Report

PENLINK Traffic and Economic Analysis

Prepared for Auckland Transport (Client)

By Beca Ltd (Beca)

30 June 2014

Revision History

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Prepared by	Andrew Murray		
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Executive Summary

This report details Beca's traffic and toll revenue forecasting and economic evaluation in accordance with the NZ Transport Agency's Economic Evaluation Manual ("**EEM**") for the PENLINK project north of Auckland. These forecasts and analysis will be used by Auckland Transport as one of the inputs to the update of the Business Case for the PENLINK toll road project, the preparation of which is being led by Price Waterhouse Coopers Ltd (**PWC**) on behalf of Auckland Transport. A draft report was provided to Auckland Transport in September 2013. This June 2014 update of that report reflects updated modelling that incorporates more recent land use forecasts provided by Auckland Transport (known as Scenario I-8b).

This report was prepared by Beca Limited ("**Beca**") solely for Auckland Transport and is provided on the basis of the Terms of Reference and the disclaimers, limitations and assumptions set out in this Report. The base traffic model on which the toll revenue forecasts are founded (the pre-existing Hibiscus Coast Traffic model) is described in this report, as are the methodology and outcomes of the base toll modelling, including flow and revenue forecasts and sensitivity testing.

Modelling Methodology and Assumptions

Traffic volumes on the future road network of a rapidly growing area such as the Hibiscus Coast depend upon many factors, including:

- Future population and employment demographics (e.g. Silverdale North, Whangaparaoa Peninsula);
- Future traffic and congestion levels on the road network, taking account of future changes to the development of the area and its road network (e.g. the travel speed on the alternative route to PENLINK through Silverdale); and
- Whether or not the predicted travel costs and behaviours, as defined in the Hibiscus Coast Traffic Model, eventuate (consideration of increased use of public transport has been included in this analysis).

Numerous other factors as more fully described in this report will also affect future travel demand. While Beca believe that it is reasonable to use assumptions and criteria of the nature described in this report as a means of preparing toll traffic forecasts and conducting the economic evaluation, these are assumptions only, and there can be no guarantee that these assumptions will be correct or accurate. If any assumption proves to be incorrect, then the toll traffic forecasts and, consequently, the toll revenue projections and aspects of the economic evaluation may, as a consequence, be incorrect and the opinions expressed by Beca in this report may no longer be valid and should be reviewed.

The Hibiscus Coast Traffic Model was updated for this work by developing a current day (2013) model, using recent population data provided by Auckland Transport. That model was calibrated and validated to appropriately account for observed traffic counts, travel speeds, and to the origin-destination movements between the Whangaparaoa Peninsula and SH1 motorway surveyed in May/June 2013. The validation of the model was undertaken using the guidelines contained in the EEM and sought to replicate current observations (within accepted tolerances) whilst retaining the underlying forecasting functions of the model.

For toll roads such as the proposed PENLINK project, future traffic volumes also depend on drivers' Willingness to Pay (**WTP**) tolls and whether the benefits (including travel time savings) are worth the payment. For this model update, the WTP parameters were based on the market research undertaken by the NZ Transport Agency in 2007 for selected Toll Roads in NZ but adjusted to

reflect evidence from operational toll roads in NZ, including the removal of the toll from the Tauranga Harbour Bridge in 2001, the increase in the toll on the Route K toll road in 2012 and the level of traffic diversion observed on the Northern Gateway Toll Road. Because of the uncertainty in the WTP of motorists to tolls, explicit sensitivity tests on higher and lower WTP values were undertaken and used in the risk-profiling applied to the forecasts.

As instructed by Auckland Transport, this analysis assumes that the toll collection would be done electronically using the NZ Transport Agency's National Toll System (such as used for the Northern Gateway Toll Road). It is an assumption of this analysis that such a system is free flowing and would not be seen by motorists as a barrier to usage of the toll road.

The forecasts of weekday peak period traffic have been expanded to produce forecasts of total annual average daily traffic (AADT), which takes account of weekend traffic as well. The toll revenues are based on the AADT traffic.

It is common practice to reduce the predicted traffic forecasts during the initial period of operation of the project to reflect a likely pattern of 'ramp-up' as motorists gradually become accustomed to the new route and learn which trips gain the greatest benefits from using the road. The patronage during these initial periods is generally assumed to be lower than the model prediction, as the models assume 'steady-state' conditions when motorists are aware of the relative merits of the various alternative routes available. This report does not consider nor apply ramp-up factors nor any allowance for potential revenue leakage through non-payment of tolls. This approach has been advised to Auckland Transport and PWC.

In accordance with standard practice in New Zealand, the economic evaluation of the PENLINK project is in accordance with the EEM and is consistent with the methodology used in previous, peer reviewed evaluations undertaken by Beca for this project.

Qualifications and Limitations of the Forecasting Methodology

Traffic modelling and toll revenue forecasting is not an exact science. Modelling relies on multifarious sets of data assumptions and inputs. In a rapidly developing area such as the Hibiscus Coast there are uncertainties about that data and, consequently, predictions about future traffic volumes. Traffic forecasts are only a prediction of what might happen in the future and these predictions may not be achieved. Further, the toll revenue forecasts and economic evaluation are reliant on the accuracy of the traffic forecasts and, consequently, any error in the traffic forecasts may have a material impact on the accuracy of the toll revenue forecasts and economic evaluation.

Traffic volumes on PENLINK will be affected by numerous factors, many of them external and unable to be controlled or forecasted by Beca's traffic modellers. Examples include:

- The capacity of the Weiti Crossing and its feeder roads (given the possibility of future development adjacent to the project)
- Additional alternatives routes not anticipated or expected at the time this report is prepared
- The pace of growth, nature and locations of population, employment and economic growth
- General traffic levels in the area and on routes to and from PENLINK
- The assumed land use in the area
- The quality, capacity and proximity of alternative roads and other transport infrastructure including passenger transport
- Final toll rates, collection systems and escalation policies;
- Fuel prices; and
- Changes in law, regulation, by-laws or policy.

Beca has relied on inputs and assumptions provided by Auckland Transport in the modelling, including those related to land use, network upgrades and population data. Beca has not independently audited nor verified that data. Beca has tested and attempted to quantify the impact on the patronage forecasts of variations in those inputs, however the broad trend and pattern of those inputs have been retained.

Approach to Traffic Studies

The traffic analysis used here as input to the Business Case was undertaken in three broad stages:

Stage 1 **Option Testing**. This was a comparative analysis of project design options such as the number of travel lanes and the form of intersections. This was used by Auckland Transport to develop its preferred project option;

Stage 2 **Toll Strategy Development**. This stage involved traffic modelling and assessment of different elements of the toll strategy for the preferred project option, such as the location and type of toll collection systems and the toll level. This was used by Auckland Transport to develop its recommended Toll Strategy; and

Stage 3 **Patronage Forecasts and Economic Evaluation.** This involved preparing the traffic and revenue forecasts, sensitivity testing and risk analysis and detailed economic evaluation based on Auckland Transport's preferred project option and recommended Toll Strategy. These inputs were used in the Business Case Report.

The technical studies were governed by a Project Control Group (**PCG**) convened by Auckland Transport.

Project Options

The study commenced with a review of the PENLINK project elements as defined previously by the former Rodney District Council. It then considered variations on the number of travel lanes and the form of the intersections with the surrounding road network. These options included:

- Variations on the general road cross-section including the previous 2-lane (1 each-way) configuration, adding passing lanes, or providing a 4-lane configuration;
- The form of the Redvale interchange with SH1, including the previous directional ramps or an alternative layout;
- The form of the connection with East Coast Road, including the previous at-grade roundabout connection or grade-separation;
- The form of the connection to Duck Creek Road, including the original twin (staggered) at-grade T intersections or grade separation over PENLINK with a single at-grade intersection; and
- The form of the connection with Whangaparaoa Road, including the original roundabout or traffic signals.

The assessment considered the traffic performance, wider-network effects, construction cost implications and relative economic efficiencies (in accordance with the EEM). From this analysis the PCG recommended modification of the preferred option previously adopted by the Rodney District Council as follows:

- Adoption of a standard 'half diamond' interchange form at the connection with SH1 at Redvale, with flexibility to allow a connection to the west of SH1 and the possibility of north-facing ramps;
- Grade separation of PENLINK over East Coast Road with east-facing ramp connections
- A 4-lane, divided carriageway cross-section for the length of the project;
- Grade separation of Duck Creek Road (south) over PENLINK with slip lanes;
- A traffic signal controlled intersection with Whangaparaoa Road;
- Retention of the associated widening of Whangaparaoa Road between Brightside Road and Arklow Lane; and
- Provision of pedestrian and cycle facilities between Whangaparaoa Road and Duck Creek Road but with on-road cycle (shoulder) facilities along the main carriageway (with a connection to East Coast Road).

Toll Strategy

The analysis considered the location, level and collection method for the tolling of PENLINK. It was based on an assumption from Auckland Transport that the NZ Transport Agency's National Toll System would be used. It assessed various locations for collecting the toll, including consideration of diversion effects, capital and operating costs and the feasibility of alternative routes for development areas directly accessing PENLINK. In assessing the recommended toll level, the analysis identified a light-vehicle toll rate between $2.00 and $2.50 that provided a balance between network performance and revenue generation. The PCG adopted a light-vehicle toll of $2.20 and a heavy vehicle toll of $4.40 ($2013) as this was within this identified range and was consistent with the nearby Northern Gateway toll road which offers very similar time and distance savings to that predicted for PENLINK (based on the forecasting for PENLINK, both projects offer approximately a 5-6km distance saving and 8-10 minute time savings over the untolled alternative route).

The toll strategy adopted by the PCG was therefore as follows:

- A single toll collection point on or near the Weiti Bridge;
- Free-flow electronic tolling using NZTA's National Toll System;
- Fixed 24/7 toll tariff but the ability to consider time-variable tolling at a later date when the technology is available;
- A light vehicle toll of $2.20 and a heavy vehicle toll of $4.40 (in $2013);
- No caps or discounts; and
- Tolls escalated regularly at the rate of inflation (CPI).

Traffic and Revenue Forecasts

Tolled traffic forecasts were prepared for the years 2021, 2031 and 2041. A range of sensitivity tests were undertaken on the input assumptions and model parameters, to which Monte-Carlo simulation was applied to provide probability-based forecasts at the 5th, 50th and 95th percentile levels. The resulting risk profiles are indicated in **Figure 1-1**. These show that in 2021 the expected (50th%ile) value is slightly below the modelled value (factor less than 1), which is due to the risks being skewed to down-side risks (primarily due to the effect of a possible lower WTP). These become skewed to the upside in later years (with probability based values higher than the modelled forecasts) due to the opportunities for higher land use growth in areas such as Weiti and west of SH1.

Figure 1-1 Risk Profiles on Patronage Predictions

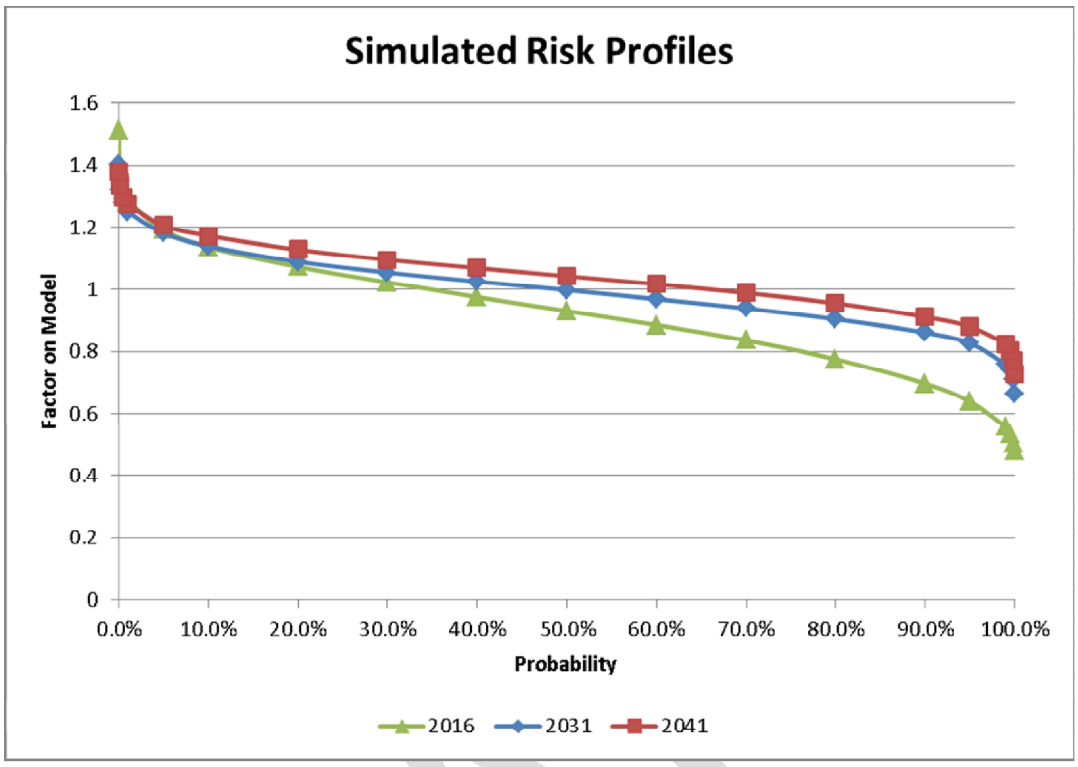
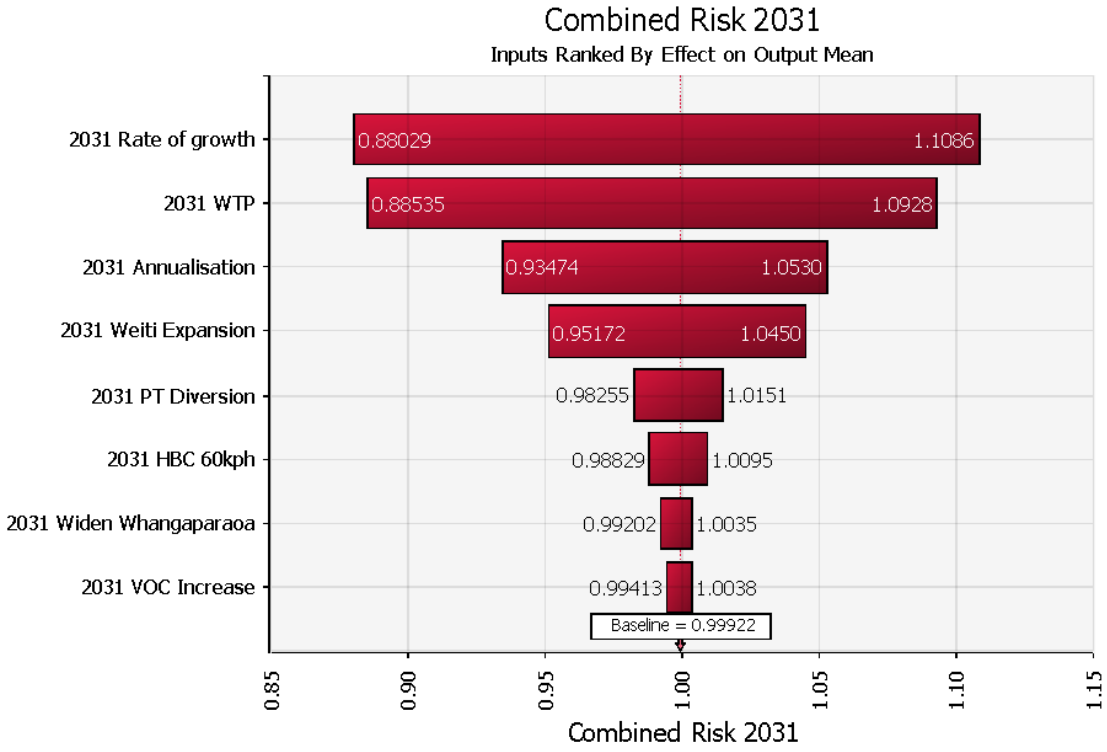


Figure 1-2 shows the key contributors to the risk profile in the year 2031, where it can be seen that the growth rates and WTP parameters contribute most to the uncertainty.

Figure 1-2 Key Contributors to Patronage Risks



The forecast AADT and annual gross revenues values with their probability ranges are summarised in **Table 2** and graphed in **Figure 1-3**.

Table 2 - Traffic and Revenue Forecasts

Year	AADT Flows at PENLINK Toll Gantry				Gross Annual Toll Revenue, $2013			
	Model	5%ile	50%ile	95%ile	Model	5%ile	50%ile	95%ile
2021	11,700	8,900	11,400	13,900	$9,700,000	$7,400,000	$9,500,000	$11,500,000
2031	12,600	10,400	12,600	14,900	$10,400,000	$8,600,000	$10,400,000	$12,300,000
2041	14,500	12,000	14,200	16,400	$11,300,000	$10,000,000	$11,800,000	$13,700,000

Figure 1-3 AADT Values and probability Ranges

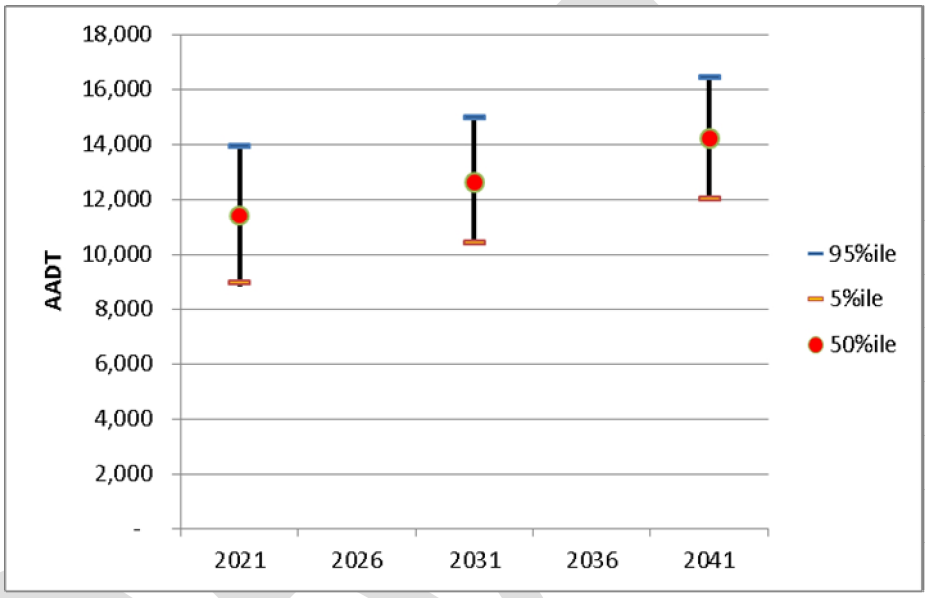
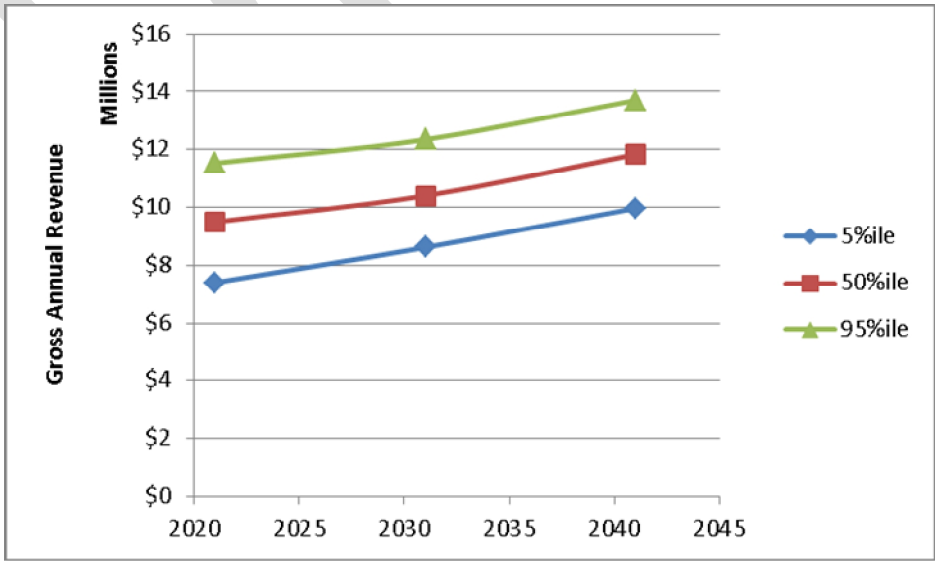


Figure 1-4 Gross Annual Revenue probability Ranges



The current patronage forecasts on PENLINK were also compared to those forecast for the Rodney District Council in 2007. Direct comparisons are not possible because the previous forecasts used different land use forecasts, a different option (2-lane with at-grade connections), different network assumptions, and a different (2-gantry) toll strategy and used a different toll model.

Not-withstanding those differences (in fact considering the changes in inputs and assumptions is in itself useful to understanding the uncertainties in the forecasts), the new forecasts show patronage levels noticeably higher than those previously forecast (between 9% and 70% depending on which of the previous toll strategies is considered).

Key Transport Outcomes

The level of service on PENLINK is expected to be high with high travel speeds, extensive passing opportunities and high safety performance through the divided carriageway and grade separation at Duck Creek and East Coast Roads. With PENLINK in place, the traffic flows are forecast to reduce (relative to the equivalent future Do Minimum scenarios) by up to 9,400 vpd (22%) on Whangaparaoa Road, up to 6,500 vpd (15%) on the HBC Highway through Silverdale and up to 15,700 vpd (17%) on SH1 between Redvale and Silverdale. Increases in traffic flow are forecast on SH1 south of Redvale of up to 4,300 vpd (5%) and on Whangaparaoa Road east of PENLINK of up to 3,900 vpd (15%). More critically, the peak-hour traffic flows on key sections such as the Silverdale interchange and on Whangaparaoa Road are forecast to reduce by nearly 500 vehicles per hour (20%-30%), bringing them below the capacity of those sections.

Auckland Transport is separately investigating widening of the section of Whangaparaoa Road between the Hibiscus Coast Highway and Red Beach Road. Auckland Transport instructed Beca that this analysis of PENLINK should exclude any such widening, although it was considered in the sensitivity testing. This modelling and testing indicated the following:

- The forecast reduction in peak-period traffic flow on this section of Whangaparaoa Road is such that widening of that section is unlikely to be required if PENLINK is constructed; and
- Including such widening in the analysis showed an improvement in network performance in the No-PENLINK scenario, but only minor changes if PENLINK was in place. This means that that widening is not predicted to make any material change in the traffic flow (and hence revenue) on PENLINK, but would reduce the economic efficiency of the project as measured against the No-PENLINK scenario (see further details below).

Relative to the 201 Do Minimum scenario, the models suggest that the travel times would be some 5 minutes quicker for those continuing to use the free HBC Highway route between Whangaparaoa and Redvale and between 13 and 20 minutes for those using the toll road. Without PENLINK, the peak direction travel times between Whangaparaoa and Redvale are predicted to increase from the current 20 minutes to over 55 minutes by 2041. With PENLINK provided these 2041 travel times are forecast to reduce by between 38 and 50 minutes, depending on the route taken.

For those using PENLINK, the travel time would be some 5.8km shorter and 8 minutes faster than using the free alternative route.

Economic Evaluation

A detailed economic evaluation of the PENLINK project was undertaken in accordance with the EEM. This analysis considered both capital and 'whole-of-life' operating and maintenance costs, assuming toll transaction costs of between 50c and 60c per vehicle (as advised by the NZ Transport

Agency). Standard transport benefits (such as travel time, vehicle operating and crash costs) were assessed. Wider Economic Benefits (WEBS) were assessed by PWC based on the traffic model outputs. Both National and Government Benefit Cost Ratios (BCRs) were assessed, which differ in their treatment of toll revenues. As specified in the EEM, Present Values are assessed over a 40-year analysis period using a 6% discount rate. The key evaluation results are summarised in **Table 3**.

Extensive sensitivity testing for a range of events considered to have a reasonable likelihood of occurring was undertaken and is summarised in **Table 4**. This may not be an exhaustive list of all events with a reasonable likelihood of occurring, nor was any attempt made to test any event that we considered did not have a reasonable likelihood of occurrence. These tests show that, of the tested items, the evaluation is most sensitive to the rate and location of growth and the discount rate.

Table 3 – Key Economic Evaluation Results

Item	Value	
Construction Cost, $M	358.5	
Property Cost, $M	26.4	
Present Value of Project Costs (including toll transaction costs), $M	387.8	
Present Value of Transport Benefits, $M	810.1	
Present Value of Agglomeration Benefits, $M	105.3	
Present Value of Other WEBS, $M	46.8	
Present Value of Gross Toll Revenue, $M	113.1	
Benefit Cost Ratios	**National (BCR_N)**	**Government (BCR_G)**
Transport Benefits only	2.1	2.5
With Agglomeration Benefits	2.4	2.9
With Agglomeration and Other WEBS	2.5	3.1

Table 4– Economic Evaluation Sensitivity Test Results

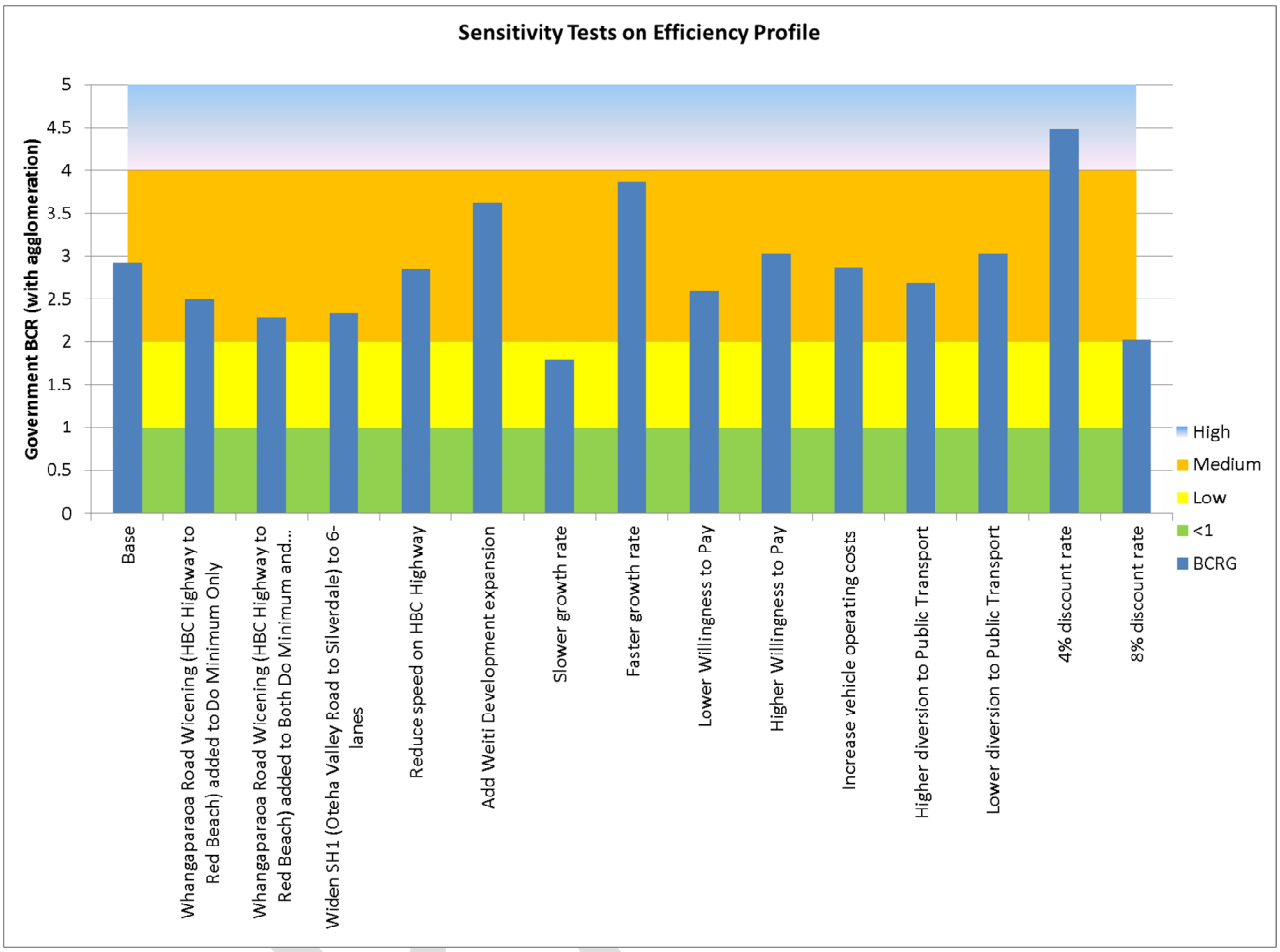
No	Test	BCR_G with agglomeration
0	**Base (6% discount rate, 40-year analysis period)**	**2.9**
1	Whangaparaoa Road Widening (HBC Highway to Red Beach) added to Do Minimum Only	2.5
2	Whangaparaoa Road Widening (HBC Highway to Red Beach) added to Both Do Minimum and PENLINK options	2.3
3	Widen SH1 (Oteha Valley Road to Silverdale) to 6-lanes	2.3
4	Reduce speed on HBC Highway to 60kph	2.9
5	Add Weiti Development expansion	3.6
6	Slower growth rate	1.8
7	Faster growth rate	3.9
8	Lower Willingness to Pay	2.6
9	Higher Willingness to Pay	3.0
10	Increase vehicle operating costs	2.9
11	Higher diversion to Public Transport	2.7
12	Lower diversion to Public Transport	3.0
13	4% discount rate	4.5
14	8% discount rate	2.0

These BCRs are used to determine the efficiency rating in the funding profile for the project. The funding profile is a three-measure profile used by the NZ Transport Agency to prioritise projects, and comprises rating the Strategic Fit, Effectiveness and Efficiency of the project as either low, medium or high. The funding profile is described and assessed in the full Business Case Report. The efficiency rating is defined by the NZ Transport Agency as follows:

- A LOW rating if the BCR is between 1.0 and 2.0
- A MEDIUM rating if the BCR is between 2.0 and 4.0
- A HIGH rating if the BCR is greater than 4.0

This analysis therefore shows that, with or without WEBS being included, PENLINK is assessed to have a MEDIUM efficiency rating. As indicated in **Figure 5**, when considering the sensitivity tests, the efficiency profile for the project is most-likely to be a MEDIUM rating, with 13 of the 14 tests indicating a BCR in this range. One of the tests showed a LOW rating while one showed a potential HIGH rating.

Figure 5 Sensitivity Testing of Government BCR (with Agglomeration)



Terms of Reference and Disclaimers, Assumptions and Limitations

The terms of reference for this report are to develop a toll model, based on Auckland Transport's existing Hibiscus Coast Transportation Model, which will be used to forecast toll revenues and the economic efficiency for the PENLINK Business Case. This report is limited to the agreed scope of work as detailed in **Appendix A**.

This report is based on the key inputs from Auckland Transport summarised in **Appendix B** subject to the assumptions detailed in this report. Beca did not review or make any determination regarding any legal, regulatory, insurance, commercial or financial matter.

In addition to the assumptions, qualifications and limitations detailed elsewhere in this Executive Summary and this report, the following limitations and disclaimers apply to Beca's engagement for this report.

This report was prepared for use by Auckland Transport only, with the usual care and thoroughness expected from a professional in the engineering consulting industry in accordance with the agreed scope of work and the conditions of engagement contained in Contract No 342-13-672-PS Penlink Advisory Services, dated June 2013 between Beca and Auckland Transport. It is based on generally accepted practices and standards at the time it was prepared.

Beca does not and cannot represent or warrant that all material relating to traffic and toll forecasting and economic evaluation issues relevant to Auckland Transport have been identified in this report. In preparing this report, Beca has relied on information identified in Appendix B. Beca has made no independent verification of this information/advice beyond the agreed scope of work. To the maximum extent permitted by law, Beca assumes no responsibility for any inaccuracies or omissions arising from the information listed in Appendix B. Opinions and conclusions presented in this report apply to the base traffic model, toll model and other assumptions, primarily produced by Beca at the time of Beca's review and necessarily cannot apply to changes made subsequently.

This report should be read in full and in the event of any inconsistency between this Executive Summary and the remainder of the report, the terms of this Executive Summary will prevail.

To the maximum extent permitted by law, (i) no warranty, expressed or implied, is made as to the professional advice included in this report; (ii) Beca disclaims responsibility for any changes or events that may have occurred after the date of this report; and (iii) Beca accepts no liability whatsoever (in contract, tort, including negligence or otherwise) for any loss or damage suffered as a result of any reliance on this report by any party other than Auckland Transport or for the use of any part of this report in any other context or for any other purposes not stated in this report.

Anyone relying on information contained in this document shall accept full responsibility and hold Beca harmless for the impacts on the traffic forecasts or the revenues from PENLINK arising from any inaccuracy in the traffic or toll revenue forecasts or the economic evaluation due to any assumption in any model or forecast proving to be inaccurate as a consequence of any change in any factor that cannot, by its nature, be predicted with any degree of precision. Without limitation, this includes factors such as changes in government policy or the pricing of fuels, road pricing generally, alternate modes of transport, the construction of other means of transport, the behaviour of competitors or changes in the policy of Auckland Transport or any other relevant authority affecting the operation of the project.

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Appendices

1 Introduction

1.1 Background

Beca was commissioned by Auckland Transport to provide technical inputs into an updated Business Case for the PENLINK Project north of Auckland. The previous Business Case was prepared in 2007 for the former Rodney District Council. This updated Business Case is being prepared by PWC on behalf of Auckland Transport. Beca provided technical input to the project concept design and cost estimation (documented elsewhere), as well as traffic forecasting, analysis and economic evaluation. First drafts of this report were prepared in mid-2013. In early 2014 the traffic models were updated to utilise new regional land use predictions provided by Auckland Transport, known as Scenario I-8b. The models also reflected some design changes to connections to Penlink, as developed during the consenting process. This report retains much of the 2013 analysis, however the traffic and economic forecasts in Chapters 7 and 8 have been revised to reflect those updated models.

1.2 Report Purpose

The purpose of this report is to detail the traffic modelling and economic evaluation that has been undertaken in the 2013 assessment of the Penlink project. It describes the updates that have been made to the traffic model, the options that were tested during the options assessment phase of work, the development of the toll strategy, the patronage forecasting and the economic evaluation.

This report is prepared solely for Auckland Transport and is provided on the basis of the Terms of Reference and Legal Disclaimer detailed in the Executive Summary to this report.

1.3 Report Structure

The remainder of this report is structured as follows:

Chapter 2 Discusses the study process and stages for the traffic and toll modelling

Chapter 3 Details the base model specification and validation results

Chapter 4 Describes the forecasting inputs and assumptions

Chapter 5 Details Stage 1 of the modelling process that has been followed – the option testing

Chapter 6 Details Stage 2 of the modelling process – the development of the toll strategy

Chapter 7 Discusses Stage 3 of the modelling – the patronage forecasting

Chapter 8 Describes the economic evaluation that has been undertaken for the project

Chapter 9 contains the summary and conclusions of this report

2 Study Process and Stages

Traffic and toll modelling and forecasting has been undertaken to update the Business Case for the Penlink project. The Business Case is being developed by a study team of Auckland Transport, PWC and Beca. Beca's involvement has been in relation to traffic modelling and engineering, planning and cost estimation.

The development of the traffic model and the resultant toll strategy and economic evaluation has been undertaken in the three stages:

- Stage 1 – Option Testing
- Stage 2 – Toll Strategy Development for the preferred option)
- Stage 3 – Patronage forecasting and economic evaluation (for the development of the Business Case)

To meet the timeframes for this study the model was progressively refined through each stage of the study. These refinements primarily related to Auckland Transport resolving issues with the land use forecasts, but also included refinements to the networks and toll response model.

The Stage 1 models used the original RDC land use forecasts but with more up to date information on specific developments in the area. The Stage 2 models included refined toll response models but also used the RDC models. Updated land use forecasts from Auckland Transport became available for the Stage 3 modelling in mid-2013 (known as Scenario I-5a), and were used in the first 2013 draft of this report. The Stage 3 modelling was updated to reflect newer land use forecasts in 2014 (using Scenario I-8b land use forecasts).

Each of these stages is described in detail in following chapters of this report.

3 Base Model Specification

This chapter details the history of the model that has been used for this analysis, the update that has been undertaken to the base model and the resultant validation.

3.1 Model History

Auckland Transport's existing Hibiscus Coast (HBC) traffic model was used to undertake the traffic modelling and toll analysis for this study. It was originally developed for the Draft Business Case forecasting for Penlink in 2004, drawing on data collected and used for the forecasting for the ALPURT B2 project. In 2005 that model was then adopted by Rodney District Council (RDC) as a general traffic planning model for the Hibiscus Coast. In 2007, version 2 of the HBC model was created to include revised geographical factors in the distribution model. The land use assumptions were further updated as and when necessary, and the economic analysis for the Penlink project was updated in April 2009, November 2009 and March 2010.

In 2007 the HBC model was updated to version 3 with the inclusion of 2006 census demographic data and new demographic forecasts, and used for various transport planning and operational studies in this area. A number of changes were made to the model for this updated PENLINK Business Case, which have been designated Version 4. The key changes include:

- Development of a 2013 base model for validation/calibration;
- Changes to the land use forecasts used in the model;
- Update of the external trip generation model and distribution model parameters to aide validation of surveyed origin-destination data;
- Inclusion of a module to reflect the Silverdale Park and Ride project directly in the TRIPS model (previously only included in the corridor simulation models); and
- Update of various forecasting inputs and assumptions, as described later in this report.

The original 2004 PENLINK model was peer reviewed by Hyder International Ltd, while versions 1 and 2 of the subsequent HBC model were peer reviewed for general planning purposes by GHD Ltd. The toll model used with version 2 was peer reviewed by Keith Long from Sydney.

3.2 Model Description

The form of the model is a three-step traffic model relating land-use to trip making through trip generation and distribution models, followed by traffic assignment models (which include the response to tolls).

The trip generation model is implemented in a spreadsheet, but all other components are implemented in the CUBE (TRIPS) software suite.

That model predicts traffic flows for various trip purposes based on input land use data and has three main components as follows:

- Trip generation. This is where traffic generation for each zone is predicted, based on land use data and daily vehicle trip rates;
- Trip distribution. This is where trip generations and attractions at each zone are matched to create origin-destination trip tables. The 'distribution' of trips from each zone to the other zones is a function of the relative generations at each zone and also the cost of travel between zones. Also within this component, daily trip tables are converted to peak period trip tables;

- Trip assignment. This is where peak period trip tables are loaded, or 'assigned' to the road network based on vehicles following the path of least cost between each origin and destination. This is also where traffic speeds and intersection delays are calculated.

The model has the following trip purposes

- HBW – Home Based Work trips (commuters)
- HBS – Home Based Shopping trips
- HBO – Home Based Other trips
- NHB – Non Home Based trips
- HBE – Home Based education trips
- HCV – Heavy Commercial Vehicles

In addition to the above trip purposes, it includes estimation of trips associated with the proposed Gateway Entertainment area in Silverdale (subject to Plan Change 123).

3.2.1 Model Extent

The model extends from Puhoi in the north to Long Bay in the south, and from the Pacific coast in the east to Upper Silverdale in the west. Although the internal zone system extends only to Long bay in the south, the network extends to Greville Road to provide more accurate loading points onto the three north-south routes, namely SH17, SH1 and East Coast Road. The extent of the model is shown in **Figure 3-1**.

3.2.2 Zone System

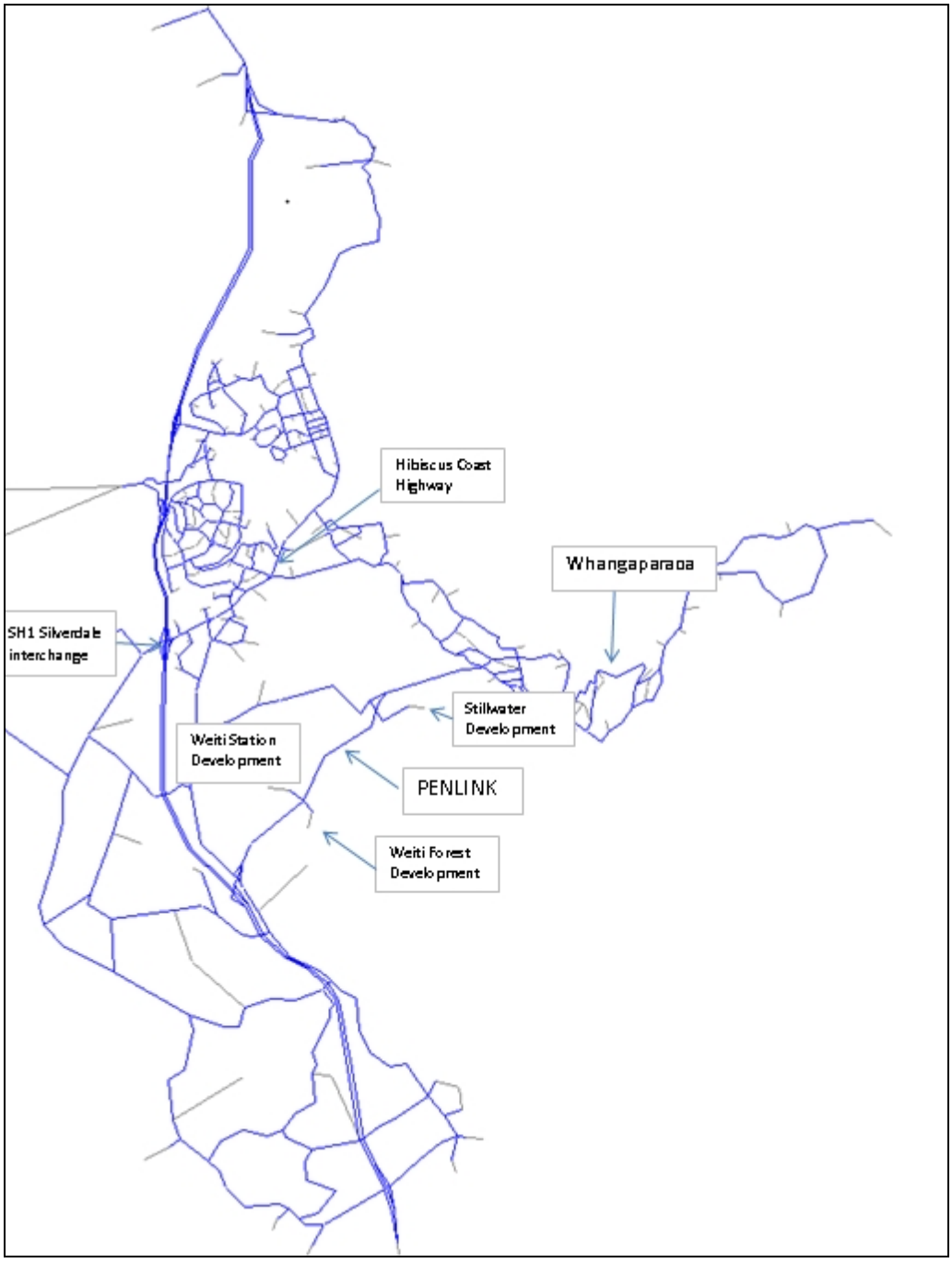
The zone system adopted in the model is based on the RDC Planning Area Units (PAUs). These are geographical units used in land use and transport planning within the Hibiscus Coast area. The PAUs have common boundaries with census meshblocks and census area units (CAU).

In some areas the PAU zones were split to provide more accurate loading of traffic to the road network, however, the relationship to PAUs was retained for forecasting purposes.

3.2.3 Network Representation

All major roads down to at least principal streets are explicitly represented in the model. Local roads are included where appropriate to improve the network loading or assignment. Generally all intersections are explicitly modelled using the inbuilt TRIPS junction modelling procedures. In some dense development areas the internal intersections are not explicitly modelled, although all connections points to the main network are.

Figure 3-1 - Extent of the HBC model



3.2.4 Park and Ride Module

This module reflects the Silverdale Park and Ride project currently under construction in Silverdale. The model uses the expected daily usage of the Park and Ride (both in terms of Park and Ride and Kiss and Ride trips) as follows:

- It adds park and ride vehicle trips from the home zone to the Park and Ride site (inbound in the morning and outbound in the evening peak);
- It adds Kiss and Ride vehicle trips from the home zone to the site and back to the home zone; and
- It removes a proportion of trips between the urban HBC areas and the southern external of the model at Albany. The trips removed are a function of the park and ride + kiss and ride demand and a diversion rate. The diversion rate is the proportion of new bus users who would otherwise be car drivers (the assumptions used in future years are documented later in **Table 4-2**).

3.3 Base Model Update

For the current work, the base model was updated to a 2013 base year, with modifications made to reflect changes in land use and networks. The following changes were made to the model:

- Recent 2012 population data provided by Auckland Transport was used to rebase the trip generation models, in conjunction with local information on new developments such as Silverdale North;
- Networks were refined in areas to reflect new information on developments, such as Silverdale North, and to add refinement in areas where the longer-range forecasts used here were indicating future congestion. This included how areas such as Red Beach, Wainui and Weiti connected to the network;
- The trip-end model was updated so that external trip ends responded to all changes in internal trip ends (previously locked to fixed totals for each year);
- The proportion of trips going to external zones was reduced as part of calibrating the origin-destination movements and to reflect the trend for greater internalisation of trips, as indicated in the ART3 model;
- Minor changes to 'K-factors' used in the distribution models and to peak period factors as part of calibrating the model; and
- Updates to the Value of Time (VoT) parameters and vehicle operating cost parameters used in the generalised cost functions for both the distribution and assignment models

3.3.1 Toll Model Update

In the HBC model tolls affect both the distribution of trips (origin-destination patterns) and the assignment of trips (the routes chosen through the network). These are reflected through generalised travel costs which include travel time, perceived vehicle operating costs and perceived toll costs. The monetary costs (tolls and vehicle costs) are converted to equivalent minutes using Values of Time (**VoT**) parameters.

In the distribution model, these generalised costs are reflected at a matrix-level and influence the destination choice in formulating the origin-destination patterns. In the route choice model, the costs are summed along the possible paths as vehicles seek the least-cost route.

A 14-class route-choice model was used for the traffic and toll modelling. This is a much simpler model than the logit-choice model used in previous forecasts and was selected due to its simplicity, ability to undertake economic evaluations specifically on each user class and because the likelihood that a multiple-gantry toll strategy would not be adopted. The model separately assigns 14 different user classes so that the wide distribution of WTP behaviour can be reflected. Those classes are based on segmenting the trip purpose classes in the HBC model into equal thirds, each with low, medium and high WTP parameters assigned.

The VoT used in the models were developed as follows:

- Start with the VoT parameters identified in the Stated Preference surveys undertaken in 2007 for the Tauranga Eastern Link Toll Road;
- Review the changes made to those parameters to calibrate the Tauranga model to match what actually occurred when the toll on the Route K toll Road was increased from $1.00 to $1.50 in 2012 (this involved increases of between 20% and 70% of the WTP parameters);
- Apply a 30% increase to the original 2007 values across all classes in the model and test the toll diversion for an initial 2021 model of PENLINK with a $2.00 toll;
- Compare the diversion against that indicated for the nearby Northern Gateway Toll Road, which offered similar distance and time savings for its original $2.00 toll in 2010; and
- Compare the combined trip suppression and diversion effect against the observed induced/diverted traffic when the $1.00 toll was removed from the Tauranga Harbour Bridge in 2001

The VoT values used showed a similar diversion and suppression response to that observed on the three NZ toll roads and so were adopted as suitable for this work (as described below). Because these values were not determined from explicit market research, and because of the uncertainty in any such behavioural response to tolls, specific sensitivity tests were undertaken on higher and lower WTP parameters.

The updated ($2013) generalised cost parameters used in the distribution model are shown in **Table 3-1** while those used in the route choice model are shown in.

Table 3-1 - Generalised Cost Parameters used in Distribution Model

Trip Purpose	VoT, $/hr	VoT, min/c	Vehicle Cost, c/km	Vehicle Cost, min/c
HBW	$18.09	0.0332	25	0.8292
HBS	$12.31	0.0487	25	1.2181
HBO	$12.31	0.0487	25	1.2181
NHB	$19.74	0.0304	25	0.7599
CV	$28.44	0.0211	35	0.7385
HBE	$12.31	0.0487	25	1.2181

Table 3-2 - Generalised Cost Parameters used in Route Choice Model

	User Class	VoT, $/hr	VoT, min/c	Vehicle Cost, c/km	Vehicle Cost, min/c
1	HBW Low VoT	$13.61	0.0441	20	0.8818
2	HBW Medium VoT	$16.16	0.0371	20	0.7426
3	HBW High VoT	$24.50	0.0245	20	0.4898
4	HBS, HBO, HBE Low VoT	$6.96	0.0863	20	1.7250
5	HBS, HBO, HBE Medium VoT	$11.25	0.0533	20	1.0669
6	HBS, HBO, HBE High VoT	$18.74	0.0320	20	0.6405
7	NHB Low VoT	$9.61	0.0624	20	1.2489
8	NHB Medium VoT	$17.16	0.0350	20	0.6992
9	NHB High VoT	$32.45	0.0185	20	0.3698
10	LCV Low VoT	$20.22	0.0297	30	0.8903
11	LCV Medium VoT	$40.82	0.0147	30	0.4410
12	LCV High VoT	$87.30	0.0069	30	0.2062
13	HCV	$35.54	0.0169	60	1.0128
14	External	$18.25	0.0329	21	0.6897

3.3.2 Benchmarking of Toll Response

The model responds to a toll both by altering the trip demands (suppression) and diverting traffic to an alternative route (diversion). This combined effect of suppression and diversion was clearly demonstrated when the $1toll was removed from the Tauranga Harbour Bridge in 2001. In that case, the flows on the bridge increased substantially and while those on the alternative initially reduced, they returned to original values within 6 months, giving a net increase in total cross-harbour traffic. If this was considered to be adding a toll rather than removing one, then the combined suppression and diversion effect was some 27%. This was with a $1 toll in 2001, so roughly similar to a $1.50 toll today. Hence we could expect a combined suppression/diversion reduction somewhat greater than 27% with a $2.00 toll.

In 2012 the toll on route K was increased from $1.00 to $1.50. The time savings compared to the alternative are much less than PENLINK, ALPURT or the Tauranga Harbour Bridge at only some 2 minutes. However, this 50c increase is estimated to have created a reduction in traffic of approximately 13% (the actual flow stayed the same as previous year, however it stopped the rapid annual increases that had been experienced). To replicate this response the WTP values from the Stated Preference surveys had to be increased by between 20% and 70%.

Analysis of the Northern Gateway in 2009/2010 showed diversion of through traffic from the $2.00[1] toll of approximately 20%. The time and distance savings are very similar to PENLINK. However the markets for the road are likely to be different to PENLINK, with less commuter trips and more business and tourist traffic. As such, the ability to transfer to PENLINK is unclear but a useful guide none the less.

[1] Since increased to $2.20.

The 2021 PENLINK model was run with a $2.00 toll and VoT parameters set at some 30% higher than those in the Tauranga Stated Preference surveys. This test found a diversion of 20% and a combined suppression/diversion reduction of a 35%. Overall, these results are considered to be reasonable and consistent with the (albeit somewhat limited) response to tolls observed in NZ. The sensitivity tests undertaken on the WTP parameters are discussed later in this report.

3.4 Base Model Validation

A validation exercise was undertaken to ensure the model was fit for purpose. Minor modifications were made to the network and matrix following the first runs of the model to address some of the discrepancies with the observed data. These were as follows:

- The free speed and capacity on Whangaparaoa Road were adjusted;
- The signal timings were changed at the following three intersections: Hibiscus Coast Highway/Whangaparaoa Road, Hibiscus Coast Highway/East Coast Road and Whangaparaoa Road/Vipond Road;
- The free speed was adjusted on East Coast Road and Dairy Flat Highway; and
- Land use adjustments were made around the Hibiscus Coast Highway/East Coast Road and Hibiscus Coast Highway and Whangaparaoa Road intersection areas to match recent developments.

3.5 Validation Results

The following sections outline the validation results, which included comparisons of link and turn traffic flows, travel times and origin-destination movements.

3.5.1 Count Comparison

A comparison was undertaken of counts collected within the study area against model counts. These were done at a link and turn flow level.

The count comparisons were measured using the following statistical tests:

- Actual and percentage differences between modelled and observed flows
- Root Mean Square Error (RMSE). This is a global measure, with an EEM suggested target value of less than 30%
- GEH, this is a form of Chi-squared statistic that is designed to be tolerant of larger errors in low flows. The formula to calculate GEH is as follows:

$$GEH = \sqrt{\frac{(q_{model} - q_{obs})^2}{(q_{model} + q_{obs})/2}}$$

Where:

q_{obs} = observed hourly flow

q_{model} = modelled hourly flow

This measure is calculated for each link and screenline. The EEM suggests the following criteria for an acceptable fit of the model:

- At least 60% of individual link flows should have GEH less than 5.0;
- At least 95% of individual link flows should have GEH less than 10.0;
- All individual link flows should have GEH less than 12.0; and
- Screenline flows should have GEH less than 4.0 in most cases

Link Counts

The model was compared against observed data at a eight locations (in each direction, giving 16 data points) on SH1 and SH17, as follows:

- SH1 - Silverdale interchange
- SH17 - North of Pine Valley Road
- SH1 - Silverdale north facing ramps
- SH1 - Silverdale south facing ramps
- SH17 – North of Orewa Bridge
- SH17 - North of East Coast Road
- SH17 – North of Whangaparaoa Road
- SH17 – North of Wainui Road, south of Whangaparaoa Road

Table 3-3 displays the statistics for AM, inter and PM peaks, with a more detailed count comparison found in **Appendix C**.

Table 3-3 - Link Count Comparison

Measure	Target	AM	IP	PM
GEH Percentage (Individual Link)				
GEH <5	60%	88%	94%	88%
GEH <10	95%	100%	100%	100%
GEH <12	100%	100%	100%	100%
RMSE	<30%	12%	9%	12%

Table 3-3 indicates that the model can be considered to have achieved a good level of fit in the model area and therefore is considered appropriate for the purpose of the Penlink study.

Figure 3-2 – **Figure 3-4** show the peak period comparisons.

Figure 3-2 - AM Peak Comparison of 2013 Peak Period Flows

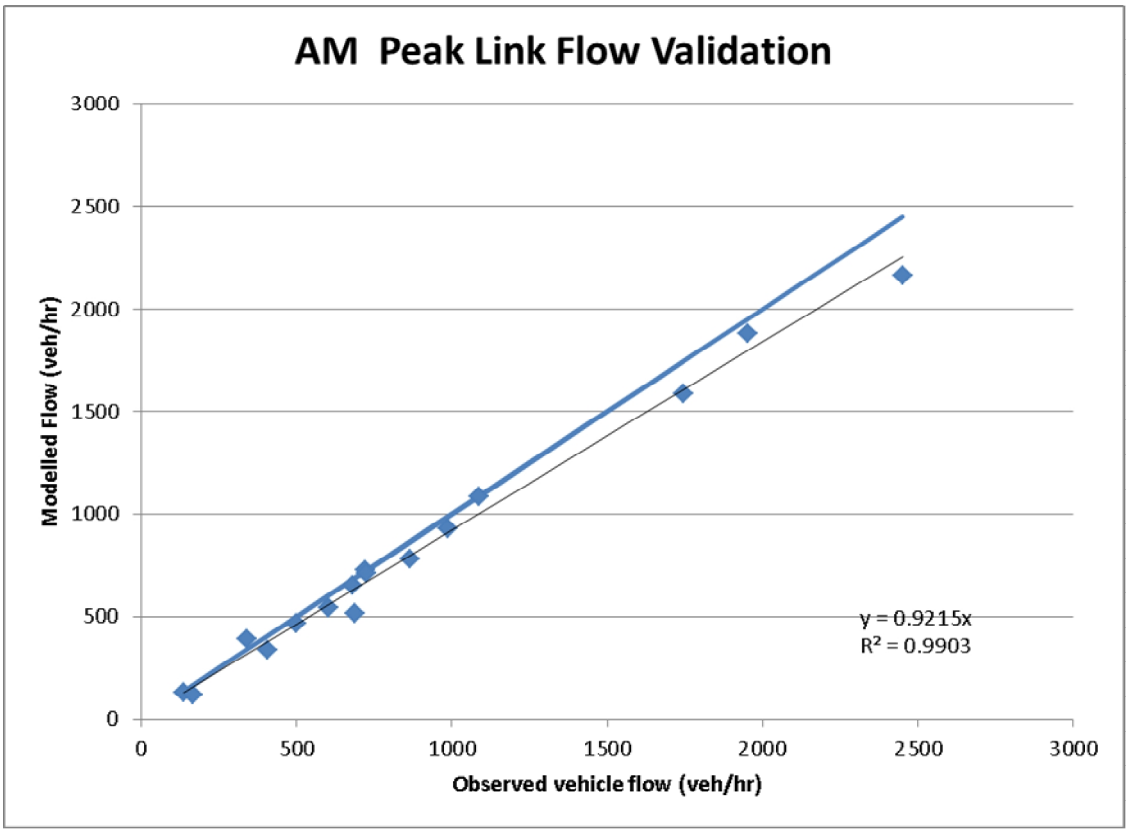


Figure 3-3 - Inter Peak Comparison of 2013 Peak Period Flows

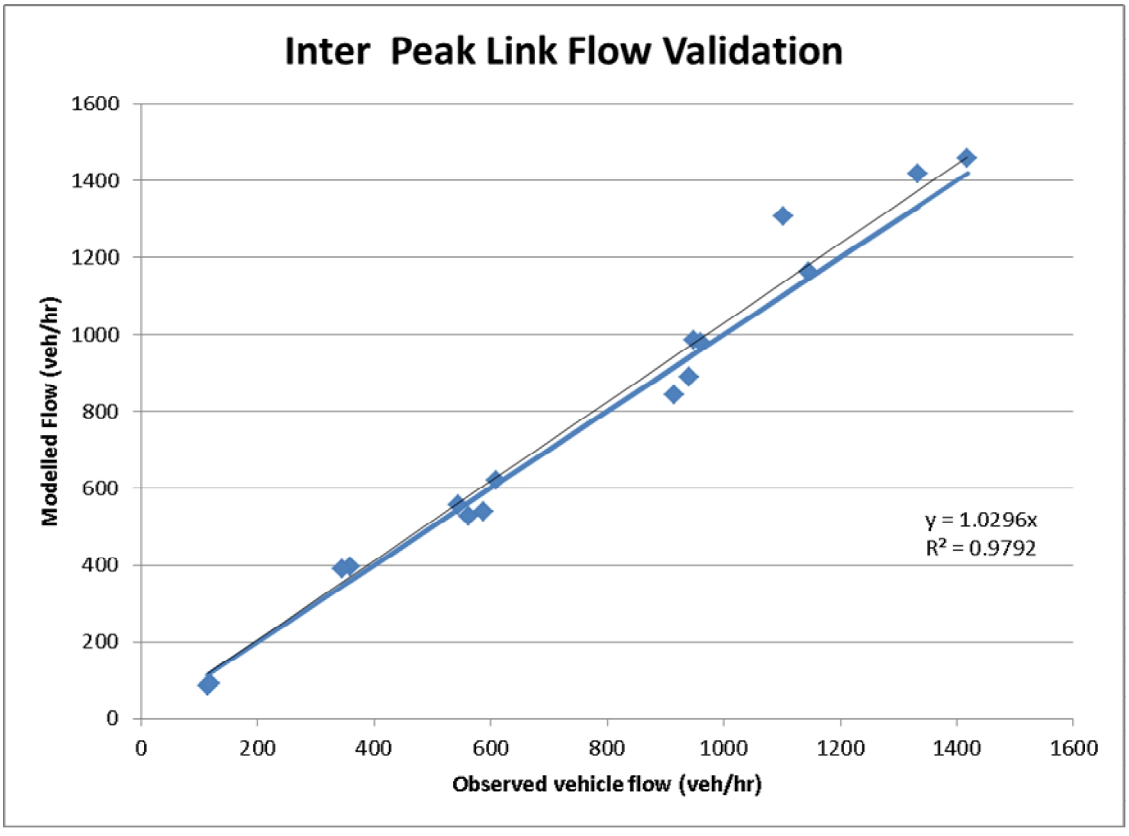
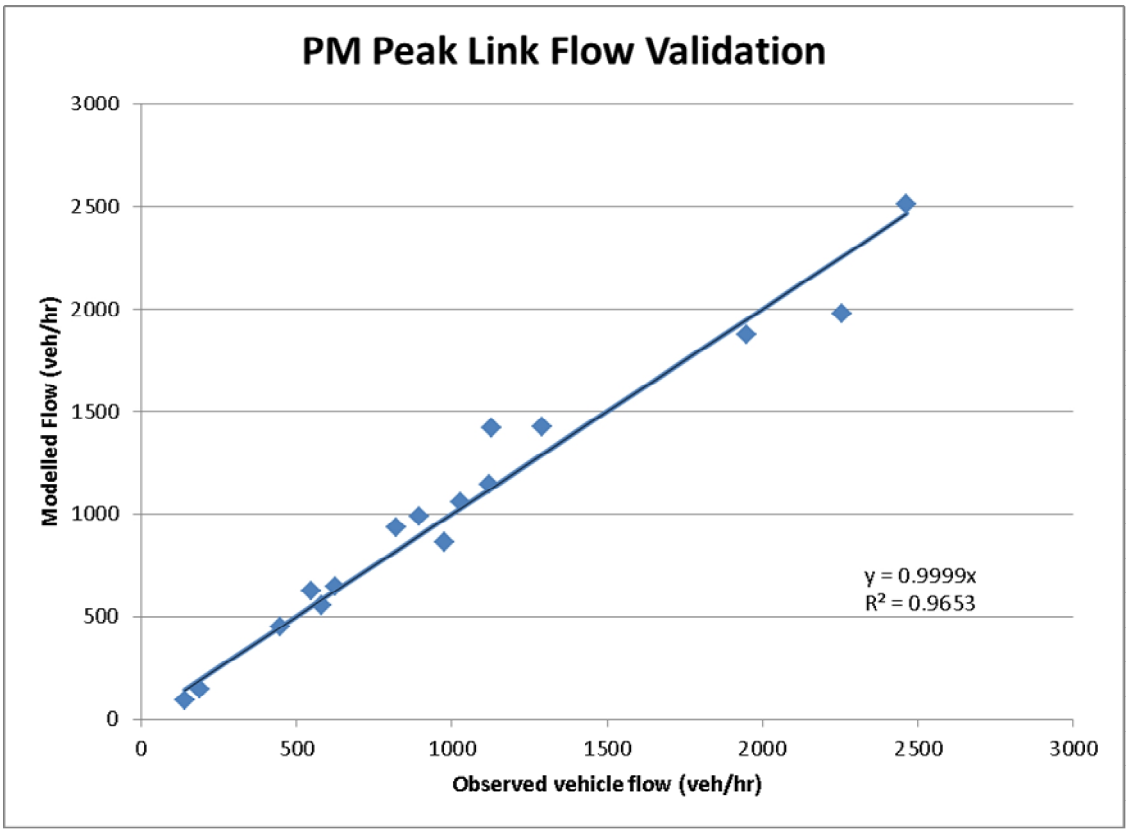


Figure 3-4 - PM Peak Comparison of 2013 Peak Period Flows



Turn Counts

The model was compared against turning count data collected at 6 intersections. The data collected was a mixture of surveyed data and SCATS data at the following intersections:

- Dairy Flat Highway, northbound off-ramp roundabout (survey data)
- Hibiscus Coast Highway, southbound on/off roundabout (survey data)
- East Coast Road/Hibiscus Coast Highway intersection (survey data)
- Whangaparaoa Road/Hibiscus Coast Highway intersection (SACTS data)
- Red Beach Road/Whangaparaoa Road intersection (SCATS data)
- Whangaparaoa Road/Vipond Road intersection (SCATS data)

Table 3-4 displays the statistics for AM, inter and PM peaks, with a more detailed count comparison found in **Appendix D**. The EEM does not have GEH targets for turn count comparisons, so the link count targets were used as a guide.

Table 3-4 – Turn Count Comparison

Measure	Target	AM	IP	PM
GEH <5	60%	65%	71%	73%
GEH <10	95%	94%	96%	92%
GEH <12	100%	98%	96%	98%

Table 3-4 shows that the model reached a reasonable level of fit for the turning counts. The AM and interpeak counts that did not reach the GEH criteria are SCATS collected data which is not thought to be as robust as the surveyed data. It is therefore is considered appropriate for the purpose of the Penlink study.

Figure 3-5 – **Figure 3-7** show the peak period comparisons.

Figure 3-5 - AM Peak Link flow Comparison of 2013 Peak Period Flows

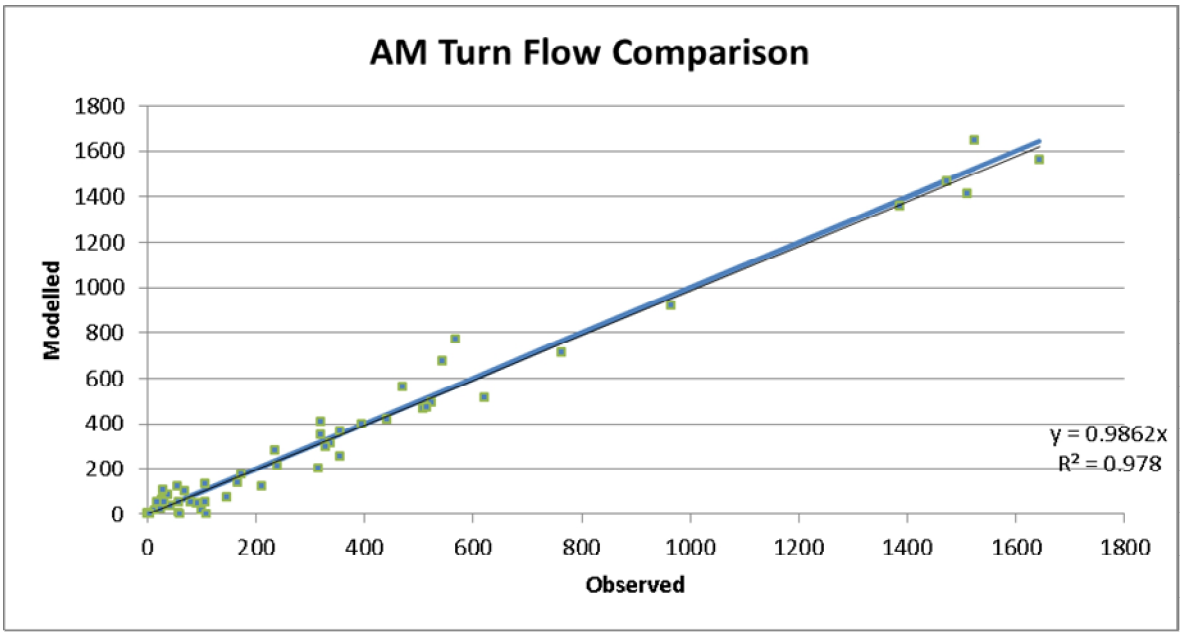


Figure 3-6 - Inter Peak Link flow Comparison of 2013 Peak Period Flows

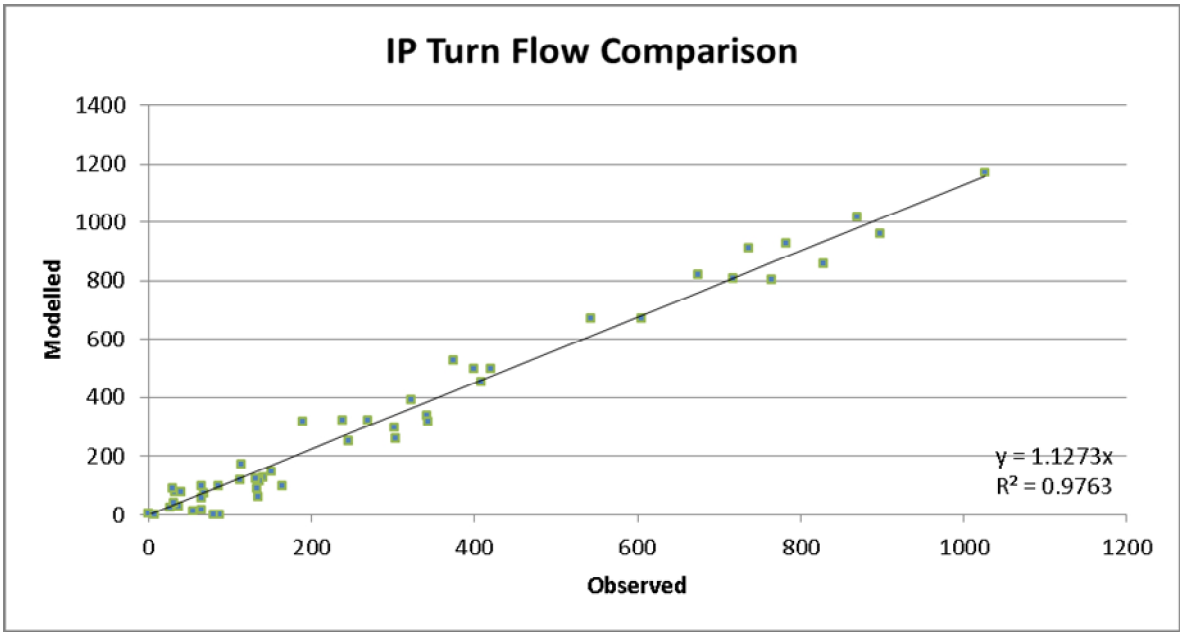
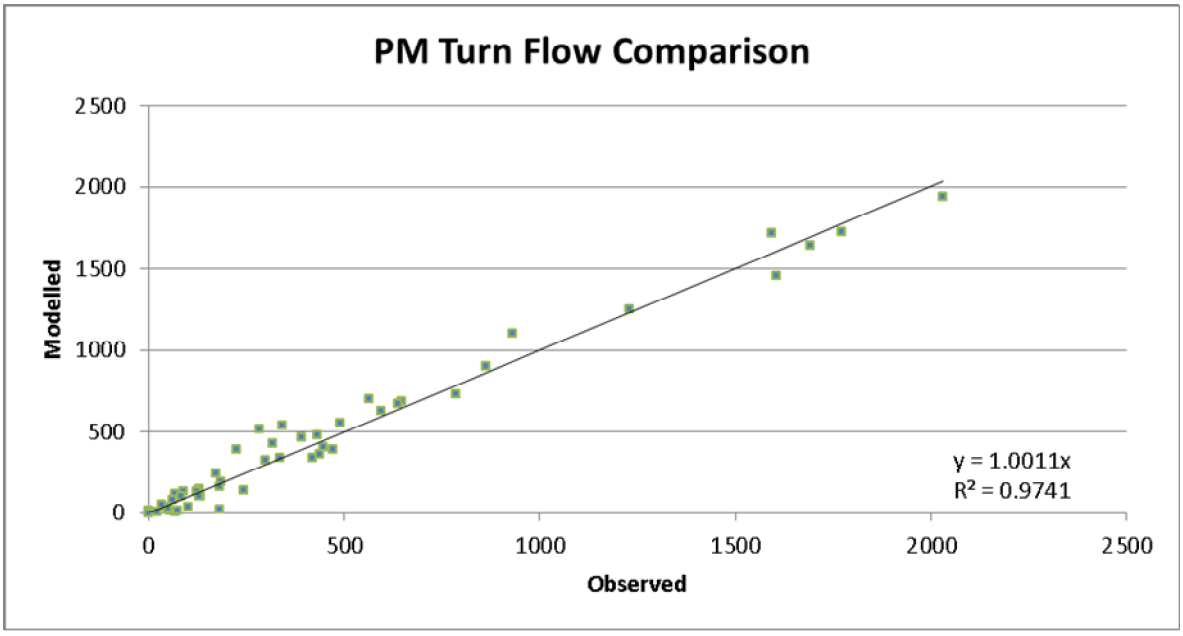


Figure 3-7 - PM Peak Link flow Comparison of 2013 Peak Period Flows



3.5.2 Travel Time Comparison

Travel time comparisons were undertaken against observed data collected on the following five routes:

- Stanmore Bay northbound to Hibiscus Coast Highway
- Hibiscus Coast Highway westbound to SH1 interchange
- SH1 Interchange southbound to Oteha Valley Road
- Oteha Valley Road northbound to Hibiscus Coast Highway off-ramp to Whangaparaoa Road
- Whangaparaoa Road southbound to Stanmore Bay

A comparison of the travel times between the observed and modelled data can be seen in **Table 3-5,** with distance-travel graphs found in **Appendix E**.

Table 3-5 shows that for the majority of routes the model is within the minimum and maximum of the observed travel time data. In the AM and inter peaks, the model is slightly faster on SH1 than the observed data.

Table 3-5 - Travel Time Summary

Route	Dir	AM				Inter Peak				PM Peak			
		Min (obs)	Mean (obs)	Max (obs)	Modelled	Min (obs)	Mean (obs)	Max (obs)	Modelled	Min (obs)	Mean (obs)	Max (obs)	Modelled
Stanmore Bay to Hibiscus Coast Highway	NB	9.09	10.13	12.15	11.03	8.00	8.30	8.62	9.13	9.75	10.07	10.38	9.21
Hibiscus Coast Highway to Sh1 interchange	WB	1.98	2.70	3.79	2.46	2.27	2.72	3.69	2.11	1.83	2.05	2.33	2.11
SH1 Interchange to Oteha Valley Road	SB	8.90	9.49	10.00	8.32	7.98	8.32	8.65	8.04	8.08	8.56	8.90	8.02
Oteha Valley Road to Hibiscus Coast interchange (end of off ramp)	NB	8.52	8.79	9.48	7.95	8.32	8.62	8.92	8.04	9.50	10.30	11.10	11.02
Hibiscus Coast Highway interchange to Whangaparaoa Road	EB	2.30	3.98	5.98	2.66	2.48	3.20	4.22	3.04	2.48	4.24	7.02	5.31
Whangaparaoa Road to Stanmore Bay	SB	9.77	9.77	9.77	9.07	8.83	9.62	10.27	9.02	8.68	10.13	12.38	12.08

3.5.3 Origin-Destination Comparison

To calibrate the origin-destination movements of people likely to use Penlink. surveys were undertaken for trips travelling between Whangaparaoa and the SH1 interchange area at Silverdale. The surveys were done by video, with automated number plate recognition, followed by vehicle matching analysis. The surveys were carried out over a 12-hour period (0630-1830), concentrating on the westbound direction (that is outbound from the Whangaparaoa Peninsula, and vehicles were segmented by light and heavy vehicle classifications. Two sites on the Whangaparaoa peninsula were used, these were:

- Vipond Road, just west of D'Oyly Drive
- Whangaparaoa Road, just west of D'Oyly Drive

Three sites at Silverdale were surveyed as follows:

- East Coast Road, just south of Tavern Road
- SH1, south-facing ramps at Silverdale Interchange
- Dairy Flat Highway, just west of SH1

The comparison focussed on the number and proportion of trips from the two sites on the Whangaparaoa Peninsula to the three sites at Silverdale. The results can be seen in **Table 3-6**, showing the breakdown of trips from the Whangaparaoa Peninsula to SH1 for the 12-hour period, AM, inter and PM peaks.

Table 3-6 - Origin-Destination Survey Comparison

	To Destination Sites			
	12-hours	**AM**	**IP**	**PM**
Observed				
Matched from Whangaparaoa	4167 (34%)	757 (42%)	305 (32%)	259 (28%)
Not Matched from Whangaparaoa	8026 (66%)	1065 (58%)	651 (68%)	669 (72%)
Modelled				
From Whangaparaoa to destination sites	4801 (38%)	953 (50%)	342 (34%)	250 (26%)
From Whangaparaoa to other sites	7957 (62%)	972 (50%)	657 (66%)	708 (74%)

Although the matches are not perfect, it was found that it was not possible to get an exact match from the 24-hour distribution model without significantly altering the model, which was found to compromise other validation data. Given that the survey data was from a single-day survey, the match is considered to show that the model does reasonable replicate the trip-making patterns for this movement.

3.6 Summary

The model has been calibrated and validated to observed data on link and turn flows, travel times and Origin-Destination movements A satisfactory match was found between the model and the observed data so it is considered that the model is suitable for the assessment of the Penlink project.

4 Forecasting Inputs and Assumptions

4.1 Land Use Inputs

4.1.1 Approach

The previous versions of the HBC model all used demographic forecasts provided by the Rodney District Council (version 3 used those from the 2009 RDC land use model). For this updated Business Case analysis Auckland Transport specified the use of land use forecasts developed by the Auckland Council for the Auckland Plan. Specifically, the Auckland Plan Scenario I forecast was specified, which used the medium-level population growth forecasts for the Auckland Region and is being used for a number of projects across the region. However, analysis of those forecasts at a detailed level raised a number of questions about their suitability for this specific work. Those issues included substantially declining population predictions in Whangaparaoa, albeit with increasing household numbers and inconsistencies with known development yields.

Because of those issues, the PCG agreed that the first two stages of this study (option analysis and toll strategy analysis) could retain the original RDC predictions developed in 2009 (albeit with specific adjustments for known developments).

Auckland Transport addressed the issues identified in work they had already underway to modify the Scenario I forecasts to address similar known issues elsewhere in the region. This resulted in two new land use scenarios developed by Auckland Transport, known as scenario 5a and 5b. Scenario 5a was used for PENLINK as it was the first one available at the time, however subsequent analysis has shown that there is no material difference between 5a and 5b in the HBC area (the differences between 5a and 5b only relate to changes in employment predictions in and around the Auckland CBD). Subsequent to the 2013 modelling, Auckland Transport further refined the regional land use predictions, resulting in Scenario I-8b, which is being used in various studies across the region.

Subsequently the 2013 patronage forecasts and economic analysis used in Stage 3 (Business Case inputs) were based on Auckland Transports Scenario 5a predictions, while this 2014 update uses Scenario I-8b forecasts. Again, in specific development areas the known yields were used in preference to the regional strategic forecasts. The most significant change between Scenario I-5a and Scenario I8b in this area relates to growth in the extended Rural Urban Boundary (RUB) areas, west of SH1 and included in the Proposed Auckland Unitary Plan as Future Urban zones. Although the Scenario I-5a forecasts included significant growth in those areas, the 2013 business case modelling excluded that growth due to the uncertainty of its location and magnitude (although sensitivity tests were undertaken). The Scenario I-8b forecasts use a more refined zone system for the land use forecasts (linked to version 3.2 of the ART3 model) and predictions that better match the PAUP zoning.

4.1.2 Developing Land Use Inputs to Business Case Models

As noted above, the HBC model is a stand-alone model that is not reliant on Auckland Council's ART3 regional strategic model. However, the land use forecasts specified for use in this work were developed for the ART3 model and its zone system. Although the zone systems of both the HBC and ART3 models are built on census meshblocks, the two zone systems use different aggregations of meshblocks and hence do not have common boundaries. The ART3 zones are much larger than those in the HBC model so does not have the spatial precision required for detailed modelling in this area. Subsequently, the general process for updating the land use in the

HBC model was to retain the spatial detail of the HBC model but factor the forecasts for aggregate areas that generally (but not exactly) matched the ART3 zones.

Also, while the original HBC model has 100 zones linked to 2006 meshblock data, a number of these zones have been split to represent specific developments or activities (e.g. development precincts, schools, park and ride etc), and which are not based on meshblocks.

The version 4 update of the HBC model also included use of available population estimates for 2011, sourced from Auckland Transport.

This detailed process was as follows:

1. Create 2013 base year models using the 2011 population forecasts and manual counts of household numbers in rapid-growth areas such as Silverdale North;
2. Identify the meshblocks that comprise each ART3 zone;
3. Review the Scenario I-8b forecasts for each ART3 zone and make minor adjustments to Household and Employment values to remove inconsistencies between the actual and forecast 2011 data to smooth fluctuations in household numbers;
4. Starting with the predicted future-year mesh-block forecasts provided in the 2009 RDC land use predictions, factor all meshblocks within an ART3 zone to match the aggregate total in the equivalent ART3 zone of the Scenario I-8b predictions;
5. Aggregate these modified meshblock values to the HBC model zone system; and
6. Make adjustments in specific development areas based on the latest known yield information, using the ART3 data to inform the take-up rates;

The assumptions used for these specific local development areas are described later in Table 4-2.

Appendix F provides the detailed comparison of the Scenario I-5a, I-8b, original RDC and final model predictions of households and employment.

4.1.3 Growth Outside the Current Rural Urban Boundary

In parallel with this study, Auckland Council were investigating changes to the current Rural Urban Boundary (RUB) west of Silverdale, as signalled in the Auckland Plan. The outcome of those investigations will be proposals to include additional growth areas within the RUB through the Unitary Plan process.

Due to the evolving nature of those investigations and the uncertainty in their final form and timing, it was agreed with Auckland Transport that growth in those potential RUB areas would be omitted from the core forecasts for PENLINK, but assessed through sensitivity tests.

4.1.4 Assumptions on Specific Developments

Appendix H summarises the assumptions used in regard specific developments in the Silverdale and Orewa areas, including:

- Silverdale North (Special 19 zone)
- Silverdale South Gateway entertainment precinct (subject to a recent decision on proposed Plan Change 123[2])
- Peninsula Lakes Golf Course (subject to a recent decision on proposed Plan Change 159)
- Mainstay development (in Silverdale)
- JCHL development (precinct 11 of Special 19 Zone)
- Silverdale Park and Ride
- Orewa West structure plan area
- Weiti Forest and Weiti Station developments

4.1.5 Comparison of Forecasts

The following figures compare the Scenario I-8b, RDC predictions and final model values for 4 broad areas as well as the total Hibiscus Coast area. Key points to note from this include:

- In **Dairy Flat** the models reflect Scenario I-8b , which has significantly more growth than the original RDC forecasts due to inclusion of known developments such as Weiti Forest, Weiti Station and Silverdale South and the Future Urban area in Wainui East;
- In **Orewa** the models use the Scenario I-8b Household growth rates, which are marginally lower long-term than the RDC forecasts;
- In **Whangaparaoa** the models use the Scenario I-8b Household growth rates, which are marginally lower than the RDC forecasts;
- In **Silverdale** the models reflect Scenario I-8b up to 2031but have lower growth in 2041. This was because analysis of the Scenario I-8b appeared to have significant residential growth that is either currently, or zoned to be industrial (ART3 zone 22). The model has higher growth than the original RDC forecasts (due to new development plans in Silverdale North (precinct 11) and Silverdale South. ; and
- For the combined **HBC** area, the models reflect Scenario I-8n, which are higher than those in the RDC forecasts.

[2] Although that decision to grant part of the area proposed by Auckland Council as entertainment areas as 'future urban' has been appealed by some land owners.

Figure 4-1 Comparison of Household Growth Forecasts by Sub-Area

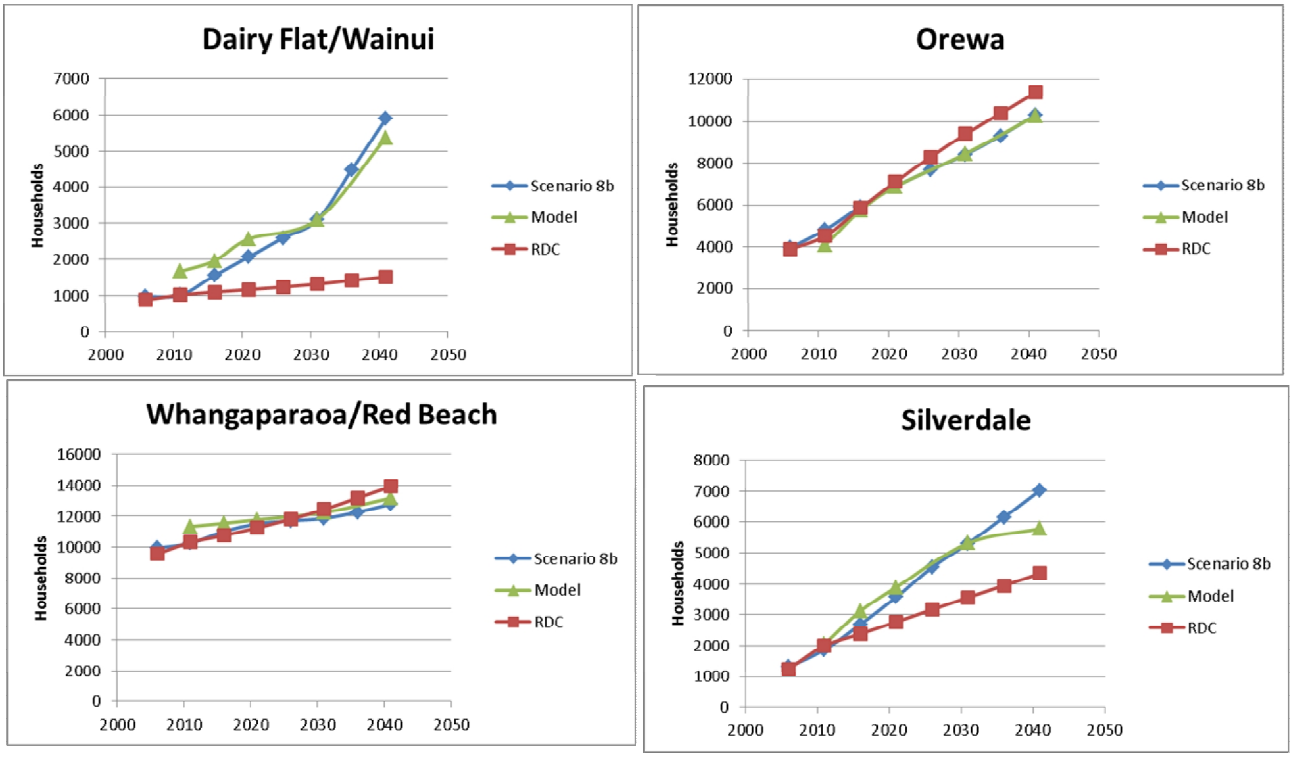
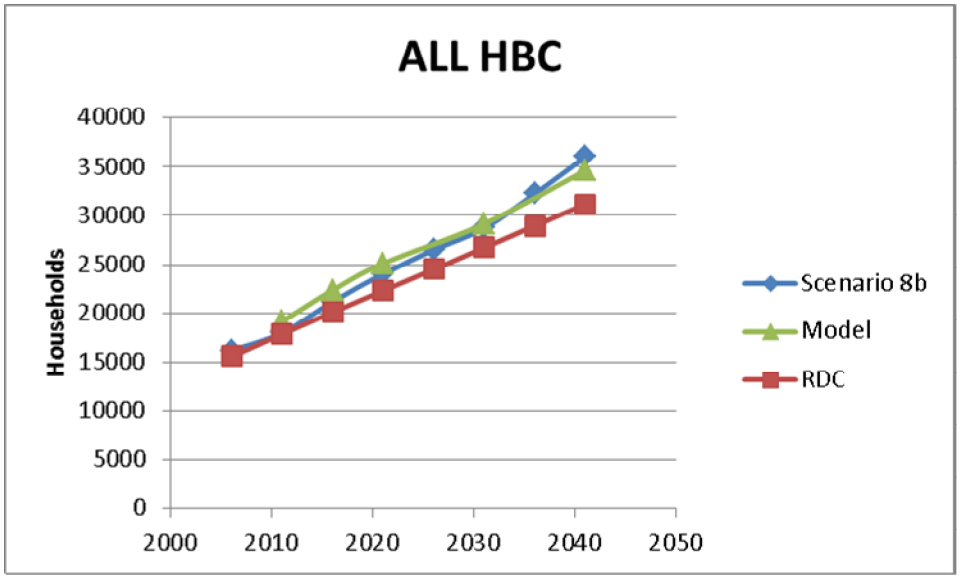


Figure 4-2 Comparison of Household Growth Forecasts for Total HBC Area

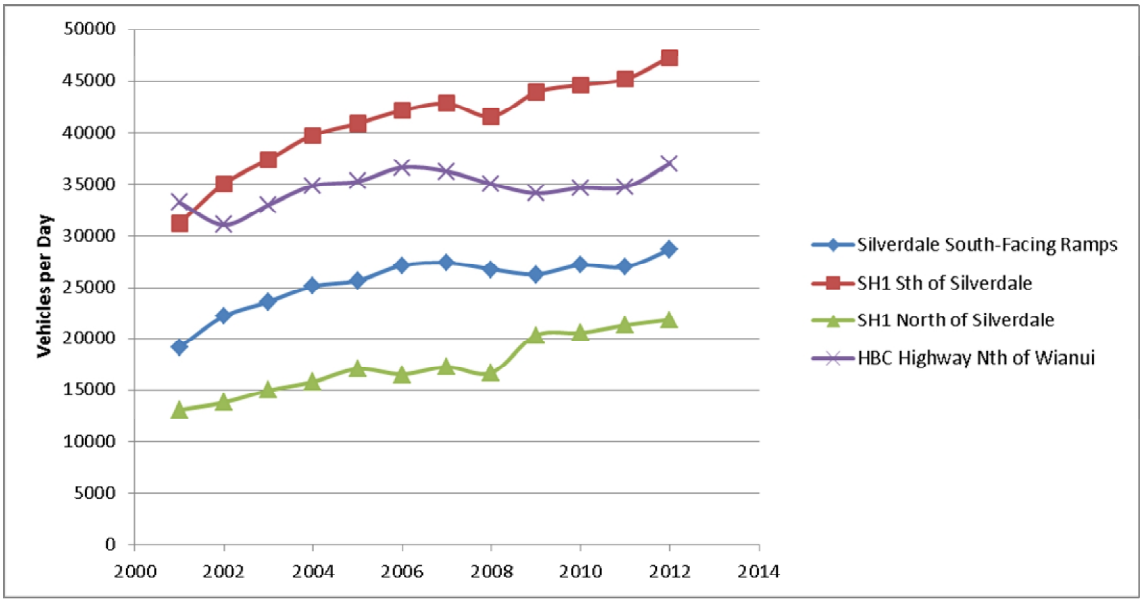


4.1.6 Historic Growth Patterns

To put the future year growth forecasts in context, the historic growth trends were assessed form traffic count data published by the NZ Transport Agency. Data was collated for three sites on SH1 and well as on the HBC Highway through Silverdale. Recent data on Whangaparaoa Road was not available. This data is shown in **Figure 4-3** for the period between 2001 and 2012. This showed annual linear growth rates (on the 2001 base) of 4.7% pa on SH1 south of Silverdale, 4.6% pa on the Silverdale South-facing ramps and 6.1% on SH1 north of Silverdale and 1.0% on the HBC Highway.

The data on the HBC highway and SH1 north of Silverdale is expected to be affected by the completion of the toll road north of Auckland. The south-facing ramps at Silverdale are considered to provide a reasonable indication of traffic growth in the Whangaparaoa and Silverdale areas.

Figure 4-3 Historic Traffic Growth Trends



4.2 Local Development and Network Assumptions

The assumptions around local developments used in this analysis are detailed in **Table 4-2** while the assumptions around changes to the current (2013) network used in this analysis are detailed in **Table 4-3.**

4.3 Annualisation Factors

The models have been developed to represent three time periods, namely AM, inter and PM peaks as follows:

- AM = 0700 – 0900
- IP 0900 – 1600 plus 1800 – 1900
- PM = 1600-1800

The assignment models are 1-hour models (this is a requirement of the software when junctions are explicitly modelled), with 1 hour demands derived from the 2 or 8-hour trip tables using fixed factors. Hence, the final output from the models represents hourly conditions for the three periods described above.

Two sets of aggregation factors were developed, one for benefits and one for annual daily flows on PENLINK.

4.3.1 Benefit Annualisation

The benefits of the project arise from across the network and are dependent on not just flow rates but also levels of congestion. The periods outside the AM and PM peaks were represented by the interpeak models. As well as adjusting for the flow differences between each off-peak hour and the representative Interpeak model flow, differences in congestion levels were also included. This means the non-linearity between flow levels and congestion is captured.

Daily flow estimates are provided from aggregation of the three peak models as shown in **Table 4-1**.

Table 4-1 – Annual Benefit Aggregation Factors (1-Hour Models)

	AM Model	Interpeak Model	PM Model
Equivalent models per weekday	2	8.02	2
Equivalent models per weekday Off peak		2.66	
Weekdays per year	245	245	245
Equivalent models per weekend/holiday day		13.06	
Weekend/Holiday days per year		120	
Base Annual Factors	490	4183.8	490

Table 4-2 - Local Development Assumptions

Region-wide Forecasts	Details	Modelled
	The HBC Model was developed using meshblock-level land use forecasts provided by Rodney District Council (RDC) in 2009. For this study, those RDC forecasts (at the detailed HBC model zone system) were adjusted to match forecasts provided by Auckland Transport at ART3 model zone level. Those forecasts are known as modified version 8b of Auckland Council's Scenario I.	Use 2009 RDC detailed forecasts adjusted to match Auckland Transports Scenario I-8b predictions.
Specific Development	**Details**	**Modelled**
Silverdale North	Silverdale North is included as Special 19 Zone of the Auckland Council's District Plan (Rodney Section). Full development includes: ■ 2,400 residential dwellings ■ 3,000 employees in the Knowledge Economy Zone (KEZ) ■ Four schools with a total school roll of 3,120 ■ 297 residential dwellings in Totara Views The staging (prior to PENLINK) as per the District Plan is capped by precinct which equates approximately as follows: ■ 60% of 2,400 residential dwellings in Precincts 4,5,6 and 7 ■ 75% of 3,000 employees in the KEZ with a 25% diversion rate (removed 25% of KEZ generation from general traffic travelling from SH1 to Whangaparaoa Peninsula) ■ Four schools with a total school roll of 3,120 ■ 297 residential dwellings in Totara Views	2016 and 2021: Constrained as per Plan rules to that development permitted prior to PENLINK 2031: 75% of remaining growth between the Constrained development and Full Development 2041:Full development
'Warehouse' triangle - Warehouse	Consented (now implemented) development of The Warehouse with 25,250m^2 GFA, generating approximately 1,000 trips in the peak hour. Consent Order was granted in October 2008 based on an adoption of Special 21 (Silverdale North Large Format Retailing) zone.	Full development to be included in all models
'Warehouse' triangle - Mainstay development	Consented (and now partially implemented) development up to 70% of 91,200m^2 GFA of mixed used activities (retail, office and residential) including a medical centre and a pool/gym facility, generating approximately 1,500 trips in the peak hour. Consent Order was granted in October 2008 based on a partial adoption of Special 19 (Silverdale North) zone.	2016 and 2021: 70% of full development 2031, 2041: Full development

18 and 20 HBC Highway	Bunnings warehouse and some retail/office blocks at 18 HBC Highway and a Pak'n Save at 20 HBC Highway with an approximate combined GFA of 20,000m^2. The total generation of these two developments is expected to be in the order of 1,200 trips in the peak hour. Both sites will be operating in 2013.	Full development from 2016
Gateway Entertainment Zone (Plan Change 123)	This area was subject to Plan Change 123, for which a decision was recently released. That decision proposed approximately half the Plan Change area become entertainment activity (as requested by Auckland Council for the full site), with the rest zoned as 'Future Urban' That decision has been appealed and is currently commencing mediation. For this analysis, the 'Future urban' zone was assumed to have an ultimate form of 600 residential dwellings and commercial/industrial activities with 550 jobs. For the remaining Entertainment area, 50% of the trip generation developed for the Plan Change 123 hearing was used (which was some 400 vph in the pm peak).	Future Urban: 20% by 2016, 33% by 2021, 80% by 2031 and 100% by 2041 Entertainment: 200 vph in PM peak
Silverdale Park and Ride	The Stage 1 (104-space) park and ride facility is under construction in 2013 and a consent for Stage 2 (500 spaces) has been lodged. The Park and Ride module in the model adds trips to/from the Park and Ride site and removes trips between the HBC area and the south. This module was also used to estimate mode shift once the Busway was extended to Silverdale, by increasing the diversion rate (which is the proportion of new bus riders that were car drivers). Increasing the diversion rate to 200% was found to remove 645 vph in the morning peak, which was found to match the approximate 1200-1500 vehicles using public transport in 2-hours in the 2041 ART3 model. The assumptions used are: 2016: 100% usage of Stage 1 with 21% Kiss and Ride, 50% private car diversion 2021: 100% usage of Stage 2 with 21% Kiss and Ride, 50% private car diversion 2031: 100% usage of Stage 2 with 21% Kiss and Ride, 100% private car diversion 2041: 100% usage of Stage 2 with 21% Kiss and Ride, 200% private car diversion	Stage 2 Park and Ride from 2021 with increasing 'diversion' rate to represent extension of the North Shore Busway to Silverdale. The diversion rates were sensitivity tested.
Peninsula Lakes development (Plan Change 159)	This private Plan Change (159) for 520 dwellings was recently approved.	2016: 33% 2021: 58% 2031: 100% 2041: 100%

Jack Hawken Lane (JCHL land)	This land is Precinct 11 of Special 19 Zone. Although anticipated to be part of the Knowledge Economy Business Park zone, the land owners are seeking a limited residential and retirement activity. Although consent has not yet been lodged, the land owners have an agreement with Auckland Transport for traffic signal-controlled access to HBC Highway at Jack Hawkin Lane. That approval is constrained to pm peak hour generation of 137 vph	2016: 20% 2021: 80% 2031: 100% 2041: 100%
Western RUB Expansion, including Wainui East, Silverdale West and Dairy Flat	Between 2011 and 2041 Scenario I-8b has some 2600 households added in Future Urban zones west of SH1 (ART3.2 zones 23,24,28-31), most of which are in Wainui East. Over the same period, some 5200 jobs are added, most of which are in Silverdale West.	Include as per Scenario I-8b
Weiti Station	This area straddles PENLINK and has consent for 220 dwellings and a direct connection to PENLINK. They have recently submitted to the Unitary Plan to increase this to approximately 1000 dwellings	2016: 20% of consented 2021: 80% of consented 2031 100% of consented 2041 100% of consented Sensitivity tested in 2031 with 1000 dwellings
Weiti Forest	This area is to the south of PENLINK and has consent for 550 dwellings. Its current access is via Weiti Station Road which sits under the PENLINK designation. Direct access to PENLINK is assumed, except in the Do Minimum where access to East Coast Road is retained. The land owners recently submitted to the Unitary Plan to increase this to approximately 1600 dwellings.	2016: 20% of consented 2021: 80% of consented 2031 100% of consented 2041 100% of consented Sensitivity tested in 2031 with 1600 dwellings
Orewa West	This development spans Grand Drive west of Orewa, with existing connections via West Hoe road, Maire Road and a proposed new connection directly to Grand Drive. The rate of growth in this area was set to match that in the regional Land Use forecasts (Scenario I-8b)	Growth rate as per Scenario I-8b

Table 4-3 - Road Network Assumptions, Relative to current (2013) network

Region-wide Forecasts	Details	Modelled
Non-development related upgrades:		
Whangaparaoa Road Western End Widening (HBC Highway to Red Beach Road)	Full widening of this section between HBC highway and Red Beach Road was suggested in the 2010 ARTRA review to be able to delay PENLINK. This widening can be deferred significantly if PENLINK is constructed. As this study looks to accelerate PENLINK, this widening has been excluded from both the Do Minimum and Option scenarios. It's inclusion has however been sensitivity tested.	Full Widening between HBC Highway and Red Beach Road **excluded** in both Do Minimum and Option scenarios.
Speed Limit along Hibiscus Coast Highway	The current speed limit is 80 km/h while a speed reduction to 70 km/h is in the consultation process. The Corridor Management Plan (CMP) for this area seeks to integrate the land use and network better and reduce its severance effect, including through reducing the operating speed. The CMP identified that such changes would only be feasible once the 'through' traffic was removed, as expected with completion of PENLINK.	70 km/h in both Do Minimum and Option. 60kph with PENLINK modelled as a sensitivity test.
Widen SH1 to 6 lanes between Oteha Valley Road and Silverdale	Included in 2031 only as a sensitivity test	Excluded from core models but sensitivity test in 2031
Silverdale North Development associated upgrades:		
Silverdale North internal road network	Internal ring road collector to service the Knowledge Economy Business Zone and residential area.	To be included.
East Coast Rd extension to Curley Avenue Extension	This is Stage 6 of Special 19 Zone and staging rules only permit this link after PENLINK (or full Whangaparaoa Road widening). This has been included in 2021 models for both Do Minimum and Options scenarios.	Assumed in 2021
North-South Link	New link to connect the Silverdale North development to Grand Drive. This was opened in 2013	Included from 2013
South-facing ramps onto SH1 at Wainui Road	New ramp connection to service Silverdale North. Included from 2016 in all models.	Included from 2016
HBC Highway / Whangaparaoa Road upgrade	New lane and phasing arrangement along HBC Highway and Parkway - now completed	Included from 2013 models

Region-wide Forecasts	Details	Modelled
SH17 / Silverdale Street signals	Signalisation has been studied a number of times, including in 2013. Not included in any models due to uncertainty regarding its safety and feasibility.	Not included
Gateway and Park & Ride associated upgrades:		
SH17 / Spine Road signalised intersection	Traffic signals installed in 2013 (opposite the Rugby Club) on HBC Highway to provide access to Gateway area and Park & Ride site, with Small Road access to HBC highway closed.	Included from 2013
Weiti Station and Weiti Forest Developments:		
Connection to East Coast Road at Weiti Station Road	Without PENLINK a connection was assumed to East Coast Road for these two developments via a roundabout.	Included from 2016 (Do Minimum Only)
Connection to PENLINK	With PENLINK in place, a direct connection to PENLINK (via grade separated connections) was assumed for these two developments.	Included from 2016 (with PENLINK only)
Peninsula Lakes Development associated upgrades:		
SH17 / Existing Golf Course access upgrade	Proposed signalisation of Totara Views intersection with HBC Highway, as proposed in the recently approved Plan Change.	Included from 2016
Red Beach Road / Bay Street upgrade	Proposed signalisation to provide all movement access to the approved development.	Included from 2016
Orewa West Structure Plan:		
Grand Drive / Site Access	Proposed new access to Grand Drive from the north.	Included with Orewa West growth from 2021
Western RUB Extension:		
Indicative Network to support RUB extension west of SH1 in Wainui East, Silverdale West and Dairy Flat	Upgraded links through Silverdale West, Wainui East and Dairy Flat. No new connections to SH1.	Only included in sensitivity tests with RUB extension
	Upgraded intersections (roundabouts) to East Coast Road at Bawden Road, Wilks Road and Awanohi Road and to Dairy Flat Highway at Durey Road.	
	Widen SH1 to 6 lanes between Oteha Valley Road and Silverdale	

Region-wide Forecasts	Details	Modelled
	With PENLINK, a link was assumed from Bawden Road (near Top Road) to the PENLINK Redvale interchange.	

4.3.2 Annual Average Daily Flow on PENLINK

Annual Average Daily Traffic flows (AADT) were estimated for PENLINK based on flow profiles from three locations:

- Whangaparaoa Road
- The south-facing ramps at the SH1 Silverdale interchange
- The Route K toll road in Tauranga

The Route K toll Road in Tauranga was considered to provide some guidance on the potential aggregation factors for toll roads, which may differ from untolled roads due to variations in Willingness to Pay outside the modelled weekday periods. The following data was calculated from each site:

- The number of equivalent weekday interpeak periods to match weekday daily totals (when added to the 2 hours of AM and 2-hours of PM flows);
- The number of equivalent weekday interpeak periods to match weekend daily totals

AADT factors were then calculated assuming 245 weekdays per year and 120 days of weekend/holiday per year. The Whangaparaoa Road and Silverdale Ramps profiles returned very similar values, however the Route K toll road showed lower flow rates during weekday evenings/nights and weekend days. It is considered that much of the reasons for these differences would be due to the different context of the Route K toll road, which predominantly provides an intra-regional movement between Tauranga central and the Waikato region, without the direct residential/recreational catchment that access to Whangaparaoa is likely to have. However, this could also indicate a lower off-peak usage of toll roads. Subsequently the values adopted for PENLINK were an aggregation of all three sites, but weighted with 50% from the Route K toll Road and 25% from each of the local sites. Sensitivity tests were undertaken on these factors. The values from each site and the adopted parameters are shown in **Table 4-4**.

Table 4-4 - AADT Factors

Item	AM Model	Interpeak model	PM model
Weekday Factors (245 days)			
Route K	2	9.69	2
Silverdale Ramps	2	11.48	2
Whangaparaoa Road	2	11.26	2
ADOPTED	**2**	**10.53**	**2**
Weekend Factors (120 days)			
Route K	0	10.05	0
Silverdale Ramps	0	12.85	0
Whangaparaoa Road	0	13.17	0
ADOPTED	**0**	**10.859**	**0**
Annual Factors (365 Days)			
Route K	1.342	9.808	1.342
Silverdale Ramps	1.342	11.930	1.342
Whangaparaoa Road	1.342	11.888	1.342
ADOPTED	**1.342**	**10.859**	**1.342**

5 Stage 1: Option Testing

This chapter details Stage 1 of the modelling that has been undertaken, which is the option testing to inform the process of confirming the preferred option. The outcomes of this work were discussed with the PCG and used to inform the 'DVAC' paper prepared by Auckland Transport, which discussed and recommended the preferred option.

5.1 Model Inputs and Assumptions

The option testing stage of the modelling, the following assumptions were used:

- Two forecast years were assessed, 2021 and 2031
- All options were tolled (an untolled test was also undertaken)
- The original RDC land use forecasts were used (but with updated assumptions for specific developments) because the Auckland Plan scenario I land use forecasts appeared to have counter-intuitive predictions for the study area, including fluctuating household numbers, a declining population, unrealistic household sizes, reductions in Gulf Harbour and large growth forecast outside the MUL. The models included known developments included in the following locations: Orewa West, Silverdale North, Silverdale South and West, and 1,600 household in the Weiti Forest.

As the toll strategy was developed in stage 2 of the modelling work, the same nominal toll was applied to each option for the assessment.

5.2 Options Tested

Six options were assessed as follows:

- The base (2 lane) option
- Grade separation at the intersection East Coast Road
- Passing lanes with a signalised intersection at East Coast Road
- Passing lanes with a grade separated intersection at East Coast Road
- 4-lane carriageway with a grade separated intersection at East Coast Road
- Untolled option

5.3 Analysis Results

5.3.1 Flows

The following **Figure 5-1** show the predicted flow on PENLINK in 2031 for the different options. It shows the 2031 peak direction, with the second graph showing the ADT. Indicative capacity ranges are also shown.

Figure 5-1 - 2031 Flows on PENLINK

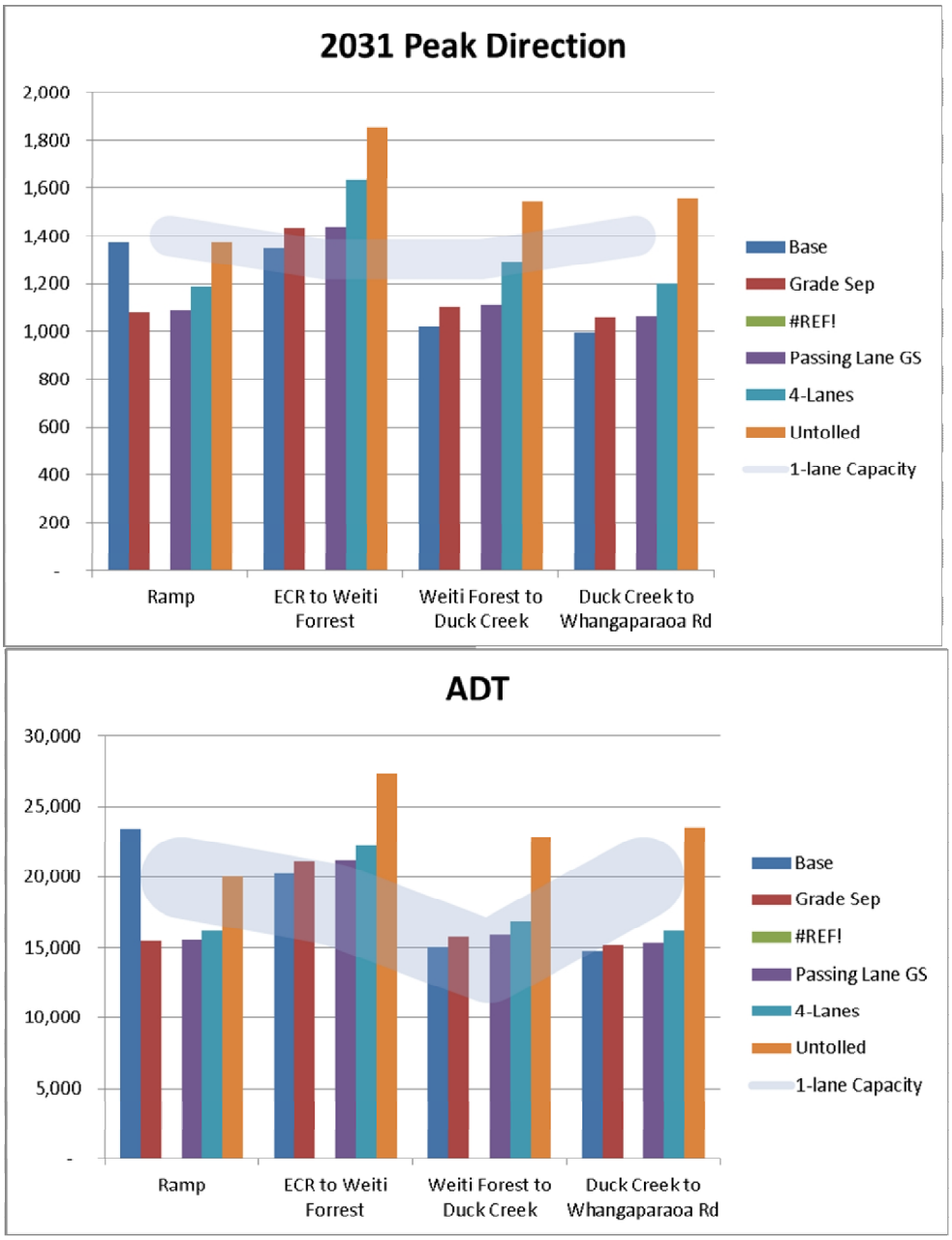


Figure 5-1 shows that a 2-lane facility would operate at, or close to, capacity, with all other options showing a similar level of flow on the facility.

5.3.2 Level of Service.

Table 5-1 shows the Level of Service for the options at both ends of the PENLINK project.

Table 5-1 - Level of Service on PENLINK

	West End	East End
Base 2-lanes	E	E
Passing Lane	D	D
4-lane	B	B

Table 5-1shows that the 4-lane option achieves the best level of service, with the 2-lane option providing the worst level of service as it is operating at, or close to, capacity.

5.3.3 Economic Evaluation

An economic evaluation was undertaken. The following assumptions were used

- Focussed on Option comparison not overall BCR
- Hence some simplifications and assumptions used (to be refined for final business case)
- Toll transactions reducing from 60c/veh in 2016 to 50c/veh in 2041
- Agglomeration estimated at 10% of Base option benefits
- Widening of Whangaparaoa Road HBC Highway to Red Beach excluded in all scenarios
- Include comparative crash analysis
- Future-year 4-laning upgrade costs were included in the 2-lane and passing lane options to reflect the need to accommodate the higher flows when the tolls are removed at the end of the concession period.

5.4 Preferred Option

Based on the above analysis, Auckland Transport prepared the DVAC paper describing the options, analysis and recommended the following preferred option:

- A half-diamond (south-facing) ramps to SH1 at Redvale
- A grade-separated link over East Coast Road, with east-facing connections from East Coast Road to PENLINK
- A 4-lane, divided expressway between East Coast Road and Whangaparaoa Road
- Traffic signals at the PENLINK/Whangaparaoa Road intersection
- Widening of Whangaparaoa Road on the approaches to this connection, from Brightside Road to Arklow Lane
- An at-grade T intersection with Duck Creek Road (north), with Duck Creek Road (south) crossing over PENLINK via an overbridge
- A roundabout on PENLINK connecting to the Weiti Station and Weiti Forest developments (the exact form of this connection is yet to be confirmed);

6 Stage 2: Toll Strategy Development

This chapter details Stage 2 of the modelling process, which involved development of the toll strategy for the Penlink project.

The recommended toll strategy is included at the end of this chapter.

6.1 Scope and Limitations

This analysis was focussed on providing analysis to support a decision on a suitable toll strategy for PENLINK. The technical analysis used interim models for which some final refinements were still required before preparation of the final patronage forecasts (e.g. receipt of updated land use forecasts from Auckland Transport, refinement of annualisation factors and assumptions on toll escalation).

Subsequent to this analysis more detailed patronage forecasts were prepared for the preferred option and for a range of forecast years. Those forecasts included sensitivity testing and risk-adjustments.

Consequently, the patronage and associated revenue values in this Stage of the Study are indicative for comparative purposes between different toll levels and strategies, and should not be used as final patronage or revenue forecasts.

6.2 Toll Strategy Analysis Process

The process used to develop the toll strategy was as follows:

- Preparation of a discussion note (Beca Memo dated 26 July 2012) on initial considerations on toll gantry method and location;
- Discussion of the key elements at the PCG on 27 July, with agreement on key assumptions to use in the modelling analysis;
- Presentation on modelling results to the PCG meeting of 16 August 2013; and
- Preparation of a technical note documenting the above process.

6.3 Elements of the Toll Strategy

The key elements to be defined with the toll strategy were as follows:

- The collection method
- Escalation of toll values in the future
- Any discounts or capping
- Differential tolls by vehicle type
- Differential tolls by time of day
- The location of collection points
- The toll tariff

6.4 Previous Strategy Selected by RDC

Public consultation on a toll strategy was undertaken by RDC in 2006. The most popular option was 'Option 4', which had three collection points (Weiti River, between Duck Creek Road and East Coast Road and on the Redvale ramps), but with the toll capped for those passing through more than one collection point.

The subsequent detailed toll forecasting however found that the extra capital and transaction costs of having three collection gantries was undesirable, and recommended a strategy with only two gantries (on the Weiti River bridge and on the Redvale ramps). That strategy was used in the subsequent financial and economic analysis for the 2007 Business Case Report.

The previously selected toll strategy assumed fully electronic toll collection with toll levels for cars, LCVs and HCVs in a ratio of 1:1:2.

The tolls were assumed to be constant across both directions and all times of the day in order to retain a simple system. The toll levels (for cars) used in the previous Business Case modelling was $1.25 on the Weiti Bridge, $0.75 on the Redvale ramps, but with a cap of $1.50 for those passing through both gantries (in $2006).

6.5 Methodology and results for current project

Appendix G details the methodology that has been followed in developing the toll strategy for the current Penlink project, as well as discussion on the toll gantry location, vehicle differential and time variable tolling. **Appendix G** also contains details regarding the development of the toll strategy including model results and vehicle flows for differing toll scenarios.

6.6 Comparison with Other Toll Facilities

Between Whangaparaoa Road (east of PENLINK) and SH1 (south of Redvale), PENLINK offers approximately a 5.8km distance saving and between 8 and 10 minutes of travel time relative to the alternative route. Those time and distance savings will differ for other start and end points.

By way of comparison, the Northern Gateway Toll Road (between Silverdale and Puhoi) offers very similar savings relative to its alternative route and approximately 5.2km of distance and 8-9 minutes of time saving. The current toll is $2.20 for light vehicles on the northern gateway.

The other NZ Toll Road is Route K in Tauranga. It is quite different in having very limited distance savings (approximately 0.5km) and time savings typically less than 3 minutes (depending on routes used and time of day). The current toll is $1.50 for light vehicles and is collected through manual toll booths.

PENLINK therefore offers a very similar benefit (relative to the untolled alternative) as the Northern Gateway Toll Road. With PENLINK anticipated to use the same NZTA toll system the two projects would offer similar 'value' propositions. It should be noted that this does not necessarily imply the same diversion rates will apply as the two projects have different 'markets' in terms of the purpose, frequency and distance-travelled of the potential users.

6.7 Overall Analysis and Tariff Selection

The analysis that has been undertaken indicates conflicting outcomes between revenue generation and network performance. In order to seek a balanced outcome for the toll level, a number of key criteria were developed and scored. It is recognised that the target thresholds are not 'hard-and-fast' rules and used for guidance only.

1. Net revenue: The net revenue was used for this measure;
2. Flow retention on PENLINK: A target threshold of keeping flows on PENLINK greater than 15,000 vpd was adopted. This flow represents a retention rate of 70% and a flow rate which clearly justifies greater than single-lane operation of PENLINK;
3. Flow on the western end of Whangaparaoa Road. A target threshold of keeping flows below 25,000 vpd on the western end of Whangaparaoa Road was adopted. This level was chosen as being a level where the existing 2-lane configuration could be retained more comfortably (albeit recognising that this is still a high flow rate on 2-lane roads);
4. Flow on the HBC Highway through Silverdale. A target threshold of keeping flows below 35,000 vpd on the HBC Highway was adopted. This level was chosen as being current-day flow levels;
5. The Level of Service on PENLINK. The different toll levels were scored relative to each other in relation to the average speed on PENLINK; and
6. The Level of Service on the alternative route. The different toll levels were scored relative to each other in relation to the average speed on the alternative route.

A five-point score was assigned to each toll level (**Table 6-1**). These scores are also shown graphically in **Figure 6-1**. Here the network scores are stacked, with the revenue kept separate (but scaled by 5 to match the scale of the network attributes). This shows that the network scores reduce more steeply after $2.50, where revenue increases most rapidly between $2.00 and $2.50. **Figure 6-2** below shows combined scores with weighting on the revenue scores set between 1 and 4.

Table 6-1: Analysis of Tariff Options

Attribute	Untolled	$1.00	$1.50	$2.00	$2.50	$3.00	$3.50
Net Revenue	0.0	0.0	0.3	1.5	3.8	5.0	4.7
Flow retention on PENLINK	5.0	5.0	5.0	5.0	3.3	1.4	0.5
Flow on Whangaparaoa Rd	5.0	5.0	3.9	2.3	1.0	0.3	0.1
Flow on HBC Highway	5.0	5.0	5.0	5.0	5.0	2.7	1.6
Speed on PENLINK	4.0	4.0	4.0	4.0	4.0	4.0	5.0
Speed on Alternative	5.0	4.0	4.0	4.0	4.0	2.0	2.0

Figure 6-1 Stacked Network Scores with Separate Revenue

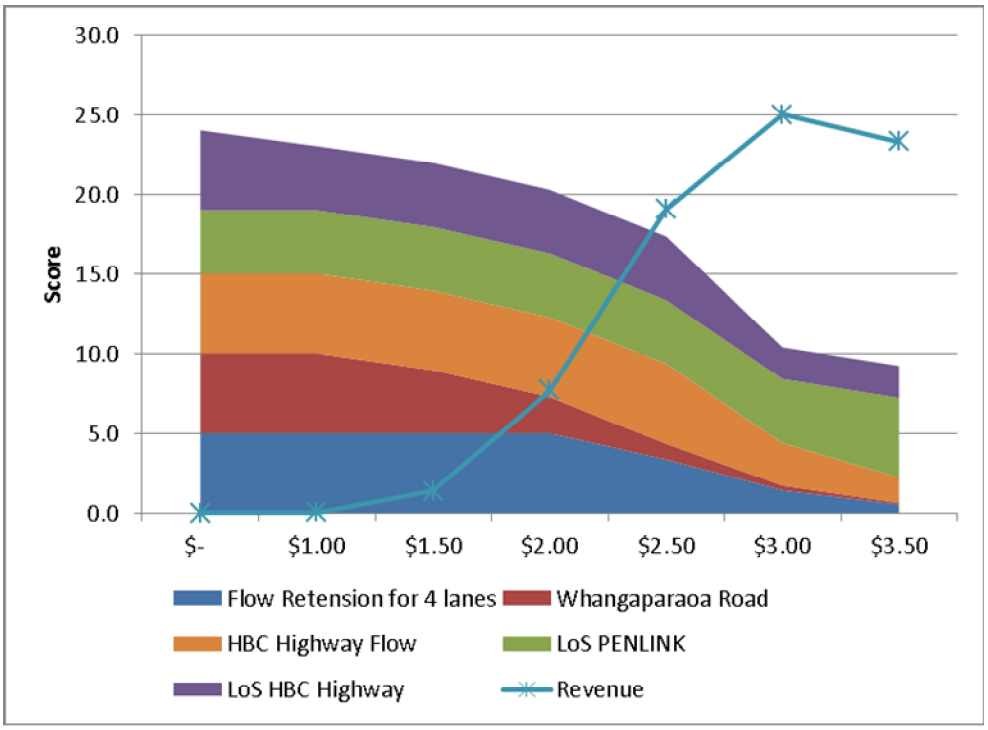
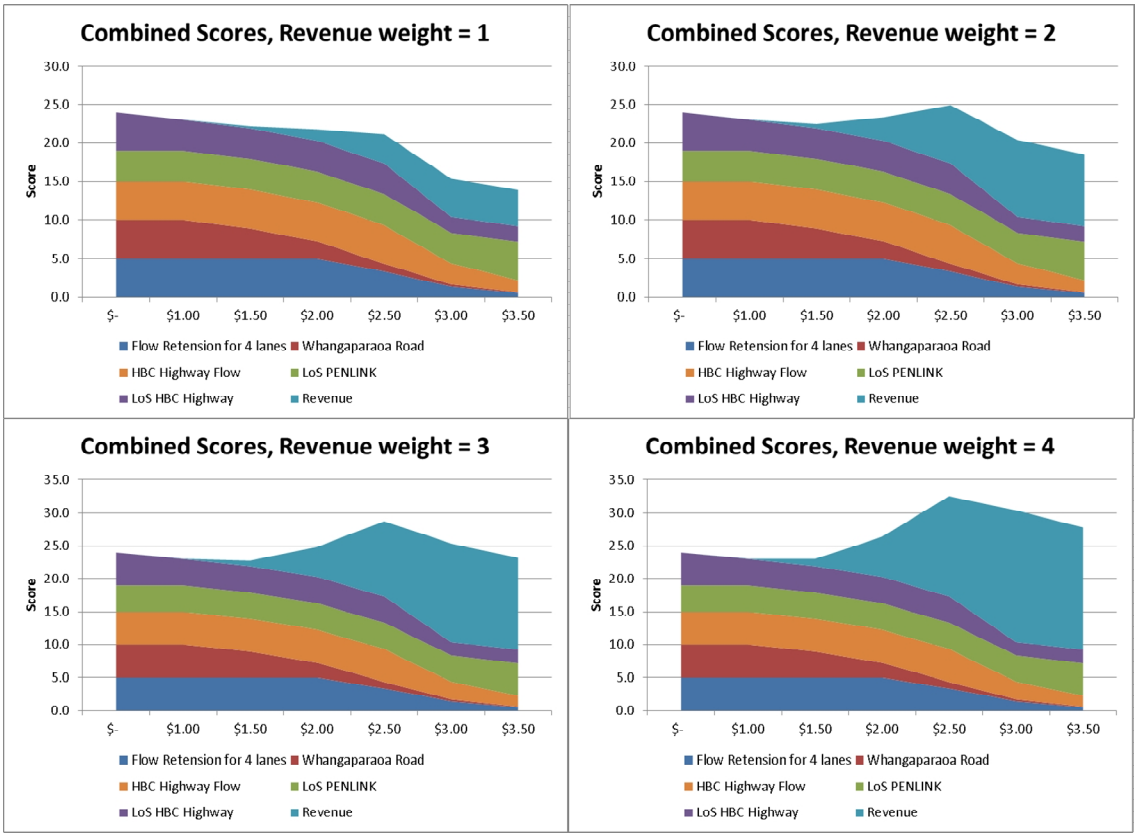


Figure 6-2 Combined Scores with Different Weight on Revenue



Combining the revenue with the network scores is highly dependent on the weighting used on the revenue. A weight of 1 applied to the revenue scores would mean that the 5 network attributes collectively out-weighed revenue 5:1.

These show that when weighted by 1 (or less), the best overall score is with no toll. However, as the weight on revenue increases, the maximum score is shown as $2.50.

Overall, the balance between network performance and revenue appears most optimal at tolls between $2.00 and $2.50.

6.8 Strategy Recommended by PCG

Toll Tariff

The Study Team PCG considered this information on Friday 16 August 2013. Based on the technical analysis presented above it was agreed that a toll between $2.00 and $2.50 was the most appropriate. For the purposes of the Business Case modelling, it was agreed that the preferred toll should be set at $2.20, as this fell within the optional range and was consistent with the toll on the nearby Northern Gateway project, which offered very similar value propositions in regard to project length and time and distance savings over the alternative route.

With only a single toll collection point, capping of the toll for users of PENLINK is not relevant. The PCG also determined that due to the different markets being served and the small number of vehicles likely to use both PENLINK and the Northern Gateway that capping of those using both need not be adopted (it is noted that the ability of the NZTA National Toll System to do such capping is not currently available).

Recommended Toll Strategy

The recommended toll strategy is therefore as follows:

- A single toll collection point on or near the Weiti Bridge
- Free-flow electronic tolling using NZTA's National Toll System
- Fixed 24/7 toll tariff but the ability to consider time-variable tolling at a later date when the technology is available
- A light vehicle toll of $2.20 and a heavy vehicle toll of $4.40 (in $2013)
- No caps or discounts
- Tolls escalated regularly at the rate of inflation (CPI)

7 Stage 3: Patronage Forecasting

7.1 Preferred Option

The patronage forecasts were assessed on the Preferred Option (described earlier) with the following toll Strategy

- Fully electronic toll collection (using the NZ Transport Agencies National Toll System)
- A light-vehicle toll of $2.20 and a heavy-vehicle toll of $4.40 ($2013)
- The tolls escalated annually at the rate of inflation

7.2 Traffic Flow and Toll Revenue Forecasts on PENLINK

The modelled traffic flows at the toll gantry are summarised in **Table 7-1** below, along with the estimate of Gross Revenue potential (being simply the traffic flows multiplied by the toll value). The toll values are $2.20 for light vehicles and $4.40 for heavy vehicles. These forecasts exclude transaction costs, ramp-up and revenue leakage. These are Annual Average Daily Traffic (AADT) values.

Table 7-1 – Modelled Traffic Flows and Revenues at the Toll Gantry

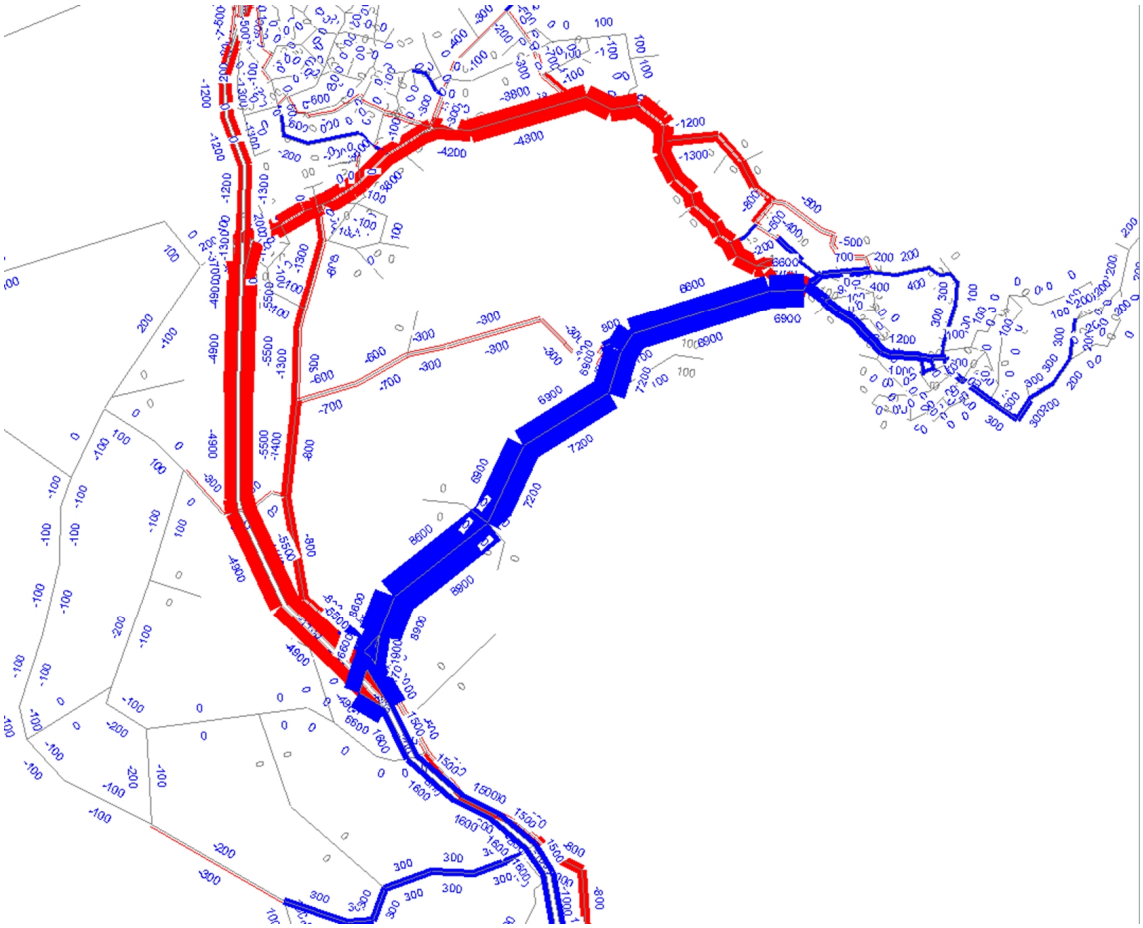
Year	AADT			Gross Daily Revenue ($2013)		
	Light Vehicles	Heavy Vehicles	Total Vehicles	Light Vehicles	Heavy Vehicles	Total Vehicles
2021	11,300	400	11,700	$24,860	$1,760	$26,620
2031	12,200	400	12,600	$26,840	$1,760	$28,6000
2041	13,100	500	13,600	$28,820	$2,200	$31,020

7.3 Wider Network Traffic Effects

Daily Traffic Flows

The modelled traffic flows for a number of locations within the wider network are summarised in **Table 7-2**. These are weekday Annual Daily Flows (ADT) using global expansion factors across the whole network. These therefore differ from the specific AADT expansion factors used for the toll road flows. The general pattern of predicted change in traffic is indicated in **Figure 7-1**, which compares the 2021 daily flows with PENLINK against the 2021 Do Minimum daily flows.

Figure 7-1 Changes in ADT (2021)



Peak Hour Traffic Flows

The peak hour traffic flows at key bottleneck locations in the network are shown in **Table 7-3**. This indicates that the reduction in peak-hour flows due to PENLINK is proportionally higher than indicated by the daily flows. The critical period in this area is during the pm peak with commuters returning from areas to the south. The effect on this critical movement is shown in **Figure 7-2**, which shows the eastbound peak period flows in relation to the estimated capacity. This analysis that the introduction of PENLINK reduces the flows below the capacity. In the Do Minimum the capacity-effect of these bottlenecks would be diverting and supressing (redistributing) traffic.

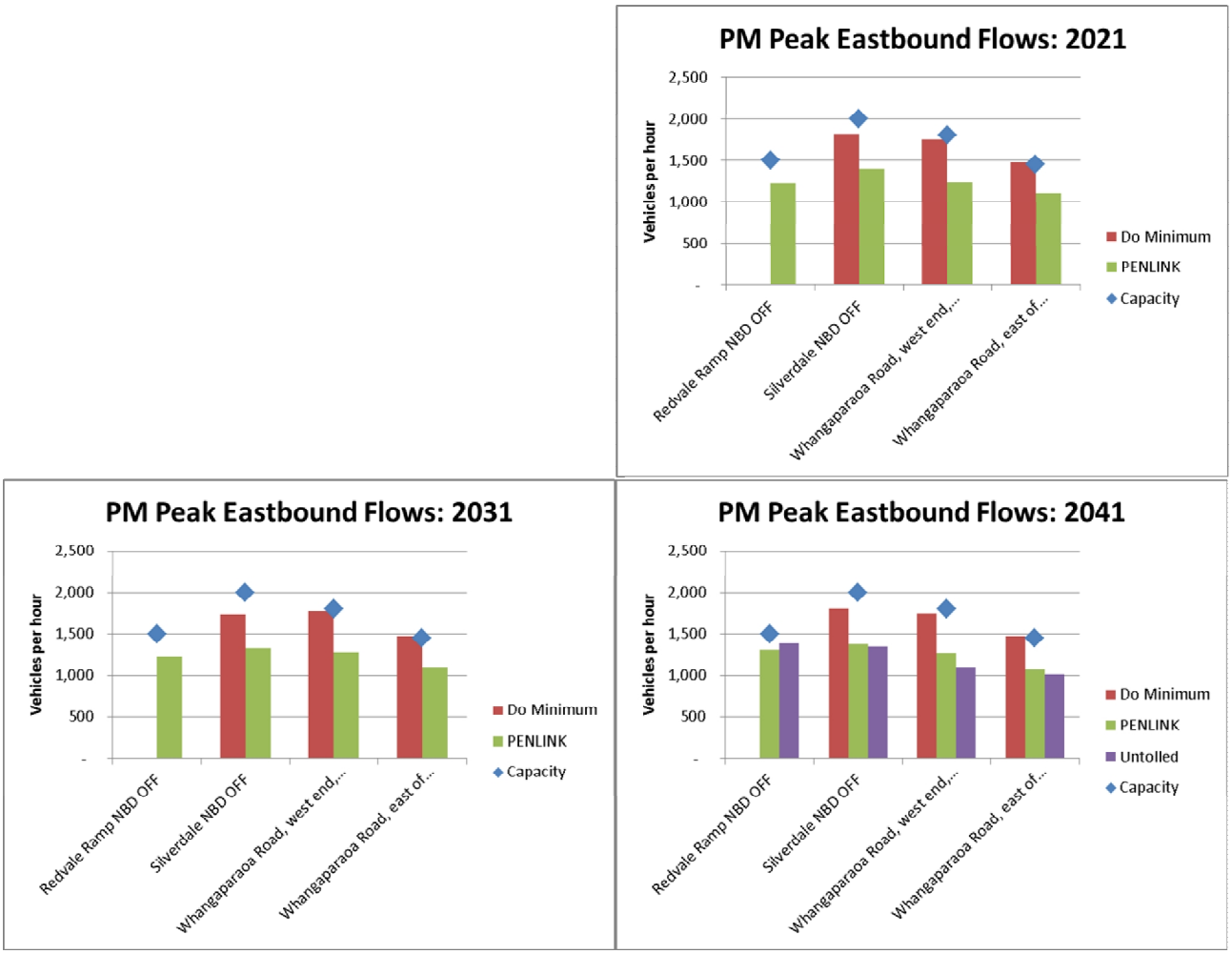
Table 7-2 - Wider Network Traffic Flows (ADT)

	2013	2021		2031		2041			Change		
Location		Do Min	Penlink	Do Min	Penlink	Do Min	Penlink	Penlink Untolled	2021	2031	2041
PENLINK - Weiti Bridge			13,300		14,100		15,200	21,500	-	-	-
PENLINK - Middle			14,100		15,000		16,500	21,500	-	-	-
PENLINK - West			17,300		18,800		20,300	24,600	-	-	-
Redvale Ramps			16,700		18,000		20,000	22,400	-	-	-
Spur Rd	3,400	3,500	2,100	4,300	2,600	5,300	3,200	3,600	-1,400	-1,700	-2,100
East Coast Rd, Nth of Spur	8,600	11,400	12,000	14,000	14,000	16,300	16,000	15,500	600	-	-300
East Coast Rd, Sth of PENLINK	9,100	12,800	11,400	15,300	13,500	17,100	16,000	16,200	-1,400	-1,800	-1,100
SH1 nth of Silverdale	20,500	34,400	32,200	42,400	39,100	53,100	48,000	47,600	-2,200	-3,300	-5,100
SH1 Sth of Silverdale	48,000	68,600	55,600	79,700	65,900	92,900	77,200	75,300	-13,000	-13,800	-15,700
SH1 Sth of Redvale	48,000	68,600	72,200	79,700	83,800	92,900	97,200	97,700	3,600	4,100	4,300
HBC Hway, west of ECR	36,900	46,500	38,100	52,000	45,800	53,200	48,100	46,200	-8,400	-6,200	-5,100
HBC Hway, west of Wainui	39,900	38,500	31,800	41,100	34,000	42,900	36,400	33,700	-6,700	-7,100	-6,500
Whangaparaoa Rd West End	26,600	30,500	22,300	32,300	24,000	32,800	24,300	21,300	-8,200	-8,300	-8,500
Whangaparaoa Rd - Red Beach to Vipond	36,700	39,600	30,600	41,000	31,800	41,800	32,400	29,800	-9,000	-9,200	-9,400
Whangaparaoa Rd - east of Vipond	25,700	27,700	21,300	28,500	22,000	28,700	21,900	21,400	-6,400	-6,500	-6,800
Whangaparaoa Rd - east of PENLINK	22,300	24,600	27,500	25,500	28,900	25,800	29,700	32,700	2,900	3,400	3,900
Vipond Road, west end	10,500	11,200	8,500	11,600	8,800	12,100	9,300	7,300	-2,700	-2,800	-2,800

Table 7-3 - Peak hour traffic flows at selected locations

		2013	2021		2031		2041		
Location	Peak		Do Min	Penlink	Do Min	Penlink	Do Min	Penlink	Untolled
Redvale Ramp SBD ON	AM			970		930		880	1,010
Redvale Ramp NBD OFF	AM			430		480		560	590
Redvale Ramp SBD ON	PM			340		390		470	540
Redvale Ramp NBD OFF	PM			1,220		1,230		1,310	1,390
Silverdale SBD ON	AM	1,540	1,640	1,000	1,710	1,180	1,790	1,300	1,240
Silverdale NBD OFF	AM	710	1,180	860	1,320	1,150	1,340	1,190	1,180
Silverdale SBD ON	PM	920	1,350	1,180	1,520	1,400	1,600	1,520	1,500
Silverdale NBD OFF	PM	1,880	1,820	1,400	1,740	1,330	1,810	1,380	1,350
Whangaparaoa Road, west end, wbd	AM	1,660	1,820	1,140	1,810	1,180	1,730	1,150	1,030
Whangaparaoa Road, west end, ebd	AM	470	640	530	700	580	740	610	540
Whangaparaoa Road, west end, wbd	PM	700	880	710	970	790	1,000	830	760
Whangaparaoa Road, west end, ebd	PM	1,720	1,750	1,230	1,780	1,280	1,750	1,270	1,090
Whangaparaoa Road, east of Vipond, wbd	AM	1,340	1,410	860	1,400	890	1,360	860	930
Whangaparaoa Road, east of Vipond, ebd	AM	520	650	520	710	570	750	610	660
Whangaparaoa Road, east of Vipond, wbd	PM	660	770	600	820	630	840	650	750
Whangaparaoa Road, east of Vipond, ebd	PM	1,460	1,470	1,100	1,470	1,090	1,470	1,070	1,010

Figure 7-2 Change in PM Peak Eastbound Traffic Flows



7.4 Travel Times

Table 7-4 compares the predicted travel times between Whangaparaoa Road (just east of PENLINK) to SH1 (just south of Redvale) across the existing route via the HBC Highway and the route via PENLINK. These comparisons are provided for the two peak directions (westbound in the morning peak and eastbound in the evening peak) and for a representative non-peak direction (selected as eastbound during the interpeak period). The table also shows the travel time savings once PENLINK is completed, measured against the Do Minimum and against using the free alternative route.

Table 7-4 - Comparison of Travel Times (minutes)

Route	2013			2021		2031		2041	
				Do Min	Penlink	Do Min	Penlink	Do Min	Penlink
AM WESTBOUND									
Via HBC Highway	14.4			18.8	13.8	19.3	13.9	19.2	13.8
Via PENLINK					5.6		5.6		5.6
Saving on HBC Route wrt Do Minimum					5.0		5.4		5.5
Saving on PENLINK wrt Do Minimum					13.1		13.6		13.6
Saving on PENLINK wrt Free HBC Route					8.6		8.3		8.1
PM EASTBOUND									
Via HBC Highway	19.9			26.7	14.2	36.8	14.9	55.1	16.7
Via PENLINK					5.1		5.1		5.2
Saving on HBC Route wrt Do Minimum					12.5		21.9		38.4
Saving on PENLINK wrt Do Minimum					21.7		31.7		50.0
Saving on PENLINK wrt Free HBC Route					9.1		9.8		11.5
INTERPEAK EASTBOUND									
Via HBC Highway	12.4			13.2	12.5	13.5	12.6	14.4	12.7
Via PENLINK					4.9		4.9		4.9
Saving on HBC Route wrt Do Minimum					0.8		0.9		1.7
Saving on PENLINK wrt Do Minimum					8.3		8.6		9.5
Saving on PENLINK wrt Free HBC Route					7.5		7.6		7.8

7.5 Summary of Key Transport Outcomes

The level of service on PENLINK is expected to be high with high travel speeds, extensive passing opportunities and high safety performance through the divided carriageway and grade separation at Duck Creek and East Coast Roads. With PENLINK in place, the traffic flows are forecast to reduce (relative to the equivalent future Do Minimum scenarios) by up to 9,400 vpd (22%) on Whangaparaoa Road, up to 6,500 vpd (15%) on the HBC Highway through Silverdale and up to 15,700 vpd (17%) on SH1 between Redvale and Silverdale. Increases in traffic flow are forecast on SH1 south of Redvale of up to 4,300 vpd (5%) and on Whangaparaoa Road east of PENLINK of up to 3,900 vpd (15%). More critically, the peak-hour traffic flows on key sections such as the Silverdale interchange and on Whangaparaoa Road are forecast to reduce by nearly 500 vehicles per hour (20%-30%), bringing them below the capacity of those sections.

Auckland Transport is separately investigating widening of the section of Whangaparaoa Road between the Hibiscus Coast Highway and Red Beach Road. Auckland Transport instructed Beca that this analysis of PENLINK should exclude any such widening, although it was considered in the sensitivity testing. This modelling and testing indicated the following:

- The forecast reduction in peak-period traffic flow on this section of Whangaparaoa Road is such that widening of that section is unlikely to be required if PENLINK is constructed; and
- Including such widening in the analysis showed an improvement in network performance in the No-PENLINK scenario, but only minor changes if PENLINK was in place. This means that that widening is not predicted to make any material change in the traffic flow (and hence revenue) on PENLINK, but would reduce the economic efficiency of the project as measured against the No-PENLINK scenario (see further details below).

Relative to the 2021 Do Minimum scenario, the models suggest that the travel times would be some 5 minutes quicker for those continuing to use the free HBC Highway route between Whangaparaoa and Redvale and between 13 and 22 minutes for those using the toll road. Without PENLINK, the peak direction travel times between Whangaparaoa and Redvale are predicted to increase from the current 20 minutes to over 55 minutes by 2041. With PENLINK provided these 2041 travel times are forecast to reduce by between 38 and 50 minutes, depending on the route taken.

For those using PENLINK, the travel time would be some 5.8km shorter and 8 minutes faster than using the free alternative route.

7.6 Sensitivity Tests and Risk Analysis

7.6.1 Sensitivity Testing

A range of sensitivity tests were undertaken on the core forecasts, covering input assumptions, model parameters and subsequent model output processes. The output of these tests (in terms of daily traffic flows), was then assigned probability distributions then analysed using Monte-Carlo simulation. The resulting probability distributions were then used to assess patronage adjustment factors for the 5%ile, 50%ile and 95%ile values.

The tests were undertaken using the models developed for the 2013 draft report. The effect of the tests (as ratios) was applied to the updated values. Most tests were undertaken only using the 2031 models, although some were also applied in the original 2016[3] models. The likely impacts of

[3] The 2016 models were not updated.

the tests on other years were then estimated from interpolation/extrapolation from those modelled results.

The modelled tests are summarised in **Table 7-5**, while **Table 7-6** shows the ratio of the test volume to the base modelled volume, including from the tests that did not require specific new model runs.

Table 7-5 - Modelled Sensitivity Tests (AADT), 2013 Draft Models

Test	2016	2031
Base Models	10,734	13,295
Bring Curley Avenue Extension forward to 2031[4]		13,106
Widen Whangaparaoa Road HBC Highway to Red Beach	10,719	13,289
Widen SH1 to 6 lanes between Albany and Silverdale		13,328
Reduce speed limit to 60kph on HBC Highway through Silverdale		13,624
Lower Value of time (30% reduction in VoT)	6,513	11,212
Higher Value of time (30% increase in VoT)	12,662	13,932
Increase Vehicle Operating cost by 30%		13,553
Increased mode shift to North Shore Busway (increase 2031 diversion factor from 1.0 to 2.0)		13,061
Reduced mode shift to North Shore Busway (reduce 2031 diversion factor from 1.0 to 0.5)		13,421
Add increased Weiti Development (an extra 1830 dwellings as sought by land owners through Unitary Plan)		14,607
Add development in expanded RUB area west of SH1 (add approximately 35% of the ultimate potential yield)[5]		14,630

[4] This test is no longer relevant in the updated models

[55] This test is no longer relevant with the updated Scenario I-8b models

Table 7-6 - Assessed Flow Ratios Relative to Base

No	Test	2016	2021	2031	2041
1	Bring Curley Avenue Extension forward to 2031	1.000	1.000	0.986	1.000
2	Widen Whangaparaoa Road HBC Highway to Red Beach	0.999	0.999	1.000	1.000
3	Widen SH1 to 6 lanes between Albany and Silverdale	1.000	1.000	1.002	1.002
4	Reduce speed limit to 60kph on HBC Highway through Silverdale	1.025	1.025	1.025	1.025
5	Lower Value of time (30% reduction in VoT)	0.607	0.764	0.843	0.843
6	Higher Value of time (30% increase in VoT)	1.180	1.092	1.048	1.048
7	Increase Vehicle Operating cost by 30%	1.019	1.019	1.019	1.019
8	Increased mode shift to North Shore Busway (increase 2031 diversion factor from 1.0 to 2.0)	1.000	0.988	0.982	0.982
9	Reduced mode shift to North Shore Busway (reduce 2031 diversion factor from 1.0 to 0.5)	1.009	1.009	1.009	1.009
10	Add increased Weiti Development (an extra 1830 dwellings as sought by land owners through Unitary Plan)	1.000	1.066	1.099	1.099
11	Add development in expanded RUB area west of SH1 (add approximately 35% of the ultimate potential yield)	1.000	1.067	1.100	1.100
12	Slower rate of growth (assume 0.9 for 2016, use 2016 results for 2021, use 2031 results for 2041 and interpolate for 2031)	0.90	0.85	0.87	0.92
13	Faster rate of growth (add 1/3rd of the 2016-to-2021 growth to the 2016 results, use 2031 results in 2021, use 2041 results in 2031 and keep the same factor in 2041 as for 2031)	1.06	1.06	1.09	1.09
14	Lower annualisation factors (use expansion factors solely from Route K toll road)	0.93	0.93	0.93	0.92
15	Higher annualisation factors (use expansion factors solely from local sites)	1.07	1.06	1.07	1.07

7.6.2 Risk Profiling

A distribution of each risk item was assumed and a Monte-Carlo simulation was then run. Tests 1 (Curley Avenue) and 11 (western RUB growth) were removed from the updated simulation due to changes in the updated model inputs. Triangular distributions were assumed for the following items:

- Willingness to Pay
- Public Transport diversion
- General rate of land use growth
- Annualisation factors
- Vehicle Operating cost increase

The triangular distributions were fitted to the sensitivity tests results for the years 2016, 2031 and 2041. Discrete distributions were assumed for key network uncertainties and two development areas as shown in **Table 7-7**.

Table 7-7 - Discrete Distribution Assumptions

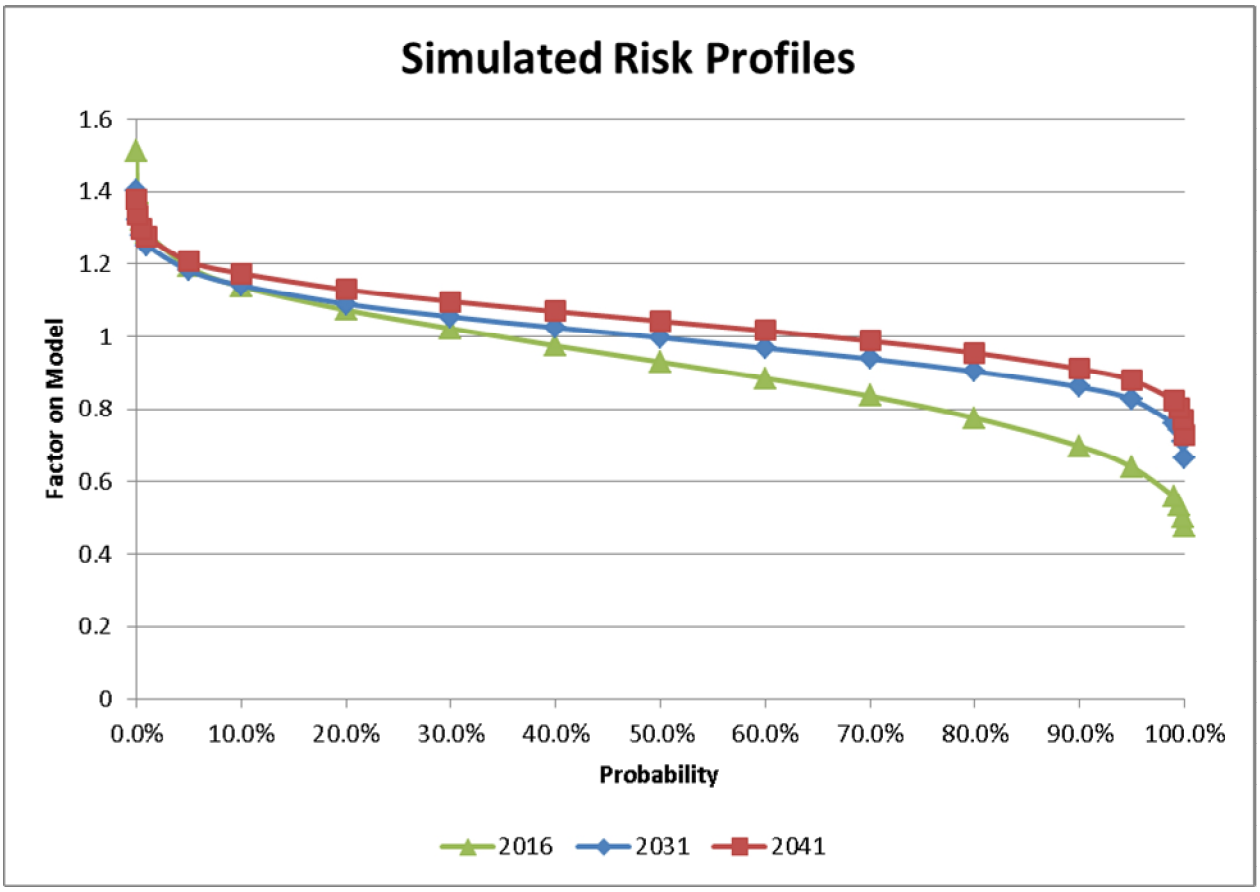
Risk Item	Base Assumption	Alternative Assumption	Probability of Alternative		
			2016	2031	2041
Widen Whangaparaoa Road HBC Highway to Red Beach Road	Excluded	Include	20%	33%	50%
Reduce HBC Highway to 60kph speed limit	Excluded	Include	20%	50%	80%
Expanded Weiti Development	Excluded	Include	10%	50%	67%

The distribution of the combined risk profiles are shown in **Figure 7-3**. The adjustment factors and resulting adjusted daily flows are presented in **Table 7-8** at the 5th, 50th and 95th percentile levels. It can be seen that the 50%ile values are very close to the model forecasts, indicating only a small skew in the risk profiles. In early years the skew is downside, moving to the upside with by 2041.

Table 7-8 - Risk Adjustment Factors

Year	Risk Adjustment Factors			AADT Flows at PENLINK Toll Gantry			
	5%ile	50%ile	95%ile	Model	5%ile	50%ile	95%ile
2021	0.764	0.975	1.187	11,700	8,900	11,400	13,900
2031	0.827	0.998	1.183	12,600	10,400	12,600	14,900
2041	0.880	1.043	1.208	13,600	12,000	14,200	16,400

Figure 7-3 - Risk Profiles



The key contributor to the risk profiles are indicated in the following 'tornado' plots. These show that in early years it is the Willingness to Pay parameters that contribute the greatest uncertainty, while in later years the rate and extent of growth becomes a larger contributor to the uncertainty.

Figure 7-4 - Risk Contributors 2016

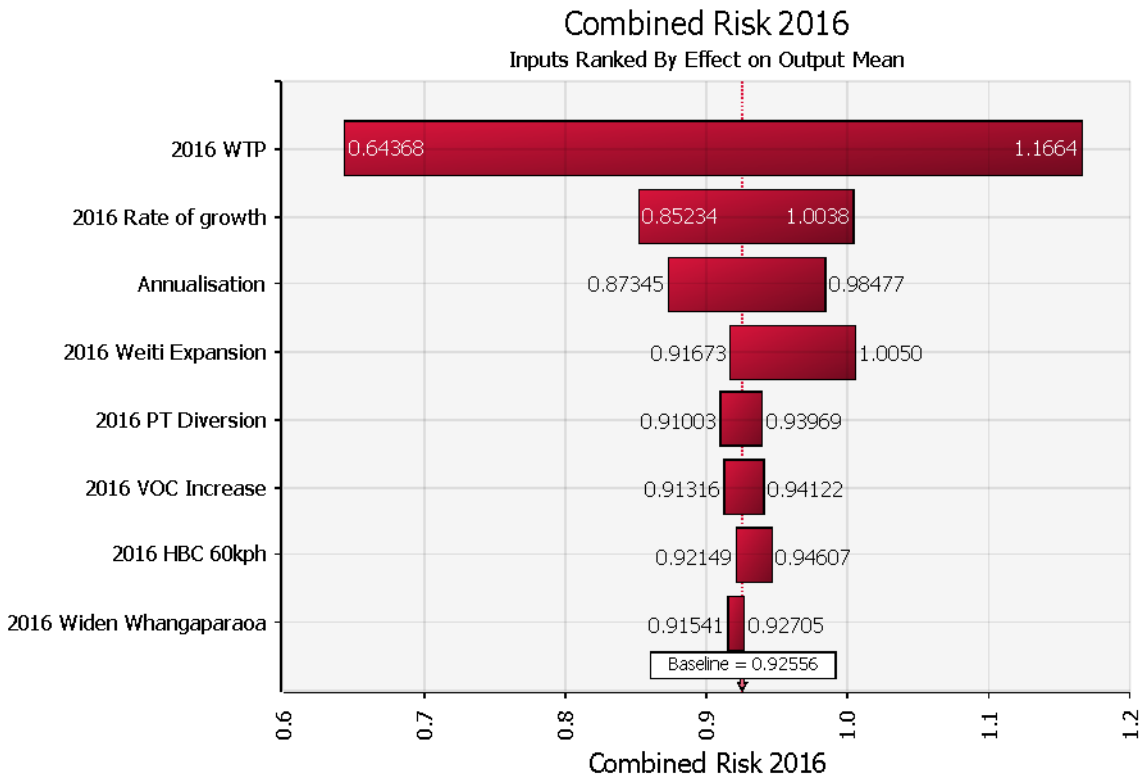


Figure 7-5 - Risk Contributors 2031

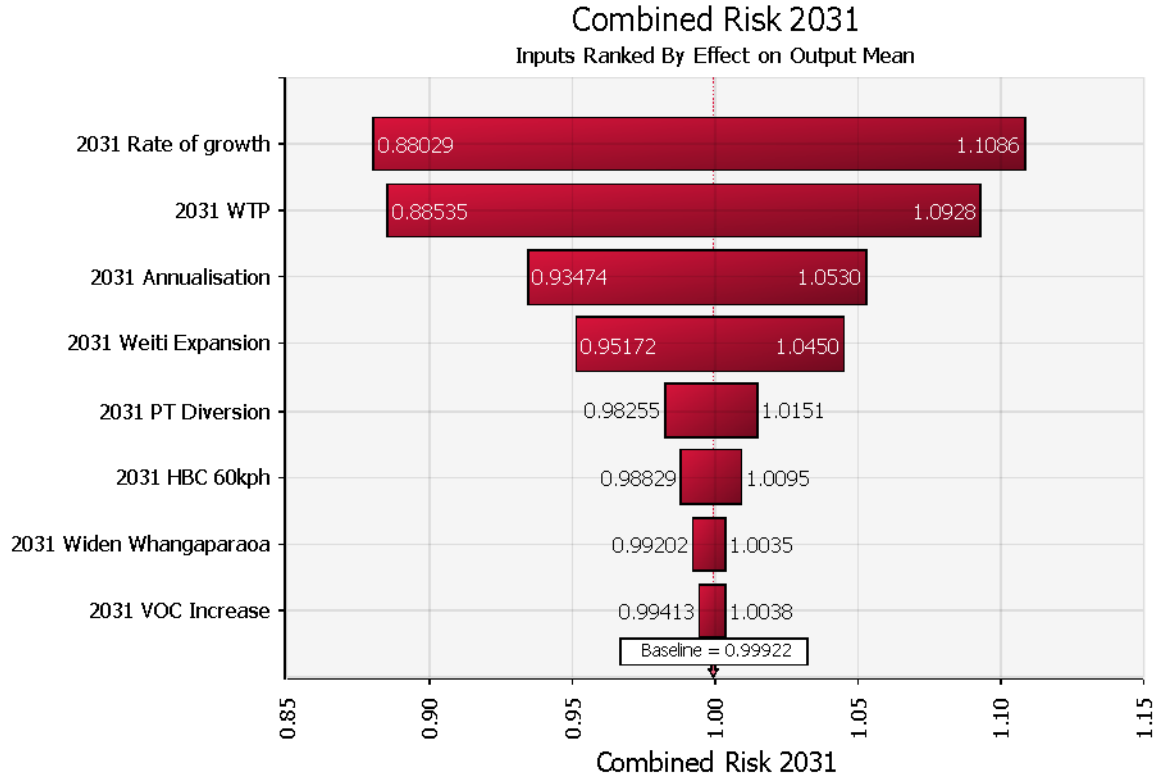
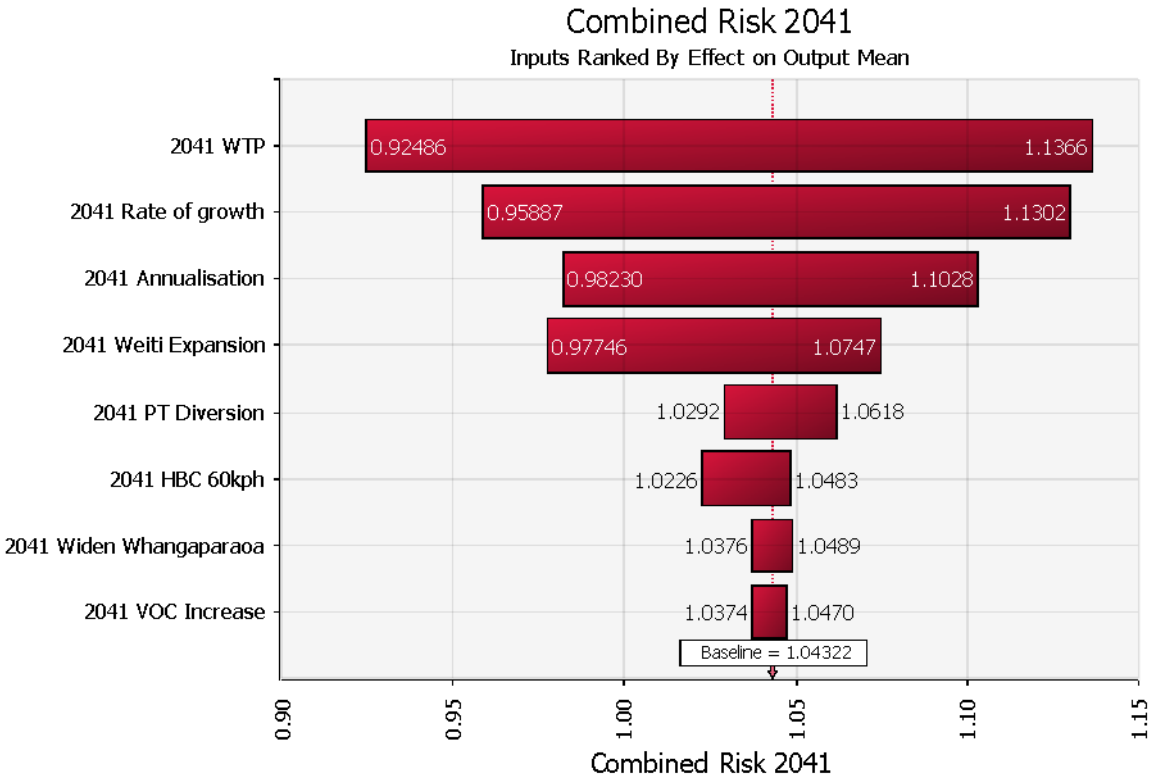


Figure 7-6 - Risk Contributors 2041



7.7 Comparison against 2007 Patronage Forecasts

Toll patronage forecasts were prepared in 2007 for RDC's Business Case Report. Those forecasts used different land use forecasts, a different option (2-lane with at-grade connections), different network assumptions, a different (2-gantry) toll strategy and used and a different toll model. It provided forecasts for the years 2016 and 2021 for a range of tolls between $1.25 and $2.00 ($2006). Although direct, like-with-like comparisons are not possible due to these differences, such changes in inputs and assumptions are expected and hence that earlier work does provide some useful information on the uncertainties and risks associated with such forecasting.

Table 7-9 Comparison with Previous Year 2021 Flow Forecasts

2007 Forecasts		2013 Forecasts, $2.20 toll ($2013)	
Toll $2006	**AADT**	**Risk Level**	**AADT**
$1.25	14,600		
$1.50 (preferred)	11,600	5%ile	8,900
$1.75	8,700	50%ile	11,400
$2.00	7,400	95%ile	13,900

These show that the current forecasts are higher than the previous. Although some of the differences are likely to be due to the change in form of the project and different growth forecasts, a significant proportion is expected to be due to the higher WTP parameters used in the update. The previous model used WTP parameters based on market research data on what motorists might be prepared to pay if such a road was provided. However, those were undertaken in 2003 when there were no toll roads operating in NZ and non in this area. The updated forecasts do not use market research specific to this project, however the response of the model has been broadly benchmarked to what has been observed to occur on toll roads in NZ. The conclusions from this comparison are that due to a wide range of changes in inputs and assumptions, the recent patronage forecasts are noticeably higher than those produced previously.

8 Economic Evaluation

This Chapter details the economic evaluation that has been undertaken. It details the assumptions, costs, benefits and resultant benefit cost ratio (BCR). The economic worksheets can be found in **Appendix H**.

8.1 Framework and Assumptions

The economic evaluation has been undertaken in accordance with the NZ Transport Agency Economic Evaluation Manual (EEM), as updated in 2012. The key aspects of this evaluation include:

- The economic evaluation is based on models for 3 weekday peak periods (AM, inter and PM peaks), for the years 2021, 2031 and 2041;
- The 2041 untolled model results were applied to the year 2051 in the evaluation of Penlink;
- The 2041 annual benefits were reduced by 10% due to high congestion in the pm peak models;
- The models have 14-separate vehicle classes, based on trip purpose, vehicle type and the user Value of Time assessed for the class in the toll response model;
- A variable Trip Matrix (FTM) methodology has been used to calculate the vehicle benefits, to account for induced traffic effects;
- Vehicle travel time and vehicle operating cost benefits have been assessed for each of the 14-classes in the models. The travel time benefits use the local user values of time, however the final aggregate benefits were factored to match the national equity value in the EEM;
- Reliability benefits have been estimated as 5% of the base travel time benefits
- Cycle benefits have been estimated at $1.4/km of new facility and the new facility has been split into two sections, Whangaparaoa to Stillwater, which is assumed to be 1.9km in length and is expected to growth from 20cyclists/day in 2016 to 100 cyclists/day in 2041. The second segment is 4.9km from Stillwater to East Coast Road. The patronage of that section is forecast to grow from 10 cyclists in 2016 to 50 cyclists in 2041.
- The time zero date has been assumed to be 1 July 2015 and the base date is 1 July 2013;
- Construction costs have been spread over three years, commencing in July 2016, with the facility assumed to be open in 2019;
- Update factors have been applied to EEM values to bring to $2012
- The evaluation has used a 40-year analysis period and a 6% discount rate.
- Toll transaction costs reduce from 60c/vehicle in 2016 to 50c/vehicle in 2041
- Crash benefits have been calculated – the crash costs for Penlink have been calculated based on crash prediction models for a 4-lane divided facility while the crash costs for the rest of the model area have been calculated by applying a rate of 5c/km
- The National BCR has been calculated as the transport benefits (excluding the toll costs) divided by the total project costs (excluding the toll revenue but including the toll transaction costs)
- The Government BCR has been calculated as the transport benefits (including the toll costs as a disbenefit) divided by the net project costs (including the toll revenue). That is, the Government BCR is assessed by subtracting the toll revenue from both the benefits and the costs
- Property costs have been assumed to be accrued in the year before construction, irrespective of when the property was purchased
- Both annual and periodic maintenance costs have been included for Penlink

8.2 Do Minimum and Preferred Option

The Do Minimum scenario is based on the future year network assumptions described earlier. Key assumptions that could influence this assessment include:

- The Silverdale Park and Ride (Stage 2) in place by 2016
- The North Shore Busway extended to Silverdale by 2031
- The Curley Avenue/East Coast Road extensions in Silverdale in place by 2021
- No widening of Whangaparaoa Road
- Inclusion of the Wainui Road south-facing ramps to SH1 by 2016
- A new roundabout on East Coast Road (near Weiti Station Road) to accommodate the consented development from the Weiti Station and Weiti Forest areas[6]
- Inclusion of traffic signals at the HBC Highway/Jack Hawkin Lane intersection, to precinct 11 of Silverdale North Special 19 Zone[7]

The PENLINK Project assessed here includes the following key elements:

- A half-diamond (south-facing) ramps to SH1 at Redvale
- A grade-separated crossing of East Coast Road, with a link to between East Coast Road and PENLINK
- A 4-lane, divided expressway between East Coast Road and Whangaparaoa Road
- Traffic signals at the PENLINK/Whangaparaoa Road intersection
- Widening of Whangaparaoa Road on the approaches to this connection, from Brightside Road to Arklow Lane
- Grade separated crossing and links to Duck Creek Road
- Grade separated connections to the Weiti Station and Weiti Forest developments;
- A toll strategy on or near the bridge crossing the Weiti River, comprising:
  - Fully electronic toll collection (using the NZ Transport Agencies National Toll System)
  - A light-vehicle toll of $2.20 and a heavy-vehicle toll of $4.40 ($2013)
  - The tolls escalated annually at the rate of inflation

[6] This roundabout is not formally proposed as these developments propose to connect directly to PENLINK. However, for the purposes of this assessment a similar-standard connection to East Coast Road was assumed.

[7] Agreement was reached between the land owners and Auckland Transport for such an intersection, if consent is granted by Auckland Council.

8.3 Capital, Maintenance and Operating Costs

The Expected (50%ile) estimates for construction of PENLINK are as shown in **Table 8-1**.

Table 8-1 - Capital Cost Estimates

	50%ile Estimate ($M)
Investigation and Reporting	5.82
Design and Documentation	20.37
Construction	332.29
TOTAL excluding Property	358.49
Property	26.35
TOTAL with PROPERTY	384.84

Suggested toll transaction costs were provided by the NZ Transport Agency at between 50c and 60c per vehicle. For this analysis, these were assumed to be 60c/vehicle in 2016 declining in a linear way to 50c by 2041.

Whole-of-life operating and maintenance costs were estimated at $2.04 million per year and $5.6 million every 10 years.

8.4 Assessment of Transport Benefits

The assessment of road user costs includes:

- Basic travel time costs;
- Congested travel time costs (CRV);
- Trip reliability travel time costs;
- Vehicle operating costs;
- Vehicle crash costs; and
- Carbon dioxide costs;

In addition to the transport user costs, economic agglomeration and Wider Economic Benefits were assessed for this project.

The travel time and vehicle operating benefits were assessed at a matrix level based on the consumer-surplus calculations in the EEM, as follows:

$$B = \frac{1}{2}\left(T_{OPT} + T_{DM}\right) \times \left(U_{DM} - U_{OPT}\right) + T_{OPT}\left(U_{OPT} - R_{OPT}\right) - T_{DM}\left(U_{DM} - R_{DM}\right)$$

where:

T_{DM} = Number of trips in the Do Minimum

T_{OPT} = Number of trips in the Option

R_{DM} = Resource cost of travel in the Do Minimum

R_{OPT} = Resource cost of travel in the Option

U_{DM} = User cost of travel in the Do Minimum

U_{OPT} = User cost of travel in the Option

(note: these calculations are done between each origin (i) and destination (j) zone but the ij subscripts have been omitted for clarity).

8.4.1 Travel Time Parameters

The traffic models used local, behavioural Values of Time (VoT). These differ from the National, Equity resource values contained in the EEM.

The consumer-surplus calculations were undertaken using these local behavioural user costs, but then adjustment factors were applied to the resulting benefits to make the outcomes consistent with the National Equity resource values in the EEM. The use of the local values in the calculations is required to fairly reflect the distribution in VOT across users and hence the differing willingness to pay for time savings. In the behavioural model, those users with high VOT would use the tolled route and accrue the time savings, while those with low VOT would use the slower, more congested alternative route. The use of average VOT for all users in the economic evaluation would inappropriately weight the benefits to users and the dis-benefits to non-users equally, thereby over-estimating the dis-benefits of the tolls.

The consumer-surplus calculations use both 'user' and 'resource' values, and Appendix 11 of the EEM provides the relationship between these values. For travel time costs, the Local User costs are assumed to be equal to 1.12[8] x the Local Resource costs. Because the local VOT used in the models was assumed to represent the Local User costs, the Local Resource costs were determined by dividing the Local User costs by 1.12.

The Local Resource costs that result from this calculation differ from the National Equity values contained in the EEM. Subsequently, in the final calculations the total benefits were adjusted by the ratio of the National Equity values to the Local Resource values.

The process used for assessing travel time benefits was therefore as follows:

- Run the model using the behavioural VOT;
- Calculate the Local User costs based on the local VoT;
- Assess the local Resource costs by diving the user VOT by a factor of 1.12;
- Calculate the benefits using these Local User and Local Resource costs for each trip purpose and VOT segment in the model;

[8] This value is a weighted-average of work and no-work factors from Table A11.1 of the PEM.

- Calculate the weighted-average Local Resource cost over all segments in the model;
- Determine the National Equity resource cost, based on the standard Urban Arterial composite cost in the EEM. Determine the ratio between the National Equity value and the Local Resource value, and apply this factor to the assessed benefits;

The average VoT parameters used in this evaluation are shown in the following **Table 8-2**.

Table 8-2 - Travel Time Benefit Parameters ($2013)

	AM Peak	Interpeak	PM Peak
Weighted-Average Local Resource Value ($2013)	16.83	17.50	17.24
National Equity Value (Urban Arterial, $2012)	20.73	24.59	20.50
Equity Adjustment Factor	1.38	1.57	1.33

8.4.2 Congested Time Costs

Local user costs for congestion were determined from the local VoT, and applying the ratio of CRV/Base travel costs in the EEM. For example, in Table A4.3 of the EEM, the am peak CRV is 25.6% of the base National Equity VTTS, and hence the Local CRV value was estimated as 25.6% of the Local VTTS. The Local resource CRV was determined as the Local user CRV divided by 1.12. The same adjustment to National Equity values used for travel time was applied to congested time.

8.4.3 Trip Reliability Benefits

Trip reliability benefits were assumed to be 5% of the base travel time benefits. This simplifying assumption is similar to that used on other projects and is based on experience using the full (and very complex) procedures included in the EEM.

8.4.4 Vehicle operating costs

Base vehicle running costs were assessed from the modelled speeds. In the consumer surplus calculations, the user costs were set as the perceived operating costs used in the behavioural models (20c/km). The resource costs were set directly to the resource values in the EEM for a standard Urban Arterial composition. The resource values therefore were typically of the order of 30c/km, although they varied depending on the link speed.

These values were updated to $2013 using the EEM update factor of 1.06.

8.4.5 Crash Benefits

As noted above, the network-wide crash costs were derived based primarily on the change in total Vehicle kilometres of travel (VKT), and an average crash cost of 5c/km $2012). That average cost is based on the value calculated for the analysis of the extension of the North Shore Busway to Silverdale, which was based on actual recorded crash data.

The crash costs on PENLINK were calculated using the predicted daily flows and the crash prediction models for a 4-lane divided expressway. The VKT on PENLINK was removed from the VKT to avoid double-counting those costs.

8.4.6 Cycling/Walking Benefits

Cycle benefits have been estimated using the simplified EEM method at $1.4/km of new facility. The new facility has been split into two sections:

- Whangaparaoa to Stillwater, which is assumed to be 1.9km in length with patronage estimated to growth from 20cyclists/day in 2016 to 100 cyclists/day in 2041; and
- Stillwater to East Coast Road, which is 4.9km with patronage assumed to grow from 10 cyclists in 2016 to 50 cyclists in 2041.

8.5 Wider Economic Benefits

Wider Economic Benefits (WEBs), including agglomeration were calculated by PWC, using economic inputs and outputs from the original traffic models related to travel costs. The values provided by PWC were as shown in **Table 8-3**

Table 8-3 - Wider Economic Benefits (Using Draft Models)

Category	Value
Agglomeration Benefits	$97.1M PV
Imperfect Competition Benefits	$24.3M PV
Labour Supply Benefits	$22.5M PV

Those benefits were found to represent 13% of the transport benefits, so this percentage was adopted for the analysis updated in June 2014.

8.6 Benefit Cost Ratio

Two BCR values have been calculated, namely a 'National' (or un-leveraged) BCR and a Government (or leveraged) BCR. In the National BCR, the capital costs included construction, land, toll system capital costs and the administration costs for the toll system (toll operational and maintenance costs).

In the Government BCR, the cost of the toll was subtracted from the user benefits while the revenue was subtracted from the total costs to Government. Because the user cost of the toll is equivalent to the revenue, this effectively means that the revenue was subtracted from both the benefits and the costs sued in the base BCR. This is summarised as follows:

$$BC_{National} = \frac{User\ Benefits}{Capital + Land + Toll\ System + Toll\ O\ \&\ M}$$

$$BC_{Government} = \frac{User\ Benefits - Revenue}{Capital + Land + Toll\ System + Toll\ O\ \&\ M - Revenue}$$

Table 8-4 displays the results of the economic evaluation.

Table 8-4 - Economic Evaluation Results

Item	Base	With Agglomeration	With all WEBS
Travel Time Costs, $M PV	543.3		
Congestion Costs, $M PV	107.8		
Trip Reliability, $M PV	27.2		
Vehicle Operating Costs, $M PV	103.1		
Accident Costs, $M PV	22.3		
Cyclists, $M PV	1.7		
CO_2, $M PV	4.1		
Agglomeration Benefits, $M PV		105.3	
Other WEBS, $M PV			46.8
PV TOTAL BENEFIT, $M	810.1	915.4	962.2
Construction, $M PV	329.3		
Annual/Periodic Maintenance, $M PV	30.50		
Toll Transaction Cost, $M PV	28.0		
PV of total costs, $M	387.8		
PV Net Revenue, $M	113.1		
National BCR	**2.1**	**2.5**	**2.5**
Government BCR	**2.4**	**2.9**	**3.1**

8.7 Sensitivity Tests

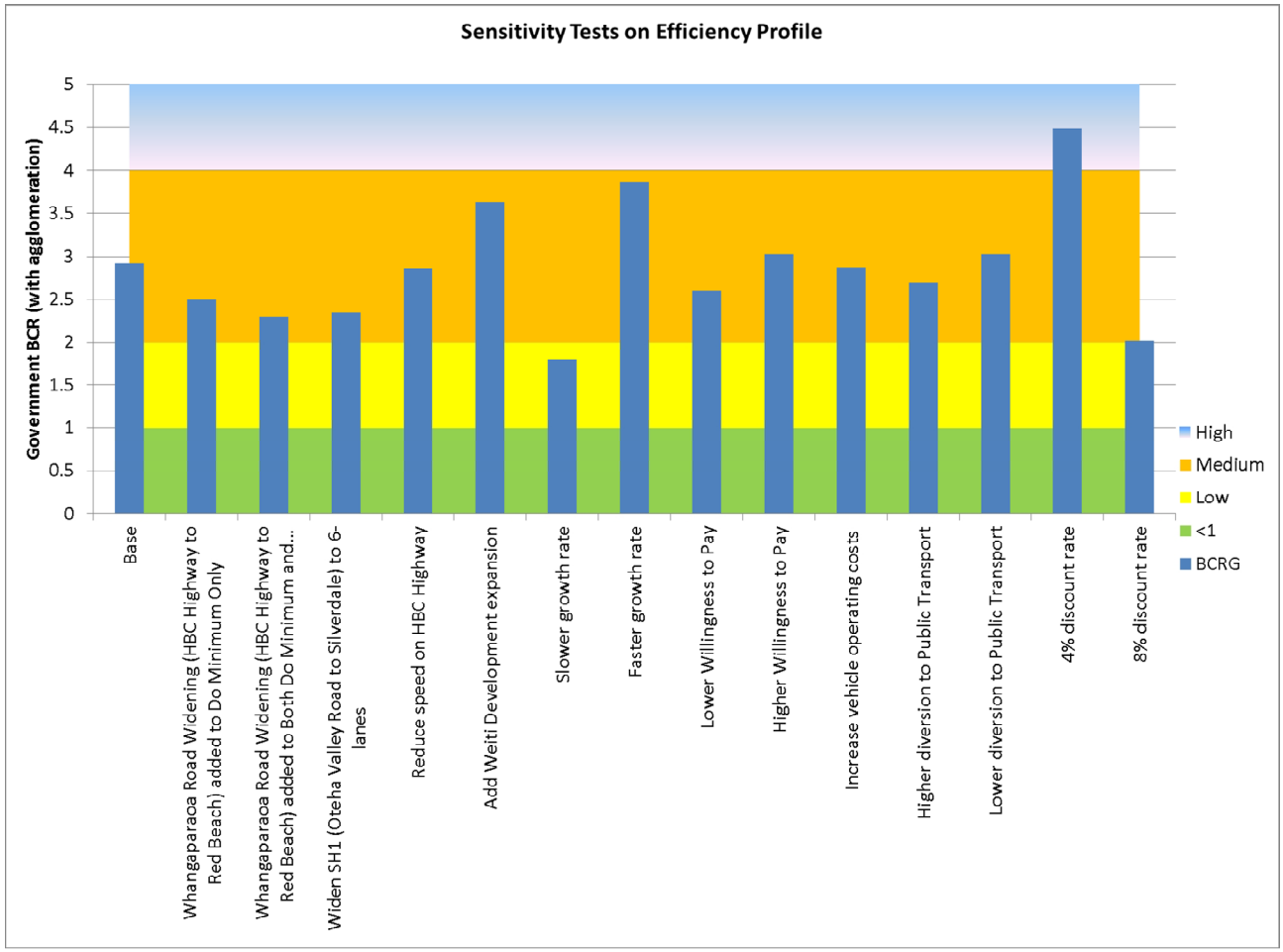
Extensive sensitivity tests were undertaken on a range of inputs to the evaluation. These tests are described in **Table 8-5** below. The BCRs shown are the Government BCR with agglomeration but excluding other WEBS. These test results, and how they fit within the LOW, MEDIUM and HIGH efficiency bands of the funding profile are indicated in **Figure 8-1.**

Of those 14 sensitivity tests, 12 show a BCR remaining with a MEDIUM efficiency rating, with one increasing to HIGH (a 4% discount rate) and one reducing to LOW (slower land use growth).

Table 8-5 - Sensitivity Tests

No	Description	Method	BCR_G with Agglomeration
0	Base	As assessed	2.9
A	NETWORKS		
	Whangaparaoa Road Widening (HBC Highway to Red Beach) added to Do Minimum Only	Add widening to Do Minimum network only (model 2016 and 2031) with indicative cost of $26 million dollars added only to Do Minimum	2.5
	Whangaparaoa Road Widening (HBC Highway to Red Beach) added to Both Do Minimum and PENLINK options	Add widening to both Do Minimum and Option scenarios (hence cost neutral)	2.3
	Widen SH1 (Oteha Valley Road to Silverdale) to 6-lanes	Include this widening in 2031 models of both Do Minimum and Option	2.3
	Reduce speed on HBC Highway	Reduce speed limit on HBC Highway through Silverdale from 70kph to 60kph, to reflect Corridor Management Plan intentions	2.9
B	Land Use and Growth		
	Add Weiti Development expansion	Include requests for further growth beyond that consented in Weiti Forest (another 1000 dwellings) and Weiti Station (another 750 dwellings)	3.6
	Slower growth rate	Slow benefit growth by delaying modelled results (e.g. 2016 benefits applied in 2021, 2021 benefits applied in 2031 etc)	1.8
	Faster growth rate	Speed benefit growth by bringing forward modelled results (e.g. 2031 benefits applied in 2021 etc)	3.9
C	Travel Behaviour Parameters		
	Lower Willingness to Pay	Reduce WTP by 30%	2.6
	Higher Willingness to Pay	Increase WTP by 30%	3.0
	Increase vehicle operating costs	Increase vehicle operating costs in both distribution and assignment models (2031 only)	2.9
	Higher diversion to Public Transport	Increase ‘diversion rate’ from 1.0 to 2.0 in 2031 (to match 2041)	2.7
	Lower diversion to Public Transport	Reduce ‘diversion rate’ from 1.0 to 0.5 in 2031 (to match 2021)	3.0
D	Evaluation Framework & Assumptions		
	4% discount rate	Reduce discount rate from 6% to 4%	4.5
	8% discount rate	Increase discount rate from 6% to 8%	2.0

Figure 8-1 Sensitivity Tests on Government BCR (including agglomeration)



9 Summary

This report details the traffic and toll modelling and economic evaluation undertaken for Auckland transports Business Case for implementation of the PENLINK project.

This technical analysis comprised three main stages:

Stage 1 **Option Testing**. This was a comparative analysis of project design options such as the number of travel lanes and the form of intersections. This was used by Auckland Transport to develop the preferred project Option;

Stage 2 **Toll Strategy Development**. This stage involved traffic modelling and assessment of different elements of the toll strategy, such as the location and type of toll collection systems and the toll level. This was used by Auckland Transport to develop the recommend Toll Strategy;

Stage 3 **Patronage Forecasts and Economic Evaluation.** This involved preparing the traffic and revenue forecasts, sensitivity testing and risk analysis and detailed economic evaluation. These inputs were used in the Business Case Report.

The technical studies were governed by a Project Control Group (**PCG**) convened by Auckland Transport.

Auckland Transport's HBC Traffic Model was updated for use in this work, including a rebasing to current-day conditions, including calibration and validation to observed data. Future year forecasts were developed using land use forecasts and key network assumptions provided by Auckland Transport.

As well as preparing the patronage and revenue forecasts, detailed sensitivity tests were undertaken on key inputs and used to develop probability distributions around the forecast values.

A detailed economic evaluation was also undertaken in accordance with the NZ Transport Agency's Economic Evaluation Manual, along with extensive sensitivity testing.

The scope, context and key findings of this work are detailed in the Executive Summary of this report, and are not repeated here.

Given the uncertainties inherent in predicting future year patronage for toll roads, this report has attempted to identify and quantify the possible uncertainties in the inputs, assumptions and model functionality. Such risk-profiling does not itself provide greater certainty in the central forecast, however it does provide greater information about the potential scale of uncertainty and the effect of particular assumptions and parameters used.

The report should be read in full to understand this context.

Appendix A

Scope of Services

Scope of services:

Beca will undertake the following:

Traffic Model Update:

The primary tasks to be undertaken to complete the update to the traffic model are outlined below:

a) **Data:** Scope survey requirements, collate existing data, and collect new survey data. The main survey is a limited Origin-Destination survey of vehicles between Whangaparaoa Road and SH1/East Coast Road. We have included a provisional sum of $15,000 for this survey, although will seek quotes to confirm the cost. We then propose to invoice AT for the actual cost of these surveys.

b) **Update Model structure:** We will liaise with the Auckland Transport modelling team on proposed changes to their model; develop a process to convert Auckland Plan land use forecasts (Art3-zones) to local zones used in HBC models; update the trip-end model to better address external trip proportions; develop a simper toll choice model using VOYAGER path-based assignment method; collate available 'Willingness to Pay' (WTP) data from available sources (no new market research);

c) **Calibrate/Validate Base Models:** We will adjust the time period/distribution models to match the OD data; check HBW (commuter) purpose against census JTW data; adjust parameters to match link and turn counts and travel time surveys; and document the validation.

d) **Forecasting:** We will agree assumptions and prepare inputs for the future year networks and land use; benchmark distribution patterns against the ART3 regional model, run and verify models; and document baseline forecasts

The output from this phase of work will be an updated Traffic Model that can be used for testing the base model and selected options.

Update Toll Strategy:

Our scope of work includes an update to the toll strategy. We will test a range of toll levels and locations, and extract a range of network performance measures (revenue, diversion, travel times etc.). The findings will be presented to AT prior to undertaking the final tests.

The output for this phase of the project will be a report documenting the selection process and preferred toll strategy.

Macroscope Study:

To confirm the macroscope for the project, we will prepare interim models (partially updated models with Auckland Plan land use). We will assess the demand under a 4-lane scenario, both mid (2026) and long term (2041), review the remaining constraints, and revise assumptions as appropriate to estimate unconstrained demands (i.e. demands unconstrained by design assumptions on the project itself). We will also consider the potential influence of tolls on corridor demands

We will develop cross-sections for each of the options (e.g. 2 lane, passing lanes, 2+1, 4-lane), and undertake preliminary testing of alternative connections to East Coast Road. The level of service will be considered for each scenario in both the short and long term.

The findings will be presented and discussed to agree final scenarios. These will then be modelled with the process and outcomes reported

The output from this phase of the study will be a report outlining recommended lane requirements of PENLINK, and a suggested way forward on connections to ECR and SH1.

Revenue Forecasts:

We will analyse the available data to create annualisation factors. The inputs and assumptions for the final scenario will be agreed with AT prior to running the final model and extracting results.

Key risks and uncertainties in forecasts will be identified, and we will develop and undertake sensitivity testing.

A risk analysis (monte-carlo simulation) will be undertaken to quantify the combined risks (i.e. revenue forecasts will be presented as percentile values, e.g. 5th, 50th and 95th%ile revenue).

The output for this stage of the project will be a report documenting patronage and risk-adjusted revenue forecasts, along with description of key patronage risks.

Economic Evaluation:

We will agree the final 'Do Minimum' assumptions with AT and finalise the 'Do Minimum' models (option models with final toll strategy assumed complete form previous task). The results will be extracted and processed. A full induced traffic (VTM) analysis is suggested, on both a tolled and untolled scenario.

We will then identify the risks and undertake sensitivity tests and a risk analysis.

The economic evaluation will then be undertaken, including National and Government BCR's (cost data assumed as an input), and the risk profile applied.

The output from this stage will be a report documenting the economic evaluation process and results

Appendix B

Report Information

Report Information

The traffic model and forecasts have been developed using the following information provided by Auckland Transport:

- The HBC model (owned by Auckland Transport but operated by Beca)
- 2012 population data provided by Auckland Transport
- Land use forecasts provided by Auckland Transport (ART3-zone level), referred to as Scenario I-8b
- Meshblock-level forecasts from the previous Rodney District Council
- The preferred form of PENLINK
- The preferred toll strategy
- Assumptions on key network upgrades (such as widening of Whangaparaoa Road), as specified by Auckland Transport
- Traffic signal (SCATS) traffic count data from the Auckland Transport/NZ Transport Agencies JTOC centre
- Toll system capital and transaction costs provided by the NZ Transport Agency (provided via Auckland Transport)

Appendix C

Link Count Validation

Appendix D

Turning Count Validation

Appendix E

Travel Time Graphs

Appendix F

Land Use Comparison

Appendix G

Toll Strategy Development

Appendix H

Economic Evaluation Worksheets