

ATTACHMENT B

**'SYDNEY LIGHT RAIL HICKSON ROAD
OPTIONS REPORT, HICKSON
ROAD/ROCKS AREA/CENTRAL STATION',
FEBRUARY 2007
PREPARED BY HYDER CONSULTING**

ATTACHMENT B

City of Sydney

Sydney Light Rail Hickson Road Options Report – Final Draft



Hickson Road / Rocks
Area/Central Station

20 February 2007

Report No 12



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Hickson Road / Rocks Area / Central Station

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1 Executive Summary

Hyder Consulting is delighted to provide a Sydney Light Rail Hickson Road Options Report in response to a request outlined by City of Sydney for two short listed options namely:-

- **Option1 Circular Quay, The Rocks, George Street, Hickson Road / Sussex Street, Hay Street, Central Station**
- **Option 3 Circular Quay, George Street, Argyle Street, Kent Street, Liverpool Street, George Street, Hay Street, Central Station**

The Hickson Road Options report follows our initial Pre-Feasibility study report on six two-way light rail options running in the Hickson, Sussex and Hay Street areas that outlined a number of options for linking Central Station via the Rocks to Circular Quay.

This Report provides further details following on from our initial report on options for light rail routes through central Sydney linking with the existing Light Rail between Lilyfield and Central Station at Hay Street and joining the proposed Central to Circular Quay route at Circular Quay. The Central Station to Circular Quay route was investigated in an earlier report for the City of Sydney by Hyder Consulting reference no. 1 that is proposed to run via Castlereagh Street.

Hyder Consulting examined associated Light Rail reports for central Sydney and carried out a number of site inspections and pre-feasibility assessments of the route. We have reviewed the main planning, transport and engineering aspects of the two preferred options that we recommended for further investigation in the initial Feasibility study to check the technical feasibility. The initial six options were reduced to two short listed options by scoring their performance against a number of criteria and objectives.

Key issues opportunities and constraints identified and commented on by Hyder Consulting are as follows:-

- 1 Two alternative route options linking Circular Quay to Central Station via Hickson Road have been reviewed. In addition sub options has been reviewed at the north end of the route to avoid potential showstoppers at the George / Loftus / Cahill Expressway and George Street junction through to the Rocks. A sub option for a tunnel linking Campbell's Cove to Walsh Bay with a 1,000 space car park under the Harbour Bridge approach at Dawes Point has been investigated. A short tunnel connection beneath Dawes Point would have many benefits for the area.
- 2 It is apparent that each option would require either:
 - the modification of existing Sydney Light Rail Vehicles; or
 - the introduction of newly designed light rail vehicles to operate successfully on the route.
- 3 Parts of the two proposed route options considered in the report would require:-
 - re-profiling of the existing roads and interchange roads in order to achieve acceptable operational vertical and horizontal alignments for the light rail vehicles and to maintain acceptable profiles for intersection road traffic and pedestrians.

To gain further confidence of operational certainty it is recommended that following this Options Report, detailed design should be developed to confirm a feasible alignment taking into account operational matters for light rail and road traffic, the extent of re-profiling, the effect on access to buildings adjoining the route, pavements drainage and existing services.

- 4 The Hickson Road options create the opportunity to provide an efficient route for light rail and associated public transport and pedestrian connections, and provide an opportunity for further light rail route extensions in central Sydney.
- 5 It will enable the restructuring of the street with the potential to redress the balance of priorities between pedestrians and traffic to make Hickson Road an attractive destination for people in its own right. The proposed Light Rail route will provide the essential public transport infrastructure to link the proposed redevelopment of East Darling Harbour (Barangaroo). There are opportunities at this conceptual stage either to route it through the heart of the development or along the wide Hickson Road Boulevard that runs along the eastern boundary of the project. By providing public transport links from this new urban quarter, it will provide greater opportunities for dynamic interaction, knitting the site to its central business district context and the rest of the city.
- 6 The steeply sloping grades through the cut in Argyle Street have been examined as they present a number of issues for consideration:
 - Costs of suitable alternative rolling stock or the potential modification of existing Variotram vehicles to enable them to operate on steeply sloping grades.
 - The detailed vertical and horizontal track alignments required to suit the performance of the existing rolling stock, given the claimed maximum 7.5% gradient for these vehicles. Even this gradient contains a significant element of risk in adverse conditions, issues such as the interruption to smooth grading for through traffic at the junction from George Street to Hickson Road in the Rocks will present challenges. We have, however, investigated sub options to minimise this risk.
 - Two possible alternatives are to:-
 - Upgrade the existing Variotrams or
 - Investigate alternative higher performance light rail vehicles with proven operational capacity to ascend grades up to 10%. This would enable the light rail network to be extended more readily to areas in the Rocks with steeper grades.
- 7 Initial discussions with Rolling stock manufactures and the Sydney Light Rail operator regarding alignment solutions, have been undertaken.
- 8 Discussions with the Sydney Harbor Foreshore Authority will be undertaken to take account of the new East Darling Harbour Concept Plan they are undertaking as well as urban design and heritage issues as set out in the Rocks Heritage Management Plan to integrate the proposed light rail route with the historic street form and heritage listed buildings in the area.
- 9 Retaining parking for service and delivery vehicles on the east side only of the streets along the proposed route would provide more space for Light Rail operations.

- 10** Service relocations will be a dominant feature of the works in terms of both cost and time and could also affect alignment of track locally. Underground utility investigations will have to be cross checked with the various authorities. In general terms they present a significant risk for escalation of costs.
- 11** Determining the appropriate method of support for the Overhead Line Electrification from a functional, economic and aesthetic point of view will require to be appropriately designed, particularly in the sensitive, heritage listed Rocks area.

2 Introduction

2.1 Background

Hyder Consulting is pleased to present this Hickson Road Options Report in response to the request outlined by City of Sydney for extending the proposed Central Sydney Light Rail network. This Report outlines two options for alternative light rail routes linking Circular Quay with:

- The Rocks;
- Walsh Bay;
- Darling Harbour;
- and the light rail system connecting Central Station with Lilyfield.

This Hickson Road Options study reports on two options linking north / south light rail routes between Central Station and Circular Quay

- **Option1 Circular Quay, The Rocks, George Street, Hickson Road / Sussex Street, Hay Street, Central Station**
- **Option 3 Circular Quay, George Street, Argyle Street, Kent Street, Liverpool Street, George Street, Hay Street, Central Station**

The Report outlines the implications of using these two north/south light rail options on the western side of the Sydney Central Business District. Integrating the Rocks, Dawes Point and East Darling Harbour (Barangaroo) is of strategic importance to Sydney and the regeneration of the area.

The Rocks area is characterised by overlapping street patterns and grid patterns related to the hilly topography of the area. There is a hierarchy of roads, streets, lanes and walkways in the area. Hickson Road forms a northern extension of George Street and provides the main metropolitan road link connecting the eastern side of the Rocks to the central business district of the city. The Rocks are congested with tourist traffic and bus routes. The proposed light rail link running along Hickson Road that forms the northern extension of Sussex Street would enhance both north/south and east/west connectivity to the central business district. It will help to re-connect the city with its western foreshore that lacks public transport accessibility at present.

This could lead to more dynamic interactions between the Rocks tourist area and the regenerating residential and commercial area on the north western edge of the city and the central business district.

Hyder Consulting has undertaken a literature review of other documentation made available by the City of Sydney. We have undertaken a pre-feasibility review of the main engineering and planning aspects of the Hickson Road options for technical feasibility.

Traffic and Transport issues have been examined to ensure the system will basically “work”, however, traffic modelling has not been undertaken to determine the effect on other transport modes or on intersection operation. Patronage forecasting does not form part of Hyder’s brief for this report but the Report has taken into consideration linkages with existing and future public transport operations and with certain other key potential patronage generators.

This review will include, but not be limited to the following aspects of the proposal:

- Two alternative route options linking Circular Quay to Central Station via George Street, Hickson Road and Kent Street have been reviewed.
- In addition sub options have been reviewed at the north end of the route to avoid potential showstoppers at the George / Loftus / Cahill Expressway and George Street junction through to the Rocks
- We have examined the feasibility of a short tunnel link under the Harbour Bridge approach linking Hickson Road to Lower Fort Street incorporating a car park at Dawes Point. Hyder Consulting previously carried out feasibility work on a Tunnel and Car Park in this area.
- Modal Interchanges at both ends;
- Interaction with other traffic at intersections, particularly through the Rocks area and along Sussex Street;
- Urban Design and integration of Light Rail system with the Rocks Heritage Area, East darling Harbour development, Street Furniture and Landscaping;
- On street parking issues and pedestrian safety



George Street, The Rocks leading to Hickson Road

3 Development Objectives and Options

3.1 Introduction

This report commissioned by the City of Sydney forms part of a series of studies to investigate light rail route options within Sydney CBD linking Circular Quay via the Rocks and Hickson Road to Central Station. In May 2003 the Department of Infrastructure, Planning and Natural Resources (DIPNR) engaged consultants to undertake a study to examine various route options for light rail within the Sydney CBD. A range of route options were evaluated against the following objectives and criteria.

3.1.1 Development of Objectives and Criteria

Study objectives for Sydney Light Rail were previously outlined in 2003 for the initial work in order to provide an appropriate framework for route evaluation. The draft project objectives were presented to a wide range of government stakeholders at a Project Reference Group meeting on 30th May 2003. The following objectives were agreed and are listed below in decreasing order of importance.

Table 3.1 Sydney Light Rail Objectives and Criteria

OBJECTIVES	CRITERIA
<p>1. OPTIMISE PUBLIC TRANSPORT USE</p> <p>Provide a public transport mode that optimises greater public transport patronage.</p>	<p>Route serves desire lines that will optimise public transport use.</p> <p>Impact on patronage from the Sydney region by improving mode choice</p>
<p>2. OPERATIONS</p> <p>Provide a transit service that is reliable, efficient and attractive to all users</p>	<p>Optimise priority and operational reliability in city streets</p> <p>Intra and inter CBD movements</p> <p>Minimise travel time</p> <p>Maximise legibility of public transport accessibility</p>
<p>3. NETWORK</p> <p>Provide a transit link that optimises transit network efficiency and integration while serving the patronage catchment</p>	<p>Community and stakeholder acceptance</p> <p>Optimise network capacity and operational flexibility (by mode)</p> <p>Minimise capital cost</p>

<p>4. TRAFFIC</p> <p>Manage impact of the Central light rail on existing and projected traffic and bus systems while maintaining and improving the safety of pedestrians and cyclists</p>	<p>Minimise level of traffic disruption</p> <p>Minimise impact on short term delivery and service vehicle parking</p> <p>Minimise impact on access to buildings on route</p> <p>Minimise impact on pedestrian and cyclist movement</p>
<p>5. INTEGRATION AND EXPANSION</p> <p>Provide a transit link that optimises transit network efficiency and integration with the existing and possible future light rail routes</p>	<p>Integration with existing light rail system</p> <p>Consider potential expansion of the light rail network</p> <p>Relationship to planned heavy rail corridors in CBD</p>
<p>6. WHOLE OF LIFE COSTS</p> <p>Minimise financial and economic costs both during construction and operation</p>	<p>Cost during (financial and economic)</p> <ul style="list-style-type: none"> - construction (direct and indirect) - operation - maintenance - Technical feasibility
<p>7. AMENITY</p> <p>Provide a transport system that improves urban amenity and preserves heritage</p>	<p>Route minimises impact on existing streetscape</p> <p>Optimise potential for improvement and redevelopment created on the route</p>
<p>8. CONSTRUCTION</p> <p>Minimise construction impact on Central Sydney</p>	<p>Minimise disruption during construction to road users (pedestrians, cyclists, private vehicles and public transport)</p> <p>Land Uses (e.g. businesses)</p> <p>Environmental impacts</p>

3.2 Development and Selection of options

3.2.1 Introduction

The development and selection of route options was undertaken as a two stage process

Firstly, a list of six potential Hickson Road route options was set out in our **Pre- Feasibility Report** presented to the City of Sydney Council in June 2006, based around surface route options, with option 5 including a proposed short tunnel. The assessment of existing tunnels for potential route options did not form part of the brief. Six options were identified and are described below. The options are also illustrated on the attached figures.

Secondly, the list of options was assessed in more detail and reduced to a “short list” of two options that are described in more detail in this report.

The list of six options and the two short listed options are outlined below:

- Option 1 Circular Quay, The Rocks, Hickson Road / Sussex Street and Central Station
- Option 2 Circular Quay via Dawes Point to Walsh Bay
- Option 3 Circular Quay, George Street, Argyle Street, Kent Street, Liverpool Street, George Street, Hay Street, Central Station
- Option 4 Circular Quay, George Street, Argyle Street, Kent Street, Clarence or York Street
- Option 5 Circular Quay, Hickson Road Tunnel and Car Park Walsh Bay
- Option 6 Routes through the Rocks

Short listed options:

- Options 1 and 3 were subsequently selected for further evaluation in this report.

3.3 List of six options

The six proposed alternative options examined would provide a significant new public transport link between Circular Quay Station and Ferry Terminals and Central Station via the Rocks, Darling Harbour, Darling Park and China Town. This link services not only some of the main existing tourist areas in the city, but would also link the new urban regeneration area of East Darling Harbour with the associated recreational, residential and commercial uses and similar residential and commercial uses lining the route.

It would provide linkages to existing public transport interchanges at Circular Quay, Wynyard, Town Hall and Central and for future linkages with the proposed Metro West or Metro Pitt heavy rail stations proposed either at The Rocks Station or Walsh Bay Station.

Cars, taxis, walking and heavy rail are still the predominant method of travel for many journeys in the central area. Reducing car dependency, traffic congestion and air pollution is a key factor in improving quality of life in the city and promoting the sustainable growth of Sydney's economy.

Local public transport provision within the corridor and the wider area is largely by bus, while rail and ferry services provide links to central Sydney and beyond. However, it is increasingly difficult to protect current bus service levels and service quality due to worsening traffic congestion levels. The effects of traffic congestion for bus services in the Central Business District are increased journey times and decreased service reliability, which leads to an increasingly negative perception by users. The proposed Hickson Road core route option and sub options are shown on the drawings contained in this report.

The list of six options is as follows:

Option1 Circular Quay, The Rocks, Hickson Road / Sussex Street and Central Station

This option links Circular Quay via George Street, the Rocks, Hickson Road, Dawes Point, Millers Point, East Darling Harbour, Sussex Street, China Town, Haymarket and Central Station.

Option 2 Circular Quay via Dawes Point to Walsh Bay

This option provides a short link from Circular Quay, along Alfred Street, through the Rocks area via George Street, Hickson Road to Dawes Point. This would provide a short scenic route through the historic tourist area of The Rocks and under Sydney Harbour Bridge to Dawes Point and the theatre, entertainment and residential developments around the Walsh Bay Wharves.

Option 3 Circular Quay, George Street, Argyle Street, Kent Street, Liverpool Street, George Street, Hay Street, Central Station

This option provides an alternative route through the Rocks via George Street and the east west steeply sloping Argyle Street to the junction with Kent Street where the route runs north south to Liverpool Street then goes via George Street to Hay Street and Central Station.

Option 4 Circular Quay, George Street, Argyle Street, Kent Street, Clarence or York Street

This option runs via the Rocks along Argyle Street to Kent Street then would branch under the Western Distributor interchange to join Clarence or York Street and run north south to Druiitt Street, then north south along Sussex Street to Hay Street and Central Station

Option 5 Circular Quay, Hickson Road Tunnel and Car Park Walsh Bay

This option provides a link from Circular Quay, along Alfred Street, through the Rocks area via George Street, and a short tunnel connection underneath Dawes Point and the Harbour Bridge. The proposed tunnel would run via Hickson Road East linking Campbell's Cove to Walsh Bay. This proposal would include the development of a multi level car park facility capable of accommodating 1,000 cars, accessed from various locations and levels serving adjacent facilities in The Rocks, Campbell's Cove, Miller's Point and Walsh Bay. This route option could either return back via Dawes Point and The Rocks to Circular Quay or proceed south via

Hickson Road past Darling Harbour along Sussex Street to Haymarket and Central Station.

Option 6 Routes through the Rocks

Other route options were considered from Circular Quay via Alfred Street, George Street, Hickson Road, Dawes Point and Walsh Bay returning via Pottinger Street through the Rocks. These have been ruled out due to steep grades and tight radii at junctions since it would not be possible to accommodate the vertical and horizontal alignments required by the dynamic envelope of the light rail vehicles.

3.3.1 List of three sub options at northern end of route

In order to avoid potential show stopper problems at the low bridge (4.4 metres clearance) junction of George / Loftus / Cahill Expressway and George St three sub options were developed –

Sub Option 1

The first sub option would be to build a dedicated route for the light rail route from the Pitt / Alfred Street junction under the railway bridge arch that is higher than the low 4.4 m bridge arch at the George St / Alfred St junction. The proposed route would go through First Fleet Park to join George Street alongside the Museum of Contemporary Arts (MCA) to avoid this congested junction and to avoid the possibility of high vehicles accidentally snagging overhead wires. This would require a ramp through First Fleet Park to George Street and a new Traffic Control Signal in George Street.

Sub Option 2

The second sub option would be to run the route via First Fleet Park from the Pitt / Alfred Street junction under the railway bridge arch then in front of the Museum of Contemporary Arts (MCA) and behind the Overseas Passenger Terminal before joining George Street opposite the Argyle Street junction north of Campbell's Store House. This would require a new Traffic Control Signal at the George / Argyle Street Crossroads

Sub Option 3

The third sub option would be to run the route from the Pitt / Alfred Street junction under the railway bridge arch via First Fleet Park in front of the Museum of Contemporary Arts (MCA) and behind the Overseas Passenger Terminal then in front of the restaurants before joining Hickson Road south of the Hyatt Hotel. This would have the advantage of avoiding the congested George Street section of the route as well as the junction with Hickson Road. This would require a new Traffic Control Signal at the junction with Hickson Road.

All the proposed options through the Rocks area would need to be assessed against the guidelines for heritage and conservation impacts. as

set out in the “Rocks Heritage Management Plan”, Sydney Harbour Foreshore Authority, February 2002.

3.3.2 East Darling Harbour development, integration with Light Rail Route

The East Darling Harbour Transport Concept Plan prepared by Masson Wilson Twiney in September 2006 for the Sydney Harbour Foreshore Authority provides detailed proposals for incorporating a light rail route along Hickson Rd. This would serve residents and workers in the East Darling Harbour development with public transport connections and links to the Central Business District and to Circular Quay via Dawes and Millers Point and to Central Station via Sussex and Hay Streets. There is an opportunity to fully integrate the proposed tram route proposals with the East Darling Harbour development given the conceptual stage that the development is currently at.

3.4 Option evaluation process

The list of six alternative options was screened against the project Objectives and Criteria as set out in Table 3.1. A matrix of assessment criteria for each of the six long listed options was prepared. The matrix is presented as Table 3.2. The table shows each route option along the top of the table and the assessment criteria listed along the left hand side of the table. Each route was scored as high compliance or low compliance with each of the statements in the compliance criteria represented with a tick, dash or cross. At this stage it was apparent that some options showed a much larger number of high compliance (✓) and complies (-) than others. Although this is a relatively simple method of assessment, it is suitable for this level of screening in determining the best options to progress to the short list round of assessment.

**Table 3.2 Central Sydney Light Rail Route Evaluation –
Hickson Road Options – Initial Evaluation Matrix**

Options	1 Core route Via Hickson Road	2. Via the Rocks to Walsh Bay	3 Via Argyle & Kent St's	4 Via Argyle & Clarence or York	5 Via Tunnel to Walsh Bay	6 Via Pottinger St, thru Rocks
Objectives / Criteria						
Network						
Minimise length	√	√	√	√	√	√
Optimise connections to transport interchanges	√	X	√	√	X	X
Reduce need for people to use Town Hall Station	√	X	√	√	X	X
Maximise patronage levels	√	–	√	√	–	–
Route meets travel desire lines	√	–	√	√	–	–
Potential to expand system	√	–	√	√	–	–
Service						
Horizontal alignment Minimise turns in network	√	√	–	–	–	X
Vertical Alignment Minimise gradient	√	√	–	–	√	X
Ability to provide physical segregation	–	–	–	–	–	–
Impact on Existing						
Minimise disruption to vehicular traffic	–	–	–	–	–	–
Minimise impact on pedestrians	–	–	–	–	–	–

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Options	1 Core route Via Hickson Road	2. Via the Rocks to Walsh Bay	3 Via Argyle & Kent St's	4 Via Argyle & Clarence or York	5 Via Tunnel to Walsh Bay	6 Via Pottinger St, thru Rocks
Objectives / Criteria						
Maximise compatibility with bus network	–	–	–	–	–	–
Construction impact						
Construction impact minimised	√	√	√	√	X	–
No. of major intersections affected	–	√	–	–	√	–
Length of route along key utilities	–	–	–	–	–	–
Urban Environment						
Impact on urban design and heritage acceptable	√	√	√	√	X	√
Proximity to noise sensitive land users Hotels, Theatres	–	–	–	–	–	–
Integration with existing transport						
Assessment of tie in to existing transport networks	√	√	√	√	X	X
Number of High compliances	11	7	9	7	3	2
No of Compliances	11	7	9	11	10	11
No of Low degree of compliances	–	2	–	–	5	5

High degree of compliances √
 Compliance –
 Low degree of compliance X

3.5 Assessment of core options

As indicated in the Table 3.2 Evaluation matrix, some options showed a much larger level of “High compliance” notably Options 1 and 3, with Options 2, 4, 5, 6 showing a lesser degree of compliance.

Applying this method of assessment the following two options presented the best compliance to the stated objectives and were short listed for further evaluation.

Option 1 Circular Quay, The Rocks, Hickson Road/Sussex Street and Central Station

Option 3 Circular Quay, George Street, Argyle Street, Kent Street, Liverpool Street, George Street, Hay Street, Central Station

3.6 Key Constraints and Opportunities

The following key constraints and opportunities have been considered:-

Constraints

Street Management

Dual use of streets by both light rail vehicles and other road vehicles, including buses, is common in many cities around the world. This is often achieved through the provision of limited access restrictions allowing for servicing and delivery vehicles in order to ensure efficient operation of streets and to reduce congestion. The proposed Hickson Road core route is predominantly three lanes wide, increasing to a six lane tree lined kilometre long boulevard from Millers Point southwards past East Darling Harbour. There are a number of pinch points along the route, particularly in the Rocks area, Walsh Bay and China Town, however, it is expected that these pinch points could be widened by adjusting pavement widths, removing on street parking or a combination of both.

Urban Renewal

Currently, the north-west side of the city centre is poorly served by public transport particularly around East Darling Harbour that is 381 metres at its closest point from Wynyard Railway Station. There are a number of Sydney Buses services terminating at Argyle Street Bus terminus at Millers Point including the 308, 339, 343, 431 and 433. The introduction of a light rail link from Central Station to Circular Quay will be an opportunity to reconnect this isolated northwest edge of the city, particularly the proposed East Darling Harbour development and it is expected to assist the ongoing regeneration / gentrification process by attracting further commercial and residential uses into the area.

Reduced Traffic Access

Any restriction on vehicular access along the proposed route will have implications for the five privately run multi storey parking car-parks located along the east side and one on the west side of Sussex Street. Any impact

on the car parks would be negated to a large extent if local access is permitted. Restrictions on vehicular access or the introduction of two-way running in streets that are currently one-way will have knock on effects for traffic circulation and intersection management in adjoining streets.

Three Pinch Points

There are three main pinch points around the Hickson Road Option 1 core route that will require re-design adjustments to accommodate the light rail dynamic envelope.

Table 3.3 Pinch Points along proposed route

Pinch Points	Current restricts
1) Intersection at Alfred and George Streets under the Cahill Expressway and Railway bridge.	The Bridge leading to the Rocks is under the 4.3 metre clearance. The carriageway or railway bridge will require further detailed design modification to accommodate light rail vehicles.
2) There is a narrow single lane accesses in either direction at Walsh Bay under the Pottinger Street Bridge to Pier Three	The road carriageways will require to be widened to accommodate light rail vehicles.
3) The T junction between Sussex and Hay Streets narrows from four to two lanes and is currently one-way.	This junction will require redesigning to accommodate two way light rail operations.

Potential Land Acquisitions

There may be a need to acquire a small amount of land to accommodate sub stations to provide power for the light rail vehicles along the route.

Major interchanges

There are a number of major interchanges where there are likely to be delays including the junctions of Alfred/George Street, and George Street / Hickson Road. Sussex Street passes through a number of busy traffic light controlled junctions. The Hay Street junction in China Town will need to be modified to enable the proposed Light Rail to link up with the existing Light Rail system from Central Station to Lilyfield.

High Pedestrian Activity areas

There are two main high pedestrian activity areas along the route :-

Table 3.4 High Pedestrian activity areas along proposed route

1) The Rocks	The Rocks is one of the main tourist areas in Sydney with high pedestrian flows, pavements have recently been widened on the western side of George Street;
2) China Town	There is high pedestrian activity in China Town visiting restaurants and commercial developments.

The pavements and streetscape in these areas will require to be modified to avoid possible pedestrian conflicts and integrate the proposed light rail route, passenger stops and infrastructure.

Opportunities

Extend accessibility and permeability

The route would link into existing city networks connecting strategic transport interchanges at Circular Quay and Central Station. The generous width of Hickson Road is ideal for Light Rail connecting the existing heavy rail services and the light rail services from Central Station to Lilyfield at Haymarket and with the Rail and Ferry links at Circular Quay.

Integrated Transport interchanges

The proposed light rail route will provide the opportunity to integrate transport interchanges with rail, bus and ferry services at Circular Quay, Rail, Bus and existing Light Rail Services at Central Station and Hay Street and connections to the Metro Monorail system at Darling Park Monorail Station. The proposed Light Rail route stops could be located close to and integrated with the proposed Metro Pitt and Metro West Rail route stations proposed at Walsh Bay, The Rocks and City West.

Streetscape Improvements

There will be the opportunity with the introduction of the Light rail route to redesign the street layout including repaving, widening pavements, introducing further landscaping and street furniture. Particularly, in the Rocks area these improvements will take into account and recognise the need to consider heritage impacts on heritage streetscapes and places when considering traffic measures. The proposed light rail route network should address the existing pedestrian networks and integrate these with the location of light rail stops.

Improved Retail environment

There will be scope for attracting further investment in retail and other facilities particularly in The Rocks and China Town areas that currently attract many outside visitors and overseas tourists.

Urban Renewal

Currently areas around the Rocks such as Walsh Bay and Millers Point are regenerating with new apartments, restaurants and theatres being established. There are further proposals for the Urban Regeneration of the East Darling Harbour area that would greatly benefit from improved public transport connectivity and accessibility links to the rest of the Central Business District.

3.7 Short list evaluation process

More detailed information was gathered for the two short listed route options. This has enabled a more detailed assessment to be made, see section 4.

4 General Analysis of Short listed Options

4.1 Introduction

The two short listed Hickson Road options provide north / south light rail routes links, namely:-

- **Option1 Circular Quay, The Rocks, George Street, Hickson Road / Sussex Street, Hay Street, Central Station**
- **Option 3 Circular Quay, George Street, Argyle Street, Kent Street, Liverpool Street, George Street, Hay Street, Central Station**

have associated specific and generic issues.

This report has been structured in a “matrix format” to understand these two sets of issues, across both short listed routes including (Traffic and Transport, Modal Interchanges, Overhead Lines, Power Supply, Signalling, Traffic Modelling, Vehicle length and height restrictions, Light Vehicle performance, Urban Design and Heritage, Urban Renewal). This will enable a better understanding of both short listed routes and as well as the background generic issues.

4.2 Traffic and Transport Issues

We have reviewed the traffic and transport issues along the core Hickson Road route in general terms to ensure the system will basically work without unreasonable constraints on other transport modes.

The main traffic and transport issues affecting the proposed Light Rail routes running north/south through the Rocks area are:

- 1) At the junction between Alfred and George Street there is a low bridge with 4.4m clearance under the Cahill Expressway and Railway line. In terms of height restrictions for a Variotram vehicle, a minimum allowance of 4.3 metres above top of rail is the minimum dynamic envelope height required. . Further investigation is required to confirm that clearance can be achieved for light rail vehicles under this bridge to meet the minimum vehicular clearance height of 4.3 metres. There is a minimum preferred contact wire height of approximately 5.5m for Light Rail vehicles however they can be powered for short distances without using overhead wires.
- 2) The pavement on the western side of the George Street has recently been widened, narrowing the carriageway to three lanes width Discussions will be required with all stakeholders to ensure that Light Rail can be integrated with the operation of other modes of transport in this congested part of the Rocks area. The Light Rail footprint would generally take up 2 lanes x 3.3 metres. A minimum lane width of 2.1 metres is acceptable for parking (the Australian standard for parking indicates this is very tight) with a 2.3 metre width being desirable. The

east side could be used as a parking lane of approximately 2.8 metres width to accommodate larger servicing and delivery vehicles.

- 3) The proposed route via George Street past Argyle Street to the junction at Hickson Road to Campbell's Cove is on a sloping gradient and is constrained by the widening of the western pavement on George Street.
- 4) An alternative sub option would be to consider running the route along Circular Quay Way along the Harbour Front before joining Hickson Road.
- 5) There are horizontal and vertical curves around the Dawes Point / Walsh Bay area under the Sydney Harbour Bridge.
- 6) There are currently pinch points under the bridge to the Walsh Bay Pier One due to lane narrowing restrictions on Hickson Road.
- 7) There are currently road works and alterations under way that may help to resolve this issue and facilitate Light Rail vehicle operations.

Beyond Millers Point the proposed route travels via the six lane Hickson Road that is flat and straight for one kilometre. Adjacent to this stretch of road is the proposed East Darling Harbour development that the Hill Thalys Berkmeier winning competition scheme proposes for a light rail or bus route along this strongly defined boulevard. The generous width of this part of the tree lined Hickson Road is ideal for light rail vehicles, connecting the existing light rail line at Central Station to Walsh Bay via the Rocks to Circular Quay. Government estimates between 11,000 and 25,000 office workers and 600 to 750 apartments will be located at the proposed East Darling Harbour site.

To the north of Napoleon Street, Hickson Road becomes Sussex Street. There are sloping grades between Market and Bathurst Streets and between Goulburn and Hay Streets in China Town. The section of Sussex Street between Market and Drutt Streets narrows to three lanes, and is further constrained by a taxi rank on the west side of the street just south of the Market Street junction. The junction itself also narrows to three lanes. A number of combined approaches will need to be struck between redesigning junctions, re-profiling the street or using higher specification light rail vehicles able to negotiate steeper grades than the present Variotram vehicles. This issue is well recognised in the GHD Report but as one would expect not entirely solved at this early stage.

In general terms the design of the tracks will be using the concept of slabtrack, Taking advantage of the latest techniques of "top down" construction. This is well established technology for light and some heavy rail applications but putting any such system in a congested and fully operating city environment will be complex and time consuming.

a. Modal Interchange at Circular Quay and Central Station

There are two main modal interchanges at the north and south of the proposed route. The **Circular Quay** interchange would connect to Rail, Bus and Ferry Services. There is also a proposed Light Rail service that would

link up with the proposed Light Rail service routed along Castlereagh Street that would connect with the proposed Hickson Road service at Alfred Street at Circular Quay. Linking both services together would provide a circular link through the Central Business District. The main modal interchange for the Sydney light rail will be at **Central Station** and it is envisaged the vehicle will use the colonnade currently occupied by the Pyrmont Light Rail. While it is not essential, we recommend that a second line be constructed in the actual colonnade to the north of the existing line to allow for either temporary layover of vehicles, or if sufficient safety aspects are addressed, passengers to board and alight from this separate line.

Modal interchange between east west bus routes across the city is simply accommodated by the positioning of stops and ensuring that the stops are located in appropriate positions close to intersections. Similarly a Light Rail stop could be located close to the Darling Park Monorail Station near the intersection between Sussex and Market Streets.

b. Overhead Line Electrification

The Light Rail will be powered by 750volts dc supplied by overhead line electrification with return current through one or both rails. Not only is this consistent with the Pyrmont Light Rail but is the effective standard for modern light rail systems throughout the world. Whilst Melbourne trams operate at 600volts dc this is historical.

c. Overhead Line Electrical Supports

Very careful consideration needs to be given to the design of the OLE Supports to ensure that they are appropriate to the urban design in the Rocks areas. Central supports with double cantilever arms have been considered from time to time however whilst these provide a heritage context they are bulky, visually intrusive and require a wider spacing in between the tracks of the doubling running vehicles This in turn compromises the clearances, and thus the amenity for all road users.

Modern light rail vehicles require tensioned contact lines to ensure efficient current transfer to the pantographs which leads to catenaries supporting the actual contact wire. The span wires, perpendicular to the contact wires generally need to consist of an upper and lower wire in order to control and stabilise these forces. In addition there are tensioning devices usually consisting of weights suspended inside poles. The gear taking these forces to the weights and the possible use of gas hydraulic tensions may be an alternative method of keeping tensioners in the system. The requirements as noted in the foregoing will certainly be visually intrusive and care will be needed in the detailed design to limit such intrusion.

We recommend connecting all the span wires to poles. However, in many areas span wires maybe attached to building and/or the Smart Poles that are located around the City providing that such poles have sufficient foundations. These alternate methods of connection are not simply ways of saving money but recognise the fact that there may be some locations

where poles can not be installed, for example where there are awnings extending out over the curb line and particularly at intersections.

d. Power Supply and Power Stations

In order to operate the light rail the high voltage power from the grid needs to be stepped down to 750volts and rectified to dc. This is done in combined transformer/rectifier stations and the GHD Report recommends that there be two such stations. Further studies will be required to select the locations of these sub-stations.

e. Signalling and Telemetry

Generally light rail vehicles in street running mode operate by line of sight and obey normal traffic signals without having their own independent signalling system. All of the traffic signals along the Hickson Road route will need to be modified and/or reprogrammed and that some of the intersections may benefit from having a “tram priority” light to improve traffic flow particularly at Alfred / George Street junction and Sussex / Hay Street junction. The existing Pyrmont Light Rail has Automatic Train Protection (ATP) and we recommend that this be continued into the Sydney City Light Rail. The Pyrmont Light Rail has ATP because of its substantial dedicated high speed track running and while it is not normal to have ATP on street running light rail vehicles we believe it to be reasonable that this be continued into the street running sections of the Central Sydney Light Rail.

4.8 Traffic modelling

The RTA has developed a micro-simulation traffic model for Sydney’s CBD based on the Paramics software to assist in assessing any proposed changes to the CBD road network. Amongst other things, the Paramics software is capable of providing details on travel times, traffic counts and queue lengths. One of the model’s advantages is that it is able to graphically represent traffic patterns. A similar model based on the Vissim micro-simulation software is currently being developed for Melbourne’s CBD.

Given the complexity of Sydney’s CBD road network, it is very difficult for the Paramics software to effectively and accurately model the reality of what will actually occur. As an example, the model led the RTA to issue warnings of severe traffic congestion across the City when the Cross City Tunnel opened and clearly, apart from delays on Macquarie Street, this has not eventuated. Notwithstanding the limitations of the model, it has been used by the RTA to test various options for a light rail route in Sydney’s CBD.

It is understood the modelling undertaken to date has not attempted to model any form of priority at traffic signals for the light rail vehicles. Providing priority for light rail would generally reduce the amount of green traffic signal time available for other movements at traffic signals and may lead to a redistribution of traffic around the CBD as well as the possibility of

delays on certain routes. The provision of priority for light rail vehicles however, is a very important step in achieving on-time running by trams and for ensuring patronage is consistent with forecasts.

Bus priority at traffic signals is currently being implemented by the RTA on certain bus routes, whereby the bus is detected in advance of the intersection, enabling the traffic signals to adjust to provide priority to buses, as required. In addition to advance detection, there is the ability to provide 'Tram Only' type lanes similar to 'Bus Only' type lanes on the approach to certain intersections, particularly if through movements by general traffic are to be prohibited. These lanes could be adjusted to permit detection by taxis also. Further traffic modelling would assist in testing the various scenarios regarding traffic signal priority, intersection layout, use by taxis etc., however, any debate on the extension of the light rail network should not solely focus on traffic modelling.

4.9 Vehicle length and height restrictions

Restrictions on driving long vehicles in the CBD are in place for much of the day and are given in Road Transport (Road Rules) Regulation 1999 Clause 87(1). Outside the hours given in this regulation, the impact of such vehicles on traffic flow is reduced and any physical restrictions resulting from the introduction of light rail are unlikely to create insurmountable problems for the infrequent movement of long vehicles along the proposed Hickson Road route.

In terms of height restrictions, a minimum allowance of 4.3 metres above top of rail for the minimum dynamic envelope height has been adopted. There is a minimum preferred contact wire height, with a preferred height of approximately 5.5m.

There are two low bridge clearances along the proposed Hickson Road route of 4.4 metres clearance at the railway bridge at the intersection between Alfred and George Streets and at the pedestrian bridge with a clearance of 4.6 metres across Sussex Street at the Market Street intersection that will need further investigation at the detailed design stage.

The standard RTA vehicle clearance of 5.3m would not appear to conflict with the overhead wires; however, further investigation is required to confirm this clearance can be achieved. There is a minimum vehicular clearance height of 4.3 metres in Central Sydney and a permit is required for vehicles in excess of this. If wire heights are reduced below the 5.3m maximum height for standard vehicles, a conflict may not occur due to the 4.3m restrictions for the CBD. Hyder has been unable to confirm the 4.3m height restriction for Central Sydney.

4.10 Restrictions on through traffic using Hickson Road route

There will continue to be a need for traffic to enter the streets along the route in order to access off-street car parks or to provide ready access to properties in adjacent streets. Allowing general traffic to utilise the north

end of George Street / Hickson Road as a through route in the Rocks area is likely to cause capacity problems at intersections such as Alfred Street, partly due to the reduction in road width due to pavement widening in George Street. Other pinch points include narrow access lanes under the Walsh Bay Pier bridges. These capacity problems are likely to cause traffic to queue back for some distance and this may impact on tram running times. Further investigation on this issue should be undertaken using traffic modelling in order to determine the likely impacts.

If through traffic is to be restricted, this will need to be managed through a combination of signs and linemarking. There are also opportunities through urban design to change the character of the street to deter through traffic and in addition the rails themselves will act as a further deterrent.

There are a number of possibilities in terms of signposting the necessary restrictions including defining the lanes as Tram Lanes under ARR Part 11, Division 6, Rule 155. Trucks are permitted to drive in a tram lane to reach a place to drop off, or pick up, passengers or goods. General traffic is permitted to drive in a Tram Lane for a distance of up to 100 metres to enter off-street car parks. Further analysis will need to be undertaken to determine whether this distance would be sufficient to allow general traffic to access all off-street car parks.

An alternative option includes restricting access to delivery vehicles, specific car parks and possibly local access and taxis only, perhaps incorporating the use of No Entry signs. Consideration should be given in assessing the regulatory signposting as to whether taxis and cyclists should be permitted access to the street.

The use of similar signs to restrict access in York Street between Market Street and Druitt Street (to the rear of the QVB) to buses, taxis, QVB car park and local access only, was successful in deterring the use of York Street as a through route during the construction of the Cross City Tunnel and has since been reinforced by the restrictions on general traffic using Druitt Street between Clarence and Kent Streets, effectively severing the route to the Anzac Bridge for general traffic via Druitt Street.

4.11 Signposting requirements

Consideration will also need to be given to the following signposting requirements:-:

- The use of height restriction / low clearance signs (dependant on the height the wires and other structures are placed at);
- Speed limit signs (Allowing the possibility of reducing the speed limit from 50km/h to 40km/h). May require specific tram speed limits in north George Street / Hickson Road through the high pedestrian activity Rocks tourist area as well as through China Town.
- Other regulatory signs such as No Right Turn, No Left Turn signs.
- Parking signs (possibility of signposting restrictions at the entry to each block only to enhance urban design by minimising street 'clutter')

caused by poles and posts). Further investigation required in regard to location of smart poles and RTA requirements for creating 'Parking Areas'.

It is recommended the opportunity is taken to cantilever light rail and vehicle restriction signs above the light rail / traffic from smart poles at the start of each block and at intervals along the block as necessary. This provides clear guidance to motorists and is consistent with the proposed signposting for the transit lane along William Street to be installed as part of the upgrade of William Street as part of the Cross City Tunnel project.

4.12 Service diversifications and modifications

At this early pre-feasibility stage we have not reviewed the presence of underground utilities beneath the Hickson Road route however a *Dial Before You Dig* search would be undertaken before the detailed design stage. Overall there are likely to be significant service conflicts that will require adjustment that will pose significant risks and costs to the location of the light rail alignment.

4.13 Clearance from Existing Structures

Over Bridges

There are eleven over bridges along the route. The lowest structure is the railway bridge at the Alfred / George Streets junction that has a 4.4 metre clearance. There are six bridges over Hickson Road around the Walsh Bay Millers Point area. There are four further bridges over Sussex Street the lowest is the pedestrian bridge at the Market Street intersection with a clearance of 4.6 metres. However, all these structures undersides are higher than 4.3 metres above street level, which is higher than the dynamic envelope light rail requirements and therefore they are not seen as obstructions to the alignment.

Underpasses

From our initial site inspections of the route we found no underpasses along the proposed route.

4.14 Ability to accommodate a variety of Light Rail Vehicles

It is preferable to adopt something similar to the Adtranz Variotram for the Central Sydney Light Rail to provide broad consistency to the fleet. However, it is apparent the existing Variotram is not able to climb steep slopes and the new trams will need to have all wheels powered to cope with the steeper slopes in the Rocks area of the Hickson Road route. This would result in exclusive vehicles for the Central Sydney Light Rail. The Pyrmont vehicles could not use the Central Sydney track. This could be a constraint which may be solved by retrofitting the bogies of the existing Variotrams with powered bogies and augmenting the former systems in the vehicles.

By designing for the Variotram kinematic envelope, we believe that this will allow a large range of light rail vehicles to use the track as it is one of the widest vehicles in the marketplace. However, a standard light rail vehicle has proven to be elusive and it has been found in Europe and North America that vehicles are usually constructed specifically for a defined network.

4.15 Modified Standard Light Rail Vehicles

In discussions with the Sydney Light Rail operator Hyder Consulting discussed how the performance of a Standard Light Rail Vehicle could be improved. A way forward would be for the central bogey to be replaced with a powered bogey. An added advantage would be that it provides additional redundancy if one bogey fails.

Sydney Light Rail considered that a Standard Light Rail Vehicle would then be able to negotiate an 8% gradient. Maximum power would then go from 360kw to 540kw, and this would require additional inverters and upgraded controls. (Note that Light Rail vehicles take in 750VDC, but convert it to AC to run the motors, hence the inverters) This modification could cost in excess of A\$500,000 per vehicle.

However, it would provide a 'solution' to the grade problem, albeit at a cost, and take it off the list as a 'potential showstopper'.

Light Rail vehicles have 3 way braking, regenerative, disc and track blocks. These will hold the tram on a grade up to 10%. The combination of vertical and horizontal curves at the bottom of the Central Station colonnade required a modification to the current standard Variotram to accommodate the 'bend' and 'twist' that would occur here. A similar bend and twist occurs through the Rocks area at Alfred Street / George Street junction and at George Street / Hickson Road junction with grade differences. Newly purchased vehicles, would require similar modification.

4.16 Higher Performance Light Rail Vehicles

In order to provide greater certainty regarding Light Rail Vehicle rolling stock performance Hyder Consulting examined a number of other systems. The Sheffield Super Tram that started operating in March 1994, twelve years ago, was supplied by Siemens and Duewag equipped with four 2-axle bogies, each with their own drive that were required to cope with **gradients in the city of up to 10%**. Light Rail vehicles with un-powered bogies were not considered viable. The result is an all steel double ended vehicle that can accommodate 88 seated and 162 standing passengers and travel up to 50mph. There are easy access entrances, four on each side, 420mm high gently sloping up a further 30mm to the centre of the car. This results in 40% of the floor area at low level with ample room for entry and exit out and provision for pushchairs and luggage. The two sections with double door entry are suited for mobility impaired passengers, or mothers with push-chairs and small children. The Sheffield Supertram is considered to be the best performing modern Light Rail Vehicle.

4.17 Urban Design and Heritage

The City of Sydney have identified the Hickson Road route as a major asset to the city particularly heritage areas along the route such as the Rocks, Walsh Bay, Darling Harbour, China Town and the East Darling Harbour area that was the subject of an international urban design competition for redevelopment. The City of Sydney is keen to reintegrate this north western edge of the Central Business District by providing an integrated public transport network to develop it as a vibrant, attractive and safe place served by a light rail system from Circular Quay to Central Station.

The creation of a two way light rail system along this corridor provides the opportunity to create an urban city street renaissance through re-design of the public domain. However, this is not simply a matter of making the Hickson Road route look better, but of extending the city grid westwards and reinforcing north south connections linking Circular Quay to the Rocks, Walsh Bay, Millers Point, Darling Harbour, China Town and Central Station making it function differently, redressing the balance of priorities between pedestrians and traffic. By enhancing connectivity and permeability of the north western edge with the central business district it will reinforce these regenerating areas that are attractive destinations for people in there own right, as well as providing an efficient route for light rail public transport connections.

In order to achieve an Urban Design renaissance of the Hickson Road route seven main urban design objectives should be applied:-

URBAN FABRIC & CHARACTER: A place with its own identity

CONTINUITY & ENCLOSURE A place where public and private spaces are clearly distinguished

QUALITY OF PUBLIC REALM: A place with attractive and successful outdoor areas

EASE OF MOVEMENT: A place that is easy to get to and move through

LEGIBILITY: A place that has a clear image and is easy to understand

ADAPTABILITY: A place that can change easily

DIVERSITY: A place with variety and choice

▪ Urban Fabric and Character

The **Hickson Road** route is characterised by distinctive areas along the route including:-

Historic Rocks area This is recognised as the old quarter of the city with historic heritage listed buildings that have become a focus for tourist activities in the city. Historic warehouses have been recycled, attractive pedestrian places have been created and the importance of streetscapes

has been reinforced through sensitive urban design. It is a place of fine restaurants, hotels, bars, theatres, and mixed use residential developments with fine views over the harbour.

The Walsh Bay/ Miller Point area This area is regenerating with mixed use residential and commercial developments.

East Darling Harbour. This area was the subject of an international urban design competition for mixed use residential commercial developments that was decided in March 2006.

Darling Harbour This is well established entertainment district with marinas, museums, exhibition centres, hotels, bars and restaurants

Sussex Street This part of the route passes through substantial commercial office, government, retail and residential high rise buildings of both heritage and contemporary design.

China Town Located at the south end of the route is a high density area of restaurants, businesses and residential development.

There are public buildings and entrances to six multi storey public parking garages particularly on the Sussex Street part of the route. The route is used by a wide range of people as a work, residential and leisure destination. The street width varies enormously from narrow and winding through the Rocks area, to a wide, flat, tree line Boulevard with three lanes on either side, ideal for light rail operations along Hickson Road west and Sussex Street, with a strong building line along both sides of the streets. There are many high rise building ranging from heritage buildings to high tech contemporary architecture. There is a mix of retail units on the ground floors ranging from fine grain individual shop units to retail and residential units occupying entire city blocks.

▪ **Action**

In order to achieve a strong and lasting identity there is a need to build on the key characteristics of the Hickson Road route and the adjoining streets along the route. The public realm and the street furniture and infrastructure associated with the Light Rail should be simple and non intrusive and should not compete with the architecture or character brought to it by people using it.

▪ **Continuity and Enclosure**

The Hickson Road route is well defined by either a continuous line of buildings or trees on either side of the street. At certain points wide streets and intersections break this continuity particularly along the Sussex Street part of the route. There are a number of public spaces along the route at Belmore Gardens adjacent to Central Station, Darling Park on Sussex Street, on the Wharf sides at Walsh Bay, under the Harbour Bridge at Dawes Point Park, pedestrianised streets in the Rocks area, the First Fleet Park at Circular Quay and the broad public square in front of the Customs House at Circular Quay.

▪ **Action**

Promote the continuity of street frontages and the enclosure of space by development which clearly defines private and public spaces. with soft landscaping to create more attractive tree lined avenues such as the tree lined Hickson Road west Boulevard.

- **Quality of the Public Realm**

Footways along the Hickson Road corridor vary enormously, the quality of materials used and the level of maintenance needs to be improved. George Street's western pavement has been recently widened through the Rocks area. The streets along the route suffer from cluttering caused by uncoordinated use of street furniture and signage.

- **Action**

There should be a coherent use of materials and workmanship along the whole length of the Hickson Road corridor. Good quality materials should be used to minimise the need for maintenance. If maintenance is required it should be carried out along strict guidelines using the same materials and workmanship. Wherever possible footways should be widened using granite paving and stone kerbing and given designated uses. Street furniture and infrastructure such as Light Rail stops should be organised and coordinated to minimize the amount of space taken up on the footway. There will need to be a consistent approach to the design of overhead wires and poles and the attachment of support wires to buildings. This will be a particularly important issue in the Rocks area where there is a concentration of heritage listed buildings as well as modern curtain wall buildings where a combined approach may be needed combining attachment to facades as well poles.

- **Ease of Movement**

The Hickson Road corridor currently has high levels of bus, car, taxi, service and delivery vehicles as well as pedestrian flows resulting in conflict between vehicles and pedestrians. The harbour side traffic, particularly the container trucks that service the portside wharves often have to queue along the southern stretches of the six lane Hickson Road to gain entry to the secure port areas. The waiting trucks generate noise and fumes by leaving their engines running while queuing, creating an unpleasant environment for pedestrians wishing to cross the street.

- **Action**

Pedestrian and vehicular balance needs to be redressed. The progressive closure and redevelopment of port facilities at East Darling Harbour will stop the need for trucks to service the wharves in the area. Public transport connectivity and pedestrian movement needs to be improved along the whole length of the route corridor allowing for a continuous and safe walkway. The introduction of light rail and a controlled access policy for all other vehicles is needed as well introducing informal crossing opportunities along the whole length of the street. This can be augmented through wider pavements and shorter crossing distances. Pedestrian friendly zones integrated with light rail use through areas such as the Rocks need to be created and successfully integrated as has been done with many tramways worldwide.

- **Legibility**

The legibility of the Hickson Road route suffers from a lack of gateways. Although both ends reach major destinations they are uncelebrated and lack any sense of definition. There will be opportunities to interchange with the Metro Monorail system at Darling Park adjacent to the route as well as with the existing light rail system at Haymarket connecting Central Station to Lilyfield.

Action

Legibility would be significantly improved by enhancing the areas around the Light Rail stops adjacent to Central Station and Circular Quay. There are substantial opportunities at either end of the route at both Circular Quay and Central Station to redesign spaces to create integrated transport interchanges. These are important gateway points into the city and would contribute to the understanding of these key transport interchange points. These key destinations points could be improved through urban design and way finding signage.

- **Adaptability**

The typology of the Hickson Road corridor and the surrounding urban structure is such that is flexible enough to adapt to changing times and has proven to do so in the past.

- **Action**

To promote adaptability through restructuring the route corridor to include light rail that can respond to changing social, technological and economic conditions

- **Diversity**

The Hickson Road corridor benefits from its location on the north-west edge of the central business district with high density mixed use developments. In order to serve the city it provides a diverse mix of uses such as tourist retail, commercial offices, leisure and entertainment and housing developments.

- **Action**

To promote diversity and choice through a mix of compatible developments and uses that work together to create viable places that respond to local needs.

- **Streetscape and location of Light Rail Stops**

The design and location of light rail stops particularly at sensitive locations such as adjacent to heritage buildings or pedestrianised spaces such as in front of the Customs House in Alfred Street will need to be integrated with the existing street fabric and urban design layout.

- **Action**

The design specification of the stops will need to include signage and ticketing. Issues such as shelters, bollards and seating provision and their impact on the urban fabric will need to be considered. The location of stops should be associated with other public transport nodes such as the Metro

Monorail at Darling Park or close to areas of high pedestrian activity such as the tourist area in the Rocks and to the Darling Harbour Passenger Terminal and at busy mixed use areas such as China Town. The stops will have to be integrated into the surrounding streetscape including paving, street lighting, tree planting, pedestrian crossings and lighting as well as disabled access provision. Light Rail Stops on the departure side of intersections are proposed this is preferable for north bound traffic as there is no general traffic however, for south bound traffic, stops on the departure side of intersections needs to be carefully positioned to allow for some queuing behind the tram from left and right turning vehicles. This may also cause queues of vehicles from cross streets – left and right turning vehicles

▪ **Streetscape Upgrade Costs**

The City of Sydney has indicated for budget purposes that work on Streetscape Upgrade costs would be in the order of \$15,000 per lineal metre of footpath. This includes design and supply items for the full scope of work (granite, smart pole, trees etc), but excludes awnings. This is based on a footpath width of 4.5 to 5m. This includes an allowance for contingencies and the risks associated with doing major streetscape upgrade works in the Central Business District.

4.18 Urban Renewal

Urban Renewal is taking place in the Rocks area particularly around Walsh Bay and Millers Point. The winners of the East Darling Harbour Urban Design competition were Hill Thalys Architecture and Urban Projects that was announced in March 2006. The proposed design retains the Hickson Road Boulevard as the eastern boundary to the site. The designers noted that the generous width of the Hickson Road “is ideal for trams connecting the existing line at Central to Walsh Bay and Circular Quay”. The brief called for an urban renewal solution to redevelop this historic dockyard area on the north western edge of the central business district.

Action

Stronger physical linkages to the north and west sides of the central business district of the city will be brought about by the light rail system. Light Rail networks have demonstrated increased investments in the immediate light rail corridor. Fixed public transport links and better service frequency attracts increased property investment, street activity and visitors' numbers.



Urban Renewal at Darling Harbour

5 Detailed analysis of two Short listed Options

5.1 Option1: Circular Quay, Rocks, Hickson Road, Sussex Street and Central Station

5.1.1 Introduction

For ease of reference, the route description of the proposed Hickson Road core route has been divided into 3 sections, each containing different characteristics. From north to south these are:

5.1.2 Northern section

The northern end of the proposed route would link up strategically important transport interchanges in the city including the Ferry, Rail and Bus Terminals at Circular Quay at Alfred Street. The route would run under the elevated Cahill Expressway and Railway Bridge at the busy 90 degree intersection with George Street.

The railway bridge has a height restriction of 4.4 metres clearance. It is understood that in Central Sydney there is minimum vehicular clearance requirement of 4.3 metres. In terms of the current Variotram vehicles there is a minimum allowance of 4.3 metres above top of rail for the minimum dynamic envelope. This is the minimum preferred contact wire height, with a preferred wire height of 5.5 metres. Conformation of the height requirements and any associated management measures would need to be undertaken in subsequent detailed design work. In the case of this specific low bridge there is a need to consider alternative sub options, three have been considered as follows:-

Sub Option 1.1

The first sub option would be to build a dedicated route for the light rail route from the Pitt / Alfred Street junction under the railway bridge arch through First Fleet Park to join George Street alongside the Museum of Contemporary Arts (MCA) to avoid this congested junction and to avoid the possibility of high vehicles accidentally snagging overhead wires. This would require a ramp through First Fleet Park to George Street and a new Traffic Control Signal in George Street.

Sub Option 1.2

The second sub option would be to run the route via First Fleet Park from the Pitt / Alfred Street junction under the railway bridge arch in front of the Museum of Contemporary Arts (MCA) and behind the Overseas Passenger Terminal before joining George Street opposite the Argyle Street junction. This would require a new Traffic Control Signal at the George / Argyle Street Crossroads

Sub Option 1.3

The third sub option would be to run the route from the Pitt / Alfred Street junction under the railway bridge arch via First Fleet Park in front of the Museum of Contemporary Arts (MCA) and behind the Overseas Passenger Terminal then in front of the restaurants before joining Hickson Road south of the Hyatt Hotel. This would have the advantage of avoiding the congested George Street section of the route as well as the junction with Hickson Road. This would require a new Traffic Control Signal at the junction with Hickson Road.

Alternatively the route could proceed along a gently rising grade in the three lane wide George Street from the Alfred Street junction through the heart of the tourist and heritage area in the Rocks. The Sydney Harbour Foreshore Authority has recently carried out major street improvement works including widening of the western footpath pavement of George Street to Lower Fort Street. These Street improvements will have implications for integration of the proposed light rail routing into this fine grain historic urban quarter of Sydney. The route then descends down a grade into Hickson Road that is four lanes wide bending around Campbell Cove and the Hyatt Hotel to the headland at Dawes Point under Sydney Harbour Bridge. Hickson Road passes under Lower Fort Street Bridge where the road currently narrows to one lane in either direction causing a pinch point for traffic circulation; this could be widened by redesign of the pavements. There are road works in progress at this point. Hickson Road then widens out to two lanes in either direction with on street parking passing under a number of bridges that service the historic wharves accommodating mixed use residential, commercial, theatre and entertainment facilities. There are time restrictions on this northern section of the route. The road is closed around the Walsh Bay area from 10pm until 4am nightly that would curtail late night light rail operations unless time restrictions are reviewed.

5.1.3 North West section

The route along Hickson Road passes Millers Point under high level bridges, new and regenerating residential apartments and commercial developments. It continues along the kilometre long, dead straight Hickson Road a tree lined Boulevard that is six lanes wide, ideal for light rail vehicles, past the existing port facilities at East Darling Harbour. The recent Design Competition for East Darling Harbour has been completed and re-development is proposed to begin in 2008. The design proposes redeveloping the 22 hectare area 50% for parkland, lined with 600-750 apartments and 11,000 to 25000 office workers. The proposed design acknowledges the wide Hickson Road Boulevard as ideal for tram / light rail operations. It forms the built edge to the proposed re-development

Sub Option 1.4

The proposed new East Darling Harbour development will be an opportunity to consider either running the Light Rail route through the heart of the area along the proposed new link road named Healy Street on the

plans or along the existing Hickson Road. It currently forms a boundary between the current dockland operations and the north western edge of the Central Business District.

5.1.4 South West section

Hickson Road south of the junction with Napoleon Street changes name to become Sussex Street that continues along the north south alignment passing under the high level elevated Western Distributor road bridge To the west is the Darling Harbour entertainment district and to the east is the Central Business District. At the junction with Market Street there is a double bridge over Sussex Street the high level bridge carries the Metro Monorail and the low level one the pedestrian bridge link to Darling Harbour. The low level pedestrian bridge has 4.6 metre clearance that is within the current Variotram vehicles allowance of 4.3 metres above top of rail for the minimum dynamic envelope. Conformation of the height requirements and any associated management measures would need to be undertaken in subsequent detailed design work.

The grade between the intersections with Sussex Street at Market, Druitt and Bathurst Street rises and falls. There are four major multi storey parking garages along this stretch of the street. South of Druitt Street the gradient increases before levelling out at the intersection with Liverpool Street where the overhead Metro Monorail crosses Sussex Street on a high level bridge. The gradient between Goulburn and Hay Streets increases through the Chinatown area. This four lane one way section of Sussex Street narrows to two lanes at the junction with Hay Street where the existing Sydney Light Rail provides links to Central Station and Lilyfield. This junction would need to be redesigned to enable the proposed light rail system to link up with the existing light rail track network.

There are a number of issues for operating north bound light rail vehicles along Sussex Street, notably traffic priorities and lane widths at the Market Street junction, also Sussex Street narrows to three lanes between Market and Druitt Streets. Parking would need to be banned on one side of the street to enable sufficient space for light Rail operations. There is also a taxi rank on the western side of Sussex Street just south of the Market Street junction that has taxi queuing further narrowing operational space on the street. There is a need to consider alternative sub options, three have been considered as follows:-

Sub Option 1

The first sub option we considered is to run the light rail vehicle from the junction at Sussex and Napoleon Streets, north and south bound via Kent and Liverpool Streets to Castlereagh Street to Central Station that would avoid junction and street width narrowing on Sussex Street.

Sub Option 2

The second sub option we have considered is to run the light rail vehicles from the junction at Sussex and Napoleon Streets, north and south bound

via Kent Street to Bathurst Street then along Harbour Street to Hay Street to join with the existing Light Rail network from Central Station to Lilyfield.

Sub Option 3

The third option would be to have north bound light rail via Harbour Street / Wheat Road although there may be conflicts with left hand turning traffic from the Western Distributor.

Overview of traffic and transport components

We have reviewed the traffic and transport information provided in the GHD Report and also undertaken a number of site investigations to identify and confirm certain issues. The introduction of light rail provides a number of opportunities to enhance the operation, reliability and interchange of public transport modes on the west side of the Sydney CBD. It also provides an opportunity to rationalise general traffic movements as well as improving pedestrian and cyclist amenity. The western pavement in George Street running through the Rocks area has recently been widened. There are also road and street improvement works underway around Dawes Point as well as time restrictions for traffic movements around Walsh Bay that is closed from 10am to 4am nightly.

With the introduction of a Light Rail route from Circular Quay through the Rocks, Hickson Road, Dawes Point, Walsh Bay, Millers Point, Darling Harbour, Sussex Street, China Town and Hay Street to Central Station it will continue to function as a through route for general traffic, with an additional function as a two-way public transport corridor. Light rail will operate in both directions. The proposals will continue to provide access for delivery vehicles and off-street car parks; there are six major multi storey parking garages along Sussex Street. The proposals will provide the opportunity to improve pedestrian amenity and also the possibility of extending the cycle route. The current cycle route begins close to the third pier in Walsh Bay on Hickson Road. Owing to poor public transport provision in the Rocks area at present, many taxis operate along Hickson Road providing links for visitors and tourists to the theatres, restaurants, and shops as well as for the Darling Harbour Cruise Terminal passengers.

The physical limitations of the street width particularly through the Rocks area support the approach of minimising intrusion by through traffic in order to introduce two-way running of light rail vehicles. Our investigations confirm the need to remove parking from the western side of the street in the Rocks area that is being endorsed by the widening of the western pavement of George Street from Alfred Street to Lower Fort Street. The physical problems of narrow street widths in this area of The Rocks will necessitate limiting parking to one side of the street only, to enable light rail operations.

Australian Road Rules Part 12, Division 8, Rule 208 (incorporated into Road Transport (Road Rules) Regulation 1999) states:

- (1) The driver must position the vehicle to face in the direction of travel of vehicles in the marked lane or line of traffic on, or next to, the part of the road where the driver parks.

- (2) If the road is a two-way road, the driver must position the vehicle parallel, and as near as practicable, to the far left side of the road.
- (3) If the road is a one-way road, the driver must position the vehicle parallel, and as near as practicable, to the far left or far right side of the road, unless otherwise indicated by information on or with a parking control sign.

5.2 Option 3: Circular Quay, George Street, Argyle Street, Kent Street, Liverpool Street, George Street, Hay Street, Central Station

5.2.1 Introduction

For ease of reference, the route description of the proposed Argyle Street Option has been divided into a number of sections, each containing different characteristics. From north to south these are:

5.2.2 Northern section

The northern end of the proposed route would link up strategically important transport interchanges in the city including the Ferry, Rail and Bus Terminals at Circular Quay at Alfred Street. The route would run under the elevated Cahill Expressway and Railway Bridge at the busy 90 degree intersection with George Street.

The railway bridge has a height restriction of 4.4 metres clearance. It is understood that in Central Sydney there is minimum vehicular clearance requirement of 4.3 metres. In terms of the current Variotram vehicles there is a minimum allowance of 4.3 metres above top of rail for the minimum dynamic envelope. This is the minimum preferred contact wire height, with a preferred wire height of 5.5 metres. Conformation of the height requirements and any associated management measures would need to be undertaken in subsequent detailed design work. In the case of this specific low bridge there may be a need to consider building a dedicated route for the light rail route under the railway bridge arch directly opposite the Pitt Street junction through First Fleet Park to rejoin George Street alongside the Museum of Contemporary Arts (MCA) to avoid this congested junction and to avoid the possibility of high vehicles accidentally snagging the overhead wires.

The route proceeds along a gently rising grade to the three lane wide George Street through the heart of the tourist and heritage area in the Rocks. The Sydney Harbour Foreshore Authority are carrying out major street improvement works at present including widening of the western footpath pavement of George Street to Lower Fort Street. These Street improvements will have implications for integration of the proposed light rail routing into this fine grain historic urban quarter of Sydney.

The route runs east west along the steeply sloping Argyle Street through a short tunnel in the embankment of the Bradfield Highway that forms the

approach road to the Sydney Harbour Bridge. The route links up to Kent Street running north south to Liverpool Street, George Street, Hay Street and Central Station.

5.2.3 North West Section

Sub Option 1

A “Rocks Loop” system could be developed from Circular Quay to East Darling Harbour by linking the route along the steeply sloping Argyle Street to the western end, with the junction of Argyle Street and Dalgetty Road then looping down hill to Towns Place to Hickson Road. The route could either continue along the eastern boundary of the East Darling Harbour development or it could be routed back through Dawes Point and the Rocks. The alternative route could be from Hickson Road up the steeply sloping and curving Napoleon Road to Margaret Street, George Street and Alfred Street back to Circular Quay.

5.2.4 South West Section

Sub Option 1

Another sub option we have considered is to run the light rail vehicle from the junction at Argyle and Kent Streets, north and south via Kent to Bathurst Street linking up to Castlereagh Street and to Central Station.

6 Assessment of Options

6.1 Introduction

The previous sections 4 and 5 of this report have outlined the key characteristics of the two short listed options from a number of specialist fields. This generic and specific information together forms a basis for selecting a preferred route against the project objectives and criteria. At this Pre-Feasibility stage we have not carried out detailed work on Patronage or Swept Path Analysis. While it is not possible to undertake a final assessment at this stage, a summary of the key considerations is outlined in order to assist with the assessment process. The proposed assessment process builds on previous studies that been undertaken on light rail proposals for light rail in Central Sydney.

6.1.1 Scoring system

A scoring system using numbers between 1 and 5 has been used to compare the two short listed options. The options have been assessed against eight objectives and criteria as set out in Table 6.1. **A score of one** represents **the worst score** i.e. least integrated with rest of public transit network, worst traffic conflicts etc and a **score of five** represents the **best score** with the least problems regarding integration and expansion, operations, amenity, traffic conflicts.

As may be seen from the above Table, there are no insurmountable “**show stopper**” issues for either of the two short listed options. The highest scoring option is 1 and the lowest scoring option is option 3.

Table 6.1 Short Listed Options - Evaluation Assessment

OBJECTIVES and Criteria	Option 1 Hickson Road Option	Option 3 Argyle Street Option
1 OPTIMISE PUBLIC TRANSPORT USE Provide a public transport mode that optimises greater public transport patronage.		2
2 OPERATIONS Provide a transit service that is reliable, efficient and attractive to all users	5	3
3 NETWORK Provide a transit link that optimises transit network efficiency and integration while serving the patronage catchment.	5	2
4 TRAFFIC Manage impact of the Central light rail on existing and projected traffic and bus systems while maintaining and improving the safety of pedestrians and cyclists	4	3
5 INTEGRATION AND EXPANSION Provide a transit link that optimises transit network efficiency and integration with the existing and possible future light rail routes	5	2
6 WHOLE OF LIFE COSTS Minimise financial and economic costs both during construction and operation	5	2
7 AMENITY Provide a transport system that improves urban amenity and preserves heritage	4	4
8 CONSTRUCTION Minimise construction impact on Central Sydney	3	3
Totals	36	21

As may be seen from the above Table 6.1 Option 1 Hickson Road scores the highest against the eight criteria and objectives through optimising public transport use, operations, network links, managed traffic impacts, opportunities for integration with other transport links and expansion of the network, costs, improving amenity and minimisation of construction impacts.

7 Recommendations and Findings

7.1 Overview

Subsequent to our pre-feasibility review of six options for routes connecting the Circular Quay via Hickson Road through the Rocks, Dawes Point, Millers Point, East Darling Harbour, Sussex and Hay Streets to Central Station, we have the following recommendations and findings.

- 1) The Hickson Road light rail options would help to meet the expected demand from redevelopment of the area particularly around East Darling Harbour for extra public transport capacity and links from this poorly served north-west corner of the Central Business District to both Circular Quay and Central Station
- 2) It has the potential to attract further investment in economic regeneration and support urban renewal that is currently occurring around Dawes and Millers Point and the planned redevelopment of East Darling Harbour area.
- 3) It provides opportunities to link with existing public transport interchanges and develop further light rail extensions to other parts of the city.
- 4) It will enable the restructuring of streets along the route with the potential to redress the balance of priorities between pedestrians and traffic to make areas along the route such as the Rocks and China Town attractive destinations for people in their own right,
- 5) Hyder Consulting reviewed three possible “**show stoppers**” Following initial discussions with Sydney Light Rail, we understand that the current Variotram Light Rail vehicles can negotiate a 7% grade. However, this has got to be viewed against the fact, that under certain conditions the Variotram Light Rail Vehicles had trouble negotiating the 5.6% grade up to Central Station Colonnade, and as a result sand boxes were introduced. If the central bogey was replaced with a powered bogey, Sydney Light Rail considered that the Variotram Light Rail Vehicles would then be able to negotiate an 8% gradient. Using the Variotram Light Rail vehicles unmodified would require digging up and re-profiling the steeper gradient streets along the route.
- 6) Hyder Consulting investigated other Light Rail vehicles that are in operation. A way of reducing risk in Light Rail Vehicle operations would be to use higher performance Light Rail vehicles, such as the Sheffield Super Trams, that are capable of negotiating steeper grades (10%). The vertical and horizontal alignment specifications would need to be confirmed and some

re-profiling of streets would be required. This would provide greater certainty of operations on the steeper city streets.

- 7) Further investigation will be required of the low bridge 4.4 metres clearance at the junction of George Street and Hickson Road. The Light Rail vehicle dynamic envelope requires 4.3 metres clearance. Consequently, sub options were investigated for the Light Rail route to go via a dedicated route from the Pitt / Alfred Street junction under the Railway Bridge / Cahill Expressway arches. that have a higher clearance through First Fleet Park to join George Street alongside the Museum of Contemporary Arts (MCA) to avoid this congested junction and to avoid the possibility of high vehicles accidentally snagging overhead wires. This would not be a problematic “**show stopper**” however, it would require detailed design testing to ensure sufficient clearance for light rail vehicles under the Railway Bridge / Cahill Expressway arches.
- 8) As may be seen from Table 2 **Hickson Road Options – Initial Evaluation Matrix**, there are no insurmountable “**show stopper**” issues for any of the six options.
- 9) All routes considered in the report require re-profiling of the existing roads and interchange roads to achieve acceptable operational vertical and horizontal alignments for the light rail vehicles and to maintain acceptable profiles for intersection road traffic
- 10) Retaining parking for service and delivery vehicles on the east side of streets only along the route would aid safe Light Rail operating.
- 11) Service relocations will be a dominant feature of the works in terms of both cost and time and could also effect alignment of track locally. Underground utilities investigations will need to be cross checked with the various authorities. They present a major risk.
- 12) Determining the appropriate method of support for the Overhead Line Electrification, from a functional, economic and aesthetic point of view will be a challenge particularly in sensitive heritage areas such the Rocks.