WestConnex Transport Modelling

Technical Report

City of Sydney

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SGS Economics & Planning

Independent insight.

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GLOSSARY

Base case	The scenario without the construction of WestConnex
CBD	Central Business District
Clockwise	A journey starting at the western end of the M4 and travelling to the southwestern end of M5 along WestConnex
Counterclockwise	A journey starting at the southwestern end of M5 and travelling to the western end of the M4 along WestConnex
KPI	Key Performance Indicators
Urban Renewal	Redeveloping an area to house more people and jobs
WDA	WestConnex Delivery Authority
LTTMP	NSW Long Term Transport Master Plan
Level of Service	Is a summary measure of the Volume Capacity (VC) Ratio
Volume Capacity (VC) Ratio	A measure that reflects mobility and quality of travel along a transport link. It compares roadway demand (vehicle volumes) with roadway supply (carrying capacity). A VC of 1.00 indicates the roadway facility is operating at its designed carrying capacity. Above 1 is over capacity and below 1 is under capacity

EXECUTIVE SUMMARY

Sydney traffic congestion will worsen with or without WestConnex, with the project only making a minor difference to Sydney's overall traffic in the future.

The WestConnex project would create newer, better motorways. But tolls mean a smaller share of Sydney's motorists would use them. Displaced motorists will instead use free alternatives, increasing traffic on other roads, including Parramatta Road. The net effect is similar to the status quo. However, some local areas could see fewer vehicles on their streets if all sections of WestConnex are built.

The WestConnex project

The WestConnex project is the biggest motorway project in Australia's history. WestConnex is a series of projects designed to upgrade and link two existing motorways in Sydney's south west (the M5) and west (the M4). The combined cost of the project is estimated at $15 billion. The business case for the project has not been released and the impacts on traffic have so far remained unknown.

The project is due to be completed in stages. Stages 1 and 2 focus on upgrading and extending the M4 and M5, and are due to be completed by 2019. Stage 3 involves the construction of a tunnel linking Stages 1 and 2 and is due to be completed by 2023.

FIGURE 1 WESTCONNEX ALIGNMENT (DECEMBER 2014)

Source: WestConnex Delivery Authority

By the time the project is complete, Sydney will be a bigger, busier and more crowded city. The metropolis is projected to grow to accommodate around 6.2 million people by 2031, and 8.5 million by 2061. Traffic volumes will have grown, and the congestion clogging Sydney will have worsened.

In this context, evaluating the traffic effects of proposed transport projects is an important part of determining whether they should proceed. The City of Sydney has commissioned this report in order to help the public evaluate WestConnex.

The effect of WestConnex on Sydney's traffic is best forecast using computer modelling. The results of such a process are presented in this report.

This report is the technical report that accompanies a summary report prepared for the City of Sydney. It denotes the methodology and assumptions applied for modelling the impacts of the proposed WestConnex motorway.

Modelling the traffic impacts of WestConnex

Modelling was completed by Veitch Lister Consulting (VLC), an expert transport modelling firm. VLC use the Zenith traffic model, which incorporates future land use changes, public transport and road travel.

The Zenith model was first established in 1988 and is a mature travel demand modelling facility that is frequently used to understand transport projects. In Australia Zenith has been used to model:

- Cross-City Tunnel (provision of expert services in legal proceedings);M5 Motorway (for a toll road operator);
- Lane Cove Tunnel (forecasting demand post opening for ABN Amro);
- Sydney Metro (as part of submission to Infrastructure Australia);
- East West Link Toll Road (for Victorian Government);
- CityLink Toll Road (for Victorian Government); and
- EastLink Toll Road (for Victorian Government).

To understand the future traffic conditions of Sydney and the impact of WestConnex, modelling was undertaken for a base case that did not include WestConnex as well as several forecasts relating to the provision of the road. For the WestConnex project, the Zenith model forecasts where and how traffic will change:

- in 2021, representing the completion of Stage 1 and 2;
- in 2026, representing the completion of Stages 1, 2 and Stage 3; and
- in 2041, representing the project at maturity.

Under the base case, Sydney traffic congestion will worsen (Figure 2). This is driven in part by a widening gap between employment and population growth, with employment growth in the east outstripping population growth in the west. The project only makes a minor difference to Sydney's overall traffic.

At each point in time, the Zenith model constructs scenarios where WestConnex is built and is not built, in order to make meaningful comparisons. Figure 3 and Figure 4 illustrate road capacity in 2026 under two future scenarios: without WestConnex (Figure 3) and with all stages of WestConnex (Figure 4).

FIGURE 2 CHANGE IN LOS – 2021 BASE CASE VS 2011 – AM PEAK

Source: Veitch Lister Consulting

FIGURE 3 VOLUME TO CAPACITY RATIO 2026 (BASE CASE WITHOUT WESTCONNEX)

Source: Veitch Lister Consulting

FIGURE 4 VOLUME TO CAPACITY RATIO 2026 WITH WESTCONNEX STAGES 1, 2 & 3

Source: Veitch Lister Consulting

Figure 3 and Figure 4 clearly show Sydney's road network will experience significant capacity constraints by 2026.

The modelling confirms that WestConnex will not improve access to the Sydney CBD. Like other parts of the Global Economic Corridor, the CBD is already congested and has little parking available.

Stage 1, the M4 widening and eastern extension, and Stage 2, the New M5 and St Peters interchange, will not be sufficient to encourage a significant level of traffic off alternate routes.

Traffic flows on parts of Parramatta Road will increase by over 20 per cent as vehicles avoid paying the toll on the M4 and M4 eastern extension. This finding is consistent with the WestConnex Delivery Authority's own assessment presented in the M4 Widening Environmental Impact Statement and with the traffic flow impacts observed when the M4 toll was removed in 2010.

Under WestConnex Parramatta Road will take more traffic in the future, not less.

This growth in traffic along Parramatta Road will clearly jeopardise the government's planned urban renewal and population growth along this corridor.

The M5 East will, despite the completion of the New M5, remain the preferred route connecting the airport, port and the city. The New M5 will not provide a more attractive route to these key destinations and will not relieve congestion on the M5 East. Traffic volumes on the M5 East will continue to increase by up to 25 per cent, leading to increased congestion and peak spreading.

The traffic from the New M5 will flow into the St Peters area via an interchange on the site of the Alexandria landfill. By 2021 over 31,000 vehicles a day will be using this interchange, increasing to over 55,000 vehicles by 2041. These vehicles will flow onto the local road network, impacting on residential and commercial areas, and increasing traffic and congestion in the corridor between the CBD and the

airport. This will impact the viability of urban renewal areas such as Green Square and Ashmore, reducing future housing potential.

Differences are most notable along the paths of the upgraded motorway sections (WestConnex Stages 1 and 2), which appear green in places – representing low volume to capacity ratios - if WestConnex is built. The change in their volume capacity ratio is due not only to increased capacity, but also tolls. WestConnex has a relatively minor impact on Sydney-wide traffic. The Sydney-wide effect of the project is summarised in the following table.

In 2026, the Sydney-wide differences in traffic between a Sydney with WestConnex and one without is very modest, as measured in car trips, car hours, or commercial vehicle hours. In 2026 the largest proportional difference is a 2.8 per cent fall in commercial vehicle hours in the morning, from 62,598 to 60,842.

TABLE 1 MODEL KPIS – PRIVATE VEHICLE STATISTICS

PRIVATE VEHICLE STATISTICS		2021 base	2026 base	2026 project Stage 1 & 2	2026 project Stage 1, 2 & 3
Car Trips	AM	2,010,602	2,146,880	2,146,335	2,147,065
	Inter Peak	10,584,355	11,326,354	11,320,905	11,325,047
	PM	2,067,151	2,208,755	2,208,155	2,208,882
	Total	**14,662,108**	**15,681,989**	**15,675,395**	**15,680,994**
Commercial Vehicle Trips	AM	111,958	118,934	118,934	118,934
	Inter Peak	599,197	637,169	637,169	637,169
	PM	98,562	104,761	104,761	104,761
	Total	**809,717**	**860,865**	**860,865**	**860,865**
Car KMs	AM	19,504,557	20,658,296	20,632,881	20,721,759
	Inter Peak	99,425,262	105,535,127	105,325,460	105,731,563
	PM	21,325,707	22,615,061	22,590,004	22,683,491
	Total	**140,255,526**	**148,808,483**	**148,548,345**	**149,136,812**
Commercial Vehicle KMs	AM	2,353,402	2,488,521	2,476,796	2,485,618
	Inter Peak	13,574,717	14,355,865	14,298,698	14,340,292
	PM	2,161,429	2,285,386	2,275,540	2,284,049
	Total	**18,089,548**	**19,129,773**	**19,051,034**	**19,109,959**
Car Hours	AM	541,192	593,566	584,112	582,188
	Inter Peak	2,338,576	2,541,915	2,516,884	2,509,705
	PM	564,946	619,700	610,642	608,512
	Total	**3,444,714**	**3,755,182**	**3,711,638**	**3,700,406**
Commercial Vehicle Hours	AM	57,319	62,598	61,233	60,842
	Inter Peak	288,509	312,311	307,761	305,964
	PM	51,160	55,874	54,703	54,345
	Total	**396,988**	**430,784**	**423,697**	**421,151**
Average Trip Length - Car [km]	AM	11	11	11	11
	Inter Peak	11	11	11	11
	PM	12	12	12	12
Average Trip Length - Commercial Vehicle [km]	AM	23	23	23	23
	Inter Peak	25	25	25	25
	PM	24	24	24	24

Source: Veitch Lister Consulting

The impact on freight movements resulting from the construction of WestConnex are generally similar to the overall impacts described above. Of particular interest is that a reduction in commercial vehicles is observed on King Georges Road (22 to 32 per cent when Stage 3 is activated) and on General Holmes Drive (11 to 17 per cent when Stage 3 is activated). ANZAC Bridge has a very small increase in commercial vehicle volumes when only Stages 1 and 2 are operational, but a 30 per cent increase is observed with the completion of WestConnex Stage 3.

Travel times along some bus corridors were examined. In general no major changes are expected, and delays will be contained within one minute. The corridor from Ramsay Road to CBD will experience a small improvement (contained within 5 minutes) due to decongestion on the M4.

Questions raised by the modelling

The modelling has provided a better understanding of the impacts of WestConnex, while also raising areas for further investigation.

The northern extension (including the Western Harbour Tunnel) and southern extension to WestConnex are vital for generating traffic for WestConnex Stage 3 but are currently outside the $15 billion price tag. As such, the currently funded WestConnex project potentially locks Sydney into a series of large scale road projects that are required to achieve the benefits of committed stages.

Should the costs as well as the benefits of these extensions be attributed to WestConnex? Or should they be financed separately from the first three stages of WestConnex, with the benefits similarly excluded?

From available information[1], Stage 1 is initially funded by the government and then sold to finance Stage 2 and 3. However, more recent announcements have indicated Stages 1 and 2 are to be delivered concurrently. The length of time government holds and operates WestConnex, the concessions (tolls and length) for a private operator and the private sectors appetite for risk will determine if WestConnex is a value for money investment for New South Wales. Are there better transport projects for New South Wales to invest in?

The role that tolls play on existing roads in managing Sydney's future traffic demand should be evaluated. Reviewing or introducing pricing mechanisms was included as part of the NSW Long Term Transport Master Plan. Congestion pricing uses tolls to alter demand and has been shown to substantially affect behaviour and reduce traffic congestion. Rather than increasing road capacity by building new road infrastructure, can congestion on the existing road network be better managed through a new or updated price mechanism?

[1] http://www.westconnex.com.au/documents/westconnex_industry_engagement_briefing_oct2013.pdf

1 INTRODUCTION

Sydney is the economic powerhouse of the nation and a gateway to the global economy. It generates almost a quarter of Australia's GDP and is host to much of the nation's key economic infrastructure, critical to the prosperity of industries and sectors across New South Wales and Australia.

Given Sydney's paramount economic and social importance, the structure and functioning of the city has ramifications across all spheres of government, whether in relation to issues of productivity, social stability, environmental sustainability, or, ultimately government taxation revenues.

The past twenty years have seen a change in economic geography, residential development and transport patterns that have signalled the end of a city whose development will be led by motorways.

In 2012, the WestConnex project was announced by Government. The project is effectively a suite of smaller road projects – the M4 Widening, M4 East, M4-M5 Link, a new M5, and links to the port and Sydney Airport. When all stages of WestConnex are completed it will be the largest continuous motorway in Australia and will influence land use and transport patterns over half of Sydney.

The Strategic Review of the proposed WestConnex, completed in February 2015, raised concerns around the impact of the project on the operation of the transport network. However, the impact the project will have on traffic flows across Sydney is not available publicly. The City of Sydney engaged SGS and VLC to undertake and complete a traffic and transport assessment focused primarily on the impacts of the proposed New M5 and St Peters Interchange on local transport networks.

1.1 Scope of work

The City of Sydney required a critical review of the WestConnex proposal in terms of the potential traffic flows that may occur in the future as a result of the project. In particular, the impacts on the local road network resulting from the proposed Stage 2 (New M5 and St Peters Interchange located at Alexandria landfill site), as well as the flow on urban amenity impacts. Impacts on the following locations are of particular interest:

- St Peters
- Newtown and Enmore, in particular King Street and Edgeware Road
- Green Square urban renewal area
- Ashmore precinct
- Sydney CBD

Using the Zenith transport model (detailed in section 2.2) this project examines the:

- Expected future transport and traffic conditions (without WestConnex)
- Impact of WestConnex Stages 1 and 2 (excluding Stage 3 and the Sydney Gateway connection) on local transport networks and urban renewal areas
- Impact of introduction / reintroduction of tolls on the M5 East and M4 (with and without WestConnex) on local transport networks and urban renewal areas
- Impact of the full WestConnex (Stages 1, 2, 3 including the Sydney Gateway) on transport networks and freight movements

This report is the technical report that accompanies a summary report prepared for the City of Sydney. It denotes the methodology and assumptions applied for modelling the impacts of the proposed WestConnex motorway.

2 WESTCONNEX TRANSPORT MODELLING

2.1 Project Details

The WestConnex project is the biggest motorway project in Australia's history. It comprises three key components:

- widening the M4 which links Western Sydney and North Strathfield, and extending it towards the city centre, via a tunnel;
- upgrades to the M5 which currently links south-west Sydney and the airport, by construction of new tunnels and new interchanges (the New M5). The New M5 will extend closer to the CBD
- a tunnel linking the M5 and M4, passing under inner Sydney and providing off-ramps to the CBD and airport.

Tunnelling components account for the bulk of the $15 billion cost of the project. Currently, the NSW Government is contributing $1.8 billion to the project and the Federal government $1.5 billion. The Federal government is also providing a concessional loan of up to $2 billion to help bring forward delivery of Stage 2, allowing work to start in 2015. The remainder is to be funded using tolls.

FIGURE 5 WESTCONNEX ALIGNMENT (DECEMBER 2014)

Source: WestConnex Delivery Authority

The points at which WestConnex links with the existing network are listed in Table 2. The Appendix provides detailed maps on the assumed road connections and tolling point for WestConnex.

TABLE 2 WESTCONNEX CONNECTIONS TO THE EXISTING NETWORK

Stage	Connection to the existing network
Stage1 (M4 widening)	Church Street, Parramatta
	M4 James Ruse Drive, Clyde
	M4 Silverwater Road, Silverwater
	M4 Hill Road, Auburn
	M4 Homebush Bay Drive, Homebush
Stage1 (M4 extension)	Concord Road, North Strathfield
	Wattle Street, Haberfield
Stage 2	Campbell Street, St Peters
	M5 exit, Arncliffe
	Bexley Road and Kingsgrove Road, Bexley North
	King Georges Road, Beverly Hills
Stage 3	Frederick Street, Haberfield
	City West Link
	Parramatta Road, Annandale
	Canal Road, St Peters

Source: WestConnex Delivery Authority and Veitch Lister Consulting

The associated Sydney Gateway project will provide access to Sydney Airport, Port Botany as well as the local road network in the future via the proposed Sydney Gateway. However, there is some uncertainty regarding when the Sydney Gateway will be constructed.

2.2 The Transport Model

VLC was engaged to support SGS in developing an understanding of the impact of the WestConnex project on the Sydney transport network. The Bureau of Transport Statistics (BTS) Travel Zone land use projections (2014 release) for 2021 and 2026 and 2041 were converted into the Zenith Zones system and used in the modelling. The Zenith model is explained in further detail in Chapter 4.

The focus of the modelling was on the:

- Number of cars that are likely to use WestConnex during the different stages and once it has been fully implemented, with a focus on the M5 before the completion of Stage 3
- Impact on the St Peters interchange and surrounding network
- Impact on already heavily congested roads such as King Street, Newtown
- Impacts on the urban renewal areas of Green Square and Ashmore
- Broader impact of WestConnex on congestion
- Impact of introducing tolls on M4 and M5 on existing infrastructure and WestConnex
- Broad impact on freight movements.

In order to help the assessment of the impacts of WestConnex, VLC used the Zenith model to test a series of scenarios. These are:

- 2021 base (no WestConnex)
- 2021 with WestConnex Stage 1 and 2
- 2026 base (no WestConnex)
- 2026 base with existing M4 (West) and existing M5 East tolled. This provides an insight to the impact of tolling rather than new infrastructure.
- 2026 with WestConnex Stage 1 and 2 with existing M4 (West) and M5 East tolled
- 2026 with full WestConnex (Stages 1, 2 and 3)

- 2026 with full WestConnex (Stages 1, 2 and 3) with existing M4 (West) and M5 East tolled[2]
- 2041 with full WestConnex.

Figure 43 to Figure 45 in the Appendix show the WestConnex alignment and tolled sections.

WestConnex Sages 1 and 2 are due to be completed by 2019, therefore the 2021 scenarios will help to understand the impact of the new infrastructure once the ramp up period ends. Stage 3 is expected to be operational by 2023.

The 2026 scenarios have been chosen to analyse the impact of WestConnex Stages 1, 2 and 3 in order to exclude the effect of population and employment growth. The 2041 scenario helps to understand the reaction of the network when the level of congestion increases significantly.

The toll levels for existing roads have been calculated using information made publicly available by Sydney Motorways and reported in Table 3.

Transport model assumptions

WestConnex toll levels

Toll levels reported in the public documents (Table 4) have been used as reference to calculate the toll value on each WestConnex section.

In order to apply the appropriate toll in the model, values from the reference tolling scenario have been converted to cents per km for each stage of WestConnex, results are listed 2013 Australian dollars.

- Stage 1: 55 c/km;
- Stage 2: about 45 c/km;
- Stage 3: about 50 c/km.

A toll cap of $7.35 has been applied in the model. A multiplier of 3 has been used for commercial vehicles (both LCV and HCV).

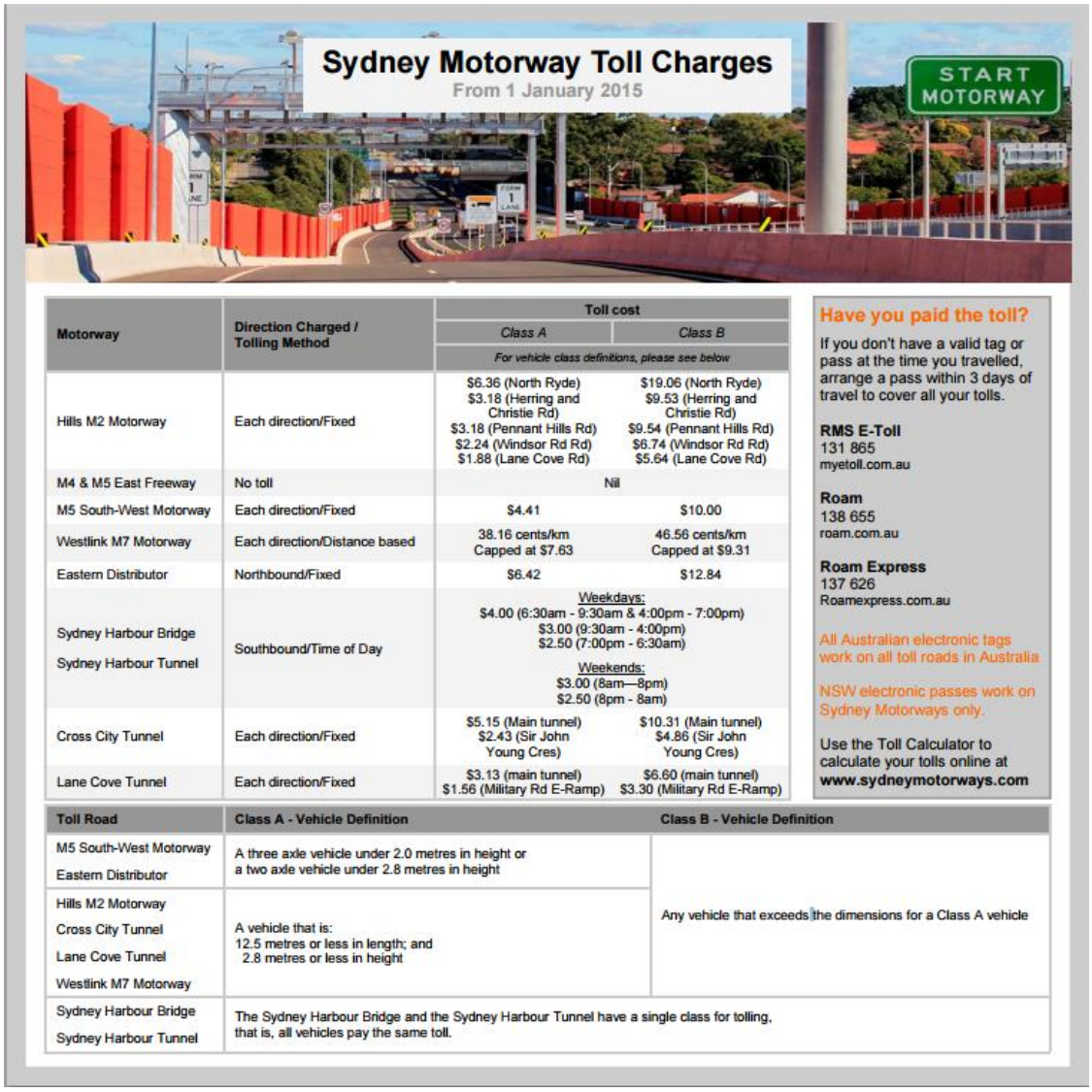
The modelling of tolls is important and has been undertaken in a conservative fashion. Existing tolls have been increased over time at CPI, and new tolls have been modelled on a conservative basis using existing public information.

Other key roads:

- **F6 toll values (2013 AUD)** 50 cents per km has been charged on the F6. A multiplier of 3 has been used for commercial vehicles (LCV and HCV).
- **Western Harbour Tunnel toll values (2013 AUD)** 50 cents per km has been charged on the Western Harbour Tunnel toll values. A multiplier of 3 has been used for commercial vehicles (LCV and HCV).
- **Existing M5 east toll values (2013 AUD)** The same WestConnex Stage 2 toll values have been used for the existing M5 East tolled sensitivity test. A multiplier of 3 has been used for commercial vehicles (LCV and HCV).
- **M4 widening toll values (2013 AUD)** The same WestConnex Stage 1 toll values have been used for the M4 tolled sensitivity test. A multiplier of 3 will be used for commercial vehicles (LCV and HCV).

[2] This is a sensitivity test, been conducted in order to see the impact of the full M4 being tolled (from the M7).

TABLE 3 TOLL CHARGES FOR EXISTING MOTORWAYS



Motorway	Direction Charged / Tolling Method	Toll cost	
		Class A	Class B
		For vehicle class definitions, please see below	
Hills M2 Motorway	Each direction/Fixed	$6.36 (North Ryde) $3.18 (Herring and Christie Rd) $3.18 (Pennant Hills Rd) $2.24 (Windsor Rd Rd) $1.88 (Lane Cove Rd)	$19.06 (North Ryde) $9.53 (Herring and Christie Rd) $9.54 (Pennant Hills Rd) $6.74 (Windsor Rd Rd) $5.64 (Lane Cove Rd)
M4 & M5 East Freeway	No toll	Nil	
M5 South-West Motorway	Each direction/Fixed	$4.41	$10.00
Westlink M7 Motorway	Each direction/Distance based	38.16 cents/km Capped at $7.63	46.56 cents/km Capped at $9.31
Eastern Distributor	Northbound/Fixed	$6.42	$12.84
Sydney Harbour Bridge Sydney Harbour Tunnel	Southbound/Time of Day	Weekdays: $4.00 (6:30am - 9:30am & 4:00pm - 7:00pm) $3.00 (9:30am - 4:00pm) $2.50 (7:00pm - 6:30am) Weekends: $3.00 (8am—8pm) $2.50 (8pm - 8am)	
Cross City Tunnel	Each direction/Fixed	$5.15 (Main tunnel) $2.43 (Sir John Young Cres)	$10.31 (Main tunnel) $4.86 (Sir John Young Cres)
Lane Cove Tunnel	Each direction/Fixed	$3.13 (main tunnel) $1.56 (Military Rd E-Ramp)	$6.60 (main tunnel) $3.30 (Military Rd E-Ramp)

Have you paid the toll?

If you don't have a valid tag or pass at the time you travelled, arrange a pass within 3 days of travel to cover all your tolls.

RMS E-Toll
131 865
myetoll.com.au

Roam
138 655
roam.com.au

Roam Express
137 626
Roamexpress.com.au

All Australian electronic tags work on all toll roads in Australia

NSW electronic passes work on Sydney Motorways only.

Use the Toll Calculator to calculate your tolls online at **www.sydneymotorways.com**

Toll Road	Class A - Vehicle Definition	Class B - Vehicle Definition
M5 South-West Motorway Eastern Distributor	A three axle vehicle under 2.0 metres in height or a two axle vehicle under 2.8 metres in height	Any vehicle that exceeds the dimensions for a Class A vehicle
Hills M2 Motorway Cross City Tunnel Lane Cove Tunnel Westlink M7 Motorway	A vehicle that is: 12.5 metres or less in length; and 2.8 metres or less in height	
Sydney Harbour Bridge Sydney Harbour Tunnel	The Sydney Harbour Bridge and the Sydney Harbour Tunnel have a single class for tolling, that is, all vehicles pay the same toll.	

Source: Sydney Motorways

TABLE 4 WESTCONNEX REFERENCE TOLLING SCENARIO

Stage	Indicative average toll ($2013, incl GST)	Indicative min/max toll ($2013, incl GST)
M4 Widening (Church Street to Homebush Bay Drive)	$3.00	Min: $1.50 Max: $3.90
M4 East (Homebush Bay Drive to Parramatta Road and City West Link)	$2.40	Min: $2.00 Max: $3.60
Stage 2 – M5 East Airport Link (Beverly Hills to St Peters)	$2.70	Min: $1.70 Max: $4.80
Stage 3 – M4 South (Haberfield to St Peters)	$3.00	Min: $1.80 Max: $4.10
WestConnex average toll	**$4.50**	**Min: $1.50 Max: $7.35 (cap)**

Source: WestConnex Delivery Authority

Increase in rates

For the scenarios, all the costs associated with vehicle operations, infrastructure and public transport have been assumed to increase by CPI. This is a conservative assumption due to the lack of publicly available information. Some sensitivity tests may be required to investigate the effect of higher growth rates that may occur.

New Infrastructure Projects

The model includes known improvements to the road and public transport system over coming decades. These are listed below and mapped overleaf.

Main included projects

2021

- M5 west widening (040)
- M2 to F3 Corridor (NorthConnex) (083)
- South West Rail Link (PT001)
- North West rail link (PT003)

2026

- M4 widening west of Parramatta Road untolled (054)
- Sydney Rapid Transit
- Badgerys Creek airport

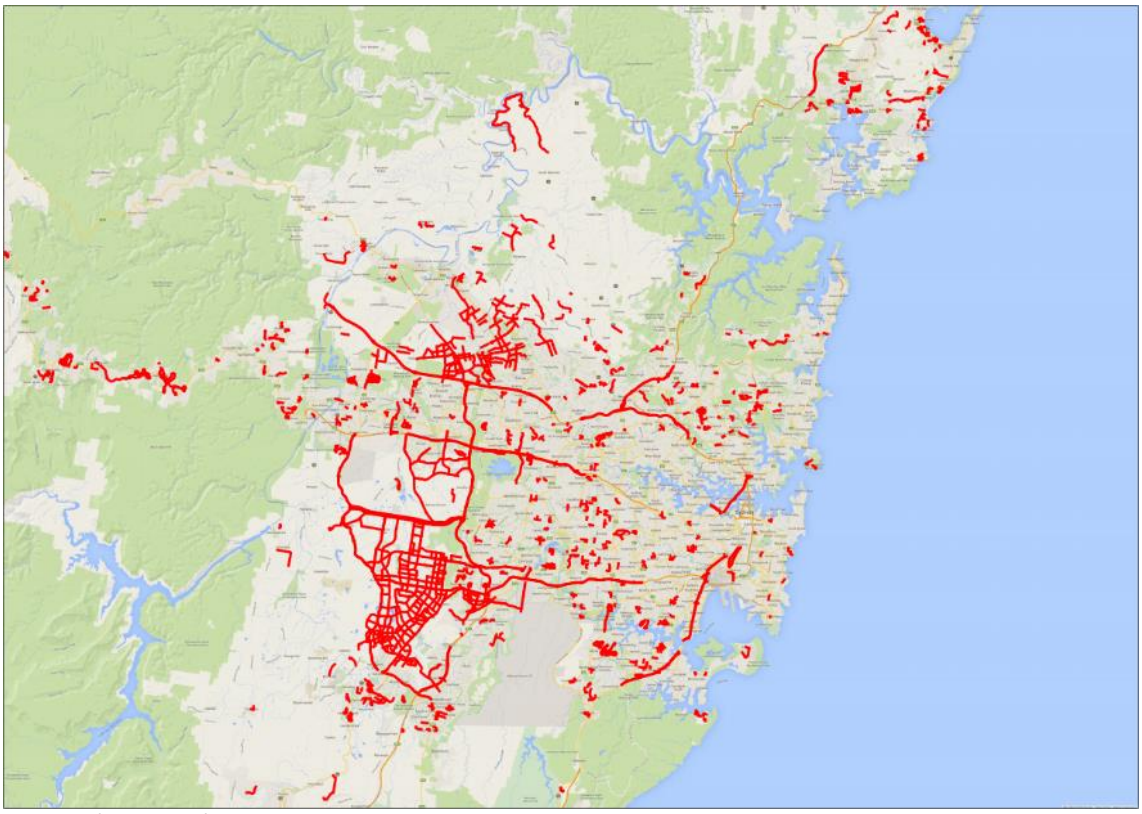
2041

- Western Harbour Tunnel
- F6
- Badgerys Creek airport rail

Main excluded projects

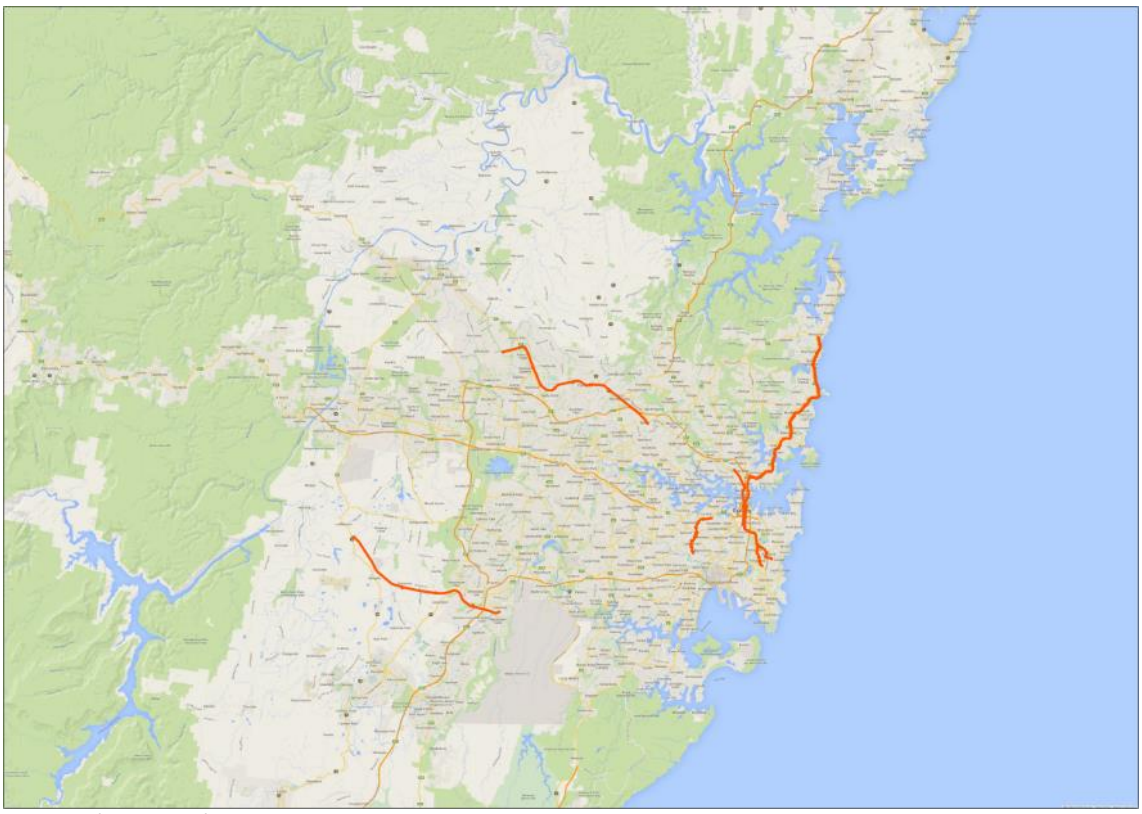
- Northern Beaches Motorway Tunnel

FIGURE 6 ROAD PROJECTS INCLUDED UNTIL 2041



Source: Veitch Lister Consulting

FIGURE 7 PT PROJECTS INCLUDED UNTIL 2041



Source: Veitch Lister Consulting

Differences from the WestConnex Delivery Authority assumptions

Where possible the same assumptions as used by the WestConnex Delivery Authority[3] regarding future regional road and public transport projects have been adopted for this study. The main differences relate to changes in NSW policy, in particular the alignment of WestConnex, which has changed several times since 2013. Potentially related to the changing alignment of WestConnex, there have been changes to some road and public transport projects. Some projects have been dropped, while others have been announced (i.e. the Sydney Rapid Transit). Table 5 compares the assumptions between the WestConnex Delivery Authority model and the VLC model used for this project.

TABLE 5 WDA VS VLC ASSUMPTIONS

Year	Road		Rail / Light Rail		BUS	
	WDA	VLC	WDA	VLC	WDA	VLC
2016	Hunter Motorway (F3-Branxton)	√	South West Rail link	√	Increased frequencies	X(1)
	M2 widening	√	LRT Dulwich Hill Extension	√		
	M5 widening	√				
	Western Sydney Employment Hub	√				
	Great Western Hwy Widening	√				
2021	M5 east duplication	Only project scenarios	North West Rail link to Rouse Hill	√	Northern Beaches Busway	√
			LRT CBD Extension	√	Bus network extensions and frequency adjustments aligned with changes in land-use and rail network assumptions	√
2026	M4 extensions	Only project scenarios	Western Express	X(1)		
	M4 widening	√				
2031	M2 to F3 Tunnel	from 2021	Parramatta-Epping Rail Line	X(1)		
	South West Growth centre	√				
2036	F6	√				
2041	M2 extension via Gladsville Bridge to M4	?				
All years	Fuel and toll costs rise with CPI	√	Fares rise with CPI	√	Fares rise with CPI	√

(1) Not implemented due to time frames Source: Veitch Lister Consulting and WDA

Run methodology and proposed sensitivity tests

Future scenario forecasts for this project have been produced by letting the model loop through distribution, mode choice and route choice (assignment) at each demand iteration. One of the consequences of this approach is a slight shortening in average trip lengths in comparison to the current situation. In order to better understand the range of potential traffic volumes on the project some sensitivity tests may be run, also including variations of other model parameters:

- toll value increase;
- fuel price;
- parking cost;
- run methodology.

3 https://majorprojects.affinitylive.com/public/cb35014b2a44c81e83fe58dfd330d39f/13_Appendix_D_Traffic_and_Transport.pdf

2.3 Land Use Data Projections 2011-2041

The NSW Bureau of Transport Statistics (BTS) has compiled population and employment projections for 2,949 travel zones in the Sydney Greater Metropolitan Area (GMA) through to 2041. The 2,949 travel zones fit into an area covered by 56 Local Government Areas (LGAs). The aggregate output of the BTS population forecasting process aligns with the 5-yearly NSW Department of Planning and Environment (DP&E) estimates at the LGA level.

The population projections for these small travel zones are based on Australian Bureau of Statistics (ABS) estimated residential population data for 2011 and DP&E population growth projections thereafter. DP&E makes projections for LGAs for five-yearly intervals.

Census Journey to Work data is compared to the BTS Workforce data. The difference generates an uplift factor which is applied to the census data to correct for undercounting. Jobs are then allocated across industries. The approach uses 34 industry categories as defined by the standard ANZSIC system's top level, plus manufacturing.

Employment estimates for forecast years are created using a model which scales the job estimates over time. The model permits alternative calculations that create multiple sets of estimates. This allows the BTS to select the set of estimates which is most appropriate. These selections are validated by comparison to trends in ABS Labour Force data.

TABLE 6 BTS EMPLOYMENT PROJECTIONS

Region (SA4)	2011	2021	2026	2041
City and Inner South	584,000	674,000	712,000	821,000
Eastern Suburbs	92,000	104,000	110,000	129,000
Inner West	117,000	130,000	138,000	166,000
Parramatta	239,000	277,000	295,000	355,000
Ryde	104,000	120,000	129,000	155,000
North Sydney and Hornsby	259,000	290,000	304,000	351,000
Northern Beaches	93,000	106,000	111,000	130,000
Inner South West	167,000	189,000	199,000	232,000
Sutherland	70,000	80,000	84,000	99,000
Outer South West	80,000	97,000	105,000	131,000
South West	128,000	172,000	197,000	257,000
Blacktown	112,000	144,000	162,000	208,000
Baulkham Hills and Hawkesbury	86,000	122,000	137,000	182,000
Outer West and Blue Mountains	109,000	131,000	144,000	179,000
Illawarra	113,000	121,000	126,000	139,000
Southern Highlands and Shoalhaven	56,000	57,000	58,000	59,000
Newcastle and Lake Macquarie	184,000	199,000	208,000	229,000
Hunter Valley exc Newcastle	100,000	107,000	113,000	130,000
Central Coast	113,000	124,000	130,000	151,000
Total	**2,806,000**	**3,244,000**	**3,462,000**	**4,103,000**

Source: Bureau of Transport Statistics

The employment shares of the 34 industries are then broken down to smaller geographical levels. First, industry share is calculated at Statistical Area 4, then the smaller Statistical Area 3. In each of these steps, multiple sets of estimates are produced via alternative calculations, permitting the BTS to select the most appropriate.

Between 2011 and 2026, employment in the GMA is projected to increase from 2.8 million to 3.5 million. 20 per cent (128,000 additional jobs) of this growth is projected to predominately occur in the City and Inner South regions. This is followed by South West with 10.5 per cent (69,000 additional jobs) and Parramatta with 8.5 per cent (56,000 additional jobs). By 2041 the GMA will reach 4.1 million jobs. In terms of population, the GMA will grow to almost 7 million people by 2026 and 8.3 million by 2041.

TABLE 7 BTS POPULATIONS PROJECTIONS

Region (SA4)	2011	2021	2026	2041
City and Inner South	284,000	344,000	372,000	452,000
Eastern Suburbs	268,000	300,000	315,000	360,000
Inner West	279,000	328,000	350,000	402,000
Parramatta	414,000	501,000	547,000	683,000
Ryde	171,000	199,000	218,000	266,000
North Sydney and Hornsby	395,000	453,000	480,000	556,000
Northern Beaches	252,000	281,000	296,000	340,000
Inner South West	552,000	627,000	666,000	775,000
Sutherland	220,000	243,000	256,000	289,000
Outer South West	244,000	307,000	327,000	394,000
South West	377,000	473,000	536,000	722,000
Blacktown	315,000	391,000	432,000	573,000
Baulkham Hills and Hawkesbury	219,000	271,000	300,000	384,000
Outer West and Blue Mountains	298,000	347,000	371,000	450,000
Illawarra	289,000	317,000	330,000	363,000
Southern Highlands and Shoalhaven	142,000	152,000	156,000	163,000
Newcastle and Lake Macquarie	358,000	387,000	401,000	436,000
Hunter Valley exc Newcastle	221,000	257,000	274,000	305,000
Central Coast	323,000	355,000	372,000	432,000
Total	**5,621,000**	**6,533,000**	**6,999,000**	**8,345,000**

Source: Bureau of Transport Statistics

2.4 Transport modelling results

There are key metrics which are used to assess transport projects. These include the volume capacity ratio and level of service. The volume capacity (VC) ratio is a measure that reflects mobility and quality of travel along a transport link. It compares roadway demand (vehicle volumes) with roadway supply (carrying capacity). A VC of 1.00 indicates the roadway facility is operating at its designed carrying capacity. Above 1 is over capacity and below 1 is under capacity.

The level of service is a summary measure of the VC ratio. For the purposes of the model six levels of service were defined.

A - VC ratio between 0 and 0.6;
B - VC ratio between 0.6 and 0.8;
C - VC ratio between 0.8 and 1;
D - VC ratio between 1 and 1.2;
E - VC ratio between 1.2 and 1.6;
F - VC ratio > 1.6.

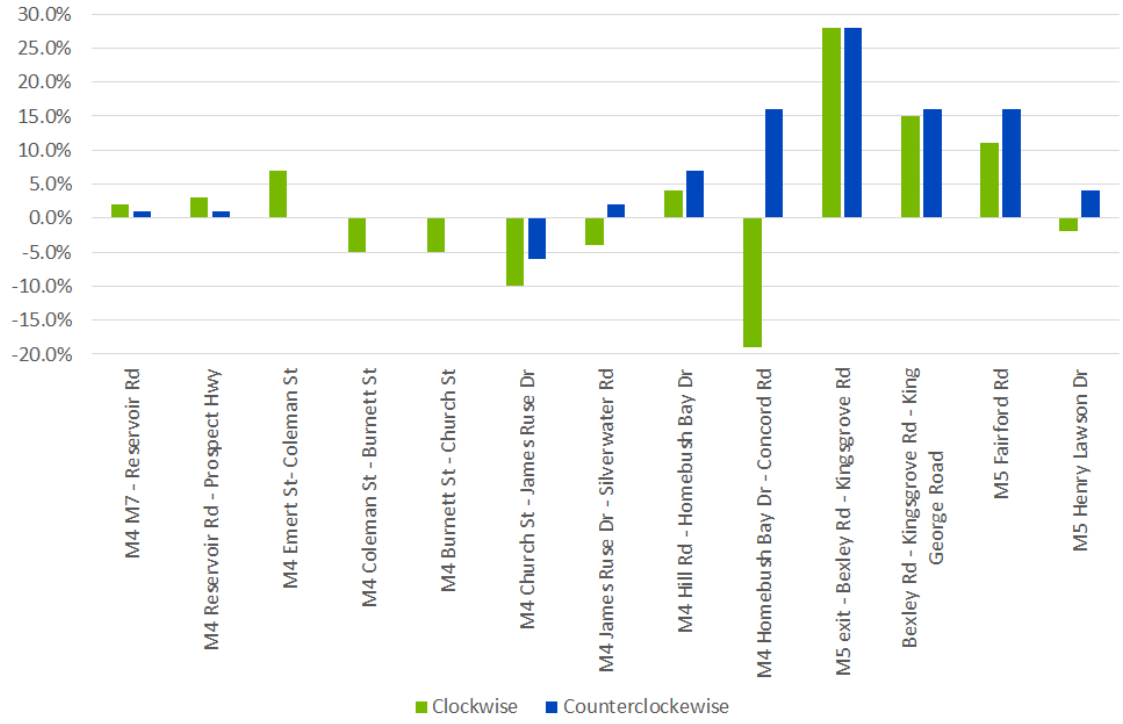
The Zenith model creates outputs for each section of the roadway at different points in time and at different stages of completion.

Modelling shows that after being upgraded, the existing M4 section of WestConnex will carry fewer vehicles. This is explained by motorists selecting alternate routes[4] to avoid tolls (FIGURE 8).

Diversion of traffic from the tolled M4 results in an increased volume-to-capacity ratio in several places, notably Parramatta Road. That road, which runs parallel to the M4, will carry increased traffic volumes under the scenario where WestConnex is constructed and tolled. This is likely to impede plans for urban renewal and residential development in the precinct.

This figure below shows the changes in traffic volumes along the M4 and M5 corridors of WestConnex in 2026. In 2026, when the project is complete, the most notable example of a traffic reduction is a 19 per cent drop on the M4 eastbound, between Homebush Bay Drive and Concord Road (Figure 9).

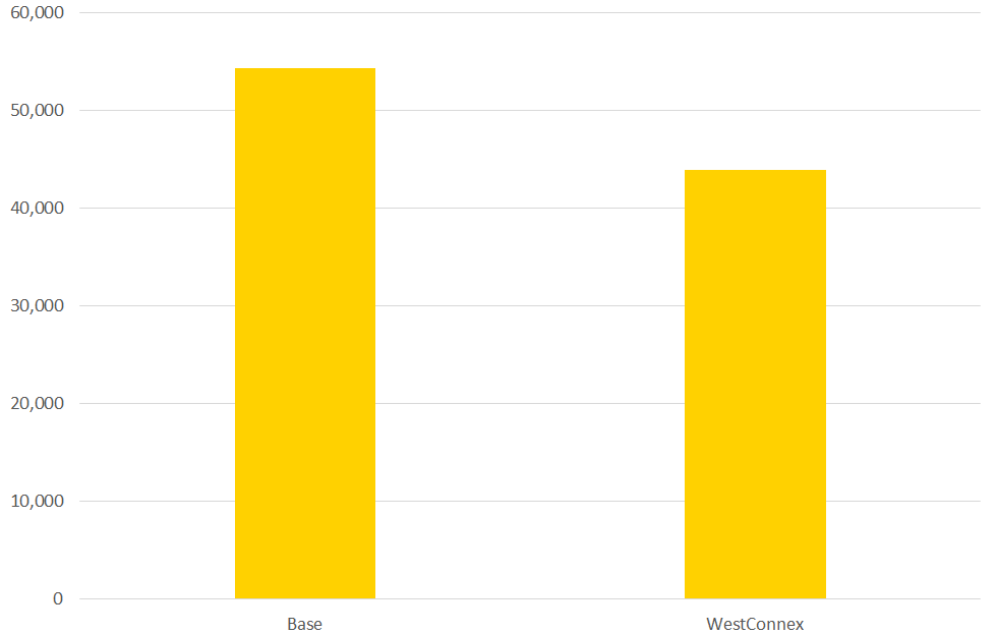
FIGURE 8 VOLUME CHANGES WESTCONNEX VS NO WESTCONNEX (2026)



Source: Veitch Lister Consulting

[4] The model suggests that even a small number of drivers will switch from their cars to public transport.

FIGURE 9 M4 HOMEBUSH BAY DR – CONCORD RD EASTBOUND TRAFFIC,(2026) .



Source: Veitch Lister Consulting

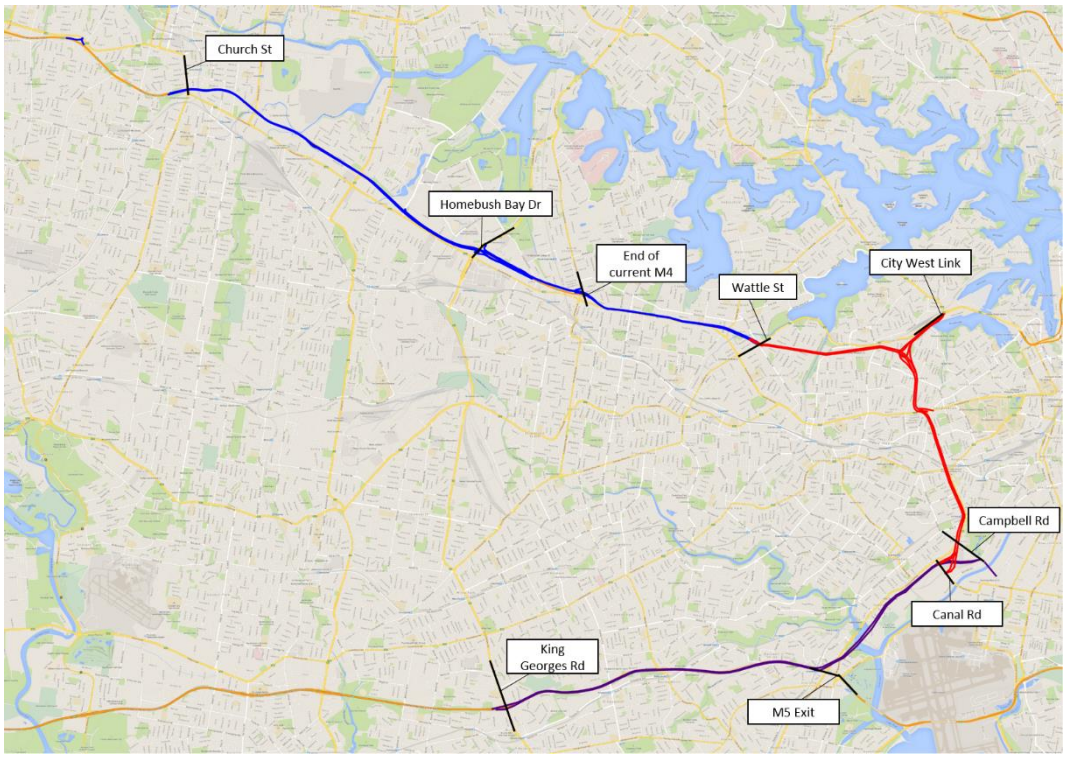
According to the model, the M5 sees a consistent but modest increase in traffic. The M4 will see mostly decreased traffic volumes travelling towards the city, and mostly no change in volumes travelling the other way, except for a 17 per cent increase at Homebush Bay Drive. The M5 East/New M5 will carry up to 15 per cent more traffic in both directions, with a 30 per cent traffic increase at Bexley Road exit[5].

The daily traffic volumes resulting from the modelling are presented in Table 9, Table 10 and Table 11 (Figure 10 shows the location of some of the key points shown in these tables). There is a significant amount of information contained in these three tables. Table 8 provides an explanation of the categories listed in each column of the three tables.

The second last column of Table 9, Table 10 and Table 11 shows the percentage change in the number of vehicles using the upgraded WestConnex in 2026, after all stages are complete. The comparison is with 2026 in a no WestConnex scenario. Table 12 and Table 13 provide network wide KPIs.

[5] The chart does not depict the changes along the Stage 3 section of tunnel because no percentage comparison is possible

FIGURE 10 WESTCONNEX SECTIONS



Source: Veitch Lister Consulting

TABLE 8 TRANSPORT MODELLING VARIABLES

	Column	Explanation
1	Corridor	The broader corridor in which the section sits
2	Section	The section of the road being examined.
3	Dir	The direction of the traffic.
4	2021 Base	The estimate of the daily volume of vehicles using that section in 2021 without WestConnex
5	2021 S12	The estimate of the daily volume of vehicles using that section in 2021 with Stages 1 and 2 of WestConnex completed
6	2021 % diff	The percentage difference between column 5 and 5.
7	2026 base	The estimate of the daily volume of vehicles using that section in 2026 without WestConnex
8	2026 S12	The estimate of the daily volume of vehicles using that section in 2026 with Stages 1 and 2 of WestConnex completed
9	2026 S12 % diff	The percentage difference between column 7 and 8.
10	2026 S123	The estimate of the daily volume of vehicles using that section in 2026 with Stages 1, 2 and 3 of WestConnex completed
11	2026 S123 % diff	The percentage difference between column 7 and 10
12	2041 S123	The estimate of the daily volume of vehicles using that section in 2026 with Stages 1, 2 and 3 of WestConnex completed

Source: SGS Economics & Planning

TABLE 9 DAILY TRAFFIC VOLUMES (CLOCKWISE[6])

Corridor	Section	Dir	2021 base	2021 S12	2021 % diff	2026 base	2026 S12	2026 S12 % diff	2026 S123	2026 S123 % diff	2041 S123
M4 Widening	M4 M7 - Reservoir Road	EB	72,800	72,100	-1%	90,000	89,800	0%	91,900	2%	99,800
	M4 Reservoir Road - Prospect Hwy	EB	74,500	73,800	-1%	91,100	90,900	0%	93,400	3%	100,900
	M4 Emert Street - Coleman Street	EB	75,900	78,000	3%	88,600	91,300	3%	94,800	7%	102,100
	M4 Coleman Street - Burnett Street	EB	85,000	74,900	-12%	97,200	87,700	-10%	92,100	-5%	99,400
	M4 Burnett Street - Church Street	EB	94,300	82,300	-13%	106,500	95,800	-10%	101,200	-5%	109,600
WestConnex Stage 1	M4 Church Street - James Ruse Dr	EB	71,000	50,900	-28%	77,000	61,500	-20%	69,300	-10%	78,800
	M4 James Ruse Dr - Silverwater Road	EB	80,000	59,700	-25%	82,700	68,000	-18%	79,200	-4%	90,200
	M4 Hill Road - Homebush Bay Dr	EB	67,900	50,800	-25%	70,100	57,200	-18%	73,200	4%	84,400
	M4 Homebush Bay Dr - Concord Road	EB	53,300	18,500	-65%	54,300	22,000	-59%	43,900	-19%	50,600
	Concord - Road Frederick Street	EB		22,900			26,400		55,400		63,900
WestConnex Stage 3	Frederick Street - White Street	EB							53,500		63,200
	White Street - Parramatta Road	SB							53,500		67,700
	Parramatta Road - Canal Road	SB							35,900		46,600
WestConnex Stage 2	Campbell Street - M5 exit	SB		16,000			17,700		23,400		28,300
WestConnex stage 2 / M5 East	M5 exit - Bexley Road and Kingsgrove Road	WB	51,200	62,600	22%	52,300	67,100	28%	66,800	28%	79,900
	Bexley Road and Kingsgrove Road - King Georges Road	WB	68,700	76,700	12%	70,400	81,600	16%	80,800	15%	94,200
M5	M5 Fairford Road	WB	6,200	6,800	10%	6,300	7,100	13%	7,000	11%	7,600
	M5 Henry Lawson Dr	WB	5,800	5,900	2%	6,000	6,200	3%	5,900	-2%	6,700
	M5 Main Toll Plaza	WB	61,400	61,800	1%	64,400	64,700	0%	64,300	0%	72,900

Source: Veitch Lister Consulting

[6] A journey starting at the western end of the M4 and travelling to the southwestern end of M5 along WestConnex

TABLE 10 DAILY TRAFFIC VOLUMES (COUNTERCLOCKWISE[7])

Corridor	Section	Dir	2021 base	2021 S12	2021 % diff	2026 base	2026 S12	2026 S12 % diff	2026 S123	2026 S123 % diff	2041 S123
M4 Widening	M4 M7 - Reservoir Road	WB	72,800	72,500	0%	91,100	90,900	0%	92,400	1%	100,900
	M4 Reservoir Road - Prospect Hwy	WB	73,700	72,800	-1%	91,200	90,500	-1%	92,300	1%	100,000
	M4 Emert Street - Coleman Street	WB	71,900	67,900	-6%	88,300	84,900	-4%	88,200	0%	95,500
	M4 Coleman Street - Burnett Street	WB	80,200	76,000	-5%	96,800	93,100	-4%	96,500	0%	104,100
	M4 Burnett Street - Church Street	WB	91,400	85,200	-7%	106,500	101,700	-5%	106,000	0%	114,800
WestConnex Stage 1	M4 Church Street - James Ruse Dr	WB	69,000	52,400	-24%	76,500	65,700	-14%	71,600	-6%	81,400
	M4 James Ruse Dr - Silverwater Road	WB	78,100	63,400	-19%	81,000	72,800	-10%	82,300	2%	93,400
	M4 Hill Road - Homebush Bay Dr	WB	68,200	56,000	-18%	70,900	63,700	-10%	75,900	7%	87,600
	M4 Homebush Bay Dr - Concord Road	WB	53,300	39,700	-26%	54,600	46,100	-16%	63,400	16%	76,400
	Concord - Road Frederick Street	WB		19,800			21,900		53,300		63,000
WestConnex Stage 3	Frederick Street - White Street	WB							52,300		63,900
	White Street - Parramatta Road	NB							48,600		63,700
	Parramatta Road - Canal Road	NB							32,500		45,000
WestConnex Stage 2	Campbell Street - M5 exit	NB		15,300			16,900		20,900		26,900
WestConnex stage 2 / M5 East	M5 exit - Bexley Road and Kingsgrove Road	EB	52,000	65,600	26%	53,400	70,500	32%	68,500	28%	82,500
	Bexley Road and Kingsgrove Road - King Georges Road	EB	69,700	80,200	15%	71,500	85,400	19%	83,000	16%	96,800
M5	M5 Fairford Road	EB	5,800	6,500	12%	5,800	6,900	19%	6,700	16%	7,300
	M5 Henry Lawson Dr	EB	5,100	5,400	6%	5,300	5,700	8%	5,500	4%	6,200
	M5 Main Toll Plaza	EB	67,200	68,200	1%	70,700	71,800	2%	70,800	0%	79,700

Source: Veitch Lister Consulting

[7] A journey starting at the southwestern end of M5 and travelling to the western end of the M4 along WestConnex

TABLE 11 DAILY TRAFFIC VOLUMES ON PARRAMATTA ROAD SECTIONS

Corridor	Section	Dir	2021 base	2021 S12	2021 % diff	2026 base	2026 S12	2026 S12 % diff	2026 S123	2026 S123 % diff	2041 S123
Parramatta Road	Parramatta Road btwn Church St and James Ruse Drive	EB	17,900	20,700	16%	18,800	21,300	13%	21,100	12%	22,300
	Parramatta Road btwn Church St and James Ruse Drive	WB	20,100	24,200	20%	21,600	24,700	14%	24,500	13%	24,700
	Parramatta Road btwn James Ruse Dr and Silverwater Road	EB	27,300	32,900	21%	29,600	33,500	13%	33,300	13%	34,800
	Parramatta Road btwn James Ruse Dr and Silverwater Road	WB	27,500	31,900	16%	30,300	32,700	8%	32,400	7%	34,400
	Parramatta Road btwn Silverwater Road and Homebush Bay	EB	18,100	21,100	17%	19,500	21,800	12%	21,200	9%	22,700
	Parramatta Road btwn Silverwater Road and Homebush Bay	WB	18,900	22,200	17%	20,100	22,800	13%	22,800	13%	24,400
	Parramatta Road btwn Homebush Bay Drive and Concord Road	EB	17,500	22,300	27%	18,400	22,500	22%	22,300	21%	24,300
	Parramatta Road btwn Hombush Bay Drive and Concord Road	WB	18,000	22,200	23%	18,900	22,300	18%	22,700	20%	25,000
	Parramatta Road btwn Concord Rd and Great N Road	EB	27,100	18,500	-32%	28,000	18,700	-33%	17,900	-36%	19,900
	Parramatta Road btwn Concord Rd and Great N Road	WB	27,000	20,400	-24%	27,900	21,300	-24%	18,200	-35%	20,300
	Parramatta Road btwn Frederick St and Liverpool Road	EB	20,000	21,300	7%	20,600	22,100	7%	15,600	-24%	16,400
	Parramatta Road btwn Frederick St and Liverpool Road	WB	21,100	22,200	5%	21,700	23,400	8%	16,500	-24%	17,500

Source: Veitch Lister Consulting

TABLE 12 MODEL KPIS – ROAD NETWORK STATISTICS

ROAD NETWORK STATISTICS	2021 base	2021 project stage 1 & 2	2026 base	2026 project stage 1 & 2	2026 project stage 1, 2 & 3	2041 project stage 1, 2 & 3
Total Network Kilometres	19,637	19,663	19,739	19,764	19,787	19,955
Total Network Capacity (Vehicle KMs/Hour)	217,518,506	226,167,699	226,830,170	227,932,428	228,594,899	229,005,785
Total Network Traversal Time (Hours at Freeflow)	2,837	3,203	3,204	3,207	3,209	3,210

In 2021, more vehicles use the M4 and M5 in the scenario where WestConnex is not built. In 2026, after the completion of Stage 3, WestConnex patronage increases and the results become mixed. Some sections of the motorway see more traffic in the scenario where WestConnex is built, despite the tolls, while others see less.

Stage 1, the M4 widening and eastern extension, and Stage 2, the New M5 and St Peters Interchange, will not be sufficient to encourage a significant level of traffic off alternate routes.

Traffic flows on Parramatta Road will increase by up to 22 per cent (between Homebush Bay Drive and Concord Road) as vehicles avoid paying the toll on the M4 and M4 eastern extension. This finding is consistent with the WestConnex Delivery Authority's own assessment presented in the M4 Widening Environmental Impact Statement. It is also consistent with the traffic flow impacts observed when the M4 toll was removed in 2010.

As a result of WestConnex, Parramatta Road will take more traffic in the future, not less. This traffic growth on Parramatta Road will clearly jeopardise the government's planned urban renewal and population growth along this corridor.

The M5 East will, despite the completion of the New M5, remain the preferred route connecting the airport, port and the city. The New M5 will not provide a more attractive route to these key destinations and will not relieve congestion on the M5 East. Traffic volumes on the M5 East will continue to increase by up to 25 per cent, leading to increased congestion and peak spreading.

The traffic from the New M5 will flow into the St Peters area via an interchange on the site of the Alexandria landfill. By 2021 over 31,000 vehicles a day will be using this interchange, increasing to over 55,000 vehicles by 2041. These vehicles will flow onto the local road network, impacting on residential and commercial areas, and increasing traffic and congestion in the corridor between the CBD and the airport. This will impact the viability of urban renewal areas such as Green Square and Ashmore, reducing future housing potential.

Given the scale of the project the total changes brought about by WestConnex are modest. The improved road will benefit those that use it, but they do not represent a large share of all Sydney travellers. Low growth in users means it is unlikely there will be sufficient demand to ensure the various WestConnex toll roads are viable. This was the experience in several recent toll road projects in Australia's major cities.

Some previous toll road projects have overestimated travel time savings and drivers' willingness to pay to the point where the toll roads have been financial failures[8]. Failed toll roads have shaken the private sector's appetite for investment in WestConnex, meaning the government would be taking on the risk of the project until toll revenues are attractive to private sector investors. Consequently NSW taxpayers could be exposed to financial risks.

From available information[9], Stage 1 is intended to be funded by the government and then sold to finance Stages 2 and 3. However, more recent announcements have proposed Stages 1 and 2 be delivered concurrently. The length of time government holds and operates WestConnex, the concessions (tolls and length) for a private operator and the private sectors appetite for risk will determine if WestConnex is a value for money investment for NSW.

[8] These include the Lane Cove Tunnel[8], Cross City Tunnel and the Clem 7.

[9] http://www.westconnex.com.au/documents/westconnex_industry_engagement_briefing_oct2013.pdf

TABLE 13 MODEL KPIS – PRIVATE VEHICLE STATISTICS

PRIVATE VEHICLE STATISTICS		2021 base	2026 base	2026 project Stage 1 & 2	2026 project Stage 1, 2 & 3
Car Trips	AM	2,010,602	2,146,880	2,146,335	2,147,065
	Inter Peak	10,584,355	11,326,354	11,320,905	11,325,047
	PM	2,067,151	2,208,755	2,208,155	2,208,882
	Total	**14,662,108**	**15,681,989**	**15,675,395**	**15,680,994**
Commercial Vehicle Trips	AM	111,958	118,934	118,934	118,934
	Inter Peak	599,197	637,169	637,169	637,169
	PM	98,562	104,761	104,761	104,761
	Total	**809,717**	**860,865**	**860,865**	**860,865**
Car KMs	AM	19,504,557	20,658,296	20,632,881	20,721,759
	Inter Peak	99,425,262	105,535,127	105,325,460	105,731,563
	PM	21,325,707	22,615,061	22,590,004	22,683,491
	Total	**140,255,526**	**148,808,483**	**148,548,345**	**149,136,812**
Commercial Vehicle KMs	AM	2,353,402	2,488,521	2,476,796	2,485,618
	Inter Peak	13,574,717	14,355,865	14,298,698	14,340,292
	PM	2,161,429	2,285,386	2,275,540	2,284,049
	Total	**18,089,548**	**19,129,773**	**19,051,034**	**19,109,959**
Car Hours	AM	541,192	593,566	584,112	582,188
	Inter Peak	2,338,576	2,541,915	2,516,884	2,509,705
	PM	564,946	619,700	610,642	608,512
	Total	**3,444,714**	**3,755,182**	**3,711,638**	**3,700,406**
Commercial Vehicle Hours	AM	57,319	62,598	61,233	60,842
	Inter Peak	288,509	312,311	307,761	305,964
	PM	51,160	55,874	54,703	54,345
	Total	**396,988**	**430,784**	**423,697**	**421,151**
Average Trip Length - Car [km]	AM	11	11	11	11
	Inter Peak	11	11	11	11
	PM	12	12	12	12
Average Trip Length - Commercial Vehicle [km]	AM	23	23	23	23
	Inter Peak	25	25	25	25
	PM	24	24	24	24

Source: Veitch Lister Consulting

2.5 The WestConnex catchment

Figure 11 shows the WestConnex volumes and trip origins in the project Stages 1 and 2. Figure 12 shows the project Stages 1, 2 and 3 scenarios.

Within the figures the bandwidths show the expected routes of WestConnex users, from where their trip originates to their final destination. The size of the 'pies' are proportional to the number of trips originating in the travel zones that use WestConnex. The slices of the pies are coloured in the same way as the bandwidths. The colouring helps to show how the 3 stages interact with each other[10]. Trips made on WestConnex in a clockwise direction are coloured in shades of blue depending on the WestConnex section they access first; anticlockwise trips are coloured in shades of purple. The various colours can be interpreted as follows:

Clockwise

- Trips accessing WestConnex Stage 1 and travelling EB are coloured dark blue, even if they keep travelling on Stages 3 and 2,

[10] For example, in **Error! Reference source not found.**, it is possible to see that when stage 3 is open to traffic, there aren't many vehicles accessing stage 1 WB directly. It is also possible to see that stage 2 is relatively independent from stage 1 and is expected to have only marginally more interaction with stage 3 – there are very few trips using stage 1 and 2 and only a few more using stage 2 and 3.

- Trips accessing WestConnex Stage 2 and travelling WB are coloured light blue,
- Trips accessing WestConnex Stage 3 and travelling SB are coloured in a blue in between dark and light, even if they keep travelling on Stage 2.

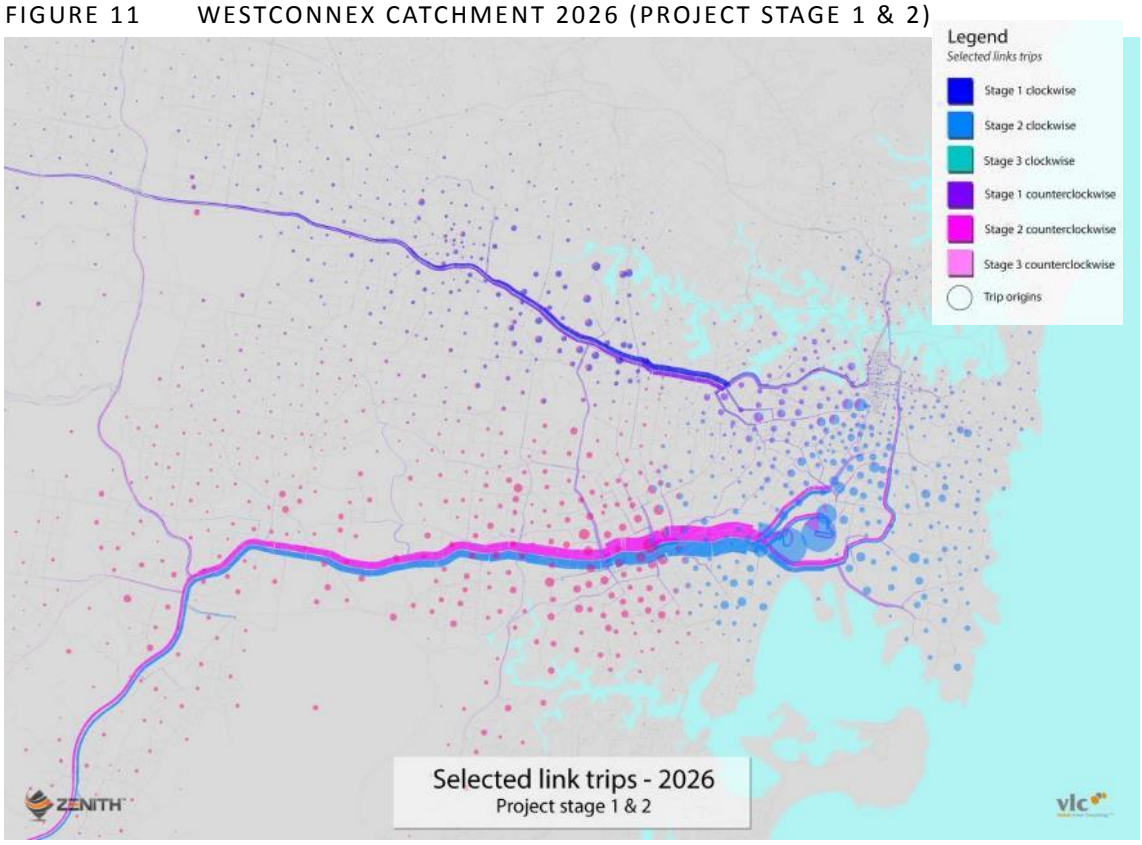
Anticlockwise

- Trips accessing WestConnex Stage 1 and travelling WB are coloured dark purple,
- Trips accessing WestConnex Stage 2 and travelling EB are coloured light purple, even if they keep travelling on Stages 3 and 1,
- Trips accessing WestConnex Stage 3 and travelling NB are coloured in a purple in between dark and light, even if they keep travelling on Stage 1.

Figure 11 makes clear that Stages 1 and 2 serve different markets. Stage 1 provides access to Parramatta and Haberfield, with vehicles at the end of Stage 1 at Frederick Street dispersing across the local network. Stage 2 serves mainly Sydney airport, Green Square and the eastern suburbs.

Note that the main Stage 2 volumes are on the M5 East, which is an existing motorway. The extension to Campbell Road carries only a small fraction of traffic coming from the M5. An interesting finding is that the catchment for Stage 2 eastbound extends to the north of the M4 along King Georges Road.

FIGURE 11 WESTCONNEX CATCHMENT 2026 (PROJECT STAGE 1 & 2)

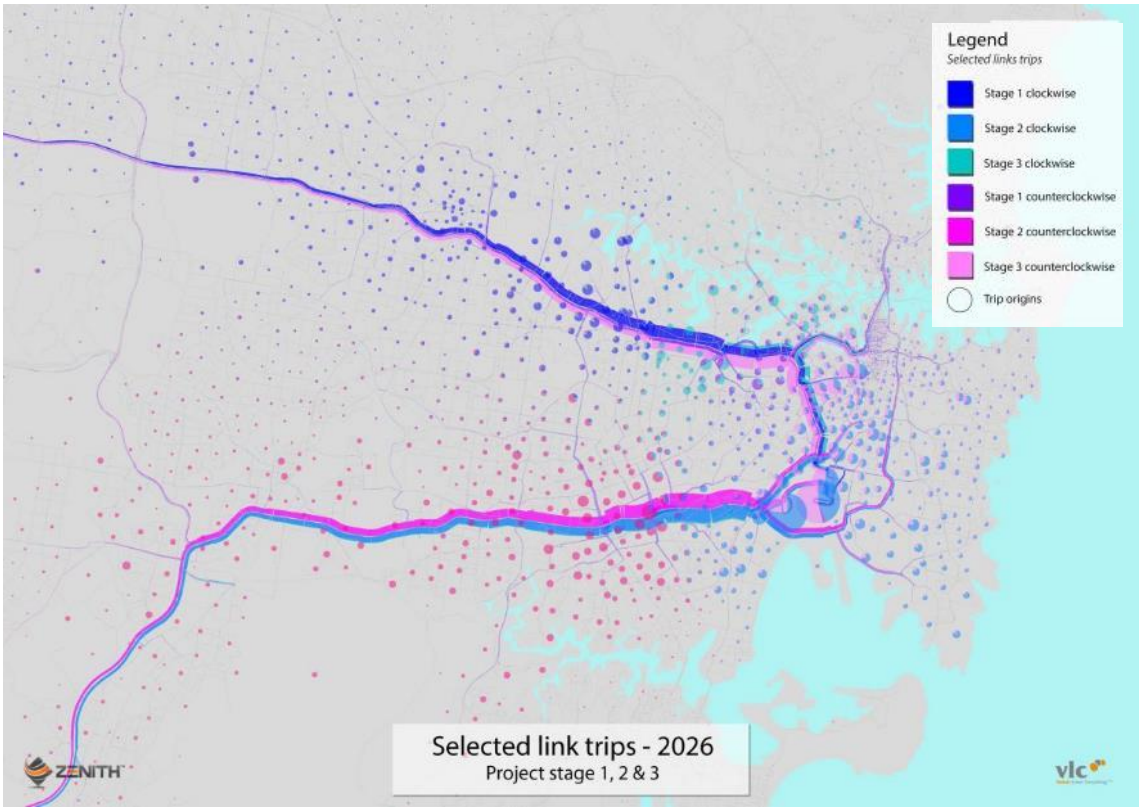


Source: Veitch Lister Consulting

When Stage 3 becomes operational, the WestConnex catchment extends again, attracting more trips from the northern side of the harbour and activating some zones located at the end of the existing M4 (Abbotsford, Canada Bay, Five Dock, Ashfield, etc.). Most of the vehicles travelling on the M4 eastern extension will continue on WestConnex Stage 3 to access the airport. The ANZAC Bridge will experience an increase in volumes due to the demand for trips originating on the northern side of the harbour and headed to the airport. Many of these trips divert from the Eastern Distributor to WestConnex Stage 3.

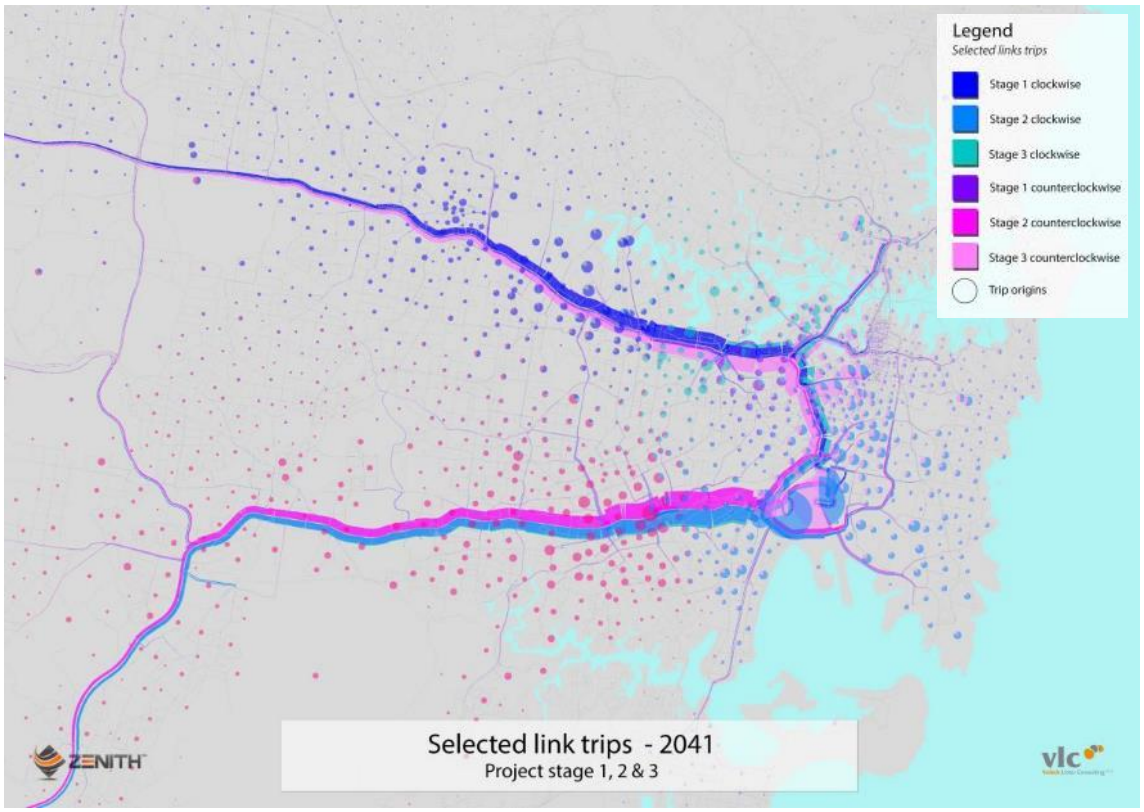
The completion of WestConnex Stage 3 also incentivises many users of King Georges Road to swap to the new infrastructure, slightly alleviating traffic on local roads. Even the M7 will have a minor decrease in volumes as Stage 3 becomes an alternative route for some trips.

FIGURE 12 WESTCONNEX CATCHMENT 2026 (PROJECT STAGE 1, 2 & 3)



Source: Veitch Lister Consulting

FIGURE 13 WESTCONNEX CATCHMENT 2041 (PROJECT STAGE 1, 2 & 3)



Source: Veitch Lister Consulting

Figure 13 shows the catchment in 2041. The major change is the introduction of the Western Harbour Tunnel, which attracts trips from the Harbour Tunnel and the Eastern Distributor.

2.6 WestConnex future extensions

WestConnex also provides for southern and northern extensions that will potentially draw more traffic onto the motorway. The Western Harbour Tunnel and southern extension to WestConnex are vital for generating traffic for WestConnex Stage 3 but are currently outside the $15 billion price tag. This traffic may be vital to the financial viability of the WestConnex motorway.

However, in assessing WestConnex should costs and benefits of these further extensions be attributed to WestConnex? This is unclear at this time.

As such, the WestConnex project potentially locks Sydney into a series of large scale road projects. Meanwhile, other formerly road-centric cities in North America and Asia are discovering that for metropolises above a certain size, public transport offers greater advantages than road.

Los Angeles – Mass Transit Transformation

Los Angeles is well known for its extensive freeway network but it has been investing significantly in mass transit since the early 1990s. The Metro Rail network was initiated by the construction of the Blue and Green light rail lines and the Red and Purple subway lines in the early 1990s. These initial bones have been added to considerably since, with extensions to existing lines as well as the construction of the Gold and Expo light rail lines in 2003 and 2012 respectively. Two bus rapid transit lines were also opened in the 2000s.

While investment has been flowing into the system for three decades, in 2008 L.A. County passed *Measure R*, a ballot proposition that raised sales taxes to create a dedicated funding stream for new transit. This revenue source is expected to generate over $40 billion (US) over the next 20 years, with these funds dedicated to transit upgrades and new line extensions. From this funding source several line extensions and two new lines are already under construction, with planning currently underway for five additional lines and further network extensions. These planned projects all have funding earmarked from *Measure R*. In addition to projects under construction or in the latter stages of planning, there are numerous proposed lines and expansions being considered (but without funding commitment).

An alternative approach for Sydney is to address particular bottlenecks that would improve the efficiency of the existing motorway network without building whole new motorways. That would allow greater investment in transit corridors which are better able to shape the city.

2.7 The broader impact of tolling

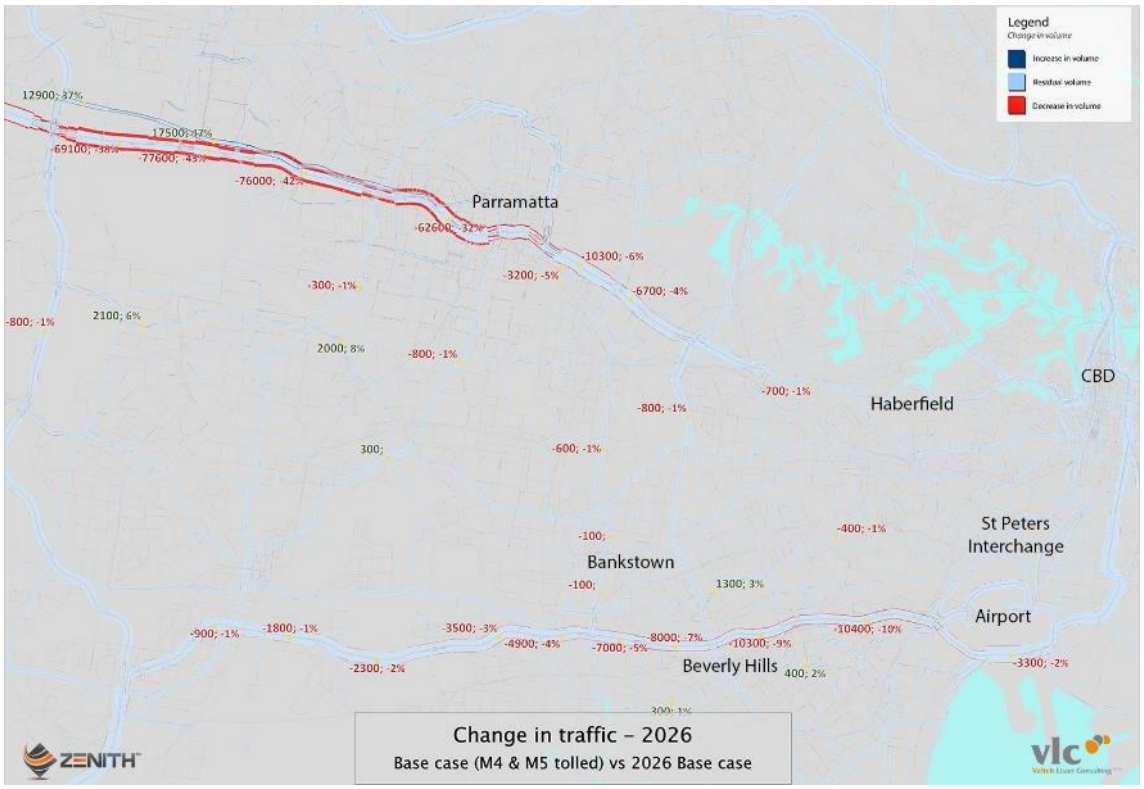
The model shows a major driver of improved volume-to-capacity ratio on the M4 is the introduction of tolls. If this were desired, a reduction in usage could be achieved simply by tolling the motorway without any upgrading.

Figure 14 shows the impact of the introduction of tolls on the full length of the M4 and on the M5 east from Beverly Hills to Princes Highway in the base case (i.e. without WestConnex).

The model predicts a heavy reduction on the M4 (of about 40 per cent) and an increase on the Great Western Highway (of about 50 per cent). There will be a small reduction on Parramatta Road mainly due to the reduction in traffic coming from the M7 via the M4. Other local roads will see a slight increase in traffic volumes.

The M5 has fewer valid alternatives, and therefore a contained increase in the toll values does not have as great an effect.

FIGURE 14 IMPACT OF M4 AND M5 TOLLED (BASE CASE)



Source: Veitch Lister Consulting

This raises a broader issue, the role that tolls play in managing future Sydney's traffic demand. The introduction of pricing mechanisms was included as part of the New South Wales Long Term Transport Master Plan. Congestion pricing uses tolls to alter demand and has been shown to substantially affect behaviour and reduce traffic congestion.

Rather than increasing road capacity by building new road infrastructure, congestion on the existing road network may be better managed through a new or updated price mechanism. The Bureau of Transport Statistics has previously produced research drawing from Household Travel Survey's that shows there are still a number of discretionary trips being made in peak periods that could be shifted to non-peak times.

2.8 The impact on the local road network

In this section the impact of WestConnex on the local road network and urban renewal precincts will be analysed. Figure 15 shows the change in traffic volumes once WestConnex Stages 1 and 2 are operational.

WestConnex Stage 1 will extend the M4 closer to the CBD, but not close enough to produce a significant change in route or mode choice to the city.

Parramatta Road will be the most affected road by the WestConnex Stage 1. Travel time savings achieved by the M4 widening and extension are not enough to counteract the effect of the new tolls introduced on the M4. The net effect is a reduction of traffic on the M4 (between 22 and 24 per cent) and an increase in traffic on Parramatta Road (between 16 and 18 per cent) and other parallel roads.

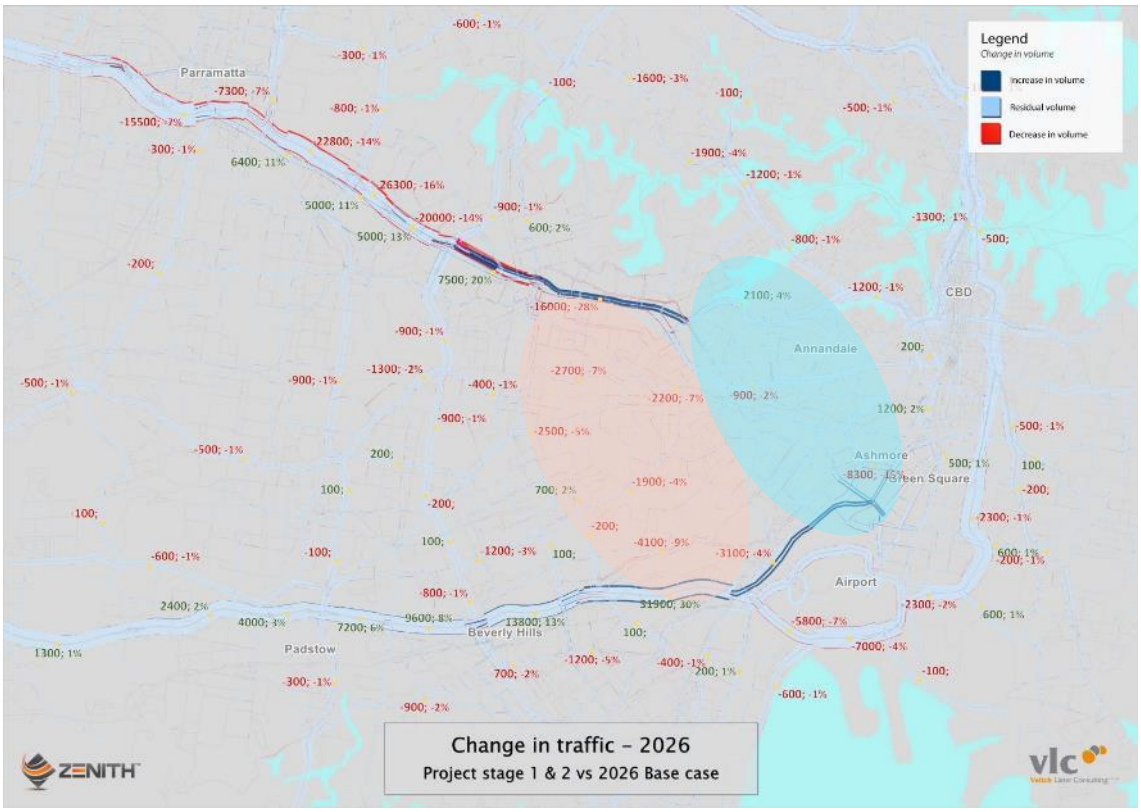
WestConnex Stage 2 will extend the M5 to Campbell Road (Green Square) closer to the CBD but once again not enough to produce a significant change in route or mode choice to the city. Traffic volumes on the M5 east tunnel will increase by about 25 per cent, while General Holmes Drive will see a reduction in traffic between 4 and 8 per cent.

WestConnex Stage 1 and 2 create two distinct corridors on the local network (highlighted in Figure 15):

- the first one (in red) where the traffic volumes generally decrease by a small amount;
- the second one (in light blue), between Haberfield and St Peters precincts, where volumes generally increase.

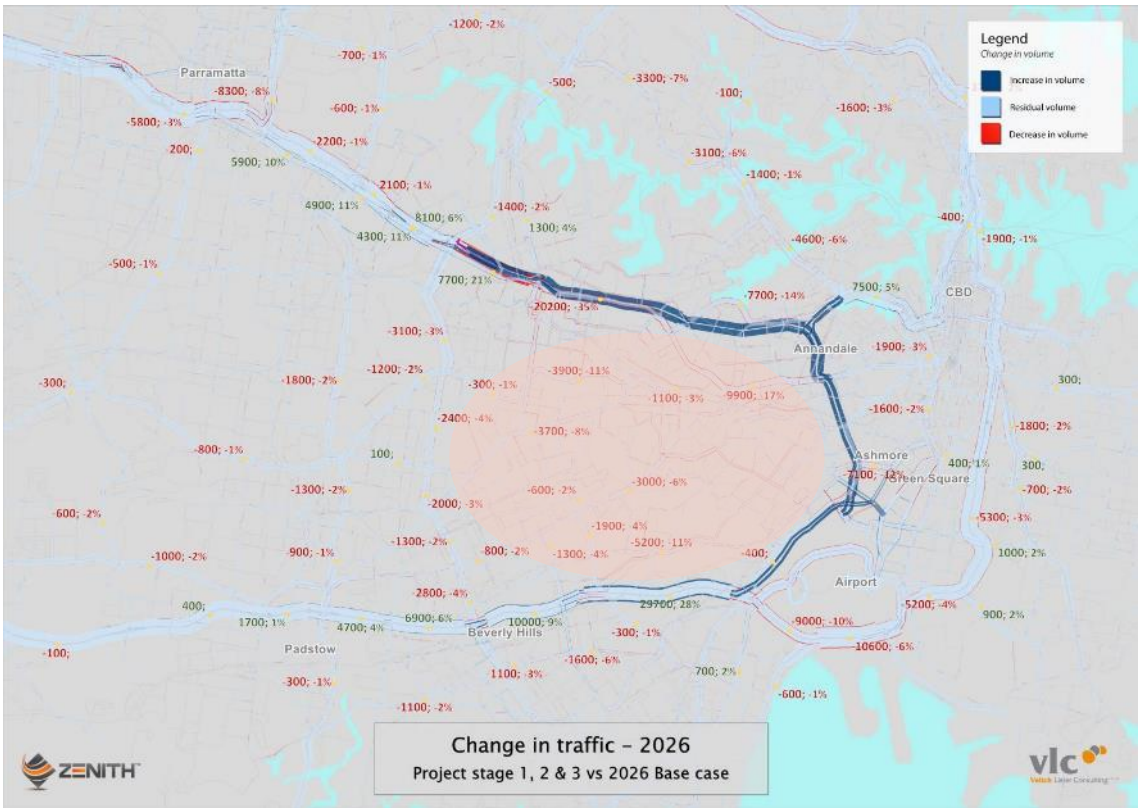
Figure 16 shows the change in traffic volumes in 2026 once the full WestConnex becomes operational. In this case the reduction in traffic volumes is more significant on the local roads located between WestConnex Stage 1 and 2. A more localised increase in traffic will occur on roads to the east of WestConnex Stage 3 and accessing the new infrastructure (ANZAC Bridge +5 per cent and St Peters Interchange).

FIGURE 15 CHANGE IN VOLUMES 2026 (STAGE 1 & 2 VS BASE)



Source: Veitch Lister Consulting

FIGURE 16 CHANGE IN TRAFFIC 2026 (PROJECT STAGE 1, 2 & 3 VS BASE)



Source: Veitch Lister Consulting

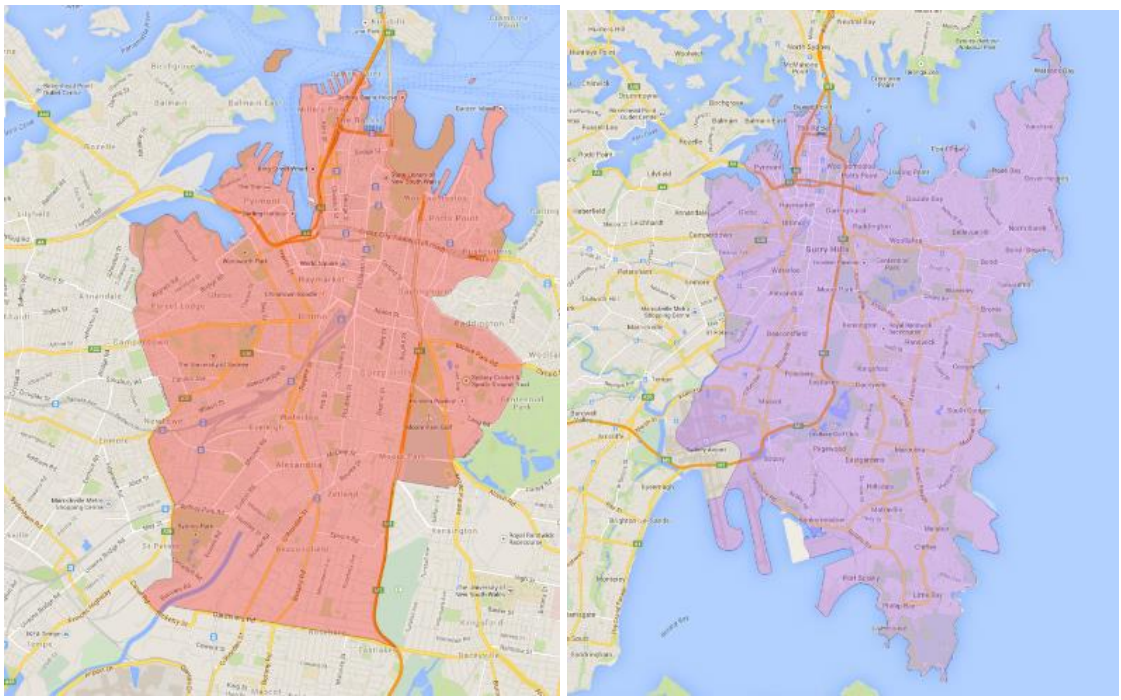
Some analysis has been conducted on car trips accessing the Sydney CBD. Table 14 reports the car trips to and eastern suburbs in the base cases and in the project cases. The table confirms that the project is not expected to bring a substantial increase in car trips to City of Sydney: less than 0.5 per cent daily when only Stages 1 and 2 are active and less than 1 per cent daily when Stage 3 is operational. A slightly higher increase in car trips is forecast to the eastern suburbs, but it will still be contained within 3 per cent daily.

TABLE 14 CAR TRIPS TO CBD AND EASTERN SUBURBS

To Eastern Suburbs					
	Base	**Stage 1 & 2**	**% diff to base**	**Stage 1, 2 & 3**	**% diff to base**
2021	380,359	383,507	0.83%	-	-
2026	394,913	398,425	0.89%	405,218	2.61%

To CBD					
	Base	**Stage 1 & 2**	**% diff to base**	**Stage 1, 2 & 3**	**% diff to base**
2021	358,093	359,016	0.26%	-	-
2026	372,760	373,438	0.18%	375,921	0.85%

FIGURE 17 CITY OF SYDNEY AND EASTERN SUBURBS (NOT SAME SCALE)



Source: Veitch Lister Consulting

3 TRAFFIC IN THE REST OF SYDNEY

Traffic conditions in the rest of Sydney will deteriorate quickly during the construction phase. This will continue after the completion of Stages 1 and 2. That deterioration will be alleviated in part when WestConnex Stage 3 is complete. However, even with that improvement, traffic conditions across Sydney will be worse than they were in 2011.

The benefits of WestConnex accrue primarily once the entire project has been constructed (i.e. Stages 1, 2 and 3). At the completion of just Stages 1 and 2, roads in the inner Sydney area are more likely to be at capacity than in the base case, as depicted in the map below.

FIGURE 18 V/C RATIO 2026 (PROJECT STAGE 1 & 2)

Source: Veitch Lister Consulting

In this scenario, the WestConnex motorways largely appear as green, because the impact of tolls is enough to dissuade many motorists from using them.

The complete WestConnex project is greater than the sum of its parts. This means that the construction phase – when Stages 1 and 2 are complete and Stage 3 is underway – will present difficulties for Sydney. Any delay in construction – not inconceivable given the scale of the tunnelling work being undertaken – would extend the problematic period.

The findings with respect to the broader financial benefits of WestConnex are consistent with Infrastructure Australia's[11] own assessment; that the benefits of any one stage of WestConnex are lower than the benefits that flow from the entire project as the stages are complementary to each other. Project delays will significantly impact the project's economic merits.

3.1 Traffic change overview

Areas of inner Sydney, for example Dulwich Hill and Petersham, will see reduced traffic volumes after the construction of Stage 3, as some north-south traffic moves to the new tunnel.

The roads around Green Square may get more crowded, but not all parts of Sydney see a traffic increase. Parts of the inner south see a reduction in traffic on local roads, as through-traffic is diverted onto the motorways, especially the tunnel constructed as part of Stage 3.

Figure 19, on the following page, shows the change in traffic levels associated with the completion of the whole WestConnex project. It allows for comparison between two alternative futures: one where WestConnex is built and one where it is not.

It shows areas of improvement in the south of Sydney, and areas where traffic gets worse, such as Green Square and Beverley Hills.

Areas that will see a benefit include Dulwich Hill and Petersham. There is little effect in the CBD.

Figure 20, on the page after, shows the total change between 2011 and 2041. It shows a significant city-wide increase in traffic congestion by 2041 despite the construction of WestConnex.

[11] http://www.infrastructureaustralia.gov.au/project_assessments/files/NSW-WestConnex.pdf

FIGURE 19 CHANGE IN LOS 2026 (PROJECT STAGE 1, 2 & 3 VS BASE)

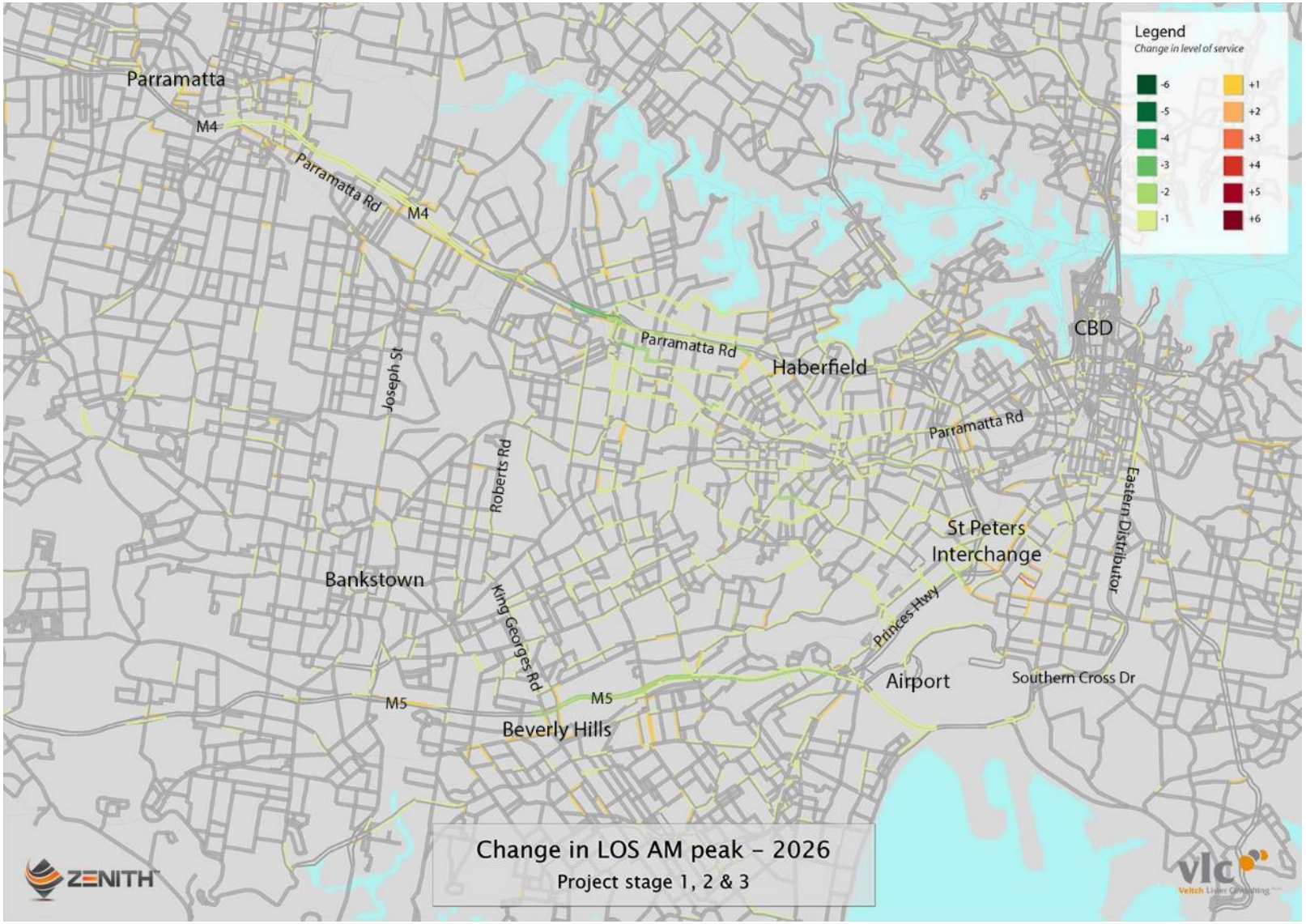
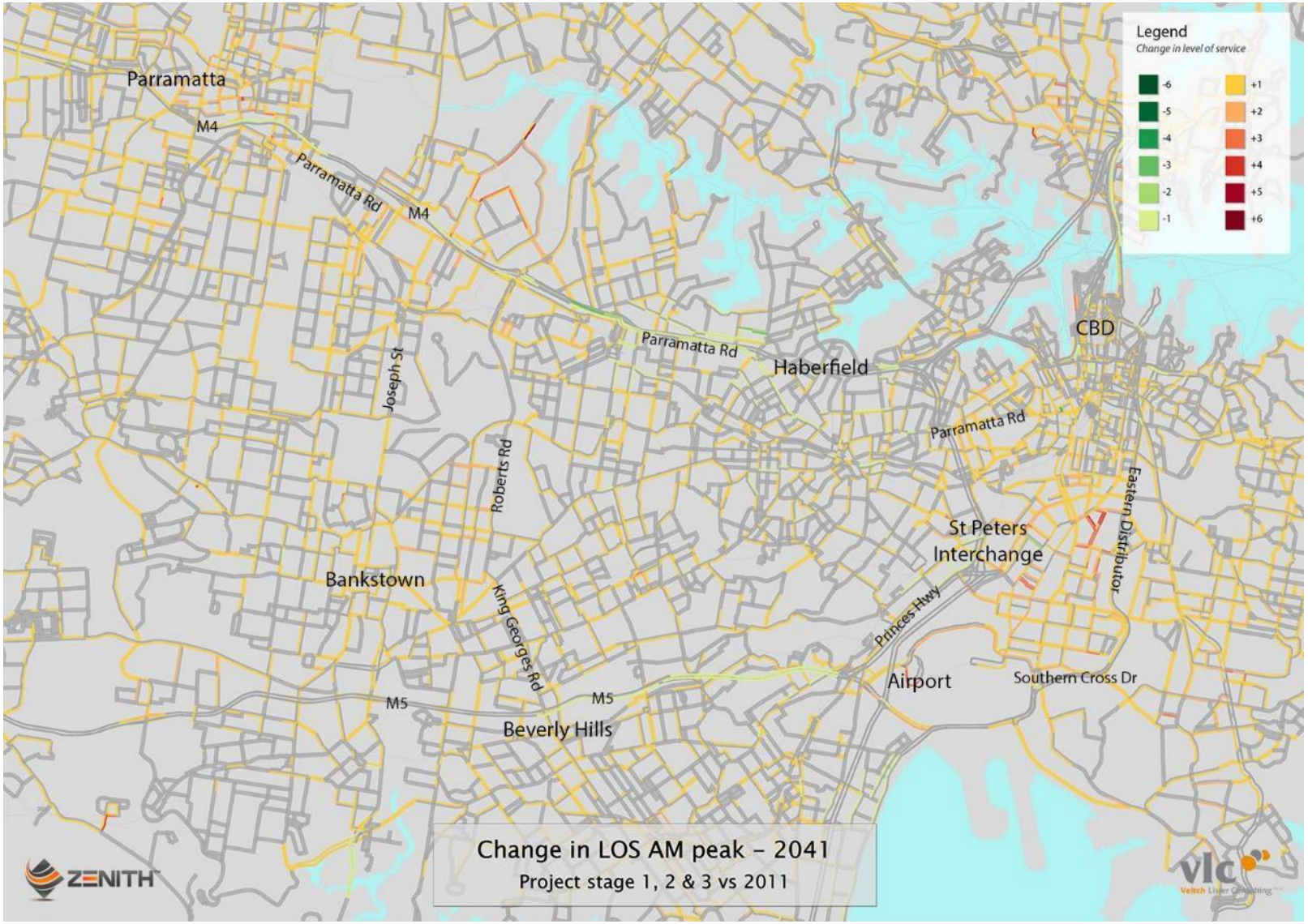


FIGURE 20 CHANGE IN LOS 2041 (PROJECT STAGE 1, 2 & 3 VS 2011)

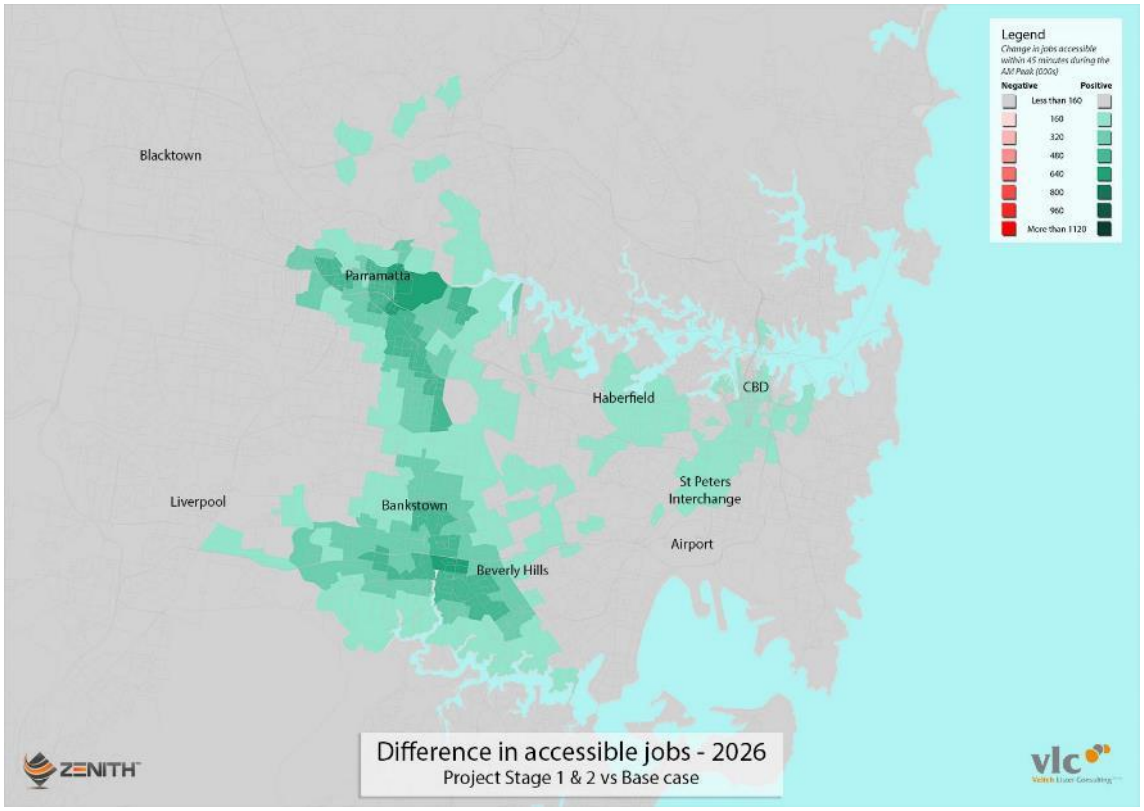


3.2 Changes in job accessibility

Figure 21 and Figure 22 show the change in jobs accessible[12] within a 45 minute drive in the two 2026 project scenarios when compared with the base case.

Figure 21 shows that Parramatta and Bankstown are expected to benefit the most in terms of vehicular accessibility to jobs when only Stages 1 and 2 are completed, while Figure 22 shows that Stage 3 will increase the accessibility from Parramatta and Bankstown as well as from Green Square. In general the introduction of WestConnex Stage 3 increases the accessibility to jobs from the M4 and the M5 corridors.

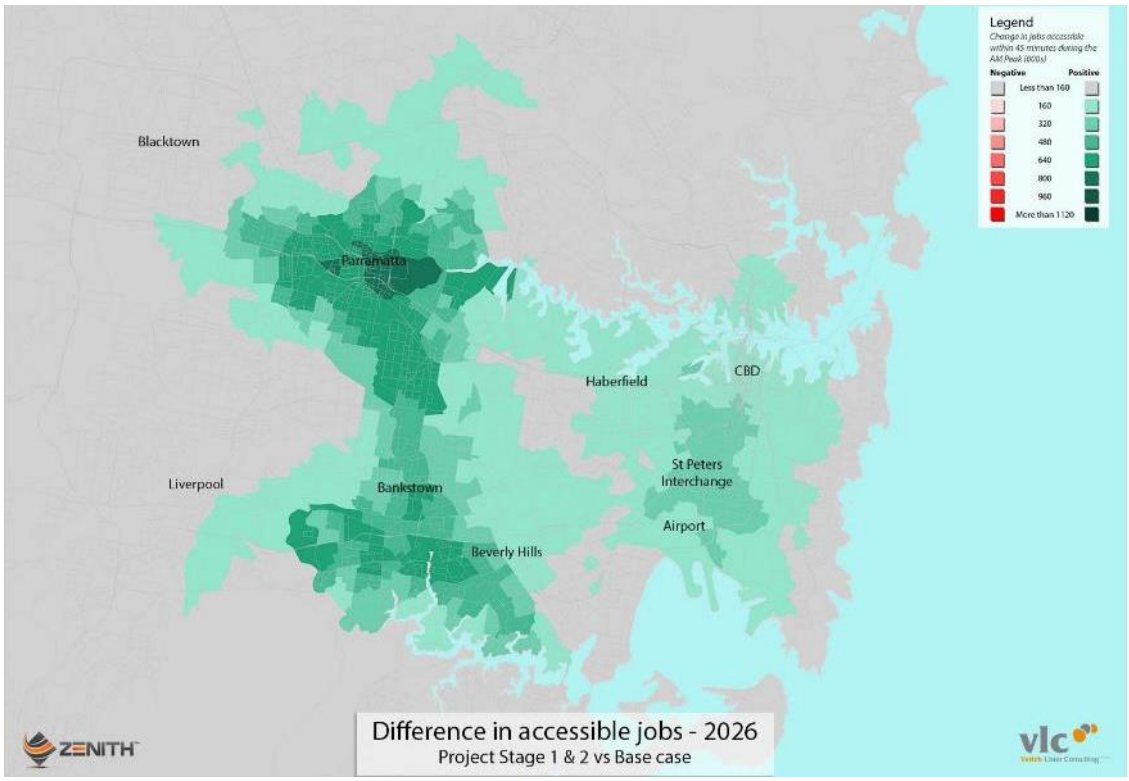
FIGURE 21 CHANGE IN ACCESSIBLE JOBS – 2026 STAGE 1 & 2 VS BASE CASE



Source: Veitch Lister Consulting

[12] That is, from someone's home, how many jobs can be accessed in 45 minutes by car during peak hour?

FIGURE 22 CHANGE IN ACCESSIBLE JOBS – 2026 STAGE 1, 2 & 3 VS BASE CASE



Source: Veitch Lister Consulting

3.3 Changes to trip patterns

Change in travel time

Figure 23 to Figure 28 show the change in vehicular travel time in the AM peak between the project scenarios and the base case in 2026, from some key locations:

- Annandale;
- Ashmore and Green Square precincts;
- Parramatta.

In both project cases, vehicle trips from Parramatta to the east and south-east benefit from the introduction of WestConnex, while trips to the west will experience some minor delays.

When only Stages 1 and 2 are operational, local trips in Ashmore and Green Square will be affected by the increase in traffic at the end of the WestConnex branches. Travel times for local trips will increase by less than 3% in Green Square and Ashmore precincts, while they will increase by 1% in Annandale. In both cases the delays will be contained within the minute.

When the full WestConnex comes into effect, the aforementioned delays in Annandale will generally be relieved, with the exception of trips to the CBD. This is most likely due to increases in traffic on the ANZAC bridge. Travel times in Green Square and Ashmore precincts slightly decrease for northbound trips. Southbound trips will still experience some delays due to the vehicles coming from WestConnex and accessing the airport and port.

FIGURE 23 CHANGE IN TRAVEL TIME – 2026 PARRAMATTA (STAGE 1 & 2)

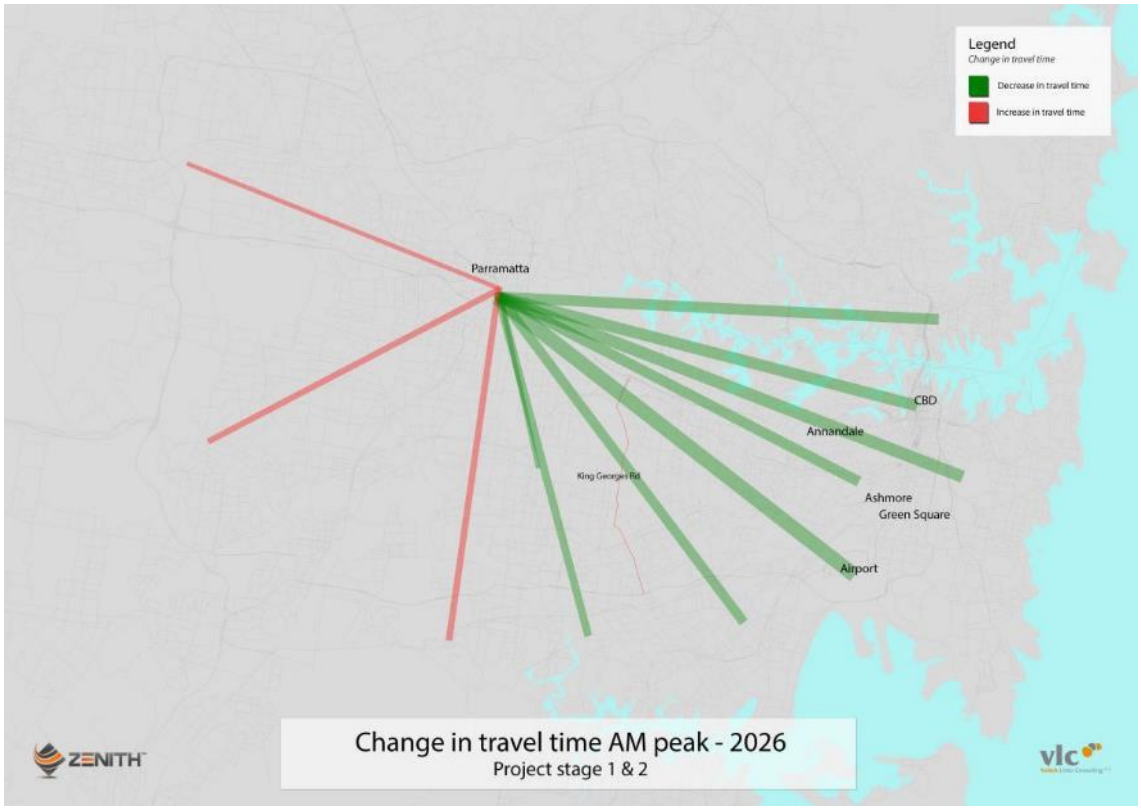


FIGURE 24 CHANGE IN TRAVEL TIME – 2026 PARRAMATTA (STAGE 1, 2 & 3)

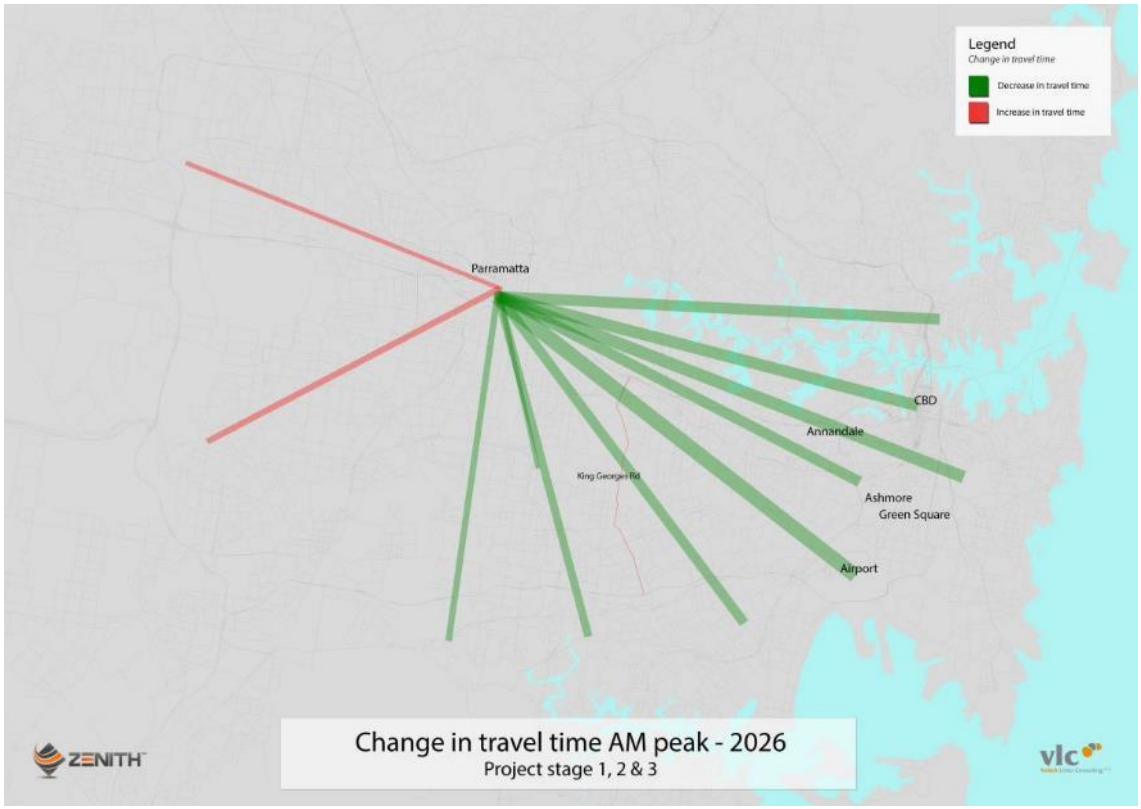


FIGURE 25 CHANGE IN TRAVEL TIME – 2026 ANNANDALE (STAGE 1 & 2)

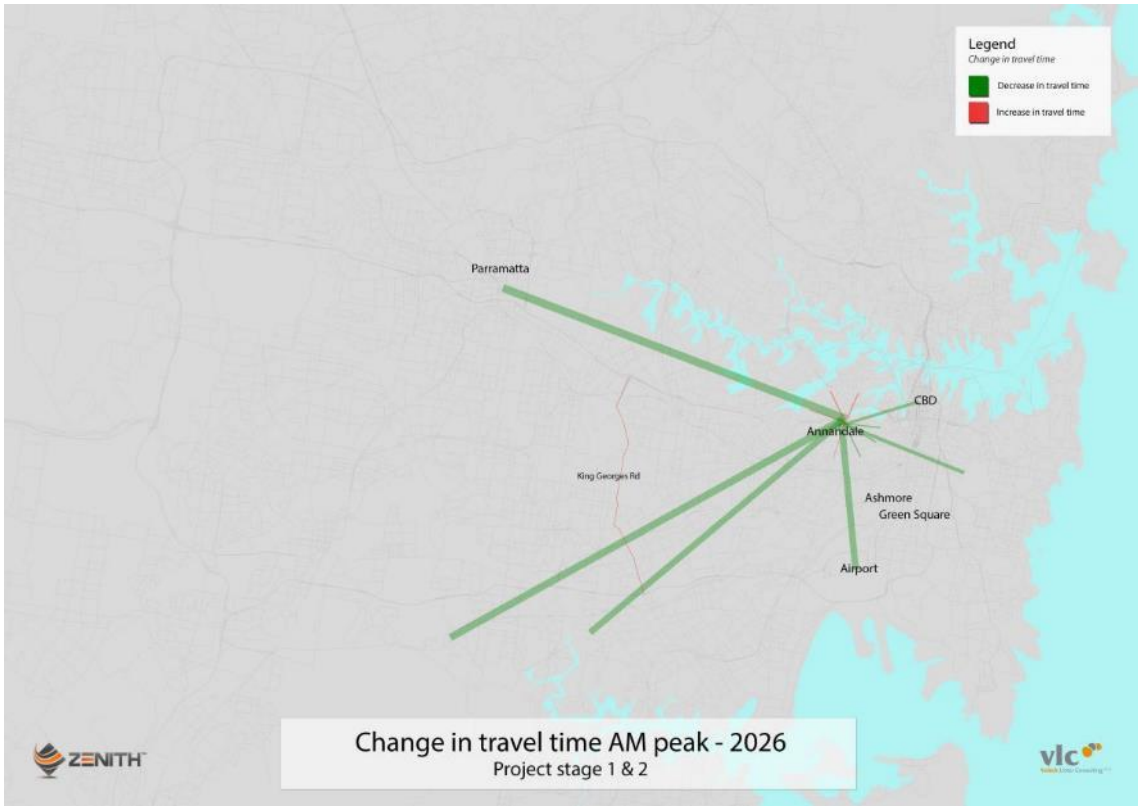


FIGURE 26 CHANGE IN TRAVEL TIME – 2026 ANNANDALE (STAGE 1, 2 & 3)

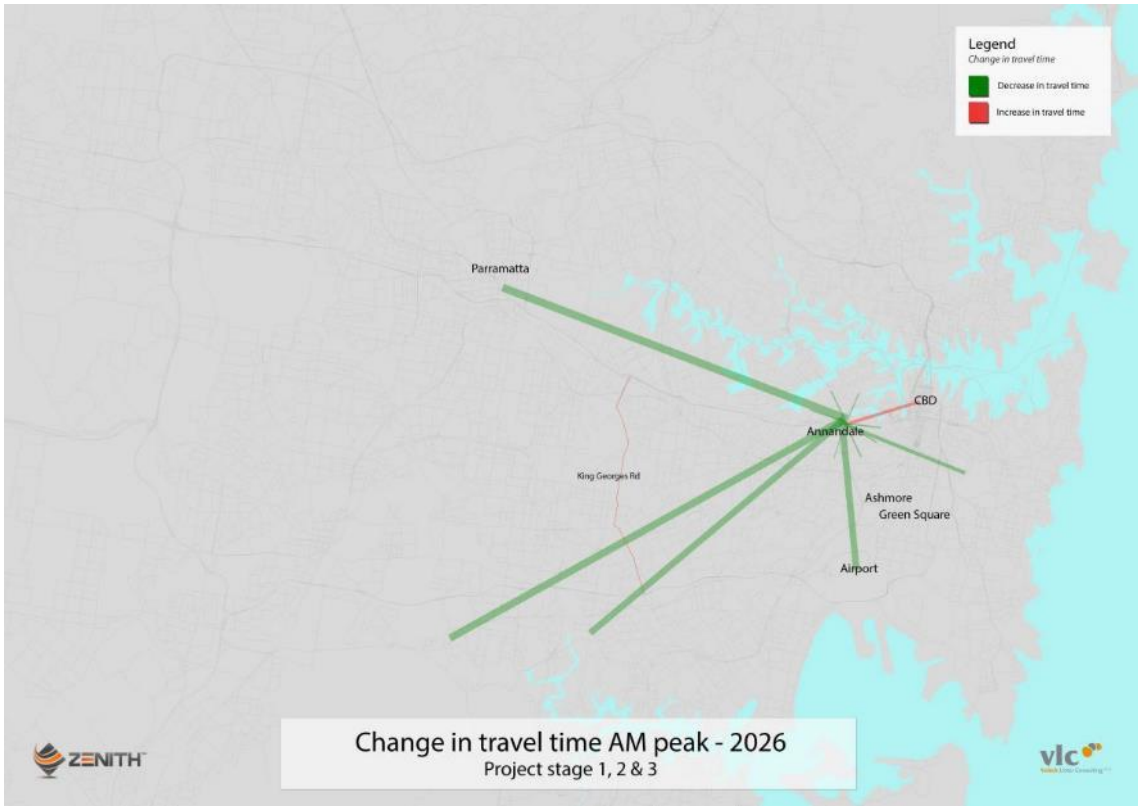


FIGURE 27 CHANGE IN TRAVEL TIME – 2026 GREEN SQUARE (STAGE 1 & 2)

FIGURE 28 CHANGE IN TRAVEL TIME – 2026 GREEN SQUARE (STAGE 1, 2 & 3)

3.4 Impact on urban renewal

The 2012 State Infrastructure Strategy that announced WestConnex highlights its strategic intent as broader than transport.

"WestConnex is intended to be more than a motorway. It is a scheme designed to act as a catalyst to renew and transform the parts of Sydney through which it passes. WestConnex is intended to develop as an integrated land use and transport scheme delivering on road transport, urban renewal and public transport outcomes"[13].

But the effect of the construction of a major toll road can be paradoxical if the tolls discourage its use. Its capacity as an agent of renewal is diminished if it actually causes more local traffic.

The Zenith model finds increased traffic along parts of Parramatta Road. This finding is consistent with the WestConnex M4 Widening Traffic and Transport Working Paper – Working Paper 4[14]. This paper (page 145, Table 7.3) shows that in 2031 there is a 20 per cent (10,460 vehicles) increase in traffic on Parramatta Road (at the Duck River) following the introduction of WestConnex.

TABLE 15 TRAFFIC VOLUMES 2031 'DO MINIMUM' AND FULL WESTCONNEX

Road	Without WestConnex (Do Minimum)	Full WestConnex	Difference
M4 Motorway	194,180	168,760	-25,420
Parramatta Road	52,030	62,490	10,460
M2 Motorway	140,430	140,840	410
Victoria Road	68,250	75,770	

Source Jacobs SKM, WestConnex Road Traffic Model, 2014

The impact of increased traffic on Parramatta Road could be significant. A major impetus for the development of a motorway project was the desire to achieve urban renewal along the Parramatta Road corridor.

The draft Parramatta Road Urban Renewal Strategy identified areas that will be the focus of growth and change along the corridor. The numbers of people living in these defined areas is expected to rise by 51,600 by 2031 to achieve a total of 69,700. The population increase in these areas is 3.2 per cent of Sydney's overall expected population growth of 1.6 million to 2031.[15]

Urban renewal would transform Parramatta Road, bringing life to local communities and improving the commercial feasibility for residential, retail and commercial development.

Initially the WestConnex project proposed that urban renewal would be achieved by directing trucks and cars underground (to improve amenity) and improving above ground public transport (to improve connectivity) in the inner west. Investments of up to $200 million will be made to improve the built environment in the Parramatta Road corridor.

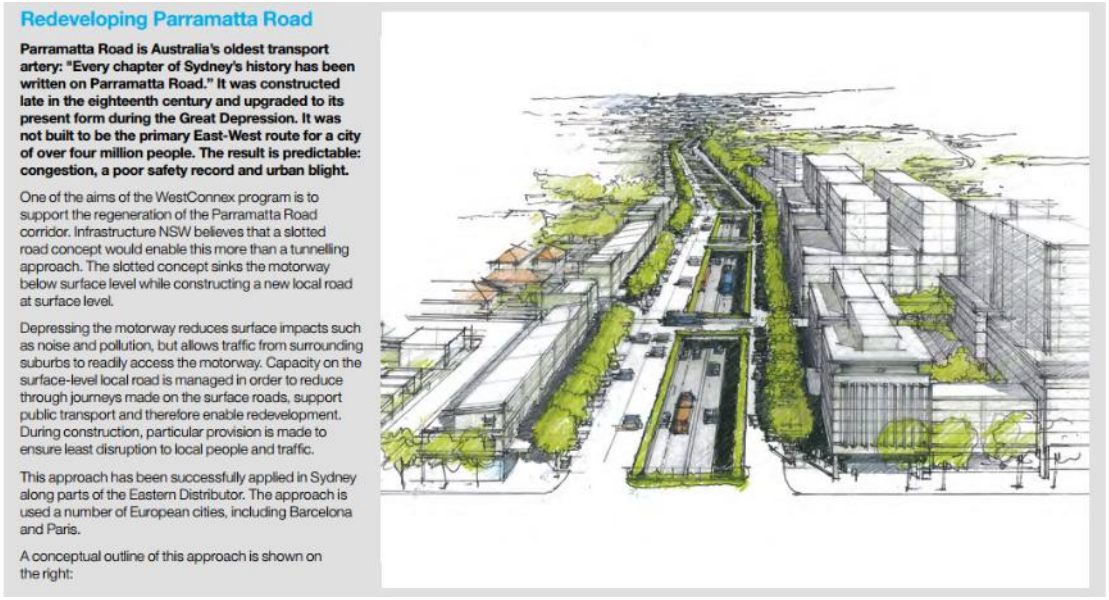
But the results of traffic modelling suggest amenity is unlikely to improve.

[13] Infrastructure NSW 2012, State Infrastructure Strategy

[14] https://majorprojects.affinitylive.com/public/cb35014b2a44c81e83fe58dfd330d39f/13_Appendix_D_Traffic_and_Transport.pdf

[15] http://www.newparramattard.com.au/downloads/file/urbanrenewal/DraftParramattaRoadURS_Web_final_20141121.pdf

FIGURE 29 DISCARDED PLAN FOR PARRAMATTA ROAD



Redeveloping Parramatta Road

Parramatta Road is Australia's oldest transport artery: "Every chapter of Sydney's history has been written on Parramatta Road." It was constructed late in the eighteenth century and upgraded to its present form during the Great Depression. It was not built to be the primary East-West route for a city of over four million people. The result is predictable: congestion, a poor safety record and urban blight.

One of the aims of the WestConnex program is to support the regeneration of the Parramatta Road corridor. Infrastructure NSW believes that a slotted road concept would enable this more than a tunnelling approach. The slotted concept sinks the motorway below surface level while constructing a new local road at surface level.

Depressing the motorway reduces surface impacts such as noise and pollution, but allows traffic from surrounding suburbs to readily access the motorway. Capacity on the surface-level local road is managed in order to reduce through journeys made on the surface roads, support public transport and therefore enable redevelopment. During construction, particular provision is made to ensure least disruption to local people and traffic.

This approach has been successfully applied in Sydney along parts of the Eastern Distributor. The approach is used a number of European cities, including Barcelona and Paris.

A conceptual outline of this approach is shown on the right:

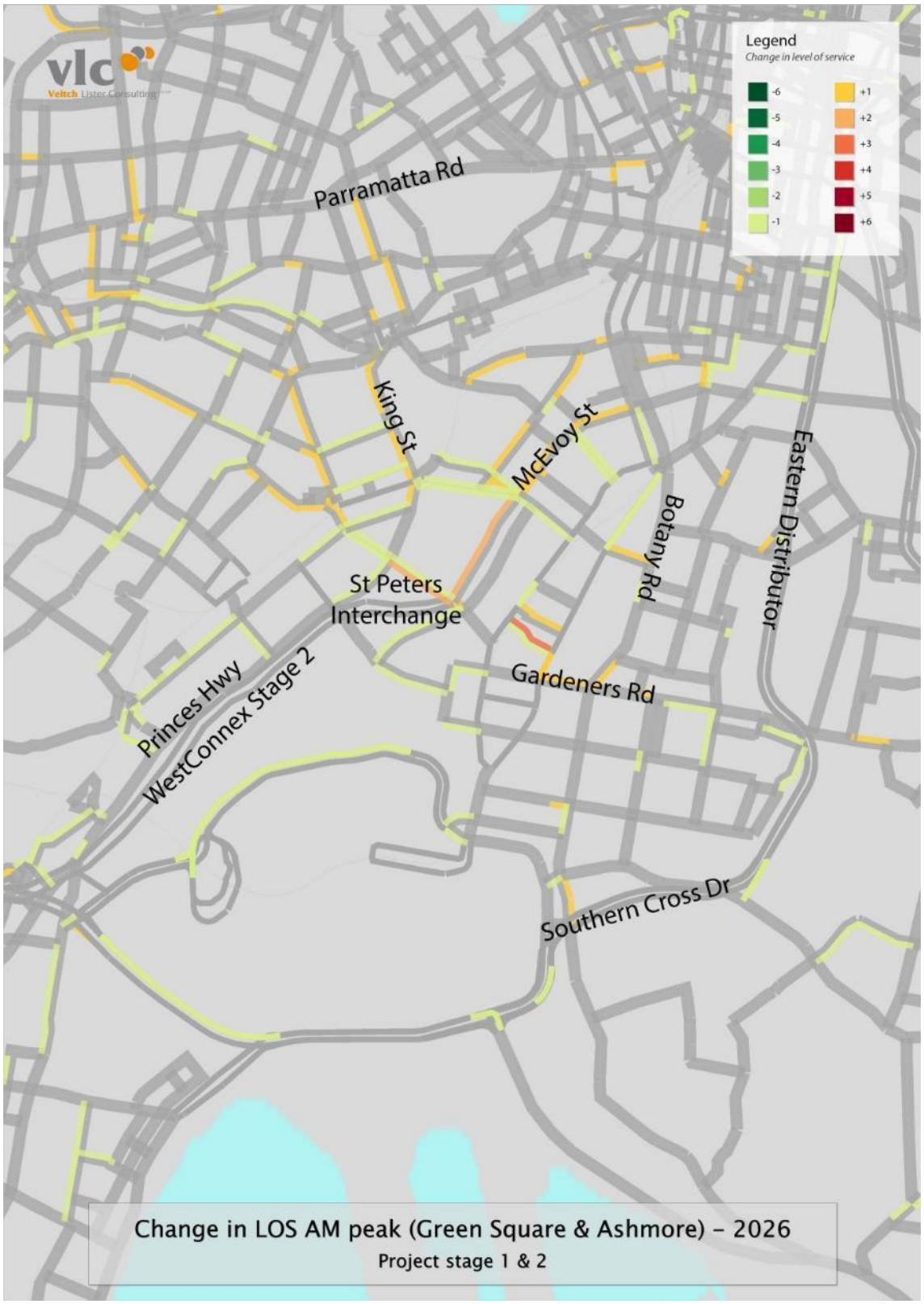
Source: The State Infrastructure Strategy

Urban revitalisation is critical for Sydney as it seeks to add an extra million people. Not all of Sydney's new residents can live on the fringes of the city. Infill development is crucial to the function of a growing city.

The key surface road of King Street in Newtown is at capacity under the base case. Due to the limited capacity of King Street the introduction of WestConnex does not have a significant adverse impact on King Street.

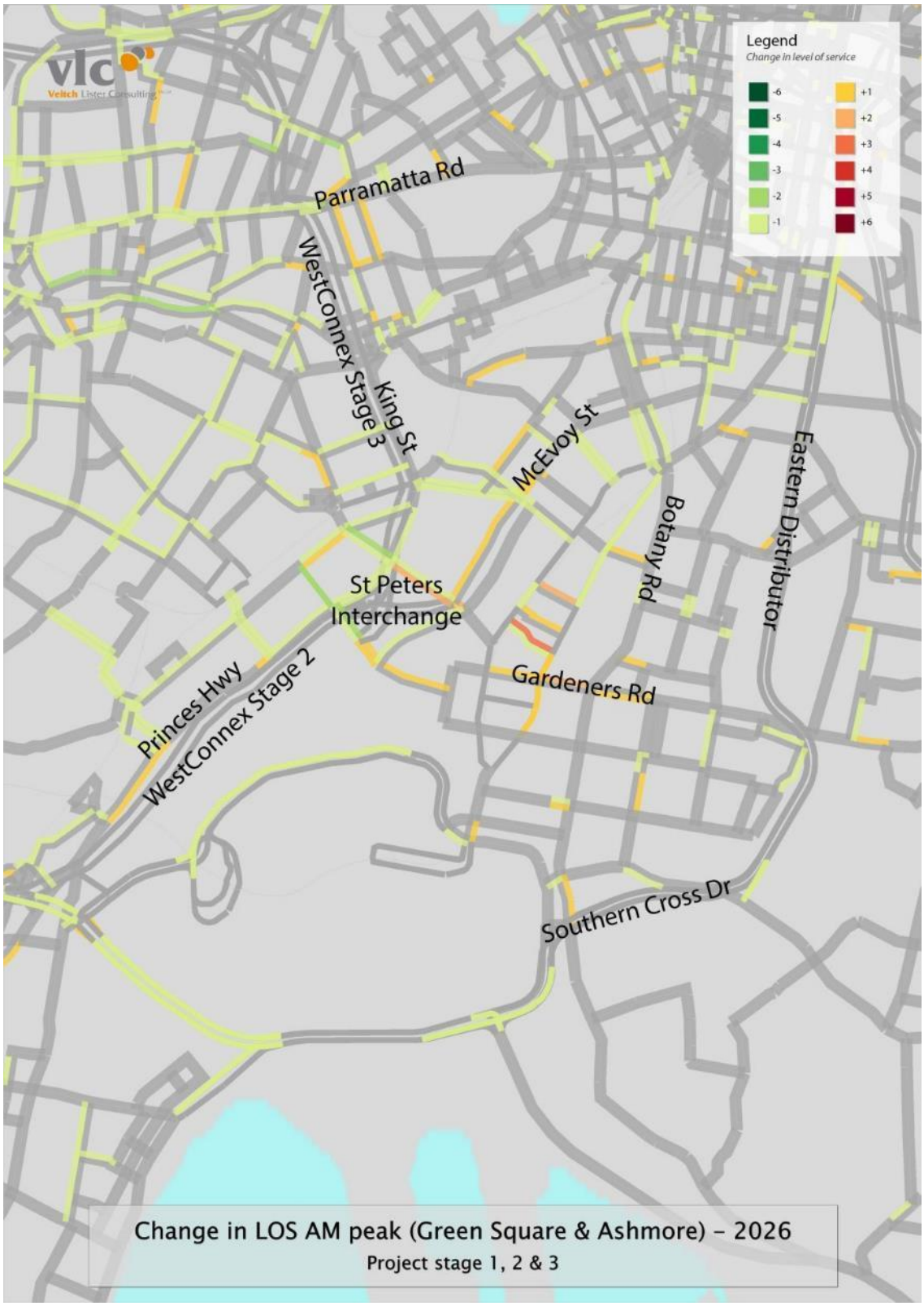
The Green Square urban renewal area will also see an increase in traffic in some areas. The increase is especially pronounced prior to the construction of Stage 3, as visible in the map overleaf. Roads which have their level of service improved (e.g. from B to A) are coloured in green, while roads where the level of service gets worse (e.g. from B to C) are coloured in yellow and red.

FIGURE 30 CHANGE IN LOS 2026 (STAGE 1 &2 VS BASE)



Source: Veitch Lister Consulting

FIGURE 31 CHANGE IN LOS 2026 (STAGE 1, 2 & 3 VS BASE)



Source: Veitch Lister Consulting

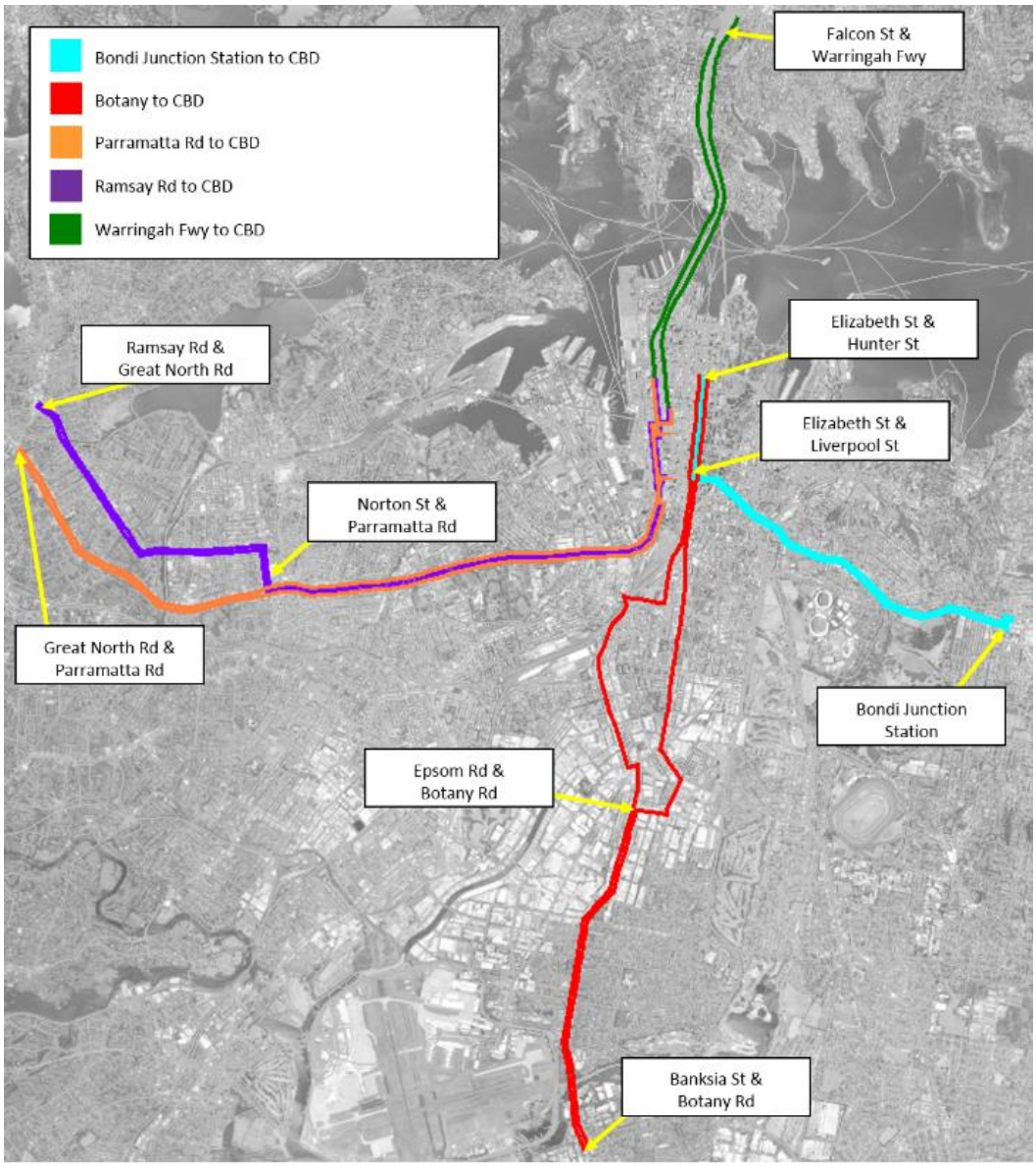
3.5 Impact on public transport

WestConnex is intended to improve public transport travel times. The modelling shows improvements, but they are minor.

Change in travel times on bus routes

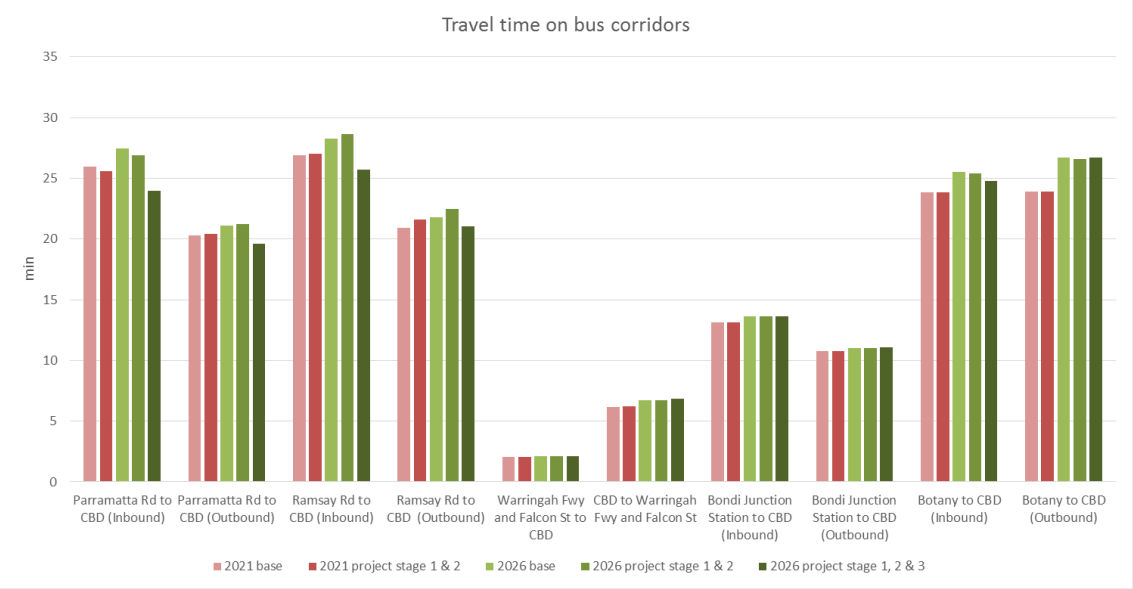
In order to understand the effect of WestConnex on the local network, travel times along some bus corridors were examined. Figure 32 shows the bus routes analysed for this purpose, while the travel times in the AM peak hours are plotted in Figure 33 for each scenario. In general no major changes are expected, and delays will be contained within one minute. The corridor from Ramsay Road to the CBD will experience a small improvement (contained within 5 minutes) due to the decongestion of the M4.

FIGURE 32 TRAVEL TIME ASSESSMENT – BUS CORRIDORS



Source: Veitch Lister Consulting

FIGURE 33 TRAVEL TIME ALONG BUS CORRIDORS



Source: Veitch Lister Consulting

3.6 Impact on commercial vehicles

Some of Sydney's roads will see a decrease in commercial vehicle traffic while other roads will see an increase.

Figure 34 and Figure 35 show the origins and the routes used by commercial vehicles using WestConnex. As expected the main commercial vehicle generators are the port and the airport, but a significant number of commercial vehicles are also produced by the CBD.

When only Stages 1 and 2 are operational (Figure 34), some trucks travel north-south on the M7 and on King Georges Road, accessing WestConnex for east-west connections. When Stage 3 is completed, the M7 and King Georges Road see a reduction in commercial vehicle volumes travelling to the completed WestConnex, with WestConnex Stage 3 providing an additional north-south connection. In factWestConnex Stage 3 provides more direct access to the port and airport for those trips originating north of the M4.

Figure 36 and Figure 37 (two pages over) illustrate the patterns of commercial vehicle travel after Stages 1 and 2; and after Stage 3. The patterns are similar to that described in the previous section. In both cases the main diversion is from the M4 to Parramatta Road and other local roads.

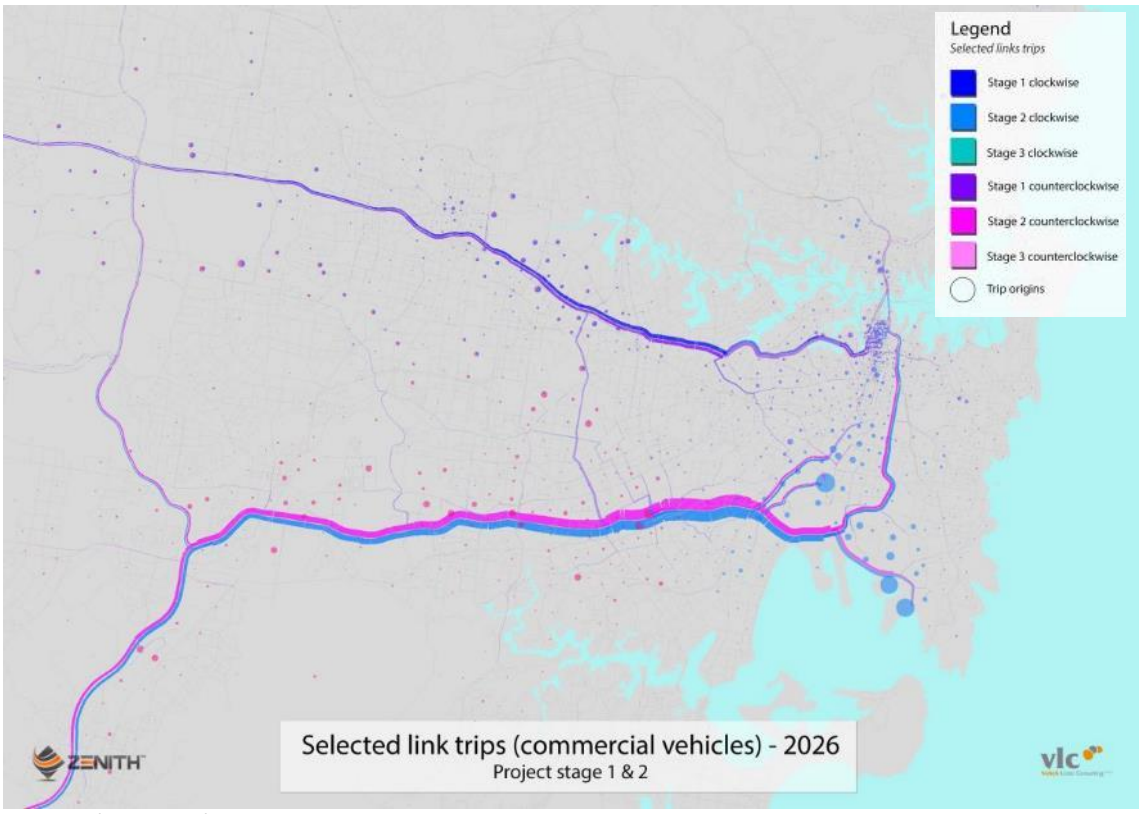
A reduction in commercial vehicles is observed on King Georges Road (up to 22 per cent and 32 per cent when Stage 3 is completed) and on General Holmes Drive (about 11 per cent and up to 17 per cent when Stage 3 is completed). ANZAC Bridge has a very small increase in commercial vehicle volumes when only Stages 1 and 2 are operational, but it reaches a 30 per cent increase with completion of Stage 3.

The green numbers on the map indicate increases in commercial vehicle traffic. Along Parramatta Road the increases[16] are as much as 53per cent after Stage 3, due to the impact of tolling.

Red numbers indicate the completion of WestConnex will reduce commercial vehicle traffic. This effect is prevalent across southern Sydney, with a maximum decrease of 44 per cent in Petersham predicted by the model.

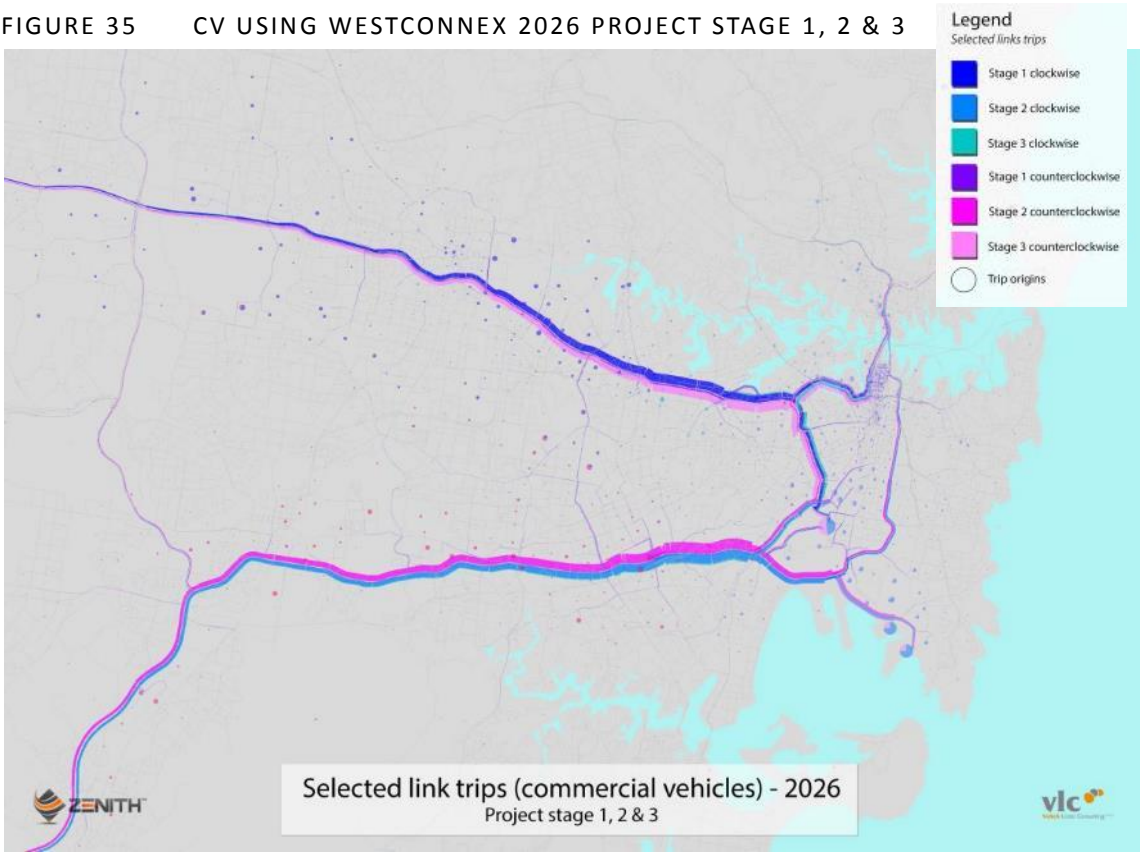
[16] This is consistent with the M4 Widening EIS.

FIGURE 34 CV USING WESTCONNEX 2026 PROJECT STAGE 1 & 2



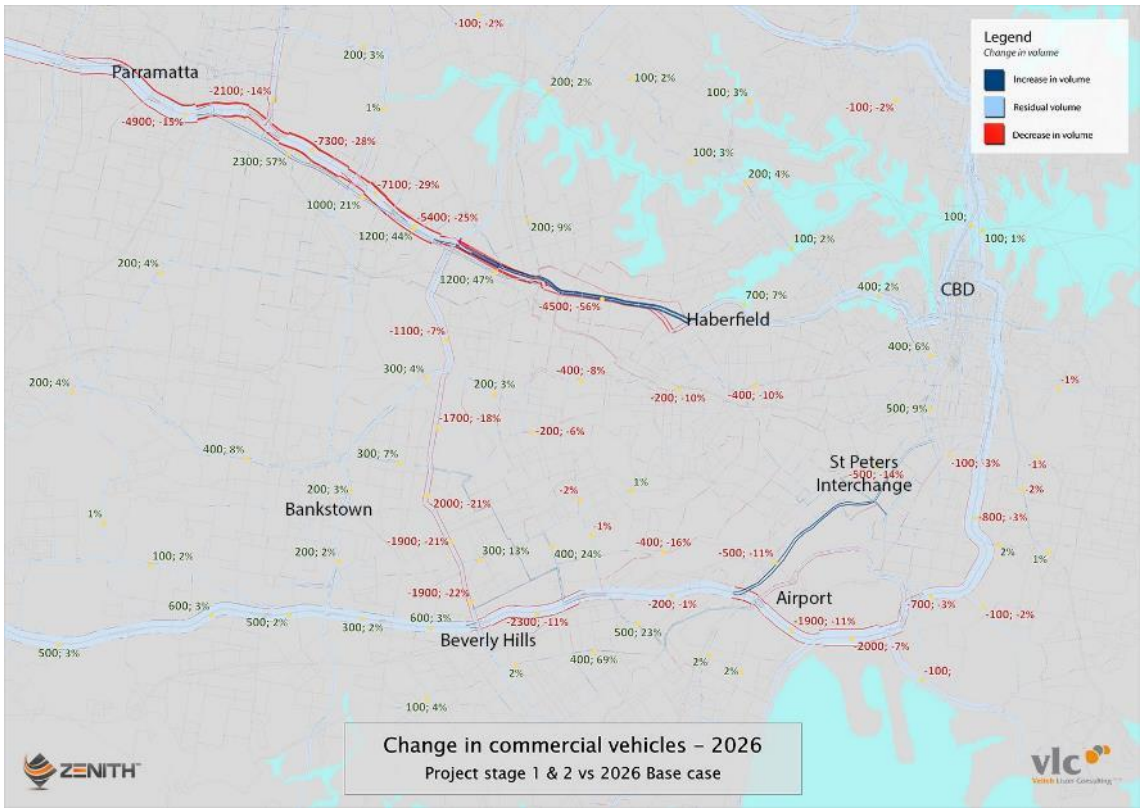
Source: Veitch Lister Consulting

FIGURE 35 CV USING WESTCONNEX 2026 PROJECT STAGE 1, 2 & 3



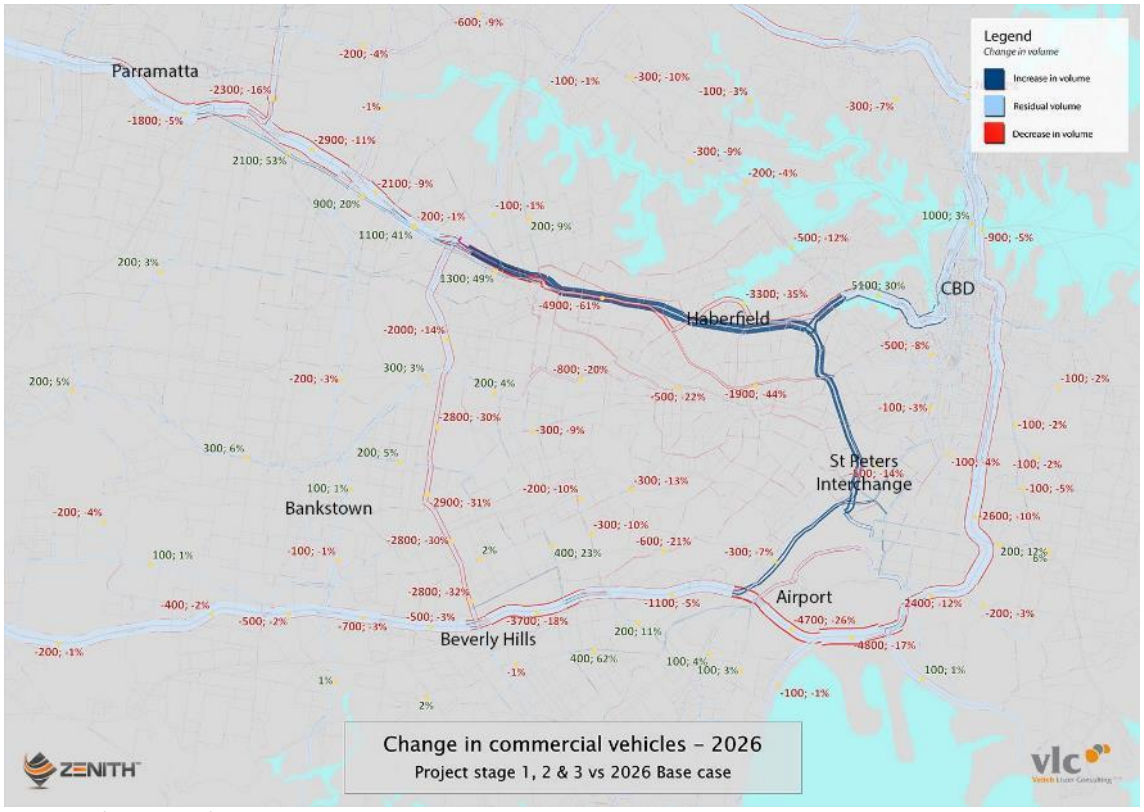
Source: Veitch Lister Consulting

FIGURE 36 CHANGE IN COMMERCIAL VEHICLES 2026 (STAGE 1 & 2 VS BASE)



Source: Veitch Lister Consulting

FIGURE 37 CHANGE IN COMMERCIAL VEHICLES 2026 (WESTCONNEX VS BASE)



Source: Veitch Lister Consulting

4 THE MODEL

The transport model – Zenith - is based on standard employment and population projections compiled by the Bureau of Transport Statistics.

The Zenith model was first established in 1988 and is a mature travel demand modelling facility that is frequently used in major projects ranging from metropolitan or regional-wide infrastructure projects to local area problems and solutions.

Zenith has produced travel demand forecasts for many major transport infrastructure projects across Australia. In NSW Zenith has undertaken modelling work for major transport projects including:

- Cross-City Tunnel (provision of expert services in legal proceedings),
- M5 Motorway (for a toll road operator),
- Lane Cove Tunnel (forecasting demand post opening for ABN Amro),
- Sydney Metro (as part of submission to Infrastructure Australia).

Other major projects include:

- East West Link Toll Road (for Victorian Government),
- Melbourne Metro Project (for submission to Infrastructure Australia),
- CityLink Toll Road (for Victorian Government),
- EastLink Toll Road (for Victorian Government).

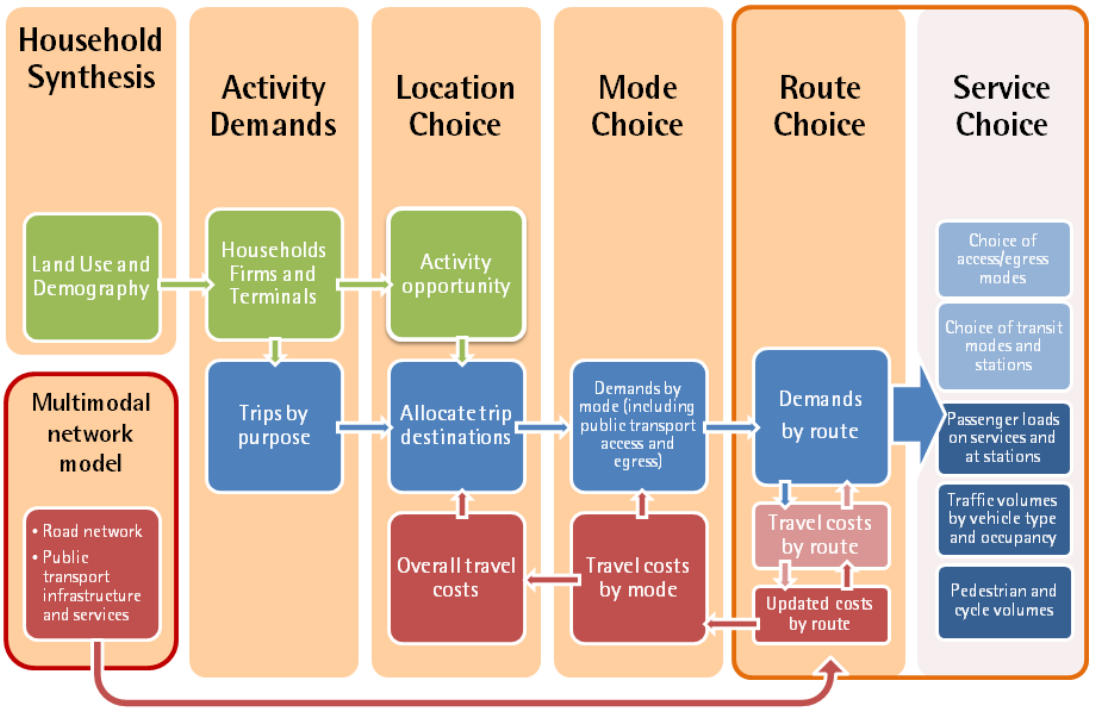
The following subsection provides an overview of Zenith. More information can be obtained from: http://www.veitchlister.com.au/zenith/overview.

Model architecture

The prime objective of Zenith is to provide a planning tool to support the evolving policy issues of relevance to planners and government. This is accomplished through replicating the demand for travel by residents and visitors in the Sydney region, which is derived from the demand for participation in activities. Travel choices may differ depending on the activity for which the travel is undertaken. The nature of the activity may influence the frequency, timing and duration of participation, the location, as well as the mode of travel and in some cases, the route chosen.

The Zenith travel demand model simulates the travel behaviour of households, businesses and visitors within the Sydney region associated with their participation in the range of activities described above. The model makes use of information that is available to describe the potential demands for these activities in each location, such as statistics on employment in various industries, enrolments at educational facilities, and demographic variables such as population and households. The key stages of the Zenith model process are illustrated in Figure 38.

FIGURE 38 KEY STAGES OF THE ZENITH MODELS



Source: Veitch Lister Consulting

The model works by dividing each region into several thousand travel zones, providing a high degree of resolution for forecasting movements between suburbs and across the city. A large range of demographic, socioeconomic and land use variables are used to identify the types of households and range of activities in each zone.

The model forecasts the number of trips made for work, education, shopping, personal business, recreation, social and "other" journey purposes (why travel?). It simulates the decisions made by households regarding the time period (when?), destination (where?) and mode of travel (how?) for each trip, with models developed from surveys of travel behaviour undertaken in each region.
Having determined the destination and mode of travel, the model then reflects the choice of route for trips by private or commercial vehicle, public transport and active travel modes such as cycling and walking.

Transport models are useful planning tools, but travel demand forecasting is not a precise science, and there are numerous outside factors which are difficult to predict or quantify. Changes in government policy, for example, occur on a regular basis and can affect modelled outcomes.

Other major assumptions, in particular fuel costs, can also prove difficult to foresee. Various factors impact the petrol price paid by motorists at the pump, including the Australian dollar exchange rate and perceptions of potential oil supply[17]. In both examples, a transport model is the ideal tool for testing the sensitivity of future travel demand to these exogenous factors, mitigating the level of uncertainty around modelled forecasts.

Multimodal transport network

The Zenith model makes use of a single integrated multimodal transport network using this object-oriented architecture, where certain attributes of each object may be differentiated by mode and period. Thus frequencies and schedule of public transport services and the speed or capacity available

[17] http://www.atrf.info/papers/2010/2010_gargett.pdf

for certain vehicles may be defined separately for each period. Buses or goods vehicles may travel on the same section of road as cars, but with different average speeds and, where separate right-of-way is provided, can be assigned separate capacities. Walking and cycling is also possible on links which do not preclude access. In general, rail infrastructure and specific public transport right-of-way is only available to public transport services.

Services may be defined by operator, line group, or any other characteristic of interest in the model. Travel times for public transport services may be derived from the speed attributed to the underlying infrastructure or by definition of timetables, and can be subject to delays due to congestion or crowding. The current version of the Zenith model defines service times from the average operating speed on each link.

Strategic model limitations

Transport models are useful planning tools, but travel demand forecasting is not a precise science, and there are numerous exogenous factors which are difficult to predict or quantify. Changes in government policy, for example, occur on a regular basis and can affect modelled outcomes.

With respect to WestConnex, numerous policy changes were announced by the NSW Government. For instance, in December 2014, the NSW Plan for Growing Sydney was released, the alignment of WestConnex Stage 3 was adjusted, and the Western Harbour Tunnel was announced. Other major assumptions, in particular fuel costs, can also prove difficult to foresee. Various factors impact the petrol price paid by motorists at the pump, including the Australian dollar exchange rate and perceptions of potential oil supply (Gargett 2010). In both examples, a transport model is the ideal tool for testing the sensitivity of future travel demand to exogenous factors and mitigating the level of uncertainty.

There are also, however, some uncertainties which transport models are less equipped to address. One example relates to recent travel behaviour observations among industrialised populations. Millard-Bell and Schipper (2011) examined the relationship between motorised passenger kilometres and GDP growth, and found that kilometres travelled had begun to slow relative to GDP. The authors do not speculate as to whether this is likely a temporary plateau or might be indicative of a more permanent shift in travel behaviours, but this trend would represent a divergence from past trends observed in travel surveys used to calibrate the travel model. Similarly, analysis by Kuhnimof et al. (2012) suggests that younger populations in many developed economies are driving less than previous generations. The authors found that in some countries (France, Japan and the United States) the net impact was an overall reduction in travel, while in others (Great Britain and Germany) the reduction in car use was offset by increased take-up of alternative modes such as cycling and public transport. In both cases, assumptions would need to be made as to whether such trends are likely to continue, and if so how significant these trends might be.

Emerging technologies, such as driverless cars, represent a further element of uncertainty in transport modelling. Potential changes to transport networks and travel behaviours include:

- Higher highway capacities due to vehicle positioning systems facilitating the more efficient use of existing infrastructure, as well as fewer traffic incidents and disruptions
- Decoupling of cars with drivers, leading to reduced demand for parking and lessening of parking charges as a car use disincentive
- Reduced disutility of travel due to ability to use travel time mode productively, with flow on impacts to land uses and potential generation of induced travel demand
- Enhanced mobility for historically less mobile segments of the population, such as younger and older people
- Lower vehicle ownership rates, making car ownership a weaker predictor of mode choice
- Higher fuel efficiency due to improved vehicle operations

Clearly, driverless cars have the potential to impact on the transport model assumptions at a number of levels, as well as the functioning of cities on the whole. Existing transport modelling frameworks are

unlikely to enable capture of the full suite of changes that might arise from automated vehicles. There is, however, currently an enormous amount of uncertainty around driverless car technology, including the level of vehicle automation that might eventuate and the likely timeframes for widespread uptake (Childress et al. 2014). The impact of driverless cars on future travel demand will likely be heavily contingent on such considerations and, as a result, are currently difficult to estimate.

Small volume roads

Strategic travel models are useful tools to forecast vehicle and people movements across the transport network through freeways, arterial and sub-arterial roads and major public transport infrastructure. Traffic volumes forecast on collectors, local roads and access streets, instead, should be treated with caution.

In a strategic model the traffic volumes on local roads heavily depend on the adopted zone system and on where centroids are connected to the network. Large travel zones will have higher intra-zonal trips that don't get assigned to the network, resulting in lower volumes and a possible under-representation of the real traffic volume. A more disaggregate travel zone system provides a much more realistic view of the access to and from local access streets – although until such time as the model can simulate each household/business individually, the volumes on these lower order roads should be treated with caution.

5 CONCLUSION

In the future Sydney will be a bigger, busier and more crowded city. The metropolis is projected to grow to accommodate around 6.2 million people by 2031, and 8.5 million by 2061. Traffic volumes will have grown, and the congestion clogging Sydney will have worsened. WestConnex is a series of projects designed to upgrade and link two existing motorways in Sydney's south west (the M5) and west (the M4). The combined cost of the project is $15 billion. However, Sydney's traffic congestion will worsen with or without WestConnex, with the project making only minor differences to Sydney's traffic.

Sydney's road network will experience significant capacity constraints by 2026. The modelling confirms the WestConnex proposal will not improve access to the Sydney CBD. Like other parts of the Global Economic Corridor, the CBD is already congested and has little parking available.

Traffic flows on parts of Parramatta Road will increase by over 20 per cent as vehicles avoid paying the toll on the M4 and M4 eastern extension. This finding is consistent with the WestConnex Delivery Authority's own assessment presented in the M4 Widening Environmental Impact Statement and with the traffic flow impacts observed when the M4 toll was removed in 2010. Parramatta Road will take more traffic in the future, not less. Traffic growth on Parramatta Road will clearly jeopardise the government's planned urban renewal and population growth along this corridor.

The M5 East will, despite the completion of the New M5, remain the preferred route connecting to airport, port and the city. The New M5 will not provide a more attractive route to these key destinations and will not relieve congestion on the M5 East. Traffic volumes on the M5 East will continue to increase by up to 25 per cent, leading to increased congestion and peak spreading.

The traffic from the New M5 will flow into the St Peters area via an interchange on the site of the Alexandria landfill. By 2021 over 31,000 vehicles a day will be using this interchange, increasing to over 55,000 vehicles by 2041. These vehicles will flow onto the local road network, impacting on residential and commercial areas, and increasing congestion in the CBD-airport corridor. This will impact the viability of urban renewal areas such as Green Square and Ashmore, reducing future housing potential.

The modelling contained within this report has provided a better understanding of the impacts relating to WestConnex. It has also raised areas for further investigation. The northern extension (including the Western Harbour Tunnel) and southern extension to WestConnex are vital for generating traffic for WestConnex Stage 3 but are currently outside the $15 billion price tag. As such, the WestConnex project potentially locks Sydney into a series of large scale road projects. Should the costs as well as the benefits of these extensions be attributed to WestConnex? Or would they been financed separately from first three stages of WestConnex, with the benefits similarly excluded?

From available information, Stage 1 is initially funded by government and then sold to finance Stage 2 and 3. However, more recent announcements have indicated Stages 1 and 2 are to be delivered concurrently. The length of time government holds and operates WestConnex, the concessions (tolls and length) for a private operator and the private sectors appetite for risk will determine if WestConnex is a value for money investment for NSW.

The role that tolls on existing roads can play in managing future Sydney's traffic demand should be evaluated. The introduction of pricing mechanisms was included as part of the NSW Long Term Transport Master Plan. Congestion pricing uses tolls to alter demand and has been shown to substantially affect behaviour and reduce traffic congestion. Rather than increasing road capacity by building new road infrastructure, can congestion on the existing network be better managed through price mechanisms?

APPENDIX

5.1 WestConnex infrastructure

WestConnex will link the M4 to the M5 and will be built in three stages:

- Stage 1 (Figure 40), this stage includes the M4 widening from Church Street and the M4 extension to Annandale with on and off ramps at Wattle Street.
- Stage 2 (Figure 41), this stage includes the widening of the M5 east tunnel and a link from the M5 to Campbell Road (Green Square and Ashmore precincts). It will also include the upgrade of Campbell Rd and Euston Road, and a new bridge across Alexandra canal connecting Campbell Road with Bourke Road.
- Stage 3 (Figure 42), this stage will connect Stages 1 and 2. The main access points to the existing network will be via Canal Road (Green Square) and City West Link (Annandale and surrounding suburbs).

FIGURE 39 WESTCONNEX

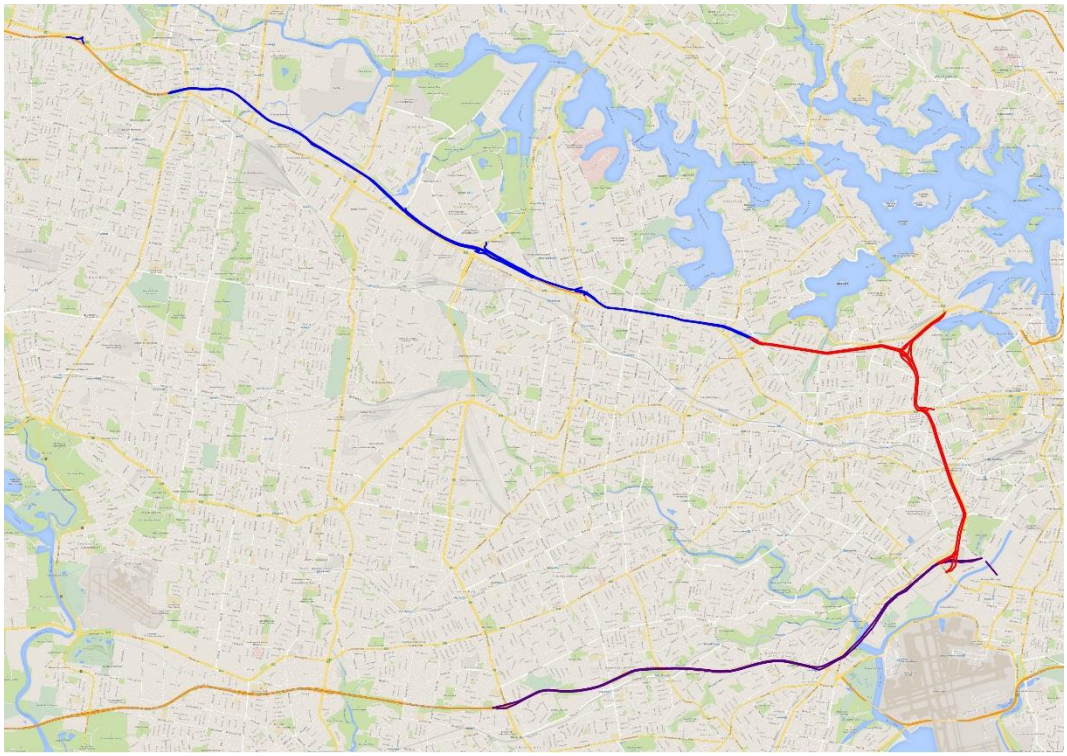


FIGURE 40 WESTCONNEX STAGE 1

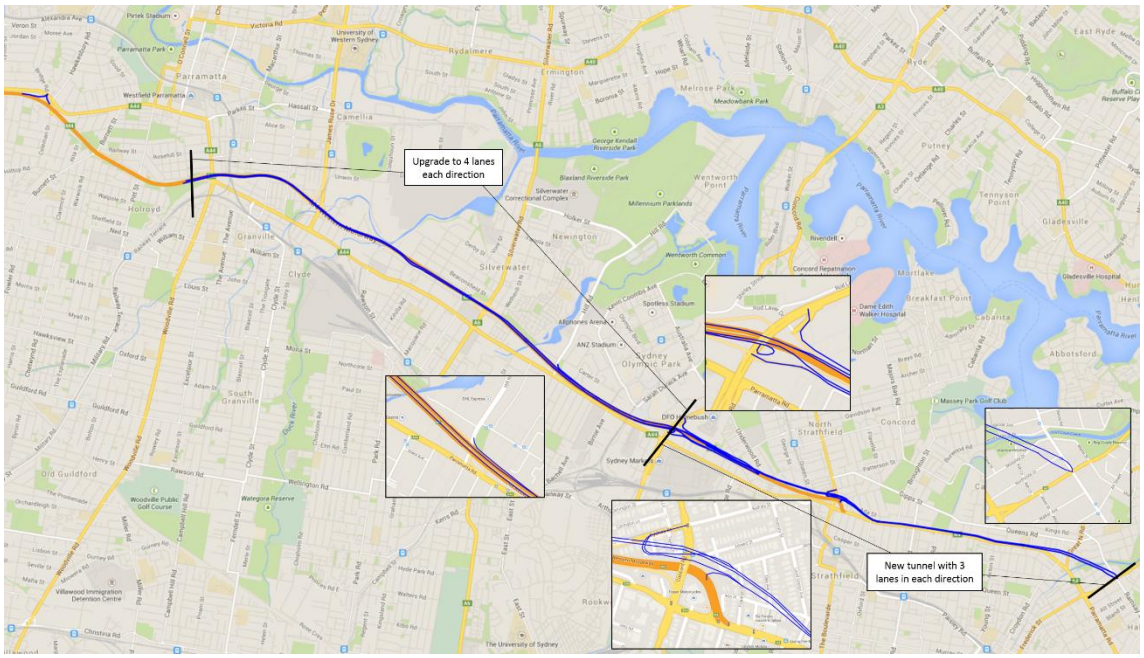


FIGURE 41 WESTCONNEX STAGE 2

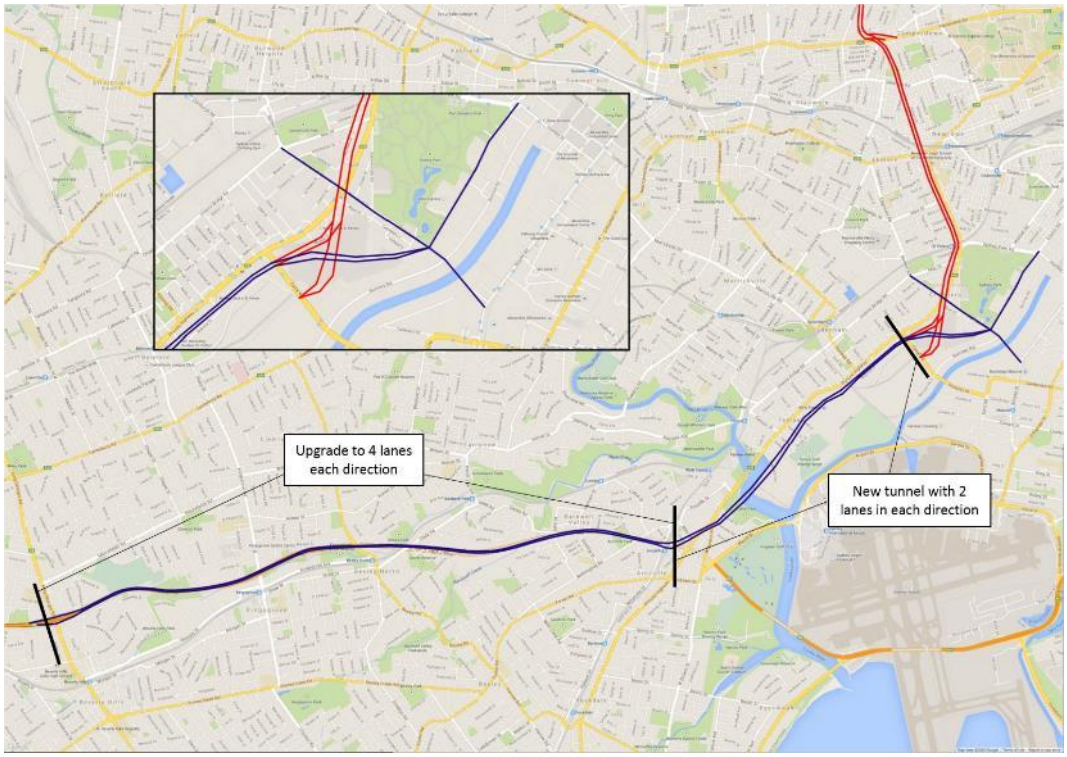
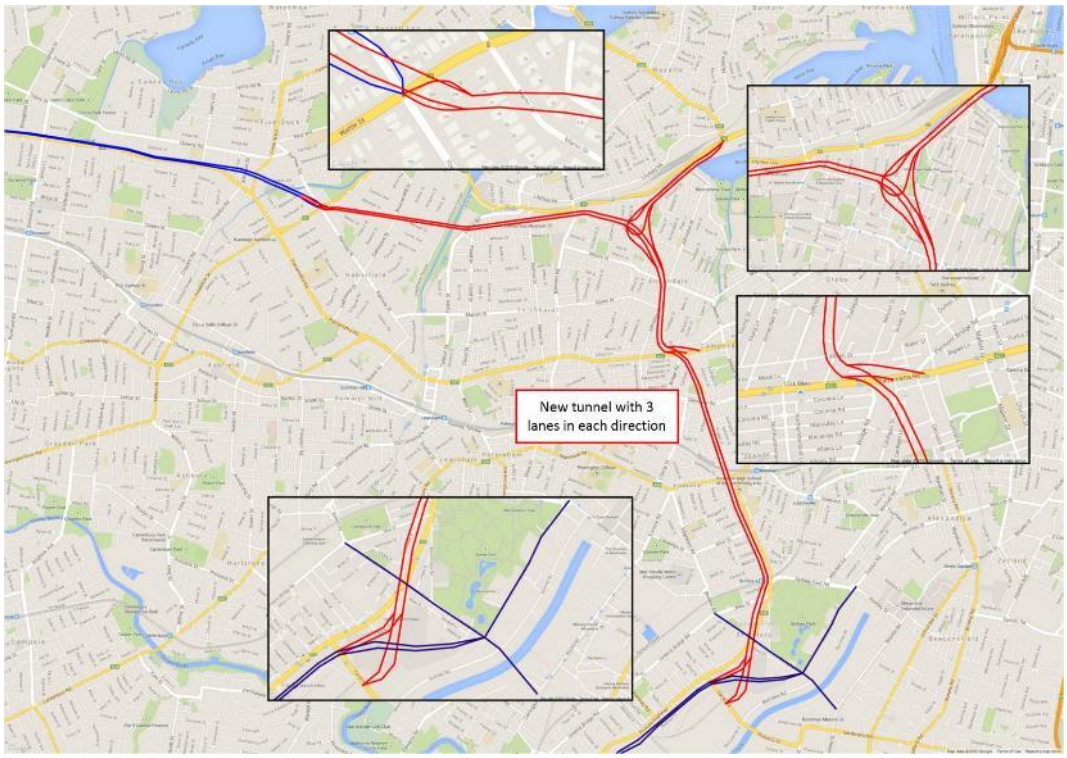


FIGURE 42 WESTCONNEX STAGE 3



5.2 WestConnex Tolling Points

In Figure 43 to Figure 45 the WestConnex alignment and tolled sections are shown.

FIGURE 43 WESTCONNEX ALIGNMENT

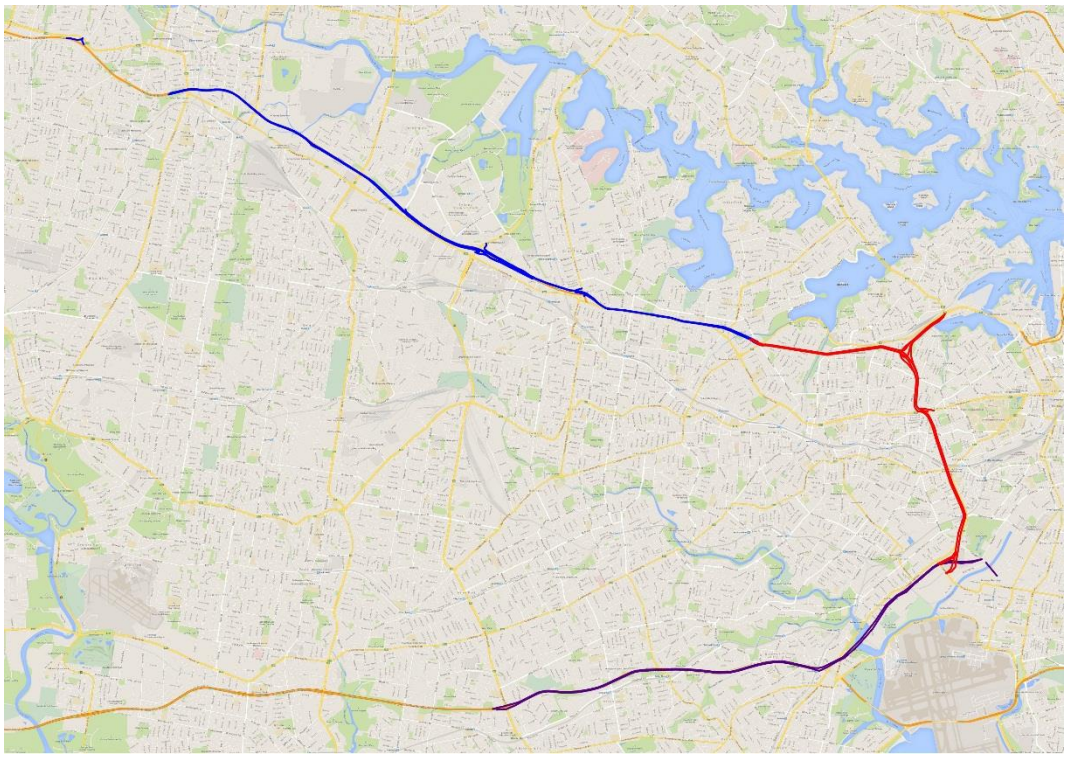


FIGURE 44 WESTCONNEX STAGE 1 ALIGNMENT AND TOLLED SECTIONS

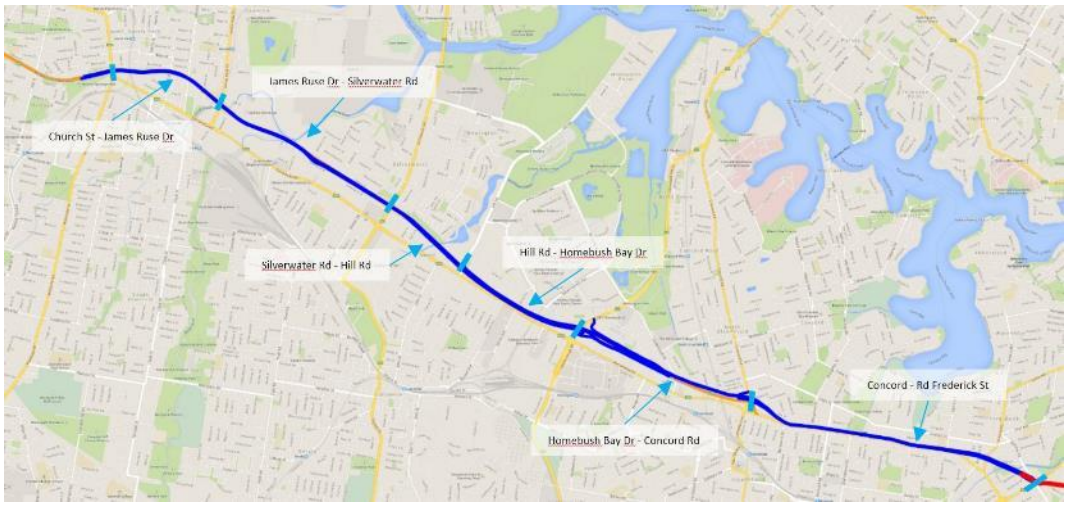


FIGURE 45 WESTCONNEX STAGE 3 ALIGNMENT AND TOLLED SECTIONS

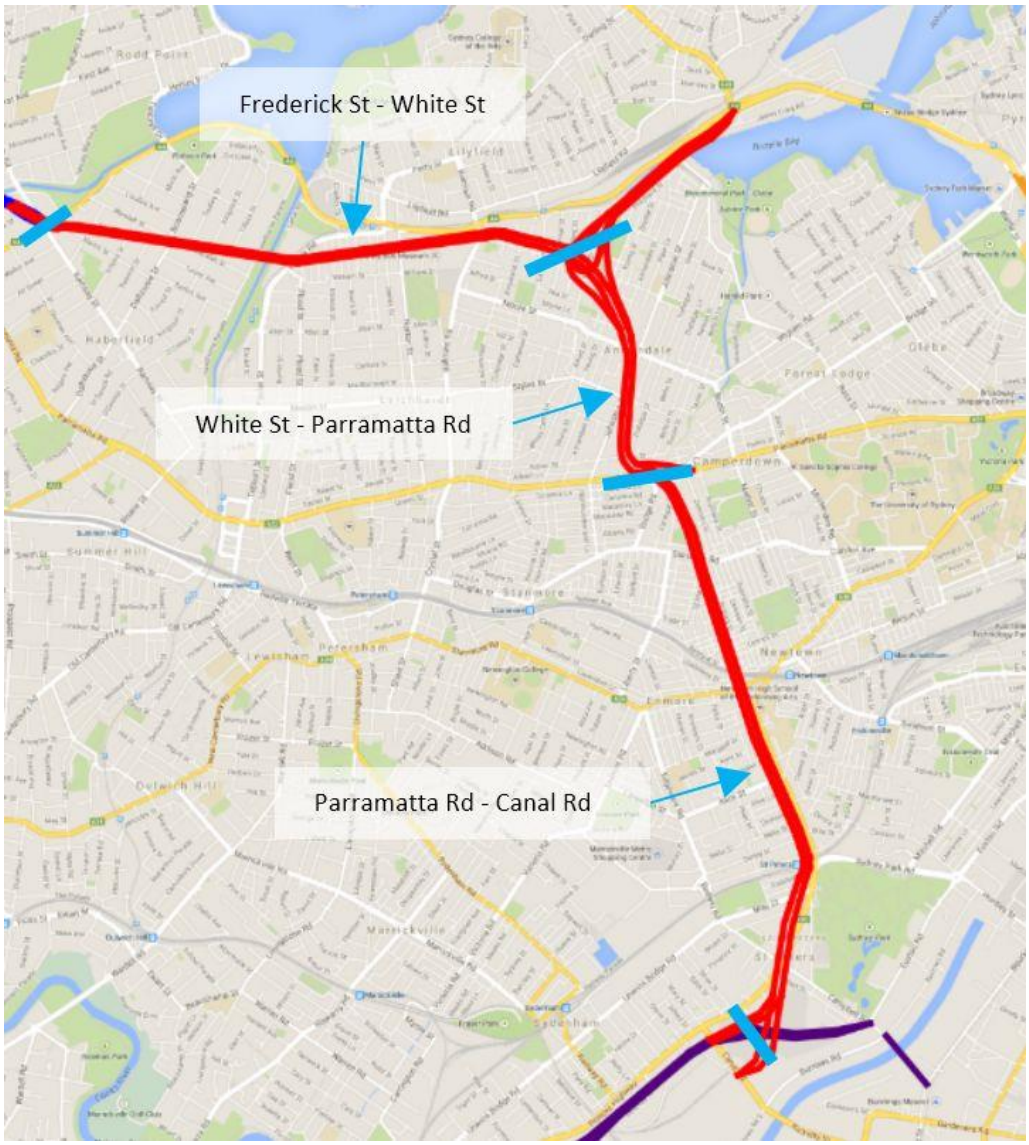


FIGURE 46 WESTCONNEX STAGE 2 ALIGNMENT AND TOLLED SECTIONS

5.3 Detailed Traffic Volumes

The forecast daily traffic volumes for the 2021 and 2026 horizons for the base and project scenarios are captured in Figure 47 to Figure 51.

FIGURE 47 TRAFFIC VOLUMES 2021 (BASE CASE)

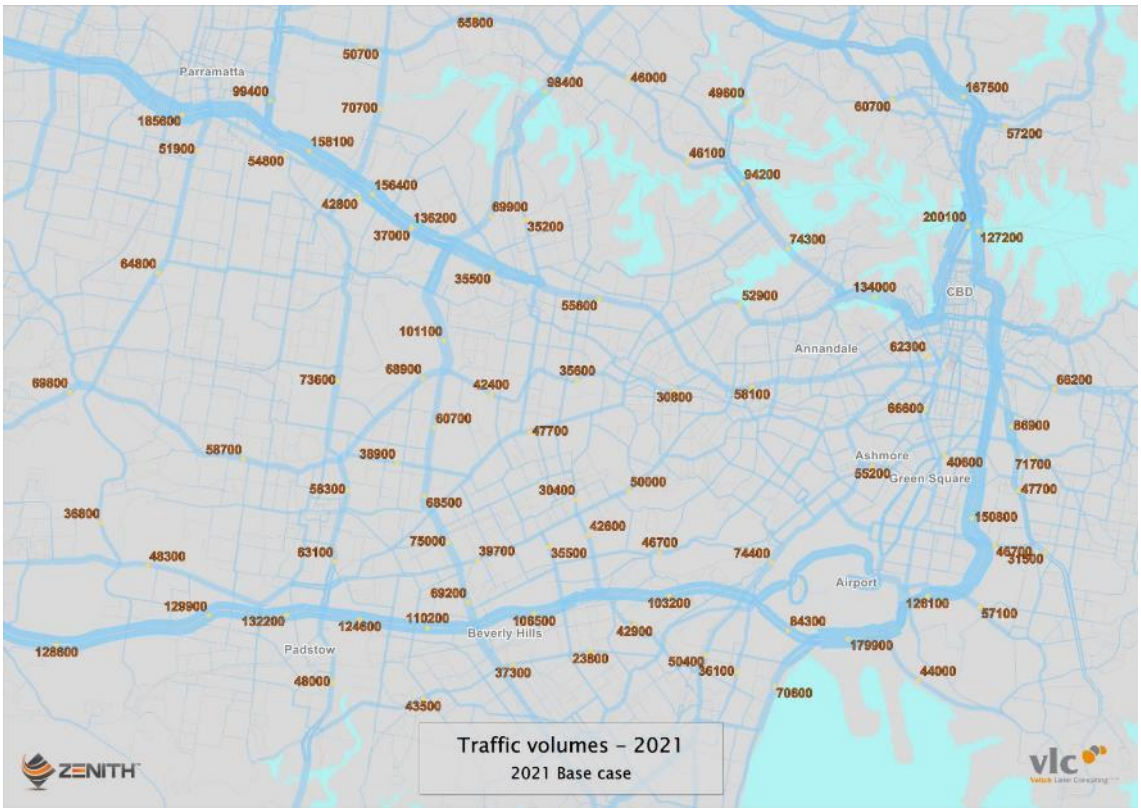


FIGURE 48 TRAFFIC VOLUMES 2021 (PROJECT STAGE 1 & 2)

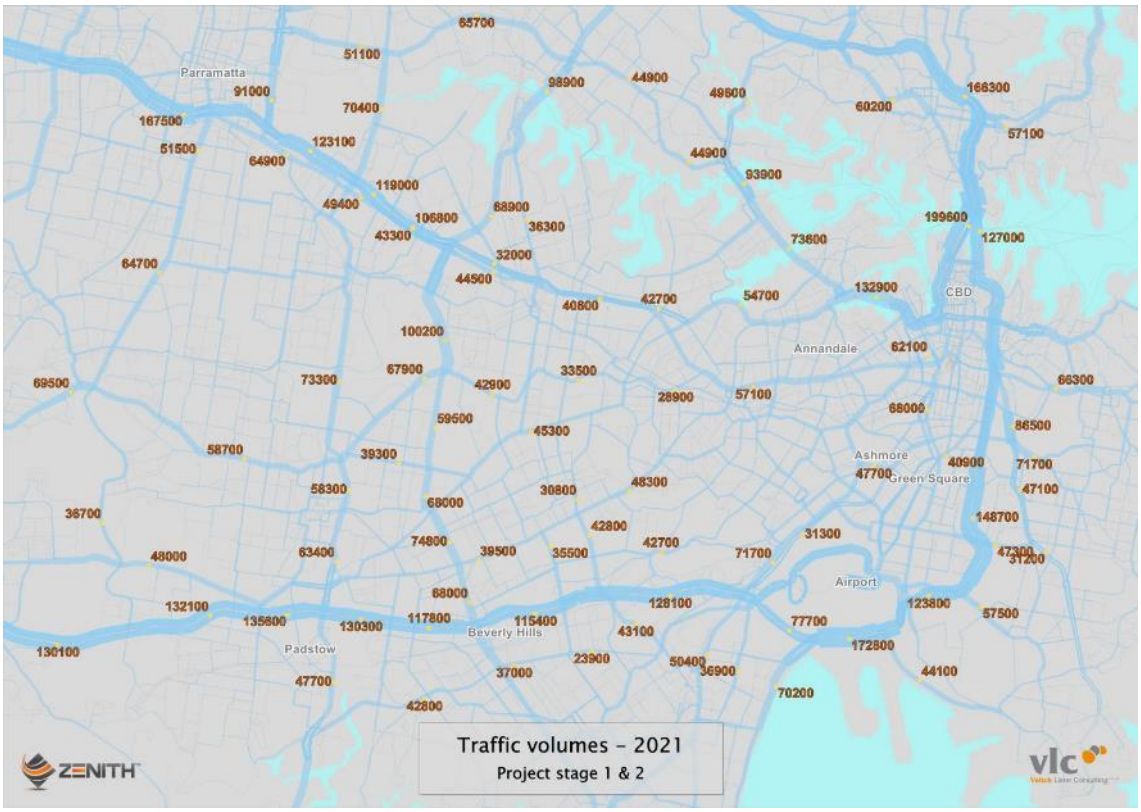


FIGURE 49 TRAFFIC VOLUMES 2026 (BASE CASE)

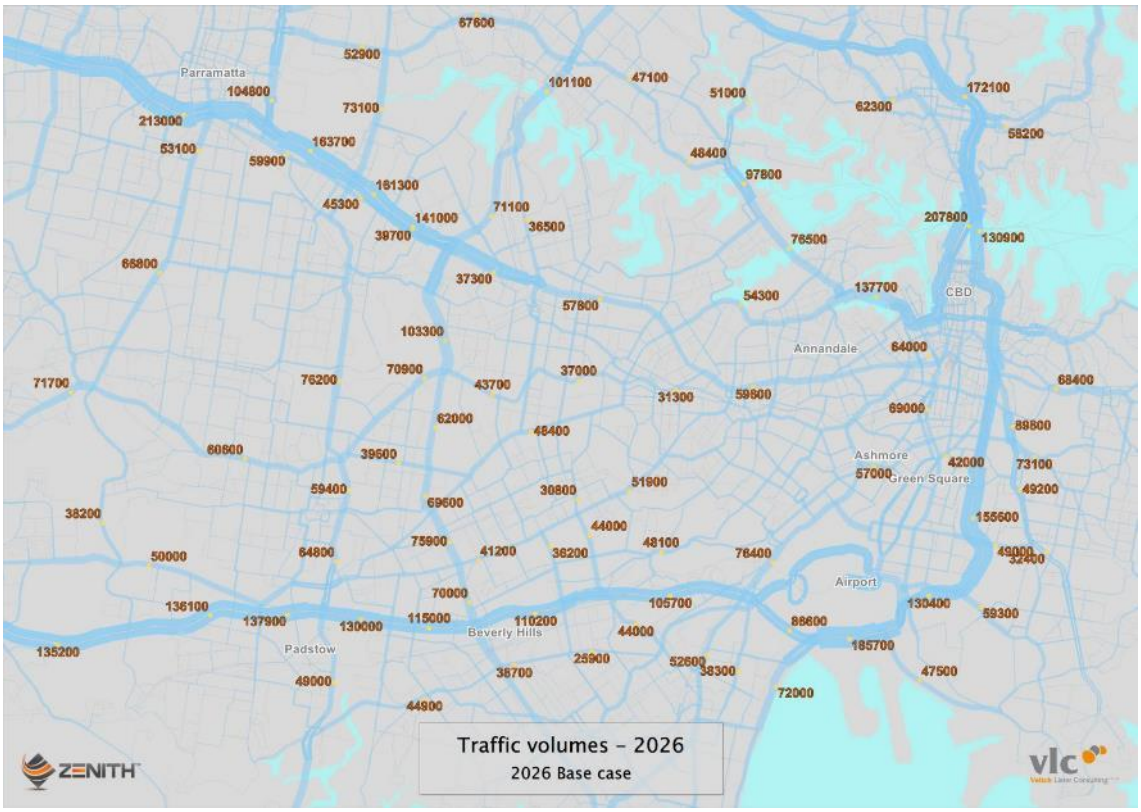


FIGURE 50 TRAFFIC VOLUMES 2026 (PROJECT STAGE 1 & 2)

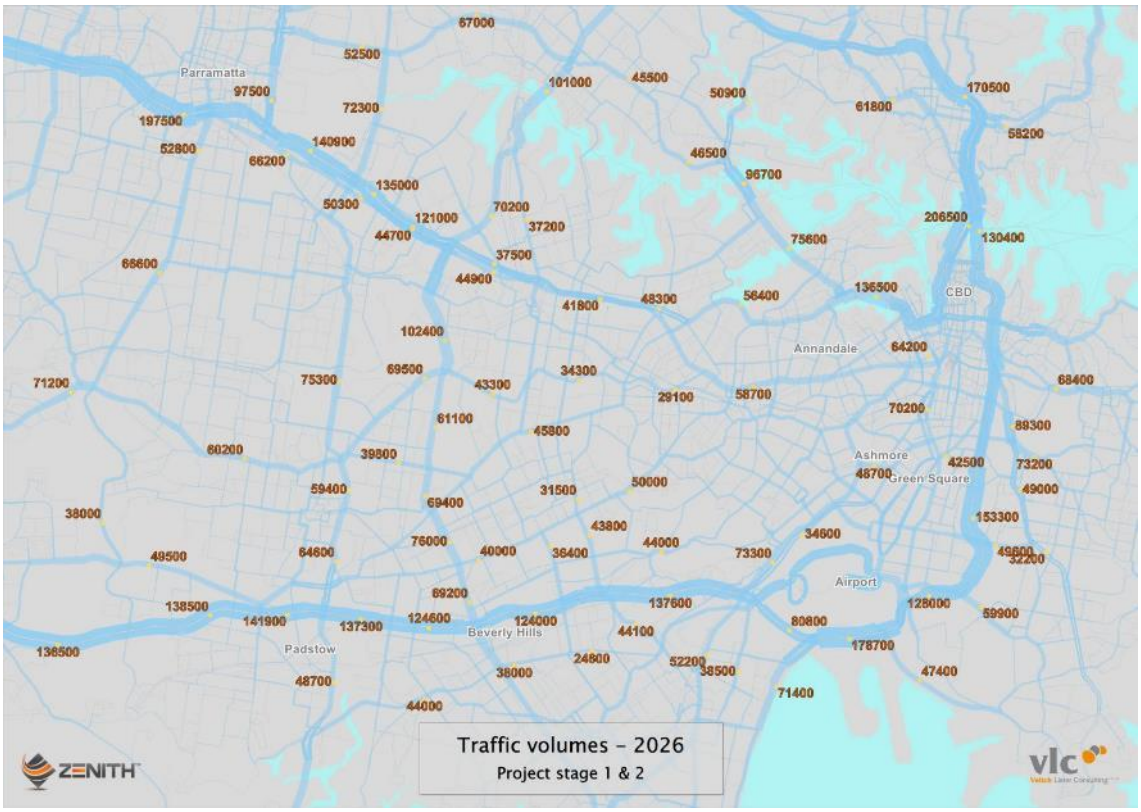


FIGURE 51 TRAFFIC VOLUMES 2026 (PROJECT STAGE 1, 2 & 3)

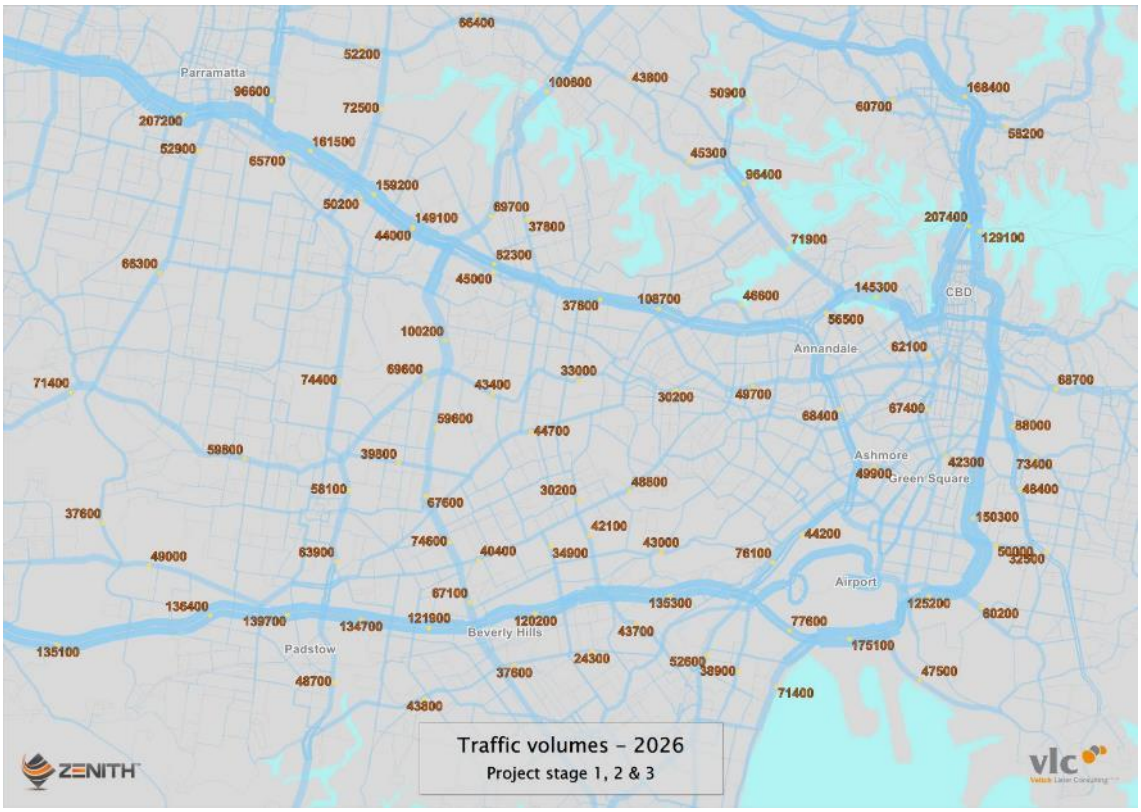
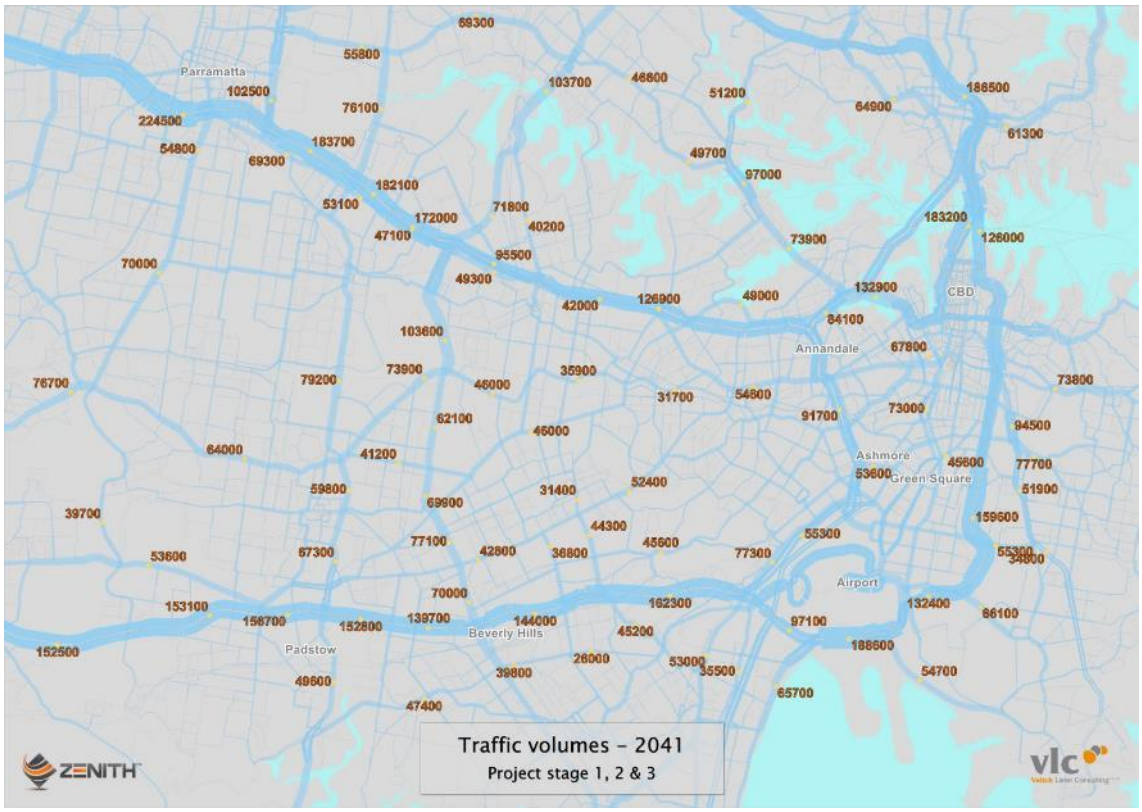


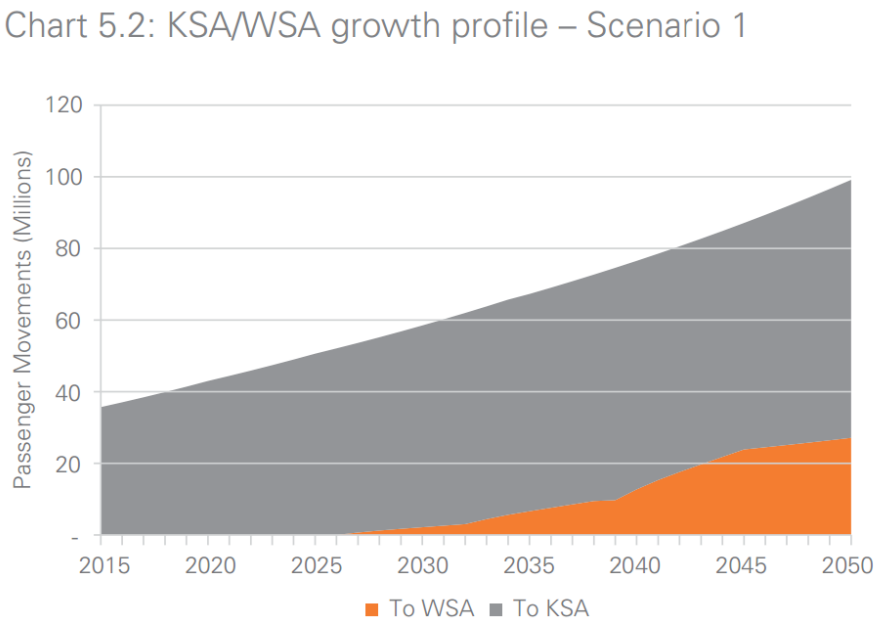
FIGURE 52 TRAFFIC VOLUMES 2041 (PROJECT STAGE 1, 2 & 3)



5.4 Airport forecasts

Airport forecasts have been taken from the Deloitte Access Economics report “Economic impact of a Western Sydney Airport”

FIGURE 53 TRAFFIC AT KINGFORD SYDNEY & WESTERN SYDNEY AIRPORT



Source: DAE analysis.

The breakdown into the Zenith airport category for KSA has been done using existing forecasts used to run the Zenith model. The breakdown into the Zenith airport category for WSA has been done using the data available from the Deloitte's report. 2030 figures have been used for the 2026 forecasts and 2040 figures have been used for the 2041 forecasts.

TABLE 16 PASSENGER TYPE AT WESTERN SYDNEY AIRPORT

Passenger movements - Scenarios 1

Table A.1: Passenger movement projections (thousands p.a.) – Scenario 1

	Domestic		International		
Year	Business	Leisure	Business	Leisure	TOTAL
2015	-	-	-	-	-
2020	-	-	-	-	-
2025	-	-	-	-	-
2030	298	1,835	-	-	2,133
2035	595	5,004	124	881	6,605
2040	1,142	8,991	334	2,242	12,709
2045	2,501	16,037	725	4,579	23,843
2050	2,803	18,129	862	5,290	27,085

Source: DAE analysis.

Table A.3: WSA passenger composition – Scenario 1

	Domestic		International		
Year	Business	Leisure	Business	Leisure	TOTAL
2015	-	-	-	-	-
2020	-	-	-	-	-
2025	-	-	-	-	-
2030	14.0%	86.0%	-	-	100%
2035	9.0%	75.8%	1.9%	13.3%	100%
2040	9.0%	70.7%	2.6%	17.6%	100%
2045	10.5%	67.3%	3.0%	19.2%	100%
2050	10.4%	66.9%	3.2%	19.5%	100%

Source: DAE analysis.

TABLE 17 AIRPORT PASSENGERS PER YEAR

Airport	2021	2026	2041
KSA	43,000,000	52,000,000	78,000,000
WSA	-	1,000,000	12,709,000

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