City of Sydney

15 April 2010

AECOM

Inner Sydney Regional Bicycle Network

Demand Assessment and Economic Appraisal

Inner Sydney Regional Bicycle Network

Demand Assessment and Economic Appraisal

Prepared for

City of Sydney

Prepared by

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Executive Summary

The City of Sydney, in co-operation with fourteen inner Sydney councils, prepared the Inner Sydney Regional Bike Plan that identified enhancements that would provide high quality radial and cross regional cycling links within the inner parts of Sydney. The network is designed to provide greater connectivity and segregation for cyclists between key destinations and along key arterial routes within inner Sydney.

After the preparation of the Bike Plan, further work was undertaken by the City of Sydney to refine the network. To this end, AECOM prepared the *Inner Sydney Regional Bicycle Network Implementation Strategy* in 2009 which identified an additional 54 kilometres of cycleways or 284 kilometres of cycleways in total. The proposed network is shown in **Figure E.3.**

AECOM was commissioned by the City of Sydney to determine the economic desirability of developing the Inner Sydney Regional Bicycle Network for the purposes of informing submissions to Federal and State bodies for project funding. As part of this study, usage forecasts were prepared to estimate the additional levels of cycling that will be generated from an expanded and improved cycle network. This study investigated benefits arising from increased levels of cycling including:

- Travel time savings;
- Environmental savings including greenhouse gas emissions, air pollution, and noise;
- Savings on public transport vehicle operations and purchase;
- Infrastructure investment timing and budget; and
- Cycling specific benefits including health and journey ambience.

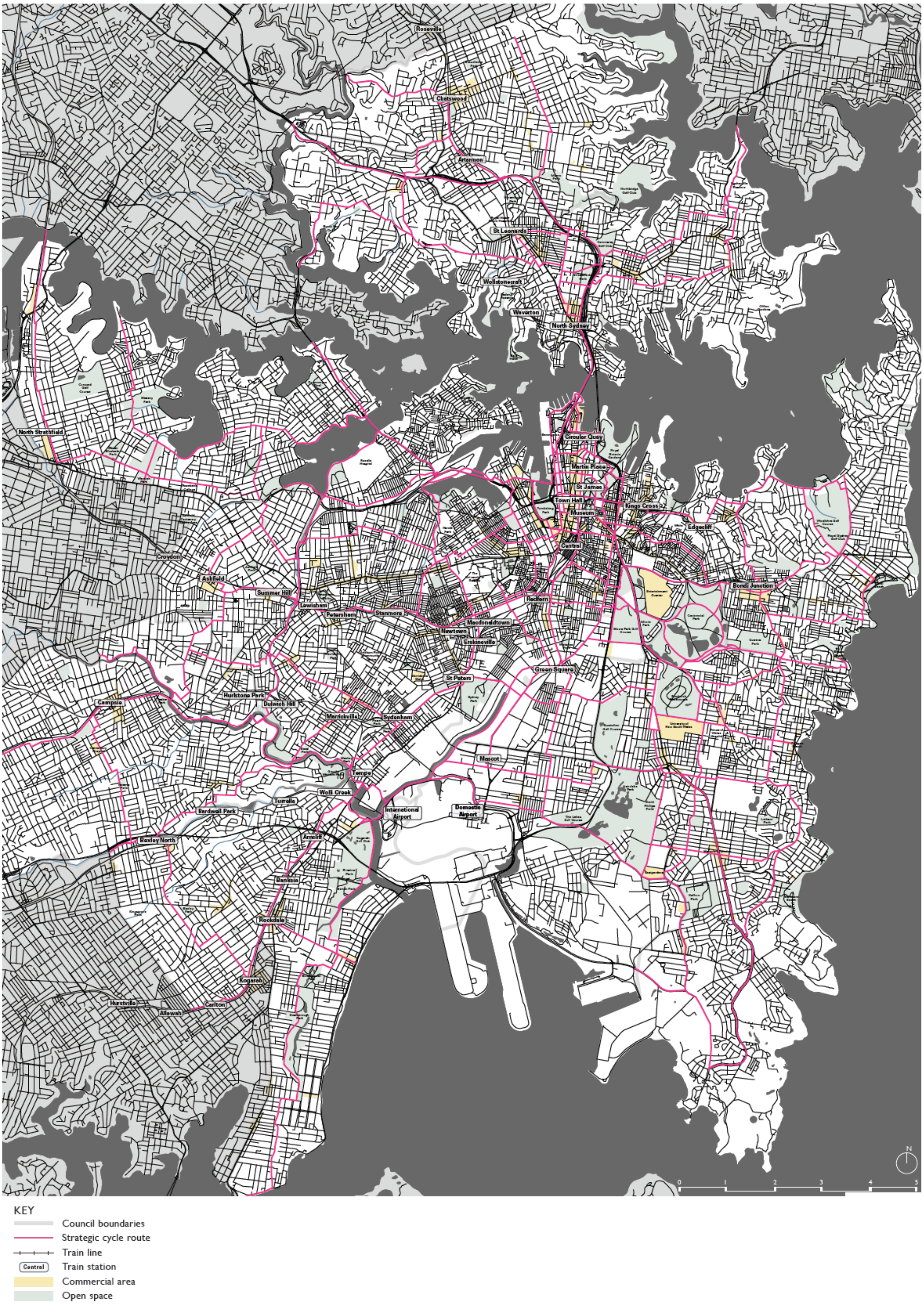
Figure E.1: King Street Separated Cycleway

Source: City of Sydney

Figure E.2: Bourke Road Separated Cycleway

Source: City of Sydney

Figure E.3: Proposed Inner Sydney Regional Bicycle Network (Routes Shown in Pink)



Source: AECOM (2009)

The Need for Separated Cycleways

Demand for cycling is growing in the study area, with noticeably higher, faster and more consistent levels of growth in usage when compared against other parts of Sydney. Within the study area, between 2001 and 2006:

- Commuter cycling levels have grown by 27 percent;
- Non-commuter cycling levels have grown by 50 percent

By comparison, cycling for commuter trips has grown by 18 percent and 36 percent for non-commuter trips across Sydney over the same period.

Although cycling is more popular as a transport mode within inner Sydney, cycling plays a small role in the overall transport task. In 2006, the commuter cycle mode share was estimated to be 0.9 percent and 0.7 percent of all trip purposes within the study area. A summary of key cycling statistics is shown in **Table E.1.**

Table E.1: Key Cycling Statistics

Variable	Study Area	Remainder of Sydney SD	Sydney SD
2006 Journey to Work (Commute Trips)			
Cycle Trips	6,246	4,618	10,864
Total Trips	675,785	1,218,874	1,894,659
Cycle Mode Share	0.92%	0.38%	0.57%
Growth in JTW cycling trips (2001 – 2006)	26.6%	7.6%	17.8%
Growth in all JTW trips (2001 – 2006)	4.4%	4.3%	4.3%
2006 Household Travel Survey (All Trip Purposes)			
Cycle Trips	44,511	78,819	123,330
Total Trips	6,276,397	9,652,222	15,928,619
Cycle Mode Share	0.71%	0.82%	0.77%
Growth in cycling trips (2001 – 2006)	50.1%	28.8%	35.8%
Growth in all trips (2001 – 2006)	10.7%	6.1%	7.9%

Source: AECOM calculations based on ABS and TDC data

Although take up of cycling is growing, the bicycle network in inner Sydney is fragmented and disjointed, with limited historic coordination between various levels of Government to develop a cohesive network. The lack of quality cycling infrastructure and the perceived dangers associated with mixing with general traffic are major hurdles identified by potential cyclists as the key factor in suppressing cycling within Sydney.

International and domestic experience demonstrate that the provision of separated cycleways, paths provided for the exclusive use of cyclists whereby cyclists are segregated from general traffic by a physical barrier, have a significant influence on emolliating safety concerns potential cyclists may have.

As a reflection of the enhanced safety that separated cycleways can offer, the provision of separated cycleways can have immediate and long term impacts on usage, with strong shifts in cycling demand observed where separated cycleway infrastructure has been constructed:

- The development of two cycleways by the City of Sydney on King Street and Bourke Road saw cycling levels increase by up to 30 percent immediately after opening, although as yet, these facilities do not connect to a wider network.
- Demand on cycleways monitored by the RTA has shown that average daily usage on inner Sydney cycleways has increased at an average rate of 12.4 percent per annum between 2003 and 2008.

The attractiveness of separated cycleways to cyclists is emerging within the literature. For instance, research undertaken by Wardman et al. (2007) found that relative to cycling in mixed traffic:

- Cycling on separated cycleways is considered three times more attractive; and
- Cycling on separated cycleways is considered as desirable as travelling in a car, train or bus.

Alignment with Government Objectives

The Inner Sydney Regional Bicycle Network is anticipated to play an important role in supporting local and NSW Government objectives to increase cycle mode shares. For instance, the NSW Metropolitan Transport Plan enunciates:

- A cycle mode share target of 5 percent mode share target for trips less than 10km in length; and
- The development of a metropolitan cycle network.

Demand forecasts prepared by AECOM indicate that the full development of the Inner Sydney Regional Bicycle Network will provide a significant contribution towards the achievement of the NSW Government's cycle mode share targets. The outcomes of the Inner Sydney Regional Bicycle Network also align with Infrastructure Australia's objectives of generating greater economic capacity and productivity, reducing environmental externalities such as greenhouse gases and enhancing social outcomes.

Assessing Demand for the Inner Sydney Regional Bicycle Network

The role of cycling in promoting better transport, health, social and environmental outcomes is well recognised. However, although the practice of appraising transport projects is well entrenched, the quantification of benefits associated with cycling projects is not well established.

Undertaking cycling appraisals has been hampered by the lack of rigorous methodologies and guidelines to follow and difficulty in estimating cycling demand. Furthermore, traditional appraisal approaches have not considered the value of cycling specific benefits such as health benefits, the quantification of which is pertinent in driving the viability of cycling projects.

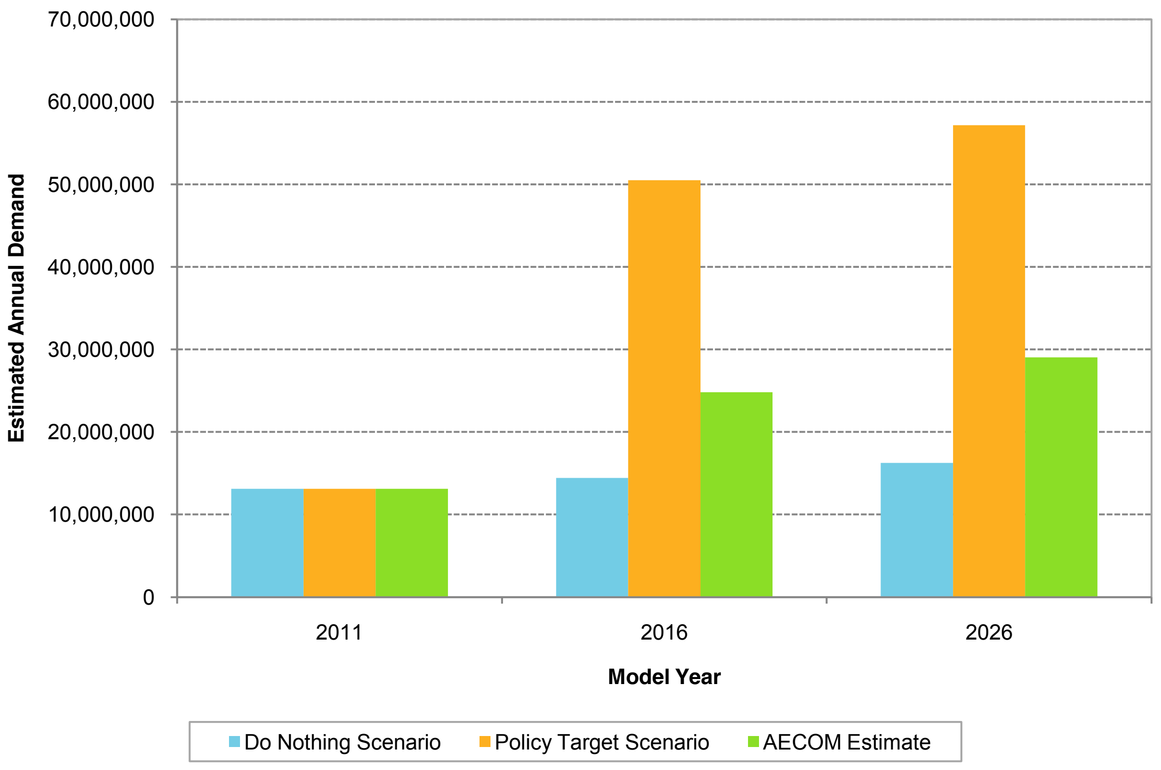
Recent work in Europe and the UK has advanced the sophistication of cycling demand and appraisal methodologies. Current best practice revolves around the use of incremental demand approaches, in particular the use of cycling choice models, to estimate the impact of cycling interventions. This is the approach used by AECOM in preparing its demand forecasts. The incremental choice model used by AECOM has been specifically designed to capture the impact of different cycleway treatments and has been calibrated for use in a Sydney context. AECOM undertook an assessment of three demand scenarios to measure the impact of the Inner Sydney Regional Bicycle Network on current levels of cycling:

Do Nothing Scenario:	A base case scenario whereby no changes in cycling infrastructure are assumed. Cycling mode share are anticipated to increase modestly over time due to increases in travel times and costs for car, train and bus relative to cycling.
Policy Target Scenario:	Assumes that the Inner Sydney Regional Bicycle Network will generate levels of mode shift from present levels in line with mode share targets that are consistent with the NSW State Plan.
AECOM Estimate:	Represents AECOM's estimate of the change in cycling demand expected to be generated from the change in travel costs, travel times as well as from the perceived value attributed by potential cyclists to infrastructure improvements created by the implementation of the Inner Sydney Regional Bicycle Network.

The full development of the Inner Sydney Regional Bicycle Network has the potential to create significant increases in cycling within the study area. *Relative to a do nothing scenario,* AECOM forecasts that cycling levels will increase by 66 percent by 2016 within the study area and 71 percent by 2026 due to the implementation of the Inner Sydney Regional Bicycle Network, as illustrated in **Figure E.4.**

In order to achieve pre-specified cycle mode share targets outlined by the NSW Government within the study area, take up of cycling will need to almost triple relative to a do nothing scenario. Whilst the full implementation of the Inner Sydney Regional Bicycle Network will provide a contribution towards achieving these targets, additional interventions will be required to achieve the NSW Government targets. Such interventions may include the provision of a public bicycle scheme, high quality end-of-trip facilities and behavioural interventions.

Figure E.4: Forecast Annual Cycle Trip Demand by Demand Scenario



Source: AECOM calculations

Assessing the Economic Outcomes from Developing the Regional Bicycle Network

Formal guidelines to prepare economic appraisals for cycling interventions are not available currently in an Australian context. However, AECOM understands that a number of government agencies are actively preparing guidelines to facilitate economic evaluations of such interventions. In preparing its economic assessment of the Inner Sydney Regional Bicycle Network, AECOM has reviewed all guidance made available and where required, made adjustments and included additional benefit streams. In its economic appraisal, AECOM has valued the following benefit streams:

- Decongestion;
- Vehicle operating costs savings;
- Parking cost savings;
- Travel time savings;
- Journey ambiance[1];
- Health benefits in the form of reduced mortality and absenteeism savings;
- Accident costs;

[1] Journey ambiance captures the improved level of enjoyment, improved wayfinding and perceived safety associated with the use of cycle lanes and separated cycleways relative to travelling with mixed traffic

- Reduced air pollution;
- Reduced noise pollution;
- Greenhouse gas reduction;
- Reduced water pollution;
- Reduced urban separation; and
- Reduced pressure on government infrastructure and services.

In addition to the abovementioned benefits, which were monetised for this study, the Inner Sydney Regional Bicycle Network will generate additional benefits including:

- Improved journey time reliability;
- Improved integration with public transport;
- Public transport decrowding;
- Improved equity and accessibility outcomes;
- Potential for wider economic benefits beyond the transport sector;
- Improved localised economic activity; and
- Reduced energy dependence.

An assessment of the economic benefits generated from the implementation of the Inner Sydney Regional Bicycle Network has been undertaken at two levels:

- A network wide level where aggregate changes in cycling demand have been evaluated; and
- Origin-destination whereby corridor specific benefits and costs have been evaluated.

The economic appraisal has been undertaken by appraising the differences in demand between the Do Nothing Scenario and two alternative demand scenarios whereby the impact of the implementation of the Inner Sydney Regional Bicycle Network has been modelled.

The full implementation of the Inner Sydney Regional Bicycle Network is predicted to have the potential to generate significant economic benefits in excess of the economic costs and deliver high returns on investment. Relative to doing nothing, the development of the Inner Sydney Regional Bicycle Network is estimated to generate net economic benefits of $507 million in today’s prices at a benefit cost ratio of 3.88.

If the demand levels required under the Policy Target scenario were achieved, economic benefits could be as high as $1.8 billion, at a benefit cost ratio of 11.08. However, it should be noted that additional initiatives and interventions will be required to deliver the level of estimated usage and economic benefits under the Policy Target Scenario, the costs of which have not been included as part of this appraisal. Hence, the level of net economic benefits under the Policy Target Scenario should be considered as an upper bound.

Table E.2: Network Wide Appraisal Results (Millions of 2010 Dollars)

Criteria	Policy Target Scenario	AECOM Estimate
Present value of benefits	1,948.3	682.3
Present value of investments	153.4	153.4
Present value of all costs	175.8	175.8
NPV	**1,772.5**	**506.5**
NPVI	**11.55**	**3.30**
BCR	**11.08**	**3.88**
IRR	**62.4%**	**27.1%**

Source: AECOM calculations. All monetary values have been discounted at a real rate of 7 percent per annum over an evaluation period of 30 years and are valued in 2010 prices. Public bicycle benefits have been excluded.

The breakdown of benefits indicates that significant benefits will be accrued by individuals, government and the general economy through the full development of the Inner Sydney Regional Bicycle Network.

Travellers stand to benefit through travel time savings, avoided car costs, journey ambiance and health benefits at the cost of a relatively small increase in accident costs. These benefits collectively account for 65 percent and 69 percent of benefits under the Policy Target Scenario and AECOM Estimate Scenario respectively. There are also material benefits accruable for government and the broader economy through road and public infrastructure and operating cost savings, environmental benefits and congestion reduction.

The breakdown of the benefits demonstrates the importance of recognising cycling specific benefits. Collectively, health benefits and journey ambiance provide a significant uplift in overall benefits, accounting for 35 percent and 41 percent of total benefits under the Policy Target Scenario and AECOM Estimate Scenario respectively. A breakdown of economic benefits under the Policy Target and AECOM Estimate Scenarios are shown in **Figure E.5** and **Figure E.6** respectively.

Figure E.5: Breakdown of Benefits Under Policy Target Scenario

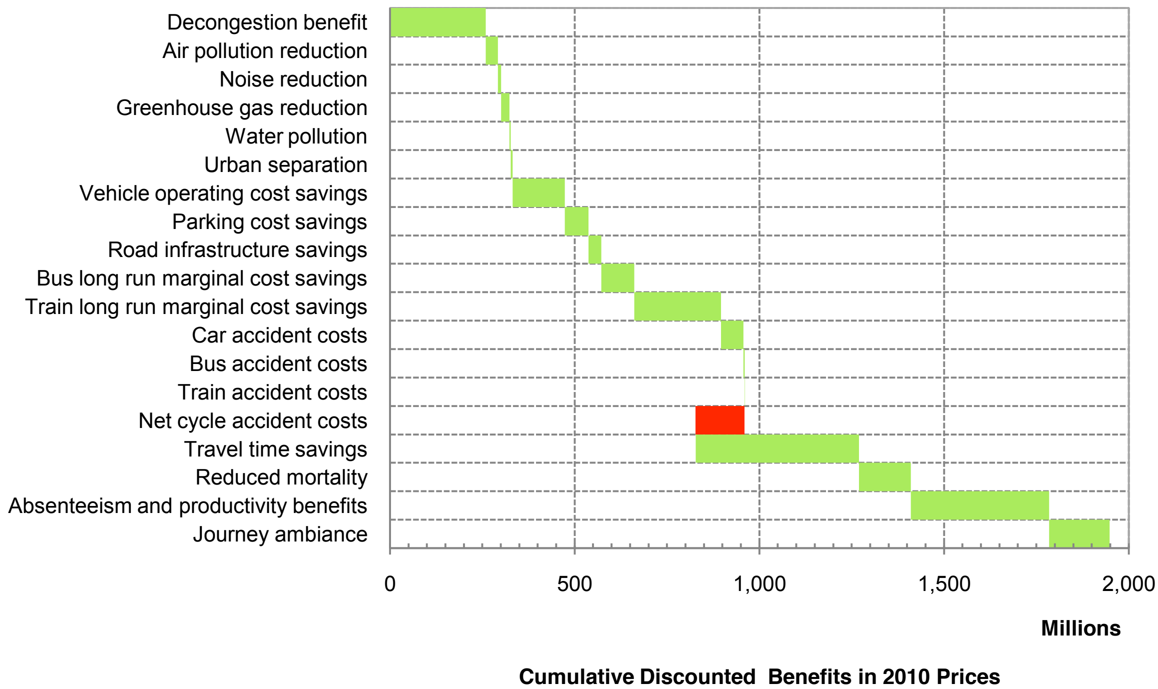
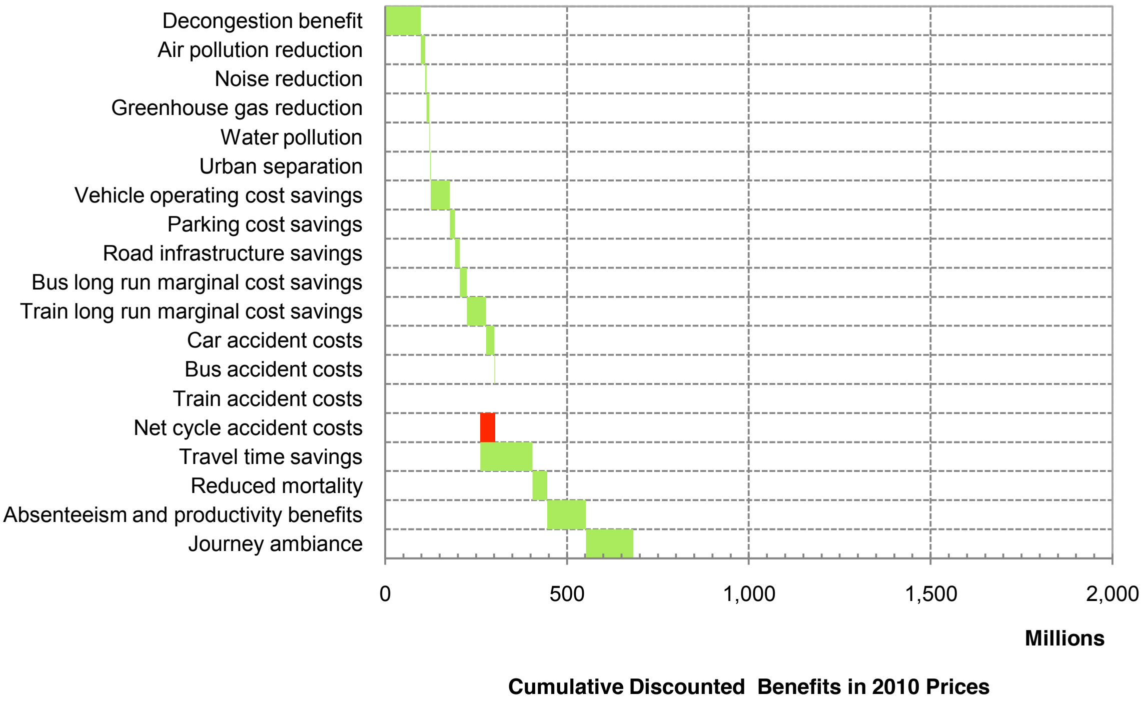


Figure E.6: Breakdown of Benefits Under AECOM Estimates



Source: AECOM calculations. All monetary values have been discounted at a real rate of 7 percent per annum over an evaluation period of 30 years and are valued in 2010 prices. Public bicycle benefits are excluded.

Sensitivity analysis has been undertaken on the results, testing the sensitivity of economic benefits with respect to higher capital costs, higher construction costs and lower usage. All sensitivity tests show that the economic viability of developing the Strategic Bicycle Network is invariant to sensible variations in construction costs, discount rates or usage. The Inner Sydney Regional Bicycle Network is still economically viable even if a “traditional” approach i.e. removing health and journey ambiance benefits was used. Indeed, the economic benefits of the Strategic Bicycle Network may well be higher if more aggressive assumptions on the level of health benefits and journey ambiance as well as the benefits stemming from the implementation of the Public Bicycle Scheme were applied.

An incremental cost benefit analysis was also undertaken to investigate whether prioritisation could enhance the delivery of economic returns. The incremental cost benefit analysis supports the development of the Bicycle Network within the City of Sydney as well as placing a high priority on radial links from the Inner West and the Eastern Suburbs feeding into the city. On the other hand, the incremental cost-benefit analysis indicates that the economic case for developing corridors from the North Shore into Sydney CBD are highly constrained by the high construction costs associated with developing HarbourLink and cycleways along the Warringah Freeway despite the potential for higher levels of cycling demand.

1.0 Introduction

The Inner Sydney Regional Bicycle Network is a proposed radial and cross-regional cycling network for Sydney designed to provide greater connectivity and segregation for cyclists between key destinations and along key arterial routes within inner Sydney.

This study seeks to determine the economic desirability of developing the Inner Sydney Regional Bicycle Network. As part of this study, usage forecasts were prepared to estimate the additional levels of cycling that could be generated from an expanded and improved cycle network. The economic benefits resulting from higher levels of cycling demand were evaluated using cycle specific cost benefit guidelines.

1.1 Study Scope

AECOM was commissioned by the City of Sydney to prepare a cost benefit analysis on the development of the Inner Sydney Regional Bicycle Network for the purposes of informing submissions to Federal and State bodies for project funding.

In order to evaluate the project benefits, AECOM undertook a demand assessment to evaluate the increase in levels of cycling from the development of the Inner Sydney Regional Bicycle Network.

Subsequently, this study investigated the benefits that may arise from increased levels of cycling, including the potential for:

- Travel time savings;
- Environmental savings including greenhouse gas emissions, air pollution, and noise;
- Savings on public transport vehicle operations and purchase;
- Infrastructure investment timing and budget; and
- Cycling specific benefits including health and journey ambience.

In order to inform the prioritisation of the Inner Sydney Regional Bicycle Network, AECOM also undertook an incremental cost benefit analysis. The incremental cost benefit analysis allows for the incremental benefits generated by one section of the network to be compared against the incremental costs expected to be incurred for that section.

The report also reviews the alignment of the Inner Sydney Regional Bicycle Network with wider government strategies and goals, including consistency with Infrastructure Australia objectives, the NSW State Plan and NSW State Infrastructure Strategies. The review provides commentary on additional non-monetary benefits from the development of the Inner Sydney Regional Bicycle Network, which will have positive impact on a range of economic, social, environmental and liveability outcomes.

1.2 Document Structure

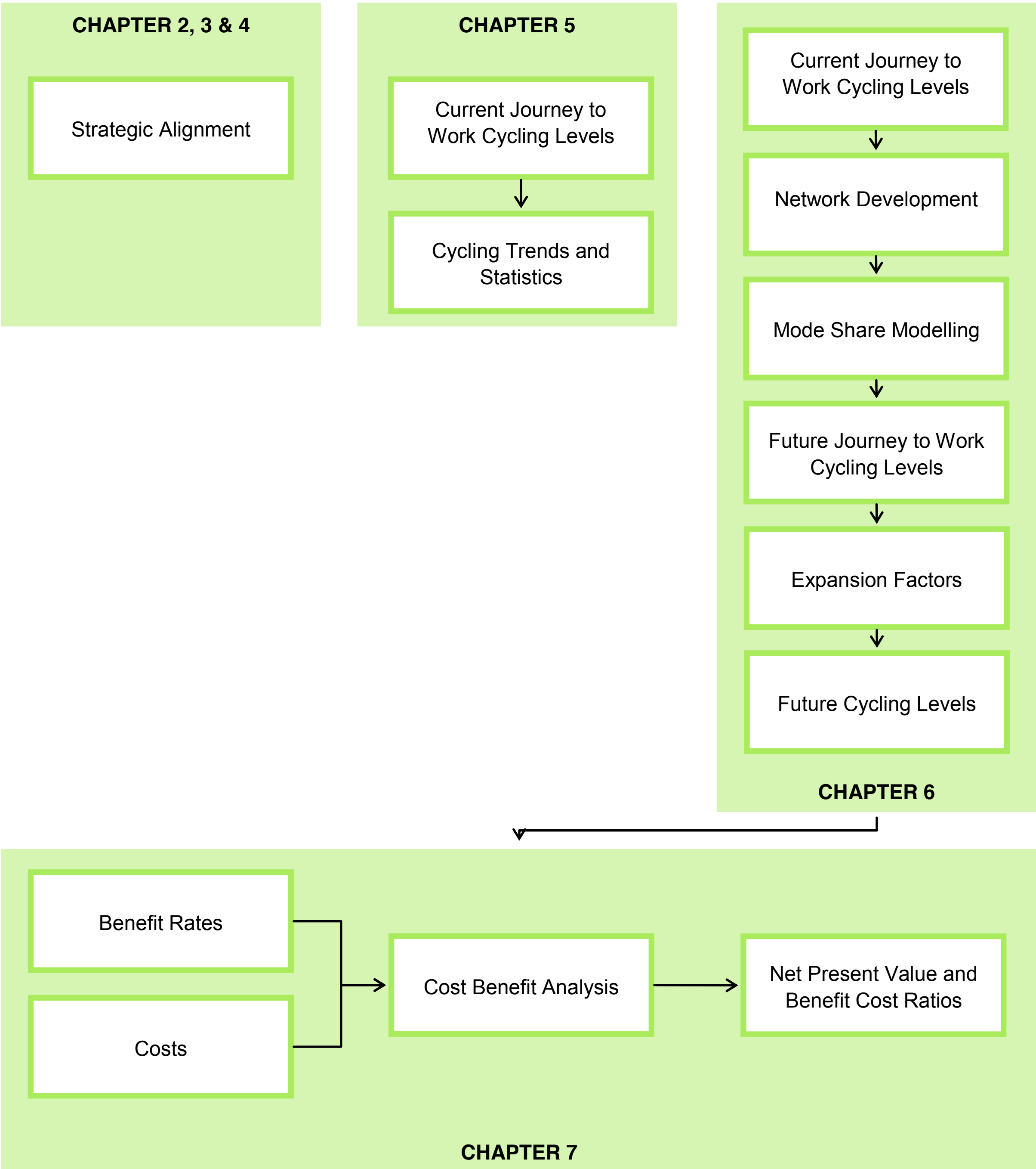
This report is structured as follows:

Section 2.0	Provides a description of the proposed project and an overview of separated cycleways, the need for separated cycleways and their effect on demand
Section3.0	Outlines the emerging role of demand modelling and economic appraisals in supporting greater levels of cycling
Section 4.0	Outlines the strategic alignment between the proposed Inner Sydney Regional Bicycle Network and relevant Federal, State and Local Government policy
Section 5.0	Summarises historic cycling trends in Sydney
Section 6.0	Presents the demand forecasting methodology and results
Section 7.0	Presents the appraisal methodology and results
Section 8.0	Reports key findings, conclusions and recommendations of the study

Section 9.0	Lists references used in this study
Appendix A	List of SLAs included in the study area
Appendix B	Demand Model Parameters
Appendix C	Target Cycle Mode Shares for Policy Target Scenario
Appendix D	Incremental Demand Results

The contents of this study are illustrated in **Figure 1.1**.

Figure 1.1: Study Methodology



1.3 Abbreviations, Acronyms and Terminologies

The following abbreviations, acronyms and terminologies have been used in this document

ABS	Australian Bureau of Statistics
CoS	City of Sydney Council
Cycle lane	A lane marked on a portion of a carriageway dedicated for cyclists
Cycleway	An on-road or off road path that provides a dedicated right of way for cyclists
DECC	NSW Department of Environment and Climate Change
DECCW	NSW Department of Environment, Climate Change and Water, formerly known as the NSW Department of Environment and Climate Change
DfT	UK Department for Transport
HTS	Household Travel Survey
JTW	Journey to Work
OECD	Organisation for Economic Co-operation and Development
PPP	Purchasing power parity
PwC	PricewaterhouseCoopers
RTA	NSW Roads and Traffic Authority
SD	Statistical Division
SSD	Statistical Sub-Division
SLA	Statistical Local Area
SSD	Statistical Sub Division
TfL	Transport for London
UK	United Kingdom
VOC	Vehicle operating costs
WHO	World Health Organisation
WTP	Willingness to pay

2.0 The Proposal

2.1 The Inner Sydney Regional Bicycle Network

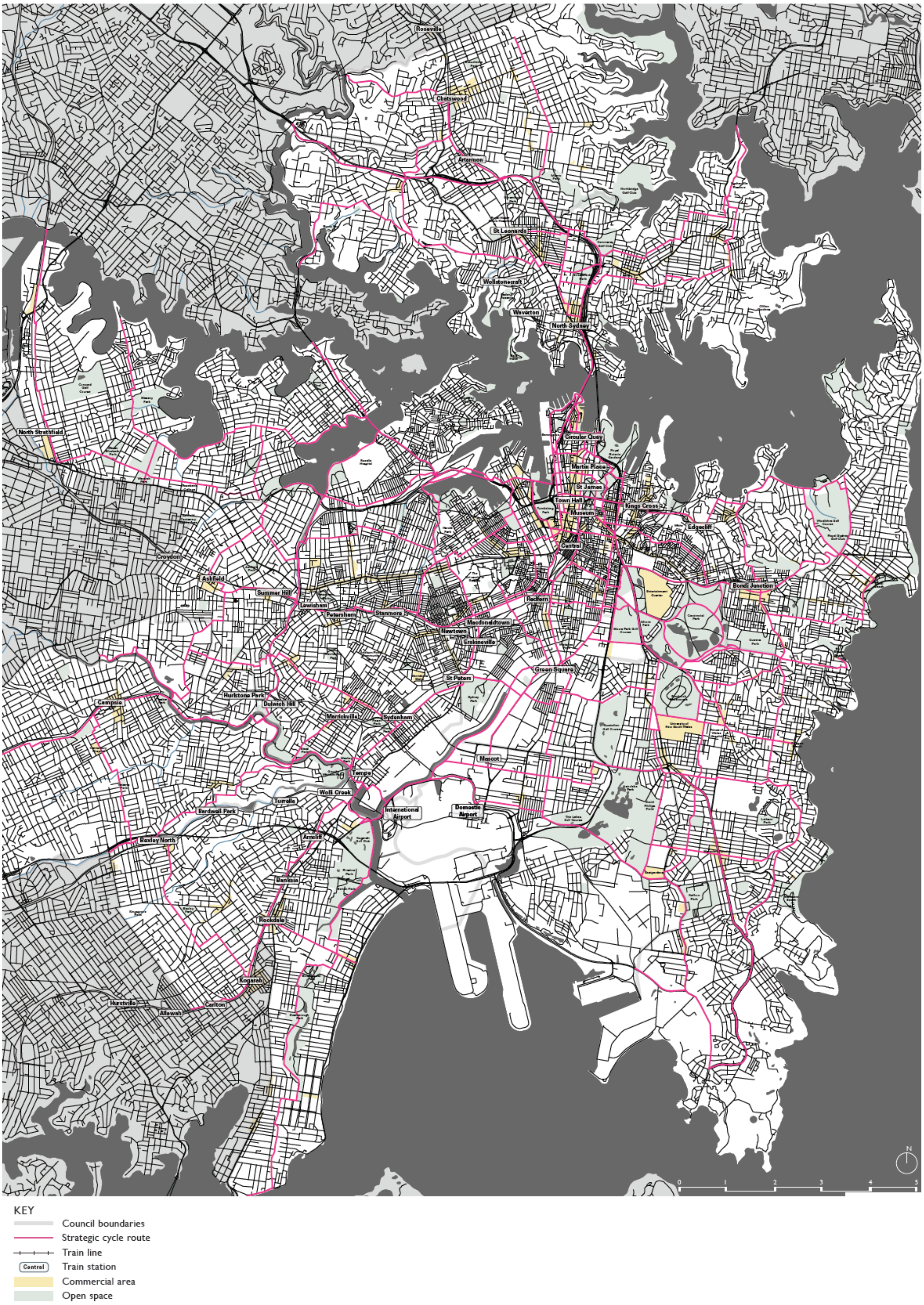
At present, Sydney's bicycle network is fragmented and disjointed. The lack of a well connected cycling network forces cyclists to mix with general traffic, leading to conflicts with larger, heavier and faster moving vehicles. Safety concerns arising from this danger discourage many individuals from considering cycling as an alternative travel option.

To address this, the City of Sydney, in co-operation with fourteen inner Sydney councils, prepared the Inner Sydney Regional Bike Plan that identified enhancements that would provide high quality radial and cross regional cycling links within the inner parts of Sydney. The network includes the construction of 160 kilometres of cycleways which are separated from general traffic and 70 kilometres of upgraded shared paths.

After the preparation of the Bike Plan, further work was undertaken by the City of Sydney to refine the network. To this end, AECOM commenced preparations on the *Inner Sydney Regional Bicycle Network Implementation Strategy* in 2009 which identified an additional 54 kilometres of cycleways or 284 kilometres of cycleways in total. This study complements the implementation strategy by quantifying the expected levels of demand and economic benefits arising from the full development of the enlarged network.

Figure 2.1 shows the routing of the proposed improvements to the bicycle network and the key destinations to be served.

Figure 2.1: Proposed Inner Sydney Regional Bicycle Network (Routes Shown in Pink)



Source: AECOM (2009)

2.2 What is a Separated Cycleway?

A separated cycleway is a path provided for the exclusive use of cyclists whereby cyclists are segregated from general traffic by a physical barrier. Two examples of a separated cycleway, the King Street Cycleway and the Bourke Road Cycleway, are shown in and **Figure 2.3** respectively.

Figure 2.2: King Street Separated Cycleway

Source: City of Sydney

Figure 2.3: Bourke Road Separated Cycleway

Source: City of Sydney

2.3 The Need for Separated Cycleways

The key benefit of separated cycleways is the perceived safety they offer to cyclists from general traffic. The level of separation between cyclists and motorists is a key driver in perceived safety, which in turn is a key driver of demand for cycling.

Limited dedicated cycling infrastructure in inner Sydney requires cyclists to ride alongside general traffic for much of their journey, heightening the safety fears in the minds of would-be cyclists, leading to a suppression of cycling demand. Although the nexus between low levels of cycling infrastructure and safety concerns is well recognised, research commissioned by the City of Sydney highlights how pervasive is this notion amongst inner Sydney residents. Approximately half of all non-regular cyclists within inner Sydney consider general on-road cycling to be sufficiently dangerous to discourage them from cycling. This proportion increases to over 80 percent with respect to on-road cycling within the Sydney CBD (Environmetrics, 2006).

However, there is a strong indication that, if separated cycleways were provided, there could be significant increase in cycling. Up to 84 percent of non-regular cyclists would be willing to consider cycling or cycling more often if dedicated bicycle lanes and off road routes were available (Environmetrics, 2006). Furthermore, community consultation undertaken for the NSW Bike Plan shows that there is a strong public desire for government to provide greater levels of dedicated cycling infrastructure (Parsons Brinckerhoff, 2009a).

2.4 Impacts of Separated Cycleways on Demand

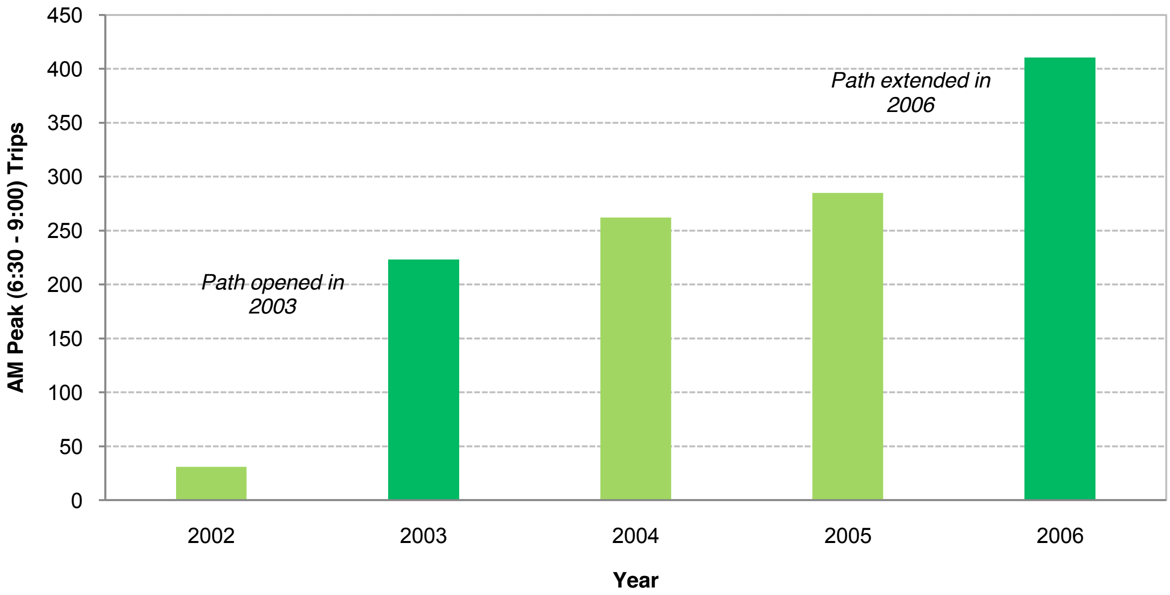
Proponents of separated cycleways point to the high levels of cycling demand achieved in The Netherlands, Denmark and Germany, countries where extensive dedicated cycling networks have been constructed. Although a number of factors contribute to high levels of cycling demand in these countries, research undertaken by Pucher and Buehler (2008) on variations in cycling demand across a range of European countries concludes:

"The key to achieving high levels of cycling appears to be the provision of separate cycling facilities along heavily travelled roads and at intersections"

Pucher and Buehler (2008)

Available demand data on separated cycleways in an Australian context demonstrates that separated cycleways create a significant and immediate upward shift in usage. **Figure 2.4** shows significant increases in usage coinciding with the initial opening and extension of the East Perth to Maylands Principal Shared Path. The path, which follows the Midland Line, was developed by the WA Department of Planning and Infrastructure.

Figure 2.4: Peak Demand on the East Perth to Maylands Principal Shared Path



Source: Bauman et al. (2008)

In a Sydney context, increases in take-up following the opening of separated cycleways have also been observed. Opened in mid-May 2009, the King Street Cycleway is the first of its kind in the CBD, linking cyclists travelling to and from the inner west, across Pyrmont Bridge, with the rest of the City. By the end of 2009, cycling volumes at King Street and Sussex Street and at King Street and Kent Street increased by 19.7 percent[2] and 34.6 percent[1] on an annualised basis relative to pre-opening levels, even though this piece of infrastructure is as yet short and isolated. Cycling levels increased by approximately 30 percent on the Bourke Road Cycleway.

Beyond opening, demand for travel along separated cycleways has also been found to be strong. Usage on inner Sydney separated cycleways has been found to outpace underlying growth in cycling trips. RTA bicycle count data has shown that average daily cycling on inner Sydney cycleways has increased at an average rate of 12.4 percent per annum between 2003 and 2008. By comparison, ABS *Journey to Work* cycling usage increased at an average rate of 5.3 percent per annum between 2001 and 2006.

2.5 Summary

The development of the Inner Sydney Regional Bicycle Network is a major step towards overcoming the lack of quality cycling infrastructure, which has been identified as a key factor in suppressing demand for cycling within Sydney. The Inner Sydney Regional Bicycle Network will seek to address the issue of limited cycling infrastructure by providing a network of 284 kilometres of separated cycleways and shared paths to connect Sydney's fragmented and disjointed cycle network.

[2] These estimates have been seasonally adjusted.

A key feature of the Inner Sydney Regional Bicycle Network is the proposed use of separated cycleways, which have the potential to offer greater protection for cyclists. International and domestic experience demonstrate that the provision of separated cycleways can have immediate and long term impacts on usage, with strong shifts in cycling observed where separated cycleway infrastructure has been constructed.

3.0 Using Economic Appraisals to Promote Cycling

As well as providing a means of transport, cycling offers a range of benefits for participants and the community. These benefits include:

- Health benefits;
- Environmental benefits;
- Reducing pressure on the road and public transport networks; and
- Providing greater accessibility particularly to marginalised individuals.

However, limited guidance has been available to assess the cycling specific benefits until recently. Furthermore, quantifying the economic benefits requires a robust means of quantifying changes in cycling which too has been lacking.

This section reviews the motivations for promoting greater levels of cycling through economic appraisals. Trends in promoting a more quantified approach to assessing the benefits of higher levels of cycling are discussed in **Section 3.1** and methods to assess demand are discussed in **Section 3.2**.

3.1 The Path towards Appraising Cycling

Evaluating the economic desirability of transport projects is a well established practice in transport planning. Economic appraisals are often carried out for new road and public transport interventions. However, this practice has not been widely extended to the appraisal of cycling facilities.

For some time, there have been efforts to encourage greater levels of cycling both domestically and overseas. These efforts have been driven by mitigating growing road and public transport congestion, environmental concerns and more recently by attempts to improve health outcomes and minimise climate change.

However, these efforts have not been matched with quantitative rigour. Whilst the benefits of promoting greater levels of cycling have been understood and promoted heavily, little effort had been undertaken to quantify these benefits. With little clarity of the extent to which cycling interventions could improve transport, environmental, social and economic outcomes, efforts to prove economic desirability and secure funding for cycling projects have arguably, and not surprisingly, been curtailed.

3.1.1 Recent Progress

Work undertaken within the past five years in Europe and the United Kingdom has focused on addressing these appraisal shortcomings by quantifying the benefits from cycling. In particular, there has been a focus on quantifying the improved health outcomes stemming from higher levels of.

Since 2005, the World Health Organisation (WHO) has been working, through the Transport, Health and Environment Pan-European Programme, to harmonise estimates quantifying the health benefits from increased cycling. This has culminated in the preparation of the Health Economic Assessment Tool for Cycling (WHO, 2008).

The UK Department for Transport (DfT) has been developing a formal and broader economic appraisal for cycling since 2007, which has been finalised in April 2009 (DfT, 2009). The Transport Analysis Guidance for cycling and walking project provides a comprehensive approach to assessing demand for new cycling schemes and a range of benefits specific to cycling including health, journey ambiance and accident reduction benefits. These benefits are in addition to traditional user benefits such as travel time savings and vehicle operating cost savings. The use of this guidance in the UK is likely to intensify with the implementation of larger Smarter Choices schemes that are aimed at altering people's travel behaviour towards more sustainable options.

3.1.2 The Australian Context

Domestically, work has begun on evaluating the benefits of cycling within an Australian context. For instance, PwC (2009) has prepared a set of benefit unit rates for the NSW Roads and Traffic Authority (RTA) and the then

NSW Department of Environment and Climate Change (DECC, now DECCW) which quantified a range of benefits including health, congestion reduction and reduced vehicle operating costs stemming from higher levels of cycling. These efforts provide a platform from which to evaluate the benefits from increased cycling within an Australian context. AECOM has reviewed this work as part of preparing its economic appraisal, the outcomes of which are presented in **Section 7.8.**

3.2 Can Cycling Demand be Estimated?

In addition to the difficulties of quantifying the benefits associated with cycling, attempts to model demand for cycling have been sporadic, and limited to small scale projects, despite demand estimation techniques having been available for some time. This is reflected in a review undertaken by Katz (1996) who concluded that traditional modelling techniques are not effective in treating a minority mode such as cycling, due to the inability of large scale models to account for idiosyncrasies unique to cycling.

Nevertheless, some guidance on preparing demand forecasting for cycling has been available within an Australian context for some time. Austroads (2001) prepared *Forecasting Demand for Bicycle Facilities* which provides an overview of potential demand forecasting methodologies. Other transport authorities have also endeavoured to produce similar guidance:

- *Guidance on the Appraisal of Walking and Cycling Schemes* prepared by the UK Department for Transport (DfT, 2009); and
- *Guidebook on Methods to Estimate Non-Motorised Travel* prepared by the US Federal Highway Administration (FHWA, 1999).

The proposed methodologies vary in difficulty of implementation. Comparative studies and sketch plans only require a factor to multiply existing usage, however attempts have been made to retrofit cycling demand models upon regional travel models which are typically used in road and public transport. A summary of the key methods used to model demand for cycling is presented in **Table 3.1**.

Table 3.1: Summary of Key Methodologies

Methodology	Description
Comparative study and sketch plans	Comparative studies involve making comparisons with other schemes similar to the one being proposed. Sketch plans predict the use of a cycling facility based on rules of thumb about travel behaviour. Arguably, these methods are the least complex to estimate future levels of cycling and the use of these methods in Australia is reasonably widespread (Austroads, 2001). However, the difficulty with this method is the many differences that may exist between the study areas being compared such as differences in transport systems and socio-economic characteristics. Also, data used to prepare comparative or sketch plan studies can be considerably difficult to obtain as these sorts of studies are not often published.
Aggregate Behaviour	Statistical methods such as regression analysis can be used to estimate demand across a large area using a range of potential explanatory variables. For instance, Parkin et al. (2008) estimated a logistic regression to investigate the impact of demographics, topology and cycling infrastructure on journey to work cycling mode shares. These methods require statistical knowledge to implement and are generally data intensive. A further drawback is that they become increasingly difficult to apply at a disaggregate level.

Disaggregate choice models	Disaggregate choice models allow for market shares for different transport modes or different routes to be calculated. Choice models calculate the level of utility, or enjoyment, derived by an individual from different combinations of travel time and travel cost for each transport mode. Choice models have the flexibility of including other attributes which may affect transport choice such as socio-economic factors. Disaggregate choice models require considerable technical skill to estimate and apply. Few choice models have sufficient detail to properly assess the impacts of cycling interventions. However, the theoretical background on which these models are based is well recognised and accepted.
Regional travel models	Regional travel models are based on a classical four stage model, which is a four step sequence requiring estimates of trip generation, distribution, mode share and assignment. Although regional travel models are available, the use of regional travel models generally requires resources which are disproportionate to the size of the project. Furthermore, idiosyncrasies unique to cycling are typically not generally well captured by regional travel models (see Sharples, 1993) such as: • Greater range of travel speeds; • Ability of bicycles to reach free-flow speeds quicker than cars; • Bicycles can move through congested conditions; • Sharing of lanes; and • Treatment of illegal manoeuvres etc.

3.3 The Role of Choice Modelling in Assessing Cycling Demand

Choice models are models which seek to forecast choices that an individual may make. The strength of choice models lies in their ability to predict variations in choice even under circumstances where the values of multiple product attributes are changed simultaneously.

Research undertaken within a multimodal context illustrates that interventions in cycling infrastructure have clear demand impacts that can be quantified. For example, Hopkinson and Wardman (1996) found that separated cycle paths and purpose built cycleways can provide a good return on the capital invested, even under conditions of low cycling demand with benefits restricted solely to reductions in perceived risk (i.e. with no time saving benefits, without mode switching and induced cycling trips).

Although the use of choice models to predict transport mode choice is well established, the development of cycling choice models is still in its infancy. Early studies on cycling choice focused on cycling route choice (e.g. Bradley and Bovy, 1984). Mode choice models incorporating cycling started to appear during the mid-1990s (FHWA, 1999).

In a Sydney context, Katz (1996) estimated a multimodal choice model which investigated the effects of variations in cycle path provision, the availability of trip end facilities and bicycle subsidies. The Sydney Strategic Transport Model (TDC, 2001) also includes cycling as a travel mode. An outline of their strengths and limitations is provided in **Table 3.2**.

Table 3.2: Limitations of Current Australian Cycling Choice Literature

Study	Strengths	Limitations
Katz (1996)	• Multimodal model incorporating car, bus, cycling and taxi • Incorporates the effects of cycling paths, subsidies to cycle and end-of-trip facilities	• Lack of variation in travel speed between modes • No travel time parameter • No variation in cycling path treatments • Train excluded as an alternative
Sydney Strategic Transport Model (TDC, 2001)	• Includes some socio-economic effects on cycling demand • Includes cycling distance as the key factor • Comprehensive multimodal model including all key transport modes (i.e. car driver, car passenger, bus, train, cycling, walk)	• No account of the effects of cycling related infrastructure including cycling path treatments • Limited ability to estimate the impacts of improved cycling speeds

The limitations of Australian cycling choice models are not uncommon – very few studies have been sufficiently holistic to capture reliably the mode shift effects of improvements to cycling specific infrastructure.

Perhaps the most significant research undertaken to date is Wardman et al. (2007), which extends a choice model to quantify the effects of better on-journey and end-of-trip cycling facilities. It has been formally adopted by the UK Department for Transport as part of its Transport Appraisal Guidelines. AECOM has adopted the Wardman et al. (2007) approach in its demand modelling, which is discussed further in **Section 6.2**.

3.4 Summary

The role of cycling in promoting better transport, health, social and environmental outcomes is well recognised. However, although the practice of appraising transport projects is well entrenched, the quantification of benefits associated with cycling projects is not well established. In particular, traditional appraisal approaches have not considered the value of cycling specific benefits such as health benefits, the quantification of which is pertinent in driving the viability of cycling projects.

Undertaking cycling appraisals has been hampered by the lack of rigorous methodologies and guidelines to follow and difficulty in estimating cycling demand.

Recent work in Europe and the UK has advanced the sophistication of cycling demand and appraisal methodologies. Current practice is to use incremental demand approaches, in particular the use of cycling choice models, to estimate the impact of cycling interventions.

4.0 Alignment with Government Policies

Cycling contributes to a wide range of transport, social, and environmental policy objectives by:

- Providing travellers with a greater range of transport choices;
- Reducing the environmental impacts of transport including greenhouse gases;
- Relieving pressure on road and public transport networks;
- Increasing the efficiency of public transport systems by increasing the “catchment”;
- Reducing dependence on private motor vehicles;
- Improving equity and community adhesion by providing access to affordable transport; and
- Improving health outcomes.

This chapter reviews key Federal, State and Local Government policies and strategies aimed at supporting and increasing cycling usage.

4.1 Federal Government

The Federal Government, through Infrastructure Australia, is increasingly becoming involved in urban planning. In addition to its role of identifying future infrastructure needs and facilitating infrastructure implementation, Infrastructure Australia actively promotes the need to increase the efficiency and sustainability of current infrastructure.

4.1.1 Better Infrastructure Decision Making Guidelines (Infrastructure Australia)

Released in October 2009, Infrastructure Australia’s *Better Infrastructure Decision Making Guidelines* outlines the recommended framework which submissions to Infrastructure Australia for investment or reform should follow. Developed in response to a review of the 2008-2009 submission process, the Guidelines provide greater detail on Infrastructure Australia’s submission requirements and the methodology used by Infrastructure Australia to prioritise projects. In particular, the Guidelines stress the need for:

- An alignment between Government, Infrastructure Australia, and project objectives;
- Evidence that the proposed project will deliver a medium to long term solution to identified problems; and
- An options assessment which includes a quantitative and detailed demand and economic assessment.

The guidelines articulate the need for submissions to fall under at least one of Infrastructure Australia’s seven themes, one of which is:

Transforming our cities: improve the efficiency and sustainability of our cities by increasing public transport capacity in our cities and making better use of existing transport infrastructure

Submissions to Infrastructure Australia are rated against seven Strategic Priorities. The development of the Inner Sydney Regional Bicycle Network is likely to be consistent with the following Infrastructure Australia’s Strategic Priorities:

- **Strategic Priority 1:** Expand Australia’s productive capacity through efficient investment in new capacity and improved utilisation of existing capacity;
- **Strategic Priority 2:** Increase Australia’s productivity by creating net economic benefits including health benefits, decongestion benefits and deferring the need for capital and operating expenditure on the road and public transport network;
- **Strategic Priority 5:** Develop our cities and regions by increasing amenity, supporting localised economic activity and reducing land space required to cater for private vehicle movements for other land uses;

- **Strategic Priority 6:** Reduce greenhouse gas emissions by diverting trips from carbon intensive transport modes such as car; and
- **Strategic Priority 7:** Improve social equity and quality of life by reducing environmental externalities and improving accessibility to lower cost transport options.

4.1.2 Building Australia Fund Evaluation Criteria (Infrastructure Australia)

The Building Australia Fund was established on 1 January 2009 to finance major capital investments in transport, water, energy and communications infrastructure. To obtain funding from the Building Australia Fund, projects are required to demonstrate that they:

- Address national infrastructure priorities;
- Achieve high benefits and effective use of resources;
- Identify and leverage on available sources of funding including pricing; and
- Achieve established standards in planning, implementation and management.

In particular, the Building Australia Fund Evaluation Criteria articulate strongly for projects to demonstrate that they significantly enhance economic activity, productivity, represent value for money and are efficiently funded. The Inner Sydney Regional Bicycle Network is likely to be consistent with the criteria in the following areas:

- Demonstrating a positive impact on national productivity and economic growth by generating net economic benefits in particular through reduced health costs and congestion;
- Developing Australia's cities and regions by increasing local amenity, reducing severance, increasing land use efficiency and promoting localised economic activity;
- Improving Australia's ability to address climate change by creating a significant shift from more carbon intensive transport modes to cycling;
- Aligning with State and Local Government objectives to increase cycling mode share;
- Satisfying a latent demand for cycling which cannot be realised due to the lack of quality cycling infrastructure;
- Articulates the inability of current cycling infrastructure or alternative forms of cycling infrastructure to attract sufficient levels of cycling demand to achieve the project's objectives; and
- Generating a range of environmental and social benefits such as pedestrian amenity, improved equity outcomes, and accessibility to low cost transport and reduced energy dependence.

To meet all aspects of the evaluation criteria, the following issues would need to be addressed by CoS:

- The availability of other sources of funding, including private sector funding;
- Mechanisms which could assist in the development of the project ;
- Analysis of project related risks; and
- Consideration of the requirements needed to be addressed prior to construction (e.g. approvals, land acquisition and planning).

4.1.3 Australian National Cycling Strategy

Endorsed by the Australian Transport Council and Austroads, the Australian National Cycling Strategy provides a five year plan setting out actions, targets, timeframes and resources identifying responsibilities that lie with the various governments of all levels, community and industry stakeholders to encourage and facilitate increased cycling in Australia.

In its present form, the Australian National Cycling Strategy identifies the following priorities:

1) Improve coordination of activities relevant to increased cycling between different levels of government;
2) Integrate cycling as part of a integrated approach to transport and land use planning;
3) Create infrastructure and facilities that support increased cycling;
4) Enable and encourage safe cycling;
5) Provide leadership, and develop partnerships, to support and promote cycling in Australia; and
6) Develop the professional skills needed to undertake actions that will increase cycling.

The Inner Sydney Regional Bicycle Network has the potential to contribute to these priorities by:

- Creating integrated, effective and safe cycling networks within urban communities;
- Outlining a methodology to quantify the costs and benefits of increased cycling; and
- Encouraging recognition of the health benefits of cycling.

4.2 State Government

4.2.1 NSW State Plan

The *NSW State Plan* is the NSW Government's long term plan to deliver services. The NSW State Plan sets out objectives and targets in key areas including transport and is reviewed on a tri-annual basis. With respect to cycling, the revised 2009 *NSW State Plan* outlines a desire to encourage greater levels of active transport by delivering:

- A Bike Plan to promote cycling as a practical, safe and enjoyable option for commuting and recreation;
- Building and strengthening the environments that facilitate and support active lifestyles; and
- Supporting the National Bike Paths Program in partnership with the Federal Government (the funds from which have been fully committed by May 2009).

The State Plan proposes a cycle mode share target of 5 percent at a local and district level across Greater Sydney by 2016.

The Inner Sydney Regional Bicycle Network has the potential to be consistent with the NSW State Plan by:

- Promoting greater levels of local commuter and non-commuter cycling; and
- Building an environment where cycling is encouraged.

However, it is worth noting that the Inner Sydney Regional Bicycle Network will go beyond the aims of the NSW State Plan by promoting greater levels of cross-regional cycling which provides a significant contribution to overall levels of cycling take-up.

4.2.2 Metropolitan Transport Plan

The Metropolitan Transport Plan, released in February 2010, outlines a revised approach to providing transport to ensure that it integrates with land use strategy through the Metropolitan Strategy and that funding sources are identified and secured.

The Metropolitan Transport Plan enunciates a greater role for cycling, with an ambitious target of five per cent travel by bike across Sydney by 2016 for all trips less than 10 kilometres. The Transport Plan commits the NSW Government to:

- Releasing the NSW BikePlan in 2010
- Constructing missing links in the Sydney Metropolitan Strategic Cycle Network;
- Implementing programs to encourage cycling; and
- Establishing new partnership opportunities with local government and business.

The development of the Inner Sydney Regional Bicycle Network is likely to be consistent with the Metropolitan Transport Plan by:

- Contributing to the development of the Sydney Metropolitan Strategic Cycle Network; and
- Assisting in increasing commuting and overall cycling mode shares.

4.2.3 NSW Bike Plan

To encourage more active lifestyles, the NSW Premier's Council for Active Living in conjunction with the RTA and DECCW have prepared the *NSW Bike Plan*, the release of which is imminent. When released, the Bike Plan will be the NSW Government's first major policy piece with respect to cycling since the release of the 1999 *Action for Bikes*. The key objective of the *NSW Bike Plan* will be to encourage more people to cycle as a clean and healthy transport choice. The Bike Plan is expected to[3]:

- Include a cycle mode share target in line with the 5 percent mode share target noted within the NSW State Plan and the Metropolitan Transport Plan;
- Promote the use of existing cycling infrastructure;
- Build upon current investment commitments;
- Identify key routes and corridors that will form part of the Sydney Strategic Cycle Network;
- Enhance cyclist safety; and
- Plan neighbourhoods and workplaces to encourage higher levels of cycling.

The development of the Inner Sydney Regional Bicycle Network is likely to be consistent with the Bike Plan by:

- Contributing to the development of the strategic cycle network;
- Filling in gaps between existing cycling infrastructure;
- Enhancing cyclist safety by providing greater segregation between cyclists and motorists; and
- Assisting in increasing commuting and overall cycling mode shares.

4.2.4 Sydney Metropolitan Strategy

The Sydney Metropolitan Strategy, first released in December 2005, is a broad framework to facilitate and manage growth and development over a 25 year timeframe. It aims to secure Sydney's status as Australia's gateway to the world, and sets the scene for more detailed planning in the subregions of Metropolitan Sydney and in the regional areas of New South Wales.

The role of cycling in influencing travel choices and encouraging more sustainable travel is recognised with Action D3.1.1: Improve Local and Regional Walking and Cycling Networks. The Metropolitan Strategy recognises the need for high quality walking and cycling networks to:

- Improve walking and cycling networks to improve local access;
- Improve walking and cycle networks to improve access to public transport for longer trips to centres across the metropolitan region.

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[3] Draft PCAL NSW Bike Plan Table of Contents, April 2009

However, it is worth noting that the Inner Sydney Regional Bicycle Network will go beyond the aims of the Sydney Metropolitan Strategy by promoting greater levels of cross-regional cycling, an important note as a high proportion of commute trips by cycling cross Council boundaries.

4.2.5 Sydney City Draft Sub-Regional Strategy

The Sydney City Draft Sub-Regional Strategy, a complementary document to the Sydney Metropolitan Strategy, was released in July 2008 to provide detail on the implementation of the Metropolitan Strategy within the City of Sydney. The Regional Strategy recognises the higher than average levels of cycling within the City and aims to support and increase these high levels into the future by:

- Increasing cycle mode share from 2 percent in 2006 to 10 percent in 2016;
- Ensuring that residents in new development areas a such as Redfern–Waterloo and Green Square in the south of the subregion have similar levels of connectivity and amenity as residents throughout the rest of the Sydney City Subregion

Relevant strategies mentioned within the Regional Strategy include:

- **Sydney City D1.2.1:** The Roads and Traffic Authority and Ministry of Transport to continue to coordinate road upgrades in existing urban areas, including bus priority measures to enhance bus services, and walking and cycling access.
- **Sydney City D3.1.1** City of Sydney Council to implement the City of Sydney's draft Cycle Strategy and Master Plan.
- **Sydney City D3.1.2:** The Roads and Traffic Authority, in cooperation with City of Sydney Council, to continue to upgrade walking and cycling facilities to improve everyday access within and across neighbourhoods, villages, town centres and Strategic Centres in the Sydney City Subregion.
- **Sydney City D3.1.3:** NSW Government and local government to align local walking and cycling networks with public transport routes to improve accessibility to public transport.

4.3 City of Sydney

4.3.1 Sustainable Sydney 2030 Vision

The Sustainable Sydney 2030 Vision proposes a Liveable Green Network to provide safe, quality, continuous routes for pedestrians and cyclists. It proposes a cycling network that is safe enough for children to use, giving priority to separated, dedicated cycle lanes.

4.3.2 Cycle Strategy and Action Plan 2007-2017

The City of Sydney Council's *Cycle Strategy and Action Plan 2007-2017* sets out the Council's commitment to improving cycling access over the next 10 years and builds on the success of its recent street upgrades and initiatives to encourage greater cycling participation. The City's *Cycle Strategy*, endorsed by Council in 2007, supports the Sustainable Sydney 2030 Vision.

Plans include connecting each of the City's village centres with a sustainable bicycle network, managing the City's streets to increase safety for cycling and delivering a series of social programs to provide the public with information and encouragement. The Strategy also identifies potential routes, treatments and priorities for establishing a comprehensive network of separated cycleways across the local government area. It identifies that the best way to dramatically increase cycling levels is to provide cycleways that are physically separated from moving traffic and parked vehicles. Bi-directional cycleways were endorsed as the preferred treatment for inner Sydney as they minimise impact on parking and increase urban and pedestrian amenity.

The Plan aims to increase the number of bicycle trips made in the City of Sydney LGA, as a percentage of total trips, from 2 per cent in 2006 to 5 per cent by 2011, and to 10 per cent by 2016.

4.4 Other Inner Sydney Councils

A number of inner Sydney councils have prepared bike plans, which emphasise the need to improve cycle networks to increase local cycle trips and to promote local economic activity.

As these bike plans have evolved, local bike plans are emphasising the nexus between the objectives of developing their individual local cycle networks and contributing to the development of a wider cycle network. Increasing recognition for the need for continuity across council boundaries is reflected in the joint development of the Inner Sydney Regional Bike Plan between the RTA, DECCW and Inner Sydney Councils in 2008. It is likely that greater emphasis on the need to develop cross-regional cycle links will be articulated at a local level following the release of the *NSW Bike Plan*.

4.5 Summary

The Inner Sydney Regional Bicycle Network represents an advance in cycling policy in Sydney as it places greater emphasis on the identification of a cross regional Bicycle Network for inner Sydney, an initiative which has only been recently pursued by NSW Government agencies and local councils.

The objectives of the Inner Sydney Regional Bicycle Network align with Infrastructure Australia's objectives of generating greater economic capacity and productivity, reducing environmental externalities such as greenhouse gases and enhancing social outcomes.

The Strategic Bicycle Network will also support State and local government objectives to increase future cycle mode shares and will contribute to alleviating congestion on both the road and public transport networks.

5.0 Historic Trends in Cycling

This section provides an overview of the trends in cycling demand within Sydney. AECOM undertook a review of relevant data sets to develop an understanding of underlying demand, travel patterns and relationships and as input into subsequent tasks. The following datasets have been reviewed across the study area:

- 2001 and 2006 Journey to Work datasets;
- 2001 and 2006 Sydney Household Travel Survey datasets; and
- Cycling permanent count site data across Sydney.

AECOM undertook all analysis in this section at a SLA level, as further disaggregation of the datasets introduces unacceptable levels of volatility, given that historical cycling usage is low at a finer level. Findings from this section have been used to inform model development and develop model assumptions, which are discussed in greater detail in **Section 6.0**.

5.1 Study Area

The area chosen for this study focuses on current and estimated future demand for cycling within areas proposed to be serviced by the Inner Sydney Regional Bicycle Network. A number of other council areas that will not be covered by the Strategic Bicycle Network but will contribute to demand on the network have also been included as part of the study area. A map of the study area is shown in **Figure 5.1**.

Figure 5.1: Study Area

Source: AECOM

Historical cycling activity has been analysed across 26 statistical local areas (SLAs), most of which are within the following statistical sub-divisions:

- Inner Sydney SSD;
- Inner Western Sydney SSD;
- Eastern Suburbs SSD; and
- Lower Northern Sydney SSD.

A full list of SLAs considered in this study is shown in **Appendix A**.

5.2 About the Datasets

Traditionally, cycling demand data has relied upon the collection of data from two major surveys, the Census and the Household Travel Survey.

5.2.1 Census (Journey to Work)

The Australian Bureau of Statistics (ABS) conducts the Census every five years. Since 1976, the ABS has collected information from respondents relating to the modes of transport used to travel to and from workplaces. This information can be disseminated to identify the level of demand between commuter origins and destinations as well as the mode of transport used between each origin-destination pair.

As almost all working adults provide responses, the Journey to Work dataset is arguably the most reliable source of data for cycling. However, it is worth noting that the Census is generally undertaken in August when cycling demand, which tends to be highly susceptible to seasonal effects, is *lower than average*[4].

5.2.2 Household Travel Survey

To supplement the Journey to Work database, the NSW Transport Data Centre commissions the Sydney Household Travel Survey to collect trip information from a sample of Sydney households. Undertaken on an annual basis since 1999, the Household Travel Survey supplements the Journey to Work dataset by collecting information regarding to journeys for all purposes.

To improve statistical reliability, data from previous years is often pooled with current year data. Given the low levels of demand for cycling relative to other transport modes, it is important to note that demand from year to year can be volatile, with volatility increasing when the data is analysed at a local level. AECOM recommends that caution be used in interpreting HTS cycling data presented at an LGA or lower level.

5.3 Cycling Demand within Sydney

In 2006, 10,900 respondents cycled on Census Day across the Sydney Statistical Division (SD). In the same year, the Sydney Household Travel Survey estimates that approximately 123,000 cycling trips (for all purposes and including commuting) are generated on an average weekday across the Sydney SD.

Although accounting for a small share of the total transport task, cycling demand within the Sydney SD continues to record strong increases. Both Journey to Work and Household Travel Survey data indicates that growth in cycling demand outstrips general growth in trips. Between 2001 and 2006, Journey to Work trips by bicycle increased by 18 percent. For all trip purposes, cycling trips increased by 36 percent over the same period.

Table 5.1 provides a summary of key Sydney cycling statistics in 2006 from the Journey to Work and Sydney Household Travel Survey datasets.

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[4] Analysis undertaken by AECOM suggests that demand is approximately six percent lower during August relative to the annual average.

Table 5.1: Key 2006 Sydney SD Cycling Statistics

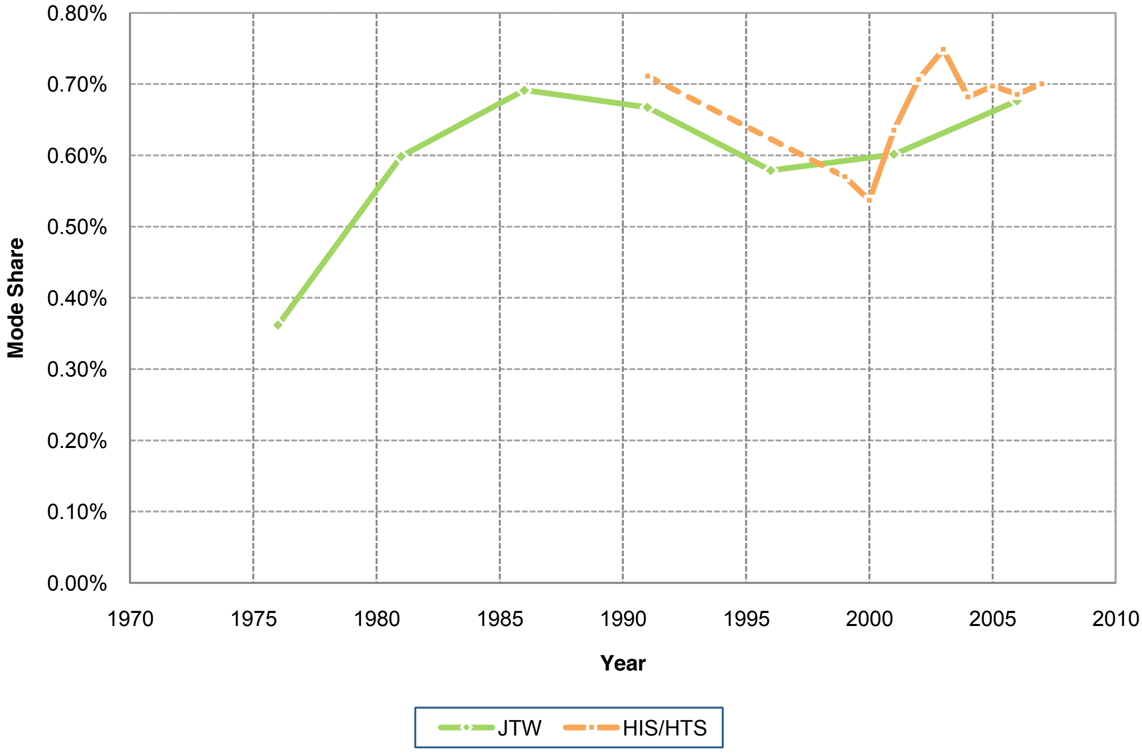
Variable	Journey to Work	Household Travel Survey
Cycle Trips	10,864	123,330
Total Trips	1,894,659	15,928,619
Cycle Mode Share	**0.57%**	**0.77%**
Growth in cycling trips (2001 – 2006)	**17.8%**	**35.8%**
Growth in all trips (2001 – 2006)	**4.3%**	**7.9%**

Analysis based on ABS and TDC data. Trips allocated to the primary mode – hence multimodal trips involving a bicycle have not been allocated to bicycle.

With cycling demand increasing at faster rates than general trip growth, cycling mode shares have increased between 2001 and 2006. Journey to Work data shows that bicycle mode share across Sydney has increased between 2001 and 2006, from 0.51 percent to 0.57 percent. Similar upward movements in cycle mode share have also been observed in the Household Travel Survey dataset, which collects data for both commute and non-commute trips. Between 2001 and 2006, cycle mode share increased from 0.64 percent to 0.69 percent.

Historic Sydney cycle mode shares from available Journey to Work and Household Interview Survey/Household Travel Survey data are shown in **Figure 5.2**.

Figure 5.2: Sydney Cycle Mode Shares



Sources: TDC & Mees et al. (2007). Legislation requiring compulsory helmet wearing took effect from January 1991, which resulted in declines in cycling demand between 1986 and 1996.

Although recent increases in cycling demand are well noted, it can be argued that underlying growth in cycling demand in Sydney has been increased since records began. Although a decline in cycling mode share is evident between 1991 and1996, declines during this period can be attributed with the introduction of helmet laws nationally in 1991. When the decline during the early 1990s is discounted, a long run upward trend in cycling is discernable between 1976 and 2006.

5.4 Cycling Demand within the Study Area

Based on 2006 data, it is estimated that the study area generated 44,500 cycle trips on an average day and 6,200 commuter cycle trips on an average workday.

A notable characteristic of cycling demand within the study area is the greater concentration of commuter cycling trips and higher commuter cycle mode shares:

- The study area generated 36 percent of Sydney's commuter trips but 58 percent of commuter cycling trips;
- Commuter demand for cycling within the study area grew by 27 percent between 2001 and 2006, faster than the remainder of Sydney and faster than general trip growth; and
- Cycle mode share for commuter trips within the study area of 0.92 percent is more than double the mode share for the remainder of Sydney.

Interestingly, the cycling mode share for all trip purposes in the study area is estimated to be lower than the Sydney average. The cycle mode share within the study area was 0.71 percent, lower than the mode share of 0.82 percent for the remainder of Sydney. However, cycling trip growth for all purposes was faster than for the remainder of Sydney, growing by 50 percent between 2001 and 2006.

A comparison of cycling demand statistics between the study area, the remainder of Sydney and for Sydney SD is shown in **Table 5.2**.

Table 5.2: Comparison of 2006 Cycling Demand within the Study Area against Sydney Averages

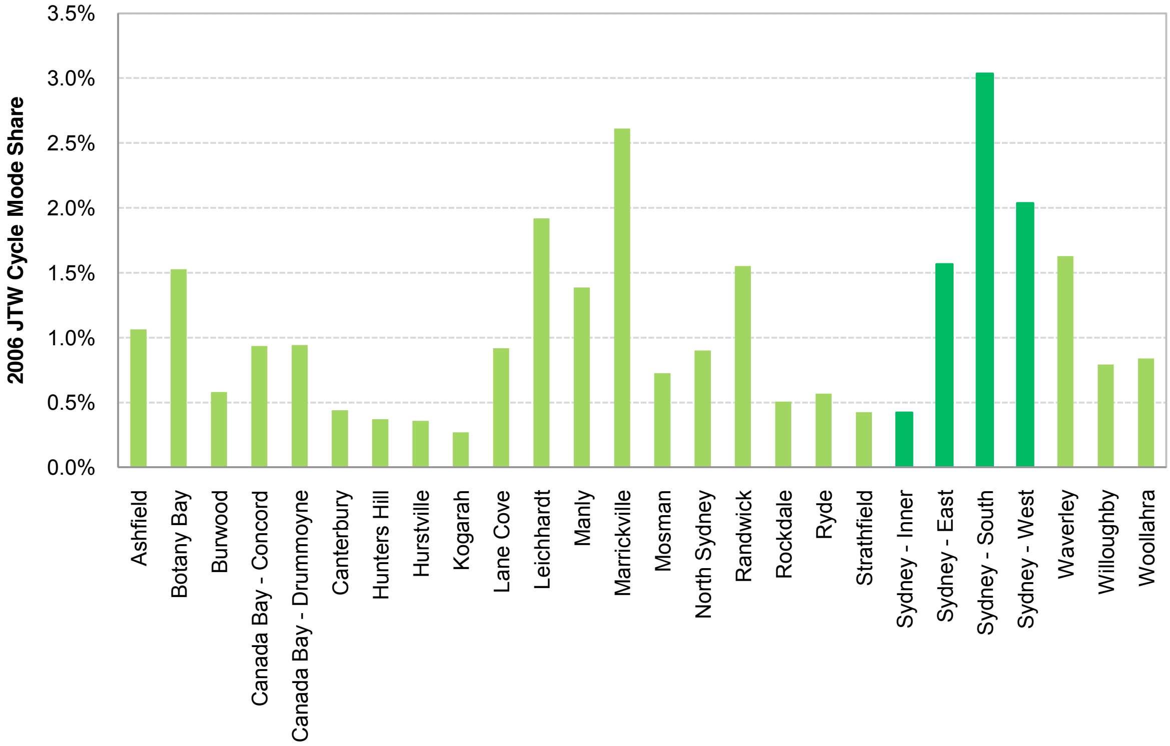
Variable	Study Area	Remainder of Sydney SD	Sydney SD
2006 Journey to Work			
Cycle Trips	6,246	4,618	10,864
Total Trips	675,785	1,218,874	1,894,659
Cycle Mode Share	0.92%	0.38%	0.57%
Growth in JTW cycling trips (2001 – 2006)	26.6%	7.6%	17.8%
Growth in all JTW trips (2001 – 2006)	4.4%	4.3%	4.3%
2006 Household Travel Survey			
Cycle Trips	44,511	78,819	123,330
Total Trips	6,276,397	9,652,222	15,928,619
Cycle Mode Share	0.71%	0.82%	0.77%
Growth in cycling trips (2001 – 2006)	50.1%	28.8%	35.8%
Growth in all trips (2001 – 2006)	10.7%	6.1%	7.9%

Analysis based on ABS and TDC data. Trips allocated to the primary mode – hence multimodal trips involving a bicycle have not been allocated to bicycle.

When the datasets are disaggregated further, the concentration and growth of cycling demand around the Sydney CBD becomes apparent. Highest cycle mode shares can be found in areas closest to Sydney CBD. For instance, the Inner Sydney SD cycle mode share was estimated to be 1.7 percent in 2006, increasing from 1.5 percent in 2001. Cycle mode shares within the study area decline moving away from Sydney CBD, with lower mode shares found at the extremes of the study area. Even so, faster rates in commuter cycle demand were recorded, albeit off lower demand bases, within the Lower Northern Sydney SSD and Inner Western Sydney SSD.

Figure 5.3 shows the cycle mode share by SLAs within the study area. A comparison between 2001 and 2006 Journey to Work mode share and all purpose mode share are presented in **Table 5.3** and **Table 5.4** by SSD.

Figure 5.3: 2006 Journey to Work Cycle Mode Shares by SLA



Source: ABS

Table 5.3 reveals that the mode share for private motor vehicles within the study area has decreased slightly, bus mode share has remained the same and rail mode share has decreased significantly, by 0.7 percentage points. The shift from rail transport has been captured by an increase in walking mode share and a smaller increase in cycling mode share. Although the overall number of trips by cycle increased in the Sydney SD as a whole, no increase in cycle mode share was apparent, with an increase in private motor vehicle mode share.

The Household Travel Survey reveals a more encouraging trend in mode share when all trip purposes are considered. **Table 5.4** reveals that both the study area and the remainder of the Sydney SD have experienced decreasing mode share for trips by private motor vehicle, bus and rail and a corresponding increase in mode share for trips on foot and by bike. This pattern is consistent across all subdivisions within the study area, although the most significant gains in cycle mode share have been within the Inner West Statistical SD.

Table 5.3: 2001 and 2006 Mode Shares by Statistical Sub-Division (Journey to Work)

Mode	Inner Sydney SSD	Eastern Suburbs SSD	Lower Northern Suburbs SSD	Inner Western Sydney SSD	Other Study Area	Study Area	Remainder of Sydney SD	Sydney SD
2001								
Private vehicle	39.1%	48.8%	50.2%	53.6%	56.9%	49.4%	65.4%	59.7%
Train	14.7%	11.1%	11.0%	19.8%	19.7%	15.0%	12.4%	13.3%
Bus	14.1%	15.4%	13.4%	6.8%	3.8%	10.8%	2.2%	5.3%
Walk only	12.7%	5.9%	6.4%	3.2%	3.2%	6.6%	2.2%	3.8%
Bicycle only	1.5%	1.0%	0.5%	0.5%	0.3%	0.8%	0.4%	0.5%
Other	17.9%	17.8%	18.5%	16.1%	16.0%	17.4%	17.4%	17.4%
2006								
Private vehicle	38.7%	48.9%	49.6%	53.5%	57.4%	49.2%	67.2%	60.8%
Train	12.8%	9.6%	10.9%	20.2%	19.2%	14.3%	11.2%	12.3%
Bus	14.1%	15.8%	13.9%	6.4%	3.5%	10.8%	2.4%	5.4%
Walk only	15.1%	6.7%	6.8%	3.6%	3.4%	7.6%	2.3%	4.2%
Bicycle only	1.7%	1.2%	0.6%	0.6%	0.4%	0.9%	0.4%	0.6%
Other	17.7%	17.8%	18.0%	15.6%	16.1%	17.1%	16.6%	16.8%
Change between 2001 and 2006								
Change in cycle trips	**28.0%**	**18.4%**	**27.6%**	**45.9%**	**24.0%**	**26.6%**	**17.8%**	**28.0%**
Change in JTW trips	**8.9%**	**-1.8%**	**1.3%**	**9.4%**	**5.0%**	**4.4%**	**4.3%**	**8.9%**

Source: AECOM calculations based on ABS 2001 and 2006 Census. Trips allocated to the primary mode – hence multimodal trips involving a bicycle have not been allocated to bicycle. "Other" includes the following categories: travel on other modes (e.g. ferry, light rail, taxi), worked at home, did not go to work and not stated.

Table 5.4: 2001 and 2006 Mode Shares based on HTS Data (All Purposes – Average Day)

Mode	Inner Sydney SSD	Eastern Suburbs SSD	Lower Northern Suburbs SSD	Inner Western Sydney SSD	Other Study Area	Study Area	Remainder of Sydney SD	Sydney SD
2001								
Private vehicle	45.0%	65.7%	68.4%	69.2%	71.9%	61.2%	80.2%	72.9%
Train	9.5%	3.0%	4.8%	6.0%	4.4%	6.1%	2.8%	4.1%
Bus	6.9%	8.2%	4.4%	4.5%	3.2%	5.5%	2.9%	3.9%
Walk only	34.4%	20.4%	20.3%	19.2%	19.2%	24.6%	12.9%	17.4%
Bicycle only	0.7%	0.8%	0.4%	0.5%	0.3%	0.5%	0.7%	0.6%
Other	3.6%	1.9%	1.8%	0.6%	1.1%	2.1%	0.6%	1.2%
2006								
Private vehicle	41.5%	65.4%	67.1%	68.6%	73.2%	59.9%	80.0%	72.1%
Train	8.9%	2.2%	4.4%	5.1%	4.4%	5.6%	2.6%	3.8%
Bus	7.4%	6.7%	4.2%	3.3%	2.3%	5.1%	2.3%	3.4%
Walk only	37.9%	23.2%	22.0%	21.5%	18.4%	26.6%	13.5%	18.7%
Bicycle only	0.8%	0.8%	0.5%	0.8%	0.7%	0.7%	0.8%	0.8%
Other	3.5%	1.7%	1.7%	0.8%	1.1%	2.1%	0.7%	1.2%
Change between 2001 and 2006								
Bicycle only	**28.8%**	**27.3%**	**47.6%**	**80.7%**	**142.1%**	**50.1%**	**28.8%**	**35.8%**
Total	**11.0%**	**16.7%**	**3.3%**	**20.3%**	**9.2%**	**10.7%**	**6.1%**	**7.9%**

Source: AECOM calculations based on ABS 2001 and 2006 Census. Trips allocated to the primary mode – hence multimodal trips involving a bicycle have not been allocated to bicycle. “Other” includes the following categories: travel on other modes (e.g. ferry, light rail, taxi).

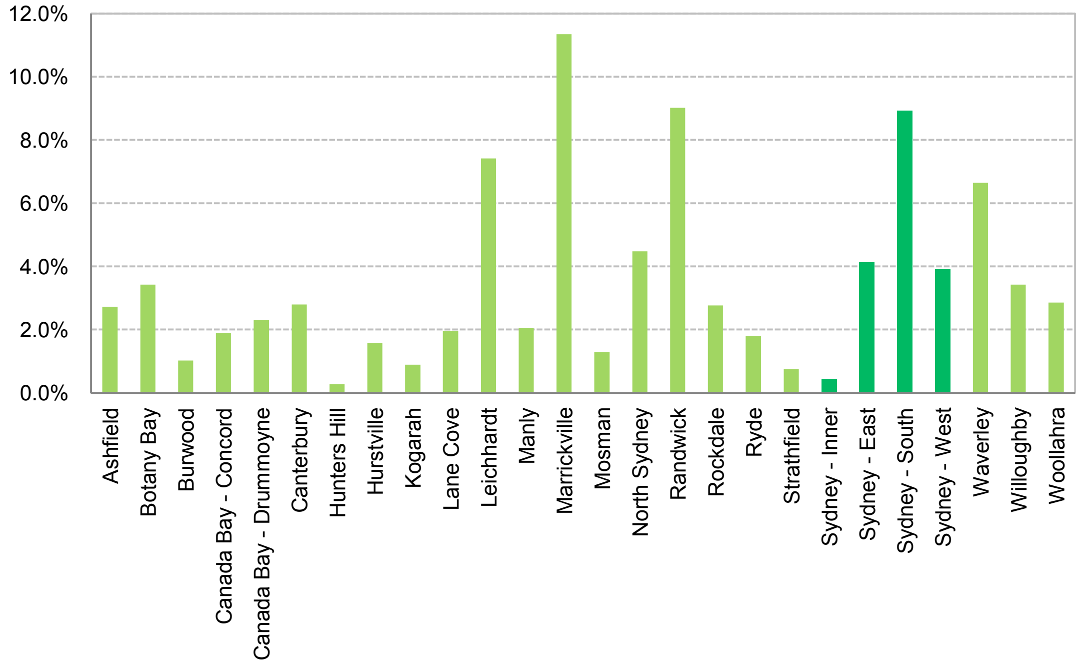
5.5 Key Origins and Destinations

Cycle travel across Council boundaries is a notable feature of demand within the study area. Of all cycle Journey to Work trips undertaken in 2006, approximately 73 percent of cycling trips generated within the study area travelled across at least one Council boundary. Household Travel Survey data indicates that this is also true of non-commute trips, with 68 percent of cycling trips for any purpose crossing Council boundaries. This tends to suggest that the Inner Sydney Regional Bicycle Network will enhance the amenity associated with a large proportion of cycle trips undertaken currently within the study area.

Key cycling origins come from south of Sydney Harbour and include Leichhardt, Marrickville, Randwick, Waverley and Sydney CBD. However, on the destination of cycling demand, demand is clearly centred on the the City of Sydney LGA where 55 percent of Journey to Work cycling trips end.

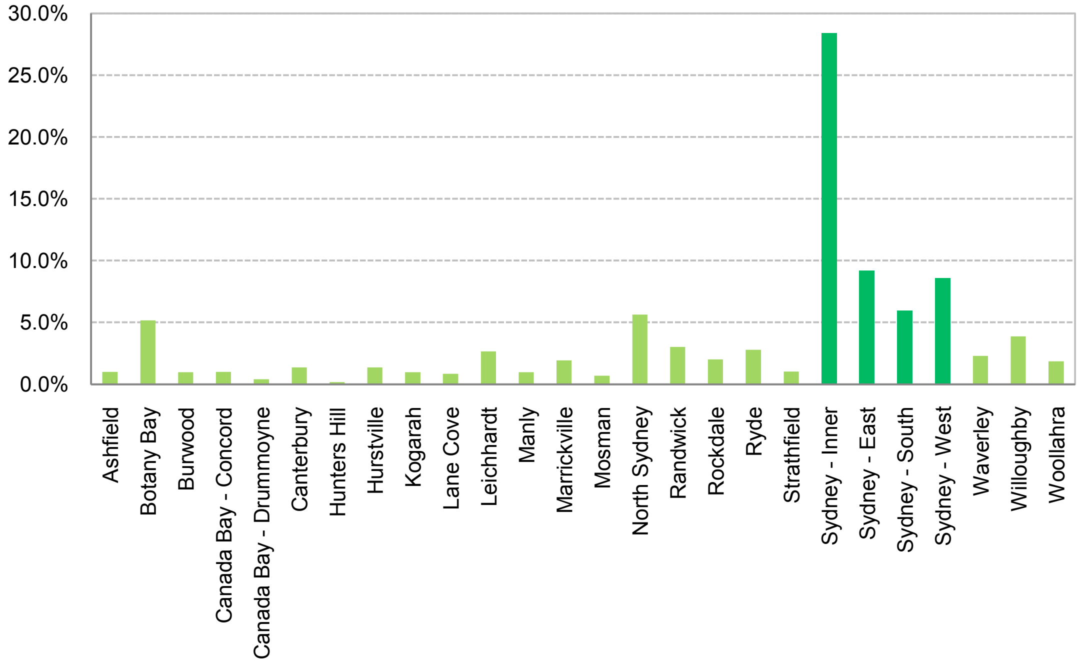
Figure 5.4 and **Figure 5.5** denote the proportion of all JTW cycling trips generated and destined for each SLA within the study area. **Figure 5.6** shows the level of demand for cycling trips to the City of Sydney LGA from each LGA in the study area.

Figure 5.4: Origin of 2006 JTW Bicycle Trips within Study Area by SLA



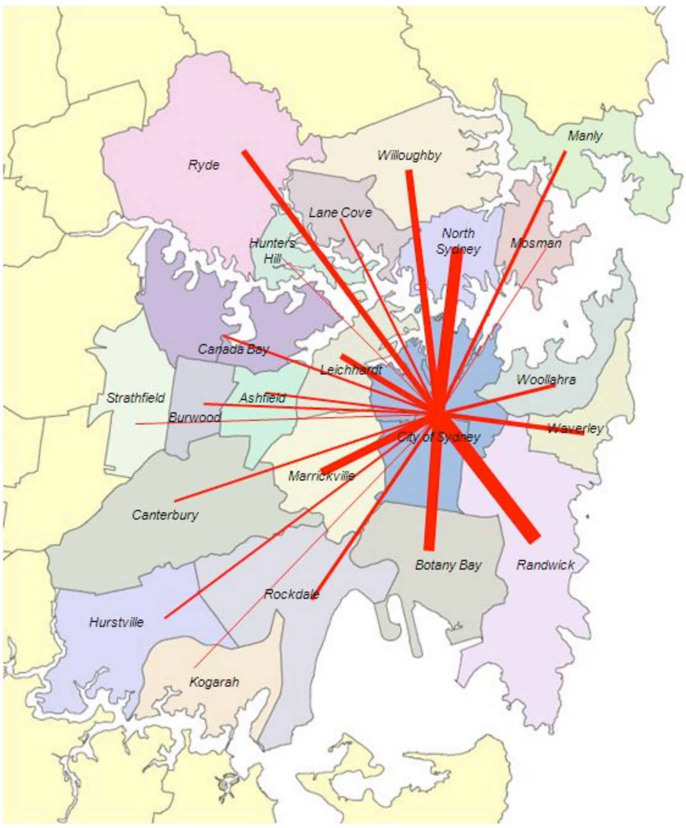
Source: AECOM calculations based on ABS Journey to Work data

Figure 5.5: Destination SLA of 2006 JTW Bicycle Trips within Study Area



Source: AECOM calculations based on ABS Journey to Work data

Figure 5.6: 2006 Journey to Work Cycle Trips into Sydney Inner LGA by LGA



Source: AECOM calculations based on ABS Journey to Work data

5.6 Summary

Although cycling appears to play a small role in Sydney’s transport task, cycling continues to take market share from other transport modes. A comparison of cycling demand between 2001 and 2006 shows that cycling demand for commuter trips has grown by 18 percent and 36 percent for non-commuter trips across Sydney, outstripping underlying trip growth.

Demand for cycling is more pertinent within the study area, with noticeably higher, faster and more consistent levels of growth in demand when compared against other parts of Sydney. In 2006, commuter cycle mode shares in the study area were estimated to be 0.9 percent, more than double the mode share for the remainder of Sydney. Growth in commuter cycling demand has grown by 27 percent between 2001 and 2006 and by 50 percent for non-commute trips over the same period.

Highest levels of cycling demand can be found closer to the Sydney CBD, which in itself is a key focal point for cycling trips. For commuting trips, the City of Sydney Council area attracts approximately 55 percent of cycling trips generated within the study area.

6.0 Cycle Demand Forecasts

The provision of cycle paths has the potential to increase the take-up demand through the extra segregation on offer for cyclists. This section outlines the assumptions and processes used to estimate future demand for cycling after the implementation of the Inner Sydney Regional Bicycle Network. Network wide forecasts of cycling demand are presented at the end of this section. Additional demand expected to be generated by a combination of the Inner Sydney Regional Bicycle Network and the introduction of a public bicycle scheme in Sydney is also discussed.

6.1 An Overview of AECOM's Demand Forecasting Methodology

AECOM has adopted an incremental demand estimation approach to estimate cycling demand for 2011, 2016 and 2026.

Broadly speaking, the estimation process focuses on estimating changes in commuting demand on an average weekday. Through the use of an incremental mode choice model, the effects of changes in travel time and travel costs on car, train, bus and cycling Journey to Work mode shares were estimated. Average weekday cycle commuting demand was then converted to annual cycling demand through the use of expansion factors.

Figure 6.1 provides an outline on the process used to develop cycling demand forecasts within the study area.

AECOM has prepared demand estimates for three scenarios:

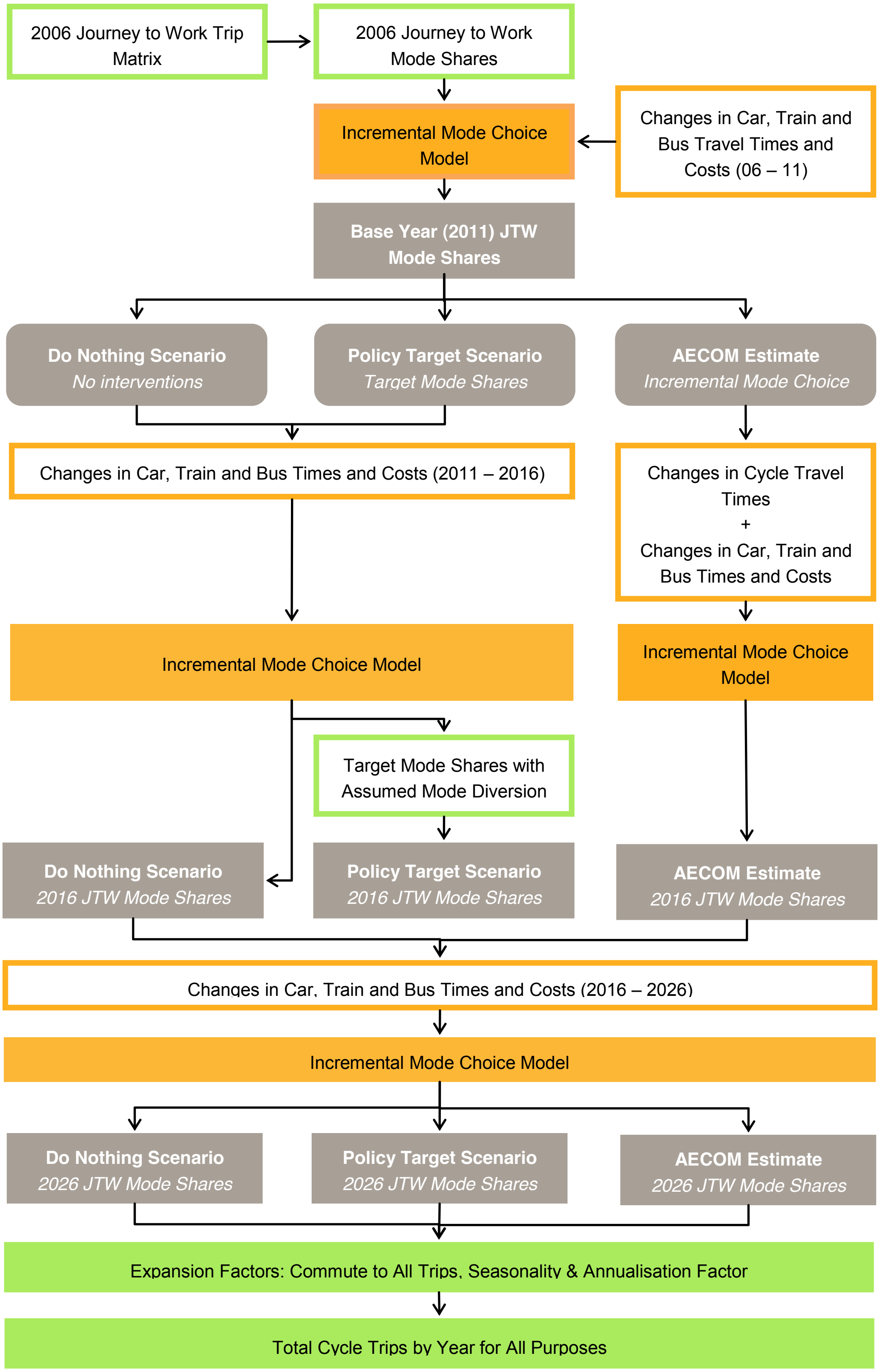
Do Nothing Scenario: A base case scenario whereby no changes in cycling infrastructure are assumed. Some shift in cycling mode share caused by changes in travel times and costs for car, train and bus has been modelled.

Policy Target Scenario: Assumes that the Inner Sydney Regional Bicycle Network will generate levels of mode shift from present levels in line with mode share targets that are consistent with the NSW State Plan. These targets are higher than would be achieved under the 'AECOM Estimate' scenario.

AECOM Estimate: Estimates the change in cycling demand expected to be generated from the change in cycling utility created by the implementation of the Inner Sydney Regional Bicycle Network.

Further detail on each demand scenario is provided in **Section 6.3**.

Figure 6.1: Demand Forecasting Framework for a Given Origin-Destination Pair



6.2 Incremental Choice Modelling

Mode choice models are used to forecast mode shares for different transport modes as a result of changes in travel times and travel costs.

When current mode shares are known, incremental choice models can be used to forecast the change in market share as a result of changes in utility caused by changes in travel times and travel cost. A key advantage of using incremental mode choice models is that they only require knowledge on current mode shares and future changes in travel attributes to forecast future mode shares. Such an approach is pertinent in assessing cycling investments as the information burden required to forecast cycling demand is reduced significantly.

Incremental choice models do require an assessment of expected changes in utility, the calculation of which is discussed in **Section 6.2.1.** However, once the changes in expected utility are known, future cycle mode shares ($p^{forecast}$) can be estimated using the current cycle mode share (p_{cycle}) and the expected change in cycling utility (ΔU), as shown in **Equation 6.5**.

Equation 6.1: Incremental Choice Mode Share Forecast

$$p_{cycle}^{forecast} = \frac{p_{cycle} e^{\Delta U_{cycle}}}{(1 - p_{cycle}) + p_{cycle} e^{\Delta U_{cycle}}}$$

This equation can be broadened to capture the effects upon cycling mode share caused by changes in travel times and costs for other modes as well as incorporating non-trader effects.

6.2.1 A Cycling Choice Model: Wardman et al. (2007)

With the little work that has been undertaken in attempting to forecast the impact of cycling related infrastructure on cycling demand within an Australian context, the Wardman et al. (2007) cycling choice model has been adopted for this study to forecast cycling demand[5]. It is worth noting that the UK Department for Transport has adopted the Wardman et al. (2007) model as part of its Transport Appraisal Guidelines.

The Wardman et al. (2007) model represents a significant advance in attempts to model cycling demand as it is one of the few choice models available that quantify the effects of Separated Cycleways within a multimodal context. The perceived quality of five types of cycling facilities was tested as part of the study:

- Separated off-road cycleways;
- Separated on-road cycleways;
- On-road cycle lanes;
- Major roads with no cycling facilities; and
- Minor roads with no cycling facilities.

Their research quantifies the anecdotal evidence that suggests that travellers prefer greater segregation from vehicular traffic. The study found:

- Separated cycleways were considered to be **more than three times more attractive** to the extent that cycling on separated cycleways is considered as desirable as travelling in a car, train or bus;
- On-road cycle lanes to be **twice more attractive**; and
- No difference in the desirability of travelling on a major or minor road with no facilities, indicating that the key driver in cycling demand is the extent of segregation between cyclists and general vehicular traffic.

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[5] AECOM understands that stated preference surveys were carried out as part of a demand and economic appraisal of the proposed Naremburn and the Harbour Bridge Active Transport Corridor on behalf of North Sydney Council, RTA and the NSW Department of Environment, Climate Change and Water. Results from this study have not been made available to AECOM.

The parameter values for each type of facility are shown in **Table 6.1**.

Table 6.1: Wardman et al. (2007) Cycle Choice Model Parameters

Variable	Parameter Value	Relative Attractiveness to Cycling without Any Facilities	Units
In-vehicle travel time – car, train, bus	-0.0390	2.97	minutes
Cycling travel time – separated off-road	-0.0330	3.52	minutes
Cycling travel time – separated on-road	-0.0360	3.22	minutes
Cycling travel time – cycle lanes	-0.0550	2.11	minutes
Cycling travel time – major road with no facilities	-0.1160	1.00	minutes
Cycling travel time – minor road with no facilities	-0.1150	1.01	minutes
Travel cost	-0.0060		pence

Source: Wardman et al. (2007). All parameters were found to be statistically significant at a five percent significance level

Note: Parameter values are rounded to 4 decimal places

The use of unscaled parameters would have seen the choice model predict larger responses to changes in time and cost than what the Sydney Strategic Travel Model would suggest. AECOM therefore made the following adjustments to the Wardman et al. (2007) model parameters to enhance their comparability with local travel behaviour:

- Conversion of the cost parameter from British pence to Australian cents using a PPP exchange rate[6];
- Adjustments to the cost parameter to bring the value of time in line with local values of time; and
- The use of a scale parameter to better match local time and cost elasticities[7].

Following these adjustments, the scaled Wardman et al. (2007) elasticities closely follow local travel behaviour, as predicted by the Sydney Strategic Travel Model (STM). In particular, car time and cost elasticities closely mirror current car user behaviour. However, train users are predicted to be slightly more sensitive to changes in time whereas bus users are predicted to be slightly less sensitive to changes in travel cost.

Unscaled parameter values and rescaled parameter values are shown in **Table 6.2**. Implied elasticities using unscaled and scaled parameters with a comparison against STM elasticities are shown in **Table 6.3**. A single set of parameter values are presented for separated cycleway travel and on-road travel as the differences between separated off-road and separated on-road facilities are not statistically significant.

[6] The 1998 PPP rate of £1 = $2.63 was used. Wardman et al. (2007) carried out their stated preference surveys during 1998.

[7] A scale parameter is a parameter used on all parameter values in order to better match predicted elasticities with real world elasticities. A scale parameter of 1.41 minimised the square differences between the implied Wardman et al. (2007) elasticities and the Sydney STM elasticities.

Table 6.2: Incremental Choice Model Parameters

Variable	Unscaled	Scaled	Units
In-vehicle travel time – car, train, bus	-0.0390	-0.0276	minutes
Cycling travel time – segregation	-0.0346	-0.0245	minutes
Cycling travel time – cycle lanes	-0.0552	-0.0391	minutes
Cycling travel time – no facilities	-0.1160	-0.0821	minutes
Travel cost	-0.0019	-0.0015	cents

AECOM calculations based on Wardman et al. (2007), TDC (2001), OECD (2009) data

Note: Parameter values are rounded to 4 decimal places

Table 6.3: Simulated Direct Time and Cost Elasticities

Mode	Unscaled	Scaled	STM
Direct Time Elasticities			
Car	-0.385	-0.273	-0.230
Train	-1.113	-0.787	-0.590
Bus	-0.732	-0.518	-0.600
Cycle	-2.189	-1.549	*No estimates*
Direct Cost Elasticities			
Car	-0.171	-0.137	-0.110
Train	-0.431	-0.345	-0.320
Bus	-0.313	-0.251	-0.350

Source: STM elasticities from TDC (2001). All other calculations based on AECOM calculations using Wardman et al. (2007) parameters and average time and cost information from TDC (2001).

6.2.2 Non-Trader Factor

The potential estimated shift in demand towards cycling is estimated based on a subset of the population that would at least be prepared to consider cycling as an alternative mode. If those who have no interest in cycling are treated in the same manner as those who are more predisposed to it, this can lead to significant overestimates in cycling demand. Hence, the choice model has been adjusted to account for individuals that will never consider cycling as an alternative mode. In a choice model context, such individuals are known as “non-traders”.

Non-trading factors are highly dependent on localised factors including weather, land-use patterns, cultural factors and car dependence which play a significant role in influencing attitudes towards cycling. Hence, AECOM has based its non-trading assumption upon local market research. Market research commissioned by the City of Sydney suggests that the non-trader factor could be relatively low within a Sydney context. Environmetrics (2006) work suggests that this figure was 25 percent, with more recent work commissioned by the City of Sydney and undertaken by Taverners Research suggests a non-trading rate of 20.8 percent. It is likely that levels of non-trading will reduce over time as cycling becomes more acceptable. However for simplicity, AECOM has adopted a fixed rate of 20.8 percent throughout the evaluation period for this study.

6.2.3 Applying the Incremental Choice Model Accounting for Non-Trading

Using the scaled parameters, changes in utility for car, train, bus and cycle users can be predicted. The following equations demonstrate how the change in utility can be estimated:

Equation 6.2: Change in Utility for Car, Train and Bus Travel

$$\Delta U_{car,train\ or\ bus} = -0.0280 \times \Delta\text{travel time} - 0.0014 \times \Delta\text{travel cost}$$

Equation 6.3: Change in Utility for Bicycle Travel

$$\Delta U_{cycle} = \begin{array}{l} -0.0249 \times \Delta\text{travel time on separated paths} \\ -0.0397 \times \Delta\text{travel time on on-road cycle lanes} \\ -0.0834 \times \Delta\text{travel time on roads with no facilities} \end{array}$$

A final adjustment to the mode share equation shown in **Equation 6.2** is required to account for non-trading and for utility changes for other modes, which is shown as **Equation 6.4**.

Equation 6.4: Incremental Choice Mode Share Forecast Accounting for Non-Trading for a Given Mode *i*

$$p_i^{forecast} = (1 - \text{non-trader factor}) \frac{p_i^{current} e^{\Delta U_i}}{\sum_j p_j^{current} e^{\Delta U_j}}$$

6.3 Demand Scenarios

AECOM has prepared demand estimates for three demand scenarios.

Under all demand scenarios, the incremental mode choice model was used to forecast changes in the 2006 Journey to Work mode shares based on observed and anticipated changes in car, train and bus travel times and travel costs to produce 2011 Journey to Work mode shares, which was used to provide the same starting point for all demand scenarios.

Description on each demand scenario is provided as follows:

6.3.1 Do Nothing Scenario (Base Case)

Under the Do nothing Scenario no changes in cycling infrastructure are assumed. The Do Nothing Scenario effectively forms the base from which the incremental cycling demand generated by the full implementation of the Inner Sydney Regional Bicycle Network can be assessed.

Between 2011 and 2016

Despite no major changes in cycling infrastructure, mode shares are influenced by changes in travel times and travel costs for car, train and bus. Furthermore, aggregate cycling demand is expected to increase in line with anticipated population and employment growth within the study area.

It is also assumed that a public bicycle scheme will be implemented by the City of Sydney across the entire local government area by 2011.

Between 2016 and 2026

Again, no major changes in cycling infrastructure are assumed. Mode shares are influenced by changes in travel times and travel costs for car, train and bus. Furthermore, aggregate cycling demand is expected to increase in line with anticipated population and employment growth within the study area.

6.3.2 Policy Target Scenario: Realisation of Policy Targets

The Policy Target Scenario seeks to measure the changes in demand from present levels to pre-specified target cycle mode shares which are consistent with State Government targets for cycling. It is anticipated that these target mode shares will be achieved through the interaction of a number of cycling interventions, including the full implementation of the Inner Sydney Regional Bicycle Network.

Between 2011 and 2016

Cycle mode share targets were provided by the City of Sydney in order to determine the demand and economic impact of achieving the targets. The pre-specified targets are broadly in line with the cycle mode share targets specified within the Sydney City Subregional Strategy and are expected to be consistent with the cycle mode share targets to be specified within the yet to be released NSW Bike Plan. The following targets were used to develop the 2016 cycle matrix:

- A 10 percent cycle mode share for all intra-LGA trips;
- A 5.0 percent mode share for all trips between any two adjacent LGAs;
- A 2.5 percent mode share for between all other destinations.

A matrix of pre-specified mode shares for the Policy Target Scenario is shown in **Appendix C**. Broadly speaking, the target mode shares were adopted for all origin-destination pairs for the 2016 model year with the following exceptions:

- Where the estimated distance was in excess of 12km, whereby the cycle mode share was set to zero; and
- Where the incremental choice model predicts a mode share in excess of the target, the mode share predicted by the incremental mode share model was adopted.

A limitation of the Policy Target Scenario is that for origin-destination pairs where pre-specified cycle mode shares are used, the incremental mode choice model is unable to predict the diversion from alternative modes. Hence, for these modes a set of assumptions on the source and size of the diversion is required. The following mode diversion rates have been used where pre-specified mode shares have been used:

- Trip diversion from car: 52.5 percent;
- Trip diversion from train: 19.8 percent; and
- Trip diversion from bus: 27.7 percent.

These levels of mode diversion reflect the study area wide mode diversions observed under the AECOM Estimate.

Between 2016 and 2026

No major changes in cycling infrastructure are assumed. Mode shares are influenced by changes in travel times and travel costs for car, train and bus. Aggregate cycling demand is expected to increase in line with anticipated population and employment growth within the study area.

6.3.3 AECOM Estimate: Incremental Modelling

The AECOM Estimate uses the incremental mode choice model for all travel attribute changes. The key difference between the AECOM Estimate and the Policy Target Scenario is that the effect of implementing the Inner Sydney Regional Bicycle Network is estimated through the incremental mode choice model for all origin-destination pairs. Usage in the AECOM Estimate is lower than in the Policy Target Scenario.

Between 2011 and 2016

The incremental mode choice model estimates the effect of cycle interventions introduced up to 2016 as well as changes in car, train and bus travel times and costs. The extent of mode diversion from car, train and bus is estimated for each origin-destination, without the application of a study area wide mode diversion assumption.

Between 2016 and 2026
The incremental mode choice model estimates the effect of cycle interventions in 2017 as well as changes in car, train and bus travel times and costs. The extent of mode diversion from car, train and bus is estimated for each origin-destination, without the application of a study area wide mode diversion assumption.

6.4 Demand Model Inputs

6.4.1 Cycling Demand Matrices

Current international practice focuses on the use of commuter cycle trips as a basis for estimating aggregate demand and the distribution of demand for all trip purposes as commuter cycling trips are the most predictable. In addition, the reliability of estimating cycling demand using Journey to Work data at a disaggregated level is significantly higher than from other sources. Pivoting off commuter cycling demand is further justified by the greater levels of commuter cycling demand within the study area compared to other parts of Sydney.

Notwithstanding, with current cycling demand in Sydney at relatively low levels, excessive disaggregation is not desirable as the demand becomes increasingly sparse and unreliable. To enhance the reliability of the analysis, AECOM has aggregated demand to focus on inter-SLA travel, which takes a broader perspective of demand along key corridors and between key destinations.

Mode Share Matrices

The 2006 Journey to Work matrix was used as to prepare estimates of car (driver and passenger), train, bus and cycling commuting demand. Demand from other modes was excluded at this point, including walking, due to the volatility in demand created by modelling the interaction between cycling and walking demand. Changes in future year Journey to Work mode share matrices were estimated using the incremental mode choice model.

Journey to Work Trip Tables
For the purpose of removing any volatility in the demand as mentioned above, only the Car (passenger and driver), train, bus and cycle trips are used from the 2006 Journey to Work matrix. As the Journey to Work trip table are one-way trips made from the origin (home) to the location of the jobs, therefore the entire matrix was transposed to get the reverse trips assuming that the work trips return from where they originated.

The 2006 Journey to Work Trip matrices are changed over time for 2011, 2016 and 2026 using the population and employment forecasts figures given by TDC. The forecasted figures include the impact of Barangaroo over the long run and an estimated 22,000 jobs in Barangaroo have been accounted in the forecasted trip matrices.

Changes in demand for cycling will also stem from changes in aggregate population and employment growth. A general increase in cycling demand is anticipated irrespective of the addition of new cycling infrastructure, as a result of underlying population and employment growth.

6.4.2 Distance Matrices

Distance matrices for car, train, bus and cycle were prepared for each of the model years as a basis for predicting travel times and costs as well as computing changes in car, train, bus and cycling kilometres.

Car, Train and Bus Matrices

A common distance matrix was used for car, train and bus for each model year. Using GIS, distances between different SLAs were measured by taking the shortest road distance from the centre of the origin SLA to the centre of the destination SLA. For the intra-SLA distances, the mean average bicycle trips distance for each SLA was based on average cycle distances from the HTS 2006 data.

Cycling Matrices

Three cycling distance matrices were prepared for each model year, with distances disaggregated by the quality of the facility to be used. GIS and CUBE have been used to identify the optimal cycle route between SLAs in the study area. Overlaying the Inner Sydney Regional Bicycle Network on top of the general road network, the route choice element within CUBE allows for the possibility of optimal routes, which may be longer in distance, to be chosen over routes that are shorter if the cycling infrastructure along the optimal route is sufficiently high to outweigh the extra travel time.

To inform the CUBE route choice module, weights of 0.30 and 0.48 were applied to all separated cycleways and on-road cycle lanes respectively to account for the higher amenity offered by greater segregation offered by these facilities relative to a road with no facilities. These weights are in line with the Wardman et al. (2007) parameters discussed in **Section 6.2.1**.

6.4.3 Travel Time and Cost Matrices

Changes in car, train, bus and cycling travel times and travel costs are a critical element in estimating future mode shifts towards cycling. Travel times and travel costs for each mode have been based on a set of time and cost functions which seek to estimate time and costs for each mode using each mode's distance matrix.

Travel Speeds

Assumed travel speeds and non in-vehicle travel time by mode are outlined in **Table 6.4**. Car, cycle and bus speeds are largely based on previous work undertaken by AECOM whereas train speeds are based on an analysis of CityRail travel times. Travel speeds on all modes with the exception of cycling are assumed to decline by one percent per annum between 2006 and 2026.

Table 6.4: Assumed Travel Speed

Mode	Assumed 2006 Speed	Assumed 2011 Speed	Access, Egress and Waiting Time
Car	25.2 km/h	24.0 km/h	2.5 min/trip
Train	41.3 km/h	40.1 km/h	22.5 min/trip
Bus	23.0 km/h	21.8 km/h	12.5 min/trip
Cycle	20.0 km/h	20.0 km/h	
Cycle (Separated Cycleways)	25.0 km/h	25.0 km/h	

Source: AECOM assumptions

Car Travel Costs

Car travel costs are based on the RTA urban vehicle operating cost model. Future travel costs have been indexed at a rate of 5 percent per annum between 2006 and 2026 based on anticipated movements in key inputs such as oil prices. For average travel speeds less than 60 km/hr, the following equation can be used to calculated average vehicle operating costs, where V is the speed and A and B are parameter values:

Equation 6.5: Stop-Start Vehicle Operating Cost Model

$$VOC = A + \frac{B}{V}$$

Vehicle operating costs include fuel vehicle operating costs, which are generally perceived in full by motorists as well as non-fuel vehicle operating costs. In line with the treatment used for the Sydney Strategic Travel Model (TDC, 2001), it has been assumed that half of all non-fuel vehicle operating costs which account for 70 percent of vehicle operating costs, or 65 percent of total vehicle operating costs, are perceived by motorists for modelling purposes.

Based on the car speed assumptions outlined in **Table 6.4**, the following vehicle operating costs have been calculated.

Table 6.5: Vehicle Operating Costs

Model Year	A	B	Average Speed (km/h)	Vehicle Operating Cost (c/km)	
				Actual	Perceived
2006	25.28	95.69	25.2	25.4	16.5
2011	27.05	27.05	24.0	34.1[8]	20.4

Source: AECOM calculations based on RTA (2009a)

In addition to vehicle operating costs, average parking costs have also been included as part of total car costs. Including car trips that do not pay for parking, the unconditional average parking costs was estimated to be 40.1 cents per trip in 2006 based on Household Travel Survey data (TDC, 2006).

Train and Bus Costs

Public transport fares were based on regressions of historic bus and train fare schedules and the pending myBus and myTrain fare schedules. Historic shares between undiscounted single tickets and discounted periodic tickets have been maintained, which have then been used to calculate weighted average fares by distance.

Table 6.6 outlines the assumed fare flagfall and cost rates for train and bus for 2006 and 2011. In line with the new myBus and myTrain fare structures, a fare cap has been applied to bus trips that are longer than six sections (approximately 9.6 kilometres).

Table 6.6: Train and Bus Flagfalls and Incremental Costs

Model Year	Train		Bus	
	Flagfall (cents)	Incremental Cost (c/km)	Flagfall (cents)	Incremental Cost (c/km)
2006	201.0	5.65	166.8	12.64
2011	244.5	6.87	202.9	15.38

Source: AECOM calculations

Fares for both train and bus are assumed to increase by 4 percent per annum between 2011 and 2026 based on historical movements in bus and train fares in Sydney.

6.4.4 Expansion Factors

Expansion factors to convert average weekday commuter metrics to annual metrics have been prepared to factor up the following cycling estimates to a set of all purpose estimates:

- Commuter cycle trips;
- Commuter cycle kilometres;
- Commuter cycle hours;

[8] Estimated to be 31.3 c/.km in September 2009 prices - increased to 2011 prices at a rate of 5 percent per annum

- Diverted commuter trips from car, train and bus;
- Diverted commuter trip kilometres from car, train and bus; and
- Diverted commuter trip hours from car, train and bus.

Details on factors follow:

Journey to Work to All Purposes

Commuting trips, particularly for cycling, only account for a small proportion of total trips. Hence, factors to expand commuting demand to aggregate demand are required. The 2006 Household Travel Survey data for the study area was analysed to derive factors to convert weekday commuter cycle demand to weekday cycle demand for all trip purposes. Two factors have been used in the demand model:

- A factor of 6.3 to convert intra-SLA commuter cycle demand to all purposes; and
- A factor of 2.1 to convert longer distance inter-SLA commuter cycle demand to all purposes.

Across the study area, the application of these factors implies that commuting trips account for approximately 23 percent of all cycling trips.

Seasonality Factor

Cycling travel demand is highly seasonal and fluctuates with prevailing weather patterns. Analysis undertaken on cycle demand data collected by the City of Sydney suggests that demand for cycling in Sydney reaches a nadir during winter and peaks during spring and autumn.

In the context that the 2006 Census, from which Journey to Work data is extracted, was undertaken during early August, daily cycling demand estimates based purely on Journey to Work data without adjustment is likely to underestimate average daily demand. Relative to all months of the year, demand for cycling during August is approximately 93.6 percent of the annual monthly average. Hence, a seasonal adjustment factor of 1.068 (1 ÷ 0.936) has been used to convert the Census daily demand estimates to average daily demand.

Annualisation Factor

Annualisation factors are used to expand average weekday estimates to an overall annual estimate. Based on an analysis of RTA cycle count data on a selection of inner Sydney cycleways, an average annualisation factor of 332 was calculated, as shown in **Table 6.7**.

Table 6.7: Annualisation Factor Estimates on Inner Sydney Cycleways

Variable	2003	2004	2005	2006	2007	2008	Average
Average annual weekday daily trips	2190	2428	2815	3130	3660	3933	3026
Average annual weekend daily trips	1601	1703	1828	2051	2625	2559	2061
Average annual daily trips	2022	2221	2533	2822	3364	3540	2750
Implied annualisation	**337.0**	**333.9**	**328.4**	**329.0**	**335.5**	**328.6**	**331.8**

Source: AECOM calculations based on RTA data. Cycleways outside the study area have been excluded.

For the purposes of demand estimation, an annualisation factor of 330 has been adopted.

6.4.5 Key Model Parameters

A summary of key parameters used in preparing cycling demand estimates for all demand scenarios is shown as follows:

Table 6.8: Key Parameters

Variable	Value
Speed	
Cycle travel speed	20.0 km/h
Separated cycleway speed	25.0 km/h
Car speed (in 2006)	25.2 km/h
Train speed (in 2006)	40.5 km/h
Bus speed (in 2006)	23.0 km/h
Travel speed changes per annum	
Car	-1.0%
Train	-1.0%
Bus	-1.0%
Cost changes per annum	
Car costs	5.0%
Train costs	4.0%
Bus costs	4.0%
Expansion factors	
Journey to work to all purposes (intra-SLA)	9.7
Journey to work to all purposes (inter-SLA)	2.2
August seasonal factor	0.936
Annualisation factor	330

All demand model parameters used for this study are outlined in **Appendix B**.

6.5 Public Bicycle Scheme

Public bicycle schemes are based on allowing members of the public to hire bicycles for short periods of time for little or no charge. There has been renewed interest worldwide in developing public bicycle schemes since 2007. Pertinently, much of this renewed interest has been from outside Europe, where the genesis of public bicycle schemes can be found.

It is understood that the City of Sydney has been exploring the desirability of implementing such a scheme within the city. Accordingly, AECOM has prepared pre-feasibility level demand estimates to measure the influence that the Inner Sydney Regional Bicycle Network may have on public bicycle demand levels. The following assumptions were used to estimate annual public bicycle demand for all demand scenarios:

- A public bicycle scheme would cover the entire City of Sydney LGA;
- A density of circa 8 public bicycle stations per km^2;
- An average of 12 bicycles per station;

- An average duration of 20 minutes per use;
- An average speed of 12km/h; and
- Annual growth in public bicycle of 2 percent per annum.

These assumptions reflect the setup of an average public bicycle schemes overseas. Under the Do Nothing Scenario, an initial utilisation rate of **5 trips per bicycle per day** has been assumed. Market research undertaken by the City of Sydney suggests that demand for public bicycle would be enhanced by approximately 60 percent if separated cycleways were also provided in addition to public bicycle facilities (Taverners Research, 2007). Hence, under the Policy Target Scenario and AECOM Estimate, the initial utilisation rate was assumed to be **8 trips per bicycle per day**.

In order to calculate mode diversion, mode diversion factors shown in **Table 6.9** have been assumed:

Table 6.9: Assumed Public Bicycle Mode Diversion

Variable	Value
Induced demand	13.0%
Capture from car	10.0%
Capture from train	20.7%
Capture from bus	30.3%
Capture from walking	26.0%

Source: AECOM assumptions based on City of Portland (undated)

6.6 Demand Forecasts

6.6.1 Weekday Journey to Work Trips

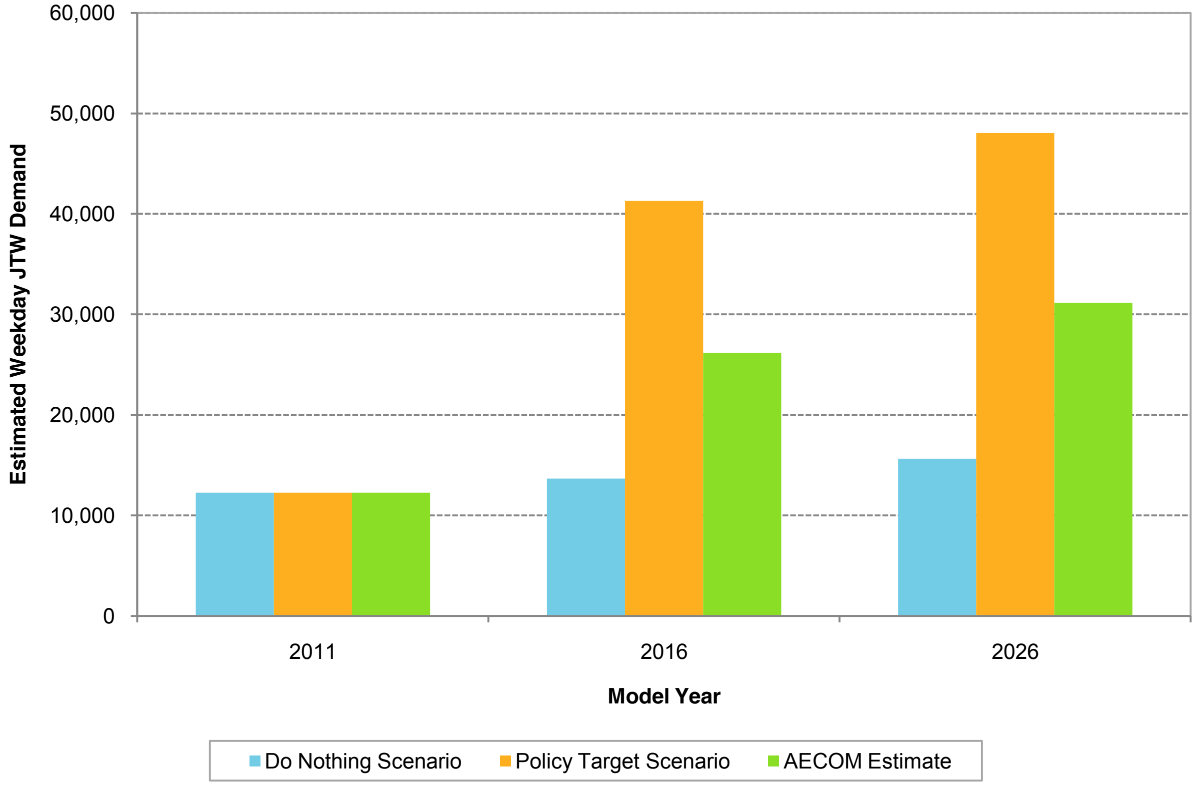
Under the Do Nothing Scenario, the number of commuter cycling trips is expected to change gradually over time. Between 2011 and 2016, total cycle trip numbers within the study area are expected to increase by 1.47 percent per annum, reducing to 1.40 percent per annum between 2016 and 2026.

In order to achieve higher target cycle mode shares, it is estimated that commuter take-up for cycling under Policy Target Scenario will see total number within the study area will increase by 209 percent between 2011 and 2016 or at an average rate of 27.2 percent per annum. The change in cycle take-up moderates to 1.35 percent per annum between 2016 and 2026.

A more modest rate of increase in commuter trips is forecast under AECOM Estimate, whereby the take-up for cycling is estimated to increase by 66 percent between 2011 and 2016, or at an average rate of 12.23 percent per annum. Between 2016 and 2026, take-up for commuter cycling is anticipated to grow at 1.71 percent.

Figure 6.2 illustrates the estimated change in average weekday commuter demand for cycling per annum.

Figure 6.2: Change in Average Weekday Journey to Work Cycle Trips



Source: AECOM calculations. Note: these estimates have not been deseasonalised and are presented on a "two-way" basis.

Detailed statistics on forecast average weekday Journey to Work cycle demand and mode diversion are presented in **Table 6.10**.

Table 6.10: Average Weekday JTW Demand

Variable	Do Nothing Scenario			Policy Target Scenario			AECOM Estimate		
	2011	2016	2026	2011	2016	2026	2011	2016	2026
Total JTW Cycle Trips	12,300	13,700	15,600	12,300	41,300	47,800	12,300	22,700	26,800
Cycling kilometres									
On road (no facilities)	66,000	74,000	86,100	66,000	97,600	107,500	66,000	58,400	65,300
On road (cycle lanes)	800	1,000	1,100	800	10,700	11,300	800	5,800	6,500
Separated	18,100	20,300	23,700	18,100	161,500	201,900	18,100	118,100	147,500
Total cycling kilometres	***85,000***	***95,300***	***110,900***	***85,000***	***269,900***	***320,600***	***85,000***	***182,300***	***219,300***
Cycling Time (hrs)									
On road (no facilities)	3,300	3,700	4,300	3,300	4,900	5,400	3,300	2,900	3,300
On road (cycle lanes)	0	0	100	0	500	600	0	300	300
Separated	700	800	900	700	6,500	8,100	700	4,700	5,900
Total cycling hours	***4,100***	***4,600***	***5,300***	***4,100***	***11,900***	***14,000***	***4,100***	***7,900***	***9,500***
Conditional JTW Mode Share									
Car	58.60%	57.01%	55.42%	58.60%	55.34%	53.55%	58.60%	56.48%	54.80%
Train	21.83%	22.61%	23.60%	21.83%	22.01%	22.90%	21.83%	22.41%	23.34%
Bus	17.97%	18.36%	18.71%	17.97%	17.51%	17.79%	17.97%	18.08%	18.38%
Cycle	1.47%	1.54%	1.70%	1.47%	4.65%	5.20%	1.47%	2.55%	2.92%

Source: AECOM calculations. Note: these estimates have not been deseasonalised and are presented on a “two-way” basis. Cycling kilometres and time are rounded to the nearest hundred.

As a proportion of car, train, bus and cycle Journey to Work demand within the study area is in line with predicted changes in commuter cycling demand, without any significant interventions, cycle mode shares are not expected to increase significantly. Under the Do Nothing Scenario, cycle mode share is expected to increase from 1.47 percent in 2011 to 1.54 percent in 2016 and 1.70 percent by 2026.

Corresponding cycle mode shares under Policy Target Scenario and AECOM Estimate are expected to be 4.65 percent and 2.95 percent by 2016 and 5.23 percent and 3.39 percent by 2026, respectively.

Overall mode diversion factors have been calculated by comparing the change in mode shares between the Do Nothing Scenario and AECOM Estimate in 2016. As shown in **Table 6.11**, approximately 53 percent of new cycling demand is sourced from car, 20 percent from train and 27 percent from bus.

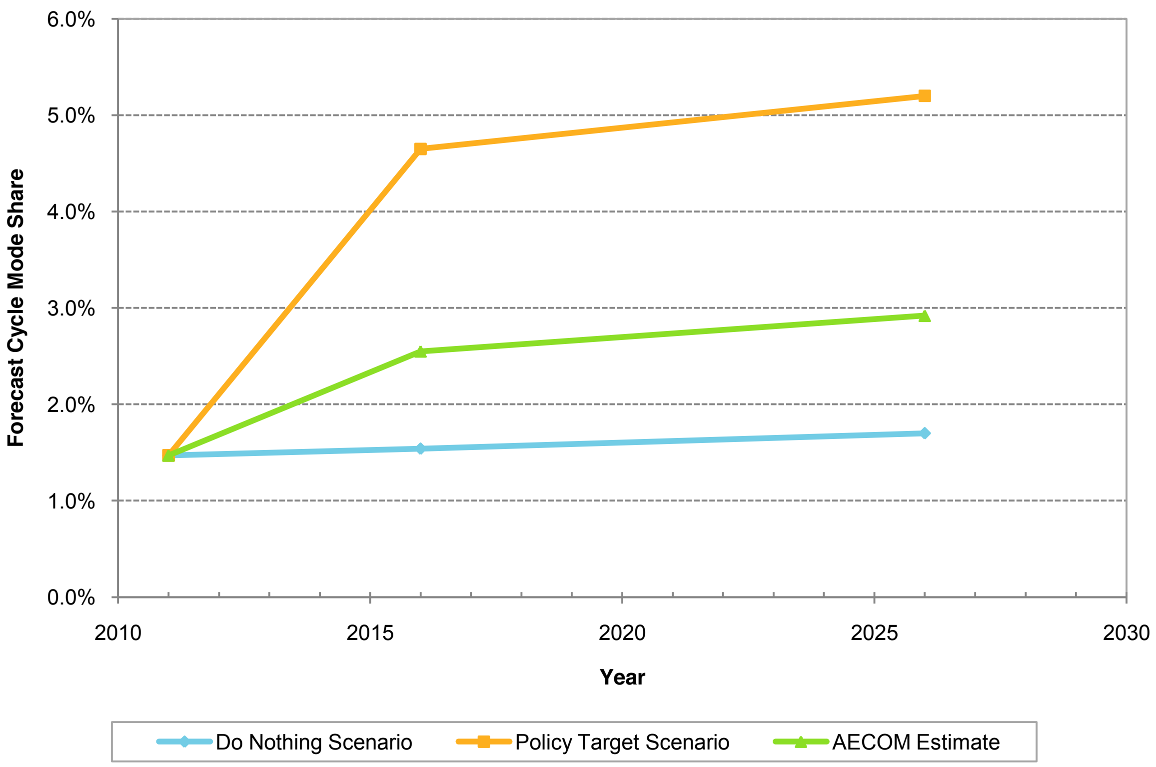
Table 6.11: Mode Diversion Factors

Mode	2016 Mode Share under Do Nothing Scenario	2016 Mode Share under AECOM Estimate	Change in Mode Share	Mode Diversion
Car	57.01%	56.48%	-0.54%	52.48%
Train	22.61%	22.41%	-0.19%	19.80%
Bus	18.36%	18.08%	-0.26%	27.72%
Cycle	1.54%	2.55%	1.00%	100.00%

Source: AECOM calculations

Projections of cycle mode shares for commuting trips are shown in **Figure 6.3**.

Figure 6.3: Forecast Cycle Mode Shares with Study Area



Source: AECOM calculations. Note: these estimates have not been deseasonalised.

6.6.2 Annual Demand

As mentioned in **Section 6.4.4**, expansion factors have been applied to forecasts of weekday commuter cycling demand to account for:

- Non-commute cycling trips;
- Seasonality effects; and
- Annualise demand.

Under the Do Nothing Scenario, the number of cycling trips is expected to change gradually over time. Between 2011 and 2016, total cycle trip numbers within the study area are expected to increase by 2.2 percent per annum, reducing to 1.4 percent per annum between 2016 and 2026.

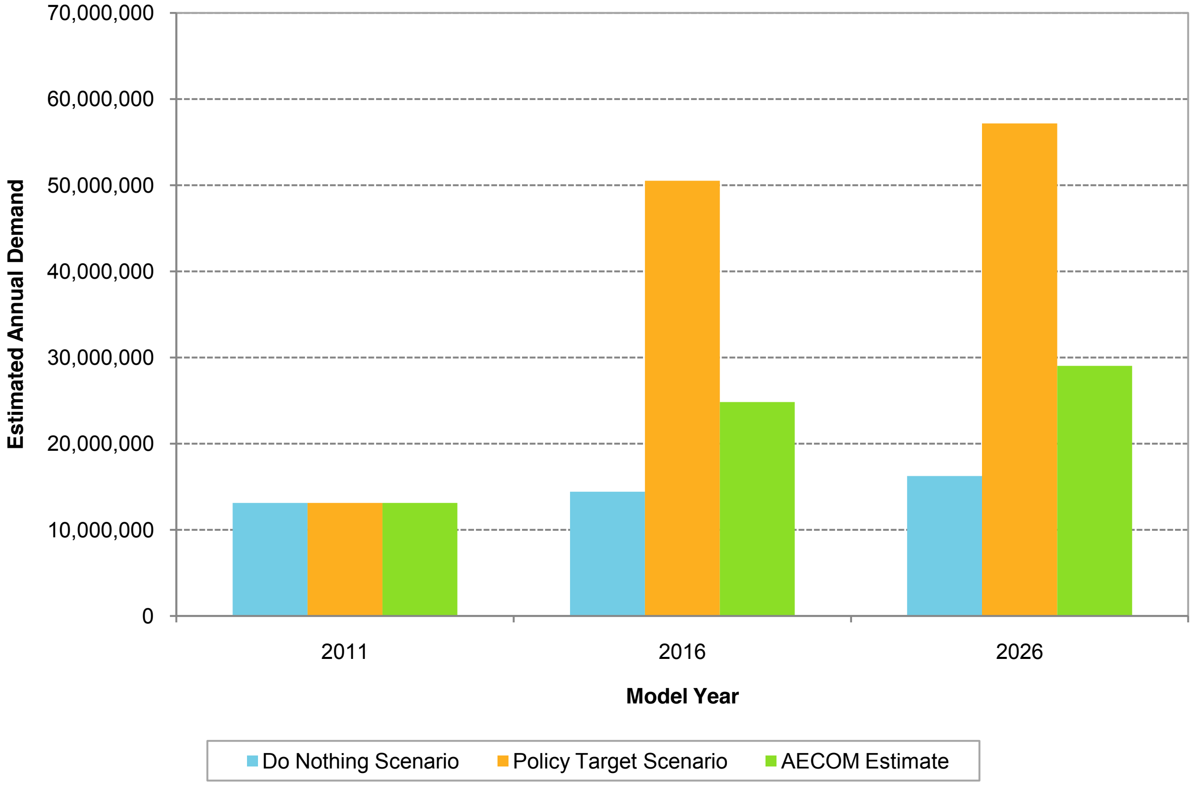
In order to achieve higher target cycle mode shares, it is estimated that annual demand for cycling under the Policy Target Scenario will see cycling levels within the study area increase by 237 percent between 2011 and 2016 or at an average rate of 28 percent per annum. The change in cycle demand moderates to 1.5 percent per annum between 2016 and 2026.

A more modest rate of increase in commuter trips is forecast under AECOM Estimate, whereby the demand for cycling is estimated to increase by 85 percent between 2011 and 2016, or at an average rate of 18.2 percent per annum. Between 2016 and 2026, demand for cycling is anticipated to grow at 1.7 percent.

Higher growth rates will apply if the incremental public bicycle demand generated by the provision of separated cycleways is also included. If public bicycle demand is included, the development of the Inner Sydney Regional Bicycle Network is estimated to increase take-up by approximately 3.1 million trips per annum by 2016 and 4.4 million trips by 2026.

Figure 6.4 illustrates the estimated change in annual demand for cycling. Detailed statistics on changes in trips, kilometres and hours by mode are shown in **Table 6.12** and **Table 6.13**. Changes in trips, kilometres and hours caused by changes in public bicycle demand are shown separated in **Table 6.14** and **Table 6.15**.

Figure 6.4: Estimated Annual Cycling Demand by Model Year



Source: AECOM calculations. Estimates are presented on a "two-way" basis.

Table 6.12: Annualised Demand (All Purposes) Excluding Public Bicycle

Variable	Do Nothing Scenario			Policy Target Scenario			AECOM Estimate		
	2011 (Base)	2016	2026	2011 (Base)	2016	2026	2011 (Base)	2016	2026
Total trips	13,127,800	14,426,800	16,249,700	13,127,800	50,519,300	56,915,900	13,127,800	21,965,800	25,513,100
Cycle kilometres									
On road (no facilities)	59,114,600	65,716,600	75,580,600	59,114,600	96,200,600	104,066,200	59,114,600	49,693,300	55,002,700
On road (cycle lanes)	884,800	979,000	1,125,100	884,800	11,532,100	11,928,300	884,800	5,269,200	5,793,900
Separated	16,570,800	18,414,500	21,199,000	16,570,800	158,437,400	193,568,000	16,570,800	97,604,000	120,901,600
Total kilometres	***76,570,100***	***85,110,100***	***97,904,700***	***76,570,100***	***266,170,100***	***309,562,500***	***76,570,100***	***152,566,500***	***181,698,300***
Cycle Time (hrs)									
On road (no facilities)	2,955,700	3,285,800	3,779,000	2,955,700	4,810,000	5,203,300	2,955,700	2,484,700	2,750,100
On road (cycle lanes)	44,200	48,900	56,300	44,200	576,600	596,400	44,200	263,500	289,700
Separated	662,800	736,600	848,000	662,800	6,337,500	7,742,700	662,800	3,904,200	4,836,100
Total hours	***3,662,800***	***4,071,400***	***4,683,200***	***3,662,800***	***11,724,100***	***13,542,400***	***3,662,800***	***6,652,300***	***7,875,900***

Source: AECOM calculations. Estimates are presented on a "two-way" basis. Values rounded to nearest hundred.

Table 6.13: Annual Diverted Kilometres and Hours (Relative to Do Nothing Scenario)

Variable	Policy Target Scenario			AECOM Estimate		
	2011	2016	2026	2011	2016	2026
Changes in Trips						
Car		-19,805,200	-22,649,200		-4,258,500	-5,099,800
Train		-6,594,600	-7,446,300		-1,357,600	-1,803,400
Bus		-9,692,600	-10,570,700		-1,922,900	-2,360,200
Cycle		36,092,500	40,666,200		7,539,000	9,263,400
Changes in kilometres						
Car kilometres		-98,150,300	-115,101,400		-36,215,000	-43,835,400
Train kilometres		-34,489,800	-41,928,800		-13,738,300	-18,322,900
Bus kilometres		-48,420,000	-54,627,500		-17,503,200	-21,635,300
Cycle kilometres		181,060,100	211,657,800		67,456,500	83,793,500
Changes in Passenger Hours						
Car hours		-5,131,600	-6,527,800		-1,766,400	-2,339,100
Train hours		-3,377,700	-4,008,500		-869,500	-1,207,700
Bus hours		-4,351,500	-5,111,600		-1,243,600	-1,644,000
Cycle hours		7,652,800	8,859,200		2,580,900	3,192,700

Source: AECOM calculations. Estimates are presented on a "two-way" basis. Values rounded to the nearest hundred.

Table 6.14: Annual Public Bicycle Demand

Variable	Do Nothing Scenario			Policy Target Scenario			AECOM Estimate		
	2011 (Base)	2016	2026	2011 (Base)	2016	2026	2011 (Base)	2016	2026
Total trips	4,677,800	5,164,700	5,702,300	4,677,800	8,263,500	10,073,200	4,677,800	8,263,500	10,073,200
Cycle kilometres									
On road (no facilities)	14,036,200	15,497,100	17,110,100	14,036,200	11,910,500	13,668,200	14,036,200	11,910,500	13,668,200
On road (cycle lanes)	339,400	374,700	413,700	339,400	1,772,100	1,961,900	339,400	1,772,100	1,961,900
Separated	4,335,800	4,787,000	5,285,300	4,335,800	19,371,600	24,662,800	4,335,800	19,371,600	24,662,800
Total kilometres	***18,711,400***	***20,658,900***	***22,809,000***	***18,711,400***	***33,054,200***	***40,292,800***	***18,711,400***	***33,054,200***	***40,292,800***
Cycle Time (hours)									
On road (no facilities)	1,169,700	1,291,400	1,425,800	1,169,700	992,500	1,139,000	1,169,700	992,500	1,139,000
On road (cycle lanes)	28,300	31,200	34,500	28,300	147,700	163,500	28,300	147,700	163,500
Separated	361,300	398,900	440,400	361,300	1,614,300	2,055,200	361,300	1,614,300	2,055,200
Total hours	***1,559,300***	***1,721,600***	***1,900,800***	***1,559,300***	***2,754,500***	***3,357,700***	***1,559,300***	***2,754,500***	***3,357,700***

Note: Values rounded to the nearest hundred.

Table 6.15: Diverted Kilometres and Hours due to Public Bicycle Only (Relative to Do Nothing Scenario)

Variable	Policy Target Scenario			AECOM Estimate		
	2011 (Base)	2016	2026	2011 (Base)	2016	2026
Changes in Trips						
Car		-309,900	-437,100		-309,900	-437,100
Train		-662,600	-934,600		-662,600	-934,600
Bus		-917,800	-1,294,600		-917,800	-1,294,600
Cycle		3,098,800	4,371,000		3,098,800	4,371,000
Walk		-805,700	-1,136,400		-805,700	-1,136,400
All modes		***402,800***	***568,200***		***402,800***	***568,200***
Changes in Passenger Kilometres						
Car kilometres		-1,239,500	-1,748,400		-1,239,500	-1,748,400
Train kilometres		-2,650,200	-3,738,200		-2,650,200	-3,738,200
Bus kilometres		-3,671,400	-5,178,500		-3,671,400	-5,178,500
Cycle kilometres		12,395,300	17,483,800		12,395,300	17,483,800
Walk kilometres		-3,222,800	-4,545,800		-3,222,800	-4,545,800
Total kilometres		***1,611,400***	***2,272,900***		***1,611,400***	***2,272,900***
Changes in Passenger Hours						
Car hours		-54,400	-84,800		-54,400	-84,800
Train hours		-69,500	-108,400		-69,500	-108,400
Bus hours		-176,800	-275,800		-176,800	-275,800
Cycle hours		1,032,900	1,457,000		1,032,900	1,457,000
Walk hours		-644,600	-909,200		-644,600	-909,200
Total hours		***87,600***	***78,800***		***87,600***	***78,800***

Note: Values rounded to the nearest hundred.

6.7 Limitations

Limitations of the demand assessment are outlined as follows:

6.7.1 Metro and Light Rail Interventions

In the context of enhancing public transport capacity, interventions such as light rail have been proposed within the study area. In light of the limited certainty regarding the type, alignment or timing and without localised mode choice parameters to assess the potential demand impacts, this study has not attempted to assess the demand impact that may arise from the development of major future public transport interventions within the study area.

6.7.2 Bicycle Parking Capacity

The quality of bicycle parking facilities have been found by Katz (1996) and Wardman et al. (2007) to lead to material impacts on demand. This study assumes that the quality of current cycle parking facilities will remain at existing levels. This study also assumes that sufficient cycle parking capacity will exist to accommodate any increases in cycling demand.

6.7.3 Route Assignment

Demand for a given inter-SLA origin-destination pair has been assigned to one route based on the route that provides the maximum utility. Whilst this will generally favour the use of separated cycle paths and cycle lanes over general traffic lanes, under certain circumstances, a parallel cycling route may not be assigned any demand.

6.7.4 Exclusion of Multimodal Cycling Trips

Whilst the Inner Sydney Regional Bicycle Network will assist in improving cycling connectivity with the CityRail network, such journeys are less prevalent and are declining as a proportion of all bicycle trips. Furthermore, given that cycling demand data in Sydney is considered not to be reliable at levels below an SLA level, it is difficult to model multimodal cycling (of which cycle-train trips predominate) as there are very few of these trips being generated to any given railway station/interchange. Moreover assessing demand for multimodal cycling is a relatively immature field and is significantly more complex as factors such as bicycle parking, train frequency and bike-on-train regulations require consideration. Hence, in the context of no reliable data on levels of multimodal trip making, no clear approach to model these type of trips and the strategic nature of the network, multimodal cycling trip generation was not considered.

6.7.5 Exclusion of Walk Trips

Given the complexity of modelling walking trips in a strategic context, walking demand has not been modelled.

6.7.6 No HarbourLink Route Bonus

Cycling demand between the Lower North Shore and Sydney is constrained by the limited number of attractive options on the approach to the Sydney Harbour Bridge. The HarbourLink proposal, which suggests the development of a grade separated shared user path between Ridge Street and the Harbour Bridge, has the potential to significantly increase cycling amenity by bypassing North Sydney CBD and providing a gentler gradient for cyclists. As a grade separated structure, HarbourLink could offer sweeping views of the harbour and as such, may generate demand in excess of what current cycling choice models may estimate due to the potential additional amenity benefits in the form of avoided congestion, harbour views and gentle slopes. This additional demand has not been incorporated into our demand estimates.

6.7.7 Decrowding Benefits

The diversion of demand away from the car, train and bus networks to bicycle will lead to some capacity being freed. For this study, it is assumed that future supply of road and public transport will be sufficiently elastic to adjust to the reduction in demand caused by a shift in demand to cycling. However in the short run, this spare capacity is available for any latent demand to use. It should be noted that these benefits nor the additional patronage that may result from decrowding have not been included as part of this assessment.

6.8 Summary

AECOM undertook a demand assessment of three demand scenarios to measure the impact of the Inner Sydney Regional Bicycle Network on current levels of cycling demand. An incremental choice model which has been specifically designed to capture the impact of different cycleway treatments and has been calibrated for use in a Sydney context, has been used to predict the level of mode diversion towards cycling.

The full development of the Inner Sydney Regional Bicycle Network has the potential to create significant increases in cycling demand within the study area. Relative to the Do Nothing Scenario, the incremental choice model predicts that overall demand for cycling will increase by 52 percent by 2016 and 56 percent by 2026 due to the implementation of the Inner Sydney Regional Bicycle Network. If State Plan target mode shares are achieved, the overall demand for cycling will increase by 263 percent in 2016 and 261 percent in 2026.

7.0 Economic Appraisal

This section outlines the assumptions and processes used to evaluate the benefits arising from the estimated increases in cycling demand attributable to the implementation of the Inner Sydney Regional Bicycle Network. These rates have then been applied to the demand estimates prepared in **Section 6.0**. Both network wide and corridor specific economic measures have been estimated to identify the viability of developing the network in its entirety and to assist in prioritising funding.

7.1 Introduction

7.1.1 Standards and Guidelines

The following appraisal guidelines were used to develop the economic appraisal framework and to extract relevant economic parameters:

- ATC Better Infrastructure Decision Making Infrastructure Australia (2009);
- ATC National Guidelines for Transport System Management in Australia (2006);
- NSW Treasury Guidelines for Economic Appraisals (TPP 07-5);
- NSW Treasury Guidelines for Capital Business Cases (TPP 08-5);
- RTA Economic Analysis Manual (1999); and
- RailCorp Compendium of CityRail Travel Statistics (2008).

In addition, the following appraisal guidelines specifically developed for the evaluation of cycling schemes were reviewed:

- Evaluation of the costs and benefits to the community of financial investment in cycling programs and projects in NSW prepared by PwC; and
- Guidance on the Appraisal of Walking and Cycling Schemes (2009a) prepared by the UK DfT.

7.1.2 Approach

AECOM has analysed the economic impacts of the full implementation of the Inner Sydney Regional Bicycle Network for three demand scenarios, as set out in **Section 6.3**:

- Do Nothing Scenario: Base Case
- Policy Target Scenario: Realisation of Policy Targets
- AECOM Estimate: Incremental Choice Modelling

The Policy Target Scenario and AECOM Estimate were compared against the Do Nothing Scenario. The economic viability of the project has been expressed in terms of a number of criteria as defined by the Australian Transport Council:

- **Net present value (NPV):** the value of the stream of benefits when discounted at the annual rate reflecting the social opportunity cost of capital;
- **Net present value per dollar of investment (NPVI):** measures the return on a dollar of investment and is calculated by dividing the net present value of all benefits by the present value of investment costs;
- **Benefit Cost Ratio (BCR):** measures the present value of benefits minus the present value of recurrent and other costs divided by the present value of the initial capital cost; and
- **Internal rate of return (IRR):** the discount rate which equalises the discounted costs and benefits.

In addition, AECOM undertook an incremental cost-benefit analysis for each key origin-destination which has identified critical cycling corridors and allow for the prioritisation of works.

7.2 Key General Parameters

The key parameters used in this economic analysis include:

Evaluation Period

An evaluation period of 30 years from the scheme opening year has been applied to this study, which is the standard timeframe recommended by the Australian Transport Council, RTA and NSW Treasury for evaluation of transport infrastructure projects.

Price Year

Real prices are expressed in a June 2010 constant price base for all cost and benefit parameters. Where costs and benefits are originally priced prior to June 2010, price adjustments are as follows:

- For income related variables such as value of time, accident costs, health costs and congestion, these have been indexed in line with nominal movements in NSW Average Weekly Earnings[9] up to September 2009. Between September 2009 and June 2010, a rate of 3.5 percent per annum has been applied[10];
- For all other variables such as environmental externalities, these have been indexed with movements in the Sydney Consumer Price Index up to December 2009. Between December 2009 and June 2010, inflation has been assumed to increase at a rate of 2.5 percent per annum[11].

Beyond June 2010, only real changes in prices have been applied. Hence for all income related variables, unit rates have been indexed at a real rate of 1 percent per annum. Car costs are assumed to increase at a real rate of 2.65 percent per annum[12], which accounts for cost increases in car inputs as well as a decline in average travel speed. Public transport costs are assumed to increase at a real rate of 1 percent per annum[13]. The values of all other variables are assumed to remain constant in real terms.

Discount Rate

In line with RTA and NSW Treasury Guidelines, a real discount rate of 7 percent per annum has been adopted in the economic appraisal to calculate present values. This study also undertakes sensitivity tests at the discount rates of 4 percent and 10 percent.

Discount Year

All cost and benefit streams have been discounted to June 2010.

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[9] Seasonally adjusted, total earnings, all persons

[10] Based on an assumed inflation rate of 2.5 percent and a real increase in average weekly earnings of 1 percent per annum, which has been based on a historical analysis of the differential in movements between NSW average weekly earnings and the Sydney Consumer Price Index

[11] Midpoint of the Reserve Bank of Australia's target inflation range

[12] Reflects the increase in vehicle operating costs based on assumptions on vehicle speeds and real input costs presented in **Section 6.2.3**.

[13] Reflects assumptions presented in **Section 6.4.3**.

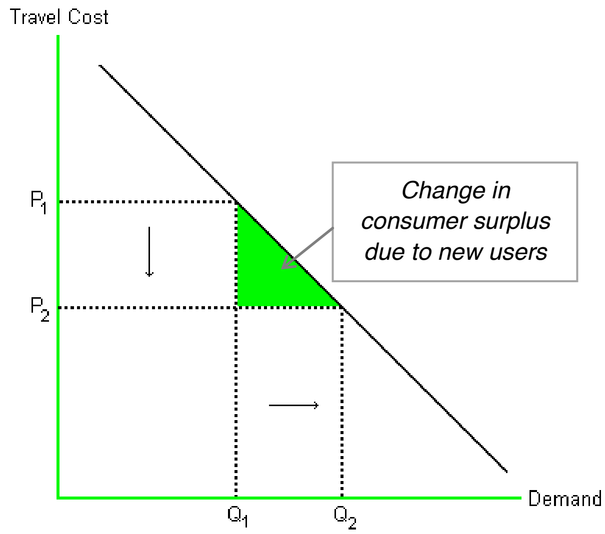
Rule of Half

Economic appraisals seek to measure the aggregate change in individual benefits, or in an economic parlance, changes in consumer surplus. Consumer surplus is the difference between the benefit enjoyed and the perceived cost of travel.

For existing users, if the perceived cost of travel is reduced, all existing users benefit by the same degree. The change in consumer surplus for existing users can be readily calculated by multiplying the change in cost (P_1 – P_2) by the level of existing demand.

However, the calculation of consumer surplus for new users is complicated by the notion that different individuals value using a given transport mode differently. For individuals that are enticed to shift from a competing mode to bicycle, some individuals value their benefit as the full difference between the old and new perceived cost of cycling. At the other end of the spectrum, other new users value their benefits close to zero with the drop in the perceived cost only just enough to entice them to cycle. As users do not value their benefits equally, changes in consumer surplus for new users are calculated as half the product of the change in perceived cost (P_1 – P_2) and the change in demand (Q_2 – Q_1), known as the rule of half. The green shaded are in **Figure 7.1** reflects the change in consumer surplus for new users.

Figure 7.1: Consumer Surplus for New Users



AECOM has applied the rule of half on the following benefits for all *new users*:

- Travel time savings;
- Vehicle operating cost savings;
- Parking costs savings;
- Journey ambiance; and
- Willingness to pay for public bicycle.

Average Cycle Trip Length

Based on output from the demand model, the average cycle trip distance was calculated to be approximately 9.00 kilometres. In assuming that there are no net changes in kilometres, this implies that the length of a diverted car passenger, train passenger and bus passenger trip is also equivalent to 9.00km.

Annual Cycle Kilometres per Cyclist

Market research undertaken by the City of Sydney found that cyclists use their bicycle for 23 trips per month on average (Environmetrics, 2006). Assuming an average trip length of 9.00km, and accounting for seasonality[14], an average cyclist is assumed to travel 2,258km per annum.

Mode Diversion

The incremental choice model has been used to calculate unique mode diversion factors for each origin-destination pair which have been subsequently used to calculate changes in demand, kilometres and hours for each mode. Economic benefits have been calculated directly using these outputs rather than converting these metrics into a cycle kilometre equivalent.

However, to aid comparison, the following mode diversion factors were estimated by the incremental mode choice across the study area:

- Trip diversion from car: 52.5 percent;
- Trip diversion from train: 19.8 percent; and
- Trip diversion from bus: 27.7 percent.

Average Car Occupancy

The incremental choice model estimates car demand to include both car drivers and car passengers. Not accounting for the possibility that some car users are car passengers will lead to an overestimation of car vehicle kilometres and car vehicle hours.

Where required, car passenger kilometres and car passenger hours were converted to car vehicles kilometres and vehicle hours using an average vehicle occupancy rate of 1.35. The weights were based on the proportion of annual demand travelling during each time period, which were based on guidance provided within the RTA Economic Analysis Manual. Data used to calculate the average vehicle occupancy rate are shown in **Table 7.1**.

Table 7.1: Average Vehicle Occupancy Kilometres

Time of Day	Average Vehicle Occupancy	Proportion of Annual Demand
Peak	1.12	68.4%
Off-peak	1.50	7.6%
Other	1.97	24.0%
Weighted average	**1.35**	

Source: AECOM calculations based on RTA (2009a)

Train Passenger Kilometres to Train Vehicle Kilometres

To estimate the reduction in train vehicle kilometres due to travellers switching from train to bicycle, the ratio between suburban train passenger kilometres and service kilometres in 2008 was used. This ratio was calculated to be 223.4 passenger kilometres for every service kilometre.

Values used to calculate the ratio between train passenger and service kilometres is shown in **Table 7.2**.

[14] The survey undertaken by Environmetrics was undertaken during October 2006. Based on seasonality analysis, demand for cycling in October is approximately 10 percent above annual average. To deseasonalise the estimate, the average monthly trip estimate was multiplied by 0.909 (1 ÷ 1.10).

Table 7.2: Ratio between Train Passenger and Service Kilometres

Variable	Average Weekday	Average Weekend	Annualised
Annual suburban service km (2008)	67,524	43,309	21,861,535
Annual suburban patronage (2008)			245,433,060
Average suburban passenger distance (km)			19.9
Annual suburban passenger km			4,884,117,894
Ratio between train passenger and service km			**223.4**

Sources: AECOM calculations based on TDC (2009), RailCorp (2008) and line specific rail patronage sourced from RailCorp. Patronage estimates exclude free travel and all tickets sold on intercity line

Bus Passenger Kilometres to Bus Vehicle Kilometres

To estimate the reduction in bus vehicle kilometres due to travellers switching from bus to bicycle, the ratio between bus passenger kilometres and bus service kilometres on the Sydney Buses network was used. This ratio was calculated to be 15.5 passenger kilometres for every service kilometre.

Table 7.3: Ratio between Bus Passenger and Service Kilometres

Variable	Value
Annual Sydney Buses Patronage (2009)	192,804,000
Average trip distance (km)	6.5
Annual Sydney Buses passenger kilometres (2009)	1,253,226,000
Annual Sydney Buses service kilometres (2009)	81,033,000
Ratio between bus passenger and service km	**15.5**

Sources: AECOM calculations based on TDC (2009) and Sydney Buses (2009)

7.3 Cycling Economic Appraisal Parameters

Formal guidelines to prepare economic appraisals for cycling interventions are not available currently within an Australian context. However, AECOM understands that a number of government agencies are actively preparing guidelines to facilitate economic evaluations of such interventions. AECOM has reviewed all guidance made available and where required, made adjustments. ACEOM has also suggested the inclusion of additional benefit streams.

Discussion on all economic benefit streams encompassed by the economic appraisal has been split by transport mode as follows:

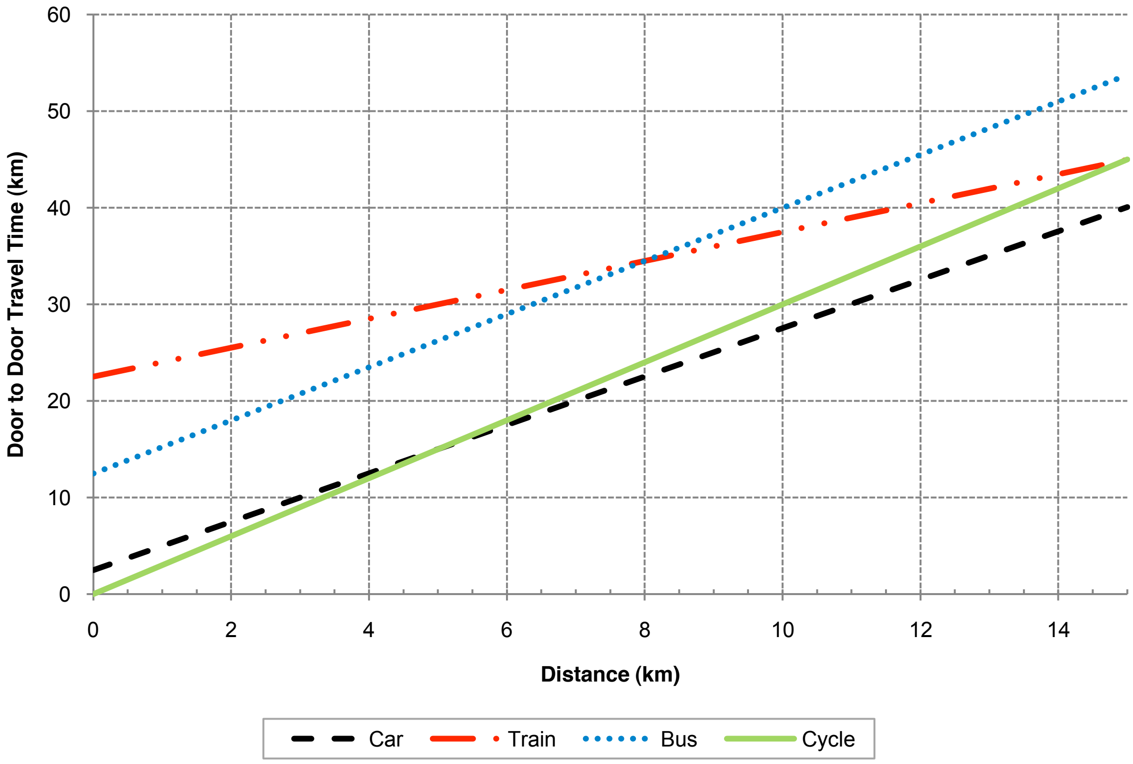
- General benefits;
- Cycle specific benefits;
- Car specific benefits;
- Train specific benefits; and
- Bus specific benefits.

7.3.1 General Benefits

Valuation of Travel Time Savings

As part of the demand assessment, AECOM undertook an assessment of the potential travel time savings travellers may derive from switching from other transport modes to cycling. The demand assessment, which accounted for door-to-door travel time, illustrates that when non in-vehicle time is considered, travel by cycling can generate travel time savings. To illustrate, based on an average trip length of 9 km, average door-to-door travel time by bicycle is comparable with car travel and is faster by almost 10 minutes than bus and train travel. Estimated door-to-door travel times for car, train, bus and bicycle for 2011 is illustrated in **Figure 7.2**.

Figure 7.2: Assumed Door-to-Door Travel Time versus Travel Distance by Mode



Source: AECOM assumptions based on **Section 6.4.3**

All travel time savings have been valued in accordance with the values of time recommended by the RTA (2009a). As at September 2009, the recommended value of one hour of travel time saved for all forms of private travel, including by public transport and by bicycle is $11.89 per hour.

AECOM has escalated the value of time to $12.20 as at June 2010. For future years, the value of time is assumed to increase in line with real movements in average weekly earnings.

7.3.2 Cycling Specific Benefit Rates

7.3.2.1 Health Benefits

There is a wealth of evidence, some of which is summarised below, suggesting a strong relation between physical inactivity and chronic diseases, including:

- Coronary heart disease;
- Chronic kidney disease;

- Stroke and cerebrovascular events;
- High blood pressure;
- Obesity;
- Type II diabetes; and
- Colon, lung and breast cancer.[15]

Therefore, the role of active transport modes as a means to become (more) physically active cannot be overstated.

Reduced mortality

Economic appraisals frequently express health benefits of active transport modes in terms of savings from avoided premature deaths due to chronic diseases. **Table 7.4** shows proposed methodologies to account for the health benefits of cycling.

Table 7.4: Health Benefits of Cycling through Reduced Mortality

Guideline	Methodology
RTA (2003) *Australia*	• Identifies the difference in the death rate due to *heart attack* in men that cycle sufficiently and insufficiently for optimum protection. Optimum protection is assumed to be reached by cycling 6 hours a week. • Multiplies this difference by the value of a life year and divides by the number of total kilometres cycled a year.
WHO (2008)[16] *Europe*	• Multiplies the expected number of deaths by the reduction in the risk of *all-cause mortality* due to cycling to calculate the number of lives saved. • The resulting value from the above step is then multiplied by the value of a statistical life. • Calculation of the reduction in the risk of all-cause mortality is based on a Copenhagen study (Andersen et al. 2000), which is the most comprehensive research to date on the impact of cycling on the risk of dying from all-causes. The assumed duration of cycling in the Copenhagen study is 3 hours a week.

In this study, health benefits are calculated using the WHO approach which is holistic in the sense that it measures the reduction in mortality for all causes rather than for a particular disease. Moreover, the WHO method allows for local factors to be taken into account.

A key deviation from the WHO approach is to use the value of a life year rather than the value of a statistical life as death rates are calculated as a *probability of death in a given year*. Hence, the use of the value of a life year has been adopted for consistency. Assuming that the value of a life year (VLY) is $160,659[17], and taking the Copenhagen's study relative risk reduction as a basis, the value of reduced mortality per cycle kilometre is calculated to be 6 cents. Calculations used to derive this value are shown in **Table 7.5**.

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15 See Genter et al. (2008) and Bauman et al. (2008).

16 To accrue health benefits, the WHO's method does not require meeting a physical activity threshold, meaning that all increases in physical activity would be associated with a reduction in the all-cause mortality risk (Cavill et al. 2008).

17 The VLY is based on Abelson's (2007) suggested value of AUD 151,000 but adjusted to account for changes in average weekly earnings up to June 2010. The value of a life year is based on the willingness-to-pay approach.

Table 7.5: The Health Benefits of Cycling

Variable	Value
Relative risk of mortality of workers that cycle to work versus general population in Copenhagen (Anderson et al., 2000)	0.720
Mean distance travelled per cyclist per annum in Sydney	2258km[18]
Mean distance travelled per cyclist per annum in Copenhagen (Anderson et al., 2000)	1620 km
Ratio between Sydney and Copenhagen to adjust relative risk factor (2258 ÷ 1620)	1.39
Estimated relative risk of mortality for cyclists versus general population in Sydney (1 – 1.39 × (1 – 0.72))	0.61
2008 NSW mortality rate for persons between 25 and 64 years of age	0.002168
Estimated NSW mortality rate for cyclists (0.002168 × 0.61)	0.001322
Change in death rate due to cycling (0.002168 – 0.001322)	0.000846
Value of a life year	$160,659
Value of reduction in mortality ($160,659 × 0.000846)	$135.92
Value of reduced mortality per cycle km per person ($135.92 ÷ 2258)	**$ 0.06**

Sources: AECOM calculations based on WHO (2008), Andersen et al. (2000), ABS (2008), Taveners Research (2007). Prices in June 2010 dollars.

It should be noted that these health benefits only relate to the influence of cycling on reduced mortality and do not account for any reductions in morbidity or improved worker productivity; the latter benefit is discussed in the following sub-section. The only known study that has factored reduced morbidity into account is a study undertaken by Ker (2004) which estimated that reduced mortality and morbidity benefits were 37.6 cents per cycle kilometre (in 2004 prices). However, this study assumed that the benefit of reduced morbidity is at least equivalent to the benefit of reduced mortality which has not been tested empirically.

Reduced absenteeism benefits and improved worker productivity

Health benefits calculated for cycling and walking schemes typically only account for the benefit of reduced mortality rates. Cycling and walking schemes, however, can provide immediate benefits to the economy through reduced absenteeism (as measured by a reduction in sick days) and improved worker productivity levels. Therefore, in this case, health benefits also accrue to employers (DfT, 2009a).

For Australia, the cost of physical inactivity has been estimated at $487.30[19] per employee per year, which divided by the average of kilometres cycled per year per cyclist gives a saving of 21.6 cents per cycled kilometre.

[18] See **Section 7.2**

[19] Econtech's (2008) estimate of the cost of physical inactivity was adjusted by changes in average weekly earnings to June 2010 values. The cost of physical inactivity is based on an average loss of 1.8 working days per year.

Since the mean distance travelled per cyclist per annum (at an average speed of 23 km/h) in the study area gives around 70 percent of the recommended amount of cycled required per week to be classified as “fully active” by the National Physical Activity Guidelines for Australians (Department of Health and Aged Care 1999), the health benefit from absenteeism savings have conservatively been reduced to 16.7 cents. Values used to calculate benefits due to reduced absenteeism are shown in **Table 7.6**.

Table 7.6: Reduced Absenteeism Benefits due to Cycling

Variable	Value
Cost of physical inactivity	$487.30
Mean distance travelled per cyclist per annum in Sydney.	2258km
Savings due to physical activity (487.30 ÷ 2258)	$0.216
Recommended hours per week in physical activity by National Guidelines (Department of Health and Aged Care 1999)	2.50 hours
Time spent cycling in study area per week (based on an average speed on 22.5km/h)	1.93 hours
Adjusted savings due to physical activity ($0.216 × 1.93 ÷ 2.50)	**$0.167 per cycle km**

Source: AECOM calculations based on Econtech (2008) and are valued in June 2010 dollars.

In addition to health benefits due to reduced mortality of 6.0 cents per cycle kilometre, AECOM has adopted an average value of 16.7 cents per cycle kilometre to account conservatively for the benefits accrued through reduced absenteeism and improved worker productivity in 2010. For future years, all health benefits are indexed with real movements in average weekly earnings.

It should be noted that these health benefits do not include reduced morbidity benefits (Cavill et al., 2008). However, the Ker (2004) value has been updated to 46 cents per cycle kilometre and has been used for the purposes of sensitivity testing.

7.3.2.2 Journey Ambiance

Journey ambiance refers to the additional enjoyment cyclists derive from the use of safer facilities. Journey ambiance includes:

- The quality and cleanliness of facilities and information provided;
- Travellers' views: the extent to which travellers can see the surrounding landscape and townscape; and
- Traveller stress: frustration, fear of potential accidents and route uncertainty.

For cyclists some of these impacts may be very important, in particular, the uncertainty associated with the fear of accidents. This is reflected in the fact that journey ambiance can account for a significant proportion of total cycling scheme benefits. According to research undertaken by Sustrans (undated) on a range of UK cycling case studies, on average, journey ambiance alone accounted for 45 percent of total economic benefits.

Whilst the inclusion of journey ambiance may be considered unconventional, the consideration of cycling journey ambiance is akin to the valuation of service quality improvements, the practice of which is highly advanced within the UK rail industry through the Passenger Demand Forecasting Handbook and an approach adopted by RailCorp as early as 2006.

Arguably, the most developed research on journey ambience for cycling trips and applying these in economic appraisals has been undertaken in the UK and incorporated into the UK Transport Appraisal Guidelines (TAG). **Table 7.7** contains willingness to pay values placed on different cycling interventions from two key studies prepared by Hopkinson & Wardman (1996) and Wardman et al. (2007). These values have been converted from pence/min to cents/min using Purchasing Power Parity exchange rates and indexed to June 2010 prices based on movements in average weekly earnings.

Table 7.7: Ambiance Value by Treatment Type

Attribute	Source	Implied Value (p/min) on Survey Date	Value (cents/min) on Survey Date	June 2010 Value (cents/min)
Separated off-road	Wardman et al. (2007)	13.83	34.69	39.05
Separated on-road	Wardman et al. (2007)	13.33	33.44	37.64
On road cycle lane	Wardman et al. (2007)	10.17	25.50	28.70
Separated off-road	Hopkinson & Wardman (1996)	4.78	10.00	11.57
Separated on-road	Hopkinson & Wardman (1996)	2.01	4.20	4.86
Wider lane	Hopkinson & Wardman (1996)	1.23	2.56	2.97

Sources: Wardman et al. (2007), Hopkinson & Wardman (1996). Revaluations based on OECD and ABS data

It is important to note that valuations from Wardman et al. (2007) are higher as the modelling was based on both revealed and stated preference data as opposed to the Hopkinson & Wardman (1996) models, which were based only on stated preference data, an approach which is known to bias willingness to pay valuations downwards.

Notwithstanding, as a conservative approach, AECOM has adopted the lower Hopkinson & Wardman (1996) values for 2010. Therefore, for *all separated cycleway travel* including travel along shared paths, a value of 4.86 cents/min or 11.66 cents/cycle km (at 25 km/h) has been adopted. A lower value has been adopted for cycle lane travel at 2.97 cents/min or 8.91 cents/cycle km (at 20km/h). Journey ambiance benefits have been indexed with real movements in average weekly earnings for future years.

7.3.2.3 Cycle Accident Costs

As travellers switch from alternative transport modes, which are considered safer than cycling at current levels, increases in cycling, *a-priori*, are expected to lead to a net increase in accident costs. However, the change in net accident costs is made somewhat more complex due to the need to consider:

- The impact of a separated Bicycle Network on accident rates;
- Differences in accident rates between different transport modes, discussed in **Sections 7.3.3** to **7.3.5**;
- Potential for cycling accident rates to reduce considerably in response to increases in cycling usage; and
- Potential for current cyclists to benefit from reductions in cycling accident rates over time.

Within an appraisal environment, accident costs are calculated typically using rates expressed in terms of a per kilometre crash rate. PwC (2009) provides an estimate of such a rate, estimating a (static) cycling accident rate of 2.4158 cycling accidents per one million cycle kilometres before accounting for the reduction in mid-block accidents from the development of a separated cycle network.

In preparing a final accident rate, PwC chose to adopt a reduction in the overall accident rate arguing that separated cycleways would reduce mid-block accident rates. Whilst this conclusion is not contentious, it has been argued that the separation of cyclists from general traffic can *increase* accidents at intersections as cyclists are not as visible to motorists. This can lead to an increase in situations where turning vehicles conflict with cyclists travelling straight on a parallel cycleway, leading to ambiguity on whether separated cycleways, apart from the additional demand they generate, have the ability to reduce accidents at intersections. Ultimately, this will be dependent on the exact treatment measures use to reduce the potential for conflict between cyclists, motorists and indeed pedestrians at this point. Furthermore, as AECOM is measuring accident costs on both the Bicycle Network and the general road network, it was considered that a downward reduction in the accident rate to account for greater levels of cycling on the separated cycleway network is unnecessary and may be unjustified.

An additional complication in estimating cycling accident costs is in establishing a reliable value for an average cycling accident. Although accident valuation techniques are sufficiently advanced to estimate car accident costs, the valuation of cycling accidents is immature presumably due to the relative infrequency or reporting of bicycle accidents occurring. Current RTA guidance suggests, in the absence of specific cycling guidance, that the average accident crash cost (for all crashes) be used, either using a human capital approach[20] or through the recently adopted willingness to pay approach. As some comfort, there is little difference in the average cycling accident costs and average car accident costs recommended by the DfT (2009a). Initial cycle accident cost rates used for the economic appraisal are shown in **Table 7.8**.

Table 7.8: Cycle Accident Rates

Approach	RTA Average Urban Cost ($) per Crash		Cycle Accident Rate (crashes/MKT)	Initial Cycle Accident Cost Rate
	September 2009	June 2010		
Human capital approach	$66,000	$67,720	2.4158	16.36 c/km
Willingness to pay approach	$88,800	$91,115	2.4158	22.01 c/km

Source: AECOM calculations based on RTA (2009a), PwC (2009)

However, the appropriateness of using constant cycling accident rates is brought into question by the weight of international and domestic experience that link increasing cycling with declining cycling accident rates.

Although factors such as quality of cycling infrastructure provision (Garrard, 2008) and local environmental influences and motorist behaviour (Bonham et al., 2006) play a role in influencing cycle accident rates, there is considerable time series and cross sectional data to suggest that there is a causal link between higher levels of cycling demand and reduced accident rates, colloquially referred to as the "safety in numbers" effect.

Table 7.9 summarises some of the key literature in this area.

Table 7.9: Selected Studies for the "Safety in Numbers" Effect

Author/Country	Findings
Jacobsen (2003) *Multiple countries including European, UK and the US*	Using data from a range of European and North American countries, Jacobsen finds the number of motorists colliding with people walking or bicycling increases less than proportionally to the number of people walking or bicycling or, alternatively, the *likelihood* of a person walking or bicycling being crashed by a motor vehicle declines as the number of people cycling or walking increases. Jacobsen (2003) found that a one percent increase in the volume of mode share or cycle kilometres travelled reduces the cycling fatality and injury rate by 0.4 percent. Analysis undertaken by AECOM on Robinson (2005) and Pucher and Buehler (2008) data provides confirmation for this rate.
Robinson (2005) *Australia*	Using 1985/86 data for all Australian states, Robinson finds the risks of fatality and injury per cyclist are lower in cities where cycling levels are higher.

[20] Car accident costs have been typically quantified using the human capital approach which attempts to value three key components: human costs (e.g. quality of life costs), vehicle costs (e.g. repairs) and other general costs (e.g. travel delays and property damage). The willingness-to-pay approach identifies the average value the community is willing-to-pay to reduce (for example) the probability of crash related injuries and road accident fatalities.

Adopting static cycling accident rates based on current accidents to value future cycling accident costs is likely to be inaccurate as cycling demand levels are anticipated to increase well above current cycling levels. Rather, AECOM has adopted a cycling accident cost rate of 16.36 c/km under the human capital approach and 22.01 c/km under the willingness to pay approach for 2011, indexed with real movements in average weekly earnings for future years. For subsequent years, accident costs are assumed to decline by 0.4 percent for every one percent increase in cycle mode share[21].

7.3.2.4 Willingness to Pay for Public Bicycles

As discussed in **Section 6.5**, the City of Sydney is proposing to introduce a public bicycle scheme. Market research undertaken by the City of Sydney indicates that usage will increase if and only if a network of separated cycleways is made available.

It is worth noting that benefits generated by public bicycle schemes such as general wellbeing and sightseeing, which are not well captured by internalised benefits such as travel time and travel cost savings, are generally difficult to measure. These additional benefits are reflected in part, through the inducement of new trips, which are not diverted from alternative transport modes. As a proxy to measure these benefits, a net willingness to pay measure has been estimated by taking the difference between the:

- Average willingness to pay for hiring a public bicycle; and
- Estimated cost associated with hiring a public bicycle.

The difference between the willingness to pay and cost accounts for the net surplus after cyclists pay a charge for using a shared bicycle or as is the case in many places in Europe, where local authorities subsidise operations.

The net willingness to pay for public bicycles has been incorporated into the economic appraisal. Market research undertaken by Taverners Research on behalf of the City of Sydney indicated that users would be willing to pay an average of $5.20 per hour (Taverners Research, 2007). Based on an average trip length of 20 minutes, users would be willing to pay an average of $1.73 per trip, or $1.84 in June 2010 prices.

On the cost side, capital and operating costs have been based on the proposed London scheme. The scheme, which is estimated to cost £75 million over 10 years for a 6,000 bicycle scheme, would cost approximately $2,500[22] per bicycle per annum. Assuming an average daily utilisation rate of 5 trips per bicycle and a 10 percent margin, this equates to a cost of $1.50 per trip or a surplus of 34 cents per trip.

AECOM has adopted a net willingness to pay value of 34.34 cents per trip on the proposed public bicycle system in 2011. The value of willingness to pay has been assumed to move in line with real movements in average weekly earnings. This benefit has been applied only to induced public bicycle trips that would not otherwise be generated in the absence of the Inner Sydney Regional Bicycle Network.

7.3.3 Car Specific Rates

7.3.3.1 Reducing Road Congestion

Benefits from reducing congestion accrue where car users switch to bicycle. Decongestion benefits are typically measured by taking the difference between the additional journey costs incurred under congested conditions relative to free-flow conditions. Under high levels of congestion, a small reduction in car demand can led to significant changes in decongestion as travel time and congestion costs increase exponentially as road capacity is exhausted. The latest available guidance on the value of reducing congestion is provided by RailCorp (2008) who recommend a decongestion value of 37.36 cents per vehicle kilometre (2008 prices).

Notwithstanding that congestion in Sydney is increasing into traditional off-peak periods and weekends, decongestion benefits are generally applied only during peak periods to reflect the higher congestion costs incurred. To reflect the assumption that decongestion benefits are accrued only during peak periods, the

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[21] An increase in cycle mode share from 1.0 percent to 1.1 percent would be considered a 10 percent increase in cycle mode share

[22] Using an OECD PPP exchange rate of £1 = $1.997

decongestion costs have been weighted by a factor of 68.4 percent, which reflects current guidance provided by the RTA on the distribution of traffic by time of day.

AECOM has adopted a decongestion rate of 27.06 cents per avoided vehicle kilometre travelled for 2010, indexed with real movements in average weekly earnings for future years.

7.3.3.2 Vehicle Operating Cost Savings

Vehicle operating cost savings are derived through the transfer of trips from car to bicycle. For the purposes of the economic appraisal, vehicle operating costs have been evaluated using the stop-start vehicle operating cost model as described in **Section 6.4.3**.

AECOM has adopted a vehicle operating saving rate of 31.94 cents per avoided vehicle kilometre for 2010. For future years, this rate is increased at a real rate of 2.65 percent per annum to reflect increases in input costs and a one percent decline in travel speed.

7.3.4 Parking Cost Savings

When travellers switch from car, travellers accrue a benefit through reduced car parking costs, which are not reflected in the calculation of vehicle operating costs. In addition, costs associated with parking facility infrastructure and maintenance are avoided.

PwC (2009) considers the avoided cost of infrastructure and maintenance and recommends a value of 1 cent per bicycle kilometre based on a study undertaken by the RTA. However, reduced expenditure for parking is not captured.

Very few attempts have been undertaken to estimate the average cost of parking in Sydney. One of the few studies undertaken on parking costs has been prepared by TDC (2006). Assuming that all drivers that pay for parking pay the equivalent of the prevailing casual rate, nominal average parking cost per trip in 2004 was estimated to be $0.39 across all drivers. A study undertaken by Hensher & King (2001) provides some further weight behind this calculation where they found the average parking fee paid by drivers into inner Sydney to be approximately $8. Based on the TDC (2006) finding that only 4 percent of trips require a payment for car parking, this would imply that for all drivers, the average parking cost would be $0.32 per trip.

It should be noted that this methodology accounts only for the actual parking costs incurred by private motorists. If costs including parking costs incurred by employers, potential for on-street parking underpricing and opportunity costs of land dedicated to car parking are taken into account, it is arguable that AECOM's approach to calculating average parking cost rate is conservative as it does not account for the externalities associated with providing parking space.

AECOM has adopted a parking cost saving of 53.1 cents per avoided car trip in 2010. Based on observations of historical growth in the cost of on and off-street parking in Sydney, a real increase in parking costs of 2 percent per annum have been assumed. It should be noted that this cost does not account for:

- Savings in parking costs incurred by others, in particular by employers;
- Underpricing of parking;
- The opportunity costs of land otherwise dedicated for car parking; and
- Any exogenous effects resulting from changes in parking levels.

7.3.4.1 Environmental Externalities

As travellers switch from car to cycling, reductions in the negative environmental externalities are accrued. Benefits from reduced environmental externalities from reduced vehicle travel are presented in **Table 7.10**.

Table 7.10: Positive Externalities from Reduced Car Travel

Externality	Benefit per Reduced VKT (¢/vehicle km) June 2010 Prices
Air pollution (cents/vehicle km)	2.77
Greenhouse gas emission	2.18
Noise pollution	0.90
Water Pollution	0.42
Urban Separation	0.64
Infrastructure provision	3.73

Source: RTA (2009a)

7.3.4.2 Car Accident Cost Savings

As travellers switch from car to bicycle, the reduction in car kilometres gives rise to car accident savings.

Assuming that cycling will displace car trips currently travelling on the local and sub-arterial road network, the car accident crash cost rate has been adjusted by applying the ratio in average urban crash costs between the human and willingness to pay approach of 1.345 to the average local/sub-arterial crash cost rate of 6.73 cents/vehicle kilometre to derive the accident rate using the willingness to pay approach. Accident rates are summarised in **Table 7.11.**

Table 7.11: Car Accident Cost Savings Rates

Approach	RTA Average Urban Cost per Crash (September 2009 Price)	Average Crash Cost Rate (June 2010 Prices)
Human capital approach	$66,000	6.73 cents/vehicle km
Willingness to pay approach	$88,800	9.06 cents/vehicle km

Source: RTA (2009a, b)

AECOM has adopted a car accident crash cost rate of 6.73 cents/vehicle kilometre in 2010. Sensitivity analysis has been undertaken with a car accident cost rate of 9.1 cents/vehicle kilometre in 2010. Future accident costs have been increased in line with real movements in average weekly earnings.

7.3.5 Train Specific Rates

7.3.5.1 Rail Long Run Marginal Cost Savings

CityRail services are heavily subsidised with farebox revenue falling well short of operating costs. To illustrate the extent to which costs exceed revenues, farebox recovery was estimated to be approximately 28 percent for the 2008/09 financial year. These levels of cost recovery are likely to continue into the foreseeable future unless working practice efficiencies or significant real increases in fare are realised.

A diversion of demand from rail to bicycle may provide scope for train service levels to be adjusted in response to a reduction in rail travel demand. Providing supply of services is sufficiently elastic, the NSW Government may be able to derive savings in the form of reduced operating subsidy payments associated by reducing service levels. However, the marginal costs associated with adjusting service levels are relatively low given significant fixed costs involved in providing rail services.

Calculating marginal costs for industries with large fixed costs such as the rail industry can pose challenges as lumpy investments cloud what costs are influenced by underlying movements in patronage. In calculating these marginal costs, a two-step approach was used by LECG (2008) which first identified the short run marginal costs which accounted for the operational costs of accommodating for an additional passenger. As a second step, the longer run capital costs were identified.

In order to identify short run marginal costs, LECG (2008) undertook a time series regression which explored the responsiveness of total costs (excluding depreciation, capital expenditure, write-offs and interest) to fluctuations in passenger kilometres. This analysis found that the cost of providing an additional seat kilometre is $0.333 (2007 prices).

An additional consideration is that a reduction in peak hour rail demand would defer the need to enhance capacity on the CityRail network, particularly during peak periods. Although recent initiatives such as the Clearways Program and the Rollingstock Public Private Partnership program have released additional capacity, the level of excess capacity in and out and through Sydney CBD during peak periods is limited and will require significant levels of investment to enhance. Indeed, future initiatives proposed by RailCorp and NSW Government including various metro rail and heavy rail enhancements point towards the strong desire to increase capacity through Sydney CBD.

The calculation of a long run marginal cost, or calculating the additional capital expenditure to cater for one extra passenger, requires a consideration of the capital costs associated with providing future infrastructure. Based on the capital costs provided as part of the Metropolitan Rail Expansion Program, announced in May 2006, LECG (2008) calculated that the long run marginal cost is equivalent to $5.90 per passenger (2007 prices). LECG note that the capital costs provided as part of the Metropolitan Rail Expansion Program are likely to be underestimated given the relative immaturity of the concept. Hence, the long run marginal cost estimated by LECG is considered to be conservative.

With significant excess capacity on the rail network during off-peak periods, the cost of providing additional capacity has been assumed to only apply to train trips switching to bicycle during peak period. A peak adjustment factor of 44.4 percent has been applied to the long run marginal cost, which reflects the current pattern that two thirds of weekday CityRail patronage is concentrated during the peak period. An average weekday to annual weekday demand factor of 220 has also been assumed.

The approach used to calculate the peak adjustment factor is shown in **Equation 7.1**. Variables used to calculate rail marginal cost savings are shown in **Table 7.12**.

Equation 7.1: Peak Hour Adjustment Factor

$$\text{PH factor} = \frac{\text{annual peak period demand}}{\text{annual demand}} = \frac{\frac{2}{3} \times \text{weekday demand} \times \text{average weekdays per year}}{\text{weekday demand} \times \text{annualisation factor}} = \frac{\frac{2}{3} \times 220}{330} = \frac{4}{9}$$

Table 7.12: Variables Used to Calculate Rail Marginal Cost Savings

Variable	Value
Cost of supplying a seat kilometre (2007 prices) based on LECG (2008)	$0.333
Cost of supplying a seat kilometre (June 2010 prices)	$0.354
Average trip distance displaced within study area	6.85km
Average marginal cost of supplying a seat (6.85km × 35.4 cents/km)	$2.425
Revenue per passenger for the 2009 financial year (June 2009 prices) based on RailCorp (2009)	$2.160
Revenue per passenger for the 2009 financial year (June 2010 prices)	$2.246
Operating subsidy per trip ($2.425 - $2.246)	$0.179
Long run marginal cost per trip (2007 prices) based on LECG (2008)	$5.900
Long run marginal cost per trip (June 2010 prices)	$6.266
Total rail marginal cost savings per trip ($0.179 + 4/9 × $6.266)	**$2.964**

Source: LECG (2008), RailCorp (2009)

AECOM has adopted 296.4 cents as the value of rail marginal cost savings for 2010. This value has been indexed with real movements in average weekly earnings.

7.3.5.2 Rail Externalities

As travellers switch from train to cycling, reductions in the negative environmental externalities are accrued albeit at a lower rate than for car or bus. Benefits from reduced environmental externalities from reduced train service kilometre are provided in **Table 7.13**.

Table 7.13: Positive Externalities from Reduced Rail Service Kilometres

Externality	Benefit per Reduced train kilometre (cents/service km) June 2010 Prices
Air pollution	4.13
Greenhouse gas emission	0.64
Noise pollution	2.04

Source: RailCorp (2008)

7.3.5.3 Rail Accidents

There is an associated benefit from the reduced exposure to train accidents as individuals shift from trains to bicycles. Train accident savings are calculated based on the accident costs shown in **Table 7.14**.

Table 7.14: Rail Accident Costs

Approach	Accident cost (cents/service km) June 2010 Prices
Human capital	0.053

Source: RailCorp (2008)

7.3.6 Bus Specific Rates

7.3.6.1 Bus Long Run Marginal Cost Savings

Although farebox recovery rates are higher for buses relative to trains and higher still for Sydney Buses operations, as with trains, bus operations in Sydney generally do not recover the full cost of providing services. Hence, if a reduction in bus patronage levels leads to a reduction in services, the level of operating subsidy required to be paid by Government can be reduced.

Unlike train services, bus operations in Sydney have greater degree of flexibility than trains in adjusting their services according to demand. As funding for service kilometres is constrained, NSW Transport & Iinfrastructure is incentivised to reallocate bus service kilometres from low patronage routes, and in some instances, across contract areas, to ensure that bus services kilometres are effectively used. Even under situations where kilometres are merely redistributed and hence leave overall costs unaffected, the redistribution generates benefits in the form of satisfying latent bus demand elsewhere and by deferring the need for future additions to capacity.

As with train costs, as bus costs are structured towards ensuring that peak hour demand is catered, reductions in peak hour patronage have a greater influence on the cost structure as fixed costs such as bus fleet size and consequently depot land are driven by the level of peak hour demand. As a proxy, AECOM have chosen to estimates prepared by INDEC (2009) for IPART, who indicate that the marginal cost of catering for an additional peak passenger on the Sydney Buses network is approximately $1.76 per passenger trip including capital costs.

There is some limit to how resources can be adjusted as there is a community expectation for bus operators to maintain a minimum level of service on some routes, particularly during off-peak periods. As with the train operating subsidy savings calculations, a peak adjustment factor of 44.4 percent has been applied to the overall subsidy per passenger estimate. This is to ensure that only reductions in service levels caused by reductions in peak period bus patronage are counted.

Variables used to estimate the level of bus long run marginal cost savings are shown in **Table 7.15**.

Table 7.15: Bus Long Run Marginal Cost Saving Calculations

Variable	Value
INDEC marginal cost per passenger trip on the Sydney Buses network (inc. capital)	$1.76
Peak adjustment factor	44.4%
Impact on subsidy	**$0.782/trip**

Source: AECOM calculations based on information contained on Sydney Buses in IPART (2009). Note: all monetary values are in June 2010 prices.

This estimate is consistent with AECOM analysis of Sydney Buses' farebox deficit where, post adjustment, operating savings per passenger trip excluding capital were estimated to be 64 cents per trip.

AECOM has adopted a bus operating subsidy saving of 78.2 cents per avoided bus trip in 2010 to reflect the impact of mode diversion to cycling on peak period operating subsidy requirements. The bus operating subsidy saving is assumed to change in line with movements in real average weekly earnings.

7.3.6.2 Bus Road Congestion Reduction

Reduced road congestion due to fewer bus services will generate road decongestion benefits. As buses occupy greater space and take longer to accelerate and decelerate, the decongestion benefits for buses are higher than for cars. According to CityRail guidance, the value of decongestion was 97.9 cents per bus service kilometre in 2008 prices, presumably for peak hour travel. Adjusting this value to ensure that decongestion benefits are only counted for reduced peak period travel, a factor of 44.4 percent has been applied (as applied previously), reducing the bus decongestion benefit to 43.5 cents per bus service kilometre.

Adjusting for movements in average weekly earnings since 2008, AECOM has adopted a bus decongestion rate of 46.1 cents per service kilometre.

7.3.6.3 Bus Environmental Externalities

As travellers switch from bus to cycling, reductions in the negative environmental externalities are accrued. Benefits from reduced environmental externalities from reduced bus service kilometres are presented in **Table 7.16**.

Table 7.16: Positive externalities from reduced bus kilometres

Externality	Benefit per Reduced Bus Service Kilometre (cents/service km) June 2010 Prices
Air pollution	28.98
Greenhouse gas emission	15.08
Noise pollution	4.41
Road damage	2.60

Source: RailCorp (2008)

7.3.6.4 Bus Accident Cost Savings

There is an associated benefit from the reduced exposure to bus accidents as individuals shift from bus to bicycle. Bus accident savings are calculated based on the accident costs given in **Table 7.17**.

Table 7.17: Bus Accident Costs

Approach	Bus Accident Costs (cents/service km) June 2010 Prices
Human capital	10.88

Source: RTA (2009a)

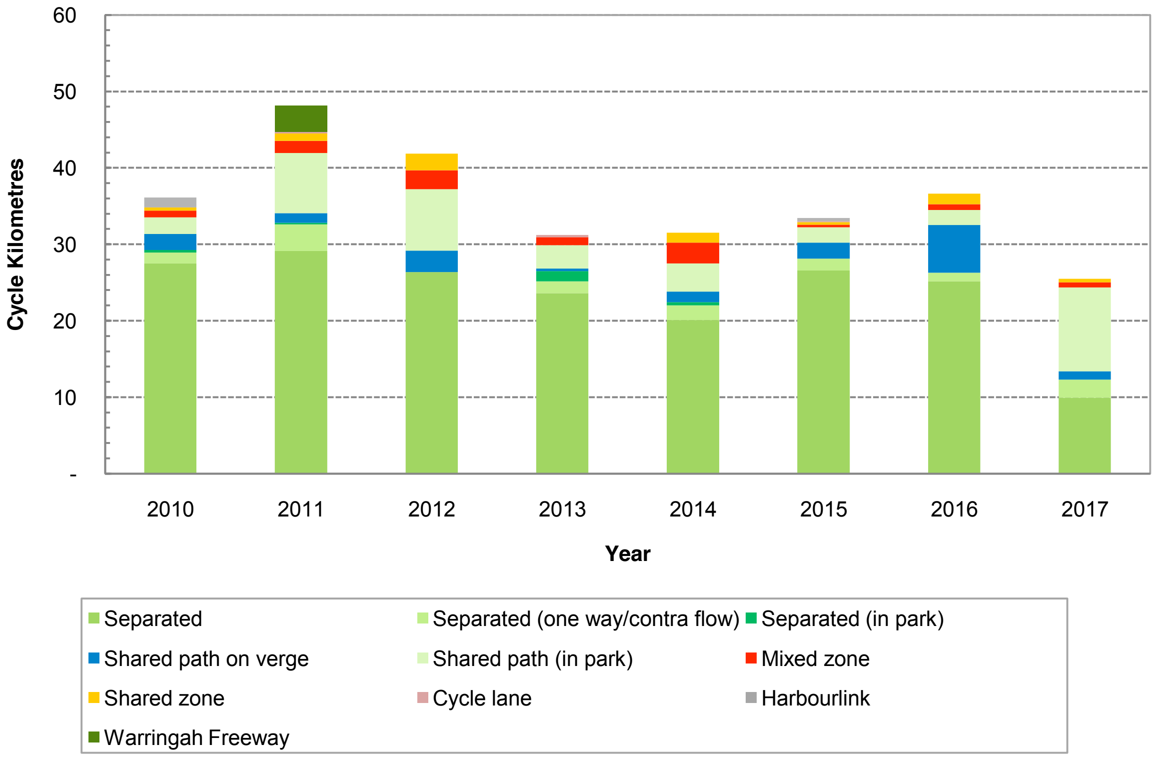
7.4 Project Costs

7.4.1 Construction Costs

The construction of the Inner Sydney Regional Bicycle Network is proposed to be staggered over a seven year period between 2010 and 2017. Separated cycleways, including HarbourLink and Warringah Freeway related works, account for 73.5 percent of total kilometres whilst shared paths much of the remaining network at 20.1 percent.

Figure 7.3 outlines the number of kilometres of the Inner Sydney Regional Bicycle Network to be constructed in accordance with the staging recommended by AECOM[23].

Figure 7.3: Cycle Paths Constructed by Type and Year



Source: AECOM calculations

Construction costs by year were estimated using construction cost rates provided by the City of Sydney for all facilities with the exception of costs associated with Warringah Freeway related works. Construction costs for Warringah Freeway have been sourced from North Sydney Council (2009), which suggest a construction cost rate

[23] As a prelude to this study, AECOM prepared the *Inner Sydney Regional Bike Plan: Implementation Strategy* on behalf of the City of Sydney which provided recommendations on the timing of all cycling links.

of approximately $10 million per kilometre. Construction costs for HarbourLink and Warringah Freeway related works are considerably higher than for all other treatment types as grade separation measures have been proposed. Construction costs are assumed to increase by 1 percent in real terms per annum. Assumed 2010 construction cost by treatment type is shown in **Table 7.18**.

Table 7.18: 2010 Construction Cost Rates

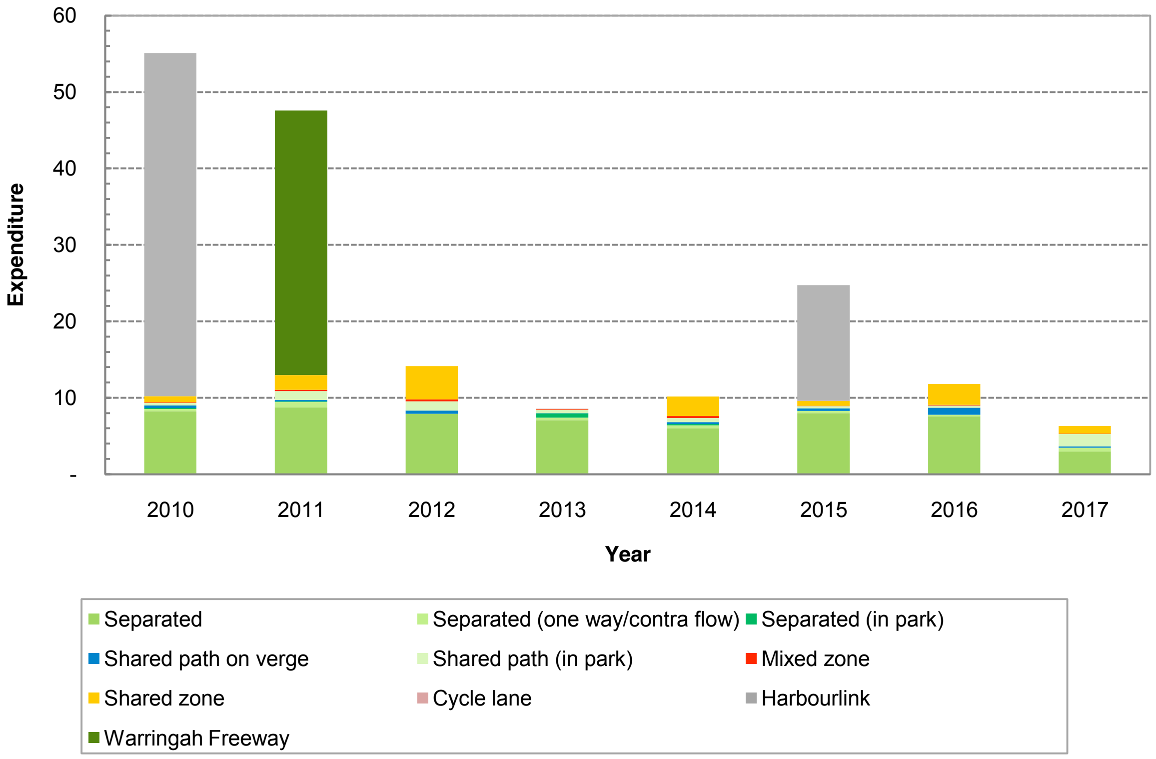
Treatment Type	Cost Rate ($/km)
Separated	300,000
Separated (one way/contra flow)	200,000
Separated (in park)	400,000
Shared path on verge	150,000
Shared path (in park)	150,000
Mixed traffic	100,000
Shared zone	2,000,000
Cycle lane (assumes green paint used for entire length)	150,000
HarbourLink	34,776,000
Warringah Freeway related works	10,000,000
Weighted average cost rate	**627,000**
Without HarbourLink and Warringah Freeway	**300,000**

Sources: City of Sydney, North Sydney Council (2009) and RTA[24]

The construction of separated cycleways is estimated to account for approximately one-third of total construction costs. Total undiscounted construction costs are estimated to be approximately $179 million including indexation. Although they provide a small contribution in terms of total kilometres, HarbourLink and Warringah Freeway related works are estimated to account for just over half of the anticipated capital costs. **Figure 7.4** provides a breakdown of capital expenditure by treatment type and by year, based on the unit rates shown in **Table 7.18**.

[24] Based on verbal discussions with the RTA

Figure 7.4: Cumulative (Nominal) Expenditure



Source: AECOM calculations. Note: construction costs have not been indexed in the above figure

7.4.2 Maintenance Costs

Maintenance costs have been set at 1 percent of the overall capital expenditure rate per kilometre. Using a weighted average construction cost of $627,000 per kilometre, this implies an annual maintenance cost rate of $6,270 per km. By comparison, the City of Melbourne (2008) spends approximately $2,000 per cycle kilometre on maintenance, albeit for lower quality cycling facilities.

Research compiled by the New Zealand Ministry of Tourism on cycle path maintenance suggests that a rate of one percent of construction costs is an appropriate proxy for maintenance costs, based on data shown in **Table 7.19.**

Table 7.19: Examples of Maintenance Cost Rates

Authority	Facility Type	Maintenance Cost per kilometre	Inner Sydney Regional Bicycle Network Capital Cost
NZTA	Footpath like facilities	NZ$2,000 per km	A$200,000 per km
NZ Department of Conservation	Off road cycle trails	NZ$5,000 per km	A$400,000 per km

Sources: NZ Ministry of Tourism (2009)

7.5 Network Wide Results

An assessment of the economic benefits generated from the implementation of the Inner Sydney Regional Bicycle Network has been undertaken at two levels:

- A network wide level where aggregate changes in cycling demand have been evaluated; and
- Origin-destination whereby corridor specific benefits and costs have been evaluated.

The economic appraisal has been undertaken by appraising the differences in demand between the Do Nothing Scenario and two alternative demand scenarios whereby the impact of the implementation of the Inner Sydney Regional Bicycle Network has been modelled. Economic benefits under the Policy Target Scenario were appraised based on the increase in cycling following the achievement of pre-specified mode share targets. Economic benefits under the AECOM Estimate were appraised based on the increase in cycling created by a mode shift towards cycling, which were modelled using an incremental choice model.

In interpreting the results for Policy Target Scenario, it should be noted that the projected levels of cycling are in excess of demand levels in the AECOM Estimate, whereby usage was predicted solely through the use of the incremental choice model. In this light, it is considered likely that additional initiatives and interventions will be required to deliver the level of estimated usage and economic benefits under the Policy Target Scenario, the costs of which have not been included as part of this appraisal. Hence, the level of economic benefits for the Policy Target Scenario should be considered as an upper bound.

Net economic benefits generated across the study area are discussed in this section whilst net economic benefits generated by each corridor are discussed in **Section 7.6**.

7.5.1 Headline Results

The full implementation of the Inner Sydney Regional Bicycle Network is predicted to have the potential to generate significant economic benefits in excess of the economic costs. Relative to the Do Nothing Scenario, the Policy Target Scenario and AECOM Estimate are anticipated to generate net economic benefits of up to $1.8 billion and $507 million respectively. Economic benefits are expected to be generated at reasonably high multiples of cost. For the Policy Target Scenario and AECOM Estimate respectively, the benefit-cost ratios are estimated to be 11.08 and 3.88 whilst the net present value per dollar of investment is estimated to be $11.55 and $3.30.

The net economic benefits of the Inner Sydney Regional Bicycle Network are unlikely to be sensitive to sensible variations in the cost of capital. The internal rates of return for the Policy Target Scenario and the AECOM Estimate are estimated to be 62.4 percent and 27.1 percent respectively.

Network wide economic indicators are shown in **Table 7.20** for the Policy Target Scenario and the AECOM Estimate.

Table 7.20: Network Wide Appraisal Results (Millions of 2010 Dollars)

Criteria	Policy Target Scenario	AECOM Estimate
Present value of benefits	1,948.3	682.3
Present value of investments	153.4	153.4
Present value of all costs	175.8	175.8
NPV	**1,772.5**	**506.5**
NPVI	**11.55**	**3.30**
BCR	**11.08**	**3.88**
IRR	**62.4%**	**27.1%**

Source: AECOM calculations. All monetary values have been discounted at a real rate of 7 percent per annum over an evaluation period of 30 years and are valued in 2010 prices. Public bicycle benefits have been excluded.

7.5.2 Distribution of Benefits

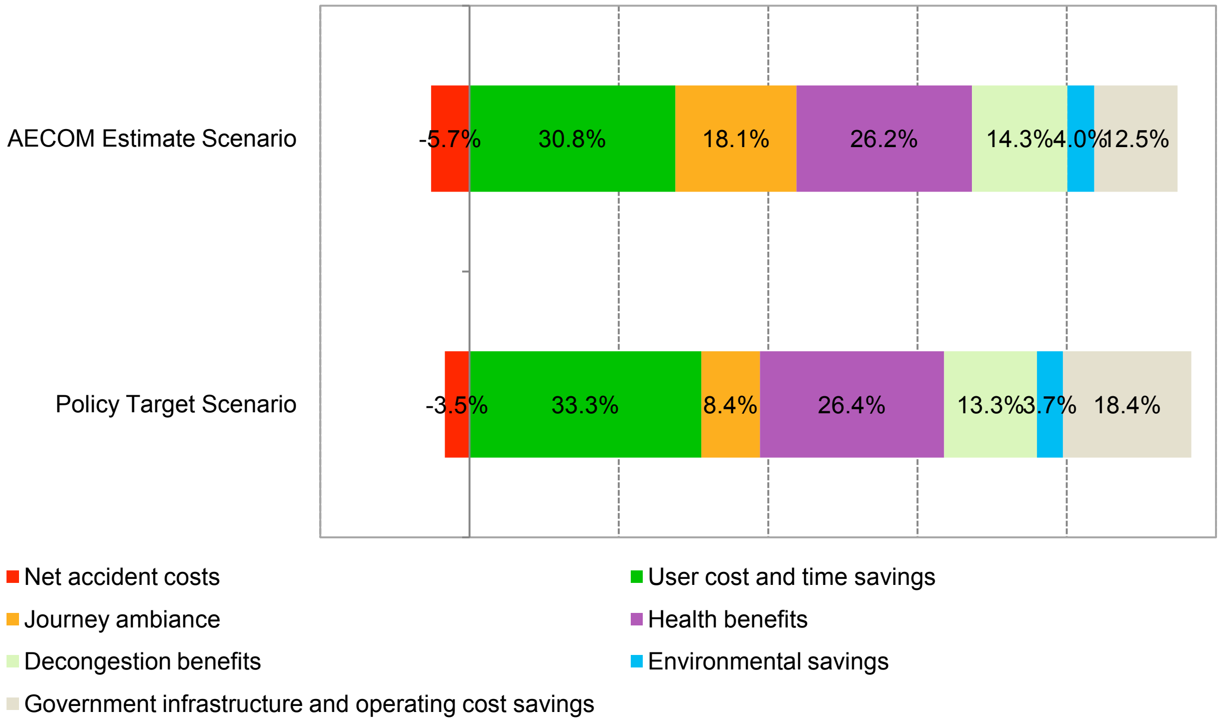
The breakdown of benefits indicates that significant benefits will be accrued by individuals, government and the general economy through the full development of the Inner Sydney Regional Bicycle Network.

Travellers stand to benefit through travel time savings, avoided car costs, journey ambiance and health benefits at the cost of a relatively small increase in accident costs. These benefits collectively account for 38 percent and 48 percent of benefits when health benefits are not included, rising to 65 percent and 69 percent of benefits under the Policy Target Scenario and AECOM Estimate respectively when health benefits are included.

There are also material benefits accruable for government and the broader economy through road and public infrastructure and operating cost savings, environmental benefits, congestion reduction and health benefits. Collectively, these benefits account for 35 percent and 31 percent of benefits excluding health benefits, rising to 62 percent and 52 percent of benefits under the Policy Target Scenario and AECOM Estimate respectively when health benefits are included.

A high level breakdown of benefits is shown in **Figure 7.5** and **Table 7.21**. A detailed breakdown of benefits is shown in **Table 7.22**, **Figure 7.6** and **Figure 7.7**.

Figure 7.5: High Level Distribution of Benefits by Type and Recipient



Source: AECOM calculations. All monetary values have been discounted at a real rate of 7 percent per annum over an evaluation period of 30 years and are valued in 2010 prices.

Table 7.21: High Level Breakdown of Benefits (Millions of 2010 Dollars)

Benefit Type	Policy Target Scenario		AECOM Estimate	
	Benefit ($m)	Contribution	Benefit ($m)	Contribution
User cost and time savings	648.0	33.3%	211.0	30.9%
Net accident costs	-68.7	-3.5%	-16.3	-2.4%
Journey ambiance	164.1	8.4%	129.8	19.0%
Health benefits	514.1	26.4%	147.3	21.6%
Decongestion benefits	259.6	13.3%	97.8	14.3%
Environmental savings	72.3	3.7%	27.3	4.0%
Govt. infrastructure and operating cost savings	358.9	18.4%	85.4	12.5%
Total	**1,948.3**	**100.0%**	**682.3**	**100.0%**

Source: AECOM calculations. All monetary values have been discounted at a real rate of 7 percent per annum over an evaluation period of 30 years and are valued in 2010 prices. Public bicycle benefits are excluded.

Table 7.22: Detailed Breakdown of Benefits by Benefit Type (Millions of 2010 Dollars)

Stream	Policy Target Scenario		AECOM Estimate	
	Benefit ($m)	Contribution	Benefit ($m)	Contribution
Decongestion benefit	259.6	13.33%	97.8	14.33%
Air pollution reduction	32.6	1.67%	12.3	1.81%
Noise reduction	8.7	0.45%	3.3	0.48%
Greenhouse gas reduction	22.7	1.17%	8.6	1.26%
Water pollution	3.3	0.17%	1.2	0.18%
Urban separation	5.0	0.26%	1.9	0.28%
Vehicle operating cost savings	141.6	7.27%	53.3	7.81%
Parking cost savings	63.8	3.27%	14.1	2.07%
Road infrastructure savings	34.4	1.76%	12.9	1.90%
Bus long run marginal cost savings	89.4	4.59%	19.0	2.79%
Train long run marginal cost savings	235.1	12.07%	53.5	7.84%
Car accident costs	60.3	3.09%	22.7	3.32%
Bus accident costs	4.1	0.21%	1.6	0.23%
Train accident costs	0.0	0.00%	0.0	0.00%
Net cycle accident costs	-133.1	-6.83%	-40.6	-5.94%
Travel time savings	442.6	22.72%	143.6	21.05%
Sub-total: "traditional" benefits	**1,270.2**	**65.2%**	**405.2**	**59.4%**
Reduced mortality	140.2	7.20%	40.2	5.89%
Absenteeism and productivity benefits	373.9	19.19%	107.1	15.70%
Journey ambiance	164.1	8.42%	129.8	19.03%
Sub-total: cycling specific benefits	**678.1**	**34.8%**	**277.1**	**40.6%**
Total	**1,948.3**	**100.0%**	**682.3**	**100.0%**

Source: AECOM calculations. All monetary values have been discounted at a real rate of 7 percent per annum over an evaluation period of 30 years and are valued in 2010 prices. Public bicycle benefits are excluded.

Figure 7.6: Breakdown of Benefits Under Policy Target Scenario

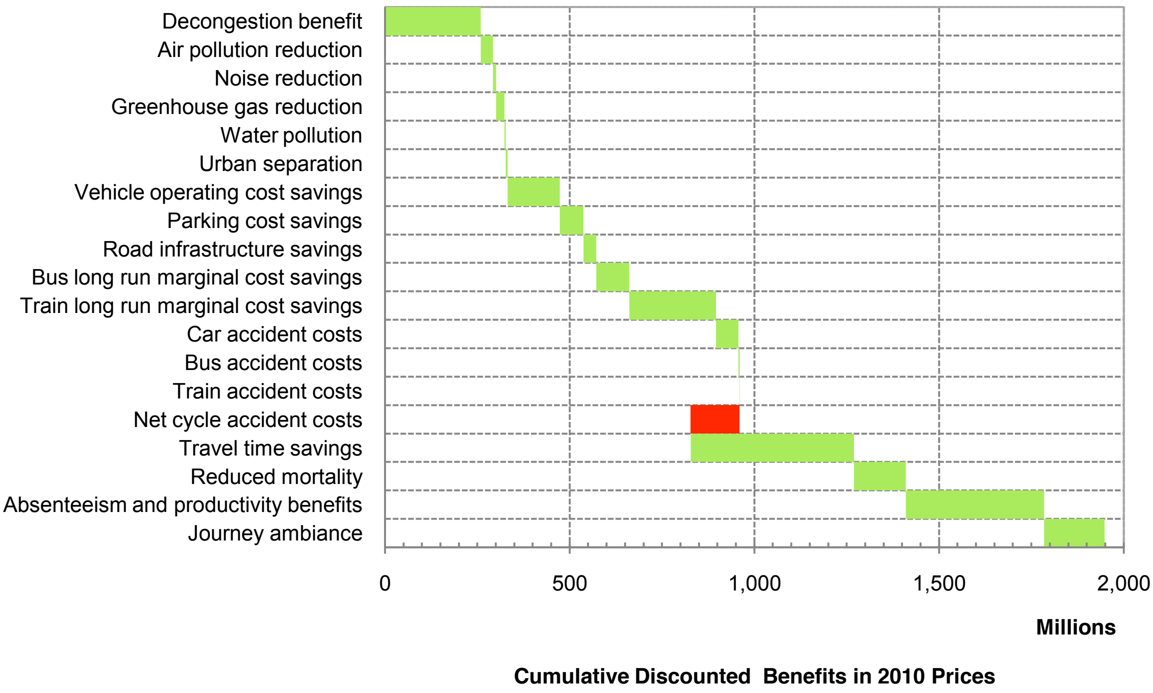
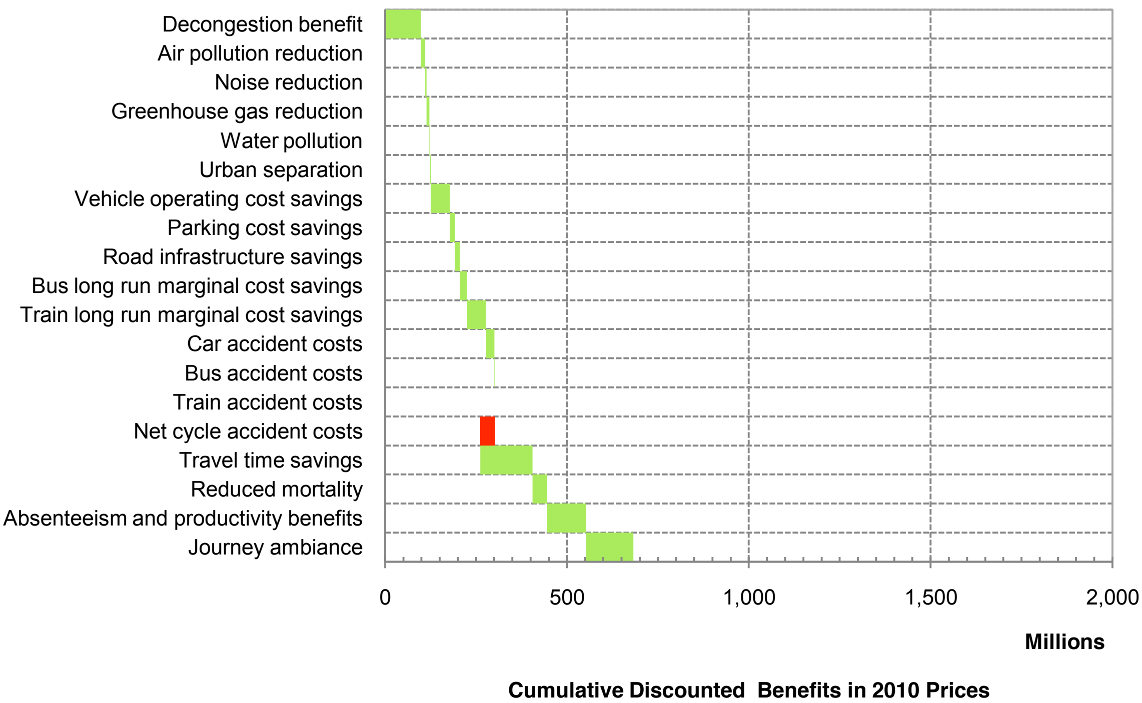


Figure 7.7: Breakdown of Benefits Under AECOM Estimates



Source: AECOM calculations. All monetary values have been discounted at a real rate of 7 percent per annum over an evaluation period of 30 years and are valued in 2010 prices. Public bicycle benefits are excluded.

The breakdown of the benefits by individual benefit stream also demonstrates the importance of recognising cycling specific benefits. Collectively, health benefits and journey ambiance provide a significant uplift in overall benefits, accounting for 35 percent and 41 percent of total benefits under the Policy Target Scenario and AECOM Estimate respectively.

Even so, the Inner Sydney Regional Bicycle Network is still economically viable even if a "traditional" approach i.e. removing health and journey ambiance benefits was used. Under a traditional approach where health and journey ambiance benefits would have been excluded, the net economic benefits are estimated to be $1.1 billion and $229 million for the Policy Target Scenario and AECOM Estimate respectively, or benefit-cost ratios of 7.23 and 2.30 respectively even without public bicycle related benefits being included.

Differences in economic outcomes using a "traditional" approach are shown in **Table 7.23**.

Table 7.23: Economic Benefits (Without Public Bicycle)

Criteria	"Traditional" Approach		With Cycle Specific Benefits	
	Policy Target Scenario	AECOM Estimate	Policy Target Scenario	AECOM Estimate
Present value of benefits	1,270.2	405.2	1,948.3	682.3
Present value of costs	175.8	175.8	175.8	175.8
NPV	**1,094.4**	**229.4**	**1,772.5**	**506.5**
BCR	**7.23**	**2.30**	**11.08**	**3.88**

Source: AECOM calculations. All monetary values have been discounted at a real rate of 7 percent per annum over an evaluation period of 30 years and are valued in 2010 prices. Public bicycle benefits are not included.

7.5.3 Contribution of Benefits under Public Bicycle Scheme

AECOM was requested to appraise the economic benefits associated with increase in public bicycle demand created by the implementation of the Inner Sydney Regional Bicycle Network.

The increase in demand for public bicycle created by the implementation of the Inner Sydney Regional Bicycle Network is estimated to be worth an additional $87 million in net economic benefits under the Policy Target Scenario and an additional $81 million under the AECOM Estimate, increasing the benefit-cost ratios to 11.58 and 4.34 for the Policy Target Scenario and the AECOM Estimate respectively. The slight difference in benefits between the two scenarios can be attributed to the differences in accident costs. Under the Policy Target Scenario, as aggregate cycling demand is significantly higher to achieve the target mode shares, the cycle accident rate is somewhat lower than under the AECOM Estimate.

Net economic benefits attributable to the Inner Sydney Regional Bicycle Network, with and without the change in public bicycle demand are shown in **Table 7.24**. A detailed breakdown of benefits from the change in public bicycle demand is shown in **Table 7.25**. A key difference in the breakdown of benefits between the appraisal of the Inner Sydney Regional Bicycle Network and the change in public bicycle demand is that total travel time savings are negative for public bicycle. This is as a slower cycling speed has been assumed for public bicycle trips.

Table 7.24: Network Wide Appraisal Results (Millions of 2010 Dollars)

Criteria	Without Public Bicycle Scheme		With Public Bicycle Scheme	
	Policy Target Scenario	AECOM Estimate	Policy Target Scenario	AECOM Estimate
Present value of benefits	1,948.3	682.3	2,035.3	762.9
Present value of investments	153.4	153.4	153.4	153.4
Present value of all costs	175.8	175.8	175.8	175.8
NPV	**1,772.5**	**506.5**	**1,859.5**	**587.1**
NPVI	**11.55**	**3.30**	**12.12**	**3.83**
BCR	**11.08**	**3.88**	**11.58**	**4.34**
IRR	**62.4%**	**27.1%**	**64.8%**	**29.9%**

Source: AECOM calculations. All monetary values have been discounted at a real rate of 7 percent per annum over an evaluation period of 30 years and are valued in 2010 prices.

Table 7.25: Detailed Breakdown of Public Bicycle Benefits by Benefit Type (Millions of 2010 Dollars)

Stream	Policy Target Scenario		AECOM Estimate	
	Benefit	Contribution	Benefit	Contribution
Decongestion benefit	6.2	7.1%	6.2	7.7%
Air pollution reduction	1.4	1.6%	1.4	1.7%
Noise reduction	0.3	0.3%	0.3	0.4%
Greenhouse gas reduction	0.8	1.0%	0.8	1.0%
Water pollution	0.1	0.1%	0.1	0.1%
Urban separation	0.1	0.1%	0.1	0.1%
Vehicle operating cost savings	2.7	3.1%	2.7	3.4%
Parking cost savings	4.5	5.2%	4.5	5.6%
Road infrastructure savings	0.7	0.8%	0.7	0.9%
Bus long run marginal cost savings	10.4	11.9%	10.4	12.9%
Train long run marginal cost savings	25.4	29.2%	25.4	31.5%
Car accident costs	1.2	1.3%	1.2	1.4%
Bus accident costs	0.4	0.4%	0.4	0.5%
Train accident costs	0.0	0.0%	0.0	0.0%
Net cycle accident costs	-6.2	-7.2%	-12.6	-15.7%
Travel time savings	-19.0	-21.9%	-19.0	-23.6%
Sub-total: “traditional” benefits	**28.9**	**33.3%**	**22.6**	**28.0%**
Reduced mortality	10.3	11.8%	10.3	12.8%
Absenteeism and productivity benefits	27.4	31.5%	27.4	34.0%
Journey ambiance	19.4	22.3%	19.4	24.0%
(Net) willingness to pay for public bicycles	0.9	1.1%	0.9	1.2%
Sub-total: cycling specific benefits	**58.0**	**66.7%**	**58.0**	**72.0%**
Total	**87.0**	**100.0%**	**80.6**	**100.0%**

Source: AECOM calculations. All monetary values have been discounted at a real rate of 7 percent per annum over an evaluation period of 30 years and are valued in 2010 prices.

It is stressed that AECOM has not attempted to appraise the economic benefits of a public bicycle scheme in its entirety. Furthermore, the economic benefits are dependent on the ultimate scheme design, the parameters of which have not been established. The assumptions used by AECOM to estimate the incremental change in public bicycle demand created by the implementation of the Inner Sydney Regional Bicycle Network have been outlined in **Section 6.5**.

7.5.4 Sensitivity Analysis

The following sensitivity tests were undertaken to assess the robustness of the business case for the Inner Sydney Regional Bicycle Network:

Discount rates:	4 percent and 10 percent
Construction costs:	An increase of 30 percent in construction and maintenance costs
Accident costs:	Use of higher accident costs through the willingness to pay approach
Journey ambiance:	Testing of higher journey ambiance rates in line with Wardman et al. (2007), whereby separated off-road travel is valued at 38.3 cents per minute (or 91.9 cents per cycle kilometre) and cycle lane travel is valued at 28.7 cents per minute (or 86.1 cents per cycle kilometre)
Health benefits:	Testing using a higher unit rate of 46 cents/cycle kilometre, which includes morbidity benefits estimated by Ker (2004)
Demand:	Reduction by 20 percent by reducing the annualisation factor from 330 to 264
Distance cap:	Removal of cycle trips longer than 12km

The results of the sensitivity analysis indicated that economic outcomes are robust to realistic variations in key inputs. However, the net economic outcomes appear to be most sensitive to variations in construction costs, whereby a 30 percent increase in construction costs resulted in a decrease in the benefit-cost ratio to 2.02. The results of the sensitivity tests are shown in **Table 7.26**.

Table 7.26: Sensitivity Test Results (BCR)

Sensitivity Test	Lower Case	Upper Case	Lower Case BCRs		Upper Case BCRs	
			Policy Target Scenario	AECOM Estimate	Policy Target Scenario	AECOM Estimate
Discount rate	10% discount rate	4% discount rate	8.39	2.93	15.06	5.33
Construction costs	30% increase in costs		5.78	2.02		
Accident costs	WTP accident rates		10.94	3.85		
Journey ambiance		Wardman et al. (2007)			17.59	9.01
Health benefits		Ker (2004)			16.4	5.41
Fluctuations in cycling demand	20% decrease in demand		8.87	3.11		
Distance cap	No cycle trips beyond 12km		9.76	2.86		

Source: AECOM calculations. All monetary values have been discounted at a real rate of 7 percent per annum (unless otherwise stated) over an evaluation period of 30 years and are valued in 2010 prices. Public bicycle benefits have been excluded.

7.6 Incremental Cost Benefit Appraisal

To inform the prioritisation of the Inner Sydney Regional Bicycle Network, an incremental cost benefit analysis has been undertaken. The incremental cost benefit analysis allows for the incremental benefits generated by one section of the network to be compared against the incremental costs expected to be incurred for that section.

7.6.1 Results for the City of Sydney

When demand for trips within the City of Sydney Council area are considered only, the economic desirability of completing the sections of the Inner Sydney Regional Bicycle Network within the council area is considered to be high. The net present value of developing the network within the council area is estimated to be $113 million and $38 million under the Policy Target Scenario and AECOM Estimate. The corresponding benefit cost ratios are estimated to be 7.96 and 3.34.

The City of Sydney's share of economic benefits from the full implementation of the Inner Sydney Regional Bicycle Network is shown in **Table 7.27**.

Table 7.27: Incremental Cost-Benefit Analysis for the City of Sydney (Millions of 2010 Dollars)

Variable	Policy Target Scenario	AECOM Estimate
Present value of benefits	147.9	58.5
Present value of costs	16.2	16.2
NPV	131.8	42.3
BCR	9.14	3.61

Source: AECOM calculations. Costs and benefits have been evaluated over a 30 year evaluation period and discounted at a real discount rate of 7 percent. Excludes benefits from public bicycle demand.

7.6.2 Results for Other Inter-LGA Trips

In a network context, undertaking an incremental cost benefit analysis for each individual link is complex. Incremental cost benefit analysis is complicated by the common use of certain links on the network, which are difficult to disaggregate. To simplify the analysis, the following steps have been undertaken:

- The incremental cost benefit analysis has been undertaken to include inter LGA trips;
- The benefits accrued by the generation of additional intra-SLA trips have not included;
- No costs assigned for origin-destination pairs which have no demand;
- Costs for a given origin-destination pair have been based on the proportion of the network used; and
- A network wide sharing factor has been applied to constrain the sum of costs to the network wide cost.

Under constrained funding conditions, the benefit-cost ratio is the preferred means of rationing capital. Of 231 possible origin-destination pairs, rankings for 65 pairs by BCR have been estimated, where there is a non-zero level of demand.

For the Policy Target Scenario, the benefit-cost ranking appears to favour pairs where the construction costs are expected to be low and/or where the proportional change in demand is anticipated to be high, whereby areas with little cycling demand have been assumed to see large shifts towards cycling. Of the top ten origin-destination pairs, only three are Sydney CBD focused. The top-ten benefit cost ratios under the Policy Target Scenario are shown in **Table 7.28**.

Table 7.28: Top 10 Origin-Destination BCRs under Policy Target Scenario

BCR Ranking	Origin LGA	Destination LGA	BCR	Cumulative Cost
1	Botany	Rockdale	34.57	2,242,000
2	Randwick	Sydney	32.59	3,581,000
3	Lane Cove	Ryde	31.49	4,477,000
4	Canterbury	Hurstville	30.85	5,601,000
5	Lane Cove	Willoughby	27.65	8,015,000
6	Kogarah	Rockdale	23.75	10,187,000
7	Canada Bay	Sydney	21.97	12,410,000
8	Hurstville	Rockdale	19.13	13,700,000
9	Woollahra	Sydney	14.29	14,501,000
10	Hunters Hill	Leichhardt	13.61	16,365,000

The incremental cost benefit ratios are somewhat lower under the AECOM Estimate. However, the prioritisation is more Sydney CBD centric from origins in the Inner West and Eastern Suburbs, in line with current demand patterns. Of the top ten origin destination pairs, only two pairs are not Sydney CBD bound. The top-ten benefit cost ratios under the AECOM Estimate are shown in **Table 7.29**.

Table 7.29: Top 10 Origin-Destination BCRs under AECOM Estimate

BCR Ranking	Origin LGA	Destination LGA	BCR	Cumulative Cost
1	Randwick	Sydney	54.14	2,242,000
2	Marrickville	Sydney	21.29	3,581,000
3	Botany	Randwick	13.99	4,477,000
4	Leichhardt	Sydney	13.24	5,601,000
5	Waverley	Sydney	11.92	8,015,000
6	Rockdale	Sydney	9.20	10,187,000
7	Canterbury	Sydney	5.23	12,410,000
8	Woollahra	Sydney	5.18	13,700,000
9	Botany	Rockdale	5.14	14,501,000
10	Botany	Sydney	5.01	16,365,000

It is worth noting that the high costs of developing HarbourLink and cycleways along the Warringah Freeway have influenced relative rankings, so that corridors that require a crossing of Sydney Harbour rank poorly.

Rankings for all origin-destination pairs where a non-zero level of demand is forecast are provided in **Appendix D.** It should be stressed that as intra-SLA demand has been explicitly excluded, the BCRs presented for each corridor may be considered to be conservative to the extent that a proportion of costs for developing the network could be attributed to intra-SLA demand.

7.7 Non-Monetised Cycling Benefits and Costs

In addition to the monetised benefits and costs considered in **Sections 7.5**and **7.6**, there are a range of benefits and costs that have not been quantified. These benefits and costs are discussed as follows:

Journey Time Reliability

Journey time reliability refers to the level of variation in travellers' journey times. These variations can be due to (unpredictable) variability in recurrent congestion at the same time of day or (unpredictable) variability in non-recurrent factors such as incidents (DfT, 2009b).

Cyclists generally enjoy consistent and reliable travel times given their relative independency of traffic conditions to motorised vehicles (TfL, 2009). Therefore, travellers switching from motorised modes can benefit from an increase in journey time reliability.

Decrowding Benefits

The diversion of demand away from the car, train and bus networks to bicycle will lead to some capacity being freed. As mentioned above, in this study it is assumed that future supply of road and public transport will be sufficiently elastic to adjust to the reduction in demand caused by a shift in demand to cycling. However, in the short run, this spare capacity is available for any latent demand to use. It should be noted that neither these benefits nor the additional patronage that may result from decrowding has been included as part of the monetised appraisal analysis.

Integration with Other Modes

Multimodal trips, with part of a trip undertaken by bicycle, have not been accounted for in the demand model used in this study. Multimodal trips are difficult to model since current bicycle interchanging is very low and seemingly reliant on the availability and quality of facilities. Yet, cycling still offers the potential to increase the catchment of public transport interchanges (Parsons Brinckerhoff, 2009b).

Option Values

Travellers may place a value on having the possibility to cycle regardless of whether they become actual users of the cycling facilities or not. The provision of safe and appealing walking and cycling infrastructure will provide a greater number of transport options available to people, although they may remain on alternative modes.

Equity

Effective cycling infrastructure provides low cost transport access for all people, namely the young and those without access to a licence or to a car, as well as extending the reach of public transport. Cycling can therefore provide a mode of transport and a greater sense of independence to disadvantaged groups.

Reduced Energy Dependence

Switching to cycling can avoid the dependency on using petrol dependent transport modes, resulting in cost savings and environmental benefits.

Wider Economic Benefits

Cycling may also lead to spill over effects on the local economy through increasing the accessibility to retail or tourism areas where visitors are prone to spend. Furthermore, cycling can offer a means to travellers to access a broader set of labour markets.

7.8 Comparability with PwC Unit Rates

In 2009 the RTA and DECCW commissioned PricewaterhouseCoopers to develop a set of economic benefit unit rates applicable for the evaluation of investments in cycling programs in NSW.

Most benefits identified by PricewaterhouseCoopers (2009) are largely based on existing guidance for road and, to a lesser extent, on public transport appraisals. A number of broad assumptions regarding mode diversion were also made as part of this study. Given that AECOM's demand estimation accounts for localised mode shifts, broad assumptions regarding mode diversion are less relevant. AECOM also considered a wider range of cycling benefits, disaggregated by mode to better measure the effects of localised mode diversion.

Although the use of mode-specific unit rates assist in estimating the benefits more precisely, AECOM has converted all unit rates into values expressed in cents per cycle kilometre to increase comparability with the PwC (2009) rates. **Table 7.30** summarises the key assumptions and differences between AECOM's and PwC's unit rates:

Table 7.30: Underlying Factors Driving Differences in Unit Rate Values

Underlying assumptions	• Average cycling trip length of 9km for new cycle trips; • Average annual distance cycled per cyclist of 2258 km; • Network wide mode diversion factors of 52.5%, 19.8% and 27.7% for car, train and bus, respectively; • Average car occupancy of 1.35; • Ratio of 223.4 passenger kilometres per train service kilometre; • Ratio of 15.5 passenger kilometres per bus service kilometre.
Consideration of additional benefits	• Journey ambiance; • Travel time savings; • Externalities related to reduced bus and train travel; • Absenteeism savings; and • Savings in operating cost subsidies for train and buses.
Revision of unit rate calculations	• Parking costs; and • Reduced (all-cause) mortality.

7.8.1 Net Benefits per Cycle Kilometre

Updated values for the PwC (2009) rates are shown in **Table 7.31** along with the net benefit of cycling per bicycle kilometre. Following indexation to June 2010 prices, PwC's net benefit is estimated to be approximately 50 cents per cycle kilometre. By comparison, AECOM's net cycling benefit is 84 cents per cycle kilometre, an increase of approximately 68 percent if accidents are valued using the human capital approach and 79 cents per cycle kilometre, or an increase of 59 percent, if accidents are valued using the willingness to pay approach.

Table 7.31: Comparison of PwC (2009) and AECOM (2010) Unit Rate Values per Cycle Kilometre in June 2010 Prices

Benefit Stream	PwC		AECOM			
	Bicycle	Car	Bicycle	Car	Train	Bus
Decongestion		25.61		10.52[25]		0.82
Vehicle operating costs savings		16.47		12.42		
Parking cost savings		1.10		3.10		
Travel time savings		NIL	13.20[26]			
Journey ambiance – on road cycle lanes		NIL	8.91			
Journey ambiance – Separated Cycleway		NIL	11.66			
Reduced mortality	1.50		6.00			
Absenteeism savings	NIL		16.70			
Accident costs – human capital approach	-2.14		-16.36	2.62	0.000	0.19
Accident costs – WTP approach			-22.01	3.52		
Air pollution		1.79		1.08	0.004	0.52
Noise pollution		0.88		0.35	0.002	0.08
Greenhouse gas reduction		0.68		0.85	0.001	0.27
Water pollution				0.16		
Urban separation				0.25		
Provision of infrastructure and services		4.04		1.45	6.52	2.45
Total cycling benefit (Human Capital)	49.93		83.77			
Total cycling benefit (Willingness to Pay)	N/A		79.03			

[25] AECOM's congestion benefit rate has been adapted so that it can be applied on all cycling demand whereas the PwC congestion benefit rate is to be applied only on weekday peak cycling demand.

[26] Travel time savings are calculated by dividing the total value of travel time savings by total hours saved and then dividing this number by the average cycling speed.

7.9 Summary

Based on the demand forecasts presented in **Section 6.0**, AECOM undertook an economic appraisal using cycle specific benefits including health benefits and journey ambiance. Relative to a review against unit rates recommended by PwC, there is scope for additional benefit streams to be incorporated as part of a cycling appraisal framework and for benefits to be adjusted according to local conditions.

Using a new set of cycling benefit rates, it is estimated that the AECOM Estimate net economic benefits accruing from the development of the Inner Sydney Regional Bicycle Network, over a 30 year evaluation period and discounted at a real rate of 7 percent, is $507 million at a benefit cost ratio of 3.88. If the Government's cycle mode share targets were to be achieved under the Policy Target Scenario, the economic benefits are estimated to be worth up to $1.8 billion at a BCR of 11.08. Health benefits, decongestion, journey ambiance and travel time saving are the key benefit streams, collectively accounting for approximately three quarters of total benefits.

Even if cycling specific benefits such as health and journey ambiance benefits are removed from the analysis, the Strategic Bicycle Network is still estimated to produce economic benefits in excess of costs.

Furthermore, sensitivity analysis has been undertaken to test the sensitivity of economic benefits with respect to higher capital costs, higher construction costs and lower demand. All sensitivity tests show that the economic viability of developing the Strategic Bicycle Network is invariant to sensible variations in construction costs, discount rates or demand.

Indeed, the economic benefits of the Strategic Bicycle Network may well be higher if more aggressive assumptions on the level of health benefits and journey ambiance were used. In addition, the development of the Strategic Bicycle Network is likely to enhance outcomes that have not been monetised including journey reliability, decrowding benefits, multimodal integration, equity, reduced energy dependence and localised economic activity.

A breakdown of demand by inter-LGA travel indicates that prioritisation can enhance the delivery of economic returns. The incremental cost benefit analysis supports the development of the Bicycle Network within the City of Sydney as well as placing a high priority on radial links from the Inner West and the Eastern Suburbs feeding into the city. On the other hand, the incremental cost-benefit analysis indicates that the economic case for developing corridors from the North Shore into Sydney CBD is highly constrained by the high construction costs associated with developing HarbourLink and cycleways along the Warringah Freeway despite the potential for higher levels of cycling demand.

8.0 Conclusions and Recommendations

AECOM was commissioned by the City of Sydney to determine the economic desirability of developing the Inner Sydney Regional Bicycle Network. The Inner Sydney Regional Bicycle Network is a proposed radial and cross-regional cycling network for Sydney, designed to provide greater connectivity and segregation for cyclists between key destinations and along important arterial routes within inner Sydney. The proposal calls for the implementation of 284 kilometres of separated cycleways and shared paths.

The bicycle network in inner Sydney is fragmented and disjointed, with limited historic coordination between various levels of Government to develop a cohesive network. The lack of quality cycling infrastructure and the perceived dangers associated with mixing with general traffic are major hurdles identified by potential cyclists as the key factor in suppressing cycling within Sydney. The development of the Inner Sydney Regional Bicycle Network would be a major step towards overcoming the lack of quality cycling infrastructure, identified as a key factor in suppressing take-up of cycling in Sydney. The Inner Sydney Regional Bicycle Network will support State and local government objectives to increase future cycle mode shares and will contribute to alleviating congestion on both the road and public transport networks.

International and domestic experience demonstrate that the provision of separated cycleways, paths provided for the exclusive use of cyclists whereby cyclists are segregated from general traffic by a physical barrier, have a significant influence on emolliating safety concerns potential cyclists may have.

AECOM undertook an assessment of three demand scenarios to measure the impact of the Inner Sydney Regional Bicycle Network on current levels of cycling:

Do Nothing Scenario:	A base case scenario whereby no changes in cycling infrastructure are assumed. Cycling mode share are anticipated to increase modestly over time due to increases in travel times and costs for car, train and bus relative to cycling.
Policy Target Scenario:	Assumes that the Inner Sydney Regional Bicycle Network will generate levels of mode shift from present levels in line with mode share targets that are consistent with the NSW State Plan.
AECOM Estimate:	Represents AECOM's estimate of the change in cycling demand expected to be generated from the change in travel costs, travel times as well as from the perceived value attributed by potential cyclists to infrastructure improvements created by the implementation of the Inner Sydney Regional Bicycle Network.

Incremental mode choice modelling undertaken by AECOM suggests that by accounting for the improved protection that separated cycleways offer, the full development of the Inner Sydney Regional Bicycle Network has the potential to create significant increases in cycling take-up within the study area. Relative to a do nothing case, the incremental choice model predicts that overall cycling levels could increase by 66 percent by 2016 and 71 percent by 2026 due to the implementation of the Inner Sydney Regional Bicycle Network.

In order to achieve pre-specified cycle mode share targets outlined by the NSW Government within the study area, take up of cycling will need to almost triple relative to a do nothing scenario. Whilst the full implementation of the Inner Sydney Regional Bicycle Network will provide a contribution towards achieving these targets, additional interventions will be required to achieve the NSW Government targets. Such interventions may include the provision of a public bicycle scheme, high quality end-of-trip facilities and behavioural interventions.

AECOM has reviewed all guidance made available for the appraisal of cycling schemes and where required, made adjustments and included additional benefit streams. In its economic appraisal, AECOM has valued the following benefit streams:

- Decongestion;
- Vehicle operating costs savings;
- Parking cost savings;
- Travel time savings;
- Journey ambiance;
- Health benefits in the form of reduced mortality and absenteeism savings;

- Accident costs;
- Reduced air pollution;
- Reduced noise pollution;
- Greenhouse gas reduction;
- Reduced water pollution;
- Reduced urban separation; and
- Reduced pressure on government infrastructure and services.

In addition to the abovementioned benefits, which were monetised for this study, the Inner Sydney Regional Bicycle Network will generate additional benefits including:

- Improved journey time reliability;
- Improved integration with public transport;
- Public transport decrowding;
- Improved equity and accessibility outcomes;
- Potential for wider economic benefits beyond the transport sector;
- Improved localised economic activity; and
- Reduced energy dependence.

The economic appraisal shows that the full development of the Inner Sydney Regional Bicycle Network is economically desirable. The net economic benefits accruing from the development of the Inner Sydney Regional Bicycle Network, over a 30 year evaluation period and discounted at a real rate of 7 percent, is $506 million at a benefit cost ratio of 3.88. If the Government's cycle mode share targets were to be achieved, the economic benefits are estimated to be worth up to $1.8 billion.

The breakdown of benefits indicates that significant benefits will be accrued by individuals, government and the general economy through the full development of the Inner Sydney Regional Bicycle Network.

Travellers stand to benefit through travel time savings, avoided car costs, journey ambiance and health benefits at the cost of a relatively small increase in accident costs. These benefits collectively account for 65 percent and 69 percent of benefits under the Policy Target Scenario and AECOM Estimate Scenario respectively. There are also material benefits accruable for government and the broader economy through road and public infrastructure and operating cost savings, environmental benefits and congestion reduction.

The breakdown of the benefits demonstrates the importance of recognising cycling specific benefits. Collectively, health benefits and journey ambiance provide a significant uplift in overall benefits, accounting for 35 percent and 41 percent of total benefits under the Policy Target Scenario and AECOM Estimate Scenario respectively

Even if cycling specific benefits such as health and journey ambiance benefits are removed from the analysis, the Inner Sydney Regional Bicycle Network is still estimated to produce economic benefits in excess of costs. The economic viability of the Inner Sydney Regional Bicycle Network is also insensitive to higher discount rates, higher constructions costs and lower demand.

Analysis of demand by inter-LGA travel indicates that prioritisation can enhance the delivery of economic returns. The incremental cost benefit analysis supports the development of the bicycle network within the City of Sydney as well as placing a high priority on radial links from the Inner West and the Eastern Suburbs feeding into the city. On the other hand, the incremental cost-benefit analysis indicates that the economic case for developing corridors from the North Shore into Sydney CBD is highly constrained by the high construction costs associated with developing HarbourLink and cycleways along the Warringah Freeway, despite the potential for higher levels of cycling take-up.

AECOM recommend:

- That development of the Inner Sydney Regional Bicycle Network commences to realise the net economic benefits identified in this study. In the absence of assistance of developing the network outside the City of

Sydney, the City could still generate net economic returns simply by developing the network within its own boundaries;

- The development of the Inner Sydney Regional Bicycle Network be prioritised to focus on high demand corridors, in particular corridors between the City of Sydney and the Eastern Suburbs and the Inner West. The viability of developing cycling corridor across the harbour is likely to be highly dependent on construction costs and further investigation of demand along corridors that require a crossing of Sydney Harbour may be required.
- Additional interventions will be required to achieve mode share targets enunciated by local and State Government. AECOM recommend that the benefits and costs associated with the following initiatives to be considered:
  - Marketing and educational programs to influence increased cycling levels;
  - Improving the quality and scale of end-of-trip facilities;
  - Introducing bicycle sharing; and
  - Pricing initiatives including parking charges and congestion charges.

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Appendix A

Study Area SLAs

Appendix A Study Area SLAs

Table A.1: SLAs Within Study Area

SLA Code	Description
150	Ashfield
1100	Botany Bay
1300	Burwood
1521	Canada Bay - Concord
1524	Canada Bay - Drummoyne
1550	Canterbury
4100	Hunters Hill
4150	Hurstville
4450	Kogarah
4700	Lane Cove
4800	Leichhardt
5150	Manly
5200	Marrickville
5350	Mosman
5950	North Sydney
6550	Randwick
6650	Rockdale
6700	Ryde
7100	Strathfield
7201	Sydney - Inner
7204	Sydney - East
7205	Sydney - South
7206	Sydney - West
8050	Waverley
8250	Willoughby
8500	Woollahra

Appendix B

Demand and Economic Appraisal Model Parameters

Appendix B Demand and Economic Appraisal Model Parameters

Table B.1: Demand Model Parameters

Cycle Speed Parameters

Variable	Units	Value
On road cycle travel speed with no facilities	km/h	20.0
On road cycle lane speed	km/h	20.0
Separated cycle path speed	km/h	25.0

JTW to All Trip Factors

Variable	Units	Value
Journey to work to all purposes (intra-SLA)	factor	6.3
Journey to work to all purposes (inter-SLA)	factor	2.1
Seasonal Factor (August)	factor	0.94
Annualisation factor	factor	330

Public Bicycle Scheme Factors

Variable	Units	Value
Activate public bicycle demand	dummy	1
Stations per km	Number	8
Bikes per station	Number	12
Average daily trips per bike under the Do Nothing Scenario	Number	5
Average daily trips per bike under Policy Target Scenario and AECOM Estimate	Number	8
Bike Speed	km/h	12
Walk Speed	km/h	5
Average time on Bike	mins	20
Annual growth in public bicycle demand	Proportion	2.0%
Induced demand	Proportion	13.0%
Capture from car	Proportion	10.0%
Capture from train	Proportion	21.5%
Capture from bus	Proportion	29.5%
Capture from walking	Proportion	26.0%

Demand Constraint Factors

Variable	Units	Value
Activate long distance cycle trips constraint	dummy	1
Remove cycle trips over…	km	17

Mode Diversion Factors (For Policy Target Scenario Only)

Variable	Units	Value
Diversion from car	Proportion	54%
Diversion from train	Proportion	19%
Diversion from bus	Proportion	27%

Choice Model Parameters

Variable	Units	Value
Original Wardman et al. (2007) Parameters		
Time	minutes	-0.0390
Time - Separation	minutes	-0.0346
Time - Cycle Lanes	minutes	-0.0552
Time - No Facilities	minutes	-0.1160
Cost	cents	-0.0022
Implied value of time (all motorised modes)	c/min	18.0
Implied value of time (all motorised modes)	$/hr	$10.77
Scale factor		1.4131
Non-trader factor	proportion	20.8%
Scaled Wardman et al. (2007) Parameters		
Time	minutes	-0.0276
Time - Separation	minutes	-0.0245
Time - Cycle Lanes	minutes	-0.0391
Time - No Facilities	minutes	-0.0821
Cost	cents	-0.0015

Car, Train and Bus Time and Cost Parameters

Variable	Units	Value
Cost per km rates (2006 Levels)		
Estimated car cost per km (in Dec 06 prices)	cents/km	27.1688
… of which is perceived by motorists	proportion	65.0%
Car	cents/km	17.6597
Train	cents/km	5.6500
Bus	cents/km	12.6400
2006 Flagfalls		
Car	cents/trip	42.5000
Train	cents/trip	201.0000

Bus	cents/trip	166.7700
Cost per km rates (2011 Levels)		
Estimated car cost per km (in Sept 09 prices)	cents/km	29.2727
Estimated car cost per km (in 2011 prices)	cents/km	30.5653
… of which is perceived by motorists	proportion	65.0%
Car	cents/km	19.0272
Train	cents/km	5.3000
Bus	cents/km	16.1700
myBus distance cap	km	9.6000
2011 Flagfalls		
Car	cents/trip	47.8000
Train	cents/trip	223.9000
Bus	cents/trip	126.6000
Speed rates (2006 Levels)		
Car	km/h	25.1965
Train	km/h	41.3141
Bus	km/h	22.9523
Speed rates (2011 Levels)		
Car	km/h	23.9664
Train	km/h	40.0870
Bus	km/h	21.8317
Access, Egress and Waiting Times		
Car	min/trip	2.5000
Train	min/trip	22.5000
Bus	min/trip	12.5000
Real increases in cost per annum (2006 - 2011)		
Car	% p.a.	2.5%
Train	% p.a.	1.5%
Bus	% p.a.	1.5%
Increases in cost per annum (2011 - 2016)		
Car	% p.a.	2.5%
Train	% p.a.	1.5%
Bus	% p.a.	1.5%
Increases in cost per annum (2016 - 2026)		

Car	km/h	2.5%
Train	km/h	1.5%
Bus	km/h	1.5%
Decline in travel speeds per annum (2006 - 2011)		
Car	% p.a.	-1.0%
Train	% p.a.	-1.0%
Bus	% p.a.	-1.0%
Decline in travel speeds per annum (2011 - 2016)		
Car	% p.a.	-1.0%
Train	% p.a.	-1.0%
Bus	% p.a.	-1.0%
Decline in travel speeds per annum (2016 - 2026)		
Car	% p.a.	-1.0%
Train	% p.a.	-1.0%
Bus	% p.a.	-1.0%

Table B.2: Unit Rates Values

Variable	Units	June 2010 Value
Value of time	c / hr	1219.99
Car Specific Values		
Decongestion benefit	cents / vehicle km	27.06
Air pollution reduction	cents / vehicle km	2.77
Noise reduction	cents / vehicle km	0.90
Greenhouse gas reduction	cents / vehicle km	2.18
Infrastructure provision	cents / vehicle km	3.73
Water pollution	cents / vehicle km	0.42
Urban separation	cents / vehicle km	0.64
Car accident costs (human capital approach)	cents / vehicle km	6.73
Car accident costs (WTP approach)	cents / vehicle km	9.06
Parking cost savings	cents / trip	53.07
Bus Specific Values		
Bus operating cost subsidy savings	cents / bus trip	66.51
Bus accident costs	cents / bus km	10.88
Road congestion	cents / bus km	46.05
Air pollution	cents / bus km	28.98
Greenhouse gas emission	cents / bus km	15.08
Noise pollution	cents / bus km	4.41

Road damage	cents / bus km	2.60
Train Specific Values		
Train operating cost subsidy savings	cents / train trip	296.10
Train accident costs	cents / train km	0.053
Air pollution	cents / train km	4.13
Greenhouse gas emission	cents / train km	0.67
Noise pollution	cents / train km	2.13
Cycling Specific Values		
Health benefits	cents / cycle km	6.00
Absenteeism and productivity benefits	cents / cycle km	16.00
Journey ambiance - on road cycle lanes	cents / cycle min	2.97
Journey ambiance - on and off road separated lanes	cents / cycle min	4.86
Journey ambiance - on road cycle lanes	cents / cycle km	8.90
Journey ambiance - on and off road separated lanes	cents / cycle km	11.66
Cycling accident costs (human capital approach)	$ / crash	67720.24
Cycling accident costs (WTP approach)	$ / crash	91114.51
Public Bicycle		
Willingness to pay for public bicycle	cents / trip	36.11

Table B.3: Construction and Maintenance Costs

Variable	Units	June 2010 Value
Construction costs		
Separated cycleway	$ / km	300,000
Separated contra-flow cycleway	$ / km	200,000
Separated cycleway in park	$ / km	400,000
Shared path on verge	$ / km	150,000
Shared path in park	$ / km	150,000
Mixed zone	$ / km	100,000
Shared zone	$ / km	200,000
Cycle lane	$ / km	150,000
Harbourlink	$ / km	40,000,000
Warringah Freeway	$ / km	10,000,000
Real construction cost indexation	p.a.	1.0%
Annual maintenance		
Maintenance cost (rel. to capex)		1.0%
Real maintenance cost indexation	p.a.	1.0%

Appendix C

Target Cycle Mode Shares for Policy Target Scenario

Appendix C Target Cycle Mode Shares for Policy Target Scenario

Mode Shares in Percentage Points (*No Constraints*)	Ashfield	Botany	Burwood	Concord	Drummoyne	Canterbury	Hunters Hill	Hurstville	Kogarah	Lane Cove	Leichhardt	Manly	Marrickville	Mosman	North Sydney	Randwick	Rockdale	Ryde	Strathfield	Sydney - Inner	Sydney - East	Sydney - South	Sydney - West	Waverley	Willoughby	Woollahra
Ashfield	10	2.5	5	5	5	5	2.5	2.5	2.5	2.5	5		5	2.5	2.5		2.5	2.5	2.5	2.5	2.5	2.5	2.5			
Botany	2.5	10				2.5		2.5	2.5		2.5		5			5	5			5	5	5	5	2.5		2.5
Burwood	5		10	5	5	5	2.5	2.5	2.5	2.5	2.5		2.5				2.5	2.5	5							
Concord	5		5	10	10	2.5	5			2.5	5		2.5		2.5			5	5	2.5	2.5	2.5	2.5			
Drummoyne	5		5	10	10	2.5	5			2.5	5		2.5		2.5			5	5	2.5	2.5	2.5	2.5			
Canterbury	5	2.5	5	2.5	2.5	10		5	2.5		2.5		5				5		5	2.5	2.5	2.5	2.5			
Hunters Hill	2.5		2.5	5	5		10			5	5			2.5	2.5			5	2.5	2.5	2.5	2.5	2.5		2.5	
Hurstville	2.5	2.5	2.5			5		10	5				2.5				5		2.5							2.5
Kogarah	2.5	2.5	2.5			2.5		5	10				2.5				5									
Lane Cove	2.5		2.5	2.5	2.5		5			10	2.5	2.5		2.5	5			5		2.5	2.5	2.5	2.5		5	
Leichhardt	5	2.5	2.5	5	5	2.5	5			2.5	10		5	2.5	5	2.5	2.5	2.5	2.5	5	5	5	5	2.5	2.5	2.5
Manly										2.5		10		5	5					2.5	2.5	2.5	2.5		5	
Marrickville	5	5	2.5	2.5	2.5	5		2.5	2.5		5		10		2.5	2.5	5		2.5	5	5	5	5	2.5		2.5
Mosman	2.5						2.5			2.5	2.5	5		10	5					2.5	2.5	2.5	2.5		5	
North Sydney	2.5			2.5	2.5		2.5			5	5	5	2.5	5	10	2.5		2.5		5	5	5	5	2.5	2.5	2.5
Randwick		5									2.5		2.5		2.5	10	2.5			5	5	5	5	5		5
Rockdale	2.5	5	2.5			5		5	5		2.5		5			2.5	10		2.5	2.5	2.5	2.5	2.5	2.5		2.5
Ryde	2.5		2.5	5	5		5			5	2.5				2.5			10	2.5						5	
Strathfield	2.5		5	5	5	5	2.5	2.5			2.5		2.5				2.5	2.5	10							
Sydney - Inner	2.5	5		2.5	2.5	2.5	2.5			2.5	5	2.5	5	2.5	5	5	2.5			10	10	10	10	5	5	5
Sydney - East	2.5	5		2.5	2.5	2.5	2.5			2.5	5	2.5	5	2.5	5	5	2.5			10	10	10	10	5	5	5
Sydney - South	2.5	5		2.5	2.5	2.5	2.5			2.5	5	2.5	5	2.5	5	5	2.5			10	10	10	10	5	5	5
Sydney - West	2.5	5		2.5	2.5	2.5	2.5			2.5	5	2.5	5	2.5	5	5	2.5			10	10	10	10	5	5	5
Waverley		2.5						2.5			2.5		2.5		2.5	5	2.5			5	5	5	5	10		5
Willoughby							2.5			5	2.5	5		5	2.5			5		5	5	5	5		10	
Woollahra		2.5						2.5			2.5		2.5		2.5	5	2.5			5	5	5	5	5		10

Mode Shares in Percentage Points (*With Long Distance Constraints*)	Ashfield	Botany	Burwood	Concord	Drummoyne	Canterbury	Hunters Hill	Hurstville	Kogarah	Lane Cove	Leichhardt	Manly	Marrickville	Mosman	North Sydney	Randwick	Rockdale	Ryde	Strathfield	Sydney - Inner	Sydney - East	Sydney - South	Sydney - West	Waverley	Willoughby	Woollahra
Ashfield	1	2.5	5	5	5	5	2.5	2.5	2.5	2.5	5		5	2.5	2.5		2.5	2.5	2.5	2.5	2.5	2.5	2.5			
Botany	2.5	1				2.5		2.5	2.5		2.5		5			5	5			5	5	5	5	2.5		2.5
Burwood	5		1	5	5	5	2.5	2.5	2.5	2.5	2.5		2.5				2.5	2.5	5							
Concord	5		5	1	1	2.5	5			2.5	5		2.5		2.5			5	5	2.5	2.5	2.5	2.5			
Drummoyne	5		5	1	1	2.5	5			2.5	5		2.5		2.5			5	5	2.5	2.5	2.5	2.5			
Canterbury	5	2.5	5	2.5	2.5	1		5	2.5		2.5		5				5		5	2.5	2.5	2.5	2.5			
Hunters Hill	2.5		2.5	5	5		1			5	5			2.5	2.5			5	2.5	2.5	2.5	2.5	2.5		2.5	
Hurstville	2.5	2.5	2.5			5		1	5				2.5				5		2.5							2.5
Kogarah	2.5	2.5	2.5			2.5		5	1				2.5				5									
Lane Cove	2.5		2.5	2.5	2.5		5			1	2.5	2.5		2.5	5			5		2.5	2.5	2.5	2.5		5	
Leichhardt	5	2.5	2.5	5	5	2.5	5			2.5	1		5	2.5	5	2.5	2.5	2.5	2.5	5	5	5	5	2.5	2.5	2.5
Manly										2.5		1		5	5					2.5	2.5	2.5	2.5		5	
Marrickville	5	5	2.5	2.5	2.5	5		2.5	2.5		5		1		2.5	2.5	5		2.5	5	5	5	5	2.5		2.5
Mosman	2.5						2.5			2.5	2.5	5		1	5					2.5	2.5	2.5	2.5		5	
North Sydney	2.5			2.5	2.5		2.5			5	5	5	2.5	5	1	2.5		2.5		5	5	5	5	2.5	2.5	2.5
Randwick		5									2.5		2.5		2.5	1	2.5			5	5	5	5	5		5
Rockdale	2.5	5	2.5			5		5	5		2.5		5			2.5	1		2.5	2.5	2.5	2.5	2.5	2.5		2.5

Mode Shares in Percentage Points (*With Long Distance Constraints*)	Ashfield	Botany	Burwood	Concord	Drummoyne	Canterbury	Hunters Hill	Hurstville	Kogarah	Lane Cove	Leichhardt	Manly	Marrickville	Mosman	North Sydney	Randwick	Rockdale	Ryde	Strathfield	Sydney - Inner	Sydney - East	Sydney - South	Sydney - West	Waverley	Willoughby	Woollahra
Ryde	2.5		2.5	5	9.1.2		5			5	2.5				2.5			1	2.5						5	
Strathfield	2.5		5	5	5	5	2.5	2.5			2.5		2.5				2.5	2.5	1							
Sydney - Inner	2.5	5		2.5	2.5	2.5	2.5			2.5	5	2.5	5	2.5	5	5	2.5			1	1	1	1	5	5	5
Sydney - East	2.5	5		2.5	2.5	2.5	2.5			2.5	5	2.5	5	2.5	5	5	2.5			1	1	1	1	5	5	5
Sydney - South	2.5	5		2.5	2.5	2.5	2.5			2.5	5	2.5	5	2.5	5	5	2.5			1	1	1	1	5	5	5
Sydney - West	2.5	5		2.5	2.5	2.5	2.5			2.5	5	2.5	5	2.5	5	5	2.5			1	1	1	1	5	5	5
Waverley		2.5						2.5			2.5		2.5		2.5	5	2.5			5	5	5	5	1		5
Willoughby							2.5			5	2.5	5		5	2.5			5		5	5	5	5		1	
Woollahra		2.5						2.5			2.5		2.5		2.5	5	2.5			5	5	5	5	5		1

Appendix D

Incremental Demand Results

Appendix D Incremental Demand Results

Table D.1: Ranking of Origin-Destination Pairs by BCR under Policy Target Scenario

BCR Ranking	Origin LGA	Destination LGA	BCR	NPV	Cumulative Cost
1	Botany	Rockdale	34.57	28,504,700	2,242,000
2	Randwick	Sydney	32.59	75,035,200	3,581,000
3	Lane Cove	Ryde	31.49	9,415,300	4,477,000
4	Canterbury	Hurstville	30.85	12,638,800	5,601,000
5	Lane Cove	Willoughby	27.65	40,602,600	8,015,000
6	Kogarah	Rockdale	23.75	13,714,900	10,187,000
7	Canada Bay	Sydney	21.97	43,179,400	12,410,000
8	Hurstville	Rockdale	19.13	25,832,700	13,700,000
9	Sydney	Woollahra	14.29	18,170,000	14,501,000
10	Hunters Hill	Leichhardt	13.61	6,644,500	16,365,000
11	Leichhardt	Marrickville	12.07	6,566,900	18,918,000
12	Botany	Sydney	12.01	21,745,600	20,862,000
13	Canada Bay	Canterbury	11.81	3,604,000	22,003,000
14	Burwood	Canterbury	11.63	2,483,700	23,809,000
15	Lane Cove	Leichhardt	11.27	2,118,600	24,863,000
16	Ashfield	Leichhardt	9.30	1,004,900	37,558,000
17	Canterbury	Marrickville	8.77	6,427,500	38,127,000
18	Ashfield	Marrickville	8.33	1,974,600	39,458,000
19	Ashfield	Lane Cove	7.92	3,142,700	39,858,000
20	Ashfield	Strathfield	7.77	8,872,800	41,323,000
21	Burwood	Leichhardt	7.43	9,810,400	41,883,000
22	Canada Bay	Leichhardt	7.26	8,291,800	42,089,000
23	Burwood	Canada Bay	7.16	3,896,100	42,253,000
24	Canada Bay	Ryde	7.04	6,747,600	43,209,000
25	Randwick	Waverley	6.78	15,629,600	62,789,000
26	Canterbury	Kogarah	6.66	7,995,600	64,227,000
27	Manly	North Sydney	6.15	5,503,700	65,561,000
28	Canada Bay	Strathfield	6.12	5,373,600	66,234,000
29	Ashfield	Canada Bay	5.77	4,316,400	67,303,000
30	Randwick	Woollahra	5.63	8,867,900	68,083,000
31	Hurstville	Kogarah	5.62	3,367,900	68,198,000
32	Marrickville	Sydney	5.46	6,320,400	68,506,000
33	North Sydney	Willoughby	5.44	8,743,900	69,194,000
34	Burwood	Marrickville	5.30	3,725,800	70,538,000
35	North Sydney	Sydney	4.62	45,893,600	90,273,000
36	Ashfield	Canterbury	3.67	1,649,700	92,244,000
37	Waverley	Woollahra	3.64	3,077,900	112,096,000
38	Rockdale	Sydney	3.21	5,093,100	112,350,000
39	Leichhardt	Sydney	3.14	2,544,200	112,574,000

40	Canterbury	Leichhardt	3.06	2,369,000	113,059,000
41	Mosman	North Sydney	2.58	1,065,200	114,160,000
42	Sydney	Waverley	2.53	3,900,900	116,059,000
43	Botany	Randwick	2.32	1,255,700	123,079,000
44	Marrickville	Rockdale	2.04	1,462,900	123,300,000
45	Canterbury	Rockdale	1.49	756,400	124,336,000
46	Hunters Hill	Sydney	1.16	134,300	124,651,000
47	Ashfield	Burwood	1.09	44,900	127,033,000
48	Hurstville	Marrickville	1.08	82,500	127,487,000
49	Canterbury	Strathfield	1.04	10,200	129,317,000
50	Sydney	Willoughby	1.00	-88,100	131,412,000
51	Leichhardt	North Sydney	0.95	-320,500	132,010,000
52	Leichhardt	Ryde	0.68	-720,700	133,000,000
53	Hunters Hill	Ryde	0.60	-206,300	133,768,000
54	Canterbury	Sydney	0.54	-1,078,900	134,819,000
55	Lane Cove	North Sydney	0.46	-979,800	135,674,000
56	Lane Cove	Sydney	0.46	-10,731,300	136,257,000
57	Manly	Mosman	0.28	-1,501,000	136,752,000
58	Marrickville	Strathfield	0.28	-1,209,600	138,002,000
59	Mosman	Willoughby	0.24	-9,791,100	139,085,000
60	Botany	Marrickville	0.20	-807,500	140,322,000
61	Mosman	Sydney	0.19	-15,940,000	141,762,000
62	Leichhardt	Woollahra	0.12	-1,779,600	143,736,000
63	Burwood	Sydney	0.00	7,116,500	144,553,000
63	Hunters Hill	Marrickville	0.00	1,399,300	145,050,000
63	Ashfield	Sydney	0.00	-1,209,000	146,629,000

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Table D.2: Ranking of Origin-Destination Pairs by BCR under AECOM Estimate

BCR Ranking	Origin LGA	Destination LGA	BCR	NPV	Cumulative Cost
1	Randwick	Sydney	54.14	119,144,100	2,242,000
2	Marrickville	Sydney	21.29	27,161,600	3,581,000
3	Botany	Randwick	13.99	11,646,600	4,477,000
4	Leichhardt	Sydney	13.24	13,757,000	5,601,000
5	Sydney	Waverley	11.92	26,362,600	8,015,000
6	Rockdale	Sydney	9.20	17,817,300	10,187,000
7	Canterbury	Sydney	5.23	9,409,500	12,410,000
8	Sydney	Woollahra	5.18	5,397,200	13,700,000
9	Botany	Rockdale	5.14	3,320,200	14,501,000
10	Botany	Sydney	5.01	7,477,700	16,365,000
11	Randwick	Waverley	4.97	10,136,500	18,918,000
12	Canada Bay	Sydney	4.95	7,677,000	20,862,000
13	Ashfield	Sydney	4.65	4,159,300	22,003,000

14	Randwick	Woollahra	3.24	4,047,000	23,809,000
15	Canada Bay	Ryde	2.94	2,048,500	24,863,000
16	North Sydney	Sydney	2.56	19,859,600	37,558,000
17	Kogarah	Rockdale	2.54	875,300	38,127,000
18	Marrickville	Rockdale	2.22	1,623,000	39,458,000
19	Canterbury	Hurstville	1.83	330,700	39,858,000
20	Canterbury	Rockdale	1.73	1,071,200	41,323,000
21	Leichhardt	Marrickville	1.68	382,300	41,883,000
22	Lane Cove	Leichhardt	1.49	101,400	42,089,000
23	Canada Bay	Lane Cove	1.39	64,200	42,253,000
24	Botany	Marrickville	1.32	306,700	43,209,000
25	Sydney	Willoughby	1.24	4,671,100	62,789,000
26	Lane Cove	Willoughby	1.21	308,800	64,227,000
27	Canterbury	Kogarah	0.97	-37,500	65,561,000
28	Mosman	North Sydney	0.91	-60,900	66,234,000
29	Manly	North Sydney	0.84	-174,400	67,303,000
30	Canterbury	Marrickville	0.83	-132,800	68,083,000
31	Ashfield	Leichhardt	0.82	-21,100	68,198,000
32	Lane Cove	Ryde	0.80	-62,700	68,506,000
33	Hurstville	Kogarah	0.72	-191,700	69,194,000
34	Hurstville	Rockdale	0.70	-409,300	70,538,000
35	Mosman	Sydney	0.65	-6,978,700	90,273,000
36	North Sydney	Willoughby	0.61	-764,900	92,244,000
37	Lane Cove	Sydney	0.56	-8,765,900	112,096,000
38	Ashfield	Marrickville	0.55	-115,500	112,350,000
39	Canterbury	Strathfield	0.53	-105,200	112,574,000
40	Hunters Hill	Ryde	0.44	-270,900	113,059,000
41	Waverley	Woollahra	0.42	-634,200	114,160,000
42	Leichhardt	Woollahra	0.39	-1,155,300	116,059,000
43	Leichhardt	North Sydney	0.38	-4,321,400	123,079,000
44	Burwood	Canterbury	0.36	-141,800	123,300,000
45	Hurstville	Marrickville	0.35	-672,400	124,336,000
46	Canada Bay	Canterbury	0.31	-215,500	124,651,000
47	Burwood	Sydney	0.31	-1,632,500	127,033,000
48	Ashfield	Lane Cove	0.31	-312,200	127,487,000
49	Lane Cove	North Sydney	0.30	-1,286,400	129,317,000
50	Leichhardt	Ryde	0.29	-1,481,900	131,412,000
51	Burwood	Canada Bay	0.27	-436,600	132,010,000
52	Canada Bay	Strathfield	0.23	-764,400	133,000,000
53	Hunters Hill	Sydney	0.23	-594,500	133,768,000
54	Hunters Hill	Marrickville	0.21	-829,300	134,819,000
55	Ashfield	Canada Bay	0.21	-677,000	135,674,000
56	Ashfield	Canterbury	0.15	-495,200	136,257,000

57	Ashfield	Burwood	0.15	-422,900	136,752,000
58	Canada Bay	Leichhardt	0.11	-1,115,900	138,002,000
59	Canterbury	Leichhardt	0.07	-1,004,200	139,085,000
60	Ashfield	Strathfield	0.07	-1,150,000	140,322,000
61	Burwood	Leichhardt	0.07	-1,343,200	141,762,000
62	Manly	Mosman	0.07	-1,842,500	143,736,000
63	Burwood	Marrickville	0.07	-763,400	144,553,000
64	Hunters Hill	Leichhardt	0.05	-472,200	145,050,000
65	Marrickville	Strathfield	0.04	-1,514,400	146,629,000