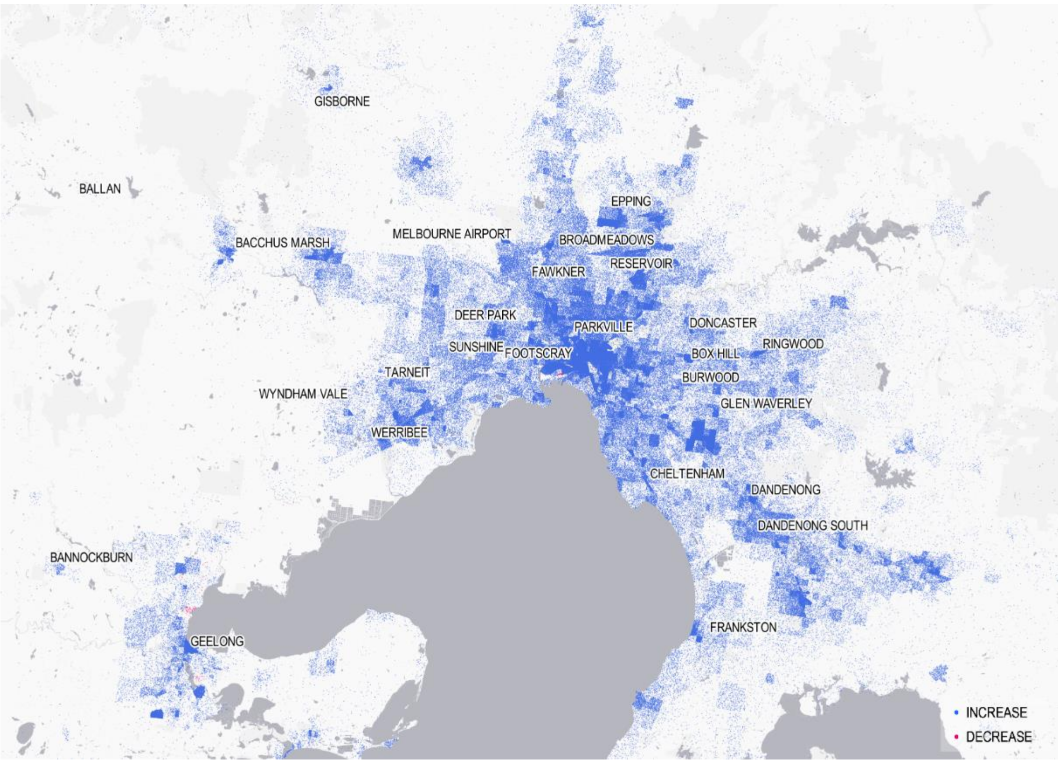


Figure 11: *Employment increases for SALUP, 2051 vs. 2018*



3.2 Travel Demand

The quantity of motorised trips occurring on Victoria's transport network increases substantially across years due to high levels of future population growth assumed by the SALUP. Table 14 provides a summary of total motorised trips throughout the state for the 2051 Do Minimum and NDS scenarios relative to 2018. Across all tested assumptions, private vehicle trips are forecast to rise more than 50% and public transport use to approximately double by 2051.

Table 14: *Comparison of total trips, 2051 vs. 2018*

Trips	2018 Current Conditions	2051 Do Minimum		2051 NDS	
Private Vehicle	17,308,000	+10,354,000	*59.8%*	+10,174,200	*58.8%*
Public Transport	1,448,700	+1,371,600	*94.7%*	+1,525,600	*105.3%*
Total	18,756,700	+11,725,600	*62.5%*	+11,699,800	*62.4%*
Public Transport Mode Share	7.7%	+1.5%	-	+2.0%	-

Throughout Melbourne, the northern and western regions are estimated to experience the largest growth in originating trips through 2036 and 2051 under both the Do Minimum and NDS assumptions. Table 15 provides a comparison of total trips originating from each FER for the NDS scenarios. Travel is expected to more than double in the west by 2051. The growth pattern of total trips is very similar under the Do Minimum infrastructure future, with trips originating in the west expected to grow 99.5% by 2051 as well under these assumptions.

Table 15: *Comparison of total motorised trips by FER for the NDS scenarios against 2018*

FER	2018 Current Cond.	2036 NDS		2051 NDS	
Inner	4,212,500	+1,323,100	*+31.4%*	+2,360,000	*+56.0%*
Northern	2,177,400	+1,072,400	*+49.3%*	+1,861,900	*+85.5%*
Eastern	2,016,000	+423,700	*+21.0%*	+796,800	*+39.5%*
Southern	2,649,000	+1,094,000	*+41.3%*	+1,825,800	*+68.9%*
Western	2,418,500	+1,403,200	*+58.0%*	+2,478,400	*+102.5%*
Peninsula	850,600	+176,700	*+20.8%*	+361,700	*+42.5%*
Other	4,432,700	+1,076,500	*+24.3%*	+2,015,200	*+45.5%*
Total	18,756,700	+6,569,700	*+35.0%*	+11,699,800	*+62.4%*

This coincides with the patterns of population growth described in Section 3.1.1, where under SALUP it is forecast that outer and growth areas will experience population growth in excess of two million people over the next thirty years.

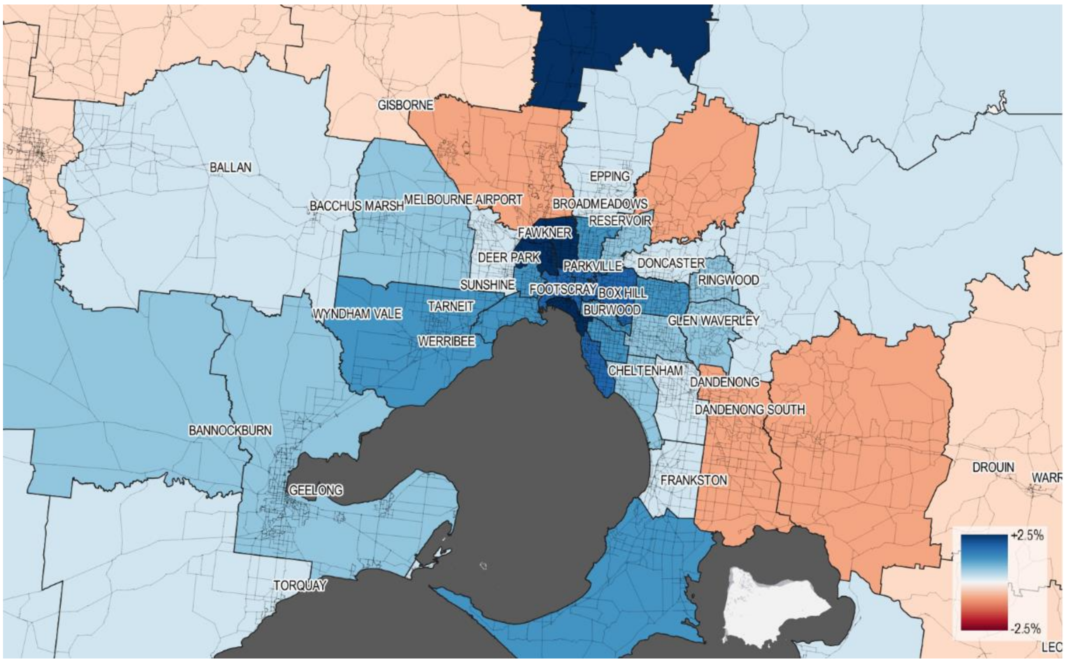
Whilst total trips is not affected, the infrastructure future does have an impact on the overall share of private vehicle and public transport travel that occurs on the network. Table 16 shows a direct comparison of trips between the Do Minimum and NDS assumptions for both 2036 and 2051. The NDS assumptions result in approximately 5% more public transport travel in the future, translating into 100,000 and 150,000 additional daily trips by 2036 and 2051. A large motivating factor behind this shift is the large increase in public transport infrastructure investment represented within the NDS assumptions compared to the Do Minimum – there is a 43% disparity in service kilometres between these scenarios in 2051.

Table 16: *Comparison of total trips, NDS vs. Do Minimum*

NDS vs. Do Minimum Trips	2036		2051	
Private Vehicle	-117,300	*-0.5%*	-179,800	*-0.6%*
Public Transport	+100,100	*+4.6%*	+154,000	*+5.5%*
Total	-17,200	*-0.1%*	-25,800	*-0.1%*
Public Transport Mode Share	+0.4%	-	+0.5%	-

Throughout Victoria, the NDS assumptions almost universally increase public transport mode share across LGAs (see Figure 12). Minor decreases are seen in rural Victorian areas as well as within Cardinia, Casey and Hume. These three municipalities sit at the fringe of metropolitan Melbourne and are in proximity to some major road network investments under the NDS assumptions. These upgrades have likely made it more attractive for future residents in these areas to drive compared to the equivalent situation in the Do Minimum case. For example, projects like the Outer Metropolitan Ring Road would significantly impact the attractiveness and accessibility of private vehicle travel in a region like Hume.

Figure 12: *Morning peak public transport mode share comparison in 2051 by LGA of origin, NDS vs. Do Minimum*



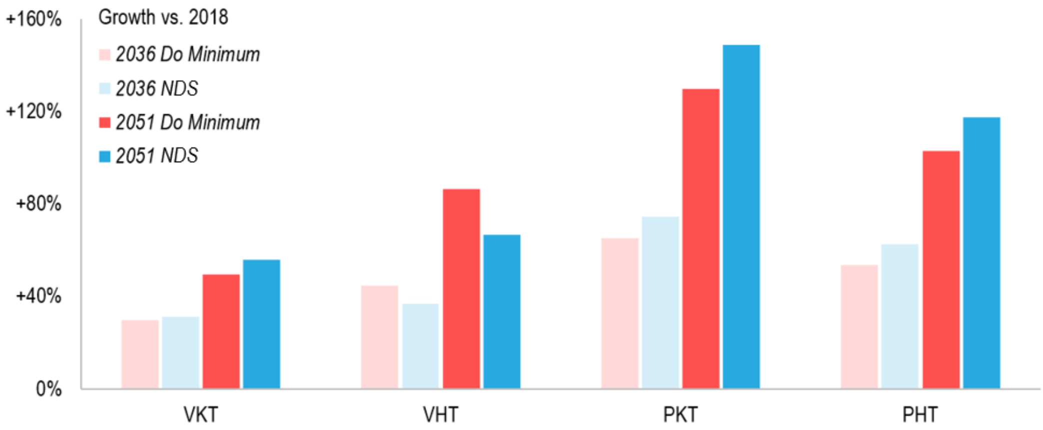
Overall, however, over 90% of travel remains private vehicle-based by 2051 regardless of infrastructure future. Table 17 shows the individual public transport mode share for different trip purposes in 2018 and 2051. Commuting (particularly white collar) and education trips show a relatively high public transport mode share. However, most travel throughout the day occurs outside of these categorisations, for shopping, socialisation, business and other purposes. These other trips are predominantly undertaken with private vehicle.

Table 17: *Daily trips numbers and public transport mode share by purpose, 2018 and 2051*

	2018 Current Conditions		*2051 NDS*	
Purpose	Trips	PT Mode Share	Trips	PT Mode Share
Commuting (White Collar)	2,034,000	23.5%	3,528,300	25.6%
Commuting (Blue Collar)	726,200	10.7%	1,114,500	14.1%
Education	1,863,200	17.0%	2,938,900	20.6%
Other	9,681,500	5.5%	16,397,900	7.4%

The estimated growth in trips translates into a much heavier utilisation of the transport network throughout the state. Figure 13 provides a summary of daily vehicle kilometres and hours travelled (VKT, VHT) for the road network as well as passenger kilometres and hours travelled (PKT, PHT) for public transport across the tested scenarios compared to current conditions. By 2051 it is estimated that there will be in excess of 50% and 65% more kilometres travelled for road and public transport respectively for both the Do Minimum and NDS infrastructure futures.

Figure 13: *Growth in network travel compared to 2018*



The comparative growth in VKT and VHT across future years is not proportional. VKT under NDS assumptions grows by 56% by 2051 but VHT grows by 67%. This disparity is even larger under Do Minimum assumptions – Table 18 illustrates this effect in an alternate form.

Table 18: *Comparison between kilometres and hours travelled against 2018*

Growth vs. 2018 Current Conditions	2036 Do Minimum	2036 NDS	2051 Do Minimum	2051 NDS
Vehicle Kilometres Travelled	*+29.6%*	*+31.2%*	*+49.5%*	*+55.8%*
Vehicle Hours Travelled	*+44.8%*	*+36.8%*	*+86.3%*	*+66.6%*
Passenger Kilometres Travelled	*+65.1%*	*+74.5%*	*+129.9%*	*+148.8%*
Passenger Hours Travelled	*+53.7%*	*+62.7%*	*+102.7%*	*+117.3%*

On average, people are spending more time in 2036 and 2051 on the road for each kilometre of travel compared to 2018. This is a direct result of greater congestion throughout the network (explored further in Section 3.3), exacerbated under the Do Minimum assumptions with lower investment in network upgrades especially in growth areas where travel is forecast to grow the most.

The opposite pattern is seen for public transport travel, with the average speed of trips increasing under both the Do Minimum and NDS assumptions – higher frequency public transport services involves less ‘dwell’ time for passengers waiting for and transferring between services. These metrics do not take into consideration crowding levels, which will also be further explored in Section 3.3.

3.3 Network Impacts

The growth in travel outlined in Section 3.2 leads to shifting levels of congestion and crowding through the network depending on the tested infrastructure future. Table 19 outlines the amount of morning peak VKT and PKT occurring under congested/crowded conditions (see Section 0) as a proportion of all travel during the morning peak for each scenario.

Table 19: *Proportion of crowded travel in the morning peak*

Crowded Travel Proportion	2018 Current Conditions	2036 Do Minimum	2036 NDS	2051 Do Minimum	2051 NDS
Crowded VKT	22%	31%	29%	36%	30%
Crowded PKT	20%	31%	13%	45%	8%

The overall proportion of congested road travel is estimated to increase into the future under both infrastructure futures. Whilst 22% of current morning peak road travel occurs in congested conditions, this is projected to increase to 31% and 29% under Do Minimum and NDS assumptions respectively. This gap further widens by 2051, with a larger difference in network performance manifesting between the Do Minimum and NDS scenarios.

Crowding on public transport is forecast to increase under Do Minimum assumptions whilst decreasing under NDS assumptions. This difference is particularly striking by 2051 – almost half of all public transport travel on the Do Minimum network is forecast to occur under crowded conditions, whilst the equivalent figure for the NDS is only 8%. This represents a sizeable improvement of public transport travel conditions, even compared to current circumstances.

Sections 3.3.1 and 3.3.2 explore the performance of the road and public transport networks in more detail respectively.

3.3.1 Road Network

Table 20 summarises how much of the physical road network is congested during the morning and inter-peak periods (see Section 1.5.3). The coverage of road congestion is expected to grow into the future – double under NDS assumptions and triple for Do Minimum by 2051.

Table 20: *Congested road kilometres compared to 2018*

Time Period	2018 Current Cond.	2036 Do Minimum		2036 NDS		2051 Do Minimum		2051 NDS	
Morning Peak	1,110	+1,090	*+98.5%*	+750	*+67.6%*	+2,040	*+184.2%*	+1,180	*+106.7%*
Inter-Peak	310	+550	*+176.9%*	+370	*+119.7%*	+1,190	*+383.2%*	+740	*+238.0%*

Worth noting is the growing amount of congestion expected during the inter-peak period. Right now, this is largely contained to select corridors and bottlenecks throughout

Melbourne. However, by 2051 the coverage of congestion during the middle of the day is expected to reach equivalent levels to today's morning peak – even under the NDS infrastructure future assumptions.

Figure 14 provides a more detailed overview of road congestion by FER during the morning peak. Inner Melbourne is estimated grow the most in terms of congestion, with approximately 30% of the network in this region congested under both Do Minimum and NDS assumptions by 2051. The north is next worst performing area with the Do Minimum network, benefiting greatly from the additional road upgrades provided by the NDS assumptions. As outlined in Table 3, growth areas are expected to receive an additional 1,650 km of new lanes – a substantial response to the high rise in population. By contrast, the Do Minimum network only receives 710 km.

Figure 14: *Morning peak congested road kilometres by FER*

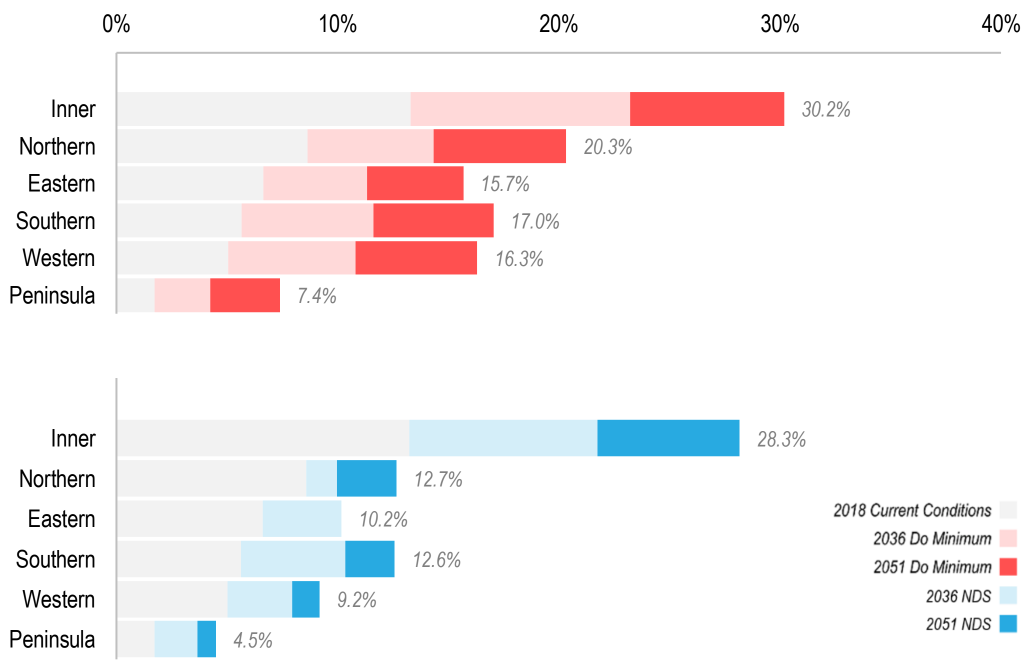


Figure 15 shows how close to capacity major roads within metropolitan Melbourne are in 2051 with the NDS network. Figure 16 then provides a comparison between this scenario and the 2051 Do Minimum network. Minimal direct relief is provided to inner and middle Melbourne from the NDS assumption upgrades, in part because these areas are already close to capacity currently. From these maps, it can again be seen that the NDS upgrades provide enormous congestion relief in precincts to the north, west and south of the city.

It should be noted that these described benefits of the NDS assumption compared to the Do Minimum are not derived solely from road upgrades. The NDS network also includes a more robust public transport system, which is resulting in almost 200,000 less daily car trips than the Do Minimum in 2051 (see Table 16).

Figure 15: *Morning peak volume capacity ratios, 2051 NDS*

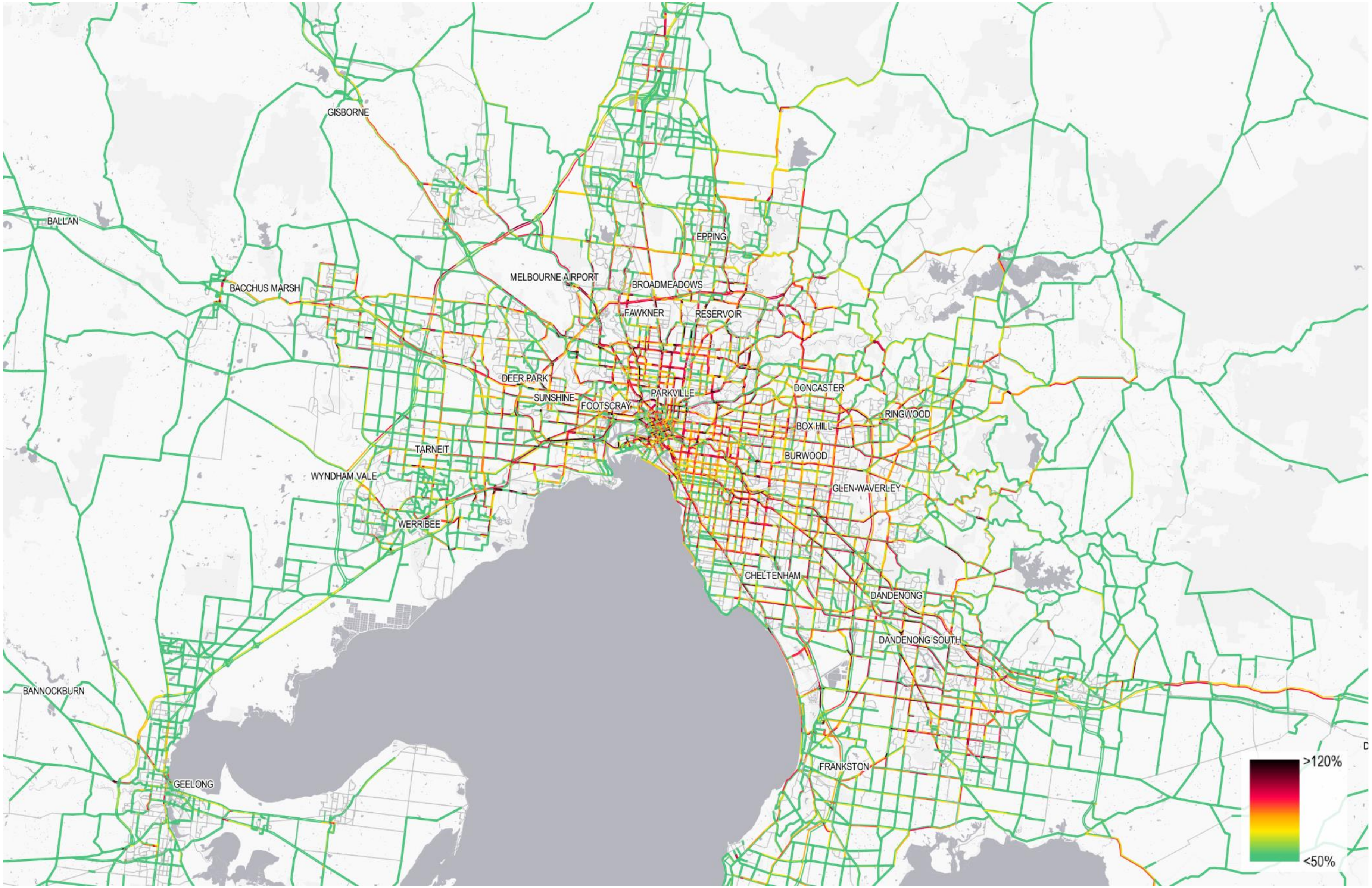
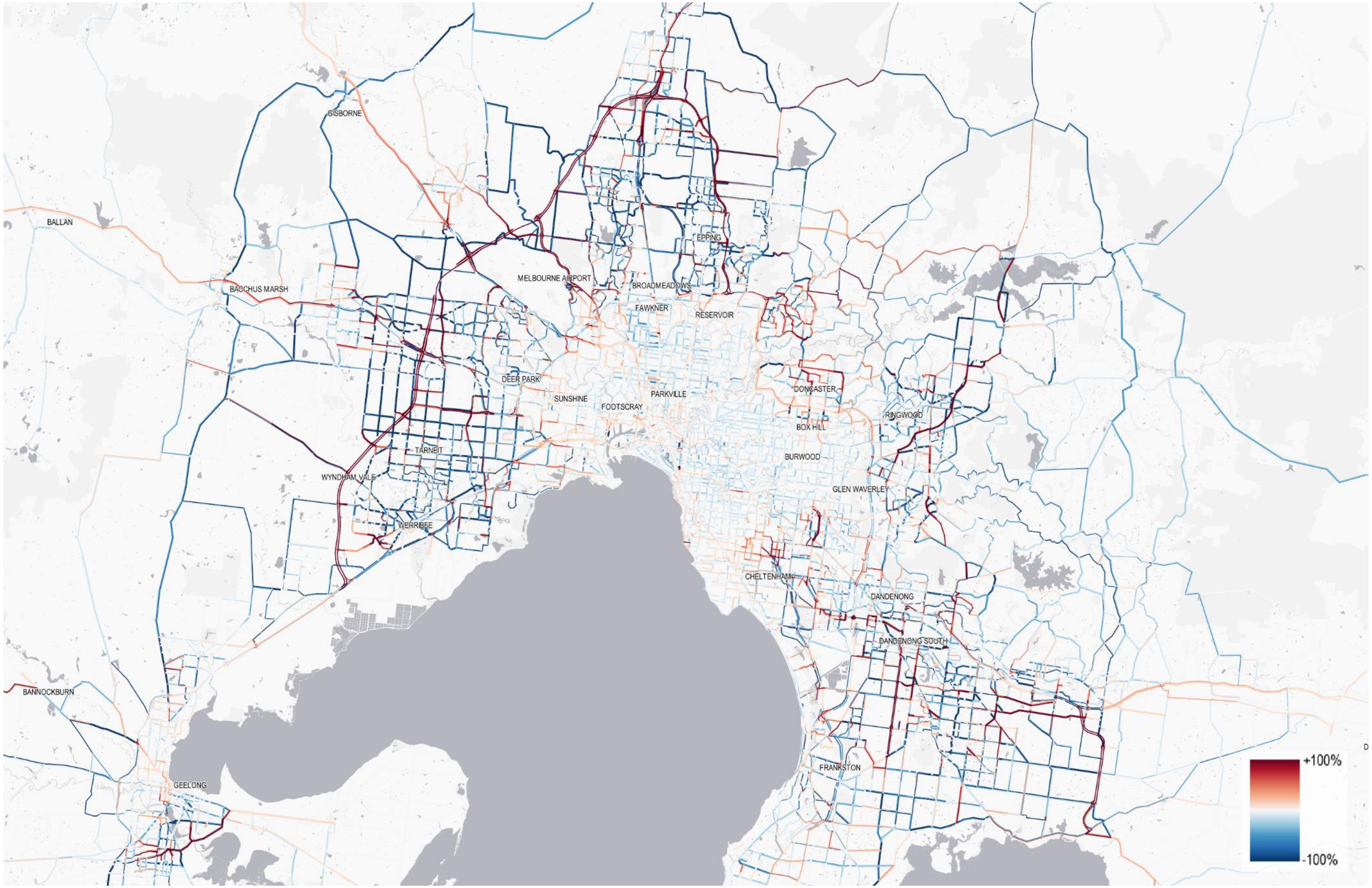


Figure 16: *Morning peak volume capacity comparison, 2051 NDS vs. 2051 Do Minimum*



3.3.2 Public Transport

Table 21 summarises the total daily boardings estimated for each scenario under Do Minimum and NDS infrastructure futures compared to 2018. Total public transport boardings are expected to more than double by 2051 under both sets of assumptions. At the same time, total service kilometres are only increasing 27% and 80% for the Do Minimum and NDS scenarios by 2051 respectively.

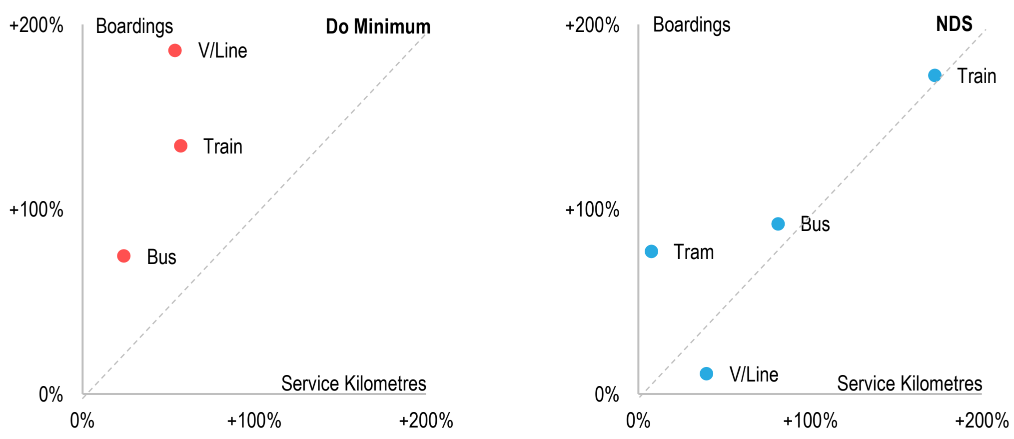
Table 21: *Daily boardings compared to 2018*

Mode	2018 Current Cond.	2036 Do Minimum		2036 NDS		2051 Do Minimum		2051 NDS	
Train	1,004,040	+659,650	*+65.7%*	+715,980	*+71.3%*	+1,351,080	*+134.6%*	+1,732,240	*+172.5%*
Tram	630,320	+251,230	*+39.9%*	+328,220	*+52.1%*	+419,610	*+66.6%*	+487,760	*+77.4%*
Bus	483,050	+190,680	*+39.5%*	+246,330	*+51.0%*	+361,510	*+74.8%*	+446,610	*+92.5%*
V/Line	77,570	+92,300	*+119.0%*	+92,450	*+119.2%*	+144,560	*+186.4%*	+8,650	*+11.2%**
Total	2,194,970	+1,193,860	*+54.4%*	+1,382,980	*+63.0%*	+2,276,760	*+103.7%*	+2,675,260	*+121.9%*

* Large portions of the V/Line network are re-classified as metropolitan trains due to electrifications (see Table 7), hence the large disparity between V/Line growth values.

Figure 17 shows a more direct comparison between growth in boardings and service provision in 2051 relative to 2018. The NDS scenario keeps or exceeds the ratio of additional boardings to service kilometres for all modes relative to 2018, except for trams. The proportional amount of public transport supply is kept more consistent than is the case with the Do Minimum network, where additional supply lags behind boardings.

Figure 17: *Growth in boardings and service kilometres vs. 2018, 2051 Do Minimum and NDS*[5]



This is ultimately an oversimplification, as the performance of public transport is additionally impacted by vehicle capacity (not captured in service kilometres) and the location of upgrades. However, it serves to demonstrate that demand for public transport is likely to continue growing at a rapid pace under both the Do Minimum and NDS

[5] Trams have been excluded from the Do Minimum portion of this graph, see Table 6.

scenarios.

Metropolitan Train

The Do Minimum and NDS assumptions present very different future configurations of the metropolitan train network as outlined in Section 2.2.1. The lack of upgrades under the Do Minimum scenario means that, by 2051, service kilometres lag behind the NDS assumptions by more than 70%. Regardless of infrastructure provision however, metropolitan train services still act as the predominant form of public transport in navigating the city in terms of both boardings and passenger kilometres travelled. Most passengers currently use this as a key link in accessing inner Melbourne from surrounding regions and this pattern does not change in time.

Figure 18 and Figure 19 show the contrast between where the NDS and Do Minimum train networks are at capacity by 2051. Demand for travel towards inner and middle Melbourne grows at a rapid pace given the concentration of new employment in these regions (Section 3.1.2). The Do Minimum network does not cater for this demand, with excessive crowding throughout – the extent to which in certain cases potential train travel is blocked from occurring due to capacity constraints. The NDS network exhibits less overall crowding than current conditions.

Both Melbourne Airport Rail Link (MARL) and the Suburban Rail Loop (SRL) exhibit minimal levels of crowding across either infrastructure future.

Figure 18: *Morning peak metropolitan train crowding, 2051 NDS*

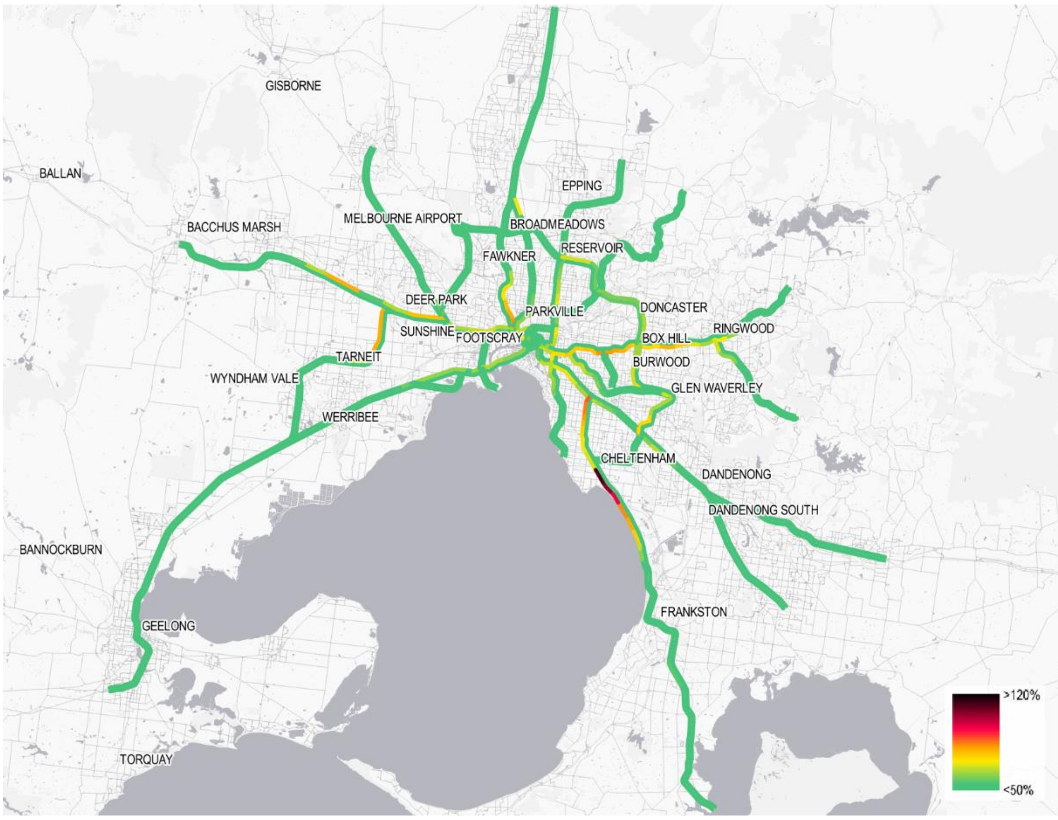
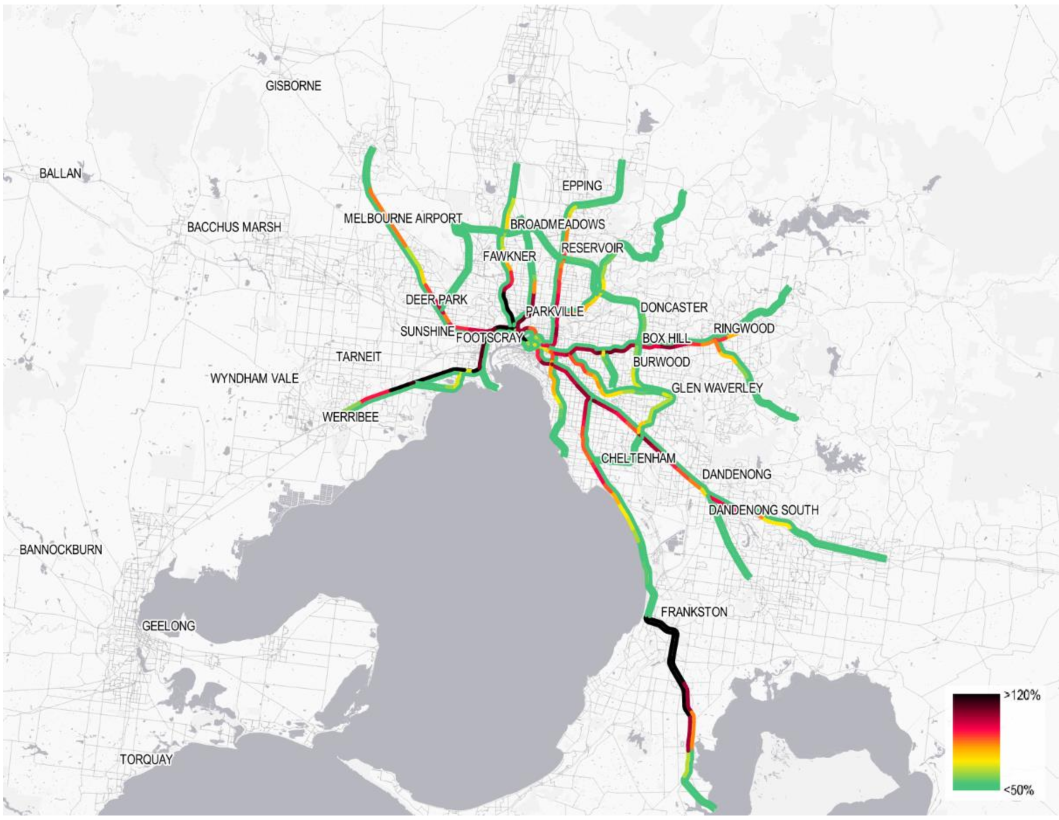


Figure 19: *Morning peak metropolitan train crowding, 2051 Do Minimum*



Tram

Much like with metropolitan trains, demand for tram use increases into the future under both the Do Minimum and NDS scenarios. The continuing consolidation of employment towards inner Melbourne results in growing demand for public transport servicing these areas. Table 22 compares several supply and demand metrics for the tram network across tested scenarios.

Table 22: *Morning peak tram network supply and demand*

Metric	2018 Current Conditions	2036 Do Minimum	2036 NDS	2051 Do Minimum	2051 NDS
Services	671	722	800	722	800
Service Kilometres	9,820	10,870	12,010	10,870	12,010
Boardings	132,980	187,170	200,050	216,930	227,900
PKT	426,090	547,110	571,750	596,120	608,040

By 2051, the number of tram boardings is similar across the Do Minimum and NDS networks. However, the NDS assumptions provide more service kilometres through shorter headways and more capacity through larger vehicles – including further deployment of E-class rolling stock as well as the next-generation F-class tram vehicles. Figure 20 and Figure 21 contrast the difference these select upgrades have on the tram travel. Under Do Minimum assumptions, much of the inner network is at full capacity.

Figure 20: *Morning peak tram crowding, 2051 NDS*

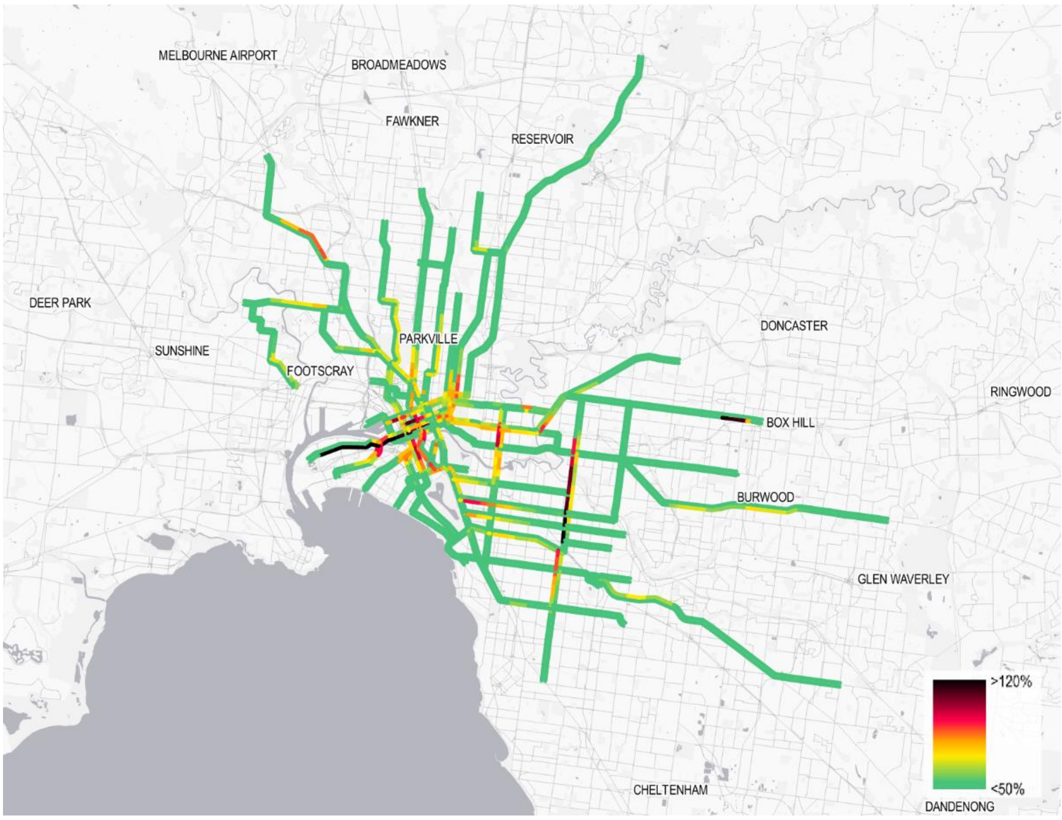
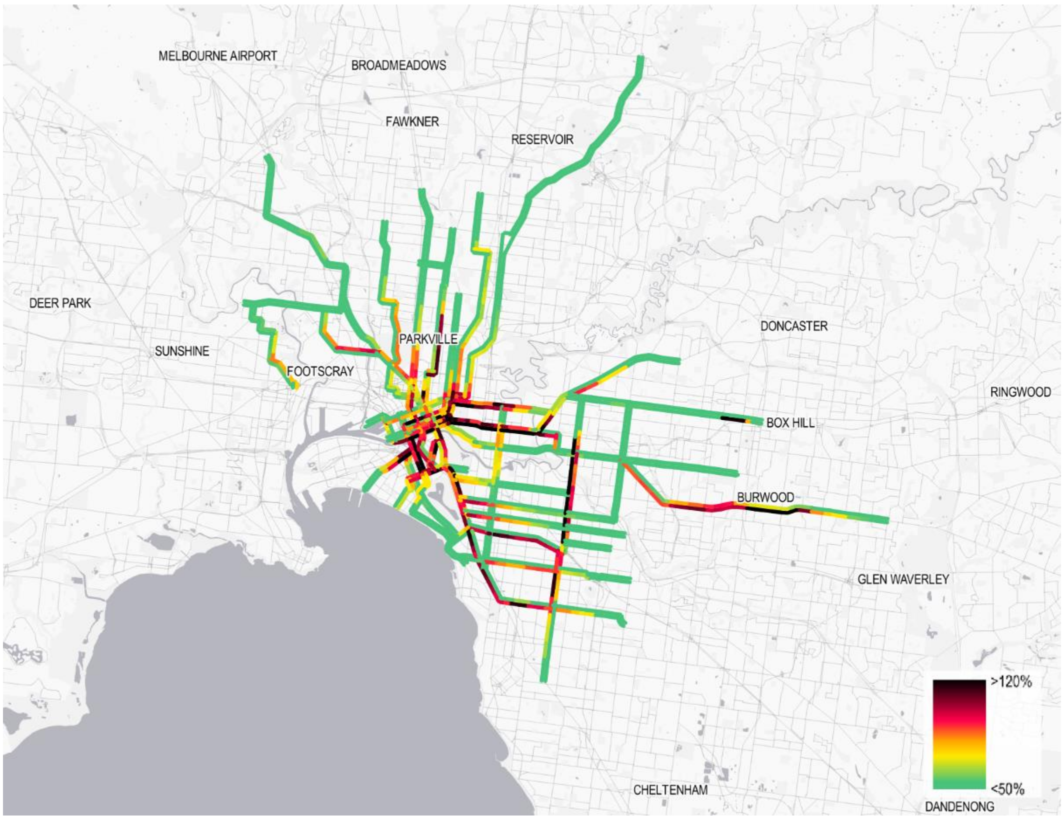


Figure 21: *Morning peak tram crowding, 2051 Do Minimum*



Bus

Table 23 provides an overview of bus network performance across all scenarios relative to 2018. Unlike other modes of public transport, much of the current bus network does not experience crowding issues because the coverage of the services is so broad throughout metropolitan Melbourne. Thus, the amount of crowded PKT as a proportion of all PKT is historically quite small. This pattern is expected to continue into the future, with concentrated crowding limited to select locations along the Eastern Freeway and Fishermans Bend.

Table 23: *Morning peak bus crowding statistics compared to 2018*

Metric	2018 Current Cond.	2036 Do Minimum		2036 NDS		2051 Do Minimum		2051 NDS	
PKT	554,310	+118,450	*+21.4%*	+196,440	*+35.4%*	+249,250	*+45.0%*	+352,180	*+63.5%*
PHT	26,900	+8,410	*+31.3%*	+10,740	*+39.9%*	+19,270	*+71.7%*	+19,650	*+73.1%*
Avg. Speed	20.6	-1.6	*-7.5%*	-0.7	*-3.2%*	-3.2	*-15.5%*	-1.1	*-5.5%*
Crowded PKT	36,220	+22,920	*+63.3%*	-1,650	*-4.6%*	+58,290	*+160.9%*	+25,670	*+70.9%*
Avg. Occupancy	9.9	-0.6	*-6.2%*	-2.9	*-29.5%*	1.6	*+16.0%*	-2.0	*-20.4%*

As outlined in Section 2.2.3, the NDS bus network is assumed to provide 46% more service kilometres than the Do Minimum by 2051. At the same time the average Do Minimum bus has a mean occupancy during the morning peak that is 46% higher (equivalence to the service kilometre increase is a coincidence). The Do Minimum road network also exhibits more congestion than its NDS counterpart – resulting in slower bus trips as well. The true impact of bus service coverage and frequency are not found in crowding or slower trip times, however. The bus network performs an important function in providing accessibility to nearby centres and major public transport hubs – the implications of which will be further explored in Section 3.4.

V/Line

Direct comparison of crowding across the V/Line network between the Do Minimum and NDS scenarios is difficult given the major alterations to the network outlined in Section 2.2. Table 24 summarises the amount of crowded PKT as a proportion of all PKT and average vehicle occupancy for the morning peak period across scenarios.

Table 24: *Morning peak crowded PKT and average occupancy compared to 2018*

Metric	2018 Current Cond.	2036 Do Minimum		2036 NDS		2051 Do Minimum		2051 NDS	
Crowded PKT %	5.2%	+13.1%	-	-4.9%	-	+25.3%	-	-5.2%	-
Avg. Occupancy	195.7	+27.2	*+13.9%*	+2.8	*+1.4%*	+86.1	*+44.0%*	-8.4	*-4.3%*

By 2051, upgrades to the metropolitan train network involve the electrification of many bottlenecks through the regional network, resulting in a complete removal of crowded travel. In contrast, crowding under the Do Minimum assumptions steadily grows into the future, reaching 30% by 2051 for the morning peak.

3.4 Accessibility

Land use, infrastructure provision and the resulting behaviours that emerge all impact the relative *accessibility* of travel throughout the state – how easy it is to reach a destination at a certain time. Table 25 and Table 26 provide a high-level summary of average trip times by FER for the morning peak.

Table 25: *Morning peak average private vehicle trip times (minutes) originating from each FER*

FER	2018 Current Cond.	2036 Do Minimum		2036 NDS		2051 Do Minimum		2051 NDS	
Inner	13.5	+0.7	*+5.1%*	+0.5	*+3.4%*	+0.9	*+7.0%*	+0.7	*+5.4%*
Northern	17.3	+1.7	*+9.7%*	-0.6	*-3.7%*	+3.5	*+20.0%*	-0.6	*-3.7%*
Eastern	15.6	+1.0	*+6.4%*	+0.6	*+4.0%*	+2.1	*+13.6%*	+0.9	*+6.1%*
Southern	15.4	+1.9	*+12.4%*	+0.9	*+5.6%*	+4.3	*+27.8%*	+1.5	*+9.6%*
Western	16.2	+1.7	*+10.7%*	-0.5	*-3.3%*	+4.2	*+25.6%*	-0.3	*-2.0%*
Peninsula	13.6	+2.4	*+17.3%*	+1.7	*+12.3%*	+4.8	*+35.2%*	+2.2	*+16.3%*
Other	9.5	+0.2	*+2.4%*	-0.3	*-2.7%*	+0.6	*+6.7%*	-0.4	*-3.9%*

Table 26: *Morning peak average public transport trip times[6] (minutes) originating from each FER*

FER	2018 Current Cond.	2036 Do Minimum		2036 NDS		2051 Do Minimum		2051 NDS	
Inner	40.3	-0.1	*-0.3%*	-0.8	*-2.0%*	+1.4	*+3.5%*	+0.1	*+0.3%*
Northern	57.6	+5.0	*+8.7%*	+2.4	*+4.2%*	+8.0	*+14.0%*	+2.6	*+4.4%*
Eastern	57.1	+2.0	*+3.5%*	+1.0	*+1.7%*	+5.0	*+8.7%*	+2.9	*+5.1%*
Southern	58.4	+0.3	*+0.4%*	-0.7	*-1.2%*	+5.1	*+8.7%*	+2.0	*+3.3%*
Western	54.4	+6.5	*+12.0%*	+2.0	*+3.7%*	+15.1	*+27.7%*	+5.0	*+9.2%*
Peninsula	74.9	+4.6	*+6.2%*	+1.8	*+2.4%*	+11.7	*+15.6%*	+0.2	*+0.2%*
Other	76.5	+7.1	*+9.3%*	+4.8	*+6.3%*	+14.0	*+18.3%*	+10.5	*+13.7%*

Overall, public transport trips are universally longer than private vehicle trips, often by a factor of three or higher. This does not change whether considering current circumstances or future years under either infrastructure future. Public transport involves waiting, transferring and slower average vehicle speeds. People also tend to use public transport less for shorter distance trips compared to private vehicle. As such, this discrepancy in travel times is expected to continue.

Under the Do Minimum assumptions, average travel times are forecast to increase across all regions. Whilst increased road congestion (Section 3.3.1) and lower service frequencies (Section 2.2) are major contributors to this, it is also worth noting that the consolidation of employment towards inner and middle Melbourne is resulting in longer trips in terms of distance. New residents in growth areas must travel further to reach their jobs and other activities, increasing the amount of time spent in transit. The NDS

[6] Public transport trip times refer to the total amount of time spent travelling from the origin to the destination, not including any non-time components such as boarding and transfer penalties.

assumptions fair better, with the north and western regions notably forecast to experience improved travel times by private vehicle in 2051 compared to 2018 – there is a 28% difference between the Do Minimum and NDS case for the west.

At an LGA level, the NDS assumptions result in travel time improvements throughout the state for both private vehicle and public transport travel compared to the Do Minimum. The largest gains are seen in outer municipalities like Melton, Wyndham, Whittlesea and Hume. Figure 22 and Figure 23 show these differences spatially.

Figure 22: *Difference in average morning peak trip times, private vehicle, 2051 NDS vs. Do Minimum*

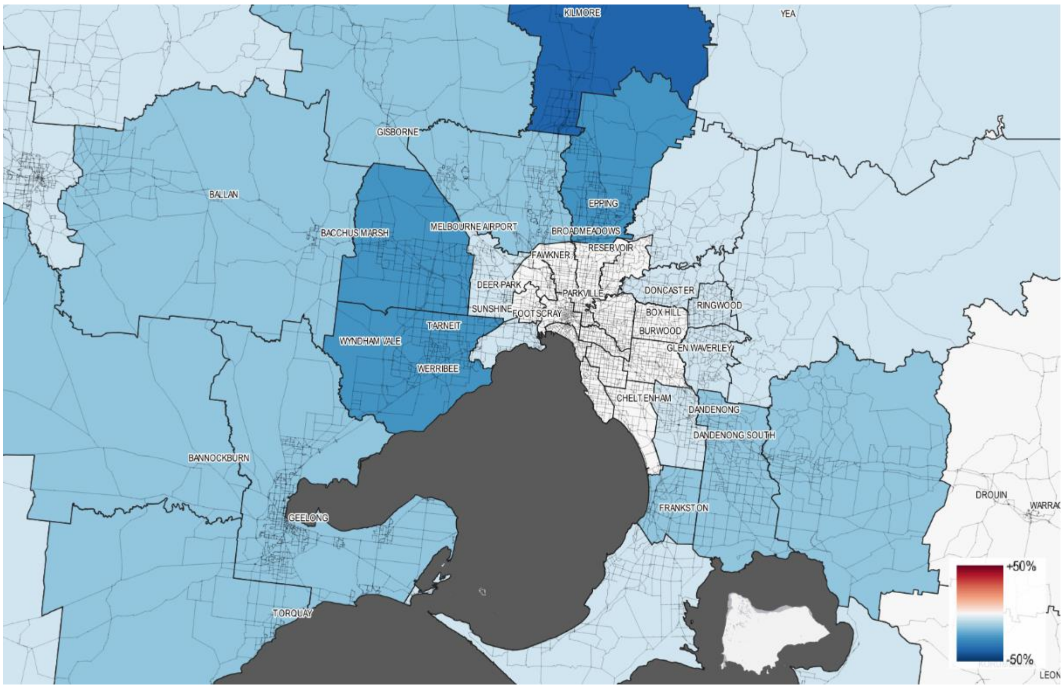


Figure 23: *Difference in average morning peak trip times, public transport, 2051 NDS vs. Do Minimum*

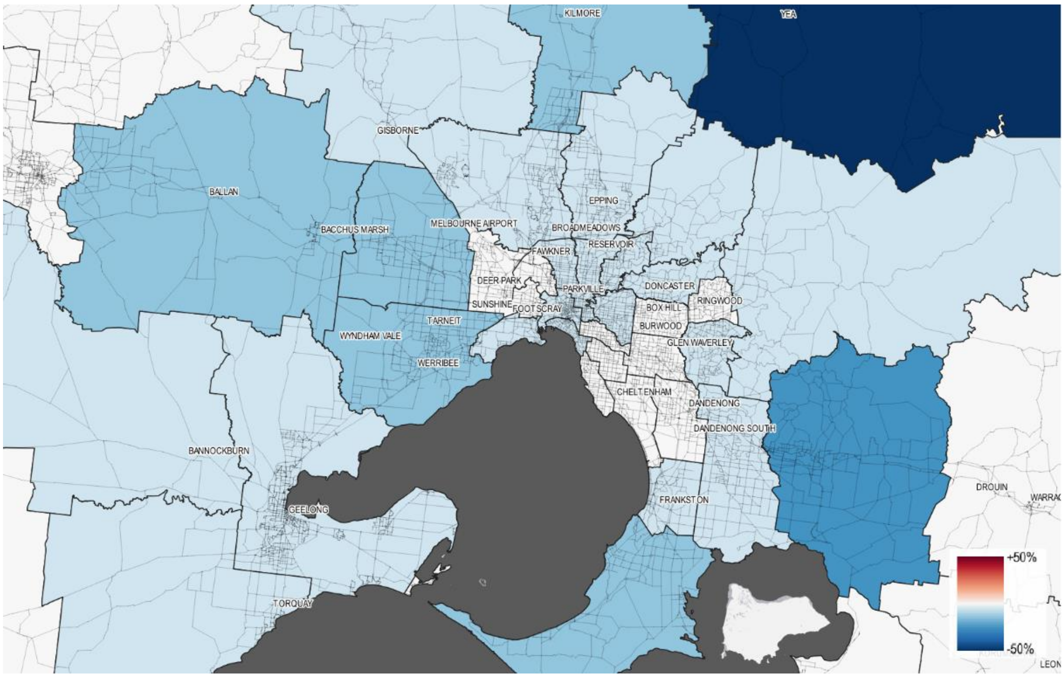


Table 27 shows average travel times specifically terminating at each of the NEICs during the morning peak. By 2051, Monash acts as the largest consolidation of employment outside of the CBD and exhibits some of the worst average travel times across both private vehicle and public transport for both infrastructure futures. Whilst this is in part due to congestion and connectivity (evidenced by the large difference between Do Minimum and NDS times), it is also due to the demographic groups travelling to the jobs in these locations. Monash attracts more residents non-local to the area for work than somewhere like Dandenong South due to its composition of industries. This results in higher average travel times.

Table 27: *Morning peak average trip times (minutes) to each NEIC*

	2051 Do Minimum		2051 NDS	
NEIC	Private Vehicle	Public Transport	Private Vehicle	Public Transport
Dandenong South	24.3	58.0	17.6	51.5
Fishermans Bend	16.7	70.0	12.7	57.4
Latrobe	29.1	82.0	21.0	76.8
Monash	61.5	84.6	51.3	72.0
Parkville	29.0	54.8	23.6	51.2
Sunshine	26.8	59.6	23.7	57.6
Werribee	43.8	55.9	38.5	51.4

As touched upon previously, public transport is less competitive than private vehicle travel in bringing residents to work in these locations. By 2051, the average length of a public transport trip to all NEICs exceeds 50 minutes, even under NDS assumptions. This has implications for how large the potential labour market is for each of these zones. As an example, Figure 24 and Figure 25 compare how large the 45-minute catchment is in reaching the Fishermans Bend NEIC via private vehicle or public transport during the morning peak.

The size of the private vehicle catchment covers several times the area of the public transport catchment in 2051 with the NDS network. Practically, this means that 17% of working population in Victoria can reach Fishermans Bend in 45 minutes when driving but only 5% can do so via public transport. The performance is worse with the Do Minimum network, with 15% and 2% of the working population accessible within 45 minutes for private vehicle and public transport travel respectively.

Unchanged from today, inner Melbourne areas remain the most accessible places to live in terms of accessibility to jobs. The LGAs of Melbourne, Yarra, Port Phillip and Stonnington have access to over 60% of the job market within 45 minutes by car for all scenarios tested. These LGAs also exhibit the largest job catchments for public transport. When comparing the performance of the Do Minimum and NDS assumptions, outer areas benefit from the additional investment included in the NDS scenario. Hume and Melton each gain an 8% larger private vehicle catchment size in 2051. Similarly, Darebin and

Kingston experience 5% larger public transport catchments compared to the Do Minimum.

Figure 24: *Morning peak 45-minute private vehicle catchment for the Fishermans Bend NEIC, 2051 NDS vs. Do Minimum*

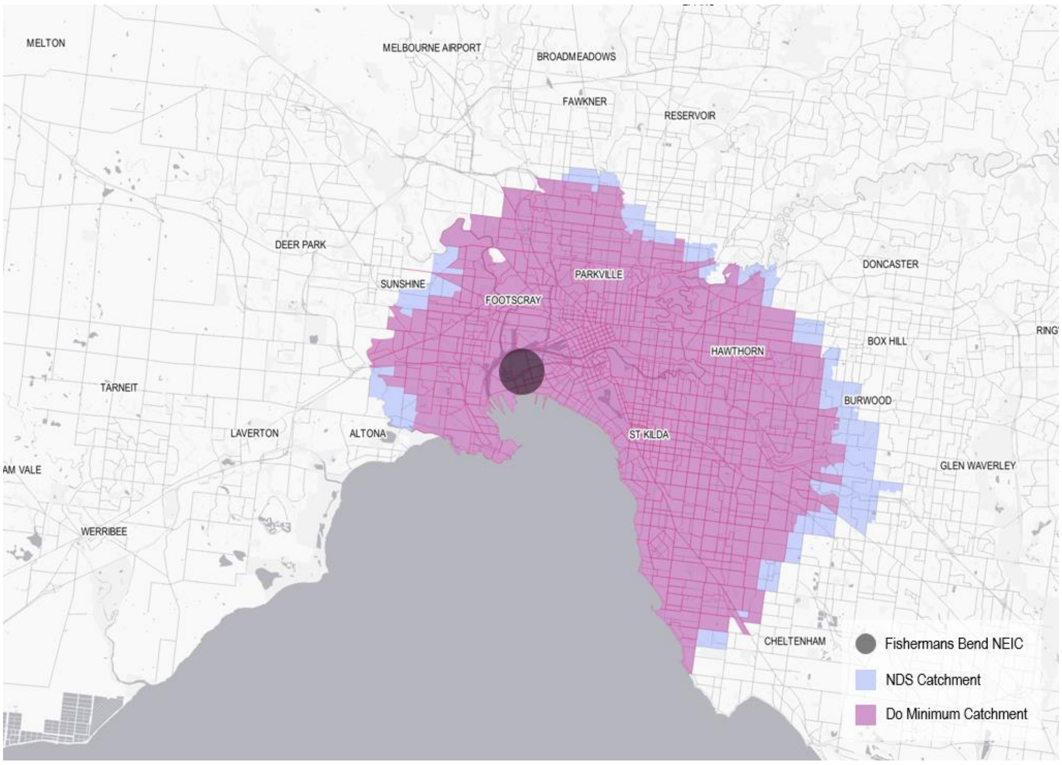
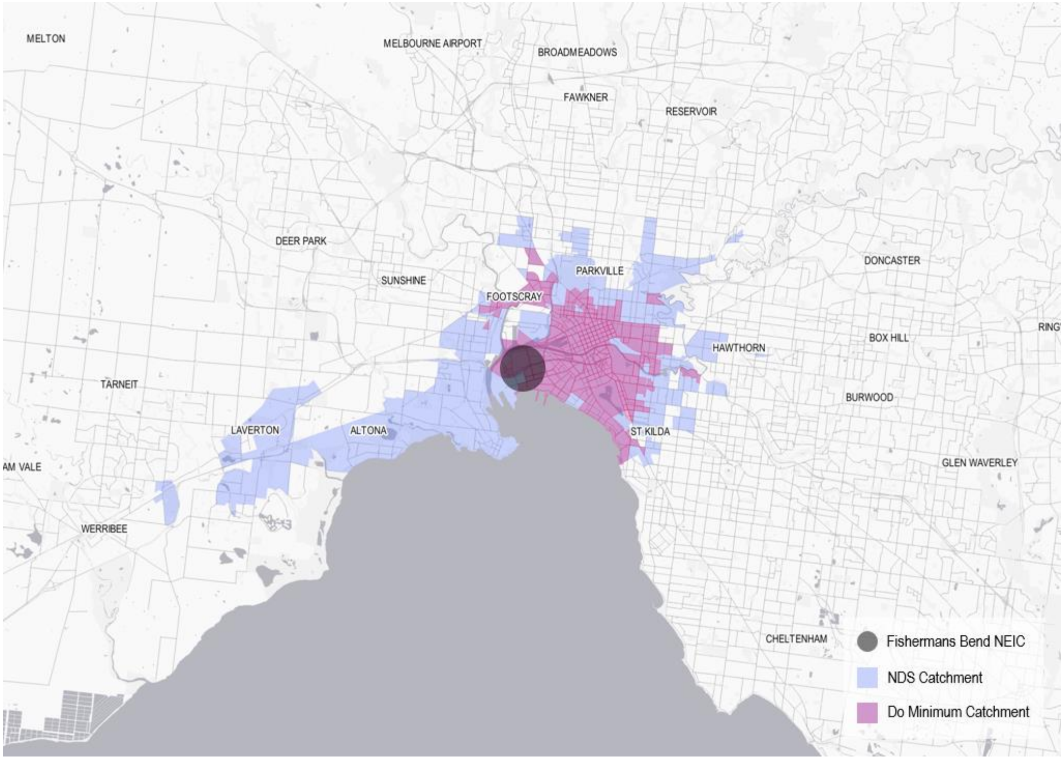


Figure 25: *Morning peak 45-minute public transport catchment for the Fishermans Bend NEIC, 2051 NDS vs. Do Minimum*



3.5 Alternate Growth Outcomes

Four additional sensitivity tests were conducted to assess, at a high-level, the impacts of higher and lower future growth assumptions (Table 2) using the Do Minimum infrastructure future. These still made use of the SALUP demographic projections, but earlier and later years were substituted to simulate different growth rates. For example, to simulate lower growth by 2036, the 2031 projections were used as an input to the sensitivity test instead of the 2036 forecasts. Table 28 outlines the specific assumptions used for each scenario.

Table 28: *SALUP data correspondence for alternate growth tests*

Assumptions	2036	2051
Low Growth	2031 SALUP	2041 SALUP
High Growth	2041 SALUP	2056 SALUP

These years were chosen to correspond closely with the Australia Bureau of Statistics' population projections[7] – specifically the Series A and Series C assumptions representing lower and higher rates of fertility, mortality and migration. Table 29 provides a comparison of state-wide demographic totals for each assumed level of growth in 2051.

Table 29: *Alternate growth scenario demographic totals*

Metric	2051 Do Minimum	2051 Do Minimum (Low Growth)		2051 Do Minimum (High Growth)	
Population	10,840,000	-1,330,000	*-12.3%*	+690,000	*+6.3%*
Employment	5,550,000	-640,000	*-11.5%*	+300,000	*+5.3%*
Households	4,310,000	-560,000	*-12.9%*	+280,000	*+6.6%*
Enrolments	2,830,000	-290,000	*-10.2%*	+140,000	*+4.9%*

These changes in growth result in largely proportional changes in the total trips occurring throughout the network when compared to the core scenario. This has expected implications for the level of crowding and congestion that occurs. Table 30 summarises the amount of congested VKT that is forecast to occur on the road network in 2051.

Table 30: *Morning peak* congested *VKT by FER for alternate growth scenarios*

FER	2051 Do Minimum	2051 Do Minimum (Low Growth)		2051 Do Minimum (High Growth)	
Inner	2,513,730	-232,290	*-9.2%*	+85,140	*+3.4%*
Northern	1,828,590	-269,090	*-14.7%*	+65,300	*+3.6%*
Eastern	1,219,450	-160,300	*-13.1%*	+64,900	*+5.3%*
Southern	2,340,170	-322,790	*-13.8%*	+82,190	*+3.5%*
Western	2,216,510	-262,950	*-11.9%*	+173,520	*+7.8%*
Peninsula	330,640	-67,720	*-20.5%*	+61,600	*+18.6%*
Other	194,870	-82,180	*-42.2%*	+50,490	*+25.9%*

7 Population Projections, Australia, 2017 (3222.0, Australian Bureau of Statistics)

The peninsular and regional areas outside of metropolitan Melbourne are most affected by the growth assumptions in terms of congestion. For the core scenario, the road network in both these areas are close to the transition point where congested conditions begin to develop. The low and high growth assumptions exaggerate this effect.

Table 31 provides an equivalent table for crowded PKT in 2051. The impact of alternate growth assumptions has a much more pointed impact on crowding levels across the public transport network. The low growth scenario exhibits more than a 30% decrease in crowded travel compared to the core scenario across all regions.

Table 31: *Morning peak congested PKT by FER for alternate growth scenarios*

FER	2051 Do Minimum	2051 Do Minimum (Low Growth)		2051 Do Minimum (High Growth)	
Inner	2,986,380	-874,440	*-29.3%*	+245,560	*+8.2%*
Northern	283,900	-126,480	*-44.6%*	+69,180	*+24.4%*
Eastern	301,210	-90,840	*-30.2%*	+21,180	*+7.0%*
Southern	739,080	-429,320	*-58.1%*	+86,600	*+11.7%*
Western	1,547,550	-513,940	*-33.2%*	+157,980	*+10.2%*
Peninsula	40,450	-21,350	*-52.8%*	-14,160	*-35.0%**
Other	117,040	-60,310	*-51.5%*	+52,720	*+45.0%*

*This unintuitive decrease in crowding is a result of broader modal shift. The higher growth in this scenario has resulted in a shift towards car use in the peninsula region, meaning less overall public transport trips and therefore less crowded travel.

The low growth scenario has the largest impact on average private vehicle travel times throughout the state, with most regions experiencing a reduction exceeding 5% during the morning peak by 2051. The high growth scenario did not exhibit a proportional response in the other direction, with an average increase in travel times of 1%. Table 32 provides a summary of these values for comparison. Public transport trips demonstrated similar patterns.

Table 32: *Morning peak private vehicle average travel times by FER*

FER	2051 Do Minimum	2051 Do Minimum (Low Growth)		2051 Do Minimum (High Growth)	
Inner	14.5	-0.1	*-0.6%*	-0.1	*-0.8%*
Northern	20.8	-1.2	*-5.8%*	+0.1	*+0.3%*
Eastern	17.7	-0.9	*-5.1%*	+0.1	*+0.8%*
Southern	19.7	-1.7	*-8.7%*	+0.2	*+1.1%*
Western	20.4	-1.5	*-7.4%*	+0.2	*+1.1%*
Peninsula	18.4	-1.8	*-9.8%*	+1.1	*+6.1%*
Other	10.1	-0.3	*-3.2%*	+0.2	*+1.5%*

Overall, the low growth scenarios for both 2036 and 2051 expectedly perform well in terms of network performance and impacts to accessibility compared to the core scenario. The high growth scenarios perform worse, but not to the same extent as which the low growth scenarios perform better.

4 Variable Land Use Tests

The VLUTI model was used to test the Do Minimum and NDS infrastructure futures assumptions for the years of 2036 and 2051. Unlike the static land use tests discussed in Section 3, these scenarios did not directly use the SALUP demographic projections. Instead the state-wide totals of population and employment are taken from the SALUP projections, and the VLUTI model itself determines the distribution of demographic attributes spatially, effectively using a combination of accessibility and economic drivers to determine location choice. Appendix A provides more background regarding the workings of this model.

Table 33 outlines the four scenario tests undertaken using the VLUTI model. A 2018 Current Conditions scenario was not conducted as the outcomes from the VITM 2018 scenario would be equivalent.

Table 33: *VLUTI scenario tests*

Assumptions	2018	2036	2051
Do Minimum		•	
NDS		•	•
NDS – Density Done Well Zoning Policy		•	

The VLUTI model uses land use zoning policy assumptions to determine how many people and jobs can be allocated to specific areas of the state. This essentially provides density limits to regions, controlling to what extent they can grow over time. The Do Minimum and NDS scenarios use a land use zoning policy that emulates the density assumptions found within the SALUP demographic projections.

The *Density Done Well* (DDW) NDS scenario uses a different land use zoning policy that allows for more densification along the principle public transport corridors within metropolitan Melbourne. This scenario does not differ from the NDS scenario in any other way.

This section is structured as follows:

- Section 4.1 outlines the differences in generated demographic distributions across the scenario tests.
- Section 4.2 explores travel behaviour changes across the four scenarios that have been influenced by the change in population and infrastructure assumptions.
- Section 4.3 covers impacts to network performance associated with each combination of land use and infrastructure assumptions for the four scenarios.
- Section 4.4 summarises the changes to accessibility in travelling to and from specific destinations given changing demographic distributions and network performance.

4.1 Demographic Changes

As mentioned in Section 4, the VLUTI model still uses state-wide population totals from the SALUP. As such, the total figures for 2036 and 2051 for these scenario tests matches those described in Table 11 within Section 3.1. Sections 4.1.1 and 4.1.2 describe the differences in spatial distribution of population and employment across scenarios respectively.

4.1.1 Population Changes

Table 34 shows the difference in population distribution across the 2036 VLUTI scenarios. The NDS assumptions results in slightly more residents living in outer and growth areas compared to the Do Minimum scenario. This version of the network provides greater capacity and coverage, particularly in these areas – making it more viable to live and work at the edges of the city. The DDW scenario serves to draw people towards inner Melbourne where more aggressive densification is now permitted, primarily from the regional cities and centres.

Table 34: *Population by FUA compared to the 2036 Do Minimum*

FUA	2036 Do Minimum	2036 NDS		2036 NDS (DDW)	
Inner Melbourne	1,380,000	-3,200	*-0.2%*	41,400	*+3.0%*
Middle Melbourne	2,290,000	-7,800	*-0.3%*	-6,800	*-0.3%*
Outer Melbourne	2,560,000	+13,200	*+0.5%*	+800	*+0.0%*
Melbourne New Growth Areas	500,000	+13,000	*+2.6%*	+9,900	*+2.0%*
Regional City	860,000	-1,200	*-0.1%*	-14,700	*-1.7%*
Regional Centres & Rural Areas	1,270,000	-14,100	*-1.1%*	-30,400	*-2.4%*
Total	8,860,000	0	-	0	-

Table 35 provides an alternate view of this land use distribution using the FERs. It can be seen that the NDS assumptions result in less people being located in the eastern regions of Melbourne and more in the west.

Table 35: *Population by FER compared to the 2036 Do Minimum*

FER	2036 Do Minimum	2036 NDS		2036 NDS (DDW)	
Inner	2,060,000	-4,300	-0.2%	+44,000	+2.1%
Northern	1,020,000	-4,300	-0.4%	-8,400	-0.8%
Eastern	1,000,000	-11,900	-1.2%	-14,300	-1.4%
Southern	1,260,000	+9,400	+0.7%	+4,900	+0.4%
Western	1,180,000	+27,100	+2.3%	+21,300	+1.8%
Peninsula	430,000	+700	+0.2%	-2,400	-0.6%
Other	1,920,000	-16,800	-0.9%	-45,000	-2.3%
Total	8,860,000	0	-	0	-

Figure 26, Figure 27 and Figure 28 show the overall distributions of this population change spatially in 2036 for Melbourne and its surrounds. At this level of detail, the impact of population distribution resulting from different provision of infrastructure is more apparent.

Figure 26: *Population comparison, 2036 NDS vs. 2036 Do Minimum (blue means NDS is higher)*

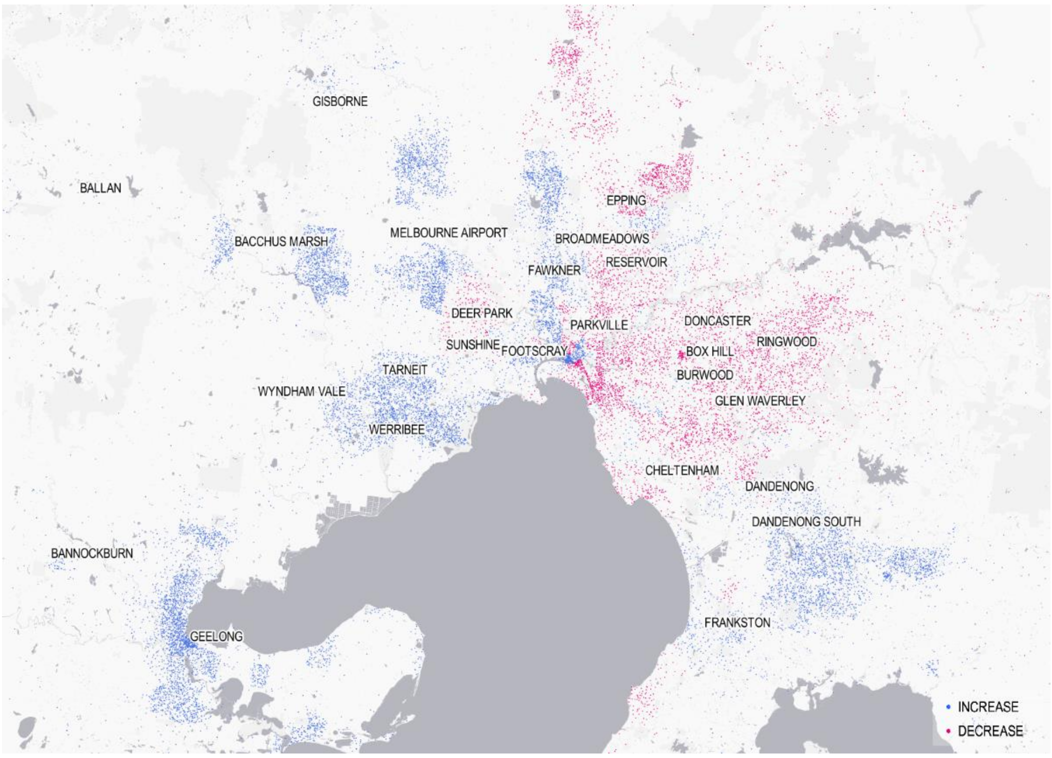


Figure 27: *Population comparison, 2036 DDW vs. 2036 Do Minimum (blue means DDW is higher)*

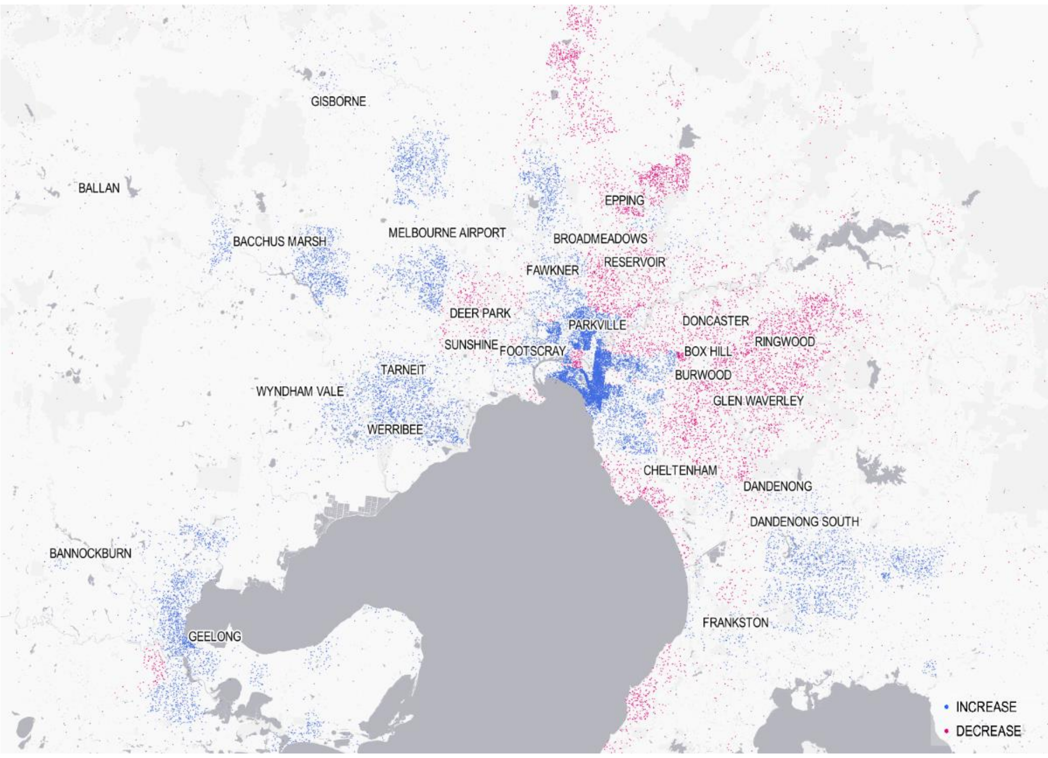
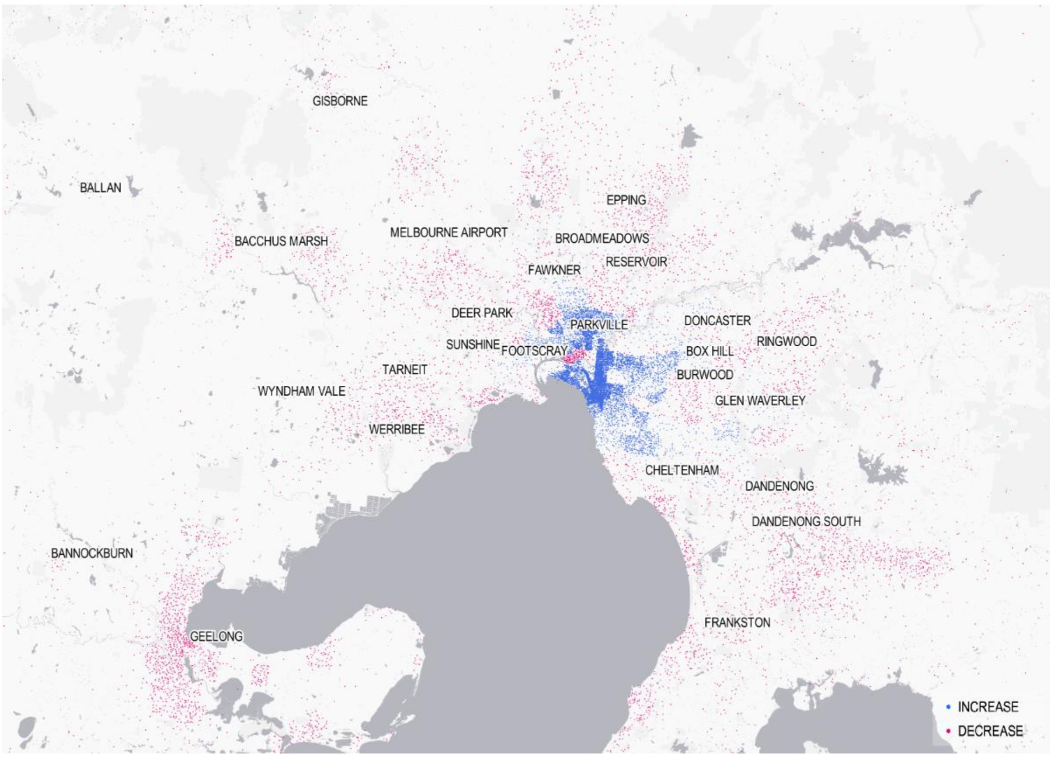


Figure 28: *Population comparison, 2036 DDW vs. 2036 NDS (blue means NDS is higher)*



4.1.2 Employment Changes

Table 36 summarises differences in employment by FUA across the 2036 VLUTI scenarios. There is little difference in the distribution of jobs throughout the state between the Do Minimum and NDS infrastructure assumptions. The NDS does attract slightly more jobs to inner Melbourne, with a corresponding loss of jobs in regional cities and centres. The DDW demonstrates a larger consolidation of employment towards inner Melbourne, drawing from regional areas as well as outer Melbourne.

Table 36: *Employment by FUA compared to the 2036 Do Minimum*

FUA	2036 Do Minimum		2036 NDS		2036 NDS (DDW)
Inner Melbourne	1,450,000	+3,500	+0.2%	+15,700	+1.1%
Middle Melbourne	1,020,000	-200	-0.0%	+2,800	+0.3%
Outer Melbourne	1,020,000	+1,500	+0.1%	-4,200	-0.4%
Melbourne New Growth Areas	70,000	+500	+0.6%	0	-0.0%
Regional City	460,000	-1,800	-0.4%	-6,000	-1.3%
Regional Centres & Rural Areas	540,000	-3,500	-0.6%	-8,300	-1.5%
Total	4,550,000	0	-	0	-

Figure 29 shows the change in both population and employment between the NDS and Do Minimum scenarios at a more granular LGA level. It is evident that the regions that grow the most from the NDS assumptions are outer municipalities of Melbourne such as Melton, Wyndham and Hume. Geelong also experiences a growth of both population and employment in this scenario. By contrast, Stonnington and Boroondara grow the most in terms of employment under the DDW scenario.

Figure 29: *Difference in population and employment by LGA, 2036 NDS vs. 2036 Do Minimum*

Figure 30, Figure 31 and Figure 32 show the overall distributions of this population change spatially in 2036 for Melbourne and its surrounds.

Figure 30: *Employment comparison, 2036 NDS vs. 2036 Do Minimum*

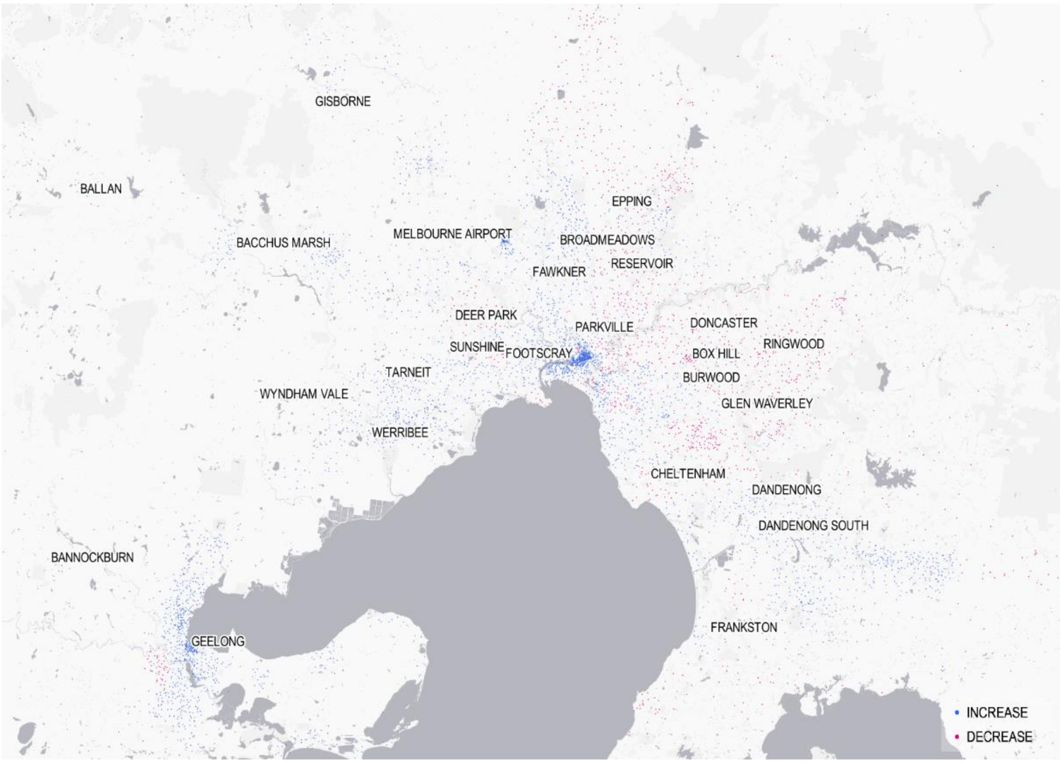


Figure 31: *Employment comparison, 2036 DDW vs. 2036 Do Minimum (blue means DDW is higher)*

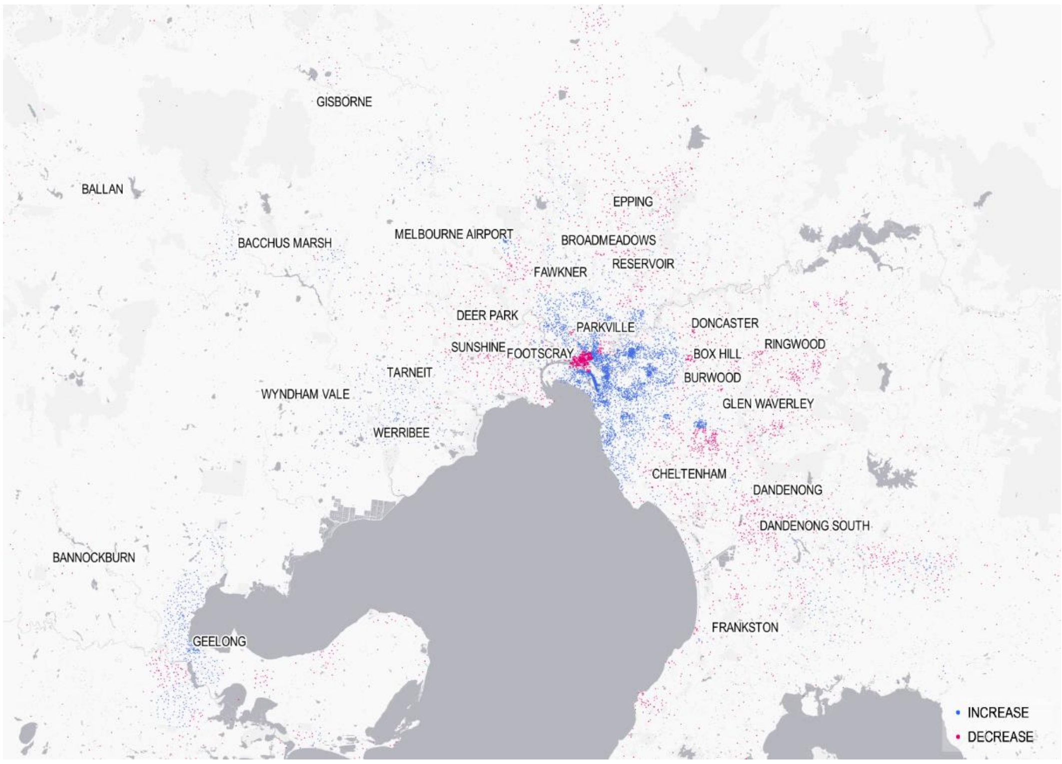
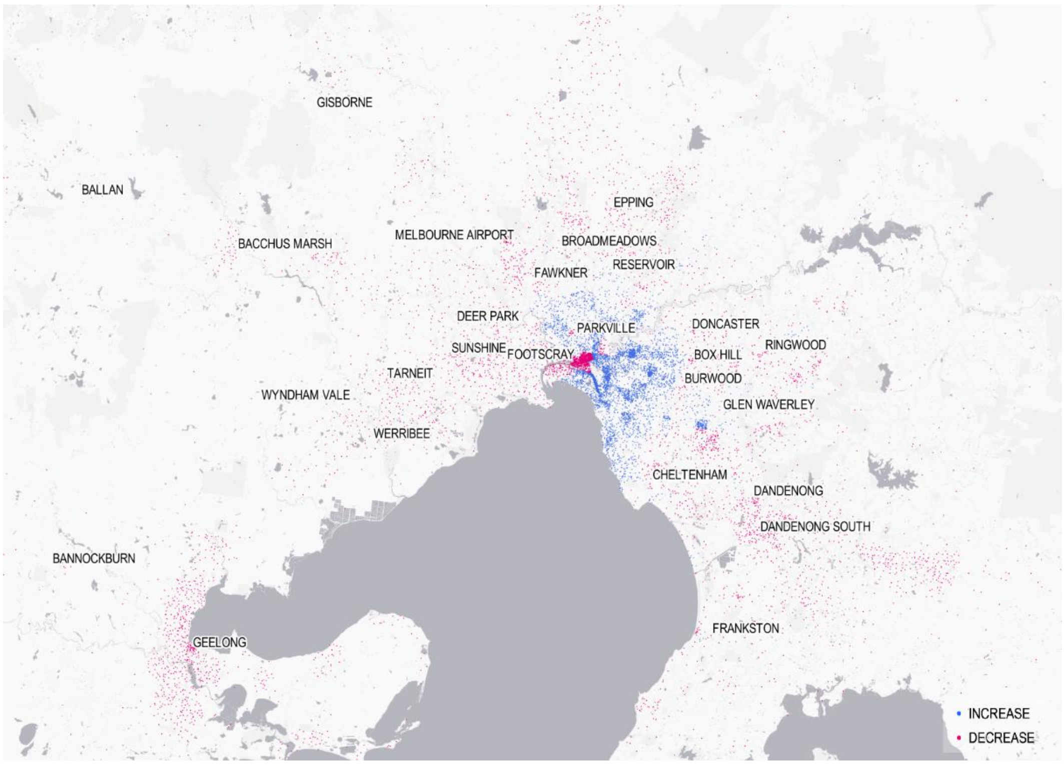


Figure 32: *Employment comparison, 2036 DDW vs. 2036 NDS (blue means DDW is higher)*



4.2 Travel Demand

Each scenario differs in both the spatial redistribution of population and jobs throughout Victoria, as well as differing levels of infrastructure provision and implementation of land use zoning policy. This results in changes in both the magnitude and nature of trips seen across the transport network. Table 37 provides a summary of total trips throughout the state for each of the 2036 VLUTI model scenarios conducted relative to the 2036 Do Minimum scenario.

The NDS network scenario results in approximately 5% more public transport travel per day compared to the Do Minimum – primarily stemming from increased service coverage and frequencies provided by these assumptions. The DDW scenario results in even more public transport use due to the increased consolidation of residents towards inner Melbourne where these modes of transport are more viable compared to private vehicles.

Table 37: *Comparison of total trips against 2036 Do Minimum*

Trips	2036 Do Minimum	2036 NDS		2036 NDS (DDW)	
Private Vehicle	22,967,200	-119,800	-0.5%	-182,480	-0.8%
Public Transport	2,116,360	+102,070	+4.8%	+117,930	+5.6%
Total	25,083,560	-17,740	-0.1%	-64,550	-0.3%
Public Transport Mode Share	8.4%	+0.4%	-	+0.5%	-

Consistent with patterns of population growth outlined in Section 4.1.1, the NDS scenario exhibits more travel in both the western and southern regions of the city compared to the Do Minimum. Table 38 provides a comparison of total trips originating from each FER for the 2036 VLUTI scenarios. Under both the NDS and DDW scenarios, the east of Melbourne and Victoria's regional cities and centres see the greatest reduction in travel compared to the Do Minimum. As mentioned previously, the improved public transport network in these scenarios has likely made it more viable to live in newer, less developed parts of metropolitan Melbourne.

Table 38: *Comparison of total trips by FER against 2036 Do Minimum*

FER	2036 Do Minimum	2036 NDS		2036 NDS (DDW)	
Inner	5,792,060	-14,330	-0.2%	+76,100	+1.3%
Northern	2,922,740	-9,960	-0.3%	-20,530	-0.7%
Eastern	2,687,890	-25,640	-1.0%	-32,240	-1.2%
Southern	3,596,910	+20,530	+0.6%	+9,250	+0.3%
Western	3,202,490	+59,090	+1.8%	+43,640	+1.4%
Peninsula	1,139,920	+1,170	+0.1%	-6,320	-0.6%
Other	5,741,550	-48,600	-0.8%	-134,440	-2.3%
Total	25,083,560	-17,740	-0.1%	-64,550	-0.3%

Public transport mode share universally increases across all LGAs under the NDS and DDW assumptions compared to the Do Minimum in 2036. This is unsurprising as there is a 36% disparity in service kilometres between the two infrastructure futures by this future year (Table 6) before taking into consideration further shifts in population and employment.

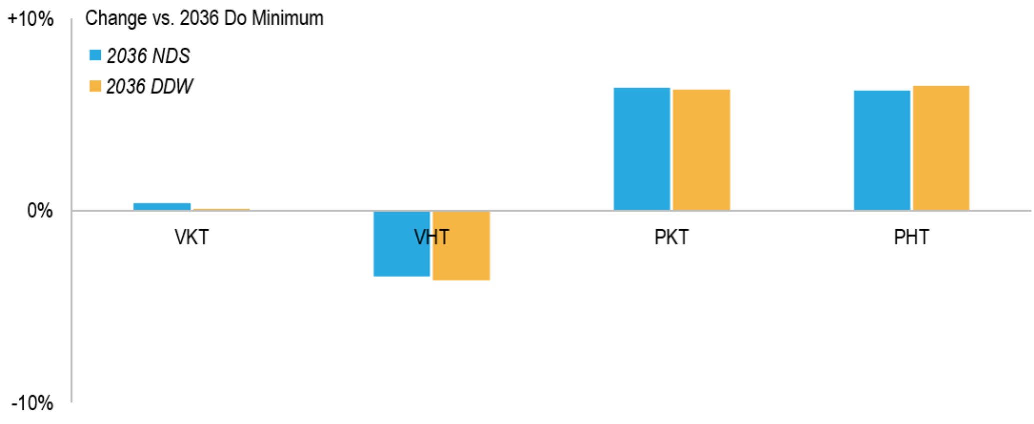
Table 39 provides a direct comparison between daily total trips for the 2036 NDS and DDW scenarios. It can be seen that whilst there is a 16,000 increase in number of public transport trips for the latter set of assumptions, there is a larger overall loss of 47,000 trips from the network. This loss of motorised trips can be traced to the redistribution of residents towards inner Melbourne, where the use of active transport is more prevalent than anywhere else in Victoria. Regional cities and centres experienced the largest decrease in population under the DDW land use zoning policy changes – where use of modes other than private vehicle is rare.

Table 39: *Comparison of total trips, 2036 DDW vs. NDS*

NDS (DDW) vs. NDS		2036
Private Vehicle	-62,680	*-0.3%*
Public Transport	+15,870	*+0.7%*
Total	-46,810	*-0.2%*
Public Transport Mode Share	+0.1%	-

Despite the decrease in total private vehicle trips, the NDS and DDW scenarios exhibit marginally higher daily VKT than the Do Minimum. VHT see a large decrease however, implying that, on average, people are travelling further distances but doing so in a shorter amount of time. This is likely connected to the nature of road upgrades included within the NDS assumptions – major new additions like the Outer Metropolitan Ring Road mean people can travel further, but at higher speeds in less congested conditions. Figure 33 shows this phenomenon graphically, along with changes in PKT and PHT. Public transport utilisation across the network expectedly sees a sizeable increase under both the NDS and DDW scenarios compared to the Do Minimum due to the aforementioned enhancement in public transport provision.

Figure 33: *Change in network travel compared to the 2036 Do Minimum*



4.3 Network Impacts

Changes in travel demand outlined in Section 4.2 lead to shifting levels of congestion and crowding throughout the network depending on the given assumptions surrounding infrastructure provision and land use policy. Table 40 shows the proportion of morning peak VKT and PKT occurring under congested/crowded conditions (see Section 0) as a proportion of all travel during the morning peak for each VLUTI scenario.

Table 40: *Morning peak proportion of crowded travel*

Congested Travel Proportion	2018 Current Conditions	2036 Do Minimum	2036 NDS	2036 NDS (DDW)
Congested VKT	22%	29%	26%	26%
Crowded PKT	20%	22%	11%	10%

The overall amount of congested road travel is estimated to increase into the future across all tested infrastructure futures and zoning policies. The proportion of morning peak road travel that occurs under congested conditions is forecast to increase to 29% from 22% by 2036 under Do Minimum assumptions. This is improved with the NDS network, only reaching 26% for both the standard and DDW zoning policies.

Crowding on public transport is forecast to decrease under both the NDS scenarios compared to the Do Minimum in 2036. This is also approximately half the level of crowding experienced during the morning peak under current conditions – a notable improvement in public transport travelling conditions.

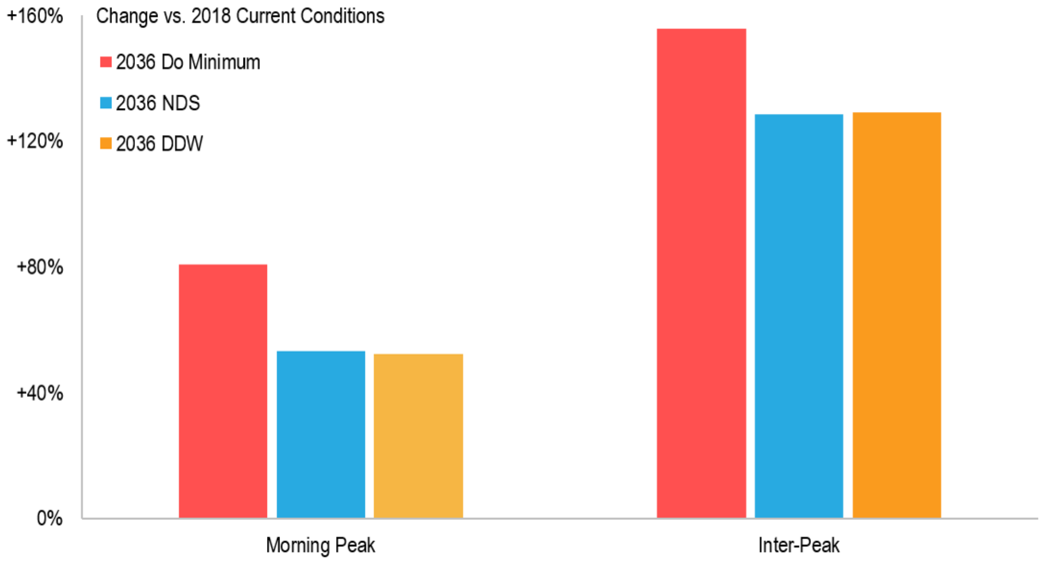
It is worth noting that the amount of crowded PKT in the 2036 Do Minimum scenario is only 2% higher than in 2018, a small difference when compared to the equivalent static land use test in Section 3.3 where crowding was 11% higher. Direct comparisons between the outcomes of the static and variable land use tests have been largely avoided in this report to avoid false equivalences due to methodological differences. However, for context, this disparity is in part due to the fact that the VLUTI scenarios have assigned less population to outer and growth areas of metropolitan Melbourne compared to SALUP. This results in crowding being concentrated towards the CBD rather than these conditions being further spread out across the public transport network.

Sections 4.3.1 and 4.3.2 explore the performance of the road and public transport networks in more detail respectively.

4.3.1 Road Network

Figure 34 summarises the growth in congested road kilometres during the morning and inter-peak periods (see Section 1.5.3) for the 2036 VLUTI scenarios. For all infrastructure futures and zoning policies tested, the coverage of congestion across the physical road network is forecast to increase over time. As was the case in Section 3.3.1, the growth in inter-peak congestion is notable.

Figure 34: *Change in daily congested road kilometres compared to 2018*



The DDW land use zoning policy, despite accommodating more residents within inner Melbourne, has a minor impact on the extent of road congestion on the network compared to the standard NDS scenario in 2036. Much of the population redistribution resulting from this policy involved movement from regional cities and centres towards metropolitan Melbourne. This ultimately results in a reduction in volumes from areas that were not congested to begin with, towards areas that already experience an existing level of congestion.

Even when considering levels of congested travel rather than proportion of the road network, the impact of the DDW land use zoning policy is minimal in terms of network performance alone. Table 41 summarises the amount of congested VKT as a proportion of all VKT during the morning peak for the NDS and DDW scenarios. There is a minor increase in congested travel within inner Melbourne corresponding with demographic consolidation (Section 4.1), but this increase is not proportional to the level of population growth seen. More people in these areas elect to use either public or active transport, dampening impacts on congestion.

Table 41: *Morning peak congested VKT proportion, 2036 NDS and DDW*

FUA	2036 NDS	2036 NDS (DDW)
Inner Melbourne	48.8%	*+0.4%*
Middle Melbourne	44.0%	*-0.1%*
Outer Melbourne	34.5%	*-0.5%*
Growth Areas	11.0%	*-0.2%*
Regional City	3.5%	*-0.2%*
Regional/Rural Areas	3.3%	*-0.1%*

Figure 35 and Figure 36 show the differences in road network utilisation during the morning peak for each of the 2036 VLUTI scenarios at a more granular spatial level.

Figure 35: *Morning peak volume capacity comparison, 2036 NDS vs. 2036 Do Minimum (blue means NDS is lower)*

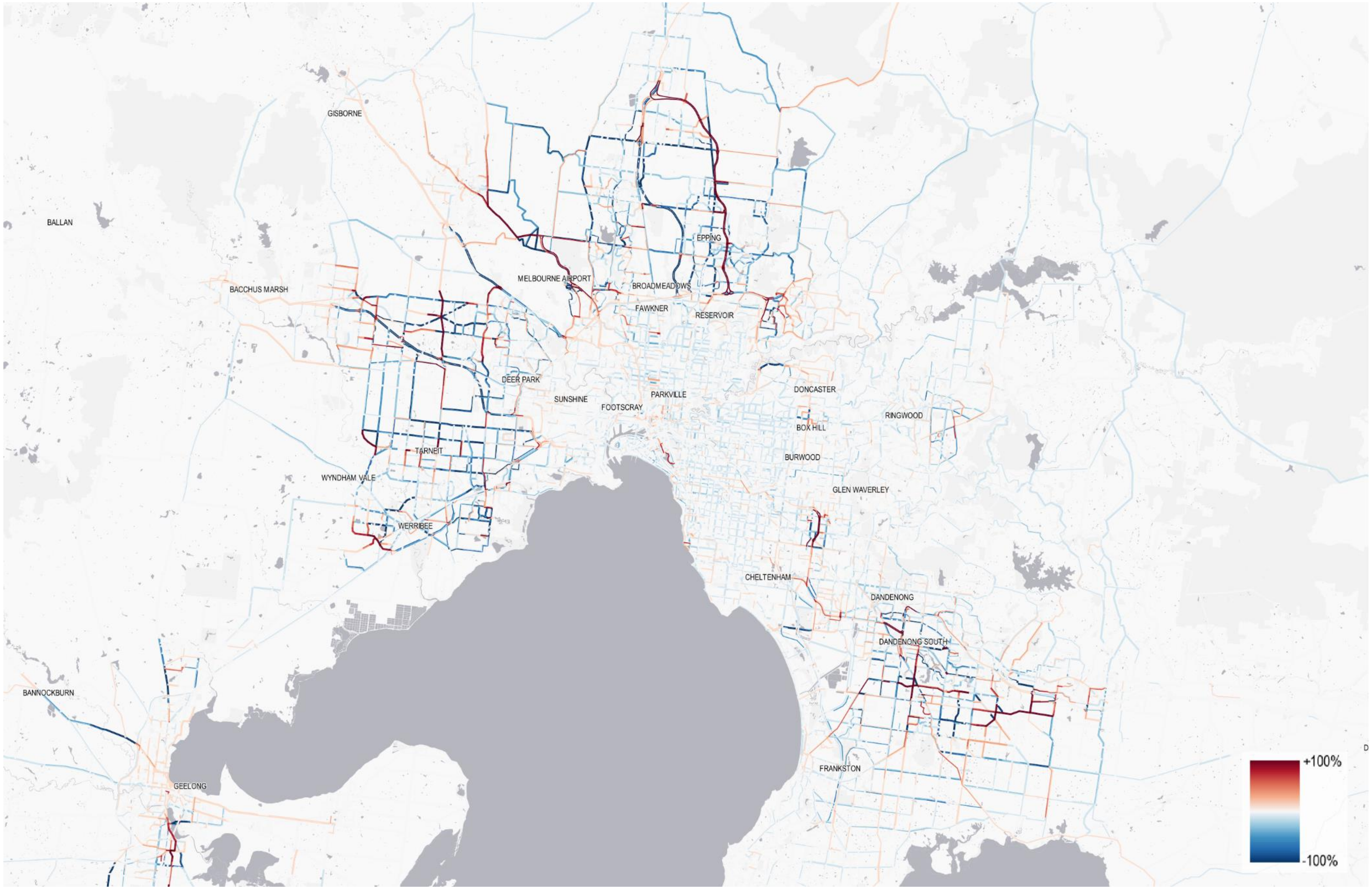


Figure 36: *Morning peak volume capacity comparison, 2036 DDW vs. 2036 NDS (blue means DDW is lower)*

4.3.2 Public Transport

Table 42 summarises the total daily boardings estimated for each of the 2036 VLUTI scenarios compared to 2018 current conditions. For all combinations of infrastructure future and land use zoning policy, boardings are expected to increase by more than 50% by 2036. As was the case for the static land use tests in Section 3.3.2, total service kilometres are increasing 19% and 63% between 2018 and 2036 for the Do Minimum and NDS assumptions respectively. Thus, whilst the NDS public transport provision keeps pace with demand, the same cannot be said for the Do Minimum network.

Table 42: *Daily boardings compared to 2018*

Mode	2018 Current Cond.	2036 Do Minimum		2036 NDS		2036 NDS (DDW)	
Train	1,004,040	+637,520	*+63.5%*	+686,310	*+68.4%*	+695,660	*+69.3%*
Tram	630,320	+250,780	*+39.8%*	+316,060	*+50.1%*	+330,510	*+52.4%*
Bus	483,050	+163,370	*+33.8%*	+231,370	*+47.9%*	+232,440	*+48.1%*
V/Line	77,570	+57,130	*+73.6%*	+62,760	*+80.9%*	+61,830	*+79.7%*
Total	2,194,970	+1,108,790	*+50.5%*	+1,296,500	*+59.1%*	+1,320,440	*+60.2%*

This has an expected impact on the amount of crowded travel that occurs across the public transport network across the difference assumption combinations. Table 43 provides a summary of these values for both the morning and inter-peak periods. By 2036, the Do Minimum network results in a 73% increase in total crowded travel during the morning peak compared to 2018. In contrast, both NDS scenarios result in less crowded travel than 2018 despite the 60% uplift in demand.

Table 43: *Crowded PKT compared to 2018*

Mode	2018 Current Cond.	2036 Do Minimum		2036 NDS		2036 NDS (DDW)	
Morning Peak	1,202,930	+879,950	*+73.2%*	-165,640	*-13.8%*	-237,110	*-19.7%*
Inter-Peak	139,820	+139,830	*+100.0%*	+59,090	*+42.3%*	+62,280	*+44.5%*

Similar to the road network as mentioned in Section 4.3.1, general uplifts in public transport demand are resulting in greater levels of crowding during the inter-peak period. It is noted however that the magnitude of this effect is still relatively low in absolute terms compared to morning peak conditions.

Metropolitan Train

As mentioned for the equivalent static land use tests in Section 3.3.2, the Do Minimum and NDS assumptions present very different future configurations of the metropolitan train network. By 2036, the Do Minimum network lags behind the NDS significantly in terms of both service frequencies and capacity. Despite these differences, metropolitan train remains the predominant form of public transport in terms of both boardings and passenger kilometres travelled.

Table 44 summarises the congested PKT proportion on metropolitan trains for the 2036 VLUTI scenarios and 2018. The Do Minimum network has reached capacity by 2036, with almost half of all travel experiencing crowded conditions within inner Melbourne. Both NDS scenarios exhibit less than half the crowded travel than in 2018.

Despite the increased population within inner Melbourne, the DDW displays less public transport crowding than the standard NDS scenario. This is because, in this scenario, the trips are shorter on average and the tram network plays a slightly larger role in moving people. These effects will be explored in more detail across subsequent parts of this section and Section 4.4.

Table 44: *Morning peak congested PKT proportion on metropolitan trains by FUA*

FUA	2018 Current Conditions	2036 Do Minimum	2036 NDS	2036 NDS (DDW)
Inner Melbourne	31.4%	47.2%	15.5%	13.7%
Middle Melbourne	15.3%	19.2%	18.2%	17.8%
Outer Melbourne	0.0%	3.0%	0.9%	0.0%
Melbourne New Growth Areas	0.0%	0.0%	0.0%	0.0%

Figure 37 and Figure 38 compare where the metropolitan train network is at capacity between the 2036 VLUTI scenarios during the morning peak.

Figure 37: *Morning peak metropolitan train crowding, 2036 NDS vs. Do Minimum (blue means NDS is lower)*

Figure 38: *Morning peak metropolitan train crowding, 2036 DDW vs. NDS (blue means DDW is lower)*

Tram

Much like with metropolitan trains, demand for tram use increases in the future across all tested scenarios. The continuing consolidation of employment towards inner Melbourne results in a growing demand for public transport services in these areas. Table 45 compares several supply and demand metrics for the tram network across the 2036 VLUTI scenarios and 2018.

Table 45: *Morning peak tram network supply and demand*

Metric	2018 Current Conditions	2036 Do Minimum	2036 NDS	2036 NDS (DDW)
Services	671	722	800	800
Service Kilometres	9,820	10,870	12,010	12,010
Boardings	132,980	182,660	194,230	196,770
PKT	426,090	538,710	565,830	571,950

As outlined in Section 3.3.2, the NDS assumptions provide a greater number of service kilometres through shorter headways and more capacity through larger vehicles when compared to the Do Minimum network. This results in a marked relief in crowding across the tram network during the morning peak.

Figure 39 and Figure 40 compares spatially where the tram network is at capacity during the morning peak between each of the 2036 VLUTI scenario. The DDW scenario exhibits minor increases in crowding throughout the network, consistent with population and employment shifts.

Figure 39: *Morning peak tram crowding, 2036 NDS vs. Do Minimum (blue means NDS is lower)*

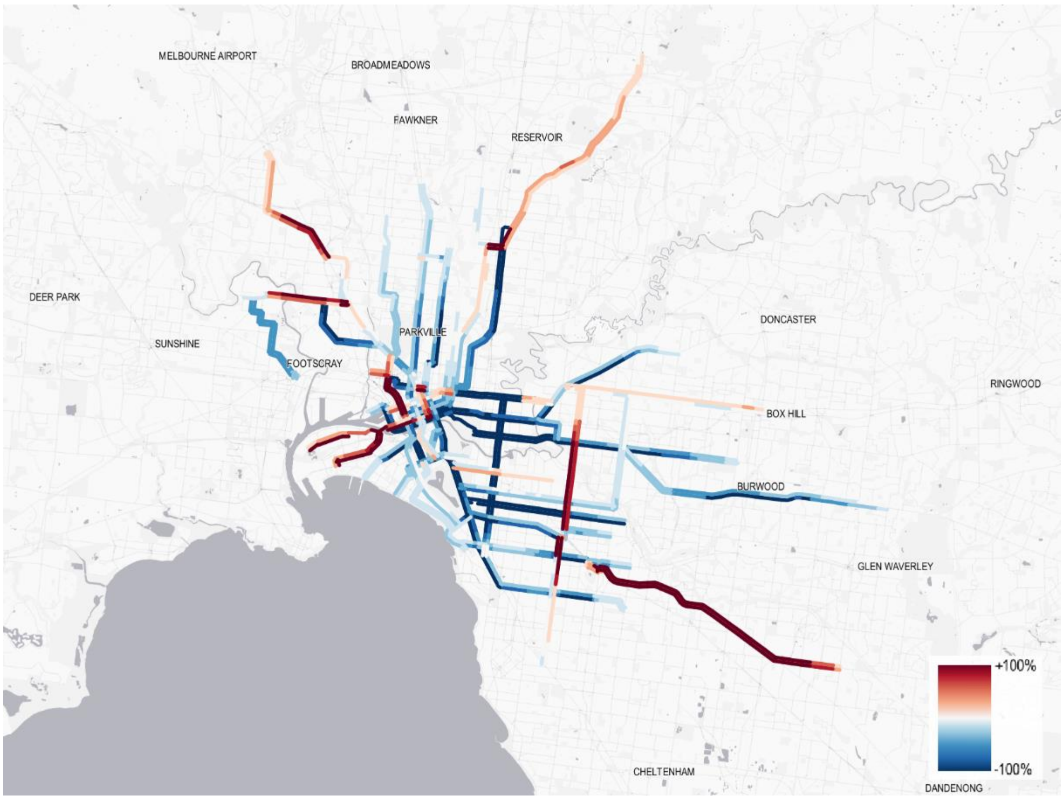
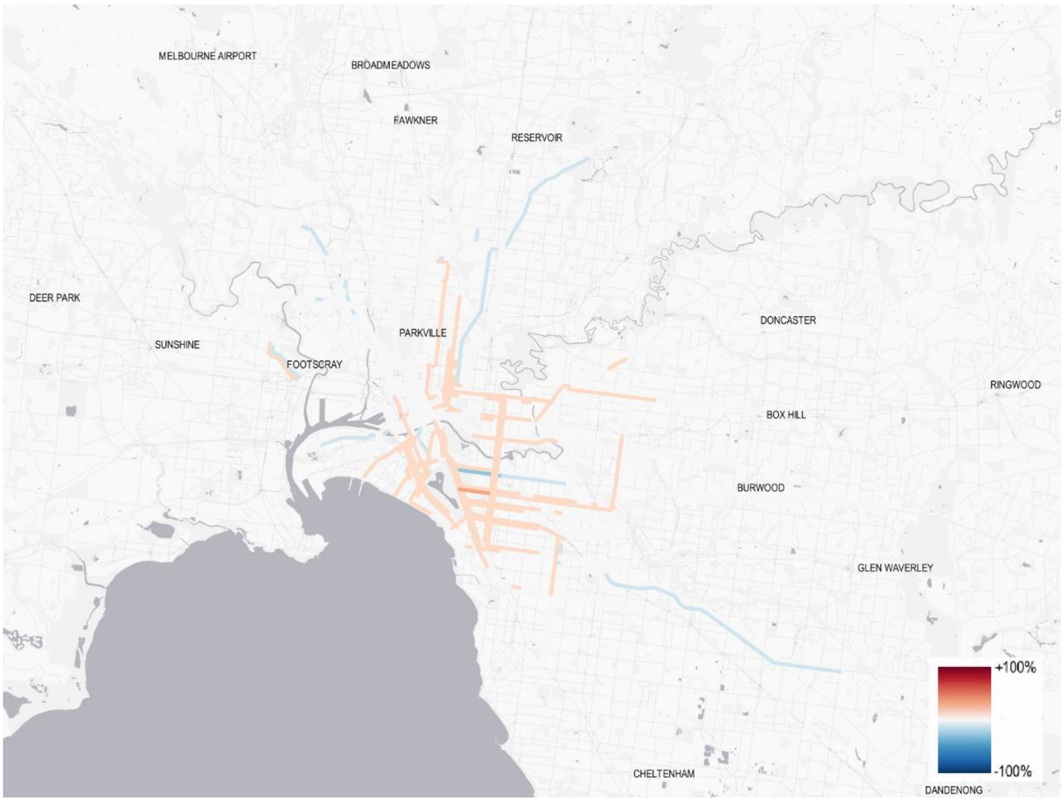


Figure 40: *Morning peak tram crowding, 2036 DDW vs. NDS (blue means NDS is lower)*



Bus

Table 46 provides an overview of bus network performance across the 2036 VLUTI scenarios relative to 2018. As was the case for the static land use tests in Section 3.3.2, crowding is not a widespread issue on the bus network, either now or in the future, with the exception of select locations including along the Eastern Freeway and Fishermans Bend.

The NDS scenarios see more utilisation of the bus network in 2036 compared to the Do Minimum, due to increased service frequency and coverage throughout metropolitan Melbourne. There is also proportionally less crowding during the morning peak in these scenarios in locations where that remains an issue. The performance of the DDW scenario differs only slightly from the standard NDS for bus performance, with more PHT but less PKT. Given the redistribution of population under this land use zoning policy, it is likely that more people are using bus routes travelling through congested parts of Melbourne – lengthening the duration of their average trips by a small degree.

Table 46: *Morning peak bus crowding statistics compared to 2018*

Metric	2018 Current Cond.	2036 Do Minimum		2036 NDS		2036 NDS (DDW)	
PKT	554,310	+117,440	*+21.2%*	+212,030	*+38.3%*	+210,210	*+37.9%*
PHT	26,900	+7,180	*+26.7%*	+10,580	*+39.3%*	+10,630	*+39.5%*
Crowded PKT	36,220	+26,190	*+72.3%*	+22,200	*+61.3%*	+18,050	*+49.8%*
Avg. Occupancy	9.9	-0.6	*-6.4%*	-2.8	*-28.0%*	-2.8	*-28.2%*

Whilst service coverage does not impact crowding substantially for the bus network, this does impact broader accessibility throughout the city. This is explored in further detail within Section 4.4.

V/Line

Direct comparison of crowding across the V/Line network between the Do Minimum and NDS scenarios is difficult given the major alterations to the network outlined in Section 2.2. Table 47 summarises the amount of crowded PKT as a proportion of all PKT and average vehicle occupancy for the morning peak period across scenarios.

Table 47: *Morning peak crowded PKT and average occupancy compared to 2018*

Metric	2018 Current Cond.	2036 Do Minimum		2036 NDS		2051 Do Minimum	
Crowded PKT %	5.2%	-5.0%	-	-5.2%	-	-5.2%	-
Avg. Occupancy	195.7	-3.5	*-1.8%*	-17.3	*-8.9%*	-18.8	*-9.6%*

By 2036, crowding on regional rail largely disappears under both the Do Minimum and NDS network assumptions for the morning peak. This is a different outcome to that described for the static land use tests in Section 3.3.2 – largely because the VLUTI scenarios have involved lower levels of growth in the regional cities and centres, resulting in less demand for V/Line services.

4.4 Accessibility

The land use changes and differences in infrastructure provision ultimately lead to network conditions and travel behaviour that affect the accessibility of travel. Table 48 and Table 49 provide a high-level summary of average trips times by FER for the morning peak for the 2036 VLUTI scenarios as well as 2018.

Table 48: *Morning peak average private vehicle trip times (minutes) originating from each FER*

FER	2018 Current Cond.	2036 Do Minimum		2036 NDS		2036 NDS (DDW)	
Inner	13.5	+1.1	+8.1%	+0.7	+5.1%	+0.7	+4.9%
Northern	17.3	+0.5	+3.0%	-0.7	-4.3%	-0.8	-4.5%
Eastern	15.6	+2.2	+14.0%	+1.6	+10.6%	+1.6	+10.1%
Southern	15.4	+0.3	+1.8%	-0.4	-2.3%	-0.4	-2.8%
Western	16.2	-1.0	-6.1%	-2.2	-13.4%	-2.2	-13.5%
Peninsula	13.6	+2.6	+18.9%	+2.1	+15.8%	+2.0	+14.9%
Other	9.5	+0.0	+0.2%	-0.3	-3.1%	-0.3	-3.1%

Table 49: *Morning peak average public transport trip times[8] (minutes) originating from each FER*

FER	2018 Current Cond.	2036 Do Minimum		2036 NDS		2036 NDS (DDW)	
Inner	40.3	+0.9	+2.3%	+0.3	+0.7%	+0.2	+0.4%
Northern	57.6	+0.9	+1.5%	-0.8	-1.3%	-0.9	-1.5%
Eastern	57.1	+4.6	+8.0%	+3.0	+5.3%	+2.9	+5.0%
Southern	58.4	-0.0	-0.0%	-0.3	-0.5%	-0.4	-0.7%
Western	54.4	-0.4	-0.8%	-1.7	-3.1%	-1.8	-3.3%
Peninsula	74.9	+4.9	+6.6%	+2.9	+3.9%	+2.8	+3.7%
Other	76.5	+5.0	+6.5%	+2.9	+3.7%	+2.9	+3.7%

Average travel times for both private vehicle and public transport travel are faster in 2036 for the NDS network when compared to the Do Minimum – with the largest differences felt in the north, south and west of the city. As was the case for the static land use tests in Section 4.4, the average public transport trip is universally longer than a private vehicle trip, often by a factor of three or higher.

There is very minimal difference in average trip times between the 2036 NDS and DDW scenarios for both private vehicle and public transport trips. However, this does not mean that overall accessibility has not been affected by this land use zoning policy. Whilst the travel times seen in inner Melbourne have not changed substantially between these scenarios, more people are now living in inner Melbourne under the DDW scenario (Section 4.1.1) – with greater access to opportunities than they previously had. It is worth

[8] Public transport trip times refer to the total amount of time spent travelling from the origin to the destination, not including any non-time components such as boarding and transfer penalties.

noting that this consolidation is achieved with relatively minimal impact on average travel times within the inner regions specifically.

At an LGA level, the NDS assumptions result in travel time improvements throughout the state for both private vehicle and public transport travel compared to the Do Minimum. The largest gains are seen in outer municipalities like Melton, Wyndham, Whittlesea and Hume. Figure 41 and Figure 42 show these differences spatially.

Figure 41: *Difference in average morning peak trip time, private vehicle, 2036 NDS vs. Do Minimum*

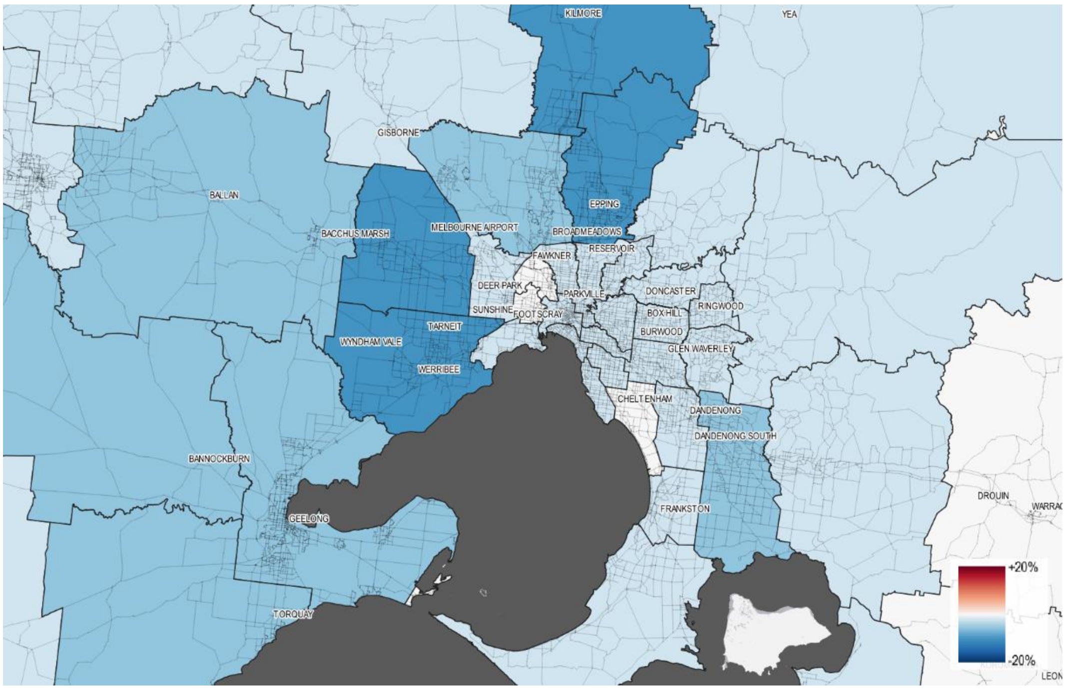
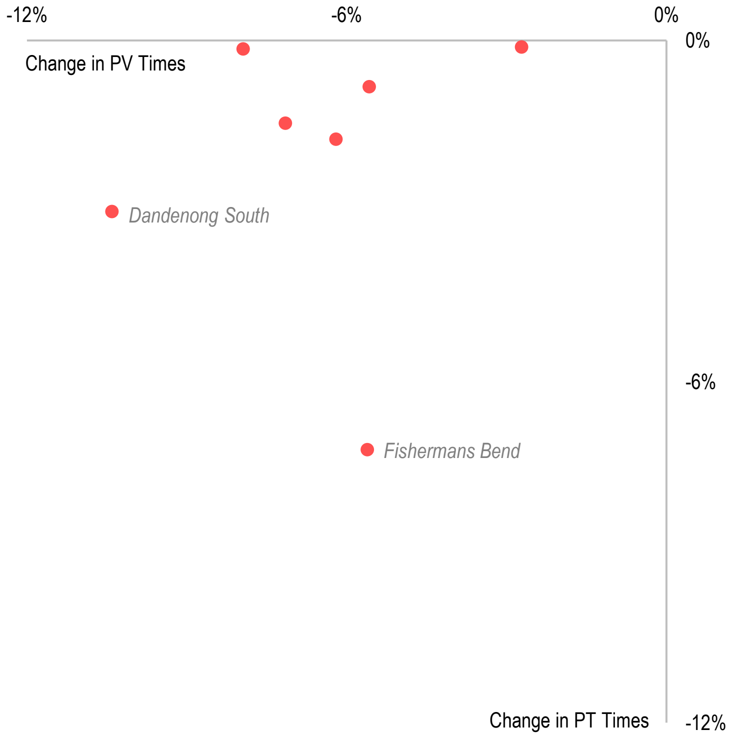


Figure 42: *Difference in average morning peak trip time, public transport, 2036 NDS vs. Do Minimum*

Figure 43 shows the percentage differences in average morning peak travel times terminating at each of the NEICs within metropolitan Melbourne. Dandenong South sees the largest benefit in terms of private vehicle access – a 10% decrease in travel times. Similarly, Fishermans Bend experiences a 7% decrease in the duration of incoming public transport trips. Public transport access is only affected marginally for all other NEICs.

Figure 43: *Morning peak average travel times to each NEIC, 2036 NDS vs. Do Minimum*



These differences in average travel times – precipitated through both improved network conditions and a redistribution of population – can have an important impact on the potential labour force market available to each location. Table 50 shows the proportion of working age residents who live within a 45-minute journey of each NEIC for both the 2036 Do Minimum and NDS scenarios.

Table 50: *Morning peak 45-minute working population catchment sizes by NEIC*

	2036 Do Minimum		2036 NDS	
NEIC	Private Vehicle	Public Transport	Private Vehicle	Public Transport
Dandenong South	42.3%	7.1%	43.9%	7.6%
Fishermans Bend	28.3%	5.9%	34.4%	7.4%
Latrobe	36.5%	5.2%	38.9%	6.5%
Monash	39.7%	10.2%	41.7%	10.4%
Parkville	31.9%	18.9%	35.9%	20.4%
Sunshine	31.4%	9.7%	35.7%	11.1%
Werribee	23.7%	2.7%	26.8%	4.6%

5 Summary Findings and Implications

5.1 Summary Findings

This report has explored how the future transport network and its performance may evolve over the next thirty years under a growing population. Two different infrastructure futures were considered, representing different scenarios of future upgrades and projects. Two different methodologies were used to predict future land use distribution – where people are expected to live and work.

The outcomes of all scenarios tested shared several common threads:

- Rapid future population growth is expected in Melbourne's growth areas as well as large regional cities such as Geelong and Ballarat. However, no part of the state will remain unaffected. Existing forecasts predict an overall 68% growth in population between 2018 and 2051.

- This increasing population and a rising density of jobs towards Melbourne's inner and middle regions results in a larger than proportional increase in travel demand. Not only are more people travelling due to growth, everyone is, on average, spending more time travelling.

The case for continued intervention across network infrastructure and policy is clear. Two infrastructure futures were assessed in this report, representing either a minimal or comprehensive approach to future upgrades. The performance impacts and connectivity differences between the two are stark:

- By 2051, it is expected that a network using the Do Minimum assumptions would have a barely functioning public transport system, wracked with over-crowding and an inability to provide adequate connectivity to the fastest growing areas of Melbourne and regional Victoria. In contrast, the NDS assumptions exhibit less crowding on public transport in 2051 than is seen today, despite handling over double the number of trips.

- The amount of road congestion is expected to increase under both tested infrastructure futures, especially within inner and middle Melbourne areas. However, the NDS assumptions provide significantly more capacity towards the edges of the city and throughout regional Victoria. This improves average travel times and general accessibility significantly throughout these regions compared to the equivalent Do Minimum network.

It is worth noting that the level of public transport provision in the NDS assumptions result in almost 200,000 less road trips per day, which has the secondary benefit of alleviating some congestion along key corridors. However, even with this level of intervention, private vehicle travel is forecast to remain dominant throughout the state.

5.2 Implications, Challenges and Opportunities

The rise in travel demand and, dependent on the infrastructure future case, associated deterioration in future transport network performance that has been identified points to ongoing challenges in meeting the future mobility needs of Victorians. This section flags some of the consequent issues that IV may need to consider in developing the updated 30-year Infrastructure Strategy.

Across all tested scenarios, state-wide public transport mode share by 2051 is not expected to increase beyond 10%. Certain trip purposes, like white collar commuting, reach 26% under certain circumstances but this represents a fraction of the overall travel that happens on an average day. Travel for shopping, socialising and business is still expected to overwhelmingly occur by car.

It is evident that increasing public transport mode share is not simply a matter of upgrading capacity throughout the existing system. The geometric layout and density of services favour inner Melbourne areas, becoming increasingly less viable for a variety of trip purposes across the outer regions. The DDW scenario demonstrated that a higher density of residents within inner Melbourne could be accommodated with minimal impacts to broader network performance. Policy interventions like this can have a significant impact on accessibility, providing the ability to re-shape the city to better use its existing strengths.

Road congestion results show significant differences across the infrastructure future cases. Compared to the Do Minimum assumptions, the NDS road network performs well in terms of congestion and average travel times. However, compared to today, future conditions for all the scenarios tested are not a picture of inspiration. In the face of this forecast growth, maintaining or improving current levels of performance appears to be a problem that cannot be solved through capacity upgrades alone. Policies that encourage the spreading of peak period travel and other fundamental behaviour change appear to have a role to play in the future, working alongside infrastructure provision.

By 2051, over 50% of forecast morning peak car travel is comprised of journeys less than 5km in length. There is an opportunity to better shape our neighbourhoods and improve the status and convenience of alternative modes such that a portion of these trips are better served by public and active transport.

As well as alleviating the direct impacts of congestion to roads users and reducing the need for infrastructure provision there are further reasons to aim for reductions in private vehicle travel. These include:

- Reducing greenhouse emissions - As modelled in the scenarios within this report, overall travel demand is expected to increase over 60% through the next thirty years – a lion’s share of which is private vehicle travel. Assuming minimal changes to the level of emissions produced by the average vehicle, this growth of travel comes with a proportional and significant growth in the carbon footprint of our transport network.

- Improving health outcomes – vehicle emissions are a significant cause of health issues in urban areas. Conversely increased levels of physical activity improve health outcomes.
- Improving road safety – lower levels of exposure reduces crashes and their associated costs.
- Improving efficiency of road freight and business travel – with flow-on benefits to the cost of goods and services.

The infrastructure and policy decisions made for the transport network today will not only influence its performance tomorrow, but also where we live, work, study and play. Bolstering the capacity of our existing network infrastructure has an important role to play in maintaining the connectivity and accessibility Victoria expects going forward. However, this alone will be insufficient in creating a future where public transport is used more frequently and road congestion is improved from today's conditions. Combining policy mechanisms such as land use zoning policy and behaviour change programs with transport improvements represents our strongest tool in shaping a successful future.

Appendix A

Model Background

A1 DoT VITM

The Victorian Integrated Transport Model (VITM) is a state-wide strategic transport model owned and maintained by the Department of Transport (DoT). It is used to test and assess transport policies and strategies, estimate future demands on the transport network and analyse the potential impacts of road, public transport and land-use planning projects.

The VITM version used for both the static land tests and the model underlying the VLUTI variable land use tests was *VITM19_v2_02*. A summary of its features is as follows:

- Four time periods, encompassing AM peak (7AM – 9AM), interpeak (9AM – 3PM), PM peak (3PM – 6PM) and off-peak (6PM – 7AM).
- Road and public transport modes.
- Multiple vehicle types including car, rigid trucks and articulated trucks.
- Multiple public transport modes including train (metro and V/Line), trams and busses.
- Optional public transport capacity constraint.
- Integration of the Freight Movement Model (FMM) to forecast truck movements and volumes.

All model runs as part of this report used *constrained capacities* – that is, crowding effects on public transport were represented. No structural changes were made to this model for the static land use tests.

A1.1 Limitations

It is crucial to acknowledge that model outputs are always an approximation of what can be expected in the real/built environment. The VITM as a strategic planning tool is more effective at representing strategic level demands and patterns (i.e. across screenlines/cordons) than individual links or segments within a network. Thus, certain outputs from the VITM must be treated with caution and interpreted with an understanding of the model's strengths and weaknesses and the input assumptions inherent to the forecasting process.

Some limitations of and key assumptions associated with the VITM worth considering in the context of this report are:

- *Land use forecasts:* land use forecasts directly affect the trip generation and distribution behaviour produced by the model. If the timing or intensity of demographic growth at a travel zone level differs from forecasts, travel behaviour will likely differ from modelled results.

- *Future road and public transport:* assumptions around the timing of road and public transport projects will affect modelled mode share and route choice. These shift over time as government expectations around future investments evolve.
- *Intersections not explicitly modelled:* during the traffic assignment phase of the model, link-based speed/flow curves are used to calculate the travel time for a link, based on the assigned volume and capacity of that link. This is a simplification of reality, where each section of the road will have unique operational behaviour and queuing back may impact adjacent intersections. This means that the model will not fully represent the impacts that significant capacity bottlenecks may cause over wider extents of the network. It also presents limitations in assessing projects that involve intersection improvements.
- *Commercial vehicles:* Future commercial vehicle movements are estimated in the Freight Movement Model (FMM) component of the VITM. Forecast movements are directly linked to the assumptions in the FMM, such as Port of Melbourne remaining the sole container port for Melbourne in the timeframes modelled. More broadly, growth in commercial vehicle movements will be directly related to the rate of growth in industry which will be influenced by the broader economic conditions at a city, state and national level. There are a series of additional factors that may impact the commercial vehicle demands that are ultimately realised. This includes considerations such as future land use patterns for commercial and industrial centres, changes to vehicle sizes and mass limits and government policy in relation to these items.

A2 IV VLUTI

The Victorian Land Use Transport Integration (VLUTI) model was developed by Infrastructure Victoria (IV) in collaboration with the Department of Transport (DoT), Victoria University (VU), Arup and AECOM. It is an extension of the VITM (Section A1), incorporating a spatial computable general equilibrium (SCGE) model designed to capture long-run macroeconomic and spatial impacts of policies and infrastructure investments.

The goal of developing the VLUTI model was to more accurately assess interactions between land use and transport. The evolution of any particular region over time influences the nature of future infrastructure intervention, whilst those interventions in turn influence where people decide to live and work. The VITM uses demographic data as a static input, whilst the VLUTI model incorporates this into a feedback process that allows it to be altered through simulation. To illustrate the benefits of this approach, consider a major future infrastructure upgrade. In the VITM, this will almost certainly result in network performance improvements, but in the VLUTI model it may also result in a reallocation of employment that itself has secondary benefits.

More details regarding the development methodology behind the VLUTI model can be found in a separate *VLUTI Model Development* report published by IV. The following draft paper describes the SCGE model specifically:

> *Mathematical structure of the VU Cities Spatial Computable General Equilibrium (SCGE) framework*, Dr. James Lennox (2020).

A2.1 Limitations

The VLUTI model still uses the VITM as the basis for its trip generation and assignment. As such, all the limitations described in Section A1.1 for the VITM apply equally to the outcomes of the VLUTI model scenario tests. Further, it is to be noted that these are still early days in the development of an overall, unified approach to LUTI modelling. Confidence in its outcomes and a deeper understanding of how to interpret its results will be gained incrementally with further use and development of the model across a diverse range of future studies.