13

Transportation Assessment

13 Transportation Assessment

The Petone to Grenada project has the potential to reduce traffic volumes around the Ngauranga Gorge Interchange on State Highways 1 and 2. This reduction should improve traffic flows in the area and reduce delays and congestion at one of the main interchanges in Wellington. As well as reducing congestion, the Petone to Grenada Link Road also has the potential to provide access to the proposed Lincolnshire Farm development and will also improve access between the Hutt Valley and Johnsonville, Porirua and areas to the north.

This section summarises the route options considered for the proposed Petone to Grenada Link Road from a traffic perspective and details the assumptions for the options and the modelling process.

13.1 Model Assumptions

13.1.1 Demand Model (WTSM) and Growth Level (medium)

The modelling has been undertaken using two key tools: WTSM and NWSM

At the top level, Greater Wellington Regional Council's Wellington Transport Strategic Model (WTSM) has been used. This model is a 4-stage transportation model that simulates transport mode decisions taking into account road and public transport modes. It replicates the volumes across the Wellington Region based on observed data. WTSM has several growth scenarios for its forecast models. The medium growth scenario has been used for the Petone to Grenada assessments discussed in this chapter.

The matrices from WTSM have been extracted and converted for use in the Northern Wellington SATURN Model (NWSM).

13.1.2 Base Year (2011) and Peak Periods (AM, IP and PM);

WTSM and NWSM both have a base year of 2011 which is when the data was collected that was used to validate both models. The process to revalidate WTSM to a base year of 2011 was completed in 2012. NWSM was updated and validated to 2011 in 2013. This involved collection of new traffic counts, public transport movements and travel times to allow the new model to be checked against observed traffic information.

The model considers the following time periods: the AM peak, the inter peak and the PM peak. In WTSM each of these modelled periods includes the peak hour but is also comprised of the time preceding the peak and after the peak to allow the replication of peak build-up and delay. The AM peak period therefore covers the time period from 07.00 to 09.00, the inter peak period represents a two hour average between 09.00 and 16.00 and the PM peak period from 16.00 to 18.00.

No weekend model is available; however, periods outside the daily peak volumes can be accounted for using a factoring process and will be included in any economic analysis of the schemes.

The modelled periods in NWSM are the average peak hours as follows:

- AM peak: 07:30-08:30;
- Inter peak: 1 hour average of 09:00-16:00;
- PM peak: 16:30-17:30

13.1.3 Calibration Results – Model Sign Off

The full results of the calibration and validation of both WTSM and NWSM can be found in the following reports:

- TN18 WTSM Calibration and Validation Final.pdf; and
- Doc04 NWSM Model Calibration Report Rev01a.pdf.

The models were both fully peer reviewed and the peer reviewer was involved in the model development process throughout the design, build, calibration, validation and forecasting processes. The models were signed off as fit for purpose.

13.1.4 Forecast Years (2021 & 2031);

WTSM has forecast years for 2021, 2031 and 2041. In the assessment of the Petone to Grenada Link Road project the 2021 and 2031 years have been used. The 2041 forecast year was not used due to the uncertainty in growth and investment beyond 2031.

The forecast process involves calculating and estimating growth in the areas of the model in terms of housing development and employment opportunities. These estimates were based on Census data and projections for the medium growth scenario. Gravity modelling was then used to ascertain where trips would start and end during the modelled periods thus providing a pattern of movements estimated for the future.

13.1.5 Model Extent

The full NWSM area is shown in Figure 13-1 with road colouring reflecting road hierarchy in the core model area. The highlighted area between Ngauranga, MacKay's Crossing and Upper Hutt (Figure 13-2) is modelled with 'simulation' coding (fairly detailed intersection modelling and all roads modelled as links with speed-flow relationships). The remainder of the area is modelled in 'buffer' coding (no detailed intersection coding but all roads modelled as links with speed-flow relationships shown in Figure 13-1). The full model area is consistent with the area covered by WTSM.

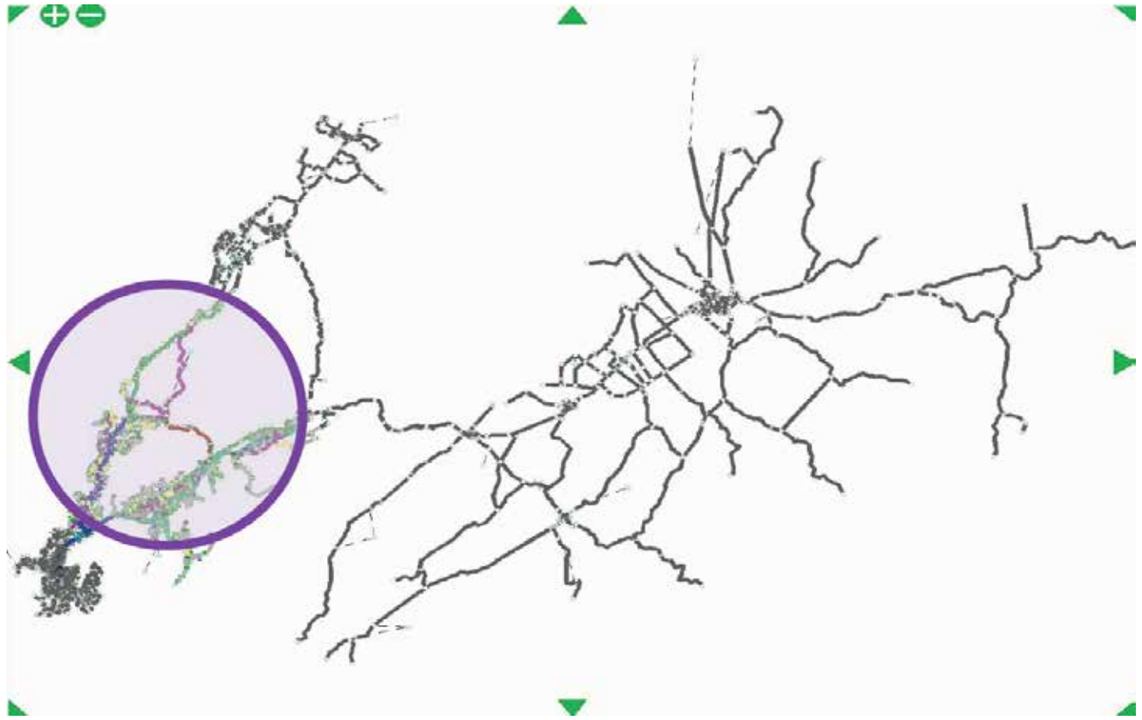


Figure 13-1: NWSM Full Network

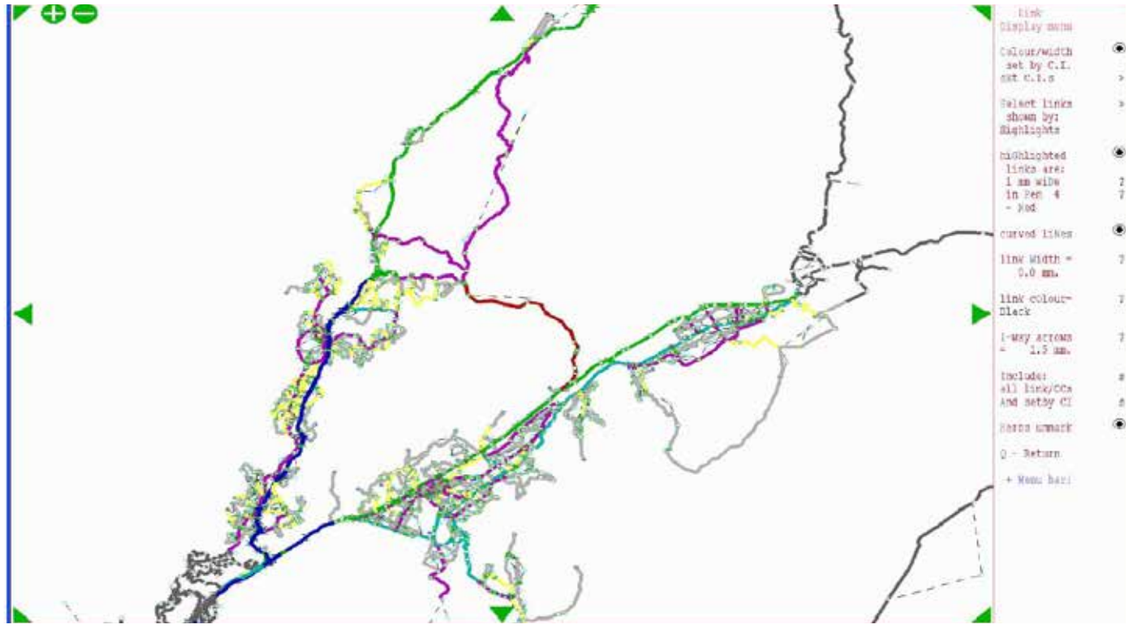


Figure 13-2: NWSM Simulation Coding

13.2 Do Minimum Assumptions

The assumptions for the do minimum models have been detailed in Table 13-1.

Table 13-1: Do Minimum Assumptions

Run #	Project	Construction Finish Date (June)	2011	2021	2031
P2G-1 (Run 1 - DM)	Airport to Mt Vic	2022	No	WTSM Only	WTSM Only
	Wellington RoNS –Tunnel to Tunnel (Including Basin Reserve, ICB Improvements and Memorial Park Underpass)	2017	No	WTSM Only	WTSM Only
	Terrace Tunnel Duplication	2024	No	WTSM Only	WTSM Only
	Ngauranga to Aotea Quay (Stages 1 to 5)	2021	No	Included	Included
	Transmission Gully	2020	No	Included	Included
	Mackays to Peka Peka	2018	No	WTSM Only	WTSM Only
	Peka Peka to Otaki	2020	No	WTSM Only	WTSM Only
	Otaki to Levin	2024	No	No	WTSM Only
	PT Improvements as per the Rail Plan		No	WTSM Only	WTSM Only
	SH2/ 58 grade separation		No	Included	Included
	Uphill passing lane extension (SH58)		No	Included	Included
	Melling Interim Improvements		No	NWSM Only	NWSM Only

No =Not built, therefore not included in WTSM or SATURN modelling

WTSM Only = Project built but located beyond SATURN model extents, therefore only in the WTSM modelling

Included= Project operational and included in both WTSM and SATURN modelling

The do minimum NWSM also includes Westchester Drive despite it not being coded in WTSM as this is a critical feeder to SH1 and the future P2G.

13.3 Option Descriptions

13.3.1 Option Connections

The following assumptions are consistent across all options:

- P2G-2 WTSM matrices (assumptions as per Table 13-1, but with the P2G Link Road included);
- 80km/hr speed environment on the P2G route; and
- Speed has been reduced on links with a gradient for HCVs and cars. An initial discussion with SKM confirmed that this would be similar to the approach used for the Transmission Gully modelling.

Table 13-2 lists the connection options at the ends of the route and any proposed mid route connections.

Table 13-2: Option Connections

Option (Model Run)	Connection to SH2	Connection Mid Route	Connection to SH1
A(P2G-6)	A full grade separated interchange between SH2 and P2G at Petone	A full grade separated interchange at Mark Avenue	Full grade separated interchange between P2G and SH1 at Grenada SH1 six laning between Grenada and TG
B (P2G-2)	A full grade separated interchange between SH2 and P2G at Petone	A full grade separated interchange at Mark Avenue	North facing ramps only at Tawa (layout consistent with the SKM PFR) Full grade separated interchange at Grenada SH1 six laning between Tawa and TG
B1 (P2G-3)	North facing ramps at the SH2 / P2G interchange at Petone	A full grade separated interchange at Mark Avenue	North facing ramps only at Tawa (layout consistent with the SKM PFR) Full grade separated interchange at Grenada SH1 six laning between Tawa and TG
C (P2G-4)	A full grade separated interchange between SH2 and P2G at Petone	A full grade separated interchange at Mark Avenue	Full grade separated interchange between P2G and SH1 at Tawa Full grade separated interchange at Grenada SH1 six laning between Tawa and TG
C1 (P2G-7)	North facing ramps at the SH2 / P2G interchange at Petone	A full grade separated interchange at Mark Avenue	Full grade separated interchange between P2G and SH1 at Tawa Full grade separated interchange at Grenada SH1 six laning between Tawa and TG
D (P2G-5)	A full grade separated interchange between SH2 and P2G at Petone	A full grade separated interchange at Mark Avenue	North facing ramps at Transmission Gully with an 80km/h speed environment; Full grade separated interchange between P2G and SH1 to provide access at Tawa and Grenada

13.3.2 SH2 Connection Options

Full Interchange

- 50km/hr speed and reduction from 6 lanes to 4 lanes on P2G route before the interchange (layout is based on SKM PFR alignment shown in Figure 13-3).

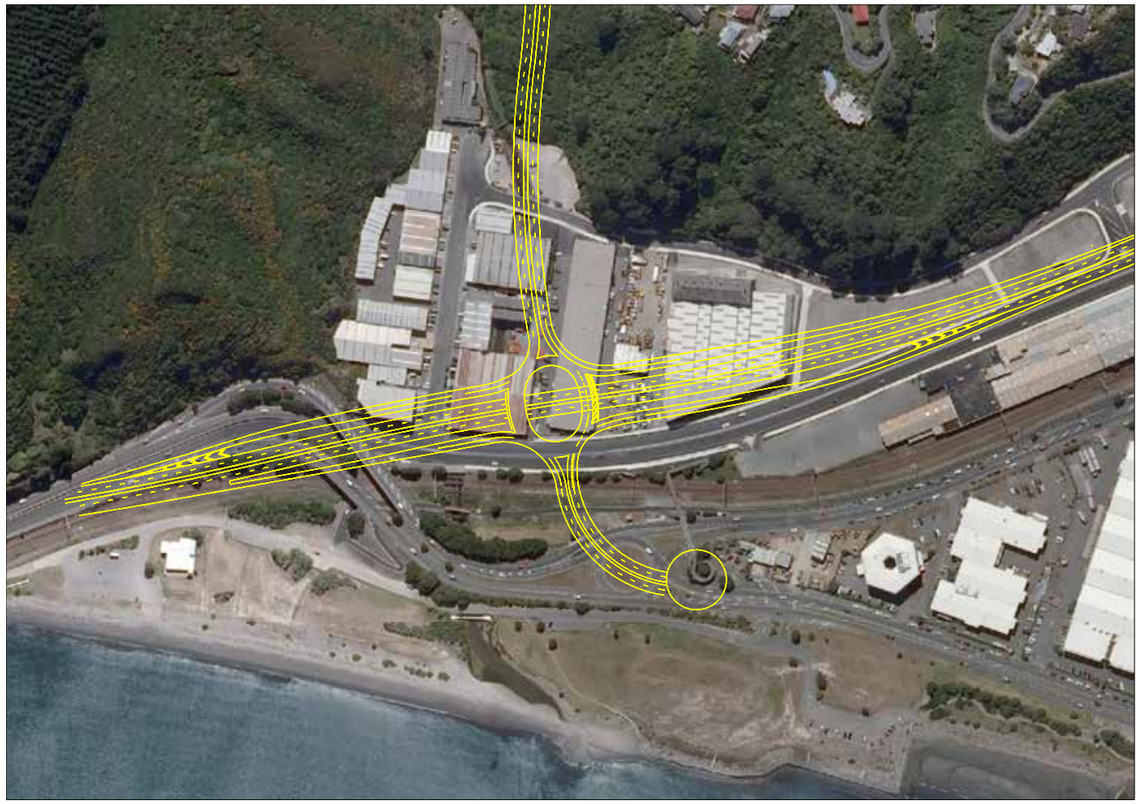


Figure 13-3: Option 1 - Petone Interchange Layout

North Facing Ramps Only

- North facing ramps at the SH2 / P2G interchange at Petone with 80km/h speed on the P2G route and lane drops 3 to 2 to 1 (layout as shown in Figure 13-4).

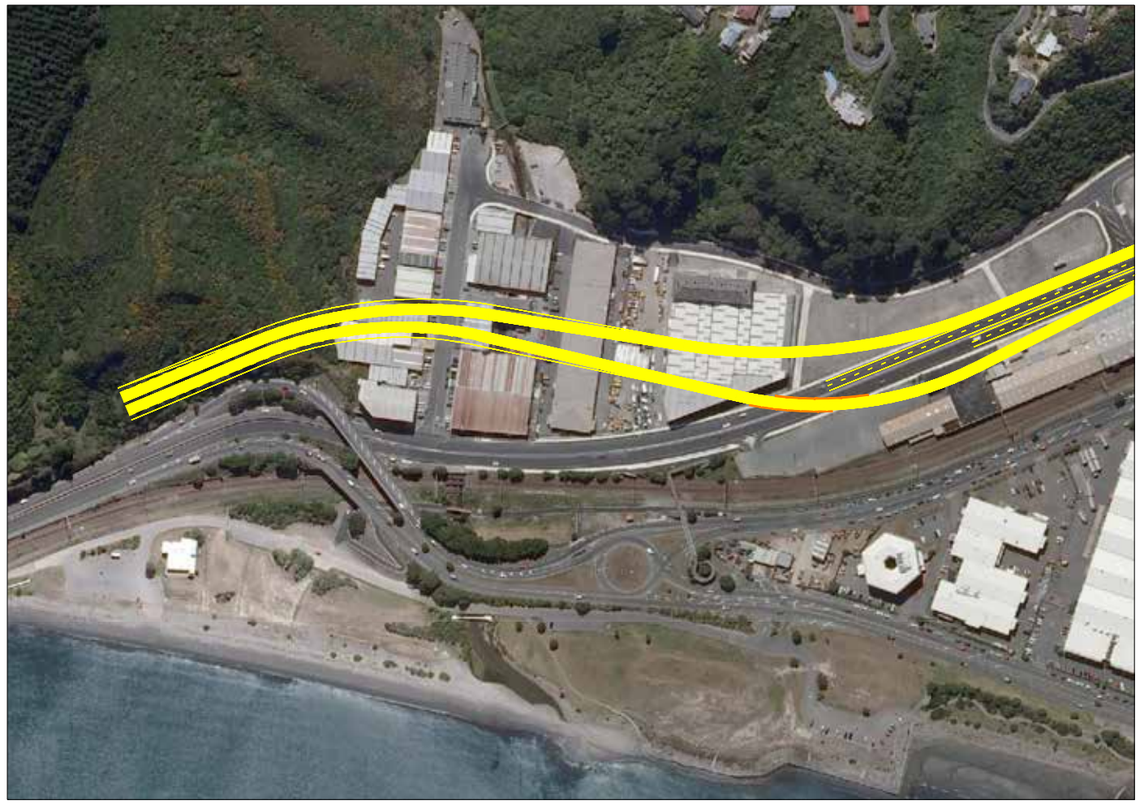


Figure 13-4: Petone Interchange with North Facing Ramps.

13.3.3 SH1 Connection Options

Full Interchange at Tawa

Full grade separated interchange between P2G and SH1 at Tawa with a 70 km/h speed limit and a reduction to a 4-lane cross section on approach to the interchange (layout as shown in Figure 13-5).

Figure 13-5: Tawa Full Interchange

North Facing Ramps at Tawa

- Layout consistent with the SKM PFR
- P2G is coded as 6-lanes prior to the intersection and reduces to 4-lanes on approach to the ramps connecting with SH1. The remaining 4 lanes allow for 1-lane merge and the other lane continues as an auxiliary lane along SH1 to the intersection with Transmission Gully (layout as shown in Figure 13-6).

Figure 13-6: Tawa Interchange with North Facing Ramps

North Facing Ramps at TG

- North facing ramps at Transmission Gully with an 80km/h speed environment (layout as shown in Figure 13-7).

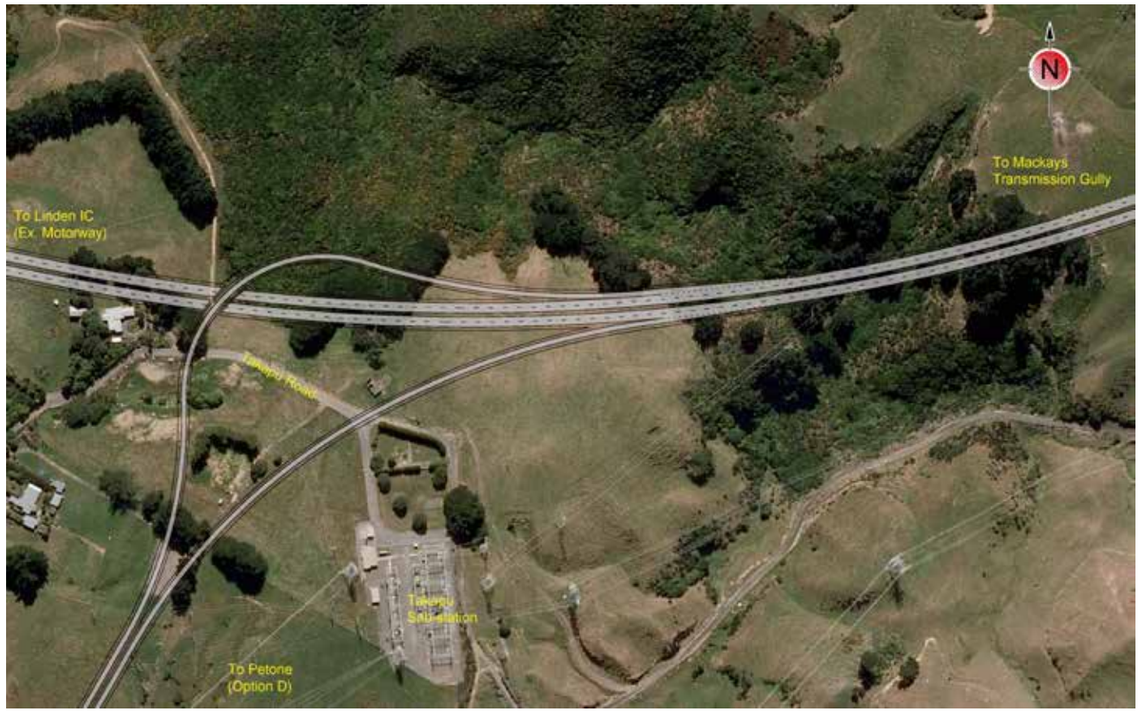


Figure 13-7: Transmission Gully Interchange with North Facing Ramps

13.4 Traffic Impacts

The following section discusses the NWSM modelling results in terms of the impacts on the network. Each section discusses one particular parameter from the modelling results. In general and unless otherwise stated the analysis that follows has been undertaken for the 2031 forecast year as this provides the highest demands on the network. Specific option performance is discussed in Sections 14-17.

13.4.1 Traffic Volumes

Background Growth

Appendix C.1 shows the two-way AADT growth comparison from current traffic volumes in the 2011 Base and the projected volumes in 2031 from WTSM. Figure 13-8 shows the difference in flows between the 2031 and 2011 SATURN models (note that TG flow difference is not shown as this is not present in the 2011 model).

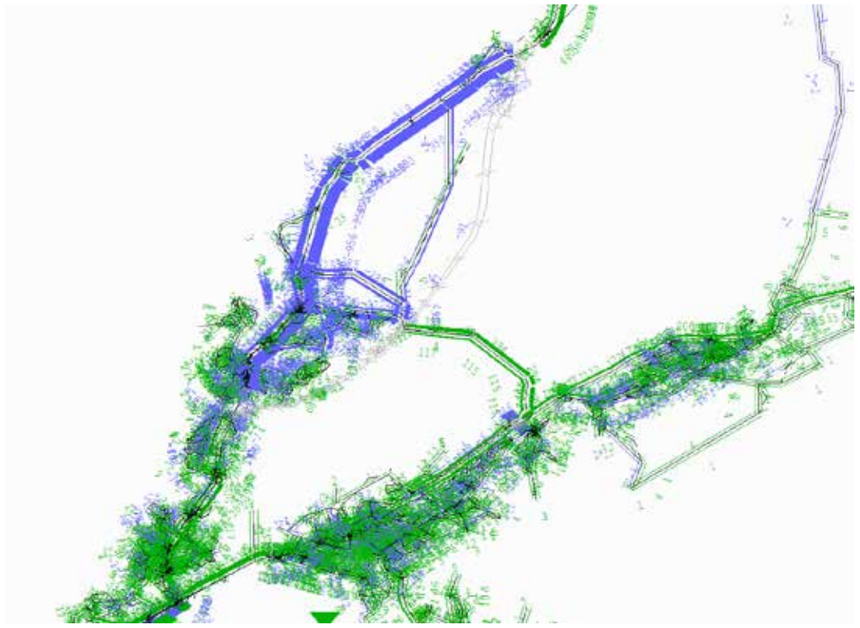


Figure 13-8: Difference in flow between 2011 and 2031 SATURN models

In the 2031 do minimum:

- The predicted growth along the SH1 corridor is 11% south of the Ngauranga Interchange and 15% north of the interchange over the 20 year period; and
- The SH2 corridor is predicted to experience growth of around 15% over the next 20 years.

Once the Wellington Northern Corridor Roads of National Significant (WNCR) schemes are constructed:

- SH1 will attract approximately 26% more traffic between Paekakariki and Porirua;
- SH2 volumes remain relatively constant, reducing by 1% south of Petone; and
- The additional traffic on SH1 is mainly cars. This is mostly a result of mode share changes where users are switching from public transport to cars.

If Petone to Grenada is constructed, in 2031:

- There are reduced volumes on SH58;
- Flows on SH2 south of Petone also reduce;
- SH1 flows north of the P2G interchange remain consistent;
- SH1 flows between the P2G interchange and Ngauranga reduce by 28%; and
- SH1 flows south of Ngauranga reduce by 3%.

Sector Movements

The basic AADT movements within certain areas were further analysed based on the sector plan shown in Figure 13-9. The sector analysis AADT matrices can be found in Appendix C.2.

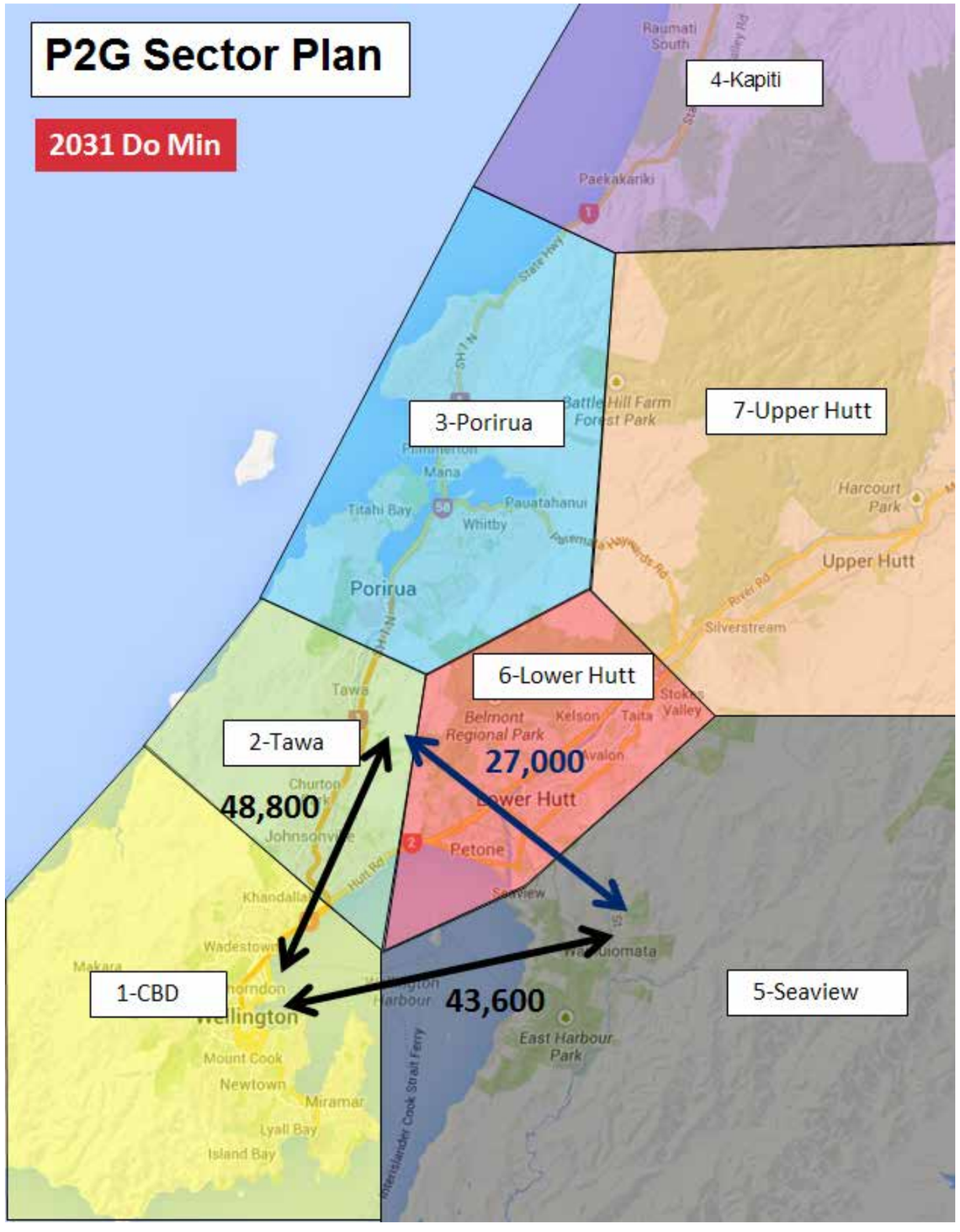


Figure 13-9: Sector Plan Showing Highest Do Minimum AADT Demands

Without construction of a link between Petone and Grenada (i.e. the do minimum), in 2031 the highest demands are generally between:

- Tawa and the Wellington CBD (48,800 vpd);
- Lower Hutt and the Wellington CBD (43,600 vpd); and
- Seaview / Lower Hutt and Tawa / Porirua (27,000 vpd).

If a Petone to Grenada Link Road is constructed by 2031 the demand volumes between the Wellington CBD and both Lower Hutt and Tawa remains minimal. However there is a 40% increase in trips between Lower Hutt / Seaview and Tawa / Porirua. These changes are shown on Figure 13-10. This increase is caused by:

- People shifting from public transport to private vehicles because of less congestion and more capacity on the network; and
- Changes in the locations where people live and work as travel is easier.

Additionally a public transport (PT) test was carried out on the P2G WTSM network to assess the effect of PT services on mode share between Petone and Grenada. The test involved adding a bus service along the P2G link with a 15 minute frequency over all periods. The service was found to have minimal usage (around 60-80 passengers per two hour peak) relative to the total demands on the link (~37,200 vehicles). The addition of this PT service also had no significant effect on sectorised movements. Investigations indicate that promoting PT usage between Petone and Tawa would require more planning than simply including a connecting PT service.

13.4.2 Network Performance

As an overview of the performance of each option the initial approach is to consider network wide statistics such as network speed, time, delay, queue and distance compared with the do minimum. The results can be seen in detail in Appendix C.3 of this report.

Across all options the network distance increases by around 3-4% in the AM peak and 4-5% in the PM peak with minimal change in the inter peak periods. The percent difference between the do minimum and options for key statistics have been presented in Table 13-3. The significant reductions in delay highlight the significant constraints imposed by the current network.

Table 13-3: Network Performance of Options compared to Do Minimum

	Option A		Option B		Option C		Option D	
	AM	PM	AM	PM	AM	PM	AM	PM
Speed	11%	7%	9%	6%	9%	6%	9%	5%
Time	-6%	-2%	-5%	-1%	-6%	-2%	-6%	-2%
Delay	-20%	-22%	-20%	-19%	-22%	-21%	-20%	-21%
Distance	4%	5%	3%	4%	3%	4%	3%	4%

13.4.3 Traffic Redistribution

Each of the options has been compared with the do minimum actual flows across the network to ensure the changes in travel patterns due to the options are logical. The detailed AADT flow diagrams for each option can be found in Appendix C.4. The AADT for key locations on the network have been presented in Table 13-4.

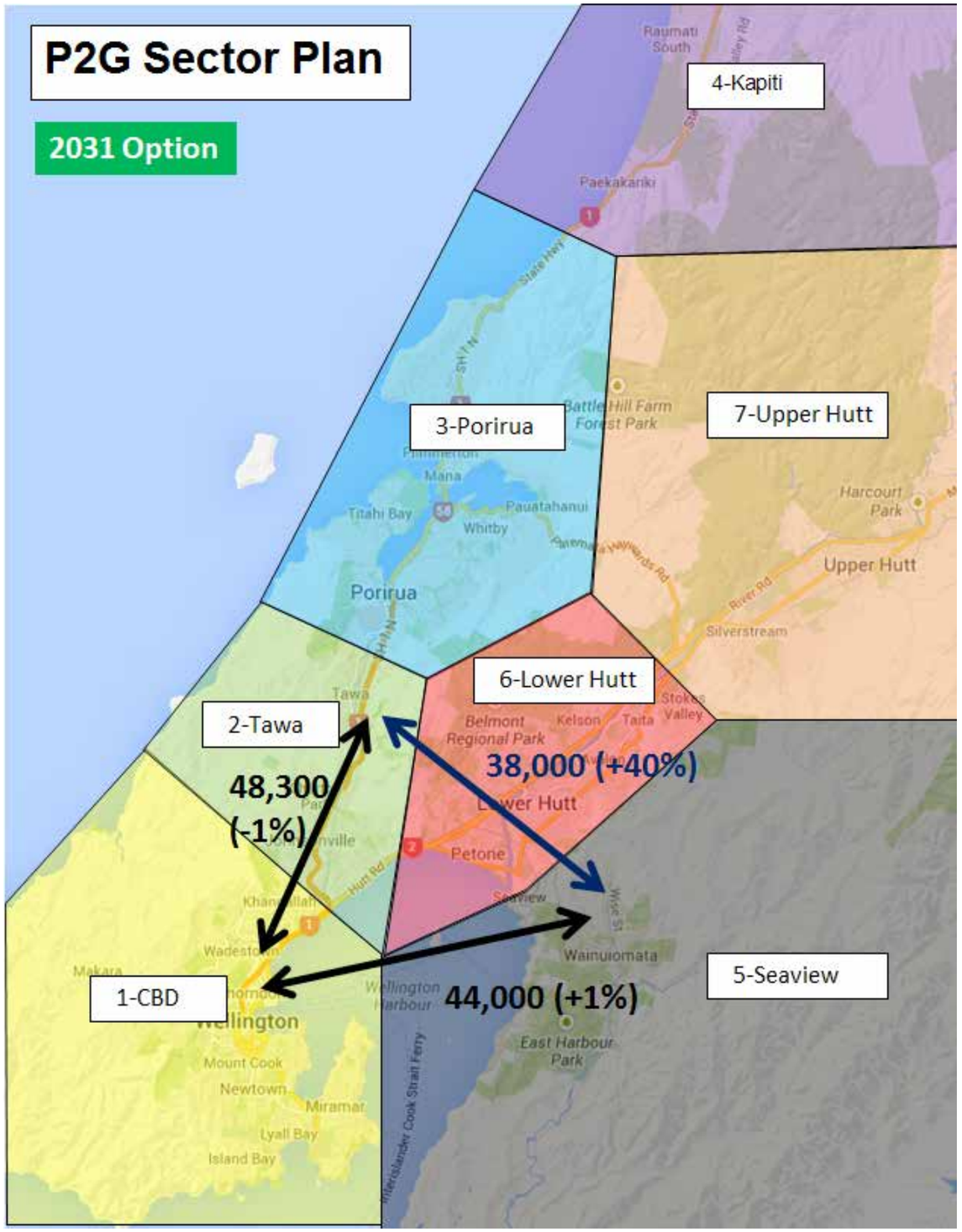


Figure 13-10: Sector Plan Showing Option AADT Demands with % Change from Do Minimum

Table 13-4: 2031 AADT at Key Locations on Network

	Do Min	Option A	Option B	Option C	Option D
P2G Link Road	N/A	31,700	29,700	30,900	31,700
SH1 South of Ngauranga	106,100	106,000	105,900	105,900	105,900
SH1 South of Grenada	59,500	56,900	51,700	54,300	54,700
SH1 South of Tawa	43,600	73,900	34,800	35,500	35,400
SH1 North of Tawa	48,500	56,800	62,300	57,700	50,500
SH2 between Ngauranga and Petone	82,700	71,000	73,100	72,900	72,100
SH2 North of Petone	50,100	60,800	60,900	61,800	61,900

13.4.4 Travel Time

Travel time analysis has been completed in NWSM for key routes associated with the project travel patterns. The results can be seen in more detail in Appendix C.5. The routes analysed are:

- Route 1 - between Petone Esplanade and Tawa;
- Route 2 - between SH2 south of Petone and Tawa;
- Route 3 - between SH2 north of Petone and Tawa;
- Route 4 - between SH2 north of Petone and SH1 south of Ngauranga;
- Route 5 - between SH2 north of Petone and Westchester Drive east;
- Route 6 - between SH2 south of Petone and Transmission Gully / P2G north of P2G;
- Route 7 - between SH1 / Transmission Gully and Ngauranga; and
- Route 8 - between Seaview and SH2 south of Petone interchange via The Esplanade.

Figure 13-11 gives an indication of the travel time routes[1] .

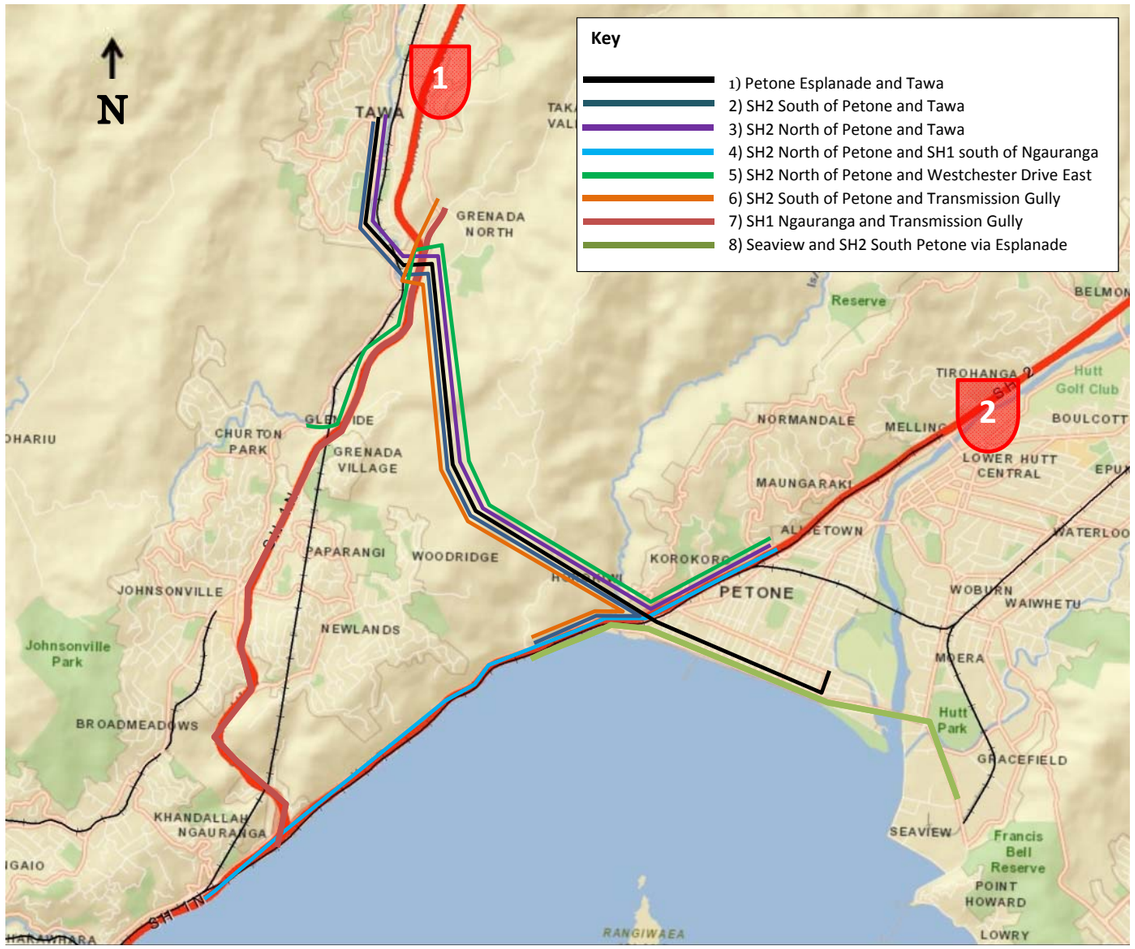


Figure 13-11: Travel Time Routes for Options

All travel time routes analysed in all time periods and options have a reduction in travel time or, at worst, the travel time is unchanged. The one exception to this is the route between SH1 Tawa to SH2 south of Petone in option C1 which has a slight increase in the AM peak 9.7% and a large increase in the PM peak 88%. This increase in travel time is because option C1 has north facing ramps only at Petone so all traffic accessing south of Petone must travel via the Dowse Interchange.

1 Travel time routes for the do minimum will differ from those routes that use the P2G Link Road as this road does not exist in the do minimum model. These routes therefore us SH1 and SH2 to reach the same destination.

The travel times for Routes 1 and 7 have been presented in Figure 13-12, Table 13-5, Figure 13-13 and Table 13-6. Presented for Route 1 are travel times in the eastbound direction for the AM peak and the westbound direction during the PM peak as these are highest travel times (i.e. the most desired direction of travel during that peak). By the same token, Route 7 shows southbound in the AM peak and northbound in the PM peak.

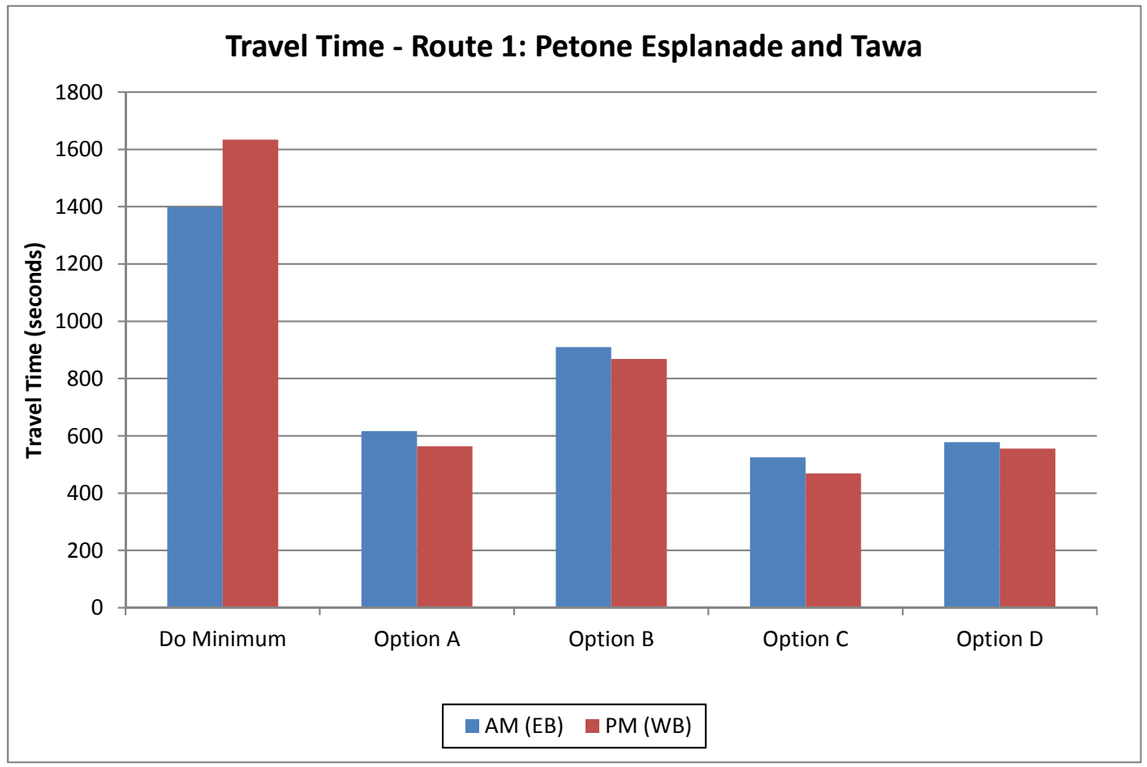


Figure 13-12: Route 1 Travel Times for Options and Do Minimum

Table 13-5: Travel Time Savings (minutes) for Options compared to the Do Minimum, Route 1

	AM (EB)	PM (WB)
Option A	13	18
Option B	8	13
Option C	15	19
Option D	14	18

The do minimum travel time for Route 1 is significantly higher than that of the options. This is in part due to the additional kilometres travelled as the options use the P2G Link Road. Option C shows the best travel times when compared to the other options.

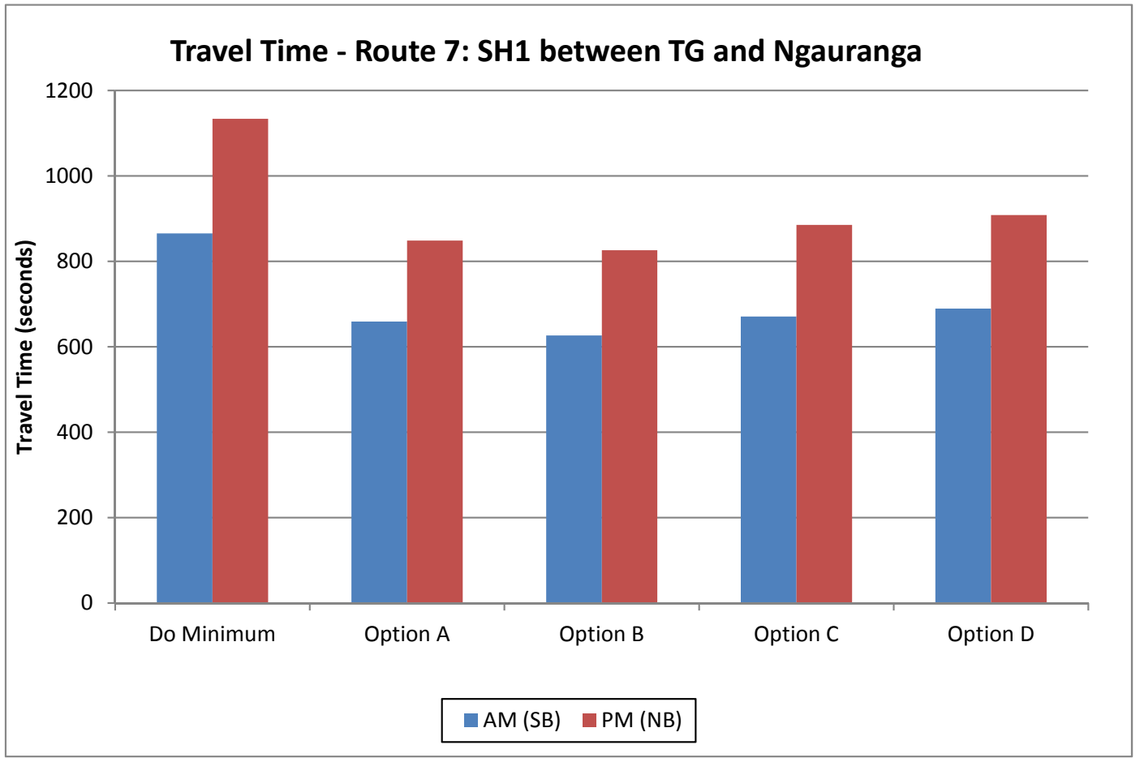


Figure 13-13: Route 7 Travel Times for Options and Do Minimum

Table 13-6: Travel Time Savings (minutes) for Options compared to the Do Minimum, Route 7

	AM (SB)	PM (NB)
Option A	11	14
Option B	10	14
Option C	11	15
Option D	11	15

For Route 7, Option B shows the best travel times along SH1 when compared to the other options. However this is due to Option B having no southbound connections to and from SH1 at Tawa. As a result traffic volumes (and associated delays) increase on the local road network at Tawa, particularly along Middleton Road.

13.5 Link Flows and Level of Service (LOS)

The Levels of Service (LOS) are calculated using link volumes in accordance with Exhibit 14-17 from the Highway Capacity Manual 2010 (HCM). For simplicity the factors used to convert the volumes to passenger car units (pcu) have been assumed to be based on a 5% proportion of heavy commercial vehicles (HCV) and a peak hour factor (PHF) of 0.85 to take into account the peak within the peak hour.

The traffic flows are 2031 link volumes (in total vehicles) from the NWSM and generally correspond to the links shown on the AADT figures in Appendix C1.

Tables 13-7 and 13-8 show the change in flows and link LOS for key routes when compared to the 2031 do minimum flows for the AM and PM peak.

13.5.1 AM Peak

The following commentary is made on the traffic flow changes:

- Northbound on SH1 between Tawa and Churton Park flows reduce where traffic is being redistributed onto the new P2G link. However, north and south of this section volumes increase from traffic using the new link via the Tawa and Grenada Interchanges, respectively.
- Southbound on SH1, flows increase north of the proposed P2G link but decrease to the south where traffic is being redistributed onto the new link.
- Traffic between Petone and Dowse Interchanges increases in both directions associated with traffic accessing the new link.
- South of Petone on SH2, northbound traffic reduces as it redistributes onto the new link. Southbound traffic increases as the capacity released by redistributing traffic is taken up by supressed demand.
- Traffic flows increase on The Esplanade in both directions.

Table 13-7: Comparison of Option flows and link LOS with the Do Minimum (2031, AM Peak)

Link	Change in flow (from Do Minimum)					Level of Service				
	Do Min	Option A	Option B	Option C	Option D	Do Min	Option A	Option B	Option C	Option D
SH1 Northbound: Between TG and Tawa	**1483**	29%	37%	29%	11%	**B**	B	B	B	B
SH1 Northbound: Between Tawa and Churton Park	**1837**	34%	-32%	-9%	-9%	**C**	D	B	C	C
SH1 Northbound: Between Churton Park and Johnsonville	**1711**	23%	4%	16%	16%	**C**	C	C	C	C
SH1 Northbound: Between Ngauranga and Aotea	**3878**	-7%	-7%	-7%	-7%	**D**	D	D	D	D
SH1 Southbound: Between TG and Tawa	**2880**	20%	32%	22%	11%	**D**	C	D	C	E
SH1 Southbound: Between Tawa and Churton Park	**3294**	28%	-27%	-12%	-11%	**E**	F	D	D	D
SH1 Southbound: Between Churton Park and Johnsonville	**3523**	-5%	-11%	-6%	-6%	**F**	E	E	E	E
SH1 Southbound: Between Ngauranga and Aotea	**6147**	2%	1%	2%	2%	**F**	F	F	F	F
SH2 Northbound: Between Petone and Dowse	**2057**	34%	35%	36%	36%	**C**	D	D	D	D
SH2 Northbound: Between Ngauranga and Petone	**3744**	-23%	-21%	-23%	-23%	**F**	D	D	D	D
SH2 Southbound: Between Petone and Dowse	**2710**	22%	22%	23%	23%	**D**	E	E	E	E
SH2 Southbound: Between Ngauranga and Petone	**3272**	6%	5%	5%	5%	**E**	F	F	F	F
The Esplanade Eastbound: Between Victoria Street and Te Puni Street	**979**	19%	19%	19%	19%	**C**	C	C	C	C
The Esplanade Westbound: Between Victoria Street and Te Puni Street	**813**	18%	18%	18%	19%	**B**	C	C	C	C

The LOS changes generally reflect the changes in the traffic flows. The key exceptions to this are in both directions on SH1 between TG and Tawa where Options A-C propose to include widening SH1 from two lanes to three lanes in each direction. Thus the increased capacity is sufficient to absorb the increased demand and the LOS remains the same or improves on this section for Options A, B and C. Option D has a lower LOS for this section despite the lower increase in flows because it remains at two lanes. Generally the options result in no change or an improved LOS on SH1 but a poorer LOS on SH2 and The Esplanade. The LOS on the new P2G link is expected to be C or better.

13.5.2 PM Peak

The following commentary is made on the traffic flow changes:

- Northbound on SH1 between Tawa and Churton Park flows reduce where traffic is being redistributed onto the new P2G link. However, north and south of this section volumes increase from traffic using the new link via the Tawa and Grenada Interchanges, respectively.
- Southbound on SH1 between Tawa and Churton Park flows reduce where traffic is being redistributed onto the new P2G link. However, north and south of this section volumes increase from traffic using the new link via the Tawa and Grenada Interchanges, respectively.
- Traffic between Petone and Dowse Interchanges increases in both directions associated with traffic accessing the new link.
- South of Petone on SH2, southbound traffic reduces as it redistributes onto the new link. Northbound traffic increases slightly as the capacity released by redistributing traffic is taken up by supressed demand.
- Traffic flows increase on The Esplanade in both directions.

Table 13-8: Comparison of Option flows and link LOS with the Do Minimum (2031, PM Peak)

Link	Change in flow (from Do Minimum)					Level of Service				
	Do Min	Option A	Option B	Option C	Option D	Do Min	Option A	Option B	Option C	Option D
SH1 Northbound: Between TG and Tawa	3079	26%	43%	27%	3%	E	D	D	D	E
SH1 Northbound: Between Tawa and Churton Park	3458	36%	-18%	-4%	-6%	F	F	D	E	E
SH1 Northbound: Between Churton Park and Johnsonville	3293	7%	1%	4%	4%	E	F	E	F	F
SH1 Northbound: Between Ngauranga and Aotea	6480	3%	3%	3%	3%	F	F	F	F	F
SH1 Southbound: Between TG and Tawa	1655	17%	42%	20%	16%	B	B	B	B	C
SH1 Southbound: Between Tawa and Churton Park	2140	22%	-36%	-11%	-12%	C	D	B	C	C
SH1 Southbound: Between Churton Park and Johnsonville	2065	8%	-2%	6%	5%	C	C	C	C	C
SH1 Southbound: Between Ngauranga and Aotea	3989	4%	4%	4%	4%	D	D	D	D	D
SH2 Northbound: Between Petone and Dowse	2805	24%	23%	26%	27%	D	F	F	F	F
SH2 Northbound: Between Ngauranga and Petone	3650	3%	3%	3%	3%	F	F	F	F	F
SH2 Southbound: Between Petone and Dowse	2802	10%	11%	13%	16%	D	E	E	E	E
SH2 Southbound: Between Ngauranga and Petone	3805	-20%	-18%	-17%	-19%	F	D	E	E	E
The Esplanade Eastbound: Between Victoria Street and Te Puni Street	949	24%	23%	22%	21%	C	C	C	C	C
The Esplanade Westbound: Between Victoria Street and Te Puni Street	1066	31%	31%	28%	23%	C	D	D	D	D

The LOS changes generally reflect the changes in the traffic flows. The key exceptions to this are in both directions on SH1 between TG and Tawa where Options A-C propose to include widening SH1 from two lanes to three lanes in each direction. Thus the increased capacity is sufficient to absorb the increased demand and the LOS remains the same or improves on this section for Options A, B and C. Option D has a lower LOS for this section despite the lower increase in flows because it remains at two lanes. Generally the options result in an unchanged or improved LOS on SH1 (with the exception of the section between Churton Park and Johnsonville). The LOS worsens on SH2 north of Petone and westbound on The Esplanade and is unchanged or improved on SH2 south of Petone and eastbound on The Esplanade. The LOS on the new P2G link is expected to be B or better.

13.6 Discussion

13.6.1 Preferred Options for Further Investigation

The amendment of the interchange at Petone to allow for only north facing ramps (Options B1 and C1) has a major impact on the network wide statistics compared with the same options with a full interchange. In general, the travel time results are worse than that of a full interchange. The north facing ramps put more pressure on the links to the north of the SH2 / P2G Interchange without providing major reductions in flow elsewhere in the network. For each of these reasons these sub-options should not be considered further.

Of the remaining four basic options, when network wide performance is compared to the do minimum Option A is considered the best, although this option also shows the greatest increase in overall distance travelled (refer Appendix C.3). Option B, while still performing better than the do minimum, shows the least improvement of the four options. Options C and D produce similar results to Option B. Options A and C provide the best travel time savings as a whole and again Option B provides some of the worst travel time savings on key routes (refer Appendix C.5). Generally the options result in an unchanged or improved LOS on SH1 with poorer results on SH2 in the peak periods despite the reduction in overall AADT seen in Table 13-4. Option A causes major increases in flow on the local links around Mark Avenue. Option D, with the inclusion of a connection to Transmission Gully, has minimal impact on the TG route itself and provides minimal additional benefit in terms of network performance or travel time. It should be noted that Option D is the only option which does not require SH1 to be upgraded within the current planning period.

The routes that should be considered further are Options A, C and D although consideration needs to be made of the local road impacts of Option A. Option D also needs further consideration of the design of the cross section for the link between Tawa and TG on the P2G Link Road as the predicted volumes would not require a 4 lane carriageway.

13.6.2 Other Opportunities

Induced trips are a large aspect of this scheme and as such can be considered to provide economic growth to the city as a whole. While some of these trips are from new demand, most of the change is due to people altering their destinations due to the increased connectivity of the network. That is, people have increased opportunities to work in different areas. Appropriate consideration of the effects and benefits of induced trips is required. However, currently the effect is similar between all options. The main disbenefit is the additional trip distance, yet there are wider economic benefits associated with these trips. This issue will be assessed in more detail in the Scheme Assessment stage of the project.

13.7 Conclusions

Four basic options have been analysed for the Petone to Grenada Link Road with two sub-options. The options have been modelled in the NWSM using SATURN and the results have been compared for network performance, local intersection performance, travel time savings on key routes and traffic redistribution impacts. Further information on option performance is discussed in Sections 14-17.

The suggested options for further consideration from a transportation perspective are Options A, C and D. Options A and C are preferred from a transportation point of view, but Option D with the connection to Transmission Gully also has merits as it negates the need to upgrade SH1 between the Tawa Interchange and TG within the current planning period. It also provides additional resilience to the network. Overall, all options provide significant transport benefits though Option B should be excluded since it provides benefits which are clearly inferior to Options A, C and D.

14

Alignment Option A

14 Alignment Option A

14.1 Key Drivers

- Full connectivity to SH2, The Esplanade and Hutt Road in Petone.
- Full connectivity to SH1 and the local road network at Grenada.
- Link to Lincolnshire Farms.
- Maintain form of Grenada Drive and the Grenada Interchange on SH1 but upgrade to increase capacity.

14.2 Description

14.2.1 Alignment

This section describes the alignment of Option A, from the eastern section of Lincolnshire Farm to Grenada. The description of the remainder of the route, from Lincolnshire Farm to Petone, is provided in the P options.

At the eastern section of Lincolnshire Farm, Option A runs northwest across the broad, undulating hilltop plateaux at Lincolnshire Farm before deviating north to the location of the roundabout at Mark Avenue. Just prior to Mark Avenue, Option A crosses a steep sided gully at an existing crossing point. From the location of the roundabout at Mark Avenue, Option A runs southwest along Grenada Drive to the location of the Grenada Interchange at SH1.

A new link from Petone to Grenada will increase traffic along SH1 north of the Grenada Interchange. To provide additional capacity, SH1 will need to increase from 4 lanes to 6 lanes between the Grenada Interchange and the proposed interchange at Transmission Gully. These details, together with the key features of Option A, are provided on Figure 14-1. Figure 14-2 shows Option A in relation to the topography between the eastern section of Lincolnshire Farm and Grenada Drive.

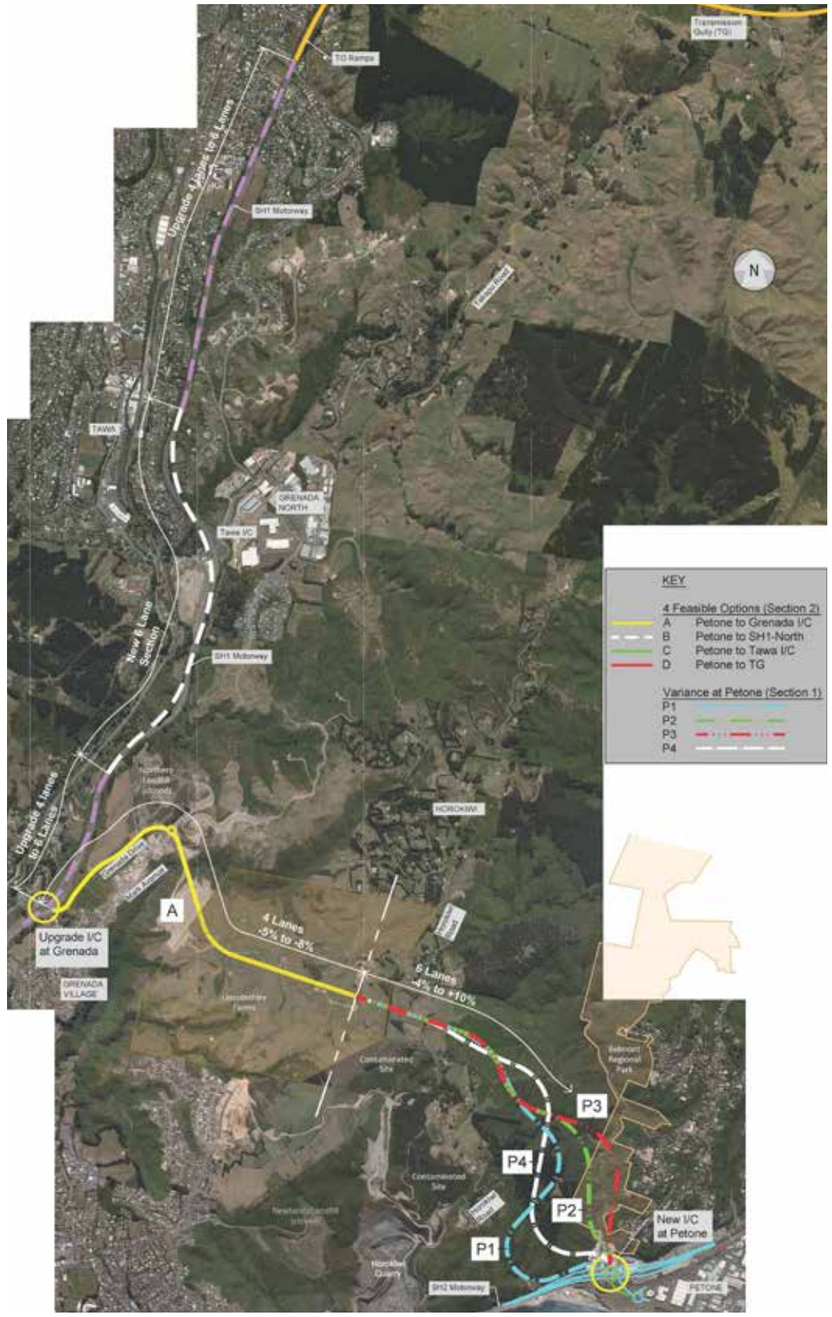


Figure 14-1: Option A

Figure 14-2: Option A In Relation to Topography

14.2.2 Lanes

- 2 new lanes in each direction from the eastern section of Lincolnshire Farm to the location of the Mark Avenue roundabout.
- Grenada Drive is upgraded from 1 lane in each direction to 2 lanes in each direction.

14.2.3 Structures

- New 2 lane circulating roundabout at Mark Avenue.
- Upgrade the existing interchange on SH1 at Grenada.

The new roundabout at Mark Avenue and the upgraded intersection on SH1 at Grenada are shown on Figure 14-3 and Figure 14-4, respectively.

Figure 14-3: New Roundabout at Mark Avenue

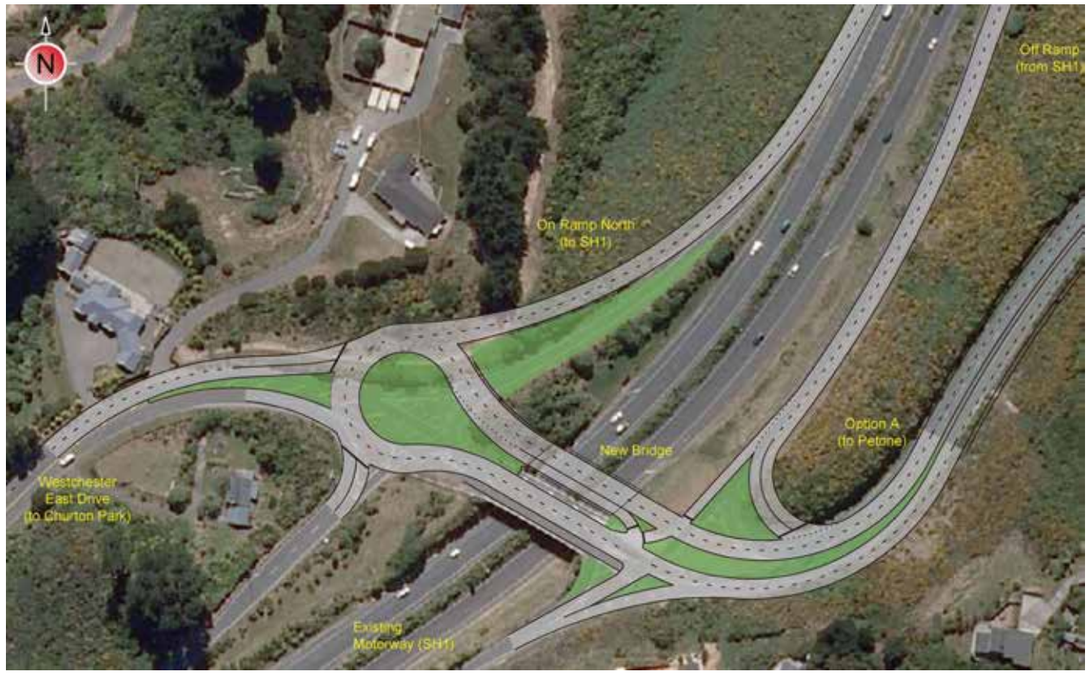


Figure 14-4: Upgraded Grenada Interchange at SH1

14.3 Rough Order Cost Estimate and BCR

The rough order cost of Option A is estimated to range between $175 million and $396 million and has an indicative cost benefit ratio of 2.1. Refer to Appendix D, Cost Estimate Development, and Appendix E, Preliminary Economic Assessment of Options, for the basis of these figures.

The rough order cost of Option A includes upgrading SH1 from 4 lanes to 6 lanes between Grenada and Transmission Gully and also includes the section between Lincolnshire Farm and Petone.

14.4 Transportation Impacts

14.4.1 Network Performance

Option A performs the best, in relation to the other options, in terms of network wide statistics with the highest increase in average network speeds; 11% in the AM peak and 7% in the PM peak. With the increase in speed, there are the associated large drops in network travel time, delay and queuing time. These results are slightly outweighed by the large increase in network travel distance with the AM peak increased by 4% compared to the do minimum and the PM peak increased by 5%.

14.4.2 Traffic Redistribution

Due to the lack of interchange at Tawa, the major impact of Option A is on the Mark Avenue local links with some large increases in volume when compared to the do minimum. The wider travel pattern changes are similar to the other options with traffic being drawn from SH1 / SH2 south of Petone and SH58 to the new P2G link. The issue will be the access of the traffic to the P2G link in particular at Mark Avenue at the P2G links northern extent.

14.5 Transportation Benefits

The transportation benefits have been based only on travel time savings, vehicle operating cost (VOC), vehicle emissions (CO2) reductions. Details on this are provided in Appendix E. Travel time savings in relation to the do minimum are discussed below.

14.5.1 Travel Times

Option A shows good travel time savings across all routes compared to the do minimum model as is shown in Figure 14-5. Generally Option A shows travel time savings over those generated from Option B and around the same level as those generated through Options C and D.

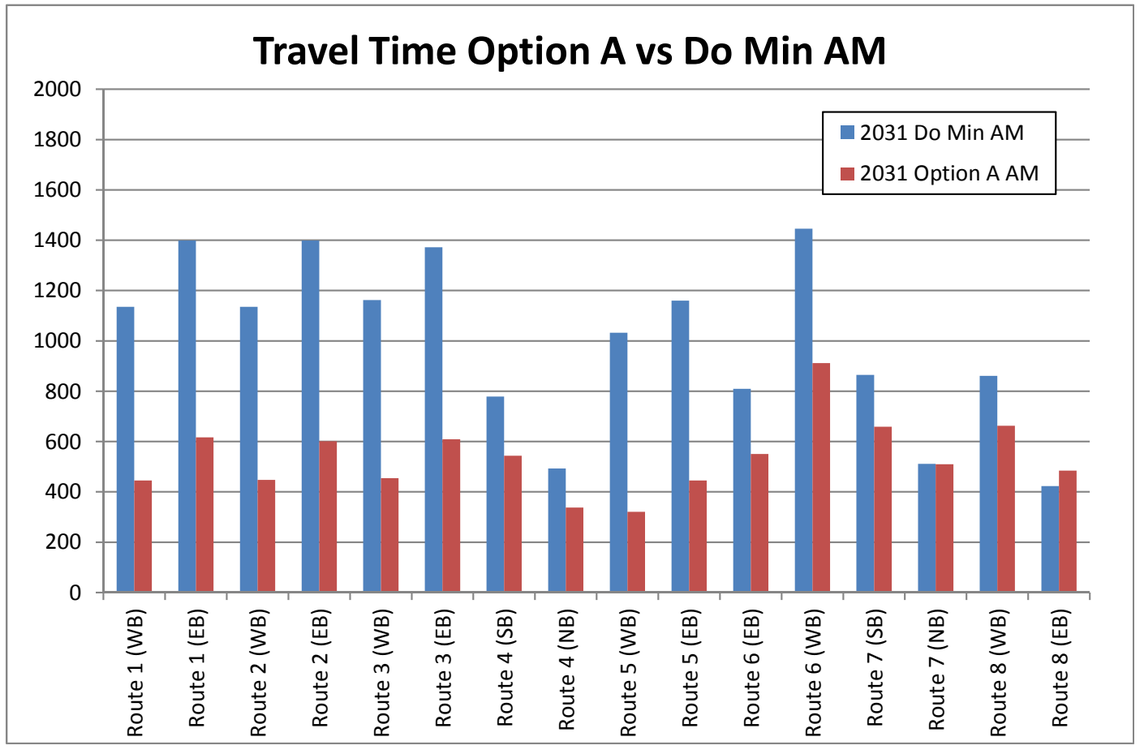


Figure 14-5: AM Travel Time – Option A vs. Do Min

15

Alignment Option B

15 Alignment Option B

15.1 Key Drivers

- Full connectivity to SH2, The Esplanade and Hutt Road in Petone.
- Full connectivity to SH1 at Tawa.
- Link to Lincolnshire Farms and SH1 at Grenada.
- Similar to the Project Feasibility Report (PFR) option which precedes this study.

15.2 Description

15.2.1 Alignment

This section describes the alignment of Option B, from the eastern section of Lincolnshire Farm to Tawa. The description of the remainder of the route, from Lincolnshire Farm to Petone, is provided in the P options.

At the eastern section of Lincolnshire Farm, Option B runs northwest across the broad, undulating hilltop plateaux at Lincolnshire Farm before deviating north to SH1. Between the northwest section of Lincolnshire Farm and SH1, Option B crosses a deep gully and cuts through the northern landfill. Beyond the northern landfill Option B connects to SH1 with north facing ramps.

A new link from Petone to Tawa will increase traffic along SH1 north of the new connection to SH1. As a result SH1 will need to increase from 4 lanes to 6 lanes between this new connection and the proposed interchange at Transmission Gully to provide additional capacity.

In addition to increasing SH1 from 4 lanes to 6 lanes, SH1 requires modifications to accommodate the north facing ramps while meeting the requirements of geometric and safety design standards. These include modifications to the alignment (to the north and south of the north facing ramps) and removing the interchange at Tawa. Removing the interchange at Tawa is required because it is not compatible with the introduction of north facing ramps just south of this interchange. With the north facing ramps in place there will be an inadequate and non-complying separation between these interchanges.

These details, together with the key features of Option B, are provided on Figure 15-1. Figure 15-2 and Figure 15-3 show Option B in relation to the topography between the eastern section of Lincolnshire Farm and SH1 at Tawa.

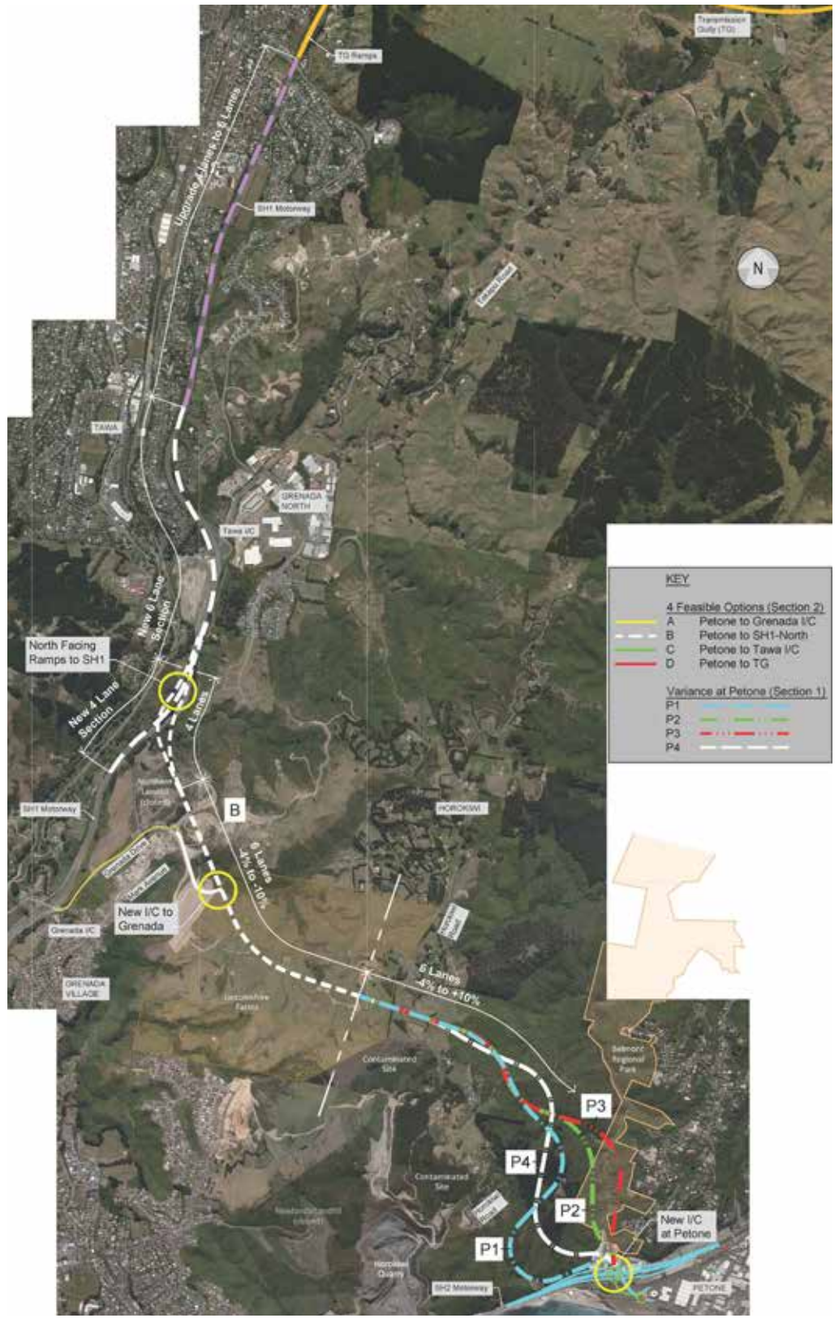


Figure 15-1: Option B

Figure 15-2: Option B In Relation to Topography at Lincolnshire Farm

Figure 15-3: Option B In Relation to Topography at SH1

15.2.2 Lanes

- 3 new lanes in each direction from the eastern section of Lincolnshire Farm to the start of the north facing ramps to SH1.
- 2 lanes for each north facing ramp connection to SH1.
- 1 lane in each direction between Option B at the northwest section of Lincolnshire Farm and the Mark Avenue roundabout.

15.2.3 Structures

- New north facing ramps to SH1 at Tawa.
- New grade separated interchange, at northwest section of Lincolnshire Farm, to provide links to Lincolnshire Farm and SH1 at Grenada.

The new north facing ramps at SH1 and modifications to the existing interchange at Tawa are shown on Figure 15-4. The new grade separated interchange is shown on Figure 15-5.

Figure 15-4: New North Facing Ramps at SH1 and Modifications to Tawa Interchange

Figure 15-5: New Grade Separated Interchange

15.3 Rough Order Cost Estimate and BCR

The rough order cost of Option B is estimated to range between $179 million and $405 million and has an indicative cost benefit ratio of 1.6. Refer to Appendix D and Appendix E for the basis of these figures.

The rough order cost of Option B includes upgrading SH1 from 4 lanes to 6 lanes between Tawa and Transmission Gully and also includes the section between Lincolnshire Farm and Petone.

15.4 Transportation Impacts

15.4.1 Network Performance

Option B provides good speed enhancement in the AM and PM peaks with associated reductions in delay and queuing time when compared to the do minimum. Network travel time is also reduced with the biggest reduction occurring in the AM peak at 5% less than the do minimum figure.

A variation of Option B, identified as Option B1, was also considered. Option B1 is identical to Option B but has north facing ramps at Petone to SH2 with no direct connections to the Esplanade and the Hutt Road. Option B1 provides less favourable results with less than half the improvement in speed when compared to Option B and whilst still providing improvement on network delay when compared to the do minimum, those improvement are inferior to those achieved by Option B.

15.4.2 Traffic Redistribution

Option B shows expected reductions in flow on SH2 / SH1 around the Ngauranga Interchange (approximately 1,500 vehicles, two-way flow) and SH58 (600 vehicles, two-way flow) with the expected increases around SH2 north of Petone and north of the Tawa Interchange.

Option B1 shows similar patterns in flow reduction on SH2 / SH1 around the Ngauranga Interchange with the expected increases around SH2 north of Petone and north of the Tawa Interchange. The north facing ramps at Petone increase the changes in flow in each direction on SH2 north of the Petone / P2G Interchange.

15.5 Transportation Benefits

The transportation benefits have been based only on travel time savings, vehicle operating cost (VOC), vehicle emissions (CO2) reductions. Details on this are provided in Appendix E. Travel time savings in relation to the do minimum are discussed below.

15.5.1 Travel Times

Option B shows travel time savings when compared against the do minimum models, as is shown in Figure 15-6. However these savings are to a lesser extent than the other options over most routes.

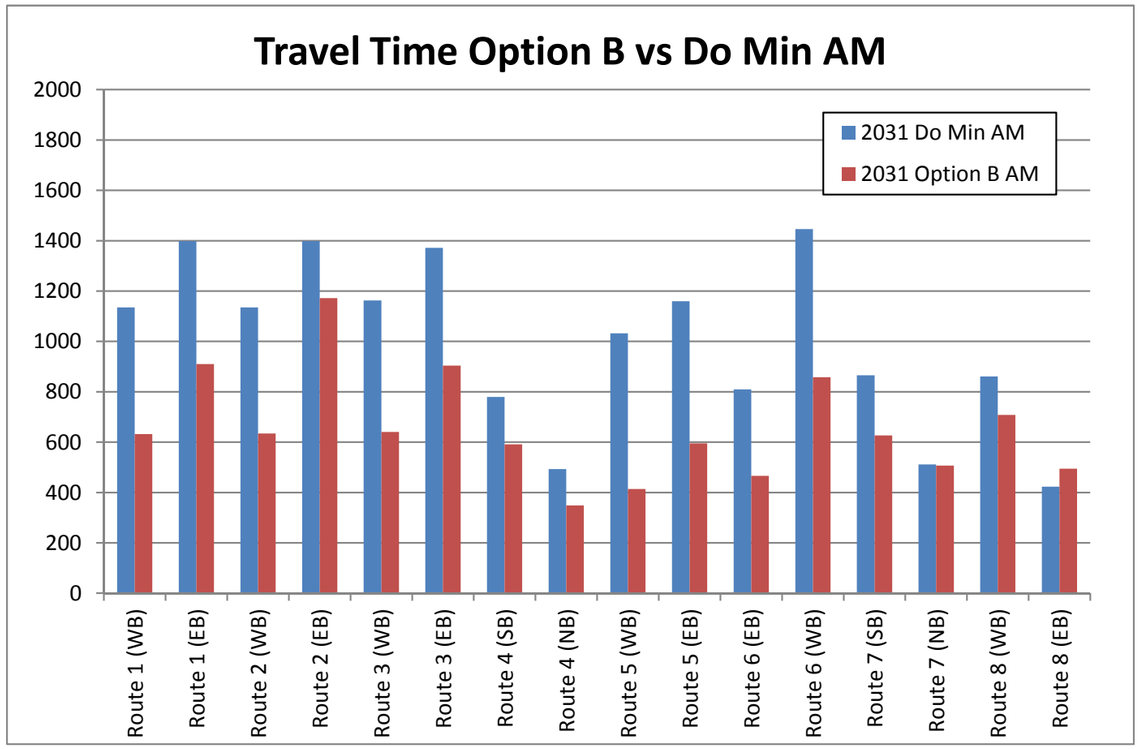


Figure 15-6: AM Travel Time – Option B vs. Do Min

Similarly to Option B, Option B1 generally shows travel time savings over the do minimum, as shown in Figure 15-7, but generally to a lesser extent than the other options. Route 2 eastbound shows an increased travel time when compared to the do minimum.

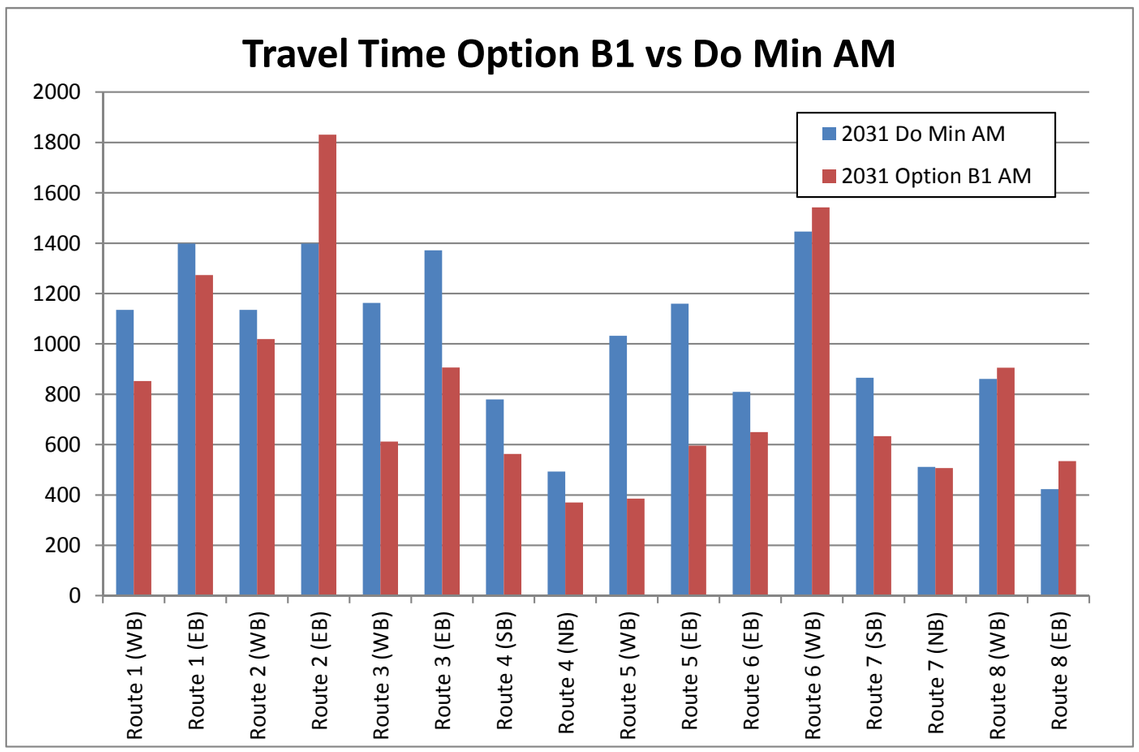


Figure 15-7: AM Travel Time – Option B1 vs. Do Min

16

Alignment Option C

16 Alignment Option C

16.1 Key Drivers

- Full connectivity to SH2, The Esplanade and Hutt Road in Petone.
- Full connectivity to SH1 and the local road network at Tawa.
- Link to Lincolnshire Farms and SH1 at Grenada.

16.2 Description

16.2.1 Alignment

This section describes the alignment of Option C, from the eastern section of Lincolnshire Farm to Tawa. The description of the remainder of the route, from Lincolnshire Farm to Petone, is provided in the P options.

At the eastern section of Lincolnshire Farm, Option C runs northwest across the broad, undulating hilltop plateaux at Lincolnshire Farm before deviating north to SH1. Between the northwest section of Lincolnshire Farm and SH1, Option C crosses a deep gully and passes east of the northern landfill. Beyond this point Option C runs parallel with SH1 to the location of the interchange at Tawa

A new link from Petone to Tawa will increase traffic along SH1 north of the new connection to SH1 at Tawa. As a result, SH1 will need to increase from 4 lanes to 6 lanes between this new connection and the proposed interchange at Transmission Gully to provide additional capacity. These details, together with the key features of Option C, are provided on Figure 16-1. Figure 16-2 and Figure 16-3 show Option C in relation to the topography between the eastern section of Lincolnshire Farm and SH1 at Tawa.

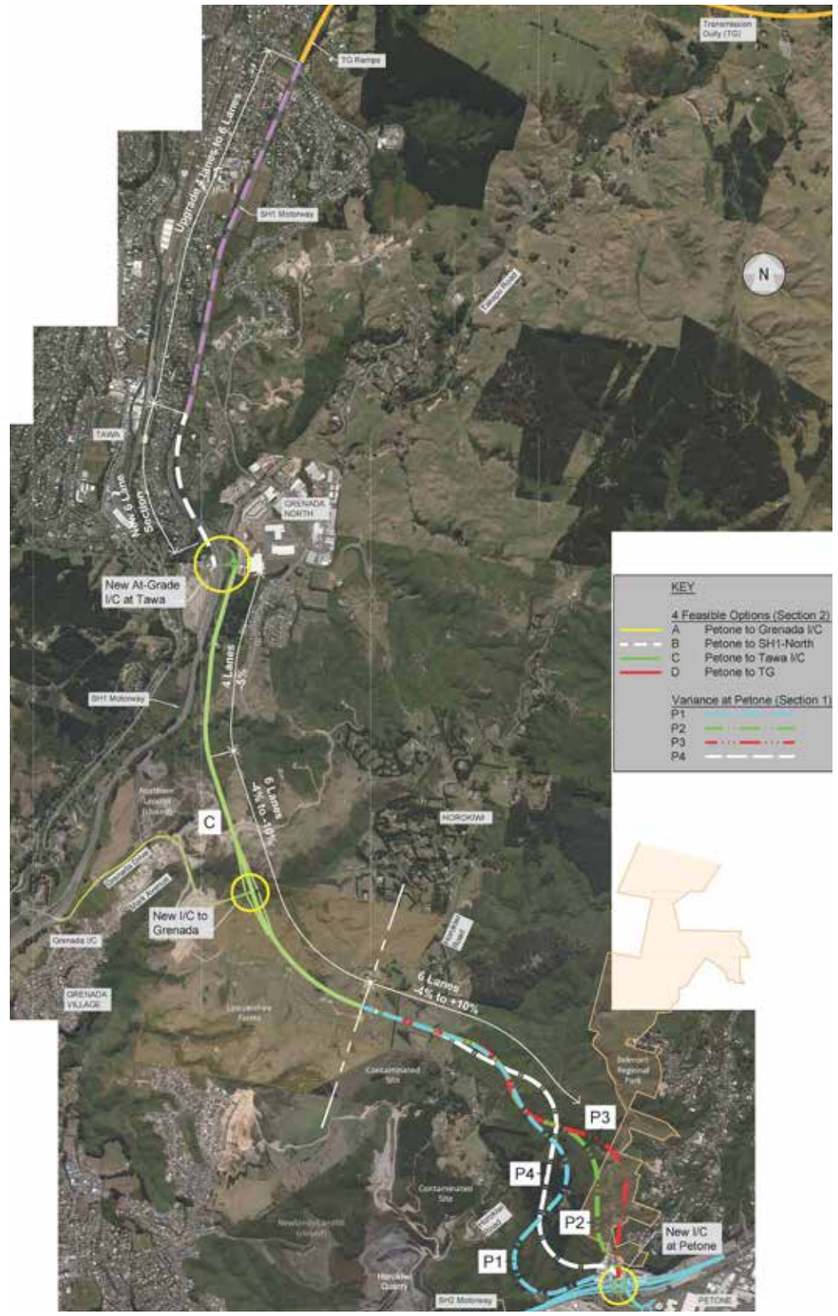


Figure 16-1: Option C

Figure 16-2: Option C In Relation to Topography

Figure 16-3: Option C In Relation to Topography at Connection to SH1

16.2.2 Lanes

- 3 new lanes in each direction from the eastern section of Lincolnshire Farm to a location just east of the northern landfill.
- 2 new lanes in each direction from a location just east of the northern landfill to the modified interchange at Tawa.
- 1 lane in each direction between Option C at northwest section of Lincolnshire Farm and Mark Avenue roundabout.

The change from three lanes to two lanes occurs approximately one kilometre north of the Mark Avenue Interchange and is associated with a change in grade from approximately 9% to approximately 5%.

16.2.3 Structures

- Modified interchange on SH1 at Tawa;
- New grade separated interchange, at northwest section of Lincolnshire Farm, to provide links to Lincolnshire Farm and SH1 at Grenada.

The modified interchange on SH1 at Tawa and the new grade separated interchange are shown on Figure 16-4 and Figure 16-5, respectively.

Figure 16-4: Modified Interchange at Tawa

Figure 16-5: New Grade Separated Interchange to Mark Avenue

16.3 Rough Order Cost Estimate and BCR

The rough order cost of Option C is estimated to range between $179 million and $381 million and has an indicative cost benefit ratio of 2.1. Refer to Appendix D and Appendix E for the basis of these figures.

The rough order cost of Option C includes upgrading SH1 from 4 lanes to 6 lanes between Tawa and Transmission Gully and also includes the section between Lincolnshire Farm and Petone.

16.4 Transportation Impacts

16.4.1 Network Performance

Option C has very similar results to Option B and is slightly better than Option B with a marginally higher reduction in network wide delays and a slightly lower network travel time.

Option C1 again provides improvement when compared to the do minimum but does not perform as well as Option C with reduced benefits for network delay, time and queue results as well as reduced network speeds.

16.4.2 Traffic Redistribution

Option C again results in the expected reductions in flow on SH2 / SH1 around the Ngauranga Interchange (approximately 1,300 vehicles, two-way flow) and SH58 (700 vehicles, two-way flow) with the expected increases around SH2 north of Petone and north of the Tawa Interchange.

A variation of Option C, identified as Option C1, was also considered. Option C1 is identical to Option C but has north facing ramps at Petone to SH2 with no direct connections to the Esplanade and the Hutt Road. As with the comparison of Options B and B1 the major change from Option C to Option C1 is to do with having only north facing ramps at Petone. This causes increased pressure on the SH2 links north of the P2G / SH2 Interchange. The shift of traffic from SH1 / SH2 south of Petone and SH58 is again fairly similar to that of Option C – the SH58 drop is marginally smaller under option C1 than option C.

16.5 Transportation Benefits

The transportation benefits have been based only on travel time savings, vehicle operating cost (VOC), vehicle emissions (CO2) reductions. Details on this are provided in Appendix E. Travel time savings in relation to the do minimum are discussed below.

16.5.1 Travel Times

Option C generally shows good travel time savings compared to the do minimum models, as is shown in Figure 16-6. Over Routes 1, 2 and 3 this option shows the greatest travel time savings.

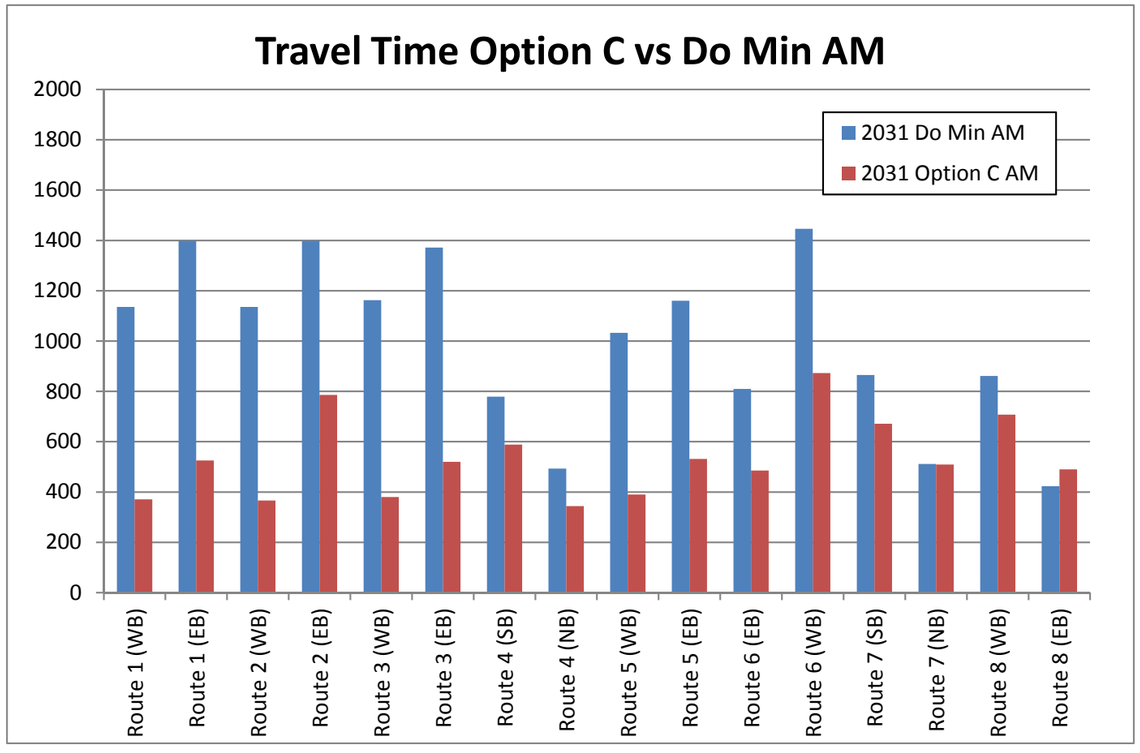


Figure 16-6: AM Travel Time – Option C vs. Do Min

Option C1 shows good travel time saving compared to the do minimum, as shown in Figure 16-7, over the majority of the journey time routes. As with Option B1, this option shows an increased journey time over Route 2 eastbound.

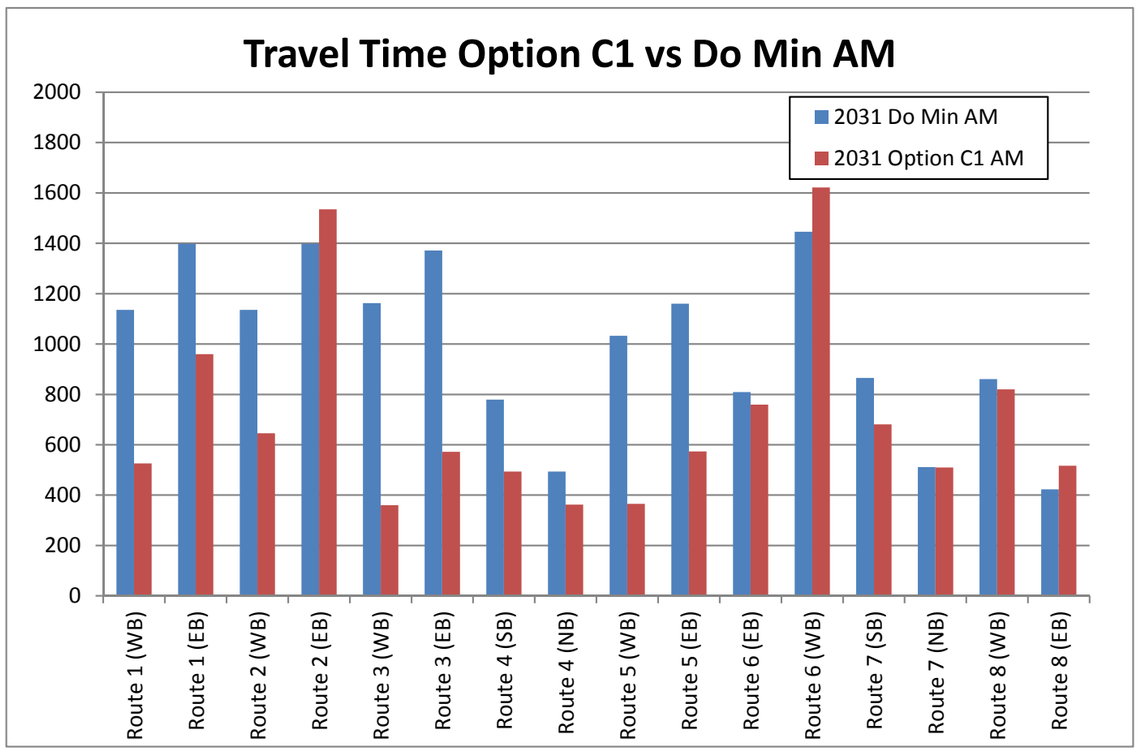


Figure 16-7: AM Travel Time – Option C1 vs. Do Min

17

Alignment Option D

17 Alignment Option D

17.1 Key Drivers

- Full connectivity to SH2, The Esplanade and Hutt Road in Petone.
- Full connectivity to Transmission Gully at Takapu.
- Link to Lincolnshire Farms and SH1 at Grenada.
- Link to SH1 at Tawa.
- Providing distributed linkages from SH2 at Petone to SH1 at Grenada, SH1 at Tawa and Transmission Gully at Takapu.

17.2 Description

17.2.1 Alignment

This section describes the alignment of Option D, from the eastern section of Lincolnshire Farm to Transmission Gully. The description of the remainder of the route, from Lincolnshire Farm to Petone, is provided in the P options.

At the eastern section of Lincolnshire Farm, Option D runs northwest across the broad, undulating hilltop plateaux at Lincolnshire Farm before deviating north to SH1. Between the northwest section of Lincolnshire Farm and SH1, Option D crosses a deep gully and passes east of the northern landfill to a new interchange at Tawa to the east of SH1. Beyond this point Option D runs northeast along the gently sloping eastern flank of Takapu Valley to Transmission Gully at Takapu.

These details, together with the key features of Option D, are provided on Figure 17-1. Figure 17-2 and Figure 17-3 show Option D in relation to the topography between the eastern section of Lincolnshire Farm and the northern section of Tawa.

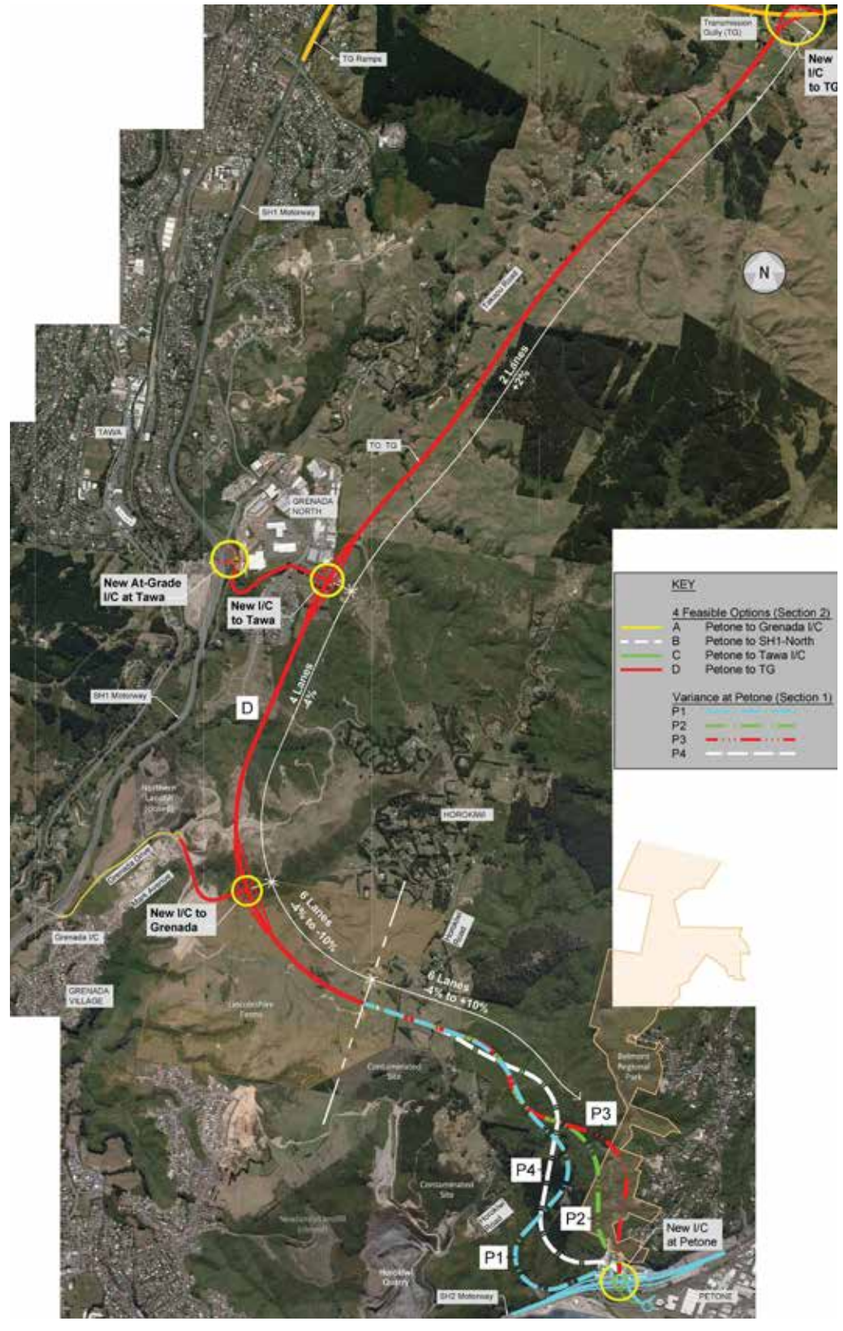


Figure 17-1: Option D

Figure 17-2: Option D In Relation to Topography at Mark Avenue

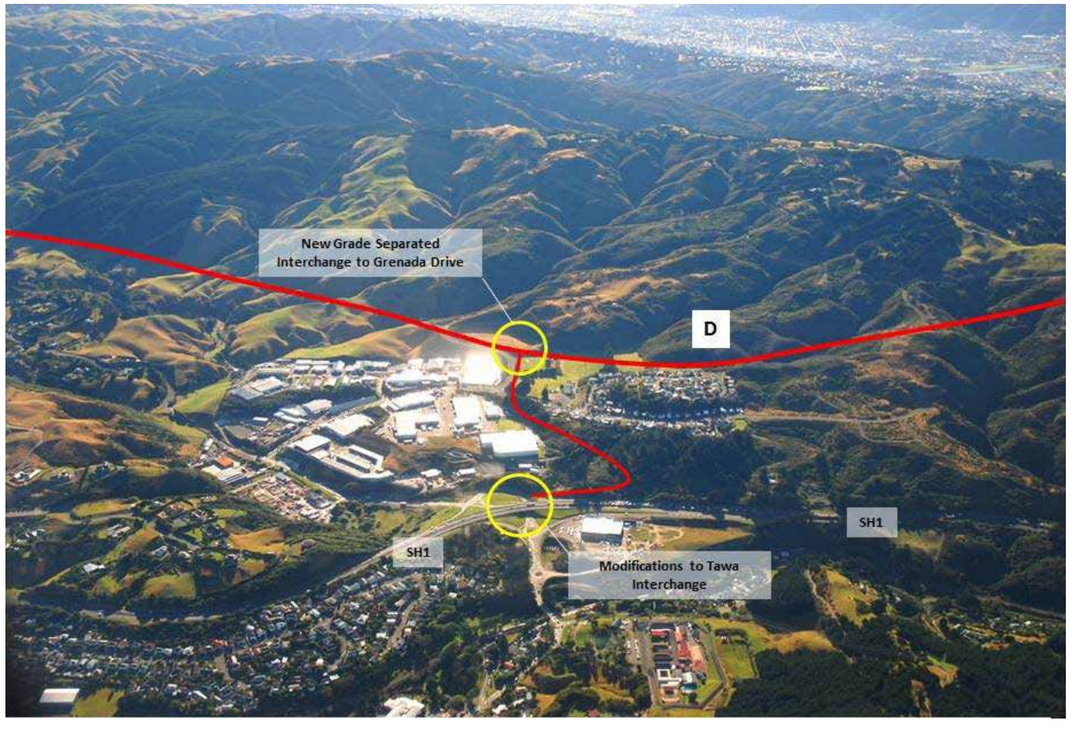


Figure 17-3: Option D In Relation to Topography at Tawa

17.2.2 Lanes

- 3 new lanes in each direction from the eastern section of Lincolnshire Farm to the northwest section of Lincolnshire Farm.
- 2 new lanes in each direction from the northwest section of Lincolnshire Farm to Tawa.
- 1 lane in each direction between Tawa and Transmission Gully.

17.2.3 Structures

- New grade separated interchange, at the northwest section of Lincolnshire Farm, to provide links to Lincolnshire Farm and SH1 at Grenada.
- New grade separated interchange to the east of Tawa to provide links to Tawa and SH1.
- Modifications to the existing interchange at Tawa.
- North facing ramps at Transmission Gully

These interchanges are shown on Figure 17-4, Figure 17-5 and Figure 17-6.

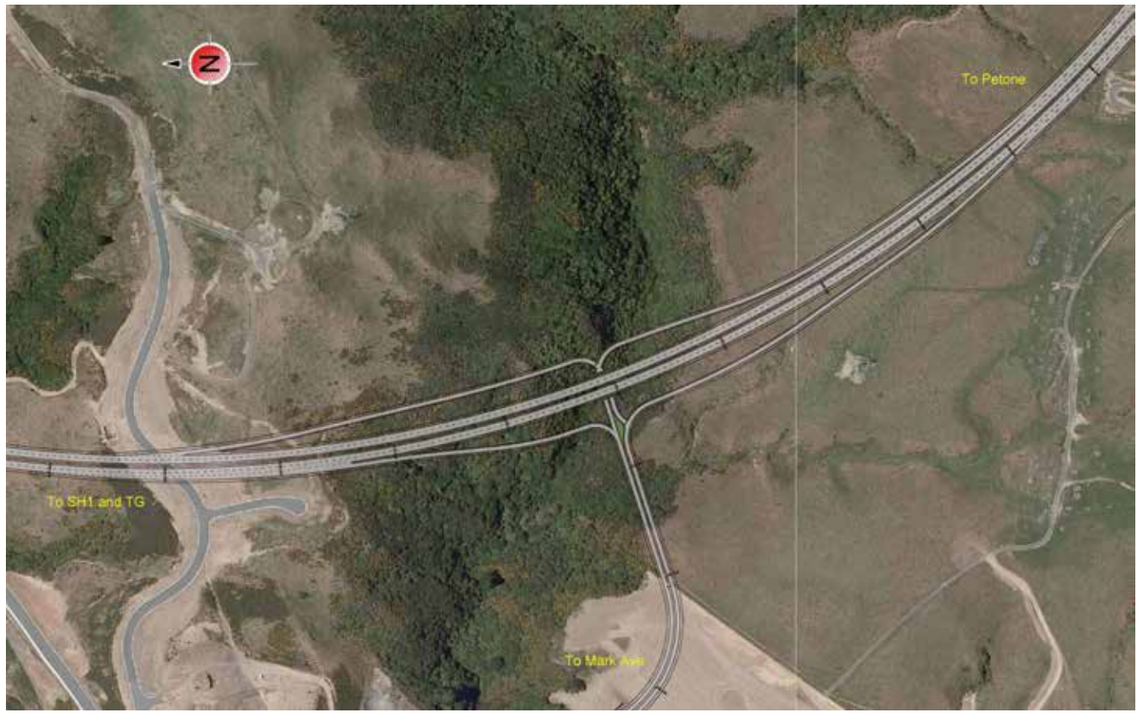


Figure 17-4: New Grade Separated Interchange to Grenada

Figure 17-5: New Grade Separated Interchange to Tawa

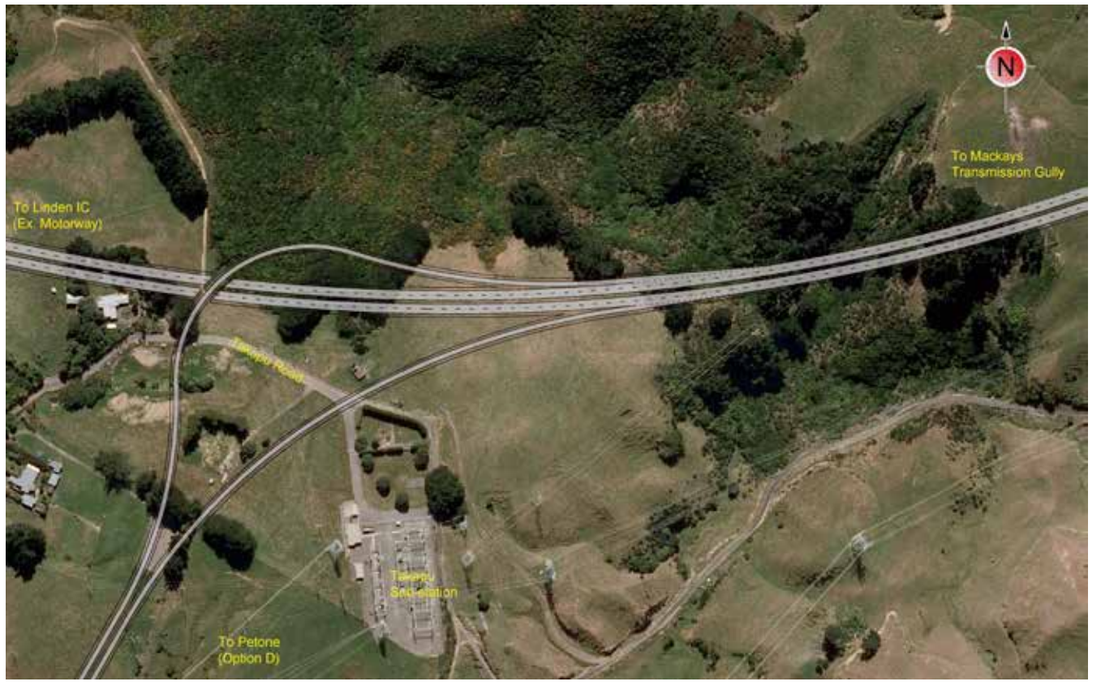


Figure 17-6: North Facing Ramps at Transmission Gully

17.3 Rough Order Cost Estimate and BCR

The rough order cost of Option D is estimated to range between $165 million and $375 million and has an indicative cost benefit ratio of 2.1. Refer to Appendix D and Appendix E for the basis of these figures.

17.4 Transportation Impacts

17.4.1 Network Performance

Option D shows comparable results to Option B with good increases in average network speed in the AM and PM peaks and the associated reductions in network time, delay and queuing. Option D marginally outperforms Option B and marginally underperforms when compared to Option C.

17.4.2 Traffic Redistribution

Despite Option D having connections to Transmission Gully its impact on TG is minimal. Option D follows a similar pattern to the other options with flow reduction on SH2 / SH1 around the Ngauranga Interchange and increases around SH2 north of Petone and north of the Tawa Interchange.

17.5 Transportation Benefits

The transportation benefits have been based only on travel time savings, vehicle operating cost (VOC) and vehicle emissions (CO2) reductions. Details on this are provided in Appendix E. Travel time savings in relation to the do minimum are discussed below.

17.5.1 Travel Times

Option D shows good travel time savings when compared to the do minimum, as is shown in Figure 17-7. The section of P2G from Tawa to TG could achieve a design speed of 110km/hr which would further enhance journey times, especially for Route 6.

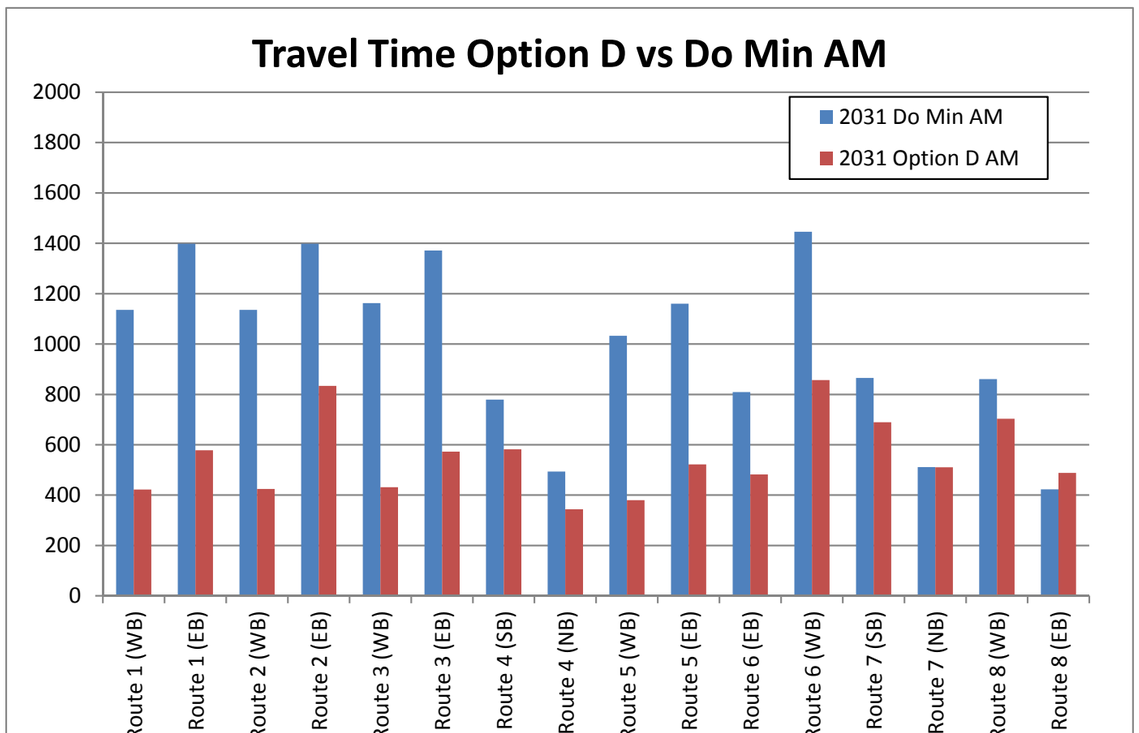


Figure 17-7: AM Travel Time – Option D vs. Do Min

18

Interchange Location Options

18 Interchange Location Options

This section summarises the process we followed to confirm the location of the interchange connection from P2G to SH2.

18.1 Background

In parallel with this project we prepared a PFR, identified as the Seaview Links Study. This study investigated alternative options to upgrade routes between Seaview and SH2, assuming that the P2G link was in place and commenced from SH2, in the vicinity of the Petone Interchange. Several options were investigated to upgrade The Esplanade, which provides the main access for high traffic volumes and freight movements between Seaview and SH2. In addition, alternative cross valley link (CVL) options were also investigated, which align with the Hutt City Council's (HCC) long term plan to de-power The Esplanade and to reassign vehicles to a CVL option.

The Seaview Links Study also assessed the options investigated in relation to urban design. The urban design assessment was in favour of CVL options combined with either connecting the P2G link to SH2 at Dowse (rather than Petone) or with north facing ramps north of the existing Petone Interchange. The urban design assessment concluded that locating the P2G link connection to SH2 at Petone, thereby providing direct access to The Esplanade, would preclude the development of a CVL route and fail to meet HCCs' aspirations to de-power The Esplanade and improve the connection to the amenity provided by the foreshore.

Although from an urban design perspective a CVL option with no interchange at Petone is preferred, the economic analysis of the options determined that upgrading The Esplanade to four lanes, without upgrading the Waione Street bridge, had the highest benefit to cost ratio. However, when considering all of the project objectives, the best option was considered to be providing a CVL as well as P2G.

All of the options, including the Do Minimum, considered in the Seaview Links Study assumed a P2G Link Road with connection to SH2 at the Petone Interchange. From a transportation perspective, the introduction of the P2G project both alleviates and exacerbates the issues on The Esplanade. The improved flow at the Petone Interchange, a known pinch point on the network, reduces congestion and delays on The Esplanade, particularly in the eastbound direction during the AM peak. However, the improved connectivity that P2G provides also increases the number of vehicles travelling on The Esplanade.

Even with a CVL option, which attracts approximately 16,000 vehicles per day in 2031, a significant amount of traffic remains on The Esplanade with modelled daily traffic volumes in 2031 remaining upward of 20,000 vehicles near the Petone Interchange and over the Waione Street bridge. This demonstrates that from a transportation perspective, even with a CVL option, an interchange at Petone is desirable.

Furthermore, as discussed in Section 12.3.5, Quantm demonstrated that alignments which commence from the existing interchange at Petone are more cost effective than connections to the north, such as Korokoro Crescent and the Dowse Interchange. At these locations the best options returned by Quantm were those that travelled southwest to Petone, before traversing northwest to Tawa. From this we can infer that Petone offers the best connection location to SH2.

Although we have concluded that the Petone Interchange provides the best location for the P2G link to SH2 in the short term, it does not preclude a CVL link combined with an interchange at Dowse in the future. A direct connection to the CVL from Dowse Interchange was not modelled as part of the Seaview Links Study; however, it is presumed that this connection would increase the use of the CVL should it be built. A direct link to P2G would further intensify this growth. Furthermore, the alignment of the connection between P2G and Dowse would remain along SH2 and would require tying into the existing, and potentially upgraded, Dowse Interchange.

18.2 Basis of Interchange Options

Once we established that the best location for an interchange to link P2G to SH2 was at Petone, we developed several interchange options at this location. Each option was developed to meet transportation requirements by providing full connectivity to SH2, The Esplanade and Hutt Road but differed in geometric form to accommodate landscape design inputs.

18.3 Integration with Beach to Bush Connection

Each option was also developed to accommodate a beach to bush connection for pedestrians and cyclists. A beach to bush connection from the Petone foreshore to the Belmont Regional Park was proposed in the Ngauranga Triangle Strategy Study completed by SKM in 2010. Furthermore, the Notice of Requirement (NOR) for SH2 Dowse to Petone Upgrade Project includes a condition which requires NZTA to investigate a pedestrian and cycle connection near the existing Petone overbridge.

Key to each option is bridging the valley mouth to maintain a wide portal from the valley to the sea, and allowing for openness and amenity for any footbridge link. In terms of landscape, the preferred outcome of this interchange is to provide a better approach to the Regional Park and an effective linkage across the interchange that has a good level of amenity separated from traffic.

The present mouth of the valley is in industrial use, with large parts of the stream replaced with culverts. This area is not designated as open space and the approach through the industrial environment is not attractive. Currently there is little visual or physical linkage, and while the present infrastructure corridor remains, there is no enticement to cross it.

The interchange does provide opportunity to provide an enhanced approach to the Regional Park and better physical, landscape and amenity connection with the foreshore.

There are heritage features at the start of the Regional Park, on the stream side. The vegetation in the immediate area is a green primarily native cover which contributes to the character of the eastern valley sides. The foreshore holds significant value for Maori. While these all contribute to landscape value and sense of place, they have not been considered in detail.

18.3.1 Petone Interchange Option 1

This option provides a conventional grade separated full diamond interchange with one pair of south facing ramps to SH2, one pair of north facing ramps to SH2 and a four lane ramp to a new roundabout at The Esplanade. The new, at-grade roundabout at The Esplanade comprises two circulating lanes and provides direct access to P2G and Hutt Road. In this option the existing Petone on and off ramps connecting SH2 to The Esplanade and Hutt Road are redundant and have been removed. The option is shown in Figure 18-1.

This option extends the footprint of infrastructure works with on and off ramps on embankment. The eastbound off ramp cuts into the toe of the coastal cliff.

Removing the existing south facing ramps to SH2 primarily benefits The Esplanade reserve in removing through traffic from the area with the potential to create a broader amenity area and possibly to re-establish coastal forest, an outlier to the hills.

In principle, there is opportunity for a pedestrian / cycle bridge to pass under the P2G main alignment before crossing above the

ramps, SH2 and rail tracks, and grading down to the foreshore. Further research is needed to see if and how accessible grades can be achieved.

Whether the entry to the valley will be benefitted depends on the degree to which the current land uses are removed and replaced by amenity and replacement forest. A broad green corridor is needed as a minimum to encourage users along the route to the bridge and connect bush and beach. The opportunity to increase daylighting of the stream is limited due to the parallel series of roads and rail tracks if current land uses remain. With little space for re-vegetation within the interchange, massing of forest in this area becomes more important.

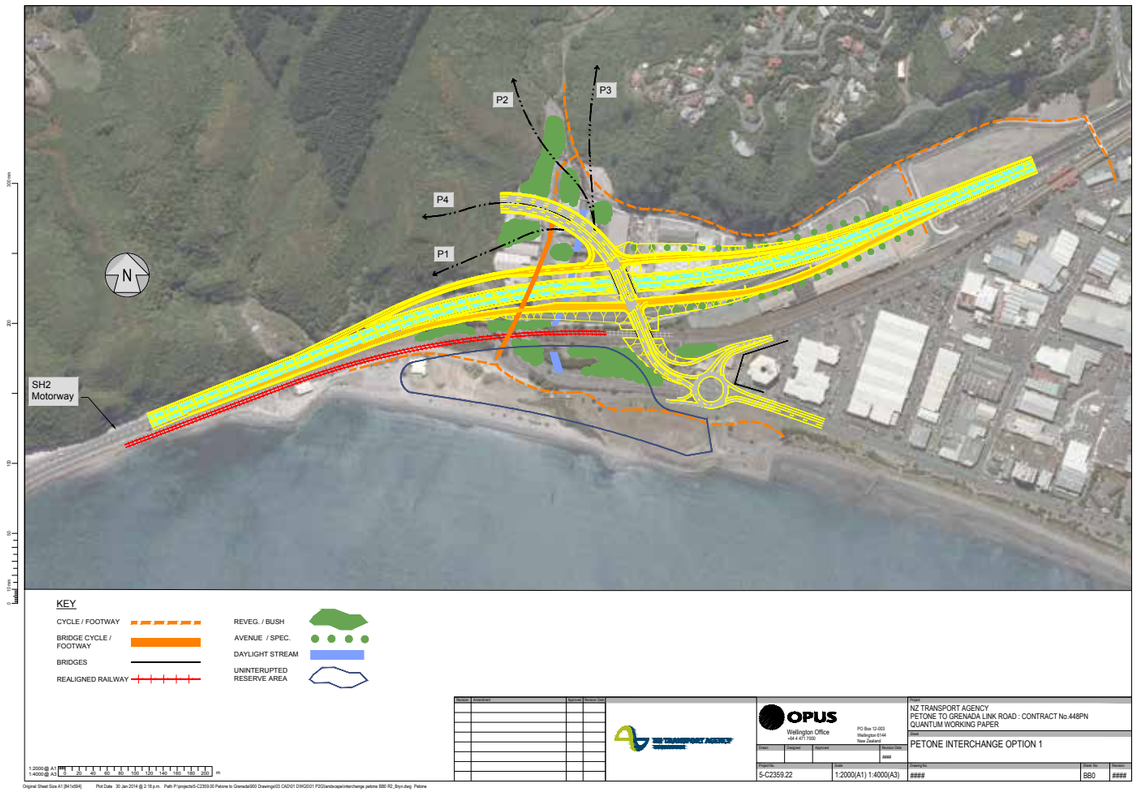


Figure 18-1: Petone Interchange Option 1

18.3.2 Petone Interchange Option 2

This option provides a conventional grade separated half diamond interchange with one pair of north facing ramps to SH2 and a four lane ramp to a new roundabout at The Esplanade. Instead of a pair of south facing ramps from the interchange to SH2, this option provides new on and off ramps connecting SH2 to The Esplanade and Hutt Road. These new on and off ramps replace the existing ones just south of the proposed interchange. Like Option 1, a new at grade roundabout is provided at The Esplanade. This roundabout comprises two circulating lanes and provides direct access to P2G, Hutt Road and SH2 to the south. Option 2 is shown in Figure 18-2.

Maintaining the pair of south facing ramps for through traffic provides less potential for improvement of recreational use or amenity of the foreshore, in comparison with Option 1. Careful design across the stream mouth at this point will be important, but may improve the existing situation if bridged.

There is greater opportunity to daylight the stream within the interchange as there is more distance between structures. The broad areas between the structures also allows for the reestablishment of coastal forest, an opportunity to establish a beach to bush sequence of vegetation and an opportunity to define the approach to Petone.

All options are developed with a pedestrian / cycle route. The wider space between structures is likely to make the bridge easier to achieve and provides not only a view to the sea, but also a view down to the stream and planting within the interchange. As this grows up, the character of the experience for those using the bridge will develop.

The observations made for Option 1 regarding the improvement to the approach at the valley mouth also apply for Option 2. If the stream and footpath can be aligned together as a green corridor this would strengthen the connection between bush and beach for users.

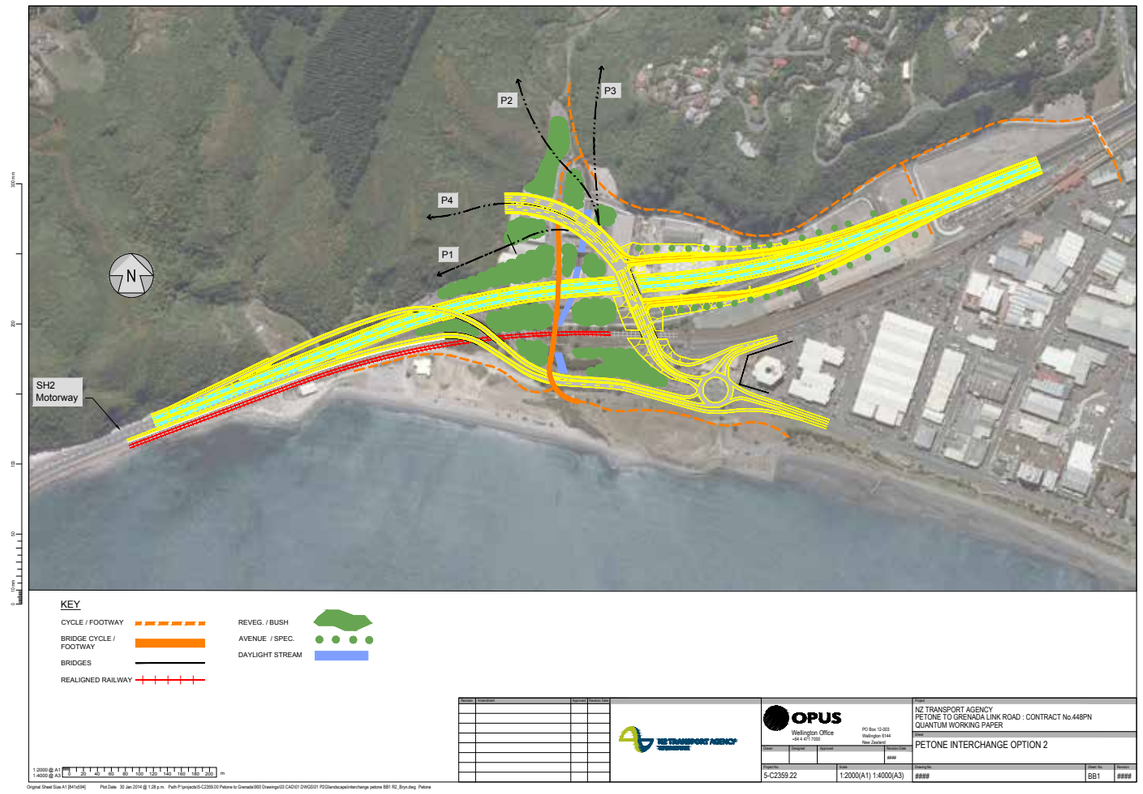


Figure 18-2: Petone Interchange Option 2

18.3.3 Petone Interchange Option 3

This option is a variation on Option 2 with the interchange located further along SH2 to the northeast. Locating the interchange further to the northeast means the new at grade roundabout is moved further to the east along The Esplanade on existing commercial land, as illustrated in Figure 18-3. Southbound ramps are in the same location as for Option 2.

This option further opens up the mouth of the Korokoro Valley. With the P2G main alignment bridging across the valley there are no other elevated structures between the "bush" and the "beach". This option enables the bush to be extended from the hillside to The Esplanade and provides a complete change of character for those entering Petone. The openness of the interchange and the degree of planting made possible is visually strong to all viewers.

Opportunities for daylighting the stream increase with this option and the location and grade of the pedestrian / cyclist bridge has more flexibility as it is further away from the junction of P2G with SH2.

Positive and negatives for The Esplanade and foreshore are the same as for Option 2, as is the treatment of the throat of the valley approaching the Regional Park. Pedestrian and cycle access is equally as good as Option 2.

This option has a greater overall footprint and affects commercial areas to a greater degree than the more southerly Options 1 and 2. In developing this option, the extent to which the commercial areas could be retained or reinstated before the landscape and amenity advantages are diminished has not been explored. Location of the northbound ramps closer to the hill side means the mass of these ramps sits within the context of the hillside reducing the visual effect of that section of the route.

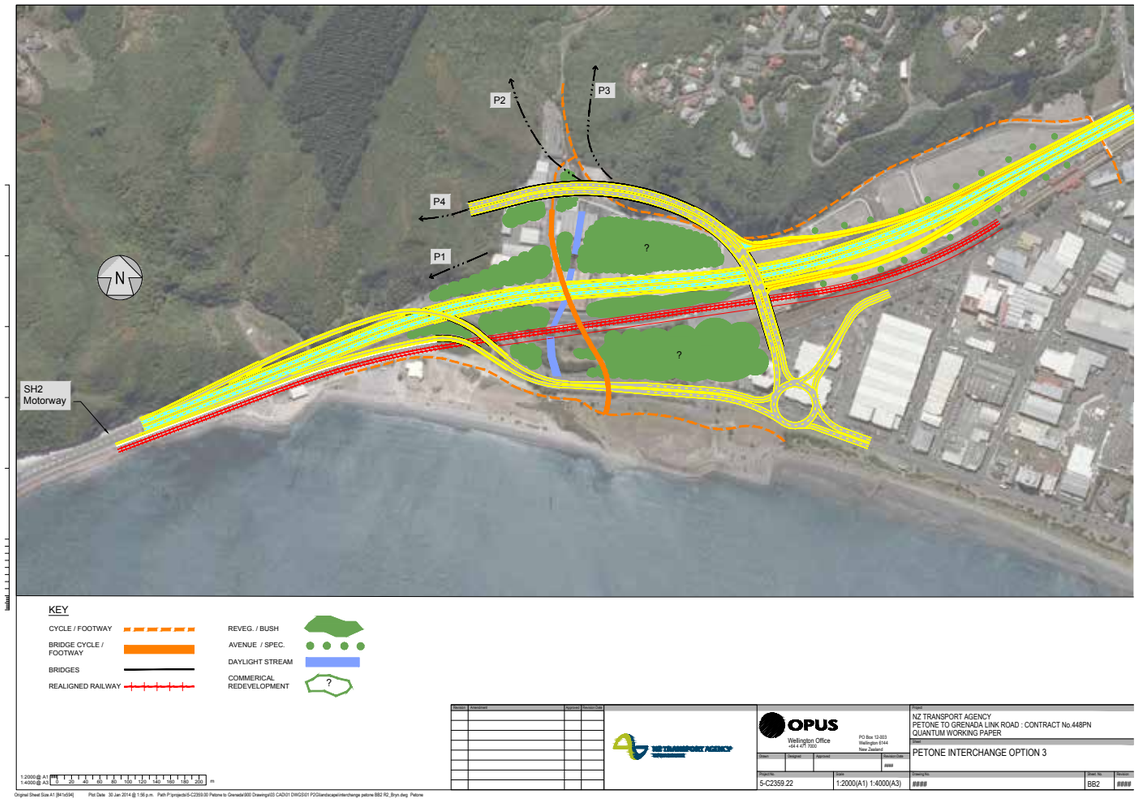


Figure 18-3: Petone Interchange Option 3

18.3.4 Petone Interchange Option 4

This option is a variation on Option 1. This option positions the interchange further along SH2 to the northeast and the at grade roundabout at The Esplanade further east along The Esplanade on existing commercial land, as is illustrated in Figure 18-4. In this option, the existing south facing ramps are removed and replaced with ramps close to the main alignment of SH2.

This option maximises the potential for the foreshore both in terms of area, lack of through traffic and for daylighting of the stream. It is likely that the north facing ramps will start rising in the vicinity of the stream, so the scale of footbridge required to cross the ramps, SH2 and the rail, is less and there is flexibility in the alignment, with a higher level of amenity.

Removal of the ramps from further south may also enable better screening of the wall which is supporting the P2G alignment beneath the major cut.

Positive and negatives for the treatment of the throat of the valley approaching the Regional Park are the same as for Option 3. Effects of location of the northbound ramps closer to the hill side are also similar to Option 3.

This option has the same overall footprint as Option 3, which is greater than that of Options 1 and 2, and affects commercial areas to a greater degree than the more southerly options. As with Option 3, the extent to which the commercial areas could be retained or reinstated before the landscape and amenity advantages are diminished has not been explored.

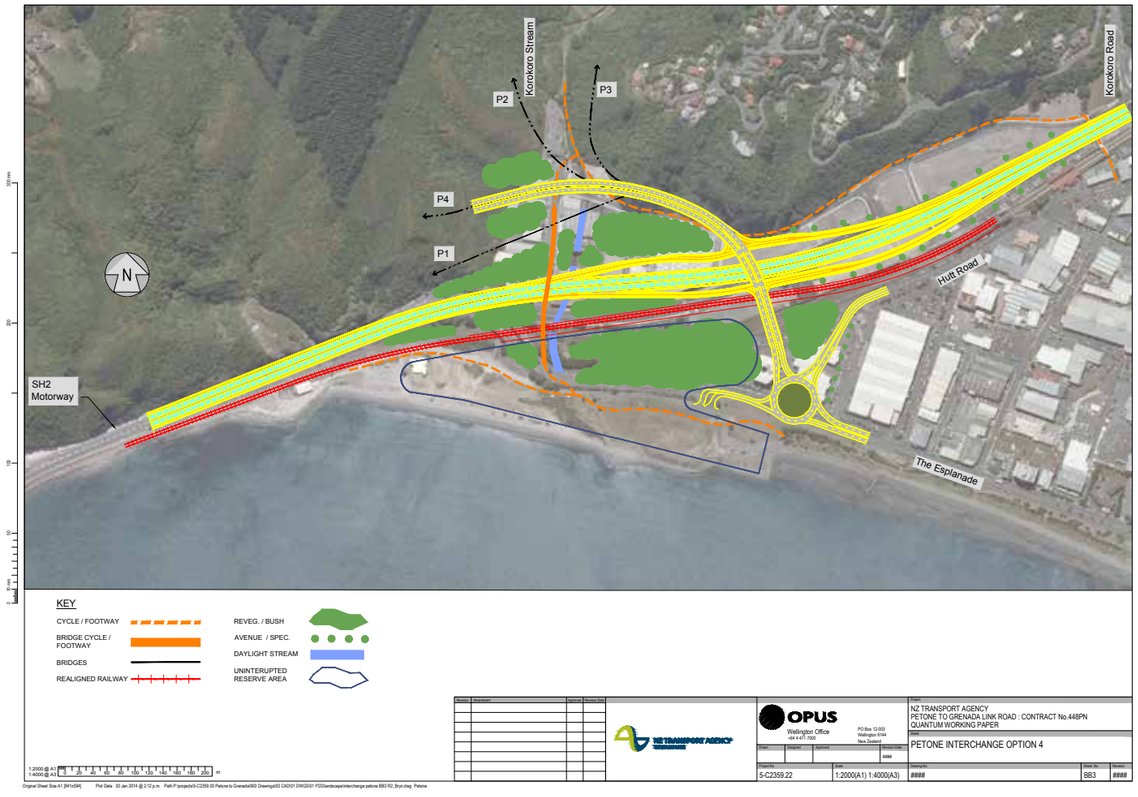


Figure 18-4: Petone Interchange Option 4

18.4 Urban Design Considerations

A preliminary urban design assessment has been completed on the four interchange options. This was a desktop based analysis identifying the issues and opportunities of the various options considered from an urban design perspective. The views and assessment presented in this section are those of Kevin Brewer, Registered Architect with Brewer Davidson and the Urban Designer for this and the Seaview Links Study.

The key urban design issues are to support the urban intensification in Petone West and general amenity considerations. Any option that unnecessarily removes urban zoned land is less preferred. Options 3 and 4 have a more northern overbridge alignment and the connections to Hutt Road removes two major commercial buildings. The more southerly alignment in Options 1 and 2 only removes the narrow lots near the Hutt Road / Esplanade intersection which are less valuable for intensification. Therefore Options 1 and 2 are the preferred overbridge alignment from an urban design perspective.

Open space and walkway linkages are also crucial for higher density living where fewer private yards are possible. Korokoro Park is at the more sheltered end of Petone Beach and forms the connections to the Great Harbour Way and possibly the Korokoro Stream walkway. The southern overbridge options are closer to Korokoro Park but with battered slopes should not dominate the park (see Figure 18-5). This opinion is solely formed from walking around the area and observing how much the existing south facing ramp bridges recede. Option 1 and 2 are set further back from the coastal park but this can be reviewed in the Scheme Assessment stage.

This assessment assumes the Great Harbour Way will be implemented and form cycling and pedestrian links south to Wellington. An additional pedestrian / cyclist crossing near the Hutt Road / Esplanade intersection will be required as Petone West intensifies. In the event the SH2 shoulder is closed and on-road cyclists are forced to use the Great Harbour Way, then the link from The Esplanade / Hutt Road to the shoulder requires consideration. The interchange options propose a separate pedestrian / cyclist bridge to connect Korokoro Stream walkway to Korokoro Park. This involves passing below the P2G road and over the SH2 ramps which are climbing to the proposed overbridge. This will result in steep level changes and add to the clutter of the interchange. Without the benefit of levels another option that may be considered is widening the daylighting of Korokoro Stream to allow a shared path to sit beside the stream and gently battered slopes. SH2 and the railway can sit on split bridge decks to allow daylight into the centre median areas. This concept is indicated on Figure 18-5. Staying with the desire for an uncluttered visual environment, Option 1 is preferred over Option 2 to avoid split ramps and to move structures away from the coastal edge. Further work is required to determine the cost and nature of a link depending on the preferred interchange design.

18.5 Maintenance and Operations Considerations

Diamond interchanges are advantageous from a maintenance and operations view because of the ability to divert the traffic via on and off ramps during activities such as pavement rehabilitations. From this perspective, Option 1 is preferred over Option 2 as Option 1 comprises a full diamond interchange while Option 2 comprises a half diamond interchange and a pair of north facing ramps.

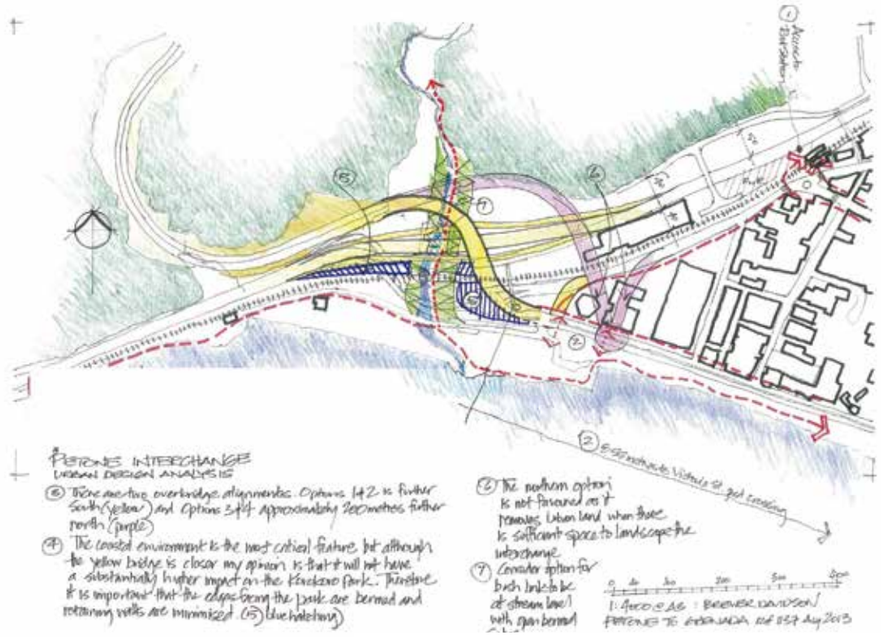


Figure 5: Petone Interchange Options Analysis

Figure 18-5: Urban Design Assessment of Petone Interchange Options (Excerpted from P2G Seaview Links Urban Design Assessment by Brewer Davidson, Aug 2013)

19

Alignment Option P1

19 Alignment Option P1

19.1 Description

19.1.1 Alignment

Option P1 is one of four sub-options from Petone to the eastern section of Lincolnshire Farm.

From the proposed interchange at Petone, Option P1 climbs to the west in a sidling cut and retaining structure along the face of the coastal escarpment at a gradient of approximately 6%. The maximum cut height along this section is approximately 60m as shown on Figure 19-2. At this point Option P1 curves to the northeast climbing at a gradient of approximately 9% just to the west of the ridgeline which forms the eastern side of Korokoro Valley. The maximum cut height along this section is approximately 62m as shown on Figure 19-3. From here this option curves to the northwest and continues to climb at a gradient of approximately 9% to the eastern section of Lincolnshire Farm. Cross sections at three locations along this portion of the route are shown on Figure 19-4 to Figure 19-6. Along this portion Option P1 is predominantly in large box cuts, however an embankment fill is required to cross a tributary of Korokoro Stream. This embankment is approximately 250m long and reaches a maximum depth of approximately 25m. The maximum cut height along this portion is approximately 53m.

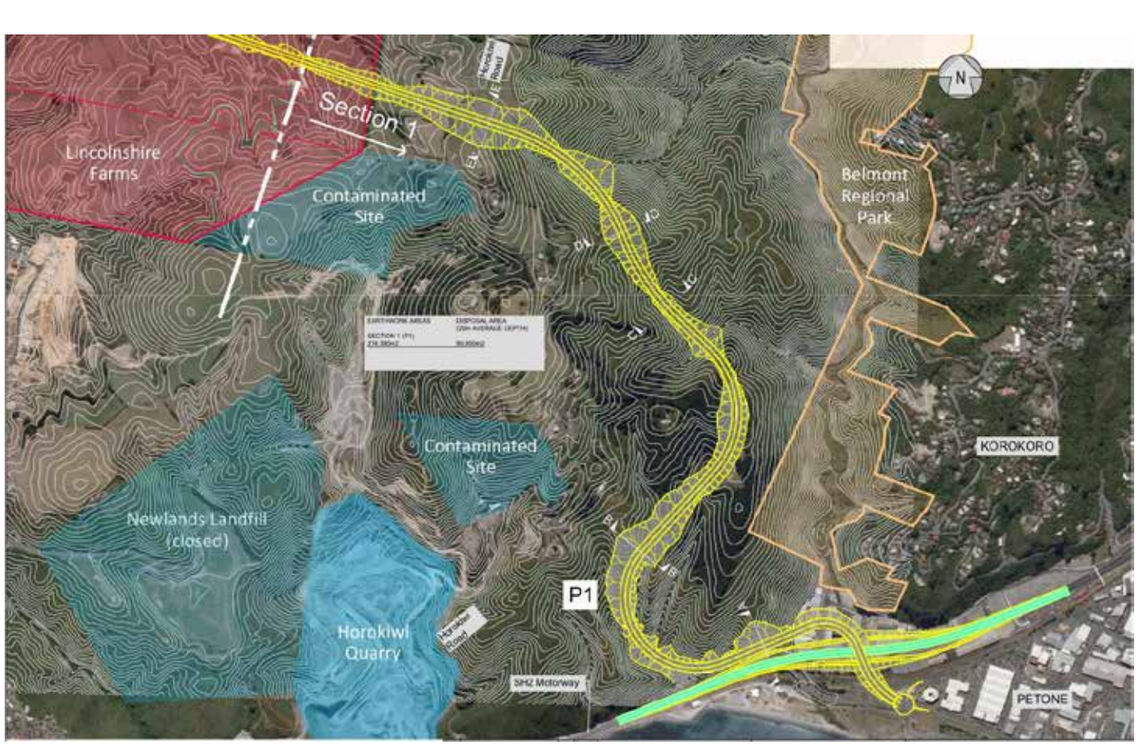


Figure 19-1: Option P1

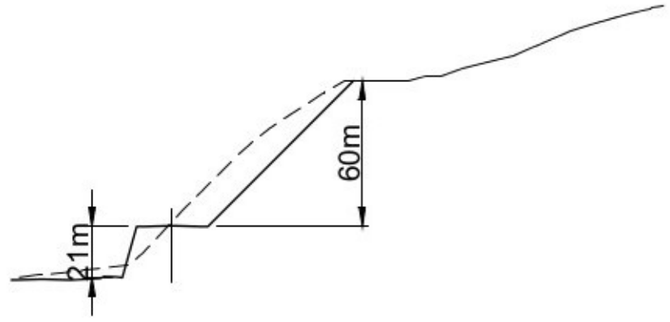


Figure 19-2: Cross Section A-A (refer to Figure 19-1) along face of coastal escarpment

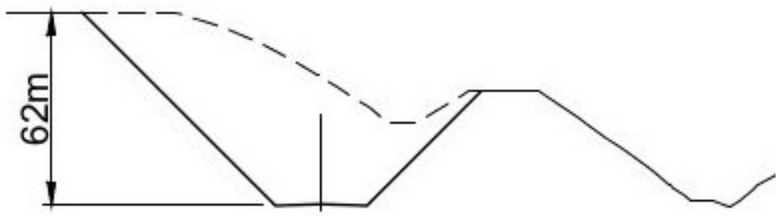


Figure 19-3: Cross Section B-B (refer to Figure 19-1)

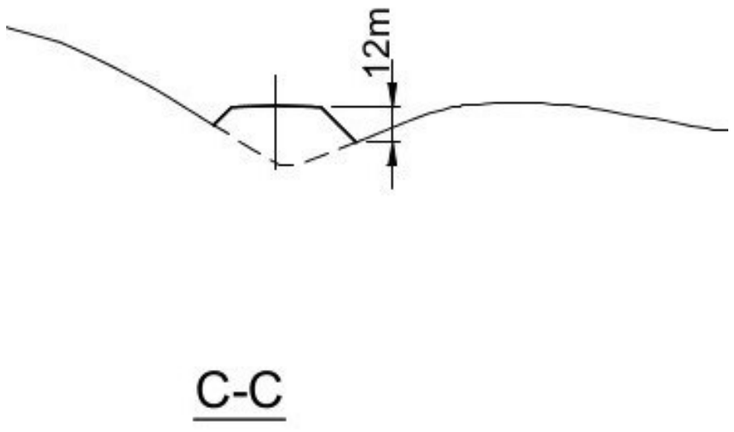


Figure 19-4: Cross Section C-C (refer to Figure 19-1) through tributary of Korokoro Stream

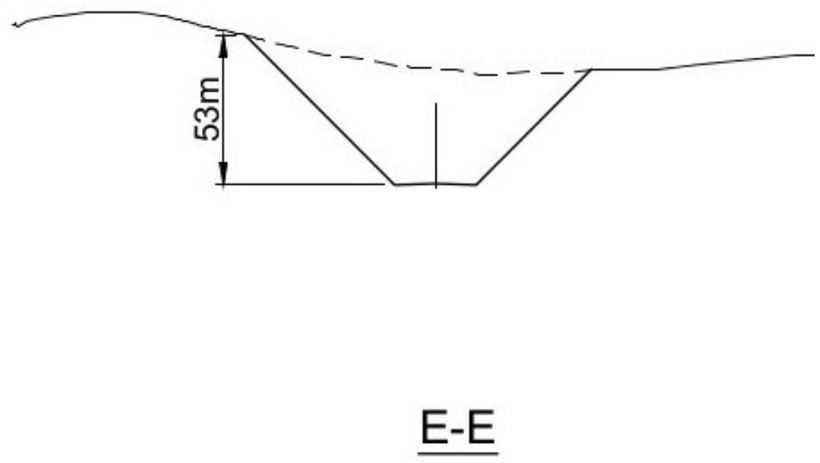


Figure 19-6: Cross Section E-E (refer to Figure 19-1)

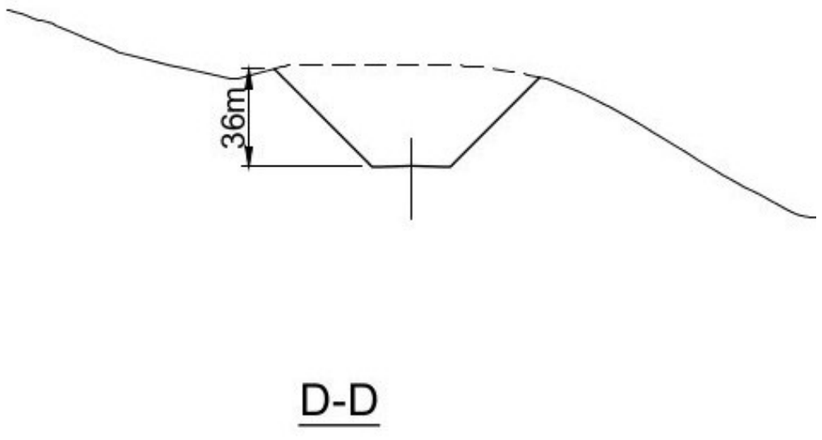


Figure 19-5: Cross Section D-D (refer to Figure 19-1)

19.1.2 Lanes

6 new lanes in each direction from Petone to the eastern section of Lincolnshire Farm.

19.1.3 Structures

Details on the new grade separated interchange at Petone are provided in Section 18.

19.2 Rough Order Cost Estimate

The rough order cost of Option P1, including an interchange at Petone is estimated to range between $70 million and $150 million. Refer to Appendix D for the basis of these figures.

20

Alignment Option P2

20 Alignment Option P2

20.1 Description

20.1.1 Alignment

Option P2 is one of four sub-options from Petone to the eastern section of Lincolnshire Farm.

From the proposed interchange at Petone, Option P2 climbs to the north in an embankment fill along the section of the Korokoro Stream which is culverted to the base of the western flank of the Korokoro Valley. The gradient along this section is approximately 6% and the maximum depth of embankment is approximately 10m. From this point Option P2 continues to ascend the western flank of Korokoro Valley in sidling cut at a gradient of approximately 9% until it reaches a tributary of the Korokoro Stream approximately 1000m north of the proposed interchange at Petone. The maximum depth of cut along this section is approximately 57m as illustrated on Figure 20-2. At this point Option P2 curves to the northwest and crosses the upper reaches of the Korokoro Stream tributary in box cut. From here this option continues to climb at a gradient of approximately 9% in a deep box cut in to the northwest to reach the broad undulating hill tops at the eastern section of Lincolnshire Farm. Cross sections at three locations along this portion of the route are shown on Figure 20-3 to Figure 20-5. Along this portion, Option P2 is predominantly in large box cuts. The maximum cut height along this portion is approximately 100m.

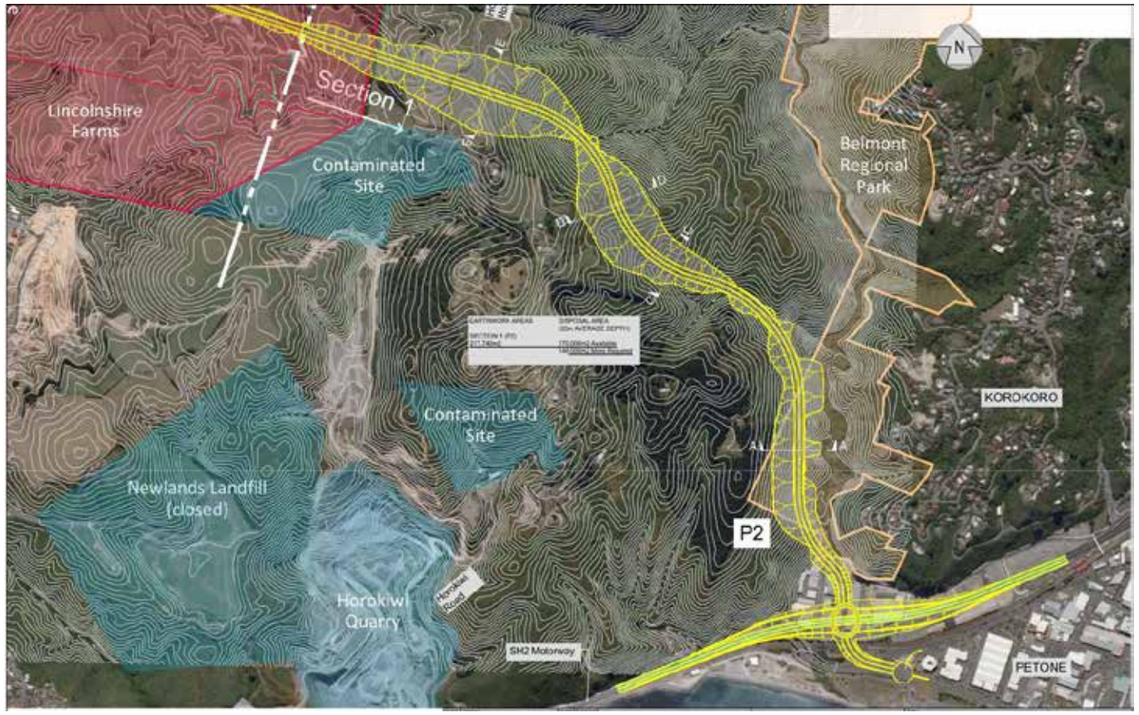


Figure 20-1: Option P2

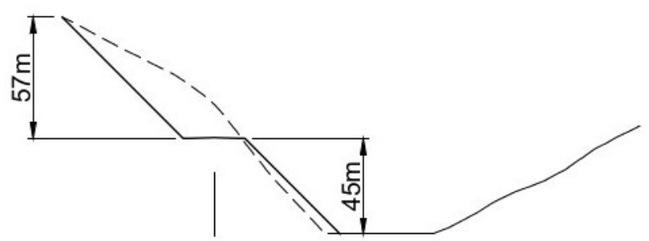


Figure 20-2: Cross Section A-A (refer to Figure 20-1) along face of coastal escarpment

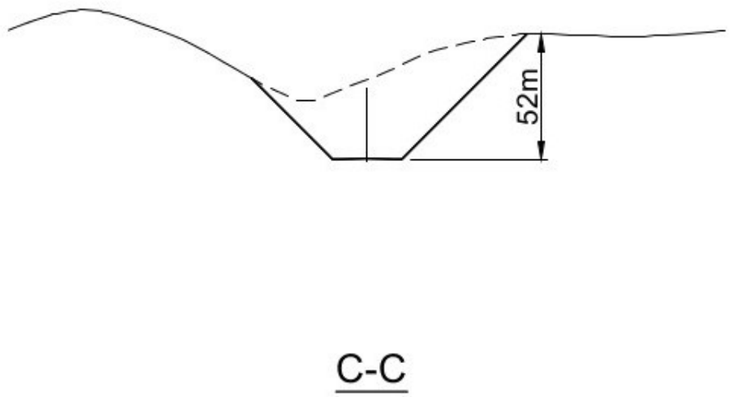


Figure 20-3: Cross Section C-C (refer to Figure 20-1) through tributary of Korokoro Stream

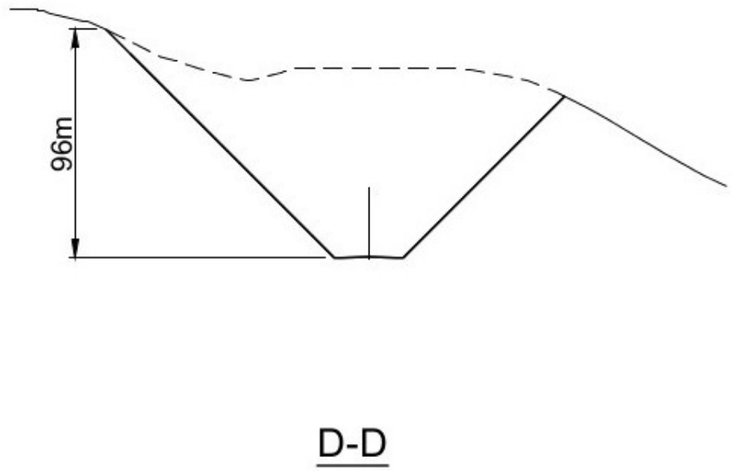


Figure 20-4: Cross Section D-D (refer to Figure 20-1)

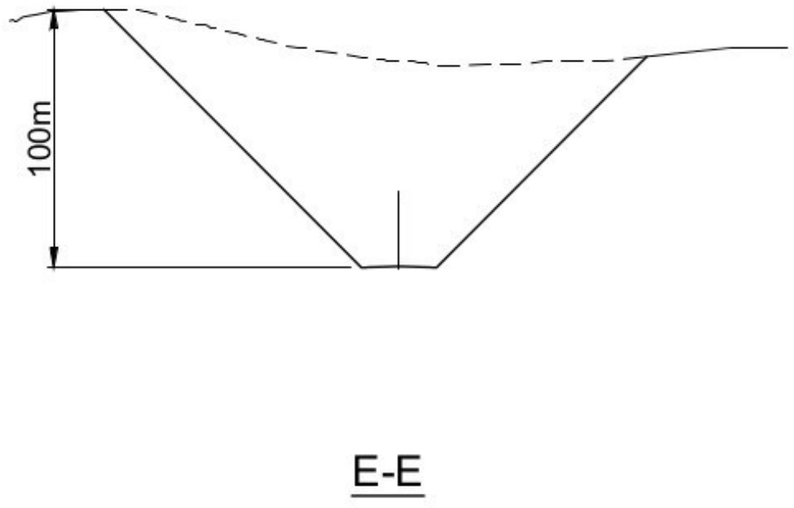


Figure 20-5: Cross Section E-E (refer to Figure 20-1)

20.1.2 Lanes

6 new lanes in each direction from Petone to the eastern section of Lincolnshire Farm.

20.1.3 Structures

Details on the new grade separated interchange at Petone are provided in Section 18.

20.2 Rough Order Cost Estimate

The rough order cost of Option P2, including an interchange at Petone is estimated to range between $84 million and $180 million. Refer to Appendix D for the basis of these figures.

Alignment Option P3

21 Alignment Option P3

21.1 Description

21.1.1 Alignment

Option P3 is one of four sub-options from Petone to the eastern section of Lincolnshire Farm.

From the proposed interchange at Petone, Option P3 climbs to the north in an embankment fill parallel to, but east of, the culverted section of the Korokoro Stream. The gradient along this section is approximately 6% and the maximum depth of embankment is approximately 10m. From this point Option P3 continues to ascend the eastern flank of Korokoro Valley in either sidling cuts, embankment fills or a combination of both at a gradient of approximately 9% for approximately 400m. Figure 21-2 shows a cross section through this portion in embankment fill which extends to the valley floor. At the end of the this section, which is approximately 600m from the interchange at Petone, Option P3 deviates to the northwest in a deep embankment fill across the Korokoro Stream while maintaining a gradient of approximately 9%. The length of this fill section is approximately 300m with a maximum depth of approximately 30m. Beyond the embankment fill this option climbs a tributary of Korokoro Stream in a box cut to reach the broad undulating hill tops at the eastern section of Lincolnshire Farm. Cross sections at three locations along this portion of the route are shown on Figure 21-3 to Figure 21-5. Along this portion Option P3 is predominantly in large box cuts reaching a maximum depth of approximately 100m as shown in Figure 21-5.

Figure 21-1: Option P3

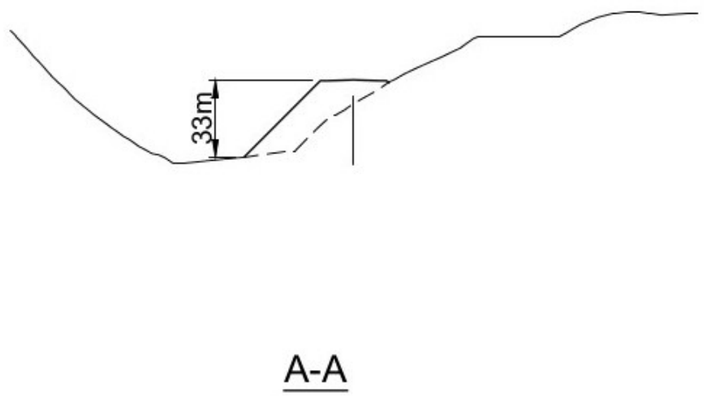


Figure 21-2: Cross Section A-A (refer to Figure 21-1) along eastern flank of Korokoro Valley

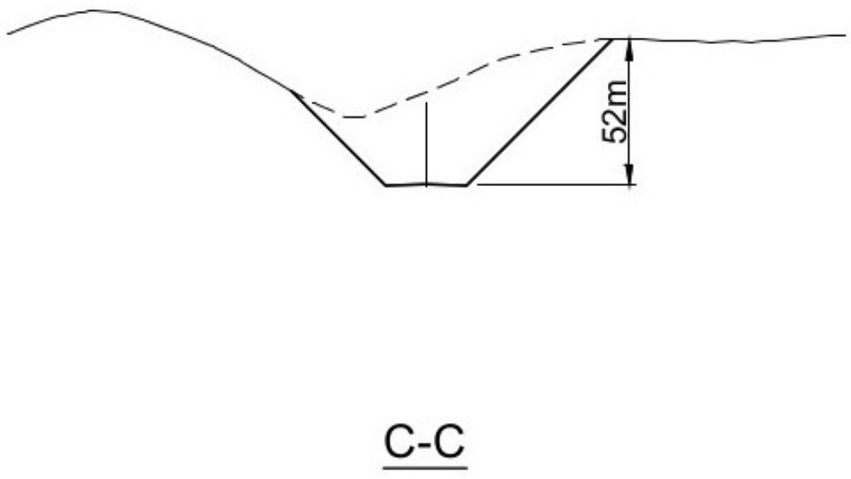


Figure 21-3: Cross Section C-C (refer to Figure 21-1)

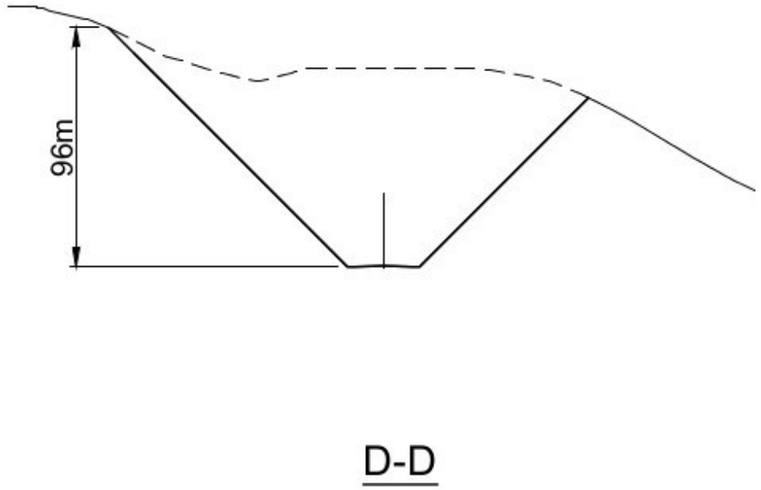


Figure 21-4: Cross Section D-D (refer to Figure 21-1)

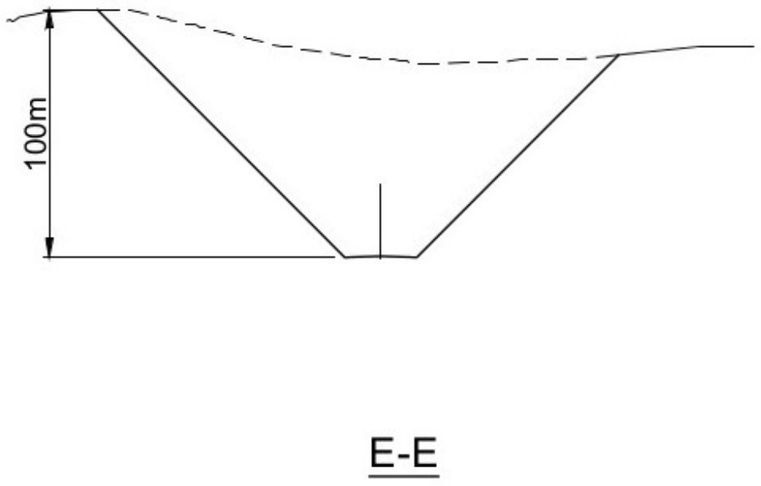


Figure 21-5: Cross Section E-E (refer to Figure 21-1)

21.1.2 Lanes

6 new lanes in each direction from Petone to the eastern section of Lincolnshire Farm.

21.1.3 Structures

Details on the new grade separated interchange at Petone are provided in Section 18.

21.2 Rough Order Cost Estimate

The rough order cost of Option P3, including an interchange at Petone is estimated to range between $84 million and $180 million. Refer to Appendix D for the basis of these figures.

22

Alignment Option P4

22 Alignment Option P4

22.1 Description

22.1.1 Alignment

Option P4 is one of four sub-options from Petone to the eastern section of Lincolnshire Farm.

From the proposed interchange at Petone Option P4 climbs to the west, at a gradient of approximately 6% in a structure to the face of the steep hill slope at the intersection of the coastal escarpment and western flank of the Korokoro Valley. From this point Option P4 runs through the steep sided hill slope in a large box cut, at a gradient of approximately 9%, before curving to the north to cross the upper reaches of a tributary of the Korokoro Stream. Figure 22-2 and Figure 22-3 characterise this section which is in box cuts up to a maximum depth of approximately 60m. After crossing the upper reaches of tributary of the Korokoro Stream in a small embankment fill, as shown on Figure 22-4, Option P4 curves to the northwest, at a gradient of approximately 9%, to reach the eastern section of Lincolnshire Farm. This section is predominantly in large box cuts apart from one portion of the route which crosses the upper reaches of another tributary of the Korokoro Stream. Figure 22-5 and Figure 22-6 illustrate the large box cuts along this section which reach a maximum height of approximately 85m.

Figure 22-1: Option P4

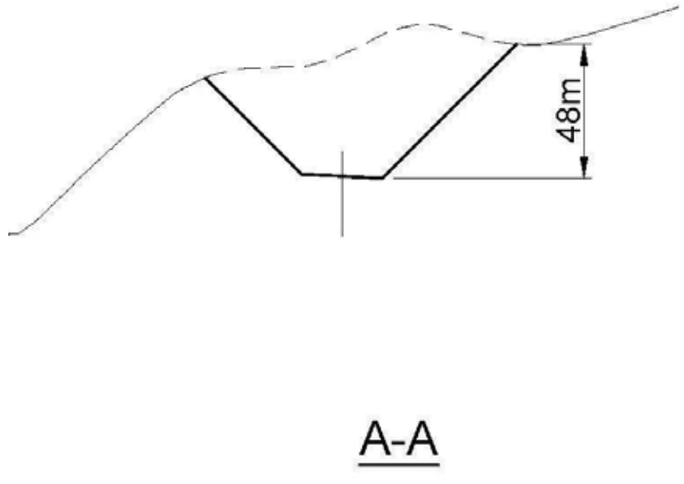


Figure 22-2: Cross Section A-A (refer to Figure 22-1)

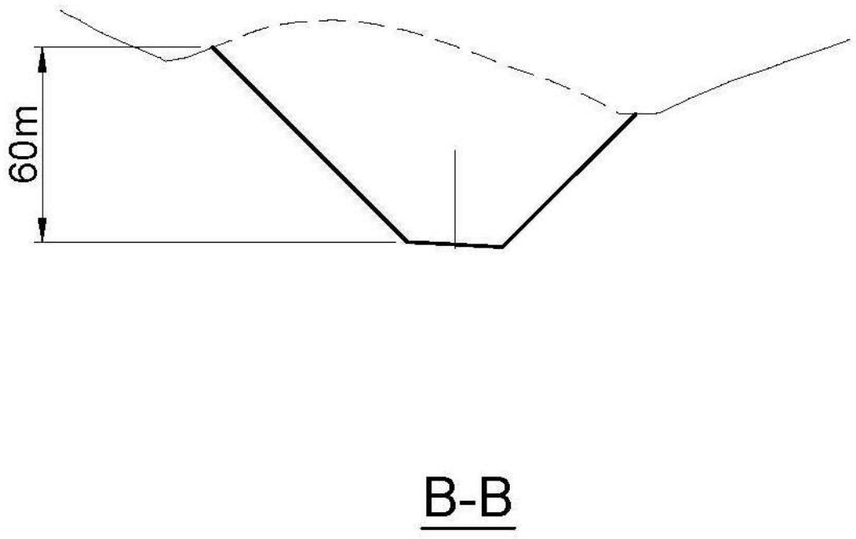
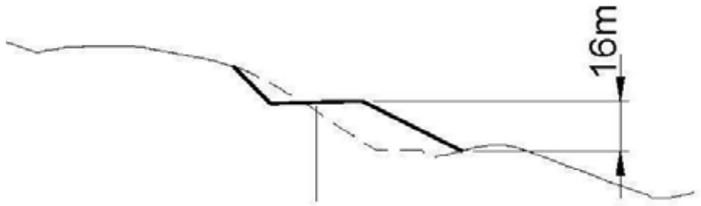
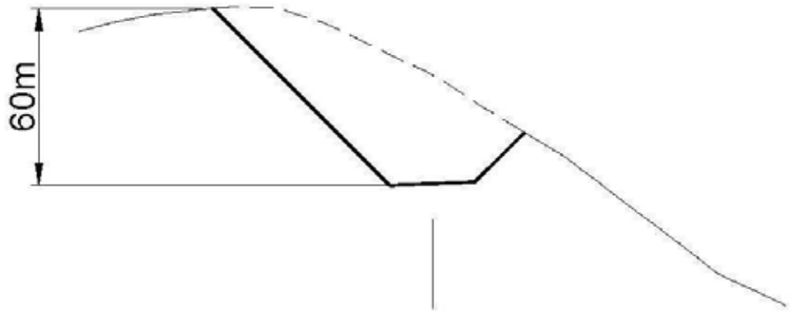


Figure 22-3: Cross Section B-B (refer to Figure 22-1)



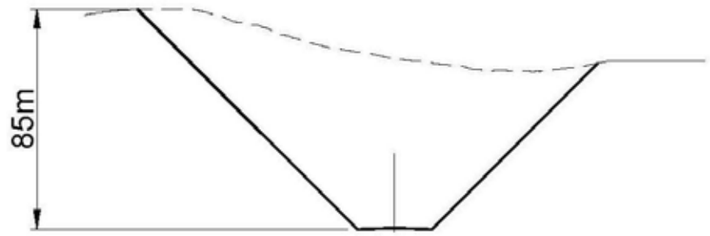
C-C

Figure 22-4: Cross Section C-C (refer to Figure 22-1) through tributary of Korokoro Stream



D-D

Figure 22-5: Cross Section D-D (refer to Figure 22-1)



E-E

Figure 22-6: Cross Section E-E (refer to Figure 22-1)

22.1.2 Lanes

6 new lanes in each direction from Petone to the eastern section of Lincolnshire Farm.

22.1.3 Structures

Details on the new grade separated interchange at Petone are provided in Section 18.

22.2 Rough Order Cost Estimate

The rough order cost of Option P4, including an interchange at Petone is estimated to range between $94 million and $201 million. Refer to Appendix D for the basis of these figures.

23

Option Evaluation

23 Option Evaluation

23.1 Introduction

This section outlines the process by which the project options were evaluated, and the preliminary outcomes of this evaluation to arrive at a preferred option for the Petone to Grenada Link Road Project. It is these options that will be taken forward to the public engagement phase, from which feedback combined with expert assessments will inform the weighting that is placed on each criteria of assessment. This will inform the decisions made and options taken for further development during the subsequent scheme assessment phases of the project.

Appendix F includes matters that were considered in evaluating options.

23.2 Evaluation Process Framework

The key focus of the evaluation process was to assist the project team come to a view of what is the preferred (or better) option. The preferred option can be considered as that option which best meets the project objectives with the least overall social, community and environmental impacts.

The project team was guided by the project objectives during the development of the options. The team has also been mindful of the potential for adverse social, community and environmental impacts and has tried to minimise these during option development. Determining the preferred option is complicated by the numerous, and often competing, demands on achieving the project objectives while minimising environmental, social and community impacts.

Where impacts of this project can be quantified and given monetary value, they can be included in a benefit cost analysis. The benefit cost analysis is the most robust method of comparing alternatives.

Where impacts are intangible and based on qualitative assessments by specialists, a multi-scaling evaluation method is required as there are no mathematical methods that can be used to compare alternatives explicitly when qualitative assessments are undertaken using two or more criteria.

A feature of a good option evaluation method is that it can help collate and summarise all the information about each option in a meaningful way that enable comparisons to be made[1] . Such a method should be seen as a tool that helps the project team gain insight into the alternatives being considered and provides clarity into which is the preferred option.

Key to the evaluation process is deciding on the evaluation criteria which will enable options to be compared. It is easy to become overwhelmed when listing all the matters that need to be included in an evaluation process. These might include the Project Objectives, Government Policy Statements, NZ Transport Strategy, the Resource Management Act, regional strategies, and other documents. Appendix F.1 lists some of these matters that could be adopted from these documents. There are several problems including all of the matters listed in Appendix F.1 as evaluation criteria. Firstly because a number of matters are repeated several times, we are likely to double count some criteria – double counting leads the evaluation team to give unintended weight to these criteria. Secondly, it turns out that we make the best decisions when we limit the number of evaluation criteria being used[2] . The decision making process becomes significantly more complex and difficult to undertake with more evaluation criteria. A good evaluation process will attempt to limit the number of evaluation criteria being used.

1 W.G Stewart & et al, Comparing Alternatives, published in Assessment of Environmental Effects: Information, evaluation and outcomes, John Lumsden, editor – Centre for Advanced Engineering, 2001.
2 John Lehrer, How We Decide, Houghton Mifflin Harcourt, 2009

For this reason, we have decided to limit the evaluation criteria to reflect the number of specialist areas being assessed in the project (summarised in Table 23-1). Appendix F.2 shows how these evaluation criteria align with the project objectives, LTMA, NZTS objectives, RMA and other key matters that should be considered. The evaluation criteria used is as follows:

- Ecology;
- Archaeology;
- Benefit Cost Ratio;
- Resilience; and
- Landscape / Visual / Recreational.

The option evaluation process is summarised in Figure 23-1. Each step is discussed below.

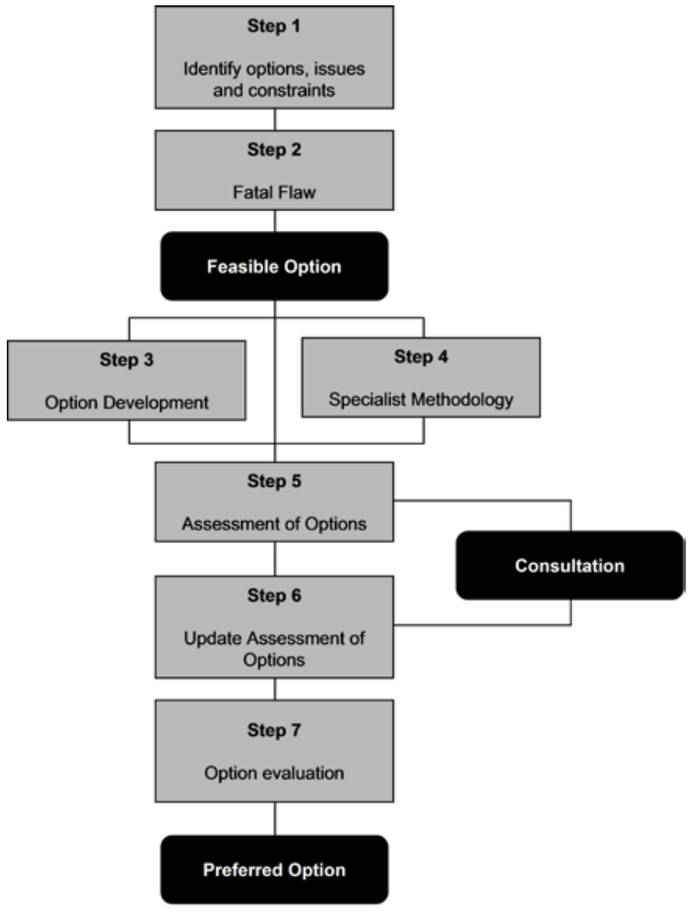


Figure 23-1: Process Chart for Option Evaluation

Step 1: Issues, opportunities and constraints

Specialists were aware of the options shown in Figure 23-1 that were identified prior to Design Surgery 1, to guide their thinking when developing the issues opportunities and constraints for the project area.

Step 2: Fatal flaw analysis

An initial assessment to confirm that each option meets the project objectives, is feasible to construct, meets the objectives of relevant strategic documents and does not have fatal or serious Part II RMA or Historic Places Act flaws. No fatal flaws have been identified in the initial assessment by any of the specialists.

Step 3: Option development

Four main options have been developed following Design Surgery 1 workshop. Each of these options has variations at each end point.

The four feasible options that are being developed have been discussed in Sections 14 – 17 (Options A – D) with the variation at each end discussed in Sections 19 – 22 (Options P1 – P4).

Step 4: Specialist Definition of Methodology

Specialists defined a methodology that they used to assess the various options. They provided the team leader an outline of their evaluation methodology, overall goals together with any sub-evaluation criteria that they intend to use. This option evaluation focuses on the overall alignment (referred to as Options A, B, C and D) combined with each of the Petone Options (referred to as P1, P2, P3 and P4).

A key aspect of this phase of the work will be to ensure that the boundaries of the different specialists are clearly defined removing any double counting by specialists. Appendix F.2 also provided a check list to ensure that they are focusing their assessments on the project objectives, the NZTS and RMA.

Step 5: Specialist assessment of all feasible options

Following development of the options the specialists received a data-pack containing a description of the four feasible options (Options A – D) and the variation at each end (Options P1 – P4) together with sufficient information to enable them to undertake their assessment. This assessment was undertaken prior to consultation enabling the results of these assessments to be shared through the consultation process. These assessments addressed a number of criteria as follows:

Tangible Criteria (The benefit cost ratio)

Costs

- This comprises a "rough order costs" made up of: the capital cost of option, which includes client property costs, and professional fees.

Benefits

- Reduced road vehicle operating costs, and time savings (including $ value of reduced congestion)[3]; and
- Reduced CO2 emissions.

3 The economic benefits associated with accidents, mode shift to passenger transport (as a result of a more efficient route) are likely to be sufficiently small on this project to be neglected during the option evaluation and selection process.

Intangible Criteria

Landscape/Visual/Recreational, including:

- Impact on character, quality and amenity of landscape;
- Relationship between spaces, including Petone Foreshore and Esplanade, Seaview and Belmont Regional Park; and
- Ability of landscape to absorb change.

Archaeology, including:

- Contextual value;
- Condition;
- Rarity;
- Information potential (scientific value);
- Amenity value; and
- Cultural association.

Ecology, including:

- Impact on vegetation;
- Impact on surface streams or water bodies;
- Impact on terrestrial ecology;
- Impact on marine ecology; and
- Impact on subsurface drainage and fish passage.

Resilience, including:

- Ability to provide overall resilience of access in the region in the event of natural hazards; and
- Ability to provide alternative route in the event of a range of hazards.

The specialists identified in Table 23-1 were responsible for making assessment for the intangible criteria

Table 23-1: Specialist Responsibilities

Area	Specialist
Landscape/Visual/Recreational	Helen Preston-Jones (Opus Auckland)
Ecology	John Turner (Opus Hamilton)
Archaeology	Cathryn Barr (Opus Napier)
Resilience	Brabha (Opus Wellington)

The effects rating to be used by specialists to estimate the overall intangible effects that each option has in terms of the above evaluation criteria is given in Table 23-2. The assessments are to be made in terms of impact that each option has against the do minimum. Assessments can be either positive or negative depending on whether the option improved outcomes or makes outcomes worse.

Table 23-2: Effects Rating

Severe Negative
Significant Negative
Moderate Negative
Minor Negative
Insignificant
Minor Positive
Moderate Positive
Significant Positive
Substantial Positive

Ratings for Evaluation Criteria

When determining the degree of the impact (minor, moderate, etc.), specialists are required to make absolute assessments of the impacts. By making an absolute assessment, the specialist is required to compare the impact in this situation against any other project that might occur in NZ or the world. In this way, if an assessment is determined as being 'severe' negative, then the specialist is saying that the option is nearly 'fatal', where fatal is the situation where the Environment Court would reject the consent or designation application based on the severity of this criterion alone. So when an assessment is rated as being severe, we are saying that the effects are severe but not quite sufficient to be fatal.

We did not want the specialists to make relative ratings. Relative ratings are when the specialists compare the effects based on the worst impacts created by the options being considered in the project. The problem with relative rating is that the differences between options and the overall impact that option has is scaled or stretched artificially. This scaling adversely impacts on the robustness of the decision making process.

In determining the overall impact value for an option, the specialists need to consider, amongst other things:

- The importance of the feature (landscape, ecology) in terms of local, regional, national or international significance;
- The severity of the effect that the proposed option has on that feature;
- How the effects vary with time including whether the impacts are temporary or permanent;
- How the effect varies spatially; and
- Any cumulative effects.

In assessing the importance of any feature, the specialists must be mindful of the matters in Part II of the RMA.

Specialists were required to provide an overall rating for their area of expertise, together with a short summary paragraph of the key issues. In arriving at this overall rating, specialists devised their own set of sub-evaluation criteria and methods for combining the results of the assessments to provide an overall assessment for their area of responsibility. The evaluation was based on no mitigation being provided. Comment is also provided on the impact mitigation might have.

Refinement Process

Specialists also identified any measures that might mitigate any adverse impacts or further enhance positive impacts. If the team decided to incorporate any proposals for mitigation into an option the option was re-assessed by all specialists, as shown in Figure 23-2.

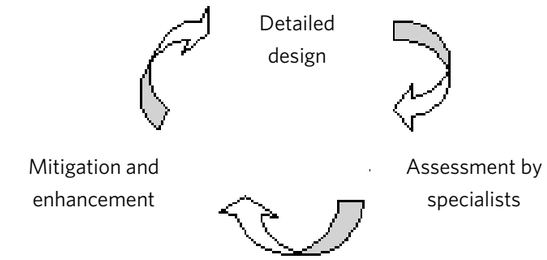


Figure 23-2: The Refinement Process

Where specialists identified more than one mitigation option, it was necessary to agree on the option to be adopted as a trade-off between likely cost to the project and the benefit in terms of overall rating, as shown in Figure 23-3. A key feature of this process was to ensure that improvements in one area, by way of mitigation, did not create more adverse impacts in another area.

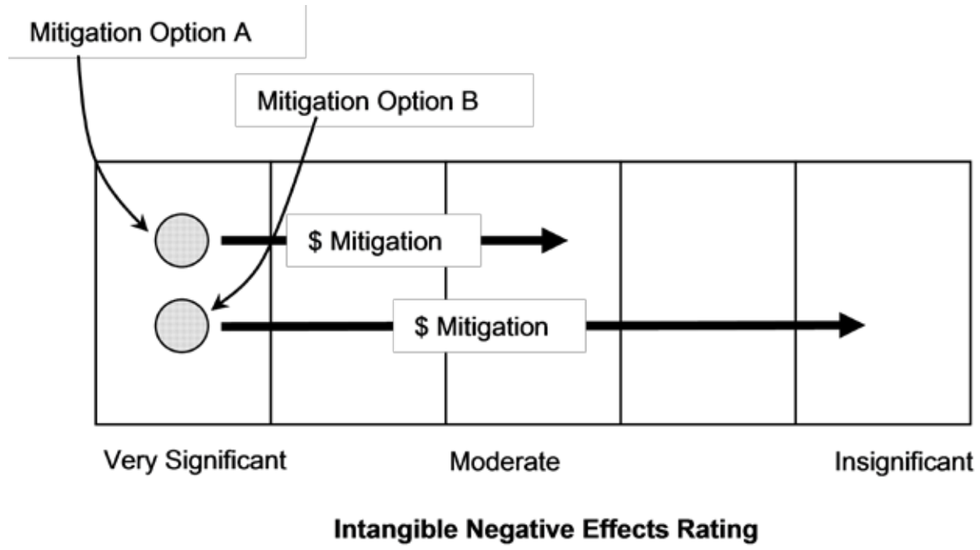


Figure 23-3: Considering a Range of Mitigation Options

As part of the option assessment, a design surgery option evaluation workshop was held on the 14th of August, 2013 with all specialists that had undertaken the assessment of feasible options and also included various other members of the Project team and those from NZTA, HCC, WCC and GWRC. The aim of this workshop was to provide an opportunity to challenge and discuss the specialists' ideas in a group forum, following their limited investigations at this point. From this workshop a number of specialists could then make alterations to their working papers which reflected a better understanding of the options. Discussions at this point also highlighted the potential need for development of further options particularly surrounding the Petone Interchange.

The Comparison Process

Any two or more options that provide an alternative can be compared with each other to determine the better option.

Key to good decision making is to limit the number of options or evaluation criteria being used. The decision making process therefore falls into three distinct problems.

a. **Eliminate options:** A pairwise analysis can be used to directly compare any two options. A pairwise analysis can be used where one option is consistently better or equal in all evaluation criteria to another option. Such a method is repeatable, is not subjective and does not require any emphasis on one criterion over another.

b. **Eliminate evaluation criteria:** Where the remaining options have similar ratings for a particular criterion it is helpful to eliminate this criterion from further analysis. This simplifies the problem you are trying to solve. For example, if ratings for environmental is much the same for all options, it can be eliminated.

c. **The options matrix:** The most challenging problem in decision making is where one option is better than another in some criteria but worse in another. In this case, the better option can often only be determined by giving emphasis to one set of criteria over another. An options matrix can be used to provide insight into the issues and help the team agree on the better option. An example of an options matrix is shown in Table 23-3.

Table 23-3: Example of an Options Matrix

Type	Description of effect	Option A	Option B
Noise	Impact of changes in traffic generated noise on properties adjacent to the highway.	Fencing and use of quiet road surfacing mitigates the majority of adverse effects along the route, while there are positive noise impacts on adjacent streets. Minor positive effects.	Fencing and use of quiet road surfacing mitigates the majority of adverse effects along the route, while there are positive noise impacts on adjacent streets. Minor positive effects.
Visual	Ability of the landscape to absorb and embrace the proposed project.	The industrial area adjacent to Ascots Park already compromises the existing visual quality of the area. Many of the landscape effects can be mitigated through plantings. Insignificant effects.	The visual effect of an elevated section of the proposed motorway will have some effect on Victoria Park. Minor adverse effects.
Ecology	Assessment of direct, indirect and cumulative ecological impacts.	There will be significant improvement of the riparian margin vegetation along Little River. Significant improvement of nationally important wetlands will be achieved through improved drainage system and storm water treatment facilities. No other notable ecological features will be affected by the proposed project. Significant positive effects.	About one hectare of regenerating indigenous and exotic scrub and trees in the vicinity of Victoria Park will be destroyed. Several remnant Tawa and associated hardwood shrubs will be removed along the terrace cliffs above Little Toot River. Significant adverse effects.
Overall summary of impacts		Moderate positive effects	Minor positive effects

Step 6: Specialist update assessment of all feasible options

Following the consultation, specialists will review and update their working papers taking into account any issues or views expressed during Phase I Consultation that may affect their assessment. Where appropriate, specialists may need to make reference to the consultation within their assessments.

At this stage any new options or mitigation proposals that come out of the consultation process will also be included.

Step 7: Option evaluation workshop

The short list of options will then be compared based on their updated specialist assessments together with the results of iwi consultation, stakeholder consultation and other consultation.

The Comparison Process

Any two or more options that provide an alternative can be compared with each other to determine the better option.

The feedback from the consultation will guide the team in terms of giving weight to the various evaluation criteria and specific impacts leading to positive and negative ratings. Where particular emphasis is needed to be given to one evaluation criteria over another in order to arrive at a better option, the views expressed during the consultation can be used in conjunction with our professional assessment to help determine the appropriate emphasis to be applied.

23.3 Specialist Option Assessment

This section summarises the results of Step 5, specialist assessment of all feasible options, of the evaluation process. The assessments and ratings provided by each specialist are reflective of the discussions at the design surgery option evaluation workshop held on the 14th of August, 2013. It is important to remember that this is a preliminary assessment consistent with a scoping study stage. These assessments and ratings may change following further design work and / or mitigation plus feedback from engagement with stakeholders and the public. While some mitigation measures have already been incorporated into the options, possible mitigation measures will receive further consideration in future phases of this project. In this section each specialist has assessed Sub-options P1 to P4 first, followed by Options A to D. Sub-options P1 to P4 commence at Petone and end at Lincolnshire Farm at a common point. Options A to D commence at Lincolnshire Farm (at the common point referred to previously) and at each option's connection point to either SH1 or TG. This is illustrated on Figure 23-4 below. At the end of each specialist's assessment a separate effects rating is provided for each Sub-option (P1 to P4) and each Option (A to D).

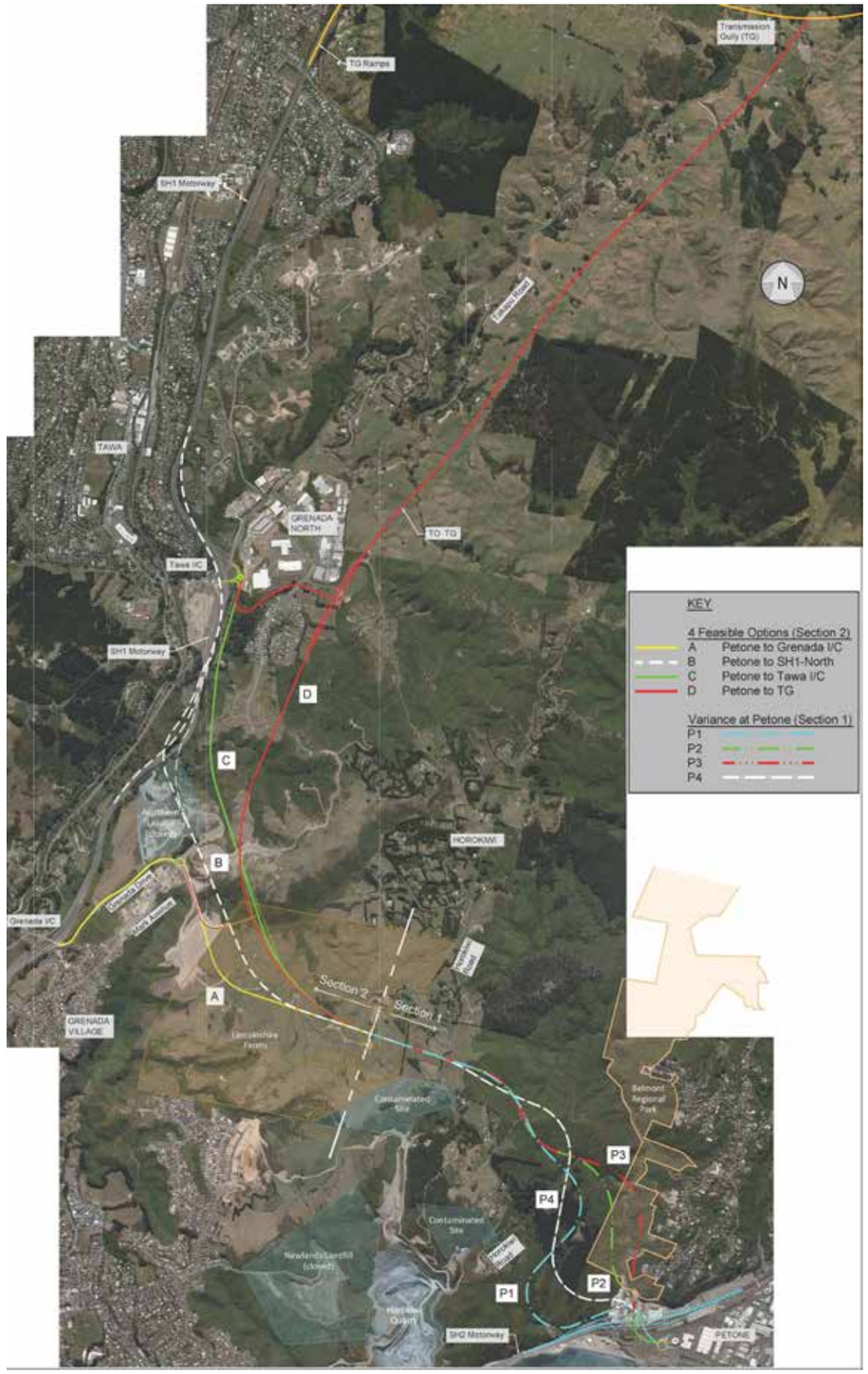


Figure 23-4 –Option Layout

23.3.1 Ecology

The criteria used for the ecological assessment were derived from the requirements under section 6(c) of the RMA. These criteria include:

- The importance of the feature in terms of local, regional, national or international significance;
- The severity of the effect that the proposed option has on that feature;
- How the effects vary with time including whether the impacts are temporary or permanent;
- How the effect varies spatially; and
- Any cumulative effects.

These criteria were used to assess specific sites within the project and each of the specific options. This was based on a range of information sources including:

- Aerial photographs;
- Street level photographs;
- Topographic maps;
- Greater Wellington Policy Statement;
- Greater Wellington Regional Plan;
- Wellington City District Plan;
- Lower Hutt District Plan;
- Data contained in existing reports and databases; and
- Preliminary option plans in Sections 14 to 22.

The most significant of the criteria identified in Table 23-4 and Table 23-5 are the extent at which the Project will impact on stream habitat and associated fish populations and the extent to which it will result in loss of exotic/mixed scrub. The other issues and constraints identified, while needing consideration by the Project team, are not major considerations for option selection, based on available information..

The assessment of options from an ecology perspective is outlined in Table 23-4 and Table 23-5 . An overall ecology summary is in Table 23-6.

Table 23-4: Ecological Assessment of Sub-options P1 to P4 (refer Figure 23-4)

Criteria	Option P1	Option P2	Option P3	Option P4
Impacts on vegetation	Affects a large area of exotic/native scrub. This scrub is considered local importance, but is a significant area. Option would result in habitat loss to the footprint.	Affects a large area of exotic/native scrub. This scrub is considered local importance, but is a significant area. Vegetation along the Korokoro Stream, within the Belmont Regional Park is identified in the HCC District Plan as within significant natural resource sites. Vegetation to the west of the stream is identified as lowland forest however it does not appear to match this description. Option would result in habitat loss to footprint.	Substantial impact on the vegetation to the east of the stream which aerial images suggest is of higher quality and closer to the description in the district plan (described as lowland forest) i.e. regenerating lowland forest. Vegetation along the Korokoro Stream, within the Belmont Regional Park is identified in the HCC District Plan as within significant natural resource sites. Option would result in habitat loss to footprint.	Affects a large area of exotic/native scrub. This scrub is considered local importance, but is a significant area. Pine plantation will also be impacted. Option would result in habitat loss to the footprint.
Terrestrial ecology effects	There will be effects on terrestrial fauna but unlikely to be a critical matter for route selection based on available information.	Two species of reptile have been recorded in Belmont Regional Park with others also potentially being present. Lizards may be affected by habitat loss along the alignment but this is unlikely to be a major issue.		There will be effects on terrestrial fauna but unlikely to be a critical matter for route selection based on available information.
	Currently available information suggests a low risk of finding significant concentrations of long-tailed bats (classified as Nationally Vulnerable – Threatened) within the Study Area. However, the occurrence of this species cannot be discounted until field surveys have been undertaken. Mature trees around Cornish Street have the highest potential bat habitat.			
Impacts on surface streams	Effects minor tributaries of the Korokoro Stream	Directly impacts on the Korokoro Stream. Dependent on the scale of the effect on the stream will result in higher negative rating.	Substantial impacts on the Korokoro Stream.	Effects minor tributaries of the Korokoro Stream.
	Erosion and sediment discharge will require very careful management given the steep terrain.			
Impacts on aquatic ecology and fish passage	The Korokoro Stream supports a number of native fish species. The stream is listed in Table 16 of the Regional Policy Statement as a stream requiring protection due to it meeting criteria as a significant indigenous ecosystem. The listing applies to all tributaries too. Fish passage, habitat loss to footprint, and habitat degradation due to sedimentation, are all potentially significant impacts. Options P1 and P4 avoid direct effects on the main stream channel but are likely to impact on the minor tributaries.			
Coastal environment	The mouth of the Korokoro Stream is potentially a sensitive area. Potential little blue penguin (At risk – declining) nesting habitat bit not likely to be significantly impacted based on current information. Effects are likely to be the same for all current options.			
Cumulative effects	Cumulative effects	Cumulative effects	Significant cumulative effects	Cumulative effects

Table 23-5: Ecological Assessment of Options A – D (refer Figure 23-4)

Criteria	*Option A*	*Option B*	*Option C*	*Option D*
Impacts on vegetation				Multiple impacts on terrestrial vegetation likely to be of at least local significance.
Terrestrial ecology effects	Terrestrial effects limited in scale.			
	Non-threatened lizards species are likely to be present along all options, with "at risk" or "threatened" species potentially present. Not likely to be a significant determining factor for route selection.			
	Currently available information suggests a low risk of finding significant concentrations of long-tailed bats (classified as Nationally Vulnerable – Threatened) within the Study Area. However, the occurrence of this species cannot be discounted until field surveys have been undertaken. Mature trees around Lincolnshire Road have the highest potential although pine plantations may also provide habitat.			
Impacts on surface streams	Crosses the Porirua Stream and minor tributaries, effects limited in scale		Crosses the Porirua Stream and small tributaries. Greater cumulative effects on features of local stream habitat	Multiple crossings of the Porirua and Takapu Stream and their tributaries
	Erosion and sediment discharge will require very careful management given the steep terrain.			
Impacts on aquatic ecology and fish passage	Porirua Stream and Takapu Stream and their tributaries are recorded as supporting native fish. They are listed in Table 16 of the Regional Policy Statement as a stream requiring protection due to it meeting criteria as a significant indigenous ecosystem. Fish passage, habitat loss to footprint, and habitat degradation, due to sedimentation, are all potentially significant impacts.			
Cumulative effects	Limited cumulative effects	Limited cumulative effects	Cumulative effects	Significant cumulative effects

Table 23 6: Ecology Effects Rating of Each Sub-option P1 to P4 and Each Option A to D (refer Figure 23-3)

Type of Assessment	Description of Effects	Option P1	Option P2	Option P3	Option P4	Option A	Option B	Option C	Option D
Ecology Assessment	Vegetation, terrestrial, stream, aquatic ecology, cumulative	**Moderate Negative**	**Moderate Negative** (tending towards significant negative)	**Significant Negative**	**Moderate Negative**	**Minor Negative**	**Minor Negative**	**Moderate Negative**	**Significant Negative**

Note:

- The effects ratings in Table 23-6 for Options A to D are not combined with the Sub-options.
- Specific relative values of part of the affected exotic/native scrub and streams are not known. Field surveys may make finding that alter the ratings of a particular option.
- Upon combining one of Option P1, P2, P3 or P4 with one Option A, B, C or D the effect more towards the negative takes precedence.
- Soil disposal areas were not considered. Any option requiring significant infill of streams is likely to rate "significant negative" for any option.
- Mitigation options have not been included in the effects rating – which could substantially reduce effects. Mitigations to be considered/adopted are:
  - » Bridging streams where possible
  - » Provision of fish passage in all culverts
  - » Habitat creation and/or enhancement to compensate for stream and scrub habitat loss.

23.3.2 Archaeology Assessment

The criteria used to assess potential impacts on archaeology are based on criteria identified and used by the Historic Places Trust (HTP) which are outlined in their Guidelines for Archaeological Assessments. These are also similar to criteria in the relevant district plans and Greater Wellington Regional Council regional policy statement. In assessing the archaeological effects of a route or option, consideration is given to the following:

- Condition;
- Rarity;
- Contextual value;
- Information potential (scientific value);
- Amenity value; and
- Cultural associations.

The assessment of impact or level of impact has been made against a "do minimum" baseline. A wide range of sources were consulted as part of the assessment including:

- New Zealand Archaeological Association Recorded Site database (ArchSite)
- Historic survey plans and titles
- Published and unpublished historic accounts
- Historic photographs
- Archaeological reports and assessments for the area

A desk top review of options was carried out, and no site inspections carried out to test or confirm assumptions.

The assessment of options from an archaeological perspective is outlined in Table 23-7. An overall summary of the archaeological assessment ratings of each option is outlined in Table 23-8.

Table 23-7: Archaeology Assessment of Sub-options P1 to P4 and Options A to D (refer Figure 23-4)

<table>
<tr><th>Criteria</th><th>Option P1</th><th>Option P2</th><th>Option P3</th><th>Option P4</th><th>Option A</th><th>Option B</th><th>Option C</th><th>Option D</th></tr>
<tr><td rowspan="5">Condition, Rarity, Contextual value, Information potential (scientific value), Amenity value, Cultural associations</td><td></td><td colspan="2">Historic weir associated with the Wellington Woollen Mills is located in the Korokoro Stream. This could be affected if works extend into or impact on the Korokoro Stream. There could also be a historic pipeline if the weir delivered water to the woollen mills.</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Further work is required to determine if any of the buildings located in the Petone footprint are associated with Woollen Mills, or whether they or the land beneath them, has archaeological values.</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="8">All options have potential to impact on unrecorded archaeological deposits associated with both Maori and early European occupation of the area.</td></tr>
<tr><td></td><td colspan="2">Pass close to the location of Te Raho o te Kapowai. This is a cultural site but there is potential that the site may also have archaeological values.</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">The Korokoro to Takapu track is located within the footprint of the route options or Petone variants. If there is physical evidence of this traditional track remaining it would be considered an archaeological site. However, location of the track on the District Plan maps may only be a representation of the traditional route.</td><td></td><td></td><td></td><td>Based on historic plans and district plan maps the Korokoro to Takapu track extends into Option D and needs to be further investigated.</td></tr>
</table>

Table 23-8: Archaeology Effects Rating of Each Sub-option P1 to P4 and Each Option A to D (refer Figure 23-4)

Type of Assessment	Description of Effects	Option P1	Option P2	Option P3	Option P4	Option A	Option B	Option C	Option D
Archaeology	Condition, Rarity, Contextual value, Information potential (scientific value), Amenity value, Cultural associations	Insignificant / minor negative (Potential for **significant negative** dependent on further investigation)	Insignificant / minor negative (Potential for **significant negative** dependent on further investigation)	Insignificant / minor negative (Potential for **significant negative** dependent on further investigation)	Insignificant / minor negative (Potential for **significant negative** dependent on further investigation)	Insignificant / minor negative	Insignificant / minor negative	Insignificant / minor negative	Insignificant / minor negative (Potential for **significant negative** dependent on further investigation)

Note:

- The effects ratings in Table 23-8 for Options A to D are not combined with the Sub-options.
- Upon combining one of Option P1, P2, P3 or P4 with one Option A, B, C or D the effect more towards the negative takes precedence.
- All of the Petone Options (P1, P2, P3 and P4) and Option D are listed as potentially significant negative. Further investigations need to be undertaken to confirm. This is because:
  - » The interchange locations have the potential for significant impact on buildings and/or archaeology potentially associated with the Woollen Mills.
  - » P2 and P3 each have the potential for significant negative archaeological effects from the interchange up until they link in again with the P1 and P4 route. Depending on final design these options may also impact on the historic weir located in the Korokoro Stream.
  - » The Korokoro to Takapu track and the location of Te Raho o te Kapowai also suggests a potential significant negative effect rating for Options P2 and P3. This has potential cultural effects and therefore also needs to be considered in the cultural assessment. Option D is also potentially significant negative as clarification of accuracy of the location of the track needs to be made, as outlined in Map 27 of the Wellington City District Plan, and where the track extends north of this map (into areas potentially impacted on by Option D).
- Mitigation could include:
  - » The recovery and recording of archaeological evidence within the Project area.
  - » The potential to provide interpretation and greater appreciation for the history and development of settlement in the Project area.
  - » Potential to enhance heritage features that will be left within the area and others that may be identified through the Project.
  - » Potential to obtain and compare archaeological information with other sites in the Wellington area.
- These or other mitigation measures have the potential to reduce the negative impacts on archaeology in the project area.

23.3.3 Landscape and Visual

The criteria used for the evaluation from a landscape/visual perspective looked at each option in terms of:

- Effect on the character, quality and amenity of the landscape
- Ability of the landscape to absorb change
- Potential for mitigation of effects

More specifically this can be broken down into:

Landscape Character and Quality

- Change in landform, land cover and land use
- Ability of the landscape to absorb change
- Effect on significant landscape elements e.g. high ridges, coastal cliff line, foreshore
- Effect on accessibility, connectivity and recreational activity and loss of amenity
- Effect on regional park/open spaces/heritage elements

Visual Change

- Proximity to residential areas, dominance of highway in the view
- Change in character or quality of views from high ground or public areas
- Sky lining of route on ridgeline/cliff face
- Urbanisation of rural views
- Interruption of views to/from sea/ridgeline

Ability to Mitigate Change

- Avoiding areas identified as significant landscape elements
- Opportunity to improve stream quality
- Opportunity to provide direct non-vehicular linkages across highway/ improved accessibility
- Opportunity to establish additional areas of re-vegetation adjacent to existing
- Ability to pattern future landscape in a way which integrates highway into the surroundings
- Ability to revegetate cut/fill faces in short-medium term to match adjacent land cover/colour
- Introduction of new viewpoints or viewing experience (opening up views to public)

Assessment was based on a range of sources including:

- Site visit;
- Aerial photographs;
- Street level photographs;
- Topographic maps;
- District and Regional Plans and Policy Statements;
- Data contained in existing reports and databases;
- Scheme options plans

Table 23-9 outlines the assessment in relation to the Petone options with Table 23-10 outlining Options A-D. Table 23-11 outlines a landscape/visual overall assessment.

Table 23-9: Landscape / Visual Assessment of Sub-options P1 to P4 (refer Figure 23-4)

Criteria	Option P1	Option P2	Option P3	Option P4
Character, quality and amenity of the landscape, ability to mitigate, level of effect with mitigation.	Intersection will maintain a permanent barrier to access from bush to beach. All options involve/require large cuttings.			
	Increases the mass and division between cliffs, Korokoro Stream and foreshore.			
	Extensive bare areas as a result of required cuts which will take 5 – 15 years for vegetation to be established and a further 15 to transition beyond shrub cover.			Extensive bare areas as a result of required cuts which will take 5 – 15 years for vegetation to be established and a further 15 to transition beyond shrub cover. Requires large cuttings affecting the east/west ridge which forms the watershed between Horokiwi and Korokoro, and is identified as a significant part of the city's defining hilltop character.
				Alignment limits the extent of cut face which will be seen by the public and minimises effect on the integrity of the coastal cliff form.
	Impact of view from Belmont Regional Park.			While angle of road limits extent of cut seen at any one time, likely that sections of tops of cuts will be visible in places from surrounding areas.
		Route runs through one of the narrowest parts of Belmont Regional Park and will affect the Korokoro Stream.		
		Steep side on which this route would follow is covered by regenerating native vegetation – however this is not significant vegetation.		Large part of route is covered in regenerating native vegetation and pines, of value for its greenness.
		Undeveloped and contained nature of the valley is highly valued for its character and recreational use.		
		Leaves large earthwork cuts exposed for some time, and changes the character of this lower section of the valley and the regional park.		
		Non-vehicular access can be maintained, the quality and amenity of this will be permanently affected.		
	Highly visible for public travelling on highway and rail and from other areas. Lighting and roading furniture will exacerbate this further.	Visual effects are limited in that the route is contained within the valley and leads immediately away from the foreshore.	Visual effects are limited in that the route is contained within the valley and leads immediately away from the foreshore. This route will be partly screened by the valley side from the housing above.	Little effect on views from coast and harbour, but significant view shaft from Petone up the cut.
		Users of the park and residents on the eastern hills will be significantly affected due to the proximity and nature of the alteration.	Users of the park will be significantly affected due to the proximity and nature of the alteration.	
		The higher section of the route will require deep cut through the ridge and extensive cleared slopes.		
			Slightly greater impact on amenity due to having an extra stream crossing.	
	Permanent effect on the Belmont Regional Park.			

Table 23-10: Landscape / Visual Assessment of Options A – D (refer Figure 23-4)

Criteria	Option A	Option B	Option C	Option D
Character, quality and amenity of the landscape, ability to mitigate, level of effect with mitigation.	Integration of transportation/urban form into route it likely to have a limited effect.			
	Key element of the route is the crossing of the main revegetated stream gully on the route – potential to expose views from this crossing point.			
		Second gully likely to be affected		
			Greater impacts on the two gullies.	
	Alignment can be blended along existing hill form and respond to future urban growth.			
		Complex intersection will be required to integrate with SH1, this intersection and realignment of the motorway will be highly visible.		
		Whether consistency and appearance of the landscape in this area can be improved to strengthen the linkage between green areas on both sides will be dependent on detailed design. While the composition of these areas is mixed there is potential for strong connection and improvement.		
			Earthworks will remove much of the natural patterning of the area.	
	Construction will also affect the east/west ridge which forms the watershed, and is part of the city's defining hilltop character.			
			Parallel course next to motorway will sever a section of land from effective use. However, could reinforce the valley side vegetation if planted up.	
				Section cuts through the centre of a well-developed sports park area having a severe impact on the functionality of this space as well as potentially the east/west green linkage.
				Further north there will be modification of natural drainage patterns as the route runs along the hillside. There will be modification to rural character by light and movement, particularly at night, which is in contrast to the local context, and introduce an urbanising effect.
				Visibility of the route is two-fold. It will result in a new experience of landscapes for travellers. The degree of exposure of the route is extensive, and views from the surrounding hilltops and valley sides. Local land form and vegetation in proximity to viewers may provide some degree of masking.
				Any attempt to settle the road into the landscape will be best achieved by emphasising the drainage patterns and by reducing the effect of structures and lighting

Table 23-11: Landscape / Visual Effects Rating of Each Sub-option P1 to P4 and Each Option A to D (refer Figure 23-4)

Type of Assessment	Criteria	Option P1	Option P2	Option P3	Option P4	Option A	Option B	Option C	Option D
Landscape/ Visual	Character, quality and amenity of the landscape, ability to mitigate, level of effect with mitigation.	**Significant negative** *(potential significant negative if mitigated)*	**Significant negative** *(potential significant negative if mitigated)*	**Significant negative** *(potential significant negative if mitigated)*	**Significant negative** *(but less than Option P1)*	**Minor negative** *(potential moderate positive if mitigated)*	**Minor negative** *(potential moderate positive if mitigated)*	**Moderate negative** *(potential minor positive if mitigated)*	**Moderate negative** *(potential minor negative if mitigated)*

Note:

- The effects ratings in Table 23-11 for Options A to D are not combined with the Sub-options
- Upon combining one of Option P1, P2, P3 or P4 with one Option A, B, C or D the effect more towards the negative takes precedence.
- Specific landscape/visual effects depend very much on the actual alignment and extent of works rather a generalised corridor width.
- This assessment has not considered alternative options to the start and finishing point of the route though these could be preferable in terms of less effects and more positive benefit, in landscape and amenity terms. The only amendment investigated is a possible modification to the form of the intersection at Petone, as this is considered to be the most critical issue.
- Other matters which have not been fully addressed, some of which require discussion and input from the project's urban designer archaeologist or ecologist include:
  - » Impact on and views from urban areas of the Hutt Valley, and of structures in that vicinity.
  - » The likely built form and land use of Plan Change 29, and the interrelationship of built form with the intersection form.
  - » Adjustments to the Lincolnshire Farm structure plan.
  - » Relationship with ecological areas and heritage areas.
  - » Any visual effects caused by noise mitigation measures not yet identified.

23.3.4 Resilience

Resilience of infrastructure lifelines such as roads is dependent on the loss of quality or serviceability, and the time taken to bring the road back into its original usage state after the reduction or loss of access due to an event.

The criteria used for the resilience assessment has been undertaken considering the following:

- Ability to provide overall resilience of access in the region in the event of natural hazards; and
- Ability to provide alternative route in the event of operation and technological hazards such as hazardous spills or accidents, or wild fire.

The key issues affecting resilience are:

- The relationship with the Wellington Fault Zone and the impact on the proposed road;
- Liquefaction and lateral spreading hazards and the impact on the route;
- Rock conditions along the route and its impact on the road;
- Steepness of the terrain along the route and the potential for landslides in earthquakes; and
- The extent of cuts and fills and their stability in earthquakes

Table 23-12: Resilience Assessment of Sub-options P1 to P4 (refer Figure 23-4)

Criteria	Option P1	Option P2	Option P3	Option P4
The relationship with the Wellington Fault Zone and the impact on the proposed road. Liquefaction and lateral spreading hazards and the impact on the route. Rock conditions along the route and its impact on the road. Steepness of the terrain along the route and the potential for landslides in earthquakes. The extent of cuts and fills and their stability in earthquakes.	Large cuts at the southern end near Petone which run parallel and adjacent to the Wellington Fault Zone. Large cuts and fills will also impact upon the resilience of SH2.	Large 60m high cuts and 45m fill embankments into the Korokoro Stream Valley. These cuts will be vulnerable to failure in earthquakes and storms and could close the route for weeks. There are 100m cuts further north, but less vulnerable due to being further away from the fault zone.	Northern part of the option has 100m high cuttings.	Overall provides alternate route with reasonably good resilience, but requires changes to reduce extent of high cuttings.
				The route is away from the Wellington Fault zone, and the inactive Korokoro Fault.
		Opportunities to reduce cut heights	Opportunities to reduce the height of these cuttings by avoiding climbing across the highest part of the plateau near Lincolnshire farms.	Rock conditions are likely to be better being away from the Wellington Fault zone, and a short crossing of the inactive Korokoro Fault scarp.
	Weak sheared rocks and defects likely at the southern end		Likely to have better rock conditions being further away from the Wellington Fault Zone	Crosses the steep hillside on the west of Korokoro Valley mouth at right angles and over a short section, where the risk could be better mitigated through design.
	Failure in storm or earthquake events would close the route and potentially SH2 as well.		Northern slopes may be cleared to provide access within days to 2 weeks.	High cuttings along significant parts of the route and up to 85 m high, but further away from the Wellington Fault zone. Away from poor rock conditions and faults, they can be engineered to reduce failures in earthquakes. Opportunities to reduce the height of these cuttings by avoiding climbing across the highest part of the plateau.
	Interchange is in a potentially liquefiable area, and within the Wellington Fault rupture zone	Interchange is partially located within the Wellington Fault Zone and opportunities exist to move this further north outside the fault zone, but it may be difficult due to the proximity of the climb onto the western flank of the Korokoro Stream.	The southern interchange with SH2 is currently located partly in the Wellington Fault zone, but could potentially be moved north to avoid the fault zone and ground prone to liquefaction and lateral spreading.	Southern interchange can be designed to mitigate liquefaction risk.
	Earthquake could close the southern section and interchange for months			Southern interchange is potentially vulnerable to liquefaction.
	Compromising opportunity to improve resilience	Option provides a completely separate route to the existing SH2 and SH58, hence enhancing redundancy and resilience of access to the Hutt Valley and the region in general.	Option provides substantially more resilience than the current situation.	Failures in cut slopes can close the road for a few weeks.
			Option provides a fully redundant alternative route to the existing SH1 SH2 and SH58 into the Hutt Valley and the Wellington region in general and thus enhances resilience.	Option provides substantially more resilience than the current situation, with resilient access into the Hutt Valley and the region as a whole, but the high cut slopes reduce time for recovery.

Table 23-13: Resilience Assessment of Options A – D (refer Figure 23-4)

Criteria	Option A	Option B	Option C	Option D
The relationship with the Wellington Fault Zone and the impact on the proposed road. Liquefaction and lateral spreading hazards and the impact on the route. Rock conditions along the route and its impact on the road. Steepness of the terrain along the route and the potential for landslides in earthquakes. The extent of cuts and fills and their stability in earthquakes.	This option has good natural hazard resilience with limited height cuts and fills.	This option provides modest natural hazard resilience with limited height cuts and fills, but crosses the Northern Landfill, and hence may be prone to subsidence and damage to the road due to settlement of the landfill.	This option provides modest natural hazard resilience with moderate height cuts and fills.	This option provides good natural hazard resilience with low to moderate height cuts and fills.
			The moderate high cuts may fail closing the route for a few days to 2 weeks.	These cut heights can be reduced with minor adjustments to the alignment.
	This route would not bypass existing moderate vulnerabilities along SH1 between Grenada South and Porirua, where the highway could be reduced to a single lane in earthquakes.			This route provides a complete bypass of some moderately vulnerable sections of SH1 and also the southern section of the proposed Transmission Gully route with large box cuts.
	This option would contribute to resilience of access to the Hutt Valley and hence the region.			It provides much improved resilience of access to the Hutt Valley and in the Greater Wellington area in general in conjunction with a suitable option in the southern section between the Lincolnshire Farm area and Petone.
	This route does not provide redundancy for the section of SH1 between Porirua and Grenada south.	This route does not provide redundancy for the section of SH1 between Porirua and Grenada.	This route provides some redundancy for the section of SH1 between Tawa and Grenada, and together with the redundancy provided by the local arterial road through Kenepuru and Tawa provides good operational resilience.	Provides excellent operational resilience by providing an alternate route to the existing SH1 between Petone and Grenada in conjunction with Transmission Gully. It provides connectivity to Tawa and Grenada south and enables bypass of any incidents on either route.

Table 23-14: Resilience Effects Rating of Each Sub-option P1 to P4 and Each Option A to D (refer Figure 23-4)

Type of Assessment	Criteria	Option P1	Option P2	Option P3	Option P4	Option A	Option B	Option C	Option D
Resilience	The relationship with the Wellington Fault Zone and the impact on the proposed road. Liquefaction and lateral spreading hazards and the impact on the route. Rock conditions along the route and its impact on the road. Steepness of the terrain along the route and the potential for landslides in earthquakes. The extent of cuts and fills and their stability in earthquakes.	**Significant negative**	**Minor Positive**	**Substantial Positive**	**Moderate Positive**	**Minor Positive**	**Minor Positive**	**Moderate Positive**	**Substantial Positive**

Note:

- The effects ratings in Table 23-14 for Options A to D are not combined with the Sub-options
- It is recommended that some modifications be made to the alignments to maximise resilience and reduce risks, as follows:
  - » Move the interchange at Petone to the north, away from the Wellington Fault zone, to maximise resilience in a Wellington fault rupture earthquake and also minimise its exposure to liquefaction and associated lateral spreading.
  - » Reduce the height of the cuttings for Options P2, P3 and P4 by refining the alignment to avoid crossing the highest part of the ridge plateau around the Lincolnshire Farm area, and thus reduce the height of the proposed cuttings.
  - » Optimise alignment of P4 by reducing the height of cuttings along the southern section of the route.

23.3.5 Benefit / Cost Ratio

The benefits and costs of the respective options were calculated based on the following:

Benefits:

- Present Value Benefits, Travel Time Benefits, Vehicle Operating Costs.

Costs:

- Undiscounted Costs, Present Value Costs, Vehicle Operating Costs

This was undertaken for the route as a whole, not distinguishing between the different interchange options at either end of each alignment.

Table 23-15: Resilience Overall Assessment

Type of Assessment	Criteria	Option A	Option B	Option C	Option D
BCR	Benefits: Present Value Benefits, Travel Time Benefits, Vehicle Operating Costs. Costs: Undiscounted Costs, Present Value Costs, Vehicle Operating Costs	2.1	1.6	2.1	2.1

23.4 Outcomes of Option Evaluation

In the previous section a separate rating by the specialists has been provided for Options A to D and Sub-options P1 to P4. Before building a decision matrix to compare Options A to D, in their entirety, we need to assess Sub-options P1 to P4. Once we have decided on the preferred sub-option, its effects ratings can then be combined with the effects ratings of Options A to D (from Lincolnshire Farm to each option's connection point to either SH1 or TG). This will then enable Options A to D, in their entirety, to be compared and evaluated.

Table 23-16 provides an overall summary of the ratings that each specialist gave to Sub-options P1 to P4.

Table 23-16: Overall Summary – Sub-options P1 to P4

Type of Assessment	Criteria	Option P1	Option P2	Option P3	Option P4
Ecology Assessment	Refer Table 23-6	P1 - Moderate Negative	P2 – Moderate Negative (tending towards significant negative)	P3 - Significant Negative	P4 – Moderate Negative
Archaeology	Refer Table 23-8	P1 - Insignificant / minor negative	P2 - Insignificant / minor negative	P3 - Insignificant / minor negative	P4 - Insignificant / minor negative
Landscape/ Visual	Refer Table 23-10	P1 - Significant Negative	P2 - Significant Negative	P3 - Significant Negative	P4 - Significant Negative
Resilience	Refer Table 23-12	P1 - Significant Negative	P2 – Minor Positive	P3 - Substantial Positive	P4 – Moderate Positive

It is easier to compare options by reducing either the number of options or the number of evaluation criteria. While it is not possible to combine ratings together without introducing some unknown scaling and weight to the various criteria, it is possible to use pair-wise comparison to reduce the size of the problem.

Pair-wise comparison is a simple technique which compares two options at a time. If one of the two options being compared is either similar or better than the other option in all evaluation criteria, then we can conclude that this option is better than the other option, without the uncertainty of solving the problem of scaling or weight. The problems of scaling and weight are inherent in all multi-criteria analysis problems where values cannot be converted to a single currency like money.

Firstly we can reduce the problem by eliminating evaluation criteria. We can see in Table 23-16 that the ratings given for archaeology and landscape/visual are identical (when further investigations allowances and mitigation are removed). These aspects can then be removed from the decision making process, reducing the factors that need to be taken into consideration (see Table 23-17).

Table 23-17: Simplified Decision Matrix 1– Sub-options P1 to P4 Ecology and Resilience

Type of Assessment	Criteria	Option P1	Option P2	Option P3	Option P4
Ecology Assessment	Refer Table 23-6	P1 - Moderate Negative	P2 – Moderate Negative (tending towards significant negative)	P3 - Significant Negative	P4 – Moderate Negative
Resilience	Refer Table 23-12	P1 - Significant Negative	P2 – Minor Positive	P3 - Substantial Positive	P4 – Moderate Positive

From Table 23-17 we can be seen that using pair-wise comparison Sub-options P1 and P2 can be eliminated as Sub-option P4 has better effects ratings for both ecology and resilience. This leaves Sub-options P3 and P4 which are compared in Table 23-18 below.

Table 23-18: Simplified Decision Matrix 2 – Sub-options P3 and P4 Ecology and Resilience

Type of Assessment	Criteria	Option P3	Option P4
Ecology Assessment	Refer Table 23-6	P3 - Significant Negative	P4 – Moderate Negative
Resilience	Refer Table 23-12	P3 - Substantial Positive	P4 – Moderate Positive

Table 23-18 shows that Sub-option P4 has a better effects rating for ecology and a similar but lower effects rating for resilience. Consequently if we give more weight to ecology then Option P4 is preferred, and if we give more weight to resilience then Option P3 is preferred. Option P3 has significant negative impacts on the Korokoro Stream within the Belmont Regional Park. The Korokoro Stream is recognised as an area of ecological and cultural significance. The RPS lists the Korokoro Stream as having significant indigenous ecosystem values. Given the significant impact on this area the team decided to give more weight to ecology thus making P4 the preferred option.

Table 23-19 below combines Options A to D (from Lincolnshire Farm to each option's connection point to either SH1 or TG) with Sub-option P4 and also provides an overall rating for Options A to D in their entirety (combined with Sub-option P4).

Table 23-19: Summary of Key Differences Options A to D (combined with Option P4)

		Option A (combined with P4)			Option B (combined with P4)			Option C (combined with P4)			Option D(combined with P4)		
Type of Assessment	**Criteria**	**Option A**	**Sub-option P4**	**Overall effects rating**	**Option B**	**Sub-option P4**	**Overall effects rating**	**Option C**	**Sub-option P4**	**Overall effects rating**	**Option D**	**Sub-option P4**	**Overall effects rating**
Ecology Assessment	Refer Table 23-6	Minor Negative	P4 - Moderate Negative	Moderate Negative	Minor Negative	P4 - Moderate Negative	Moderate Negative	Moderate Negative	P4 - Moderate Negative	Moderate Negative	Significant Negative	P4-Moderate Negative	Significant Negative
Archaeology	Refer Table 23-8	Insignificant / minor negative	Insignificant / minor negative (Potential for significant negative dependent on further investigation)	Insignificant / minor negative (Potential for significant negative dependent on further investigation)	Insignificant / minor negative	Insignificant / minor negative (Potential for significant negative dependent on further investigation)	Insignificant / minor negative (Potential for significant negative dependent on further investigation)	Insignificant / minor negative	Insignificant / minor negative (Potential for significant negative dependent on further investigation)	Insignificant / minor negative (Potential for significant negative dependent on further investigation)	Insignificant / minor negative (Potential for significant negative dependent on further investigation)	Insignificant / minor negative (Potential for significant negative dependent on further investigation)	Insignificant / minor negative (Potential for significant negative dependent on further investigation)
Landscape/ Visual	Refer Table 23-10	Minor negative (potential moderate positive if mitigated)	Significant negative (but less than Option P1)	Significant negative (but less than Option P1)	Minor negative (potential moderate positive if mitigated)	Significant negative (but less than Option P1)	Significant negative (but less than Option P1)	Moderate negative (potential minor positive if mitigated)	Significant negative (but less than Option P1)	Significant negative (but less than Option P1)	Moderate negative (potential minor negative if mitigated)	Significant negative (but less than Option P1)	Significant negative (but less than Option P1)
Resilience Assessment	Refer Table 23-14	Minor Positive	P4 - Moderate Positive	Minor Positive	Minor Positive	P4 - Moderate Positive	Minor Positive	Moderate Positive	P4 - Moderate Positive	Moderate Positive	Substantial Positive	P4 - Moderate Positive	Moderate/ Substantial Positive
BCR	Refer Table 23-15	2.1			1.6			2.1			2.1		

We can see in Table 23-19 that the ratings given for archaeology and landscape/visual are identical (when further investigations allowances and mitigation are removed). These aspects can then be removed from the decision making process, reducing the factors that need to be taken into consideration (see Table 23-20).

Table 23-20: Summary of Key Differences Options A to D (combined with Option P4)

		Option A (combined with P4)			Option B (combined with P4)			Option C (combined with P4)			Option D(combined with P4)		
Type of Assessment	**Criteria**	**Option A**	**Sub-option P4**	**Overall effects rating**	**Option B**	**Sub-option P4**	**Overall effects rating**	**Option C**	**Sub-option P4**	**Overall effects rating**	**Option D**	**Sub-option P4**	**Overall effects rating**
Ecology Assessment	Refer Table 23-6	Minor Negative	P4 - Moderate Negative	Moderate Negative	Minor Negative	P4 - Moderate Negative	Moderate Negative	Moderate Negative	P4 - Moderate Negative	Moderate Negative	Significant Negative	P4-Moderate Negative	Significant Negative
Resilience Assessment	Refer Table 23-14	Minor Positive	P4 - Moderate Positive	Minor Positive	Minor Positive	P4 - Moderate Positive	Minor Positive	Moderate Positive	P4 - Moderate Positive	Moderate Positive	Substantial Positive	P4 - Moderate Positive	Moderate/ Substantial Positive
BCR	Refer Table 23-15	2.1			1.6			2.1			2.1		

The criteria has then been reduced to ecology, resilience and BCR. It can be seen in Table 23-20 options A and B are the same in terms of both ecology and resilience, but differ in terms of BCR where Option A is higher. On this basis Option B can be eliminated. In comparing Options A and C, it can be seen that the overall rating of each in terms of ecology are the same. However, Option C delivers higher resilience than Option A. On this basis Option A can be eliminated from the option evaluation process. Option C also has very similar NPV benefits to Option A and D.

In comparing the remaining Options C and D it can be seen that BCR is the same for each - this criteria can therefore be removed from the option evaluation process. The remaining comparison between Option C and D in terms of ecological and resilience effects can be found in Table 23-21 below.

Table 23-21: Summary of Key Differences Options C and D (combined with Option P4)

		Option C (combined with P4)			Option D(combined with P4)		
Type of Assessment	**Criteria**	**Option C**	**Sub-option P4**	**Overall effects rating**	**Option D**	**Sub-option P4**	**Overall effects rating**
Ecology Assessment	Refer Table 23-6	Moderate Negative	P4 - Moderate Negative	Moderate Negative	Significant Negative	P4-Moderate Negative	Significant Negative
Resilience Assessment	Refer Table 23-14	Moderate Positive	P4 - Moderate Positive	Moderate Positive	Substantial Positive	P4 - Moderate Positive	Moderate/Substantial Positive

It is at this point that the option evaluation process comes to a halt, as further development of the decision making process cannot proceed without attaching a "weighting" to each of the criteria.

23.5 Determination of a Preferred Option

From Table 23-21 we can see that Option C is preferred over Option D if more weight is given to ecology, whilst Option D is preferred over Option C if more weight is given to resilience. It is highly likely the additional ecological effects associated with Option D can be mitigated. At this stage in the process both options are considered feasible and should be taken forward to the public engagement phase.

24

Conclusions and Recommendations

24 Conclusions and Recommendations

Building the P2G link route will cost between $175m and $381M and attract approximately 38,000 vehicles in 2031. The route will have a design speed of 80km/hr with 9% grades and will require 2 lanes in each direction plus crawler lanes. For a P2G link to TG, the northern section of route between Lincolnshire Farm and TG, could be upgraded to a design speed of 100km/hr.

Four options, identified below, were developed based on a southern connection at Petone and a range of northern connection points to SH1:

1. Option A – Petone to Grenada;
2. Option B – Petone to Tawa (with north facing ramps to SH1);
3. Option C – Petone to Tawa (with a full interchange to SH1 and local road network); and
4. Option D – Petone to TG (with connections to Grenada and Tawa).

Quantm, a rapid geometric route option software tool, was used to assist in developing these options by testing:

- The difference in cost between alignments with design speeds of 60km/hr, 80km/hr and 100km/hr;
- Alternative options to the Project Feasibility Report (PFR) option between Petone and Tawa; and
- Alternative southern connections to SH2 at Dowse, Horokiwi Road and Korokoro Crescent.

The results of Quantm indicated that:

- 80km/hr design speed should be adopted for this project which was also supported by the findings of the safety report (refer Appendix A);
- Numerous alignments between Petone and Tawa are significantly more cost effective than the PFR alignment (up to 50% cheaper) and avoid landfills and the Belmont Regional Park;
- Petone is the most cost effective southern connection point for the interchange which is also supported by the transportation assessment (refer Section 13).

Options A, B and C also require upgrading SH1, from 4 lanes to 6 lanes, between each option's northern connection at SH1, to TG. The upgrading is required to provide additional capacity due to increased traffic from the P2G link route and either maintains or improves the LOS on this section of SH1 for these options compared with the 2031 do minimum. Option D, on the other hand, does not require any upgrades to SH1 between Tawa and TG as it has minimal impact on traffic volumes on SH1 north of Tawa. While there is a reduction in LOS on the SH1 southbound between Tawa and TG with Option D, compared with the 2031 do minimum, the reduction is not to the extent which requires upgrading SH1.

Options A to D share a common alignment along the southern section of the route between Petone and the eastern section of Lincolnshire Farms. There are significant challenges along this section which include the proximity of the Belmont Regional Park and the steep hill slopes which rise sharply from sea level at Petone up to 290m elevation around Horokiwi. To address these challenges four sub-options were developed identified as P1, P2, P3 and P4. The main differences between these four sub-options are the alignments they follow to traverse the steep hill slopes just north of Petone to reach the broad undulating hill tops of Horokiwi and Lincolnshire Farms. Sub-option P1 traverses the coastal escarpment in a large sidling cut to wind its way to Lincolnshire Farms while Sub-options P2 and P3 run directly up the Korokoro valley in large cuts and fills. Sub-option P4, on the other hand, avoids both the coastal escarpment and Korokoro valley but involves large cuts over a long distance resulting in greater earthworks than Sub-options P1 to P3.

There are also significant challenges at Petone for an interchange, including liquefaction potential, the proximity of the Wellington Fault and the consideration of a beach to bush connection for pedestrians and cyclists from the Petone foreshore to the Belmont Regional Park. Several preliminary interchange options were developed, with landscape and urban design inputs, to meet these challenges as well as provide full connectivity to SH2, The Esplanade and Hutt Road. Further assessment is required at the scheme assessment phase to determine a preferred form of interchange at this location.

A P2G link route will intersect with Horokiwi Road at some point north of Horokiwi Quarry. Either maintaining Horokiwi Road at this intersection (by a bridge or tunnel for instance) or providing connections to the P2G Link Road needs to be considered.

A connection to Lincolnshire Farms will be provided by a link to the Mark Avenue roundabout at Grenada.

Options A to D together with Sub-options P1 to P4 were evaluated following a structured process based on the following criteria:

- Ecology;
- Archaeology;
- Benefit Cost Ratio;
- Resilience; and
- Landscape / Visual / Recreational.

The evaluation concluded that Sub-option P4 was preferred as it not only rated a moderate positive with respect to resilience, but also avoided the significant negative ecological effects associated with Sub-options P2 and P3, whilst also avoiding the significant negative resilience effects of P1.

The rough order cost (ROC) and BCR of Options A to D (assuming Sub-option P4) are shown in Table 24-1 below.

Table 24-1: Summary of ROCs and BCRs for Options A to D

Option	Rough Order Cost ($M)	BCR
Option A	$185M to $396M	2.1
Option B	$189M to $405M	1.6
Option C	$178M to $381M	2.1
Option D	$175M to $375M	2.1

The evaluation concluded that Option C was preferred if more weight was given to ecology, whilst Option D was preferred if more weight was given to resilience. Ecological effects can be mitigated. At this stage in the process, both Option C and D are considered feasible and should be taken forward to the public engagement phase.

A

Appendix A
Influence of Design Criteria on Design Speed

A. Influence of Design Criteria on Design Speed

A.1 Purpose

The purpose of this memo document is:

- To review the SKM Ngauranga Triangle Project Feasibility Report: Petone to Grenada Link Road (P2G PFR) November 2010 with respect to the risk of the present alignment adopting a design speed of 70km/hr and a posted speed of 60km/hr;
- Comment on the level of risk NZTA could face (e.g., high risk/big issue, low risk/minor issue) on adopting this design speed following a safety review;
- Recommend an appropriate design speed for this alignment.

A.2 Current Proposal

The P2G PFR states that the design speed of the proposed alignment is 70km/hr and the posted speed is 60km/hr. This proposed arterial, approximately 6 km long, provides a more direct link between SH 1, just south of the Tawa Interchange and SH 2 at Petone, compared to the existing route via Ngauranga Gorge, which is twice the distance.

The 4 lane divided alignment, as shown on the plans accompanying the report, show a horizontal alignment consisting of a series of curves and straights with radii between 320m up to about 1500m, except for a 120m radius curve near the summit and a 120m and 70m radii curve on the approach to the proposed Petone Interchange roundabout. The larger curves are purely circular while the lower radii curves include transitions leading in to the circular curves, although 2 horizontal curves are shown with transitions at only one end.

The vertical alignment is dominated by steep grades, with the main grade from the connection with SH 1 to the summit at Horokiwi, being at 7.0 and 8.6% over a length of 2.4 km and a 2.9km long steep approximately 9% grade from the summit down to SH 2 at Petone.

Information supplied from traffic modelling states that the predicted AADT is 25000 with 10% heavy vehicles in the traffic flow. Although the plans show 2 lanes in each direction the report mentions the possibility of additional climbing lanes, although it is not shown on the plans and it is not clear whether this has been allowed for in the estimate.

A.3 Speed Environment and Design Speed

The speed environment is used to describe a characteristic of a section of road. It is regarded as being uniform over a section of highway that is reasonably consistent in both terrain and general geometric standard. Speed environment and design speed are both defined by the 85th percentile value of their distributions. The speed environment is numerically equal to the desired speed of the 85th percentile driver over a section of road. Although it can be measured on existing roads it must be estimated for new roads. The speed environment is influenced partly by the terrain and partly by the horizontal alignment. The long steep grades associated with this project add another factor in assessing the speed environment, although normally driver speed is influenced by the horizontal alignment. However interpreting Table 4.6 in the SHGDM and assessing the terrain between hilly and mountainous, the speed environment on this proposed link is in the order of 85 to 95km/hr. This equates to an 85th percentile speed, or design speed, of about 80km/hr. To be compatible with the design speed of SH 1 near the Tawa Interchange, the link road connections will need to be based on a higher design speed of at least 100km/hr, while at the Petone connection the design speed will need to be gradually reduced so as not to exceed 50km/hr entering the proposed Petone Interchange roundabout. Adopting an 80km/hr design speed is consistent with the existing 80km/hr speed limit on similar highways such as at Ngauranga Gorge and 0n the Wainuiomata Hill.

A.4 Comparison with Similar Projects

There are 2 other local existing highways which traverse this steep escarpment and fault line on the west side of the Hutt Valley and Wellington Harbour:

1. SH 1 on the Ngauranga Gorge section, which is on a grade of 8% over a length of just under 2km, is restricted to a speed limit of 80km/hr. This is enforced by electronic signage and a speed camera adjacent to the southbound lanes near the top of the Gorge. The radii of the curves down the Gorge range between 200m and 400m. The divided carriageway is 3 lanes in each direction. The AADT is approximately 60,000.

2. Haywards Hill on SH 58, which connects to SH 2 at Manor Park, traverses the same escarpment as the Petone to Grenada Link Road. The speed limit on this section of SH 58 is 100km/hr but a number of curves have speed advisory signs of 65 and 75km/hr. The carriageway is basically one lane in each direction with some sections of passing lane. The opposing carriageways are separated by a mixture of flush median and wire rope barrier. The AADT is approximately 14,000.

Both these highways are classified as state highways. For comparative purposes it is assumed that the Petone to Grenade link will become a local arterial road instead of a state highway and therefore more similar to the road between the Hutt Valley and Wainuiomata. This highway is mainly 2 lanes in each direction, plus a 3rd climbing lane on the Hutt Valley side, with a physical median. This road over the Wainuiomata Hill is also at a posted speed of 80km/hr. However in a number of cases the curve radii are as low as 50 to 60m on the eastern side and as low as 90m to 100m on the western side, which result in a design speeds less than 80km/hr. The grade on the Wainuiomata Hill appears to range between 9 and 12% (scaled from contours).

A.5 Safety Issues

Safety is a major goal of road design in achieving a functional, economical and aesthetically pleasing design. The design needs to enable drivers to perceive hazards in time and take appropriate action through the use of geometric parameters consistent with the likely speed of traffic operation. Good design practice requires elimination of all avoidable hazards and combining all geometric elements into one harmonious whole consistent with the speed environment, so drivers will be encouraged to maintain a reasonably uniform speed over the route.

It is difficult to assess accident risk against design speed and the influence which steep grades have on accidents because of the lack of appropriate data. However there are fundamental design issues that if they are not properly addressed can increase the risk of accidents. These include:

- Having a consistent alignment. Consecutive horizontal curves should not vary by more than 10 to 15km/hr
- It is desirable that the vertical alignment design is based on a design speed 10 to 15km/hr greater than the horizontal alignment
- Sharp horizontal curves should not be used near the top of crest vertical curve as drivers may not perceive the change in

alignment, especially at night. Any sharp horizontal curve in a crest vertical curve is undesirable as it creates the potential for accidents.

- Where adjacent reverse curves occur it is desirable for driver comfort and safety that a length of straight is provided between the 2 curves.
- Allowance for grade effects should be made hence assessing sight distance and stopping distance and HCV requirements checked (see Austroads Urban Road Design Section 8.4.4)
- Provide runoff areas or barriers, frangible signs and poles, adequate sight distance, etc.
- Use high friction pavement, especially at braking areas on steep grades and approaching intersections and roundabouts.
- Big differences in operating speeds increase accident risk. Long steep grades will result in heavy vehicle speeds being reduced down to 20 to 25km/hr compared to the much higher operating speeds of light vehicles. With a predicted AADT of 25,000 and 10% heavy vehicles to use the route the differential speed will effect capacity and increase accidents unless allowance is made for additional climbing and possibly descending lanes. Climbing lanes should extend over the summit so that the heavy vehicle speeds can increase to match the operating speed of the through lane as they merge. However partial climbing lanes or slow vehicle bays may be a compromise because of high construction costs, but this is likely to increase the accident risk compared to a fully design climbing lane.

A.6 Predicted Accidents Rates:

It is difficult to analysis likely accident rates for different design speeds for this proposed link, as there is little information available for multi-lane highways on steep grades, based on current available NZTA and Austroads data. However a comparison with existing accident data from Ngauranga Gorge, SH 58 at Haywards Hill and the Wainuiomata Hill will give some indication of likely future accident rates on the proposed Petone to Grenada link road. A quick analysis of the Wainuiomata Hill accident data from the CAS database indicates injury accidents at the rate of approximately 60 injury accidents per 100 million veh/km. There is a big concentration of accidents at the intersections at either end of this hill road. This rate is high and will reflect the tight horizontal curves on this alignment. A similar analysis can be done for Ngauranga Gorge and SH 58, where the accident rate would be expected to be lower. This compares with the suggested rate in the PEM for a motorway or 4 lane divided highway of 10 injury accidents per 100 million veh/km, which is unlikely to take into account grades of 7 to 10%.

Interpreting rural mid-block accident rates from the PEM (1997) for hilly and mountainous terrain, with allowance for an injury reduction for 3 and 4 lane undivided highways, indicate a possible accident rate of 25 to 30 injury accidents per 100 million veh/km. The accident rate for this new Petone to Grenada link is likely to be somewhere between this value, or the Ngauranga and Haywards Hill accident rate, and the Wainuiomata Hill accident rate, with good design influencing the final outcome.

There is other data available, including a RTA research paper, which suggests avoiding curve radii in the range of 300m to 460m as curves in this range are more difficult for drivers to read and lead to a higher accident, but this range of curves is difficult to avoid with New Zealand's topography. Another paper shows how an out of context horizontal curve in an alignment can increase the accident rate of that curve.

A.7 Modification to the Feasibility Design

The key to lessening the accident risk of this link road in this difficult terrain is adopting good design practice. Because of the steep and long grades additional measures should be investigated to include the use of variable speed signs (in case of inclement weather, accidents, etc.), a high friction pavement, a runaway vehicle facility on the Petone side and increased super-elevation on the steep down grades.

The main feasibility alignment, which according to the report has been discussed with the key interested parties, should not require major changes to the horizontal alignment. Although no super-elevation values are shown on the plans, radii of 320m or 350m, which are the minimum values apart from the 120m radius curve near the summit, do provide an 80km/hr design with 4 and 4.5% super-elevation, although these values need to be adjusted for the steep downhill grades. The R120m curve needs to be increased to make it compatible with the overall alignment and the curves leading in to the Petone roundabout need to be checked to ensure adjacent curve design speeds do not exceed 10 to 15km/hr. The recently completed Mark Avenue Extension and roundabout has been ignored in the design. The current alignment passes close to these features, which may require some modification to the alignment and level in this vicinity.

Warp rates need to be checked to make sure they do not exceed the recommended maximum. If possible these modifications should also consider the best practice for the appropriate ratio between transitions and circular curve lengths, to improve the aesthetics of the alignment, especially where the total length of individual curves can be seen by drivers. Co-ordination of horizontal and vertical curves should also be achieved if possible and vertical curve lengths preferable to exceed the minimum.

The posted speed adopted can be the same as the design speed. It is New Zealand practice (see Austroads Guide to Road Design Part 3 Section 7.7.1) to not use the maximum friction value unless the curve radius is at the minimum for the design speed. With radii of 320m and greater and a design speed of 80km/hr, this does not occur, therefore full maximum friction is not used. If the maximum friction factor was used the "safe speed" would be higher than the design speed.

A.8 Conclusion

- It is difficult, because of the lack of hard data, to rank the level of accident risk against various design speeds.
- Based on an assessment of the speed environment and associated design speed, plus other examples of multilane divided highways traversing similar topography in the Hutt Valley, adopting a design speed of 80km/hr appears an appropriate solution. This is consistent with the 80km/hr speed limit on similar highways as Ngauranga Gorge and Wainuiomata Hill. Obviously the design speed with the off and on ramps at SH 1 will need to be higher, while the roundabout connection at Petone will need to be reduced to 50km/hr.
- Adopting a 80km/hr speed design should not have to significantly change the 70km/hr feasibility report horizontal alignment
- Predicted accident rates would be best determined by comparing with accident rates on Ngauranga Gorge, Haywards Hill and Wainuiomata Hill, as there is little other relevant published data available.
- Good design will have an influence on the accident risk of this project. Adopting good design practice is unlikely to pose a high risk/big issue problem for NZTA.
- Because of the challenging nature of this alignment and the importance of the connections to SH 1 and SH 2, it would be prudent to engage the NZTA National Office safety team in this project at an earlier stage.

Murray Carpenter
7th February 2013.

B

Appendix B
HCV on Grades Analysis

B. HCV on Grades Analysis

The Petone to Grenada (P2G) PFR route traverses some very steep topography with proposed grades of approximately 9% for extended section lengths. As part of the scoping stage of the project, the project manager wished to investigate the impact of grades on Heavy Commercial Vehicles (HCVs) to inform the route selection process.

This memorandum summarises the investigation into the impacts of grades on HCVs, and presents a spreadsheet design tool that can be used to assess alternative routes.

B.1 Methodology

The essential question being considered is whether longer and shallower routes are preferred over shorter and steeper routes for HCVs. While steep grades have an impact on cars and light commercial vehicles, they are still able to accelerate and maintain a reasonable average speed and therefore this is not likely to affect their routing decisions. Hence this analysis focusses only on HCVs in terms of travel time, speed and vehicle operating costs.

B.1.1 Route Options

Three options were assessed between the Petone Interchange on SH2 and the Takapu Interchange on Transmission Gully (TG):

- Existing (Do Minimum): Existing SH2 from Petone to Ngauranga, SH1 to Kenepuru, and TG to Takapu;
- Option X: P2G PFR route from Petone to Grenada (Tawa) , SH1 to Kenepuru, and TG to Takapu; and
- Option Y: New P2G route from Petone to Takapu.

Takapu Interchange was selected as the northern extent, as all three routes can be compared on a 'like to like' basis geographically. The three routes are shown in Figure B-1. The length and vertical profile of the three routes was based on preliminary geometric designs of each route.

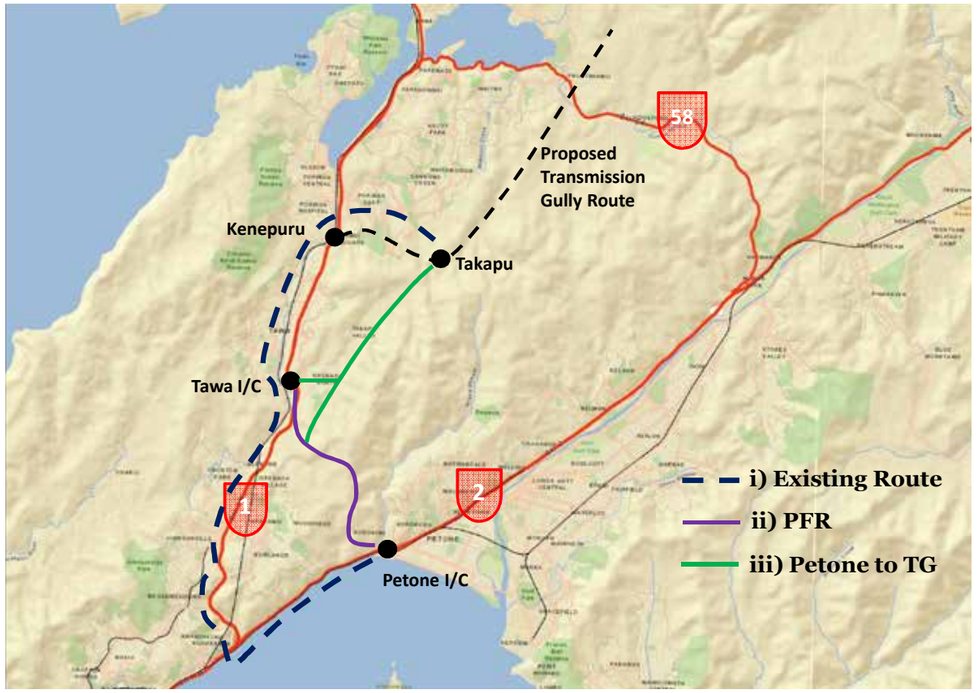


Figure B-1: Routes between Petone and Takapu

B.1.2 HCV Demands

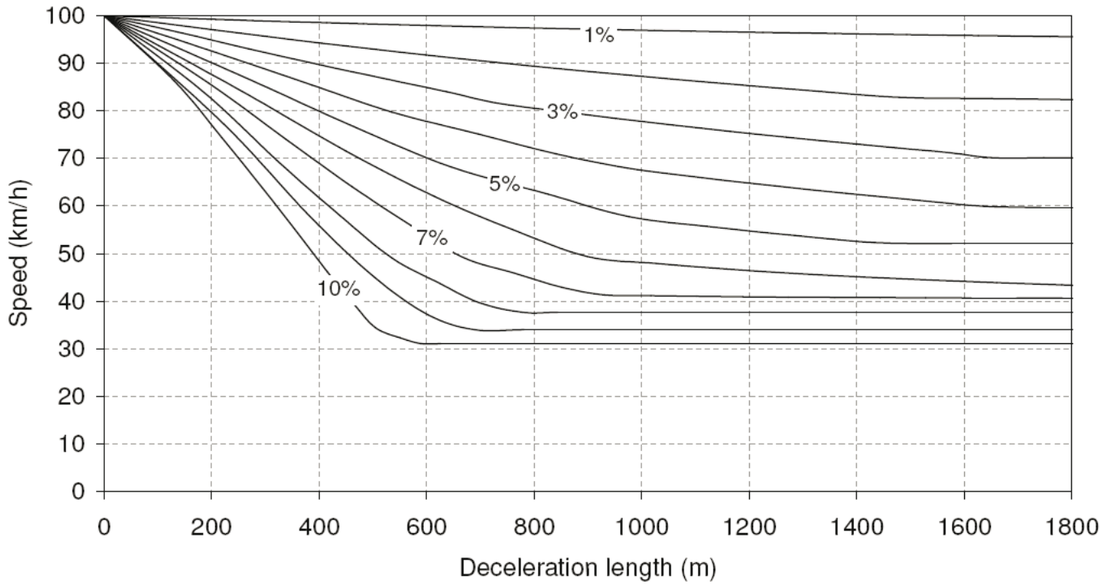
The HCV demands used for the analysis are not really that important, as the time, speed and cost are calculated for a single HCV. In this analysis they are effectively a scaling factor to get an appropriate magnitude on the benefits.

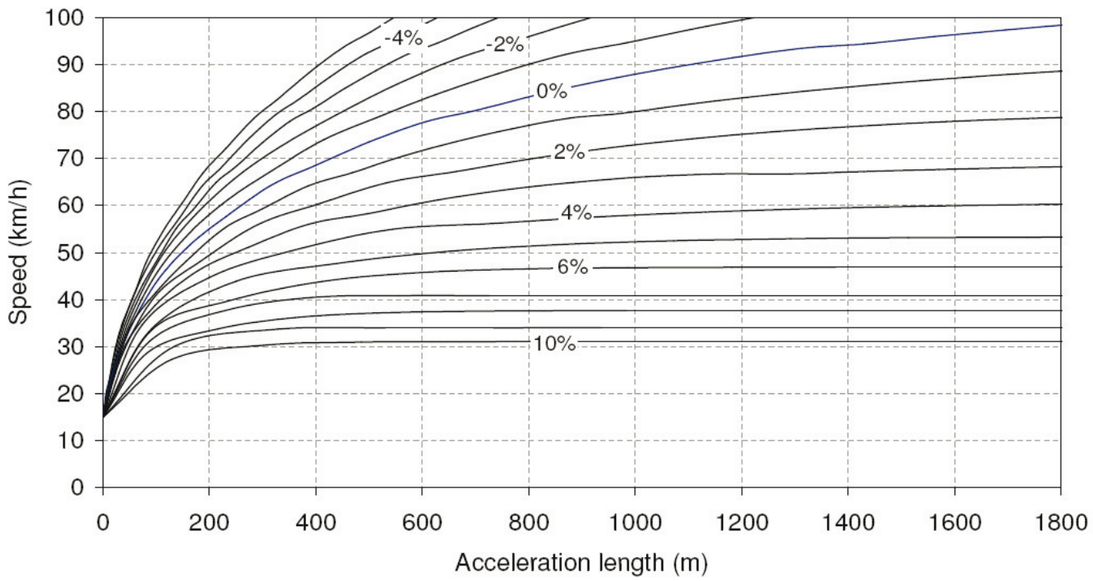
HCV demands were calculated from WTSM 2031 model outputs. Select links were obtained for the new P2G link for both options. The HCV proportion from WTSM was used to factor the total vehicles down to HCVs, and the results averaged between the options resulting in 59 HCVs per day travelling northbound and 104 southbound in 2031.

We would expect that these numbers should be higher than this, and are likely to be balanced in both directions on a daily basis. Hence we believe these estimates should only be used under heavy caveats. The WTSM HCV user class is based on synthetic information and is currently being updated through a separate project. Therefore it is anticipated that new HCV data will need to be collected to support the freight story for the SAR.

B.1.3 HCV Acceleration / Deceleration Curves

The basis of this analysis is acceleration / deceleration curves from "Austroads Guide to Road Design, Part 3: Geometric Design, Austroads (2010)", Figure 3.9 as shown in Figure B-2. This in turn is based on the "Road Planning and Design Manual, Department of Transport and Main Roads Queensland, (April 2002)", Chapter 15: Auxiliary Lanes.





Source: Queensland Department of Transport and Main Roads (2002c).

Figure 3.9: Determination of truck speeds on grade, 19 m semi-trailer (33 t), 12 l diesel carrying an average load (9.7 kW/t)

Figure B-2: Austroads Guide to Road Design Part 3 Figure 3.9

Figure B-2 was used to approximate the speed of HCVs on the profile generated by the design team. The upper graph was used to generate speeds on the upgrade sections of the route. Particular account was taken of the HCV speed at the end of each section, and therefore the start of the following section. Where the upgrade allowed, HCV speeds were assumed to increase as indicated in the lower graph on Figure B-2. Some professional judgement was required when interpreting this information.

As instructed by the documentation, speeds on downgrades were assumed to be the same as for upgrades, which reflects the reality of HCVs crawling at slow speeds downhill. As a result, the analysis was completed in the northbound direction and assumed to apply equally in the southbound direction of travel.

HCV cruise speeds are assumed to be 100km/hr on a level grade. After the Design Surgery, the design speed of P2G is likely to be 80km/hr, so some modification to the analysis may be needed in the future.

B.2 Analysis Results

B.2.1 Average Speed and Travel Time

The elevation changes in km for the three routes versus distance (km) are plotted on the primary axis in Figure B-3. The average section speeds (km/hr) are plotted on the secondary axis. Summary statistics for average speed and travel time are shown in Table B-1. The percent difference between the existing route and the option are shown in brackets.

Table B-1: Average Speed and Travel Time

Route	Distance (km)	Travel Time (min)	Average Speed (km/hr)
Existing	19.8	15	79
Option X	12.8 (-35%)	13.1 (-12%)	59 (-26%)
Option Y	10.8 (-45%)	9.2 (-39%)	71 (-11%)

Table B-1 shows that Option X is 35% shorter and 12% faster than the existing (Do Minimum) route, which results in an average speed of 59km/hr. Option Y is 45% shorter and 39% faster than the existing, resulting in an average speed of 71km/hr.

Figure B-3 shows that the elevation profile for Options X and Y are far steeper initially than the existing SH1 / SH2 route, which results in the slow average speeds for the options. The graph also shows that Options X and Y are much shorter than the existing route. An important trend to note is that both the existing and Option X have steep climbs to end at Takapu, while Option Y has a much shallower grade resulting in higher average speeds.

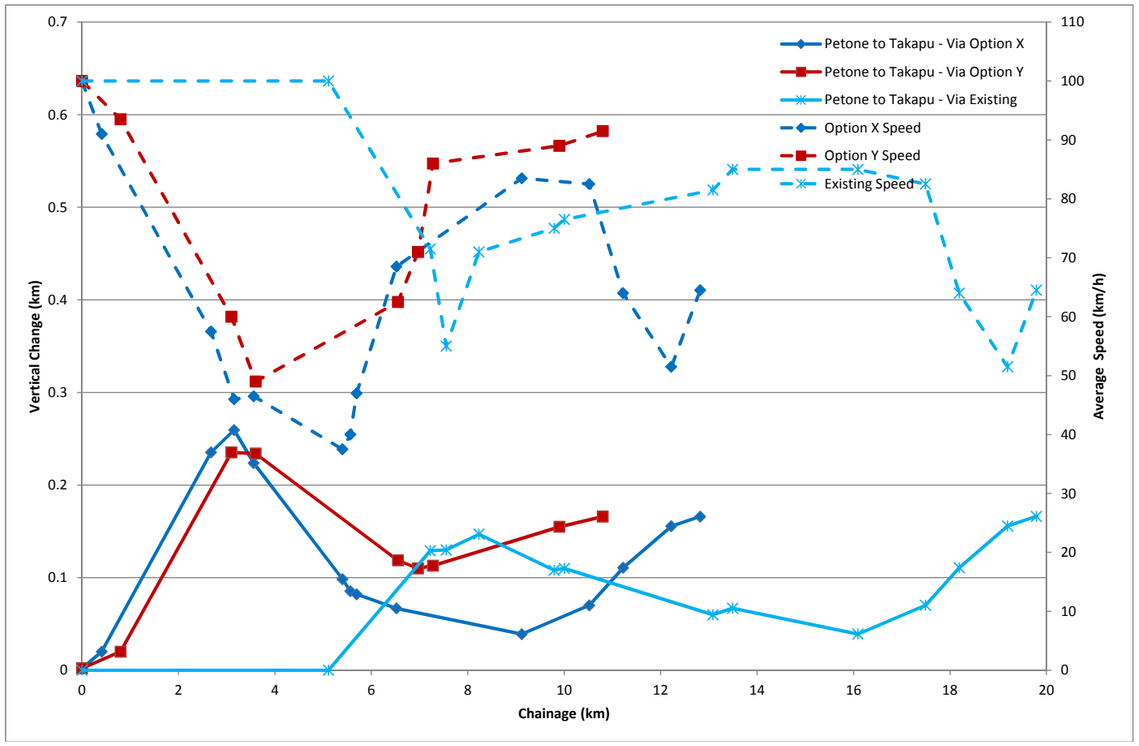


Figure B-3: Austroads Guide to Road Design Part 3 Figure 3-9

B.2.2 Travel Costs

The speeds and section lengths were used to generate travel time and vehicle operating costs (VOC) for the three routes in accordance with the NZTA Economic Evaluation Manual (EEM). The evaluation has been based on the following assumptions:

- HCV demands as summarised in Section B.1.2 have been fixed for all options;
- As outlined in Section B.1.3, HCV speeds have been assumed to apply for both up and downgrades, and hence northbound costs have been assumed to apply in the southbound direction;
- NZTA Rural Strategic road classifications apply; and
- NZTA January 2013 update factors apply.

The resulting travel time and VOC results for the three routes are shown in Table B-2. The percent difference between the existing route and the option are shown in brackets.

Table B-2 : Travel Time and VOC Costs (2012$)

Route	Travel Time Cost	Vehicle Operating Cost	Total Cost
Existing	$2,256	$5,701	$7,956
Option X	$1,977 (-12%)	$4,364 (-23%)	$6,342 (-20%)
Option Y	$1,383 (-39%)	$3,506 (-39%)	$4,889 (-39%)

Table B-3 shows that Option X is 12% cheaper than the existing in terms of travel time cost and 23% cheaper in terms of VOC, resulting in an overall 20% saving in costs for HCVs travelling the route. Option Y is 39% cheaper in all measures, which is a significant saving from both the existing and Option X routes. Clearly the results indicate that analysis of costs using the EEM values favours a shorter and steeper route over a longer and shallower route.

The trends shown in Table B-2 are illustrated in Figure B-4.

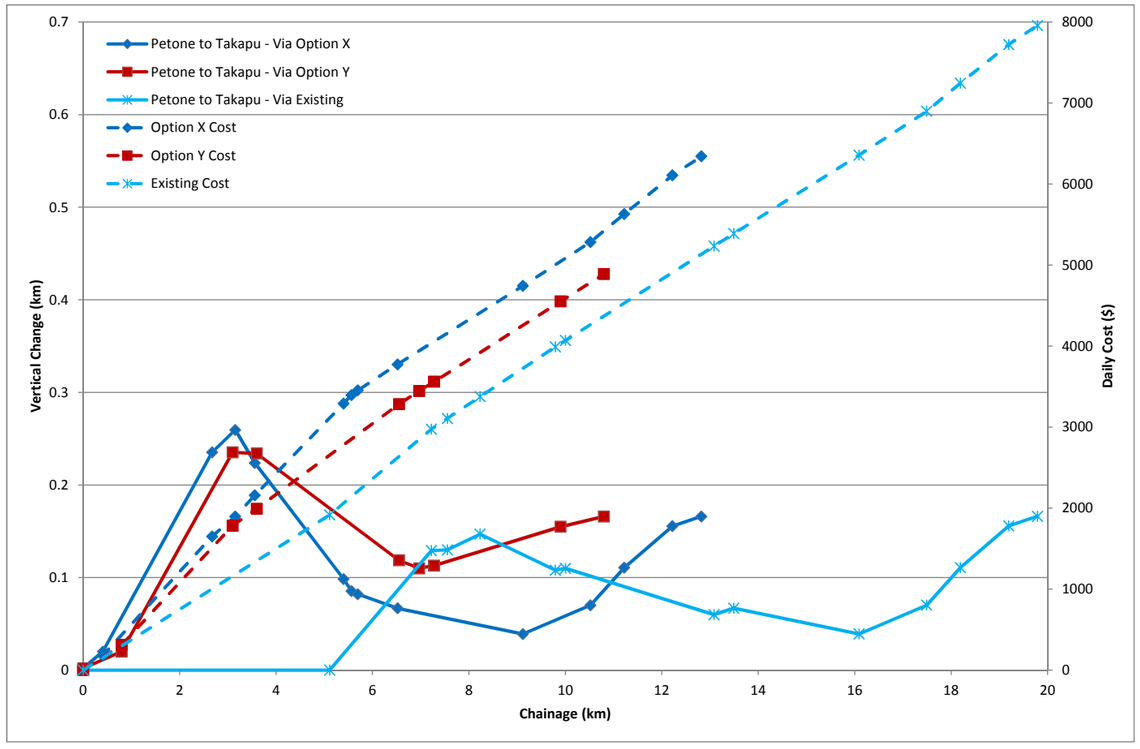


Figure B-4: Distance vs. Total Cost

B.3 Conclusions and Recommendations

The analysis has shown that both route Options X and Y are far shorter and have lower travel times for HCVs than the existing SH1 / SH2 route between Petone and Takapu. This is despite the lower average speeds from sustained high grades in the southern section of the route.

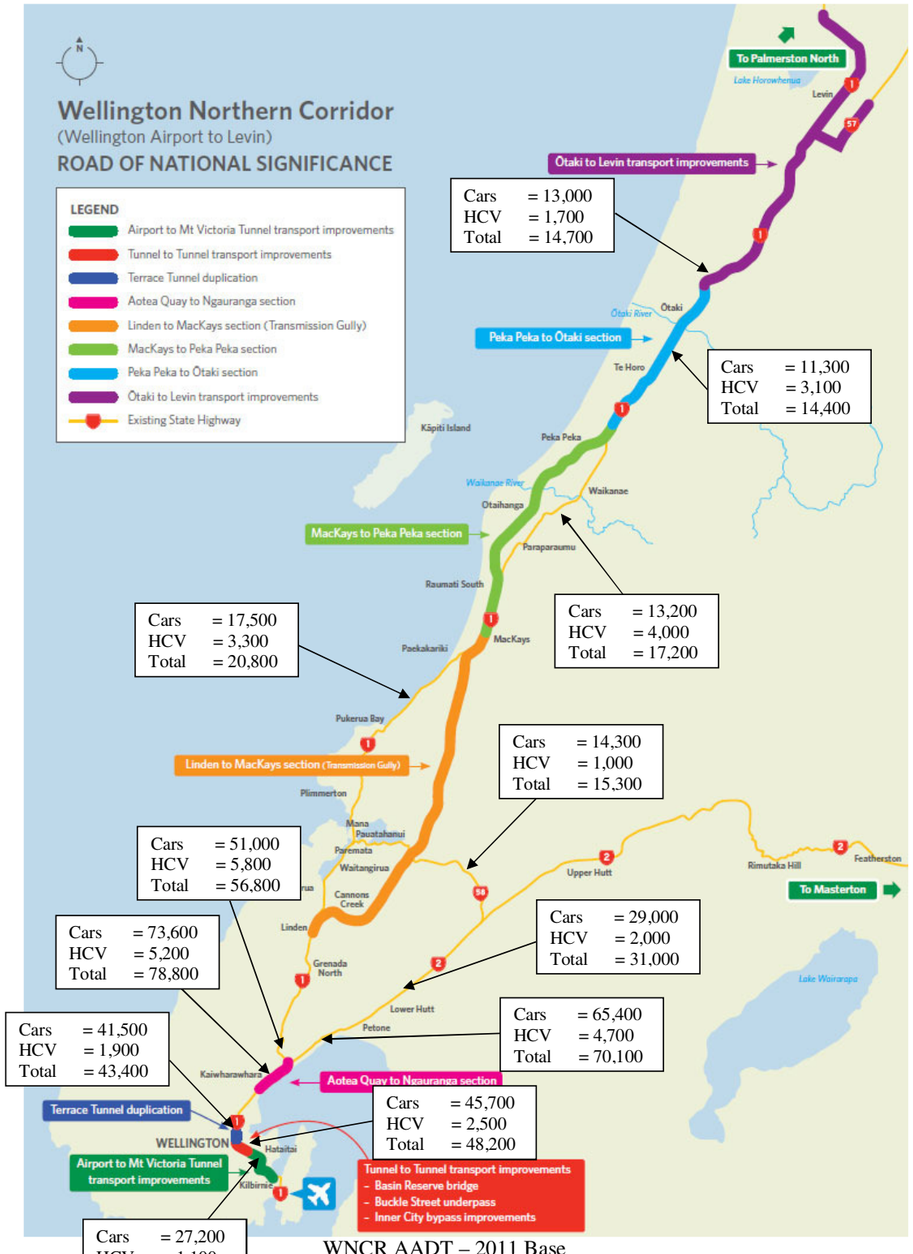
In terms of total cost, Option X is estimated to be around 20% more efficient and Option Y around 40% more efficient for HCVs than the existing route. The results indicate that analysis of HCV travel costs using the EEM values favours a shorter and steeper route over a longer and shallower route.

C

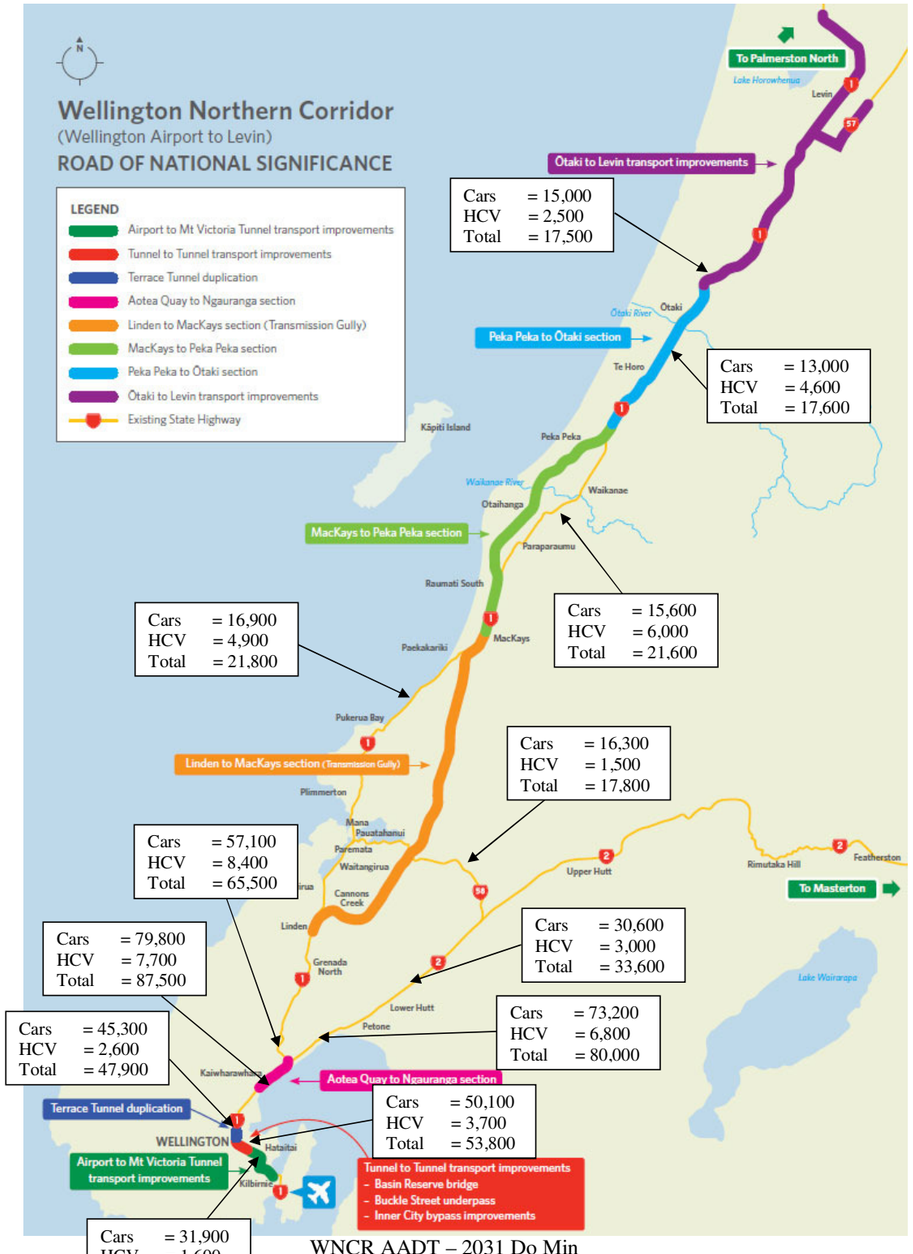
Appendix C
Transportation

C. Transportation

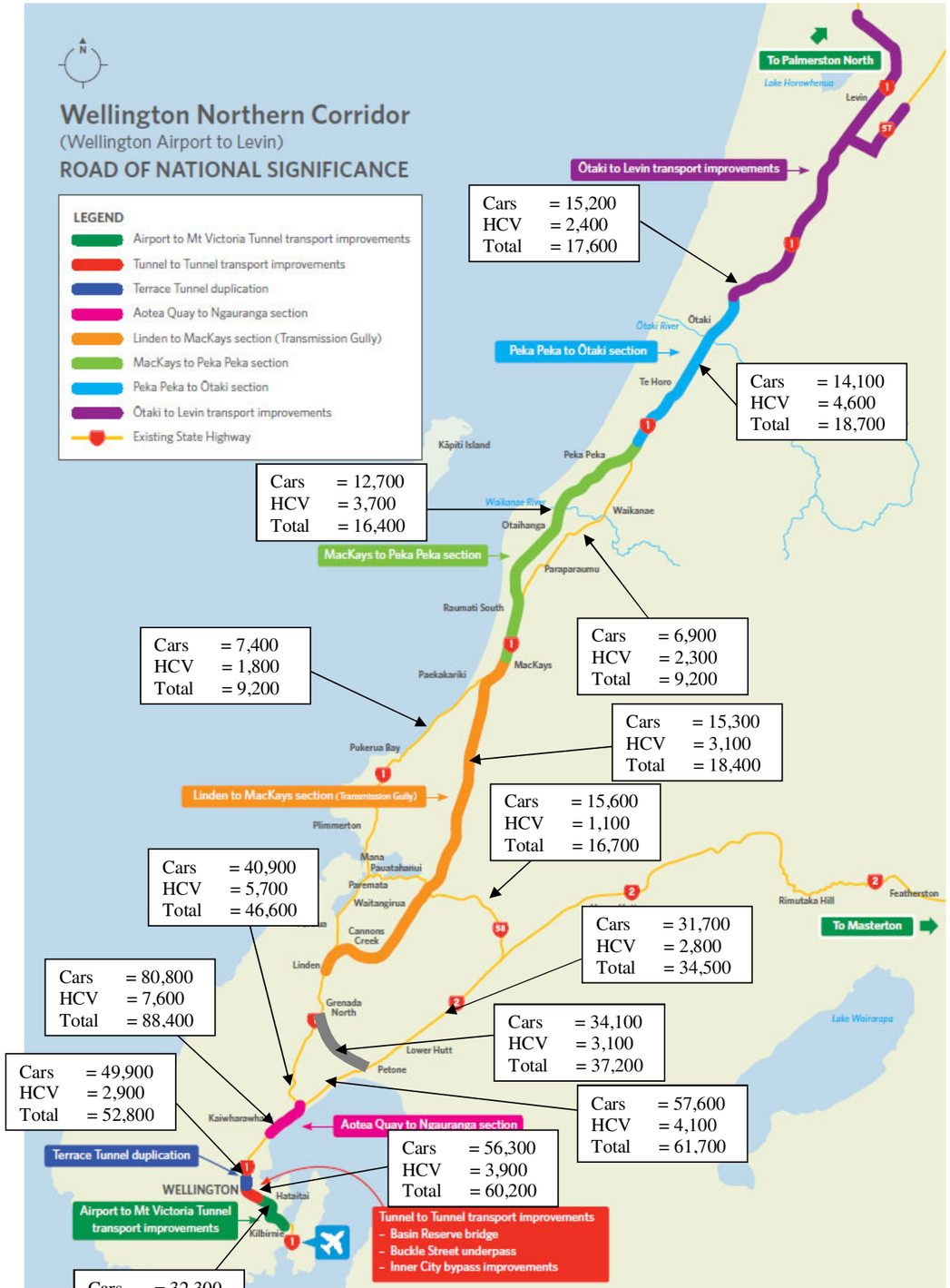
C.1 AADT Volumes



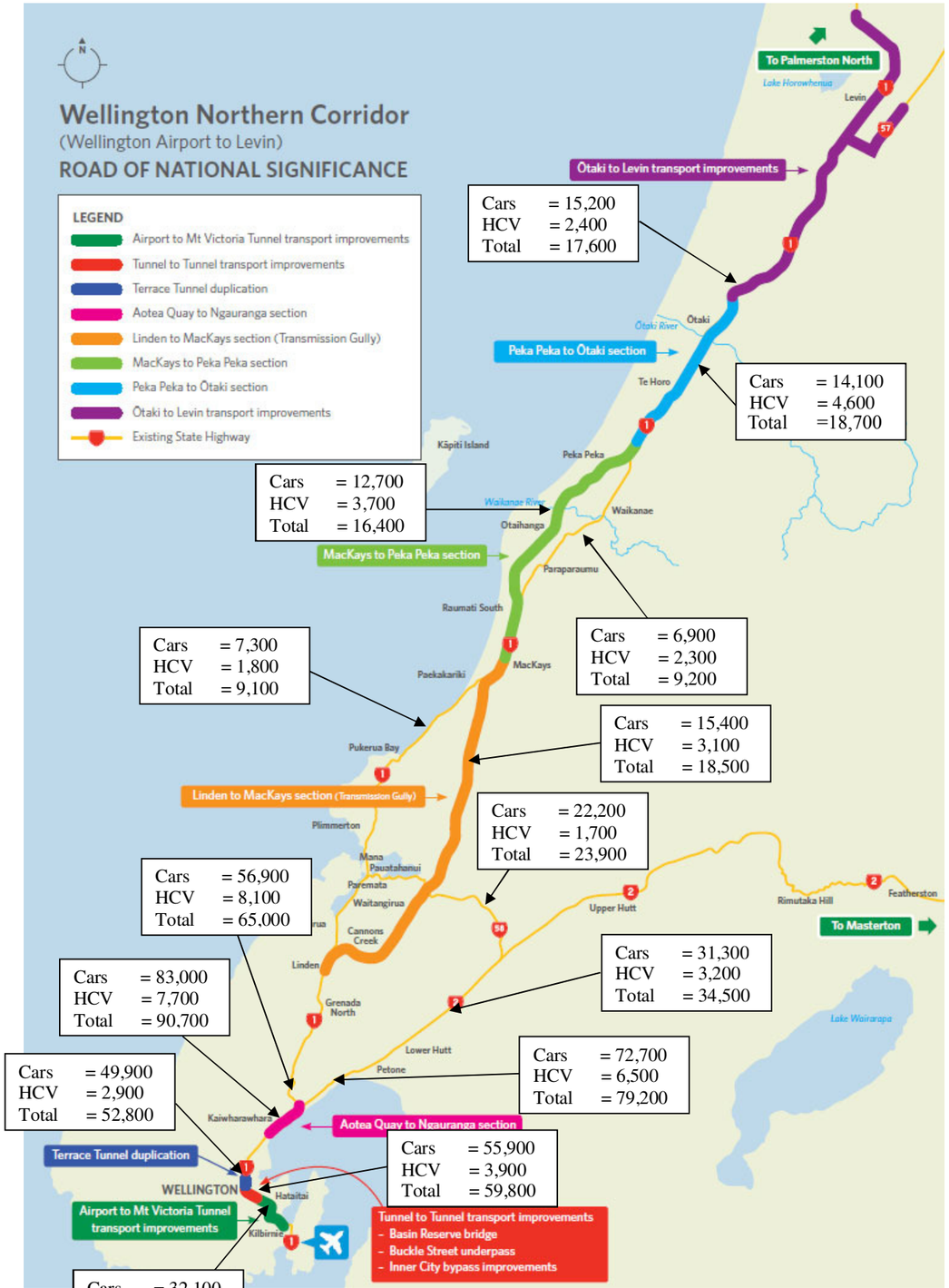
WNCR AADT – 2011 Base



WNCR AADT – 2031 Do Min



WNCR AADT – 2031 RONS with P2G



WNCR AADT – 2031 RONS without P2G

C.2 Sector Analysis AADT Matrices

2031 Do Min Sector analysis (AADT)								
		1-CBD	2-Tawa	3-Porirua	4-Kapiti	5-Seaview	6-Lower Hutt	7-Upper Hutt
Light	1-CBD	441378	20613	10717	2991	4449	20745	4806
	2-Tawa	23648	64163	11228	2135	1036	5927	1490
	3-Porirua	10380	11407	89917	4110	661	5235	2042
	4-Kapiti	2705	2090	3832	128141	330	2064	917
	5-Seaview	5183	1060	677	332	25835	12162	3277
	6-Lower Hutt	19586	5283	4857	2011	11583	168137	11497
	7-Upper Hutt	4213	1415	1997	1045	2677	11616	181934
HCV	1-CBD	33936	2132	471	471	344	1854	269
	2-Tawa	2385	4333	1144	167	159	887	124
	3-Porirua	400	900	8098	617	35	284	26
	4-Kapiti	420	159	639	7581	62	316	97
	5-Seaview	337	148	44	56	1747	1787	139
	6-Lower Hutt	1403	741	283	368	1678	9571	663
	7-Upper Hutt	413	124	37	162	69	569	13263
All	1-CBD	475313	22745	11188	3462	4793	22599	5076
	2-Tawa	26033	68496	12371	2302	1195	6814	1614
	3-Porirua	10781	12307	98015	4728	696	5520	2068
	4-Kapiti	3125	2249	4471	135722	392	2380	1014
	5-Seaview	5521	1208	721	387	27581	13949	3416
	6-Lower Hutt	20989	6023	5140	2379	13261	177709	12160
	7-Upper Hutt	4626	1539	2033	1207	2746	12185	195196

2031 Option Sector Analysis (AADT)								
		1-CBD	2-Tawa	3-Porirua	4-Kapiti	5-Seaview	6-Lower Hutt	7-Upper Hutt
Light	1-CBD	441394	20322	10632	3004	4540	20943	4963
	2-Tawa	23477	62251	10888	2108	1551	8446	1662
	3-Porirua	10278	11060	88305	4088	1312	7156	1992
	4-Kapiti	2717	2060	3804	128158	344	2129	911
	5-Seaview	5287	1567	1302	345	25375	11555	3256
	6-Lower Hutt	19820	7723	6673	2065	10983	164940	11377
	7-Upper Hutt	4379	1559	1921	1032	2659	11536	181847
HCV	1-CBD	33936	2132	471	471	344	1854	269
	2-Tawa	2385	4333	1144	167	159	887	124
	3-Porirua	400	900	8098	617	35	284	26
	4-Kapiti	420	159	639	7581	62	316	97
	5-Seaview	337	148	44	56	1747	1787	139
	6-Lower Hutt	1403	741	283	368	1678	9571	663
	7-Upper Hutt	413	124	37	162	69	569	13263
All	1-CBD	475329	22454	11103	3474	4884	22797	5232
	2-Tawa	25862	66583	12032	2276	1710	9334	1786
	3-Porirua	10679	11960	96404	4705	1347	7441	2018
	4-Kapiti	3137	2218	4443	135739	406	2445	1008
	5-Seaview	5625	1715	1345	400	27122	13342	3395
	6-Lower Hutt	21223	8464	6956	2433	12661	174512	12039
	7-Upper Hutt	4792	1683	1957	1194	2728	12105	195109

C.3 Network Statistics

Option	Do Min			Option A			Option B			Option B1			Option C			Option C1			Option D		
Year	2031			2031			2031			2031			2031			2031			2031		
	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
Network speed (kph)	48.4	62	46.8	53.6	62.3	50.2	52.7	61.6	49.5	50.2	61.6	47.6	52.7	61.9	49.6	50.7	61.8	47.8	52.8	61.8	49.3
Network time (pcu hrs/hr)	11171.6	5589.5	12692.5	10471.7	5645.8	12384.7	10623.3	5700.6	12539.9	11147.1	5708	13038.7	10554.5	5638.6	12425.7	10951.6	5663.2	12858.3	10545.8	5652.1	12476.6
Network delay (pcu hrs/hr)	1418.9	119.3	2084.6	1129.8	102.9	1630.1	1135.9	114	1687	1212.5	117.8	1851.7	1113.5	104.9	1642.9	1186.7	110.7	1741.7	1132.5	104.8	1641.1
Network queue (pcu hrs/hr)	2189.6	483.6	2228	1507.9	481.1	2008.4	1591.1	489.7	2064.4	2041.7	490.8	2370.8	1622.6	484.7	2072.5	1956.2	491.1	2387.8	1573.5	485.4	2106
Network distance (pcu kms/hr)	541087	346683	594073	560830	351538	621660	559521	351114	620166	559222	351421	620169	556126	349297	616126	555416.6	350149.9	615176.2	556628	349084	615643.3
Demand (pcu's)	97235.3	86223.4	112319	97707.5	86276.8	112878	97701.8	86276.8	112878	97735.5	86248.5	112986	97705.1	86276.8	112878	97702.2	86276.8	112878.3	97706	86276.8	112878.3

Options minus Do Min

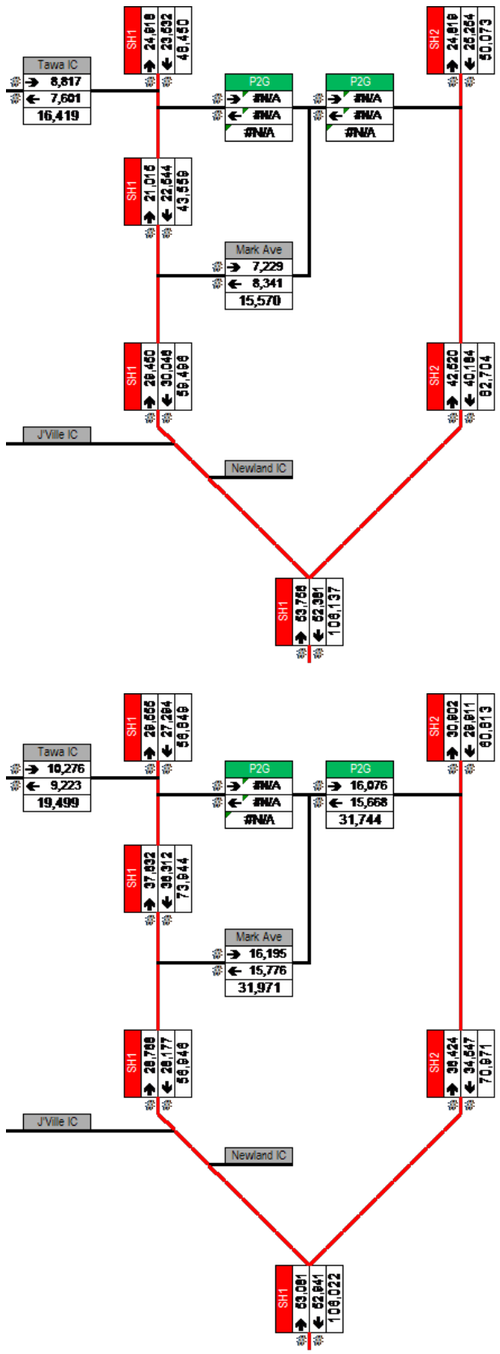
Option				Option A			Option B			Option B1			Option C			Option C1			Option D		
Year				2031			2031			2031			2031			2031			2031		
	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
Network speed (kph)	-	-	-	5.2	0.3	3.4	4.3	-0.4	2.7	1.8	-0.4	0.8	4.3	-0.1	2.8	2.3	-0.2	1	4.4	-0.2	2.5
Network time (pcu hrs/hr)	-	-	-	-699.9	56.3	-307.8	-548.3	111.1	-152.6	-24.5	118.5	346.2	-617.1	49.1	-266.8	-220	73.7	165.8	-625.8	62.6	-215.9
Network delay (pcu hrs/hr)	-	-	-	-289.1	-16.4	-454.5	-283	-5.3	-397.6	-206.4	-1.5	-232.9	-305.4	-14.4	-441.7	-232.2	-8.6	-342.9	-286.4	-14.5	-443.5
Network queue (pcu hrs/hr)	-	-	-	-681.7	-2.5	-219.6	-598.5	6.1	-163.6	-147.9	7.2	142.8	-567	1.1	-155.5	-233.4	7.5	159.8	-616.1	1.8	-122
Network distance (pcu kms/hr)	-	-	-	19742.3	4855.4	27586.5	18433.5	4431.7	26092.8	18134.3	4738.6	26095.8	15038.8	2614.3	22052.9	14329.3	3467.4	21103.1	15540.7	2401.5	21570.2
Demand (pcu's)	-	-	-	472.2	53.4	558.9	466.5	53.4	558.9	500.2	25.1	666.9	469.8	53.4	558.9	466.9	53.4	558.9	470.7	53.4	558.9

Options minus Do Min as %age of Do Min

Option				Option A			Option B			Option B1			Option C			Option C1			Option D		
Year				2031			2031			2031			2031			2031			2031		
	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
Network speed (kph)	-	-	-	11%	0%	7%	9%	-1%	6%	4%	-1%	2%	9%	0%	6%	5%	0%	2%	9%	0%	5%
Network time (pcu hrs/hr)	-	-	-	-6%	1%	-2%	-5%	2%	-1%	0%	2%	3%	-6%	1%	-2%	-2%	1%	1%	-6%	1%	-2%
Network delay (pcu hrs/hr)	-	-	-	-20%	-14%	-22%	-20%	-4%	-19%	-15%	-1%	-11%	-22%	-12%	-21%	-16%	-7%	-16%	-20%	-12%	-21%
Network queue (pcu hrs/hr)	-	-	-	-31%	-1%	-10%	-27%	1%	-7%	-7%	1%	6%	-26%	0%	-7%	-11%	2%	7%	-28%	0%	-5%
Network distance (pcu kms/hr)	-	-	-	4%	1%	5%	3%	1%	4%	3%	1%	4%	3%	1%	4%	3%	1%	4%	3%	1%	4%
Demand (pcu's)	-	-	-	0.5%	0.1%	0.5%	0.5%	0.1%	0.5%	0.5%	0.0%	0.6%	0.5%	0.1%	0.5%	0.5%	0.1%	0.5%	0.5%	0.1%	0.5%

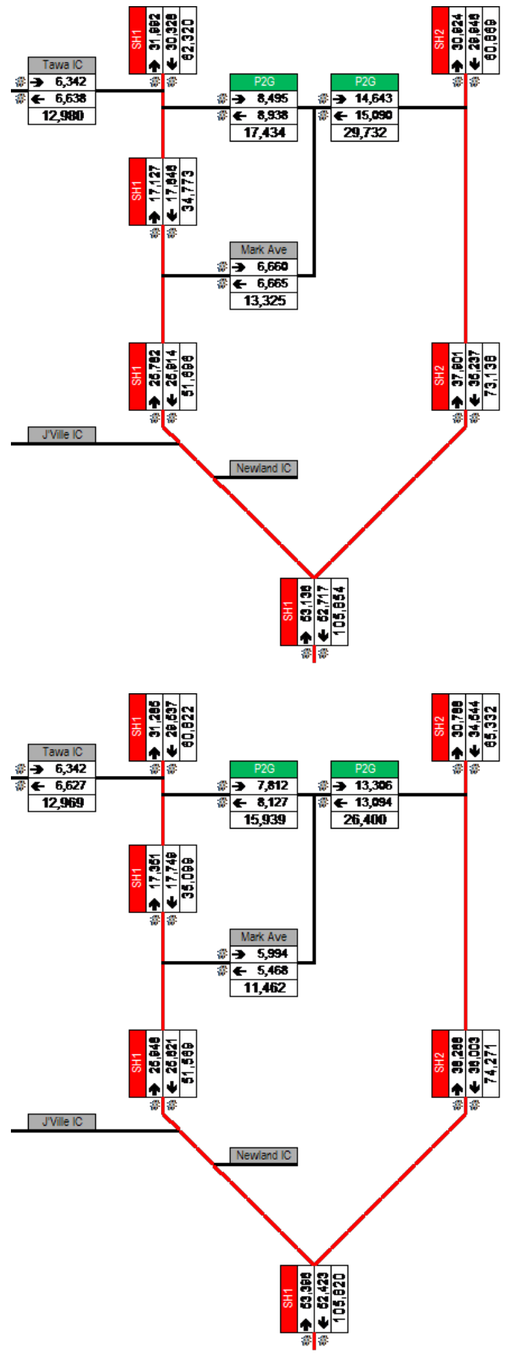
C.4 2031 AADT Flow Diagrams

Do Minimum

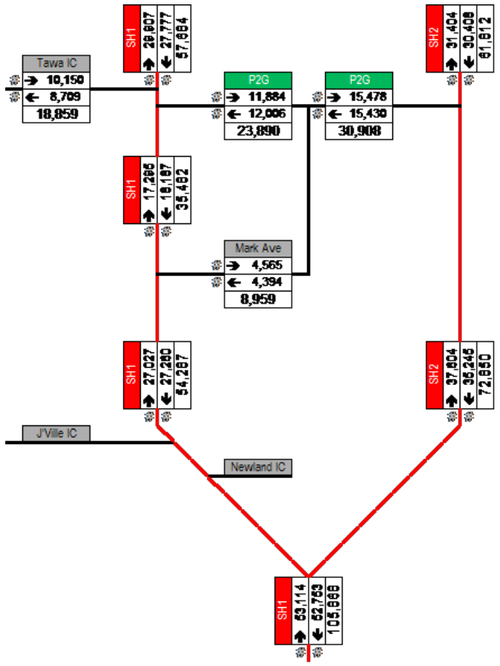


Option A

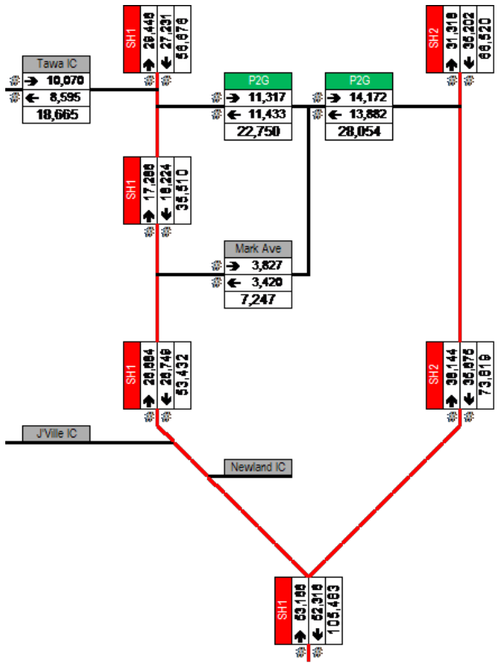
Option B



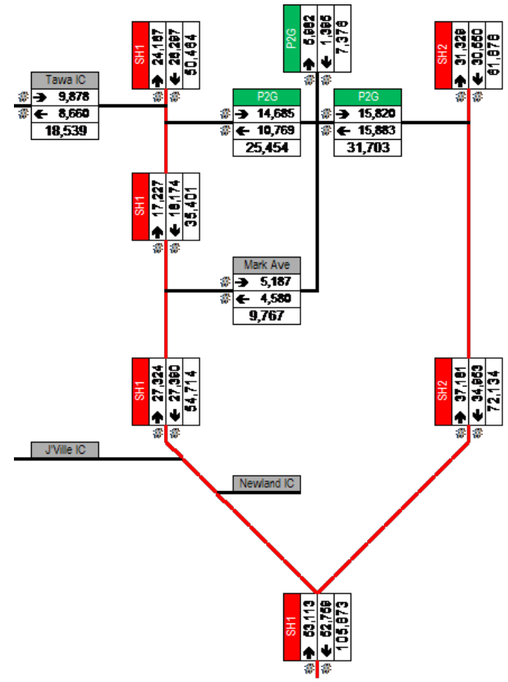
Option B1



Option C



Option C1



Option D

C.5 Travel Time Statistics

Travel time table For P2G Options (time in minutes, distance in km)

		Do Minimum 2031			Option B 2031			Option B1 2031			Option C 2031			Option D 2031			Option A 2031			Option C1 2031		
	Direction	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance
Route 1	Esplanade to SH1 Tawa (via Mark Avenue)	18.9	27.2	14.0	10.5	14.5	9.0	14.2	19.3	10.7	6.2	7.8	6.9	7.0	9.3	7.5	7.4	9.4	8.8	8.8	12.9	8.7
	SH1 Tawa (via Mark Avenue) to Esplanade	23.3	18.6	14.3	15.2	13.7	9.1	21.2	18.2	10.7	8.8	8.2	7.0	9.6	9.9	7.5	10.3	9.4	8.9	16.0	13.5	8.6
Route 2	SH2 south of Petone to SH1 Tawa	18.9	21.7	13.2	10.6	15.0	9.1	17.0	18.6	11.4	6.1	8.2	7.1	7.1	9.2	7.6	7.5	10.0	9.0	10.8	13.5	9.4
	SH1 Tawa to SH1 south of Petone	23.3	17.5	13.4	19.5	13.7	9.4	30.5	29.2	11.4	13.1	8.3	7.2	13.9	9.9	7.8	10.0	9.2	9.2	25.6	32.8	9.3
Route 3	SH2 north of Petone to SH1 Tawa	19.4	24.4	14.2	10.7	14.4	9.2	10.2	13.6	9.1	6.3	7.3	7.1	7.2	8.2	7.6	7.6	9.3	9.0	6.0	7.5	7.1
	SH1 Tawa to SH1 north of Petone	22.9	18.2	14.4	15.1	14.1	9.2	15.1	13.8	9.1	8.7	8.8	7.0	9.5	10.4	7.6	10.2	9.9	9.0	9.5	8.6	7.0
Route 4	SH2 north of Petone to SH1 south of Ngauranga	13.0	7.8	5.9	9.9	4.7	5.9	9.4	4.9	5.9	9.8	4.7	5.9	9.7	4.6	5.9	9.1	4.6	5.9	8.2	4.8	5.9
	SH1 south of Ngauranga to SH2 north of Petone	8.2	14.2	8.2	5.8	12.1	8.2	6.2	13.6	8.2	5.7	11.7	8.2	5.7	11.7	8.2	5.6	11.1	8.2	6.0	12.4	8.2
Route 5	SH2 north of Petone to Westchester Drive east	17.2	20.3	11.4	6.9	7.8	6.1	6.4	7.2	6.1	6.5	7.2	6.1	6.3	7.1	6.0	5.4	6.2	6.3	6.1	7.3	6.1
	Westchester Drive east to SH2 north of Petone	19.3	15.8	11.4	9.9	9.2	6.1	9.9	9.0	6.1	8.9	8.8	6.1	8.7	8.7	6.0	7.4	7.4	6.1	9.6	8.6	6.1
Route 6	SH2 south of Petone to TG / P2G north of P2G	13.5	24.3	17.5	7.8	9.8	11.4	10.8	11.9	13.6	8.1	10.2	11.4	8.0	9.8	10.6	9.2	11.7	13.3	12.6	15.4	13.7
	TG / P2G north of P2G to SH2 south of Petone	24.1	19.0	17.2	14.3	9.3	11.3	25.7	25.0	13.3	14.5	9.5	11.3	14.3	9.5	10.5	15.2	10.5	13.0	27.0	34.1	13.3
Route 7	SH1 TG to Ngauranga	14.4	7.2	12.0	10.4	7.1	12.0	10.6	7.1	12.0	11.2	7.2	12.0	11.5	7.2	12.0	11.0	7.2	12.0	11.4	7.2	12.0
	Ngauranga to TG	8.5	18.9	14.2	8.4	13.8	14.2	8.4	14.0	14.2	8.5	14.8	14.2	8.5	15.1	14.2	8.5	14.1	14.2	8.5	14.9	14.2
Route 8	Seaview to SH2 south of P2G interchange via Esplanade	14.3	10.2	4.6	11.8	7.9	4.7	15.1	7.8	4.6	11.8	8.2	4.7	11.7	8.5	4.7	11.0	7.8	4.7	13.7	7.7	4.6
	SH2 south of P2G interchange to Seaview via Esplanade	7.0	7.8	4.7	8.2	10.0	4.8	8.9	9.2	4.7	8.2	10.3	4.7	8.1	10.2	4.7	8.1	10.2	4.7	8.6	9.2	4.7

Difference between Options & Do Minimum (time in minutes, distance in km)

		Do Minimum 2031			Option B 2031			Option B1 2031			Option C 2031			Option D 2031			Option A 2031			Option C1 2031		
	Direction	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance
Route 1	Esplanade to SH1 Tawa (via Mark Avenue)	-	-	-	-8.4	-12.8	-5.1	-4.7	-7.9	-3.3	-12.7	-19.4	-7.1	-11.9	-18.0	-6.6	-11.5	-17.8	-5.2	-10.2	-14.3	-5.4
	SH1 Tawa (via Mark Avenue) to Esplanade	-	-	-	-8.1	-4.9	-5.2	-2.1	-0.3	-3.6	-14.6	-10.3	-7.4	-13.7	-8.7	-6.8	-13.0	-9.2	-5.4	-7.3	-5.1	-5.7
Route 2	SH2 south of Petone to SH1 Tawa	-	-	-	-8.4	-6.8	-4.1	-1.9	-3.2	-1.8	-12.8	-13.6	-6.1	-11.9	-12.6	-5.6	-11.5	-11.7	-4.2	-8.2	-8.3	-3.8
	SH1 Tawa to SH1 south of Petone	-	-	-	-3.8	-3.7	-4.0	7.2	11.8	-2.0	-10.2	-9.2	-6.2	-9.4	-7.6	-5.6	-13.3	-8.3	-4.2	2.3	15.4	-4.1
Route 3	SH2 north of Petone to SH1 Tawa	-	-	-	-8.7	-10.0	-5.0	-9.2	-10.8	-5.1	-13.0	-17.1	-7.1	-12.2	-16.2	-6.6	-11.8	-15.1	-5.2	-13.4	-16.9	-7.1
	SH1 Tawa to SH1 north of Petone	-	-	-	-7.8	-4.1	-5.2	-7.8	-4.4	-5.2	-14.2	-9.4	-7.4	-13.3	-7.8	-6.8	-12.7	-8.3	-5.4	-13.3	-9.6	-7.4
Route 4	SH2 north of Petone to SH1 south of Ngauranga	-	-	-	-3.1	-3.1	0.0	-3.6	-2.9	0.0	-3.2	-3.2	0.0	-3.3	-3.2	0.0	-3.9	-3.3	0.0	-4.8	-3.0	0.0
	SH1 south of Ngauranga to SH2 north of Petone	-	-	-	-2.4	-2.1	0.0	-2.1	-0.6	0.0	-2.5	-2.4	0.0	-2.5	-2.5	0.0	-2.6	-3.0	0.0	-2.2	-1.7	0.0
Route 5	SH2 north of Petone to Westchester Drive east	-	-	-	-10.3	-12.5	-5.3	-10.8	-13.1	-5.3	-10.7	-13.1	-5.3	-10.9	-13.2	-5.4	-11.9	-14.1	-5.1	-11.1	-13.0	-5.3
	Westchester Drive east to SH2 north of Petone	-	-	-	-9.4	-6.5	-5.3	-9.4	-6.8	-5.3	-10.5	-7.0	-5.3	-10.6	-7.0	-5.4	-11.9	-8.4	-5.3	-9.8	-7.2	-5.3
Route 6	SH2 south of Petone to TG / P2G north of P2G	-	-	-	-5.7	-14.5	-6.2	-2.7	-12.4	-3.9	-5.4	-14.1	-6.1	-5.5	-14.5	-7.0	-4.3	-12.7	-4.2	-0.8	-8.9	-3.9
	TG / P2G north of P2G to SH2 south of Petone	-	-	-	-9.8	-9.7	-5.9	1.6	6.0	-3.9	-9.5	-9.5	-6.0	-9.8	-9.5	-6.7	-8.9	-8.5	-4.2	2.9	15.1	-3.9
Route 7	SH1 TG to Ngauranga	-	-	-	-4.0	-0.1	0.0	-3.9	-0.1	0.0	-3.2	-0.1	0.0	-2.9	0.0	0.0	-3.4	-0.1	0.0	-3.1	-0.1	0.0
	Ngauranga to TG	-	-	-	-0.1	-5.1	0.0	-0.1	-4.9	0.0	0.0	-4.1	0.0	0.0	-3.7	0.0	0.0	-4.7	0.0	0.0	-4.0	0.0
Route 8	Seaview to SH2 south of P2G interchange via Esplanade				-2.5	-2.3	0.0	0.7	-2.3	0.0	-2.6	-2.0	0.0	-2.6	-1.6	0.0	-3.3	-2.4	0.0	-0.7	-2.5	0.0
	SH2 south of P2G interchange to Seaview via Esplanade				1.2	2.3	0.1	1.9	1.4	0.0	1.1	2.5	0.0	1.1	2.4	0.0	1.0	2.4	0.0	1.6	1.4	0.0

Difference between Options & Do Minimum as percentage of Do Minimum

		Do Minimum 2031			Option B 2031			Option B1 2031			Option C 2031			Option D 2031			Option A 2031			Option C1 2031		
	Direction	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance	AM	PM	Distance
Route 1	Esplanade to SH1 Tawa (via Mark Avenue)	-	-	-	-44.3%	-46.8%	-36.0%	-24.9%	-29.0%	-23.7%	-67.3%	-71.3%	-50.5%	-62.8%	-66.0%	-46.9%	-60.8%	-65.5%	-37.1%	-53.7%	-52.6%	-38.2%
	SH1 Tawa (via Mark Avenue) to Esplanade	-	-	-	-34.9%	-26.2%	-36.6%	-8.9%	-1.8%	-24.9%	-62.5%	-55.6%	-51.4%	-58.6%	-46.9%	-47.5%	-55.9%	-49.4%	-37.6%	-31.4%	-27.3%	-39.7%
Route 2	SH2 south of Petone to SH1 Tawa	-	-	-	-44.1%	-31.1%	-30.7%	-10.3%	-14.6%	-13.6%	-67.7%	-62.5%	-46.2%	-62.6%	-57.8%	-42.3%	-60.6%	-53.9%	-31.9%	-43.1%	-38.0%	-29.1%
	SH1 Tawa to SH1 south of Petone	-	-	-	-16.2%	-21.4%	-30.2%	30.9%	67.4%	-15.1%	-43.8%	-52.7%	-46.0%	-40.4%	-43.4%	-41.9%	-57.0%	-47.4%	-31.3%	9.7%	88.0%	-30.9%
Route 3	SH2 north of Petone to SH1 Tawa	-	-	-	-44.9%	-41.1%	-35.4%	-47.3%	-44.4%	-35.8%	-67.3%	-70.0%	-49.8%	-62.9%	-66.4%	-46.2%	-60.9%	-61.9%	-36.5%	-69.1%	-69.3%	-50.2%
	SH1 Tawa to SH1 north of Petone	-	-	-	-34.1%	-22.4%	-36.3%	-33.9%	-24.2%	-36.5%	-62.1%	-51.8%	-51.1%	-58.2%	-42.9%	-47.2%	-55.6%	-45.8%	-37.4%	-58.3%	-52.6%	-51.2%
Route 4	SH2 north of Petone to SH1 south of Ngauranga	-	-	-	-24.1%	-40.0%	-0.1%	-27.8%	-37.0%	0.0%	-24.5%	-40.4%	-0.1%	-25.4%	-41.3%	-0.1%	-30.3%	-41.9%	-0.1%	-36.6%	-38.2%	0.0%
	SH1 south of Ngauranga to SH2 north of Petone	-	-	-	-29.4%	-14.8%	-0.1%	-25.0%	-3.9%	0.0%	-30.3%	-17.1%	-0.1%	-30.3%	-17.7%	-0.1%	-31.5%	-21.5%	-0.1%	-26.6%	-12.4%	0.0%
Route 5	SH2 north of Petone to Westchester Drive east	-	-	-	-59.9%	-61.6%	-46.3%	-62.6%	-64.5%	-46.7%	-62.2%	-64.5%	-46.2%	-63.2%	-65.2%	-47.6%	-68.9%	-69.6%	-45.0%	-64.6%	-64.0%	-46.7%
	Westchester Drive east to SH2 north of Petone	-	-	-	-48.7%	-41.5%	-46.2%	-48.6%	-43.1%	-46.4%	-54.2%	-44.2%	-46.2%	-55.0%	-44.6%	-47.6%	-61.6%	-53.2%	-46.5%	-50.5%	-45.7%	-46.4%
Route 6	SH2 south of Petone to TG / P2G north of P2G	-	-	-	-42.4%	-59.8%	-35.2%	-19.7%	-51.1%	-22.2%	-40.1%	-58.1%	-34.9%	-40.5%	-59.8%	-39.7%	-31.9%	-52.0%	-24.1%	-6.2%	-36.8%	-22.0%
	TG / P2G north of P2G to SH2 south of Petone	-	-	-	-40.6%	-51.2%	-34.5%	6.7%	31.8%	-22.7%	-39.6%	-50.0%	-34.5%	-40.7%	-49.9%	-39.1%	-36.9%	-44.8%	-24.4%	12.2%	79.4%	-22.8%
Route 7	SH1 TG to Ngauranga	-	-	-	-27.6%	-1.4%	-0.2%	-26.8%	-1.5%	-0.2%	-22.4%	-0.7%	0.0%	-20.3%	-0.5%	0.0%	-23.8%	-0.8%	0.0%	-21.3%	-0.8%	0.0%
	Ngauranga to TG	-	-	-	-0.9%	-27.1%	-0.2%	-0.9%	-25.7%	-0.2%	-0.4%	-21.9%	0.0%	-0.2%	-19.8%	0.0%	-0.3%	-25.1%	0.0%	-0.4%	-21.1%	0.0%

D

Appendix D
Cost Estimate Development

D. Cost Estimate Development

D.1 Basis of Estimate

The project is currently considering four options identified as A to D with variance at the southern end which includes four sub-options P1 to P4.

The rough order cost estimates (ROC) have been developed on a parameter cost basis to provide an 'Optimistic', 'Most Likely', and 'Pessimistic' cost for the purpose of comparing project options. The estimates have been based on preliminary designs, limited site information and general information about the scope of work and type of construction. The design and estimate will be updated at the Scheme Assessment stage, once a preferred option has been selected.

The 'Optimistic' estimate has been assessed at 70% of the 'Most Likely' estimate while the 'Pessimistic' estimate has been assessed at 150% of the 'Most Likely' estimate. As a result the ROC is represented as a range of cost between -30% and +50% of the 'Most Likely' estimate.

The estimates have been prepared to the cost index as at May 2013.

The estimates make no allowance for future escalation or GST.

The estimates have not been peer reviewed by an external consultant.

D.2 Assumptions for Estimates

This section clarifies the assumptions made for the ROC estimates of all options.

Property

Property estimates have been developed to provide a net property cost for each option and only includes the corridor required for each option. The corridor for each property typically includes the footprint area with a minimal offset of between 3m to 5m.

The range of property costs adopted is shown in Table D-1.

Table D-1: Property Cost Range

Property Type	Cost / ha ($M)
High value	2.5
Medium High value	1.15
Medium value	0.7
Medium Low value	0.2
Low value	0.05

The property types were selected to reflect the range of property values throughout the project area. 'High value' represents the commercial area at Petone in the vicinity of the proposed interchange while 'Medium High value' represents high density residential/commercial areas adjacent to the SH1 corridor between Grenada and Kenepuru. On the medium to lower spectrum 'Medium value' to 'Low value' represents semi-rural to rural areas between the SH1 and SH2 corridors.

The cost per hectare values shown in Table D-1 were derived from NZTA State Highway Valuation as at 30 June 2013. This valuation includes cost/ha values of state highway corridor land valued at the fair value or market value of the adjacent land through which it passes. Professional judgement was applied to define the areas of the existing state highway network which were deemed to be comparable with the various types of land comprising each option.

Professional Fees and Client Managed Costs

15% of the physical works costs has been allowed for Consultant and NZTA fees for the I&R, D&PD and MSQA phases of this project.

Physical Works

Parameter costs have been developed for the physical works, on a cost per kilometre basis. These costs have been derived from various other projects throughout the country. Different rates were used for low, medium and high earthwork quantities. The parameter costs include:

i. Environmental compliance;
ii. Earthworks;
iii. Drainage;
iv. Pavements and surfacing;
v. Traffic services;
vi. Service relocations;
vii. Traffic management and temporary works; and
viii. Preliminary and general.

Three parameter costs were adopted for each type of carriageway section as shown in Table D-2.

Table D-2: Costs of Physical Works

Description	Cost / km ($M)
2 lane carriageway	
Low earthworks	4.0
Medium earthworks	5.0
High earthworks	6.0
4 lane carriageway	

Low earthworks	6.0
Medium earthworks	8.0
High earthworks	10.0
6 lane carriageway	
Low earthworks	8.0
Medium earthworks	10.0
High earthworks	25.0
Very high earthworks	30.0

In addition to green field development, Options A, B and C require upgrading SH1 between the connection of each option to SH1 and the intersection of SH1 with Transmission Gully. Separate parameter costs were developed for the various types of upgrade to SH1 as shown in Table D-3.

Table D-3: Costs to Upgrade SH1

Description	Cost / km ($M)
Upgrade SH1	
4 lanes to 6 lanes	8.0
Realign SH1 with New Sections of Carriageway	
New 6 lanes	20.0
New 4 lanes	15.0

The physical works costs also include structures such as interchanges and bridges.

Various interchange types are expected for each option ranging from full grade-separated interchanges to at-grade roundabouts. The various types of interchanges and corresponding lump sum cost developed for this project are summarised in Table D-4.

Table D-4: Costs of Interchanges

Interchange Type	Cost ($M)
Grade-separated simple	12.5
Grade-separated moderate	15.0
Grade-separated complex	20.0
At-grade complex	6.0
At-grade simple	2.0

While interchange costs were developed on a lump sum basis, bridge structure costs were based on a cost 0f $3,500 per square metre ($.035M/m2).

D.3 Option Specific Assumptions

D.3.1 Option A

Option A includes the following assumptions:

i. Full grade-separated interchange at Petone with a direct link to The Esplanade and Hutt Road;

ii. New 2 lane circulating roundabout at Mark Avenue to provide access to the Lincolnshire Farm development;

iii. Upgrading the Grenada Interchange at SH1;

iv. Upgrading Grenada Drive between Mark Avenue and SH1 from 1 lane in each direction to 2 lanes in each direction; and

v. Upgrading and providing new realigned sections of SH1 to provide 6 lanes between Grenada and Transmission Gully.

D.3.2 Option B

Option B includes the following assumptions:

i. Full grade-separated interchange at Petone with a direct link to The Esplanade and Hutt Road;

ii. New north facing ramps to SH1 at Tawa;

iii. New grade-separated interchange at northwest section of Lincolnshire Farm, to provide links to Lincolnshire Farm and SH1 at Grenada; and

iv. Upgrading and providing new realigned sections of SH1 to provide 6 lanes between Tawa and Transmission Gully.

D.3.3 Option C

Option C includes the following assumptions:

i. Full grade-separated interchange at Petone with a direct link to The Esplanade and Hutt Road;

ii. Modified interchange on SH1 at Tawa;

iii. New grade-separated interchange at northwest section of Lincolnshire Farm, to provide links to Lincolnshire Farm and SH1 at Grenada; and

iv. Upgrading and providing new realigned sections of SH1 to provide 6 lanes between Tawa and Transmission Gully.

D.3.4 Option D

Option D includes the following assumptions:

i. Full grade-separated interchange at Petone with a direct link to The Esplanade and Hutt Road;

ii. New grade-separated interchange, at northwest section of Lincolnshire Farm, to provide links to Lincolnshire Farm and SH1 at Grenada;

iii. New grade-separated interchange to the east of Tawa, to provide links to Tawa and SH1;

iv. Modifications to the existing interchange at Tawa; and

v. North facing ramps at Transmission Gully.

D.4 Risk Contingency

The ‘general’ approach has been used to calculate the risk contingency and funding risk.

D.5 Option Estimates

ROCs of Options A to D combined with sub-options P1, P2, P3 and P4 have been calculated and are summarised in Table D-5 and Figure D-1.

Table D-5: Option Rough Order Cost Estimates

Option	ROC ($M)		
	Optimistic	Most Likely	Pessimistic
A(P1)	161	230	345
B(P1)	165	236	354
C(P1)	154	220	330
D(P1)	151	216	324
A(P2)	175	250	375
B(P2)	179	256	384
C(P2)	168	240	360
D(P2)	165	236	354
A(P3)	175	250	375
B(P3)	179	256	384
C(P3)	168	240	360
D(P3)	165	236	254
A(P4)	185	264	396
B(P4)	189	270	405
C(P4)	178	254	381
D(P4)	175	250	375

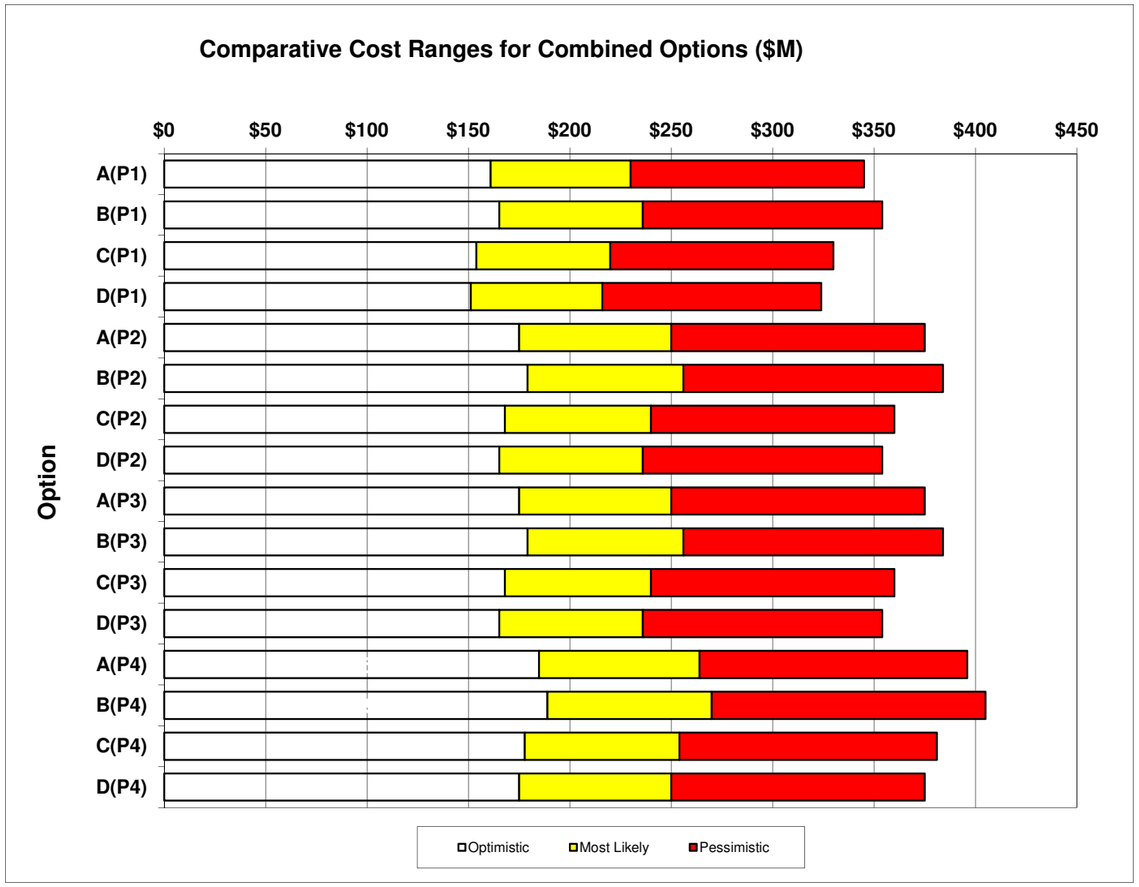


Figure D-1: Comparative Cost Ranges for Combined Options ($M)

D.6 Comparison to PFR Estimate

As part of the Ngauranga Triangle Strategy Study – Petone to Grenada Link Road Project Feasibility Report a Feasibility Estimate (FE) was produced for the preferred option of this study. The Expected Estimate of the preferred option, identified as the 'PFR' option, was approximately $250M (as at September 2009). When escalated to the June 2013 cost index this figure becomes $275M.

Option B, presented in this report, is based on the PFR option. The ROC for Option B ranges between a lower bound cost estimate of $161M (with P1 as a sub-option) to $405M as an upper bound estimate (with P4 as a sub-option). The PFR option is within this range but did not include upgrading SH1 between Tawa and Transmission Gully.

E

Appendix E
Preliminary Economic Assessment of Options

E. Preliminary Economic Assessment of Options

This memorandum summarises the scoping level economic evaluation of the route options for the Petone to Grenada (P2G) project, in accordance with the NZTA Economic Evaluation Manual (EEM) procedures.

E.1 Basis of the Evaluation

E.1.1 Route Options

The existing network and four options were assessed:

- **Option A:** Petone Interchange (SH2) to Grenada Interchange (SH1);
- **Option B:** PFR route from Petone Interchange (SH2) to north facing ramps at SH1 south of Tawa Interchange;
- **Option C:** Petone Interchange (SH2) to Tawa Interchange (SH1); and
- **Option D:** Petone Interchange (SH2) to Transmission Gully at Takapu (future SH1). Connection to Tawa Interchange (SH1).

Four variations have been prepared for 'Section 1', being the southern section of the alignment from Petone to the top of the grade. These are referred to as P1, P2, P3 and P4. The transportation modelling has only been completed for the P2 variant, as the difference in benefits between the variants is believed to be small, and therefore was not considered to be material to the economic evaluation.

Variations were also tested for Options B and C (B1 and C1), with only north facing ramp connections at Petone.

E.1.2 Transportation Modelling

The Do Minimum (existing) and options were modelled using the Northern Wellington SATURN model (NWSM) by SKM. Models were developed for the AM, inter and PM peaks for the forecast years of 2021 and 2031.

The transportation modelling forms the basis of benefits for the economic evaluation.

E.2 Economic Evaluation

E.2.1 Assumptions

General assumptions for the economic evaluation of the scheme are as follows:

- The Base Date for the evaluation is 1 July 2013;
- Time Zero is 1 July 2013;
- The evaluation period is 40 years;
- Construction has been assumed to commence on 1 January 2020 for the duration of four years. Therefore a 36 year benefit period from years 11 to 46 has been assessed;
- Project benefits start at the end of construction;
- Benefits have been straight line extrapolated between the model years of 2021 and 2031;
- The base assumption for the discount rate is 6%; and
- All update factors, base value travel times, congestion relief values, vehicle operating costs etc. are based on NZTA's EEM Volume 1 (January 2013 Update).

E.2.2 Annualisation Factors

Vehicular benefits have been based on the extrapolation of the AM, inter and PM peaks NWSM outputs, using the following annualisation factors:

- AM Peak: 245 days, at 2 hour per day (0700-0900);
- Inter Peak: 245 days, at 7 hours per day (0900-1600);
- PM Peak: 245 days, at 2 hours per day (1400-1800);
- Off Peak: 245 days, at 13 hours per day (1800-0700) at 0.329 x inter peak volumes;
- Weekends and Public Holidays Peak: 120 days, at 7 hours per day (1100-1800) at 1.077 x inter peak volumes; and
- Weekends and Public Holidays Off Peak: 120 days, at 17 hours per day (1800-1100), at 0.315 x inter peak volumes.

These annualisation factors were obtained by analysis of 2011 count data on SH1 near Tawa College (TMS Reference Site Number 01N01058) and on SH2 north of Block Road (00200969).

E.2.3 Costs

Construction Costs

Table E-1 summarises the 'most likely' cost estimates for the four main P2G Options (P2 variant), both undiscounted and discounted present value (PV) costs.

Table E-1: Summary of Costs ($M) P2 Variant

Cost	*Option A*	*Option B*	*Option C*	*Option D*
Undiscounted Cost	250	256	240	236
PV Costs	**158.9**	**162.1**	**154.0**	**150.4**

Table E-1 shows that Option D is the least cost option with a PV of $150M, followed by Option C, Option A and Option B.

Variants P2, P3 and P4 have similar construction costs; however P1 is $20M cheaper than P2. Therefore the evaluation will be conservative if variant P1 is adopted.

Maintenance Costs

Maintenance costs have been omitted at this scoping level, as these are likely to be similar for all options and therefore not material to the economic evaluation.

E.2.4 Benefits

This section outlines the tangible benefits of the Options, based on the NZTA's EEM Volumes 1 and 2. All base value travel times, congestion relief values, vehicle operating costs and update factors etc. have been based on the January 2013 Update of the EEM.

The benefits summarised in this section are stated as a comparison of the Options and the 'Do Minimum' scenario using a variable trip matrix methodology.

Only travel time and vehicle operating cost (VOC) benefits have been calculated from NWSM modelling outputs, based on 'Urban Arterial' costs. Vehicle emissions (CO2) reductions have been estimated at 4% of VOC benefits. These benefits make up the majority of total benefits of the scheme, and therefore are appropriate for objective decision making on route selection in the scoping stage. Section E.3 discusses possible benefits that may be investigated in the Scheme Assessment Report (SAR), once the preferred route is known.

The PV benefits of the options are summarised in Table E-2.

Table E-2 : Summary of PV Benefits ($M) P2 Variant

Benefit	Option A	Option B	Option C	Option D
Travel Time	299.8	224.4	289.7	277.6
VOC	35.1	34.4	41.0	43.4
CO2	1.4	1.4	1.6	1.7
PV Benefits	**336.3**	**260.1**	**332.3**	**322.7**

Table E-2 shows that Option A is predicted to result in the highest PV benefits with $336M, followed by Option C ($332M) and Option D ($323M). Option B has the lowest total PV benefits with $260M.

As expected, travel time makes up the bulk of benefits at between 86% and 89%, with VOC benefits contributing between 10% and 13%.

E.2.5 Evaluation Results

Benefit to Cost Ratios

The benefit to cost ratios (BCRs) for the options are presented in Table E-3.

Table E-3 : Benefit Cost Ratios, P2 Variant

Cost	Option A	Option B	Option C	Option D
PV Costs ($M)	158.9	162.1	154	150.4
PV Benefits ($M)	336.3	260.1	332.3	322.7
BCR	**2.1**	**1.6**	**2.1**	**2.1**

Table E-3 shows that Options A, C and D have the highest BCRs, all at 2.1. This is rated as 'Medium' for Economic Efficiency under NZTA Planning and Investment Knowledge Base (PIKB) Assessment Profile criteria. Option B is rated as a 'Low', as a result of low benefits and high costs. This is as a result of limited traffic reassignment by Option B with only north facing ramp connections onto SH1.

While not presented, the P3 and P4 variants all have similar BCRs to those presented in Table E-3, and therefore these variants are not a major influence on the route selection. The P1 variant will have a higher BCR for all routes.

The northern ramps variants at Petone also resulted in 'low' BCRs as a result of limited traffic reassignment with only north facing ramp connections onto SH2.

First Year Rate of Return

The First Year Rate of Return (FYRR) for all Options is approximately 13%.

Incremental Analysis

An incremental analysis of the Options is presented in Table E-4. The target incremental BCR used is 2.0.

Table E-4 : Incremental Analysis, P2 Variant

Base Option	Next Higher Cost Option	Incremental Costs ($M)	Incremental Benefits ($M)	Incremental BCR	Base Option for Next Step
D	C	3.6	9.6	2.6	C
C	A	5.0	4.0	0.8	C
C	B	8.2	-72.2	-9	C

Table E-4 shows that Options C and D are the most economic route options for P2G. Option C is slightly preferred, however this is within the margins of error for this analysis.

E.3 Looking Ahead to the SAR

Project benefits will likely improve with the potential investigation at the SAR stage of:

- Accident savings;
- Congestion relief;
- Trip reliability;
- Wider economic benefits;
- HCV costs on grades; and
- Network resilience.

These benefits are expected to be similar for all route options, and are therefore neutral to current route analysis in the scoping stage.

Consideration of these further benefit sources will potentially result in a higher absolute BCR for the P2G project.

E.4 Conclusions and Recommendations

The scoping level economic evaluation has shown that:

- Both route Options C and D are the most economic, rating as a 'Medium' for Economic Efficiency under NZTA PIKB criteria and performing well in the incremental analysis;
- Option C is slightly preferred, however this is within the margins of error for this analysis;
- The P2, P3 and P4 variants did not have a significant impact on the project BCRs;
- The P1 variant will have a higher BCR than P2 to P4;
- The northern ramps variants at Petone resulted in 'low' BCRs; and
- Consideration of further sources of benefit will potentially result in a higher absolute BCR for the P2G project in the SAR.

The recommendations are:

- Route Options C and D should be considered against other project criteria (resilience, consenting, landscape etc.) to determine which route should be taken forward for the SAR;
- Similarly the decisions on which of the P1, P2, P3 and P4 variants is preferred will be determined by other project criteria;
- Full connectivity to SH2 should be sought at Petone; and
- Further sources of benefit should be investigated in the SAR to improve the BCR.

F

Appendix F
Option Evaluation

F. Option Evaluation

F.1 List of matters that could be considered in option evaluation

Project objectives:

1. Improve safety and efficiency of the transport network including efficiency of HCVs travelling between Seaview and SH1 to the north and maximise value for money;
2. Support the economic growth and development of the region by improving connectivity within the region;
3. Enhance resilience of the State Highway network within the region; and
4. Minimise adverse environmental impacts.

In developing options that meet these objectives, the project team must have due regard to:

1. Creating options that are economically efficient to construct, operate and maintain;
2. The objectives and requirements of the PFRs which form part of this project namely the Seaview Links, SH58 and SH2 Petone to Ngauranga and their relationship to this project;
3. Recognising the relationship to other projects including Transmission Gully and Petone to Ngauranga Cycling and Pedestrian Improvements;
4. Recognising natural features in the surrounding environment e.g. the Urban Coastal Edge, Ridgelines and Hilltops and the Petone foreshore;
5. Recognising areas of ecological and cultural significance e.g. Korokoro Stream valley within Belmont Regional Park;
6. The impact of the Petone West Plan Change (Change 29) which provides for future land intensification in terms of additional residential and commercial occupants;
7. Enabling the Lincolnshire Farm Development to connect to the P2G Link Road as required in the Lincolnshire Farm Structure Plan;
8. Ensuring that urban design and landscaping is integrated into option development particularly at Petone and Lincolnshire Farm. For example creating a "Beach to Bush" link as part of the option development at Petone; and
9. Recognise relationship with Ngauranga to Aotea project.

LTMZ/NZTS

- Assisting economic development.
  - » Promotes accessibility to employment opportunities.
  - » Promotes accessibility to, between and within key economic and knowledge centres.
  - » Promotes general accessibility.
  - » Promotes transport network resilience.
  - » Promotes freight accessibility.
- Assisting safety and personal security.
  - » Reducing accidents, injuries and deaths. Improving actual and perceived levels of security.
  - » Promoting safety and personal security for vulnerable users (e.g. cyclist and pedestrian safety).
- Improving access and mobility.
  - » Promotes connectivity.
  - » Promotes availability of travel choices to key destinations.
  - » Promotes general accessibility.
  - » Promotes accessibility for those without access to a car.
  - » Promotes public transport.
  - » Promotes accessibility for people with disabilities.
- Protecting and promoting public health.
  - » Promotes trips by active modes, walking, cycling.
  - » Ability to manage emissions to air and water.
  - » Ability to manage noise and vibration.
- Ensuring environmental sustainability.
  - » Ability to manage emissions to air, water and land.
  - » Ability to optimise the use of non-renewable resources.
  - » Impact on heritage, cultural, visual, landscape and ecological sites.
  - » Ability to manage energy efficiency and greenhouse gas emissions.
  - » Ability to manage or reduce community severance.
- Supporting the growth strategy.
  - » Promote relative accessibility to, within and between key Regional Growth Strategy growth centres.
  - » Promote community coherence.
  - » Ability to reinforce RGS urban form and growth patterns.
- Improving energy efficiency and reducing greenhouse gas emissions.
  - » Ability to manage energy efficiency and greenhouse gas emissions.

Government Policy Statement

- Investing in the State Highway network, as a key to the efficient movement of freight and people.
- Generating better value for money from the Government's investment across all land transport activity classes and enhancing the economic efficiency of individual projects.

Resource Management Act

- Section 5: - RMA Purpose: -
  - » Promote the sustainable management of New Zealand's resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while avoiding, remedying or mitigating adverse effects on the environment.
- Section 6: - Matters of National Importance (shall recognise & provide for): -
  - » Preservation of the natural character of the coastal environment including CMA, wetlands, lakes & rivers & margins from inappropriate use & development.
  - » Protection of outstanding natural features & landscapes from inappropriate use & development.
  - » Protection of significant indigenous vegetation & significant habitats of indigenous fauna.
  - » Maintenance & enhancement of public access to & along CMA, lakes & rivers.
  - » Relationship of Maori & their culture & traditions with ancestral lands, water, sites, waahi tapu & other taonga.
  - » Protection of historic heritage from inappropriate use & development.
  - » Protection of recognised customary activities.
- Section 7: - Other Matters (shall have particular regard to): -
  - » Kaitiakitanga /Stewardship.
  - » Protection of significant indigenous vegetation & significant habitats of indigenous fauna.
  - » Maintenance & enhancement of public access to & along CMA, lakes & rivers.
  - » Relationship of Maori & their culture & traditions with ancestral lands, water, sites, waahi tapu & other taonga.
  - » Protection of historic heritage from inappropriate use & development.
  - » Protection of recognised customary activities.
  - » Efficient use & development of natural & physical resources.
  - » Efficiency of the end use of energy.
  - » Maintenance & enhancement of amenity values.
  - » Intrinsic values of ecosystems.
  - » Maintenance & enhancement of the quality of the environment.
  - » Finite characteristics of natural & physical resources.
  - » Effects of climate change
  - » Benefits to be derived from the use & development of renewable energy.
- Section 8 Treaty of Waitangi
  - » Take into account the Treaty of Waitangi.

F.2 Evaluation criteria check list

Matters to be Considered		Evaluation Criteria					Consultation
		Tangible	Intangible				
		Benefit Cost Ratio	Landscape/ Visual/ Recreational	Environmental (Ecology)	Archaeology	Resilience	
Project objectives							
1	To improve safety and efficiency of the transport network including efficiency of HCV travelling between Hutt Valley and SH1 to the north.						
2	Maximise value for money.						
3	Support the economic growth and development of the region by improving connectivity within the region.						
4	Enhance resilience to the State Highway network within the Region;						
5	To avoid, remedy or mitigate adverse effects on the environment.						
Project specific things that the team needs to have due regard to							
1	Petone and its surrounds contain natural features in the surrounding environment (e.g. the Urban Coastal Edge, Ridgelines and Hilltops and the Petone foreshore)						
2	Areas of ecological, cultural and recreational significance (e.g. Korokoro stream valley within Belmont Regional Park)						
3	The objectives and requirements of the PFRs which form part of this project namely the Cross Valley Link, SH58 and SH2 Petone to Ngauranga and their relationship to this project.						
4	Land use provisions in district plans and policies (e.g. Petone West Plan Change (Change 29), Lincolnshire Farm Structure Plan, and Northern Growth Management Framework 2009) and how these are integrated into option development particularly at Petone and Lincolnshire Farm.						
LTMZ/NZTS							
1	Assisting economic development						
2	Assisting safety and personal security						
3	Improving access and mobility						
4	Protecting and promoting public health						
5	Ensuring environmental sustainability						
6	Supporting the growth strategy						
7	Improving energy efficiency and reducing greenhouse gas emissions						
Government Policy Statement							
1	Investing in the State Highway network, as a key to the efficient movement of freight and people						
2	Generating better value for money from the Government's investment across all land transport activity classes and enhancing the economic efficiency of individual projects						
RMA - Matters of National Importance (Section 6)							
1	Promote the sustainable management of New Zealand's resources.						
2	Preservation of the natural character of the coastal environment						

Matters to be Considered		Evaluation Criteria					Consultation
		Tangible	Intangible				
		Benefit Cost Ratio	Landscape/ Visual/ Recreational	Environmental (Ecology)	Archaeology	Resilience	
3	Protection of outstanding natural features & landscapes						
4	Protection of significant indigenous vegetation & significant habitats of indigenous fauna						
5	Maintenance & enhancement of public access to & along CMA, lakes & rivers						
6	Relationship of Maori & their culture & traditions with ancestral lands, water, sites, waahi tapu & other taonga						
7	Protection of historic heritage						
8	Protection of recognised customary activities						
RMA - Other Matters (Section 7)							
1	Kaitiakitanga /Stewardship						
2	Protection of recognised customary activities						
3	Efficient use & development of natural & physical resources						
4	Efficiency of the end use of energy						
5	Maintenance & enhancement of amenity values						
6	Intrinsic values of ecosystems						
7	Maintenance & enhancement of the quality of the environment						
8	Finite characteristics of natural & physical resources						
9	Effects of climate change						
10	Benefits to be derived from the use & development of renewable energy	N/A					
RMA - Treaty of Waitangi (Section 8)							
1	Take into account the Treaty of Waitangi						

Want to find out more?

Our contact details

For general enquiries, or contact information about NZ Transport Agency please check our website ***www.nzta.govt.nz*** or email us at ***info@nzta.govt.nz***

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