Puhoi to Wellsford Toll Modelling Assessment

Prepared for NZ Transport Agency - Wellington
Prepared by Beca Limited

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Contents

Appendices

No table of contents entries found.

Table of Abbreviations

AADT	Annual Average Daily Traffic
ADT	Average Daily Traffic
AFC	Auckland Forecasting Centre
ART3	Auckland Regional Transport Model 3
ATAP	Auckland Transport Alignment Project
CPI	Consumer Price Index
DBC	Detailed Business Case
DSI	Death Serious Injury
GPS	Government Policy Statement
HCV	Heavy Commercial Vehicle
IBC	Indicative Business Case
km	kilometres
m	million
min	minute
MSM	Auckland Macro Strategic Model
NGTR	Northern Gateway Toll Road
NZ	New Zealand
NZTA	New Zealand Transport Agency
OIC	Order in Council
P2W	Puhoi to Warworth
PPP	Private Public Partnership
SGA	Supporting Growth Alliance, also known as Te Tupu Ngatahi
SH	State Highway
TDM	Travel Demand Management
TTSM	Tauranga Transport Strategic Model
VEPM	Vehicle Emissions Prediction Model
VoT	Value of Time
VKT	Vehicle Kilometres Travelled
vpd	vehicle per day
WtP	Willingness to Pay
WW2W	Warkworth to Wellsford

Revision History

Revision Nº	Prepared By	Description	Date
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1.1	**Caleb Deverell / Andrew Murray / Mark Man**	Working Draft for Review	11/12/2019
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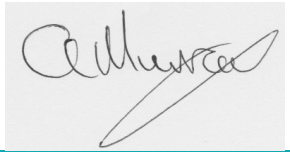
Approved by	**Andrew Murray**		30/04/2020
on behalf of	Beca Limited		

Executive Summary

Purpose and Scope

This report describes an analysis of the effects of tolling on the Ara Tūhono corridor north of Auckland. The purpose of this work is to provide information to NZTA to support their decision making on whether to proceed to public consultation of tolling. This analysis is based on existing traffic models (albeit updated to current conditions) and driver willingness to pay (WtP) parameters from other studies and those implied from other toll roads. Detailed market research into WtP has not been undertaken specifically for this work however the effects of key uncertainties in inputs and assumptions have been estimated via sensitivity tests and risk-profiling. While this work provides estimates of network demands and revenue suitable for network planning, the revenue estimates are not considered 'investment grade' such as might be required for private-sector investment.

The first part of the corridor between Puhoi and Warkworth is currently under construction with completion expected in late 2021. As such, decisions on tolling need to be made in early 2020 to allow sufficient time for public consultation, and Order in Council to be completed before opening of the new road. A detailed business case for the northern section between Warkworth and Te Hana has been completed, however the implementation timing for that element remains uncertain. The DBC suggested traffic flow and safety triggers for implementation, however a decision on proceeding to route protection has yet to be made. Funding was identified as a key issue for that project. Because of the differing levels of certainty and urgency for the two sections, greater analysis was applied to the Puhoi-Warkworth section, including estimates of opening-year traffic flows should it be tolled. Longer-term and more conceptual analysis was applied to the section north of Warkworth.

Approach and Methodology

The analysis focused on the revenue potential and network impacts of tolling of the corridor. The measured network impacts were derived from the specific project objectives, key transport priorities (such as from the GPS) and items specific to tolling. These included:

- Road safety, specifically any additional crash costs of diverting traffic from the new motorway back to the existing highways
- Accessibility, measured via estimated travel times between key locations through the corridor
- Environmental impacts such as estimated changes in CO_2 emissions
- Amenity impacts from traffic increases in sensitive areas such as central Orewa and Warkworth
- Travel demand impacts, such as reduced amount of vehicle travel from higher travel costs
- Equity of pricing different users

The traffic flow and network outcomes were primarily derived from an updated version of the traffic model owned by the Auckland Forecasting Centre (AFC), and used for development of key projects in this area such as the P2W, WW2W, Matakana Link Road, Hill Street and Supporting Growth Alliance projects. Key updates to that model included an extension south to include the existing Northern Gateway toll road, a switch to the new regional demand model for forecast traffic flows (rather than the now superseded ART3 model), rebasing and calibrating the model to 2018 conditions and adding a toll response element.

An initial assessment of alternative toll strategies was considered for both the short-term and longer-term (full corridor) scenarios, resulting in a short-list of scenarios for testing. More detailed testing for the P2W project was then undertaken for the forecast year 2038 to identify a preferred range of toll tariffs. This preferred range was determined balancing between the increasing revenue potential of higher tolls against the worsening network outcomes. A similar approach was then undertaken for the WW2W

project. Representative revenue estimates were then developed for the P2W project from opening year to 2048, including risk-adjusted factors to provide 5%, 50% and 95%ile estimates.

Puhoi-Warkworth Toll Strategy

Two toll location strategies were identified for this project:

- A1: Increasing the toll at the existing Northern Gateway toll gantry at Orewa but adding ramp toll gantries on the Puhoi Ramps to allow discounting of the tolls for those users
- A2: A new mainline gantry located north of Puhoi

Strategy A1 has the advantage of lower transaction costs as it utilizes the existing gantry. The discounting of tolls for those exiting at Puhoi is considered necessary as they would accrue the higher toll charge at the Northern Gateway gantry without using the new toll road. Therefore, the two strategies are effectively the same in terms of traveler's payment and use of the toll road but differ in terms of toll system operation. This strategy does require a change to the national toll processing system to identify and invoice the linked trips and potentially requires a more complex Order in Council (OIC) process[1].

The potentially more efficient A1 strategy is recommended if it can be confirmed that the processing system can efficiently accommodate linked and discounted trips.

The modelling and analysis identified the following key outcomes:

- Revenue increased with increasing tolls, up to a maximum at about $9, after which the revenue reduces
- Travel times on both routes were not significantly changed with tolls below $5
- Crash costs increase with tolls as traffic is diverted to the lower-standard existing highway
- Tolling marginally reduces the amount of travel through the corridor
- Only minor changes in vehicle CO_2 emissions is expected, with the demand suppression effects of tolls being offset by increased trip lengths on the alternative routes
- The corridor includes both local and inter-regional travel, resulting in hourly traffic flow profiles more consistent throughout the day with less dominant commuter peaks than is experienced within major urban areas. This would make time-varying tolls difficult to implement with clear transition points. Therefore, a uniform 24/7 toll rate is recommended, as per the other peri-urban toll roads in NZ.
- Truck tolls are recommended to be 2 times that for light vehicles, consistent with the adjacent northern Gateway toll road.

From the assessment an optimal toll tariff between $2 and $3 is suggested, being a balance between the increasing revenue potential and worsening network outcomes of higher tolls.

A mid-point toll of $2.40 would provide the same per-km toll rate as the Tauranga Eastern Motorway and a similar per-minute time saving as the Northern Gateway.

Puhoi-Warkworth Revenue Potential

A representative toll of $2.40 was used to estimate the traffic flows and revenue potential. Opening year annual average daily flows of some 18,200 vpd are expected in 2022, increasing to 36,300 in 2048. This is estimated to generate gross revenue of some $16.3m from the new gantry in 2022, increasing to $32.3m in 2048. However, the toll transaction cost is assumed to remain at 70c per vehicle, while tolling the new project does result in a small reduction in traffic on the existing Northern Gateway toll (relative to an untolled scenario). Therefore, tolling the P2W project is expected to increase the combined net revenue of the two toll gantries by between $8.2m (5%il) and $15.6m (95%ile), with an expected value of $11.4m in 2028.

[1] As it would involve altering the toll applied on the Northern Gateway toll road

This analysis suggests the 35-year net revenue estimate is between $304m (5%il) and $794m (95%ile), with an expected value of $569m. The equivalent net present value at 6% discount rate would be $184m

The potentially more cost-efficient A1 toll strategy could potentially save $100m (2018$) over 35 years. This would take the total 35-year expected net revenue estimate from $404m to $894m.

Warkworth to Wellsford Toll Strategy

Unlike other toll roads in NZ, this corridor could potentially have multiple adjacent toll points resulting in a significant cost of travellers of the full corridor. This has a number of implications including:

- A potential impact on an objective of the corridor to enable economic growth in Northland by imposing high travel costs
- An equity or 'fairness' concern about treatment of this corridor versus other inter-regional corridors in NZ
- Uncertainty about traveller's willingness to pay for the cumulative effect of multiple adjacent toll roads. Most toll road assessments rely on WtP assessments based on single stand-alone toll roads

Toll models are used attempt to reflect the trade-off between travel times and costs for each of the individual sections of toll roads, and don't consider the cumulative effect on travel budgets from multiple toll sites. There is a sparsity of research into the scale of effect on driver's willingness-to-pay from cumulative tolls, so this effect remains somewhat uncertain. Advice from international experts suggests this is a real effect and that slightly more conservative willingness to pay parameters should be adopted than for stand-alone toll sites. As such, these cumulative and equity effects have been considered mostly qualitatively rather than determined from the models.

Analysis of various toll strategies identified the following:

- Tolling the two sections of the WW2W project is likely to lead to very high toll costs for using the full corridor so is not recommended
- Tolling only the section between Warkworth and Wayby Valley interchanges results in limited diversion of through traffic but higher diversion of trips between Warkworth and the north via Dome Valley
- This local diversion could be partially mitigated by also tolling the north-facing ramps at Wayby Valley, however that results in such low usage of those ramps that tolling would not be worthwhile
- Tolling of just north-facing ramps at Warkworth and Wayby Valley would not increase through-traffic tolls but would not be worthwhile due to low usage of those ramps.

It is therefore recommended that any tolling of this project be via a new mainline gantry north of Warkworth with a toll in the range of $1.20 and $2.00.

Due to the uncertain timeframe for implementation of this part of the corridor, only annual revenue estimates for 2038 and 2048 have been assessed. This suggests potential annual net revenue from a $1.20 toll north of Warkworth of:

- an expected 2038 net revenue of $7.7m with 5% and 95%ile values of $5.5m and $10.7m respectively
- an expected 2048 net revenue of $9.3m with 5% and 95%ile values of $6.4m and $14.0m respectively

Conclusion

This analysis has identified potential of significant revenue from tolling on both the P2W and WW2W projects. However, increasing tolls will reduce the expected outcomes of the projects, especially in terms of allowing travel on safer roads. Relatively modest tolls of between $2-$3 on P2W are considered to represent a balance between revenue generation and network outcomes. A single additional toll point north of Warkworth is also the preferred strategy, with a more modest tariff of between $1.20 and $2.00.

As well as potential revenue generation, tolling offers some level of demand management (albeit quite modest) and also signals a transition to pricing for road usage as indicated as being needed for Auckland through ATAP.

Unlike other toll roads, this corridor needs to consider the effects of up to three adjacent toll roads, with cumulative impacts on inter-regional travel costs, equity with other inter-regional corridors and the uncertainties of motorist's cumulative willingness to pay.

1 Introduction

1.1 Purpose

Beca Ltd was commissioned by New Zealand Transport Agency (NZTA) to investigate the effect of tolling on the Ara Tūhono project (Puhoi to Wellsford motorway extensions), to inform decisions whether to proceed with tolling. This work considered the types of tolling strategy and expected outcomes in terms of toll revenue and impacts on the transport network.

The work focussed more on the first part of the corridor (Puhoi to Warkworth) which is currently under construction and due for completion in late 2021. Planning of the next section (Warkworth to Wellsford) is progressing, however the timing for implementation remains uncertain. As such, the northern section was considered at a more conceptual level, focussing on potential toll strategies and outcomes with less extensive modelling.

1.2 Scope and Limitations

The purpose of our advice will be to support a decision by NZTA to progress consideration of tolling or not, including undertaking public consultation, in accordance with the parameters of our agreed scope as set out in our proposal. Further analysis may be required in order to support more detailed financial analysis. Specifically, this work does not provide 'investment-grade' revenue estimates.

Although in this report, Beca offers professional advice and may express opinions on likely or possible outcomes, we cannot guarantee any particular outcome and any decision to proceed with the next phase of investigation is a commercial decision for NZTA.

It should be noted that the toll revenue estimates provided as part of the Services are not a statement of absolute revenue suitable for detailed investment decisions, rather they will have an accuracy range commensurate with various factors such as the extent of relevant information provided, the certainty of data and the level of detail available at the time of preparation.

The Puhoi to Warkworth project is being constructed and operated via a Private Public Partnership. This report does not explore the commercial implications in regard to the PPP, nor jurisdictional issues in regard to any revocation of the current State Highway Status (with assumed transfer to an Auckland Transport asset).

1.3 Ara Tūhono Corridor

The project study area is shown in **Figure 1-1**. The Puhoi to Warkworth (P2W) project is under construction and involves an extension of the northern motorway corridor, immediately north of the existing Northern Gateway toll road. The northern Gateway toll road has been operational since 2009 and currently has a $2.40 toll for light vehicles and $4.80 for heavy vehicles. The expected completion of this element within the next 2 years means a decision on tolling must be made in 2020 if any tolling system is to be installed before operation commences.

The Warkworth to Wellsford (WW2W) part of the corridor has a completed business case, with the next steps being route protection. The Business Case did not recommend a specific implementation date, rather recommending triggers on traffic growth and safety be used to guide decisions in implementation. The business case identified funding as a constraint on implementation. Although the business case has developed a proposed design, subsequent route protection, consenting and detailed design processes could result in changes to the form of project. As such, there is significant uncertainty about the timing of this part of the corridor.

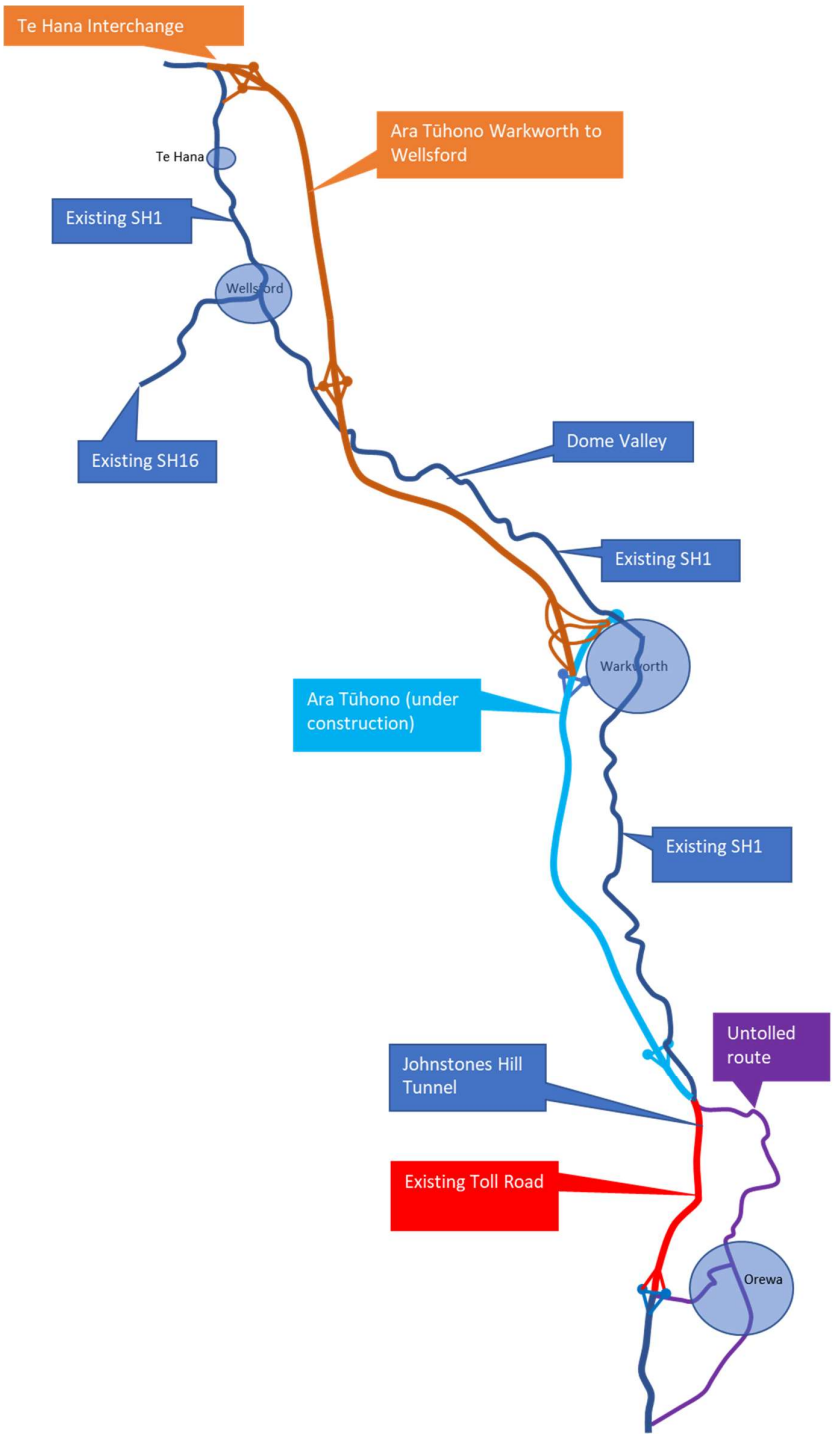


Figure 1-1: Project Study Area

1.4 Other Projects

The Matakana Link Road project in Warkworth is planned to be operational concurrently with the Puhoi to Warkworth project. Matakana Link Road is a local arterial road to be implemented by Auckland Transport as part of the longer-term network proposed for Warkworth.

The Hill Street project in Warkworth has considered upgrades to this complex intersection. Short-listed options have been identified but the final version is yet to be confirmed. The intersection is very complex requiring more detailed models than the SATURN models used here, so a simple representation of the likely increased capacity has been used.

Significant urban growth is planned for Warkworth, with an approximate 20,000 increase in resident population. The planning for the future transport network to support this growth is being undertaken by Te Tupu Ngatahi (the Supporting Growth Alliance). An Indicative Business Case (IBC) has been completed for Warkworth that identified the preferred long-term network. Detailed business cases and route protection is planned for that network over the next few years. Of significance to the state highway network is the recommendation of an additional interchange in south Warkworth.

1.5 Study Approach

The broad approach adopted for the assessment was as follows:

- Undertake preliminary testing of a range of toll levels on the Puhoi-Warkworth project for a single forecast year (2038) to understand the impact of tolling and a suggested toll range
- Consider the longer-term full corridor scenario, focussed on issues and options with limited modelling
- Select a preferred toll strategy for Puhoi-Warkworth project and provide a fuller set of forecasts based on the preferred strategy, including more detailed risk analysis of forecasting uncertainties

1.6 Report Structure

The remainder of this report is structured as follows:

Chapter 2	Describes the assessment methodology used in this assessment
Chapter 3	Describes the outcome measures used to assess each toll strategy
Chapter 4	Describes the elements of a toll strategy and a preliminary assessment of options
Chapter 5	Describes the Preliminary modelling and analysis of the toll strategies on the Puhoi-Warkworth project
Chapter 6	Assess the longer-term considerations for tolling on WW2W with the full corridor in place
Chapter 7	Details the refined outcomes from the agreed preferred strategy for P2W
Chapter 8	Summary and Conclusions

2 Modelling Methodology

2.1 Approach

The assessment of traffic flows, revenue and network performance is based on a series of models and assessments, comprising:

- A regional multi-modal **demand model** to estimate future travel demands from land use and network inputs
- A detailed **corridor traffic model** that predicts traffic flows and network performance in detail
- A **toll diversion model**, added to the corridor model to predict diversion between available tolled and untolled routes based on the Willingness-to-pay (WTP) for a range of demand segments
- A **demand response** element, that predicts change in travel pattern within the corridor (such as mode shift, change in destination etc) as well as diversion to the wider SH16 corridor
- An **annualization process** to expand weekday, peak period model predictions into daily then annual flows
- A **revenue model**, that estimates potential toll revenue from the traffic flows, allowing for revenue leakage and transaction costs
- A **risk-analysis process**, that considers the key forecasting uncertainties to provide range of forecasts that reflect those uncertainties

These elements are described in the following sections.

2.2 Regional Demand Model

The Auckland Macro Strategic Model (MSM) is owned and operated by the Auckland Forecasting Centre (AFC), and estimates future travel patterns (via origin-destination trip patterns by period, purpose year and mode). Key inputs to that model are future land use and demographic forecasts, future network assumptions and policy and economic inputs. For this study those key inputs have been adopted from recent models developed by the AFC for the update of the Auckland Transport Alignment Project (ATAP). These include:

- Land use forecasts based on Scenario I-11.4 (as used in SGA)
- Project assumptions from ATAP in the wider network, revised as needed for use in this study (such as addition of the Warkworth-Wellsford project and testing of toll responses)
- Future year networks in Warkworth based on the SGA Indicative Business Case

The regional model covers both this corridor as well as the wider SH16 corridor and alters the travel patterns in response to travel costs such as tolls. The model was run for un-tolled and tolled scenarios to inform the demand response, which includes changes in trip distribution, mode shift and route choice to SH16.

Auckland wide network assumptions have been described in a separate note “P2W Technical Note 4 – MSM Forecast Network Assumptions”.

2.3 Saturn Corridor Traffic Model

The corridor traffic model was developed from the SGA SATURN traffic model of the corridor between Puhoi and Te Hana (versions of which were also used for the planning of the Warkworth to Wellsford and Matakana Link Road projects). The base year Saturn model has been developed and is discussed in a separate document “P2W Technical Note 5 – Base Year Model Development”.

For this work the model was extended to Orewa and re-based to 2018 conditions based directly on the MSM demands, rather than demands from the now superseded ART regional model. The model reflects average Monday-Thursday AM, interpeak and PM peak periods. Analysis of Friday data indicated slightly different traffic flow levels than for Monday-Thursday. The effect of Friday and holiday flows were then reflected in

the annualization factors. Friday and holiday periods currently have much more significant congestion in the corridor than weekdays, not just higher flows. However, with the committed completion of the Puhoi-Warkworth and Matakana Link Road in all future scenarios, that congestion in the SH1 corridor is expected to significantly reduce. As such, it is considered suitable to reflect the higher-flow periods via annualization factors rather than via specific models for such periods.

The standard traffic model only had two demand segments, being light and heavy vehicles. This was expanded as part of the toll diversion model described below.

Model demands have been sourced from the MSM for the years 2028, 2038 and 2048. The demands are adjusted based on the calibration and matrix estimation process described in the base year model development report; "P2W Technical Note 5 – Base Year Model Development".

2.4 Toll Diversion Model

This study adopted a multi-class route choice form of toll response model. This involves segmenting the traffic demand matrices into different segments, which is assigned a WTP value. The toll is then included in the route choice model, where the model seeks to find the least-cost paths through the network.

The toll diversion model therefore comprises the following elements:

- Segmentation of the travel demands into 12 user classes[2]. These classes reflect the same classes used in the WTP module available in MSM.
- Allocation of WTP parameters to each user class
- Modification of the route choice cost functions to include tolls
- Development of a 12-class assignment model (rather than the previous 2-class model)

2.4.1 Willingness to Pay

In this model, WTP comprises three elements:

- The Value of Time (VoT) in $/hour. This parameter converts the monetary toll into equivalent minutes of travel. User classes with higher VoT will have a high WtP.
- Road perception factors, that reflect perceptions of the relative safety, convenience, amenity or reliability of the competing routes. To suit the SATURN model software, these were included as penalties on links with poorer characteristics. No penalties were applied to the tolled motorways.
- Escalation of VoT. This accounts for a change in value of time based on income growth.

Development of the model is detailed in Appendix A.

A key uncertainty in toll modelling are the VoT values. Two key sources were used for this study:

1. The values included for the same 12 user classes in the MSM[3]
2. The values used in the Tauranga demand models

Stated Preference surveys were undertaken in Tauranga in 2005 to assess VoT values for the proposed eastern motorway toll road. However progressive modelling of the existing Takitimu Drive toll road in Tauranga found those values underestimated usage of the toll road. They were also found to over-predict reductions in traffic with successive increases in tolls. The VoT values were therefore progressively increased over various model updates to better reflect observed behaviour. Those revised values were found to provide good prediction of usage when the Eastern Motorway toll road opened in 2015.

[2] Refer to P2W Technical Note 5 – Base Model Development Report for detail on user class segmentation

[3] The MSM VoT is based on the Economic Evaluation Manual VoTs and adjusted for the Auckland region

The data collection carried out for this project demonstrated that the through traffic diversion was approximately 5%. With an uncongested travel time saving of approximately 8 minutes; 95% of drivers have a value of time equal to or greater than $18/hr. The model willingness to pay segmentation and VoT was validated against this.

For this study the VoT was adopted as follows:

- A 'central' estimate that was a simple average of the Auckland (MSM) and Tauranga (TTSM) values
- Sensitivity testing with the lower MSM values and the higher full Tauranga values

The VoT adopted is shown in **Figure 2-1**.

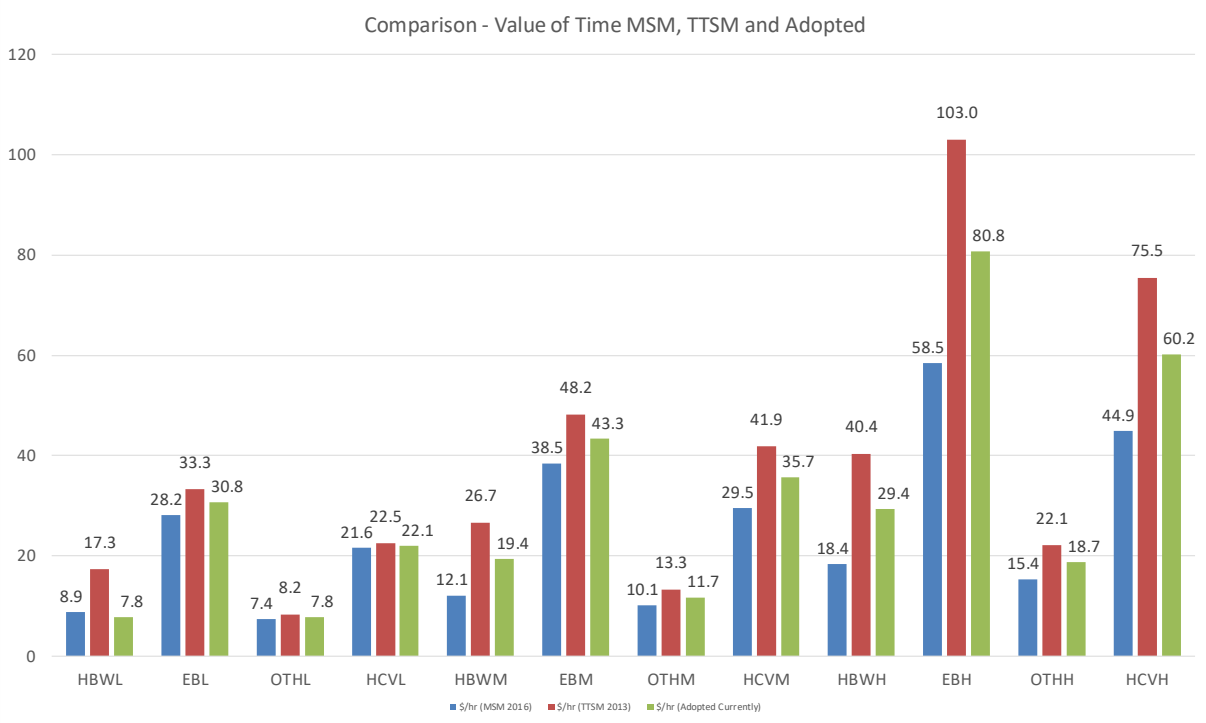


Figure 2-1: Value of Time

2.4.2 Escalation of VoT

Previous tolling studies have assumed the following:

- Tolls will be escalated, on average at the rate of inflation (CPI)
- VoT is likely to escalate based on income growth
- Average weekly earnings have historically been found to growth at some 1%-1.1% faster than CPI
- This means that the WtP is expected to increase over time in real terms

Figure 2-2 below shows the indexed growth in CPI versus average weekly earnings, which suggested earnings growing at 1.1% faster than CPI.

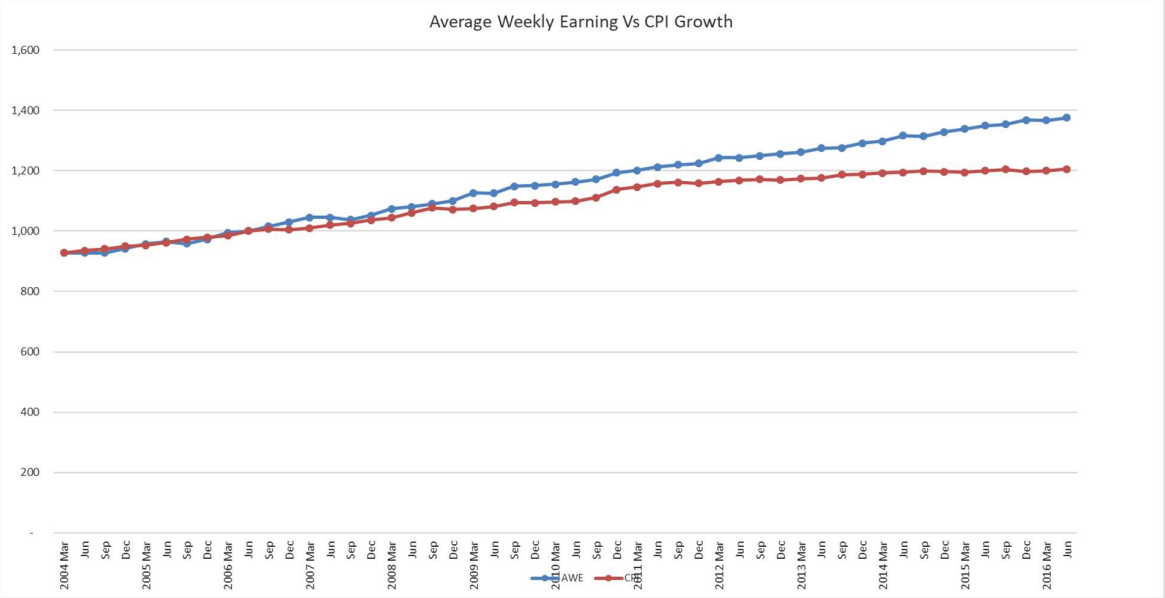


Figure 2-2: Indexed Growth in Weekly Earnings and CPI

Within the models all tolls were applied in $2018 terms and the 2018 VoT values retained[4]. To account for the difference in CPI growth and VoT growth a 1% WtP escalation effect was applied to the representation of toll costs in the models.

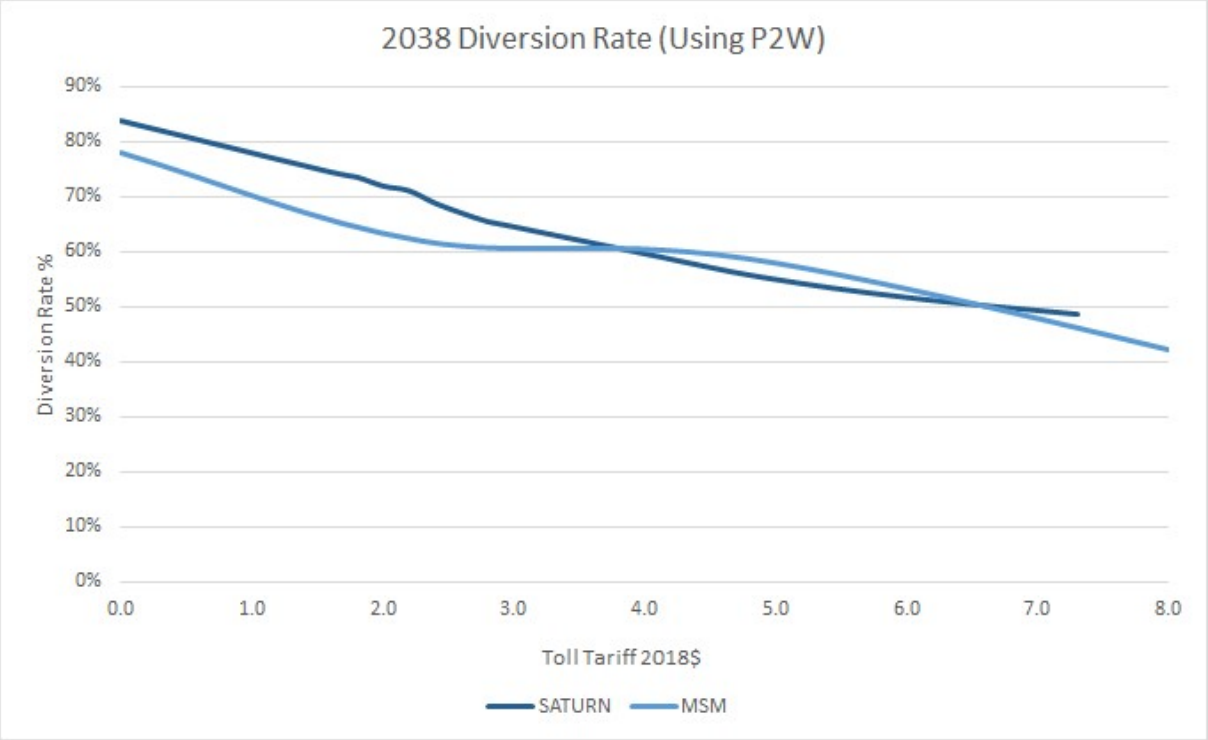
2.5 Demand Response

Tolling is expected to alter both the travel routes (diversion) as well as the travel patterns (mode share, destination choice etc). The diversion is the primary response however the demand response is also important. In this corridor, the potential for longer-distance trips to divert from the SH1 corridor to the SH16 corridor further west is not captured in the local corridor model. As such, while that effect is technically a diversion effect, in this corridor it is included as a 'demand response' as such trips are removed from the SH1 corridor.

The key source of demand response was the MSM, from which the effect on corridor flows with differing toll levels was determined. Testing in the 2038 regional model suggested corridor flows reduced by some 5% with a $2.30 toll north of Puhoi and 8% with a $5 toll. The regional model extends to the Auckland Boundary, north of Te Hana. Trips entering the model at this point have a fixed travel pattern that does not respond to travel costs. As such, it is expected that the demand response may be slightly higher than estimated by MSM. Additionally, the MSM responds to increases in travel times determined by its simpler representation of the network. These changes in delays and speeds may differ from the more detailed SATURN corridor model. Therefore, the revised tolled travel demands from MSM were not used directly in the SATURN model, rather a mechanism was added to the SATURN model to represent the likely demand response directly form the travel times. This involved use of a 'shadow network', that allowed trips to travel between Orewa and Warkworth (or Wellsford) as travel costs on the real network increae. The speeds on the shadow network were set to have no usage in an untolled scenario but had increasing traffic as tolls increased. The

[4] 2018 was used as this is the base calibrated model.

reduction in travel on the real network was set to reflect the MSM testing, albeit targeted at a slightly higher level to reflect the lack of MSM response in the external trips[5].



2.6 Annualization Factors

Annualization factors are required to convert the modelled traffic volumes for each modelled peak (AM, IP, PM) into average daily traffic (ADT) and annual average daily traffic (AADT).

The factors have been determined by following the steps described below. TMS data on the State Highway corridor have been used in the calculations.

- For each hour in a day assign the most appropriate model peak
  - For four scenarios: Mon-Thu average weekday, Friday, Saturday and Sunday
  - Modelled peak assigned based on total flows and north-south directional split
- Determine peak flow factor for each hour
  - Flow factor to convert model peak flow to observed hour flow
- Sum the peak flow factor for each scenario and modelled peak
  - This gives the factor for each modelled peak to determine the total daily flow for each scenario
- Determine the number of days in the year each scenario occurs
- Determine the weighted average modelled peak factors to give the AADT factors

The AADT Factors are shown in **Table 2-1**:

[5] At higher tolls the MSM demand model had no users of the toll road, so the demand was not fully reflecting increasing tolls. The final assignment in MSM has a more detailed toll response which does capture the wider diversion to SH16.

Table 2-1: AADT Factors

Modelled Peak (1-hr)	AADT Factor
AM	1.70
IP	11.07
PM	2.23

2.7 Revenue Calculation

The following steps are taken in order to calculate the annual net toll revenue for each toll tariff level tested:

- Multiply the toll tariff by the annual traffic using the toll road to get gross revenue
- Deduct the revenue leakage, i.e. users of the toll road that either do not pay the toll or are exempt from paying
- Deduct the transaction cost for each vehicle, set at $0.70 per transaction to get net revenue

2.7.1 Annual Traffic

The annual traffic on the toll road is determined by running the SATURN model for each modelled peak, extracting the volume on the toll road for each peak and then using the annualization factors to convert this to an annual traffic volume.

2.7.2 Transaction Cost

The transaction cost of $0.70 per transaction has been provided by NZTA. This has been assumed to be an average transaction cost that covers all transaction types and circumstances, for example toll payment notices for non-payers. It is possible the transaction cost reduces over time as more toll roads are added to the national system and other reasons. No information on this is available, however this has been addressed in the risk analysis.

2.7.3 Revenue Leakage

The revenue leakage has been determined by analysing the Northern Gateway Toll Road (NGTR) gantry data. This represents the percentage of traffic that does not pay for the toll road, either through non-compliance or are exempt from paying the toll. The revenue leakage is summarised in **Table 2-2**:

Table 2-2: Revenue Leakage

Vehicle Class	Percent of Vehicles Not Paying
Motorcycle	10%
Car / Light Truck	3%
Heavy Truck / Bus	2%

The percent of vehicles not paying was calculated using data from 2018 and 2017.

2.8 Risk Analysis Process

This process is detailed more fully in later chapters for the preferred toll strategy. It involves the following key steps:

- Prepare model forecasts using agreed inputs
- Identify key areas of uncertainty that influence the forecasts
- Test or assess the potential scale of the uncertainty
- Set potential probability functions for the uncertainty

- Run Monte-Carlo type simulation that combines the effects of all the uncertainties to give adjustment factors to apply to model results at differing levels of certainty (e.g. 5th, 50th and 95th percentile adjustments)
- Apply factors to the model results to provide ranges in forecasts

3 Outcome Measures

3.1 Approach

This section describes the key outcome measures used to assess the impact of tolling on the network. The source of these measures are outlined in Technical Note #2 contained in Appendix B.

The outcome measures include the following:

- Safety
- Accessibility
- Environmental
- Value for Money (including revenue)
- Equity
- Influencing Demand

These outcome measures have considered both the Government Policy Statement (GPS 2018), outcomes used in similar studies and the various project objectives in the study area, which includes; Puhoi-Warkworth, Warkworth-Wellsford and Matakana Link Road.

3.2 Safety Measures

Improving road safety is a key outcome sought by the Ara Tūhono projects, as the high traffic flows result in high crash rates on the existing 2-lane, curvilinear terrain, including the well-known crash risk areas of Schedeways Hill and Dome Valley.

As well as a measure of traffic flows on these existing sections of State Highway, estimates of the potential social costs of crashes was used, based on simple crash rates calculated from existing crash history. For example, scenarios with a high toll will encourage more use of the existing State Highway which in turn will produce a higher number of DSIs and therefore a higher social cost.

3.3 Accessibility Measures

Four measures are proposed for accessibility:

- Point-to-point travel time through the corridor
- Impact on travel costs between communities (a simple summary of additional costs imposed on key movements)
- Changes in mode share (as a measure of travel choice)
- Travel consistency, based on any variability between the modelled travel time over the three modelled peaks; AM, IP and PM.
- Notable changes in predicted delay/congestion in Warkworth as a result of tolling Ara Tūhono

3.4 Environment

Three measures are proposed for environmental impacts:

- Estimated vehicle emissions using the Vehicle Emissions Prediction Model (VEPM), and measured over the extent of the corridor project model

- Changes in traffic volumes in sensitive urban environments including Grand Drive (Orewa), Hibiscus Coast Highway at the Orewa Town Centre, Hill Street intersection in Warkworth and SH1 in the Wellsford Town Centre

3.5 Value for Money

The 'value for money' is measured by:

- the potential annual toll revenue and associated transaction costs
- The potential capital costs, based on a simple estimate per toll gantry
- A simple Internal Rate of Return for the toll system

3.6 Equity

Equity is proposed to be a measure of the 'fairness' of the proposed toll system. This will be assessed subjectively based on two simple indicators:

- Whether users of each section of Ara Tūhono have similar paid/free access (i.e. can some users use parts for free)
- Whether payment is similar on a per-km basis
- Whether tolling is consistent with similar toll road corridors in NZ

3.7 Influencing Demand

This was assessed by how the toll influences demand through:

- Mode shift
- Change in travel (VKT)

4 Tolling Strategies

The corridor comprises the following three elements as indicated in **Figure 4-1**:

- The existing toll road between Orewa and Puhoi
- The Ara Tūhono project currently under construction between Puhoi and Warkworth (P2W)
- The proposed future Ara Tūhono extension from Warkworth to Wellsford (WW2W)

The configuration of the access points to each part of the corridor are critical to development of the toll strategy, and are assumed as follows:

4.1 Existing Orewa-Puhoi Toll Road

The toll gantry is located between the Grand Drive interchange in Orewa and the Johnstone's Hill Tunnels at Puhoi. Access to the toll road is therefore via SH1 south or from Grand Drive in Orewa and from SH1 at Puhoi. At Puhoi there are currently no direct movements possible between the toll road and the Hibiscus Coast Highway, although indirect movement is possible via a u-turn on Puhoi Road.

4.2 Puhoi-Warkworth

The project currently under construction removes the connection between the toll road and the alternative route at the northern tunnel abutment but provides south-facing ramps to Puhoi Road. No north-facing ramps are proposed.

An interim termination of the road is being constructed on SH1 immediately north of Warkworth via a roundabout allowing all movement access north (towards Dome Valley) or south into Warkworth town centre.

Although not currently being constructed, The Supporting Growth Alliance (SGA) project has identified an additional interchange to the south of the (future) urban area of Warkworth, via south-facing ramps.

4.3 Warkworth-Wellsford

This project proposes a new SH corridor from Warkworth to north of Te Hana. The currently proposed connections are:

- Warkworth: full system interchange
- Wellsford: an all-movement interchange on Wayby Valley Road, some 4 km south of the Wellsford town centre
- Te Hana: an all-movement interchange on Mangawhai Road, some 2.5 km north of the Te Hana village
- Northern tie-in: the new road will connect directly into the existing road approximately 1.5km north of the Te Hana interchange, with no local road access

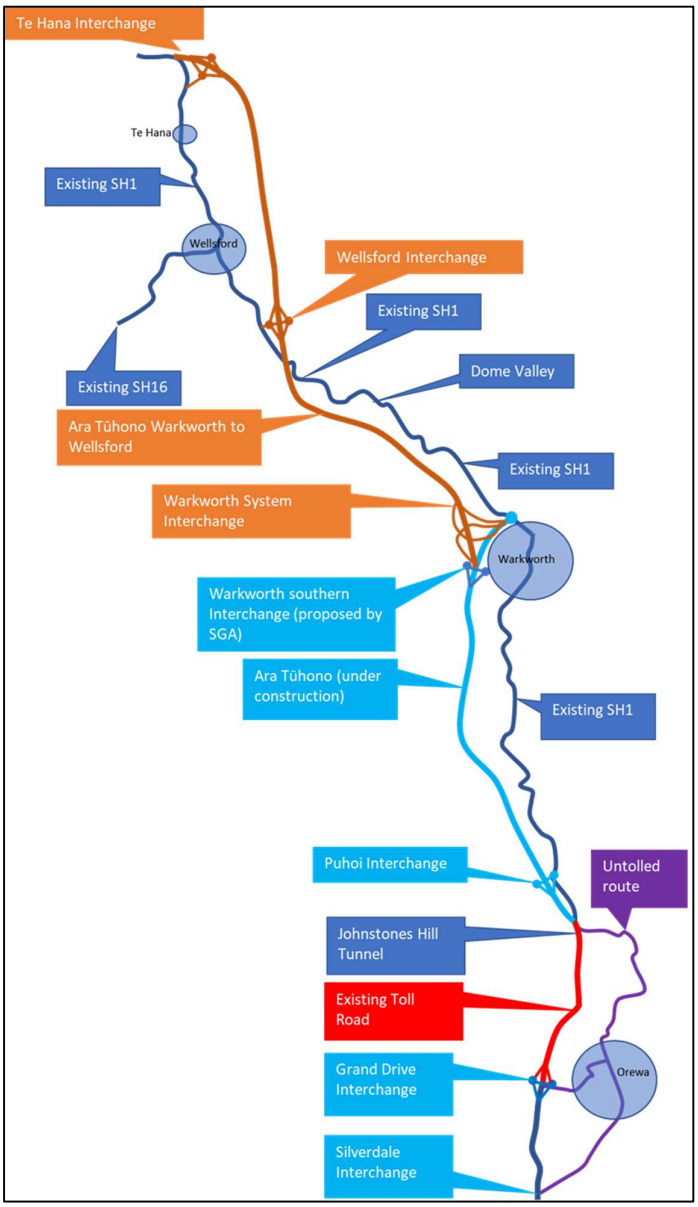


Figure 4-1: SH1 Ara Tūhono Corridor and Interchanges

4.4 Toll Strategy Elements

The key elements considered with the toll strategy include:

- The toll collection and payment methods
- The location of toll points/gantries
- The toll tariff
- Any discounting or capping
- Any differentials by vehicle type
- Any differentials by time of day
- How toll tariffs are escalated over time

4.4.1 Existing Toll Roads

The attributes of the three existing NZ toll roads are shown in **Table 4-1**. Given those are also State Highways, it is assumed that similar attributes would be expected.

Table 4-1: Attributes of Existing Toll Roads

Attribute	SH1 Northern Gateway Auckland	SH2 Eastern Link Tauranga	SH2 Takitimu Drive Tauranga
Toll Collection	Free-flow electronic toll gantry		
Payment Methods	NZTA automated Toll account Pay on-line Cash (at selected service stations)		
Toll Tariff (as at October 2019) Light Vehicle Heavy Vehicle (over 3.5t) Trailer	 $2.40 $4.80 $0	 $2.10 $5.20 $0	 $1.90 $5.00 $0
Heavy Vehicle toll relative to light vehicle	2 times	2.5 times	2.6 times
Length of toll road	7km	15km	5.4km
Distance saving relative to alternative route Typical time saving (uncongested)	5km 8 min	2.8km 7 min	1-2km 4 min
Equivalent light vehicle toll/km of toll road	$0.34/km	$0.14/km	$0.35/km
Equivalent light vehicle toll/minute saved	$0.3/min	$0.3/min	$0.95/min
Collection points	One mainline gantry per project		
Discounting or capping	none		
Escalation	Generally CPI, but to nearest 10c		

Figure 4-2 demonstrates the toll pricing for each corridor section when following the equivalent light vehicle toll / km and light vehicle toll / minutes saved:

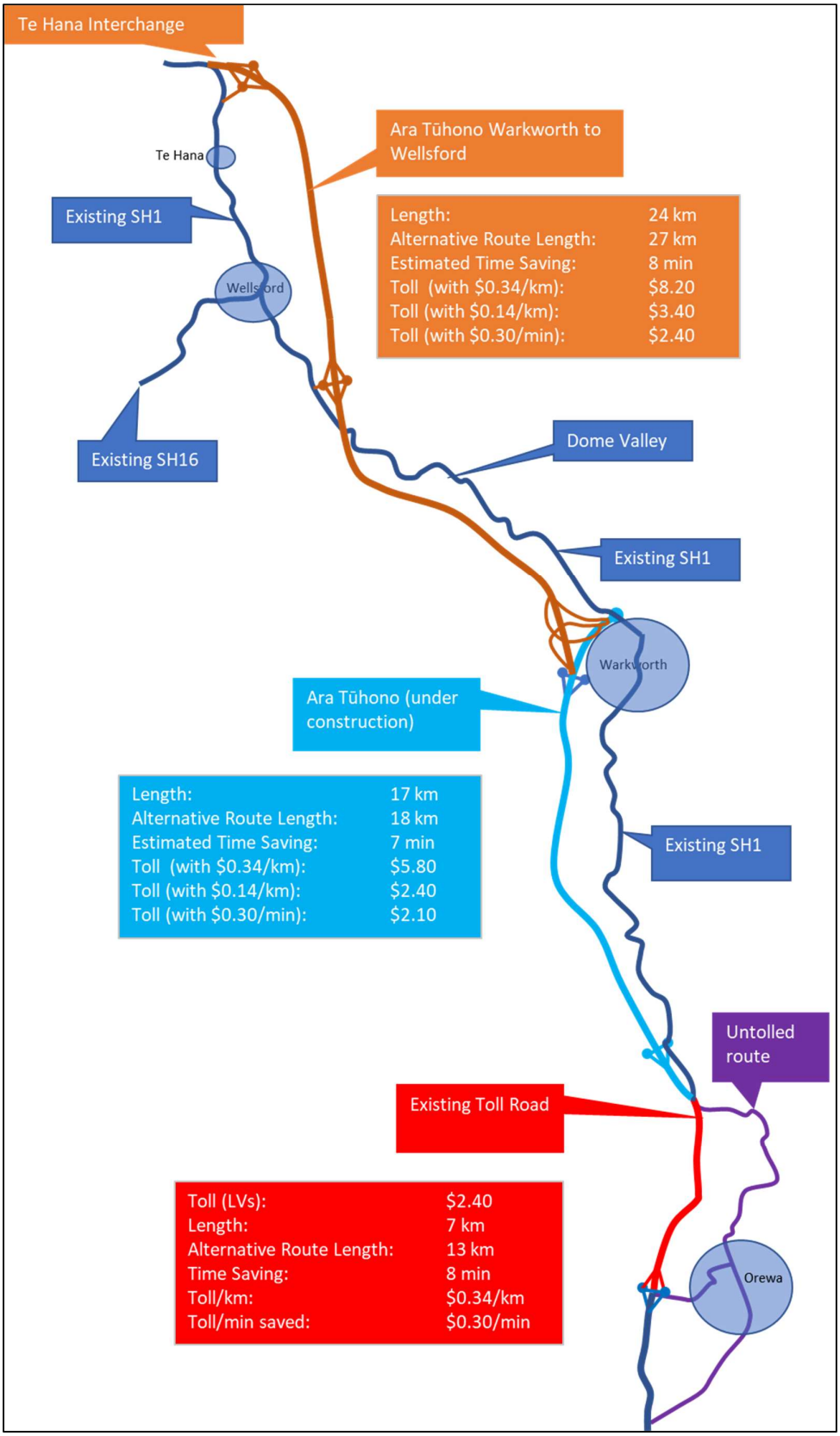


Figure 4-2: Toll Pricing Equivalence

4.4.2 Assumptions and Options

For the purposes of this analysis it is assumed that a consistent approach to existing toll roads would be adopted in this corridor, including:

- All toll collection will use the same kind of free-flow electronic toll gantries
- All toll payment methods will be as per the existing toll roads
- Escalation of tolls will be as per the existing toll roads

This means that the following attributes need to be considered in this corridor:

- The toll collection points
- Any associated discounts or caps where there are multiple collections
- Heavy vehicle differential (although it is assumed it would be in the similar ratio of 2-3 times the light vehicle toll)
- Any time of day differential

4.5 Approach to Corridor Assessment

4.5.1 Corridor Segments

Given the different status of the two section of Ara Tūhono, the assessment has been undertaken in two parts:

- Part A: Assuming only the Puhoi – Warkworth section is in place
- Part B: Assuming the full corridor between Puhoi and Te Hana is operational

Alternative toll strategies for Part A have been assessed initially for a medium-term horizon (2038).

4.5.2 Toll Tariffs

Various levels of tolls have been explicitly tested.

4.5.3 Vehicle and Time of Day Differentials

For consistency with existing toll roads, the following assumptions have been used for initial modelling:

- Consistent 24/7 tolls
- A heavy vehicle differential of 2 times the light vehicle toll

The inter-regional nature of this corridor indicates that time-varying tolls may not be applicable for longer-distance strategic trips, however there could be potential Travel Demand Management (TDM) benefits for tolling some potential commuter movements, such as from Warkworth. This has been considered further in **Section 5.10**.

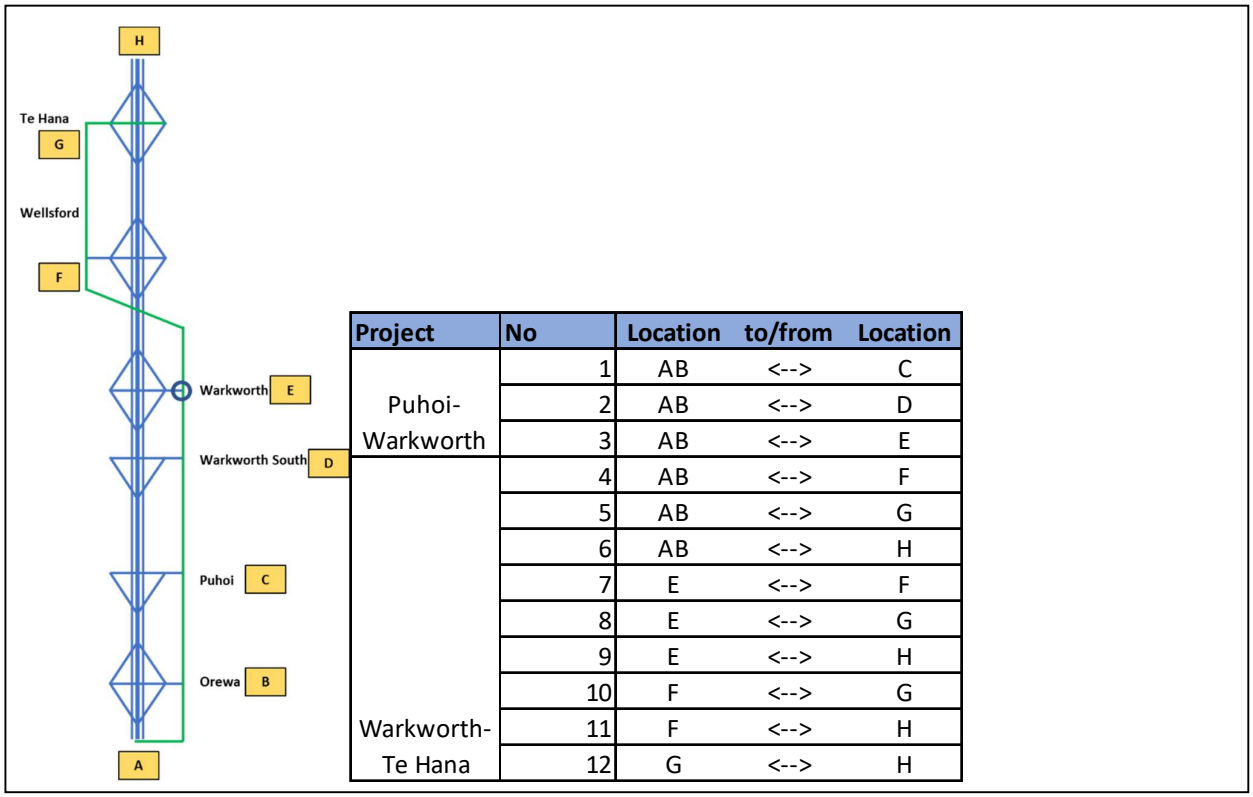
The HCV toll ratio is likely to be driven more by policy decision that technical analysis. While HCVs are likely to have high willingness-to-pay for tolling, they might also be movements that influence other objectives like economic growth in Northland.

4.6 Toll Gantry Location Strategies

4.6.1 Access Points and Movements

The key access points and potential movements using the full corridor are indicated in **Figure 4-3**. In the short term with Ara Tūhono only extended to Warkworth, the location options are simple as there are only three 2-way movements in the corridor. With the full corridor in place, there are 12 possible 2-way movements, making for many more possible combinations of toll collection points.

The following sections consider the potential location strategies for each project.



Project	No	Location	to/from	Location
Puhoi-Warkworth	1	AB	<-->	C
	2	AB	<-->	D
	3	AB	<-->	E
Warkworth-Te Hana	4	AB	<-->	F
	5	AB	<-->	G
	6	AB	<-->	H
	7	E	<-->	F
	8	E	<-->	G
	9	E	<-->	H
	10	F	<-->	G
	11	F	<-->	H
	12	G	<-->	H

Figure 4-3: Corridor Access Movements

4.6.2 Puhoi-Warkworth

The limited number of corridor access points and movements with only this part of the corridor in place allow a preliminary assessment of each possible gantry location, as undertaken below in **Table 4-2**.

Table 4-2: Filtering of Collection Locations (Puhoi-Warkworth)

Potential Collection Point	Discussion	Recommended for Assessment
Existing Toll gantry at Orewa	All users of the new road must also pass through the existing toll gantry. Hence an increased toll at this location could be used as a 'payment' for the new section. This could be very cost-effective and would not impact through traffic, however it would impose an additional cost for users going to the Puhoi area, without any significant benefit. This inequity issue is such that this simple strategy is not recommended. The equity issue could be addressed by including gantries at Puhoi and applying discounts to those using the Puhoi Ramps.	✓ (only in conjunction with gantries at Puhoi ramps)
Ramp gantries at Puhoi	On its own this option would duplicate the function of the existing Orewa gantry. However, it could be used in conjunction with an increased toll at the existing Orewa gantry to apply discounting to Puhoi trips. Functionally this would be similar to simply adding a new mainline gantry north of Puhoi. However, it requires the need to have an enhanced toll transaction system that can identify linked trips, but it could have lower capital costs depending on the relative cost of mainline versus ramp gantries.	✓ (only in conjunction with increased toll at Orewa)
Mainline gantry north of Puhoi	A new mainline gantry could be used to collect tolls on the new road without penalising those only going to Puhoi. This gantry would apply to those using either entry to Warkworth.	✓

Ramp gantries at Warkworth Southern Interchange	This location would not offer any benefit over a mainline gantry south of Warkworth, unless differential tolls are desired between the two access points to Warkworth. There does not appear to be a case for differential access to Warkworth so this location is not recommended in this scenario.	✗
Mainline gantry north of the Warkworth Southern interchange	This location would not offer any benefit over a mainline gantry south of Warkworth, unless differential tolls are desired between the two access points to Warkworth. There does not appear to be a case for differential access, so this location is not recommended in this scenario.	✗

Based on the above initial assessments, two location strategies are proposed for more detailed assessment (see **Figure 4-4**):

- A1: An increase in the tariff at the existing Orewa gantry in conjunction with ramp gantries at Puhoi to allow discounting
- A2: An additional mainline gantry north of Puhoi

Depending on the discounting applied to Puhoi users, these two strategies could be functionally the same for road users, with the differences only in relation to capital and operating costs.

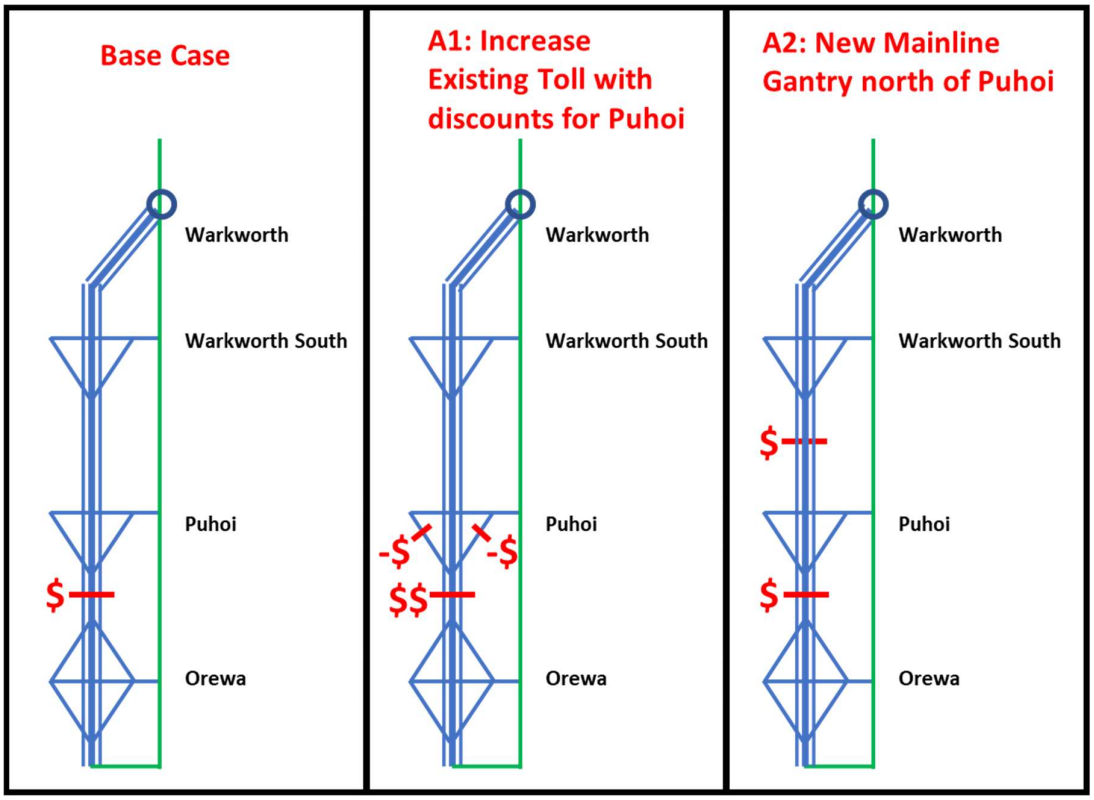


Figure 4-4: Toll Location Options for Puhoi-Warkworth Project

The preliminary toll analysis has assumed that the decrease in toll for the Puhoi ramps is the same as the increase in toll at the existing Northern Gateway Toll Road. Therefore, the modelled results between the two options will be the same. These two options are then differentiated by capital cost, transaction cost and the ability to link the toll gantries to apply a discount for the Puhoi ramps. The complexity of communicating the toll system to users for A1 is an additional differentiator between the two options.

4.6.3 Full Corridor Toll Location Options

The corridor becomes much more complex longer-term with the extension of Ara Tūhono to Te Hana, with multiple access points and many possible movements. Preliminary traffic flow and diversion analysis of each individual section of the corridor has been undertaken to inform the toll strategies in more detail. Prior to that analysis, general types of strategies have been considered as outlined below and illustrated in **Figure 4-5**:

B1. Mainline toll collection between each access point

B2. One Toll for each project

B3. Single closed system tolled at entry

B4. 2-network system (existing and future) tolled at entry

Strategy B3 would likely require a single Order in Council (OIC) for both schemes to be made next year, even though the Warkworth-to-Wellsford component may not be implemented for many years after the Puhoi-to-Warkworth project. This could have risks around acceptability of seeking an OIC for a longer-term project which is yet to even be route protected.

A preliminary assessment of each potential strategy is included in **Table 4-3**, based on the following criteria:

- Indicative gantry costs. This is a simple count of gantries, assuming that a ramp gantry is half the cost of a mainline gantry
- Equity, based on two measures:
  - Number of free-sections
  - Approximates a per-km user-pays system
- Through traffic toll points. This considers how many toll points drivers pass through for a trip between Orewa to Te Hana (the full length of the long-term project).
- Consistent with Short-term strategies (A1/A2 above). This considers if gantries could become redundant or need to be removed.
- The possible strategy for obtaining OIC (i.e. the ability to stage the OIC applications)

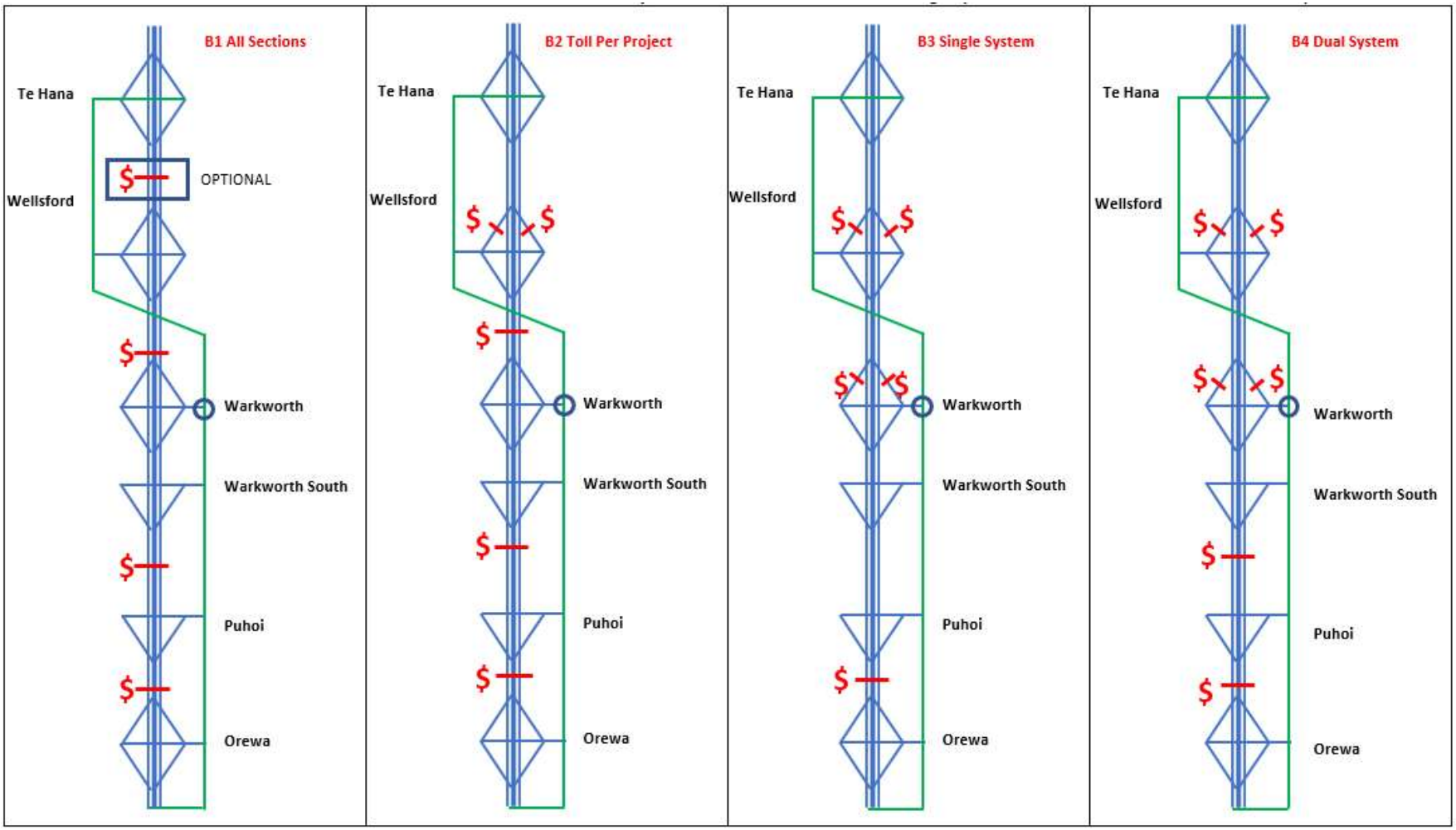


Figure 4-5: Full Corridor Potential Toll Location Strategies

Table 4-3: Preliminary Assessment of Full Corridor Toll Strategies

Criteria	B1 All Sections	B2 Each Project	B3 One System	B4 Dual System
# of new gantries	3 (3 mainline only)	3 (2 mainline + 2 ramps)	2 (4 ramps)	3 (1 mainline, 2 ramps)
Free-sections	none	none	none	None
Approximates per-km tolling	✓✓	✓	××	×
Through traffic toll points (Orewa – Te Hana)	3-4[6]	3	1	2
Consistent with Short-Term	✓	✓	× mainline (A2) ✓Puhoi ramps (A1)	✓
Possible OIC strategy	Staged OICs for each project	Staged OICs for each project	Single OIC for whole corridor	Staged OICs for each project

It should be noted that the above broad strategies are all subject to refinement following initial modelling. For example, the traffic volumes and diversion levels at some locations may mean that some sections do not justify being tolled. This will be explored in initial modelling of each section. However, this preliminary analysis suggests that strategies B3 and B4 are less likely to be considered 'equitable' while strategy B3 is likely to mean the new gantry in the short-term A2 strategy could become redundant (this would not apply to A1). B3 would also require a single OIC for the whole corridor, rather than ability to consider the OICs separately.

Based on this preliminary assessment, the single-system strategy (B3) is not recommended to be assessed further. Strategy B4 will be reviewed after preliminary modelling analysis of other strategies.

[6] Depending on whether there is a toll on the Wellsford to Te Hana section

5 Preliminary Toll Outcomes - Puhoi to Warkworth (2038)

The purpose of this section is to investigate the options and recommend a toll strategy. Refined flow and revenue results are reported later in this report. These preliminary results are all for a 2038 forecast year.

The preliminary modelling results have focused on Puhoi to Warkworth corridor and the year 2038..

Two networks were developed for the forecast year 2038:

- Standard forecast network, including only confirmed projects and design layouts
- Additional scenario to test the impact of proposed southern Warkworth motorway interchange (south facing ramps only)

Early testing of the models indicated delays at the Puhoi interchange priority intersections at high toll levels. Investigation of this resulted in refinement of the model coding (to better reflect the proposed design) and the development of a demand-response process. With these refinements significant delays at the interchange was not noted at the level of tolls tested. Upgrades (such as to roundabouts) could be required if very high tolls were proposed, or if new development occurred in this area.For the volume and revenue, tolls were tested at $0.20 increments, however for the remaining outcome measures, three scenarios were modelled at $2.40, $4.90 and $7.30. The toll tariff at the Northern Gateway Toll Road was assumed to remain at $2.40. Note that all toll tariffs quoted are in $2018.

5.1 Corridor Traffic Flows

Figure 5-1 shows the daily traffic volumes on the toll road and the alternative route for increasing toll tariffs. This graph also shows the current 2018 traffic flow in the corridor for context.

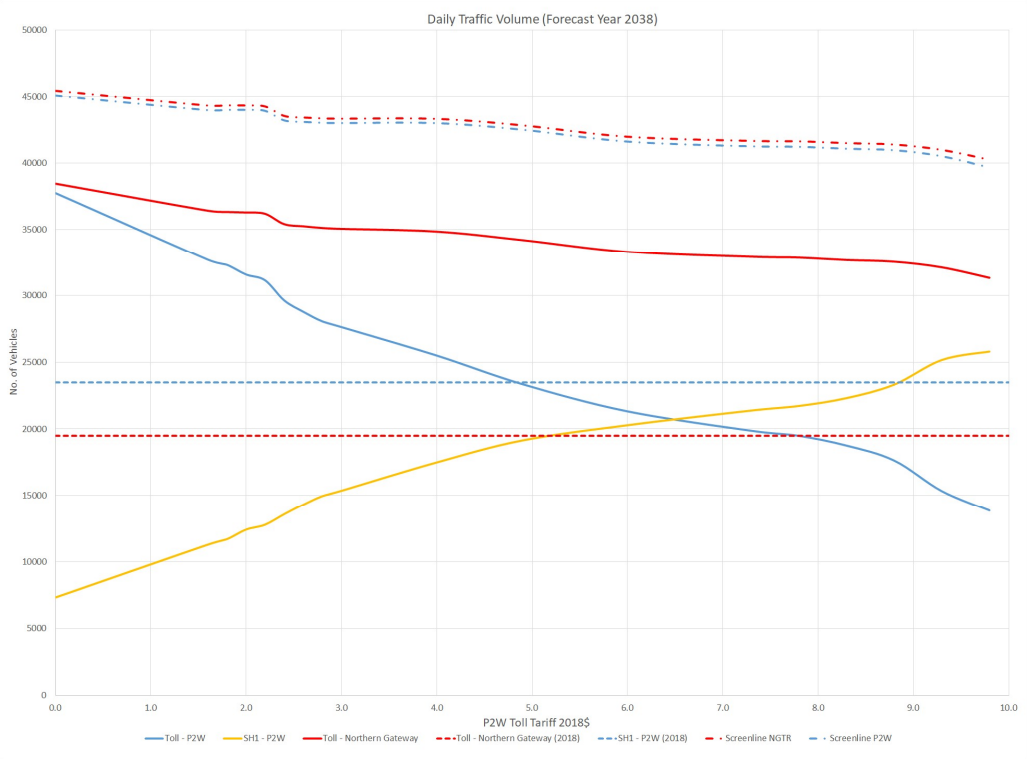


Figure 5-1: Daily Traffic Volume

- At tolls of $6.40 there is a 50-50 split between the corridors
- At $9.00 the volume on the alternative route is matching the current 2018 volumes

- Given the anticipated removal of passing lanes in this corridor, traffic flows below 15,000 on the alternative route would be desirable. This volume is achieved at approximately $2.50
- At $2.40 there is an approximate 65-35 split between the new and old corridor

Tolls in excess of $2.40 would be less desirable.

5.2 Safety

Safety has been measured by determining a crash cost per vehicle kilometres travelled for the existing SH1. The existing road has been divided into eight sectors and the new corridor one sector. The sectors were based on both changes in speed environment and access to the future motorway. The sectors are shown in **Figure 5-3**. Crash data was collected for 5 years to determine the crash rate and therefore the crash cost for each sector. The new motorway had an assumed crash cost per vehicle kilometres travelled based on Auckland motorway crash data averages. The crash cost for each sector is summarised in **Table 5-1**. Additionally, the Economic Evaluation Manual (EEM) requires an adjustment of future predicted crash costs based on a trend of historic crash rates. The 2038 annual vehicle kilometres travelled for each sector have then been determined for each scenario tested and the annual crash cost determined.

Table 5-1: Crash Cost by Sector

Sector	Speeds(km/hr)	2038 Annual Crash Cost (Cents/Veh km) – 2018$
1	>=80	16.4
2	<=60	2.1
2	<80	12.3
2	>=80	6.6
3	<80	8.5
3	>=80	8.5
4	<=60	25.2
4	<80	0.2
4	>=80	8.6
5	<80	9.2
6	<80	0.8
6	>=80	0.8
7	>=80	3.1
8	>=80	3.1
9	<=60	11.3
9	<80	8.5
9	>=80	8.5

Figure 5-2 shows the additional crash cost for each toll tariff level tested compared to the un-tolled scenario. The un-tolled scenario has a total crash cost of $46.5 million per annum:

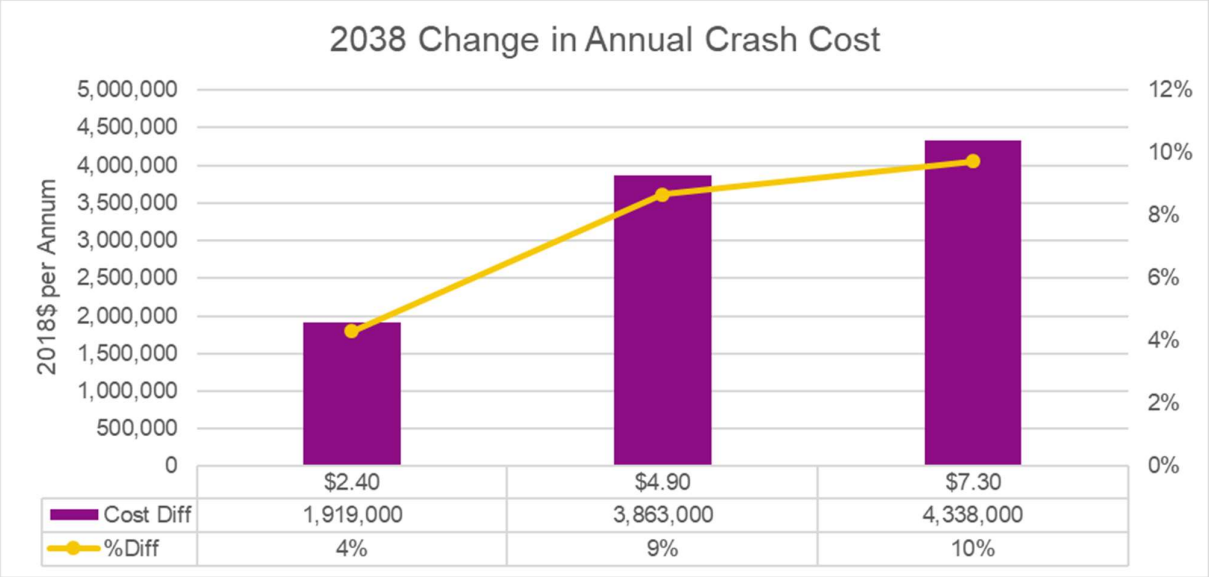


Figure 5-2: Annual Crash Cost

As expected, the annual crash cost increases as the toll tariff increases. As the toll tariff increases, more vehicles use the alternative route. The alternative route has a high occurrence of crashes compared to the anticipated higher safety new motorway, resulting in more crashes per vehicle kilometre travelled and therefore a higher annual crash cost. The increase in crash cost is dampened by the lower total demand at higher toll tariffs due to suppression of trips at higher toll tariffs.

Any tolling diverts traffic to the older, lower standard highway with a potential increase in crash costs. This is offset slightly by the demand response with a lower VKT.

The increase in crash cost at $2.40 is quite modest.

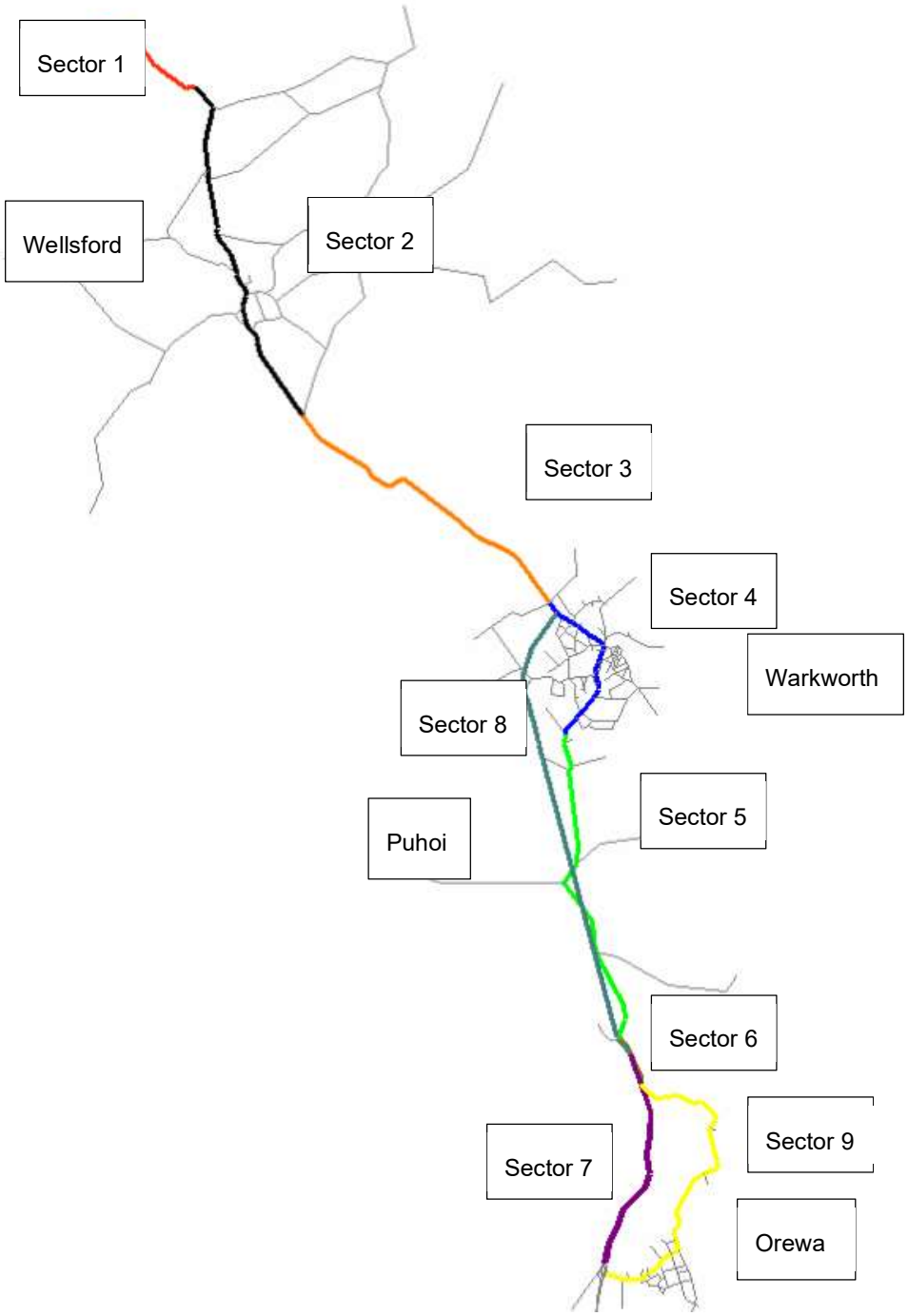


Figure 5-3: Crash Cost Sectors

5.3 Accessibility

5.3.1 Travel Time

The travel time between Orewa to north of Warkworth has been measured for routes using both the toll road and alternative route.

Figure 5-4 and **Figure 5-5** summarise the travel time between each location:

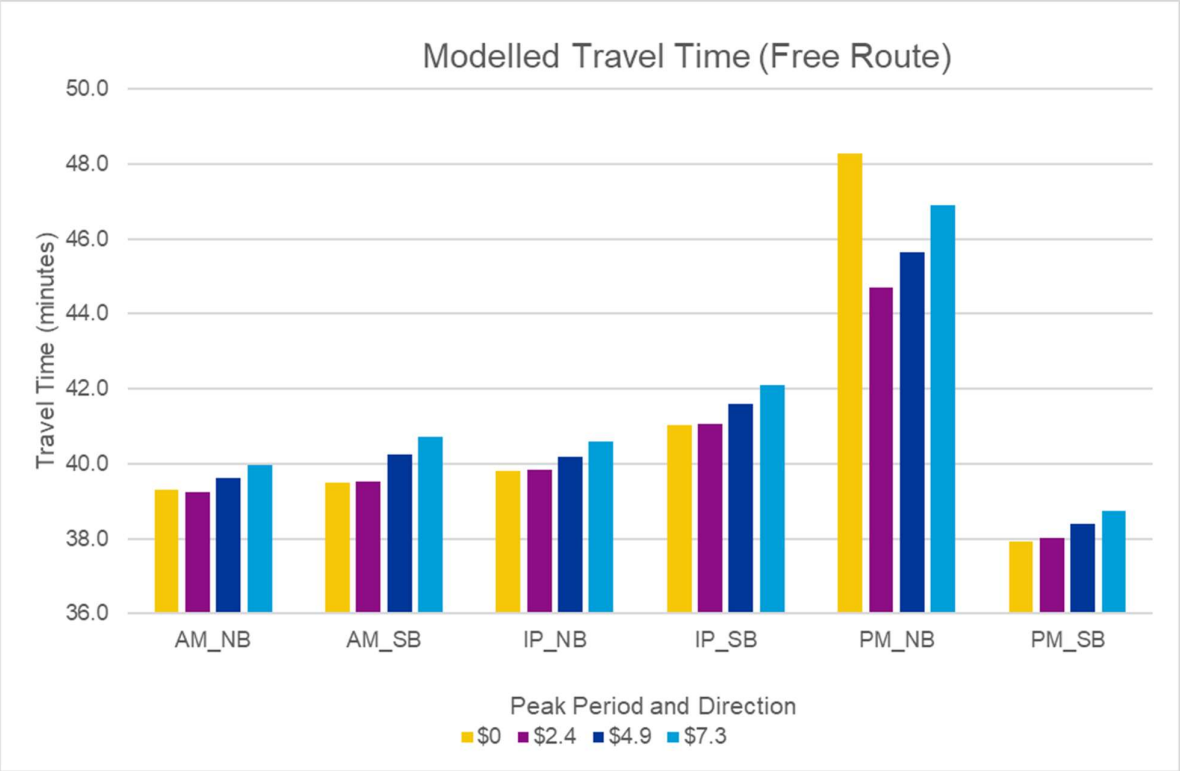


Figure 5-4: Travel Time - Free Route

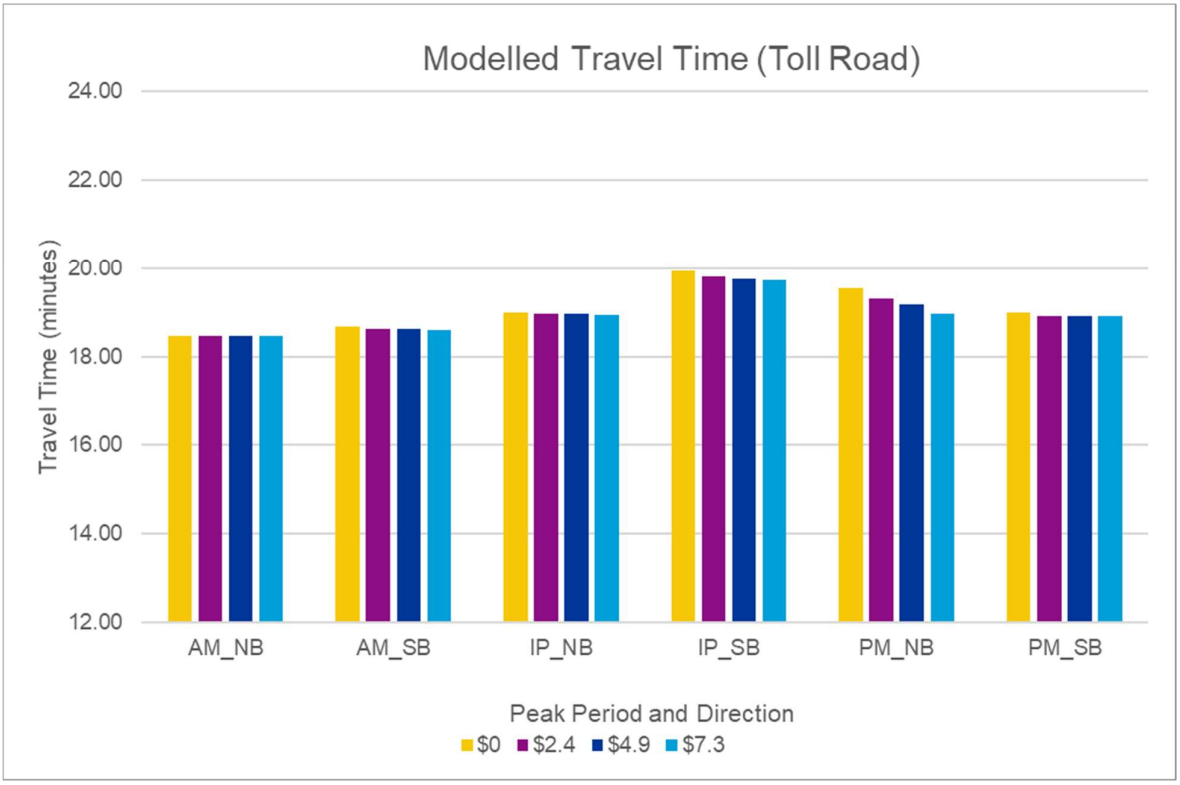


Figure 5-5: Travel Time - Toll Road

- On the toll road, there are generally limited changes in travel time as the toll tariff increases due to the adequate capacity.
- On the free route, the $2.40 toll had minimal change in travel time of less than 0.5 minutes, the $4.90 had slightly higher changes of less than 1.0 minute, while the $7.30 toll had increases of up to 2.0 minutes.
- In the PM peak some reductions in travel time were noted, which were found to be associated with a single issue on Grand Drive. In the un-tolled scenario, there is a higher number of vehicles using Grand Drive heading westbound towards the NGTR, this creates a higher delay for eastbound traffic on Grand Drive due to the delay for right turners. When a toll on the Puhoi to Warkworth motorway is implemented, traffic on Grand Drive westbound decreases, therefore decreasing the delay for eastbound right turners on Grand Drive.

A toll of up to $4.90 is feasible with limited impact on corridor travel time.

5.3.2 Travel Toll Cost

The toll cost for vehicles using the toll road between communities have been summarised in **Table 5-2**. The Northern Gateway Toll Road has been included in the values below and has been assumed to remain at $2.40.

Table 5-2: Travel Toll Cost

Journey	Toll Cost			
	$0.00	**$2.40**	**$4.90**	**$7.30**
Orewa to Puhoi / Puhoi to Orewa	$2.40	$2.40	$2.40	$2.40
Orewa to Warkworth / Warkworth to Orewa	$2.40	$4.80	$7.30	$9.70

For the majority of people who do choose to use the toll road, their cost of travel will generally increase. The overall impact of this will depend on the frequency of their travel.

5.3.3 Mode Share

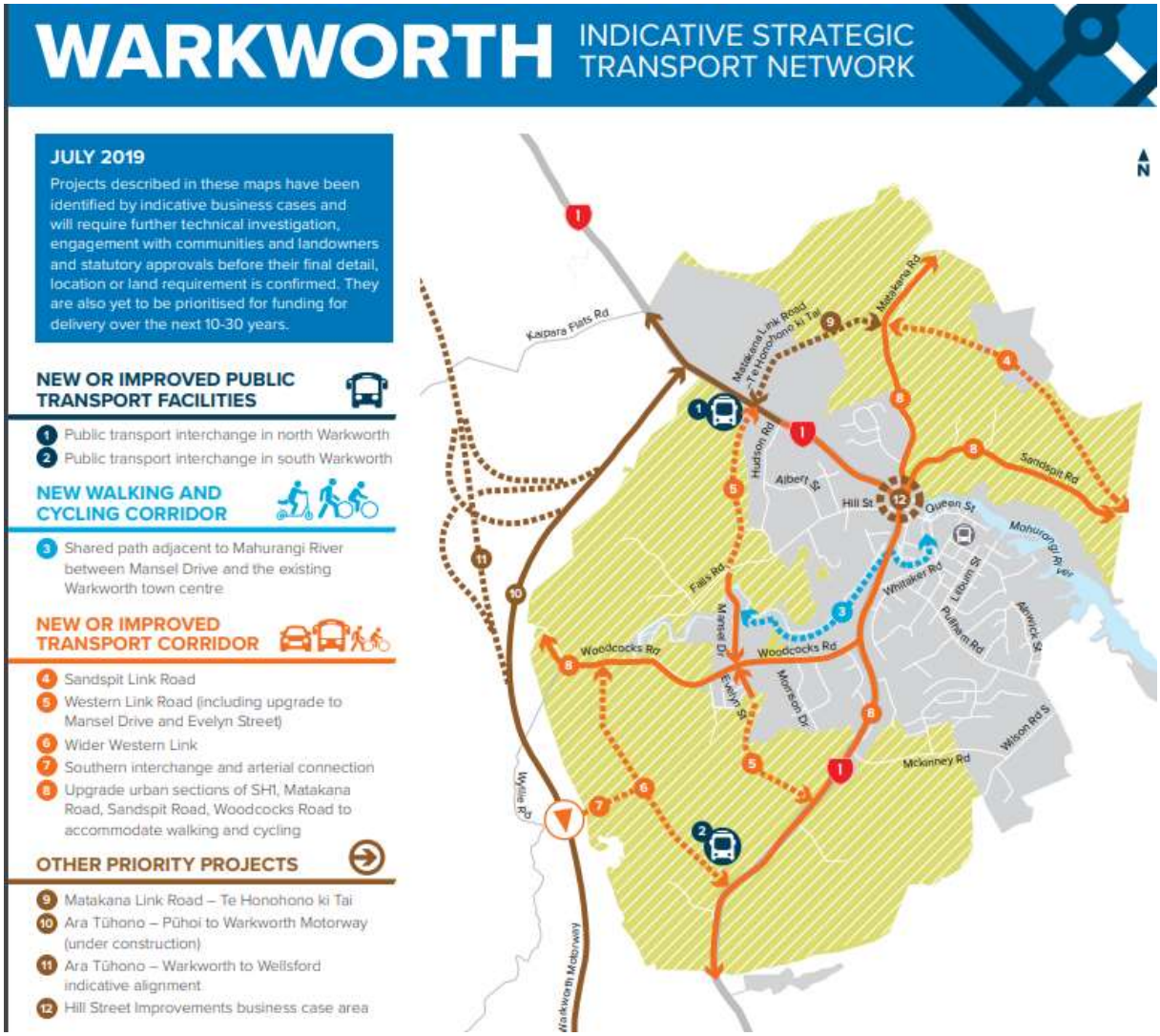
Changes in mode share come directly from the MSM. Running un-tolled and tolled scenarios have a negligible impact on the mode share with less than 100 new public transport trips being made on a daily basis.

5.3.4 Travel Time Consistency

Travel time consistency has been measured by comparing the travel time between each modelled peak, AM, IP and PM, on the toll road and the alternative route. As per the figures above, there aren't strong trends in travel time consistency for tolls less than $7.30

5.3.5 Delay in Warkworth

In this preliminary modelling, no significant increases in delay has been noticed in Warkworth. However, this is dependent on what future Supporting Growth networks are included. The Supporting Growth Alliance (SGA) has identified a recommended transport network to support the planned growth in Warkworth. The proposed network is indicated in the figure below. SGA is focussed on route protection of the proposed corridors, rather than delivery. As such, the specific timing of those projects will depend on other processes, including funding and the programme of re-zoning the land by Auckland Council to allow the planned development. The models have included the planned projects generally to integrate with the currently indicated development timing, however the timing of both the development and the projects remains uncertain at this time.



5.4 Environment

5.4.1 Vehicle Emissions

The NZTA vehicle emissions prediction model (VEPM) has been used to determine the emissions for each toll tariff level tested. The VEPM assumes a vehicle fleet mix[7] and uses the vehicle kilometres travelled to determine the level of emissions.

Figure 5-6 below summarises the emissions for each toll tariff level tested. The graph shows the change in annual vehicle CO2 emissions, both in terms of tonnes and dollars. The total emissions in the un-tolled scenario is 140,000 tonnes, equivalent to approximately $9m.

[7] Vehicle fleet mix available in "Vehicle Emission Prediction Model: VEPM 6.0 update technical report"

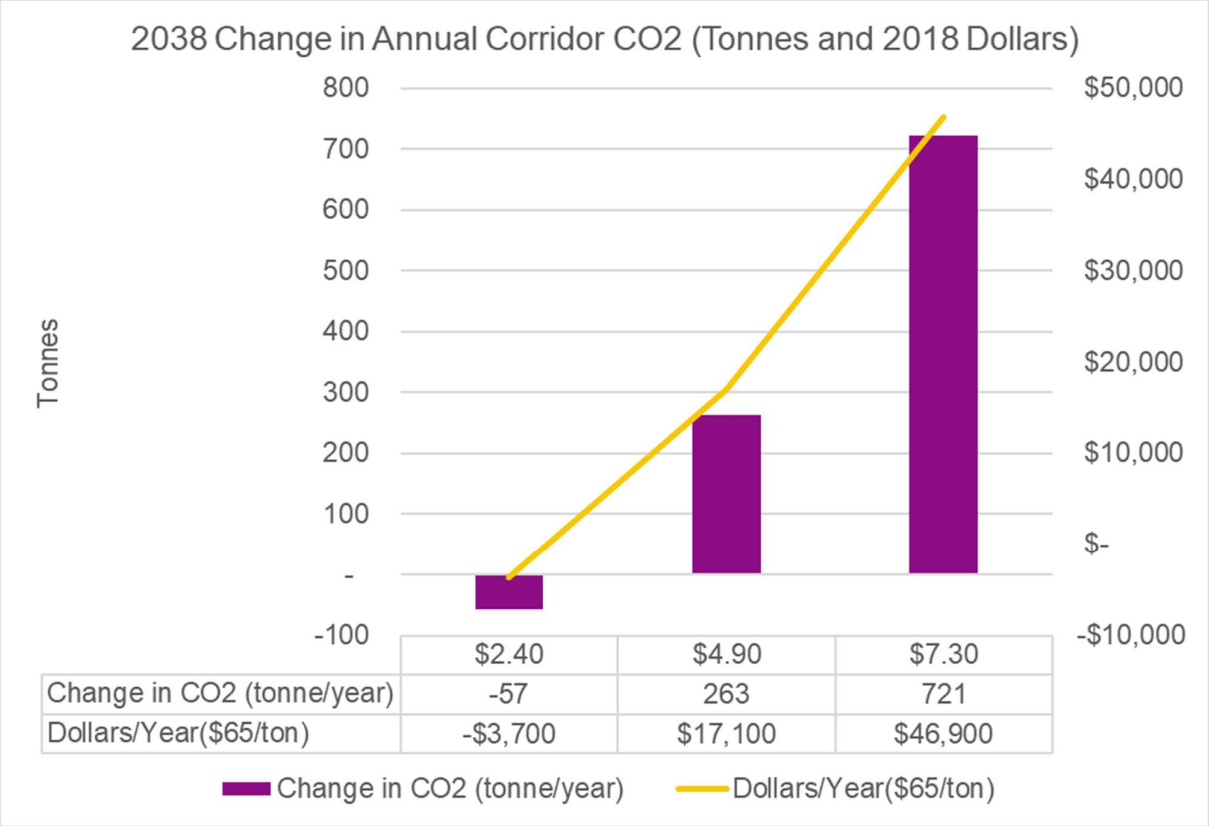


Figure 5-6: Change in Annual Corridor CO2 emissions

It can be seen that C02 is initially lower than the untolled scenario, but increases with the toll tariff, mainly due to the increasing vehicle kilometres caused by vehicles diverting to a longer route. The initial reduction in CO2 is due to the higher emissions caused by higher speed on the toll road, before the increase in vehicles taking a longer route overrides this benefit.

It can be seen that at a $2.40 the emissions are lower than an untolled scenario, however at all toll tariffs the change in CO2 is relatively minor.

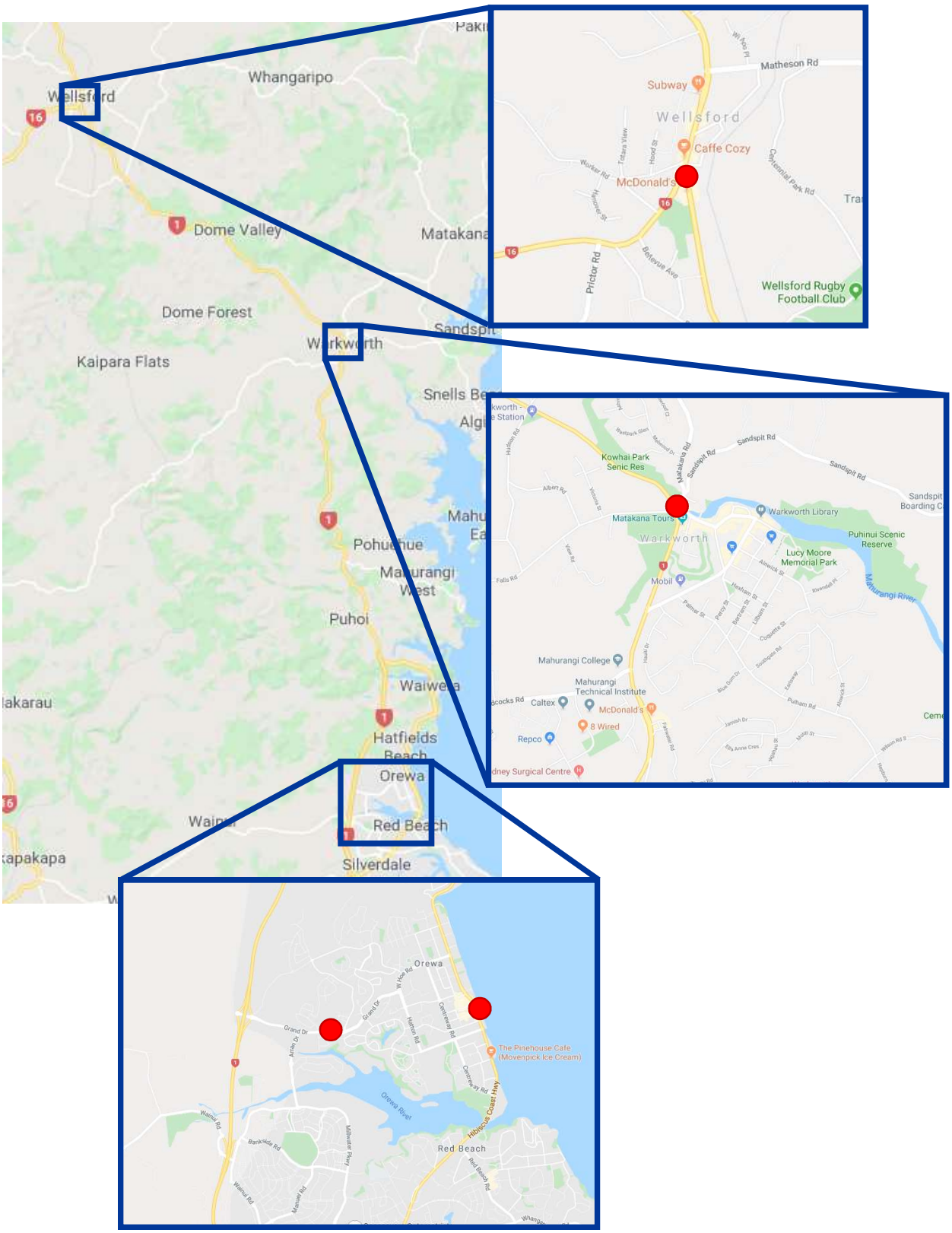


Figure 5-7: Traffic Sensitive Locations

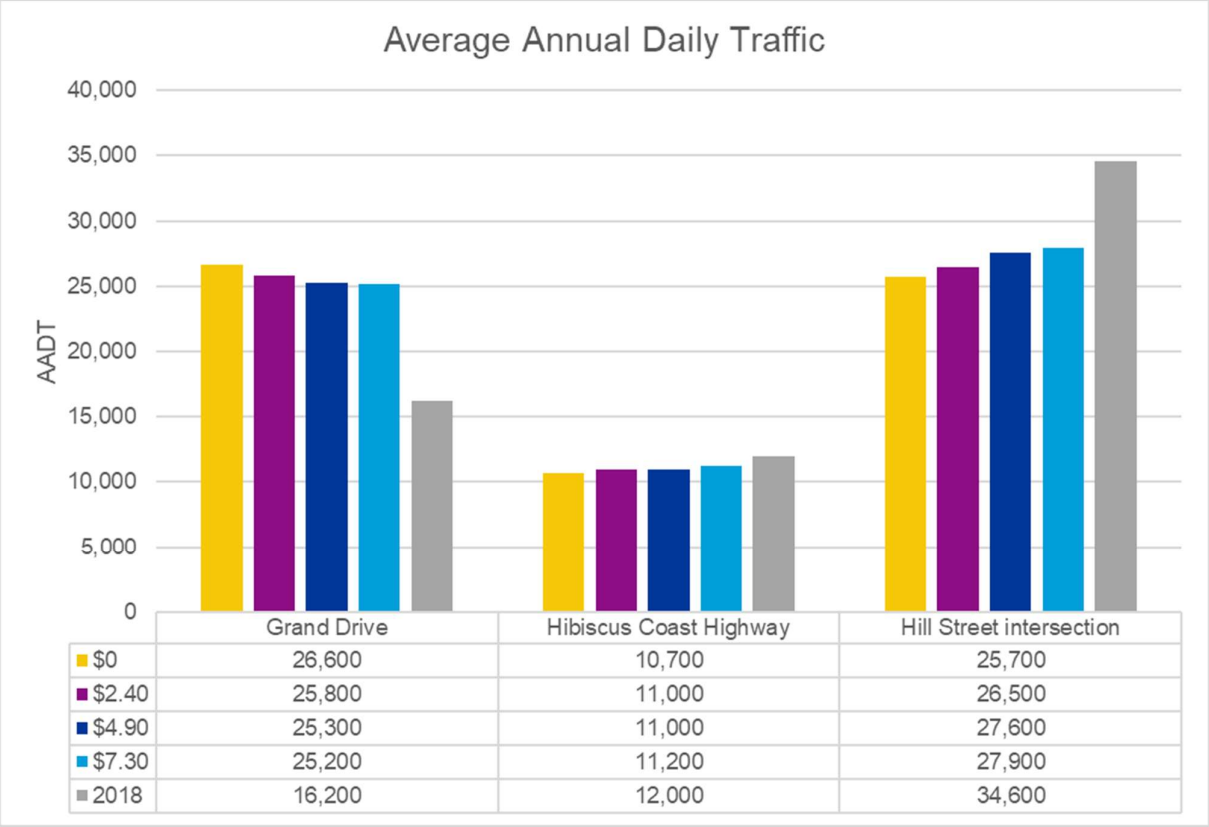
5.4.2 Traffic Volumes in Sensitive Locations

A number of locations have been identified as being sensitive to high traffic volumes. For P2W these include:

- Grand Drive in Orewa
- Hibiscus Coast Highway at the Orewa Town Centre
- Hill Street intersection in Warkworth

The locations are shown in **Figure 5-7**.

Figure 5-8 shows the annual average daily traffic at these locations for the toll tariff levels tested (and includes the 2018 volumes for comparison). The peak periods have a similar pattern as the daily traffic shown.



	Grand Drive	Hibiscus Coast Highway	Hill Street intersection
$0	26,600	10,700	25,700
$2.40	25,800	11,000	26,500
$4.90	25,300	11,000	27,600
$7.30	25,200	11,200	27,900
2018	16,200	12,000	34,600

Figure 5-8: Average Annual Daily Traffic at Key Locations

- Grand Drive in Orewa sees a small reduction in AADT, this is due to reduction in people using the north facing ramps at Grand Drive
- No significant change on Hibiscus Coast Highway in Orewa
- Relatively modest increase in total throughput at the Hill Street intersection in Warkworth. However, it is noted that this remains lower than the 2018 total throughput.

Within the toll values up to $7.30 there are no significant increases in AADT at the key sensitive locations.

5.5 Value for Money

5.5.1 Toll Revenue

Figure 5-9 shows the gross revenue curve on the new toll road and the existing toll road. While **Figure 5-10** shows the combined net revenue for both toll roads. The net revenue is the gross revenue less the transactions costs of $0.70 per vehicle.

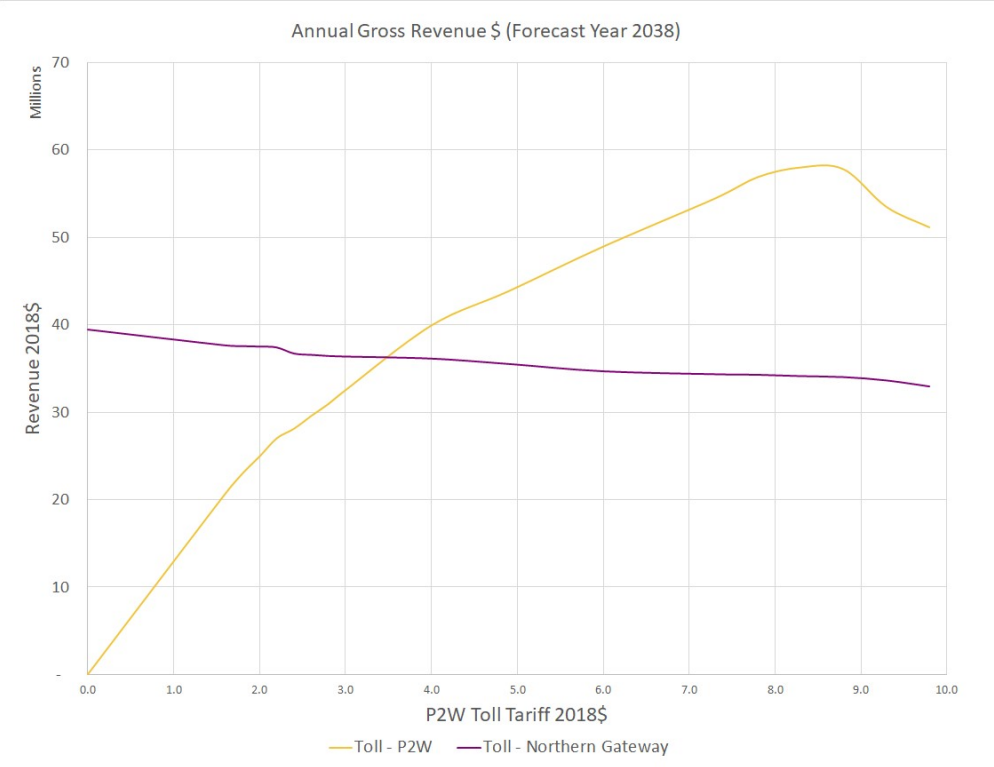


Figure 5-9: Annual Gross Revenue

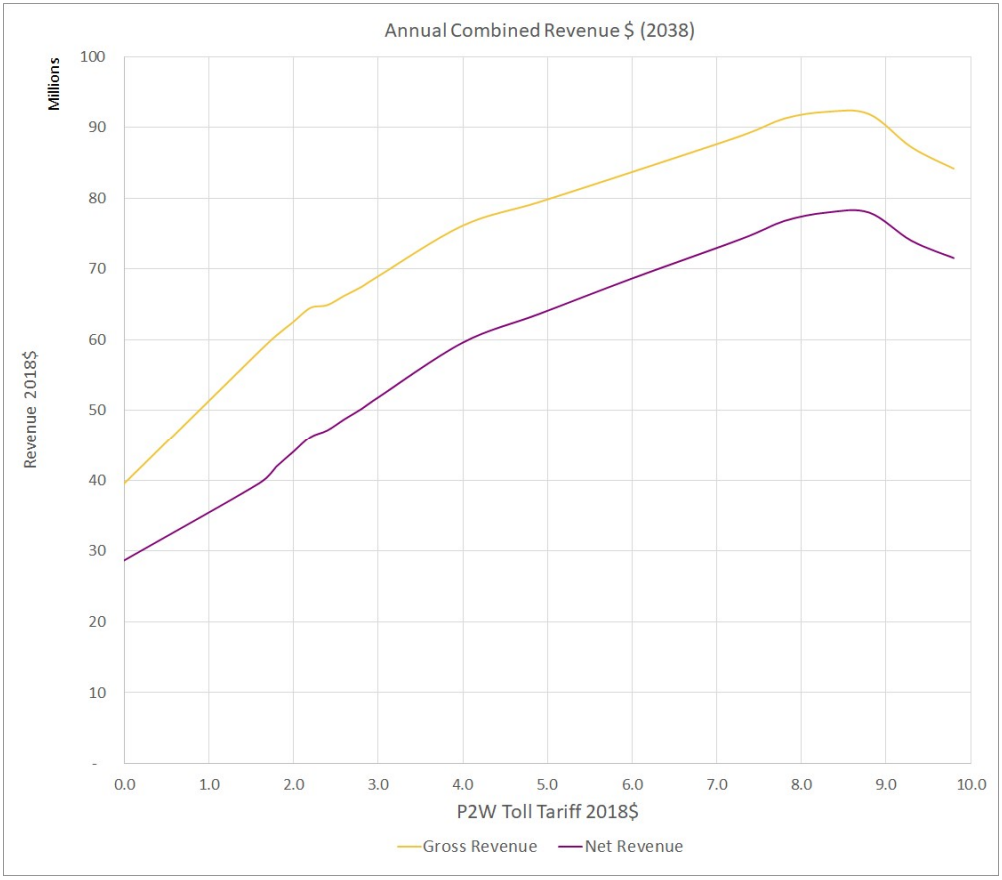


Figure 5-10: Annual Net Revenue

The figure shows that the maximum gross revenue on the new toll road occurs at a toll tariff of $9.00, which is a similar point for the maximum net revenue for both sites combined.

With respect to the new toll road the gross revenue is estimated to be over $65m with an $9.00 toll. At a $2.40 toll this would be $30m per annum gross.

For the combined system tolling at $9.00 on the new toll road could add $59m net revenue. At a $2.40 this increase would be closer to a $21m increase per annum.

It is noted that as the toll tariff on P2W increases, the revenue on the NGTR decreases. The reason for this is that at the Puhoi interchange, there are only south facing ramps, and therefore northbound traffic cannot access the P2W motorway if they are not already on the NGTR. In an untolled scenario northbound users pay the NGTR toll and get the benefit of both the NGTR and P2W. Therefore, users that previously avoided the NGTR are now willing to use the toll road due to the increased benefit it provides. Tolling P2W increases the cost of this route and therefore reduces the volume of traffic on NGTR.

Tolling the new road has the potential to add significant revenue, with a revenue maximising toll potentially as high as $9.00 and generating net increase in revenue of $21 - $59m.

5.6 Equity

Equity has been measured as the 'fairness' of the proposed toll system. Only toll strategies that were deemed equitable were brought forward to the model testing phase. Therefore, in the toll strategy tested, no users are able to use any part of the toll road for free, similarly no users are paying a higher toll while not being able to use the new road. As a result, all users are paying the same toll per kilometre travelled.

Unlike other toll roads, this corridor needs to consider the cumulative effects of up to three adjacent toll roads, with cumulative impacts on inter-regional travel costs, equity with other inter-regional corridors and the uncertainties of motorist's cumulative willingness to pay.

5.7 Influencing Demand

Tolling Ara Tūhono is expected to have negligible impact on mode share in this area but is expected to marginally reduce travel through the corridor.

The increased travel costs could support Auckland Council's designation of Warkworth as a self-sustaining satellite town.

Additionally, introducing road toll could help signal a move towards the ATAP plan to introduce road pricing across the Auckland region.

5.8 Summary of Outcomes

In terms of all the key outcomes, the following is concluded:

- Tolls in excess of $2.40 would be less desirable for balancing traffic volumes between the new and alternative route
- Introducing a toll diverts traffic back to the existing road, with the potential to increase crash occurrence and costs. The increase in crash cost at $2.40 is quite modest
- A toll of up to $4.90 is feasible with limited impact on corridor travel time, however some mitigation might be need on the alternative route at tolls above $2.40.
- Introducing a toll diverts traffic back to a longer route, increasing VKT, however at lower toll tariff levels the increase in VKT is offset by the reduced emissions for lower vehicle speeds. The emissions decrease at $2.40. Emission change at all toll tariffs are relatively minor.
- Even though the flows on the existing State Highway corridor would increase with tolls there are no significant increases in AADT expected at the key sensitive locations in Orewa and Warkworth

- Tolling the new road has the potential to add significant revenue, with a revenue maximising toll potentially as high as $9.00 and generating net increase in annual revenue between $21m ($2.40 toll) and $59m ($9.00)
- Tolling has the potential to marginally influence demand through the corridor mostly through changes in trip distribution and frequency rather than by mode shift. This could also support Auckland Council's designation of Warkworth as a self-sustaining satellite town as well as helping to signal a move towards the ATAP plan to introduce road pricing across the Auckland region
- National equity – adding to Northern Gateway $2.40 would be between $4.40 - $6.40

There is a balancing act between achieving revenue and demand management outcomes against potential detrimental outcomes, especially on crash costs and vehicle emissions. A reasonable balance is considered viable between $2 and $4. However, due to the cumulative toll for through traffic, a toll tariff between $2 and $3 is considered viable. The new toll road also has similar travel time savings relative to the alternative as the existing Northern Gateway toll road.

5.9 Consideration of Vehicle Differentials

The consideration of toll tariff for heavy vehicles against light vehicles is as follows:

- The higher VoT associated with heavy vehicles could mean an ability to generate greater revenue through larger heavy vehicle differentials
- However, high truck tolls could result in more trucks on local roads and have an economic impact on economic growth
- It could be perceived as perverse to have to different heavy vehicle differentials between the existing toll road and new toll road

It is recommended to adopt the same ratio (2) for heavy vehicles as the adjacent Northern Gateway Toll Road.

5.10 Consideration of Time-Varying Tolls

There is potential to apply different toll tariffs by time of day. The following points are considered with respect to this option:

- Consistency of toll would be desirable for driver legibility, operating costs, enforcement etc.
- Pricing commuter peak flows could be beneficial to manage downstream congestion south of Silverdale
- However, as per the figure below the base year flow profile does not have clear commuter peaks which would make setting of discernible and logical points of switching the tolls difficult
- Residential growth in Warkworth could result in greater commuter trips in the southern section potentially making for more distinguished peaks, although this could be moderated by increases in inter-regional traffic
- The models do not indicate significantly different revenue between the AM, Interpeak and PM peak 1-hour models.

In summary, the benefits of time-varying tolls appears to be limited from a revenue perspective do not seem to justify moving away from the simplicity and legibility of a simple 24/7 toll. The benefits of time-varying tolls would therefore be more related to demand management, and considered as part of wider demand management or road-pricing policies in the future. Although not considered justified in this current context, including flexibility in any current Order in Council to allow future consideration of higher tolls in commuter peaks could be useful. For example, via flexibility to allow higher escalation of tolls in 'high demand' periods.

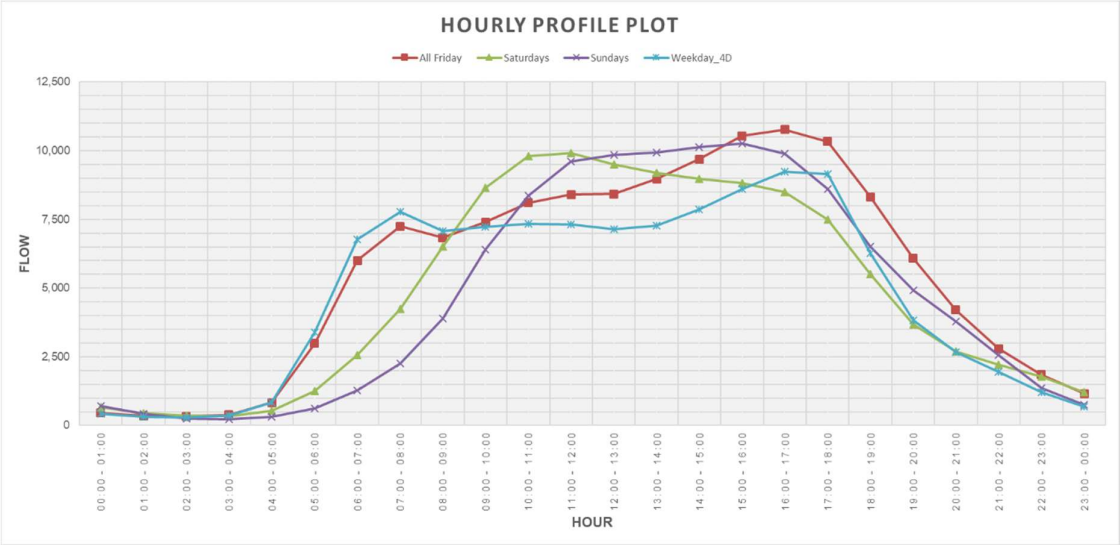


Figure 5-11: Hourly Profile Plot

Therefore, recommended to adopt a 24/7 toll system at least in the short term. Time varying tolling could be considered as part of a wider regional road pricing strategy.

5.11 Consideration of Alternative Toll Gantry Location

As per **Section 4.6.2**, there is an alternative toll strategy involving ramp gantries at Puhoi rather than a mainline gantry (but with an increase in the existing Northern Gateway toll tariff). For equity reasons it is assumed that users of the Puhoi ramps would be identified through the toll system and have their toll discounted to only the original Northern Gateway toll. Under this strategy, usage is expected to be as per the strategy assessed above with the only differences being capital and transaction costs. Estimates from NZTA suggest two ramp gantries could be similar in capital cost as a single mainline gantry. Therefore, the only difference with this strategy would be in the changes in transaction costs. There would be savings in transaction costs from using the existing Northern Gateway gantry, however this could be offset by the need for processing linked trips. At a toll of $2.40, the annual transaction cost would be $2.6m for two ramp gantries at Puhoi and $8.2 for a mainline gantry north of Puhoi. Therefore, assuming that the transaction cost per vehicle remains at $0.70, there would be a saving of $5.6m per year in 2038. The current system cannot process linked / discounted trips, so it is uncertain whether the transaction cost would remain at $0.70.

This discounting strategy would be more difficult to communicate to travellers and would therefore be perceived by the public as more complex and harder to understand. However, there is potential for reduced transaction cost of $5.6m per year in 2038. As such, this alternative strategy is recommended, if there is the ability to link trips and the capital cost of a ramp gantry is less than half a mainline gantry.

5.12 Recommended Short-Term Strategy

The recommended toll strategy for the Puhoi to Warkworth is as follows:

- Two ramp gantries at the Puhoi south facing ramps (subject to confirmation of transaction cost of linked trips)
- A 24/7 toll
- Light vehicle toll of between $2 and $3 and a heavy vehicle toll between $4 and $6

6 Modelling of Longer-Term Scenario – Warkworth to Wellsford

The longer-term scenario includes the Warkworth to Wellsford section of Ara Tūhono. The Warkworth to Wellsford project is not a confirmed project, and therefore the timing and certainty of it is unknown. As a result of this, preliminary testing has been done for 2048.

Initial analysis of the forecast traffic flows and selected toll strategy tests was undertaken to refine the preferred toll gentry location.

As discussed earlier in **Section 4.6.3**, four potential toll location strategies were identified.

Strategy B1

This strategy has mainline toll gantries on the two main sections: Warkworth-Wayby Valley plus Wayby Valley-Te Hana. Although the traffic flows on those sections is high (40,000 and 34,500 respectively in 2048), the cumulative effect of tolls in the corridor becomes very high. For example, assuming $2.40 tolls at both the existing gateway toll location and on the Puhoi-Warkworth project gives $4.80 just to Warkworth. Adding two additional mainline gantries of even only $2 each takes the full-corridor toll to $8.80. The toll at the two gantries on WW2W could be reduced, however the high capital and transaction costs for the two gantries makes lower tolls less worthwhile.

Therefore, a B1 strategy with two mainline toll gantries is not preferred due to the high cumulative toll on the corridor. Subsequently a test was undertaken with only a single mainline gantry between Warkworth and the Wayby Valley interchange. The estimated 2048 traffic flows on the mainline and alternative route via Dome Valley are shown in **Figure 6-1**). This test showed very little diversion of through traffic to/from south of Warkworth, but significant diversion of traffic between Warkworth and the north. A high proportion of that traffic travelled through Dome Valley to then enter the motorway via the Wayby Valley interchange.

Therefore, the B1 strategy was considered suitable with only a single mainline gantry. However, this was expected to have high diversion of Warkworth traffic to the Wayby Valley interchange (from their untolled level of 140 vpd to some 3,000 vpd) and have a lower perceived equity with some users of the northern section to Te Hana being untolled.

Based on the existing flows through Dome Valley of some 11,500 vpd, a target maximum flow in 2048 was set at 12,000 vpd. This flow is expected at a toll of some $1.80.

Tolls below $1 would not be worthwhile given the $0.70 transaction cost, so a lower-bound toll of $1.20 is suggested. A toll in the range $1.20-$2.00 is therefore recommended north of Warkworth.

Assuming $2.40 at each of the Gateway and proposed Puhoi tolls, this would give full-corridor tolls of between $6 and $6.80.

Strategy B2

This strategy would be similar to B1 but with the addition of tolls on the north-facing ramps at Wayby Valley. This strategy would seek to address the diversion of Warkworth traffic to Dome Valley and the Wayby Valley interchange and would also provide greater equity with the use of the section to Te Hana also paying tolls. Initial tests assumed the same toll on the ramps as on the mainline north of Warkworth. This showed high diversion from the Wayby Valley ramps so the ramp tolls were then set at half the rate of the mainline toll. The resulting estimated traffic flows on the Mainline and in Dome Valley are shown in **Figure 6-2** This indicated marginally higher flows retained on the mainline, but also significant reduction in flows at Wayby Valley (down to some 100 vpd). It also indicated an increase in traffic through Wellsford as some traffic avoided the new road altogether.

Although the ramp tolls at Wayby Valley were intended to mitigate the diversion from the Warkworth ramps, the resulting very low flows on Wayby Valley would mean that the such tolling would not be worthwhile (it would be more cost effective to simply not construct the ramps at Wayby Valley).

Subsequently, the B2 Strategy with its additional ramp access tolls at Wayby Valley were not considered worthwhile or justified.

Strategy B3

As noted earlier, this strategy adds ramps access tolls but no additional toll for through traffic. This strategy would not be consistent with the strategy recommended for the P2W project and would raise only very low additional revenue. Hence this strategy was not considered further.

Strategy B4

This strategy only tolled north-facing ramps at Warkworth and Wayby Valley. This addressed equity effect with all users of the corridor paying and does not add an additional toll for through traffic (over that recommended at Puhoi). However, testing showed that this strategy would have very high capital costs with 4 ramp gantries being required, yet would generate very little revenue due to the low ramp flows.

See **Figure 6-3**.

Summary of Initial Testing:

Based on the long-term testing and analysis, a single mainline gantry north of Warkworth would be the recommended strategy for this project, with a toll between $1.20 and $2.00.

Key outcomes for this suggested strategy were assessed with representative tolls as follows:

- $2.40 at the existing Northern Gateway
- $2.40 at a mainline gantry north of Puhoi
- $1.20 at a mainline gantry north of Warkworth

The same outcome measures have been used in testing the longer-term scenario as the initial Puhoi to Warkworth testing.

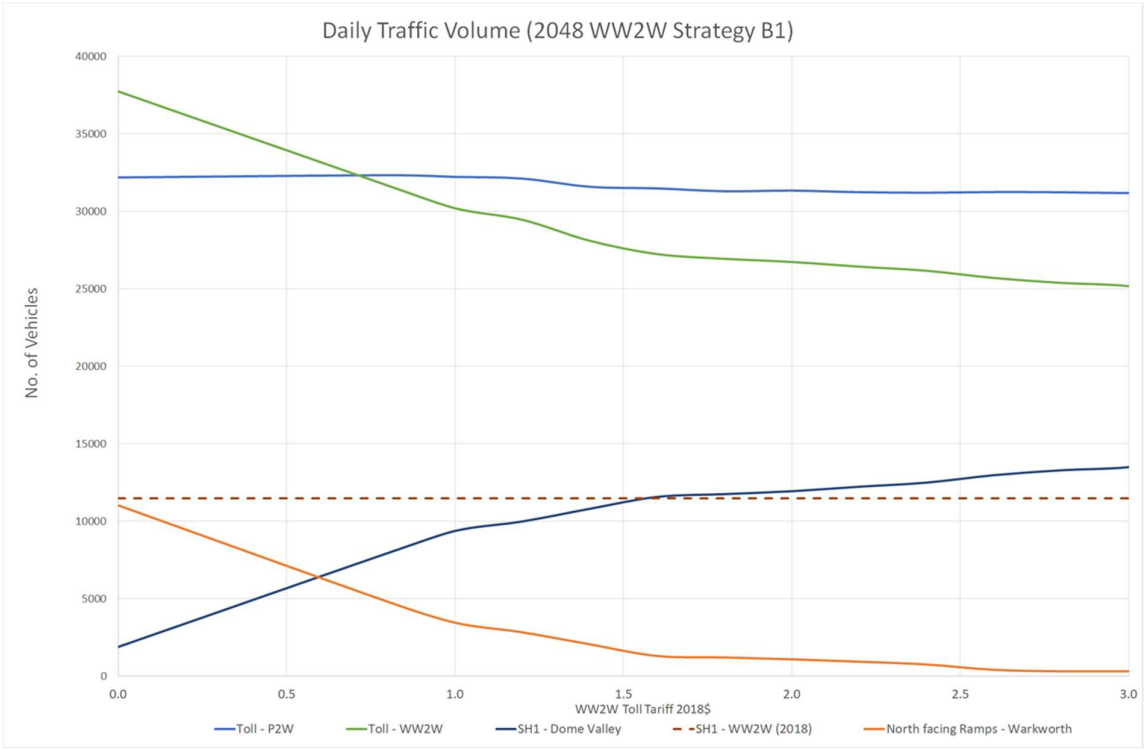


Figure 6-1: Daily Traffic Volume (2048 Strategy B1)

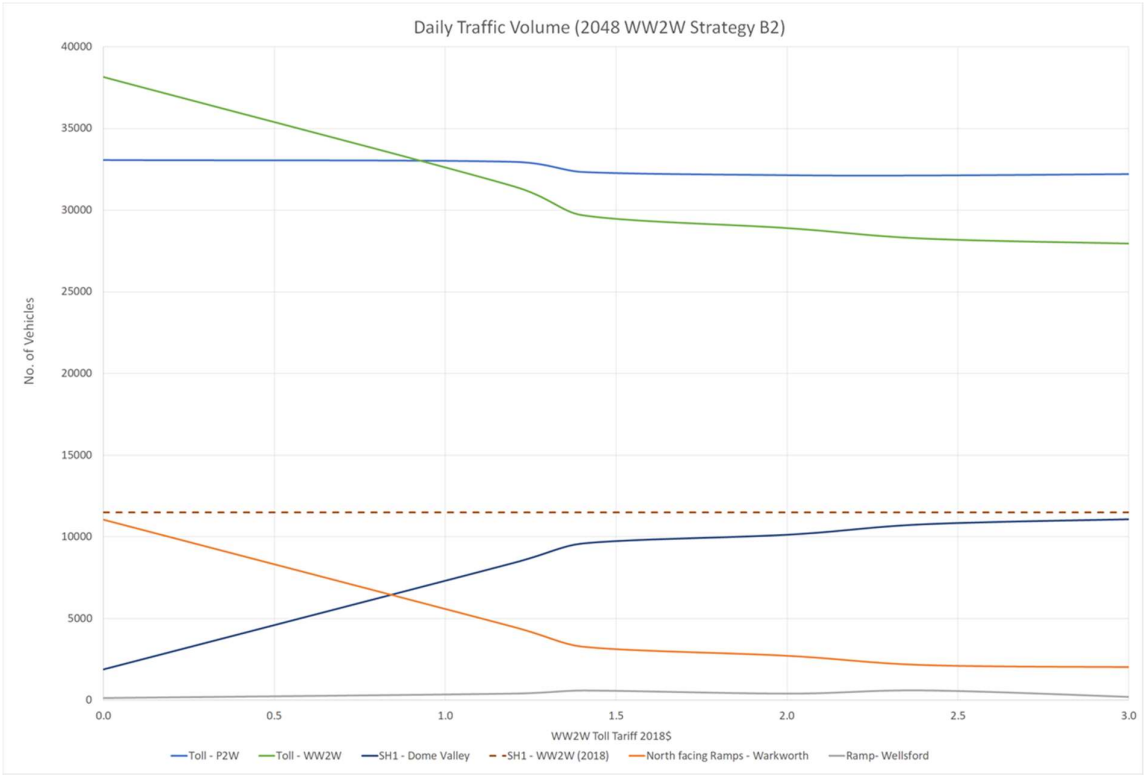


Figure 6-2: Daily Traffic Volume (2048 Strategy B2)

Figure 6-3: Daily Traffic Volume (2048 Strategy B4)

6.1 Corridor Traffic Flows

Figure 6-4 shows the daily traffic volumes on the Warkworth to Wellsford toll road and the alternative route for each toll tariff tested and the un-tolled scenario. The volumes on the Puhoi to Warkworth section and alternative route south of Warkworth are also shown, as well at the 2018 SH1 Warkworth to Wellsford volumes.

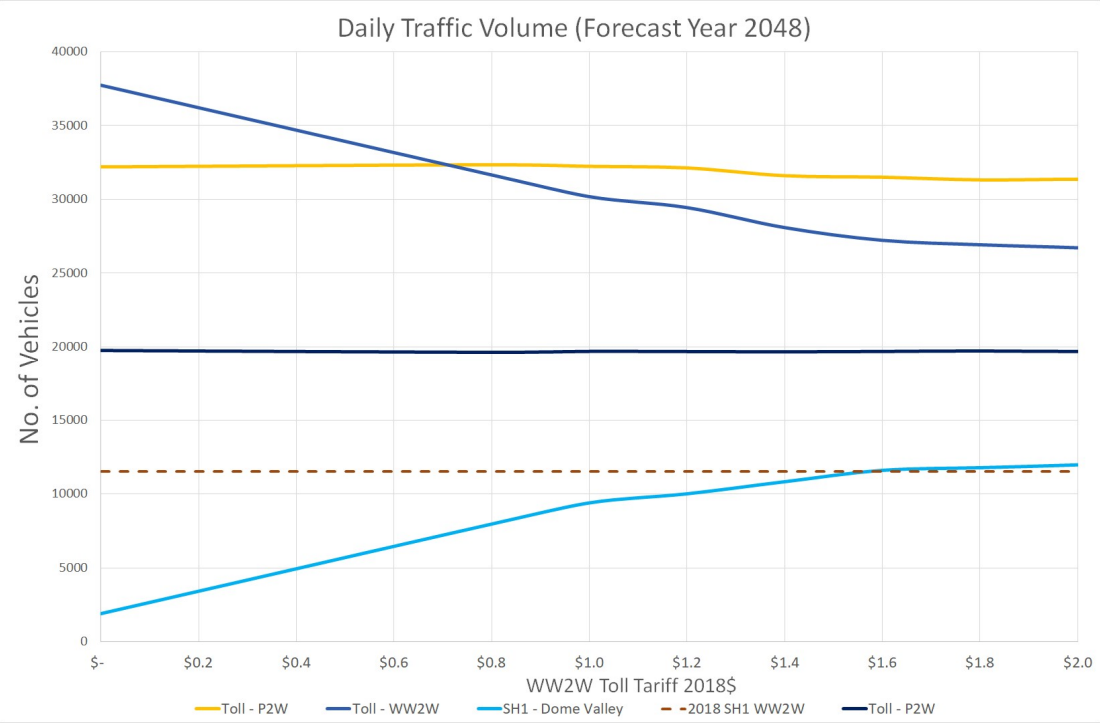


Figure 6-4: 2048 Daily Traffic Volume

- At $1.70 the volume on the alternative route is matching the current 2018 volumes
- Traffic flows below the approximately 12,000 vpd currently on this section of existing road would be desirable, representing a reasonable balance between safety and level of service and utilisation of the motorway
- At $1.20 there is an approximate 75-25 split between the new and old corridor between Warkworth and Wellsford

6.2 Safety

The additional crash cost for the $1.20 toll tariff is approximately $1.3m in 2048. This is an increase of 3.4% on an un-tolled crash cost of $41.4m. This is a modest increase in crash cost.

The increase in crash cost at $1.20 is quite modest.

6.3 Accessibility

6.3.1 Travel Time

The travel time between Warkworth to Te Hana has been measured for routes using both the toll road and alternative route.

Figure 6-5 and **Figure 6-6** summarise the travel time between each location:

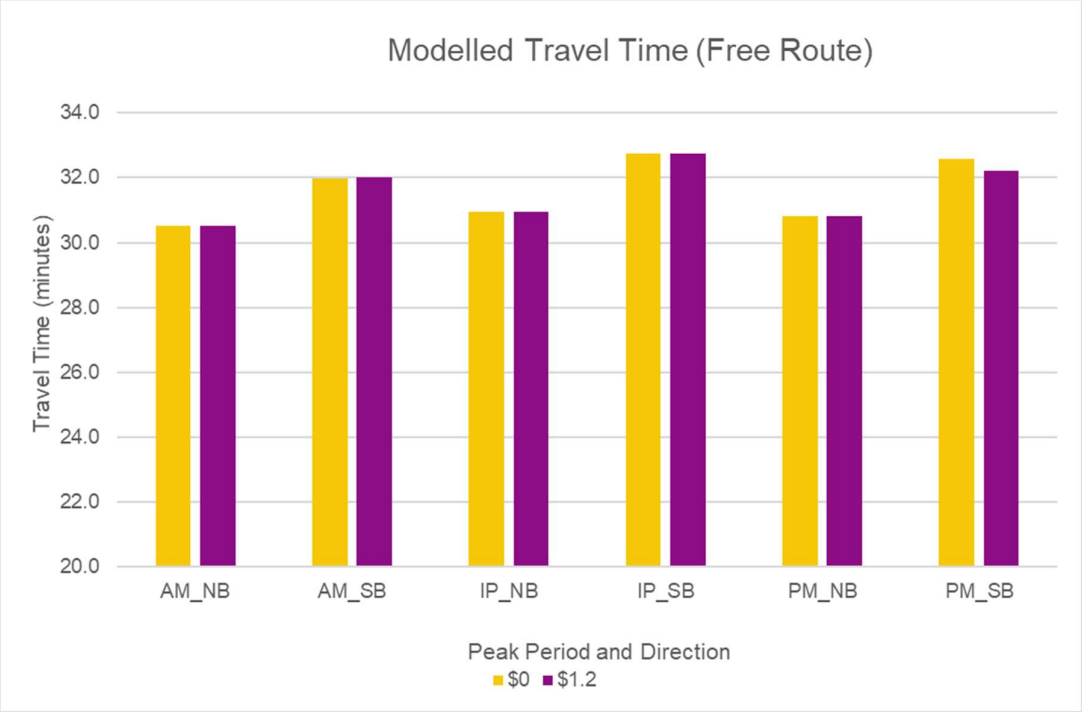


Figure 6-5: Free route travel time (Warkworth to Te Hana)

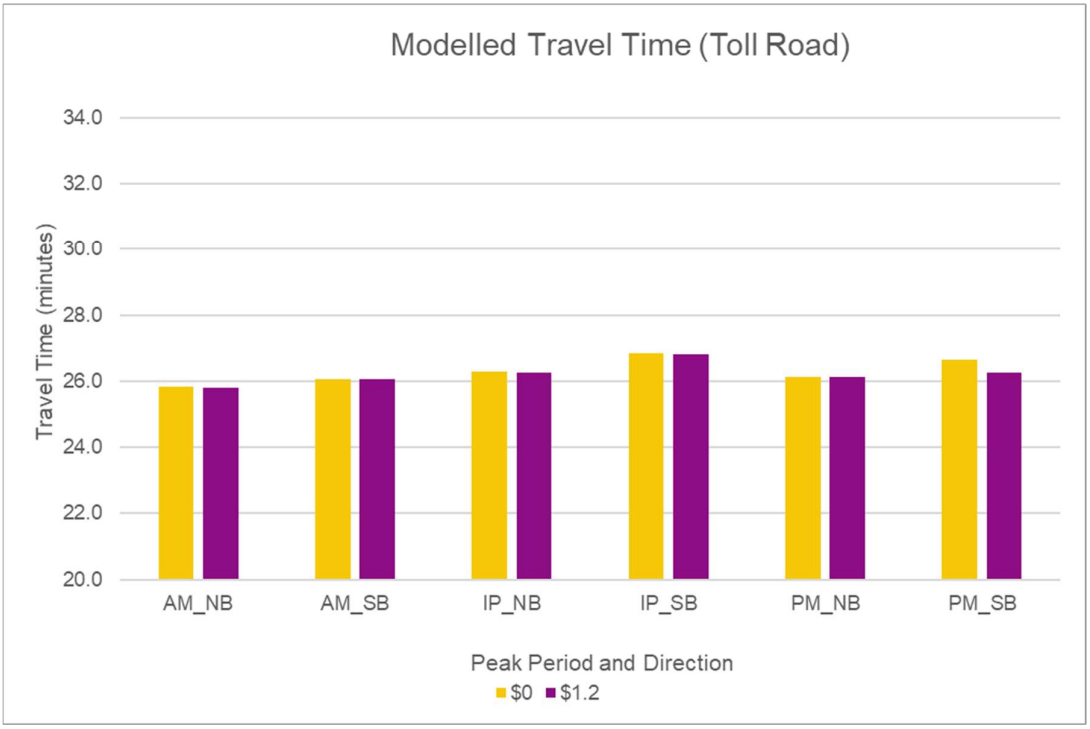


Figure 6-6: Toll road travel time (Warkworth to Te Hana)

- On the toll road, there are generally limited changes in travel time as the toll tariff increases due to the adequate capacity
- The free route also sees limited changes in travel time between the untolled and the tolled scenario

6.3.2 Travel Toll Cost

The toll cost for vehicles using the toll road between communities has been summarised in **Table 6-1**. The Northern Gateway Toll Road has been included in the values below and has been assumed to remain at $2.40, with the Puhoi to Warkworth toll also remaining at $2.40.

Table 6-1: Travel Toll Cost

Journey	Toll Cost	
	$0.00	**$1.20**
Orewa to Puhoi / Puhoi to Orewa	$2.40	$2.40
Orewa to Warkworth / Warkworth to Orewa	$4.80	$4.80
Warkworth to Wellsford / Wellsford to Warkworth	$0.00	$1.20
Orewa to Te Hana / Te Hana to Orewa	$4.80	$6.00

For the majority of people who do choose to use the toll road, their cost of travel will generally increase. The overall impact of this will depend on the frequency of their travel.

6.3.3 Mode Share

Changes in mode share come directly from the MSM. Running un-tolled and tolled scenarios have a negligible impact on the mode share with less than 100 new public transport trips being made on a daily basis.

6.3.4 Travel Time Consistency

Travel time consistency has been measured by comparing the travel time between each modelled peak, AM, IP and PM, on the toll road and the alternative route. As per the figures above, there aren't strong trends in travel time consistency for tolls of $1.20.

6.3.5 Delay in Warkworth

There is limited change in delay within Warkworth due to tolling of the Warkworth to Wellsford motorway.

6.4 Environment

6.4.1 Vehicle Emissions

The CO2 for the $1.20 toll tariff decreases by 144 tonnes/year, or $9,400 per year in 2048. This is a minor change in emissions. The un-tolled total vehicle emissions is 85,160 tonnes, which is equivalent to $5.5m.

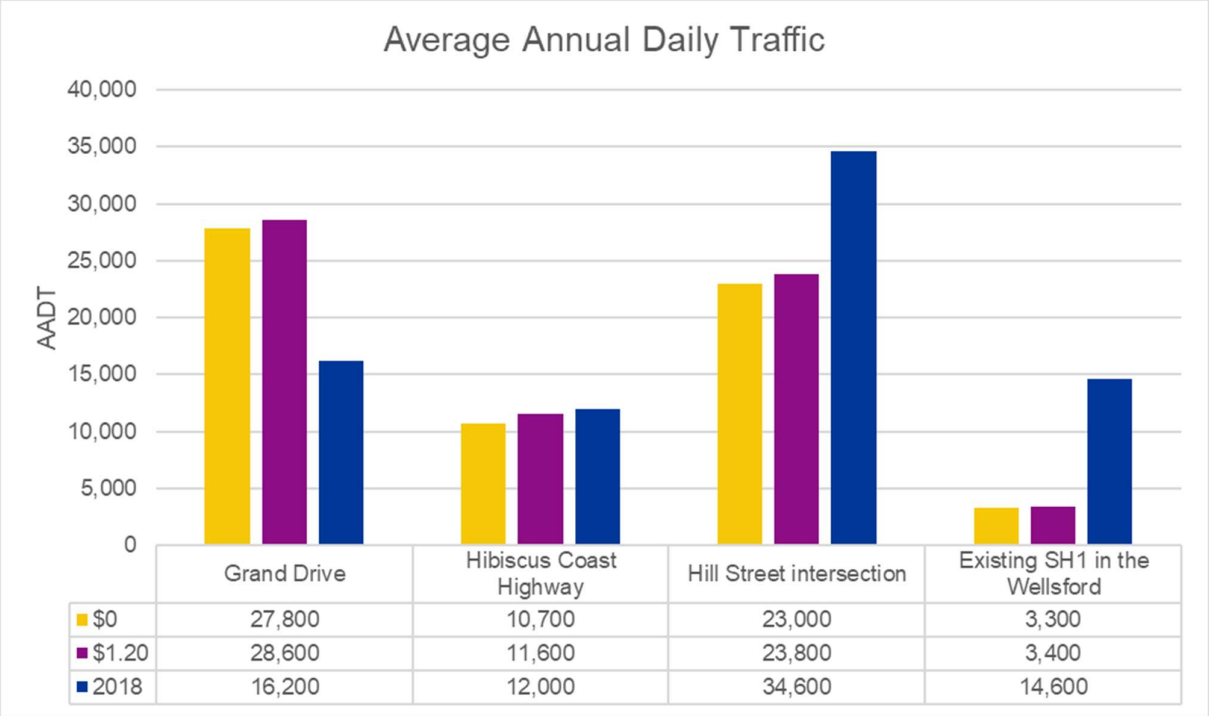
6.4.2 Traffic Volumes in Sensitive Locations

A number of locations have been identified as being sensitive to high traffic volumes. These include:

- Grand Drive in Orewa
- Hibiscus Coast Highway at the Orewa Town Centre
- Hill Street intersection in Warkworth
- Existing SH1 in the Wellsford Town Centre

The locations are shown in **Figure 5-7**.

Figure 6-7 shows the annual average daily traffic at these locations for the toll tariff levels tested:



	Grand Drive	Hibiscus Coast Highway	Hill Street intersection	Existing SH1 in the Wellsford
$0	27,800	10,700	23,000	3,300
$1.20	28,600	11,600	23,800	3,400
2018	16,200	12,000	34,600	14,600

Figure 6-7: AADT at Sensitive Locations - 2048

- Grand Drive shows a slight increase in traffic with the $1.20 toll
- No significant change on Hibiscus Cost Highway in Orewa
- No significant change in the total throughput at the Hill Street intersection in Warkworth
- Wellsford town centre sees a slight increase in AADT as the toll tariff increases
- Both the Hill St intersection throughput and existing SH1 at Wellsford volume are lower than the 2018 volumes

6.5 Value for Money

6.5.1 Toll Revenue

Figure 6-8 shows the net revenue for 2048 for three toll tariff levels for the Warkworth to Wellsford toll road, $0, $1.20 and $2.00.

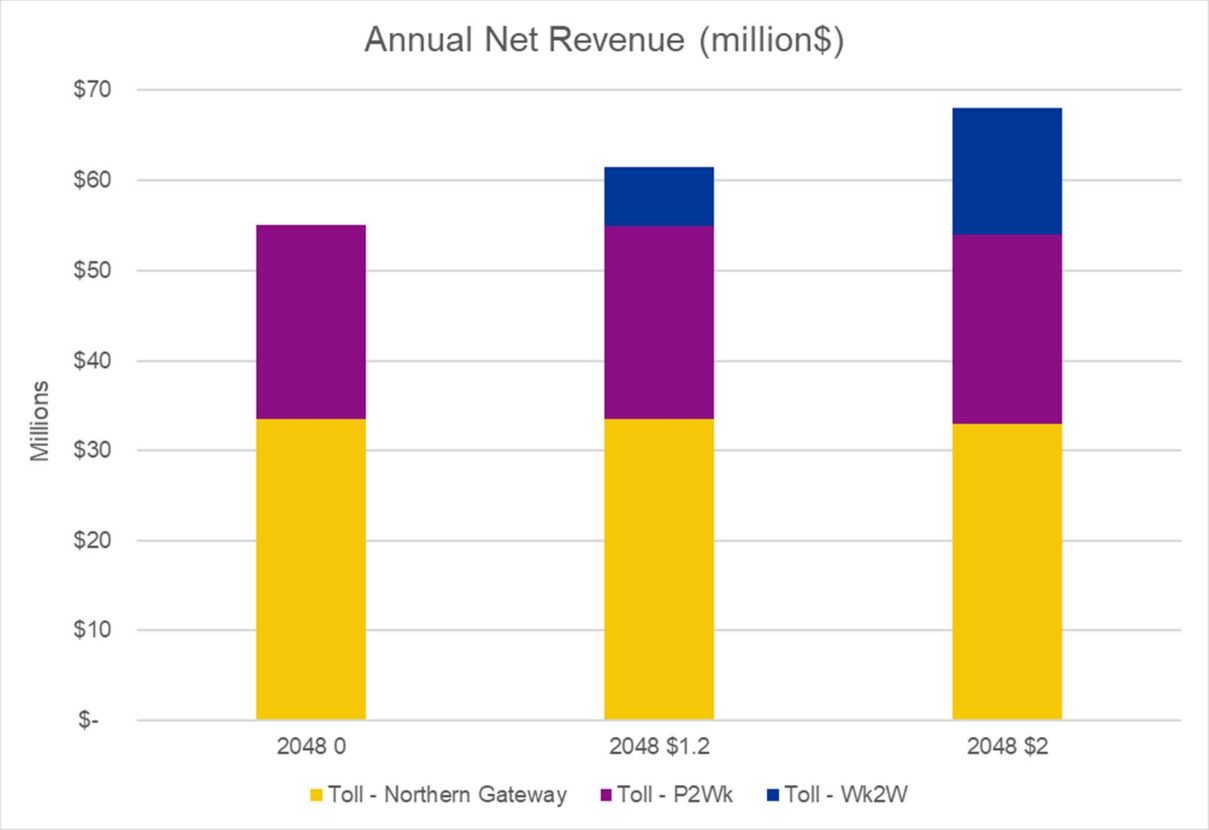


Figure 6-8: 2048 Annual Net Revenue

With respect to the new toll road the net revenue is estimated to be over $6.5m with a $1.20 toll. At a $2.00 toll this would be $14m per annum net.

The northern gateway toll road and P2W toll road reduce in net revenue by up to $0.5m for the $2.00 toll on the Warkworth to Wellsford section.

Tolling the new road has the potential to add revenue, generating net increase in revenue of $6.3 - $13m.

6.6 Equity

Equity has been measured as the fairness of the proposed toll system.

The system tested is equitable if the northbound ramps at the Wellsford interchange are tolled. However, given the low volume of vehicles using these ramps it is difficult to justify tolling at this location, then the section between Wellsford to Te Hana could be accessed for free.

6.7 Influencing Demand

Tolling Ara Tūhono is expected to have negligible impact on mode share in this area but is expected to marginally reduce travel through the corridor.

The increased travel costs could support Auckland Council's designation of Warkworth as a self-sustaining satellite town.

Additionally, introducing road toll could help signal a move towards the ATAP plan to introduce road pricing across the Auckland region.

6.8 Summary of Outcomes

In terms of all the key outcomes, the following is concluded:

- Toll in excess of $2.00 would be less desirable for balancing traffic volumes between the new and alternative route
- There is a modest increase in crash cost with tolling of $1.20
- There is a minor change in emissions with a toll of $1.20
- There are minor changes in traffic volumes and throughput at sensitive locations for a toll of $1.20
- There is the potential to generate a net increase in annual revenue of between $6.3m ($1.20) and $13m ($2.00) from tolling the Warkworth to Wellsford section of Ara Tūhono
- Tolling has the potential to marginally influence demand through the corridor mostly through changes in trip distribution and frequency rather than by mode shift. This could also support Auckland Council's designation of Warkworth as a self-sustaining satellite town as well as helping to signal a move towards the ATAP plan to introduce road pricing across the Auckland region
- National equity – adding $1 - $2 to existing Northern Gateway $2.40 and proposed Puhoi to Warkworth $2.40 would be between $5.80 - $6.80

There is a balancing act between achieving revenue and demand management outcomes against potential detrimental outcomes, especially on cumulative toll cost for through traffic. A reasonable balance is considered viable between $1 and $2.

6.9 Consideration of Vehicle Differentials

The consideration of vehicle differentials is as reported for the Puhoi to Warkworth section.

It is recommended to adopt the same ratio for heavy vehicles as the adjacent Northern Gateway Toll Road.

6.10 Consideration of Time-Varying Tolls

The same considerations highlighted in the Puhoi to Warkworth section apply to Warkworth to Wellsford.

Therefore, recommended to adopt a 24/7 toll system at least in the short term. Time varying tolling could be considered as part of a wider regional road pricing strategy.

6.11 Recommended Long-Term Strategy

The recommended toll strategy for Warkworth to Wellsford is as follows:

- Single mainline gantry north of Warkworth
- A 24/7 toll
- Light vehicle toll of between $1 and $2 and a heavy vehicle toll between $2 and $4

7 Assessment of Preferred Strategy

7.1 Approach

This chapter provides more detailed forecasts for the recommended toll strategy. It remains focussed more on the Puhoi-Warkworth project, but also includes indications of the effects of tolling the Warkworth-Wellsford section. It also includes an analysis of historic growth trends to both inform opening-year traffic estimates and also gauge the level for growth implied from the agreed land use forecasts used in the regional models.

7.2 Modelled Scenarios

The modelled scenarios are based on a combination of projects and tolling, as indicated in **Table 7-1**. The Warkworth southern interchange was included in the 2038 and 2048 scenarios only.

Table 7-1: Modelled Scenarios

No	Puhoi-Warkworth	Warkworth-Wellsford	Modelled Years
1	Untolled	No Project	2028, 2038, 2048
2	Tolled	No Project	2028, 2038, 2048
3	Untolled	Untolled	2038, 2048
4	Tolled	Untolled	2038, 2048
5	Tolled	Tolled	2038, 2048

7.3 Growth Analysis

The forecast results have been assessed in the context of the historic growth rates and the forecast land use growth, to inform the consideration of key uncertainties.

7.3.1 Historic Growth Analysis

Annual average daily traffic counts were obtained for State Highway 1 south of Puhoi. This location includes users of the NGTR and of the free alternative route. The data has been presented in two sets, prior to the toll road opening and following the toll road opening in 2009. Data was readily available from 2001 onwards. This data is presented in **Figure 7-1** below.

The following trends have been found:

- Prior to the NGTR opening there is an annual average growth rate of 0.8%
- Following the opening of NGTR there is an annual average growth rate of 5.0%
- The average growth rate over 2001 – 2018 was 3.6%

7.3.2 Forecast Corridor Growth

The model has adopted the growth from the Land Use Scenario i-11.4. This has provided the modelled growth shown in **Figure 7-1**. The growth shown is reasonably consistent with the growth in the corridor between 2009 and 2018 (highest historical growth rate). Therefore, the risk analysis shall include a lower

growth rate estimate based on the average growth rate between 2001 and 2018. This produces a corridor forecast shown in **Figure 7-1**. The lower growth rate is equivalent to the following:

- 2028 growth slowed by approximately 4 years
- 2038 growth slowed by approximately 8 years
- 2048 growth slowed by approximately 12 years

The higher growth rate has been set by increasing the 2038 volumes by 4% and extrapolating the trend from 2018 volumes to the remaining years.

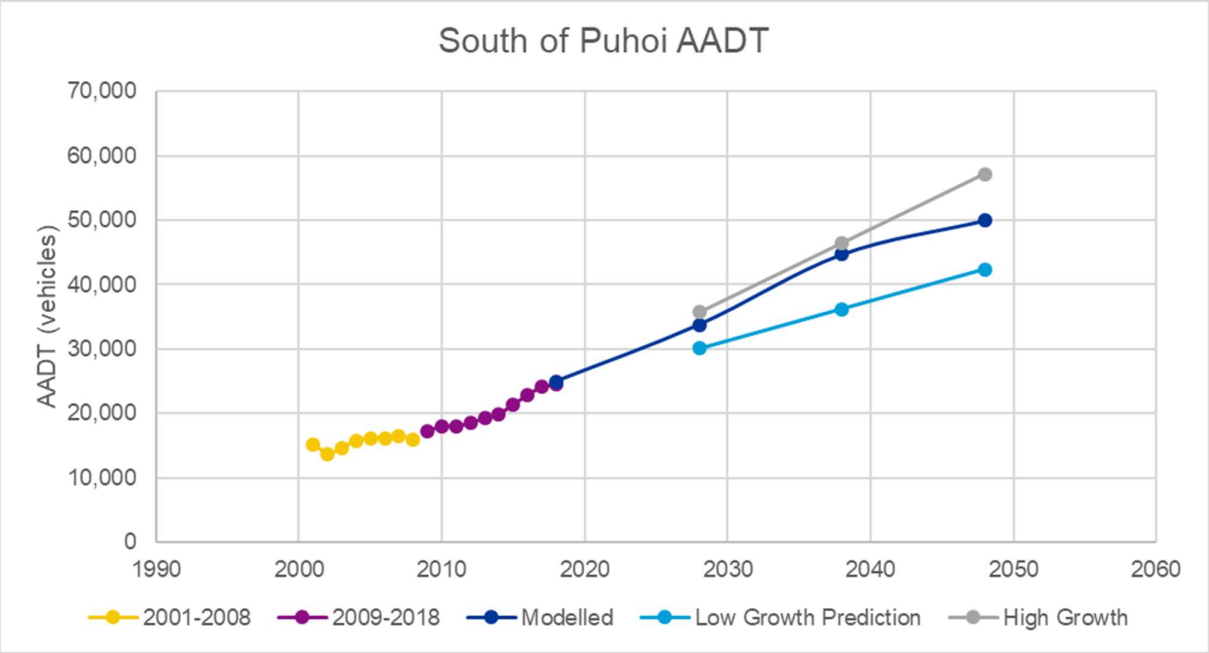


Figure 7-1: Historic and Forecast Growth Analysis

7.4 Puhoi to Warkworth Preferred Toll Strategy

Two potential toll location strategies have been considered for the P2W project:

- A1: increase in the toll at the existing Northern Gateway toll gantry with ramp gantries at Puhoi to discount those users
- A2: A new mainline toll gantry located north of Puhoi,

The preferred strategy for P2W is A1, however that strategy requires a change to the existing national toll processing system to allow linked trips and toll discounting, the feasibility and cost implications of which are uncertain. It may also involve a more complex OIC process. Therefore, the following analysis has been undertaken assuming the alternative A2 strategy involving a new mainline gantry north of Puhoi. This alternative is expected to generate the same gross revenue as A1 but have higher transaction costs.

The following traffic and revenue analysis is therefore based on the following:

- A 24/7 toll
- A recommended light-vehicle tariff of between $2 and $3, modelled at $2.40 (in 2018 terms)
- A heavy vehicle toll ratio of 2 times that for light vehicles

7.5 Opening year Traffic Estimates (P2W)

The Puhoi-Warkworth project is expected to open in late 2021, however the earliest available model is for 2028. To allow for a ramp up period, we have estimated 2022 annual average daily traffic flows. This has been assessed from two methods:

- Extrapolation of historic growth trends. This uses actual observed trends but is likely to understate the effect of induced demand
  - This gives a corridor flow of 28,000 and an assumed split to toll road based on the model of 65% = 18,200 vehicles per day
- Interpolation between the 2018 (no project) corridor flow and the 2028 modelled corridor flow
  - This uses the full corridor flow (existing roads + new motorway) and an assumed split to the toll road of 65% to determine the toll road traffic volume in 2022. This provided a similar estimate of 18,300 vehicles per day

These two methods suggest an AADT flow of just over 18,000 vehicles per day. Risk profiling is applied as described in the next section.

7.6 Risk Analysis (P2W)

Key risks and uncertainties have been identified that could influence the predicted outcomes. Probabilities and scale of impact of these effects were then estimated, followed by a Monte-Carlo-type simulation that combined all the risks. The risks are summarised in **Table 7-2** below. Items 1 – 8 have impacts on the traffic volumes on the toll road and hence also the revenue, items 9 and 10 only impact the net revenue of the toll roads. **Table 7-3** demonstrates the 5th, 50th and 95th percentile values for each item.

Table 7-2: Risk Analysis

No	Item	Discussion	Assumed Distribution	Distribution Parameters			
					2028	2038	2048
1	Growth	The forecast growth in land use is significant and therefore has high levels of uncertainty due to economic or other conditions. This is assessed by assuming results are either accelerated or slowed for each modelled year. The low growth scenario has been determined by the growth trend of the previous 20 years extrapolated to the forecast years. The high growth scenario has been determined by using a nominal 4% growth in 2038 and interpolating and extrapolating from the growth trend between the upper 2038 and 2018.[8]	Triangular	Low: Likely: High:	0.89 1.0 1.06	0.81 1.0 1.04	0.85 1.0 1.15
2	WtP -VoT	The key VoT values are uncertain and difficult to determine. Sensitivity tests use the lower MSM values and the higher Tauranga VoT.	Triangular	Low: Likely: High:	0.88 1.0 1.12	0.88 1.0 1.12	0.88 1.0 1.12
3	WtP - Escalation	The assessment assumes that the tolls are escalated at the rate of inflation but that WTP will escalate 1% faster. This is tested with the 1% margin removed and also with it increased to 1.1%	Triangular	Low: Likely: High:	0.98 1.0 1.01	0.96 1.0 1.01	0.95 1.0 1.01
4	Demand Response	The models include corridor flow reductions from a demand response. This was tested with an upper limit of no demand response (1.02) and lower limit of a 10% reduction (0.9)	Triangular	Low: Likely: High:	0.9 1.0 1.02	0.9 1.0 1.02	0.9 1.0 1.02
5	Alternative Route speed treatments	No specific speed treatments have been assumed on the alternative routes, other than through the urban section of Warkworth (based on SGA planning). Speed management plans could lower the attractiveness of the untolled route, resulting in lowered diversion.	Binary	Probability: Result: Alternative Result:	50% 1.05 1.0	50% 1.05 1.0	50% 1.05 1.0
6	Puhoi Interchange Treatments	The model uses the design layout. Alternative is that the interchange is upgraded, making it easier for vehicles to divert from the toll road.	Binary	Probability: Result: Alternative Result:	10% 0.95 1.0	20% 0.95 1.0	40% 0.95 1.0

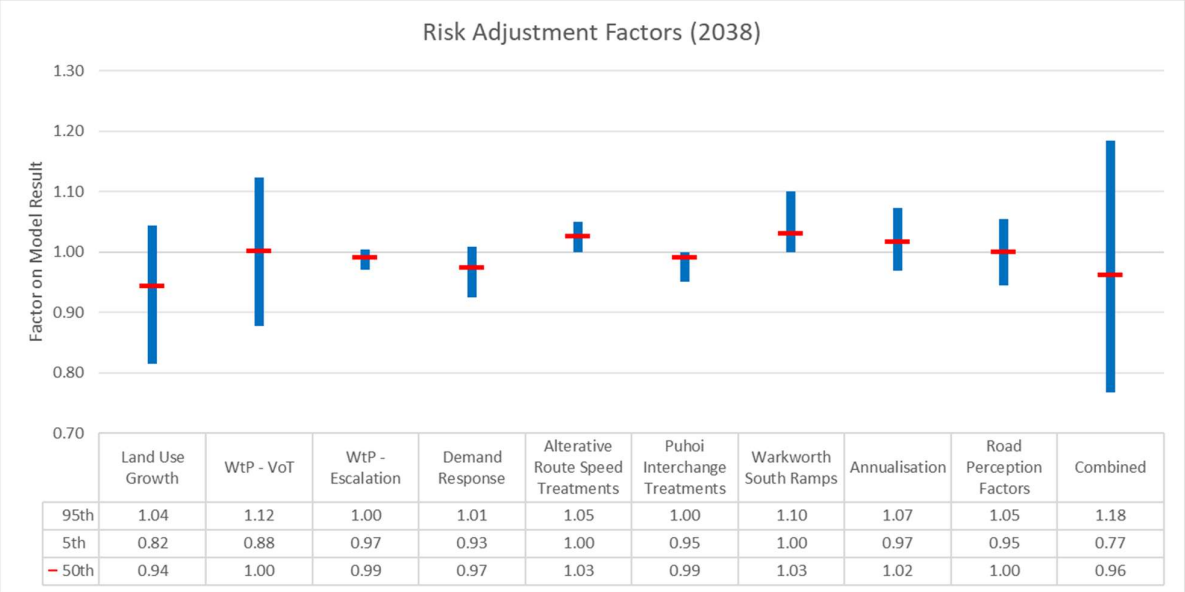
[8] The low and high values for growth and willingness to pay represent the targeted 5th and 95th percentile values

7	Warkworth South Ramps	The model doesn't include the Warkworth ramps. The alternative is that the ramps are included, which would encourage users to use the toll road if travelling to/from Warkworth south. 2048 includes the ramps, alternative is not including the ramps	Binary	Probability: Result: Alternative Result:	20% 1.1 1.0	30% 1.1 1.0	80% 1.0 0.9
8	Annualisation	The model has used available count data to determine annualization factors. The counts and model may have bias in the count location and time of year observed. A distribution is developed to account for this uncertainty. There is a skew upwards to consider potential higher induced demand for recreational trips.	Triangular	Low: Likely: High:	0.95 1.0 1.1	0.95 1.0 1.1	0.95 1.0 1.1
9	Road Perception Factors	Road perception factors are used to distinguish road characteristics such as safety, comfort and gradient. A sensitivity test has been run with +-50% on RPFs (increasing and decreasing users' perception and therefore difference to the toll road).	Triangular	Low: Likely: High:	0.92 1.0 1.08	0.92 1.0 1.08	0.92 1.0 1.08
10	Revenue Leakage	The assessment assumed a 3% loss of revenue form non-payments. This was tested at 2% and 5%	Triangular	Low: Likely: High:	0.95 0.97 0.98	0.95 0.97 0.98	0.95 0.97 0.98
11	Transaction Costs	The assessment has assumed a transaction cost of $0.70 per vehicle, as advised by NZTA. It could be expected that this value reduces as more toll projects are included in the system, so this was tested with: $0.65 in 2028, $0.50 in 2038 and $0.45 in 2048	Triangular	Low: Likely: High:	0.6 0.7 0.75	0.5 0.7 0.75	0.4 0.7 0.75

Table 7-3: Risk Adjustment Values

	2022			2028			2038			2048		
Item	**5th**	**50th**	**95th**	**5th**	**50th**	**95th**	**5th**	**50th**	**95th**	**5th**	**50th**	**95th**
1	0.94	1.00	1.05	0.89	0.98	1.06	0.82	0.94	1.04	0.86	1.00	1.15
2	0.88	1.00	1.12	0.88	1.00	1.12	0.88	1.00	1.12	0.88	1.00	1.12
3	0.99	1.00	1.01	0.99	1.00	1.01	0.97	0.99	1.00	0.96	0.99	1.00
4	0.99	1.00	1.01	0.92	0.97	1.01	0.93	0.97	1.01	0.92	0.97	1.01
5	1.00	1.01	1.05	1.00	1.02	1.05	1.00	1.03	1.05	1.00	1.03	1.05
6	0.95	1.00	1.00	0.95	1.00	1.00	0.95	0.99	1.00	0.95	0.98	1.00
7	1.00	1.00	1.00	1.00	1.02	1.10	1.00	1.03	1.10	0.90	0.98	1.00
8	0.97	1.00	1.03	0.97	1.02	1.07	0.97	1.02	1.07	0.97	1.02	1.07
9	0.95	1.00	1.05	0.95	1.00	1.05	0.95	1.00	1.05	0.95	1.00	1.05
Combined	0.86	1.00	1.17	0.83	1.00	1.20	0.77	0.96	1.18	0.76	0.96	1.19
10	0.96	0.97	0.98	0.96	0.97	0.98	0.96	0.97	0.98	0.96	0.97	0.98
11	0.67	0.70	0.73	0.63	0.68	0.73	0.55	0.65	0.72	0.47	0.62	0.72

The 2038 traffic volume risk profile is demonstrated in **Figure 7-2**.



	Land Use Growth	WtP - VoT	WtP - Escalation	Demand Response	Alterative Route Speed Treatments	Puhoi Interchange Treatments	Warkworth South Ramps	Annualisation	Road Perception Factors	Combined
95th	1.04	1.12	1.00	1.01	1.05	1.00	1.10	1.07	1.05	1.18
5th	0.82	0.88	0.97	0.93	1.00	0.95	1.00	0.97	0.95	0.77
50th	0.94	1.00	0.99	0.97	1.03	0.99	1.03	1.02	1.00	0.96

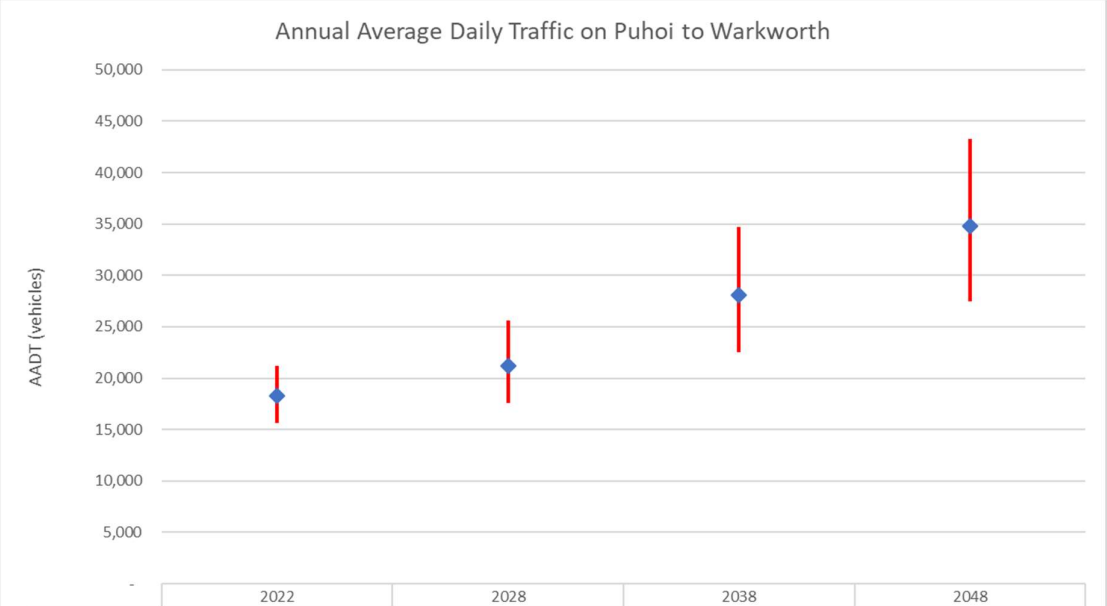
Figure 7-2: Traffic Volume Risk Adjustment Factors (2038)

From the figure the following can be determined:

- The willingness to pay adjustment has the largest range of 5th and 95th percentile adjustments
- The demand response reduces the 50th percentile traffic volumes the most
- The Warkworth south ramps have the potential to increase the 95th percentile traffic volumes the most

7.7 Forecast Traffic Volumes (P2W)

The AADT on the Puhoi to Warkworth toll road is reported for three levels; 5th percentile, 50th percentile and 95th percentile. The AADT shown is for a toll tariff of $2.40. This is shown in **Figure 7-3**:



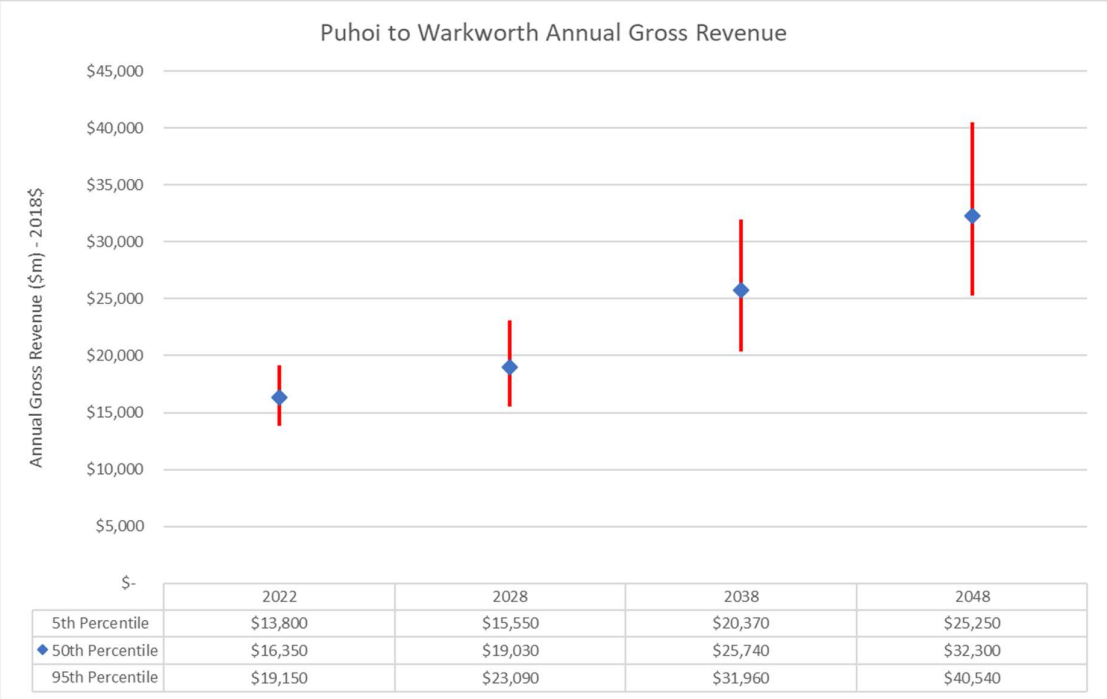
	2022	2028	2038	2048
5th Percentile	15,600	17,600	22,500	27,500
◆ 50th Percentile	18,300	21,200	28,100	34,800
95th Percentile	21,200	25,600	34,700	43,300

Figure 7-3: Risk Adjusted AADT

7.8 Estimated Revenue (P2W)

The revenue graphs shown below are based on the toll tariff of $2.40.

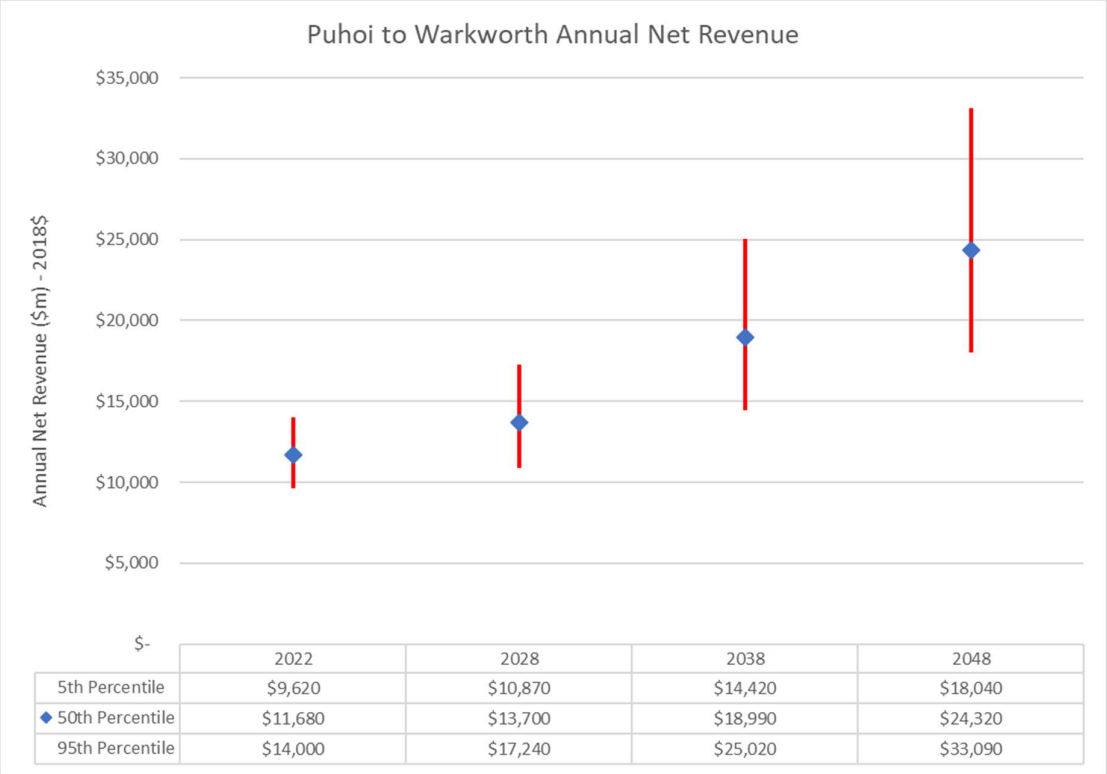
Figure 7-4 shows the risk adjusted gross revenue for Puhoi to Warkworth for 5th percentile, 50th percentile and 95th percentile.



	2022	2028	2038	2048
5th Percentile	$13,800	$15,550	$20,370	$25,250
◆ 50th Percentile	$16,350	$19,030	$25,740	$32,300
95th Percentile	$19,150	$23,090	$31,960	$40,540

Figure 7-4: Puhoi to Warkworth Risk Adjusted Annual Gross Revenue

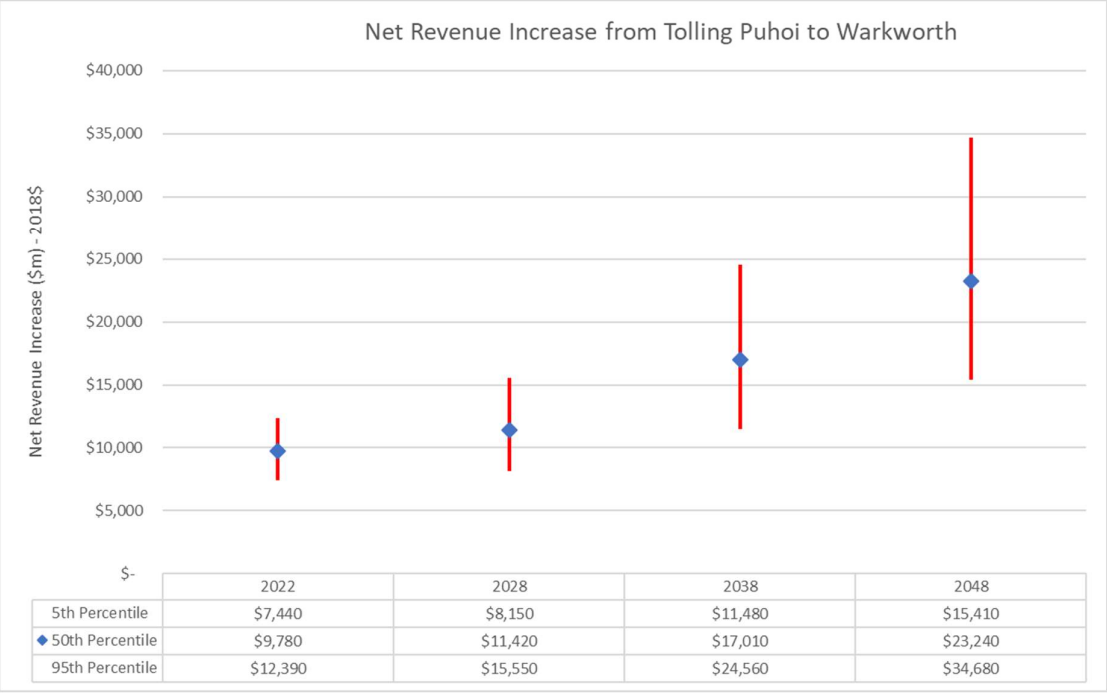
Figure 7-5 shows the risk adjusted net revenue for Puhoi to Warkworth for 5th percentile, 50th percentile and 95th percentile.



	2022	2028	2038	2048
5th Percentile	$9,620	$10,870	$14,420	$18,040
50th Percentile	$11,680	$13,700	$18,990	$24,320
95th Percentile	$14,000	$17,240	$25,020	$33,090

Figure 7-5: Puhoi to Warkworth Net Revenue

Figure 7-6 shows the risk adjusted net revenue increase for the combined system (P2W and NGTR) for 5th percentile, 50th percentile and 95th percentile.



	2022	2028	2038	2048
5th Percentile	$7,440	$8,150	$11,480	$15,410
50th Percentile	$9,780	$11,420	$17,010	$23,240
95th Percentile	$12,390	$15,550	$24,560	$34,680

Figure 7-6: Combined System Net Revenue Increase from Tolling Puhoi to Warkworth

For the purpose of a simplistic[9] financial analysis, the following assumptions have been made:

- Mainline gantry cost of $12.7m
- Yearly operating / maintenance cost of 2% of the mainline gantry cost ($250,000)
- Maintenance / replacement cost of 80% of mainline gantry cost every 15 years
- Crash cost for each modelled year is linearly interpolated for each year (this is not a direct monetary cost – so two net revenue values are presented; with and without crash costs)

This results in the 35-year cumulative revenue and costs for the 50th percentile estimates shown in **Figure 7-7**. Resulting in an internal rate of return of 72% without crash costs and 63% including crash costs. All values are shown for 2018$.

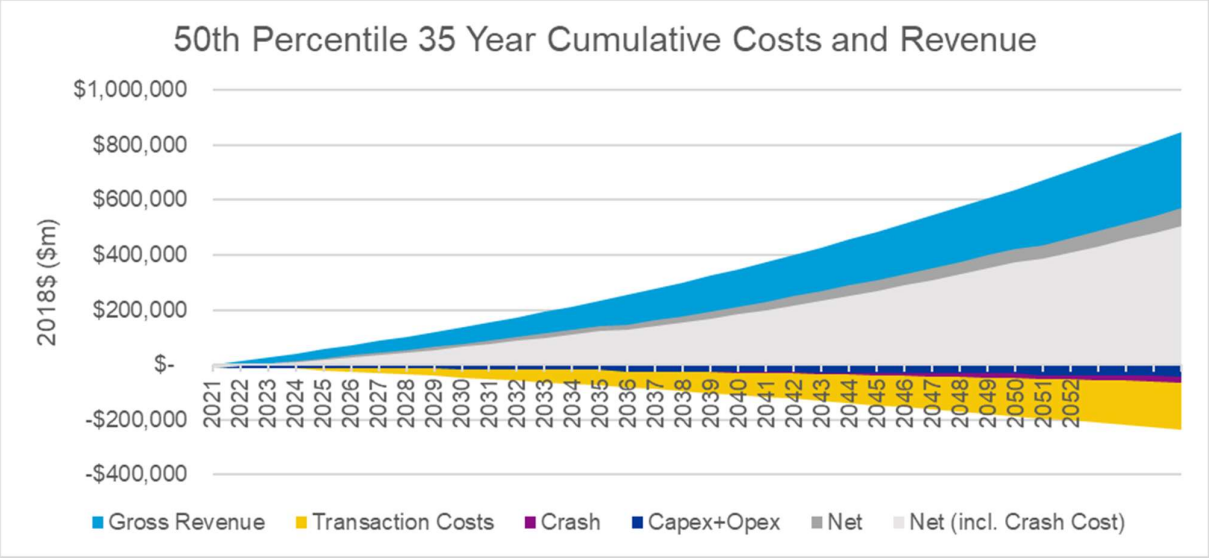


Figure 7-7: 50th Percentile 35-year Cumulative Costs and Revenue

The following table shows the cumulative net revenue (in 2018$) for 10, 20, 25, 30 and 35 years of operation for the 5th, 50th and 95th percentile (not including crash costs):

Table 7-4: Cumulative Net Revenue ($m)

	Years of Operation (2018$)					NPV @ 6%
	10	20	25	30	35	35
5th	$61	$157	$211	$254	$304	$110
50th	$88	$230	$330	$436	$569	$184
95th	$121	$319	$458	$609	$794	$257

The 35-year net revenue (gross revenue less capital costs, operating costs and transaction costs) ranges from $324m to $823m for the 5th and 95th percentile net revenue respectively, with a 50th percentile net revenue of $593m.

Table 7-5 shows the cumulative net revenue including the crash costs:

[9] E.g. no consideration of costs of capital, tax implications etc.

Table 7-5: Cumulative Net Revenue ($m) – including crash costs

	Years of Operation (2018$)					NPV @ 6%
	10	20	25	30	35	35
5th	$51	$132	$179	$212	$253	$91
50th	$75	$200	$289	$385	$506	$161
95th	$105	$283	$408	$546	$716	$229

The 35-year net revenue (gross revenue less capital costs, operating costs, transaction costs and crash costs) ranges from $273m to $745m for the 5th and 95th percentile net revenue respectively, with a 50th percentile net revenue of $530m.

7.9 Effect of Alternative Gantry Strategy

The preferred strategy for P2W involves an increase in the toll at the existing Northern Gateway toll gantry with gantries at Puhoi ramps to discount the users of those ramps (as they do not use the P2W project). However, that strategy requires a change to the existing national toll processing system to allow linked trips and toll discounting, the feasibility and cost implications of which are uncertain. It may also involve a more complex OIC process.

The above analysis has therefore been undertaken assuming an alternative strategy involving a new mainline gantry north of Puhoi. This alternative is expected to generate the same gross revenue but have higher transaction costs.

Assuming the feasibility of the preferred system is confirmed, and that the transaction cost remains at 70c per vehicle, the preferred strategy is estimated to save some $4.9m per annum (2038). This has been determined by calculating the difference in volume between the Puhoi ramps and the P2W mainline north of Puhoi. Over 30 years this could equate to additional net revenue of approximately $100m.

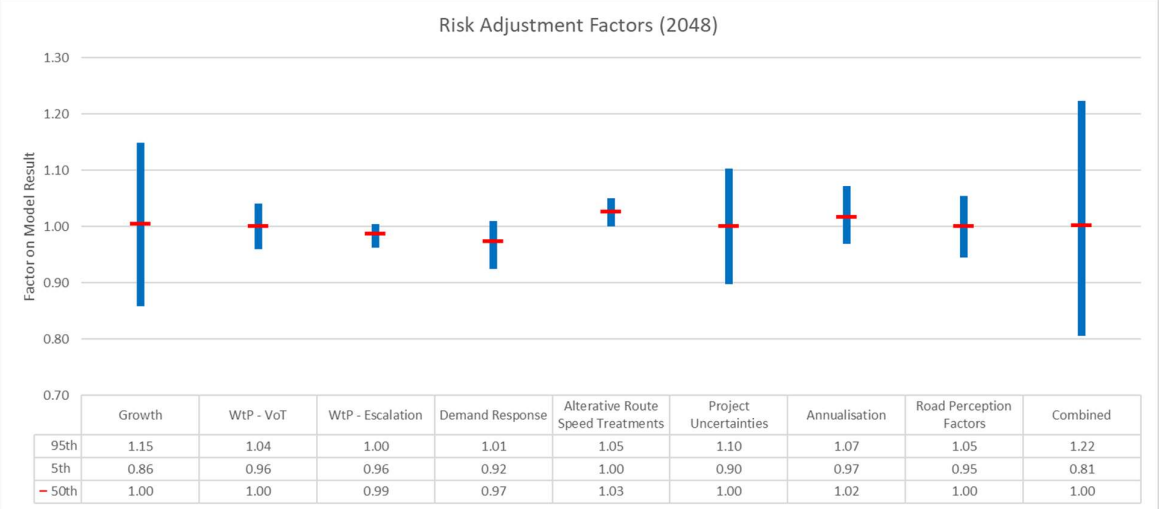
7.10 Warkworth to Wellsford

Based on the analysis undertaken a preferred toll strategy for this section of the corridor includes:

- A single mainline toll gantry located north of Warkworth but south of the proposed Wayby Valley interchange
- A 24/7 toll
- A light-vehicle tariff between $1.20 and $2.00 (in 2018 terms)
- A heavy vehicle toll ratio of 2 times that for light vehicles

Given the uncertain timeframe for this project only 2038 and 2048 year modelling has been undertaken. Estimates of potential revenue for those years has been based on a light-vehicle toll of $1.20 on WW2W, with $2.40 on P2W and the existing Northern Gateway toll road.

The 2048 traffic volume risk profile is demonstrated in Figure 7-8



	Growth	WtP - VoT	WtP - Escalation	Demand Response	Alterative Route Speed Treatments	Project Uncertainties	Annualisation	Road Perception Factors	Combined
95th	1.15	1.04	1.00	1.01	1.05	1.10	1.07	1.05	1.22
5th	0.86	0.96	0.96	0.92	1.00	0.90	0.97	0.95	0.81
50th	1.00	1.00	0.99	0.97	1.03	1.00	1.02	1.00	1.00

Figure 7-8: 2048 Risk Adjustment Factors

Table 7-6 Estimated Net Revenue for the WW2W Project ($1.20 toll)

Value	2038	2048
5%ile Net Revenue	$ 5,552,000	$ 6,418,000
50%ile Net Revenue	$ 7,668,000	$ 9,277,000
95%ile Net Revenue	$ 10,703,000	$ 13,953,000

8 Summary and Conclusions

This report described an analysis of the effects of tolling on the Ara Tūhono corridor north of Auckland. The purpose of this work is to provide information to NZTA to support their decision making on whether to proceed to public consultation of tolling. While this work provides estimates of network demands and revenue suitable for network planning, the revenue estimates are not considered 'investment grade' such as might be required for private-sector investment.

The analysis focused on the revenue potential and network impacts of tolling of the corridor. The measured network impacts were derived from the specific project objectives, key transport priorities (such as from the GPS) and items specific to tolling. These included:

- Road safety, specifically any additional crash costs of diverting traffic from the new motorway back to the existing highways
- Accessibility, measured via estimated travel times between key locations through the corridor
- Environmental impacts such as estimated changes in CO_2 emissions
- Amenity impacts from traffic increases in sensitive areas such as central Orewa and Warkworth
- Travel demand impacts, such as reduced amount of vehicle travel from higher travel costs
- Equity of pricing different users

The traffic flow and network outcomes were primarily derived from an updated version of the traffic model owned by the Auckland Forecasting Centre (AFC), and used for development of key projects in this area such as the P2W, WW2W, Matakana Link Road, Hill Street and Supporting Growth Alliance projects. Key updates to that model included an extension south to include the existing Northern Gateway toll road, a switch to the new regional demand model for forecast traffic flows (rather than the now superseded ART3 model), rebasing and calibrating the model to 2018 conditions and adding a toll response element.

An initial assessment of alternative toll strategies was considered for both the short-term and longer-term (full corridor) scenarios, resulting in a short-list of scenarios for testing. More detailed testing for the P2W project was then undertaken for the forecast year 2038 to identify a preferred range of toll tariffs. This preferred range was determined balancing between the increasing revenue potential of higher tolls against the worsening network outcomes. A similar approach was then undertaken for the WW2W project. Representative revenue estimates were then developed for the P2W project from opening year to 2048, including risk-adjusted factors to provide 5%, 50% and 95%ile estimates.

This analysis has identified potential of significant revenue from tolling on both the P2W and WW2W projects. However, increasing tolls will reduce the expected outcomes of the projects, especially in terms of allowing travel on safer roads. Relatively modest tolls of between $2-$3 on P2W are considered to represent a balance between revenue generation and network outcomes. A single additional toll point north of Warkworth is also the preferred strategy, with a more modest tariff of between $1.20 and $2.00.

Unlike other toll roads, this corridor needs to consider the effects of up to three adjacent toll roads, with cumulative impacts on inter-regional travel costs, equity with other inter-regional corridors and the uncertainties of motorist's cumulative willingness to pay.

The executive summary contains a more detailed overview of the analysis and outcomes.

		Toll - Northern Gateway			Toll - P2W			Daily Gross Toll Revenue (Not incl. Leakage)			Daily Revenue Leakage		
Year	Scenario / Risk Adjustment	Total Car	Total Truck	Total	Total Car	Total Truck	Total	Toll - Northern Gateway	Toll - P2W	Toll1 + Toll2	Toll - Northern Gateway	Toll - P2W	Toll1 + Toll2
2022	Untolled	24300	1600	25900	23000	1700	24700	$ 65,900	$ -	$ 65,900	$ 1,900	$ -	$ 1,900
2022	5%	21300	1500	22800	14700	900	15600	$ 58,300	$ 39,500	$ 97,800	$ 1,700	$ 1,700	$ 3,300
2022	50%	21300	1500	22800	17200	1000	18300	$ 58,300	$ 46,200	$ 104,500	$ 1,700	$ 1,400	$ 3,100
2022	95%	21300	1500	22800	20000	1200	21200	$ 58,300	$ 53,700	$ 112,000	$ 1,700	$ 1,300	$ 2,900
2028	Untolled	28900	1900	30800	26800	2000	28900	$ 78,400	$ -	$ 78,400	$ 2,300	$ -	$ 2,300
2028	5%	25300	1800	27100	16600	1000	17600	$ 69,300	$ 44,500	$ 113,800	$ 2,000	$ 1,900	$ 3,900
2028	50%	25300	1800	27100	20100	1200	21200	$ 69,300	$ 53,800	$ 123,200	$ 2,000	$ 1,700	$ 3,700
2028	95%	25300	1800	27100	24200	1400	25600	$ 69,300	$ 64,800	$ 134,100	$ 2,000	$ 1,500	$ 3,500
2038	Untolled	38400	3100	41500	34100	3300	37400	$ 107,200	$ -	$ 107,200	$ 3,100	$ -	$ 3,100
2038	5%	35400	3000	38400	20700	1800	22500	$ 99,400	$ 58,200	$ 157,600	$ 2,800	$ 2,400	$ 5,200
2038	50%	35400	3000	38400	25900	2200	28100	$ 99,400	$ 72,800	$ 172,200	$ 2,800	$ 2,200	$ 5,100
2038	95%	35400	3000	38400	31900	2700	34700	$ 99,400	$ 89,600	$ 189,100	$ 2,800	$ 2,100	$ 4,900
2048	Untolled	43400	4600	48000	39300	4500	43800	$ 126,200	$ -	$ 126,200	$ 3,600	$ -	$ 3,600
2048	5%	41900	4500	46400	24900	2600	27500	$ 122,100	$ 72,100	$ 194,200	$ 3,400	$ 2,900	$ 6,400
2048	50%	41900	4500	46400	31500	3300	34800	$ 122,100	$ 91,300	$ 213,400	$ 3,400	$ 2,800	$ 6,200
2048	95%	41900	4500	46400	39200	4100	43300	$ 122,100	$ 113,700	$ 235,800	$ 3,400	$ 2,600	$ 6,100

		Daily Gross Toll Revenue			Transaction Costs			Daily Net Toll Revenue			Annual Gross Toll Revenue			Annual Net Toll Revenue		
Year	Scenario / Risk Adjustment	Toll - Northern Gateway	Toll - P2W	Toll1 + Toll2	Toll - Northern Gateway	Toll - P2W	Toll1 + Toll2	Toll - Northern Gateway	Toll - P2W	Toll1 + Toll2	Toll - Northern Gateway	Toll - P2W	Toll1 + Toll2	Toll - Northern Gateway	Toll - P2W	Toll1 + Toll2
2022	Untolled	$ 64,000	$ -	$ 64,000	$ 18,100	$ -	$ 18,100	$ 45,900	$ -	$ 45,900	$ 23,359,000	$ -	$ 23,359,000	$ 16,749,000	$ -	$ 16,749,000
2022	5%	$ 56,600	$ 37,800	$ 94,400	$ 16,700	$ 11,400	$ 28,200	$ 39,900	$ 26,400	$ 66,300	$ 20,668,000	$ 13,798,000	$ 34,466,000	$ 14,562,000	$ 9,624,000	$ 24,186,000
2022	50%	$ 56,600	$ 44,800	$ 101,400	$ 15,900	$ 12,800	$ 28,700	$ 40,700	$ 32,000	$ 72,700	$ 20,668,000	$ 16,345,000	$ 37,013,000	$ 14,847,000	$ 11,683,000	$ 26,530,000
2022	95%	$ 56,600	$ 52,500	$ 109,100	$ 15,200	$ 14,100	$ 29,300	$ 41,500	$ 38,400	$ 79,800	$ 20,668,000	$ 19,153,000	$ 39,820,000	$ 15,133,000	$ 14,001,000	$ 29,134,000
2028	Untolled	$ 76,100	$ -	$ 76,100	$ 21,100	$ -	$ 21,100	$ 55,000	$ -	$ 55,000	$ 27,779,000	$ -	$ 27,779,000	$ 20,063,000	$ -	$ 20,063,000
2028	5%	$ 67,300	$ 42,600	$ 110,000	$ 19,800	$ 12,800	$ 32,700	$ 47,500	$ 29,800	$ 77,300	$ 24,578,000	$ 15,555,000	$ 40,133,000	$ 17,346,000	$ 10,868,000	$ 28,215,000
2028	50%	$ 67,300	$ 52,100	$ 119,500	$ 18,600	$ 14,600	$ 33,200	$ 48,700	$ 37,500	$ 86,300	$ 24,578,000	$ 19,030,000	$ 43,608,000	$ 17,783,000	$ 13,702,000	$ 31,486,000
2028	95%	$ 67,300	$ 63,300	$ 130,600	$ 17,000	$ 16,000	$ 33,000	$ 50,300	$ 47,200	$ 97,600	$ 24,578,000	$ 23,092,000	$ 47,671,000	$ 18,375,000	$ 17,238,000	$ 35,613,000
2038	Untolled	$ 104,100	0	$ 104,100	$ 27,300	$ -	$ 27,300	$ 76,800	0	$ 76,800	$ 37,991,000	$ -	$ 37,991,000	$ 28,028,000	$ -	$ 28,028,000
2038	5%	$ 96,600	$ 55,800	$ 152,400	$ 27,800	$ 16,300	$ 44,100	$ 68,800	$ 39,500	$ 108,200	$ 35,256,000	$ 20,366,000	$ 55,622,000	$ 25,094,000	$ 14,417,000	$ 39,511,000
2038	50%	$ 96,600	$ 70,500	$ 167,100	$ 25,200	$ 18,500	$ 43,700	$ 71,400	$ 52,000	$ 123,400	$ 35,256,000	$ 25,737,000	$ 60,993,000	$ 26,043,000	$ 18,993,000	$ 45,036,000
2038	95%	$ 96,600	$ 87,600	$ 184,200	$ 21,100	$ 19,000	$ 40,100	$ 75,500	$ 68,600	$ 144,100	$ 35,256,000	$ 31,960,000	$ 67,216,000	$ 27,567,000	$ 25,024,000	$ 52,591,000
2048	Untolled	$ 122,700	$ -	$ 122,700	$ 30,200	$ -	$ 30,200	$ 92,500	$ -	$ 92,500	$ 44,770,000	$ -	$ 44,770,000	$ 33,764,000	$ -	$ 33,764,000
2048	5%	$ 118,700	$ 69,200	$ 187,900	$ 33,400	$ 19,800	$ 53,100	$ 85,300	$ 49,400	$ 134,700	$ 43,322,000	$ 25,248,000	$ 68,570,000	$ 31,139,000	$ 18,035,000	$ 49,174,000
2048	50%	$ 118,700	$ 88,500	$ 207,200	$ 29,100	$ 21,900	$ 51,000	$ 89,500	$ 66,600	$ 156,200	$ 43,322,000	$ 32,296,000	$ 75,617,000	$ 32,682,000	$ 24,320,000	$ 57,002,000
2048	95%	$ 118,700	$ 111,100	$ 229,700	$ 21,800	$ 20,400	$ 42,200	$ 96,800	$ 90,700	$ 187,500	$ 43,322,000	$ 40,536,000	$ 83,858,000	$ 35,350,000	$ 33,092,000	$ 68,441,000