greater WELLINGTON
REGIONAL COUNCIL

Ngauranga to Airport Modelling

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FOR FURTHER INFORMATION

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Contents

1. Overview

The Greater Wellington modelling team has been asked to undertake some modelling of individual road and PT schemes, and packages for the Ngauranga to Airport study. A number of runs were requested and the time frame was ambitious. There are caveats around this modelling that need to be considered when interpreting the results.

The schemes that have been coded as part of this project are the Greater Wellington modelling teams understanding of the projects and (given their limited involvement in the study to date) are likely to differ from the schemes modelled previously. This is particularly true of the PT schemes, where the reduction in road capacity due to buslane/busway implementation is less aggressive than previous modelling.

Due to the recent delivery of the model, output processes are now only being developed, and whilst every attempt has been made to ensure model outputs and benefits are correct, the processes have not been peer reviewed. In particular, the process of calculating benefits differs slightly from that previously used.

Given these caveats, these runs **cannot** be directly compared with the previous modelling for this project. However these runs can be used to develop broad themes around some of the schemes.

A brief comment about the Inner City Bypass

In modelling these options, it became apparent that the Inner City bypass along Vivian St (southbound) is a potential bottleneck reducing the effectiveness of the road schemes at either end. WTSM is **not** the right tool to look at these issues given its approximate modelling of intersections, but the capacity for Vivian St would need to be looked at in more detail; in particular focusing on signal timings and the use of the parking along the side of the streets. If further work is undertaken the findings from this could be represented in WTSM.

2. Modelled Project Summaries

The Greater Wellington modelling team has been asked to undertake modelling of individual road and PT schemes, and packages for the Ngauranga to Airport study. Constraints placed on this exercise require that caveats found in Section 1 of this document be noted in understanding this Study report.

The corridor schemes/packages examined in this modelling exercise are:

a) Terrace Tunnel Tidal Flow

b) Terrace Tunnel Duplication (4L)

c) WaterFront Minus 1 Lane Each Way

d) Ngauranga – Aotea Peak Directional 4L

e) Basin Reserve Grade Separation

f) Mount Victoria Tunnel & Ruahine St. Duplication

g) WaterFront PLUS Terrace Tunnel Duplication (c + b)

h) Ngauranga – Aotea PLUS Terrace Tunnel Duplication (d+b)

i) Road Package A (Tunnels): Nga-Aotea, Waterfront, Terrace Tunnel Dup, Basin Reserve, Mount Vic/Ruahine (d+c+b+e+f)

j) Buslanes

k) Busway

l) Road Package A (Tunnels) PLUS Buslanes (i+j)

m) Road Package A (Tunnels) PLUS Busway (i+k)

n) Road Package B (No Tunnels) PLUS Buslanes (d+e+j)

The central case assumes committed future schemes. We have also assumed that the northern branch of the ICBP has a similar capacity to the southern (in terms of vehicles/lane/hour). A lower capacity ICBP currently exists and would need to be tuned properly to have an efficient ring road.

Sensitivities to various assumptions were examined to determine impact on schemes and packages. The sensitivities examined include:

- 30% Fuel Price Increase
- Parking charge increase +30% for 2016 and +50% for 2026

The discussion presented here focuses on the 2016 future year modelling, with **significant** differences in 2026 mentioned. A more detailed discussion is provided in Appendix A.

a) Terrace Tunnel Tidal Flow

The Terrace Tunnel Tidal Flow changes the lane configuration on the Terrace Tunnel from 1SB:2NB to 2SB:1NB in the AM peak only. No speed changes have been assumed.

The Terrace Tunnel Tidal Flow option partially relieves the WaterFront route SB, but increases the flows on the WaterFront NB due to a reduction in capacity in the Terrace Tunnel NB. The two effects tend to cancel each other so there are no benefits.

b) Terrace Tunnel Duplication

The Terrace Tunnel Duplication changes the lane configuration from 1SB:2NB to 2SB:2NB in all time periods. The speed in the Terrace Tunnel SB (and link south) has been increased from 70km/h to 80km/h to be consistent with the previous coding. No changes have been assumed to the NB coding as there is no improvement to infrastructure.

The Terrace Tunnel Duplication increase speeds and flows SB through the Tunnel and partially relieves the WaterFront route SB flow, but has little impact NB.

This project generates $2.3M in benefits ($3.4M in 2026), primarily as a result of travel time improvements.

c) WaterFront Lane Reduction (minus 1 lane each way)

The WaterFront Lane Reduction removes a lane between Bunny St and Taranaki St in all time periods. Further, the intersection capacities at each of the intersections have been reduced by 1/3 to reflect the lower capacity. There are no Terrace Tunnel improvements in this option.

Removing 1 lane in each direction between Bunny St and Taranaki St reallocates demand onto parallel routes within the CBD, and has little interaction with the Terrace Tunnel and Inner City Bypass. This lack of interaction is a result of limited access from the Motorway to the CBD south of Aotea offramp, and congestion in the Terrace Tunnel.

This project generates -$2.2M in disbenefits (-$3.7M disbenefits in 2026), primarily as a result of worsening travel time and increased levels of congestion.

d) Ngauranga to Aotea 8 Lane Tidal Flow

This project adds an extra lane in the peak direction (by using the shoulders) as a tidal flow (in the AM for example 4SB:3NB). In the Interpeak it is assumed a 3SB:3NB configuration. The speed in the peak direction has been reduced from 95km/h to 80km/h to reflect possible speed restrictions under tidal flow conditions. Note that this lower speed will reduce the benefits from this project.

The Ngauranga to Aotea Tidal Flow option relieves demand on the Hutt Road, whilst also improving operating speeds on SH1. There is little impact on flows in the CBD due to marginal induced traffic from the north.

This project generates $3.4M in benefits ($4.0M in 2026), primarily as a result of travel time improvements and congestion relief.

e) Basin Reserve Grade Separation

Coded as outlined in the Option H (modified) in phase one working paper.

The Basin Reserve Grade Separation reduces delays with the removal of signals and the grade separation of conflicting movements. Rat-running is reduced through roads parallel to Adelaide Rd and demand increases on the north-south Adelaide Rd – Kent Terrace corridor. Flows around the Oriental Parade are reduced.

This project generates $6.5M in benefits ($7.9M in 2026), primarily as a result of travel time improvements and vehicle operating cost savings.

f) Mount Victoria Tunnel Duplication + Ruahine 4-Laning

Mount Victoria Tunnel Duplication + Ruahine 4-Laning provides 2 lanes each way along the existing Mount Victoria alignment, continuing to Kilbirnie Crescent. Conflicting movements (right) turn bans have been added at the intersection of Wellington/Crawford/Ruahine St. No other changes have been assumed (eg. Basin Reserve road configuration and signal controls are not improved).

This improvement reduces flows around the Oriental Parade. There is an increase in demand on the Mount Victoria Tunnel in both directions, around the Basin Reserve and up Cambridge Terrace/ICBP NB. Increased demand particularly at the Basin and on the ICBP reduces speeds at these locations which will offset benefits. The benefits for this improvement are more focused on peak periods than spread out through the day.

This project generates $11.9M in benefits ($12.4M in 2026), primarily as a result of travel time improvements and congestion relief.

g) WaterFront minus 1 lane + Terrace Tunnel Duplication

Combination of the individual schemes.

The Terrace Tunnel Duplication with the WaterFront lane reduction complement each other. On an individual basis the benefits of the Terrace Tunnel duplication slightly offset the disbenefits of the WaterFront reduction in capacity on the WaterFront.

Access to the CBD through the Terrace Tunnel and Vivian St./Willis St. sees some use as an alternative for trips to the southern CBD. This adds distance disbenefits to CBD bound trips (backtracking). Other trips added to the Terrace Tunnel are due to reduced capacity on the WaterFront. This reduction in Waterfront capacity and speed contributes to the WaterFront disbenefits.

This project generates $0.9M in benefits ($0.1M in 2026), showing that the effects of the two projects cancel each other out on benefits. There are however, synergy benefits of the combined projects of $0.8M (compared with the sum of the two individual projects).

h) Ngauranga to Aotea 8 Lane Tidal Flow + Terrace Tunnel Duplication

Combination of the individual schemes.

The Terrace Tunnel Duplication and the Ngauranga-Aotea Tidal Lane complement each other, extending improvements in flow past the CBD to the Inner City Bypass, with the Terrace Tunnel Duplication being able to handle the small amount of induced traffic.

This project generates $5.8M in benefits ($7.7M in 2026), primarily as a result of travel time improvements and congestion relief.

i) Combined Road Package A (Tunnels)

Combination of the following individual schemes:

- Ngauranga to Aotea 8 lane tidal flow
- WaterFront Lane Reduction
- Terrace Tunnel Duplication
- Basin Reserve Grade Separation
- Mount Victoria Tunnel Duplication and Ruahine St 4 Laning

The Ngauranga to Aotea Tidal Flow, Terrace Tunnel Duplication and Waterfront Lane Reduction all impact traffic flow in the SBD direction in the AM Period. The combination of the Terrace Tunnel Duplication and WaterFront Lane Reduction generates few benefits since some Terrace Tunnel Duplication capacity is used by (prior) WaterFront volume while the WaterFront Lane Reduction reduces mobility in the CBD. In the NBD, flows going through the Terrace Tunnel show little change under this package (consistent with individual projects).

The Ngauranga–Aotea project now feeds into a revised combination of roadways with a reduced capacity (the Waterfront reduction) to access the CBD area. This has some impact on the benefits it can generate as part of this entire package.

The Basin Reserve Grade Separation and the Mount Victoria Tunnel/Ruahine St improvements impact flow primarily in the NBD direction in the AM Period.

The road package combines 2 projects impacting NBD traffic flows with 3 projects impacting SBD flows. Combining Basin Reserve and Mount Victoria Tunnel/Ruahine St improvements has some synergy. The Mount Victoria Tunnel /Ruahine St improvements have significant volume shifts off of the Oriental Parade to the Mount Victoria Tunnel. Basin Reserve benefits to the N-S traffic on Adelaide St/Kent Terrace remain strong including the reductions in rat-running. SBD volume changes on the Inner City Bypass (Vivian Street) are higher in the road package than either the Basin Reserve or Mount Vic/Ruahine St packages. This is the expected effect of the other three projects in the road package improving flow in the SBD direction.

This project generates $23.3M in benefits ($25.1M in 2026), primarily as a result of travel time improvements and congestion relief. There are synergy benefits of the combined package compared with the individual schemes of $1.4M ($1.1M in 2026), showing they compliment each other.

j) CBD Buslanes

Buslanes are assumed to operate only in the peaks periods (not the Interpeak). Further, there is assumed to be no reduction in road capacity apart from the roads highlighted in blue in the Arups plot[1] (Murphy and Molesworth Streets, Willis and Victoria Streets). The project also assumes that buses on Buslanes do not incur any intersection delays (function of the current model), and so is akin to a signal pre-emption option.

The Buslanes option as modelled here shows an increase in bus patronage in the AM peak, into and through the CBD. There are some minor car time disbenefits (16% of PT time benefits), however road benefits are very sensitive to assumptions about where general lane capacity has reduced. Given the assumptions about removal of road space, the benefits/impacts presented are viewed as optimistic.

This project generates $3.0M in benefits ($4.6M in 2026), with PT benefits of $4.9M being offset by road disbenefits of -$1.9M.

k) CBD Buslanes and Busway

[1] Refer to Arups Phase 1 Modelling Report (Option 2) plot (pdf) showing Wellington City CBD with proposed Buslanes and Busways routing highlighted by colour.

This option builds on the Buslanes option, adding a Busway Corridor from the Railway Station, along the Golden Mile to Kent/Cambridge Terrace and south to Wellington Hospital. There is no assumed addition road capacity reduction due to the Busway and it is assumed to operate in all time periods at a fixed speed of 26km/h in the CBD to Courtney Place, and 35km/h to Wellington Hospital (see Appendix A for workings). Where passengers can board and alight on the network has not changed as part of the Busway option.

The Busway option as modelled here shows a good increase in bus patronage in the AM peak, into and through the CBD, with minor road disbenefits as a result. However, road benefits are very sensitive to assumptions about where general lane capacity has reduced, and the benefits presented here can be viewed as optimistic.

This project generates $6.5M in benefits ($6.9M in 2026), with PT benefits of $7.6M being offset by road disbenefits of -$1.1M. If more road capacity was required for the busway, the disbenefit to road users would be larger.

l) Combined Road Package A (Tunnels) + CBD Buslanes

Combination of the following individual schemes:

- Ngauranga to Aotea 8 lane tidal flow
- WaterFront Lane Reduction
- Terrace Tunnel Duplication
- Basin Reserve Grade Separation
- Mount Victoria Tunnel Duplication and Ruahine St 4 Laning
- CBD Buslanes

In this package a PT component is added - Buslanes, which are assumed to operate only in the peaks periods (not the Interpeak). Further, there is assumed to be no reduction in road capacity apart from the roads highlighted in blue in the plot (Murphy and Molesworth Streets, Willis and Victoria St). The scenario also assumes that buses on Buslanes do not incur any intersection delays (function of the current model), and so is akin to a signal pre-emption option.

This option, combining auto and PT modes generates large benefits. Reduced congestion on significant portions of the corridor give large auto time benefits and the PT improvements increase PT boardings and minimize potential shift to auto mode.

This package generates $26.3M in benefits ($28.7M in 2026). There are little in the way of synergy benefits between the road and PT projects. However the removal of more road space to accommodate buslanes could result in project synergies.

m) Combined Road Package A (Tunnels) + CBD Buslanes + Busways

This option builds on the combined road and Buslanes option, adding a Busway Corridor from the Railway Station, along the Golden Mile to Kent/Cambridge Terrace and south to Wellington Hospital. There is no assumed additional road capacity reduction due to the

Busway and it is assumed to operate in all time periods at a fixed speed of 26km/h in the CBD to Courtney Place, and 35km/h to Wellington Hospital (see Appendix A for workings). Where passengers can board and alight on the network has not changed as part of the Busway option.

The addition of the Busway option to the package as modelled here shows an additional increase in bus patronage in the AM peak based on improved levels of service, adding to what is already a significant benefit.

This package generates $29.2M in benefits ($31.3M in 2026). There are little in the way of synergy benefits between the road and PT projects. However the removal of more road space to accommodate the busway could result in project synergies.

n) Combined Road Package B (No Tunnels) + CBD Buslanes

Combination of the following individual schemes:

- Ngauranga to Aotea 8 lane tidal flow
- Basin Reserve Grade Separation
- CBD Buslanes

The road portion of this package is scaled back from Road Package A in that the tunnel works (Terrace Tunnel Duplication and Mount Victoria Tunnel/Ruahine St 4L) have been removed. The Waterfront Lane Removal (-1 lanes each way) is also not in this package. The Buslanes portion remains as per other schemes and packages. This option, combining auto and PT modes generates only about half the benefits of Bus lanes + Road Package A.

The Basin Reserve Grade Separation reduces delays with the removal of signals and the grade separation of conflicting movements. Rat-running is reduced through roads parallel to Adelaide Rd and demand increases on the north-south Adelaide Rd – Kent Terrace corridor.

The Ngauranga to Aotea Tidal Flow project relieves demand on the Hutt Road, whilst also improving operating speeds on SH1.

The addition of the Busway option to the package as modelled here shows an additional increase in bus patronage in the AM peak based on improved levels of service, adding to the benefit.

This package generates $13.3M in benefits ($14.9M in 2026). Overall daily benefits are about 50% lower than of Road Package A + Buslanes with the road component at about 40% of Road Package A.

3. Project Benefits

Benefits for each scheme/package have been estimated from the model. The benefits have been calculated using the process outlined in the Economic Evaluation Manual. It should also be noted that the process used to generate these benefits is not exactly the same as the process used in other phases of this study, and as such are not directly comparable.

Benefits have been produced for 2016 and 2026 future years and are given in Table 1. In summary:

- Of the individual road schemes, Mount Victoria provides the largest benefits and the Basin Reserve the second largest.

- As expected, the Waterfront project provides disbenefits, which are around the same order of magnitude as the benefits of duplicating the Terrace Tunnel

- Generally, the road schemes when added together complement each other (synergy benefits).

- The PT projects provide net benefits, but include a small disbenefit to road users. This disbenefit to road users will be sensitive to the amount of existing road space required to deliver the buslane/busway options.

- In general, benefits/disbenefits are higher in 2026 than 2016 – on average by around 10%.

Component	TT Tide	TT Dup	Waterfront	Ngau-Aotea	Basin	Mt Vict/Ruahine	WF+TT Dup	Ngau-Aotea + TT Dup	Roads A (w/ Tunnels)	Buslane	Busway	Buslane + Roads A (w/ Tunnels)	Busway + Roads A (w/ Tunnels)	Buslane + Roads_B (No Tunnels)	Buslane + Roads B (No Tunnels) + 30% Fuel Increased
Car TT	0.0	1.6	-1.0	1.6	3.6	6.2	1.0	3.3	12.8	-1.3	-0.8	11.8	12.0	4.5	3.7
Car Congested TT	-0.0	0.2	-0.4	0.7	0.4	2.9	0.0	0.8	4.0	-0.3	-0.1	3.8	3.9	0.9	1.0
Car VOC	-0.0	0.2	-0.1	0.2	0.7	0.6	-0.0	0.4	1.7	-0.1	-0.2	1.6	1.5	0.7	0.5
Car Congested VOC	0.0	0.0	-0.1	0.5	0.1	0.8	-0.0	0.5	1.4	0.0	0.1	1.4	1.5	0.6	0.6
HCV TT	0.0	0.3	-0.3	0.3	0.9	0.6	0.1	0.7	2.1	-0.2	-0.1	1.9	2.0	1.0	1.0
HCV Congested TT	0.0	0.0	-0.1	0.0	0.0	0.2	-0.0	0.1	0.2	-0.0	-0.0	0.2	0.2	0.0	0.0
HCV VOC	0.0	-0.1	-0.0	-0.0	0.1	0.0	-0.1	-0.1	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.0
HCV Congested VOC	0.0	0.0	-0.1	0.1	-0.0	0.2	-0.1	0.1	0.3	0.0	0.0	0.3	0.3	0.2	0.2
PT TT	-0.0	0.0	-0.1	-0.0	0.8	0.3	-0.0	0.0	0.7	4.9	7.6	5.4	7.8	5.4	5.4
2016 Total ($M/annum)	-0.0	2.3	-2.2	3.4	6.5	11.9	0.9	5.8	23.3	3.0	6.5	26.3	29.2	13.3	12.4
2016 Synergy benefits							0.8	0.1	1.4			0.0	-0.6	0.4	N/A
2026 Total ($M/annum)	-0.2	3.4	-3.7	4.0	7.9	12.4	0.1	7.7	25.1	4.6	6.9	28.7	31.3	14.9	N/A

Table 1: 2016 and 2026 Scheme/Package Benefits by Year and Component

4. RLTS Outcomes

Indicators broadly consistent with RLTS outcomes have been generated for each scheme/package, and are given in Table 2. These indicators presented are specific to the WCC area rather than regional totals – given the focus of the study. However, it should be noted that the WCC area includes parts of the network that are outside the study area, where the schemes/packages will have little influence. The indicators include:

- AM peak PT vs. Car mode share – this in based on trips to WCC in the AM peak
- AM PT boardings – this is the total boardings across all PT modes that occur in the WCC area during the AM peak period
- Interpeak PT boardings
- Ratio of PT vs. Car generalised costs – compare relative user costs -PT vs. car modes
- AM vehicle hours spent in LOS E/F conditions – measure of congestion
- Average AM peak network travel times – average travel times for trips within the WCC area
- Annual CO_2 – this is the amount of CO_2 expelled in the WCC area – note this number has been corrected so the regional total in 2006 matches the AMR. Future assumptions about vehicle efficiency have a big bearing on the 2006-2016 change. At a region-wide level, CO_2 is forecast to be higher in 2016 than 2006 – primarily due to increases in HCV trips that have minimal future efficiencies. In WCC area, there is a lower proportion of HCV trips and so the increase is not as marked.

Key findings from the indicators include:

- PT modeshare/boardings: As expected, the PT projects have a significant impact on PT boardings and modeshare. The road projects reduce PT modeshare (due to a decrease in PT trips and increase in car trips), but has less of an impact on boardings.
- Ratio of PT to car costs: Road projects make PT slightly less competitive, but PT projects have a much larger impact in making PT more competitive.
- Vehicle hours at LOS E/F[2]: Terrace Tunnel Duplication and Waterfront projects have a negative impact on severe congestion. Other roads projects, such that the combined Roads Packages have a positive impact over the base. PT projects also have a positive impact on severe congestion; however removal of road capacity under Buslane/Busway options will cause a more negative impact.
- Annual CO_2: All projects improve CO_2, but only marginally.

[2] Whilst the projects appear to have little impact on levels of severe congestion, around 60% of the Do Minimum indicator value lies outside the study area (typically on SH1 and SH2 north of the Ngauranga merge) which will not be directly affected by study area projects. Correcting for this, the combined road and Busway option provides around an 11% reduction in severe congestion against the Do Minimum.

Including two significant road projects outside the study area such as Petone-Grenada and Transmission Gully impacts on the indicators within the study area. In particular:

- The addition of Petone-Grenada reduces PT modeshare and boardings, significantly reduces severe levels of congestion in the WCC area (due to the scheme directly improving some areas of severe congestion), and marginally improves CO_2.

- The addition of Transmission Gully also reduces PT modeshare and boardings and marginally improves CO_2 (has a smaller impact than Petone-Grenada), but has a slight negative impact on severe levels of congestion in the WCC area due to induced road traffic from outside the WCC area (and Transmission Gully not directly addressing area issues).

WCC Area Indicators	2006 Existing	Do Minimum	TT Tide	TT Dup	Waterfront	Ngau-Aotea	Basin	Mt Victoria/Ruahine St	WF+TT Dup	Ngau-Aotea + TT Dup	Roads A	Buslanes	Busway	Buslanes + Roads A	Busway + Roads A	Bus Lane + Road B	Bus Lane + Road B with 30% Fuel increase	Bus Lane + Road B + PG[3]	Bus Lane + Road B + TG	Bus Lane + Road B+ PG+TG
AM PT vs Car Modeshare	25.2%	25.8%	25.8%	25.7%	25.8%	25.7%	25.8%	25.7%	25.8%	25.6%	25.4%	26.4%	26.6%	26.0%	26.2%	26.2%	27.5%	25.5%	26.0%	25.4%
AM PT Boardings	19461	22810	22750	22774	22812	22696	22847	22671	22777	22640	22502	24270	24603	23936	24251	24110	25264	23532	24076	23509
Interpeak PT vs Car Modeshare	8.3%	8.6%	8.6%	8.6%	8.6%	8.6%	8.6%	8.5%	8.6%	8.6%	8.5%	8.8%	8.9%	8.6%	8.8%	8.7%	9.2%	8.6%	8.7%	8.6%
Ratio of PT:Car generalised costs	2.7	2.4	2.5	2.5	2.4	2.5	2.5	2.5	2.5	2.5	2.5	2.3	2.3	2.3	2.3	2.3	2.2	2.4	2.3	2.4
AM Vehhrs on LOS E/F	6043	9571	9596	9638	9702	9342	9399	9295	9682	9340	9235	9476	9392	9249	9212	9003	7424	7149	9162	7265
AM Avg. network travel times	11.8	13.1	13.1	13.0	13.1	12.9	13.0	12.9	13.0	12.9	12.7	13.2	13.2	12.8	12.8	12.9	11.4	11.9	12.9	12
Annual CO_2 Kilotonnes	390	389	388	389	390	387	387	384	390	387	383	387	387	382	381	384	353	382	383	380

Table 2: 2016 Scheme/Package Indicators by component

[3] These shaded scenarios include schemes that are outside the study area (Petone-Grenada Link and Transmission Gully). The Petone-Grenada link is outside the study area, but inside the WCC area for indicators and so will have a direct impact on some of the numbers. Transmission Gully is also outside the study area, as well as outside the WCC area, and so its impact will be seen as an external influence.

5. Sensitivity Testing

Three sensitivity tests have been undertaken on the schemes/packages discussed in Section 1. These tests include:

- 30% increase in real fuel prices
- Parking charge increases of 30% to 2016 and 50% to 2026 – this sensitivity tests the impact of limited increases in parking capacity in the CBD through the use of a pricing mechanism

Figure 1 below shows a comparison between benefits for the sensitivities and the central case scenarios. It should be noted that the benefits listed here are **NOT** the same as the benefits presented in Section 2 as they are calculated using a different methodology.

On average, the impact of a **30% increase in fuel** is to reduce the scheme/package benefits by about 10%. This is due to less demand on the road network taking advantage of capacity improvements.

Interestingly, the impact of **increasing parking charges by 30%** (in 2016) is to increase benefits slightly by around 2%. The reasons for this are less clear, but might be due to less demand wanting to go to the CBD having a reduced adverse impact on the schemes/benefits (ie. more people want to use the ring-road to go round the CBD rather than into).

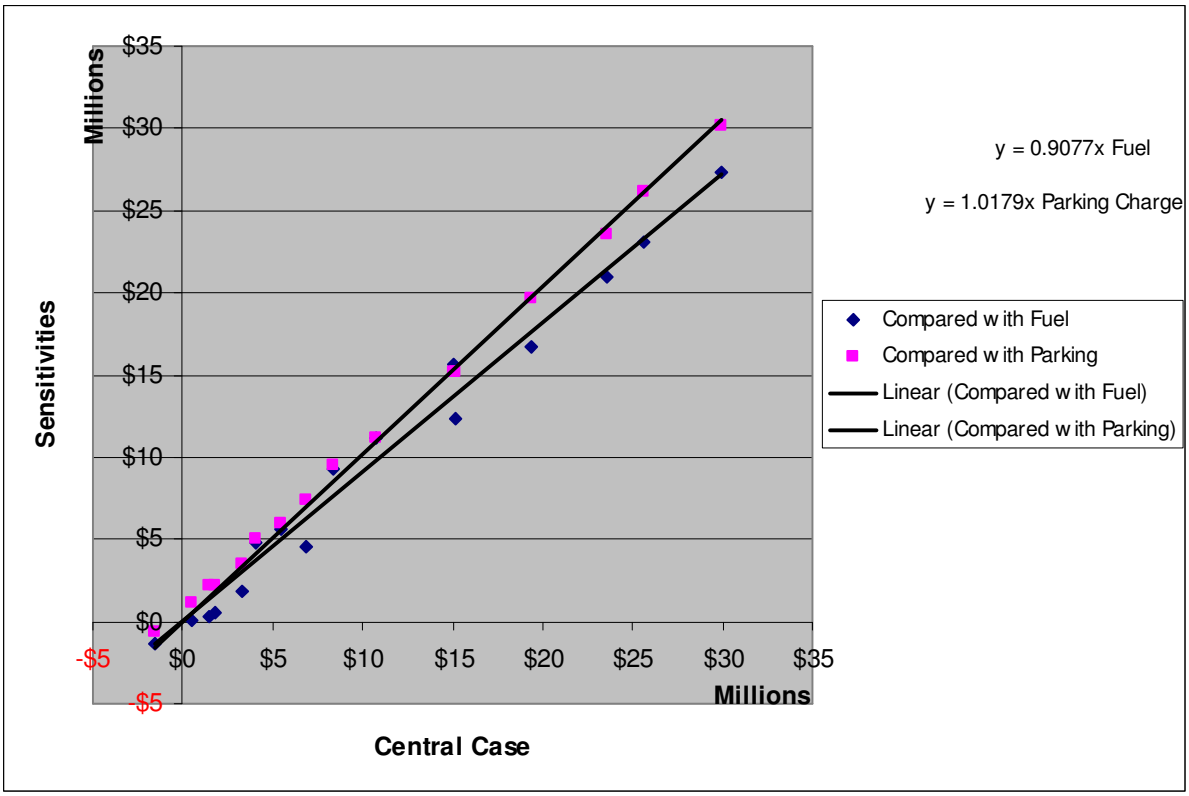

Figure 1: Comparison of 2016 benefits by sensitivity

The impact of the sensitivity tests on the RLTS outcome indicators has also been tested. The following has been found on average:

- AM PT mode share increases by 1.3% in absolute terms under the fuel scenario, and 1.4% under the parking charge scenario
- Reduces vehicle hours on severely congested roads by 2000 hours under the fuel scenario, and 1035 hours under the parking charge scenario
- CO_2 reduces by on average 31 kilo tonnes under the fuel scenario and 4 kilo tonnes under the parking charge scenario

6. CBD Corridor Congestion

Indicators relating to vehicle hours (VHRs) in high levels of congestion (LOS E and F) were developed for the WCC TLA area. These indicators show a significant increase in vehicle hours between 2006, 2016 and 2026 Do Minimum with the study interventions having little impact on overall future congestion levels.

An initial analysis of CBD Corridor Congestion was carried out with a focus on the Wellington City area south of Ngauranga interchange. Relative to the 2016 Do Minimum scheme, all packages have a positive effect on the network in reducing congestion. Of concern is that LOS E & F are growing rather than shrinking.

The analysis compared the travel time on individual roads in the study area with freeflow travel times (travel time without delay). The delay experienced is a combination of travelling on congested roads, as well as having to wait at intersections (which is a combination of traffic flows/congestion, the signal timing at the intersection, and priorities for pedestrian movements). By separating the delay into non-intersection and intersection-based delay, a better understanding of where the sources and contribution to the overall increase in delay could be determined.

It was found that within the study area:

- In 2006 AM, 42 seconds per km are spent in delayed conditions, split as 12.5 seconds for non-intersection (congestion) and 29.5 for intersection delay
- The 2006 PM has slightly less delay per km than the AM, with a slightly lower non-intersection and higher intersection delay
- The 2006 IP has less delay than the peak, with most of the delay experienced at intersections
- The 2016 DM exhibits higher levels of delay than 2006, with a larger increase in the AM than the IP or PM
- Of this increase in delay, a higher percentage change in non-intersection delay is seen than intersection delay (although on a much smaller base in the case of the IP)
- Corridor improvements reduce the delay per km in the study area by up to 6.5seconds per km (approximately 12%), with the most optimistic package improving general

congestion on roads to better than 2006 levels (8.2 seconds per km vs 12.5 seconds per km)

- Reductions in general road congestion are offset by an increase in intersection congestion.

- The impact of road network improvements outside the study area (eg. addition of Petone-Grenada) generates additional traffic into the study area, which in turn increases delay on the network.

In summary, this initial analysis concludes that:

- By 2016 average delay in the study area due to increases in the level of congestion will increase by less than 1 minute per trip

- The cost of this additional delay can be valued (conservatively) at $25M/annum. Analysis shows that the proposed corridor plan intervention will reduce this increase.

- Much of the delay is spread in the CBD and other areas of the WCC and will not be directly affected by the corridor plan proposals.

- While the proposals will increase capacity through a part of the network, access to and from the ring route must be considered more fully. It is recommended that more detailed modelling with Saturn is undertaken.

Further information about this analysis is found in Appendix B.

In the study corridor, analyses alongside this exercise indicate that some of the delay in the peak periods takes place at access/egress points between SH1 and the CBD. Additionally, proposed Bus Lanes and proposals for reduction of the Waterfront route would reduce capacity and increase congestions as well. While improvement in corridor operation is seen in all of these schemes, measures to ensure a good level of access to and from the corridor are vital to reducing delay.

7. Fuel prices, fuel usage and CO_2 emissions

The modelling to date implicitly assumes that the real price of fuel increases by around 20% by 2016 and 25% by 2026. However, this real increase in fuel prices is assumed to have no impact on the cost to use private vehicles, as private vehicles are assumed to be around 20% more fuel efficient by 2016 and 25% by 2026. These assumptions on future fuel efficiencies have been obtained from the Ministry of Transport's vehicle fleet emissions model (VFEM), and is the best information we have at this time.

The number of HCV trips in the model are not sensitive to fuel price changes. The relationship between fuel price and HCV use is not well understood (particularly the split between road and rail freight), and it could be assumed that any changes in fuel price would be passed on to consumers. HCV trips are highly correlated with economic activity.

For the WCC area, CO_2 emissions in 2016 are around the same as 2006 levels. This is due primarily to assumptions around future fuel efficiencies, where the amount of fuel used (and subsequently CO_2 emitted) is 20% less than current levels for private vehicles. Individual

projects and packages have little impact on CO_2 emissions, but a combined road and PT package gives the largest improvement (although minor).

A model run sensitivity has been undertaken to examine the impact of further 30% increase in the real fuel price in 2016 (above and beyond the 20% - so 50% in total), but with no change to future fuel efficiencies. This sensitivity resulted in a 6.7% reduction in benefits for the Buslanes + Roading (no bottlenecks) package (reduced from $13.3m to $12.4m) due to less traffic benefiting from the road improvements.

Increasing fuel prices further had a positive impact on all of the RLTS indicators. In particular, for Buslanes + Roading (no bottlenecks) package within the WCC area:

- AM PT modeshare increased from 26.2% to 27.5%, and AM PT boardings from 24.1k to 25.2k
- Interpeak PT modeshare also increased from 8.7% to 9.2%
- Levels of high road congestion improved from 9000 to 7400 vehicle hours at LOS E/F
- Average network travel times improved from 12.9 to 11.4 minutes – an improvement on 2006 levels
- Annual CO_2 kilotonnes reduced from 384 to 353 – a significant improvement on 390 kilotonnes in 2006

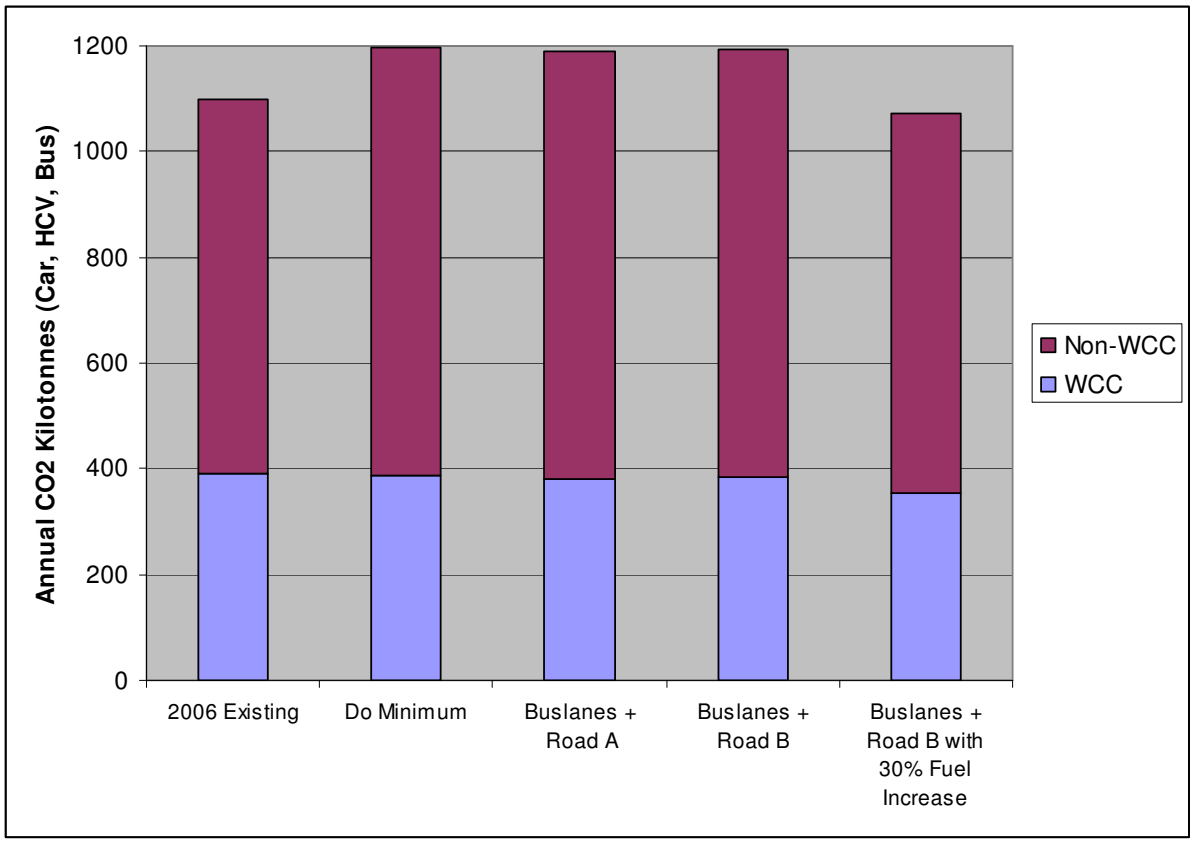

Figure 2: Regional Annual CO_2 Kilotonnes by Scenario by Area

We can conclude that future changes in fuel prices (and associated changes in vehicle fuel economy) have the propensity to provide a larger impact on the RLTS outcomes than infrastructure and PT service interventions. In particular, the largest determining factors of future CO_2 emission levels within the WCC area are future vehicle fuel efficiencies and prices.

Appendix A

a) Terrace Tunnel Tidal Flow

The Terrace Tunnel tidal flow changes the lane configuration on the Terrace Tunnel from 1SB:2NB to 2SB:1NB in the AM peak only. No speed changes have been assumed.

Findings

- Increase in Terrace Tunnel SB volume in AM peak - +1090 SB. Of that, approximately 160 from the WaterFront (Aotea Quay), 400 from Thorndon/Murphy, and 530 from Terrace offramp. Increase in SB traffic along Vivian St. and a slight reduction in traffic around the Oriental Parade.

- Significant speed reductions in the NB due to removal of 1 lane in the AM peak period cause about -860 flow reduction in NB direction, resulting in an increase NB on Taranaki St. and the WaterFront route.

- Minor impact on the number of PT users

- This project shows zero benefits in 2016 (-$0.2M disbenefit in 2026).

In summary, the Terrace Tunnel tidal flow option partially relieves the WaterFront route SB in the AM period, but increases the flows on the WaterFront NB due to a reduction in capacity in the Terrace Tunnel. The two effects tend to cancel each other so there are no benefits.

b) Terrace Tunnel Duplication

The Terrace Tunnel duplication changes the lane configuration from 1SB:2NB to 2SB:2NB in all time periods. The speed in the Terrace Tunnel SB (and link south) has also been increased from 70km/h to 80km/h to be consistent with the Arup coding. No changes have been assumed to the NB coding as there is no improvement to infrastructure.

Findings

- Increase in Terrace Tunnel SB volume in AM peak by 1150. Approximately 150 appear to come from the WaterFront (Aotea Quay), 280 from Thorndon/Murphy, 200 from Hawkestone, and 250 from Terrace offramp. About 300 trips access the Motorway SB as congestion decreases in the Terrace Tunnel. Small increases in traffic off Vivian St. Slight reduction in traffic around Oriental Parade and Kent Terrace.

- Significant speed increases in the SB direction through the Tunnel, partially offset by a reduction in speed approaching the Willis/Vivian intersection. Other speed reductions along Vivian St. due to increases in traffic. The capacity through the ICBP should be looked at in more detail.

- The Waterfront route SB sees a reduction of up to 470 SB in the AM Period through the middle section with no change in the NB.

- The improved Terrace Tunnel and Vivian St./Willis St. sees some additional use as an alternative route for trips to the southern CBD that previously used the Terrace.

- Benefits are exclusively time benefits (car & HCV) and accrue primarily to Wellington City CBD (26%), Wellington City west (19%) and Wellington City south (14%).

- Minor impact on the number of PT users

- Project generates $2.3M in benefits ($3.4M in 2026), primarily as a result of travel time improvements

In summary, the Terrace Tunnel Duplication increases speeds and flows SB through the Tunnel and partially relieves the WaterFront route SB flow, but has little impact NB.

c) WaterFront minus 1 lane

The WaterFront minus 1 lane (in each direction) removes a lane between Bunny St and Taranaki St in all time periods. Further, the intersection capacities at each of the intersections have been reduced by 1/3 to reflect the lower capacity. We suspect this definition is different to the coding undertaken by Arups, which (according to the descriptions in the modelling reports) removes a lane all the way up to and along Aotea Quay. Our reduced definition will reduce the impact of the WaterFront reduction. The Terrace tunnel is not improved in this option (1SB:2NB all periods).

Findings

- Reducing capacity on the WaterFront has a larger impact in the SB than NB direction in the AM peak period. SB flows reduce by -100 to -520 (depending on location), with the majority of people reassigning to other parallel CBD routes such as Featherston St. This lack of interaction is a result of limited access from the Motorway to the CBD south of Aotea offramp, and congestion in the Terrace Tunnel, suggesting that as an unimproved alternative the Terrace Tunnel does not compete well with the WaterFront.

- Little impact on Oriental Parade, with most reduction seen for traffic going up Kent Terrace.

- Speeds are reduced along the WaterFront due to the lower road and intersection capacity. Other speed reduction on parallel routes such as Featherston St as traffic is rerouted.

- Minor impact on the number of PT users. Some PT time disbenefit in the CBD as traffic reroutes from the WaterFront creating more congestion on other roads

- A select link analysis of the WaterFront route has been undertaken. This analysis shows that in the AM peak period, of the demand heading SB on Waterloo Quay, 70% are still using it as Jervois Quay passes Frank Kitts Park, and 57% are still using the WaterFront route up to Taranaki St. At the end of Cable St 39% are still on the

route - 15% then go round the Oriental Parade (some drop off to zone), whilst 22% head up Kent Terrace. Of the total trips at the start of the select link, 12 % are destined to the Airport.

- Over 40% of the disbenefit for this option is placed on the CBD on a daily basis. In the AM a significant disbenefit (15% of car time disbenefit to AM destinations) is found for trips destined to Wellington east. Without a viable alternative to the WaterFront route, SB traffic volumes to and through the CBD area must manage with less roadway capacity as one less lane is available in each direction.

- Total annual disbenefits of -$2.2M in 2016 (-$3.7M disbenefits in 2026), primarily as a result of worsening travel time and increased levels of congestion

In summary, removing 1 lane in each direction between Bunny St and Taranaki St reallocates demand onto parallel routes within the CBD, and has little interaction with the Terrace Tunnel and Inner City Bypass. This lack of interaction is a result of limited access from the Motorway to the CBD south of Aotea offramp, and congestion in the Terrace Tunnel

d) Ngauranga to Aotea 8 Lane Tidal Flow

Assumes an extra lane in the peak direction (by using the shoulders) as a tidal flow (in the AM for example 4SB:3NB). In the Interpeak it is assumed a 3SB:3NB configuration. The speed in the peak direction has been reduced from 95km/h to 80km/h to reflect possible speed restrictions under tidal flow conditions. Note that this lower speed will reduce the benefits from this project.

Findings

- Shifts a significant amount of traffic from the Hutt Rd (-1630, of which about-180 from Ngauranga Gorge and -1450 from SH2) to SH1 (+1990). Some minor reductions in rat-running through Khandallah and Wadestown.

- Little induced demand from the north as a result – SH1 down Ngauranga +120, SH2 +70. As such, there is little impact on volumes and speeds in the CBD.

- Significant speed increases in the SB direction along SH1 and minor speed improvements on Hutt Rd. Speed reductions on Aotea Quay offramp, and SH1/SH2 north of improvements.

- Minor impact on the number of PT users

- Geographically the CBD receives over 30% of the benefit of this project based on the number of trips to and from the CBD (primary employment area for the Wellington Region) that use SH1 and now benefit from increased capacity of an additional lane in the peak direction during peak periods.

- Total annual benefits of $3.4M in 2016($4.0M in 2026), primarily as a result of travel time improvements and congestion relief.

In summary, the Ngauranga to Aotea Tidal Flow option relives demand on the Hutt Road, whilst also improving operating speeds on SH1. There is little impact on flow volumes in the CBD due to marginal induced traffic from the north.

e) Basin Reserve Grade Separation

Coded as outlined in the Option H (modified) in phase one working paper.

Findings

- Shifts traffic from Oriental Parade, reduces rat-running through Wallace and Tasman St, and increases flows through Adelaide Road and along Cambridge/Kent Terraces. Minor increases are seen on the ICBP in both directions.

- Minor reduction in flows on the Mount Victoria Tunnel due to a redistribution of trips using Constable/Riddiford/Adelaide.

- Significant speed increases on Wallace and Tasman due to reduction of rat-running. Minor speed reductions on the ICBP and through an unimproved Terrace Tunnel.

- Minor reduction in bus users using the Parie St Bus Tunnel inbound due to an improvement in speeds on the north-south alignment through Adelaide Rd. On average the grade separation improves travel times on bus routes by around 3 minutes in the peak direction and 2 minutes in the offpeak.

- Most benefits accrue to Wellington City south and then to Wellington City CBD with congestion reduced north-south on Adelaide St and Cambridge/Kent Terrace and reduced rat-running on adjacent roads. The daily distribution of benefits points to all day benefits, and not a peak directional bias.

- Total annual benefits of $6.5M in 2016 ($7.9M in 2026), primarily as a result of travel time improvements and vehicle operating cost savings.

In summary, the Basin Reserve Grade Separation reduces delays with the removal of signals and the grade separation of conflicting movements. Rat-running is reduced through roads parallel to Adelaide Rd and demand increases on the north-south Adelaide Rd/Kent Terrace corridor. Flows around Oriental Parade are reduced.

f) Mount Victoria Tunnel Duplication + Ruahine 4-Laning

Mount Victoria Tunnel Duplication + Ruahine 4-Laning provides 2 lanes each way along the existing Mount Victoria alignment, continuing to Kilbirnie Crescent. Conflicting movements (right) turn bans have been added at the intersection of Wellington/Crawford/Ruahine St. No other changes have been assumed (eg. Basin Reserve road configuration and signal controls are not improved).

Findings

- Increases traffic using the Mount Victoria Tunnel WB by over 2100 vehicles in the AM peak period and reducing Oriental Parade flows by around 990. Increases on Cambridge Terrace of around 650 due to more traffic using the Mt Victoria Tunnel/Basin route.

- Speed increases are significant through the tunnel in both directions. Minor speed improvements on Oriental Parade and through Adelaide Rd (and parallel routes). Speed reductions around the Basin (no improvements to capacity) and on parts of the ICBP NB.

- Minor reduction in bus users using the Pirie St bus tunnel inbound partially due to an improvement in speeds on the north-south alignment through Adelaide Rd.

- This project in the AM period is primarily benefits trips originating from Wellington east (45%) and Wellington south (19%). Benefits for this project tend to be biased toward the peak periods than the Interpeak. The population/employment data and directional/geographic constraints of the Wellington east area support this pattern of more peak period directional benefits.

- Total annual benefits of $11.9M in 2016 ($12.4M in 2026), primarily as a result of travel time improvements and congestion relief.

In summary, the Mount Victoria Tunnel and Ruahine improvements reduce flows around the Oriental Parade. There is an increase in demand on the Mount Victoria Tunnel in both directions, around the Basin Reserve and up Cambridge Terrace/ICBP NB. Increased demand particularly at the Basin and on the ICBP reduces speeds at these locations which will offset benefits.

g) WaterFront minus 1 lane + Terrace Tunnel Duplication

Combination of the individual schemes.

Findings

- Increase in Terrace Tunnel SB volume in AM peak by 1200. Reductions are seen of about 240 from the WaterFront (Aotea Quay), 290 from Thorndon/Murphy 180 from Hawkstone, and 250 from Terrace offramp. An increase of about 300 vehicles access the Motorway SB as congestion decreases in the Terrace Tunnel. Small increases in traffic off Vivian St. Slight reduction in traffic around Oriental Parade and Kent Terrace. The Waterfront sees reductions of 250-700-depending on location.

- Access to the CBD through the Terrace Tunnel and Vivian St./Willis St. sees some use as an alternative for trips to the southern CBD.

- Significant speed increases in the SB direction through the tunnel, partially offset by a reduction in speed approaching the Willis/Vivian intersection. Other speed reductions along Vivian St due to increase in traffic. Speed reductions along the WaterFront due to a reduced capacity, but not as significant reductions as the WaterFront on its own.

This suggests there are synergies between the WaterFront and an improved Terrace Tunnel.

- The Wellington CBD has a net disbenefit, while Wellington City west has some benefit and East/airport is mostly neutral. The car time improves as cars shift to take advantage of an additional lane SBD at the Terrace Tunnel. At the same time, travel distance increases as CBD traffic reroutes to other roads off of the WaterFront and also to Terrace Tunnel coming at the CBD from the south rather than the north. In this project the distance travelled goes up as the travel time goes down. The increased distance travelled impacts car operating cost so that a disbenefit is generated for car distance damping further potential benefits.

- Minor impact on the number of PT users. Some PT time disbenefit in the CBD as traffic reroutes from the WaterFront creating more congestion on other roads.

- Total annual benefits of $0.9M in 2016 – synergy benefits of $0.8M ($0.1M in 2026).

In summary, the Terrace Tunnel duplication with the WaterFront reduction complement each other, as indicated by the large proportion of synergy benefits.

h) Ngauranga to Aotea 8 Lane Tidal Flow + Terrace Tunnel Duplication

Combination of the individual schemes.

Findings

- Little induced demand from the north as a result – SH1 down Ngauranga +130, SH2 +80.

- Shifts a significant amount of traffic from the Hutt Rd (-1630, of which about -280 from Ngauranga Gorge and about -1450 from SH2) to SH1 (+2070). Some minor reductions in rat-running through Khandallah and Wadestown.

- Significant speed increases in the SB direction along SH1 and minor speed improvements on Hutt Rd. Speed reductions on Aotea Quay offramp, and SH1/SH2 north of improvements. Also, significant speed increases in the SB direction through the tunnel, partially offset by a reduction in speed approaching the Willis/Vivian intersection. Other speed reductions along Vivian St due to increase in traffic. This increased congestion would have a damping effect on possible benefits to the east and south areas of Wellington City.

- Increase in Terrace Tunnel SB volume in AM peak by 1200. Decreases of up to 450 from the WaterFront (depending on location), 150 from Thorndon/Murphy, and a small amount from the Terrace offramp. Small increases in traffic off Vivian St. Slight reduction in traffic around the Oriental Parade.

- Volume Shifts indicate that some trips previously destined to the Basin Reserve via WaterFront/Kent now use Terrace Tunnel to Vivian St. to Kent Terrace. No change in WaterFront configuration in the project. Redistribution of through trips from the

WaterFront to the Terrace Tunnel in this option frees up some capacity in the CBD (Featherston, Thorndon Quay, Aotea Quay). This congestion reduction improves car travel time and gives a small benefit to PT time as well.

- Geographically the CBD receives over 30% of the benefit of this project. This is based on the number of trips to and from the CBD (primary employment area for the Wellington Region) that use SH1 and now benefit from increased capacity of an additional lane in the peak direction during peak periods. Wellington City overall receives 75% of the project benefits.

- Minor impact on the number of PT users

- Total annual benefits of $5.8M ($7.7M in 2026), primarily as a result of travel time improvements and congestion relief.

In summary, the Terrace Tunnel Duplication and the Ngauranga-Aotea Tidal Lane complement each other, with the duplication being able to handle the small amount of induced traffic.

i) Road Package A (Tunnels)

Combination of the following individual schemes:

- Ngauranga to Aotea 8 lane tidal flow

- WaterFront Lane Reduction

- Terrace Tunnel Duplication

- Basin Reserve Grade Separation

- Mount Victoria Tunnel Duplication and Ruahine St 4 Laning

Findings

- Little induced demand from the north as a result – SH1 down Ngauranga +40, SH2 +60.

- Shifts a significant amount of traffic from the Hutt Rd (-1610, of which about -150 from Ngauranga Gorge and about -1460 from SH2) to SH1 (+1870). Some minor reductions in rat-running through Khandallah and Wadestown.

- Increase in Terrace Tunnel SB volume in AM peak period by about 1230. Decreases are seen of about -240 to -720 from the WaterFront (depending on location), -240 from Thorndon/Murphy/Hawkestone, and -220 from Terrace offramp.

- Significant speed increases in the SB direction along SH1 and minor speed improvements on Hutt Rd. Speed reductions on Aotea Quay offramp, and SH1/SH2 north of improvements. Also, significant speed increases in the SB direction through the Terrace Tunnel, partially offset by a reduction in speed approaching the

Willis/Vivian intersection. Other speed reductions along Vivian St due to increase in traffic. This increased congestion would have a damping effect on possible benefits to the east and south areas of Wellington City.

- Speed reductions along the WaterFront due to a reduced capacity, but not as significant as the WaterFront reduction on its own. Suggests there are synergies between the WaterFront and an improved Terrace Tunnel.

- Reduces rat-running through Wallace and Tasman St, and increases flows through Adelaide Road and along Cambridge/Kent Terraces.

- Increases traffic using the Mount Victoria Tunnel WB by 1950 vehicles in the AM peak period and reducing the Oriental Parade flows by up to 1090. Increases to about 1000 on Cambridge Terrace due to more traffic using Mt. Vic Tunnel/Basin route

- Trips originating in Wellington City receive about 85 % of total benefits (east (32%), south (20%), CBD (22%), west (7%), and north (5%)). Primary destinations for these benefits in the AM are the CBD and Wellington City east. Primary origins for these benefits are Wellington City east & south and the CBD. This indicates that improvements to the Basin Reserve and Mount Victoria Tunnel Duplication are primary sources of the total benefits.

- PT time benefit is 3% of the total benefit and appear to be based on improved roadway flows.

- Minor impact on the number of PT users. Minor reduction in bus users using the Parie St bus tunnel inbound due to an improvement in bus speeds on the north-south alignment through Adelaide Rd. On average the grade separation improves travel times on bus routes by around 4 minutes in the peak direction and 3 minutes in the offpeak.

- Total annual benefits of $23.3M in 2016 ($25.1M in 2026) – synergy benefits of -$1.4M.

Total benefits for this combined package may be expected to be greater than the sum of the parts with a combination of synergies between the individual projects. In this package the synergy is not as clearly defined.

The Ngauranga to Aotea tidal flow option relieves demand on the Hutt Road, whilst improving operating speeds on SH1. Benefits were not large because there was no significant change in travel patterns, only speeds.

The Ngauranga–Aotea Tidal Flow/Terrace Tunnel Combination saw a lengthening out of flow improvements (speed and capacity) and some volume shifts from the WaterFront without taking away capacity from the WaterFront. This added a synergy that made the combination worth more than the sum of the projects.

With the Terrace Tunnel Duplication /WaterFront Lane reduction package, the drop in the WaterFront because of lane reduction was picked up by the Terrace Tunnel Duplication. As a package this worked well though few benefits were generated.

The three projects together fit in a way that does not add additional synergy. Some Terrace Tunnel Duplication capacity is used by (prior) WaterFront volume while the WaterFront Lane Reduction reduces mobility in and through the CBD. The Ngauranga–Aotea project now feeds into a revised combination of roadways with a reduced capacity to access the CBD area. This will have some impact on the benefits that it can generate as part of this entire package.

It is noted that all three projects benefit the SB flow of traffic while there is no significant change to NB flows in any of these projects in the AM Period.

The Inner City Bypass continues to be an area of concern as it bridges the space between the Terrace Tunnel Duplication and the Basin Reserve Grade Separation.

The Basin Reserve Grade Separation generated significant benefits as a standalone project. It provided relatively balanced improvements in operation to both NB & SB traffic on Adelaide St/Kent Terrace and to EB & WB from Mount Vic Tunnel to the ICBP (and on the Terrace Tunnel).

The Mount Victoria Tunnel/Ruahine St improvement to 2 lanes each way generated significant benefits as a project on its own. Basin Reserve Grade Separation was not included in this project and signals at the Basin Reserve remained in place. Significant volume shifts from Evans Bay Parade/Oriental Bay Parade and improved flow through the tunnel are seen.

Combining Basin Reserve and Mount Victoria Tunnel/Ruahine St improvements has a synergy effect. The effects of the Mount Vic/Ruahine are similar to the project on its own with significant volume shifts off of the Oriental Parade. Basin Reserve benefits to the N-S Adelaide route remain strong including the reductions in rat-running. At the NBD entrance to the Terrace Tunnel the volume shift are about the same in all 3 projects.

It is noted that the two projects benefit the NB flow of traffic. There is no significant change to SB flows in these projects in the AM Period

SB volume changes on the Inner City Bypass (Vivian Street) are higher in the road package than either the Basin Reserve or Mount Vic/Ruahine St packages. This is the expected effect of the other three projects in the road package improving flow in the SBD direction.

The road package combines 2 projects improving NB traffic flows with 3 projects that improve SB flows in the AM period. While these groupings do not cancel or work against each other, neither do they build on each other to add a synergy to the package.

j) CBD Buslanes

CBD Buslanes have been coded as per the diagram in the Arups Phase 1 Modelling Report (Option 2) plot. Buslanes are assumed to operate only in the peak periods (not the Interpeak). Further, there is assumed to be no reduction in road capacity apart from the roads highlighted in blue in the plot (Murphy, Molesworth, Willis and Victoria St). The scenario also assumes that buses on Buslanes do not incur any intersection delays (function of the current model), and so is akin to a signal pre-emption option.

Findings

- Lane reductions occur on Willis St. and Victoria St. from the south as well as Murphy St. and Molesworth St. from the west to accommodate Buslanes. These lane reductions have a disbenefit impact on car trips from Wellington City south and west to the CBD. The reduction in car trips from the south does not fully appear on parallel routes, suggesting some mode switching).

- Increases in PT volumes from the south and east of about 500 and about 100 from the west and north suggest some mode shift to PT. Minor decreases in PT trips such as from Wallace St. to Adelaide St may be passengers shifting to take advantage of more desirable routing.

- Some speed reductions on Vivian/Webb/Tasman St, and speed increases on Brooklyn Rd and some locations in the CBD.

- Significant increases in bus demand into and through the CBD. For example, about 600 extra bus passengers along Cambridge, 700 extra through Courtney Place NB, 700 extra through Willis St. Also, a minor increase in rail demand.

- Total annual benefits of $3.0M in 2016 ($4.6M in 2026). Of that, approximately -$1.9M are disbenefits to road users.

In summary, the Buslanes option as modelled here shows an increase in bus patronage in the AM peak period, into and through the CBD, with road disbenefits as a result. However, road benefits are very sensitive to assumptions about where general lane capacity has reduced, and the numbers presented here could be considered optimistic.

k) CBD Buslanes and Busway[4]

This option builds on the Buslanes option, adding a Busway Corridor from the Railway Station, along the Golden Mile to Kent/Cambridge Terrace and south to Wellington Hospital. highlighted in green on the Arups Phase 1 Modelling Report (Option 2) plot. There is no assumed addition road capacity reduction due to the Busway and it is assumed to operate in all time periods. For operation on the Busway, a fixed speed of 26km/h has been assumed in the CBD to Courtney Place, and a speed of 35km/h to Wellington Hospital. These speeds are based on a 30km/h freeflow speed in the CBD to end of Courtney Place, and then 45km/h to

[4] The definition of the busway is based on comparison against other BRT systems. http://www.cutr.usf.edu/research/nuti/busway/Busway.htm provides guidelines on busway implementation "at-grade". A Wellington CBD system was assumed to be similar to the example in Abidjan (which runs through the CBD). This has a stop every 400metres (Table 2.6), and has boarding time of 0.9seconds/pax (Table 2.7). The same boarding time is assumed as it is expected electronic ticketing will be in operation, and passengers would already have validated tickets before boarding.

the Hospital, 0.6minutes per km spent stopping (2.5 stops per km based on a stop every 400 metres, and 0.225 mins per stop based on 0.9 seconds per passenger boarding and 15 passengers per service per stop), and a further 10% increase in speed to reflect improved reliability over the existing (or Buslanes) option. Where passengers can board and alight on the network has not changed as part of the Busway option.

Findings

- The Busway option tells a similar story to the Buslanes, but the magnitude of changes is higher.

- Increased time benefits for the Busway project over Buslanes is based on improved operating standards of a Busway over a Buslanes as noted with the assumptions above.

- Total annual benefits of $6.5M in 2016 ($6.9M in 2026). Of that, approximately -$1.1M are disbenefits to road users.

In summary, the Busway option as modelled here shows a significant increase in bus patronage in the AM peak, into and through the CBD, with road disbenefits as a result However, road benefits are very sensitive to assumptions about where general lane capacity has reduced. This modelling has assumed no change in road capacity above that outlined in the Buslanes option, which is likely to be conservative given the Busway runs through the golden mile.

l) Road Package A (Tunnels) + Buslanes

Combination of the following individual schemes:

- Ngauranga to Aotea 8 lane tidal flow

- WaterFront Lane Reduction

- Terrace Tunnel Duplication

- Basin Reserve Grade Separation

- Mount Victoria Tunnel Duplication and Ruahine St 4 Laning

- CBD Buslanes (coded as per the diagram - Arups phase 1 modelling report (option 2)

Findings

- Little induced demand from the north as a result – SH1 down Ngauranga +110, SH2 +60.

- Shifts a significant amount of traffic from the Hutt Rd (-1600, of which -150 from Ngauranga Gorge and -1450 from SH2) to SH1 (+1940). Some minor reductions in rat-running through Khandallah and Wadestown.

- Increase in Terrace Tunnel SB volume in AM peak period by about 1170. Volume decreases of about -240 to -720 from WaterFront (depending on location), -690 from Thorndon/Murphy/Hawkestone, and a small amount from Terrace offramp.

- Significant speed increases in the SB direction along SH1 and minor speed improvements on Hutt Rd. Speed reductions on Aotea Quay offramp, and SH1/SH2 north of improvements. Also, significant speed increases in the SB direction through the Terrace Tunnel, partially offset by a reduction in speed approaching the Willis/Vivian intersection. Other speed reductions along Vivian St due to increase in traffic. This increased congestion would have a damping effect on possible benefits to the east and south areas of Wellington City.

- Speed reductions along the WaterFront due to a reduced capacity, but not as significant as the WaterFront reduction on its own. Suggests there are synergies between the WaterFront and an improved Terrace Tunnel.

- Reduces rat-running through Wallace and Tasman St, and increases flows through Adelaide Road and along Cambridge/Kent Terraces.

- Increases traffic using the Mount Victoria Tunnel WB by about 1850 vehicles in the AM peak period and reducing the Oriental Parade flows by about 1100. Increases up to 1300 on Cambridge Terrace due to more traffic using the Mt. Vic Tunnel/Basin route

- Trips originating in Wellington City receive about 85 % of total benefits (east (34%), south (21%), CBD (12%), west (6%), and north/Tawa (10%)). The primary destinations for these benefits are the CBD and Wellington City east. Primary origins for these benefits are Wellington City east & south and the CBD. This indicates that improvements to the Basin Reserve and Mount Victoria Tunnel Duplication are primary sources of the total benefits.

- PT time benefit is about 20% of the total benefit. The time benefits to PT are found primarily in the CBD and Wellington City east and appears to be based on the addition of Buslanes and improved roadway flows.

- Minor impact on the number of PT users. Minor reduction in bus users using the Parie St bus tunnel inbound due to an improvement in bus speeds on the north-south alignment through Adelaide Rd.

- Total annual benefits of $26.3M in 2016 ($28.7M in 2026)

Total benefits for this combined package may be expected to be greater than the sum of the parts with a combination of synergies between the individual projects. In this package the synergy is not as clearly defined.

The Ngauranga to Aotea tidal flow option relieves demand on the Hutt Road, whilst improving operating speeds on SH1. Benefits were not large because there was no significant change in travel patterns, only speeds.

The Ngauranga–Aotea Tidal Flow/Terrace Tunnel Combination saw a lengthening out of flow improvements (speed and capacity) and some volume shifts from the WaterFront

without taking away capacity from the WaterFront. This added a synergy that made the combination worth more than the sum of the projects.

With the Terrace Tunnel Duplication /WaterFront Lane Reduction package, the drop in the WaterFront because of lane reduction was picked up by the Terrace Tunnel Duplication. As a package this worked well though few benefits were generated.

The three projects together fit in a way that does not add additional synergy. Some Terrace Tunnel Duplication capacity is used by (prior) WaterFront volume while the WaterFront Lane Reduction reduces mobility in and through the CBD. The Ngauranga–Aotea project now feeds into a revised combination of roadways with a reduced capacity to access the CBD area. This will have some impact on the benefits that it can generate as part of this entire package.

It is noted that all three projects benefit the SBD flow of traffic. There is no significant change to NBD flows in any of these projects in the AM Period.

The Inner City Bypass continues to be an area of concern as it bridges the space between the Terrace Tunnel Duplication and the Basin Reserve Grade Separation.

The Basin Reserve Grade Separation generated significant benefits as a standalone project. It provided relatively balanced improvements in operation to both N-S traffic on Adelaide St/Kent Terrace and to E-W from Mount Vic Tunnel to Buckle Street (and on the Terrace Tunnel). Mount Victoria Tunnel/Ruahine St improvements are not included in the Basin Reserve grade separation.

The Mount Victoria Tunnel/Ruahine St improvements to 2 lanes each way generated significant benefits as a project on its own. Basin Reserve Grade Separation is not included in this project and signals at the Basin Reserve remained in place. Significant volume shifts from Evans Bay Parade/Oriental Bay Parade and improved flow through the tunnel are seen.

It is noted that all three projects benefit the NBD flow of traffic. There is no significant change to SBD flows in any of these projects in the AM Period

Combining Basin Reserve and Mount Victoria Tunnel/Ruahine St improvements has a synergy effect. The effects of the Mount Vic/Ruahine are similar to the project on its own with significant volume shifts off of the Oriental Parade. Basin Reserve benefits to the N-S Adelaide route remain strong including the reductions in rat-running. At the NBD entrance to the Terrace Tunnel the volume shift are about the same in all 3 projects.

SBD volume changes on the ICBP (Vivian Street) are higher in the road package than either the Basin Reserve or Mount Vic/Ruahine St packages. This is the expected effect of the other three projects in the road package improving flow in the SBD direction.

In summary,the road package combines 2 projects improving NBD traffic flows with 3 projects that improve SBD flows. While these groupings do not cancel or work against each other, neither do they build on each other to add a synergy to the package. The PT Buslanes benefits combining with the roads benefits generate the sum of the packages.

m) Roads Package A (Tunnels) + CBD Buslanes and Busway

This option includes the changes as part of the Roads Package +CBD Buslanes option, but also includes modelling of the Busway.

Findings

- The Roads + Busway option tells a similar story to the Roads + Buslanes, but the magnitude of changes is higher.

- Increased PT time benefits for the Busway project over Buslanes is based on improved operating standards of a Busway over Buslanes. Minor impact on number of PT users

- Total annual benefits of $29.2M in 2016 ($31.3M in 2026)

In summary, the Roads + Busway option as modelled here shows some PT time benefits, into and through the CBD, along with significant road package benefits. Regarding the Busway, road benefits will be sensitive to assumptions about where general lane capacity has been reduced and this modelling has assumed no change in road capacity above that outlined in the Buslanes option, which is likely to be conservative given the Busway runs through the golden mile.

n) Combined Road Package B (No Tunnels) + CBD Buslanes

Combination of the following individual schemes:

- Ngauranga to Aotea 8 lane tidal flow

- Basin Reserve Grade Separation

- CBD Buslanes

Findings

- Little induced demand from the north as a result – SH1 down Ngauranga +80, SH2 +50.

- Shifts a significant amount of traffic from the Hutt Rd (-1440, of which about -130 from Ngauranga Gorge and about -1310 from SH2) to SH1 (+1690). Some minor reductions in rat-running through Khandallah and Wadestown.

- Significant speed increases in the SB direction along SH1 and minor speed improvements on Hutt Rd. Speed reductions on Aotea Quay offramp, and SH1/SH2 north of improvements.

- Increase SB on Thorndon Quay and reduction from Murphy with Buslanes on Murphy St & Molesworth St.

- ,Increases flows through Adelaide Road and along Cambridge/Kent Terraces and reduces rat-running through Wallace and Tasman St. Minor increases are seen on the ICBP in both directions.

- Significant speed increases on Wallace and Tasman due to reduction of rat-running. Minor speed reductions on the ICBP and through an unimproved Terrace Tunnel

- Minimal impact on roads to/from Wellington City east with only some rerouting to Constable St to take advantage of the improved Adelaide St corridor.

- Minor impact on the number of PT users. Minor reduction in bus users using the Parie St bus tunnel inbound as route choice via Constable St/Adelaide St becomes more attractive with Basin Reserve improvements. On average the grade separation improves travel times on bus routes by around 4 minutes in the peak direction and 3 minutes in the Interpeak.

- Total annual benefits of $13.3M in 2016 ($14.9M in 2026) – synergy benefits of -$0.4M.

The package's road portion is scaled back from Road Package A in that the tunnel works (Terrace Tunnel Duplication and Mount Victoria Tunnel/Ruahine St 4L) have been removed. The Waterfront Lane Removal (-1 lanes each way) is not in this package. The Buslanes portion remains as in other schemes/packages.

The roads portions of this package are quite separate and do not add synergy to each other. The Ngauranga-Aotea 8L tidal flow improves conditions in the SB direction in the AM Peak period. The Basin Reserve improves conditions N-S along Adelaide St/Kent Terrace and E-W on the ICBP. The Buslanes component contributes strong PT benefits and a minor auto benefit. The effect of pulling these 3 components together is primarily cumulative.

Overall daily benefits are about 50% lower than of Road Package A + Buslanes with the road component at about 40% of Road Package A with Buslanes.

Sensitivites around l) Road Package B (No Tunnels) + CBD Buslanes including Grenada-Petone Link and Transmission Gully

These schemes are not part of the study corridor but were generated in response to the model showing increasing LOS E & F in the WCC TLA, and a large portion of this increase being outside the study corridor on SH1 and SH2 north of Ngauranga interchange. The exercise should show whether the Petone-Grenada Link or Transmission Gully would have an impact on this increasing LOS E&F in the WCC TLA. The schemes were added on to Road Package B + Buslanes scheme for 2016 only. Of the three schemes, the Grenada–Petone Link addition showed the most change and is the only scheme discussed.

Built on the Road Package B + Buslanes scheme, the Grenada–Petone Link was added, in order to reduce the traffic volumes on SH1 and SH 2. A significant number of trips go between the Petone/Hutt City area and the Newlands/Grenada/ Johsonville and Porirua areas. These trips are presently captive to SH2 and SH1, increasing congestion and experiencing long travel distance and time base on road alignments. This option, stepping outside the defined corridor study area adds significant benefits versus Package B on its own.

Combination of the following individual schemes:

- Ngauranga to Aotea 8 lane tidal flow
- Basin Reserve Grade Separation
- CBD Buslanes
- Grenada – Petone Link

Findings (relative to Package B)

- New Grenada–Petone Link carries volumes of about 1500-2200 EB and 1800-2600 WB between Grenada and Petone depending on location.
- Shifts a significant amount of traffic from SH1 and SH2. On SH1, AM period volumes are reduced NB by about -900 to -300 from Ngauranga interchange to Grenada interchange. In the SB direction volumes are reduced by about -670 SB on the same section. From Petone to Ngauranga Interchange, traffic is reduced by about -450 SB and by about -1650 NB for SH2.
- Reduces traffic on Burma Road/Box Hill (rat running) by up to -530.
- Increase in auto trips on SH1(+870) and Hutt Road (+590 dropping to +300) from Ngauranga interchange to Aotea Quay versus Package B on its own. Some of this is a shift from rat running to the primary motorway and some is induced traffic using auto mode based on reduced congestion.
- Increased SB traffic into Wellington City CBD means increased traffic of about 440 on off ramps. Thorndon Quay SB traffic increases 250 from Package B only. About 170 more trips make the trip though the Terrace Tunnel to the south CBD area.
- PT trips see some reduction relative to Buslanes+Package B as an increase of about 700 SB on SH1 and Hutt Road (combined) is offset by a reduction of 1200 rail trips. This appears to be function of PT bus/rail competition and reduced road congestion.
- Total annual benefits of $45.4M in 2016 versus $13.3M for Buslanes+Package B alone. The incremental benefit of $32.1M from Buslanes+Package B is due to the inclusion of the Petone-Grenada scheme, and does not represent an additional benefit of the corridor schemes.

In summary, added to Buslanes+Package B, the Grenada–Petone Link reduces traffic volumes and congestion on SH1 and SH 2 from LOS F to LOS E north of Ngauranga interchange. The Petone-Grenada link carries significant volumes and adds high benefits to this package. As congestion is relieved, SH1 south of Ngauranga interchange sees higher volumes toward the CBD, and some rat running is reduced. LOS F is reduced relative to Package B on its own as noted in Appendix B, Table 2. Car freeflow and congested travel time changes are significantly more positive as noted in Project Benefits Table 1. Car time spent (vehicle hours) at LOS E & F in the WCC TLA is reduced as notes in RLTS Outcomes Table 2.

Appendix B

Note on CBD Corridor Congestion

Overview

This appendix investigates the impact of future demand and the CBD corridor projects on congestion levels within the corridor. In the modelling report indicators relating to vehicle hours (VHRs) in high levels of congestion (LOS E & F) were developed for the WCC TLA area. These indicators show a significant increase in vehicle hours between 2006, 2016 and 2026 DoMin (6043,9571,12367 respectively) in the AM peak, with the study interventions having little impact on overall future congestion levels. A significant amount of this LOS E & F increase is outside the study area (north of Ngauranga interchange) and thus the study interventions having little impact on overall future congestion levels.

This analysis has looked at links that are broadly included inside the study area (WCC south of Ngauranga gorge).

Table 1 (AM Period Vehicle Hours by Area) showing total vehicle hours by the various Levels of Service (LOS) indicates that most travel and most congestion is in the WCC area, particularly at Level of Service E & F. This table show that the relationship continues into the future. It also shows congestion increasing significantly going forward.

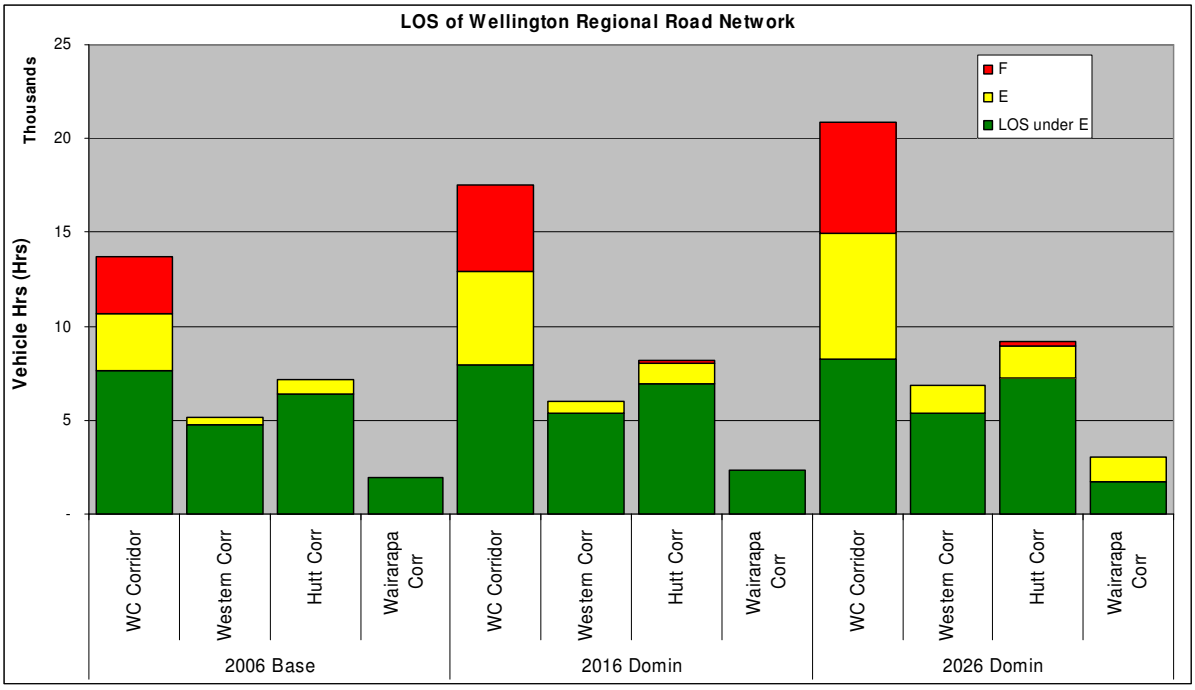

Figure 1 AM Period Vehicle Hours by Area

Table 2 shows the AM, and Table 3 the Interpeak Period Vehicle Hours for various schemes relative to each other and to 2006. It should be noted that a portion of the increase in Vehicle hours from 2006 to 2016 is based on more cars on the road and greater activity including more employment in the CBD. Comparison between AM and Interpeak plots in Tables 2 & 3 show that the Interpeak will in future operate much as it does now.

Relative to the DoMin scheme, all packages have a positive effect on the network in reducing congestion. Of concern is that LOS E & F are growing rather than shrinking. It is important to note that about half of the WCC congestion is outside the Ngauranga-Airport Study area (i.e.SH1 & SH2 north of Ngauranga Interchange). A scheme that includes the Petone-Grenada link (primarily in WCC area) does significantly reduce the vehicle hours which indicates that a significant amount of vehicle hours at Level of Service E & F are not in the Ngauranga – Airport Corridor.

The vehicle hours of greatest concern are vehicle hours operating at LOS E & F. In most schemes, LOS E & F increases significantly in the Peak Periods while LOS A,B,&C are stable, relative to 2006. Vehicle hours at LOS E&F are most concerning because links at LOS E & F are highly congested and can rapidly increase travel times. Because of the amount of time taken on congested links due to low speeds, a relatively few highly congested links can have a disproportionately large impact on this indicator. The impact of these relatively few links can be mitigated by looking at a combination of time and distance and working out what impact the scheme has on average travel times.

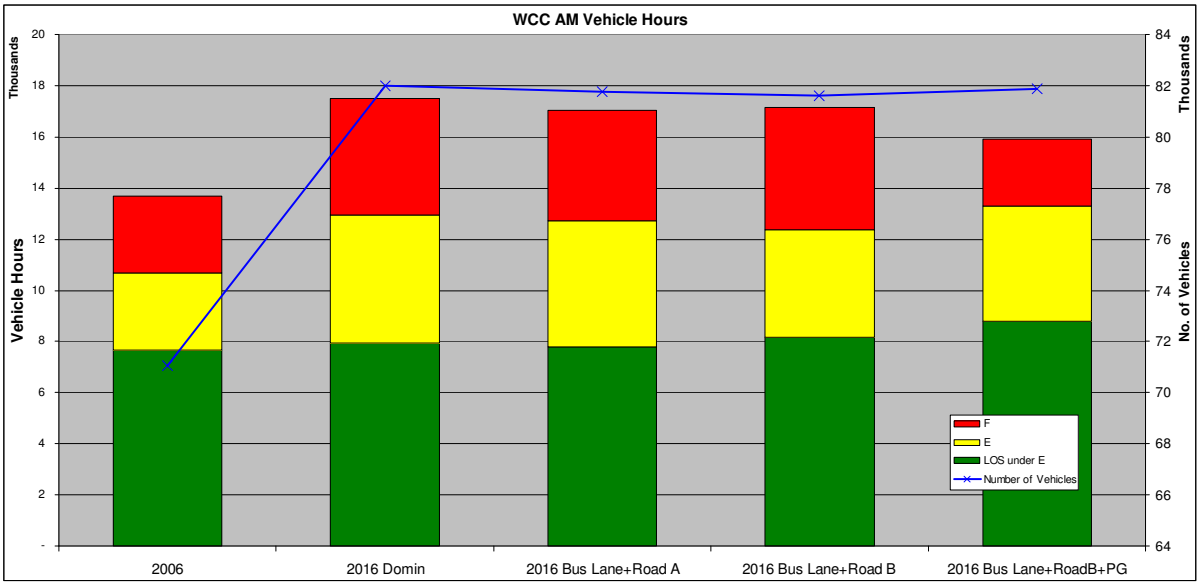

Figure 2 AM Period Vehicle Hours by LOS by Scheme

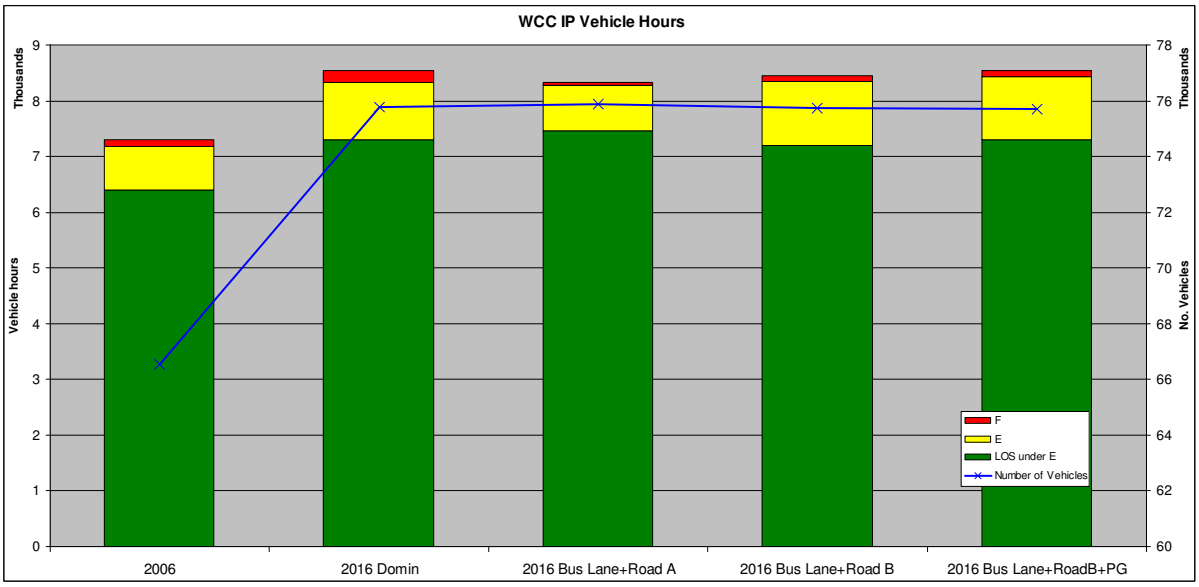

Figure 3 Interpeak Period Vehicle Hours by LOS by Scheme

Geographic Area

The modelling report (Ngauranga to Airport Modelling Report) informed on indicators for the whole of the WCC area. This area is larger than the study area, and includes significantly congested roads (such as SH1 and SH2 north of Ngauranga), which are outside the scope of the study. This analysis has looked at links that are broadly included inside the study area (WCC south of Ngauranga gorge).

Sources of Delay

In WTSM, the time its takes for a vehicle to use the road network is comprised of three main components:

- The freeflow speed on the road
- The impact of other vehicles on the road (congestion as road reaches capacity)
- The impact of intersection delays

If there was no congestion or intersections in the network, the traffic would operate at the freeflow speeds, with congestion and intersections being a source of delay. By comparing the differences between freeflow car hours and actual car hours, the magnitude of delay can be examined. For links in the model which do not include intersections, the additional delay is purely due to congestion. For links which have intersections, the delay will be a combination of congestion, but also a function of the delay at that intersection (including signal timings and proportion of time lost to pedestrian cycles). Therefore, the delay represented at intersections is a combination of congestion and signal timings, with the two components almost impossible to separate.

Analysis

The difference between freeflow and delay time was determined for roads within the study area segmenting by links that have no intersections/intersections, and dividing by the total car kms operated in the study area. This gives an average delay per km by segment. Taking the car kms and dividing by the number of car trips to/from the study area, gives an average trip length for trips within the study area. Multiplying average trip length by the average delay per km gives an average delay per trip.

This has been done for the three time periods modelled; namely the AM, Interpeak (IP) and PM.

Compare 2006 to 2016 DM

Table 1 shows the average time per km within the study area (in seconds) for 2006, 2016 DM and three schemes by time period. In summary (on average):

- In 2006 AM, 42 seconds per km are spent in delayed conditions, split as 12.5 seconds for non-intersection (congestion) and 29.5 for intersection delay
- The 2006 PM has slightly less delay per km than the AM, with a slightly lower non-intersection and higher intersection delay

- The 2006 IP has less delay than the peak, with most of the delay experienced at intersections

- The 2016 DM exhibits higher levels of delay than 2006, with a larger increase in the AM than the IP or PM

- Of this increase in delay, a higher percentage change in non-intersection delay is seen than intersection delay (although on a much smaller base in the case of the IP)

- Corridor improvements reduce the delay per km in the study area by up to 6.5seconds per km (approximately 12%), with the most optimistic package improving general congestion on roads to better than 2006 levels (8.2 seconds per km vs 12.5 seconds per km)

    - Reductions in general road congestion are offset by an increase in intersection congestion.

    - The impact of road network improvements outside the study area (eg. addition of Petone-Grenada) generates additional traffic into the study area, which in turn increases delay on the network.

		2006	2016 DM	Pkg A + BLanes	Pkg B + BLanes	Pkg B +BLanes + P-G
Total	AM	41.9	53.4	46.9	48.6	50.4
	IP	26.7	30.2	26.6	29.3	29.3
	PM	40.3	45.6	41.6	41.7	42.2
Non-Intersection	AM	12.5	18.1	8.2	12.8	14.1
	IP	2.8	5.1	2.6	5.0	5.2
	PM	8.9	14.0	6.6	9.5	9.8
Intersection	AM	29.4	35.3	38.7	35.8	36.3
	IP	24.0	25.1	24.0	24.3	24.1
	PM	31.4	31.7	35.0	32.3	32.4

Table 1: Average delay per Km in the study area (seconds)

Table 2 shows the average delay per trip within the study area (in minutes) for 2006, 2016 DM and three schemes by time period. This was done by multiplying the delay/km (Table 1) by the average trip length within the study area. In the case of 2006 AM, the average trip length was 4.25km, and for 2016 DM 4.15km. In summary:

- In 2006 AM, an average delay of 3 minutes per trip is seen within the study area, comprised of around 1 minute for non-intersection delay, and 2 minutes for intersection delay – the PM shows a slightly lower delay.
- The 2006 IP shows around 2 minutes delay per trip with most of the delay seen at intersections.
- 2016 DM AM adds around 0.7 minutes of delay to the average trip, or around 10% onto of a total AM trip time of 7.1minutes in 2006 AM. Of the 0.7minute increase, 0.4 minutes is due to extra delay on non-intersection road segments and around the same increase at intersections.
- The 2016 DM IP and PM increase by a smaller amount, with most of the increase seen on non-intersection links.
- The same impact of the schemes is seen on a delay per trip basis as is the case in the delay per km.

		2006	2016 DM	Pkg A + BLanes	Pkg B + BLanes	Pkg B +BLanes + P-G
Total	AM	3.0	3.7	3.3	3.4	3.5
	IP	1.9	2.1	1.8	2.0	2.0
	PM	2.9	3.2	2.9	2.9	2.9
Non-Intersection	AM	0.9	1.3	0.6	0.9	1.0
	IP	0.2	0.4	0.2	0.3	0.4
	PM	0.6	1.0	0.5	0.7	0.7
Intersection	AM	2.1	2.4	2.7	2.5	2.5
	IP	1.7	1.7	1.7	1.7	1.7
	PM	2.2	2.2	2.4	2.2	2.2

Table 2: Average Delay per Trip in the study area (minutes)

Analyses alongside this exercise indicate that some of the delay in the peak periods takes place at access/egress points between SH1 and the CBD. Additionally proposed Bus Lanes and proposals for reduction of the Waterfront route would reduce capacity and increase congestions as well. Improvement in corridor operation is seen in all of these schemes, however measures to ensure a good level of access to and from the corridor are vital to reducing delay.

Pricing

An attempt to quantify the cost of the additional delay has been made. Note however that this is not a detailed analysis (is based on averages), and only includes car travel times (and does not include the additional operating cost, reliability costs or cost to HCVs).

The cost of delay has been calculated by taking the average total delay from Table 2 for 2006, 2016 DM and three schemes by time period, multiplying this by the number of cars using the study area in each year, and then multiplying by a value of time. The value of time used is around $18.50/hour in $2006 (based on a weighted average of EEM with car occupancy to give $14.30 plus the addition of $4.20 for travelling in congested conditions – weighted average from EEM). Time period numbers have then been annualised using 245 for the AM and PM, and 2038 for the IP.

Table 3 shows that the price of delay in the study area in 2006 is around $90M per annum, increasing to $115M per annum in 2016 (an increase of $25M). This increase is partly due to the increase in average delay, but also because more trips are being made within the study area. Note that this does not include any delay in other parts of the network.

	2006 Trips	2006 Delay Cost	2016 Do Min Trips	2016 Delay Cost	2016 Pkg A +BLane Trips	2016 Pkg A +BLane Delay Cost	2016 Pkg B +BLane Trips	2016 Pkg B +BLane Delay Cost	2016 Pkg B +BLane + P-G Trips	2016 Pkg B +BLane + P-G Cost
AM	69,219	$63,129	78,722	$89,533	78819	$78,695	78555	$81,074	79445	$85,516
IP	48,606	$28,640	55,238	$35,917	56138	$32,173	55344	$34,813	55158	$34,830
PM	73,777	$64,744	83,030	$80,735	83791	$74,211	83131	$73,685	84457	$75,844
Annual (M)	134.1	$89.7	152.2	$114.9 **+$25.2 (on 2006)**	154.23	$103.0 **+$13.3**	152.38	$108.9 **+$19.2**	152.55	$110.5 **+$20.8**

Table 3: Car price of delay

Conclusions

An initial analysis of the magnitude of delay within the Ngauranga-Airport study area has been undertaken. This analysis concludes that:

- By 2016 average delay in the study area due to increases in the level of congestion will increase by less than 1 minute per trip
- The cost of this additional delay can be valued (conservatively) at $25M per annum. Analysis shows that the proposed corridor plan intervention will reduce this increase.
- Much of the delay is spread in the CBD and other areas of the WCC and will not be directly affected by the corridor plan proposals.
- While the proposals will increase capacity through a part of the network, access to and from the ring route must be considered more fully. It is recommended that more detailed modelling with Saturn is undertaken.