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Randwick City Council

Randwick Light Rail Pre-feasibility Study

Final Report

26 September 2011

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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Executive Summary

Purpose

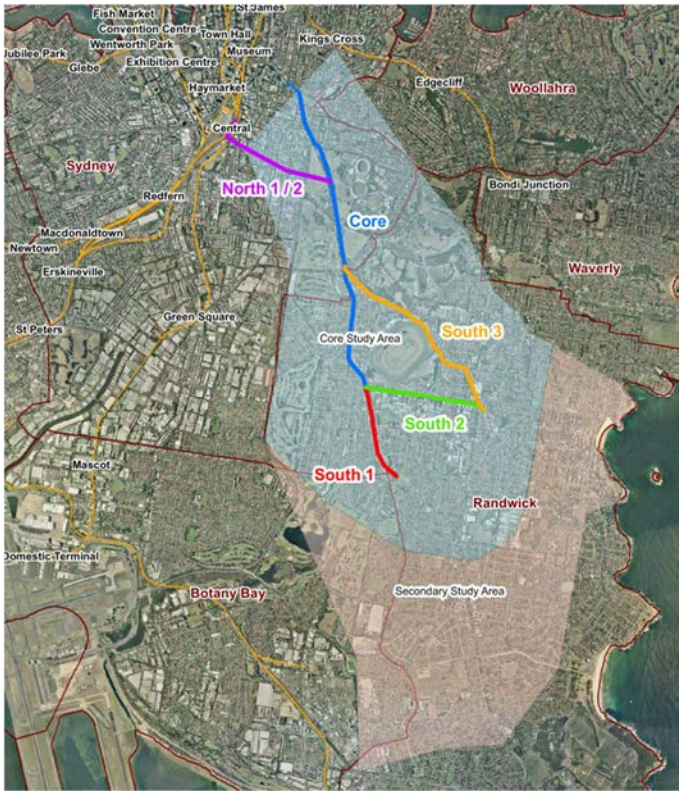
The Client Group Partners (Randwick City Council, University of NSW and Australian Turf Club) commissioned the *Randwick Light Rail Pre-Feasibility Study* to place themselves in a more informed position to engage with the NSW Government in the development of its *Sydney Light Rail Strategic Plan*. To this end, this Randwick Study has been undertaken in advance of the NSW Government Strategic Plan[1].

Scope

The *Randwick Light Rail Pre-Feasibility Study* constitutes a broad-level, initial-stage consideration of re-introducing light rail in the Randwick area. The scope of this Study is to:

- Assess the need for light rail in Randwick.
- Understand feasibility of implementing a light rail service in Randwick through:
  - Assessment of routes.
  - Development of preliminary route layouts.
- Determine where additional investigation may be required.

The Study Area and Routes incorporated into this study are shown in the following figure.



[1] The request for tender for the *Integrated Transport and Land Use Services for the Sydney Light Rail Strategic Plan* was released in August 2011.

Approach

In broad terms, the approach to this study was structured as follows:

1. Establish the Case for Light Rail (*Strategic Drivers*).
2. Develop and assess potential light rail *routes* at a broad level.
3. Develop more detailed *route layouts* as a preliminary test of feasibility.

Strategic Drivers

The *Strategic Drivers* adopted for this study are:

- Strategic Driver #1 - *Improve the Customer Experience.*
- Strategic Driver #2 - *Improve the Transport System.*
- Strategic Driver #3 - *Integrate with Land Use.*
- Strategic Driver #4 - *Optimise likelihood of Implementation.*

Strategic Drivers are a mechanism for understanding *what light rail should do* in different contexts and/or locations. They articulate the *need* for light rail and constitute a 'common thread' in the study process that help to*:*

- Focus on *outcomes* rather than *projects.*
- Recognise the complexity of the transport system.
- Ensure that any light rail option(s) implemented will provide a public transport service that is valued by and brings value to the people of Sydney.
- Recognise that light rail is only one of a number of different transport modes / interventions for Sydney's future public transport system.

Route Options Assessed

For the purpose of undertaking this study, GHD classified the routes outlined in the Client Group's brief into a number of *route options*:

- ***Core Route***: Anzac Parade between Flinders Street (Surry Hills) and High Street (Kensington);
- ***South 1***: Anzac Parade between High Street (Kensington) and Sturt Street, south of the Nine Ways (Kingsford);
- ***South 2***: High Street between Anzac Parade (Kensington) and Belmore Road, east of Avoca Street (Randwick); and
- ***South 3***: Alison Road and Belmore Road between Anzac Parade (Centennial Park) and Cuthill Street, east of Avoca Street (Randwick).

Over the course of the study, two additional route options were added in order to make consideration of a potential link to Central Station:

- ***North 1***: Link between the Sydney Cricket Ground and Central Station, involving a long tunnel and then Devonshire Street; and

- ***North 2***: Link between the Sydney Cricket Ground and Central Station, involving tunnel under Anzac Parade, an at grade link across Moore Park, Eastern Distributor and Bourke Street and then Devonshire Street.

Findings of Route Options Assessment

- The Core Route should be established first and would need to extend to UNSW.
- The South 1 Route Option would ideally be delivered concurrently with the Core Route.

  If not delivered concurrently with the Core Route, then the South 1 Route Option is considered to be the highest priority of the Southern Route Options.
- It is unlikely that both South 2 and South 3 Route Options would be implemented.

  If the Core Route and the South 1 Route Option are established, it is considered that the South 3 Route Option (Alison Road) would offer superior benefits to the South 2 Route Option (High Street), as it serves a wider catchment than South 2 (which is overlapped by much of South 1).
- Future Route Extensions.

  Following on from the previous point, it is considered that there would be superior benefits in extending light rail from Randwick further to the east or from Kingsford to Maroubra than in implementing both the South 2 and South 3 Route Options.
- Further investigation is required to assess the case for (and most feasible option) for a light rail link to Central Station.

Pre-feasibility Capital Cost Estimates

Pre-feasibility capital cost estimates for the route options investigated in this study are summarised below.

Summary of Pre-feasibility Capital Cost Estimates

Route Option	Length	Total of Estimate
Core *	5.9 km	$308.6 M
South 1	1.3 km	$96.7 M
South 2	1.6 km	$122.4 M
South 3	3.3 km	$231.6 M
North 1	1.7 km	$282.8 M
North 2	1.7 km	$170.0 M

Note: *excluding UNSW loop.

The estimates include all direct costs, contractor and project indirect costs, and contingencies, and include a weighted average contingency of 50%-60% of total project costs. This contingency was applied in recognition of limitations of accuracy of the cost estimates due to the preliminary nature of concept layouts that were developed in this study. The estimates also exclude rolling stock, escalation and GST.

Key Issues for Further Consideration

This study identified a number of issues for further consideration, as summarised below:

The Study Area Offers Strong Potential for Viable Light Rail

- The study area has the characteristics generally associated with viable public transport. These include relatively high residential and employment densities, a number of mixed use and employment centres, several regional-scale facilities that constitute major trip generators (education, sport, recreation), urban structure and form that could be classified as transit-oriented, and strong passenger demand in both the peak and off-peak direction as well as outside peak periods and on weekends.
- With numerous characteristics that would appear to support a strong business case for light rail, the study area would offer a good test case for light rail in Sydney. This could be of interest for a Government that wishes to invest in 'game-changing' public transport such as light rail.
- It is also noted that the study area incorporates a number of regional destinations (UNSW, Randwick Hospital / Health Precinct, Randwick Race Course, SCG/SFS) which necessitate good levels of regional public transport access in order to optimally benefit the metropolitan area they serve and the economy and competitiveness of NSW in general. Each of the regional destinations is a state or nationally significant institution which serves the people of NSW under the wider NSW Government.

The Need for a Strategy for Light Rail in Sydney

A robust Strategy for Light Rail in Sydney will provide the necessary context for further development of light rail concepts within the study area. At the time of publication of this study, the NSW State Government was in the process of developing a strategic plan.

The following table identifies the degree of overlap of scope between the *Randwick Light Rail Pre-feasibility Study* (this study) and the Sydney Light Rail Program milestones as outlined in the Services Brief for the *Integrated Transport and Land Use Services for the Sydney Light Rail Strategic Plan* (DoT, August 2011).

It is noted that the *Integrated Transport and Land Use Services for the Sydney Light Rail Strategic Plan* would be a more in depth study than the *Randwick Light Rail Pre-feasibility Study.* The rating of *scope overlap* refers to the degree of commonality in scope (••• = high overlap, • = low overlap).

Sydney Light Rail Program Milestones	Scope Overlap	Section of this Study	Comment
1. Report – Strategic Needs Assessment and Program Objectives	●●●	5, 6	Covers the breadth at a more strategic level
2. Report – Light Rail: Benefits, Challenges, Opportunities	●●	6	Limited consideration of network issues.
3. Report – Options Identification	●●	6, 7	Scope defined options, but expanded to include link to Central.

Sydney Light Rail Program Milestones	Scope Overlap	Section of this Study	Comment
4. Report – CBD Light Rail Patronage and Operations	●	6	No assessment of patronage but some assessment of bus restructure.
5. Report – Options Assessment Report	● ●	6, 11	Limited assessment provided.
6. Report – Recommended Product Specification and Staging Strategy	● ●	6,8	Limited depth.
7. Report – Sydney Light Rail Strategic Plan	▬	-	No strategy developed, outside scope.

Compromises Required to Implement Light Rail

It should be noted that a successful light rail line will require high levels of operational priority in order to provide fast and reliable services that are largely immune from congestion and delays caused by general traffic. On this basis, the implementation of light rail will require compromises in terms of the allocation of road space. This will have impacts on general traffic and parking as well as buses in some cases.

Light Rail Extension into the CBD is a Key Enabler for a Viable Eastern Suburbs Light Rail

A fast and reliable light rail link into the CBD (i.e. north of Flinders Street) would be a critical 'enabler' for a viable light rail service in the study area on the basis that key impacts to reliability occur in area north of the study area (i.e. within the CBD). This said, it may be appropriate (as an interim stage) to connect an eastern light rail to Central Station.

Bus Restructure to Support and Integrate with Light Rail

It will be critical to restructure the bus network to support and integrate with any light rail line serving the study area. Any restructure will need make strong consideration of the needs of customers and the need to provide an overall improvement in the passenger experience relative to the existing situation.

Reduce the number of public transport vehicles entering the congested CBD

With higher capacity, light rail offers the potential to deliver people into the CBD more efficiently than by bus (from the perspective of time and space used on the transport network).

A key benefit of establishing light rail within the study area, therefore, would be the potential it offers to reduce the number of public transport vehicles entering the congested CBD.

Consideration of Operational Requirements and Supporting Facilities

Future considerations need to include operational requirements, service provisions and other 'back of house' facilities required to support the operational requirements such as stabling, maintenance, control systems and staff accommodation.

Limitations to the Potential for Light rail to Serve Special Events

Although light rail could offer the potential to serve peak loads (or a proportion of peak loads) associated with events at major venues within the study area, further work would need to be undertaken to test fleet requirements and the financial implications at different stages of development of a future light rail network.

1. Introduction

Randwick City Council, the University of NSW and the Australian Turf Club (*The Client Group Partners*) commissioned GHD to undertake *The Randwick Light Rail Pre-Feasibility Study* into a light rail service between the City of Sydney and Kingsford / Randwick.

Figure 1.1 shows the indicative study area for this *Randwick Light Rail Pre-Feasibility Study*.

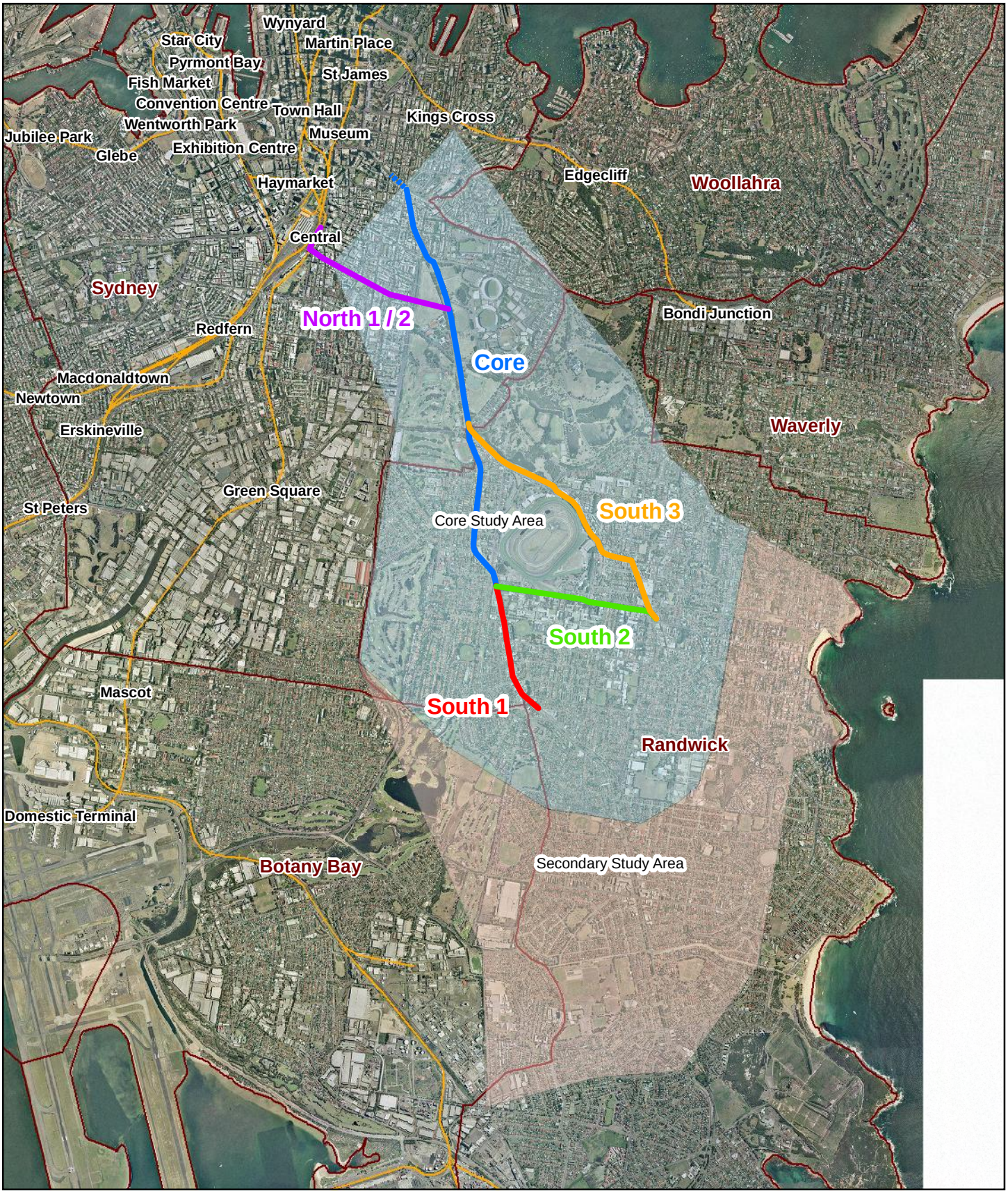
What is a Pre-Feasibility Study?

Being a pre-feasibility study, the *Randwick Light Rail Pre-Feasibility Study* has been undertaken to:

- Bring together the breadth of issues and considerations affecting the feasibility of light rail in the study area;
- Assess the light rail options outlined in the project brief at a broad but consistent level of detail in order to determine whether some would deliver more benefits than others (without identifying a preferred option or staging plan);
- Identify key issues affecting the feasibility of the light rail routes investigated (without necessarily resolving these issues); and
- Provide a resource that increases the level of knowledge and understanding of light rail within the Client Group and thus improves their ability to engage with the State Government and other stakeholders from a more informed position in respect to light rail planning, development and implementation.

Purpose, Scope and Limitations of the Study

A concise outline of the purpose, scope and limitations of the *Randwick Light Rail Pre-Feasibility Study* is provided in Section 2, below.



Legend

Route Options
- South 1
- South 2
- South 3
- CBD Connection
- Core
- North 1 / 2

Study Areas
- Core Study Area
- Secondary Study Area

- Train Lines
- Train Stations
- LGAs

Paper Size A4

0.75 0.375 0 0.75 Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Randwick City Council
Randwick Light Rail Pre-feasibility Study

Indicative Study Area

Job Number 21-20812
Revision A
Date 26 Aug 2011

Figure 1.1

G:\21\20812\GIS\Maps\MXD\2120812_Z002_Study Area.mxd

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Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:nbuchanan

2. The *Randwick Light Rail Pre-Feasibility Study* – Purpose, Scope and Limitations

This section provides a concise summary of the confirmed purpose and scope of the *Randwick Light Rail Pre-feasibility* study; these were developed on the basis of:

- The study brief;
- The GHD proposal; and
- Input received at Stakeholder Meeting #1 – *Inception Meeting.*

2.1 The Purpose of the Randwick Light Rail Pre-Feasibility Study

The Randwick Light Rail Pre-Feasibility Study has been undertaken in advance of a study to be commissioned by the NSW Government in the near future. It is understood that while the NSW Government study will incorporate consideration of a light rail link to the University of NSW, it would have a significantly broader scope and remit than the *Randwick Light Rail Pre-Feasibility Study*.

In undertaking *The Randwick Light Rail Pre-Feasibility Study*, the Client Group is seeking to place itself in an informed position to engage with the NSW Government. The outcomes of *the Randwick Light Rail Pre-Feasibility Study* will also help the Client Group to understand key issues and challenges that will affect them and thus will inform their planning and policy development.

2.2 The Scope of the *Randwick Light Rail Pre-Feasibility Study*

The *Randwick Light Rail Pre-Feasibility Study* constitutes a broad-level, initial-stage consideration of light rail in the Randwick area. The scope of this study is to:

- Assess the need for light rail in Randwick. This need incorporates:
  - Addressing problems - such as congestion or poor quality of public transport service; or
  - Realising benefits - such as improved quality of access and public transport service, urban renewal or economic development.
- Understand key challenges and risks (show-stoppers) associated with implementing a light rail service in Randwick. These include:
  - Physical constraints (such as grades, turning paths or cross sections);
  - Operational challenges (such as capacity, interfaces with general traffic, level of priority); and
  - Balancing benefits and costs (such as optimally serving travel markets, achieving best value from investment).
- Determine where additional investigation may be required.

Light Rail Route Options Assessed

The scope of the Randwick Light Rail Pre-feasibility Study specified the routes that should be assessed. GHD classified these into the following *route options*:

- *Core Route*: Anzac Parade between Flinders Street (Surry Hills) and High Street (Kensington);

- *South 1 Route Option*: Anzac Parade between High Street (Kensington) and Sturt Street, south of the Nine Ways (Kingsford);
- *South 2 Route Option*: High Street between Anzac Parade (Kensington) and Belmore Road, east of Avoca Street (Randwick); and
- *South 3 Route Option*: Alison Road and Belmore Road between Anzac Parade (Centennial Park) and Cuthill Street, east of Avoca Street (Randwick).

Over the course of the study, it was determined that an additional route should be assessed. For this route, two route options were developed:

- *North 1 Route Option*: Link between the Sydney Cricket Ground and Central Station. Higher cost option involving long tunnel and Devonshire Street; and
- *North 2 Route Option*: Link between the Sydney Cricket Ground and Central Station. Lower cost option involving tunnel under Anzac Parade, an at grade link across Moore Park, South Dowling Street and Bourke Street and then along Devonshire Street.

2.3 Limitations of the *Randwick Light Rail Pre-Feasibility Study*

By its nature, the scope of the *Randwick Light Rail Pre-Feasibility* is constrained by:

- The timing of the study (i.e. this study precedes the preparation of a strategy for light rail by State Government);
- The time and budget available to undertake the study; and
- The level of engagement possible with key stakeholders.

Limitations to Route Options Assessed

Given the limitations to the scope of this study, it is noted that assessment of alternative route options was not incorporated into the study. Notably the following routes were not assessed:

- Surface links into the CBD;
- Routes using the Eastern Distributor Tunnels between Moore Park and CBD North;
- Alternative links to Central, including via Cleveland Street, Albion Street or Campbell Street;
- Routes to Green Square and /or Central; and
- Routes to Bondi Junction.

Limitations to Scope

Key limitations to the scope of the *Randwick Light Rail Pre-Feasibility Study* are outlined below:

- No definition of the potential light rail alignment linking the study area to the core of the Sydney CBD;
- No assessment of demand or patronage;
- No consultation with key stakeholders such as Transport for NSW, Roads and Traffic Authority, Sydney Buses, City of Sydney or Metro Transit Sydney (light rail operator);
- Preliminary light rail layouts were developed in consideration of interfaces with general traffic, but without detailed investigation of traffic operations or traffic modelling; and
- No assessment of economic viability.

- The option of a light rail route between Central and UNSW has been addressed in terms of feasibility (i.e. route layouts were developed for the Core Route and the North 1 / North 2 Route Options). However, this option was not specifically assessed in terms of cost estimates or modifications to bus routes.

More specific limitations of the scope of development of Preliminary Route Layouts are outlined in Section 8.2.

3. Review of Background Information

3.1 Previous Studies

A review of relevant previous studies was undertaken to inform the development of this study. Table 3.1 provides a short summary of relevant points in relation to technical, planning, patronage and other issues.

Table 3.1 Review of Previous Studies

Title	Client / Author	Date	Technical	Planning	Patronage	Other	Key Points
Eastern Suburbs Light Rail: Preliminary Feasibility Assessment	NSW Department of Transport	1999	●	●●	●●	●● Financial evaluation	This study was undertaken as a condition of consent for the Eastern Distributor road scheme and looked at various light rail route options between Randwick and either Redfern, Central or the CBD. It was found that no single option performed highly against all the identified criteria. The option with the greatest travel time savings was a tunnelling option under Surry Hills to Central Station. It was estimated that only 15% of passengers would solely use light rail without modal interchange. Overall, it was recommended that light rail not be pursued in the short to medium term, with increased bus services expected to cater for public transport trips.

Title	Client / Author	Date	Technical	Planning	Patronage	Other	Key Points
City-Wide Strategic Plan 2021: Transport Study Investigations – Stage Two Final Report	Randwick City Council by Kellogg Brown and Root	2003		●●●	●●	● Cost estimates	The study identified that the preferred public transport system for Randwick as a surface light rail system from the Sydney CBD to Kensington along Anzac Parade. The preferred route continued to La Perouse, with a branch to Coogee along High Street at the University of NSW. Reference was made to an earlier report; *Eastern Suburbs Light Rail Preliminary Feasibility Assessment* (1999) by the Department of Transport looked at links to Central Station via Devonshire Street and Green Square.
Campus 2020 Master Plan: Transportation Strategy Report	University of New South Wales by Chris Stapleton Consulting	2005		●●	●●		59% of students arrive by public transport (69% in peak), 19% walk (21% in peak), and 33% of staff arrive by public transport. 245 buses per hour travelled past the University in the morning peak hour (8-9 am). Of the 245 buses, 160 were northbound and 85 were southbound. It was recommended that the University work with Council to introduce a metro or light rail service to Randwick and the University.

Title	Client / Author	Date	Technical	Planning	Patronage	Other	Key Points
Randwick Economic Activity Study	Randwick City Council by SGS Economics and Planning	2008		●	●●		Non-residential floorspace capacity estimates in the main centres (2007 data) indicate that there is capacity to double floorspace from 333,577 sqm to 668,883 sqm. Public transport to the specialised centre currently consists of bus services only. Ideally, alternative forms of mass public transit will be introduced if the intensity of economic activity in the centre is to increase.

Title	Client / Author	Date	Technical	Planning	Patronage	Other	Key Points
Randwick Education and Health Specialised Centre Discussion Paper	Randwick City Council	2010		●	●●●		Several major institutions and destinations are located in the Centre, including the University of NSW, the Randwick Health Campus with four major hospitals, the Prince of Wales Medical Research Institute and Royal Randwick Racecourse. The Centre is a major economic and employment destination, attracting around 50,000 people daily. Around 13,200 people work there. Growth is estimated at an additional 4,000 jobs to 2031 (1.2% per annum). Council to provide locations for future rail mass transit stations. The University has over 42,000 students and 5,200 staff. The campus accommodates approximately 3,100 students. Four major hospitals comprise the Randwick Health Campus: the Prince of Wales Hospital; the Royal Hospital for Women; Sydney Children's Hospital; and the Prince of Wales Private Hospital. Collectively they treat over 70,000 acute and emergency patients and over 1.2 million outpatients per year. There is a total of around 5,600 staff across 20 different employers. Royal Randwick Racecourse employs 100 permanent staff and 300-400 training and track workers.

Title	Client / Author	Date	Technical	Planning	Patronage	Other	Key Points
							Population growth over 1996-2006 has been 1.6%. The dwelling growth rate for the City is well expected to be over 16% to 2031, requiring well over 1000 additional dwellings in the Centre. In 2006, Randwick City's population was 122,373. Population density was 33 people per hectare for Randwick City [Note that in the context of the *Randwick Light Rail Pre-feasibility Study*, it should be recognised that within the study area and along the corridors under consideration, densities are substantially higher than the LGA average]. Mode of travel for work trips with Randwick City as a destination: 22.2% by bus, 49.3% by car, 6.3% walked, 3.5% by train, 1.3% cycled.
2010 UNSW Travel Survey	UNSW	2010			●●		Mode of travel to and from UNSW for Students and Staff: Car driver (21%), Car passenger (2%), Motorbike (1%), Bus (20%), Train and bus (35%), Ferry and bus (1%), Bike (4%), Walk only (15%), live on campus (2%).

Title	Client / Author	Date	Technical	Planning	Patronage	Other	Key Points
Metropolitan Plan	NSW Government	2010		●●●			Randwick Education and Health cluster: Expected employment growth: +5,000 between 2006 and 2036. Future Directions: ◗ Intensify the cluster of education and health enterprises. ◗ Support increased investment in research and medical infrastructure. ◗ Integrate the multi–functional aspects of Randwick Racecourse with the education and health elements of the centre. ◗ Improve walking and cycling access to and within centre. ◗ Identify opportunities for increased housing including student housing and short term housing. ◗ Investigate long–term improvements in public transport capacity in the city–Malabar corridor. ◗ Strategic bus corridors 19, 20, 29, 30.

Title	Client / Author	Date	Technical	Planning	Patronage	Other	Key Points
Open Space and Environment Discussion Paper	Randwick City Council	2011		●			1-11, 13-21 Rainbow Street, Kingsford (Kingsford Market Site) is primarily zoned as Open Space. The car parking area (13-21 Rainbow Street, about 2,000 m^2) is under Council ownership. The remaining area (1-11 Rainbow Street, about 3,500 m^2) is owned by STA and leased to Council. A future commercial zoning will allow for public parking and any future public transport facilities.

3.2 Mode Share in Randwick

Table 3.2 presents an indication of existing mode shares to and from Randwick, for the journey to work (JTW) recorded in the 2006 Census. It can be seen that at approximately 60% of travel undertaken to/from Randwick is by car, with bus use ranging from 10-26%. Walking is also high, ranging between 7-11%.

Table 3.2 Existing Mode Share in Randwick

Source (Year)	Data	Train	Bus	Car Driver	Car Pass	Bicycle	Walk	Other
Census (2006)	Randwick JTW Origin LGA	4%	26%	52%	6%	2%	7%	5%
Census (2006)	Randwick JTW Destination LGA	6%	10%	64%	6%	1%	11%	2%

Source: Australian Bureau of Statistics (ABS).

4. Consultation

This section incorporates a brief outline of consultation undertaken over the course of the study. The meetings were attended by the Client Group Partners (Randwick City Council, the University of NSW and the Australian Turf Club) and GHD.

4.1 Project Meeting #1

Project Meeting #1 was held at Randwick Council Offices on 11th July 2011.

The meeting incorporated:

- Project Inception; and
- A workshop to understand the aims of the Client Group.

This section provides a summary of key outcomes of Project Meeting #1.

4.1.1 Study Context

Randwick City Council (with contribution from other members of the Client Group) outlined the context in which the *Randwick Light Rail Pre-Feasibility Study* is being undertaken. Key themes include:

- State government commitment to light rail serving the Randwick area provides a window of political opportunity.
- Recent comments in the media have reinforced support for light rail serving the Randwick area, one key Government Stakeholder referring to this proposal as 'low hanging fruit'.
- In addition to established residential and employment areas the study area is characterised by a high level of visitor activity including:
  - University.
  - Hospitals.
  - Parklands.
  - Beaches.

  A comment was made that the Randwick area can be busier on weekends than weekdays.
- Need to determine if the light rail is 'doable' – i.e. technical viability.
- Council has signed a heads of agreement that brings together a number of key stakeholders for the purpose of addressing the potential need for light rail.

4.1.2 The Purpose of the Study – Input from Stakeholders

Attendees at the meeting were asked to describe (briefly and from their own perspective) the purpose of undertaking the *Randwick Light Rail Pre-Feasibility Study*, i.e. 'why we are doing the study'.

The key points raised are summarised below, with more detailed notes of stakeholder input provided in Appendix A.

- Undertake a pre-feasibility study into light rail serving Randwick with the aim of:

– Bringing together the necessary information.
– Undertaking the necessary analysis and assessment to place stakeholders in an informed position to engage with the NSW Government.
– Developing a clear position for the Stakeholder group in terms of key issues to pursue.

4.1.3 The Role of Light Rail – Input from Stakeholders

Attendees at the meeting were asked to describe (briefly and from their own perspective) the role of light rail in the context of this study, i.e. 'what the light rail should do'.

The key points raised are summarised below, with more detailed notes of stakeholder input provided in Appendix A.

- Improve the quality of public transport service to customers, including: speed, reliability, integration, frequency, comfort.
- Improve access to key city-level trip generators, including: University of NSW, Randwick Racecourse, Prince of Wales Hospitals / Health precinct, SCG/Entertainment Quarter. A key component of improving access to these city-level trip generators is to improve their competitiveness and optimise the value of these major assets to the state as a whole.
- Improve the efficiency and attractiveness of the overall public transport system serving the region. This includes providing adequate public transport capacity to meet current and future needs within the context of the broader surface road network.
- Provide sufficient quality of public transport service to facilitate the desired level of development and redevelopment / renewal within the study region.

4.2 Project Meeting #2

Project Meeting #2 was held at Randwick Council Offices on 25th July 2011.

4.2.1 Meeting Outline

Broadly, the meeting covered:

- A discussion of the strategic drivers to be used for the study;
- The route options being assessed; and
- Preliminary findings of different criteria being assessed.

4.3 Project Meeting #3

Project Meeting #3 was held at Randwick Council Offices on 4th August 2011.

4.3.1 Meeting Outline

Broadly, the meeting covered:

- A discussion of the preliminary analysis in relation to the route options being assessed; and
- Presentation and discussion of preliminary route layouts.

4.4 Project Meeting #4

Project Meeting #4 was held at Randwick Council Offices on 10th August 2011.

4.4.1 Meeting Outline

Broadly, the meeting covered:

- Clarification over bus numbers and frequencies serving the CBD, Central Station and UNSW;
- Review and clarification of expected development within the study area; and
- Alternative northern options to connect to Central Station.

5. The *Strategic Drivers* for Light Rail – Framework for Preliminary Assessment of Routes

5.1 Introduction – *Strategic Drivers*

This section outlines the *strategic drivers* developed to guide this study of potential light rail services in Randwick.

Strategic Drivers are a mechanism for understanding the complexity of the transport system and ensuring any light rail options that are pursued in the future will provide a public transport service that is valued by and brings value to the people of Sydney. The *Strategic Drivers* have been developed in recognition that light rail is only one of a number of different transport modes / interventions that could form part of Sydney's future public transport system.

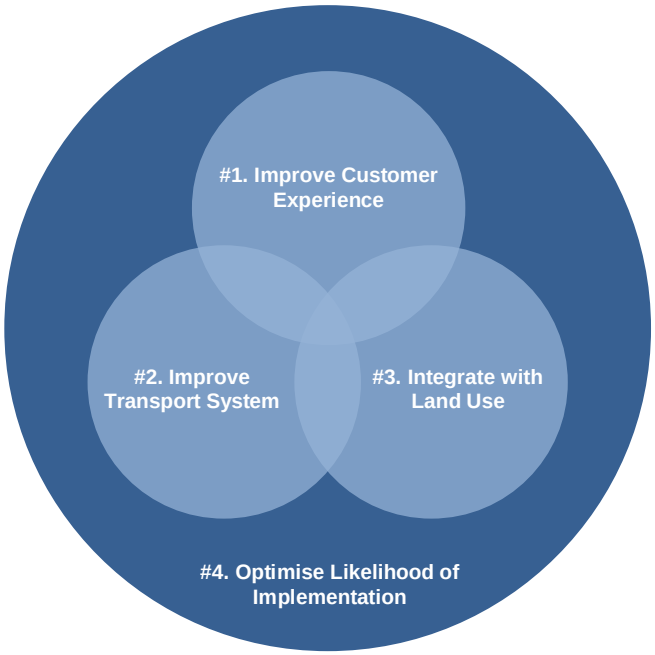
The *Strategic Drivers* inform the development of route options and also form the basis of a set of criteria to assess the potential for different route options to deliver the desired outcomes in Randwick and Sydney more broadly.

The descriptions of *Strategic Drivers* have been categorised into *aims* and *enablers* in order to aid comprehension:

- ***Aims*** - A more in depth explanation of *what* needs to be achieved to respond to the *Strategic Drivers*.
- ***Enablers*** – An outline of *how* to achieve the aims (i.e. key mechanisms / steps).

It should be noted that by their nature, there is a degree of overlap between the *Strategic Drivers* for this study. The four *Strategic Drivers* (and the interplay between them) is outlined graphically below and discussed in the following subsections.

Figure 5.1 Strategic Drivers – Summary



5.2 Strategic Driver #1 - Improve the Customer Experience

AIM: Provide attractive level of service to public transport customers

At the most basic level, the public transport system is built and operated to help people access the activities, goods and services they require as part of their everyday lives.

The study area has the characteristics generally associated with high mode share to public transport. These include:

- Relatively high residential densities and employment;
- A number of mixed use and employment centres;
- Urban structure and form that could be classified as transit oriented.
- Several regional-scale facilities that constitute major trip generators. These include:
  - Education - UNSW, Randwick TAFE, secondary schools (selective and private).
  - Health - Prince of Wales Hospital and associated health facilities and infrastructure.
  - Recreation - SCG, SFS, Fox Studios, Centennial and Moore Park and Randwick Racecourse.

  These regional-scale facilities necessitate good levels of regional public transport access in order to optimally benefit the metropolitan area they serve and the state economy in general.

People will value and use public transport when it offers an attractive level of service, providing fast, frequent and reliable services throughout the day (from early morning to late evening). It is important that the public transport service is comfortable in terms of amenity of stops, level of crowding, ride quality etc.

It is important to note that since the closure of tram lines, buses have provided the public transport services the study area. From the users' perspective, therefore, any new light rail routes will need to provide a level of public transport service at least as good (but ideally better) than the existing bus service.

Method of assessment:

Travel time estimates of light rail relative to bus

This assessment makes informed assumptions of likely light rail commercial speeds and then compares calculated travel times to existing bus services in order to determine the relative attractiveness of light rail services to current bus users.

ENABLER: Provide the required operating priority for light rail

Light rail constitutes a significant investment, and in the context of this study needs to materially improve the quality of service to customers in order to pay dividends by attracting a higher proportion of trips to the public transport system.

On this basis, the *product* that light rail offers (as part of a broader public transport system) needs to be comparable (or preferably superior to) the situation before it was implemented.

In simplistic terms, the light rail will need high levels of operational priority in order to ensure:

- High operational speeds.
- Reliable travel times.

This generally requires:

- A high level of physical segregation from the impacts of traffic congestion.
- A high level of priority at intersections.

While there are some sections of the future light rail route that are already segregated, on other sections, priority for light rail might come at the cost of:

- Reducing space currently available to general traffic; and/or
- Modification to current traffic arrangements (i.e. traffic management); and/or
- Investment in grade separation of light rail and general traffic.

ENABLER: Strong Integration between light rail and buses

It is noted that light rail cannot serve every bus route in the catchment. In order to optimise the value of investment in light rail while also improving the service provided to public transport users in the catchment, it will be crucial that there is strong integration between any light rail route and the existing (and future) bus system.

This will necessitate the restructuring of the bus network to best integrate with light rail services in order offer attractive travel options to passengers as well as achieving the desired outcomes on the transport system.

5.3 Strategic Driver #2 - Improve the Transport System

AIM: Improve the efficiency of the overall surface transport network

A key aim of any modifications to the public transport system within the study area is to improve the efficiency of the *overall* surface transport network. This will generally be achieved by:

- Reducing the impacts of congestion associated with the current transport mix; and
- Delivering public transport services more efficiently.

To achieve this, a reallocation of road space is often required to benefit modes that deliver higher carrying capacity within constrained corridors.

Method of assessment:

Reduce the Number of Buses Running to the CBD

This assessment incorporates the development of one potential option for restructuring the existing bus system around light rail in order to reduce the number of buses running into the congested CBD. This has notionally been undertaken for 'day one' of light rail operation, and thus is not premised on a wholesale restructure of the overall bus system.

AIM: Provide Sufficient Capacity to cater for desired mode share

One of the justifications of investing in light rail in the study area is to increase the mode share to public transport. If light rail is implemented it will therefore be necessary for it to provide sufficient capacity along key links to cater for increases in demand.

> **Method of assessment:**
>
> ***Capacity of light rail to serve public transport demand in the Study Area***
>
> This assessment provides a broad level indication of the feasibility of light rail to carry the level of passenger volumes currently carried by buses along key links (plus 30% and plus 50% to consider growth in demand).

AIM: Provide the ability to integrate with potential future extensions to the light rail system

There is currently no agreed vision for a future light rail network in Sydney. There are, however, a number of potential future extensions that would be likely candidates should there be any extensions to the light rail system. Any light rail routes under consideration, therefore, should be assessed in view of the potential to integrate with potential future extensions.

It is noted, however, that it may also be feasible to commence development of a particular light rail project in advance of an agreed strategy for light rail in Sydney. While this would entail a degree of risk (i.e. the strategy does not identify the light rail project as being of high priority), it could materially reduce the time taken for project implementation. Time-consuming parts of the project development (such as concept design, environmental impact assessment etc.) could be undertaken at relatively low cost, meaning that the modest investments made at the early stages could be recouped in terms of reductions in the time taken to implement the project should it proceed.

> **Method of assessment:**
>
> ***Potential to integrate with future extensions***
>
> This assessment maps likely candidates for future light rail links to determine the potential for these links to integrate with the routes under consideration.

ENABLER: Restructure the surface transport system to provide integrated transport outcomes

Experience in implementing or expanding light rail systems in numerous cities shows that light rail acts as a structuring element and catalyst for the reorganisation of the surface transport system.

To optimise the benefits of investing in light rail it will be necessary to re-structure / reorganise the surface public transport system in order to better serve the needs of users and to address the inefficiencies of the existing transport systems.

ENABLER: Improve operating conditions for public transport at key locations on the transport network

In an integrated transport system, it is sometimes necessary to invest in improvements to one part of the system in order to reduce impacts in other, more critical locations.

In the case of the surface transport system in central Sydney, there are significant pressures within the CBD and around Central due to bus congestion (and overall traffic congestion). In these cases, implementation of light rail will need to provide a more efficient means of meeting demand along key corridors.

The potential for any light rail in Randwick to deliver benefits will be strongly dependent on the conditions provided for light rail beyond Anzac parade (i.e. into the CBD and potentially to Central Station). In concise terms, a high degree of operational priority will be required north of Anzac Parade in order to ensure that travel times that are shorter and more reliable than those currently offered by bus.

5.4 Strategic Driver #3 - Integrate with Land Use

Light rail routes will need to optimally integrate with the land use they serve. In this matter, it is crucial to consider the existing situation and the potential future situation.

AIM: Serve key *activity zones*

In this context, the term *activity zone* is used to describe a land use that serves the Sydney metropolitan area.

These regional scale land resources constitute major trip generators including:

- Education - UNSW, Randwick TAFE, secondary schools (selective and private).
- Health - Prince of Wales Hospital and associated health facilities and infrastructure.
- Recreation - SCG, SFS, Fox Studios, Centennial and Moore Park and Randwick Racecourse.

Notably, the characteristics of the travel demand vary significantly between these trip generators.

The provision of high levels of access to these major regional generators via public transport is important for the economic competitiveness of NSW, of which many have been identified in the *Metropolitan Plan* (NSW Government, 2010).

Methods of assessment:

Key activity zones and town centres

This assessment maps likely key *activity zones* to determine the potential for different light rail options to serve and integrate with them.

Compilation of visitor data for Key Activity Zones

This assessment provides a compilation of visitor data for key *activity zones* (prepared by Randwick City Council) in order to help construct a picture of the magnitude of trips associated with these areas.

AIM: Serve areas of highest residential and employment densities

There is a strong correlation between public transport ridership and areas of higher residential and employment densities.

As a rule of thumb, residential densities above 15-30 dwellings per hectare (approximately 30-60 residents / hectare) provide 'fertile grounds' for viable public transport routes. Employment and 'mixed use' activities further drive public transport ridership.

The ambient residential densities within the study area are in the range of 30 – 90 people per hectare, confirming that the routes under investigation have strong potential to attract good levels of public transport patronage. This is to be expected as the study area was initially developed around a light rail system and exhibits many characteristics of 'transit oriented development'.

Method of assessment:

Residential and employment densities

This assessment maps the residential and employment densities within the study area to determine the potential for different light rail options to serve and integrate with them.

AIM: Serve areas of Population and Employment Growth

A key justification of investment in higher capacity, higher quality public transport is the need to respond to projected growth in population and employment, as this will influence travel demand.

Population growth is minimal in the catchment area of the routes being studied (at the broad scale, residential development will generally keep up with reducing household sizes). There are, however, parts of the study area where significant growth in employment is projected.

Method of assessment:

Projected Population and Employment Growth

This assessment maps the population and employment growth projections within the study area to determine the potential (or need) for different light rail options to support / catalyse the projected growth.

AIM: Catalyse Land Use Development

Strategic planning projections indicate that within the catchment area, there will be a limited amount of development of previously undeveloped sites and that the balance of development activity will be associated with intensification, redevelopment and renewal.

Most notable areas of redevelopment activity where intensification of mixed land uses is occurring are along Anzac Parade in Kensington (zoned building height up to 27 metres) and Belmore Road in Randwick (zoned building height: 12 metres).

At this local level, light rail could offer a degree of stimulation of the quantity, speed and quality of redevelopment and renewal in these areas.

Method of assessment:

Areas of Projected Floorspace Increases

This assessment maps the projected floor space increases within the study area to determine the potential for different light rail options to catalyse areas of localised redevelopment.

AIM: Improve Equity of Access

Equity of access is an important contributor to overall social equity within a region, as it enables access to education, employment, social and cultural activities.

Improvements to the quality of access through improvements to public transport services can raise the level of access within the catchment area.

Method of assessment:

Mapping of Socio-Economic Disadvantage

The Index of Relative Socio-Economic Disadvantage (SEIFA) is derived from Census variables related to disadvantage, such as low income, low educational attainment, unemployment and dwellings without motor vehicles.

It provides a broad identification of areas where improved public transport access could contribute to addressing socio-economic disadvantage.

5.5 Strategic Driver #4 – Optimise likelihood of Implementation

If it is determined that light rail constitutes a valid transport option within the study area, then a key driver is to develop a project in such a way that optimises the likelihood that of implementation.

AIM: Minimise the cost and time to implement light rail

Within the context of the study area, the implementation of light rail could be viewed as *opportunistic* (being an established urban area and travel market) rather than *structural* (as would be the case in a greenfield area under development).

As such, the ease of implementation of light rail is a key consideration for project stakeholders. Key influences on the ease of implementation include:

- Physical feasibility.
- Cost of construction (per service kilometre delivered).
- Time of implementation.
- Project risk.

Methods of assessment:

Assessment of grades

This assessment identifies sections of the light rail routes where grades exceed those generally considered as feasible for the operation of light rail vehicles. This is done on the basis that the key complicating factor in terms of technical feasibility (at this level of study) is light rail alignment.

Reference to historical precedents

This assessment identifies sections of the light rail routes that coincide with former tram lines. This is done on the basis that former tram lines are a strong indicator of technical feasibility (and thus less complicated implementation).

Aim: Develop public transport options that aligns with the current drivers within Government

It is recognised the first four strategic drivers adopted for this study do not cover the full extent of considerations in pursuing the development of light rail.

Experience in Australia and overseas shows that investment in 'game-changing' public transport such as light rail, bus rapid transit or heavy rail is rarely justified purely by an assessment of costs and benefits with narrow parameters. The development and delivery of these interventions are often justified by a broader range of conditions. For light rail in the context of this study, these could include such themes as:

- A change in the way that the State Government serves the travelling public. The scope of analysis in the past have meant that public transport services have delivered 'more of the same' (i.e. new buses, new bus routes), but with little benchmark shift in quality of service for customers or mode share to public transport.
- A change in the priorities for transport in inner city areas.
- The desire to test a 'new' mode in an area with many of the characteristics necessary to optimise the viability of light rail ("picking the low hanging fruit").
- The desire for transformation of inner city areas.

6. Preliminary Analysis

6.1 Introduction

6.1.1 The Route(s) Being Assessed

For the purpose of undertaking this study, GHD has classified the routes outlined in the Client Group's brief into a number of route options:

- **Core Route**: Anzac Parade between Flinders Street (Surry Hills) and High Street (Kensington);
- **South 1**: Anzac Parade between High Street (Kensington) and Sturt Street, south of the Nine Ways (Kingsford);
- **South 2**: High Street between Anzac Parade (Kensington) and Belmore Road, east of Avoca Street (Randwick); and
- **South 3**: Alison Road and Belmore Road between Anzac Parade (Centennial Park) and Cuthill Street, east of Avoca Street (Randwick).

It is noted that over the course of the study, an additional set of route options were added in order to make consideration of a potential link to Central Station:

- **North 1**: Link between the Sydney Cricket Ground and Central Station. Higher cost option involving long tunnel and Devonshire Street; and
- **North 2**: Link between the Sydney Cricket Ground and Central Station. Lower cost option involving tunnel under Anzac Parade, an at grade link across Moore Park, Eastern Distributer and Bourke Street and then along Devonshire Street.

It is noted that the Core Route Option and Route Options South 1, 2 and 3 are analysed in this section.

Route Options North 1 and 2, however have only been analysed against Strategic Drivers #1 and #4.

The route options being assessed in this study are shown in Figure 6.1.

Preliminary Definition of Light Rail Stops

Figure 6.1, described earlier, shows indicative locations for light rail stops. These stop locations were defined based on the analysis incorporated in the remainder of this section.

Key characteristics of potential stops for different route options are outlined below:

- **Core Route**: Stop spacing ranging from approximately 300 to 800 metres, with a major interchange at the SCG/SFS/Entertainment Quarter precinct;
- **South 1:** Stop spacing ranging from approximately 300 to 550 metres, with a major interchange at the Kingsford Nine Ways;
- **South 2:** Stop spacing ranging from approximately 200 to 600 metres, with a major interchange at High Cross Park;
- **South 3**: Stop spacing ranging from approximately 200 to 450 metres, with major interchanges at High Cross Park and Randwick Racecourse (at Alison Road/Darley Road); and

- **North 1 and North 2**: Stop spacing ranging from approximately 350 to 700 metres, with major interchanges at Central Station and the SCG/SFS/Entertainment Quarter precinct.

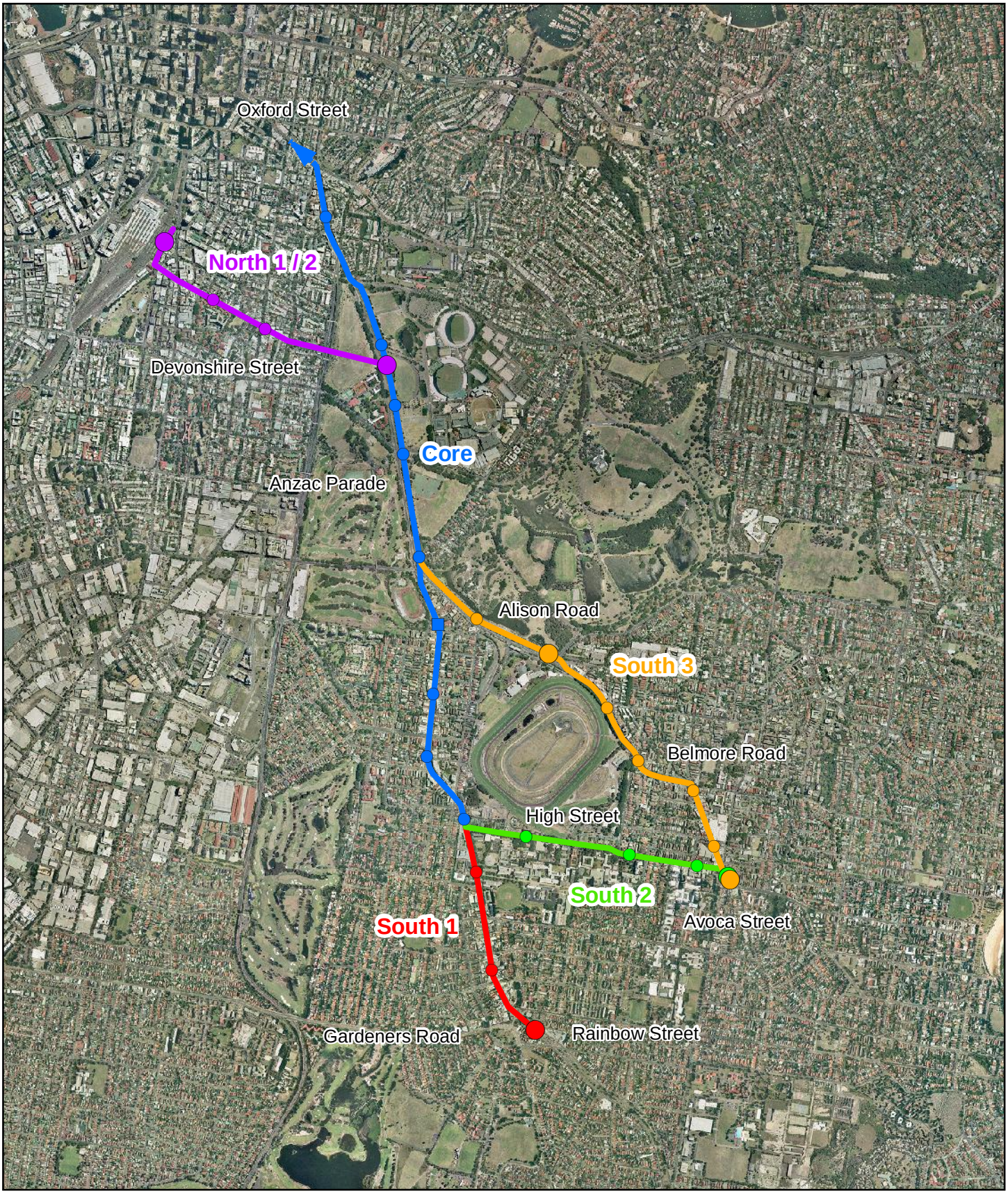
6.1.2 Study Area

This study focuses on the area surrounding the routes identified in the Study Brief (and outlined above). It is recognised, however, that consideration needs to be made of functional connections to a broader area. For this reason, the study area has been categorised as follows:

- Core study area; and
- Secondary study area.

It is noted that due to the degree of uncertainty and complexity associated with light rail in central Sydney, the study area does not extend to the CBD.

The study area was shown graphically in the *Introduction* in Figure 1.1.



Legend

Route Options
- CBD Connection
- Core
- North 1
- South 1
- South 2
- South 3

Potential Light Rail Stops
- Light Rail Stop
- Interchange
- Future Stop

Paper Size A4

0.5 0.25 0 0.5 Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD
CLIENTS | PEOPLE | PERFORMANCE

Randwick City Council
Randwick Light Rail Pre-feasibility Study

Route Options

Job Number	21-20812
Revision	A
Date	26 Aug 2011

Figure 6.1

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6.2 Analysis associated with Strategic Driver #1 - *Improve the Customer Experience*

6.2.1 Travel time estimates of light rail relative to bus

Purpose of the Analysis

This assessment makes informed assumptions of likely light rail commercial speeds and then compares calculated travel times to existing bus services in order to determine the relative attractiveness of light rail services to existing bus users.

Key Outputs of the Analysis

A comparison of bus and light rail travel times is provided in Table 6.1.

Table 6.1 Indicative Bus and Light Rail Travel Times

Journey	Route	Travel Time (Minutes)	
		Bus (AM) (Timetabled)	**Light Rail (Calculated)**
Kingsford Nine Ways to Martin Place	via Anzac Parade (South 1)	28:00	25:01
High Cross to Martin Place	via High Street (South 2)	29:00	27:14
High Cross to Martin Place	via Alison Road (South 3)	26:00	25:35
UNSW to Central	via Anzac Parade and Devonshire Street (North 1)	16:00 – 17:00 *	14:14
UNSW to Central	via Anzac Parade and Devonshire Street (North 2)	16:00 – 17:00 *	14:52

* Note: Timetabled travel times vary depending on the type of bus service; either running with no stops or with stops.

Key Inputs to the Analysis

The bus travel times were sourced from published (timetabled) travel times of a range of bus routes that reflect the different route options.

In respect to travel times, however, the following is noted:

- Timetabled trip times (i.e. in vehicle) do not reflect the total trip time (which also includes wait time);
- Perceived trip times (including wait times) are dependent on the quality of experience (both waiting and travelling); and
- There is evidence that wait times on certain major bus routes (such as UNSW shuttles) can be considerable (in proportion to in the time spent in vehicle) and also that the amenity of the waiting facilities for some routes is low (in terms of adequate lighting, protection from weather etc.).

The light rail travel times were calculated based on the assumptions for *commercial speeds* of different sections along the route option. These are outlined in Table 6.2.

Commercial speed refers to average operating speed of light rail over the route (or portion of the route), and includes dwell time at stops and intersections. The Core route was divided into three sections in order to make a more accurate estimate of the overall commercial speed.

Table 6.2 Commercial Speed

Route	Section of Route		Length (Km)	Commercial Speed (Km/h)	
	Start	**End**		**Bus (Timetabled)**	**Light Rail (Estimated)**
Core	Martin Place / Elizabeth	Anzac Parade / High Street	5.9	16.1	17.0
Core 1	*Martin Place / Elizabeth*	*Oxford / Flinders*	*1.9*	*14.3*	*13*
Core 2	*Oxford / Flinders*	*Anzac Parade / Cleveland St*	*1.8*	*17.5*	*20*
Core 3	*Anzac Parade / Cleveland St*	*Anzac Parade / High Street*	*2.2*	*16.5*	*18*
South 1	Anzac Parade / High Street	Nine Ways	1.3	25.4	18
South 2	Anzac Parade / High Street	High Street / Belmore Road	1.6	15.7	16
South 3	Anzac Parade / Cleveland St	High Street / Belmore Road	3.3	19.8	18
North 1	SCG	Chalmers / Elizabeth	1.7	19.8	19
North 2	SCG	Chalmers / Elizabeth	1.7	19.8	17

Light rail trip times were calculated using estimates for commercial speed that were premised on the assumption of high levels of operational segregation for light rail.

As a measure, *Commercial speed* incorporates (or serves as a proxy for) a number of key considerations, including:

- Level of operational priority provided for light rail:
  - Degree of segregation from general traffic; and
  - Level of signal priority;
- Number of stops and dwell time at stops.

6.2.2 Outcomes of Analysis associated with Strategic Driver #1 - *Improve the Customer Experience*

Points to Note

- For key trips, preliminary estimates indicate that light rail would provide marginally faster trip times than buses.
- In addition to this, it could be anticipated that light rail would provide levels of reliability that are superior to bus services (operating in their current configurations), since high levels of operational priority would be required to achieve the required commercial speeds / trip times for light rail. It should be noted, however, that investment in high levels of priority for bus along the routes under consideration could be expected to deliver improvements to the reliability of bus services in their current configurations.
- A fast and reliable light rail link into the CBD (i.e. north of Flinders Street) would be critical to the viability of light rail services in the study area on the basis that key impacts to reliability occur in area north of the study area (i.e. within the CBD).
- Future, more in-depth work would need to incorporate consideration of all aspects of the overall trip times / customer experience. This would include:
  - The potential need to interchange between bus and light rail for some services (due to restructuring of existing bus system).
  - The impact of waiting time on the overall passenger experience.

Key Findings

For Strategic Driver #1 - *Improve the Customer Experience*, there are no major differences between the route options (Core, South – S1, S2, S3 and North – N1, N2) at this level of investigation, although the following is noted:

- Travel times between key destinations will be a key consideration should a decision be made between establishing light rail on Route Option South 2 (High Street) or Route Option South 3 (Alison Road) as they serve similar travel demands. At this stage, indications are that Option South 3 (Alison Road) would offer slightly better travel times than Option South 2 (High Street).
- The travel times between key destinations will be a key consideration should a decision be made between establishing light rail on Route Option North 1 (long tunnel) or Route Option North 2 (short tunnel) as they serve the same travel demands. At this stage, indications are that Option North 1 (long tunnel) would offer slightly better travel times than Option North 2 (short tunnel), although this would entail a major cost increase.

Conclusions

At this level of investigation, indications are that:

- Option South 3 (Alison Rd) would offer slightly better travel times than Option South 2 (High Street).
- Option North 1 (long tunnel) would offer slightly better travel times than Option North 2 (short tunnel), although this would entail a major cost increase.

6.3 Analysis associated with Strategic Driver #2 - *Improve the Transport System*

Note with respect to the Sources of Bus Data

It should be noted that different data sets have been used for Section 6.3.1 (Bus restructure) and Section 6.3.2 (Capacity to serve bus numbers). Key points are:

- The data used for the bus restructure were sourced from current (2011) published timetables for potentially affected routes.
- The data used to calculate the light rail capacity to serve bus numbers were sourced from a Bureau of Transport Statistics (BTS) dataset from 2008 of bus volumes on different parts of the transport network, as this incorporated volumes along specific road links pertinent to the study area.
- It was found that generally, the 2008 data was some 20% higher than the 2011 data, however two routes (348 and 371) had been withdrawn from service over this period.
- Information provided by UNSW for this study has also indicated that STA buses generally operated 5-10% more services than published, both to and from the university.

6.3.1 Reduce the number of buses entering the CBD from the Eastern Suburbs

Purpose of the Analysis

This assessment incorporates the development of one potential option for restructuring the existing bus system in the Eastern Suburbs around light rail in order to reduce the number of buses running into a currently congested CBD. This has notionally been undertaken for 'day one' of light rail operation, and thus is not premised on a wholesale restructure of the overall bus system.

Key Outputs of the Analysis

The key assumptions and outcomes of the analysis associated with this investigation are incorporated into two tables in Appendix B.

Key Inputs to the Analysis

In order to assess the potential for light rail options to reduce the number of bus services running through the CBD, the following process was undertaken:

- Using published (2011) timetables, identify the number of inbound (or city-bound) buses arriving in the CBD during the morning peak (8-9 am);
- Identify existing bus services and reasonable changes to these services as a result of the introduction of light rail. Options for existing buses services were:
  - Remain the same;
  - Truncate; and
  - Reroute.
- A more detailed breakdown of the assumptions per route option is provided in Appendix B.
- The following should be noted:
  - This analysis is premised on a 'modest' restructure of the existing bus network rather than a more long-term evolution of the existing network.

Key Findings of the Analysis

Based on the above methodology for an indicative bus restructure, it was found that:

- Core: From a total of 150 buses, 70 would continue to run as they currently do, resulting in a reduction of 80 buses entering the CBD in the morning between 8-9 am.
- South 1: As South 1 is also along Anzac Parade, the results were the same as the Core route option.
- South 2: While the South 2 route option is along High Street, it is expected that this would not alter any services from travelling into the CBD. Therefore, the results were the same as the Core route option.
- South 3: Different to the other south options, this option along Alison Road would replicate more bus routes, and therefore it has been assumed that some would be truncated at High Cross Park. Consequentially, it is assessed that the number of buses entering the CBD in the one hour morning peak would be reduced by a further 13 buses.

Separate from bus trips into the CBD, should a North 1 / 2 route option be introduced, this would effectively replace the UNSW services, of which there are 36 travelling to UNSW from Central between 8-9 am.

6.3.2 Capacity of light rail to serve public transport demand in the Study Area

Purpose of the Analysis

This assessment provides a broad level indication of the feasibility of light rail to carry:

- Existing public transport traffic - the level of passenger volumes currently carried by buses along key links;
- Increased public transport traffic - the level of passenger volumes currently carried by buses along key links factored up by a notional 30% and 50% to take account of growth in demand over time or due to mode shift.

Key Outputs of the Analysis

Full details of this preliminary level analysis are provided in Appendix C.

Table 6.3 provides a summary of key outputs of the preliminary assessment and incorporates the following:

- Peak (1 hour) 'link volumes' of buses at different cordons - i.e. how many buses (from diverse routes) are passing a point during the peak 1 hour;
- The number of light rail vehicles that would be required to serve the existing bus traffic under an extreme case where all bus services were converted to light rail services (assuming 30 metre long light rail vehicles);
- The number of 30 metre long light rail vehicles that would be required to serve the existing bus traffic plus 30% and plus 50% (under an extreme case where all bus services were converted to light rail services). These arbitrary growth rates would incorporate mode share and / or demand growth into the future; and

- The numbers underlined indicate the locations where light rail frequencies are higher than the theoretical maximum capacity of link (60 light rail services per hour) that was adopted for this analysis.

Table 6.3 Indicative Bus and Light Rail Capacity (AM Peak 1hr, 100% Conversion from Bus)

Route	Cordons	Bus/hour (existing)	LRT equivalent (existing)	LRT equivalent (+30% growth)	LRT equivalent (+50% growth)
Core	Anzac Parade (Moore Park)	114	45	59	68
Core	Anzac Parade (Centennial Park)	133	53	69	80
Core	Anzac Parade (North of High Street)	43	17	22	26
S1	Anzac Parade (South of High Street)	32	13	16	19
S1	Anzac Parade (South of Rainbow Street)	19	8	10	11
S1	Anzac Parade (North of Maroubra Road)	19	8	10	11
S2	High Street	11	4	6	7
S3	Alison Road	73	29	38	44

Key Inputs to the Analysis

This analysis draws on existing (2008) Bureau of Transport Statistics (BTS) data of bus volumes on different parts of the transport network. Of note in respect to these data:

- Base Data:
  - Date of preparation: 2008
  - Scale: Broad, prepared for key bus links across the Sydney Metropolitan area.
  - Time period: Data was for a four hour peak period. AM: 6:00-10:00 hours, PM: 15:00-19:00 hours).
  - Key Limitations:
    - It appears that the AM volumes reflect PM volumes and inbound peak volumes reflect outbound peak volumes. This would indicate that data was extrapolated from one peak period/direction;
    - There was a gap in the data for Alison Road, which was updated from existing (2011) timetables;

- This data set differs from that used in conjunction with the bus network restructure, which was based off current timetables.

- GHD processing of Data:
  - Factor to convert 4 hour peak bus volumes to 1 hour peak bus volumes: 0.4.
  - Factor to convert buses to light rail (30 m long): 0.4 (i.e. 2.5 buses = 1 LRT).
  - Factor to convert buses to light rail (45 m long): 0.25 (i.e. 4 buses = 1 LRT).
  - Theoretical maximum capacity of link (LRT services per hour): 60 LRT services / hour.

Key Findings of the Analysis

Based on an analysis of the available data, and using the processes and broad assumptions outlined above, the following is evident:

- For a 50% increase in existing bus traffic, and using 30 metre long light rail vehicles:
  - Most routes being studied would provide sufficient light rail capacity under an 'extreme' scenario of a 100% travel mode shift from bus to light rail. The exceptions are the links identified by:
    - Anzac Parade Cordon at Moore Park - which would only have sufficient capacity to carry up to 80% of the transferred bus traffic.
    - Anzac Parade Cordon at Centennial Park - which would only have sufficient capacity to carry up to 70% of the transferred bus traffic.
- For a 30% increase in existing bus traffic, and using 30 metre long light rail vehicles:
  - Most routes being studied would provide sufficient light rail capacity under an 'extreme' scenario of a 100% travel mode shift from bus to light rail. The exceptions are the links identified by:
    - Anzac Parade Cordon at Centennial Park - which would only have sufficient capacity to carry up to 80% of the transferred bus traffic.
- For a 50% increase in existing bus traffic, and using 45 metre long light rail vehicles, all routes being studied would provide sufficient light rail capacity under an 'extreme' scenario of a 100% travel mode shift from bus to light rail.
- The following is noted:
  - According to the analysis provided above, the highest intensity of bus or light rail traffic would be at the Anzac Parade Cordons (on the Core route in the Moore Park / Centennial Park area). This is to be expected as it is the link where currently most bus services occur. It is noted that these areas offer good potential for capacity augmentation (such as additional light rail track or roadways for buses).
  - It is likely that a proportion of buses will continue to travel on part (or all) of the light rail routes being studied. This would reduce the operating capacity (and/or efficiency) for light rail. The actual numbers (i.e. the mix) of light rail vehicles and buses using different parts of the routes being studied would be the ultimate determinant of the links' capacity to meet demand.
  - There is likely to be a degree of reorganisation / restructuring of bus routes and services associated with the implementation of any light rail service. This would result in changes to the existing (and projected) bus volumes on the various links incorporated into this analysis.

6.3.3 Potential to Integrate with Future Extensions

Purpose of the Analysis

This assessment maps likely candidates for future light rail links to determine the potential for these links to integrate with the routes under consideration.

Key Outputs of the Analysis

While there is currently no agreed vision for a future light rail network in Sydney, Figure 6.2 shows indicative options for potential light rail extensions serving the study area and/or intersecting with the route options being investigated for this study.

Key Inputs to the Analysis

Potential light rail extension options that are currently under consideration (or have recently appeared in the public domain) are presented on Figure 6.2. These include:

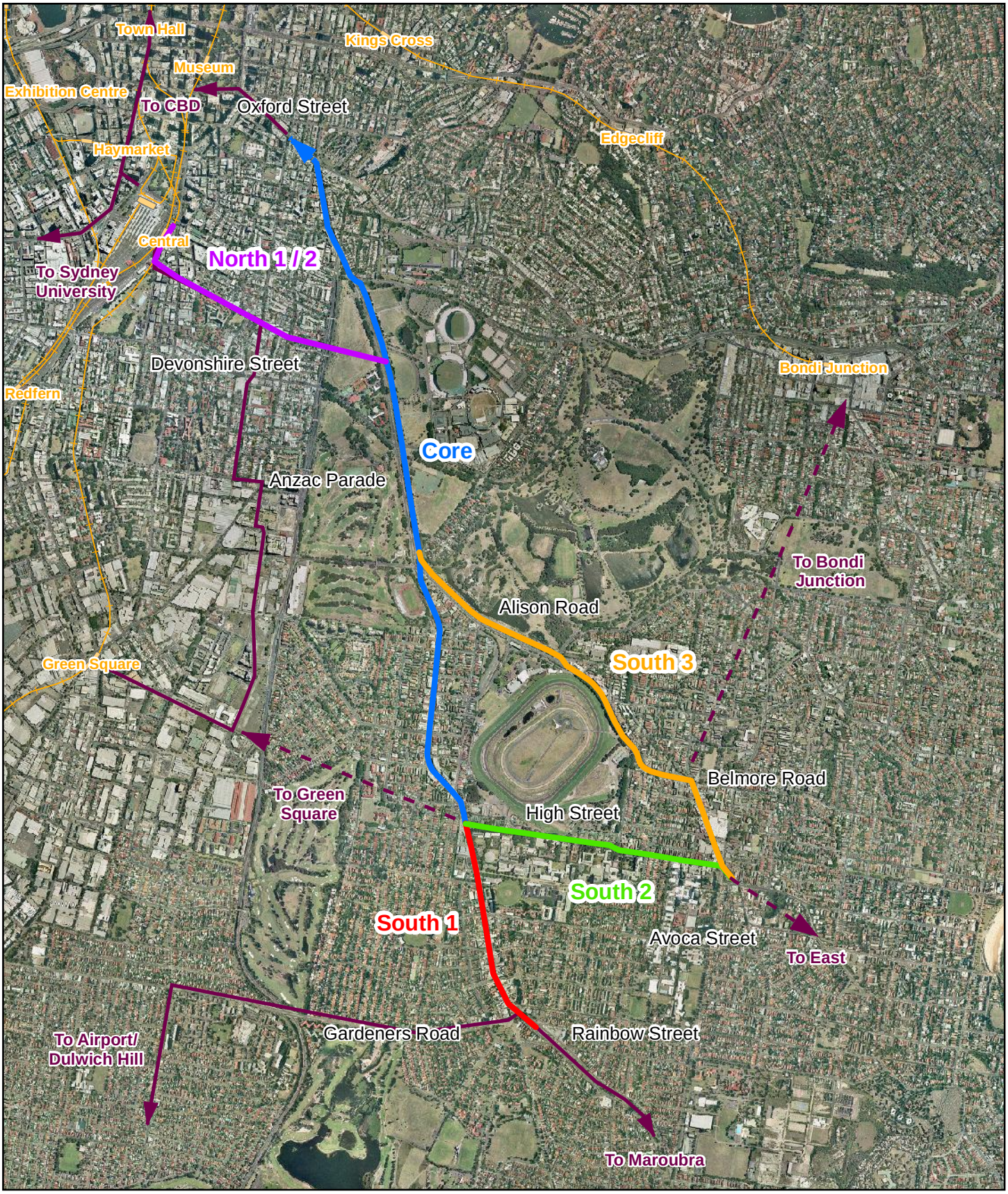
- CBD extensions – preliminary study by GHD (2010) and reported in recent articles in the Sydney Morning Herald (6 May 2011).
- Green Square – preliminary study by GHD (2010).
- Coogee / Airport / Dulwich Hill – Sydney Morning Herald (15 December 2010), and Ecotransit.
- Sydney University – Minister for Transport press release (14th June 2011).

Key Findings of the Analysis

Based on the potential light rail extension options presented on Figure 6.2, the following observations are made:

- Core: This route option would enable an extension north into the CBD, of which there are several possible sub-options once in the CBD;
- South 1: This route option would enable an extension further south to Maroubra along Anzac Parade and an extension west to the Airport and Dulwich Hill;
- South 2: This route option would enable an extension to the East;
- South 3: This route option would enable an extension to the East; and
- North 1: This route option would enable a connection to the Green Line (proposed between Green Square and Central Station via Devonshire Street), and a potential connection to the CBD and/or existing light rail line.

Other indicative potential extension options would be to Green Square from the Core Route and to Bondi Junction from the South 3 option.



Legend

Route Options

- Train Lines
- CBD Connection
- Train Stations
- Core
- North 1
- South 1
- South 2
- South 3

Paper Size A4

0.5 0.25 0 0.5 Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Randwick Light Rail Pre-feasibility Study

Future Extensions

Job Number	21-20812
Revision	A
Date	15 Sep 2011

Figure 6.2

G:\21\20812\GIS\Maps\MXD\2120812_Z003_Future_Extensions.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:nbuchanan

6.3.4 Outcomes of Analysis associated with Strategic Driver #2 - *Improve the Transport System*

Points to Note

- From an economic perspective (i.e. the assessment of benefit to society) a key source of project benefit would be the reduction in buses entering a currently congested CBD. With their higher capacity, light rail could deliver people into the CBD more efficiently (from a network perspective) than bus.
- The following preliminary observations are made of light rail and bus operations:
  - Core Route - It is likely that light rail and buses would share the same facility.
  - Route Options S1, S2 and S3 – It is likely that bus services along the same corridor would run on the road, parallel to the light rail facility.
  - Route Options N1, N2 – It is likely that bus services would run along different corridors.
- Further work would be required to determine whether design development would be based on a 30 metre light rail vehicle or a 45 metre light rail vehicle.

Key Findings

For Strategic Driver #2 - *Improve the Transport System*, the key differences between the route options (Core , South – S1, S2, S3) at this level of investigation are:

- **Reducing the numbers of buses entering the CBD during the morning peak hour**. The Core route would have the greatest benefit (with a notional reduction from 150 to 70 buses). The South 3 option would further reduce the number of buses entering the CBD in the one hour morning peak by some 13 buses, while other South options would have negligible impact on the number of buses entering the CBD. The North route options would affect the number of buses to/from Central Station, but largely not in the rest of the CBD.
- **Capacity for light rail to meet public transport demand in the study area**. Capacity is unlikely to be a key determinant in selecting route options, as in general terms, light rail would provide sufficient capacity to carry the required demand along all corridors within the study area.
- **Potential to Integrate with Future Extensions.** In terms of a potential future light rail system, the Core and South 1 Route offer the best potential for a range of extensions, whereas the South 2 and 3 route options offer a further extension to the east.

Conclusion

Overall, in terms of improvement to the transport system, the Core Route and South 1 Route options are considered to be the most critical, with South 3 offering more substantial benefits than the South 2 route option.

6.4 Analysis associated with Strategic Driver #3 - *Integrate with Land Use*

6.4.1 Key Activity Zones and Town Centres

Purpose of the Analysis

This assessment identifies key *activity zones* to determine the potential for different light rail options to serve and integrate with them. The assessment also provides a compilation of visitor data for key *activity zones* (prepared by Randwick City Council) in order to help construct a picture of the magnitude of trips associated with these areas.

Key Outputs of the Analysis

Figure 6.3 shows the key *activity zones* within the Study area. By route options, these include:

- Core: Regional generators such as the Sydney Cricket Ground (SCG), the Sydney Football Stadium (SFS), Entertainment Quarter, the Royal Randwick Racecourse, the University of New South Wales (UNSW), high schools, parks and Kensington town centre;
- South 1: UNSW, the National Institute of Dramatic Art and Kingsford town centre;
- South 2: UNSW, the Royal Randwick Racecourse, the Randwick Health Campus with four major hospitals and the Randwick town centre;
- South 3: Centennial Park, the Royal Randwick Racecourse, the Randwick TAFE and the Randwick town centre; and
- North 1 / North 2: The SCG/SFS/Entertainment Quarter precinct and Central Station.

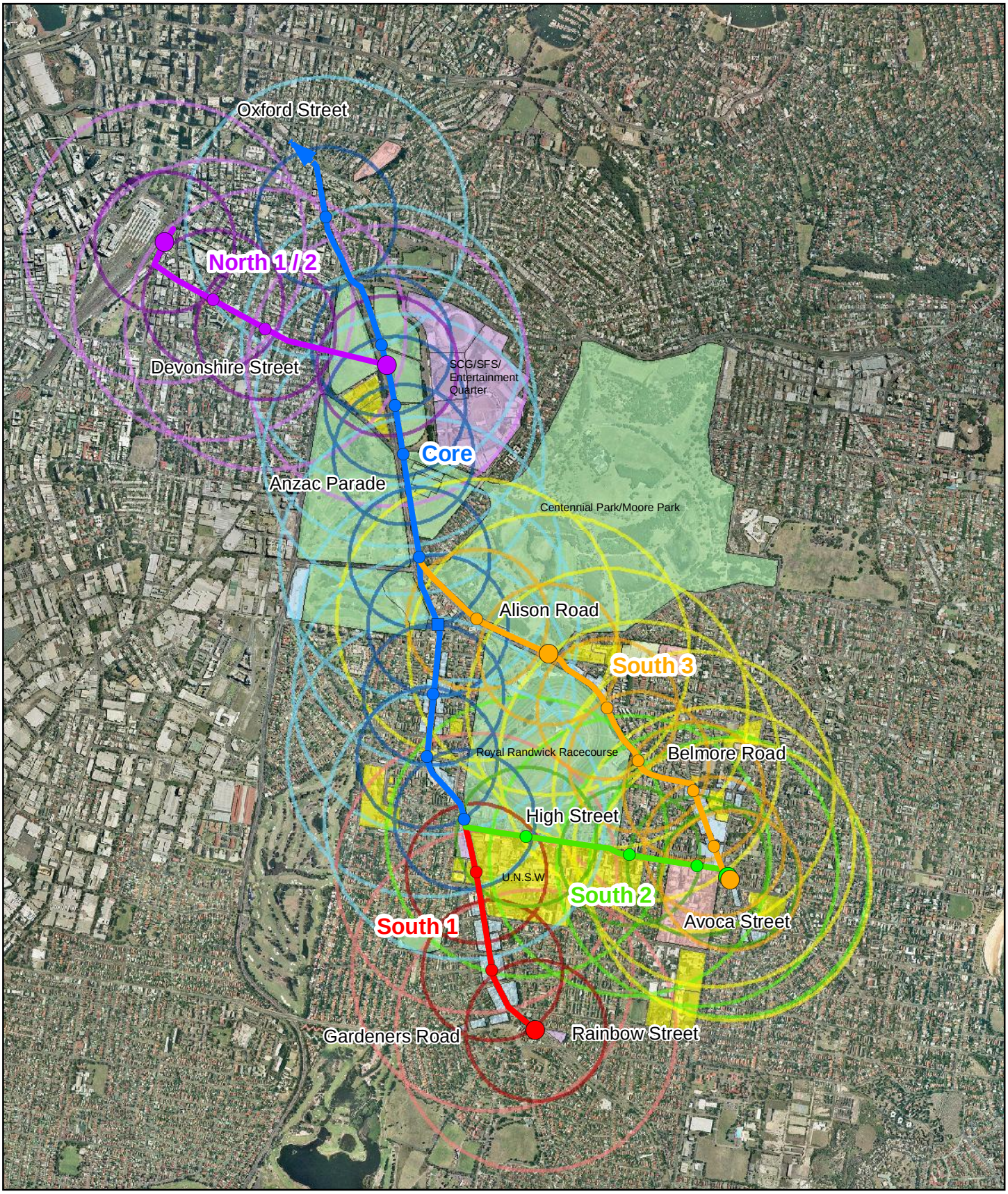
In the case of this study, several of the key *activity zones* serve a metropolitan area-wide catchment, and thus constitute an important consideration for the route options under investigation.

Figure 6.3 also shows how the indicative stops on different route options (and their catchment areas) serve different *activity zones*. The catchments shown in this figure are indicative (straight line) walk-up catchments around light rail stops. The values adopted for walk-up catchments for light rail (400 metres and 800 metres) are commonly used (internationally and in Australia) as indicative areas where people would comfortably walk to a public transport node. The catchments were adopted as part of a broad assessment of competition between different transport modes in the vicinity of the proposed light rail.

Table 6.4 summarises key *activity zones* in the study area and outlines the nature and drivers of the travel demand associated with each *activity zone*.

Table 6.5 provides an indication of the quantum of trips associated with key *activity zones*. Trip estimates are in one direction only and are provided per day and/or per year.

It is noted that these data were provided by Randwick City Council, and were collated from a number of sources. Together, these data help to present a more complete picture of the travel task throughout the entire day, as commonly used data typically only captures travel to and from work, and does not often include other trips including travel to education (secondary and tertiary), health care facilities and recreational / special events venues.



Legend

Route Options
- CBD Connection
- Core
- North 1
- South 1
- South 2
- South 3

Potential Light Rail Stops
- Light Rail Stop
- Interchange
- Future Stop

Stop Buffer (400m)
- Core Route
- South 1
- South 2
- South 3
- North 1

Stop Buffer (800m)
- Core Route
- South 1
- South 2
- South 3
- North 1

Key Activity Zones
- Business Zones
- Council
- Educational
- Entertainment
- Health
- Industrial
- Recreation
- Transport

Paper Size A4

0.5 0.25 0 0.5 Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Job Number 21-20812
Revision A
Date 26 Aug 2011

Key Activity Zones, Route Options, Indicative Stops and Catchments

Figure 6.3

G:\21\20812\GIS\Maps\MXD\2120812_Z004_Trip_Generators&Stops.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Table 6.4 Key Activity Zones and the Nature and Drivers of Demand

Key Activity Zone	Nature of Demand	Drivers of Demand
Sydney Football Stadium, Sydney Cricket Ground	Weekends (day and night), Friday and Monday nights, and special events Sydney-wide/subregional catchment	Total seating capacity around 90,000
Fox Studios/Hordern Pavilion/Hall of industries/ Entertainment Quarter	Evenings and daytime, higher on weekends. Sydney-wide catchment for events, otherwise local/subregional	Hordern capacity: 5,500, Hall of industries: 4,000 Showring capacity 15,000 people
Centennial Park and Moore Park Trust	Weekends, public holidays and special events. Primary catchment within 5-10 km of the parklands (except events).	
University of NSW	Primary time/direction is weekdays AM peak southbound traffic from Central Station (based on current available public transport)	42,000 enrolled students (peak attendance approximately 30,000 based on analysis in UNSW *Transport Strategy* 2005) 5,200 employees
Randwick TAFE	Operates 6 days per week; 8 am – 9.30 pm 50-60% students from local/subregional catchment	7500 students enrolled 200 full time staff; 500 part-time staff
Randwick Racecourse	Weekends and special events Sydney-wide catchment	100 permanent staff, plus 300-400 track workers Casual race day workers
Randwick Hospitals Complex	Constant – peaks at shift change over (3 shifts per 24 hour period). Higher visitation during regular weekday working hours	5,600 staff 1.2 million health services delivered each year (ambulatory care/outpatients) – in addition to admissions/visits
Randwick City beaches	Most intense during summer months and on weekends.	
Schools	Daily commute (SBH/SGH Sydney-wide catchment, other schools subregional catchment)	Sydney Boys High: 1160 students; Sydney Girls High: 923 students. Randwick Boys/Randwick Girls High Schools: total 1550.

Source: Collated data provided by Randwick City Council (2011). Note these are draft numbers provided for this study only to inform route development and assessment.

Table 6.5 Estimated Trips to / from key Activity Zones (trips in one direction only)

Trip Types	Per day	Per year	Notes
Randwick residents commuting to CBD	11,000	2,600,000	Assumed 48 week year
Students per day to UNSW	30,000	6,000,000	Assumed 40 week year
Trips per day to work in Randwick Education and Health Centre	13,200	3,000,000	Assumed 48 week year
Outpatients/visitors to hospitals	3,000	1,100,000	Daily figure based on 1.2 million outpatients pa – averaged
Randwick TAFE	3,000	600,000	Assumed 40 week year
Students per day to SBHS/SGHS	2,000	400,000	Assumed 40 week year
Centennial and Moore Parklands	N/A	10,000,000	From Centennial Park and Moore Park Trust
Randwick Racecourse	N/A	700,000	From Australian Jockey Club
SFS/SCG	N/A	1,100,000	Estimate based on 90,000 seats @50% capacity 25 times/year (also 2004 attendance data from SCG)
Randwick City Beaches	N/A	3,200,000	Estimated by Randwick City Council
Fox-Entertainment Quarter/Hordern Pavilion	N/A	500,000	Estimate based on 24,500 capacity used 20 times/year

Source: Collated data provided by Randwick City Council (2011). Note these are draft numbers provided for this study only to inform route development and assessment.

Key Inputs to the Analysis

The estimates of trip numbers associated with key *activity zones* within the study area were developed and provided by Randwick City Council.

Key Findings of the Analysis

Key findings are:

- The Core Route would serve the Kensington town centre as well as a number of the regional activity zones, including:
  - Education: University of New South Wales (UNSW), Sydney Boys and Girls High Schools.
  - Special Events / Recreation: The Sydney Cricket Ground (SCG), the Sydney Football Stadium (SFS) and Entertainment Quarter, Moore Park and Centennial Park; Randwick Racecourse (Western entrances).
- The South 1 route catchment includes the majority of UNSW, the National Institute of Dramatic Art and the Kingsford town centre.

- The South 2 and South 3 route catchments serve the Randwick Hospital Health precinct and the Randwick town centre (Belmore Road). Key differences between the South 2 and South 3 options are:
  - South 2 option provides better access to UNSW (eastern end of campus).
  - South 3 option serves the main entrance to the Randwick Racecourse and serves a larger residential catchment (north of Alison Road) than South 2.
- The North 1 / North 2 option is located in close proximity to the SCG / SFS / Entertainment Quarter precinct, Sydney Boys and Girls High Schools and provides a link to Central Station.

It is noted that the large number of key *activity zones* in the study area mean that the characteristics of the travel demand would expand the travel demand above and beyond the traditional commuter market. Of note:

- Strong spikes in demand associated with special events, most often outside peak periods;
- Strong weekly demand associated with education in the counter peak direction, thus offering ridership in the 'back-loading' operations; and
- Strong links to the suburban rail network for special events, education and health.

6.4.2 Residential and Employment Densities

Purpose of the Analysis

This assessment maps the residential and employment densities within the study area to determine the potential for different light rail options to serve and integrate with them. It is noted that the data that inform this analysis were sourced from the Bureau of Transport Statistics (2011, Travel Zone data). Because residential or employment density is calculated by dividing the number of persons by the area of the travel zone, the thematic mapping of densities can sometimes distort the realities on the ground.

Key Outputs of the Analysis

Residential Density

Figure 6.4 maps population density (persons / hectare) for 2011 within the study area. Generally, it can be seen that there are higher densities close to the CBD, with lower densities in Randwick. Nevertheless, densities in the order of 100 persons/ha are present in close proximity to several route options. Densities of approximately 30-60 persons/ha are typically associated with successful / viable public transport services. This indicates that most of the study area would be suitable for light rail. Current bus patronage levels and mode share to public transport support this observation.

Employment Density

Figure 6.5 maps employment density (persons / hectare) for 2011 within the study area. Similar to population density, employment densities generally increase closer to the CBD, and other employment areas can clearly been seen in Alexandria and Bondi Junction.

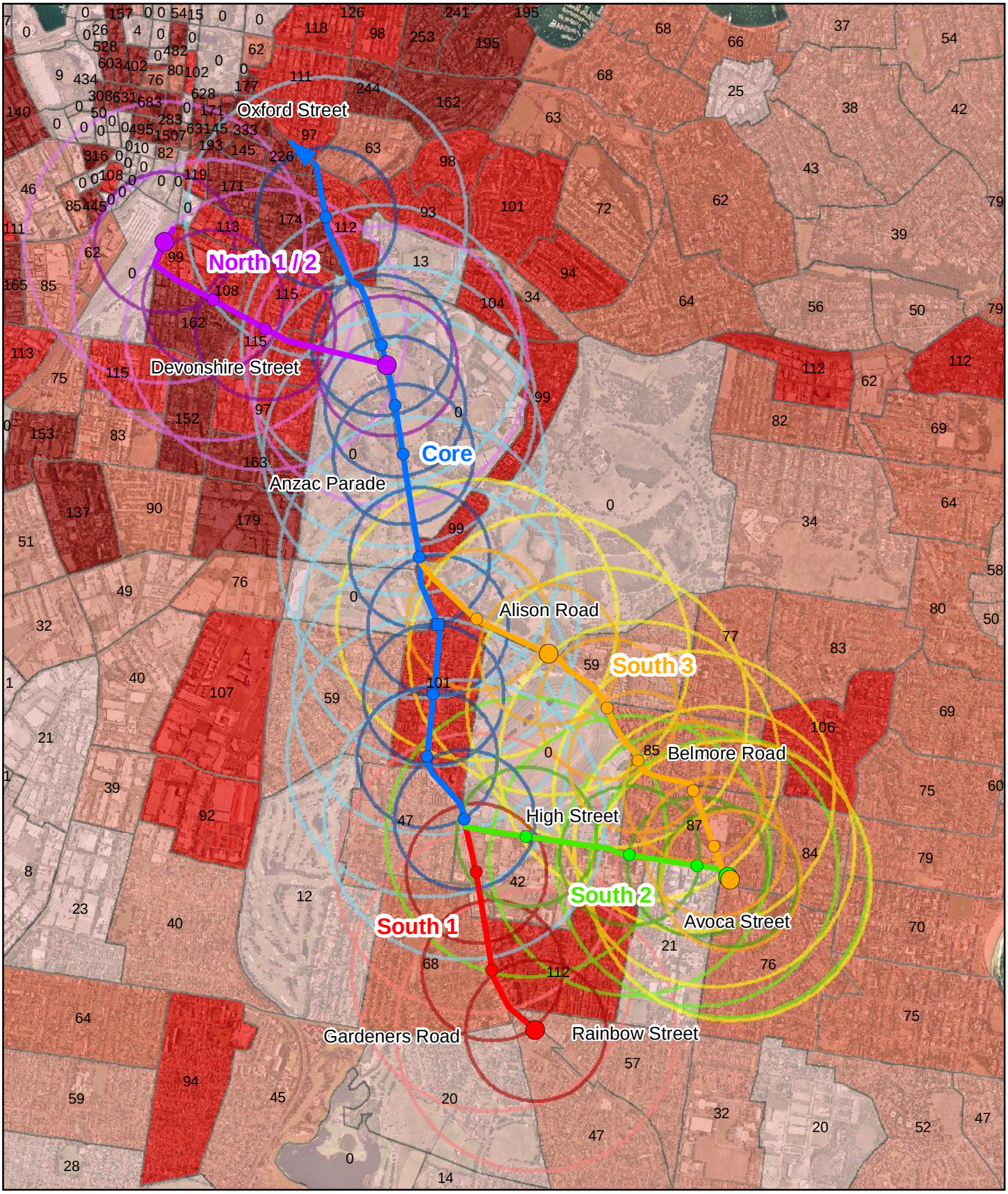
Key Inputs to the Analysis

Both residential and employment density (persons / hectare) for 2011 were based on Travel Zone data from the BTS.

Key Findings of the Analysis

Residential Density

- The core route serves a corridor with residential densities around 100 p/ha between Alison Road and High Street, but north of Alison Road, there is a lengthy section that has no population density due to the SCG/SFS/Entertainment Quarter precinct (however this is to be expected as they are regional generators with different peak periods and often cater for special events).
- The South 1 route option also serves a corridor with residential densities averaging around 100 p/ha.
- The South 2 and South 3 routes run to similar destinations, but serve slightly different residential catchments:
  - The South 2 route serves a corridor (predominantly to its south) that overlaps with the catchment of the Core and South 1 route options in the vicinity of UNSW.
  - The South 3 route serves a corridor (predominantly to its north) with residential densities around 70 p/ha between Centennial Park and High Street. It has less of an overlap with the Core and South 1 route options than South 2.
- The North 1 / North 2 catchment through Surry Hills has densities between 100 – 160 p/ha.



Legend

Route Options
- CBD Connection
- Core
- North 1
- South 1
- South 2
- South 3

Potential Light Rail Stops
- Light Rail Stop
- Interchange
- Future Stop

Stop Buffer (400m)
- Core Route
- South 1
- South 2
- South 3
- North 1

Stop Buffer (800m)
- Core Route
- South 1
- South 2
- South 3
- North 1

Residential Density (2011)
- 0 - 30
- 31 - 60
- 61 - 90
- 91 - 120
- 121 - 2000

Paper Size A4

0.5 0.25 0 0.5 Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Residential Density (2011)
Per Hectare @ Travel Zone level

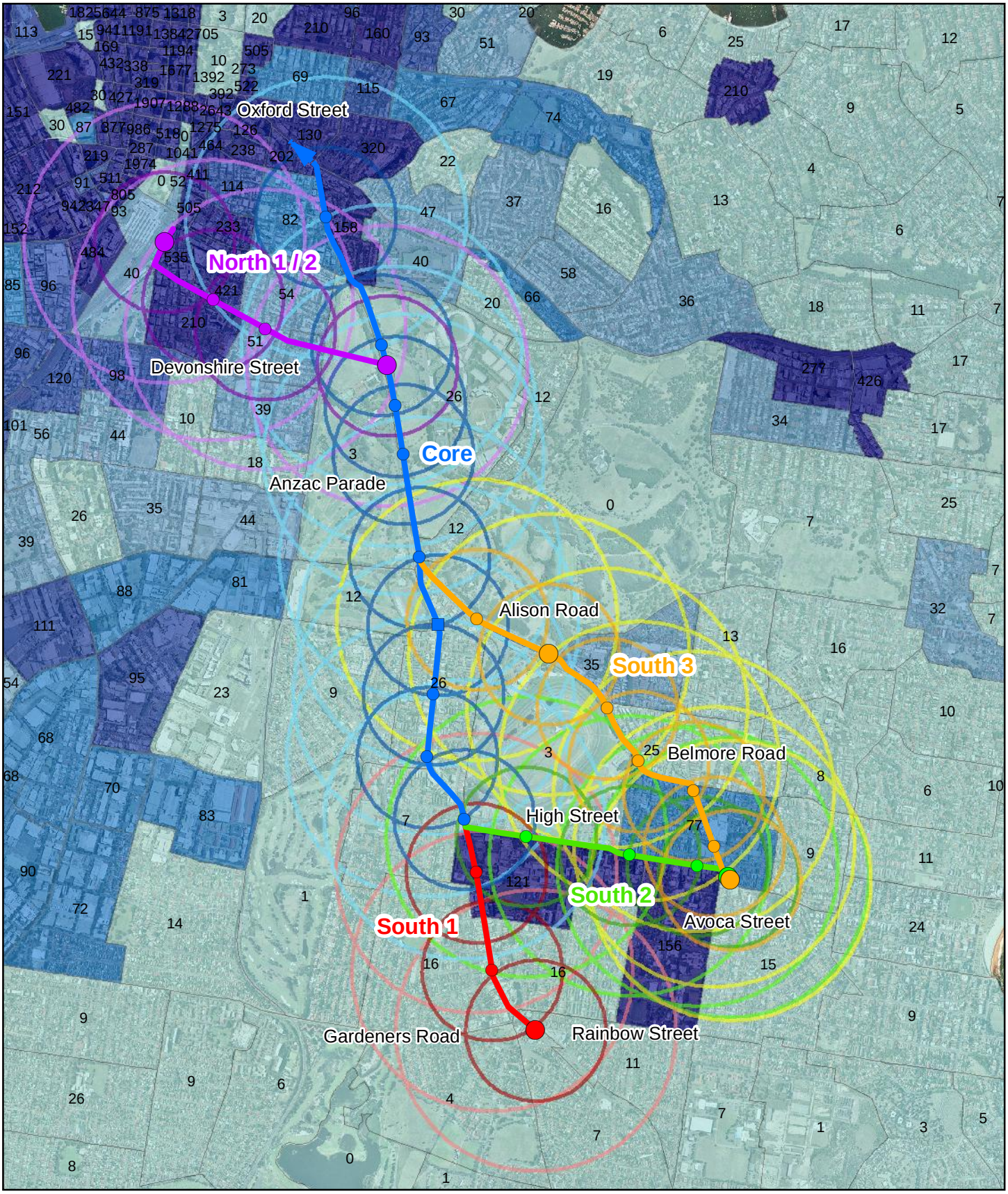
Job Number 21-20812
Revision A
Date 26 Aug 2011

Figure 6.4

G:\21\20812\GIS\Maps\MXD\2120812_Z005_Pop_Density.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:nbuchanan



Legend

Route Options
- CBD Connection
- Core
- North 1
- South 1
- South 2
- South 3

Potential Light Rail Stops
- Light Rail Stop
- Interchange
- Future Stop

Stop Buffer (400m)
- Core Route
- South 1
- South 2
- South 3
- North 1

Stop Buffer (800m)
- Core Route
- South 1
- South 2
- South 3
- North 1

Employment Density (2011)
- 0 - 30
- 31 - 60
- 61 - 90
- 91 - 120
- 121 - 4115

Paper Size A4

0.5 0.25 0 0.5 Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Employment Density (2011)

Per Hectare @ Travel Zone level

Job Number 21-20812
Revision A
Date 26 Aug 2011

Figure 6.5

G:\21\20812\GIS\Maps\MXD\2120812_Z006_Emp_Density.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:nbuchanan

Employment Density

- The northern sections of the Core Route and North Route extend into the areas of high employment density in Surry Hills and Darlinghurst (employment densities between 100 and 500 p/ha).
- The only other area of note in terms of high employment densities is the UNSW and the Health Precinct to the south of High Street (approximately 120 persons/ha). Of interest in relation to this area is:
  - The catchment of South 2 route option serves this area;
  - Together, the catchments of the South 1 and South 3 route options serve this area as well.

6.4.3 Projected Residential and Employment Growth

Purpose of the Analysis

This assessment maps the residential and employment growth projections within the study area to determine the potential (or need) for different light rail options to support / catalyse the projected growth.

It is noted that the data that inform this analysis were sourced from the Bureau of Transport Statistics (2011, Travel Zone data). These data are not always up to date, nor do they necessarily reflect the detailed situation on the ground.

Key Outputs of the Analysis

Residential Change (2011 – 2036)

Figure 6.6 presents projected residential change from 2011 to 2036.

Of note is a relatively insubstantial projected change in population within the catchments of the light rail routes being assessed. Most notable increases are south, south east and south west of High Street (i.e. served by the South 1 and/or South 2 and/or South 3 Route Options).

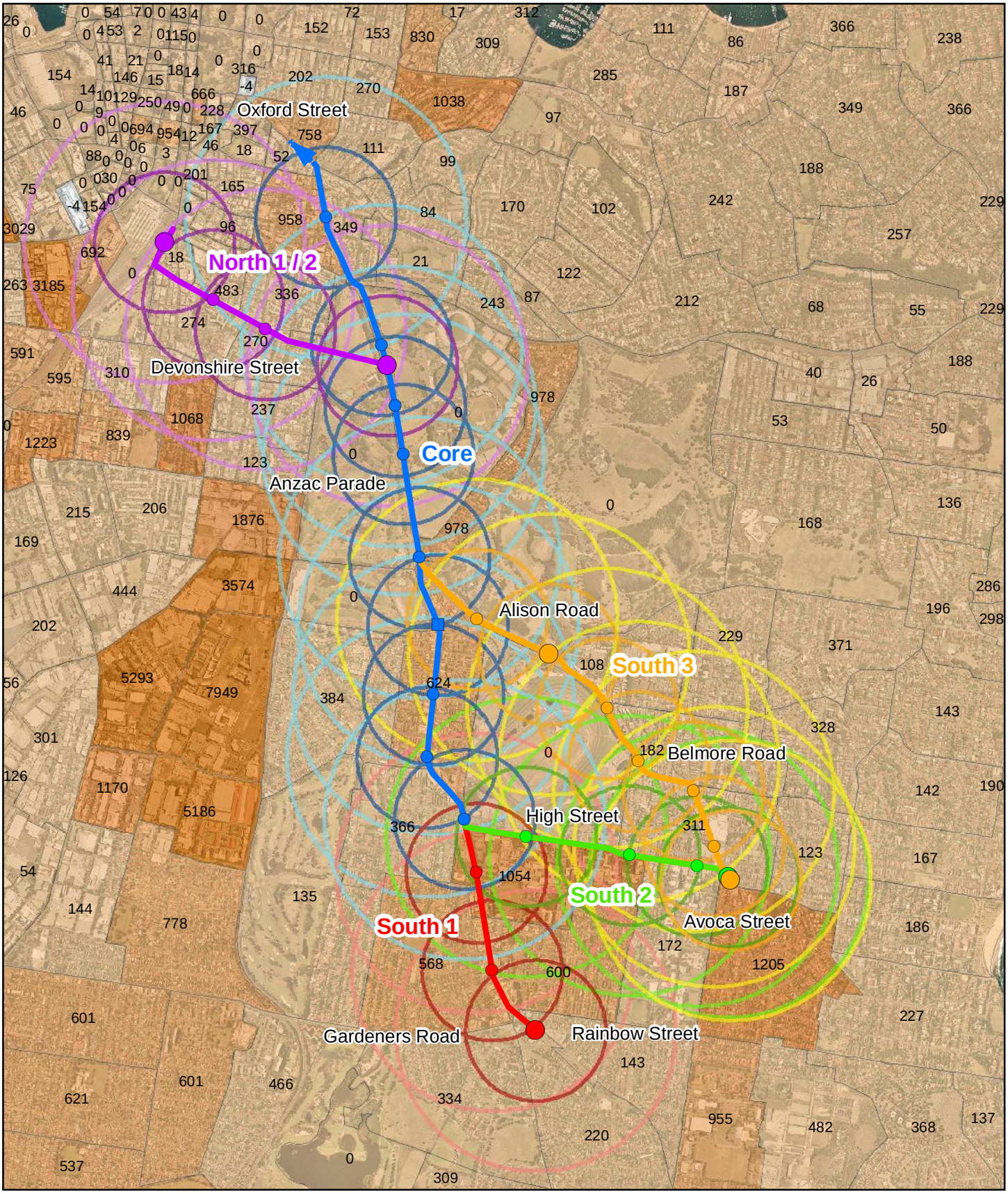
Employment Change (2011 – 2036)

Figure 6.7 presents projected employment change from 2011 to 2036.

Of note is a relatively insubstantial projected change in employment within the catchments of the light rail routes being assessed. Most notable increases are immediately south of High Street (i.e. served by the South 1, and/or South 2 and/or South 3 Route Options).

Key Inputs to the Analysis

Projected residential and employment growth from 2011 to 2036 were shown in relation to the route options investigated for this study, based on Travel Zone data from the Bureau of Transport Statistics.



Legend

Route Options
- CBD Connection
- Core
- North 1
- South 1
- South 2
- South 3

Potential Light Rail Stops
- Light Rail Stop
- Interchange
- Future Stop

Stop Buffer (400m)
- Core Route
- South 1
- South 2
- South 3
- North 1

Stop Buffer (800m)
- Core Route
- South 1
- South 2
- South 3
- North 1

Residential Change (2011-2036)
- -58 - -1
- 0 - 500
- 501 - 1000
- 1001 - 2000
- 2001 - 9485

Paper Size A4

0.5 0.25 0 0.5 Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Randwick Light Rail Pre-feasibility Study

Residential Change (2011-2036)
@ Travel Zone level

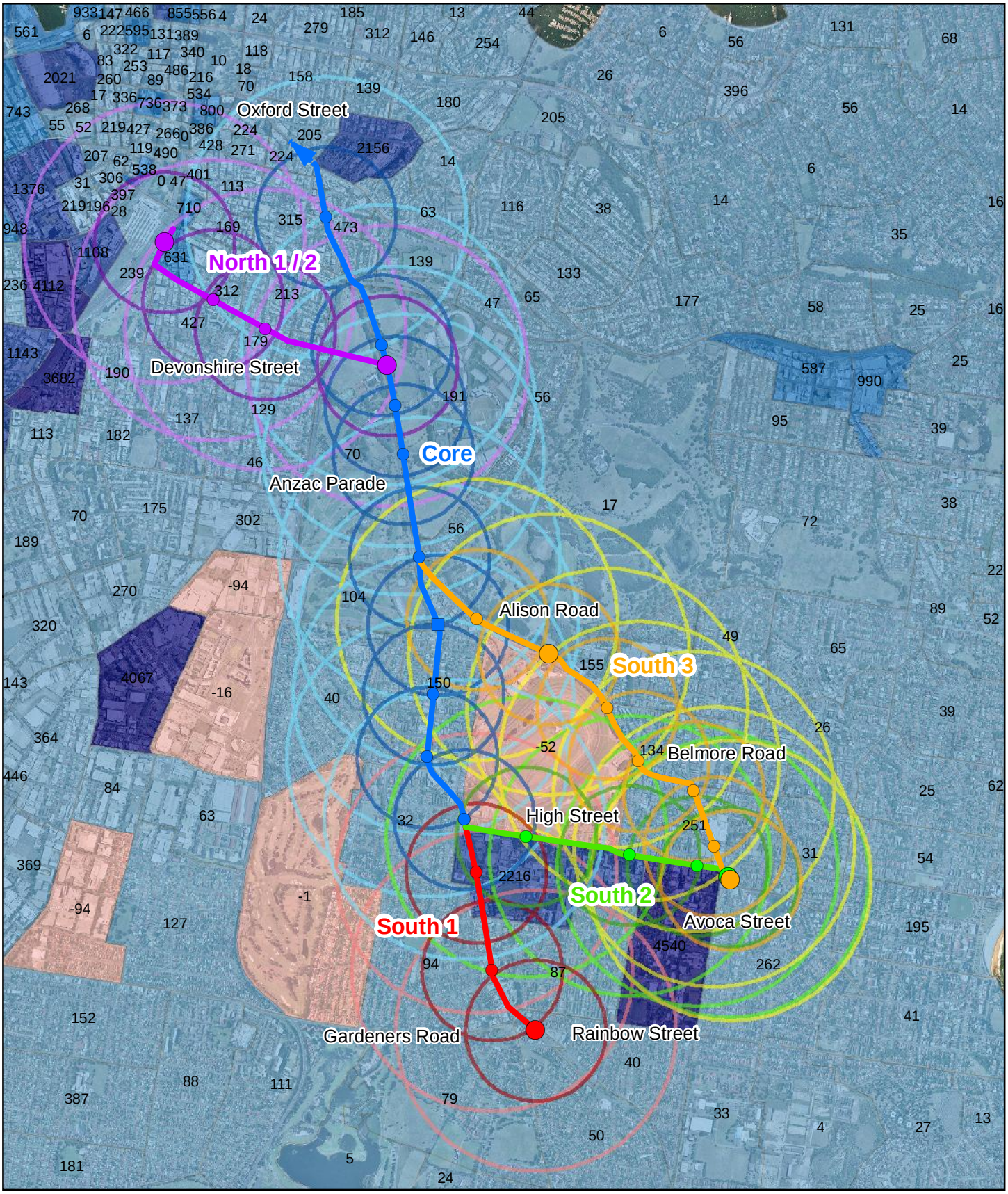
Job Number	21-20812
Revision	A
Date	26 Aug 2011

Figure 6.6

G:\21\20812\GIS\Maps\MXD\2120812_Z007_Pop_Growth.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:nbuchanan



Legend

Route Options
- CBD Connection
- Core
- North 1
- South 1
- South 2
- South 3

Potential Light Rail Stops
- Light Rail Stop
- Interchange
- Future Stop

Stop Buffer (400m)
- Core Route
- South 1
- South 2
- South 3
- North 1

Stop Buffer (800m)
- Core Route
- South 1
- South 2
- South 3
- North 1

Employment Change (2011-2036)
- -283 - -1
- 0 - 500
- 501 - 1000
- 1001 - 2500
- 2501 - 19580

Paper Size A4

0.5 0.25 0 0.5 Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Randwick City Council
Randwick Light Rail Pre-feasibility Study

Job Number 21-20812
Revision A
Date 26 Aug 2011

Employment Change (2011-2036)
@ Travel Zone level

Figure 6.7

G:\21\20812\GIS\Maps\MXD\2120812_Z008_Emp_Growth.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:nbuchanan

Key Findings of the Analysis

- The core route serves a corridor with little projected change in residential or employment numbers.
- The South 1 route option serves a corridor with modest projected increases in residential and employment numbers.
- The only other area of note in terms of high projected growth is the UNSW and the Health Precinct to the south of High Street which is projected to experience a modest growth in employment. Of interest in relation to this area is:
  - The catchment of South 2 route option serves this area; and
  - Together, the catchments of the South 1 and South 3 route options serve this area as well.

6.4.4 Areas of Projected Floor Space Increases

Purpose of the Analysis

This assessment maps the projected floor space increases within the study area to determine the potential for different light rail options to catalyse areas of localised redevelopment.

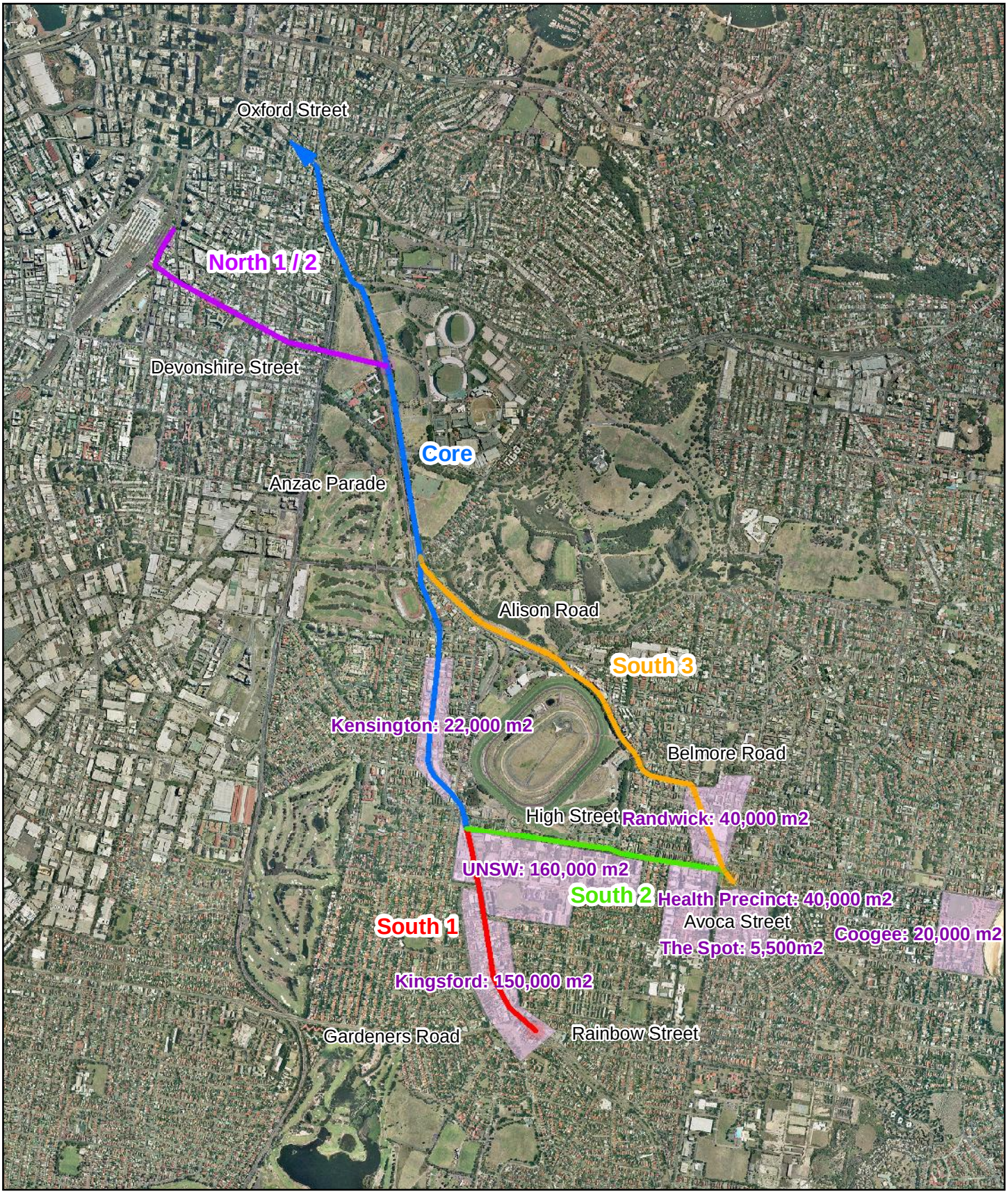
Key Outputs of the Analysis

Figure 6.8 provides a schematic, strategic-level representation of projections of floor space increases to 2031.

Key Inputs to the Analysis

The data shown in an aggregate form was compiled from the *Randwick Economic Activity Study* (undertaken for Randwick City Council by SGS Economics and Planning, 2008) and the *Randwick Education and Health Specialised Centre Discussion Paper* (Randwick City Council, 2010).

Randwick Racecourse has also been progressing several development opportunities including new stables and spectator areas, which have been approved after public exhibition.



Legend

Route Options

- CBD Connection
- Core
- North 1
- South 1
- South 2
- South 3

Projected Floor Space (m2)

Paper Size A4

0.5 0.25 0 0.5 Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Randwick City Council
Randwick Light Rail Pre-feasibility Study

Projected Floor Space Increases to 2031

Job Number	21-20812
Revision	A
Date	26 Aug 2011

Figure 6.8

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Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:nbuchanan

Key Findings of the Analysis

It can be seen in Figure 6.8 that:

- The Core route along Anzac Parade would serve:
  - The Kensington town centre - minor projected floor space increase of 22,000 m^2
  - The north western corner of UNSW - major projected floor space increase of 160,000 m^2.
  - The western part of Randwick Racecourse - there are current plans to redevelop parts of the racecourse, however these developments would be subject to further planning.
- The South 1 option would serve:
  - The main (western) gateway of the UNSW campus – major projected floor space increase of 160,000 m^2.
  - The Kingsford town centre – major projected floor space increase of 150,000 m^2,
- The South 2 option would serve:
  - The UNSW - major projected floor space increase of 160,000 m^2 (also served by Core and South 1 route options).
  - The health precinct on High Street - moderate projected floor space increase of 40,000 m^2.
  - The Randwick town centre (including the Spot) - moderate projected floor space increase of 45,500 m^2.
- The South 3 option would serve:
  - The health precinct on High Street - moderate projected floor space increase of 40,000 m^2.
  - The Randwick town centre (including the Spot) - moderate projected floor space increase of 45,500 m^2.
  - A smaller portion of the UNSW than the South 2 option.
- A key theme of this analysis is the overlap of catchments served by the Core, South 1, South 2 and South 3 route options.

6.4.5 Areas of Socio-Economic Disadvantage

Purpose of the Analysis

This assessment maps the Relative Socio-Economic Disadvantage (SEIFA) within the study area to determine the potential (or need) for different light rail options to provide additional levels of public transport access.

The Index of Relative Socio-Economic Disadvantage (SEIFA) is derived from Census variables related to disadvantage, such as low income, low educational attainment, unemployment and dwellings without motor vehicles.

Key Outputs of the Analysis

Figure 6.9 maps the study area based on SEIFA scores at the Collector District level.

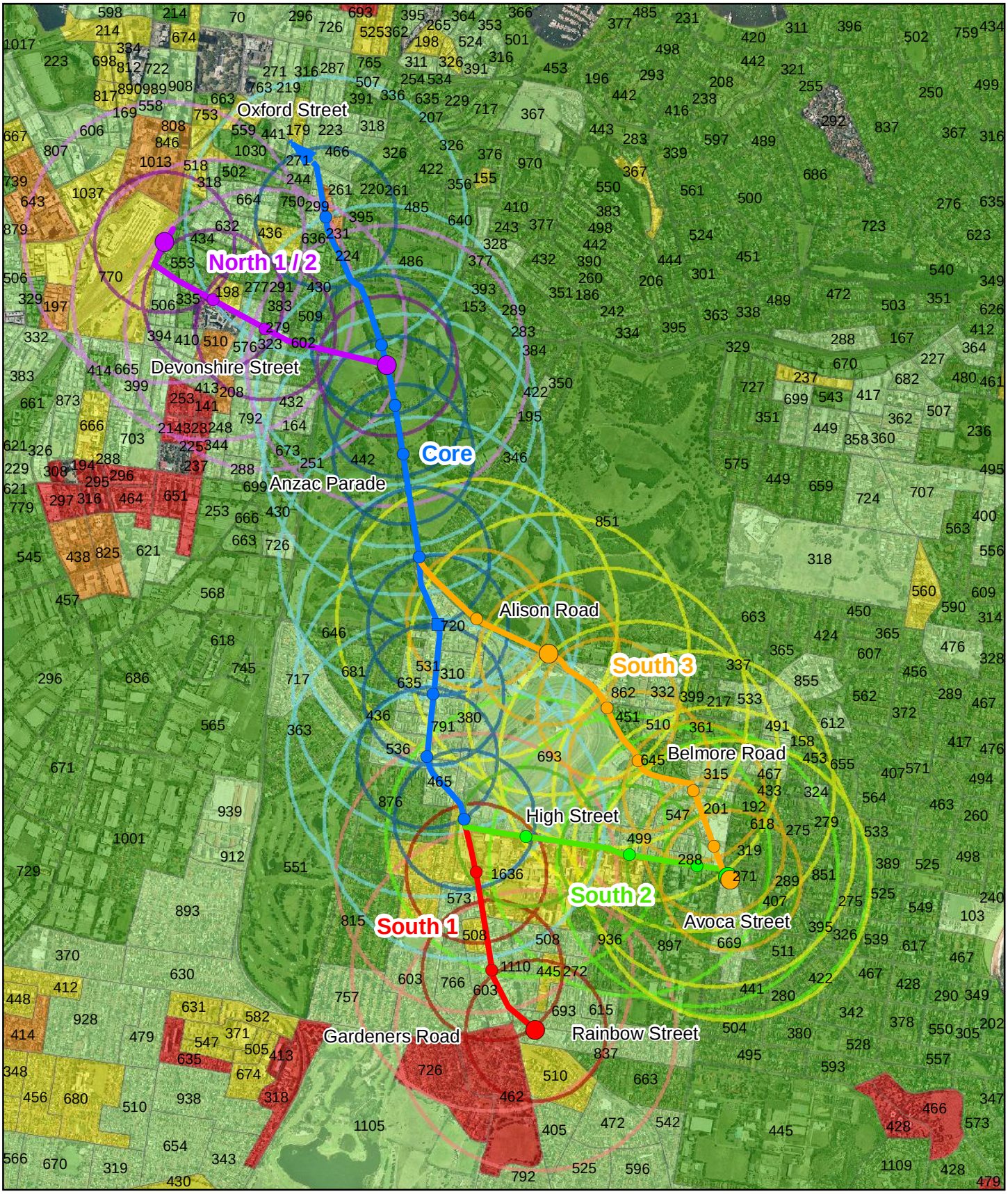
The mapping indicates that the majority of the study area has a low level of disadvantage (i.e. incorporates more advantaged areas), with the exception being Daceyville (to the south-west of the Kingsford Nine Ways).

Key Inputs to the Analysis

SEIFA scores from the Australian Bureau of Statistics were used. This data is from 2006 and at the census defined Collector District level.

Key Findings of the Analysis

- The whole study area is relatively well serviced by public transport, so implementing light rail would not provide a benchmark change in the level of public transport access.
- The South 1 option would improve public transport access to an area of high disadvantage south of Gardeners Road.



Legend

Route Options
- CBD Connection
- Core
- North 1
- South 1
- South 2
- South 3

Potential Light Rail Stops
- Light Rail Stop
- Interchange
- Future Stop

Stop Buffer (400m)
- Core Route
- South 1
- South 2
- South 3
- North 1

Stop Buffer (800m)
- Core Route
- South 1
- South 2
- South 3
- North 1

SEIFA Score
- 460 - 774
- 775 - 898
- 899 - 985
- 986 - 1065
- 1066 - 1179
- Population (2006)

Paper Size A4

0.5 0.25 0 0.5 Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Randwick City Council
Randwick Light Rail Pre-feasibility Study

SEIFA Index (2006)
@ Collector District level

Job Number 21-20812
Revision A
Date 26 Aug 2011

Figure 6.9

G:\21\20812\GIS\Maps\MXD\2120812_Z010_SEIFA.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:nbuchanan

6.4.6 Outcomes of Analysis associated with Strategic Driver #3 - *Integrate with Land Use*

Points to Note

- The most effective public transport routes aim to carry reasonably balanced passenger loads and good levels of ridership throughout the day. The land use and transport characteristics of the Study Area offer strong potential to achieve both these aims. In the morning peak, for example, residential land uses will serve as trip origins while employment and education areas will serve as trip destinations, and vice versa in the evening peak. Activity centres and special events precincts will provide a source of trip generation outside peak periods and on weekends.

Key Findings

For Strategic Driver #3 - *Integrate with Land Use*, an overall key finding is that:

- The South 2 Route Option has a high degree of catchment overlap with other Southern Route Options:
  - The western end of the Route Option S2 overlaps with Route Option S1
  - The eastern end of the Route Option S2 overlaps with Route Option S3

  This constitutes a key consideration when assessing different route options.

The key differences between the route options (Core , South – S1, S2, S3 and North – N1, N2) at this level of investigation are:

- **Key Activity Zones and Town Centres**. The Core Route Option is critical to serving many of the key activity zones. Although Route Option S2 appears to serve a high concentration key activity zones, this observation needs to be tempered by the overall observation made above in relation to the overlapping catchments. Once this consideration is made, there is little tangible difference between the southern options at this level of investigation.
- **Residential and Employment Densities**. In general, the study area has residential densities greater than 100 persons per hectare, which is considered as a broad benchmark of a market for feasible, high quality public transport. Notwithstanding the sections of the route which passes Centennial / Moore Park and Randwick Racecourse, the Core Option serves solid public transport markets.
- At this level of investigation, it is difficult to 'drive light' between the S1, S2 and S3 Route Options. The point made earlier in relation to overlaps of catchments again holds, as the South 2 and South 3 routes run to similar destinations, but serve slightly different residential catchments:
  - The South 2 route serves a corridor (predominantly to its south) that overlaps with the catchment of the Core and South 1 route options in the vicinity of UNSW.
  - The South 3 route serves a corridor (predominantly to its north) with residential densities around 70 p/ha between Centennial Park and High Street. It has less of an overlap with the Core and South 1 route options than South 2.
- **Projected Residential and Employment Growth**. In general terms, there are only minor points of difference between route options due to a limited degree of projected residential or employment growth. The South 1 route option serves a corridor with modest projected increases in residential and employment numbers. The only area of note in terms of high projected growth is the UNSW and the Health Precinct to the south of High Street which is projected to experience a modest

growth in employment. In this case, the point made earlier in relation to overlaps of catchments again holds, as the catchment of South 2 route option serves this area, but so too does the combined catchments of the South 1 and South 3 route options.

- **Areas of Projected Floorspace Increases**. The areas of major projected floor space increases are the main (western) gateway of the UNSW campus and the Kingsford town centre. These are served by the Core and South 1 Route Options (respectively). This means that Route Option S2 and S3 do little additional in terms of serving these areas.
- **Areas of Socio-Economic Disadvantage**. Given that whole study area is relatively well serviced by public transport, implementing light rail unlikely to provide a benchmark change in the level of public transport access to areas of disadvantage.

Conclusions

Overall, in terms of integration with land use, the Core Route and South 1 Route options are considered to be the most critical. If it is assumed that the South 1 Route Option would be built in advance of any other South option, then South 3 would offer more substantial benefits than the South 2 route option.

6.5 Analysis associated with Strategic Driver #4 – *Optimise Likelihood of Implementation*

6.5.1 Assessment of Physical Constraints

Purpose of the Analysis

This preliminary assessment identifies physical constraints along the light rail routes. This predominantly focuses on locations where grades exceed those generally considered as feasible for the operation of light rail vehicles. This is done on the basis that a key complicating factor in terms of technical feasibility (at this level of study) is light rail alignment.

Additionally, there are a few locations which have a cluster of heritage-listed properties, and these are discussed under the relevant route.

Key Outputs of the Analysis

Figure 6.10 and Figure 6.11 provide an indication of the grades on High Street and Alison Road, respectively. These figures illustrate the steepest sections on both routes, which are at the Randwick end of the route options.

Figure 6.10 Indicative Grades on High Street

Figure 6.11 Indicative Grades on Alison Road

Key Inputs to the Analysis

For the purposes of this study, two metre contours were provided by Randwick City Council. From this data, approximate grades were calculated in GIS.

As way of introduction, existing light rail vehicles are typically limited to grades of approximately 6.5%. This is the notional grade limit used on the Melbourne tram system.

Although it is dependent on the actual specification of the particular model of light rail vehicle, a standard, modern light rail vehicle can feasibly climb grades of 7.0% and vehicles with a more powerful specification can negotiate grades of up to approximately 8.5%.

Key Findings of the Analysis

In light of the discussions above, it was found that:

- **Core**: No major physical constraints were identified.
- **South 1**: No major physical constraints were identified.
- **South 2**: There are steep grades on High Street, however these can likely be overcome as discussed below:
  - The critical grade identified on High Street is to the east of the racecourse starting area towards Wansey Road. Based on available information, it was identified that the steepest grade is approximately 10%, which is greater than the grade achievable by light rail.
  - There is a potential opportunity to establish a feasible grade for light rail by constructing a ramp within or adjacent to the Randwick Racecourse property. There are at least two viable options for grading a light rail alignment, the steeper having less impact on existing buildings and the more gradual requiring the demolition of existing buildings. A common constraint to both is the close proximity of the racecourse starting area, just to the north of High Street.
  - It should also be noted that on High Street between Botany Street and Belmore Road that the existing grade is generally 5%, with the steepest section at 6%. These grades should be readily achievable by light rail.
  - In summary, while the current grades along High Street are steep adjacent to UNSW and Randwick Racecourse, it is feasible to re-grade the northern side of High Street in this vicinity to achieve a grade manageable by light rail.
- **South 3**: There are steep grades on Alison Road. While there is potential to overcome these, it will require additional investigation, as discussed below:
  - It is noted that former tram lines did not use Alison Road. Rather, trams ran along a corridor that cut across the grade. The former tram corridor between Centennial Park and Belmore Road has been built out, particularly between Cowper Street and Prince Street (with two developments of approximately 18 and 24 apartments). The former tram corridor between Frances Street and Church Street has been retained, and is sufficiently wide to operate light rail. Between Church Street and Cook Street, an easement of sorts has been retained, although it is in the order of 6 metres wide, with apartments built immediately adjacent, making it problematic to run light rail through this section.
  - The existing grades on Alison Road constitute a major constraint to light rail feasibility, particularly on either side of the intersection with Church Street. The critical grade identified at this location has a grade of approximately 8.1%, while over a longer section flattens out to

approximately 8.0%. This is less than the maximum grade (8.5%) requiring a fully motorised vehicle, so is achievable, although requiring specialised rolling stock.

- Additional investigations were undertaken to assess the potential to regrade Alison Road (northern two lanes) between Prince Street and Church Street (embankment) and between Church Street and Belmore Road (cutting). These investigations are presented in Section 7, and indicate that a grade of around 7.0% is achievable. This indicates that the option of routing light rail along Alison Road warrants more detailed design work to test the feasibility of this option on the basis of:
  - This grade is at the limit of standard light rail vehicle performance.
  - There are six heritage listed properties along Alison Road adjacent to where the road would likely need regrading. It is noted, however, that there are no property accesses in this section.

- **North Options**: There are few viable options for a light rail link from Anzac Parade to Central Station due to steep grades. Cleveland Street provides the closest option to the south of Central, but would be very challenging due to traffic impacts. Campbell Street provides the closest option to the north of Central Station. Both of these options would entail indirect routes and thus slower travel times than the existing bus services using Albion or Devonshire Street. The two North Route Options were developed as possible solutions to overcoming these constraints. They incorporate:
  - North 1: A tunnel running from the existing special events bus interchange at the Sydney Cricket Ground, under Anzac Parade, Moore Park and the Eastern Distributor to Nobbs Street (south of Bourke Street, Surry Hills). The light rail alignment would then ramp up to Bourke Street and run along Devonshire Street to Central. Nobbs Street would require widening of some 4 metres (through acquisition) for the length of the ramp.
  - North 2: A tunnel running from the existing special events bus interchange at the Sydney Cricket Ground, under Anzac Parade to Moore Park. Then running in trench / cutting through Moore Park and crossing South Dowling Street (at grade, at the level of the existing pedestrian bridge) to Parkham Street, then to Bourke Street and Devonshire Street to Crown Street.
  - West of Crown Street, the North 1 and North 2 Route Options would coincide with the alignment of the Green Line light rail currently proposed by the City of Sydney.

6.5.2 Reference to Historical Precedents

Purpose of the Analysis

This assessment identifies sections of the light rail routes that coincide with former tram lines. This is done on the basis that former tram lines are a strong indicator of technical feasibility (and thus less complicated implementation).

Key Outputs of the Analysis

The Eastern Suburbs have a long history of trams, or light rail, which helped shape the development of the region. Trams were in operation in the Eastern Suburbs from the late 1800s and early 1900s through to the late 1950s and up to 1961. Anzac Parade was heavily utilised by trams, forming a trunk corridor serving several routes (or 'lines'), including the Clovelly Line, the Coogee Line, the Maroubra Line and the La Perouse Line.

These lines combined to provide public transport services both within and to/from the Eastern Suburbs, the Sydney Cricket Ground, Randwick Racecourse and the CBD. Another line ran from Coogee via Randwick to Bondi Junction, while special service trams ran to Randwick Racecourse, which incorporated six platforms.

A feature of many of these lines was that they were located in a series of dedicated tram reservations. Some of these still exist today and/or are used by buses (such as through Moore Park or as reflected in a wide road reserve along much of Anzac Parade). Many of these reservations could potentially be utilised for light rail again. Additionally, several bus routes still operate along old tram routes in the Eastern Suburbs.

Key Inputs to the Analysis

Background information for this section was obtained from *Tramways of Sydney* (David Keenan, 1979).

Key Findings of the Analysis

The following observations are made in relation to the former tram routes/reservations along the current route options:

- Core Route: Multiple tram lines/routes ran along Oxford Street, Flinders Street, Anzac Parade (which has left a wide median along much of its length), through Moore Park (currently utilised by buses) and to Randwick Racecourse via Abbotsford and Ascot Streets;
- South 1: Multiple tram lines/routes ran along Anzac Parade which have left a wide median or road reserve;
- South 2: No trams ran along High Street, which had grades that were too steep for trams;
- South 3: Multiple tram lines ran through the southern edge of Centennial Park and Alison Road past Randwick Racecourse to Darley Road. From Darley Road, the tram line to Coogee ran along a tram reservation (parallel to Alison Road) to reach Belmore Road. However, this tram reservation has been built out by development over the intervening years. This means that while there is adequate space at the western end of Alison Road, there is no precedent for trams running directly up Alison Road to Belmore Road; and
- North 1 / 2: While there were special event tram services to the Sydney Cricket Ground and trams operated on a short section of Devonshire Street close to Central Station, there were no direct connections between the two locations, and as such any future connection would require an entirely new corridor and/or infrastructure.

6.5.3 Outcomes of Analysis associated with Strategic Driver #4 – *Optimise Likelihood of Implementation*

Points to Note

- This study has been undertaken on the premise that being an established urban area with a proven public transport market, the study area offers 'fertile ground' for light rail. Leading on from this, it is recognised that the establishment of light rail in the study area is unlikely to have a material effect on the urban structure.
- Consistent with this theme, GHD has sought options that deliver maximum benefit while avoiding complex and costly light rail solutions where possible.

Key Findings

For Strategic Driver #4 – *Optimise Likelihood of Implementation*, an overall key finding is as follows:

- The Core Route Option and South 1 Route Option are considered to be feasible as these route options generally follow alignments that were previously tram lines. It is considered feasible to establish a light rail line along the South 2 Option. Initial investigations indicate that it is likely that it would be feasible to establish a light rail line along the South 3, N1 and N2 alignment, although more detailed design development would be required.

Conclusions

Overall, in terms of optimising the likelihood of implementation, the Core Route and South 1 Route options are considered to be the most feasible. South 2 is considered likely to be implementable and the South 3 and Northern Route Options would require additional investigation to ascertain the feasibility of implementation.

7. Additional Investigations to Assess Feasibility of Route Option South 3 (Alison Road)

7.1 Introduction

The initial investigation of the feasibility of running light rail along Alison Road (in Section 6.5.1) indicated that existing grades were steeper than those which standard light rail vehicles can feasibly climb.

On this basis, the option of minor regrading of Alison Road was considered. A preliminary investigation based on two metre contours on GIS mapping found that grades of in the order of 7% were achievable, indicating that feasibility was 'borderline'. On this basis, GHD and Randwick City Council agreed that even at this early stage, a more detailed investigation of the vertical alignment would be required to determine whether this option was sufficiently feasible to merit being taken forward.

Randwick City Council then commissioned a localised survey of the northern lane of Alison Road for the purpose of GHD preparing a more detailed vertical alignment based on a more reliable and detailed understanding of the profile of Alison Road.

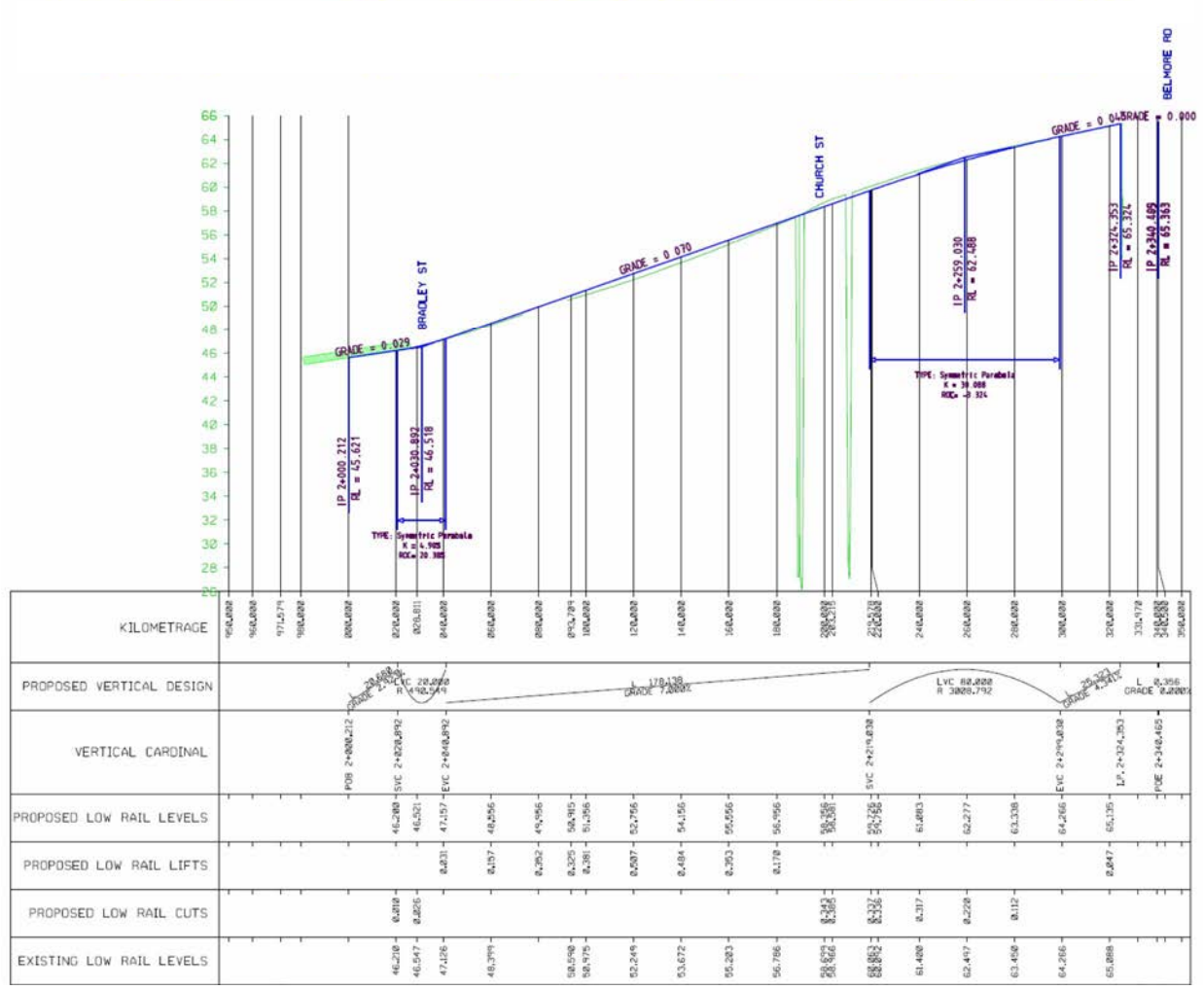
7.2 Key Features of Preliminary Regrading

- It is proposed to regrade the northern two lanes of Alison Road, where light rail would run segregated from the general traffic;
- Regrading is proposed between the eastern end of the proposed stop at Prince Street (adjacent to Bradley Street at the 'bottom' of the hill) and Belmore Road (at the 'top' of the hill);
- The regrading has been designed in two portions in order to maintain access between Alison Road and Church Street, such that:
  - Between the eastern end of the proposed stop at Prince Street and Church Street, the light rail would run along a low embankment; and
  - Between Church Street and Belmore Road, the light rail would run along a shallow cutting.

7.3 Preliminary Longitudinal Section

A preliminary longitudinal section of the portion of Alison Road where the regrading is proposed is shown in Figure 7.1.

Figure 7.1 Alison Road Regrading - Preliminary Longitudinal Section



7.4 Key Findings

Preliminary investigations indicate that although at the limit of feasibility it is considered that it would be possible to establish a light rail route along Alison Road south of Belmore Road.

Track Regrading Along Alison Road: Prince Street – Church Street

- Based on the preliminary regrading, a grade of 7.0% has been achieved between the eastern end of the proposed stop at Prince Street and Church Street. This is at the limit of the grades that 'standard' light rail vehicles can climb.
  - It is noted that although not optimal from a customer access perspective, relocating the light rail stop further north would offer the potential to reduce this grade if required.
- Based on the preliminary regrading, a maximum embankment height of some 550 mm above existing road level could be expected.

Track Regrading Along Alison Road: Church Street – Belmore Road

- Based on the preliminary regrading, a grade of 4.3% has been achieved between Church Street and Belmore Road. This is easily within the grades that 'standard' light rail vehicles can climb.
- Based on the preliminary regrading, a maximum cutting depth of some 100 mm below existing road level could be expected.

Grade of Stop / Intersection of Alison Road and Prince Street

- It is noted that the preliminary regrading has not modified the current grades of the stop at Prince Street (adjacent to Bradley Street at the 'bottom' of the hill), which would be in the order of 3%.
- Due to DDA requirements for people boarding light rail vehicles as well as operational and safety requirements for light rail, it is generally required that grades at stops are less than 2%.
- On this basis, more detailed design work would likely be required in the vicinity of the Intersection of Prince Street and Alison Road in order to:
  - 'Lift' the light rail alignment at the western end of the platform to reduce the grade of the stop;
  - Minor regrade / reconfiguration of Prince Street / Tram Lane at their intersection with Alison Road in order to accommodate the 'lifting' of the light rail alignment at the western end of the platform.
- It is noted that although not optimal from a customer access perspective, relocating the light rail stop further north would offer an alternative option for reducing the grade of the stop if required.

Intersection of Alison Road and Church Street

- The preliminary regrading undertaken to test the feasibility of a light rail line along Alison Road endeavoured to avoid impacting on the intersection of Alison Road and Church Street. It is noted, however, that this investigation did not extend to a detailed grading of this intersection.
- Although this preliminary regrading indicates that it would be feasible to run light rail line along Alison Road and maintain access between Alison Road and Church Street, the investigation did not extend to a detailed redesign of the intersection of Alison Road and Church Street. This would be required at later stages of design development.

8. Preliminary Route Layouts

8.1 Scope of Development of Preliminary Route Layouts

This subsection briefly outlines the scope of the development of preliminary route layouts.

It is noted that a broad outline of the scope (and limitations) of the *Randwick Light Rail Pre-feasibility Study* as a whole was provided in Section 2 of this document.

Why the *preliminary route layouts* were developed

The preliminary route layouts have been developed to add a level of rigour to the assessment of feasibility by testing the spatial aspects for the different route options.

How the *preliminary route layouts* were developed

The preliminary route layouts have been developed in response to the *horizontal* opportunities and constraints, which (in general terms) incorporate:

- User requirements (access to stops etc);
- Rights of way; and
- Requirements of other road users (pedestrians, cyclists, buses, general traffic etc).

Although driven by considerations of the plan, the route layouts were developed in considerations of *vertical* opportunities and constraints, which incorporate:

- Vertical grades (i.e. the slope of the light rail alignment). These were informed by on-site assessment, the use of GIS-based contour information, on-site measurements and reference to previous tram alignments; and
- Vertical profiles. This considers localised issues associated with the profile of the road or ground surface over which the route passes.

What the *preliminary route layouts* show

The preliminary route layouts show light rail tracks and the extent of the *light rail operating envelope*. GHD uses the *light rail operating envelope* at this preliminary stage as an indication of the spatial requirements of an operating light rail vehicle. It is a concept akin to the *developed kinematic envelope* (DKE), which is used for the same purpose, but at alignment design stage.

The preliminary route layouts show also provide an indication of locations where the light rail alignment runs in a configuration other than at grade:

- *Regrade* (shown as a broken black line along the track) – Parts of the alignment that run on a ramp, in a cutting or on an embankment.
- *Tunnel* (shown as a solid black line along the track) – Parts of the alignment that run in tunnel (either cut and cover or 'mined').

Limitations of the Development of Preliminary Route Layouts

Key limitations to the development of preliminary route layouts are outlined below:

- Preliminary route layouts were developed on the basis of high resolution aerial photography overlaid with cadastral information (in GIS format). No detailed ground survey was used (the exception being for the portion of Route Option S3 on Alison Road between Prince Street and Belmore Road).
- Where consideration was made of grade, they were based on contours on GIS mapping and site measurements (the exception being for the portion of Route Option S3 on Alison Road between Prince Street and Belmore Road).
- Siting of stops was made in consideration of serving surrounding land uses and ease of user access, but without detailed demand modelling.
- Preliminary light rail layouts were developed in consideration of interfaces with general traffic and potential impacts on parking, but without detailed investigation of traffic operations or traffic modelling.
- Preliminary light rail layouts were developed in consideration of urban design and amenity (including impacts on street trees), but without a specific study into these aspects.
- Although consideration was made of the need to minimise regrading of roads and intersections, no specific detailed design was undertaken.
- Although consideration was made of the operational requirements of a light rail system whilst developing route layouts, no detailed operations planning was undertaken.
- No consultation with key stakeholders such as Transport for NSW, Roads and Traffic Authority, Sydney Buses, City of Sydney or Metro Transit Sydney (light rail operator).

8.2 Technical Inputs into the Development of Preliminary Route Layouts

This section brings together a set of technical parameters used for the development of preliminary route layouts for the route options incorporated in this study. The route layouts constitute an important input to the assessment of the engineering feasibility of the project.

Given the scope of this Study, care has been taken to maintain an appropriate level of detail in the development of route layouts. On this basis the parameters are, by design, broad and slightly conservative.

It is noted that at the time of progressing to more detailed design of the project, it is possible that there will be a refinement of the technical parameters to satisfy the requirements of other stakeholders.

8.2.1 Vehicle Dimensions and Clearances

In order to provide a basis for preliminary route layouts and evaluation of route options, a set of spatial requirements associated with vehicle dimensions and clearances were developed. These are summarised in Table 8.1, below.

Table 8.1 Vehicle Dimensions and Clearances

Measure	Dimension	Notes
Track gauge	1,435 mm	Standard
Vehicle width	2,650 mm	Standard
Assumed width of operating envelope	3,300 mm	Indicative spatial requirements of moving vehicle
Allowance for Overhead Wiring support	700 mm	Where light rail tracks ran together, an allowance for a centre-located overhead wiring stanchion was made.
Minimum vertical clearance for light rail	4.3 metres	
Vehicle length	45 m	Standard length for longer vehicle, influences length of platforms, turnbacks and storage

8.2.2 Alignment Requirements and Limitations

In order to provide a basis for preliminary route layouts and evaluation of route options, a set of spatial requirements associated with horizontal and vertical alignments were developed. These are summarised in Table 8.2 and Table 8.3.

Horizontal Alignment (turning radii limitations)

Table 8.2 Parameters Relating to Horizontal Alignment

Alignment	Minimum (m)	Desirable minimum [2] (m)
Radii for Horizontal Curves (slow speed)	20.0	25.0
Radii for Horizontal Curves (higher speed)	250	350.0
Radii for Curve Transitions (spirals)	10.0 (city street) [1]	25.0 [1]

Notes: 1. Or that required for development of applied cant and cant deficiency.

2. *Desirable minimum* refers to a dimension that provides appropriate outcomes in a range of areas including: terms of travel speed, passenger comfort and wear and tear on the LRV.

Vertical Alignment (grade limitations)

Table 8.3 Parameters Relating to Vertical Alignment

Alignment	Maximum	Desirable
Maximum Grade on line (using standard vehicles)	7%	5.5%
Maximum Grade at stops	2%	0.5%

8.2.3 System Requirements

It is strongly noted that even at this preliminary stage of feasibility assessment, the *technical requirements* are not limited to physical characteristics of the light rail infrastructure. Strong consideration needs also to be made of the non-physical aspects of the transport system. These are outlined briefly below:

Level of Priority

This study is being undertaken in advance of any strategy or policy to provide priority to light rail either in terms of physical segregation or signal priority. On this basis, the study assumes a level of priority based on the opportunities available in different sections of the route options. For example, where the light rail would run off-street or within a median, full priority is assumed; where light rail runs on-street, a degree of segregation and signal priority is assumed if considered warranted and feasible. In some locations, mixed running with general traffic is considered appropriate.

Frequency

Required levels of light rail service frequency would be determined through two considerations:

- Minimum level of service – sufficient frequency to respond to the needs / expectations of users; and
- Minimum capacity – sufficient frequency to deliver the required capacity to meet demand.

Although no detailed assessment has been made of the required frequencies for different route options at different times of the day or week, it is considered that the public transport demand associated with the study area would warrant frequencies that would be attractive to users (at least during peak periods). On this basis, two observations are made:

- The routes would warrant a high quality service with sufficient priority to deliver fast and reliable travel times; and
- In the case where the light rail system is extended into the CBD, it should be noted that the frequency of eastern services could be driven by the service requirements of a (potentially busier) CBD extension.

Fares and Ticketing

At this level of investigation, the main point of differentiation between options as a result of fare and ticketing policy will be:

- The tendency for passengers to use light rail as part of a multimodal journey; and
- The efficiency with which passengers can board (or transfer to) light rail. Boarding times (and reliability of boarding times) are a major determinant of travel time and reliability.

This study assumes there would be integrated ticketing with no penalty for intermodal transfer, i.e. that light rail would be part of a distance-based, free transfer fare structure.

8.3 Description of Key Features of Route Layouts

This section describes key components of the preliminary route layouts for the different route options assessed in this Study. The layouts are provided in Appendix D.

The descriptions provided below are broken into sections, with reference to the relevant figures provided in brackets.

8.3.1 Core Route

Flinders Street between Oxford Street and Moore Park Road (Figures C1 & C2)

- This section of route layout is provisional, as there is no information on the likely route layout along Oxford Street (this is outside the scope of this study).
- This route segment has both tracks side-running on Flinders Street, in the existing bus lanes.
- It has been assumed that with the implementation of light rail there would be a reduction in the number of lanes available for general traffic along Flinders Street.
- Stops are provisionally located south of the intersection at Oxford Street and north of the South Dowling Street intersection.
- Minor changes would be required to signalling / intersection operation to allow passage of light rail into the current busway along Moore Park.

Anzac Parade between Moore Park Road and Dacey Avenue/Alison Road (Figures C2 – C5)

- This route segment would run adjacent to Anzac Parade on the former tram reservation within Moore Park, which is currently used as a busway.
- While dependent on the structure of the bus system after the introduction of light rail, it is likely that some buses would continue to operate along this corridor, which would result in mixed running with light rail vehicles for this route segment. As a result, all stops are edge platforms, although it is noted that it is unlikely that buses could feasibly use the actual light rail platforms due to height differences. For this reason, bus stops would need to be in front or behind light rail stops.
- Stops are provisionally located across from Sydney Boys / Girls High Schools, south of the intersection with Cleveland Street/Lang Road, and north of the intersection with Dacey Avenue/Alison Road. These correspond to the location of existing bus stops.

Anzac Parade between Dacey Avenue/Alison Road and High Street (Figures C5 – C7)

- Some 100 metres the north of the intersection of Anzac Parade and Dacey Avenue/Alison Road, the light rail track alignments would divert onto Anzac Parade. Traffic signals would be required for light rail operations in this location in order to facilitate the light rail crossing of southbound traffic lanes. It is noted that a 45 metre long bay (one light rail vehicle length) has been provided in the median to permit the storage of light rail northbound light rail vehicles waiting to cross southbound traffic lanes into the reservation.
- South of the intersection of Anzac Parade and Dacey Avenue/Alison Road, the tracks would run along the centre of Anzac Parade and run in what is currently a concrete median.
- The tracks would continue along the existing median south to Kensington. South of Abbotford Street, the distance between centre lines would widen such that there would be space between the track alignments to facilitate right turning lanes on Anzac Parade.
- This track alignment follows the former tram route and most is located within a median so that there would be limited impact on traffic lanes.
- Stops are provisionally located at the intersections of Anzac Parade and Abbotford Street, Ascot Street and Todman Avenue.

- A short line into Randwick Racecourse is shown on Abbotford Street for special event services. Parking could potentially occur in the median outside special event periods.
- It is assumed that any buses operating in this section would travel in the general traffic lanes and would stop at the kerbs. They would not be able to use the light rail island platforms.

Anzac Parade between High Street and Day Avenue – Side Running (Figure C8a)

- This study has looked at two options in relation to UNSW. The track alignment for the (a) option is side running south of High Street, with side platforms outside UNSW.
- The side platform configuration is considered essential to cater for large passenger loads associated with the University, especially those waiting to board in the afternoon peak. Island platforms could constitute safety risks due to high demand and constrained capacity.
- For this option, the Core Route would continue south of High Street and have a terminus in the centre of Anzac Parade.
- The need to slew the light rail track from centre to side running on Anzac Parade between High Street and Day Avenue would necessitate additional signalling and would have impacts on existing traffic arrangements.
- It is noted that there are opportunities for local and sub-regional level traffic management initiatives to relieve traffic on Anzac Parade in the vicinity of UNSW. For example, the establishment of north-facing ramps from Gardiners Road to Southern Cross Drive could divert some non-local traffic from Anzac Parade.

Anzac Parade between High Street and Day Avenue – within UNSW Campus (Figure C8b)

- As per the above, this study has looked at two options in relation to UNSW. The (b) option would enter the UNSW campus and have a terminus stop within the campus. This would cater for large passenger loads associated with the University, especially those waiting to board in the afternoon peak.
- This would potentially require the demolition of several buildings (including the Squarehouse), however it is noted that UNSW could redevelop the airspace above the stop terminus.
- There would also be traffic impacts associated with slewing the track from Anzac Parade into the campus, which would need to occur at signalised intersections.
- As noted earlier, there are opportunities for local and sub-regional level traffic management initiatives to relieve traffic on Anzac Parade in the vicinity of UNSW. For example, the establishment of north-facing ramps from Gardiners Road to Southern Cross Drive could divert some non-local traffic from Anzac Parade.

8.3.2 South 1 Route Option

Anzac Parade between Day Avenue and Nine Ways (Figures S1-1 & S1-2)

- For this route segment, the tracks would be centre running south to Kingsford.
- Modifications to the current traffic management arrangements could be required in order to provide the necessary segregation of light rail.
- It is likely that right turning lanes would be maintained on Anzac Parade for this segment.

- A stop is provisionally located on Anzac Parade between Strachan Street/Middle Street and Borrodale Road/Meeks Street.

Anzac Parade South of Nine Ways (Figure S1-2)

- Based on the assumptions that the light rail line would not continue further south at this stage, a light rail terminus stop would be located in the median of Anzac Parade just south of the Nine Ways roundabout. This would need to incorporate a bus interchange and a turnback for light rail vehicles. It could also extend to provide stabling for several light rail vehicles if required.
- The layout of this facility would require a level of work beyond the scope of this study, but at this stage, it has been assumed that the terminus / interchange would provide cross-platform transfer between buses and light rail, with buses using the existing roundabout (or re-configured intersection and nearby streets) to turn around.
- The Nine Ways roundabout would require detailed analysis to determine the optimal way of incorporating safe and efficient light rail operations through this major traffic node. Options would include signalisation and/or wholesale reconfiguration.

8.3.3 South 2 Route Option

High Street between Anzac Parade and Wansey Road (Figures S2-1 & S2-2)

- Between Anzac Parade and the racecourse gate, the track would notionally be centre running, although detailed analysis of intersection reconfiguration and signalling requirements could modify this.
- East of the racecourse gate, the track alignment would shift to the northern side of High Street. This route layout has assumed the potential to establish a light rail corridor along the southern boundary of the Turf Club (i.e. within the Turf Club property). This light rail corridor would run to Wansey Road and is required to facilitate the construction of an embankment that would provide grades manageable for light rail. The corridor / embankment would need to avoid impacts on the racecourse starting area and could require the demolition of some existing buildings.
- A stop is provisionally located to the east of the racecourse gate.

High Street between Wansey Road and High Cross Park (Figures S2-2 & S2-3)

- East of Wansey Road, it is likely that the track would be centre running on High Street. It is likely that this segment would entail mixed running with general traffic.
- A terminus stop with a bus interchange would be at High Cross Park. This would likely require a small amount of park space to be resumed, and potentially reduce the number of available traffic lanes on the Belmore Road side of the park. At this location, Belmore Road and Cuthill Street would potentially require conversion from one-way traffic to two-way traffic, or provision of a bus contra-flow lane, in order to cater for bus interchange movements.
- Stops are provisionally located on High Street between Wansey Road and Botany Street and to the west of Clara Street in addition to the terminus stop at High Cross Park.

8.3.4 South 3 Route

Alison Road between Anzac Parade and Darley Road (Figures S3-1 & S3-2)

- To the north of the Anzac Parade and the Dacey Avenue/Alison Road intersection, the light rail alignment would continue in the former tram reservation along the southern edge of Centennial Park, which is currently used as a busway. However, instead of joining Alison Road at the intersection with Doncaster Avenue (as the busway currently does), the light rail track would continue along the reservation to Darley Road.
- To cater for special event crowds at the racecourse, an extra track has been provided to store light rail vehicles, and stops with longer platforms have been provided to accommodate multiple light rail vehicles simultaneously.

Alison Road between Darley Road and Belmore Road (Figures S3-3 & S3-4)

- Based on a number of geometric and operational considerations associated with the option of re-joining Alison Road at the intersection with Darley Road, the proposed route layout has the light rail continuing along King Street (as per the former tram line), and William Street before on re-joining Alison Road (at its intersection with William / Cowper Street). This option provides the potential for accessing stabling / depot opportunities at the former Randwick tram workshop off King Street (currently utilised as an STA bus depot).
- Once on Alison Road, the track alignment runs along the northern side of Alison Road. This would require trams running in a reservation. There appears to be only one property access between Belmore Road and the property immediately to the south of Tramway Lane, and it has been assumed that this portion of the light rail route would not be trafficable by general traffic. South of the stop at Prince Street, however, private vehicles will be required to cross the reservation in order to access properties. There would be a reduction in the number of lanes for general traffic, which would be re-configured to the southern side of the road.
- The section of Alison Road between Bradley Street and Belmore Road has been identified as having grades that are greater than those on which standard light rail vehicles can operate. The route layout assumes regrading the northernmost two lanes of Alison Road between the intersection with Prince Street and the intersection with Belmore Road. In general terms, this would involve a section of fill to the west of Church Street and a cutting to the east of Church Street. There appear to be no property accesses in this section at present, although it is noted that several buildings are heritage listed. Further detail on the regrading under consideration is provided in Section 7.
- Stops are provisionally located on William Street at the intersection with Cowper Street, and on Alison Road at the intersection with Prince Street.

Belmore Road between Alison Road and High Cross Park (Figures S3-4 & S3-5)

- This route section would be centre running on Belmore Road through the Randwick Town Centre to a terminus at High Cross Park. It is likely that this would entail mixed running with general traffic. This said, traffic management planning would be required to minimise the level of non-essential traffic using Belmore Road.
- Stops are provisionally located on Belmore Road close to Alison Road, Short Street and at High Cross Park.

- As per the South 2 Route option, a terminus stop with a bus interchange would be at High Cross Park. This would likely require a small amount of park space to be resumed, and potentially reduce the number of available traffic lanes on the Belmore Road side of the park. At this location, Belmore Road and Cuthill Street would potentially require conversion from one-way traffic to two-way traffic, or provision of a bus contra-flow lane, in order to cater for bus interchange movements.

8.3.5 North 1 Route

Devonshire Street between Central Station and Bourke Street (Figures N1-1 & N1-2)

- GHD has previously developed a preliminary route layout for the 'Green Line' light rail being considered by the City of Sydney to link Green Square to Central Station. This work located light rail tracks and a terminus stop on the eastern side of Chalmers Street. Along Devonshire Street, the light rail would be mixed running with general traffic. Due to width constraints, the introduction of light rail may necessitate a one-way traffic flow in Devonshire Street, however this would be subject to further investigation.
- Stops are provisionally located on Devonshire Street close to Waterloo Street, and between Crown Street and Bourke Street.

Connection between Bourke Street and Moore Park (Figures N1-2 & N1-3)

- This route option proposes a long tunnel in order to establish a light rail link between Bourke Street and Moore Park. The alignment would require a dive between the eastern kerb of Bourke Street and a point some 85 metres to the east (under Nobbs Lane). To accommodate the dive would require a narrow strip of property acquisition (approximately 4 metres wide) of a single landholding at the north-western end of Nobbs Lane. It would also require some road closures in this area (at the intersection of Nobbs Lane and Olivia Lane), and the reopening of access between Parkham Lane and Olivia Lane (through the existing landscaped easement) in order to maintain access to the underground parking area. Along the eastern section of Nobbs Lane, the light rail would be in tunnel and rear lane access would be maintained as per the existing situation.
  - The following approximate information on indicative heights was used to test the feasibility of grades. It is provided by way of background information:
    - Vertical distance between South Dowling Street and the Eastern Distributor: 5.3 m.
    - Vertical distance between South Dowling Street and Nobbs Lane: 1.6 m.
    - Vertical distance between the Eastern Distributor and Nobbs Lane: 3.7 m. Say 4.0 m.
  - To test the feasibility of grades, the following assumptions in relation to dimensions and clearances were adopted:
    - Tunnel dimension (rail to underside of tunnel roof): 5.0 m.
    - Tunnel structure depth (rail to underside of tunnel roof to top of tunnel structure): 1.5 m.
    - Depth of rock cover (top of tunnel structure to road surface (Eastern Distributor): 2.5 m.
    - Top of rail to road surface at crossing under Eastern Distributor: 9.0 m.
    - Maximum Grade 6.5%.
- The tunnel would continue under the Eastern Distributor and Anzac Parade, before surfacing in Moore Park near the SCG. The tracks would loop back towards Anzac Parade, providing potential connections to either the north or south along the Core route.

- At Moore Park, there would be a major interchange stop with up to four platforms and three tracks. The track configuration would allow for the queuing and loading of light rail vehicles associated with special events.

8.3.6 North 2 Route

Devonshire Street between Central Station and Crown Street (Figures N2-1 & N2-2)

- As per the North 1 Route Option.

Connection between Crown Street and Moore Park (Figures N2-2 & N2-3)

- This route option proposes a predominantly at-grade light rail link between Devonshire Street and Moore Park. The alignment would run from Devonshire Street, via a short section of *gauntlet* along Bourke Street into Parkham Street. It would then run across South Dowling Street at grade, through Moore Park and under Anzac Parade.
- Based on the preliminary layout, it is assessed that along Bourke Street, light rail could only run in one direction at any one time. This option would maintain general traffic access between Devonshire Street and Bourke Street (north of Devonshire Street), maintain southbound traffic on Bourke Street and largely maintain the new segregated bicycle path along Bourke Street. However, there would be a loss of car parking spaces on Bourke Street (between Devonshire Street and Parkham Street). These arrangements are shown in Figure 8.1, below:

Figure 8.1 Indicative Traffic Arrangements in Devonshire, Bourke and Parkham Streets

- Parkham Street has residential development only on the north side, with the Bourke Street Public School on the south side. Based on the preliminary layout, it is assessed that light rail operations could be contained between the existing kerblines and there would be no need for property acquisition. However, light rail operations would impact on the residents of Parkham Street in a number of ways:
  - Noise and vibration - although these could be minimised through the use of insulating / dampening technology under / around the tracks;
  - Loss of on-street parking on Parkham Street – although vehicular access to properties would be maintained through Parkham lane (at the rear of properties);
  - Traffic access in Parkham lane – although it is noted that there are no vehicle accesses to properties that would affected and that it is proposed to allow eastbound traffic movements for drop-offs and pick-ups, (although this could provide a source of conflict for light rail operations).
- It is proposed that light rail would cross South Dowling Street at grade on the alignment of the existing footbridge (this would maintain light rail grade-separated from the Eastern Distributor). It is observed that the location and operation of intersections at Moore Park Road (to the north) and Cleveland Street (in the south) result in relatively intense platooning of traffic travelling along South Dowling Street between these two intersections. This offers the opportunity of running light rail

across South Dowling Street via a signalised, at-grade crossing without having major impacts on the existing traffic flows.

- After crossing the Eastern Distributor/South Dowling Street the light rail route would run through Moore Park in a trench before diving under Anzac Parade. There are a range of configurations possible through Moore Park, ranging from a shallow cutting to a cut and cover tunnel (should continuity of the green space is required to be maintained). While this study has assumed a shallow trench, a cutting could be covered if required.
- There would be a short tunnel under and Anzac Parade, before surfacing in Moore Park near the SCG. The tracks would loop back towards Anzac Parade, providing potential connections to either the north or south along the Core route.
- At the SCG, there would be a major interchange stop with up to four platforms and three tracks. The track configuration would allow for the queuing and loading of light rail vehicles associated with special events.

8.4 Stabling and Depot Requirements

Stabling and depot locations constitute critical requirements for a feasible light rail system. The identification of sites (and spatial requirements) for these activities is closely linked to the operational planning of the future light rail system, which cannot be determined at this stage of development.

Nevertheless, at this stage of investigation, we have identified indicative locations where it could be possible to site stabling or depots for light rail. These are outlined below.

8.4.1 Use of Stabling and Depot Facilities in Other Parts of Light Rail System

Once integrated into a broader light rail system, light rail vehicles serving the eastern line(s) have the opportunity of using stabling and depot facilities elsewhere on the system.

In general, it is advisable to locate stabling facilities and light depot facilities (e.g. washing, light maintenance) at different locations throughout the network. This minimises the amount of 'dead-running' required and saves on operating costs.

Facilities for heavy / irregular maintenance can be more centralised at a location that is efficient in terms of land costs and impacts on surrounding areas.

8.4.2 Core Route

Randwick Racecourse

Randwick Racecourse could offer the potential for stabling light rail vehicles in landholdings to the west of the racecourse. There is a broad easement in this location that was formerly used for marshalling trams.

If planned appropriately, the facility could also provide a light rail marshalling area / stop for special events.

It is noted that former State Government land was sold in this area, and that this could constrain the layout of a stabling / marshalling area. This said, the Turf Club has signalled that there are a number of potential options to remedy this situation.

Given the close proximity to residential areas, it is considered unlikely that it would be appropriate to locate a depot in this location.

E.S. Marks Athletic Field

E.S. Marks Athletic Field (near the Anzac Parade / Dacey Avenue intersection) is several metres above road level. If there were limited alternative options, it could be possible to rebuild this facility to establish a light rail depot / stabling facility underneath the sports field. The sporting facility could be re-instated after construction of any light rail infrastructure underneath.

8.4.3 South 1

In Median of Anzac Parade (South of Terminus)

For the South 1 Route Option, a terminus/turnback is proposed in the Anzac Parade median south of the Nine Ways roundabout. It is considered feasible to establish a stabling facility south of this location (potentially south of Sturt Street), although it is unlikely that it could also serve as a depot.

8.4.4 South 2

Randwick Racecourse

This option would likely utilise a stabling/depot location at Randwick Racecourse.

8.4.5 South 3

STA Bus Depot

The South 3 Route Option provides the potential to access stabling / depot opportunities at the former Randwick tram workshop off King Street, which is currently utilised as an STA bus depot.

9. Outline of Planning Approvals and Process

This section provides an overview of the potential planning approval process that would be required to re-establish light rail to Randwick.

It should be noted that this overview assumes that a State government department or agency is the project proponent. Certain legislative provisions would not apply if Randwick City Council is the project proponent.

9.1 Summary

If the proposed light rail route is declared by regulation under the *Transport Administration Act 1988*, the light rail system would be subject to assessment under Part 5 of the *Environmental Planning and Assessment Act 1979*. The Director-General (as determining authority) must "*examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity*" (EP&A Act section 111) and determine whether or not the works are "*likely to significantly affect the environment (including critical habitat) or threatened species, populations or ecological communities, or their habitats*" (EP&A Act section 112).

If the light rail system is considered not likely to significantly affect the environment, typically a Review of Environmental Factors (REF) is prepared. There is no statutory requirement to publicly exhibit an REF. The Director-General of the Department of Transport would be the determining authority. If other approvals or licences are required under other legislation, then there may be other determining authorities whose approval would also be required prior to the works commencing.

If the light rail system is considered likely to significantly affect the environment, the light rail system would be 'State significant infrastructure', and approval from the Minister for Planning would be required. An Environmental Impact Statement (EIS) would need to be prepared, and this EIS would be publicly exhibited.

9.2 Relevant legislation and environmental planning instruments

- *Environmental Planning and Assessment Act 1979* (EP&A Act).
- *Transport Administration Act 1988* (TA Act).
- *State Environmental Planning Policy (Infrastructure) 2007* (ISEPP).

9.3 Discussion

It is important to note that the EP&A Act is currently in the process of being amended. The Environmental Planning and Assessment Amendment (Part 3A Repeal) Bill 2011 passed both Houses of Parliament in June, and is awaiting proclamation.

The *Transport Administration Act 1988* (TA Act) prescribes the need or otherwise for development consent for light rail.

A 'light rail system' is defined under the TA Act (section 104N) as

a system for the provision of light rail services along a route declared under subsection (2), including tracks, catenaries, supports for tracks and catenaries, stops, access to stops, signalling and other control facilities, vehicles, vehicle depots and other facilities and equipment associated with the provision of those services.

For this definition to apply, the proposed light rail route must be declared by regulation. If this definition applies, then all works associated with the light rail, including a maintenance depot, is included.

Section 104P of the TA Act states:

(2) Development for the purposes of a light rail system:

(a) may be carried out without the necessity for development consent under Part 4 of the EPA Act, and

(b) may be so carried out even if the development would be prohibited, or would require development consent, in the absence of this section.

(3) Development for the purposes of a light rail system is an activity within the meaning of Part 5 of the EPA Act and the Director-General is the proponent and a determining authority in relation to that activity for the purposes of that Part.

If the light rail route is declared by regulation, as per the definition in section 104N, then the zoning provisions relating to the light rail route do not apply.

As the light rail system would be an 'activity' under Part 5 of the EP&A Act, the relevant provisions of Part 5 apply. In this regard, the Director-General (as determining authority) must "*examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity*" (EP&A Act section 111) and determine whether or not the works are "*likely to significantly affect the environment (including critical habitat) or threatened species, populations or ecological communities, or their habitats*" (EP&A Act section 112).

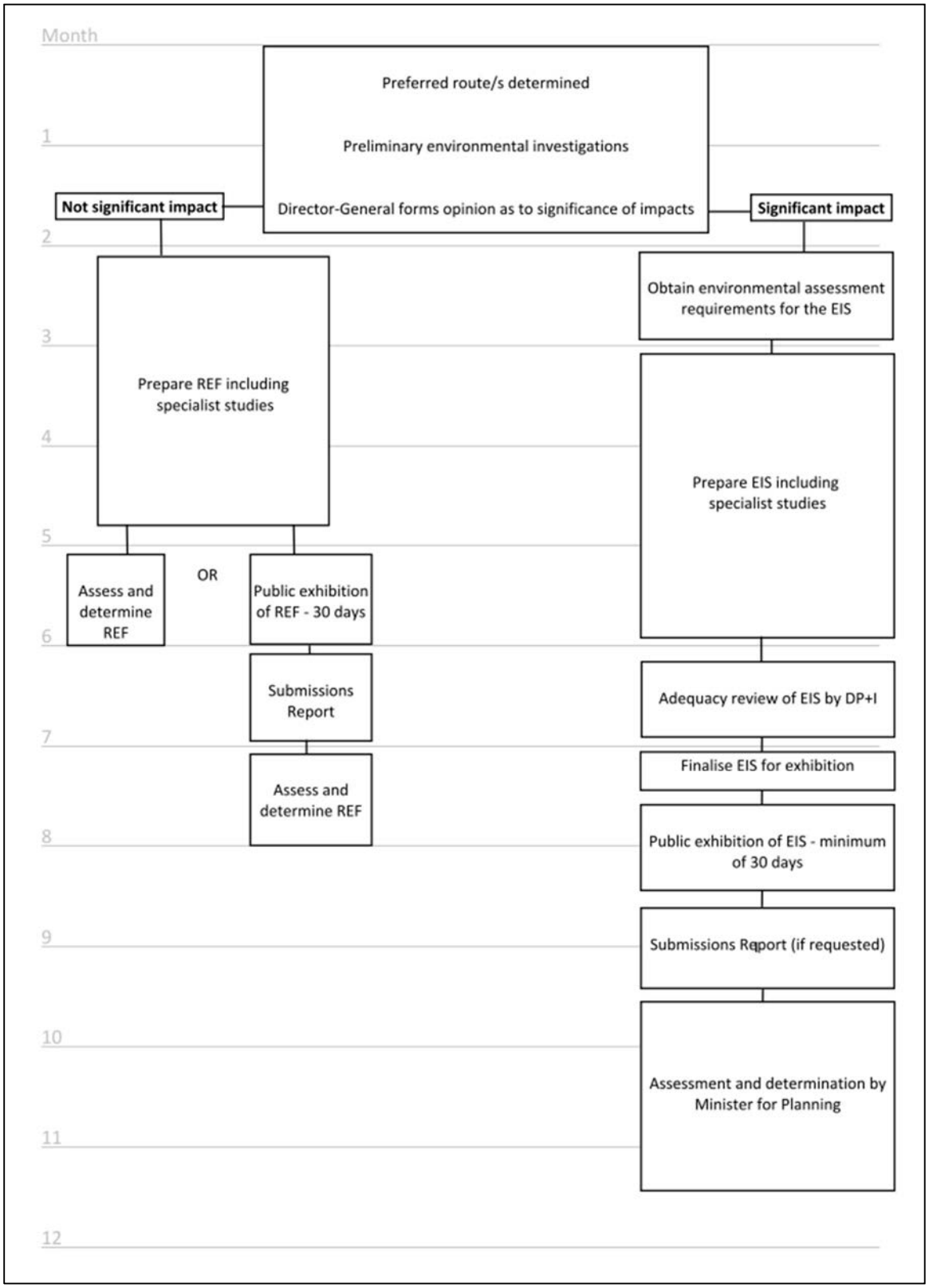
In order to determine the likely significance of impacts to make an assessment under sections 111 and 112 of the EP&A Act, preliminary environmental studies will be required, once the preferred route is selected.

If the Director-General forms the opinion that the works are likely to significantly affect the environment, by virtue of the expected declaration under the soon to commence Part 5.1 of the EP&A Act, the light rail system would be 'State significant infrastructure', and approval from the Minister for Planning would be required. An Environmental Impact Statement (EIS) will need to be prepared, and this EIS will be publicly exhibited.

If the works are not likely to significantly affect the environment, typically a Review of Environmental Factors (REF) is prepared. There is no statutory requirement to publicly exhibit an REF. The Director-General of the Department of Transport would be the determining authority. If other approvals or licences are required under other legislation, then there may be other determining authorities whose approval would also be required prior to the works commencing.

The approval process and likely timeframe is shown in Figure 9.1. It should be noted that while achievable, the identified timeframes are somewhat optimistic and delays could occur at a number of points in the process.

Figure 9.1 Potential Planning Approval Timeframes



10. Pre-feasibility Capital Cost Estimates

10.1 Summary

GHD commissioned Aquenta Consulting to develop pre-feasibility capital cost estimates for the route options investigated in this study. Table 10.1, below, provides the summary of the cost estimates ($ million) for the route options, which include all direct costs, contractor and project indirect costs, and contingencies.

Table 10.1 Summary of Pre-feasibility Capital Cost Estimates

Route Option	Length	Total of Estimate
Core *	5.9 km	$308.6 M
South 1	1.3 km	$96.7 M
South 2	1.6 km	$122.4 M
South 3	3.3 km	$231.6 M
North 1	1.7 km	$282.8 M
North 2	1.7 km	$170.0 M

Note: *excluding UNSW loop.

The estimates include a weighted average contingency of 50%-60% of total project costs (depending of the perceived level of risk in constructing different options). The estimates exclude rolling stock, escalation and GST.

10.2 Basis of Pre-Feasibility Design Capital Cost Estimates

10.2.1 General

It is envisaged that these works will be carried out on a design and construct approach. This approach will ensure that the client can stipulate the standard to which the works have to be constructed, based on agreement and approval of the design with the necessary Authorities prior to award of the contracts.

The level of information used in developing the costs is currently at pre-feasibility design which limits the accuracy of the estimate. Costs have generally been drawn from previous estimates carried out by Aquenta with GHD on other sections of Light Rail system extensions, with the rates and costs adjusted as required for differing circumstances and based on August 2011 baseline costs.

GHD provided Aquenta with the major quantities of works, e.g. track length, tunnel length, which Aquenta used as the basis to calculate these estimates.

Levels of contingency were assessed for each major element of the works giving consideration to the broad risk profile of that element, and a weighted average of these levels applied to the total project cost. The highest risks were assessed at this time to be associated with the existing services along the route of the track, and the tunnelling.

10.2.2 Route Options

These options are individually priced, and cumulative; i.e. if the physical route is for a track from Oxford Street to UNSW then the costs would be approximately ($ Core route + $ South 1). Although it is noted that the option of UNSW to Central Station in isolation (or as an interim stage) was not specifically priced and would be made up of a reduced $ Core Route (given that the portion of the route north of the SCG would not be required) plus $ North 1 or $ North 2 Route Option.

It is recognised that in any particular combination of routes that the Indirect costs of a larger route may result in a lower total cost than that of the two separate route estimates added together, however the number of possible route combinations precludes the calculation of each combination at this stage of the design process.

The one exception to this is that the rail/bus interchange at the southern end of the route for South 2 and South 3 is included within the cost estimates for both route options.

10.3 Capital Cost Estimate Assumptions and Exclusions

The following assumptions have been made within the capital cost estimates. These assumptions are common across all of the Options.

10.3.1 General Assumptions

- Traffic and pedestrian planning and management throughout construction are included. Traffic controls for the light rail line (e.g. train lanterns) are included.

10.3.2 Civil Works

This section of the estimate includes for works to the roads and intersections based on the following assumptions.

- Works to the roads and intersections have been costed as being carried out in normal working hours, assuming the ability to shut down e.g. half of the road at a time.
- Traffic and pedestrian management costs have been included.
- Track formation generally is taken as 500mm deep with 3 off 100mm conduits below each track at a minimum of 900mm below the track, with 100mm bed and 100mm cover of stabilised sand.
- Existing traffic lanes have been taken as an average 2.6m wide. For single track running widths of excavation have generally been taken as:
  - Central running: 2.5m.
  - Kerb running: 3.0m.
- Where tracks run close together width of excavation has generally been taken as twice the width of a single track plus 1m.
- Assumed that street cross gradients do not affect the assumptions above.
- Temporary reinstatement of the road surface has been included for the area of the excavation where relevant, with permanent reinstatement being included for the entire width of the roadway, the latter being priced at the City of Sydney rates.

- Each section of route has been assessed by GHD / Aquenta with respect to the complexity of existing buried services. No further detail is available so the following allowances have been made per m run of road for the for the protection and/or relocation of existing minor services, and the protection (but not relocation) of HV cabling, major water main, stormwater or sewer drain, major telecoms cable or fibre optic cabling;
  - Low $ 500 /m.
  - Medium $ 2,000 /m.
  - High $ 3,000 /m.
- Each intersection was similarly assessed for complexity, and the following allowances made per intersection;
  - Low $ 100,000.
  - Medium $ 300,000.
  - High $ 750,000.
- In North 1, allowance has been made for a 500m long tunnel, with a further 180m of approach ramps. A maximum track gradient of 7% has been assumed. Note that the depth of the Eastern Distributor tunnel and associated structures has not been verified, therefore it has been assumed that the new tunnel will clear the existing installations given these criteria. Tunnelling by 'mining' techniques has been assumed due to the high level of obstructions and interfaces anticipated.
- The tunnel under Anzac Parade in North 2 has been assumed to be constructed by 'cut-and-cover' methodology in stages across the road.

10.3.3 Permanent Way

Track has been based on 60 kg head hardened rail on independent concrete slabs throughout with:

- Turnouts.
- Crossovers.
- Diamonds.
- Buffer stops.

10.3.4 Light Rail Systems

The scope included in this section covers OHW, traction substations, signalling, ATP, SCADA, PIDS, train and platform communications, and earthing & bonding together with the following assumptions.

- Two poles per track location have been allowed for with wires spanning between them. No differentiation has been made at this level of estimate for centre pole running.
- New traction substations have been allowed for. Two new substations have been included in the Core route, with one further substation in each of the additional route options.
- New train radio rebroadcast stations have been allowed for. Two new stations have been included in the Core route, with one further station in each of the additional route options.
- No allowance made for land purchase etc for traction substations or radio rebroadcast stations.

- No allowance made for any upgrade, modifications etc required by Ausgrid to provide power to substations.
- No allowance made for upgrades to existing infrastructure systems, e.g. signalling controls, SCADA, traffic control systems, or existing control facilities.

10.3.5 Stops

The scope included covers platform structure, kerbs and surface finishes, DDA ramps, drainage, lighting, canopies, Help Point, PA and CCTV together with Station Equipment Modules, power supplies and data interfaces. Other assumptions are:

- Platforms are generally based on 3m wide construction at the lengths stated.
- No works have been included at the racecourse and other 'event' locations for any other footpaths or infrastructure modifications required to integrate the new stops with existing facilities.

10.3.6 Urban Design

An allowance of $50,000 per platform for urban design additions at the stops has been included. No allowance for general additions to urban design along the length of the track has been included.

10.3.7 Contractor's Indirect Costs

An allowance has been made for the Contractor's indirect costs, based on a design and construct contract. This allowance includes for the following items and has been evaluated as 40% of the Direct Costs.

- Time related Preliminaries for management and administrative staff, and site office expenses
- Cost related Preliminaries covering:
  - Insurances.
  - Contractor's Offsite Overheads & Profit.
  - Contractor's Risk.
  - Bank Guarantees.
  - Contractors design.

10.3.8 Client's Project Costs

An allowance has been made for the Client's indirect costs, based on a design and construct contract. This allowance includes for the following items and equates to approximately 16% of the Direct Costs:

- Project management and project controls.
- Design to Tender Stage.
- Services location survey.
- Planning and Environmental.
- Traffic management planning for the completed system.
- Geotechnical investigation.

- Community relations and communication
- Stakeholder interfaces.

The values of these allowances have been benchmarked against similar and recent projects.

10.3.9 Escalation

Escalation has been excluded from these estimates.

10.3.10 Contingency

Levels of contingency were assessed for each major element of the works giving consideration to the broad risk profile of that element, and a weighted average of these levels at 50% to 60% was applied to the total project costs. The highest risks were assessed at this time to be associated with the existing services along the route of the track.

10.4 Breakdown of Estimates

Table 10.2 presents a breakdown of each of the option estimates into the principal cost headers.

Table 10.2 Breakdown of Pre-feasibility Capital Cost Estimates

Route / Works	Core	South 1	South 2	South 3	North 1	North 2
Civil Works	$74.5 M	$24.0 M	$26.6 M	$49.4 M	$69.8 M	$31.3 M
Permanent Way	$13.7 M	$5.0 M	$8.0 M	$17.2 M	$17.9 M	$18.1 M
Light Rail Systems	$26.4 M	$7.5 M	$10.2 M	$17.9 M	$14.6 M	$13.4 M
Stops & Urban Design	$12.4 M	$3.4 M	$5.6 M	$10.9 M	$6.8 M	$6.8 M
Contract Indirects	$50.7 M	$15.9 M	$20.1 M	$38.0 M	$43.6 M	$27.9 M
Total Contract Cost	$117.7 M	$55.7 M	$70.5 M	$133.4 M	$152.7 M	$97.9 M
Project Costs	$28.0 M	$8.8 M	$11.1 M	$21.0 M	$24.1 M	$15.4 M
Total for Construction	**$205.7 M**	**$64.5 M**	**$81.6 M**	**$154.4 M**	**$176.8 M**	**$113.4 M**
Contingency	$102.9 M	$32.2 M	$40.8 M	$77.2 M	$106.1 M	$56.7 M
Total of Estimate	**$308.6 M**	**$96.7 M**	**$122.4 M**	**$231.6 M**	**$282.8 M**	**$170.0 M**

The alternative option to the Core route at UNSW, as shown on drawing C-8B, was assessed but no final figure was determined. The costs of the works as shown on the drawing, i.e. the additional platform and minor lengths of added track, total in Direct costs approximately $1 Million, an addition to the Total of Estimate including all indirect costs and Contingency of approximately $2.5 Million.

However, Aquenta have walked this particular section of the route and note that for the track to be aligned as shown at least one significant building would need to be demolished, a number of old, established native trees removed, and a significant amount of an embankment cut away. Given the impact these large undetermined costs would have on the relatively small value of additional works it was felt that to give a figure at this time could be misleading.

10.5 Exclusions

The following items have been excluded from these estimates:

- Stabling facility, maintenance yard or depot facilities.
- Rolling stock.
- Provision of spare parts (infrastructure and rolling stock).
- Upgrades to existing infrastructure systems, e.g. signalling controls, SCADA, traffic control systems, including control buildings etc.
- Ticketing systems.
- Civil/structural works beyond direct impacts on roads and pavements of the new track and platforms etc – e.g. no works allowed for any modifications to bridges or any other overhead structures.
- No costs included for relocating/modifying any existing overhead cabling, structures or other services.
- Costs associated with land acquisitions, creation of easements, demolition of existing structures.
- Soft landscaping, e.g. replacing trees etc.
- Any upgrade of Ausgrids' existing network i.e. assumed that there is sufficient capacity in the network for this extension.
- Relocation of any HV cabling, major water main, stormwater or sewer drain, major telecoms cable or fibre optic cabling.
- Restricted working hours or night time working.
- Active security during construction.
- Possessions.
- Abnormal ground conditions.
- Aboriginal and European heritage.
- Works to any heritage buildings or structures (including drains and sewers).
- Expense costs, e.g. operational running costs, maintenance etc.
- Escalation.
- Finance Costs, Taxes, GST etc.

11. Key Findings

11.1 Introduction

This Section brings together the outcomes of earlier sections into an overall assessment of the relative merit of different route options and key associated findings.

It is noted that these findings are based on an investigation that was limited to the study area and routes incorporated in the Study Brief. Consideration of a broader set of route options in a wider geographical area would be necessary in order to reach a sound position in terms of understanding benefits to the broader community and priorities.

It is also noted that the basis of the analysis, investigations and findings were the four *strategic drivers* developed for the purpose of this study, as discussed earlier in Section 5, and outlined below:

- Strategic Driver #1 - *Improve the Customer Experience.*
- Strategic Driver #2 - *Improve the Transport System.*
- Strategic Driver #3 - *Integrate with Land Use.*
- Strategic Driver #4 – *Optimise Likelihood of Implementation.*

11.2 Findings of Route Option Assessment

Based on the preliminary analysis presented in Section 6, the following key findings are made in relation to the route options investigated in this study.

The Core Route would need to be established first and would need to extend to UNSW

The Core Route would need to be established in order to enable any other route options, thus it would need to be established first.

Based on the local context and operational and integration requirements associated with light rail and bus, the Core Route should extend to the main gateway of the University of NSW.

The South 1 Route Option would ideally be delivered concurrently with the Core Route

It is considered that delivering the South 1 Route Option concurrently with the Core Option (i.e. extending the light rail line from UNSW to a location south of the Nine-Ways at Kingsford) would bring a range of benefits. Key justifications are summarised below:

- Reach a location with good potential (and sufficient space) to serve as a light rail terminus and a purpose-built bus-light rail interchange (c.f, Strategic Driver #1 - *Improve the Customer Experience* and Strategic Driver #2 - *Improve the Transport System*).
- Provide a logical location (from the perspective of the users, bus system and operations) for transfer between buses serving Anzac Parade south of Kingsford and light rail serving Anzac Parade north of Kingsford, thus delivering the potential to truncate one set of bus services entering the CBD (c.f, Strategic Driver #1 - *Improve the Customer Experience*, Strategic Driver #2 - *Improve the Transport System*).
- Serve development opportunities along Anzac Parade in Kingsford (c.f, Strategic Driver #3 - *Integrate with Land Use*).

- Ease of Implementation. The length of the South 1 Route Option between the main Gateway of UNSW and the terminus in Kingsford is in the order of one kilometre and is relatively uncomplicated from a construction perspective. (c.f, Strategic Driver #4 – *Optimise Likelihood of Implementation*)

If not delivered concurrently with the Core Route, then the South 1 Route Option is considered to be the highest priority of the Southern Route Options.

It is unlikely that both South 2 and South 3 Route Options would be implemented

It is considered unlikely that both the South 2 and South 3 routes would be implemented. This position is based on the following:

- The assessment of the benefits of the South 2 Route Option relative to South 3 Route Option is based on the previous finding that both the Core Route and the South 1 Route Option are operational.
- In this case, then the combination of the Core route and South 1 route option plus either the South 2 or South 3 route options would serve very similar destinations. i.e. implementing both the South 2 and South 3 route options would bring only minor benefit compared to implementing only one of them.

If the Core Route and the South 1 Route Option are established, it is considered that the South 3 Route Option (Alison Road) would offer superior benefits to the South 2 Route Option (High Street), as it serves a wider catchment than South 2 (which is overlapped by much of South 1).

Future Route Extensions

Following on from this (and notwithstanding potential extensions outside the Study Area), it is considered that there would be superior benefits in extending light rail from Randwick further to the east than in implementing both the South 2 and South 3 Route Options. While the South 3 Route Option (Alison Road) would offer superior benefits to the South 2 Route Option (High Street), an extension further to the east would be possible from either of these two options.

In a similar vein it is considered that there would be superior benefits in extending light rail from Kingsford to Maroubra than in implementing both the South 2 and South 3 Route Options.

Further investigation is required to assess the need (and most feasible option) for a light rail link to Central Station

Consideration of a light rail link to Central Station was added to the scope of this study on the following bases:

- If a light rail was built between the CBD and the UNSW (and potentially other locations in the Eastern Suburbs), it is likely that it would divert a proportion of trips into the CBD that currently link to Central Station.
- From a transport network and system efficiency perspective, it is considered counterproductive to attract additional public transport trips to the CBD (in general) and/or to transfer to the CityRail network at Town Hall Station (in particular) as this would exacerbate current congestion at within the CBD and at CBD train stations.

While a tunnel would provide the means for light rail to run directly under Surry Hills to Central, this would constitute a very expensive option that might be unfeasible from the perspective of economic benefit.

On this basis, GHD developed two options for a light rail link to Central Station. Both of these options would require additional, more detailed investigation in order to:

- Assess their potential to respond to the transport needs that they are to address;
- Prove their feasibility; and
- Assess the relative benefits and costs.

11.3 Issues for Further Consideration

The Study Area Offers Strong Potential for Viable Light Rail

The study area has the characteristics generally associated with viable public transport. These include:

- Relatively high residential and employment densities;
- A number of mixed use and employment centres;
- Several regional-scale facilities that constitute major trip generators (education, sport, recreation);
- Urban structure and form that could be classified as transit-oriented; and
- Strong passenger demand in both the peak and off-peak direction as well as outside peak periods and on weekends.

With numerous characteristics that would appear to support a strong business case for light rail, the study area would offer a good test case for light rail in Sydney. This could be of interest for a Government that wishes to invest in 'game-changing' public transport such as light rail.

It is also noted that the study area incorporates a number of regional destinations (UNSW, Randwick Hospital / Health Precinct, Randwick Race Course, SCG/SFS) which necessitate good levels of regional public transport access in order to optimally benefit the metropolitan area they serve and the economy and competitiveness of NSW in general.

The Need for a Strategy for Light Rail in Sydney

A robust Strategy for Light Rail in Sydney will provide the necessary context for further development of light rail concepts within the study area. This strategy would need to be developed by the NSW State Government in strong consultation with key stakeholders.

There are number of aspects of such a strategy that would provide the Client Group with valuable input in further developing planning and policies around light rail. These include:

4. Develop and agree on the *strategic drivers* for light rail – "*why the NSW Government should invest in light rail*";
5. Agree on the future context for which the Strategy for Light Rail is being developed;
   - Future land use / transport context;
   - Future public transport network and system context.
6. Agree on the funding and financing options to be considered for the strategy;
7. Identify candidate corridors that respond to the agreed *strategic drivers;*
8. Develop and agree on the *functional specification* for each of the candidate corridors – "*what role and function does public transport need to serve on each of the candidate corridors*"? A key 'umbrella'

measure in the development of the functional specification for light rail is the required 'commercial speed' for light rail and the associated level of priority to be provided to light rail (physical segregation / intersection priority)

9. Assess the viability of light rail (relative to other potential modes) to deliver the *functional specification;*
10. Develop a Strategic Plan for light rail in Sydney, incorporating:
    - A plan of the corridors considered feasible for light rail;
    - Indicative staging / 'trigger points' for each light rail corridor;
    - Functional specifications for each light rail corridor;
    - Approval, funding and financing requirements / options for each light rail corridor.

Compromises Required to Implement Light Rail

It should be noted that a successful light rail line will require high levels of operational priority in order to provide fast and reliable services that are largely immune from congestion and delays caused by general traffic. On this basis, the implementation of light rail will require compromises in terms of the allocation of road space. This will have impacts on general traffic and parking as well as buses in some cases.

In the same vein, consideration needs to be made in terms of compromises ('costs and benefits') at a broader level. For example, if light rail was to run from Anzac Parade / Flinders Street along Oxford Street to the CBD, it would be necessary to consider the impacts on bus travellers from the east (Paddington, Bondi etc) as a result of serving Randwick / Kensington with light rail.

Light Rail Extension into the CBD is a Key Enabler for a Viable Eastern Suburbs Light Rail

A fast and reliable light rail link into the CBD (i.e. north of Flinders Street) would be a critical 'enabler' for a viable light rail service in the study area on the basis that key impacts to reliability occur in area north of the study area (i.e. within the CBD). It is considered likely that light rail services would need to extend north of Town Hall Station as part of an initial stage. However, it may also be possible (as an interim stage) to connect an eastern light rail to Central Station. It is noted, however, that the economic viability of a light rail that does not provide a direct and rapid service to the CBD would be considerably reduced as a link to (or via) Central Station would be less attractive to the customer market.

Bus Restructure to Support and Integrate with Light Rail

It will be critical to restructure the bus network to support and integrate with any light rail line serving the study area. This restructure will need make strong consideration of the needs of customers and the need to provide an overall improvement in the passenger experience relative to the existing situation. I.e. any penalties associated with transfers would need to be mitigated by improvements in quality of service (frequency of services, overall trip time, reliability, comfort).

The location and quality of interchange facilities between light rail and bus will be critical to attract passengers to light rail and achieve the benefits of reducing bus kilometres travelled within the congested CBD.

Reduce the number of public transport vehicles entering the congested CBD

With higher capacity, light rail offers the potential to deliver people into the CBD more efficiently than by bus (from the perspective of time and space used on the transport network).

A key benefit of establishing light rail within the study area, therefore, would be the potential it offers to reduce the number of public transport vehicles entering the congested CBD. In turn, the road capacity 'freed-up' through this reduction could be made available for other purposes, such as:

- Catering for growth in public transport demand from other parts of Sydney; and
- Carrying public transport vehicles diverted as a result of other initiatives (e.g. establishment of light rail in the George Street would subsequently result in a need to divert a proportion of buses to other streets across the CBD).

Consideration of Operational Requirements and Supporting Facilities

Operations are a critical part of the planning, development, design and implementation of a light rail service, and include:

- The potential to operate light rail services in a way that responds to customers' needs and expectations efficiently;
- The provision of a reliable and resilient transport system, i.e. one that will respond to special events, service interruptions and future expansion of the system; and
- The 'back of house' facilities required to support the operational requirements. These include stabling, maintenance, control systems and staff accommodation.

These non-physical aspects of the transport system constitute crucial considerations of future development of light rail in the Study Area.

Limitations to the Potential for Light rail to Serve Special Events

During the era when Sydney was served by an extensive tram network, it was possible to draw on a large fleet of trams to serve the peak demand associated with events at the Sydney Cricket Ground, Show Ground and Randwick Racecourse. Today, crowds are served by a battery of buses drawn from the available fleet.

Although light rail could offer the potential to serve peak loads associated with events at these venues, further work would need to be undertaken to test the required fleet and the financial implications of this at different stages of development of a future light rail network. In essence, if the fleet required for the 'normal' service offering of the light rail system could also meet the peak requirements associated with special events, then it would be financially viable for the operator to do so. However, if additional vehicles needed to be purchased to serve a sporadic demand (such as special events), then that would impact on the financial viability of doing so. It is likely that while the light rail system is of a limited size, the available light rail fleet would only be able to serve a proportion of the peak demand associated with special events at key venues in the Study Area.

Length of 'Design' Light Rail Vehicle and Stops

This study has assumed a 45 metre long 'design' light rail vehicle. The main implications of this assumption include:

- The length of stop applied in the route layouts;
- The capacity of the light rail system (passengers per hour); and
- The frequency of services to provide the required capacity (a longer vehicle will carry more passengers).

The decision in relation to the ‘design’ light rail vehicle for the extension into the CBD will be a key driver of the ‘design’ light rail vehicle for the study area (i.e. light rail routes to the east).

Depot and Stabling Areas

Once there is a better understanding of the route options likely to be implemented, as well as the broader light rail system (notably, how the eastern light rail would access the CBD and/or Central), it will be necessary (and feasible) to identify the requirements for depot and stabling and the potential locations to serve these activities.

Appendix A

Stakeholder Input

From Project Meetings

Purpose of Study

UNSW

- This is a pre-feasibility study, timed so that stakeholders can engage more effectively in a future NSW government study by being in a position to:
  - Present an agreed position of partners.
  - Bring knowledge / informed position into discussions.
- Want to ensure that light rail is superior to alternatives that are cheaper (such as improving buses etc).

Randwick City Council

- Want increased knowledge to work with, to gain respect based on sound advice in order to put stakeholder group into a better position – "go with wisdom".
- Fill in data / information gaps.
- Provide background, clear position / education.

Australian Turf Club – Royal Randwick

- Consider demand, will it stack up financially.
- Provide recommendations.
- Timing: outputs of this study could help expedite delivery of light rail in first term of government.

Role of Light Rail

UNSW

- UNSW is conscious that good access from the broader Sydney metropolitan area is crucial to the university's competitiveness (for the best students) with other universities.
- UNSW reported that the ability of STA to offer any additional university bus services is limited due to capacity constraints in Eddy Avenue.
- Desire to maximise the value of land through reducing the need to 'waste' land on car parking.
- Promote a more active and vibrant university district (extending to Anzac Parade and beyond).

Randwick City Council

- Provide best public transport service to customers.
- Catalyse urban renewal / revitalisation.
- Present a clear position to the community.
- Planning to deal with current situation and potential growth.

Australian Turf Club – Royal Randwick

- This area is 'Sydney's playground' (Centennial Park, Moore Park, Fox studios, Randwick Racecourse etc.), so there is a need to improve access in order to attract and retain major events. This brings major benefits to Sydney and NSW.

- Address declining attendance at race meets over past 20 years by improving access to facilities.
- Optimise development opportunity at High Street through better public transport access.
- Address community backlash against traffic associated with special events.
- Consider potential to use major landholdings to facilitate feasibility of light rail (e.g. grade of High Street could be addressed by ramp in racecourse).

Appendix B

Indicative Bus Restructuring

Assumptions and Data

Table A Bus Route Assumptions Based on Light Rail Route Options

Bus Route	Core	Core+S1	Core+S2	Core+S3
339	Same	Same	Same	Same
372	Same	Same	Same	Same
373	Same	Same	Same	Truncated (b)
374	Same	Same	Same	Same
376	Same	Same	Same	Same
377	Same	Same	Same	Truncated (b)
391	Rerouted (c)	Rerouted (c)	Rerouted (c)	Rerouted (c)
392	Truncated (d)	Truncated (e)	Truncated (e)	Truncated (e)
393	Same	Same	Same	Same
394	Truncated (d)	Truncated (e)	Truncated (e)	Truncated (e)
395	Same	Same	Same	Same
396	Truncated (d)	Truncated (e)	Truncated (e)	Truncated (e)
397	Truncated (d)	Truncated (e)	Truncated (e)	Truncated (e)
399	Truncated (d)	Truncated (e)	Truncated (e)	Truncated (e)
L94	Truncated (d)	Truncated (e)	Truncated (e)	Truncated (e)
X39	Truncated (d)	Truncated (e)	Truncated (e)	Truncated (e)
X73	Truncated (d)	Truncated (e)	Truncated (e)	Truncated (e)
X74	Truncated (d)	Truncated (e)	Truncated (e)	Truncated (e)
X77	Truncated (d)	Truncated (e)	Truncated (e)	Truncated (e)
X94	Truncated (d)	Truncated (e)	Truncated (e)	Truncated (e)
X96	Truncated (d)	Truncated (e)	Truncated (e)	Truncated (e)
X97	Truncated (d)	Truncated (e)	Truncated (e)	Truncated (e)
X99	Truncated (d)	Truncated (e)	Truncated (e)	Truncated (e)
M10	Discontinued	Discontinued	Discontinued	Discontinued
M50	Same	Same	Rerouted (f)	Same

Notes:

C = Core (Anzac Parade to UNSW only)

S1 = Anzac Parade to Kingsford Nine ways

S2 = High Cross via High Street

S3 = High Cross via Alison Road

(b) Truncated at High Cross Randwick

(c) Rerouted via Cleveland and Truncated to Railway (Central) only

(d) Truncated to UNSW

(e) Truncated to 9-ways interchange

(f) Rerouted via Alison Road

Table B Bus Route Continuation to CBD Under Route Option Assumptions

Bus Route	Existing	Core	Core+S1	Core+S2	Core+S3
339	11	11	11	11	11
372	7	7	7	7	7
373	9	9	9	9	0
374	8	8	8	8	8
376	7	7	7	7	7
377	4	4	4	4	0
391	5	0	0	0	0
392	6	0	0	0	0
393	14	14	14	14	14
394	7	0	0	0	0
395	4	4	4	4	4
396	4	0	0	0	0
397	3	0	0	0	0
399	2	0	0	0	0
L94	5	0	0	0	0
X39	8	0	0	0	0

Bus Route	Existing	Core	Core+S1	Core+S2	Core+S3
X73	10	0	0	0	0
X74	7	0	0	0	0
X77	7	0	0	0	0
X94	5	0	0	0	0
X96	3	0	0	0	0
X97	1	0	0	0	0
X99	1	0	0	0	0
M10	6	0	0	0	0
M50	6	6	6	6	6
Total	**150**	**70**	**70**	**70**	**57**
Reduction into CBD	**-**	**80**	**80**	**80**	**93**

Appendix C

Light Rail Capacity Calculations

Assumptions

Peak Bus volumes: Factor to convert from 4hr to 1hr peak	**0.4**
LRV Capacity: Factor to replace bus with LRV (45m long). 4 buses = 1 LRV (45 m)	**0.25**
LRV Capacity: Factor to replace bus with LRV (30m long). 2.5 buses = 1 LRV (30 m)	**0.4**
Maximum capacity of link (LRT services	**60**
Test growth rate (low end)	**30%**
Test growth rate (high end)	**50%**

EXISTING BUS DEMAND

Convert to Light rail (30 m long)	Buses (Pk 1hr, Pk direction)	Number of LRT Services per hour to provide same capacity as bus (at different % of shift from bus to lrt)									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Anzac Parade (Moore Park)	114	5	9	14	18	23	27	32	36	41	45
Anzac Parade (Centennial Park)	133	5	11	16	21	27	32	37	43	48	53
Anzac Parade (North of High Street)	43	2	3	5	7	9	10	12	14	15	17
High Street	11	0	1	1	2	2	3	3	4	4	4
Anzac Parade (South of High Street)	32	1	3	4	5	6	8	9	10	11	13
Alison Road	73	3	6	9	12	15	18	20	23	26	29
Anzac Parade (South of Rainbow Street)	19	1	2	2	3	4	5	5	6	7	8
Anzac Parade (North of Maroubra Road)	19	1	2	2	3	4	5	5	6	7	8

Convert to Light rail (45 m long)	Buses (Pk 1hr, Pk	Number of LRT Services per hour to provide same capacity as bus (at different % of shift from bus to lrt)									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Anzac Parade (Moore Park)	114	3	6	9	11	14	17	20	23	26	28
Anzac Parade (Centennial Park)	133	3	7	10	13	17	20	23	27	30	33
Anzac Parade (North of High Street)	43	1	2	3	4	5	6	7	9	10	11
High Street	11	0	1	1	1	1	2	2	2	3	3
Anzac Parade (South of High Street)	32	1	2	2	3	4	5	6	6	7	8
Alison Road	73	2	4	5	7	9	11	13	15	16	18
		0	0	0	0	0	0	0	0	0	0
Anzac Parade (South of Rainbow Street)	19	0	1	1	2	2	3	3	4	4	5
Anzac Parade (North of Maroubra Road)	19	0	1	1	2	2	3	3	4	4	5

EXISTING + 30% BUS DEMAND

Convert to Light rail (30 m long)	Buses (Pk 1hr, Pk	Number of LRT Services per hour to provide same capacity as bus (at different % of shift from bus to lrt)									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Anzac Parade (Moore Park)	148	6	12	18	24	30	35	41	47	53	59
Anzac Parade (Centennial Park)	173	7	14	21	28	35	42	48	55	62	69
Anzac Parade (North of High Street)	56	2	4	7	9	11	13	16	18	20	22
High Street	15	1	1	2	2	3	3	4	5	5	6
Anzac Parade (South of High Street)	41	2	3	5	7	8	10	12	13	15	16
Alison Road	95	4	8	11	15	19	23	27	30	34	38
Anzac Parade (South of Rainbow Street)	24	1	2	3	4	5	6	7	8	9	10
Anzac Parade (North of Maroubra Road)	24	1	2	3	4	5	6	7	8	9	10
Convert to Light rail (45 m long)											
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Anzac Parade (Moore Park)	148	4	7	11	15	18	22	26	30	33	37
Anzac Parade (Centennial Park)	173	4	9	13	17	22	26	30	35	39	43
Anzac Parade (North of High Street)	56	1	3	4	6	7	8	10	11	13	14
High Street	15	0	1	1	1	2	2	3	3	3	4
Anzac Parade (South of High Street)	41	1	2	3	4	5	6	7	8	9	10
Alison Road	95	2	5	7	10	12	14	17	19	21	24
Anzac Parade (South of Rainbow Street)	24	1	1	2	2	3	4	4	5	5	6
Anzac Parade (North of Maroubra Road)	24	1	1	2	2	3	4	4	5	5	6

EXISTING + 50% BUS DEMAND

Convert to Light rail (30 m long)	Buses (Pk 1hr, Pk	Number of LRT Services per hour to provide same capacity as bus (at different % of shift from bus to lrt)									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Anzac Parade (Moore Park)	170	7	14	20	27	34	41	48	55	61	68
Anzac Parade (Centennial Park)	200	8	16	24	32	40	48	56	64	72	80
Anzac Parade (North of High Street)	64	3	5	8	10	13	15	18	21	23	26
High Street	17	1	1	2	3	3	4	5	5	6	7
Anzac Parade (South of High Street)	47	2	4	6	8	9	11	13	15	17	19
Alison Road	110	4	9	13	18	22	26	31	35	40	44
Anzac Parade (South of Rainbow Street)	28	1	2	3	5	6	7	8	9	10	11
Anzac Parade (North of Maroubra Road)	28	1	2	3	5	6	7	8	9	10	11
Convert to Light rail (45 m long)	Buses (Pk 1hr, Pk direction)	Number of LRT Services per hour to provide same capacity as bus (at different % of shift from bus to lrt)									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Anzac Parade (Moore Park)	170	4	9	13	17	21	26	30	34	38	43
Anzac Parade (Centennial Park)	200	5	10	15	20	25	30	35	40	45	50
Anzac Parade (North of High Street)	64	2	3	5	6	8	10	11	13	14	16
High Street	17	0	1	1	2	2	3	3	3	4	4
Anzac Parade (South of High Street)	47	1	2	4	5	6	7	8	9	11	12
Alison Road	110	3	5	8	11	14	16	19	22	25	27
Anzac Parade (South of Rainbow Street)	28	1	1	2	3	4	4	5	6	6	7
Anzac Parade (North of Maroubra Road)	28	1	1	2	3	4	4	5	6	6	7