F6 Corridor Public Transport Use Assessment

Final Draft Report

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Roads and Traffic Authority, NSW

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Executive Summary

Parsons Brinckerhoff Australia was engaged by the NSW Department of Infrastructure, Planning and Natural Resources (DIPNR) and the Roads and Traffic Authority of NSW (RTA) to undertake a study to identify and provide a preliminary assessment of potential public transport uses of the F6 corridor and local road connections. Based on the outcomes of this assessment the study identifies those parts of the corridor likely to be surplus to public transport requirements and able to be used for other purposes. A number of stakeholder meetings were held to obtain major stakeholder views on options and the implications these may have for the future use of the corridor.

The study focussed on investigating the range of potential modes that may best meet the objectives of the study. Based on the requirements of the brief, it is not necessarily intended that any one mode would be recommended but rather a range of feasible modes that may operate in the corridor have been identified.

The F6 Corridor

The F6 corridor currently traverses fifteen suburbs between Campbell Road, St Peters to the Royal National Park, Loftus. Originally set aside as part of the 1951 County of Cumberland Planning Scheme, the then road reservation connected central Sydney with the then planned Southern Freeway at Waterfall. However, a previous Government reduced the F6 corridor, particularly in the southern sections between Loftus and Waterfall, to preserve National Parks land and established open space areas. Over time, sections of the remaining reservation have been used as community open space and active recreation space.

The F6 reservation passes through four local government areas: Sutherland, Rockdale, Marrickville and the former South Sydney (now City of Sydney). The majority of the reservation passes north-south through the length of Sutherland and Rockdale areas. The northern end of the corridor crosses the eastern edge of Marrickville then into the southern edge of the City of Sydney local government areas.

On 6 September 2002, the then Minister for Transport and Roads, the Hon. Carl Scully MP, announced that the Government believed that the remainder of the reservation would better serve the population as a public transport corridor. The Minister also stated that such a public transport corridor would require a narrower reservation than that currently provided for a future freeway and would therefore allow the determination of which parts of the corridor can be provided as open space. (Refer to Appendix A for Ministerial press release).

On 28 February, 2003 the Minister for Roads also directed that the " Roads and Traffic Authority (is) not to construct any freeway or motorway on the proposed F6 corridor between St Peters and the Royal National Park which passes through the local government areas of Marrickville, Rockdale and Sutherland Shire". The Minister further directed "that the Roads and Traffic Authority (is) not to construct any road or transport development of any type between the Royal National Park and the southern side of Gymea Station, so this portion of the F6 corridor can be preserved, as much as possible. (Refer to Appendix A for copy of Government Gazette No. 54).

Stakeholder Consultation

Consultation with community and other stakeholders was a key component of this study with two rounds of community forums conducted at both the southern end (Sutherland) and the northern end of the corridor (Rockdale). Interested members of the public, community groups, special-interest groups and industry associations were invited to attend a workshop held early in the study process. Additional forums are planned at the end of the study to provide the community with the opportunity to comment on the study's outcomes.

Consultation was also conducted with relevant local Councils, RailCorp, the State Transit Authority and Sydney Airport Corporation through the project reference group and individual meetings.

The public submissions received through the consultation process mainly related to concerns over increasing population and congestion over the next ten years. Changes in the demographic characteristics of the area was also raised, in particular, the transport needs of an ageing population. Several issues were raised concerning public transport in the area such as a lack of frequent bus services, additional access required to connect centres including the hospitals and Caringbah town centre. Suggestions for improved public transport in the F6 corridor included: express bus services, light rail, a branching bus corridor, redirecting public transport from the F6 reservation onto existing roads and reducing the cost of public transport options. The improvement of cycling conditions to and between rail stations was also raised and the inclusion of a cycleway along the F6 reservation. Submissions also supported the use of the corridor for open space and nature reserves.

Study Overview and Key Findings

The study has investigated a range of possible public transport uses for the F6 corridor. Options have been considered for both the alignment of the corridor and the mode which would best meet the future needs of the population. As described above it was not the intention of the brief to identify a sole mode for implementation at this stage, but rather to identify a preferred mode or modes, to provide a basis for decision making on the continued reservation of land for public transport purposes and the extent of residual land which may result.

The study considered a range of options including alignments within the F6 reservation plus one that utilises adjacent local streets for public transport. The range of modes considered for use in the corridor included heavy rail, metro, light rail and busways. Each mode was assessed in conceptual design terms with regards alignment, cross sectional width and station locations. For the purpose of this strategic study and because of their similar performance characteristics, light rail and busways were grouped together as medium capacity modes for demand assessment purposes. Broad order of cost estimates were developed for each option. The options are summarised as:-

- *Heavy Rail – there are two options, both linking to the Cronulla Line at Miranda and running via the F6 reservation. One option is to connect to the Illawarra Line near Sydenham and the other option connects to the Airport Line west of the International Airport station;*
- *Light Rail and Busway – starting from Miranda and running via the F6 reservation to link to Sydenham Station and/or the International Airport station; and*
- *Light Rail and Busway – starting from Miranda and running on-street, generally parallel to the F6 reservation to link to Sydenham Station and/or the International Airport station.*

Modelling of the medium capacity modes demonstrated the best potential to attract passengers within the 2020 timeframe for this study with demands in the order of 4,000 peak direction passengers in the peak two hours. Within the two basic options, operation in an exclusive corridor was found to attract marginally more peak direction passengers. However, the on-street option *attracted more contra-peak passengers and also has the potential for closer integration with the community.*

These modes also exhibited least cost per passenger in comparison to heavy rail with the on-street option being the lowest cost overall in terms of passenger and capital costs. The following table summarises the cost per passenger for each mode and alignment option.

Cost per Passenger for Various Modes and Options at Forecast Patronage

Mode/Option Description	***Broad Costs***	***Total Cost per Passenger***
Heavy rail	*$670-$1,000M*	*$50.00*
Light rail in exclusive corridor	*$350-$440M*	*$9.20*
Bus in exclusive corridor	*$200-$260M*	*$3.80*
Light rail on street	*$280-$340M*	*$9.00*
Bus on street	*$120-$150M*	*$2.70*

Heavy rail's high cost can be attributed to its high capital cost and relatively low patronage, which is below that which would support heavy rail within the 2020 timeframe for this study. However, when considering the requirement to reserve land within the corridor for future public transport, the timeframe should be beyond 2020. The Illawarra Line is reaching capacity towards the end of the next decade and RailCorp's patronage forecasts for the South Coast and Illawarra Lines have demonstrated the need for additional capacity and/or lines, including potential metro lines in this corridor and other parts of the metropolitan area. In this regard it is considered that any change to the F6 corridor reservation should not preclude the potential for future development of a high capacity mode and hence an alignment width of 40 metres has been recommended. Based on this width it has been found that there are potentially residual lands which could be appropriately zoned for other uses.

A major challenge for the medium capacity system will be integration with the existing rail system. Whether the alignments connect with the Illawarra line at Sydenham or the Airport line, there are potential problems in finding seats on already congested trains. Further studies should examine the potential for extension of these options towards the city and in this regard extensions via the Airport towards Green Square and the CBD may offer the best opportunities.

This study has found that within the next 10 to 20 years a medium capacity mode could fulfil an effective public transport role in increasing the level of public transport use and management of travel demand in the corridor. These findings point to the need to consider the staged development of public transport services in the corridor. In principle, a staged approach could include:

1. *Preservation of the option to provide for long term needs by establishing a reservation capable of meeting the needs of a heavy or metro style rail line. In this way the potential to develop lower capacity systems would also be protected.*

2. *In the short term, rationalise the existing bus network to develop high quality, high frequency, feeder services to existing Illawarra line stations, Sydney Airport and the CBD. The proposed initiatives under the Review of Bus Services in NSW (March 2004) could provide the basis for this rationalisation.*

3. *Through this rationalisation process progressively develop a strategic bus service which mirrors the proposed corridor (similar routes are also referred to in Review of Bus Services in NSW). Provide a high quality service at minimum levels of service of 10 to 15 minutes in peak periods. In addition, consider improving catchment coverage by adjusting the service to use Chuter Avenue instead of the parallel "one sided" route along General Holmes Drive from Sans Souci to Monterey.*

4. *The strategic bus route/s should be structured to take advantage of current and future developments along the corridor. For example, consideration should be given to taking advantage of provisions within the Cooks Cove development for priority access to the airport across the Cooks River.*

5. *Develop bus priority systems on existing roads and where appropriate make use of the reserved exclusive public transport corridor to by-pass points of congestion.*

6. *Put in place a strategy to progressively develop a medium capacity transport system over the full corridor. This could be focused on either side of the Georges River in the initial stages of development and include connections to key transport nodes such as Rockdale and Miranda.*

7. *This strategy should firstly, fully investigate and recommend the most effective medium capacity mode (light rail, bus rapid transit systems) to serve this corridor. The strategy should include a schedule for development of the corridor over the next 10 to 20 years.*

Recommendations

The following key recommendation is made:

- *establish a reservation 40 metres wide to preserve the potential to develop a high capacity mode in the long term.*

Given the strategic nature of this study, consideration should be given to undertaking the following supplementary tasks;

- *undertake detailed network and patronage studies and a financial/economic assessment to confirm the most appropriate medium capacity mode and technology to serve the corridor;*
- *develop the engineering design, geotechnical studies and environmental assessment for the selected mode to confirm the reservation boundary to enable residual lands to be appropriately zoned for other uses.*
- *Undertake a detailed road network assessment of the selected public transport system including addressing potential by-pass opportunities (e.g. Miranda Town Centre) and their potential land requirements; and*
- *develop a detailed implementation strategy for progressive development of high quality public transport services in the F6 Corridor.*

Future Actions

This study has addressed a wide range of issues associated with the development of a public transport system within the F6 corridor. The study has highlighted the need for a range of additional studies and actions required to assist decision making with regards to a possible medium capacity mode and the final reservation of the corridor lands. These future actions should include:

- *detailed public transport feasibility and operations study. The study scope should include:*
  - *a more detailed patronage assessment (based on the current assessment) to focus on the passenger needs in the catchment and to support final decision making on the most appropriate mode for the corridor;*
  - *determination of the long term medium capacity mode best suited to meeting the passenger demands within the corridor;*
  - *engineering feasibility study to develop an optimum long term alignment and staging plan;*
  - *traffic studies to identify the interaction with the road network and necessary works to establish public transport priority;*
  - *public transport operations plan which integrates all modes within the corridor; and*
  - *detailed staging strategy for the progressive implementation of the public transport strategy.*

The above scope could be undertaken as a single feasibility study or managed as a series of sequential studies.

- *Once a preferred mode is chosen, land use and urban design studies should be undertaken at an appropriate stage to address the most appropriate use for residual lands and to identify the urban design solutions for future station locations and the corridor in general.*
- *In order to improve the level of confidence for the definition of the future reservation the following activities should be undertaken:*
  - *obtain more detailed survey of the study area. We have established that digital aerial photography is available that will allow the generation of DTM mapping to 2 metre contours and an ortho-rectified aerial photo base with 0.3 metre pixels;*
  - *obtain a more accurate definition of the corridor boundary by obtaining the corridor coordinates from the RTA and plotting this on the cadastral base (the RTA has advised that it may require up to two years to acquire this data); and*
  - *undertake sufficient field investigations to allow zoning of the corridor in terms of environmental constraints, geotechnical conditions and flooding.*

1. Introduction

As part of the 1951 County of Cumberland Planning Scheme, a road reservation was set aside that connected central Sydney with the then planned Southern Freeway at Waterfall. This reservation, named the F6 Corridor, was planned to cater for the access requirements of anticipated future populations.

With the previous Government's focus on other major arterial transport routes, the extent of land occupied by the F6 corridor was reduced, particularly in the southern sections between Loftus and Waterfall, to preserve National Parks land and established open space areas. Over time, sections of the remaining reservation have been used as community open space active recreation space and have therefore maintained significant environmental value.

On 6 September 2002, the then Minister for Transport and Roads, the Hon. Carl Scully MP, announced that the Government believed that the remainder of the reservation would better serve the population as a public transport corridor. The Minister also stated that such a public transport corridor would require a narrower reservation than that currently provided for a future freeway and would therefore allow the determination of which parts of the corridor can be provided as open space. The Ministers' release is contained in *Appendix A.*

This study assessed the viability of using an existing asset, the F6 corridor road reservation, as a public transport corridor. The study evaluated a number of mode types that could fulfil a role in travel movements to, from and through the areas adjacent to the corridor.

1.1 The F6 Corridor

The F6 corridor currently extends between Campbell Road, St Peters to the Royal National Park, Loftus. The corridor generally refers to the area between St Peters and Loftus that could provide for transport connections between key nodes.

The reservation runs through the suburbs of Tempe, Kyeemagh, Banksia, Rockdale, Brighton-Le-Sands, Kogarah, Monterey, Ramsgate, Sans Souci, Sandringham, Taren Point, Miranda, Gymea, Kirrawee and Loftus. The indicative alignment of the F6 Corridor is shown in *Figure 1.1*. The Minister for Roads also directed that the " Roads and Traffic Authority (is) not to construct any freeway or motorway on the proposed F6 corridor between St Peters and the Royal National Park which passes through the local government areas of Marrickville, Rockdale and Sutherland Shire". The Minister further directed "that the Roads and Traffic Authority (is) not to construct any road or transport development of any type between the Royal National Park and the southern side of Gymea Station, so this portion of the F6 corridor can be preserved, as much as possible, for open space (NSW Government Gazette No 54). A copy of the relevant notation is contained in *Appendix A*.

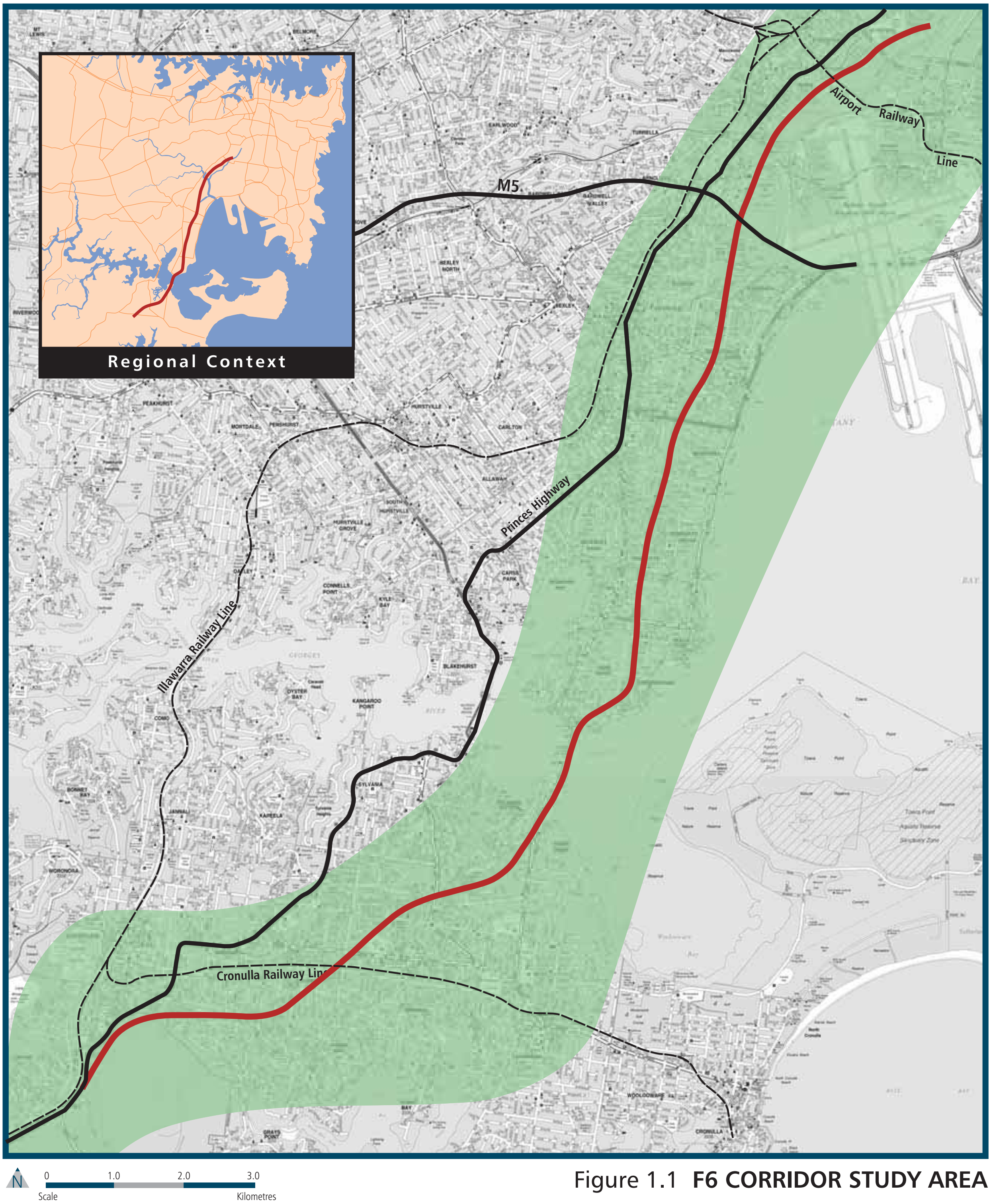


Figure 1.1 **F6 CORRIDOR STUDY AREA**

- Study area
- Current alignment of F6 corridor
- Highways
- Railway

The study area extends beyond the general corridor as described above to ensure that broad consideration is given to potential connections to the regional transport network and major land use destinations. In particular, the study area covers the area west to the Illawarra Rail Line, north to the Airport Rail Line and Central rail station.

The F6 reservation passes through four local government areas: Sutherland, Rockdale, Marrickville and the former South Sydney (now City of Sydney). The majority of the reservation passes north-south through the length of Sutherland and Rockdale areas. The northern end of the corridor crosses the eastern edge of Marrickville then into the southern edge of South Sydney local government areas.

Development of any project within the transport corridor along the F6 reservation was not identified in Action for Transport 2010, the State Government's 10 year strategic planning document for transport infrastructure and services released in 1998.

1.2 Background

The F6 Freeway corridor was one of the major roads for Sydney proposed in the 1951 County of Cumberland Planning Scheme. The County of Cumberland Planning Scheme provided an overall perspective of the planned future growth of the Sydney Region. Once the corridor was identified, the Department of Main Roads established a program of purchasing land within the corridor for future road infrastructure development. The original corridor extended from the end of the Southern Freeway at Waterfall through to the central Sydney CBD area. In the 1960s the section of the corridor over the Captain Cook Bridge and its southern approaches was built. This is the only section of the corridor that has been developed to a freeway standard.

In November 1977, the then Minister for Highways announced that the F6 corridor would be abandoned except for the section between Campbell Road, St Peters and Miranda. At that time, the Minister noted that the location of the termination point at Miranda required further investigation by the Department of Main Roads. Further investigations were also needed to determine appropriate connections to the CBD or to other planned motorways in the region such as the M5 East and Eastern Distributor.

In September 1987, the Minister for Roads formally abandoned the section of the F6 corridor between Farnell Avenue, Loftus and Waterfall. This reservation travelled mainly through the Royal National Park. The NPWS was notified of this advice in October 1987 and the reservation was removed from planning instruments.

In 1998 the Roads and Traffic Authority completed studies to reduce the width of the reservation between Campbell Road, St Peters and the Cooks River. The study identified a reservation wide enough for a future arterial road to service the adjoining industrial zoned land and to provide local traffic relief to the Princes Highway. The actual reservation is yet to be rezoned in local councils LEPs.

On 6 September 2002, the then Minister for Transport and Roads, Carl Scully MP, announced that the 20 kilometre freeway would be abandoned in favour of a public transport corridor and recreational uses. As a consequence of the Minister's announcement, this current study was commissioned by former Transport NSW and

RTA. Following changes in Government Departments, management of the study was transferred to the Transport Planning Division of DIPNR.

The following terminology will be used through the study process in all reporting and documentation:

Term	Description
Alignment	A geometric layout, in plan following a general route within the reservation.
Reservation	The actual land as shown on RTA plans and zoned for transport uses.
Corridor	Refers to the general area between St Peters and Loftus that could provide for transport connections between key nodes. Includes movement systems and land uses. Refer Figure 1.1
Local Catchment	The immediate area that any potential public transport station or stop would serve. Typically within one kilometre of station locations and the area from which the majority of potential users of the transport facility would come from.
Regional Catchment	The broad area that any potential public transport facility would serve. Area from which potential users of a transport facility would come from using another mode of transport to connect to the services.

1.3 Study Objectives

The brief outlines the primary objectives of the study as:

- identify and provide a preliminary assessment of potential public transport uses of the corridor and local road connections;
- as a consequence, determine those parts of the corridor likely to be surplus to public transport requirements and able to be used for other purposes; and
- incorporate major stakeholder views on options and the implications.

The study is focussed on investigating the range of potential modes that may best meet the objectives of the study. It is not necessarily intended that any one mode would be recommended but rather a range of feasible modes that may operate in the corridor. An underlying objective is focussed on achieving broader government objectives for reduced levels of vehicle kilometres travelled (VKT) and improved air quality.

1.4 Study Process and Outcomes

The study process involved the generation of issues and ideas relating to the use of the F6 Corridor for public transport through community forums and technical reference group workshops. The paper included the strategic planning context, traffic and transport issues, community workshop summaries, social and environmental opportunities and constraints and a framework for the options evaluation.

The options were assessed in two phases. Phase 1 considered potential modes and alignment option, both within the corridor and on adjacent roads with five short listed options being carried over to the next phase. Phase 2 involved a more detailed assessment of the five options including:

- two heavy rail
- two medium capacity modes encompassing operation ”on road” and “in exclusive alignment”:
  - light rail
  - bus transit

Each option was modelled using the Transport Data Centre Strategic Travel Model. This report summarises the options assessment and study findings.

The study area for assessment of public transport options is illustrated in *Figure 1.1*.

1.5 Stakeholder Consultation

Consultation with community and other stakeholders was a key component of this study.

Two rounds of community forums were conducted as part of the study. Interested members of the public, community groups, special-interest groups and industry associations were invited to attend a workshop held early in the study process. The first series of forums were held on the 10 and 13 March 2003. The forums were held at both the southern end (Sutherland) and the northern end of the corridor (Rockdale). Additional forums will be held at the end of the study to provide the community with the opportunity to comment on the study’s preliminary outcomes.

Consultation was also conducted with relevant local Councils, RailCorp, the State Transit Authority and Sydney Airport Corporation through the project reference group and individual meetings.

The purpose of the initial community forums was to inform the community about the study and for the community to assist with identifying issues for consideration. The focus of the forums was a facilitated discussion with the community. The discussion was based on the following:

- identifying the potential major changes and key transport issues in the local area for the next 10 years; and
- determining what contributes to a successful public transport system.

A broad outline of the forums is provided in *Appendix B*. A comment sheet was made available at the meeting for attendees to complete if they had additional information they wished to provide. A total of 7 comment sheets were returned, along with three written letter submissions and 12 suggestion sheets for uses of the F6 corridor from Citizens Advocating Responsible Transport for the Shire (CARTS).

The submissions received mainly related to concerns over increasing population and congestion over the next ten years. Changes in the demographic characteristics of the area was also raised, in particular, the transport needs of an ageing population. Several issues were raised concerning public transport in the area such as a lack of frequent bus services, additional access required to connect centres including the hospitals and Caringbah town centre. Suggestions for improved public transport in the F6 corridor, included express bus services, light rail, a branching bus corridor, redirecting public transport from the F6 reservation onto existing roads and reducing the cost of public transport options. The improvement of cycling conditions to and between rail stations was also raised and the inclusion of a cycleway along the F6 reservation. Submissions also supported the use of the corridor for open space and nature reserves. A summary of the initial community forums is provided below.

Rockdale

A total of 34 members of the community attended the forum at Rockdale Council Administration building on Monday 10 March 2003. Representatives from Council and Action for Public Transport also attended.

Key issues raised at this forum included:

- concerns about future development demands – increased urban densities leading to more traffic and pressure on public open space;
- effects of ageing population;
- concerns about existing public transport system, particularly access;
- concerns about cost of public transport system for the F6 corridor, its likely connections, impacts on existing road networks and patronage;
- suggestion to improve existing public transport systems first; and
- concerns about impacts on the environment and residential amenity.

Notes from the workshop are contained in *Appendix B*.

Sutherland

A total of 23 members of the community attended the forum at Sutherland Community Centre, Stapleton House, on Thursday 13 March 2003. Participants included the Member for Miranda, Hon Barry Collier MP, and representatives from Sutherland Council, the Southern Sydney Regional Organisation of Councils, Miranda Residents Precinct Association and Sutherland Shire Environment Centre. Some representatives attended the forum in a local resident capacity and some represented their groups.

Key issues raised at this forum included:

- impacts of likely demographic changes on public transport;
- concerns about issues of parking, transport and housing for Sydney's future;
- desire for east-west access not just north-south access;
- need for integrated public transport systems, appropriate planning and effective government-community communication;

- need for public transport systems to be attractive enough to encourage people to use rather than relying on motor vehicles;
- need to prioritise access as key issue for public transport;
- need to consider environmental and social/community impacts; and
- concerns about people who currently want to travel by train to Eastern Sydney, the CBD and beyond from the Cronulla area need to travel west for some 15 minutes before heading north.

Notes from the workshop are contained in *Appendix B*.

1.6 Base Engineering Model

A base engineering model in AutoCAD was created to develop and assess mode options.

The base engineering model consists of ortho-rectified photo mapping. The coverage of the model is to a minimum width of one kilometre either side of the F6 reservation from Campbell Road, St Peters (2003 UBD map 255 ref L14) to Farnell Avenue, Loftus (2003 UBD Map 332 ref G12) is 0.2 metre pixel aerial photography. The model also includes cadastral data for the same area. The enclosing rectangle is one metre pixel data to show the regional context and broader network connections.

The data sources for the base engineering model are:

- 0.2 metre pixel aerial ortho-rectified photo mapping, SKM 2000;
- 0.2 metre pixel aerial ortho-rectified photo mapping resampled Webmap 2000 data;
- 1 metre pixel aerial ortho-rectified photo mapping, Land and Property Information 1998 data, and
- Land and Property Information cadastral boundaries, 1998.

The RTA provided hard copy PIMS maps showing the F6 reservation on a cadastre base plan. This mapping was used to digitise an estimate of the F6 reservation onto cadastre and aerial photo mapping in CADD. The digitising was completed by estimating the location of the reservation based on property boundaries. The F6 reservation was not available from the RTA in digital georeferenced format. Therefore, the F6 reservation in the engineering model should be treated as indicative only.

Standard typical cross sections of heavy rail, light rail and bus based transit were developed to support the study and develop alignment options. These typical cross sections provide an indication of potential treatments and reservation requirements for a public transport corridor including a shared cycle and pedestrian path. Alternative treatments may evolve as part of further detailed design processes of preferred options in future studies.

The alignments, for these typical cross sections, include the horizontal design only and limited vertical design at key points only, such as the Georges River and Cooks River crossings. It should be noted that vertical design sections are indicative only as they were completed using existing information sourced from the RTA and RIC and were not based on detailed engineering surveys or fieldwork.

More refined engineering evaluation would involve the development of a two-metre contour digital terrain model, to provide a precise analysis of the vertical alignments of the options and production of long sections and actual cross-sections. This analysis, along with a detailed geotechnical assessment of ground conditions, is required to determine the land requirements for batters and retaining walls.

Vertical alignments were not considered necessary at this pre-feasibility stage of assessing public transport uses for the F6 corridor.

Therefore a detailed assessment of batter requirements was not made. A conservative approach was taken to the corridor width and assessment of corridor requirements to allow for detailed engineering assessments as required to progress planning for a potential public transport system in this reservation.

This assumes that additional costs would be involved with developing retaining walls, if they were deemed to be required once detailed engineering designs were completed. The need for retaining walls would depend on the actual use of residual lands.

Further details on the assumptions are included in the relevant sections of this report.

2. Urban Planning Context

2.1 Strategic Planning Context

Sydney is increasingly being challenged to provide for anticipated population growth, and changes in household formation while maintaining environmental quality. The NSW Government has released a series of plans and strategies over the past five years to guide development and provision of infrastructure in Sydney. A new Metropolitan Strategy is currently being developed by DIPNR and will replace Sharing Our Cities and Action for Transport 2010. The Metropolitan Strategy website (www.metrostrategy.nsw.gov.au) states that the document will set out how the State Government intends to sustainably manage growth and change in Sydney and the Greater Metropolitan region over the next thirty years. It will be used to:

- promote community discussion on issues and directions;
- provide leadership and vision about the type of Sydney we want to live in and the options and challenges we face;
- coordinate State Government infrastructure, investment and service delivery decisions; and
- provide a framework for industry investment.

The F6 corridor reservation passes through four local government areas: Sutherland, Rockdale, Marrickville and the former South Sydney (now City of Sydney). There is strong support from each of these councils to reduce the impacts of increasing private vehicle and commercial freight travel and encourage public transport use through improvements to infrastructure, services and walking and cycling access. An overview of relevant State Government strategic plans and Council planning policies are provided in *Appendix C*.

The F6 reservation is a unique asset in an established urban area. The challenge, now that the freeway use has been abandoned, will be to ensure that decisions regarding the potential use of the reservation do not preclude any public transport options that may address longer term community needs. The corridor has been reserved for over 50 years and is a valuable community asset. Any decision regarding the strategic use of the asset should consider long term potential community needs in the corridor to ensure opportunities are not foregone.

2.1.1 Key Issues in the Corridor

A review of existing information, community consultation and discussions with key stakeholders identified several issues for consideration in the study. The key issues raised, that were considered to be important in the context of this study, were:

- Existing traffic congestion;
- Lack of integrated public transport options;

- Large development demands in surrounding areas;
- High existing environmental and residential amenity; and
- Demographic changes such as an ageing population and smaller household occupancy rates impacting the population in the area and how people travel.

The F6 corridor as a potential public transport route presents several opportunities for addressing these issues in the corridor.

2.2 Current Land Use Zoning and Ownership

There is a mix of private and public land ownership along the F6 reservation. The majority of the corridor is in public ownership with land owned by various State and Local Government agencies. Assuming an average reservation width of 90 metres, the reservation occupies a substantial 180 hectares of land. The following section outlines zoning and ownership for various sections of the corridor starting from the southern end of the reservation.

The section of the corridor between Farnell Avenue, Loftus and Auburn Street South, Kirrawee lies mostly within the Royal National Park. The remaining corridor within Sutherland Shire is zoned in the current 2000 Local Environment Plan as "Special Use – Future Arterial Road". Most of the land within the F6 Reservation in Sutherland Shire is publicly owned, the majority by the RTA. The 2003 Draft Peoples' LEP proposes to rezone the land within the F6 reservation to "Transport Corridor". The zone is generally described in the Draft LEP as having the potential to serve as a multi-modal transport link to serve metropolitan demands.

North of the Georges River land ownership in the corridor is split between private owners, DIPNR (formerly Planning NSW), Rockdale Council and the RTA. Small areas of land are also owned by the Department of School Education and Sydney Water. The land within this corridor is zoned 7(c) – "Transport Reservation Zone" in the Rockdale LEP.

The section of the F6 reservation between the Cooks River and Canal Road is located within the Marrickville local government area and is zoned 9(c) – "Arterial Road and Arterial Road widening". Land adjacent to the corridor in Marrickville LGA is zoned open space, special uses, residential and industrial.

The section of the F6 reservation between Canal Road and Campbell Road is within the City of Sydney LGA. The actual corridor is zoned as 9 (a) - Arterial Road Reservation and adjacent properties are zoned 4 – Industrial. There are also some mixed uses and residential properties to the north of Campbell Road adjacent to Sydney Park, a major recreation and open space area for the residents of South Sydney. The section of the reservation in Sydney City LGA runs parallel to the Alexandra Canal.

2.3 Future Land Use Scenarios

The provision of public transport services in the F6 reservation has the potential to influence the land use and development patterns in the corridor.

The degree of influence will vary according to the mode that is implemented and the levels of service provided. However, generally, the provision of high quality trunk services will enable a higher level of land use development, particularly around public transport nodes such as heavy/light rail stations, bus stations/stops and interchanges. The types of land use opportunities along the corridor are, however related to the current use of the residual and surrounding land, overall demand for land uses in the region and compatibility with adjacent existing uses.

The current land use pattern within and surrounding the corridor reflects a situation where the private motor vehicle is the dominant form of transport. Residents rely on motor vehicles to travel between major land uses such as shopping centres, schools, the CBD and recreational facilities. Hence, a more dispersed pattern of land use is apparent. Improved transport choice (in the form of a public transport corridor) and convenience is likely to generate demand for changing land uses.

The majority of land use change would be in close proximity to key transport nodes. The provision of a public transport link would stimulate residential population growth the area, and in turn stimulate development, local commerce and demand for other transport services such as buses and taxis.

There would be opportunities for the provision of appropriate housing within walking distance of key nodes. This would provide more convenient and accessible housing choice and in turn lead to a reduction in dependence on car travel. Other relatively high intensity and employment land uses are appropriate for areas within walking distance of public transport nodes. These include commercial offices, libraries and civic uses, post offices, personal and convenience retailing, restaurants, education facilities, medical and health facilities and entertainment and recreation uses. Low intensity, car-oriented land uses such as industrial premises and bulky goods retailing would not be appropriate for areas surrounding stations.

The level of service of the mode of public transport to a particular node has a greater propensity to influence the level and range of development and activity surrounding it.

The types of land uses on residual lands and on areas between stations would, however, be influenced by the types of public transport under consideration. For example, a light rail line would enable a wider range of activities to be located in close proximity to the corridor as it would enable greater horizontal connectivity with pedestrian and vehicular crossing at surface level and allow maximum development to the edge of the rail corridor. Given that light rail is relatively quiet, more sensitive uses such as housing, schools and other community uses could also be located closer to stations and the corridor.

The width of the corridor and noise and safety provisions associated with a heavy rail option would restrict the range of land use potential along the corridor, particularly between stations. Uses such as light industry/commercial, open space and recreation would be more suitable in these areas. The type of use is related to the existing use of the land and its compatibility with adjacent existing uses. For example, it would not be suitable to rezone an open space area to industrial particularly if it were adjacent to a residential area.

2.3.1 Current Population Projections

Current population and employment projections for Council areas surrounding the corridor indicates an overall increase in population of 10 percent and growth in employment of 10.5 percent between 2001 and 2021 (TPDC Land Use Model 2003 v1). Data for relevant local government areas is shown in the tables below.

The TPDC Land use model assumes a total population in Sydney for 2021 at 4.893 million. The ABS 2002 Year Book for Australia provides projections for the Australian population to the year 2021 based on a combination of assumptions concerning future levels of births, deaths and migration. Three series of projections have been produced based on differing levels of these assumptions. The ABS 2021 population projection for Sydney ranges from 4.986 million (Series III) to 5.143 million (Series I). The TPDC population projections are low in comparison to the ABS projections. This data (*Tables 2.1* and *2.2*) will be used in further discussions of land use scenarios in Section 7.

Table 2.1: Local Government Area Population, 2003 and 2021

Local Government Area	2001	2021	**Percentage Change**
Sutherland Shire	213,400	220,000	3%
Hurstville	73,700	79,100	7%
Rockdale	93,000	108,100	16%
Kogarah	52,800	57,600	9%
Marrickville	78,000	82,300	6%
South Sydney	89,700	121,300	35%
TOTAL	600,600	668,400	11%

Source: TPDC Sydney Landuse Model (2003 v1)

Table 2.2: Local Government Area Employment, 2001 and 2021

Local Government Area	2001	2021	**Percentage Change**
Sutherland Shire	63,600	75,600	19%
Hurstville	26,800	32,700	22%
Rockdale	26,900	23,900	-11%
Kogarah	18,400	22,900	24%
Marrickville	34,100	33,900	-1%
South Sydney	111,700	120,400	8%
TOTAL	218,500	309,400	**10%**

Source: TPDC Sydney Landuse Model (2003 v1)

2.3.2 Council Planning Strategies

The corridor traverses four local government areas, including from north to south: South Sydney, Marrickville, Rockdale and Sutherland. The following provides an overview of the current strategic land use opportunities adjacent to the reservation.

Sutherland Shire

Sutherland Shire's housing strategy indicates that much of the growth in new multi-unit development has occurred in the residential flat buildings zones (Multi-dwelling 'B' Zones) located around main railway stations such as Sutherland, Gymea, Engadine, Miranda, Caringbah and Cronulla, and the Menai Town Centre, and in the multi-dwelling housing (townhouses) in the Multi-dwelling 'A' zone in areas in close proximity to retail/commercial centres, public transport, services and employment.

The capacity for further multi-unit development in existing zones is limited in the Multi Dwelling B zones with the exception of some areas within Sutherland, Cronulla and Caringbah. Further opportunities could be investigated for increasing the volume of land Multi Dwelling B zones adjacent to potential stations on a proposed F6 public transport corridor, particularly in the section north of the Kingsway to Port Hacking Road.

North of the Kingsway, the reservation is adjacent to open space, local housing, educational uses, community facilities and a child care centre. The section of corridor between Port Hacking Road and Taren Point Road has high environmental values and it is recommended that it remain as open space, recreational space and threatened specified buffer areas and protected wetlands.

The existing reservation skirts the north west boundary of the large Taren Point employment area. Whilst the opportunity for increasing the volume of industrial land appears limited, there could well be a strategic opportunity for the development of a commercial development as part of a potential Taren Point station.

Rockdale City Council

The Illawarra rail line, in the Rockdale local government area, has experienced significant levels of urban consolidation. Medium-high rise developments have been established along the rail line, particularly at Kogarah and Rockdale stations. Additional urban consolidation is currently underway with the residential and employment development at Wolli Creek rail station and the North Arncliffe precinct.

The F6 reservation passes through existing medium density residential zones through the suburbs of Brighton Le Sands, Monterey, Ramsgate and Sans Souci. These suburbs do not have high capacity public transport service to support any increases in residential development. The development of the F6 reservation as a high capacity public transport service may lead to the development of higher density residential uses in appropriate residual lands in and adjacent to the F6 reservation.

Rockdale City Council has adopted a strategy for the relocation of sporting clubs to accommodate the Cooks Cove Project. The F6 reservation is adjacent to some of these sporting fields and residual land should be considered for open space and recreation uses through this area.

Rockdale has two industrial employment zones, at Ramsgate and Rockdale, which would be accessible to the reservation. Redevelopment potential may centre upon the development opportunities within the Bay Street precinct. At the northern end of the Rockdale LGA, the Cooks Cove project will present a major mixed use redevelopment opportunity, adjacent to the airport on the existing Kogarah Golf Course site. It is intended that the golf course be relocated to links south of the Cooks Cove site.

Marrickville Council

The land use opportunities adjacent to the F6 corridor within the Marrickville municipality are limited to industrial, open space and road transport uses such as the St Peters Industrial Route (SPIR) corridor, discussed in *Section 4.3* of this report. However, it can be expected that the proposed upgrading of Sydney Airport (through its recent Masterplan) would be expected to induce significant land use change in areas close to the airport.

City of Sydney Council

There is only a short section (0.5 km) of the F6 corridor within the former South Sydney Council area. The lands adjoining this section of the corridor are industrial in nature and expected to remain so into the future. It is noted that, as with the Marrickville Council section, the expansion of the airport could be expected to influence land use in this area in future years.

3. Social and Environmental Characteristics

The information in this section of the report is largely drawn from a desktop review of previous studies, an understanding of the potential impacts of public transport infrastructure and a study team site visit. Input has also been included from the initial community forums held on 10 and 13 March 2003.

3.1 Overview of Social Characteristics

The corridor was designated for future road use under the County of Cumberland Plan (1951). Since this time, a range of residential, commercial, industrial and recreational/open space land uses have developed within and adjacent to the corridor. However, a relatively large proportion of the corridor has remained as open and recreational space for local communities. Indeed, many communities along the corridor appear to have developed an ownership of the corridor, and for some residents, it forms the only recreational area available in close proximity.

The F6 corridor largely starts at Cambell Road, St Peters in the north. This residential street is surrounded by industrial uses to the east, particularly transport related infrastructure and industries taking advantage of the proximity to several transport modes, including air, sea, rail and road. Along the Princes Highway are the predominantly medium density residential suburbs of Sydenham and Tempe, south to Rockdale which are dispersed with higher density residential and commercial precincts.

Parks, sports fields and associated facilities have developed within and adjacent to the route from its start in the north to Sans Souci. Particular uses include the Kogarah Golf Course and parks (such as Scarborough, Bicentennial and Bona) as well as many sporting fields and recreational activities such as horse riding, walking, sightseeing, bowling, picnicking and cycling. The corridor is also used as an educational resource. Rockdale City Council has recognised the multiple environmental and community values associated with the corridor and has developed a Rockdale Wetlands and Recreation Corridor Management Strategy to guide its future usage.

The southern portion of the corridor crosses the Georges River and passes through the suburbs of Taren Point, Miranda, Gymea through to the Royal National Park. schools, sports fields, a golf course, parklands and a caravan park.

Sutherland Shire has also included the corridor in their Greenweb strategy, a strategy to protect and enhance vegetation and habitat corridors that exist throughout the Shire.

To this effect, the corridor has largely become part of the urban and social fabric of these suburbs and their communities. The corridor provides for a range of recreational activities and contributes to the local amenity of many residential areas. Its community and environmental values have been recognised by local councils.

3.2 Overview of Environmental Characteristics

The wetland, hydrology, flora and fauna, noise, visual heritage and air quality characteristics in the corridor are briefly outlined below.

3.2.1 Wetlands

There are wetlands located within the F6 reservation and corridor study area. These wetlands include both freshwater and estuarine environments, and comprise natural creek and gully lines, tidal estuaries and freshwater ponds and drains. These wetlands support a diverse range of flora and fauna, contribute to maintenance of water quality, nutrient recycling, flood mitigation and are most often associated with recreational open space and facilities. All types of wetlands within the Sydney Basin have been much reduced in size, and those remaining are generally degraded by urban development. As a result, there is much interest in the conservation of remaining wetlands.

The Rockdale Wetlands and Recreation Corridor is a significant area of wetlands, remnant bushland and open space that forms an almost continuous link from the Cooks River south to the Georges River (*Figure 3.1*) (Rockdale City Council, 2000). The northern portion of the Corridor drains north into the Cooks River and comprises Muddy Creek and Eve Street Wetlands, including Spring Creek and Landing Lights wetlands. These wetlands are a mixture of brackish and freshwater wetlands. The central portion of the Wetlands and Recreation Corridor is made up of wetland depressions associated with Kings Wetland in Rockdale and Scarborough Ponds and Patmore Swamp in Monterey. The central freshwater wetlands drain east into Botany Bay. At the southern end of the Wetlands and Recreation Corridor is San Souci Drain number 2, a stormwater drain carrying fresh water into the Georges to the south.

South of the Captain Cook Bridge, tidal river estuaries are found within the study area at Sylvania Waters adjacent to Gwawley Park and Forshaw Field and at Taren Point, near Production Road. These estuaries drain north into the Georges River (*Figure 3.2*). In addition, the Georges River itself is an important wetland environment.

The southern end of the study area, from Gymea to Royal National Park is characterised by deep sandstone gullies and ephemeral streams. Savilles Creek and Dents Creek and other creeks and gullies draining into the Port Hacking River and would be expected to support some ephemeral freshwater wetlands.

All of the wetland environments within the study area are degraded. Many of the wetlands associated with the Rockdale Corridor have been substantially altered, by land filling low lying areas and dredging watercourses and by formation of concrete drains and artificial ponds. These areas are also subject to pressures from adjacent residential and industrial land uses, resulting in the introduction of exotic plant and animal species, rubbish dumping and water contamination by a range of pollutants. The watercourses in the Kirrawee and Gymea area are in a relatively natural state, but have been subject to weed invasion, rubbish dumping, poor water quality and erosion.

Cultural heritage
Bushland, wetlands and buffer
Other recreational open space
Threatened species and buffer
Significant group of trees or vegetation
Significant tree
Significant landform
Riparian zone
Major employment, commercial, education or other visitation focus

N

Scale 0 1.0 2.0 3.0 Kilometres

Figure 3.1 **ENVIRONMENTAL CONSTRAINTS, NORTH OF GEORGES RIVER**

Source: Rockdale City Council, State of the Environmebnt Report, 1999-2000.
Rockdale Wetlands and Recreation Corridor Management Strategy.

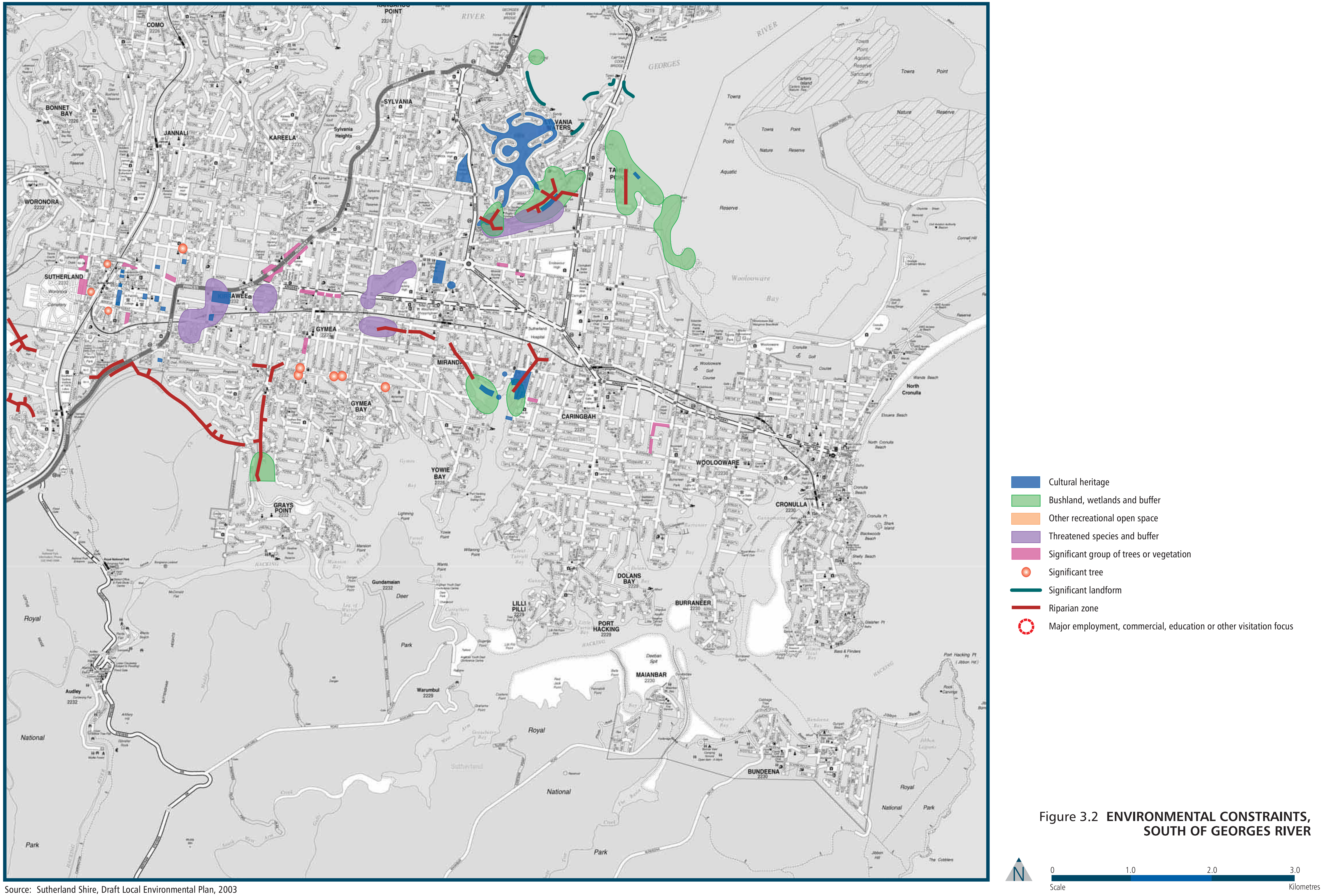


Figure 3.2 **ENVIRONMENTAL CONSTRAINTS, SOUTH OF GEORGES RIVER**

Source: Sutherland Shire, Draft Local Environmental Plan, 2003

3.2.2 Hydrology and Geology

The hydrology of the study area, and in particular the F6 corridor, is influenced by its geology and topography. The major features of the hydrology of the study area from north to south are:

- the low lying alluvial areas in the north associated with the confluence of the Cooks River and Botany Bay that have been substantially altered due to land filling;
- the shallow lakes and low-lying swamp lands that lie in a north-south line between the Botany Bay sand dune system to the east and a sandstone ridge that runs between the Cooks and Georges River to the west;
- the Georges River and its estuaries and tributaries; and
- the Hawkesbury sandstone ridges and deeper gullies in the south west, which to the south form tributaries of the Hacking River.

In the low lying northern portion of the study area, from St Peters to areas just south of the Cooks River, the hydrology is much modified as a result of its history of land filling, dredging and formation of channels. Prior to substantial modification, the landscape here would have been level to undulating alluvial floodplain dominated by tidal estuaries and salt marsh. The geology would have been silty to peaty quartz sand and medium to fine marine sand.

Further south, freshwater and brackish shallow lakes and low-lying swamps dominate the hydrology. This area corresponds with the Rockdale Wetlands and Recreation Corridor. Due to the Botany Bay dune system to the east forming a natural barrier, the northern portion of this swampy area flows to the north into the Cooks River and Botany Bay. The central portion of the corridor flows east directly into Botany Bay through a constructed drain. The southern end drains south into the Georges River. The dredging of wetlands and the formation of deeper ponds and channels, land filling activities and adjacent urban development has substantially altered the hydrology of this area. While the area does retain some wetland environmental values, the hydrological system has been modified to deal with stormwater events in an urban environment.

In the Sutherland Shire, the F6 reservation rises from the Georges River and coastal estuaries, through shale-based soils on the intermediate slopes, to sandstone ridges in the south west, where the catchment changes from the Georges River to the Hacking River. The sandstone-dominated areas of Gymea and Kirrawee have more deeply divided gullies and shallower soils. The transition between Georges River and Hacking River catchments is approximately where the F6 reservation crosses the Kingsway, Miranda. The hydrology of this area more closely resembles its natural state as a result of less densely built up areas and less disturbance of natural watercourses. However, the hydrology has been altered by the urban development and stormwater infrastructure.

3.2.3 Flora and Fauna

The flora and fauna of the study area is greatly influenced by its urban nature. Except for the areas within the Royal National Park at the southern end of the study area, the flora and fauna habitats are highly fragmented and subject to exotic plant and animal invasion and human disturbance. Native flora and fauna species within these areas are generally highly adaptable species and common. However, urban habitats can be of special significance, supporting threatened species, populations and communities. The areas that support significant populations of flora and fauna, from north to south are those associated with the Rockdale Wetlands and Recreation Corridor, specifically Eve Street, Marsh Street and Landing Lights wetlands at Arncliffe, Kings Wetlands Rockdale, Patmore Swamp and Scarborough Ponds Monterey, Leo Smith Reserve/ Hawthorn Street Ramsgate and Bona Park and adjacent areas at San Souci (*Figure 3.1*).

Within Sutherland Shire there are threatened vegetation communities associated with wetlands at Sylvania Waters and at Miranda and Kirrawee (*Figure 3.2*). Sutherland Shire Council recognises the flora and fauna values of the F6 reservation by including it as an integral part of their Greenweb strategy; a strategy to improve existing bushland vegetation corridors by increasing the quality and number of linkages within the Shire.

The Eve Street and Marsh Street wetlands, Arncliffe, comprise a large area of reclaimed and disused land, stormwater facilities and water canal between the Kogarah Golf Course and Barton Park. The wetlands include both freshwater and estuarine environments, are all highly artificial and subject to exotic plant and animal invasion, rubbish dumping and water pollution. They are variously disturbed and fragmented by the M5 East and the South Western Suburbs Outfall Sewer (SWSOOS). However, the area contains the only extant population of the endangered Green and Golden Bell Frog (Litoria aurea) in the St. George area. Also, the Eve Street estuarine wetland is a well known habitat for protected migratory bird species.

The Landing Lights wetland, Banksia, is a mixture of wetland types that exist within a strip of highly disturbed land that runs parallel with the Spring Street Canal towards Muddy Creek. The largely reclaimed land was cleared for the installation of landing lights for nearby Sydney Airport, and has regenerated over time. The area is low lying and subject to periodic inundation by salt water during particularly high tides. This has resulted in the development of a narrow salt marsh area at the western end that is foraging habitat for a number of protected migratory birds.

Kings Wetland, Brighton-Le-Sands, includes an isolated remnant of Flood Plain Forest. It is between industrial and residential land and divided by tracks, land reclamation and invasion of exotic trees. It does provide habitat for native birds and forms part of the wetlands corridor.

The Patmore Swamp and Scarborough Ponds, Monterey, have been highly modified. Dredging of Scarborough Ponds and land filling has fragmented and much reduced the wetlands area. However, the area does provide reasonable habitat for a range water birds.

The Leo Smith Reserve and associated Hawthorn Street Natural Area, Ramsgate, lies at the southern end of Scarborough Park, and is the most intact example of remnant vegetation within the Rockdale portion of the study area. The area has escaped many of the land use changes that have compromised other conservation areas. A range of habitats are present in the natural area and these include the only remaining Kurnell Dune Forest away from the Kurnell peninsula, Flood Plain Forest, a tidal creek and freshwater lagoon The site contains a range of animal and plant species and is home to a threatened species of bat, the Mouse-eared Fishing Bat Myotis adversus (also called the Large-footed Myotis).

Bona Park and the Ritchie Street/ Russel Avenue area in San Souci consist of remnants of a meandering creek and flood plain. Lower sections have been dredged to form a single channel. A variety of aquatic habitats are present including ephemeral wetlands, a freshwater creek that becomes more brackish and tidal further south before draining into the Georges River. The ephemeral freshwater wetlands in particular provide habitat for breeding for birds and frogs despite much of the surrounding native vegetation having been cleared and the area subject to exotic weed invasion and disturbance. The Russell Avenue south area supports the only remaining habitat for Green Tree Frogs (Litoria caerulea) in the St George District (Rockdale City Council 2000). This species and this population are of local significance but are not listed in the Threatened Species Conservation Act 1995.

The wetlands at the southern side of Sylvania Waters are associated with Gwawley Park and Forshaw Field. This estuarine area has been subject to disturbance and land filling, but is marked within the Sutherland Shire Draft Local Environmental Plan 2003 as a threatened species buffer zone. The area contains Sydney Coastal Estuary Swamp Forest Complex in more saline areas, with transition to remnant Sydney Coastal Riverflat Forest on higher areas. Both of these communities are listed under the Threatened Species Conservation Act as endangered ecological communities. The Sydney Coastal Estuary Swamp Forest Complex community occurs on waterlogged estuarine alluvial soils influenced by periodic saline conditions. Of particular importance to fauna is the winter flowering Swamp Mahogany Eucalyptus robusta. Threatened species such as the Australasian Bittern Botaurus poiciloptilus and the Large-footed Myotis Myotis adversus are likely to use these areas as habitat. The area also has significant areas of regenerating mangrove Avicennia marina which is protected under the Fisheries Management Act due to its importance as fish breeding habitat and other environmental values.

Areas marked as threatened species buffer zone within the Sutherland Shire Draft Local Environmental Plan 2003 at Miranda and Kirrawee also contain scheduled endangered ecological communities. This area is characterised by a change from the sandstone-based geology to the south and south west and the shale derived soils to the north east. On the sandstone ridge tops at Kirrawee, Gymea and Miranda remnants of Sandstone Shale Transition Forest are found. Sydney Turpentine Ironbark Forest remnants are also found, mainly existing as scattered trees on the more shale-based soil types. The F6 reservation near the corner of Kingsway and Sylvania Road for example, contains single remnant Ironbark trees (Eucalyptus paniculata), with the number of Turpentine (Syncarpia glomulifera) increasing to the north east on the lower slopes.

3.2.4 Noise

The noise environment of the study area is typical of urban areas. The factors that affect the noise character of the northern portion of the study area are the transport and industrial related land uses of adjacent areas. The suburbs within the study area in Marrickville Local Government Area, and areas in the northern portion of Rockdale City Council area would be subject to noise impacts from air traffic from Sydney Airport, and road and rail traffic at particular locations. There is a greater concentration of transport and industrial activity in this area. Further south in suburban environs within Rockdale and Sutherland Local Government Areas, there is a much quieter noise environment. Sources of noise, however, can be found around major transport and industrial/commercial centres such as Princes Highway, The Grand Parade and General Holmes Drive, President Avenue Kogarah, Rocky Point Road, Rockdale commercial district, Taren Point Road, Miranda Commercial district, Kingsway, the Boulevarde and Port Hacking Road.

3.2.5 Visual Impacts

The F6 reservation has been retained as a future road alignment and is used as open space along the majority of the reservation. In addition to the recreational opportunities that this provides to the community, there is also a valuable contribution that this open space makes to the visual amenity of the area. The open space provides for particular views at key locations, which contributes to the sense of place and character of the location. Locations where the visual character is strongly related to the open space provided by the F6 reservation include lands within the Rockdale Wetlands and Recreation Corridor that correspond with roads, such President Avenue Kogarah. The visual amenity for individual adjacent landholders is greatly enhanced by the current open space character of the F6 reservation.

3.2.6 Heritage

Within the Rockdale Local Government Area, the F6 corridor contains little evidence of its long Aboriginal and more recent European history. This is due partly to the significant modifications to the land within the corridor. The areas that have been identified as having cultural heritage focus within the Rockdale Wetlands and Recreation Corridor are shown in *Figure 3.1*, and include three areas of market gardens and Wilson's Farm. These areas all provide evidence of the local area's long association with providing food for a growing city. There are other features of heritage significance adjacent to the corridor within Rockdale, including heritage buildings such as the old tram stop in San Souci.

The Sutherland Shire's Draft Local Environmental Plan 2003 identifies areas of heritage significance, including trees and groups of trees and landforms. The locations have been identified in *Figure 3.2*. Those features and items that are of relevance include the 1965-built Captains Cook Bridge and its southern approach and Taren Point foreshores. Also, the areas adjacent to Gwawley Park Sylvania Waters and Captain Cook Golf Course show evidence of Aboriginal occupation in association with the nearby estuaries. Within the Shire there are a range of buildings and structures of more recent development, including a stone arch bridge, North West Arm Road, Gymea. There are also a number of individual and groups of trees that are of cultural and/or natural heritage value scattered throughout the suburbs, particularly on the higher on the sandstone ridges at Gymea, Kirrawee and Sutherland. The F6 corridor corresponds with a group of trees adjacent to Gymea Bay Road South, Gymea.

3.2.7 Air

Air quality in Sydney is a significant issue, as in most large cities, due significantly to increasing population and high reliance on motor vehicles. Air quality is also influenced at a local and regional level by atmospheric conditions and geographic constraints to air movements. Around 1.2 million tonnes of pollutants enter Sydney's air each year, of which motor vehicles are responsible for about 75% (Rockdale City Council – State of the Environment Report 1999-2000). Other sources of pollutants are industrial, commercial and domestic activities.

The Sydney airshed is located in the valleys and estuaries of the Georges, Parramatta and Hawkesbury-Nepean Rivers and surrounded to the west and south by mountains. The movement and concentration and dispersion of pollutants in the Sydney airshed is a result of interactions between the physical character and atmospheric conditions. Of particular interest to the southern Sydney region are airflows that occur from approximately 11 am onwards, where onshore breezes can bring already polluted air into the area, for a period well into the afternoon. The pollution is from the morning peak hour and in some cases from recirculated air from the previous day. This polluted air is pushed further west and will settle in the Hawkesbury Basin.

Factors that place pressure on the air quality within the northern portion of the study area include Sydney Airport, motor vehicles, industrial, commercial and domestic air pollution, including wood burning heating in winter. Further south, air quality impacts from Sydney Airport are diminished.

4. Transport Context

4.1 Existing Transport

4.1.1 Road Transport

There are increasing community concerns over the quality of life impacts of increasing transport demands and resulting congestion in the corridor.

The area surrounding the F6 reservation experiences demands for travel to major trip generators in the region and through traffic from the southern regions of Sydney and the Illawarra accessing the CBD, Eastern Sydney and the airport precinct.

The Metroad 1 route in this area follows the Princes Highway, President Avenue, The Grand Parade, and General Holmes Drive. Metroad 1 is the current route that has the most in common with the F6 alignment. Metroad 1 has the highest movement of vehicles within the corridor, with an Average Annual Daily Traffic (AADT) of over 87,000 in 2002 at the Tom Ugly's Bridge, which is a slight reduction from 1999 flows (approximately 900 vehicles). However, traffic has increased at this bridge by about 20% since 1991, while traffic at the Captain Cook Bridge has only grown by 7% (to around 59,800) over the same period. The most significant traffic change in the region has come as a result of the opening of the M5 East freeway which has seen traffic on General Holmes Drive, at the airport tunnel, grow by almost 53% to 133,400 (1999 to 2002). While there has been a significant increase at this point, the data shows that there has been a reduction in traffic flow on nearby north-south arteries. In particular, traffic on General Holmes Drive (at Brighton Le-Sands) has reduced by 4.5% since 1999 to 66,300 AADT and on the Princes Highway at Banksia by 3.5% to almost 36,800 AADT over the same period. These changes highlight the general shift in traffic patterns that would be expected with the introduction of such a major piece of transport infrastructure as the M5 East.

North of the Georges River two major north south arterials serve through trips which originate in Sutherland Shire and the Illawarra as well as those which originate locally. Heavy traffic flows are experienced on east-west streets, with a large proportion of these trips likely to be associated with vehicles (both local and through) seeking to use General Holmes Drive rather than the Princes Highway for north/south travel beyond the study area. It is noted that this study has not included traffic network modelling or the detailed examination of traffic flows, which may have provided a greater insight into vehicle trips and their origins and destinations.

In general terms, the geography of the area influences travel opportunities and impacts. In particular, the two major water crossings (the Georges and Cooks Rivers) significantly constrain north/south road capacity. While this study has not included traffic modelling of the road network in the region, it is clear that the major north/south arterial roads are subject to significant demands and are capacity constrained. Further increases in demand for travel would further stress the system pointing to the need to consider the potential for public transport to take on a larger role in the overall transport task.

4.1.2 Rail Transport

The Illawarra Line and the Easter Suburbs Railway connects Waterfall in the South with Bondi Junction in the Eastern Suburbs of Sydney. The Illawarra Railway Line connects to the South Coast Rail Line at Waterfall, which continues to Wollongong and Bomaderry and to the Cronulla Branch Line at Sutherland.

The Illawarra Line runs parallel to and in the proximity of the F6 corridor. Carlton, Kogarah, Rockdale and Banksia Station catchments overlap with the catchment which would potentially be attributable to public transport in the F6 Corridor. The F6 Corridor crosses the Cronulla Line between Miranda and Gymea Stations.

Infrastructure

Figure 4.1 shows the diagrammatic lay-out of the network between Waterfall and Sydenham. The diagram shows the Illawarra Line, the Cronulla Branch Line and the Airport Line complete with all junctions and stations. The following infrastructure features are relevant for the F6 transport corridor:

- there is no track junction between the Airport Line and the Illawarra Line: the Airport Line crosses the Illawarra Line at Wolli Creek and connects directly to the East Hills Line at Turrella;
- passenger interchange is possible between the Airport Line and the Illawarra Line at Wolli Creek Station;
- the Illawarra Line is dual track from Sutherland to Hurstville where it branches into quad track (Illawarra Main and Local Lines);
- from Hurstville to Erskineville Junction the Illawarra Line is quad-track (Locals and Mains);
- at Erskineville Junction, two lines (the Up and Down Illawarra Relief Lines) branch off to Bondi Junction to connect to the Eastern Suburbs Railway (shown in *Figure 4.1*) effectively providing six tracks (Locals, Mains and Reliefs);
- the dual-track East Hills Line joins the quad-track Illawarra Line at Wolli Creek; and
- the dual-track Bankstown Line joins the Illawarra Line at Sydenham.

Service Structure

The Illawarra Line accommodates trains in two generalised services[1]:

- South Coast inter-city services that originate south of Waterfall (Bomaderry, Dapto, Port Kembla) and run into the inter-city platforms at Sydney Terminal with the odd exception;

[1] *The Airport, South Coast and Illawarra Line timetables are complex with a wide variety of stopping patterns, and this discussion is not intended to be an exhaustive review of the timetable but to give the reader a general overview of the service structure.*

- Illawarra/ESR services that originate at Cronulla, Waterfall or Sutherland and generally (with the odd exception) run through to Bondi Junction.

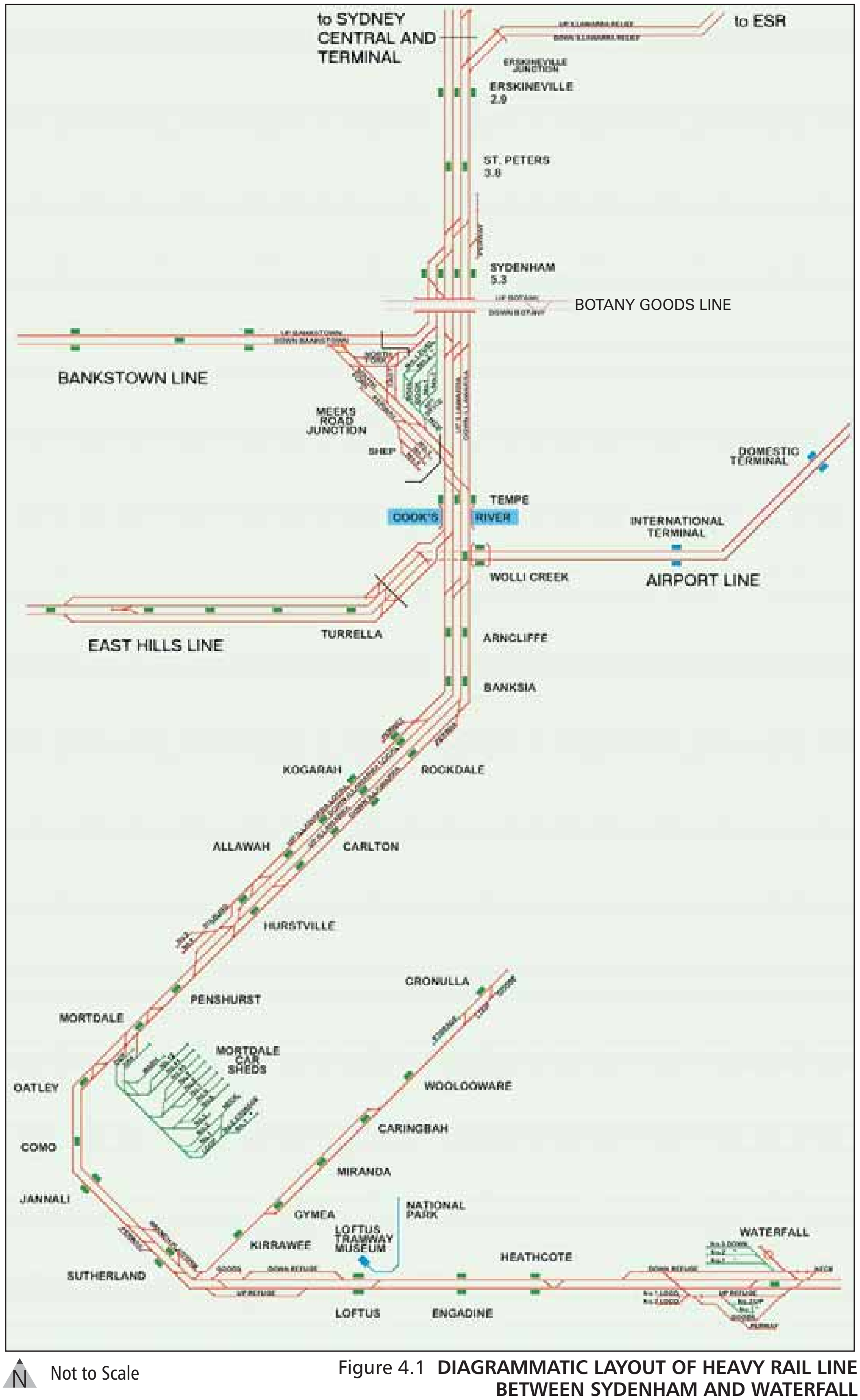


Figure 4.1 **DIAGRAMMATIC LAYOUT OF HEAVY RAIL LINE BETWEEN SYDENHAM AND WATERFALL**

Between Sutherland and Hurstville the Illawarra Mains (dual track) accommodate demand from all the South Coast Services as well as the Illawarra/ESR services from Cronulla, Waterfall and Sutherland. North of Hurstville, the Illawarra Local lines are added to increase track capacity. However, demand is added at Wolli Creek (East Hills Line) and at Sydenham (Bankstown Line). Relief is provided at Erskineville Junction where the (aptly named) Illawarra Relief Lines Branch off to Bondi Junction with the bulk of the Illawarra/ESR services, leaving the South Coast, East Hills and Bankstown trains to continue along the Illawarra Mains and Locals to Sydney Central or Sydney Terminal (via the Illawarra Dives).

The Airport Line (New Southern Railway) is dual tracked and links to the City Circle at Central and to the East Hills Line at Wolli Creek. Services on the Airport Line are timetabled to and from Town Hall Station via the City Circle and stop at all City Circle stations as well as all stations on the Airport Line (Green Square, Domestic Terminal, International Terminal and Wolli Creek). Beyond Wolli Creek services via the Airport Line follow a complex stopping pattern on the East Hills Line and may terminate at Turrella, East Hills or MacArthur Stations.

With the possible exception of Wolli Creek Station, the current services on the Airport Line do not cater for demand from the F6 Corridor area as the line essentially crosses the corridor at right angles. Our discussion below of existing rail infrastructure and its constraint therefore focuses on the Illawarra Line and the demand relief that may be provided by a public transport service in the F6 Corridor.

Infrastructure Constraints

The principal constraints on the Illawarra Line are:

- the dual-track section between Sutherland and Hurstville which carries the Illawarra/ESR and South Coast Services; and
- the quad-track section between Wolli Creek and Erskineville Junction where East Hills services as well as Bankstown services (Sydenham-Erskineville) are added to the Illawarra/ESR and South Coast trains.

Illawarra/ESR services now run at a peak frequency of around fourteen trains per hour (a train every four minutes or so) but are nevertheless unable to fully cope with passenger demand. Overcrowding is common and CityRail's target maximum load of 130% of seated capacity is often exceeded during the peak periods. More Illawarra/ESR services are needed, but amplifying the track capacity between Sutherland and Erskineville Junction in itself does not provide a solution as the ESR is also currently capacity constrained to fourteen trains per hour due to turnback arrangements. Consequently, StateRail had developed a programme of infrastructure enhancements that will progressively increase track capacity on the Illawarra Line and ESR. These works include:

- upgrading the turnback infrastructure at Bondi Junction to increase reliable capacity on the ESR to 20 trains per hour and scheduled for completion by 2005;
- progressive duplication of the Cronulla Branch Line, to be completed by 2008; and

- progressive track amplification between Sydenham and Erskineville Junction and south of Hurstville to eliminate bottlenecks (completion by 2009/10); along with
- ongoing improvements to junctions, signalling and stations.

These infrastructure enhancements have, to a large extent, been incorporated in the NSW Government's "Rail Clearways" programme, publicly announced on 21 October 2004 by the Minister for Transport Services.

Capacity on the Airport Line is constrained by congestion on the City Circle and the East Hills Line. Adding any new rail services from a future heavy rail line in the F6 Corridor to the Airport Line will need to take these constraints into account.

Rail Clearways Plan

According to the CityRail website (CityRail, 2004), "The NSW Government's Rail Clearways plan is a $1 billion initiative of the NSW Government to improve capacity and reliability on CityRail's Sydney suburban network, presently recognised as one of the most complex in the world."

The website further states that "Due for completion in 2010, the Rail Clearways plan comprises 15 key projects that will separate the network's 14 metropolitan rail routes into five independent clearways. These projects will remove bottlenecks and junctions, reduce congestion and delays, and allow for simpler timetables for more reliable and frequent services." *Figure 4.2* below, obtained from the CityRail website, shows the proposed clearways projects. The media release announcing the clearways plan is contained in *Appendix A*.

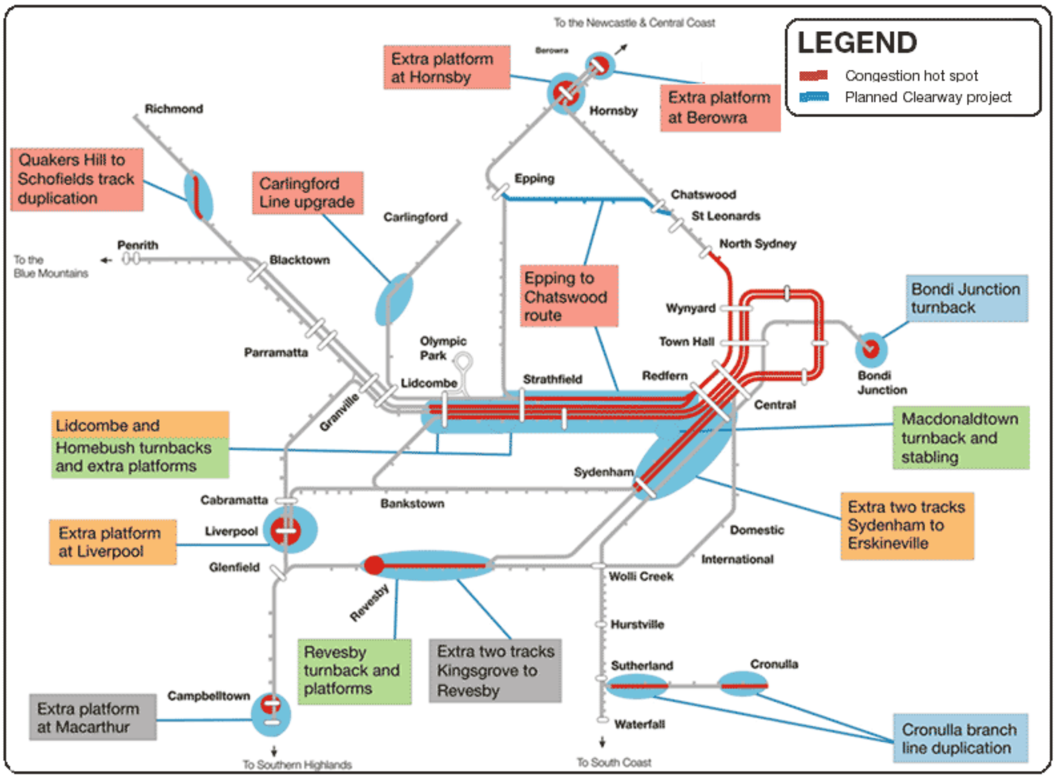


Figure 4.2: Proposed Rail Clearways Projects

The Illawarra Line forms part of "Clearway 1 – Illawarra and ESR" and three of the 15 proposed Clearways projects, the Cronulla branch line duplication, two extra tracks between Sydenham and Erskineville and the Bondi Junction Turnback, directly affect capacity on this Clearway.

Rail in the Long Term

The Christie Report tabled in the NSW Parliament in 2002 (but not endorsed by the State Government) includes plans beyond 2021 for a Cronulla – Miranda – Metro West – Dee Why line as a separate new operational sector. The first stage of this line is described as a possible section along the F6 corridor to Sydney Airport's International Terminal Station, initially with light rail operation and later with heavy rail. The Miranda – Airport – City corridor could potentially provide relief for the Illawarra Line, which by then is likely to be severely capacity constrained.

4.1.3 Bus Services

Connex and the State Transit Authority (STA) are the main services operators of local bus services along the F5 corridor. The STA runs a number of local bus services north of the Georges River. The private operator Connex also has a number of services within the corridor primarily servicing areas to the south and east from Hurstville rail station. The key destinations for bus routes in this area are Kogarah and Rockdale rail stations. Ramsgate and Sans Souci are well served by buses to Rockdale and Kogarah rail stations and Rockdale Plaza, both in frequency and coverage. frequent services operate between Brighton Le Sands and Rockdale rail station.

Private operators run the majority of local bus services south of the Georges River. The operators include Connex (which has the most services), Caringbah Bus Service, and Bus Link Crowthers. The key destinations for buses originating in this area are Miranda, Sutherland and Hurstville rail stations and shopping centres.

Cross-regional services currently operate between Miranda and Rockdale, Miranda and Hurstville, Burwood and Bondi Junction via Rockdale, Sans Souci and the CBD, Sutherland and Padstow. They provide key connections to the rail network and destinations between the major centres. There are currently no bus priority initiatives in the F6 Corridor. *Figure 4.3* and *4.4* show the current bus route structure for the study area. A summary of bus services is included in *Appendix E*.

On 17 March 2004 the Ministerial Review of Bus Services in New South Wales (the" Unsworth Report") (Unsworth, 2004) was released. It recommended, inter alia, that "The Government should progressively implement, for Sydney, Wollongong, Newcastle and the Central Coast, a network of viable strategic corridors to provide fast, frequent, direct and convenient links to regional centres. The identification of suitable corridors should be finalised on the basis of patronage modelling results and stakeholder inputs". The NSW Government, in its response, stated that "The concept of strategic corridors is supported. Those strategic corridors that will have the greatest patronage impact should be introduced first, subject to funding availability". The Unsworth report further indicates that two of the proposed strategic corridors might make operate generally in close proximity to the F6 corridor:

- Route 21 from Miranda to the City;
- Route 29 Bondi Junction to Burwood; and
- Route 30 from Hurstville to Bondi Junction.

The map of proposed Sydney Metropolitan Bus Corridors is included as Figure 4.5.

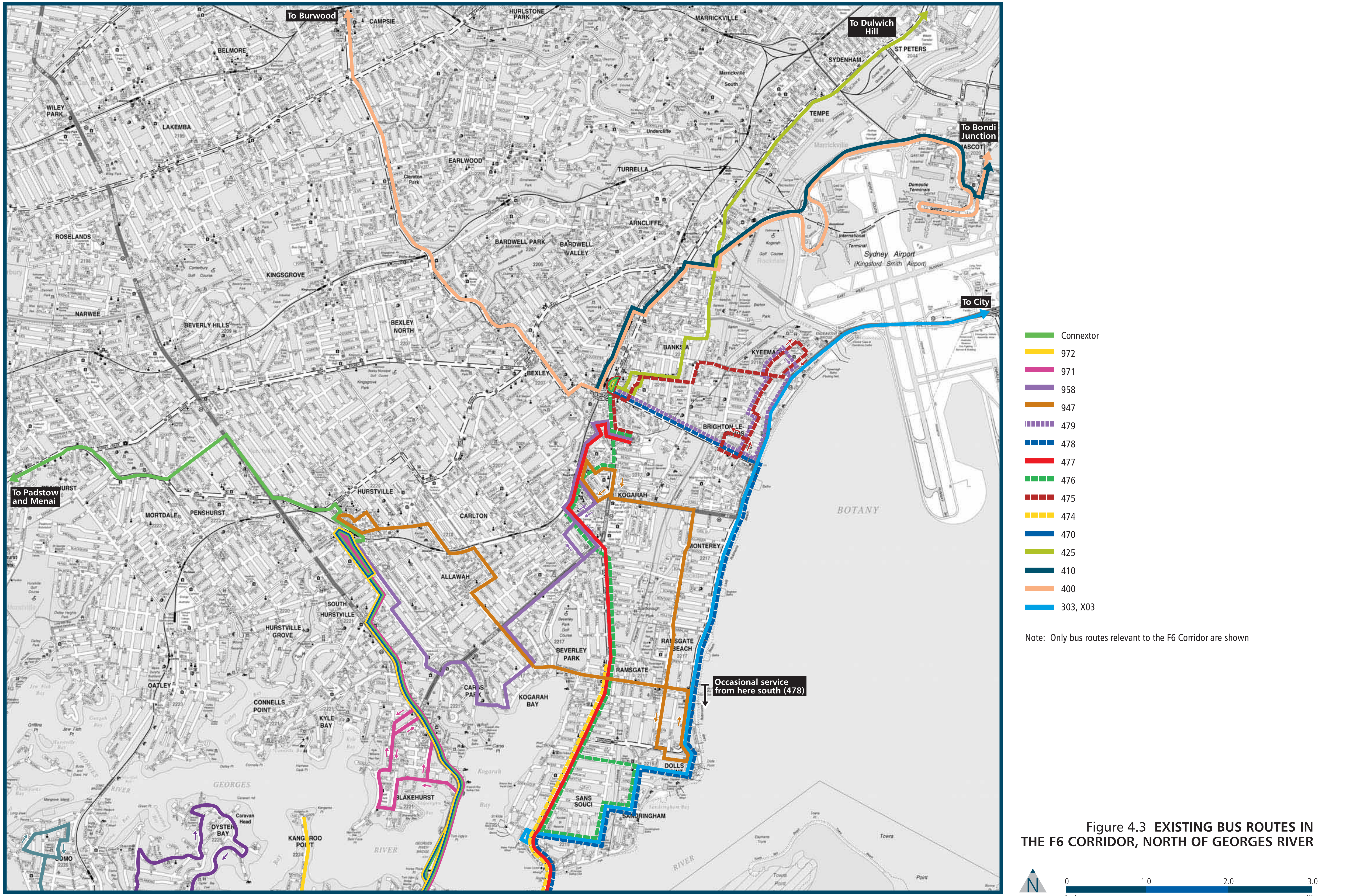


Figure 4.3 **EXISTING BUS ROUTES IN THE F6 CORRIDOR, NORTH OF GEORGES RIVER**

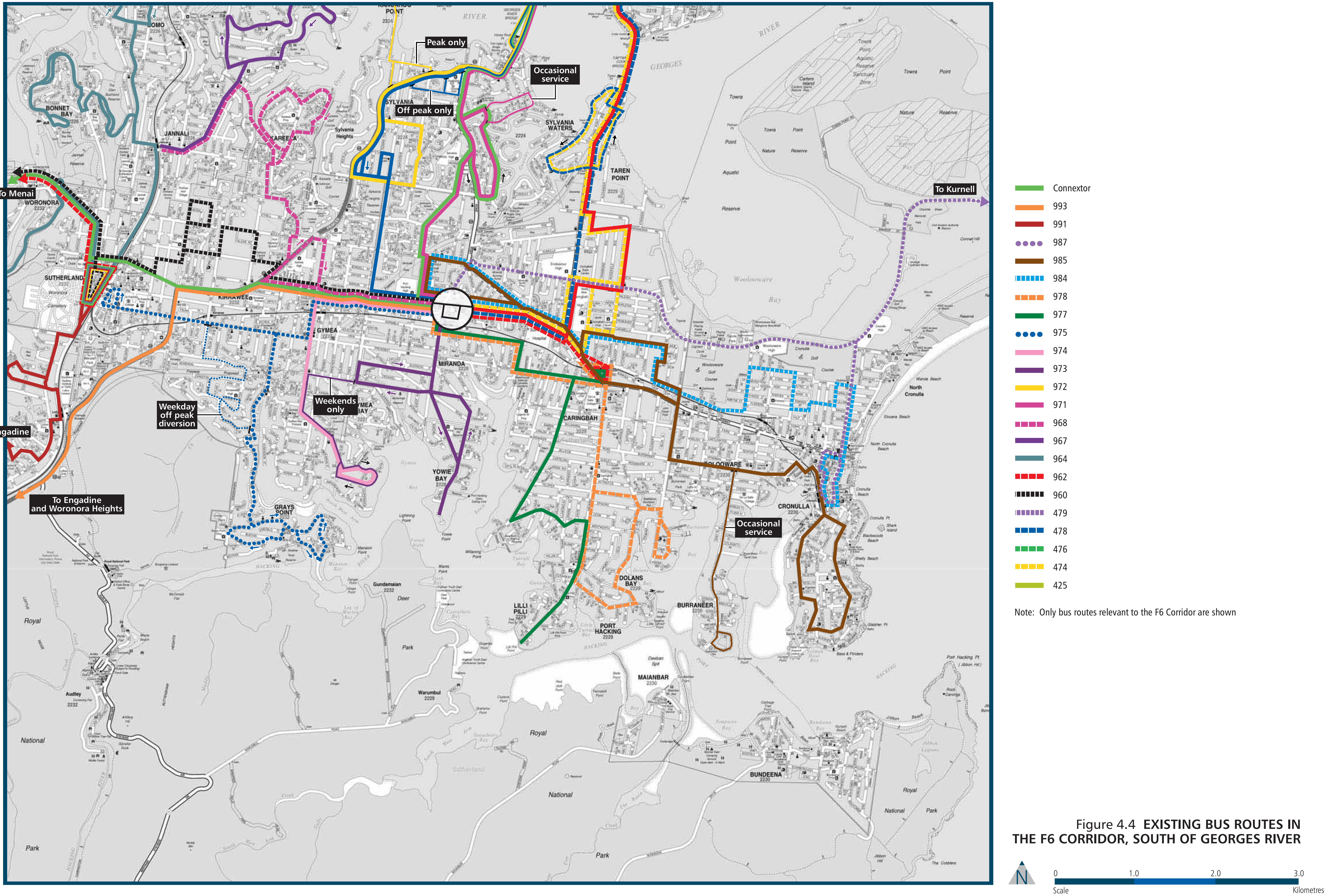
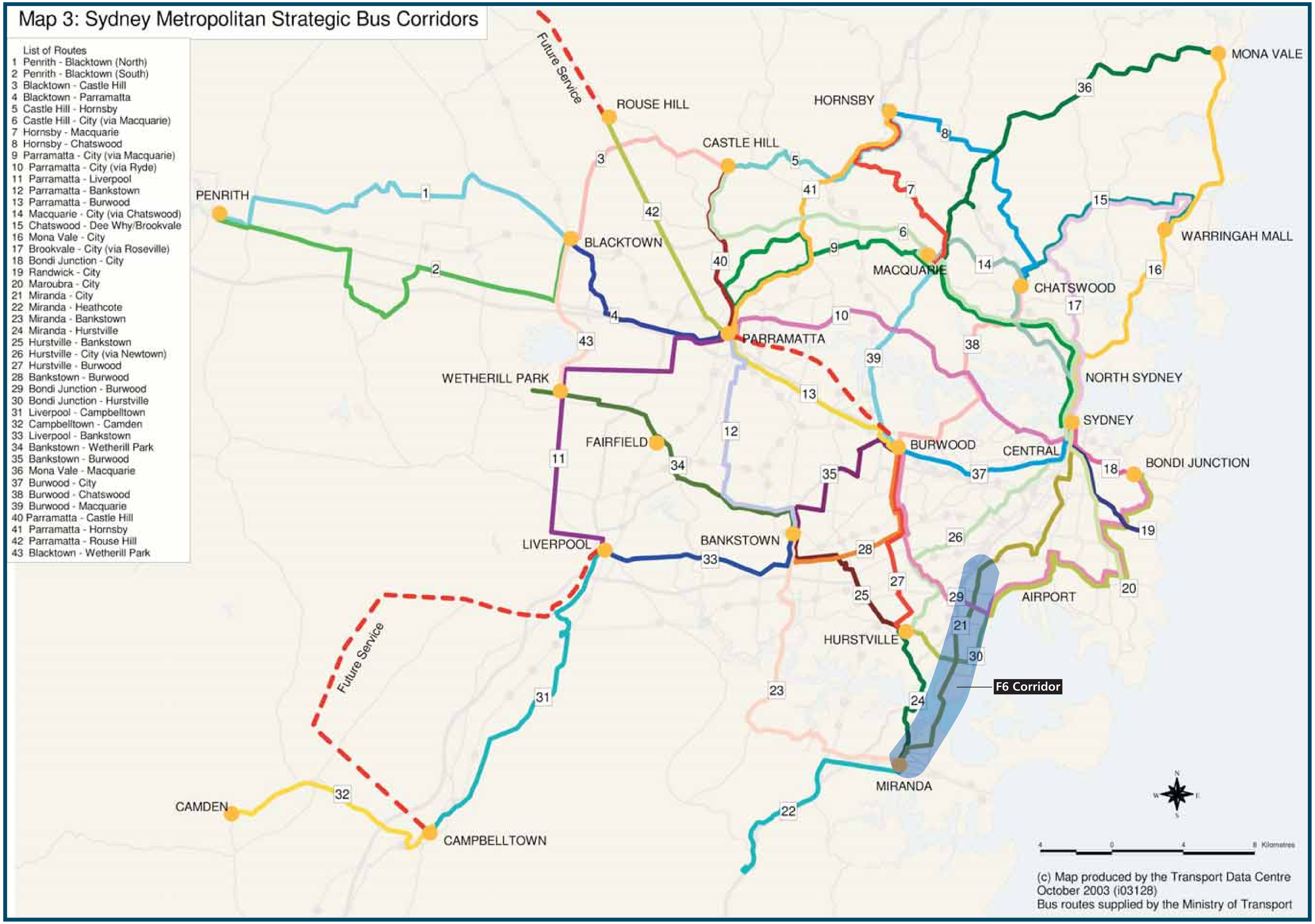


Figure 4.4 **EXISTING BUS ROUTES IN THE F6 CORRIDOR, SOUTH OF GEORGES RIVER**



Map derived from Ministerial Review of Bus Services (Unsworth Report)

Figure 4.5 **METROPOLITAN STRATEGIC BUS CORRIDORS**

4.2 Travel from the Wollongong Region

4.2.1 Travel between Wollongong and Sydney

Table 4.1 shows that at the time of the 2001 census, 15 percent of Wollongong region's workforce (Wollongong, Kiama and Shellharbour LGAs) travel to Sydney for jobs - this represents about 15,700 trips.

Table 4.1: Work Travel to Sydney from the Wollongong Region (2001)

SLA	Workplace in Sydney SD	Total Workforce	% of Workforce in Sydney SD
Wollongong	13,361	72,417	18.5
Shellharbour	1,846	22,546	8.2
Kiama	481	7,762	6.2
TOTAL	15,688	102,725	15.3

Source: 2001 Journey to Work Data, TPDC.

Of these, the local government areas with the largest number of trips from Wollongong were Sutherland Shire (3 percent of total Wollongong work trips) Sydney Inner (1.9 percent), South Sydney (1 percent) Sydney Remainder (0.9 percent), Campbelltown (0.9 percent), Wollondilly (0.7 percent) and Bankstown (0.6 percent). Commuters are more likely to be public transport users than those travelling for other purposes. Of those Wollongong residents employed in Sydney, approximately 20 percent travelled by train, an estimated 3,400 trips.

Table 4.2 shows the choice of rail for commuting trips from Wollongong to Sydney varies considerably according to the actual destination. The main destinations and their mode shares to train are shown in the table below. The mode share to train is higher for those destinations with longer travel times from Wollongong and with strong parking controls.

Table 4.2: Major Work destinations for Wollongong Commuters and Mode Share to Rail (2001 Census)

Destination	Mode Share by Train of all Trips from Wollongong to Destination
Sydney Inner	76%
Sydney Remainder	63%
South Sydney	38%
North Sydney	61%
Hurstville	38%
Sutherland East	10%
Kogarah	25%
Rockdale	23%
Sutherland West	6%

Source: 2001 Journey to Work Data, TPDC.

Existing and Future Rail Services

The Illawarra Rail Line is shared with the suburban trains to provide inter-urban services to Wollongong and the South Coast.

TMG International and PPK Environment and Infrastructure completed a Strategic Review of Rail Services from Sutherland to Wollongong for Rail Infrastructure Corporation in 2001. The review found a number of capacity constraints that limit operations to 15 trains per hour. The constraints would need to be addressed to allow an increase in demand for train paths from the South Coast. The constraints include:

- increasing the number of platforms and upgrading the freight refuges at Waterfall Station;
- relieving the capacity constraints between Sutherland and Hurstville;
- increasing capacity between Sydenham and Erskineville; and
- increasing the capacity of the turn-back at Bondi Junction.

These constraints were confirmed in an engineering assessment of the South Coast Railway Line by Connell Wagner in 2003. Three of these constraints are also recognised in the Government's Rail Clearways programme, previously discussed in *Section 4.1.2.*

CityRail Patronage Estimates

There are currently three services per hour that start south of Waterfall Station to enter the Illawarra Rail line with forecasts indicating that this would need to increase to four trains an hour by 2016. Assuming CitiRail's prediction of a 50 percent increase on the Illawarra line over the next years, the peak passenger flows would increase to six trains per hour north of Waterfall.

Future patronage for rail services from Wollongong would be influenced by:

- proposed improvements to the South Coast Rail Line that may reduce overall travel times by rail;
- road improvements such as the Menai by-pass, King Georges road upgrades that may improve travel conditions for car users and reduce rail patronage;
- an increase in the population of the Wollongong region;
- lower than anticipated increase in employment opportunities in Wollongong region

CityRail, in its long-term planning, has estimated that interurban patronage could increase by 50 percent in the next 20 years based on projection of its patronage growth over the five years to 2002. PPK patronage forecasts completed for Rail Infrastructure Corporation in 2002 (PPK, 2002) indicated that the CityRail projections may overestimate demand but still forecast that additional services would have to be added to the current services originating in the Illawarra to accommodate demand for travel between the Illawarra and the Sydney region. These conclusions were supported by the outcomes of further patronage studies undertaken by Halcrow in 2003 (Halcrow Rail, 2003).

Key Issues & Findings

The data previously summarised in *Table 4.1* and *Table 4.2* indicate that Wollongong residents that commute to Sydney have destinations across the metropolitan area but predominantly in the Sydney CBD, south and south-western Sydney. There is significant demand to major centres along the Illawarra line, including Sutherland, Hurstville and Rockdale. Consequently, it will be important that Wollongong trains continue to operate along the Illawarra Line in the long term. A public transport service from Wollongong through the F6 corridor would not add significantly to the quality of services to this region, as only a very small proportion of commuters have their destinations within the study area.

This conclusion suggests that even if a new rail line is developed in the F6 corridor, it is unlikely that there would be a requirement to connect it to the Illawarra line south of Sutherland to meet the needs of Wollongong travellers. However, one of the main advantages of developing public transport in the F6 corridor may well be the relief of capacity constraints on the Illawarra Line north of Sutherland, thereby freeing capacity to better serve the Wollongong region.

4.3 Road Network Proposals within the F6 Corridor

4.3.1 St Peters Industrial Route (SPIR) Corridor

A study establishing a future road corridor from Tempe to St Peters within the existing F6 County Road Corridor was completed by Kinhill for the RTA (Kinhill 1999). The new surface road is referred to as the St Peters Industrial Route or SPIRE, between Tempe and Campbell Road. The SPIRE connects the Princes Highway at Holbeach Avenue to Campbell Road at Euston Road and includes an upgrade of Campbell Road and a bridge structure across the Alexandra Canal with connections to Bourke Road and Gardeners Road.

The study identified a narrower road corridor and land within the F6 County Road reserve that was no longer required for road purposes and could be rezoned for other uses. The study was completed after the decision to relocate the M5 East Motorway via Arncliffe meant that the need to retain the Tempe County Road Corridor diminished. The local and State government agencies that own land within the corridor made representations to abandon the corridor. The study identified environmental and community issues relating to the design of a new road corridor and broadly identify relevant matters prior to further analysis and public exhibition phases as requiring when rezoning land. The study findings identified 14 hectares of land that would no longer be required for the road and would be available for rezoning.

Marrickville Council's preferred zoning for the 14 hectares of residual land is a balance of open space and viable industrial zoned land (Marrickville State of Environment Report, 2000).

The surplus F6 corridor land has not been rezoned in Council's current Local Environmental Plan and is currently zoned as a road reservation.

4.3.2 Miranda By-Pass

Miranda is a major regional centre and a focus for retail, commercial and residential activity in the Sutherland Shire. The Kingsway is one of the major east-west routes across the Shire and carries over 25,000 AADT (2002) in the vicinity of Miranda.

The Kingsway is a primary access road serving the town centre, Miranda Rail Station and Westfield Shoppingtown. Sutherland Council has prepared a masterplan for the Kingsway with the objective of reducing the amount of through traffic on the Kingsway and improving the level of street amenity in Miranda town centre in the vicinity of Westfield. This is achieved through the provision of a by-pass road to remove through traffic from the centre. Council's surveys showed that through traffic constituted an average of just over 50% of traffic within the centre between 7am and 5pm. The removal of this traffic made it possible to improve pedestrian facilities and enhanced accessibility for public transport.

While the plan was put before the People's LEP Advisory Committee in Sept 2002 where it was endorsed for exhibition, this has not yet occurred and Council has not adopted the proposal.

The plans show a possible alignment for a by-pass road linking between The Kingsway and The Boulevarde within the F6 reservation. The concept includes 2 traffic and 2 bus lanes. This section of the F6 reservation varies in width from about 150 metres near The Kingsway to around 85 metres close to The Boulevarde and is currently used as open space and sports fields. On this basis there is ample room to accommodate both a public transport function and the by-pass road and therefore it is considered that the reservation should be retained in this area pending resolution of the by-pass plans. Additionally, planning and design of facilities in this section should ensure that both functions are preserved. It is noted that there is no current RTA proposal to develop this by-pass.

4.3.3 Brighton By-Pass

During the course of this study it has become apparent that various proposals have emerged to develop a by-pass of Brighton-Le-Sands and the traffic congestion which develops around General Holmes Drive and Bay Street. In general terms, sections of the F6 corridor have been included in the by-pass proposals. There is no current RTA proposal to develop this by-pass.

4.4 A Road Reservation as a Public Transport Corridor

The F6 road reservation is 20km long and varies between 60 metres to 150 metres wide. It was designated to allow for a major road connection between the South of Sydney to the CBD. The reservation is of adequate width to design a major freeway with safe and efficient conditions. A major road connection optimises the movement of vehicles along the main corridor minimising the interruptions to traffic flow. Major freeways are designed with a generally straight alignment, broad sweeping curves, limited vertical alignment changes to ensure safe sight distances. Traffic is generally separated from adjacent land uses, avoiding activity centres. Vehicles travelling in the opposite direction and crossing traffic are typically separated, to facilitate higher speeds and increase safety.

A public transport corridor has different characteristics. In general, a public transport corridor can be designed to fit a much narrower width than a freeway or arterial road. Public transport infrastructure is designed to connect activity centres and maximise the accessibility of people along the corridor, integrating with surrounding land uses and traffic where appropriate. Public transport and vehicle access crossing the corridor are integrated to ensure increased connectivity and integration of services.

The characteristics of a major freeway and a public transport corridor are quite different. Therefore, careful consideration should be given to supportive land use, development, and integration issues if the development of the F6 reservation as a public transport corridor is pursued.

4.5 Summary of the Strategic Transport Context

The review of the strategic planning context and traffic and transport issues indicates that:

- the F6 Corridor is in a strategic location connecting the southern suburbs of Sydney, particularly in the Sutherland Shire to the inner city;
- the reservation is adjacent to various land uses including open space, recreation space, residential, industrial and education facilities;
- the land use adjacent to the corridor has generally "turned its back" on the space, and a future change to public transport use would be expected to see significant land use change (i.e. residential and commercial development would have to be planned closer to the corridor) in future years;
- existing transport corridors serving these areas (road and rail) are congested during peak periods;
- Sutherland Council has considered a proposal for a by-pass of Miranda town centre using a section of the F6 reservation;
- additional pressures for urban consolidation will continue;
- the congestion on the Illawarra Rail Line is like to increase and a rail line in the F6 corridor may free up some capacity on the Illawarra Line;
- even if a new rail line is developed in the F6 corridor, it is unlikely that there would be a requirement to connect it to the Illawarra Line south of Sutherland to meet the needs of Wollongong travellers; and
- employment growth in the catchment will add to transport demand across all modes.

5. Option Identification

5.1 Guiding Principles and Alignment Options Selection

The guiding principles were developed following consultations with the community and stakeholders along with a comprehensive review of background material.

A public transport system in the F6 corridor should follow these guiding principles:

- serve existing centres;
- integrate with existing public transport;
- integrate with land use;
- be competitive with private vehicle travel;
- conserve the quality of the environment;
- provide a high quality service;
- improve access in the corridor; and
- improve access between the corridor and surrounding land uses.

A series of sections were identified in the study area that reflected discrete parts of the corridor where there were potential options for the provision of public transport connections. Consideration was given to options in six sections along the corridor.

The sections were:

1. Princes Highway, Loftus to Cronulla Rail Line;
2. Cronulla Rail Line to Georges River;
3. Georges River to Sandringham St;
4. Sandringham St to Bay St;
5. Bay St to Cooks River; and
6. North of Cooks River.

The criteria for the initial options assessment were

- patronage potential;
- travel needs;
- engineering constraints; and
- environmental and open space impacts.

Options were developed based on stakeholder and community consultation and an understanding of the mode operations. Options were developed for a high capacity mode (heavy rail or metro) and medium capacity modes (light rail transit or bus based transit).

A series of options were developed for each section and discussed at the Reference Group meeting on 30 May 2003. The reference group acknowledged the alignment options for further assessment. These options are provide for:

- high capacity mode (such as heavy rail) with an alignment generally following the F6 corridor and connecting to the Cronulla line at Miranda. At the northern end options include a connection to the Illawarra line and the Airport Rail Link; and
- medium capacity mode (such as light rail or bus rapid transit) with an alignment generally following the F6 corridor, similar to the high capacity option with an additional option on streets adjacent to the corridor.

These options are discussed in more detail in Sections 5.3 and 5.4.

5.2 Opportunities and Constraints

5.2.1 Social Opportunities and Constraints

Broad opportunities and constraints relating to the social aspects of public transport options for the F6 corridor are outlined below. These opportunities and constraints would vary depending on the type of transport mode identified for the corridor, and would also differ during its construction and operational phases.

Social opportunities that may arise for the community with the development of public transport in the F6 corridor include:

- improved access to recreational, employment, retail, entertainment and other facilities near or adjacent to the corridor;
- improved transport choice for residents, visitors and employees;
- improved access on local road networks due to the removal of through-traffic;
- use of existing roads for public transport priority to provide improved access for residents to existing local facilities such as retail, commercial, employment, entertainment and recreation areas;
- economic development opportunities associated with improved accessibility;
- safety improvements related to decreases in traffic. Public transport is known to be a safer form of transport than private vehicles. Attractive public transport options that are able to attract commuters away from private vehicles could improve road safety by reducing the number of vehicle incidents;
- potential to maintain public recreation and open space;
- potential for resources to be allocated to improve the corridors recreational and other social and environmental values;

- opportunities to provide an efficient and reliable public transport system linking areas along the corridor to areas in western and northern Sydney and the CBD;
- opportunities to maintain existing, or improve local residential amenities along the corridor when compared to a road corridor;
- localised changes in land values;
- potential to minimise impacts to directly affected and adjacent property owners; and
- increased public transport use leading to improved local and regional air quality.

Potential issues that may arise for the community with the development of public transport in the F6 corridor include:

- noise impacts on residential properties both during construction and operational phases;
- community severance due to a transport corridor fragmenting some local communities;
- changes to suburban character and amenity;
- changes to air quality, particularly during construction;
- loss of residential properties;
- potential loss of some open space and recreational facilities; and
- potential for changes in existing access and transport networks to either alter or reduce access and circulation for local residents, particularly during construction.

Some of these potential constraints and resulting negative impacts could be managed through appropriate mitigative measures. The application of new and emerging technologies could also assist to minimise potential impacts.

5.2.2 Environmental Opportunities and Constraints

Within and Adjacent to the F6 Corridor

The broad environmental opportunities and constraints are discussed below. The actual opportunities and constraints would vary according the mode of transport developed in the corridor as well as engineering, design and operational characteristics of the option. The issues are discussed generally and would be further discussed as options are developed in more detail.

Environmental **opportunities** that may arise for the community with the development of public transport in the F6 corridor include:

- a greater value placed on the environmental character of the transport corridor;
- potential for resources to be allocated to improve the corridors recreational and other social and environmental values;

- use of existing roads for public transport priority to provide improved access for residents to existing local facilities such as retail, commercial, employment, entertainment and recreation areas;
- increased public transport use leading to improved local and regional air quality; and
- a contribution to the restoration or rehabilitation of wetlands, habitat areas and recreational facilities within the corridor could be a valuable additional benefit.

Environmental **constraints** that may arise for the community with the development of public transport in the F6 corridor include:

- noise;
- water pollution;
- visual impacts;
- direct and indirect impacts on the extensive wetlands and other habitats that exists within the F6 reservation, particularly within the Rockdale Wetland and Recreational Corridor;
- like most transport infrastructure projects, there will be some direct and indirect impacts that may result from the development and operation of the public transport system in the F6 reservation. These may include direct loss of wetland and habitat areas, direct loss of threatened plant communities and threatened flora and fauna, changes in underground and surface hydrology, loss of flood mitigation environmental services, noise impacts, loss of existing aesthetic values, loss of some features of cultural significance and changes in water quality and nutrient recycling environmental services; and
- potential loss of recreation space.

There are opportunities to avoid sensitive natural environments and to mitigate adverse effects resulting from public transport development. Avoiding direct impacts on habitats, for example, by locating infrastructure away from core areas could be achieved in most cases. However, balancing the protection of habitat against the resulting increase in other social impacts (noise, vibration, loss of aesthetics, loss of open space) would have to be considered. The development of attractive alternative transport options may reduce car travel, which may lead to some reduction in local traffic and improvements in local air quality. Mitigation measures are also available to ensure direct and indirect impacts are minimised depending on the options and alignments proposed.

The application of new and emerging vehicle and fuel technology would significantly mitigate any air, noise and water quality impacts that are typically associated with some public transport modes, cars and trucks; especially with regards diesel engines. The application of technology to development of a based transit system that would allow for route and engineering modifications that may substantially avoid or minimise impacts on the environment. This could include the use of existing roads in strategic places to avoid sensitive environments within the F6 corridor. This may in turn create opportunities for the expansion and/or improvement of the environmental values and recreational facilities within the F6 corridor.

The constraints and opportunities for the development of public transport options in the corridor are summarised in *Figures 5.1* and *5.2*. The maps identify a broad range of opportunities and constraints covering social, environmental, economic, development, operational and transport issues.

Northern Section of the F6 Corridor

Considerable constraints were identified in the northern section of the corridor between the M5 East and the Cooks River. These are discussed further below and are also shown in *Figure 5.1*.

- M5 East: The M5 East crosses the F6 corridor between Marsh St and Southern Cross Drive. The M5 East is at surface level at Marsh St then goes underground to cross the Cooks River and raises again to surface level to connect with Southern Cross Drive. Any public transport option will need to be grade separated in crossing the M5 which may present engineering difficulties and come into conflict with airport height restrictions (an assessment of vertical alignment was not part of this study).
- SWSOOS: The South Western Suburbs Ocean Outfall Sewer (SWSOOS) pipeline passes west to east crossing the F6 reservation south of the Cooks Cove redevelopment area. The SWSOOS is in tunnel.
- Cooks Cove: The reservation passes through the proposed Cooks Cove redevelopment. Draft Sydney Regional Environmental Plan No. 33 — Cooks Cove (SREP 33) rezones the land around the reservation to Open Space (private recreation and public access) and gateway commerce and technology.
- Airport Rail Link: The airport rail passes through the reservation between Wolli Creek Station and the International Airport Station. The rail link is in tunnel for the entire section.
- Airport: There are restrictions on the height of infrastructure and buildings within the aircraft obstacle limitation surface (OLS) boundariese. These will restrict the range of alignment options in and around the airport. Sydney Airport Corporation Limited (SACL) published the Sydney Airport Draft Master Plan (DMP) in July 2003, predicting a future travel demand of 68 million passengers per year by 2025. The DMP proposes significant redevelopment of airport land including access roads and the provision of more car parking. In its response to the Sydney Airport Draft Master Plan, the NSW Government made a clear case for increasing public transport's mode share to reduce the demand on the surrounding road network.
- St Peter's Industrial Route (SPIR): Proposed industrial route connecting Princes Highway with Canal Road at Tempe. The SPIR route is in the M5/F6 reservation. The SPIR route at Bellevue Street is adjacent to a site proposed for sale and redevelopment for Bulky Goods retailing.
- Cooks River: At the location where it crosses the F6 reservation (see *Figure 5.1*), the Cooks River is used for recreational boating and fishing, Princes Highway, Rail Line and M5 East also cross the river near this location. The airport rail line is in tunnel

under the Cooks River near this location. There are limited locations where the F6 can cross the river at grade. There are also many engineering, economic and environmental constraints for tunnelling and height restrictions.

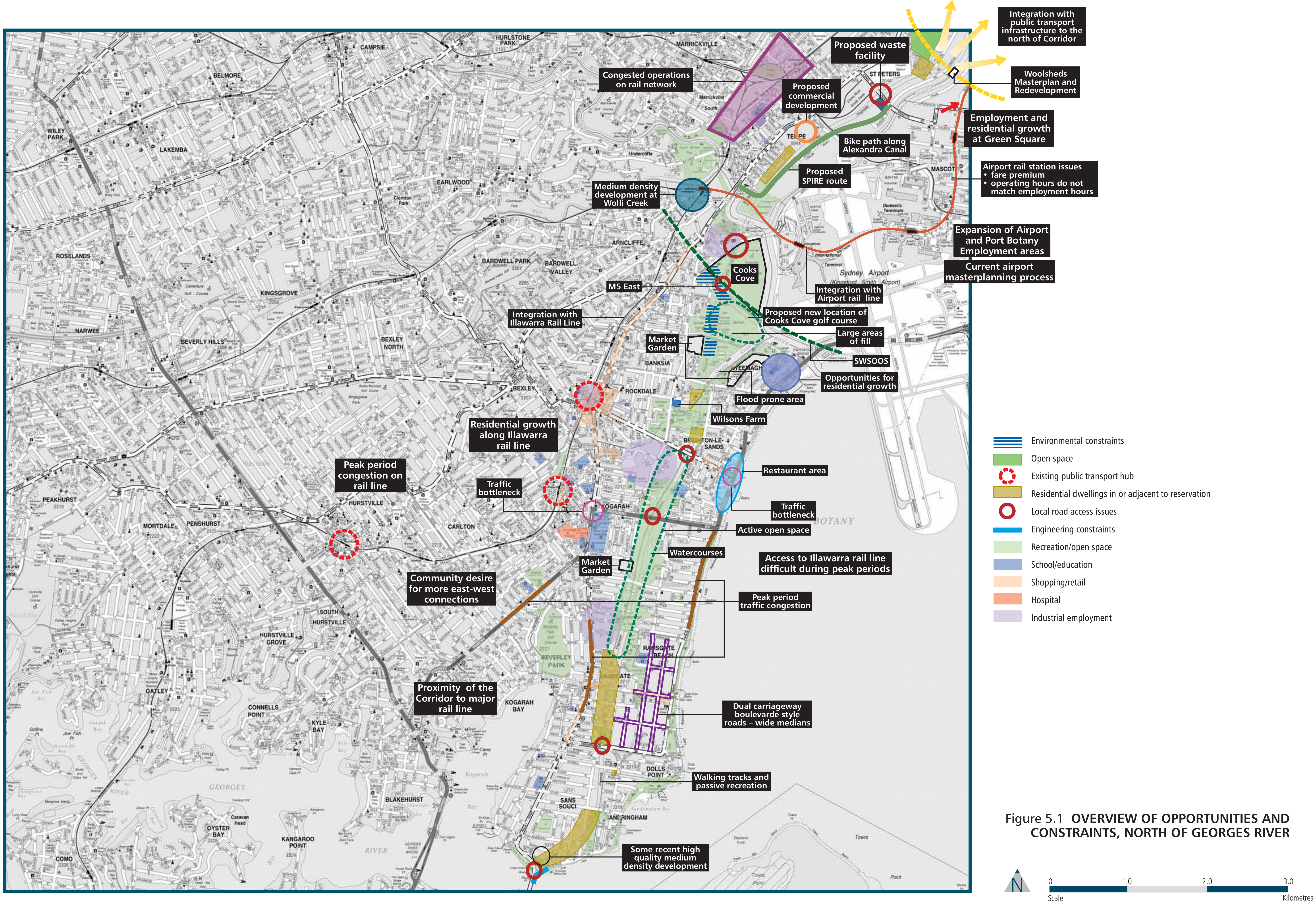


Figure 5.1 **OVERVIEW OF OPPORTUNITIES AND CONSTRAINTS, NORTH OF GEORGES RIVER**

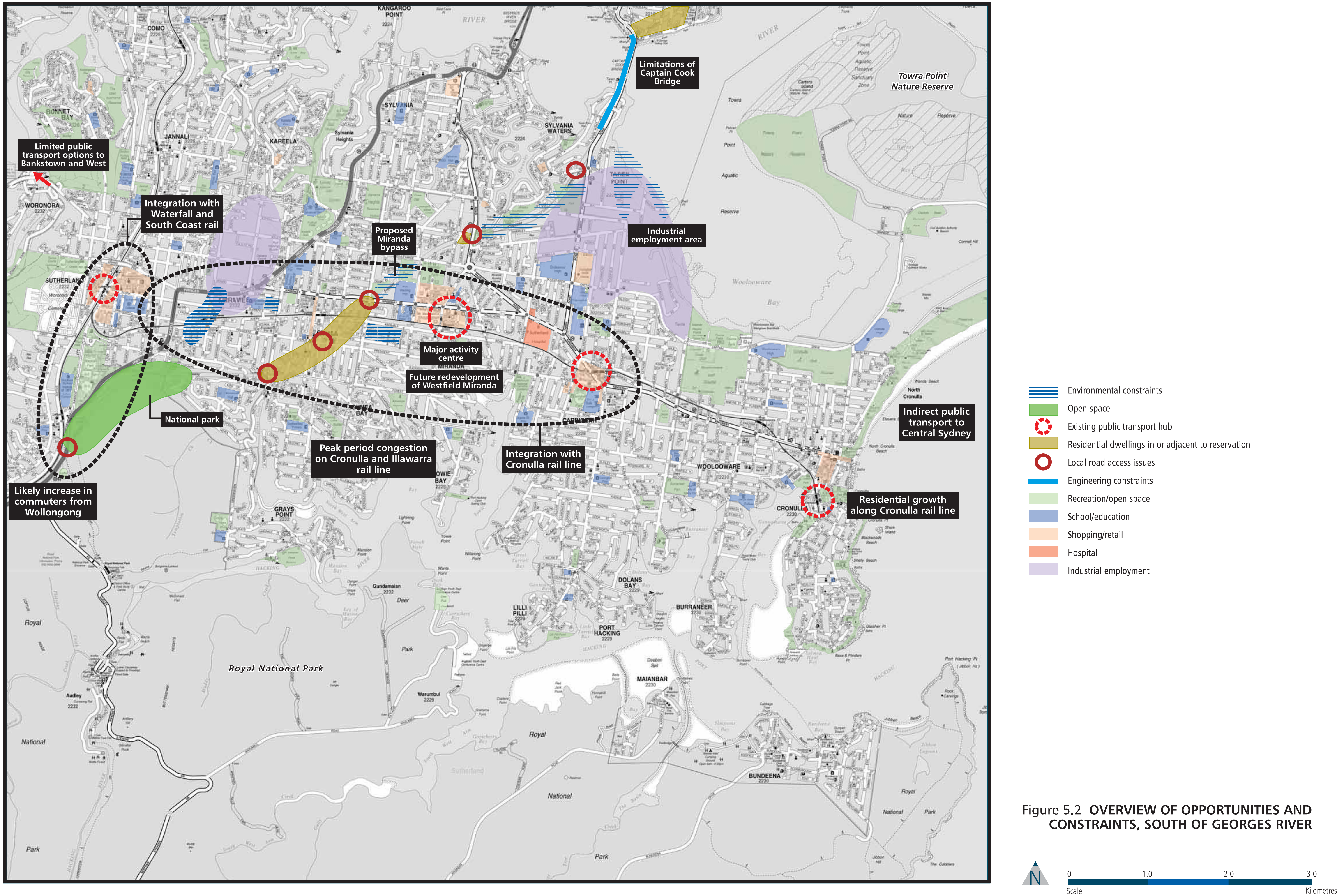


Figure 5.2 **OVERVIEW OF OPPORTUNITIES AND CONSTRAINTS, SOUTH OF GEORGES RIVER**

North of the Cooks River, the reservation is located within the Tempe Reserve. The Reserve is an old landfill location. There would be engineering and environmental issues with tunnelling through land fill at this site.

The F6 reservation ends at Campbell Road in St Peters. The issue of where a potential F6 public transport corridor would continue to north of the F6 reservation is considered briefly in this study. This study assumes that the airport and the Sydney CBD are major attractors of travel demand and any public transport in the F6 reservation would need to make some connection to these major centres.

There are a range of options being considered for connecting the F6 public transport options into the existing transport system. The main destinations/interchanges that public transport services along the F6 corridor could connect with to the north are:

- Sydenham Station and access via the Illawarra Rail Line;
- Sydney Airport, both international and domestic terminals;
- the Sydney CBD;
- the Eastern Suburbs;
- Green Square; and/or
- University of NSW.

There are limited options for on surface connections to the north of the corridor that would not have significant impacts on employment lands, residential communities and recreation space.

5.3 High Capacity Modes

High capacity modes considered include either a conventional heavy rail system (such as the Sydney metropolitan rail system) or a metro rail system (such as the Paris Metro or London Underground).

Sydney CityRail Tangara Train

5.3.1 Sydney's Metropolitan Passenger Rail System

High capacity rail in Sydney has the following characteristics:

- line capacities of up to twenty trains per hour are achievable within the constraints of station dwell times and signal spacing. This translates into a maximum passenger capacity of approximately 24,000 passengers per track per hour;
- in the urban environment typical maximum operating speeds of up to 80 kilometres per hour are achievable;
- the railway is provided with an exclusive, secured right of way with protected and grade separated crossings;
- stations are to be built to CityRail standard with platforms placed at door level;
- a minimum corridor width of 15 metres is required to conform with lateral clearance and maintenance access requirements. This width would have to be increased to 22 metres at stations;
- stations are spaced between 2 and 3 kilometres apart, depending on the adjacent residential density or the location of employment and commercial and use;
- Class 1 mainline track is required to have a minimum horizontal curve radius of 400 metres, a desirable mainline gradient of 1 percent (maximum gradient of 3 percent) and vertical crest and sag curve radii of 1,300 metres or more;
- at stations the gradient should not exceed half a percent (zero gradient preferred) and the minimum horizontal curve radius through stations is 800 metres[2]; and
- the metropolitan network is electrified with 1500 Volt direct current (1500VDC) traction power.

[2] *RIC Standard (C2200 Mainline Track Geometry)*

5.3.2 Typical Metro Systems

Metro systems have been introduced in many international cities (Madrid, Spain; London, Paris, New York, Washington, Singapore, Hong Kong). These systems have limited seating and several doors on each side of the carriage. This design allows a high capacity with a larger number of standing passengers and faster times for passengers to move in and out of the carriages, reducing station dwell times. These metro systems operate in higher density cities in inner metropolitan areas and rely on interchanges with suburban rail systems to serve commuters from further afield. Metro systems are typically introduced to cater for high volume, short distance passenger trips.

A metro system generally has the following characteristics:

- capacity to transport up to 20,000 people per hour;
- typical average operating speeds between 35 and 65 kilometres per hour depending on geometry and other design parameters;
- exclusive rights of way and protected at-grade crossings with grade-separation preferred;
- a corridor width of 12 metres for track sections and 18 metres at stations;
- stations spaced at between 1 to 2 kilometres apart, the adjacent residential density or the location of employment and commercial and use; and
- a minimum radius of 50 metres and 400 metres at platforms with a maximum gradient of 6 to 8 percent.

Paris Metro System

5.3.3 High Capacity Rail Options in the F6 Corridor

Previous planning studies, such as the Long Term Strategic Plan for Rail (Christie Report) have suggested that a metro style network may be introduced in Sydney and that the F6 corridor could potentially form part of such a system. Integrating a metro style rail system with a heavy rail system such as exists in Sydney is also subject to a range of technical complexities. It is not the purpose of this document to elaborate on these issues other than in as much as these affect the future boundaries of the corridor. Given that the design criteria for heavy rail are in all cases more stringent than those for a metro system, considering heavy rail only should not preclude the construction of a metro system in the corridor at any time in the future.

The initial assessment of options identified two route options, and these are assessed in more detail as part of the study:

- Miranda to Sydney City via Miranda and Sydenham; and
- Miranda to Sydney City via Miranda and Airport.

A high capacity rail line would need to connect to the network such that it provides access to the City if it is to meet the travel demand, and both options are therefore proposed to connect to lines that continue to the City:

- the first option connects to the Illawarra Line at Sydenham, which continues to Central and then through the City to Bondi Junction via the ESR; and
- the second option connects to the Airport Rail Link at International Terminal Station, which continues to Central and then through the City via the City Circle.

The two options are shown in *Figure 5.3*. Both options start at Miranda and head west looping onto the F6 alignment, collecting trains from Cronulla. It is noted that the analysis of Wollongong travel data in *Section 4.2*, together with StateRail advice during the reference group workshop concluded that a connection to the Illawarra Line south of Gymea station on the Cronulla line would not be required. The key considerations being:

- trains would miss Sutherland, Hurstville and other major employment and commercial centres to the north; and
- there is very little demand for access to the F6 Corridor by commuters from the Illawarra Region.

Figure 5.3 **HEAVY RAIL OPTIONS**

- The limiting factor affecting future growth in train travel from the Illawarra is the capacity along the Illawarra Line north of Sutherland. The introduction of either a new train service or alternative public transport improvements in the F6 corridor could serve as an alternative to infrastructure enhancements north of Sutherland to relieve these capacity constraints.

Both options then follow the F6 reservation north, via a new crossing of the Georges River, to a point just south of the Cooks River. From this point, the two options differ as one diverts to Sydenham Station to connect into the Illawarra line while the other is to connect to the Airport Line west of the International Terminal Station.

It is most likely that both options would need to divert underground south of the M5 to avoid the M5, SWOOS, and Cooks River and would remain underground to the vicinity of Sydenham station where new underground platforms would be required. The Airport Line connection would also go underground.

5.4 Medium Capacity Modes

Medium capacity modes are considered as either a light rail transit system or a bus based transit system. They are highly flexible modes and can be integrated with surrounding environments to provide for medium volume short passenger trips. Medium capacity modes bridge the gap between heavy rail and local bus services.

A medium capacity mode generally has the following characteristics:

- capacity for up to some 20,000 passengers per hour;
- typical operating speeds between 30 to 60 kilometres per hour;
- priority or shared environments;
- corridor width of 12 metres for track sections and 14 to 22 metres at stations;
- stations spaced at between 800 metres and 2 kilometres apart, depending on land uses;
- light rail systems have an absolute minimum radius of 25 metres and 300 metres at platforms with an absolute maximum gradient of 6 to 8 percent;
- bus based systems have an absolute minimum radius of 10 metres with a maximum gradient of 8 to 15 percent; and
- low floor vehicles allowing for high quality accessible stations.

5.4.1 Typical Light Rail Systems

There are different categories of light rail systems depending on their operating areas, catchment and service requirements. Light rail systems can be built as:

- entirely new exclusive track in an exclusive alignment on the surface, elevated or in tunnel;

- new track on an existing roadway converted to exclusive use by the light rail system; or
- track embedded on roadways that are also used for private vehicles.

The performance of light rail systems varies according to the level of priority relative to other modes, station locations, boarding and alighting capacities. In suburban areas, light rail vehicles can be routed along sections of heavy rail track. In these cases, vehicle design need to be able to operate on two different system and stations need to be equipped with both high level and low level platforms. In the case of the F6 Corridor, it is unlikely that interoperability with heavy rail will be required.

Light rail systems have been developed through green strips or parks in many cities. They require low investment and maintenance costs and offer a pleasant travel environment minimising visual impacts.

Examples of Light Rail Systems: Sydney and Zurich

5.4.2 Typical Bus Transit Systems

Bus based transit systems operate on purpose built exclusive right of way or with priority on existing roads. Systems are designed to suit its urban environment and patronage demands.

A bus based transit system can provide high quality, frequent and fast travel between centres. Services can be integrated to allow for line haul high frequency services, local feeder services and integrated feeder express services. This means that local bus services collect passengers through residential areas then operate express on the right of way sections. Technology (through the application of compressed natural gas (CNG), hybrid and fuel cell vehicles) has allowed the development of several vehicles that provide a higher quality level of service, comfort and environmental performance than typical diesel buses. These technologies, applied to bus based transit systems, have raised the performance and profile of services.

Examples of Bus based systems, Liverpool to Parramatta Transitway and Rouen, France (TEOR System with CIVIS vehicle)

Medium capacity mode options were developed and reviewed at a Reference Group workshop.

5.4.3 Medium Capacity Options in the F6 Corridor

Two medium capacity options were developed for the F6 corridor. At this strategic level of assessment the medium capacity option has been based on either light rail or bus transit system. Each mode requires a similar cross section and exhibits similar performance characteristics. Future more detailed studies would determine the most appropriate mode based on meeting the travel needs of the population. Accordingly, while the routes for both these options could be served by either light rail or bus-based transit systems, they were developed to ultimately suit the engineering requirements of light rail systems:

- medium capacity modes in an exclusive corridor; and
- medium capacity modes on street.

The first option is based on the F6 alignment and could be grade separated at major junctions along the F6 alignment in its long term configuration. The route originates at Kiora Road in Miranda, turns west down The Kingsway to join the F6 alignment. The route follows the F6 alignment for its entire length, including Captain Cook Bridge over the Georges River, up to Tempe where it diverts to Sydenham Station. There is an option for a connection to the International Terminal at Sydney Airport via a crossing of the Cooks River.

It may be desirable to have a direct light rail/bus transit system connection to the CBD rather than provide an interchange with the Illawarra Line at Sydenham Station or the Airport Line at the Interantional Airport, but evaluation of such a direct connection does not form part of this study.

The second option is a road-based option that would have minimal diversions from the existing road network. The route would not be grade separated at junctions but would have signal priority and bus lanes where possible.

The route of the on-road option is as follows:

- the route originates at Kiora Road in Miranda and turns east down The Kingsway; from where it proceeds;

- north along Taren Point Road (Miranda and Taren Point), over the Captain Cook Bridge, following Rocky Point Road (Sans Souci), and then east along Sandringham Street. It then proceeds;
- north along Chuter Avenue (Ramsgate), east along President Avenue, north along Crawford Road (Brighton Le Sands), at this point two options have been identified which show:-

  a) east on Bay Street; and then north on Moate and Jacobson Avenue. The alignment would then cross over Muddy Creek and on a new bridge alignment or a tunnel depending on clearances around the airport runway envelope and the M5; and continue through the Cooks Cove development, before crossing the Cooks River to the international and domestic airport terminals; or

  b) west on Bay Street to West Botany Street to Marsh Street to the F6 alignment where it would then cross the Cooks River before linking up with the proposed St Peters Industrial Route (SPIRE) from where it diverts to Sydenham Station.

As with the exclusive corridor option it may be desirable to have a direct light rail/bus transit system connection to the CBD rather than provide an interchange at the Airport Line or illawarra Line at Sydenham. The routes for the two medium capacity options are shown in *Figures 5.4* and *5.5*.

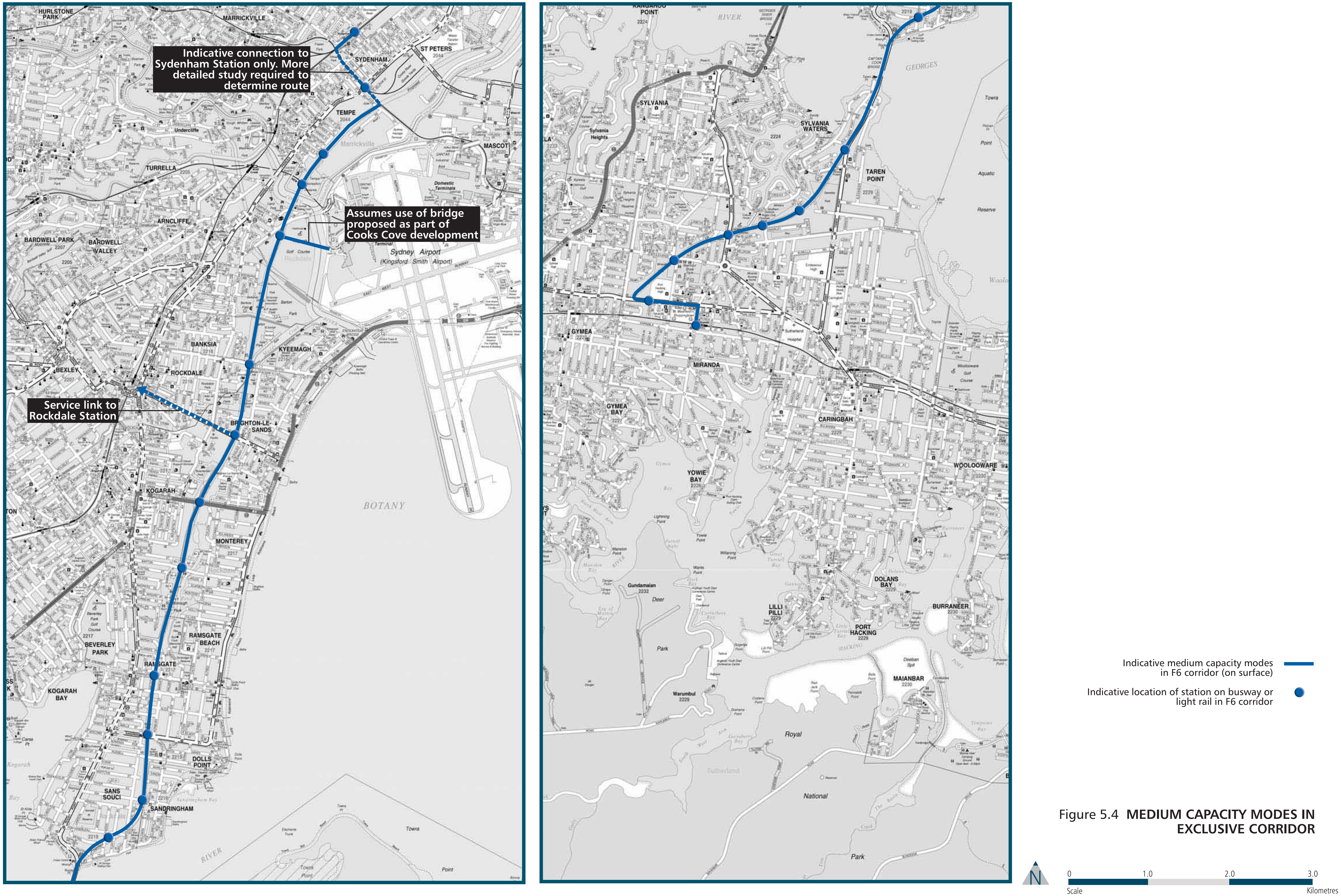
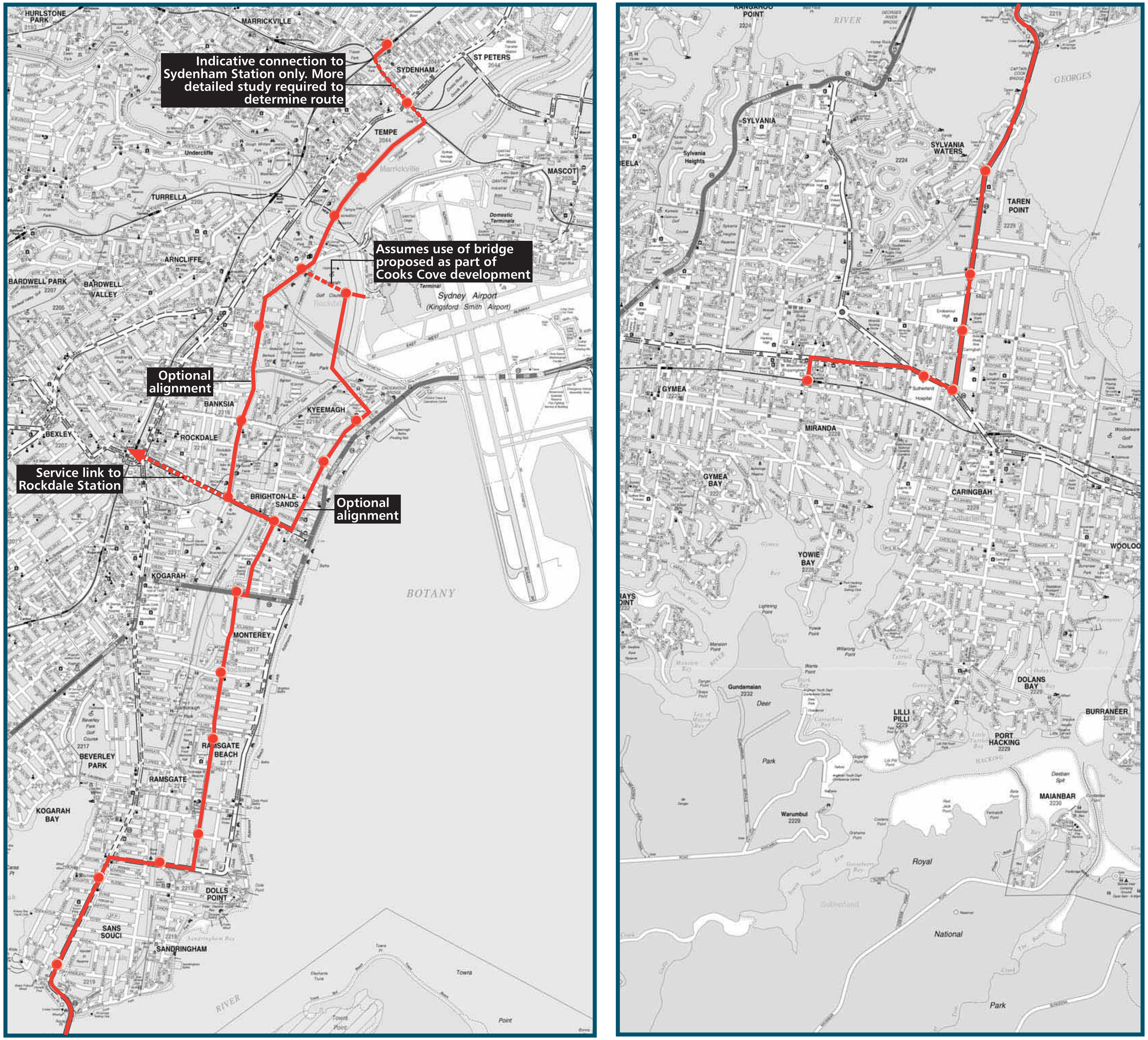


Figure 5.4 **MEDIUM CAPACITY MODES IN EXCLUSIVE CORRIDOR**



Indicative medium capacity modes on streets

Indicative station on busway or Light Rail on streets

Figure 5.5 **MEDIUM CAPACITY MODES ON STREET**

N

Scale 0 1.0 2.0 3.0 Kilometres

5.5 Other Technology

There have been many advances in technology across most modes in recent years. These include light rail vehicles, bus propulsion systems that deliver low emissions, guidance technology (for example O-Bahn and optical guidance) and new forms of transit vehicles (for example Civis[3]). New and emerging technology could be applied to a public transport system for the F6 corridor. However, it should be noted that at this strategic stage of assessing potential public transport uses for the corridor, the focus is on quality of services and market demands rather than technology alone.

5.5.1 Guided Bus Technology

Guided bus technology has been developed as a possible alternative to light rail technology. Most guided buses are conventional buses fitted with equipment to enable them to run on special tracks as well as on regular streets. The most commonly referred to example is the German designed O-Bahn system that operates in Adelaide, Australia. This system involves self-steering, kerb-guided buses running on a special concrete track. The main advantage over a bus based system is the higher speed that can safely be achieved on a restricted right of way. Automatic steering permits this right of way to be only fractionally wider than the bus itself. However, the track profile does not permit at-grade crossings by pedestrians, cyclists or other vehicles. The right of way requires a special guideway which means that other buses or other vehicles are not able to use it, raising additional costs for service integration.

Either of these technologies, O-Bahn or Civis Vehicles, could be applied to the medium capacity options assessed for the F6 corridor. A decision on whether this technology is appropriate to the F6 Corridor would be made at the design stage and would be dependent on whether the minimisation of the final right-of way width is a priority. The corridor width reserved as a consequence of this study is wide enough to accommodate a full-width busway without guidance requirements.

O-Bahn

Civis

[3] *CIVIS is a bus rapid transit vehicle manufactured by Irisbus of France. It has four wide doors and a low floor, allowing for fast and easy boarding and handicap accessibility. The vehicle looks more like a tram than a bus, and runs on rubber tires.*

5.5.2 Ultra Light Rail

New technology such as the Austrans Ultra Light Rail (ULR) system, offers a possible alternative to other medium capacity modes. The Austrans vehicle is driverless and has the capacity to seat nine passengers in coach style seating and carry up to a further 9 standing passengers in the peaks. With 15-second headways and on-line stations Austrans is able to carry approximately 4,000 passengers per hour per direction.

In theory, the footprint required to implement and operate the ULR is significantly narrower than other modes (less than 6 metres width for a double track) and the system has the potential to provide a quieter, energy efficient and less visually obtrusive alternative. Stations are also short and narrow. The vehicle specifications capable of climbing 20% gradients and can negotiate 8-metre radius turns. The guideway is small and lightweight and can be attached to existing structures for example, the Captain Cook Bridge, Austrans could therefore be more adaptive to existing transport infrastructure than other medium capacity options. An additional advantage claimed by Austrans is that in typical urban applications it does not require a subsidy from Government. Austrans' claims that, typically, fare revenue would exceed its operating costs and it can make a contribution to capital costs. In addition it offers passengers advantage through very high frequency services (headways of less than one minute are claimed) and high levels of passenger comfort (based on Information supplied to DIPNR by Bishop Austrans Pty Ltd).


Austrans Prototype demonstration (Photos by PB)

While the Austrans system claims several ground-breaking innovations, the system has not been demonstrated in revenue service. Consequently, the system can not be evaluated based on its performance in similar applications.

6. Development of Options

6.1 Heavy Rail

6.1.1 Infrastructure Requirements

Lateral Space Requirements

The minimum separation between obstructions and the track specified by NSW railway design standards needs to be maintained to avoid intrusion of any obstacles into the path of a moving train (kinematic envelope). Using current RIC transit space standards, minimum track centres of 4.0 metres should be provided for straight mainline track.

A maintenance access way should be provided within the fenced corridor and on at least one side of the tracks. On the maintenance access side of the tracks the rail boundary fence should be no closer than 6.2 metres from the nearest track centreline. The other fence should be at least 4.3 metres from the nearest track centreline. Using these lateral clearance standards, the minimum right-of-way width for straight mainline track with no structures or stations is 14.5 metres. Lateral clearance requirements may increase around curves due to centre/end throw effects and an increase in the kinematic envelope. These effects should be further assessed during detail design.

Stations

The maximum right-of-way width requirement occurs at potential station locations. StateRail's CityRail Station Design Guide (SRA, 1996) was used as reference to develop a typical station layout for the Western Sydney Orbital corridor. The station configuration is based on a single island platform, 170 metres long to accommodate an eight car passenger train set. The platform has a maximum width of 10 metres at the mid-point and tapers to a width of five metres at the platform ends. The 10 metre width provides a 3.5 metre clearance to the platform edge on both sides of a 3 metre wide access stairway located in the middle of the platform. The layout of a typical station with an island platform is shown in *Figure 6.1*.

The platform width could be reduced to 7.0 metres by placing the stairway at one of the platform ends. However, this layout would result in end-loading of the platforms, a configuration StateRail generally does not support as it affects the station's operational efficiency. At the point where the platform is at its widest, construction of the station will therefore require a clear median width of 21.9 metres, as shown in *Figure 6.2* below.

Station locations are indicative, based on connecting existing activity nodes. The patronage assessment assumes that stations will be located at Miranda North, Taren Point, Sandringham, Bay Street and Cooks Cove. The station locations are also shown in *Figure 5.3* and in the previous section.

The development of a high capacity public transport option would be anticipated to have significant impacts on land use through the corridor. These impacts could lead to the development of new activity nodes, supported by increased public transport accessibility. The indicative reservation therefore has to allow sufficient width such that station locations may be moved subject to additional planning studies. Sufficient land requirements have been allowed in the engineering base model to adjust station locations.

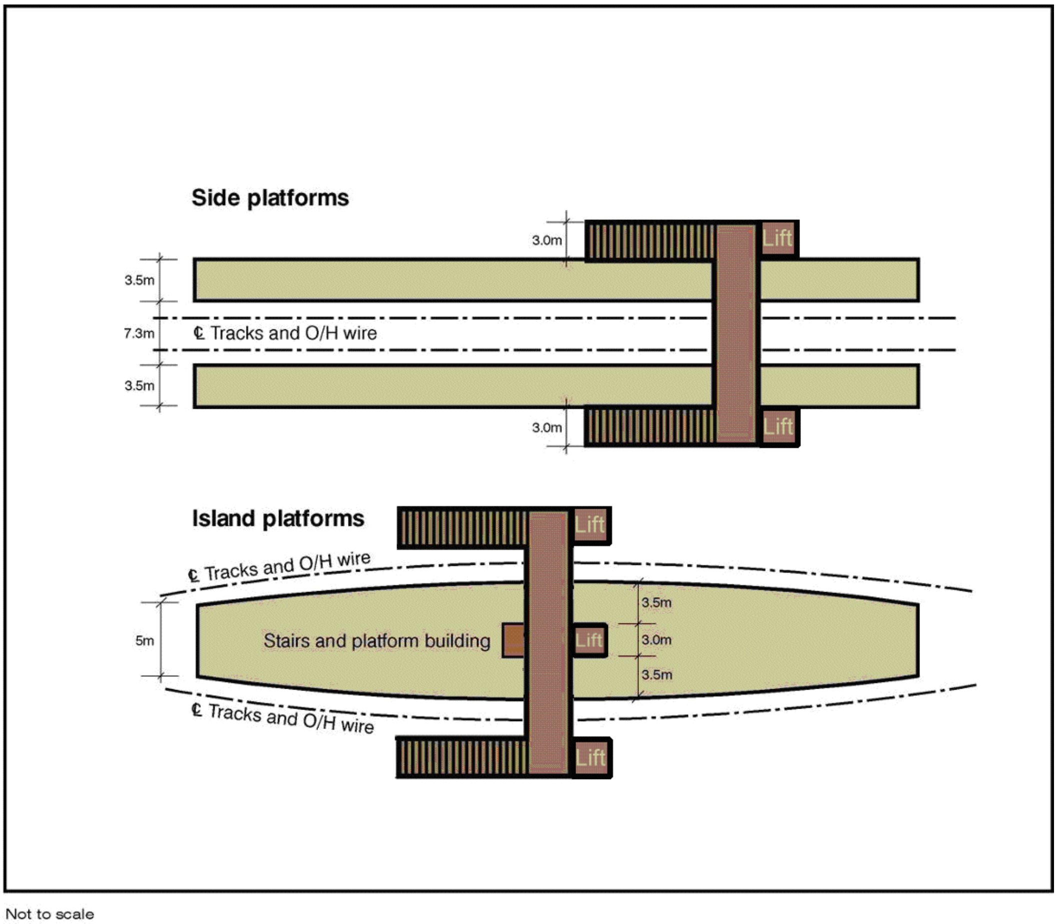


Figure 6.1: Typical Station Layout

Over-bridges and Vertical Clearances

Where over-bridges are likely to be required over the railway, a 5.65 metre vertical clearance is required between the top of the rail and the underside of the over-bridge to allow for provision of the traction power overhead wire (OHW) installation.

Three typical cross sections were developed to assess the minimum space requirements of rail within the F6 Corridor and these typical cross sections are shown in *Figure 6.2*. Note that these cross-sections:

- are minimum requirements and do not show cycleways and/or footpaths. Cycleways and footpaths are provided outside the railway boundary as shown in *Figure 6.3*; and

- provide for a maintenance access road only in plain track areas as is normal practice. At stations or over-bridges the access road is stopped short either side of the station area or structure.

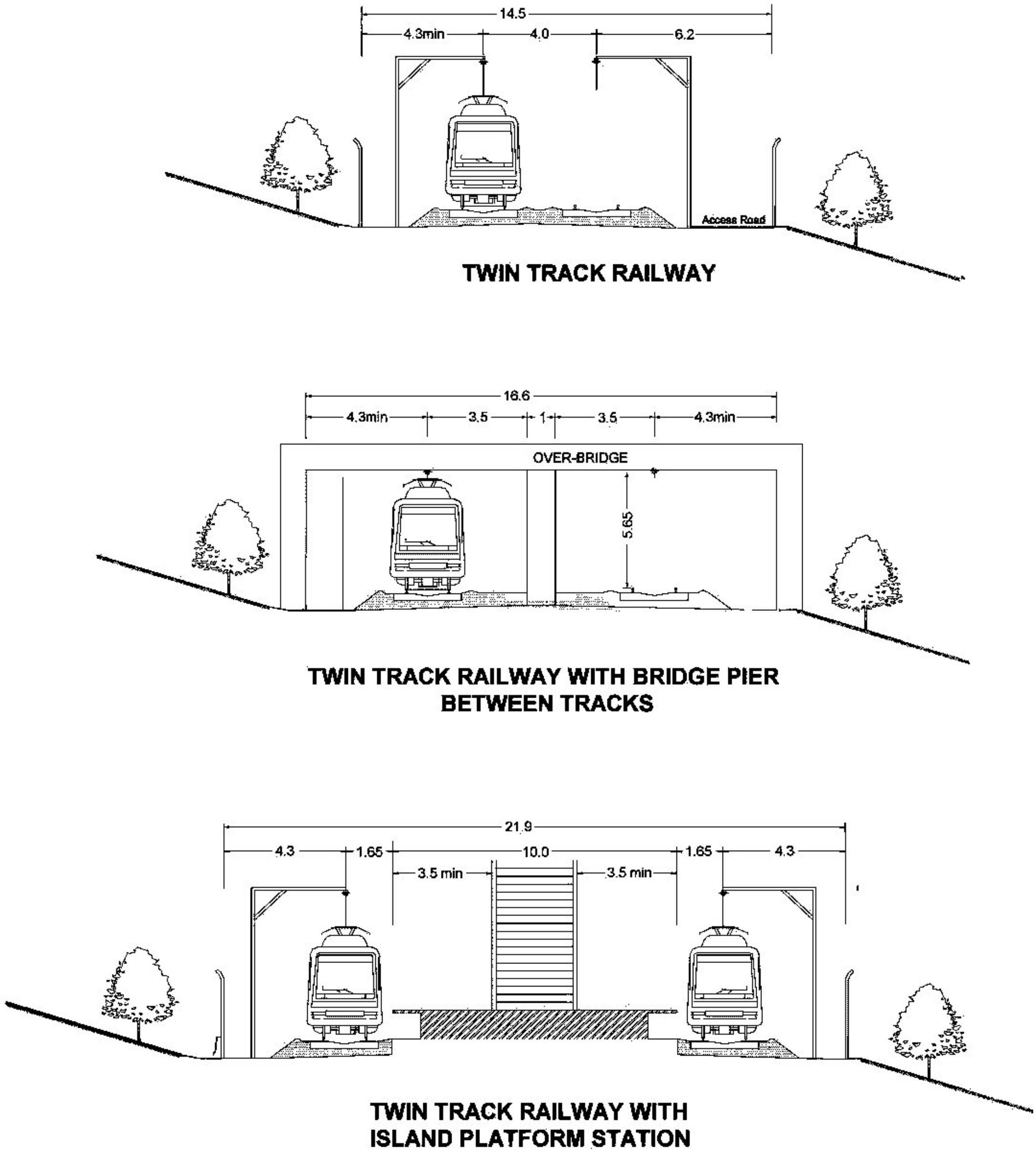


Figure 6.2: Typical Minimum Cross-sections for Heavy Rail

Alignment Standards

A proposed twin track passenger railway, designed to Class 1 standard, should have a minimum horizontal curve radius of 400 metres, a desirable mainline gradient of 1% (maximum gradient of 3%) and vertical crest and sag curve radii of 1,300 metres or more. At stations the gradient should not exceed half a percent (a zero gradient is preferred) and the minimum horizontal curve radius through stations is 800 metres.

6.1.2 Land Requirements

If the future development of a rail link in the F6 Corridor is to be retained as an option, it would be necessary to provide a corridor of sufficient width to accommodate:

- no less than two heavy rail tracks of appropriate standard (requires a corridor width of 14.5 metres);
- potential in some locations for a third "turnback" line (requires another 5.2 metres);
- overhead traction power supply mast structures, signal sticks and gantries;
- traction supply substations, sectioning huts and other lineside electrical equipment;
- a maintenance access road on at least one side of the corridor;
- potential stabling facilities that may be required in addition to those located at Cronulla and Waterfall; and
- stations at strategic locations.

A rail corridor should reserve a right-of-way sufficient to accommodate the twin tracks, stations and rail systems. Ancillary needs such as parking and interchange facilities can be provided outside the reservation boundaries and more appropriately situated in the future when land use changes are apparent. The absolute minimum fence-to-fence rail corridor width for rail is based on the typical cross-sections in *Figure 6.2*:

- for general main line twin tracks with an access road on the one side the minimum width would be 14.5 metres;
- for main line tracks through bridge structures, where a 1 metre wide bridge pier is located between the tracks but no access road is provided, the minimum width would be 16.6 metres; and
- at stations with island platforms the minimum width would be 21.9 metres.

It should be recognised that no vertical alignment design was carried out for this study. Consequently, it has not been possible to assess the space requirements of cut and fill batters or retaining structures. Allowance should also be made within or near the corridor for pedestrian and cycle access.

Given that final station locations would be very difficult to identify during the current study, it was acknowledged during the Reference Group workshop that a corridor of adequate width would be reserved to retain full flexibility in placing stations. It was also agreed that it would be prudent to retain sufficient land to accommodate a footpath and/or cycleway as well as some reserve for earthworks (batters).

Given the uncertainty with regard to vertical alignment design and the need for cut/fill batters, the location of stations and the appropriate location of turnback facilities and stabling yards a right-of-way width of 40 metres was selected for the assessment of residual land. This width would allow for:

- the minimum total width required at stations of 21.9 metres;
- an additional 5.2 metres for a third turnback/stabling road; and

- an allowance of 12.9 metres to accommodate fencing, cycleways and footpaths and cut/fill batters

A typical 40 metre corridor width is shown in *Figure 6.3.*

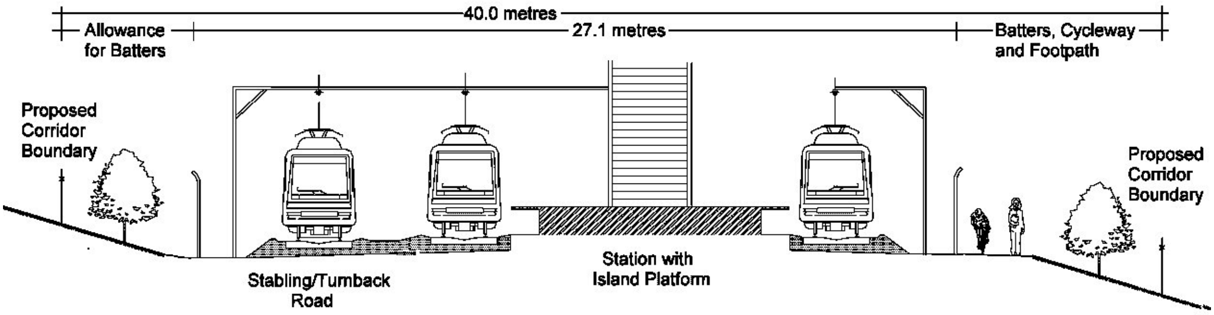


Figure 6.3: Recommended Corridor Requirement

Note that the rail maintenance access road is not required through the station area and is therefore not shown in *Figure 6.3*.

6.1.3 Rail Network Context

Both heavy rail options would connect to the Cronulla Branch Line at Miranda and head west, looping onto the F6 alignment, collecting trains from Cronulla. Option HA would connect to the Illawarra Line immediately south-west of Sydenham Station. Option HB would connect to the Airport Rail Link immediately south-west of International Terminal Station.

Both options would be able to divert demand from the capacity constrained sections of the Illawarra Line between Sutherland and Sydenham, provided trains would be able to continue to destinations in the CBD. However, the headways on a potential heavy rail link in the F6 Corridor would be constrained by the capacity of the line into which it connects:

- capacity on the Illawarra Line at Sydenham is likely to be a constraint on Option HA unless the infrastructure on the Illawarra Line is enhanced to increase line capacity between Sydenham and Erskineville Junction. This constraint is explained in more detail in *Section 4.1.2*; and
- Option HB may potentially be less capacity constrained than Option HA as there is some scope to run an independent shuttle service on the Airport Rail Line between Miranda and the unused platforms at St James Station in the City. Such a service would require less drastic infrastructure enhancements, mainly to junctions at Central and at St James Station. Retaining the current operational pattern and timetabling four Airport services onto the East Hills Line would realistically make four Airport trains divertible to Miranda via the East Hills corridor; and
- it may also be possible for rail in the F6 Corridor to connect to a future (proposed) metro line through the CBD.

Development of an integrated network strategy and timetable and resolution of network constraints was outside the scope of this study. For the purpose of patronage modelling, it was assumed that four services per direction per hour would be able to be provided within the F6 Corridor.

There is an alternative to be considered for the southern end of the alignment to collect services from the Illawarra. This could be achieved by creating a new link from the Illawarra line between Sutherland and Loftus to the Cronulla line and connecting to the F6 alignment prior to Miranda. A Y-link could also be provided at Miranda to provide connections from Sutherland to the CBD. This would require further analysis to determine its feasibility.

6.1.4 Engineering Considerations

The development of detailed alignments, vertical or horizontal, did not form part of this study. Parsons Brinckerhoff developed a typical cross-section for the rail system (shown in *Figure 6.3*), representing a practical corridor for a heavy rail system stations, shared footpath and cycleway and limited cut and fill batters.

A concept centreline was developed within the F6 Corridor using the design criteria described in *Section 6.1.1* and a corridor width of 40 metres was applied to this centreline. A preliminary assessment of the potential geotechnical constraints that could be encountered along the alignment was also undertaken, based on a limited desktop study. From this conceptual development of the horizontal alignment it has been concluded that:

- the southern connection to the Cronulla Branch Line at Miranda would require a tight radius curve to turn a rail line in the F6 corridor to connect to the Cronulla Line;
- the topography between the Cronulla line and the Georges River is such that deep cuttings or even a cut and cover tunnel may be required in this area;
- a new crossing of the Georges River is likely to be required. It is assumed that this crossing of the Georges River is likely to be a tunnel;
- from the Georges River to just south of the M5 motorway at Cooks Cove, the topography is reasonably favourable but adverse geotechnical conditions may be encountered. These include existing landfill materials, watercourse and wetlands as well as alluvial sediments comprising peat, sandy peat and mud. Significant differential settlements are likely due to the loose and variable nature of the landfill materials and the low bearing capacity of the alluvial sediments;

In addition to the challenges listed above, two significant issues will require careful study if concepts for heavy rail in the corridor are to be developed further. Firstly, the alignment is likely to be in tunnel from immediately south of the M5-East motorway at Cooks Cove. This area is likely to present a technical challenge as tunnelling beneath the M5 East within the alluvial sediments is likely to induce significant settlements that the M5 East structures are probably not designed to withstand. A future railway in corridor is also expected to pass beneath the Airport Rail Line with similar difficulties expected as for the traversing of the M5 East. Secondly, a junction between a future possible F6 railway and the Airport Rail Line should ideally be located south-west of the

International Terminal Station. This may result in tight radius curves and expensive and complex tunnels if a grade separated junction were considered.

6.1.5 Cost Estimate

An order of cost for the development of rail in the F6 corridor was calculated using experience on other similar projects. Rates for the following major elements were extracted from Parsons Brinckerhoff's current projects such as the Parramatta Rail Link and the extension of the Gold Coast Rail Line:

- track system;
- signalling, traction power and communications systems;
- bridges and tunnels; and
- other civil works

Estimates were prepared for each of the two options and are subject to the following assumptions:

- an immersed tube tunnel will be required under the Georges River;
- most other tunnelling will occur in soft ground;
- road overbridges may be required at up to twelve locations and these may require property acquisition; and
- most of the permanent way construction will take place on existing landfill materials, or alluvial sediments comprising peat, sandy peat and mud.

Based on these assumptions, our initial assessment indicates a unit cost of approximately $48.6 to $62.5 million per kilometre for twin track heavy rail in the corridor. The cost of a heavy rail link between Miranda and Sydenham or International Airport Stations is in the range of $670 million to $1.0 billion.

Table 6.1 Estimated Range of Costs for Heavy Rail in the F6 Corridor

Description	Miranda to Sydenham	Miranda to International Airport
Length	16.0 km	13.8 km
Track and systems	$270 to $320 million	$240 to $270 million
Stations (5)	$50 to $80 million	$50 to $80 million
Civil works, including tunnels and bridges	$480 to $620 million	$390 to $500 million
Total	**$790 to $1000 million**	**$670 to $850 million**
Cost per kilometre	$49.4 to $62.5 million	$48.6 to $61.6 million

A conservative approach for the development of costs has been adopted given the conceptual nature of the investigations to date. Consequently the range of costs in *Table 6.1* is indicative only and is subject to further project development. The estimated costs appear reasonable in the context of other similar projects. The current estimated

Parramatta Rail Link cost is approximately $70 million per kilometre for a tunnelled railway in favourable tunnelling conditions[4].

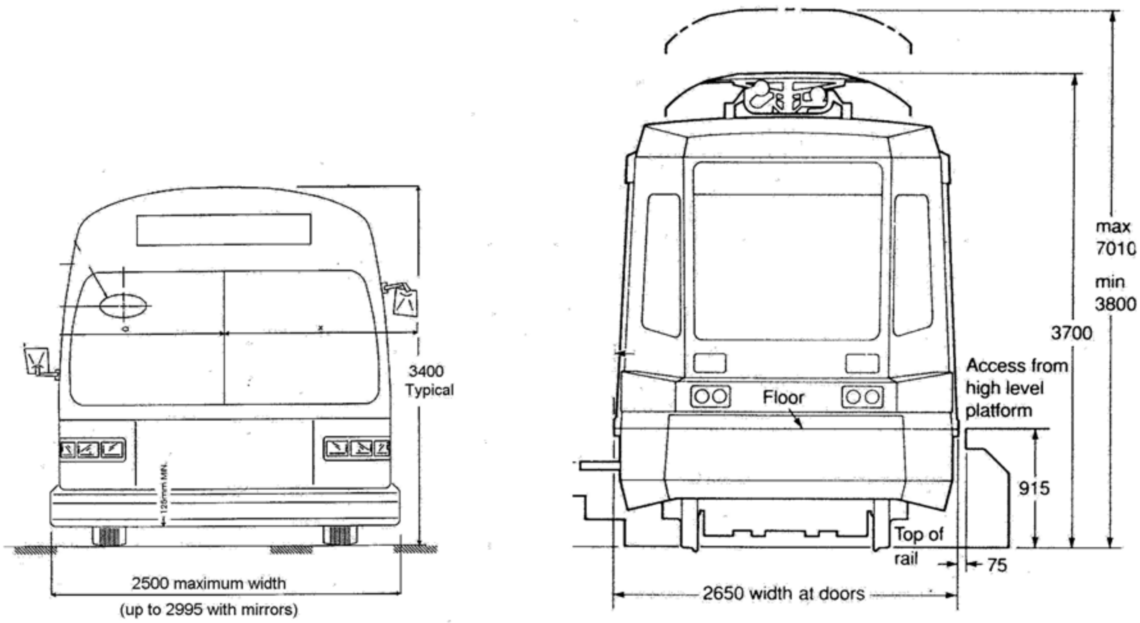
6.2 Medium Capacity Modes: Light Rail or Bus Rapid Transit in Exclusive Corridor

6.2.1 Infrastructure Requirements

Bus and Light Rail Compatibility

Over the long term, land uses adjacent to public transport links can be expected to change with any consequent patronage increases, warranting consideration of a change in operating technology. In this respect, as much flexibility as is reasonable should be incorporated in the design of the busway to allow possible future conversion to light rail operation. The busway should therefore be designed to current light rail standards in respect of transit space and geometry.

Infrastructure for light rail and busways can be designed to be compatible as the transit space requirements are very similar. *Figure 6.4* shows the frontal dimensions of typical bus and light rail vehicles for comparison.



Note: Additional width for mirrors on light rail vehicles can vary by around 50-400mm on either side, depending on whether CCTV or mirrors are used.

Figure 6.4: Typical Bus and Light Rail Vehicle Dimensions

In general, busway alignments are suitable for light rail, except for minimum turning radii at intersections. Intersection treatment and priority arrangements would be subject to complete redesign should a busway alignment be converted to light rail operation. As

[4] *Source - Parsons Brinckerhoff PRL design team*

long as design criteria for light rail are applied in defining the right-of-way, compatibility with busway requirements will be assured.

Due to its application in the urban environment modern light rail vehicles run with 750 Volt DC. Dual voltage light rail vehicles would be required if these vehicles should be extended to Cronulla using the existing railway line concurrently with CityRail suburban trains. This option was not investigated fully as part of this study. However, it is noted that some restrictions may apply in running light rail and heavy rail vehicles on the same track due to the differences in crash resistance.

Lateral Space Requirements

Busways would typically have two lanes, each 3.5 metres wide, one in each direction, with shoulders 0.6 metres wide, for a total roadway width of 8.2 metres. *Figures 6.5* and *6.6* shows a typical cross-section for the provision of a busway and light rail in an exclusive alignment.

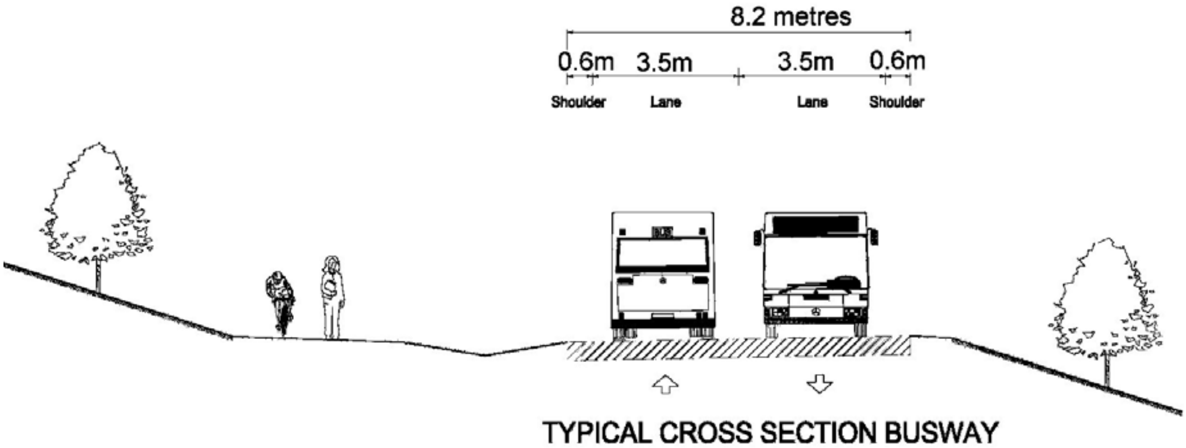


Figure 6.5: Typical Cross-section of Busway in Exclusive Alignment

A light rail system would be characterised by a double track alignment. Transit space requirements for typical (2.65 metre wide) light rail vehicles are similar to those for buses and a corridor width of between 6.65 metres and 7.55 metres is required depending on design speed and on whether the mast for the overhead wire is placed between the tracks or not. Consequently, the 8.2 metre roadway width provided for a busway would be adequate for retrofitting of a light rail system.

It is noted that cross-sectional requirements for light rail systems must provide for the “developed kinematic envelope”. This is the maximum width under any circumstances, of a light rail vehicle in motion at a particular point. The developed kinematic envelope takes into account all the possible effects of curvature, including track super elevation, and end and centre throw of the vehicle. This would be developed and confirmed during a detailed design process.

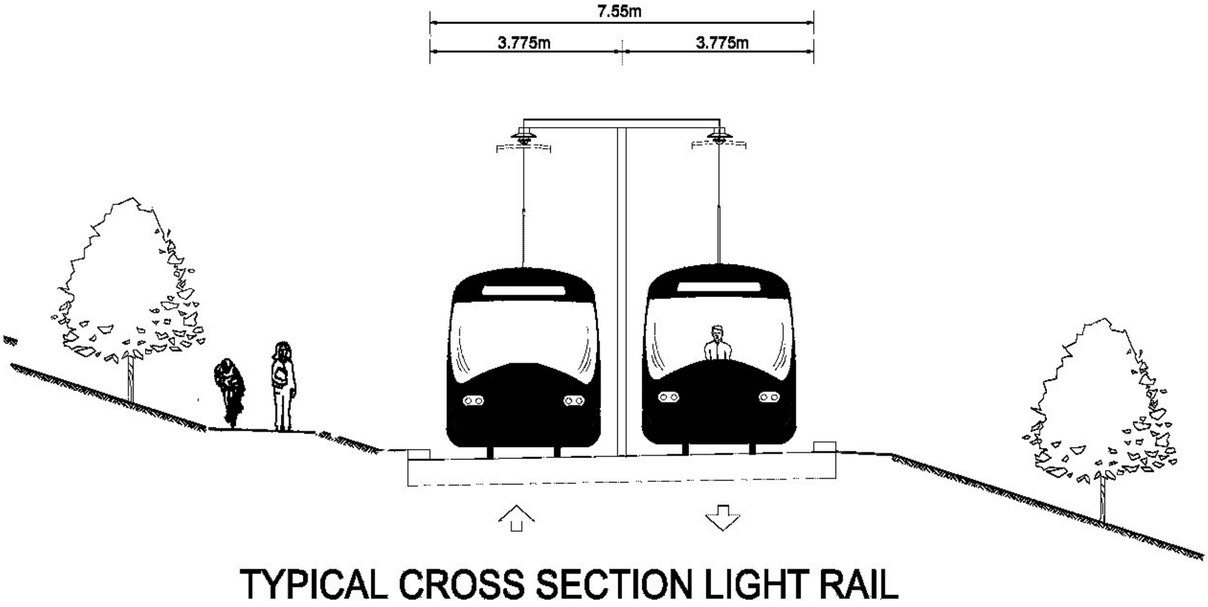


Figure 6.6: Typical Cross-section of Light Rail in Exclusive Alignment

Over-bridges and Vertical Clearances

In terms of vertical clearances, light rail vehicles are typically 3.4 metres to 3.7 metres high. The preferred height of the traction power contact wire is 5.5 metres minimum on street running sections with an absolute minimum clearance in emergency situations of 4.95 metres. In this situation special design and general traffic restrictions should apply and buses may not operate in the light rail corridor. While a single deck bus has a minimum height of about 3.0 metres, a clearance of 4.5 to 5.0 metres is preferred to allow for any future use of double-decker vehicles.

It is proposed that the heavy rail vertical clearance standard be applied to ensure future compatibility with both light rail and heavy rail using separate gantries or masts for carrying the overhead wire. Where over-bridges are likely to be required over the corridor, a 5.80 metre vertical clearance should therefore be provided between the top of the rail or road surface and the underside of the over-bridge

Alignment Standards

The design standards for light rail and busways were compiled from recent similar projects undertaken by Parsons Brinckerhoff, such as the Liverpool - Parramatta Transitway and the Gold Coast Light Rail (PB 2003 & PPK 2002).

Light rail vehicles require a minimum horizontal curve radius of 330 metres to maintain a speed of 70 kilometres per hour and this radius provides an equivalent busway design speed of 90 kilometres per hour. The absolute minimum curve radius for light rail at intersections is 25 metres (compared to 15 metres for buses) with a minimum radius of 70 metres applying elsewhere.

The maximum desirable longitudinal grade for a busway or light rail should not exceed eight percent, with busways potentially accommodating a ten percent grade. At stations the grade should not exceed 2.5 percent to ensure ease of access for wheelchair users.

Longitudinal grades should not be less than 0.35 percent on kerbed sections to ensure acceptable drainage. Gradient requirements for light rail are similar to those of the busway, with 7 percent gradients being the desirable maximum gradient for mainline track.

Stations

Indicative station locations are shown in *Figure 5.4* in the previous section. Busway stations are often staggered to reduce the right-of-way width requirement and this arrangement would require a total width of 17.5 m. However, the maximum width requirement is associated with a parallel platform arrangement as shown in *Figure 6.7*, where the width is 22 metres.

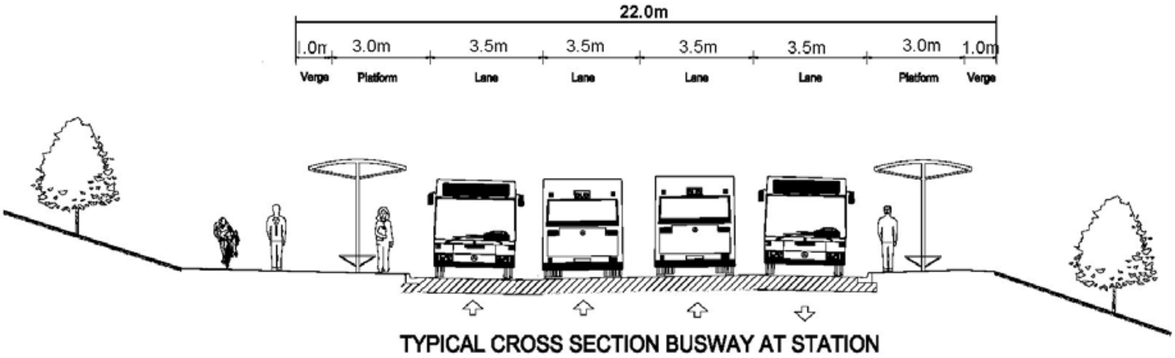


Figure 6.7: Cross-section of Staggered Busway Station

Experience has shown that passengers who cross tracks at or near a stop are exposed to a considerable degree of risk. For this reason, safe level crossings for light rail operation or bridges or underpasses for suburban or light rail operation have to be built. Interchange stations, serving passengers changing from buses or cars or bikes to the rail system, have to provide short and safe walkways equipped with good signage.

Light rail stations can be provided in either side or island platform configurations. An island platform should have a minimum width of 3.5 metres and is shown in *Figure 6.8*. The minimum corridor width at light rail stations is 10.4 metres.

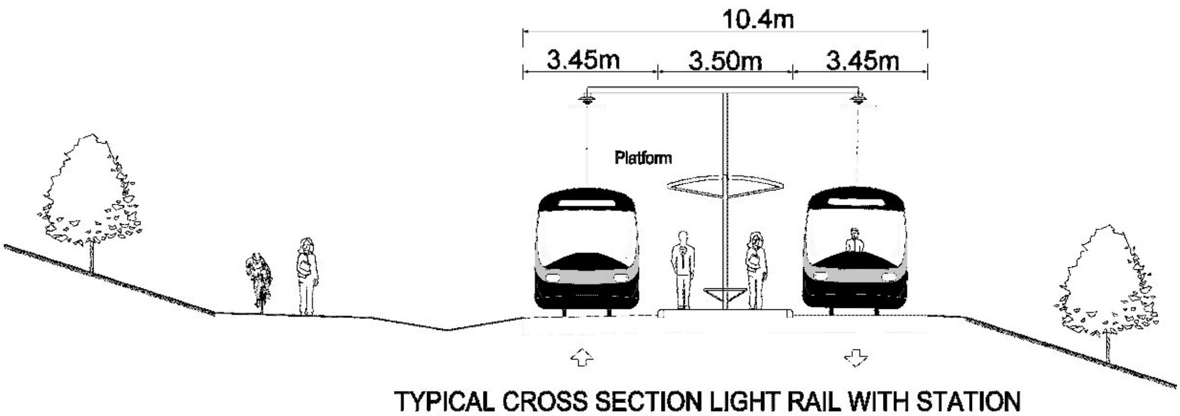


Figure 6.8: Cross-section of Light Rail Station with Island Platform

Other Infrastructure Requirements

If the F6 corridor is served by light rail, there will be a need to provide stabling facilities for secure storage, vehicle servicing and maintenance either at Cronulla or at Miranda for at least sixteen light rail train sets. A light rail train set consists of a maximum of three light rail vehicles, each with a maximum length of 25 metres. Inspection walkways will need to be provided between stabling roads and the minimum width of such a walkway is 1.5 metres. It is estimated that around 7,200 square metres for light rail stabling area will be required.

6.2.2 Land Requirements

If the future development of an exclusive busway or light rail system in the F6 Corridor is to be retained as an option, it would be necessary to provide a corridor of sufficient width to accommodate either the busway or light rail as well as the stations.

Ancillary needs such as parking and interchange facilities as well as stabling yards may be provided outside the corridor boundaries with property acquisition and more appropriately situated in the future when land use changes are apparent. The absolute minimum fence-to-fence rail corridor width for rail is based on the typical cross-sections in *Figure 6.5* and *Figure 6.6*:

- for general main line busway or light rail a minimum width would be 8.2 metres; and
- at stations with island platforms the minimum width would be 10.4 metres.

It should be recognised that no vertical alignment design was carried out for this study. Consequently it has not been possible to assess the space requirements of cut and fill batters or retaining structures. Allowance should also be made within or near the corridor for pedestrian and cycle access. The width required for footpaths and cycleways would vary depending on their configuration (shared or exclusive) and placement on the cut/fill batters.

Given that final station locations would be very difficult to identify during the current study, a corridor of adequate width should be reserved to retain full flexibility in siting stations. It would also be prudent to retain sufficient land to accommodate a footpath and/or cycleway as well as some reserve for earthworks (batters). It is proposed that a corridor width equivalent to that required for heavy rail (i.e. 40 metres) be retained to ensure that no public transport options are precluded. This would also retain adequate flexibility in placing stations, footpaths and cycleways and provide sufficient width for cut/fill batters. The final corridor boundary would be delineated during future studies after further detailed concept development has been undertaken.

6.2.3 Network and Service integration

A busway or light rail service in the F6 corridor would connect Miranda with Sydenham, and/or the Airport effectively running parallel with the Illawarra Line. The catchment of the service would potentially overlap with that of the Illawarra Line, particularly in the vicinity of Rockdale Station and northwards.

The key destinations for existing bus routes in this area are Kogarah and Rockdale rail stations. Ramsgate and Sans Souci are well served by buses to Rockdale and Kogarah rail stations and Rockdale Plaza, both in frequency and coverage. Frequent services operate between Brighton Le Sands and Rockdale rail station. Cross-regional services currently also operate between Miranda and Rockdale, Miranda and Hurstville, Burwood and Bondi Junction via Rockdale and Sydney Airport, Sans Souci and the CBD, Sutherland and Padstow. They provide key connections to the rail network and destinations between the major centres.

There are currently no bus priority initiatives in the area. The F6 corridor could potentially become a rapid transit sector for some of the cross-regional bus services. This is also recognised in the Unsworth Report as described in *Section 4.1.3* and would, if implemented, provide connectivity to the Sydney CBD and Bondi Junction.

Connectivity to the CBD may also be provided at Sydenham or International Terminal Station where passengers may interchange to a heavy rail service. Ideally this connectivity should be provided without requiring a mode change, but interchange requirements may need to be further assessed at these locations.

6.2.4 Engineering Considerations

The development of detailed alignments, vertical or horizontal, did not form part of this study. Parsons Brinckerhoff developed a typical cross-section for the light rail and busway and a right-of-way width of 22 metres was acknowledged by stakeholders as representing a practical corridor for a light rail or busway system, stations, shared footpath and cycleway and limited cut and fill batters.

A concept centreline was developed within the F6 Corridor using the design criteria described in *Section 6.2.1* and a corridor width of 22 metres was applied to this centreline. The route is described in *Section 5.5.3*, *Figure 5.4*.

A preliminary assessment of the potential geotechnical constraints that could be encountered along the alignment was also undertaken, based on a limited desktop study. From this conceptual development of the horizontal alignment it has been concluded that:

- the southern connection at Miranda Station will require on-street running along Kingsway and the traffic impacts of this arrangement needs to be assessed;
- the Captain Cook Bridge currently has a cantilevered footpath. Capacity reduction on the bridge due to replacement of traffic lanes with a public transport lane may not be acceptable therefore it may be required to widen the bridge with an extra public transport lane. As the footpath is currently already cantilevered, simply replacing the footpath is not an option. Under the busway option there is the potential to consider the approach whereby bus lanes are provided up to the bridge where buses then merge with normal traffic lanes. This may provide a reasonable compromise by delivering priority on approaches and trading off some measure of reduced performance while crossing the bridge against the substantial cost of modifying the bridge.

- from the Georges River to just south of the M5 motorway at Cooks Cove, adverse geotechnical conditions are likely to be encountered. These include existing landfill materials, watercourse and wetlands as well as alluvial sediments comprising peat, sandy peat and mud. Significant differential settlements are likely due to the loose and variable nature of the landfill materials and the low bearing capacity of the alluvial sediments;
- the alignment needs to cross over the M5 and the details of this crossing needs to be further investigated for obstacle clearance implications for the airport;
- a new crossing of the Cooks River will be required to connect to the International Airport Terminal Station. A bridge over the Cooks River would need to be at least the same height or higher than the existing Cooks River road bridge. However, the Cooks Cove development proposes to build a bridge over the Cooks River which includes provision for public transport and this may provide the appropriate link;
- a new bridge will be required over the Cooks River to provide for the connection to Tempe and Sydenham Station this would be within the F6 alignment at this point and its clearance requirements would need to be determined;
- the light rail or busway would share a corridor with the St Peters Industrial Route (SPIR) at St Peters (This is discussed further in *Section 6.4); and*
- the connection to Sydenham Station poses a number of constraints in terms of the road network conditions in the area. This link requires more detailed study should the option proceed and options to be considered should include use of the existing goods railway corridor.

It should be recognised that busways have some advantages in mixed-mode environment where the available transit space is shared with cars. At Sydney Airport for example, buses would be able to merge with other traffic.

6.2.5 Cost Estimate

An order of cost for the development of light rail and a busway in the F6 corridor was calculated using experience on other similar projects. Rates for the major elements such as were extracted from Parsons Brinckerhoff's current projects such as the Gold Coast Light Rail and the Western Sydney Transitways studies for the NSW Roads and Traffic Authority (PB 2003 & PPK 2002). Estimates were prepared for a busway and a light rail and are subject to the following assumptions:

1. GST is excluded and all costs are quoted in 2003 dollars;
2. at-grade crossings with signal priority will be provided at all road intersections except with the M5-East;
3. an overbridge over the M5-East will be required;
4. a new bridge over the Cooks River will be required; and
5. most of the permanent way/road construction will take place on existing landfill materials or alluvial sediments comprising peat, sandy peat and mud.

Based on these assumptions, our initial assessment indicates a unit cost of approximately $25 to $32 million per kilometre for twin track light rail in the corridor and between $14 and $19 million per kilometre for an exclusive busway with priority. The cost of a light rail link between Miranda and Sydenham or International Airport Stations is in the range of $350 million to $440 million and for a busway it is estimated between $200 and $260 million.

Table 6.2: Range of Costs for Light Rail or Busway in the F6 Corridor

Description	Light Rail	Busway
Length	16.4 km	16.4 km
Systems and/or track including stations	$170 to $200 million	$40 to $50 million
Civil works	$190 to $250 million	$170 to $220 million
Total	**$350 to $440 million**	**$200 to $260 million**
Cost per kilometre	$25 to $32 million	$14 to $19 million

The cost estimate assumes that grade separated road intersections will not be provided at any of the crossing roads except the M5-East. If grade separation were required at all intersections, up to eleven road overbridges would be required at eleven locations with associated property acquisition. The additional cost for these grade separated intersections, if incorporated during the initial construction, would be approximately $140 million.

A conservative approach for the development of costs has been adopted given the conceptual nature of the investigations to date. Consequently the range of costs in *Table 6.2* is indicative only and is subject to further project development.

6.3 Medium Capacity Modes: Light Rail or Busway on Street

6.3.1 Route Description

This is a road-based option that would have minimal diversions from the existing road network. The route would not be grade separated at junctions but would have signal priority. The conceptual alignment is shown in *Figure 5.5* in the previous section.

The route originates at Kiora Rd in Miranda, turns east down The Kingsway, north along Taren Point Rd, over the Captain Cook Bridge following Rocky Point Road and turning east along Sandringham St and north along Chuter Avenue, east President Avenue, north along Crawford Rd, at this point two options have been identified which show:-

c) east on Bay Street; and then north on Moate and Jacobson Avenue. The alignment would then cross over Muddy Creek and on a new bridge alignment or a tunnel depending on clearances around the airport runway envelope and the M5; and continue through the Cooks Cove development, before crossing the Cooks River to the international and domestic airport terminals; or

d) west on Bay Street to West Botany Street to Marsh Street to the F6 alignment where it would then cross the Cooks River before linking up with the proposed St Peters Industrial Route (SPIRE) from where it diverts to Sydenham Station.

It would be desirable to have a direct connection to the Sydney CBD rather than provide an interchange at the Airport Line or Sydenham Station.

Another potential extension that could be considered is a link to Rockdale station along Bay Street as a means of improving overall system integration.

6.3.2 Infrastructure Requirements

The infrastructure requirements for light rail and busways running on streets are similar to those for an exclusive corridor, with the exception that the infrastructure needs to be integrated into an existing road alignment.

Intersection treatment and priority arrangements would need to be carefully designed, particularly since light rail vehicles are not common on Sydney roads as they are in other cities (such as Melbourne).

Due to its application in the urban environment modern light rail vehicles run with 750 Volt DC and an overhead wire system would need to be provided.

Lateral Space Requirements

Busways would typically have two lanes, each 3.5 metres wide, one in each direction while a light rail system would be characterised by a double track alignment in a corridor width of 7.15 metres. The mast for the overhead wire would be placed between the tracks.

Vertical Clearances

The preferred minimum height of the traction power contact wire is 5.5 metres and structures would have to provide a minimum vertical clearance of 5.80 meters.

Alignment Standards

The absolute minimum curve radius for light rail at intersections is 25 metres (compared to 15 metres for buses) with a minimum desirable radius of 70 metres applying elsewhere.

The absolute maximum desirable longitudinal grade for a busway or light rail should not exceed ten percent. At stations the grade should not exceed 2.5 percent to ensure ease of access for wheelchair users.

Stations

Indicative station locations are shown in *Figure 5.5*. Stations can be provided in either side or island platform configurations depending on the road layout. The station locations are based on medium capacity modes with a station spacing of around 800m to 1 kilometre.

6.3.3 Engineering Issues

A list of engineering constraints is provided below for the on street option:

- features of the existing road network that may need to be altered or removed such as traffic control devices to accommodate a public transport option;
- the Captain Cook Bridge currently has a cantilevered footpath. Capacity reduction on the bridge due to replacement of traffic lanes with a public transport lane may not be acceptable therefore it may be required to widen the bridge with an extra public transport lane. As the footpath is currently already cantilevered, simply replacing the footpath is not an option. Under the busway option there is the potential to consider the approach whereby bus lanes are provided up to the bridge where buses then merge with normal traffic lanes. This may provide a reasonable compromise by delivering priority on approaches and trading off some measure of reduced performance while crossing the bridge against the substantial cost of modifying the bridge.
- a bridge over the Cooks River Bridge, would need to be at least the same height or higher than the existing Cooks River road bridge. The existing height of this bridge is approximately 4.5m from water level;
- the links to International Airport Station will require further investigation. Under Option A there is an option for a crossing to Tancred Avenue over Muddy Creek through the Cooks Cove development with a stop at this location (see *Figure 5.5*). Then there would be a crossing over the Cooks River to the airport via the proposed bridge included in the Cooks Cove development submission;
- there are significant engineering constraints at the Sydney International Airport terminal for a light rail or busway alignment operating through the airport. Elevated roadways serve the terminal, however an at-grade option could be sought to avoid the existing roadways. It should be accepted that on the way to and around the airport terminal the alignment would have to significantly deviate from the existing road alignments.

6.3.4 On-site Survey

An onsite survey was undertaken to assess the on road option for medium capacity modes. The survey aim was to assess the suitability of the existing road network to accommodate the inclusion of the medium capacity modes. Factors that were considered during the survey were:

- road widths;
- location of the light rail or busway within the available road space (centre of road or along kerb);
- existing traffic calming and traffic control devices;
- potential suitable locations for stations;
- intersection layouts; and

- method of river crossing. Existing bridge construction and the ability of the bridges to accept another lane.

South of the Georges River, the opportunities for on-road bus services are primarily on higher capacity arterial roads of up to six lanes. North of the Georges River, these opportunities would occur on lower capacity local roads of around 13 metre width with a large amount of traffic calming.

Roads along the on-road route are generally wide enough to accept the inclusion of a bus or light rail services within the existing road reservation. The exception to this was further to the north of the study area along Jacobson Avenue, which has a road width of 11 metres, and Tancred Avenue, Kyeemagh, where the road is 10.5 metres wide. Chuter Avenue, Sans Souci is currently a dual carriageway lay-out but does not function as a dual carriageway road ins some areas. This is apparent around the Ramsgate RSL, where the second carriageway has been made into a car park. This means that, at present, the single remaining carriageway would not be wide enough to accommodate the bus or light rail and these would have to use the wide median or, alternatively, the dual carriageway operation would have to be reinstated.

The roads on the route have quite a high level of traffic calming north of the Georges River. There are numerous roundabouts, refuge islands and squeeze points along the selected route. These traffic calming devices would need to be removed or altered to allow the operation of bus or light rail along the road.

The route also involves a number of short doglegs onto main roads running perpendicular to the F6 alignment. These doglegs using the main roads are ideal station locations allowing connections to east west running bus services to be much more legible and accessible.

Centre of road or kerbside options

It is likely that there is insufficient space for middle of road options considering stations. Locating stations at the kerbside would be more suitable with priority signalling at intersections to allow turning manoeuvres from the outside lane.

A number of optional road alignments were also assessed on site and it was found that:

- Francis Avenue, Brighton-Le-Sands would be unsuitable for public transport use due to its restrictive width.
- the option to divert the route off the roadway onto the F6 alignment just south of O'Connell Street, Monterey is feasible. The route would divert west off the road at A.S Tanner reserve and run along the back of the houses fronting Colson Cr, Monterey. The route could dogleg at President Avenue, Kogarah and then turn right onto West Botany Street, Kogarah or alternatively could join into the proposed off street F6 alignment.
- West Botany Street (Arncliffe) is a feasible option to the proposed on-street alignment. The grades would need to be further clarified for use by light rail. There are a number of pedestrian refuges that would need to be removed. The road width is sufficient being 4 lanes. However, there may be considerable impacts on traffic flow.

- Bestic Street, Kyeemagh is sufficiently wide except at the bridge at Muddy Creek where the road narrows.

The best option is expected to follow the proposed on road route up to O'Connell Street, Monterey, then divert west through the reserve left onto President Avenue, Kogarah, then Right onto West Botany Street, Kogarah or use the F6 alignment north from this diversion.

6.3.5 Cost Estimate

An order of cost for the development of light rail and a busway on road was calculated based on other similar projects. Rates for the major elements were extracted from Parsons Brinckerhoff's current projects such as the Gold Coast Light Rail and the Western Sydney Transitways studies for the NSW Roads and Traffic Authority (PB 2003 & PPK 2002). Estimates were prepared for a busway and a light rail.

Based on these assumptions, our initial assessment indicates a unit cost of approximately $17 to $21 million per kilometre for twin track light rail and between $7 and $10 million per kilometre for busways on streets. The cost of an on-street light rail link between Miranda and Sydenham or International Airport Stations is in the range of $280 million to $340 million and for a busway it is estimated between $120 and $150 million.

Table 6.3: Range of Costs for Light Rail or Busway on Street

Description	Light Rail	Busway
Length	18.5 km	18.5 km
Systems and/or track including stations	$190 to $230 million	$40 to $50 million
Civil works including bridges	$90 to $120 million	$80 to $100 million
Total	$280 to $340 million	$120 to $150 million
Cost per kilometre	$17 to $21 million	$7 to $10 million

A conservative approach for the development of costs has been adopted given the conceptual nature of the investigations to date. Consequently the range of costs in *Table 6.3* is indicative only and is subject to further project development.

6.4 Local Bus Concept

Bus services in the study area are provided by multiple operators with the largest of these being State Transit and Connex. Services are generally focused on railway stations with Miranda, Rockdale and Kogarah being the most significant, while Hurstville is also the destination for some services. Buses provide the sole public transport option for most people in the corridor for access to rail or local centres. Service frequencies vary significantly as do hours of operation, with generally poor levels of service outside peaks and on weekends. Existing bus service structures are shown in Section 4.1.3 above and *Appendix E*.

Traditionally the structure of services in the area has been largely built around contract areas. Removal of these often artificial barriers has the potential to improve the overall coverage and performance of the bus network. An example can be drawn from the area between Sans Souci and Brighton-Le-Sands where both STA and Connex operate either to Rockdale (STA) or Kogarah and Hurstville (Connex) on roads within about 400 metres of each other. Because of contract area restrictions some of the routes operate along General Holmes Drive on the shores of Botany Bay with a significantly reduced patronage potential because of the one sided catchment. This form of structural inefficiency is wasteful of scarce public transport resources. This problem is further exacerbated by the fact that STA cannot run services into the key regional centre of Hurstville from its area of operation.

More specifically, STA routes 303 (to City) and 478 (to Rockdale) use General Holmes Drive, while Connex's route 947 travels along Chuter Avenue (400 metres back from the Bay). Common use of Chuter Avenue and a rationalisation of route structures could increase the overall effectiveness of services in this area leading to increased frequencies, improved patronage potential and lower operating costs.

However, recent changes to bus contract areas being instituted by the government in response to the recommendations of the "Review of Bus Services in NSW, Unsworth Report" (MOT 2004) indicate that the contract for the area along the F6 corridor (north of the Georges River) will come under the control of STA. In his report, Unsworth recognised that the structure of contract areas is a key impediment to improved bus services in Sydney. This should open the way to a restructuring of services to remove some of the impediments to bus travel in the corridor.

In conceptual terms the bus network in the corridor could be expected to respond to the operational requirements of any mode which was selected to operate along the F6 corridor in the following way:-

- Under a heavy rail option buses would be restructured to serve new railway stations and provide an interconnection with the existing Illawarra Line stations.
- A light rail system could see similar changes, however, the closer spacing of stations would increase the walk catchment of the line and potentially reduce the need for bus services in the area.
- A BRT system, either in an exclusive corridor or on road would be the catalyst for a major restructuring of the bus network in the area. Service integration would be expected to deliver a combination of service types which would feed through residential areas before joining the F6 public transport corridor to run to a destination either on or off the corridor (e.g. Rockdale, Sydney Airport, Central Sydney etc).

The Unsworth report identifies three Strategic Bus Routes within this corridor. These are shown on Figure 4.5 above. One route (No. 21) parallels the alignment of the corridor and could conceptually, be seen as the "first stage" of the F6 public transport corridor with later stages making use of the F6 corridor to deliver high priority public transport services. As demand grows the system could transition to light rail. Issues of staging are addressed later in this report.

6.5 Road Network Context

6.5.1 Potential Road Network Impacts

The F6 alignment crosses major roads at the following locations:

- Marsh Street, Arncliffe
- Bestic Street, Banksia;
- Bay St, Brighton-Le-Sands;
- President Avenue, Kogarah;
- Barton St, Monterey;
- Sandringham St, Sans Souci;
- Taren Point Road, Taren Point;
- Port Hacking Road, Sylvania;
- The Boulevarde, Miranda;
- The Kingsway, Miranda;

These road crossings have implications for the design of any public transport options that require an exclusive right-of-way in the F6 corridor above ground (heavy rail and light rail/bus options). The indicative alignments have broadly taken into consideration the need for grade separation at these intersections. However, there will be a need to consider local road closures but these would only happen where there is viable alternative public access available.

The preliminary concept shows that the roads that may need to be closed at the point where they cross the alignment inlcude:-

- Wingello Road, Miranda
- Tuffy Avenue, Sans Souci
- Ritchie Street, Sans Souci
- Park Road, Sans Souci
- Meurants Lane, Ramsgate
- Clarkes Road, Ramsgate
- Margate Street, Ramsgate
- Bruce Street, Brighton-Le-Sands

These roads are shown graphically in *Appendix D*, Any potential road closure is subject to a detailed traffic study that would need to be undertaken to assess the traffic impacts and to devise mitigation measures. Such a detailed local area traffic study was not part of this investigation. However, it should be recognised that road closures and the introduction of transit priority (under some options) could potentially increase road congestion on arterial and other roads, and therefore increase road user costs.

The RTA has undertaken preliminary modelling to establish an indicative measure of road network impacts. The measures are dependant on the public transport option tested and the level of priority provided on arterial roads. The results show that between 500 and 1,000 hours of additional vehicle delay in the two hour morning peak could be experienced on the wider road network. The differentiating factor between these figures is the assumption regarding the level of priority provided on Captain Cook Bridge. The lower figure assumes no impact on road capacity while the higher figure assumes removal of capacity to accommodate a public transport system. The comparative costs are in the range of $14 million to $36 million per annum. (see also *Section 7.3.1*)

The construction cost estimates for bus and light rail services in the F6 corridor do not allow for road overbridges (at-grade intersections are provided) where crossing roads are to remain open. For the heavy rail option, the cost of grade separated crossings, including property acquisition that may be necessary on the bridge approaches, are included in the estimates.

The detailed studies that would be required to support further consideration of a public transport option for this corridor would include development of a detailed road strategy which would address road network implications and local access needs as discussed above.

6.5.2 The St Peters Industrial Route

The alignment of the proposed St Peters Industrial Route (SPIR) is shown on *Figure 6.9*. This has been plotted from information provided by the RTA and includes the recent Marrickville Council adjustment to cater for the proposed retail development in Tempe fronting Bellevue Street and the Princes Highway to the west of the F6 corridor. It is noted that electronic data was not available so the boundaries as shown are scaled only and would be subject to detailed survey.

An *Overview Report* prepared by Kinhill Pty Ltd in 1999 identified the need for a six lane carriageway and a reserve width of 50 metres minimum. The proposed carriageway cross section shows a total width of 34.8 metres kerb to kerb.

The only public transport option that is affected by the SPIR route is the busway / light rail option which links to Sydenham Station. The following are among the key considerations for this section of the corridor:

- in theory, there could be enough space to co-locate the busway / light rail line with the a four-lane roadway within the 50 metre minimum, SPIR reserve width. However, this would need to be investigated in more detail and may require widening of the reserve.
- if the busway / light rail option becomes the preferred option then traffic demands should be re-evaluated to confirm the lane requirements. A reduction to four lanes would ensure the required space to co-locate the two modes within the 50 metre

reserve without widening. It is noted that there are a number of closely spaced intersections along this route that may require flaring to cater for traffic demand.

- the optimum option for access to Sydenham station lies within the existing rail corridor. However, this requires further investigation to confirm viability. If confirmed, the busway / light rail alignment would need to deviate from the SPIR reserve in order to pass under the bridge which will carry the road over the Botany goods line.

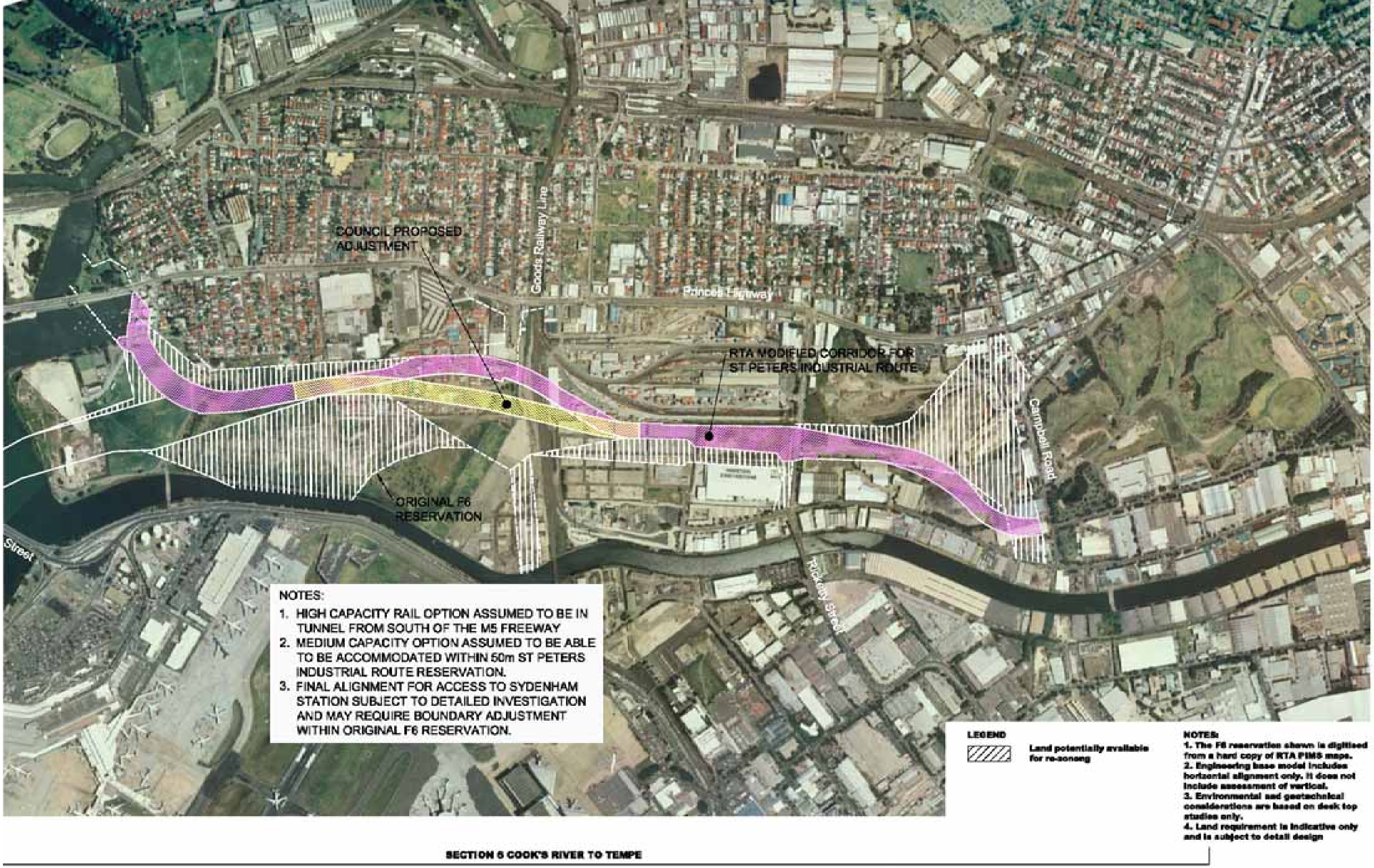


FIG 6.9 ST Peters Industrial Route Reservation

- The alignment falls within the area of influence of the airport approach paths. A review of the *Obstacle Limitation Surface Plan* provided by SACL indicates a maximum height of about 16 metres AHD for any structure of passing vehicle under the flight path at the SPIR route. There is no data which shows the surface levels along the SPIR route however, a review of contour information suggests that the level where it crosses the flight path may be in the order of 5 to 8 metres AHD. Assuming that a maximum structure clearance of 6 metres would be associated with a light rail system then the overall height 'envelope' would be in the order of 11 to 14 metres AHD. In this regard the RTA has advised that it's investigations indicate the need to lower the road to comply with flight path restrictions. It is noted that this issue may also impact on the crossing of the railway by the SPIR route.

In summary, it may be feasible to co-locate the busway / light rail alignment with a four lane road within the 50 metre wide SPIR corridor. However, this should be confirmed through design of the SPIR route and the busway / light rail. This design must also consider the constraint of the flight path on vertical elements of both the road and the public transport facilities.

7. Assessment of Options

7.1 Assessment Approach

7.1.1 Travel and Accessibility

The Patronage Model

Modelling was carried out to determine the likely patronage for the various public transport options under consideration in this assessment. This was based on current population and employment projections for 2021 supplied by the Transport and Population Data Centre (TPDC) of Department of Infrastructure, Planning and Natural Resources (DIPNR).

Three heavy rail options and two light rail options were modelled:

- Heavy Rail – Base Option: Wynyard to Waterfall (via Sydenham);
- Heavy Rail – Option 1: Wynyard to Cronulla (via Sydenham);
- Heavy Rail – Option 2: Town Hall to Cronulla (via Airport and Museum);
- Light Rail – Option 1: Sydenham to Miranda (via F6 corridor); and
- Light Rail – Option 2: Domestic Airport to Miranda (via road network).

The Sydney Strategic Travel Model (STM) was used for undertaking patronage forecasts and assessment of various public transport options within the F6 Corridor. The STM is a combined destination-mode choice model and is used extensively for public transport modelling in Sydney and was developed and run by the TPDC.

At the time of this study only Stage 1 of the STM's development process was completed and available for use. Stage 1 of the STM involves a mode/destination choice model for home to work (commute) trips and models for estimating inputs to this model (such as models for license holding, vehicle ownership etc). Stage 1 STM uses a factoring process to develop the purpose "other" trip table based on "commute" trips. The factors for purpose "other" have been developed based on observed trip length distribution in Household Travel Survey (HTS) data.

The mode/destination model can be run in an iterative process to include feedback from network assignment to network skims input to mode choice model. The model is currently set up for up to four cycles. Detailed information on structure and parameters of STM can be obtained from TPDC.

As the F6 corridor would be a new public transport corridor, additional nodes and links were required to be coded for the heavy rail alignment and the light rail (Option 1) alignment that are within this corridor. While the Light Rail Option 2 alignment predominantly uses the existing public transport road network, some additional links were required. Where new nodes and links were required, these were developed using the same coding conventions with regards to link types and other user defined parameters for the rail network and public transport road network respectively.

Model Assumptions

In developing the transit service distributions for the heavy rail and light rail options, the stopping patterns and travel times need to be given. For the rail options, the travel time between each rail station is required while for the light rail options the average travel time for the service is required.

For the heavy rail options, PB formulated the stopping patterns and travel time between heavy rail stations along the F6 corridor. The stopping patterns and travel time between heavy rail stations for the existing rail corridors were based on the existing rail services along these corridors (i.e. Eastern Suburbs/Illawarra line and the Airport/East Hills line). For the light rail options, PB formulated the stopping patterns and the model determined the travel time between light rail stations based on the link speeds of the network.

The new heavy rail options were proposed to have a 15-minute frequency with a potential seated capacity of 3,360 passengers and a total capacity of 4,800 passengers per hour. The medium capacity (light rail) options were proposed to have a 5 minute frequency and a travel speed of 35 kilometres per hour, with a seated capacity of 1,800 passengers and a total capacity of 2,400 passengers per hour.

The STM model does not explicitly code dwell time at the heavy rail or light rail stations or a layover time period at the end of each route, but these are included in the overall run times specified in the model.

The patronage outputs are outlined in the following sections for each option.

Potential Land Use Changes due to Public Transport in the F6 Corridor

While recognising the intention to retain open space opportunities in the corridor, it is believed that there may be some potential for an increase in population density and increases in employment in the catchment of the F6 Corridor should public transport be developed in it (the F6 Corridor). Consequently, high land use assumptions were developed within the corridor catchment on the basis of the public transport line influencing land use densification near stations. Transit Oriented Development (TOD) oppportunities have been assessed in the corridor at key station locations, both at existing stations such as Cronulla and Caringbah and the new stations suggested along the corridor.

The purpose of developing the forecasts was to derive an upper bound for densification around stations. In producing a “bullish” forecast, some assumptions were made regarding development potential. Accordingly, in the case of residential development potential it was assumed that the overall potential residential density on land that is developable would be as follows:

- 1-200 m from a station, 50 dwellings per hectare;
- 200-400 m from a station, 30 dwellings per hectare;
- 400-800 metres from a station, 20 dwellings per hectare; and

- for the remainder of the corridor, densities either matching prevailing or 10 dwellings per hectare, whichever is the greater.

For the purposes of identifying developable land, the following land uses were excluded from residential redevelopment areas:

- the current corridor
- industrial areas
- schools, playing fields and parks; and
- high density commercial areas around Miranda and Cronulla stations.

It was assumed that there is potential for shop-top redevelopment in the Caringbah shopping area.

The total population potential was based on an average household size of 2.9 persons and is expressed as an increase over the most recent TPDC forecasts (TPDC 2003v1). In these forecasts, TPDC has already adopted quite intensive growth in Cronulla, Woolooware, Miranda and Ramsgate, Brighton-Le-Sands and the aggressive TOD assumptions result in only small further increases in these areas. The major potential is seen in Burraneer, Miranda, Sandringham and Arncliffe around the new Cooks Cove development. The “bullish” forecasts for residential population in the F6 Corridor catchment for 2021 thus developed is some 13 percent higher that the TPDC’s current forecasts for the same timeframe. Given that this bullish forecast applies to the F6 Corridor catchment, the patronage forecasts for public transport options in the corridor could be increased by a similar proportion to represent the impact of higher than forecast land use change. However, for the purposes of this study the current TPDC forecasts have been applied for the evaluation of options.

Employment changes are significantly more difficult to quantify. The Sydney Airport Preliminary Draft Masterplan alludes to the development of additional airport-related employment, but the anticipated growth is not quantified. We have therefore adopted a sensitivity approach, assuming that for travel zones within one kilometre of the corridor, employment could increase by 10-20%.

The recent TPDC forecasts show, compared to employment in 2001:

- increases in employment in Cronulla, Miranda and Sandringham;
- decreases in employment in the Ramsgate-Kyeemagh area;
- an increase in Airport employment of around 5,000; and
- a net increase in employment of around 6% in the corridor from 2001.

The sensitivity approach results in lower and upper limit increases of 16% and 27% respectively in total employment in the corridor compared to 2001.

7.1.2 Social and Land Use

The social and land use assessment is aimed at establishing to what extent the different options:

- ensure equitable access to social and economic activities; and/or
- reduce journey times for all journeys to, from and within the corridor.

The performance of each option was evaluated against the following criteria:

- relative and subjective assessment of potential travel times to CBD from the catchment;
- the number of intra or inter mode transfers that may be required; and
- the estimated population within walking distance of stations

7.1.3 Environmental Impacts

Environmental opportunities and constraints may arise for the community with the development of public transport in the F6 corridor, and these are discussed in more detail in *Section 3* of this report.

An attempt was made to asses the potential for each option to enhance the potential beneficial effects and manage potential adverse environmental impacts. The assessment criteria were based on the extent to which each option potentially:

- conserves biological diversity and ecological integrity
- improves air quality and reduces greenhouse gas emissions
- minimises the use of energy and non-renewable resources

Measures of performance against the criteria are based primarily on:

- potential of each option to encourage mode shift from car based travel to public transport, as measured by the potential change in vehicle kilometres travelled (vkt's);
- the opportunity to avoid sensitive natural environments and to mitigate adverse effects resulting from public transport development through design of appropriate alignments. As all alignments follow the same route the best basis for comparison would be the width of the corridor used by the transport infrastructure; and
- the subjective energy use and emission impacts of the different modes

Consideration was also given to the relative potential for each option to maintain connectivity across the corridor, particularly for pedestrians and cyclists.

7.1.4 Economic and Financial

The economic and financial performance of the various options was assessed by calculating the cost per passenger for each option. The costs are restricted to operations in the corridor itself and are at a fairly broad level in that no detailed operational planning has been undertaken.

Costs

Infrastructure costs were estimated as part of the study. The lowest cost of the ranges estimated was used in the cost estimates for each mode. An annual value was estimated using asset lives and a discount rate of 7 per cent. The following costs were used:

- CityRail provided unit costs for operating suburban trains and the capital costs of trains. An annual value was estimated using an asset life of 35 years and a discount rate of 7 per cent. No costs are included for station operations. CityRail costs are available for existing stations but it is not clear that they would be appropriate for the F6 corridor where the stations would be small and have low operating costs;
- light rail operating costs were estimated from tram operating costs in Melbourne. The unit costs used are below those in Melbourne as a new system in an off street environment is being costed. The cost of new articulated low floor trams in Melbourne was used for the light rail car costs. An annual value was estimated using an asset life of 30 years and a discount rate of 7 per cent;
- bus costs were estimated for the evaluation of the western Sydney Transitways. Because these costs assumed services would be provided by a private operator, or a contracting approach would deliver private operator cost structures, the bus costs will be underestimated if bus services in the F6 corridor are provided by the public operator. The capital cost of new buses was converted to an annual value using an asset life of 15 years and a discount rate of 7 per cent. No operating cost estimates are available for stations on a busway or light rail, but these are likely to be low compared to other operating costs; and
- infrastructure maintenance costs are estimated as 1 per cent of the capital costs of systems/track/stations. No maintenance costs are included for civil works. All costs exclude GST but include other taxes such as payroll tax and fuel excise, ie they are financial, not resource, costs.

Patronage

The demand modelling gave results for 2-hour peak passenger flows in the peak and contra peak direction. The contra flow direction for busway and light rail modes was about 40 per cent of the peak direction flow, and 50 per cent for heavy rail, and 65 per cent for bus and light rail on street. Those percentages are used to estimate total 2 hour peak flows. Only the peak direction flow is used to estimate the number of vehicles required to meet demand.

Using this method implies that all modes of transport attract the same level of patronage. However, in this strategic study the assumption has been that the medium capacity modes (light rail and bus transit) will be afforded the same level of design and priority and will therefore attract similar levels of demand. Nevertheless it is recognised that there is some evidence that rail modes generate more trips than on-street buses.

Whether this preference for rail modes holds for busway services, which are intended to mimic the characteristics of rail modes, is less certain.

The 2-hour peak demand and costs need to be extrapolated to give annual figures to estimate costs/passenger on an appropriate basis. A factor of 1,000 was used to extrapolate passengers in the 2-hour peak to an annual total and a factor of 1,400 was used to calculate the annualised costs from 2-hour peak costs per passenger. These factors are based on analysis of bus services in western Sydney and were used in the evaluation of the Transitways. Other factors may be more appropriate for rail services, depending on the level of peaking; a brief check against data in the CityRail document "A Compendium of CityRail Travel Statistics, July 2001" suggests that any differences are unlikely to affect the overall analysis.

Basis for Calculation

The cost per passenger were estimated on an incremental basis to arrive at the total cost for each mode:

- vehicle operating costs were calculated first, and these include crew/drivers, fuel/electricity, vehicle maintenance, vehicle cleaning, etc;
- the capital cost of the vehicles were then calculated and added to the operating costs;
- the infrastructure maintenance cost was then added, which provided an indication of the total recurring operating cost of a given mode system excluding the capital cost of the infrastructure; and finally
- the infrastructure costs were added to the operating costs to provide the total cost for each mode per passenger. The capital cost was distributed over the total patronage over an assessment period 35, 30 and 15 years for heavy rail, light rail and bus respectively.

The costs per passenger were estimated for 2-hour peak direction patronage of between 1,000 to 10,000. The demand modelling patronage estimates indicated that the 2-hour peak direction demand would be around:

- 1,200 passengers in the 2-hour peak direction for heavy rail;
- 4,000 passengers in the 2-hour peak direction for busway/light rail in an exclusive corridor; and
- 3,700 passengers in the 2-hour peak direction for on-street bus/light rail.

These levels of patronage demand are shown as vertical lines on the graphs of cost vs demand in *Figure 7.1*, *Figure 7.2* and *Figure 7.3*.

Calculations

Figure 7.1 below shows the vehicle operating cost per passenger (excluding capital cost of infrastructure and vehicles and infrastructure maintenance costs).

It shows that light rail in the F6 reservation generally has the lowest operating cost of the modes over the range of passenger numbers between 1,000 and 1,000 in the peak 2-

hour. However, above 6,000 passengers per peak direction, the heavy rail and light rail operating costs are virtually the same.

There is little variation in the bus and light rail costs with the number of passengers carried as the operating costs for these modes are almost directly related to the number of passengers carried. This is due to the small capacity of the vehicles; vehicles are essentially all travelling full and more passengers mean more vehicles are required. The heavy rail costs vary with passengers carried because operating costs are significant for each train set and the number of seats per train is large; costs decrease as demand increases (as more seats are filled) but at some point the costs increase again as a new train set is added (i.e. the train seats are filled and another train is added to cater for the next passenger). The effect is not so marked for the lower capacities of buses and light rail vehicles. This explains why the cost graphs for heavy rail fluctuates up and down with increased passenger numbers. This fluctuation is visible in all three the cost graphs below.

The differences between costs for operations on street and in the reservation are due to speed of services, with 25 kilometres per hour used for on street operations and 30 kilometres per hour for operations in the F6 reservation. A speed of 40 kilometres per hour was used for heavy rail as fewer stations are proposed.

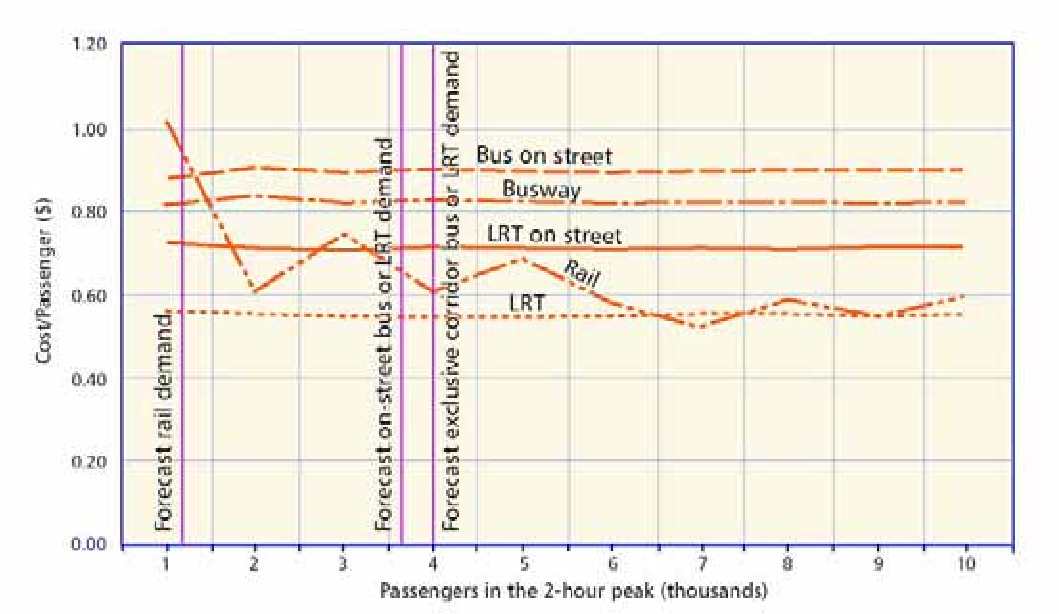


Figure 7.1: Operating Costs per Passenger by Mode

The assumptions underlying the capital cost of vehicles for each mode estimates are shown in *Table 7.1* below. The last row shows that light rail vehicles have the highest purchase cost per passenger. *Figure 7.2* shows how costs per passenger by mode change when vehicle captial costs are added to the equation.

Table 7.1: Calculation of vehicle Capital Costs per Passenger

Description	Buses	Light Rail	Heavy Rail
Purchase cost per vehicle	$350,000	$3 million	$3.4 million
Purchase cost per consist	$350,000	$6 million	$27.2 million

Seated passengers per consist	50	150	840
Total passenger capacity	65	202	1,100
Purchase cost per passenger	$5,385	$29,702	$24,727

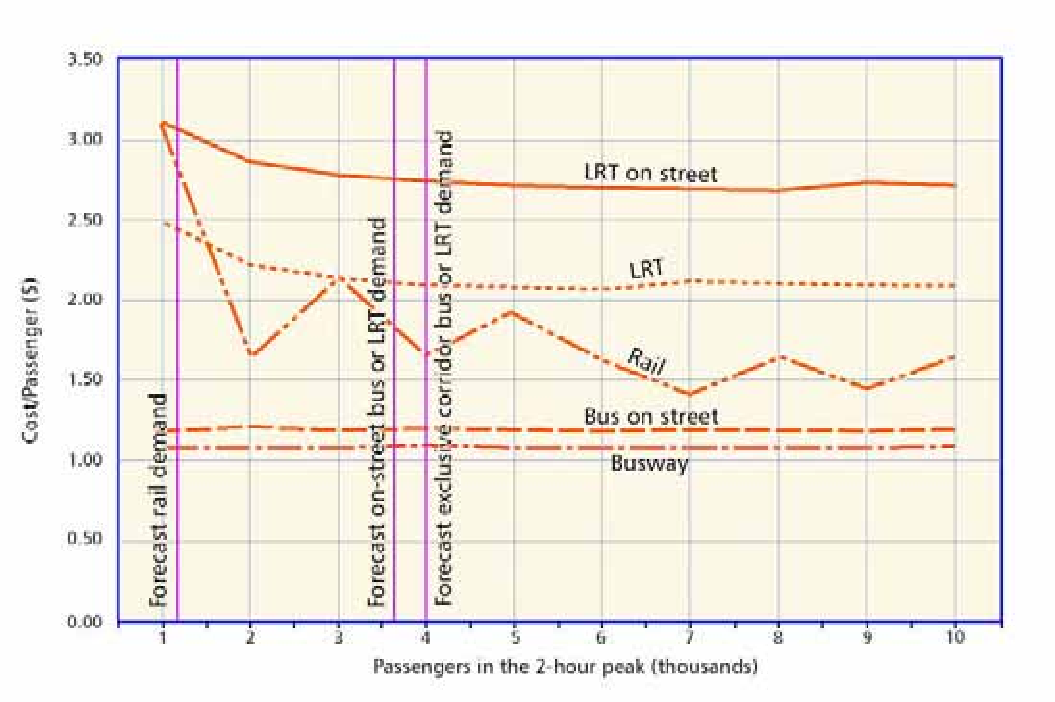


Figure 7.2: Operating Costs per Passenger by Mode, including Vehicle Capital Cost

The inclusion of infrastructure maintenance costs makes little difference to the pattern of costs by mode. At lower levels of passengers carried costs of both of the rail modes increase somewhat but the effect decreases with increases in the number of passengers carried. Buses remain the lowest cost mode.

When the costs of infrastructure capital are included, heavy rail becomes the highest cost mode at all levels of passengers carried. The two bus modes have the lowest cost, and on street costs are lower than corridor costs for both bus and light rail. The latter is to be expected as less new infrastructure is required for on street operation. The effect of more passengers on cost per passenger carried is clearly shown in the downward sloping curves, with the effect more marked the higher the infrastructure costs. *Figure 7.3* shows the dramatic effect on cost per passenger that the addition of infrastructure costs has on the financial and economic assessment. Because the infrastructure costs are fixed and relatively large compared to the operating costs, the cost per passenger becomes very sensitive to the forecast total passenger demand.

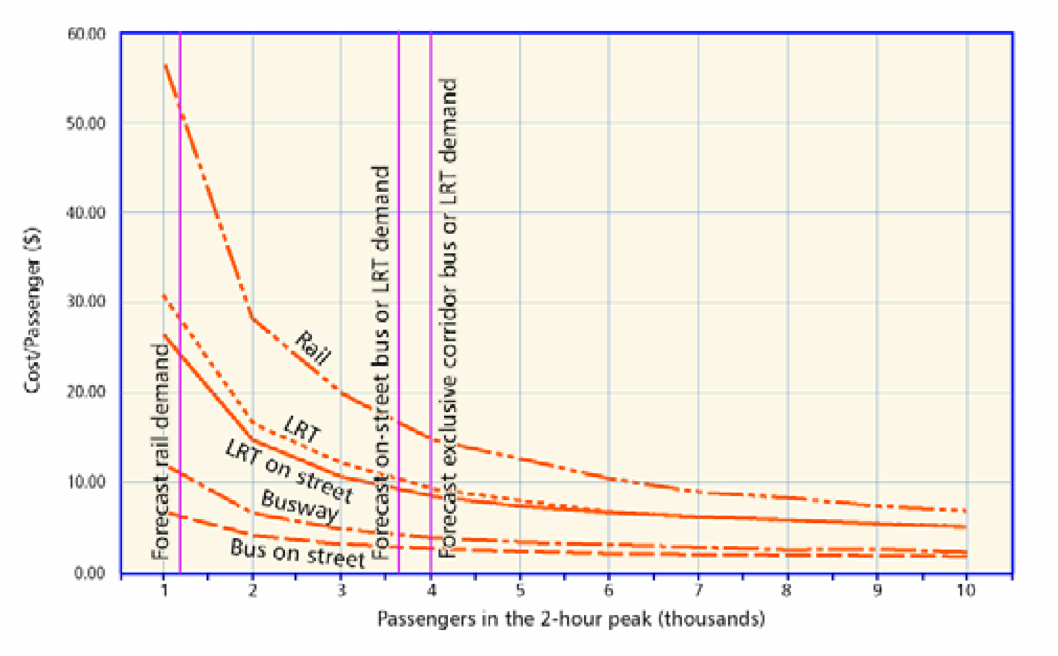


Figure 7.3: Total Cost per Passenger

7.2 Assessment by Option

7.2.1 Heavy Rail

Travel and Accessibility

Demand figures based on 2021 TPDC strategic model forecast a relatively low level of patronage demand for both rail options, with a maximum demand of approximately 1,200 passengers in the peak two hours being predicted. The following should be considered in the evaluation of this demand prediction:

- the demand of 1,200 passengers in the peak two-hour would fill the seats on a 12 heavy rail carriages (i.e. one and a half 8-car sets). The Illawarra Line, by comparison, is acknowledged to be at capacity with the worst overcrowding in the CityRail network. CityRail patronage numbers indicate that the dual-track section between Sutherland and Hurstville would be carrying in excess of 20,000 passengers in the peak 2-hour;
- a minimum level of service in the F6 Corridor of four trains per hour has been adopted for this analysis (two trains per hour from Cronulla would still be routed via Sutherland and the Illawarra Line) even at this low frequency the line would still provide seated capacity in the peak period of up to eight times the forecast demand in 2021;
- the patronage model does not take account of the capacity constraints on the Illawarra Line which are expected to become a significant issue towards the end of the next decade, even with the completion of identified works (now called the “Clearways”) to increase capacity. While heavy rail in the F6 Corridor would provide some relief between Sutherland and Sydenham, the Illawarra Line would

become a constraint to capacity north of Sydenham if a heavy rail line in the F6 Corridor were to join the Illawarra Line at Sydenham;

- the Airport Line is also subject to capacity constraints, particularly given that additional traffic will be diverted to this Line as quadruplication of the East Hills Line continues; and
- the patronage demand modelling is considered to underestimate potential demand because it does not fully reflect the adjustments that would be made to the feeder network (local bus routes, for example) should a railway line be implemented.

When considering the future public transport role for the corridor a much longer view is required than reflected in the available 2021 modelling. It is reasonable that thinking should project beyond a 50 horizon as has been reflected in the “Christie Report”, which identifies the potential for a “commuter” (or Metro style) rail line in this corridor.

The following factors should also be taken into account in the assessment:

- heavy rail would provide for about five stations, requiring the restructuring of the local bus network and provision for other access modes including a drop-off zone, commuter parking and bus and taxi interchange;
- while the heavy rail options could divert some Cronulla Line passengers off the Illawarra Line, the northern section of the alignment parallels the Illawarra Line (within about 1.5 kilometres) and therefore a rail line in the F6 Corridor would share its catchment with the Illawarra Line in this section;
- if a rail line in the F6 Corridor is connected to the Airport Line, it has the potential to provide improved access to Sydney Airport from the south. This access is, however, also currently potentially[5] possible through interchange at Wolli Creek Station; and
- heavy rail has the best potential to deliver travel time advantage over the car. All road intersections will be grade-separated and widely spaced stations contribute to maximum possible travel speeds.

Social and Land Use

Heavy rail has the best potential to provide a relatively fast and interchange free public transport service to the Sydney CBD and other major employment centres to residents in the catchment area. However, the relatively low patronage forecasts (compared to other modes) reflect the fact that:

- the heavy rail stations would be widely spaced and in the middle of a rather wide open space corridor, making pedestrian access less attractive;
- the service frequency would be no more than four trains per hour during the two-hour peak, and even this frequency can not be justified given the low demand; and

The patronage assessment does not take account of the fact that station localities are likely to become nodes for higher density residential development and employment creation which would increase demand.

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[5] *Cronulla trains do not currently stop at Wolli Creek*

However, a heavy rail corridor would act as a barrier to pedestrians, cyclists and other traffic, except at locations where grade separated crossings are provided. Furthermore, the relative isolation of the stations within a public open space may lead to security concerns for passengers, particularly outside the peak periods.

Environmental Impacts

Over much of its length, heavy rail in the F6 Corridor would require an easement width of around 14.5 metres. This is narrower than a road corridor with the same potential capacity but wider that that required for a busway. The rail corridor would also be inaccessible to pedestrians and cyclists and would not be able to be maintained as a public open space. Furthermore, stations are large in area and will require more land while other facilities such as turnbacks and stabling tracks may increase the land requirement even further. The resulting corridor could be up to 40 metres wide in some areas.

Trains are generally expected to perform better than buses and cars in terms of greenhouse emissions but this benefit may be offset by the low patronage forecast for heavy rail which may result in low load factors in the corridor at the required minimum service frequency.

Heavy rail may also generate significant noise levels that may require mitigation.

As the heavy rail option generates the lowest forecast demand of the assessed options, it also performs worst in terms of mode shift from car to public transport.

Economic and Financial

The economic and financial assessment clearly shows up the high fixed costs that would be incurred by heavy rail (both infrastructure and rollingstock). The low patronage demand forecast for this mode means that the total cost per passenger is in excess of $50 per passenger at the forecast demand of approximately 1,200 passengers in the two-hour peak.

Heavy rail becomes more cost effective as the patronage increases, but it needs to carry upwards of 10,000 passengers in the peak two-hour before it becomes cost effective. In the case of the F6 corridor, this appears unlikely to be achieved given the current modelling results.

7.2.2 Medium Capacity Modes in Exclusive Corridor

Travel and Accessibility

This option assumes that bus or light rail services would link to rail at Miranda in the south and at either Sydenham or International Airport at the northern end of the corridor. There is also the potential to develop a service structure that connects to both Sydenham and the Airport.

In the longer term, a bus or light rail service may connect to a larger network of services. In the case of bus services this is also contemplated in the Unsworth report. The existing Sydney light rail system may also expand in the long term to allow the integration of light rail in the F6 corridor with a wider network. Consideration of these future integration options was beyond the scope of this study

It is also possible that services could extend beyond the airport to the north to connect to destinations such as Green Square and Redfern but these options have not been investigated in detail as part of the current study.

Demand figures based on 2021 TPDC strategic model show moderate levels of demand in the order of a maximum of 4,000 in the two hour morning peak period city bound and 1,700 in the opposite direction. This demand applies to the busiest link towards the northern end of the corridor. The peak two-hour demand south of the Georges River is in the order of 1,400 passengers city-bound and 1,200 in the opposite direction. This level of demand is achieved using an approximate 5-minute service frequency for light rail and 2 minutes for a bus based system (assuming peak vehicle loads) north of the river and 10 minutes and 3.5 minutes for light rail and bus respectively, south of the river.

Operation in an exclusive corridor offers the greatest potential to maximise travel speeds. The optimum arrangement would be provided through grade-separation at road intersections. However, the most cost effective arrangement would be provided through a combination of grade separated and priority controlled signalised intersections.

The development of an alignment within an exclusive corridor offers the advantage of permanent infrastructure and traffic free operation. The travel way would be defined by rail tracks and overhead wiring in the case of light rail and exclusive bus roadway in the case of a bus based system. In lower density environments busways offer greater flexibility through the ability of the vehicle to feed onto the corridor from adjacent neighbourhoods anywhere along the corridor. Conversely, they can use only a section of the corridor before leaving to gain access to an intermediate destination such as, for example, Rockdale Station.

Social and Land Use

In an exclusive corridor, the medium capacity modes still have a high potential to provide a relatively fast public transport service to the Sydney CBD and other major employment and commercial centres. However, without express links to the CBD, mode change at major interchanges may be required to transfer to city-bound trains. This could be achieved at stations such as Sydenham, but the available capacity of trains at these locations may make it difficult for passengers to find a seat, reducing the attraction of the service.

Medium capacity modes will provide frequent opportunities for passenger access by virtue of station spacing of around 800 metres to 2 kilometres, providing about 16 to 20 stations. Consequently, the medium capacity modes provide higher levels of local accessibility and would normally attract a relatively high proportion of walk-up passengers. However, pedestrian access to stations under this option will be potentially restricted because of the relative remoteness of some sites from adjacent residential development. This relates to the fact that land use in this corridor has historically "turned its back" on this former road reservation.

Headways of between 2 (buses in the peak) and 10 minutes (light rail in the peak) will provide a higher service level than a relatively infrequent heavy rail service (15 minutes in the peak and hourly in the off-peak).

Bus or light rail infrastructure would present a lesser barrier to pedestrians and cyclists than a heavy rail line or a busy road, even at its peak headway of two minutes. The relative isolation of the stations within a public open space may again lead to security concerns for passengers, particularly outside the peak periods.

Environmental Impacts

Medium capacity modes such as bus or light rail in the F6 Corridor would require an easement width of less than 10 metres. This is narrower than a road corridor with the same potential capacity and narrower than the easement required for a heavy rail system. Light rail and bus corridors also do not need to be isolated to the same extent as a heavy rail corridor and can form part of the public open space. Stations are less intrusive than those required for heavy rail, requiring less infrastructure and land take.

Light rail and busway systems as a whole also do not present a significant barrier to pedestrians and cyclists.

Light rail vehicles are low energy consumers and consequently produce low emission levels. While buses are still viewed as being less environmentally friendly, modern low-emission natural gas buses are increasingly being introduced and future trends point to technologies such as fuel cell powered buses which are for all intents and purposes, emission free. Light rail vehicles have a different noise signature to buses and are generally considered to have lower noise impacts than both buses or heavy rail.

Economic and Financial

The economic and financial assessment clearly shows up the effectiveness of medium capacity modes in corridors where patronage is likely to be at the lower end of the scale. In terms of operating cost only, light rail is the most cost efficient mode but the capitalisation of the vehicle costs reduces the cost effectiveness, with bus-based modes becoming the most cost effective.

At the forecast patronage for the medium capacity systems (approximately 4,000 passengers in the two-hour peak), light rail in an exclusive corridor has a total cost per passenger of just over $9 per passenger while busways are expected to cost under $4 per passenger.

7.2.3 Medium Capacity Modes on Street

Travel and Accessibility

This option assumes priority operations on roads generally parallel to the F6 corridor. The operational characteristics are similar to those discussed in *Section 7.2.2* for medium capacity modes in exclusive corridors.

The key points of difference are:

- operation on street in priority lanes;
- stations located closer to residential areas than for exclusive corridors, providing shorter walks and potential higher level of natural surveillance;
- station spacing is assumed to be similar at 800 metres to 1 kilometre. However there is greater flexibility in the positioning of the stations under this option and more homes will be within walking distance of stations than for the exclusive corridor options; and
- slower average operating speeds (than for the inclusive alignment) leading to a potentially less attractive service.

Demand figures based on 2021 TPDC strategic model show moderate levels of demand similar to the exclusive corridor option. Demand in the northern section of the corridor is similar at 3,800 passengers in the two hour morning peak period city bound. However, this option exhibits higher levels of contra peak demand at 2,700 passengers. Demand south of the Georges River is significantly higher, at around 2,300 passengers city bound, and 2,300 in the opposite direction. The closer proximity of this alignment to trip generators, such as the Taren Point employment area, appears to be a key factor in the higher level of demand south of the Georges River.

This level of demand represents an approximate 5 minute service frequency for light rail and 2 minutes for a bus based system (assuming peak vehicle loads) north of the river and 6.5 minutes and 2 minutes for light rail and bus respectively, south of the river.

The major risk in meeting these levels of demand will be potential conflict with traffic and the ability to ensure priority:

- typically, the light rail or busway vehicles would operate in exclusive lanes either at the kerbside or on a centre alignment;
- there are not likely to be any opportunities to provide grade separation at intersections. Priority would be afforded by signal priority;
- traffic flows in Taren Point Road represent a level of demand that may require three lanes at its northern end towards Captain Cook Bridge;
- more detailed traffic study is required to determine the level of traffic impact associated with providing public transport priority; however
- the level of demand highlighted in the modelling shows that, for the section south of the Georges River, there may be significant advantages associated with following the street based alignment on the Kingsway and Taren Point Road; and
- should this option be considered further there may be value in including an option to use some sections of the F6 corridor (between Holt Road and Kingsway, Miranda) for general traffic in order to provide a high quality public transport outcome of the Kingsway and Taren Point Road. For this reason it would be prudent to ensure that the corridor reserved for public transport should be wide enough for use as a local road.

The light rail and bus medium capacity modes operating on streets offer the following characteristics:

- light rail offers advantages of permanence and an unambiguous operating environment; and
- bus priority in an on-road environment would be provided by bus lanes or potentially transit lanes (T2 or T3). These have the advantage of flexibility in balancing traffic and bus demands but lack the high level of system legibility associated with a light rail line. Enforcement can also be a problem under bus lane/transit lane conditions;

Social and Land Use

When operating on-street, the medium capacity modes have reduced potential to provide a fast public transport service to the Sydney CBD and other major employment nodes. Furthermore, mode change at major interchanges may be required to transfer to city-bound trains. This could be achieved at stations such as Rockdale or Sydenham, but the available capacity of trains at these locations may make it difficult for passengers to find a seat, reducing the attraction of the service.

Medium capacity modes on street will have stations located closer to residential areas than for exclusive corridors, providing shorter walks and potential higher level of natural surveillance. There would also be greater flexibility in the positioning of the stations under this option and more homes will be within walking distance of stations than for the exclusive corridor options.

As for the exclusive corridor, headways of between 2 and 10 minutes will provide a higher service level than a relatively infrequent heavy rail service.

Bus or light rail infrastructure would be constructed within existing road easements and will therefore not result in a barrier to pedestrians and cyclists in the F6 Corridor.

Environmental Impacts

Because the bus or light rail infrastructure would not be constructed within the F6 Corridor the land take would be minimised and the impacts on environmentally sensitive areas would be avoided. Instead, the bus or light rail system would be placed in an area already occupied by transport infrastructure.

The lower level of priority afforded by on-street running would reduce the efficiency of the light rail vehicles and buses compared with running in an exclusive corridor.

Economic and Financial

This option is the most cost effective of the three options considered. Adding infrastructure to road reservations already developed for transport use allows re-use of a lot of the basic civil engineering features such as earthworks and drainage. Consequently, the total cost per passenger for medium capacity modes developed on street could be under $9 per passenger for light rail and under $3 per passenger for a bus system.

7.3 Comparison of Options

7.3.1 Comparative Assessment

The assessment of the various options as described in Section 6.2 are collated in this section to provide a comparative assessment.

Travel and Accessibility

A relatively low level of patronage demand is forecast for both heavy rail options, with a maximum demand of approximately 1,200 passengers in the peak two hours being predicted. Both the medium capacity modes fare significantly better, with modelling predicting a maximum patronage of up to 4,000 passengers in the two-hour peak.

The service level for heavy rail would be relatively low, with 15-minute headways during the peak period being the best that can realistically be justified. Bus or light rail would be servicing the corridor at headways as short as two minutes during the peak, resulting in a very frequent service.

Heavy rail has the potential to provide better connections to the Sydney CBD however, provided capacity is made available on either the Illawarra Line or the Airport Line to accommodate services via the F6 Corridor.

Light rail services may be more difficult to connect to the CBD and would, at least initially, be reliant on interchange with heavy rail at locations such as Sydenham. The shortage of available capacity on trains at these locations may make it difficult for passengers to find a seat, reducing the attraction of the service. Bus services would face similar interchange issues unless buses were able to run an express service into the CBD, through the introduction of priority lanes or use of the Eastern Distributor.

Social and Land Use

Heavy rail has the best potential to provide a relatively fast and interchange free public transport service to the Sydney CBD and other major employment nodes to residents in the catchment area. Light rail and bus services would, as described above, be reliant on interchange with heavy rail unless suitable express services can be provided.

Public transport developed in the F6 Corridor would be relatively remote from adjacent residential development because land use in this corridor has historically “turned its back” on this former road reservation. The relative isolation of the stations may also lead to security concerns for passengers, particularly outside the peak periods. Medium capacity modes developed on existing streets would overcome these issues.

Medium capacity modes, either on street or in the F6 Corridor, would potentially provide a higher service level than heavy rail services.

Environmental Impacts

The lowest impact on environmentally sensitive areas would result from development of medium capacity modes on street as these result in virtually no land take from the F6

Corridor. These options also avoid the creation of barriers to pedestrian and cyclists wishing to cross the F6 Corridor. Heavy rail would have the highest environmental impact on the corridor and its surroundings as it requires the most land for tracks, stations and other infrastructure while the resulting railway easement would need to be securely fenced to prevent people and animals from entering onto the tracks.

In terms of greenhouse gas emissions light rail is potentially the mode with the lowest emissions per passenger. This is not because light rail vehicles are necessarily more efficient than heavy rail but because the energy use *per passenger* (and therefore emissions generated to produce that energy) is expected to be lower because the load factors on light rail would be higher, given that the low patronage forecast for heavy rail is likely to result in very low load factors in the corridor at the minimum service frequency. Emissions attributable to buses would be dependent on the composition of the bus fleet and the increasing proportion of low emission buses being deployed.

Economic and Financial

The economic and financial assessment has shown that light rail is the lowest cost mode when the only the direct operating cost is considered. When the total vehicle operating costs, including capitalised vehicle costs, are considered, buses become the lowest cost mode for proposed public transport services as their capital costs per passenger carried are lower than for light rail vehicles (and heavy rail). At higher levels of demand, light and heavy rail have similar costs per passenger carried.

The inclusion of infrastructure maintenance costs makes little difference to the pattern of costs by mode. At lower levels of passengers carried, costs of both of the rail modes increase somewhat but the effect decreases with increases in the number of passengers carried. Buses remain the lowest cost mode.

When the costs of infrastructure capital are included, the order of modal preference is unchanged. The cost per passenger carried for each mode/option combination at the forecast patronage for that option is shown in *Table 7.2*.

Table 7.2: Cost per Passenger[6] for Various Modes and Options at Forecast Patronage

Mode/Option Description	Total Cost per Passenger
Heavy rail	$50.00
Light rail in exclusive corridor	$9.20
Bus in exclusive corridor	$3.80
Light rail on street	$9.00
Bus on street	$2.70

The financial and economic assessment of public transport in the corridor was undertaken without consideration of its flow-on and direct benefits beyond the study area. This may unfairly disadvantage the assessment of heavy rail services in the F6 Corridor which may have significant patronage and capacity benefits that extend to the rail network beyond the study area. Light rail services would be provided on a

[6] *Costs include all operating costs, maintenance costs, vehicle costs and infrastructure costs.*

standalone basis as there are no other light rail services in the vicinity. Bus services could be integrated with other bus services in the area of the F6 corridor but that possibility has not been considered in the estimated costs.

Table 7.3 provides a summary of the key findings of this comparison.

Table 7.3: Comparison of Options

Option Description	Assessment by Criteria			
	Travel and Accessibility	**Social and Land Use**	**Environmental Impacts**	**Economic and Financial**
Heavy Rail Options				
Miranda to Sydenham/Airport via F6 Corridor	Patronage of approximately 1,200 in the peak 2-hour (2021). Peak service frequency of 4 trains per hour.	Best potential to provide a fast and interchange free service. Low service frequency (4 trains per hour in peak). Isolated environment leads to poor access and security. Shares catchment with Illawarra Line. Creates barrier to cross-corridor travel.	Minimum easement for infrastructure 14.5 metres, but could be up to 40 metres wide at some locations due to stations, turnback/stabling needs and other facilities. Emission benefits may be offset by empty running (inefficiency). Noise impacts may require mitigation. Low patronage also means low mode shift from car	Low patronage results in a high cost per passenger in excess of $50 at the forecast demand. Is only likely to become viable if demand approaches 10,000 in 2-hour peak or more.
Medium Capacity in Corridor				
Busway or Light Rail	Maximum patronage of approximately 4,000 in the peak 2-hour. Peak service frequency of up to 30 buses per hour or 20 LRT services per hour. Exclusive corridor maximises speed and service reliability. LRT provides permanence and unambiguous environment. Bus provides operational flexibility and connects with local network.	Have a high potential to provide a relatively fast public transport service. Requires express bus services to CBD. LRT, and possibly bus, require interchange to heavy rail for journeys to CBD. Isolated environment leads to poor access and security. Less of a barrier in the corridor than heavy rail. High service levels.	Minimum easement for infrastructure of around 10 metres. Stations/bus stops are small and do not require much land. LRT has very low emissions. Bus emissions dependent on fleet mix. Higher patronage also means better mode shift from car	Medium capacity modes are more effective, with total cost per passenger of under $4 for busway and just over $9 per passenger for LRT

<table>
<tr><th rowspan="2">Option Description</th><th colspan="4">Assessment by Criteria</th></tr>
<tr><th>Travel and Accessibility</th><th>Social and Land Use</th><th>Environmental Impacts</th><th>Economic and Financial</th></tr>
<tr><td>Medium Capacity on Street</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Bus or Light Rail</td><td>Maximum patronage of approximately 3,800 in the peak 2-hour.
Higher patronage in contra-peak direction than options in the F6 Corridor.
Peak service frequency of up to 30 buses per hour or 20 LRT services per hour.
Potential conflict with traffic and loss of priority.
Option to use some sections of the F6 corridor for general traffic.</td><td>Lowest potential to provide a fast/direct public transport service to CBD
Requires express bus services to CBD.
LRT, and possibly bus, require interchange to heavy rail for journeys to CBD.
Best security and accessibility.
No barrier in the F6 Corridor.
High service levels.</td><td>No land take
Stations/bus stops are small and do not require much land.
LRT has very low emissions. Bus emissions dependent on fleet mix.
Higher patronage means better mode shift from car</td><td>Medium capacity modes are more effective, with total cost per passenger of under $3 for busway and $9 per passenger for LRT</td></tr>
</table>

7.3.2 Relationship between Options and Staging

Chief among the findings of this strategic study are the following:

- it is important that a reservation be retained within the previous F6 corridor for the long term (beyond 20 to 50 years) development of a heavy rail or metro style rail line;
- there may be some potential for heavy rail to provide relief to the Illawarra Rail Line in the medium term (10 to 20 years), however, this would require network improvements north of Sydenham; and
- the demand analysis suggests that, within the next 10 to 20 years, a medium capacity mode could fulfil an effective public transport role in increasing the level of public transport use in the corridor.

These findings point to the need to consider the staged development of public transport services in the corridor. The principles of a staged approach could include:

1. Preservation of the option to provide for long term needs by establishing a reservation capable of meeting the needs of a heavy or metro style rail line. In this way the potential to develop other, lower capacity systems would also be protected.
2. In the short term, rationalise the existing bus network to develop high quality, high frequency, feeder services to existing Illawarra line stations, Sydney Airport and the CBD. The consolidation of contract areas to remove structural anomalies is addressed in the *Review of Bus Services in NSW (March 2004)*.
3. Through this rationalisation process progressively develop a strategic bus service which mirrors the proposed corridor (a similar route is also referred to in *Review of Bus Services in NSW).* Provide a high quality service at minimum levels of service of 10 to 15 minutes in peak periods. For example, this rationalisation could include the extension of the Route 303 City service beyond its current San Souci terminus to Miranda. In addition, consider improving catchment coverage by adjusting the service to use Chuter Avenue instead of the "one sided" route along General Holmes Drive.
4. The strategic bus route should be structured to take advantage of developments along the corridor. For example, consideration should be given to taking advantage of provisions within the Cooks Cove development for priority access to the airport across the Cooks River.
5. Develop priority systems on existing roads and where appropriate make use of the reserved exclusive public transport corridor to by-pass points of congestion.
6. Put in place a strategy to progressively develop a medium capacity transport system over the full corridor. This could be focused on either side of the Georges River in the initial stages of development and include connections to key transport nodes such as Rockdale and Miranda.
7. This strategy should firstly, fully investigate and recommend the most effective medium capacity mode (light rail, bus rapid transit system or other mode) to serve this corridor.

8. The strategy should include a schedule for development of the corridor over the next 10 to 20 years.

8. Residual Lands

The existing F6 freeway reservation occupies approximately 180 hectares of land (assuming a 20 km length and average width of 90 metres). Given that the maximum width for any public transport option is approximately 40 metres, a substantial area of the land would be able to be rezoned and be available for alternative uses.

8.1 Development of the Reservation Boundary

The total area of residual land that will ultimately be available will dependent on the type of public transport mode developed. The corridor is a strategic transport resource, however, and care should be taken not to preclude its use to cater for the growing transport demands of Sydney over the long term and beyond the 20 year assessment period used in this study.

The current patronage forecasts were undertaken to 2021. These forecasts indicate that the development of a heavy rail system in the F6 Corridor would not be justified by the anticipated demand by the end of the forecast period. The demand analysis suggests that within the next 10 to 20 years a medium capacity mode could fulfil an effective public transport role in increasing the level of public transport use in the corridor. However, it is important that a corridor be reserved for the long term (beyond 20 to 50 years) development of a heavy rail or metro style rail line. Furthermore, the current study did not undertake a sufficient level of design to accurately determine:

- the land requirements of grade separated road and river crossings;
- the impact of localised soil and groundwater conditions on the future alignment(s);
- the location and land requirements of stations, parking facilities, stabling yards and other associated infrastructure;
- the vertical alignment considerations such as cut and fill batters; and
- the location and land requirement of cycleways and footpaths.

As described in Section 5.1.2, a corridor width of 40 metres would allow for any of the public transport modes to be developed, including heavy rail. It would also allow full flexibility in the placement of stations, stabling yards, turnbacks and other associated infrastructure while providing an adequate allowance for batters, cycleways and footpaths.

In developing the boundary of the corridor care was therefore taken to ensure that a minimum corridor width of 40 metres was reserved. Furthermore, the corridor boundaries were adjusted to:

- provide land for constructing grade-separated crossings at major road intersections;

- selectively widen the corridor to provide better tolerance of localised uncertainty with respect to soil, groundwater and environmental conditions;
- include parcels of land that would be isolated between the corridor boundary and wetlands or creeks; and
- allow adequate land at boundary intersections to accommodate curved alignments, particularly at intersections with major roads.

The resulting corridor boundary is shown on the drawings attached as *Appendix D*. It should be noted that this work is limited by the accuracy of the existing corridor boundaries that were digitised from the RTA Property Information Management System (PIMS) database and are therefore of an indicative nature only.

8.2 Further Work to Develop the Corridor Boundary

The approach taken in this study was to adjust the corridor width to allow for the lack of available information and early stage of engineering development. This short term approach reduces the available land to be released from the current corridor. Ultimately, the accuracy and detail of the available information will have to be improved and it should be recognised that the accuracy of the proposed corridor width and location is constrained by the accuracy and detail of available information:

- the boundaries of the existing F6 corridor were digitised from RTA hardcopy Property Information Management System maps and are indicative only. No survey has been undertaken;
- no vertical alignment design was undertaken as part of the current study and cut/fill batters and retaining structures have not been identified or detailed;
- geotechnical information was obtained from a general desktop study of available information and specific zoning of the geotechnical conditions has not been undertaken; and
- no detailed assessment of environmental constraints has been undertaken.

In order to improve the level of confidence for future work we recommend that the following activities be undertaken:

- obtain more detailed survey of the study area. We have established that digital aerial photography is available that will allow the generation of DTM mapping to 2 metre contours and an ortho-rectified aerial photo base with 0.3 metre pixels;
- obtain a more accurate definition of the corridor boundary by obtaining the corridor coordinates from the RTA and plotting this on the cadastral base; and
- undertake sufficient field investigations to allow zoning of the corridor in terms of environmental constraints, geotechnical conditions and flooding.

This will allow the design to be developed within an accurately defined corridor to full horizontal and vertical alignment standard with all earthworks shown.

8.3 Alternative Land Use

The Minister for Roads, in his announcement on 6 September 2002 (NSW Government Gazette No 54, see *Appendix A*) directed that no road or transport development of any type would be allowed in the F6 corridor between the Royal National Park and the southern side of Gymea Station. The Minister further stated that he had asked the RTA and (the then) Transport NSW "to determine which parts of the corridor can be given back to the community for permanent open space".

The useability of land within some sections of the corridor is very limited, given the existing land uses surrounding. For example in the northern section of the corridor, within the Marrickville local government area, north of the Cooks River the majority of residual land would adjoin existing industrial areas. Hence, an appropriate land use may be to allow an extension of the industrial zoning.

Areas to the centre of the corridor within the Rockdale local government area offer many more opportunities to diversify land use and optimise the use of residual lands. For example in the section between Kings Road and Bruce Street in Brighton-Le-Sands there is potential for residential, commercial and retail development around Bay Street (a potential station location) and medium density residential on either side of the corridor. Other areas of land within this section would be suitable for open space or industrial uses.

The potential residual land opportunities in the F6 corridor can be divided into the following major categories:

Table 8.1: Use Categories in Residual Lands

Land Use	Potential Use in Residual Lands
Residential	Medium/high density residential, on reservation land adjoining residential zones adjacent to identified station locations. Low density residential (single occupied or vacant lots) on reservation land adjacent to an existing residential area.
Commercial & Retail	Higher density commercial and retail developments on reservation land adjacent to identified station locations. Commercial and retail developments on reservation land to adjacent to existing developments.
Industrial	Rezone reservation land adjacent to existing industrial employment areas to support expansion where appropriate.
Open Space and/or recreation	Rezone reservation land to open space and/or recreation space, where appropriate.

Hence, the possibilities and practical uses of residual lands is largely determined by the characteristics of the land and its compatibility with the public transport corridor/use and the surrounding area. Section 2.3 of this report discusses future land use scenarios within and adjacent to the corridor, particularly with reference to key nodes.

Table 8.2 provides an overview of possible residual land uses along specific sections of the F6 corridor.

Table 8.2: Land Use Opportunities in Residual Lands

Local Government Area	Corridor Section	Corridor Sub-Sections	Residual Land Use Opportunities	
			Potential Land Uses	**Comments**
Sutherland	Princes Hwy Loftus - Cronulla Rail Line	Princes Hwy Loftus - Auburn St South Kirrawee	National Park	Corridor within existing National Park boundary
	- to be preserved, as much as possible, for open space[7]	Auburn St South Kirrawee - Forest Rd South Kirrawee	Open Space	Section of steep bushland and rocky terrain. Existing recreational uses (tennis courts). Adjacent to local housing residential zones.
		Forest Rd South Kirrawee - Cronulla Rail Line	Residential	Adjoins residential local housing zone up to President Avenue. Some residential dwellings within reservation. Medium density potential between Presidents Avenue & Gymea Station.
	Cronulla Rail Line - Georges River	Cronulla Rail Line - Georges River	Residential Commercial Industrial Open Space	Adjacent to predominantly low density residential. Existing caravan Park on Port Hacking Road. Commercial and industrial uses on Taren Point Road. Open space opportunities between Port Hacking Road and Taren Point Road. Potential for Taren Point station commercial development.
Rockdale	Georges River - Sandringham St	Georges River - Margate St Ramsgate	Residential Open Space	Adjoins residential zone. Existing residential dwellings within reservation.
	Sandringham St - Bay St	Margate St Ramsgate - Kings Rd Brighton-Le-Sands	Residential Open Space	Adjoins residential zone. Existing residential dwellings within reservation. Medium density residential potential.
	Bay St - Cooks River	Kings Rd Brighton-Le-Sands - Bruce St Brighton-Le-Sands	Residential Commercial Retail Industrial Open Space	Higher density potential near Bay St Station. Medium density residential potential. (east & west of reservation) Commercial opportunity (west of reservation).

[7] *NSW Government Gazette No. 54 Official Notices 28 February 2003*

Local Government Area	Corridor Section	Corridor Sub-Sections	Residual Land Use Opportunities	
			Potential Land Uses	**Comments**
Rockdale (cont'd)`	Bay Street – Cooks River (cont'd)	Bruce St Brighton-Le-Sands - Kogarah Golf Course	Residential Open Space	Residential zone to west of reservation. Open space uses (east of reservation).
		Kogarah Golf Course - Cooks River	Residential Commercial Open Space	Development opportunities in accordance with Cooks Cove master plan.
Marrickville	North of Cooks River	Cooks River - Bellevue St	Industrial Open Space	Adjoins existing industrial zone. Portion of reservation may only be suitable for open space.
		Bellevue St -Canal Rd	Industrial	Adjoins existing industrial zone.
City of Sydney		Canal Rd - Campbell Rd	Industrial	Adjoins existing industrial zone.

8.4 Determining Surplus Requirements

Table 8.3 summarises the potential changes to the existing reservation with the implementation of various high and medium capacity public transport options.

Table 8.3: Reservation Retention Implications

Local Government Area	Corridor Section	Corridor Sub-Sections	Reservation Retention Implications for Various Options	
			High Capacity-Rail	**Medium Capacity-LRT/Busway-Exclusive and On Street**
Sutherland	Princes Hwy Loftus - Cronulla Rail Line	Princes Hwy Loftus - Auburn St South Kirrawee	Remove Reservation	
		Auburn St South Kirrawee - Forest Rd South Kirrawee	Remove Reservation	
		Forest Rd South Kirrawee - Cronulla Rail Line	Remove Reservation	
	Cronulla Rail Line - Georges River	Cronulla Rail Line - Georges River	Reduce Reservation	
Rockdale	Georges River - Sandringham St	Georges River - Margate St Ramsgate	Reduce Reservation	
	Sandringham St - Bay St	Margate St Ramsgate - Kings Rd Brighton-Le-Sands	Reduce Reservation	
	Bay St - Cooks River	Kings Rd Brighton-Le-Sands - Bruce St Brighton-Le-Sands	Reduce Reservation	
		Bruce St Brighton-Le-Sands - Kogarah Golf Course	Reduce Reservation	
		Kogarah Golf Course - Cooks River	Reduce Reservation	
Marrickville	North of Cooks River	Cooks River - Bellevue St	Reduce Reservation	
		Bellevue St -Canal Rd	Remove Reservation	
City of Sydney		Canal Rd - Campbell Rd	Remove Reservation	

Appendix D contains plans which show the potential extent of land which could be released for other uses under the assumption that a 40 m corridor is reserved for long term public transport use.

Subject to adoption of the preferred public transport option, a site specific study of the residual lands potential uses should be undertaken prior to any rezoning application and approval. An overview of the statutory planning process involved to rezone residual lands is discussed below.

8.5 Statutory Planning Process

Following the adoption of the report recommendations regarding the designation of the corridor width and the survey of a reduced corridor, the public transport corridor would be established under Section 3 of the of the *Environmental Planning and Assessment Act, 1979*.

The final boundary of the F6 reservation is unlikely to be defined until the full implications of detailed design and construction are known. This study proposes that the retention of a reservation no less than 40 metres wide should in the future allow the engineering of a public transport system (heavy rail, light rail or bus) within that reservation. It is likely that further land may be released from the proposed new reservation once public transport has been developed. Conversely, localised needs of the future public transport system may, in the future, require acquisition of some land (which may or may not have been part of the original F6 corridor) to facilitate the provision of ancillary infrastructure such as commuter car parks and interchanges.

Following the submission of rezoning applications to the various councils, the rezoning is the next step in handing over residual lands to local government and the community, in accordance with Part 3 of the *Environmental Planning and Assessment Act*, 1979 a draft local environmental plan will need to be prepared detailing the amendments to current zoning.

In accordance with Section 57 of this Act, where Council decides or is instructed by the Minister for Infrastructure and Planning to prepare a draft local environmental plan, an environmental assessment of the residual land needs to be prepared. The Director-General of the Department of Infrastructure, Planning and Natural Resources can notify councils as to the form, content and preparation of the study and may also agree to waive the need for an environmental assessment.

The local environmental study would usually have regard to matters such as:

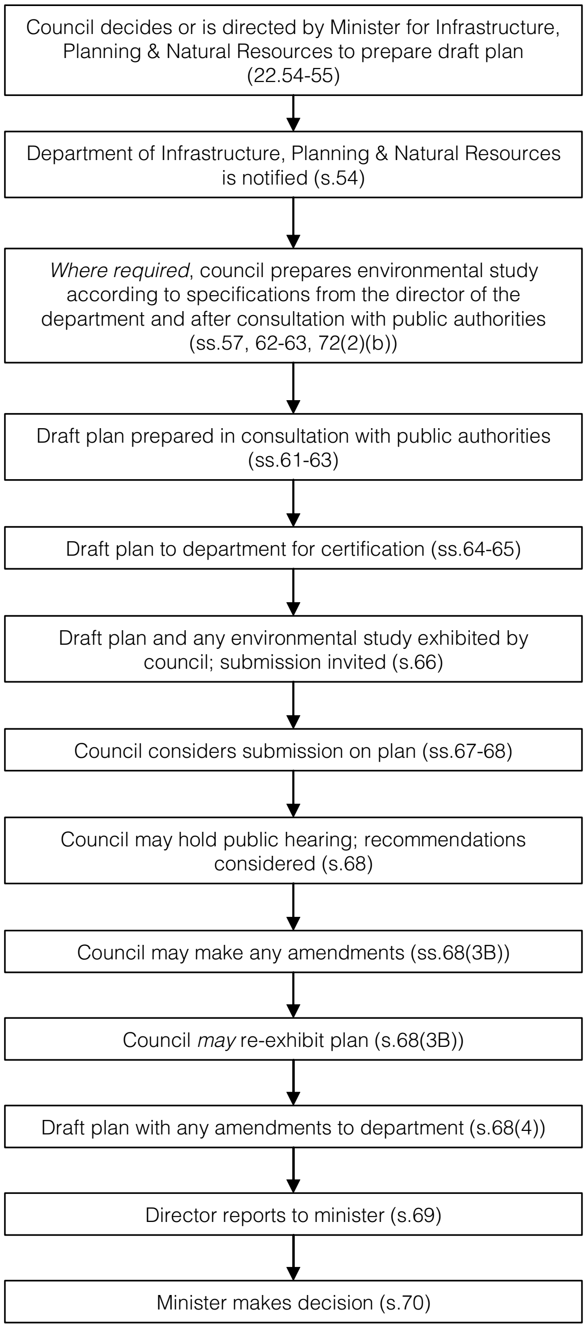
- land uses, zoning, ownership, demand and supply;
- public transport requirements;
- environmental issues;
- flora and fauna; and
- open space needs.

Due to the length of the reservation corridor in the Rockdale and Sutherland local government areas, it may be necessary to divide each of these studies into a number of sections or precincts.

In accordance with Section 64 of the *Environmental Planning and Assessment Act*, council is required to submit the draft LEP to the Director-General of the Department of

Infrastructure, Planning and Natural Resources for approval to publicly exhibit the document. *Figure 8.1* shows the process for preparing a new LEP.

A report reviewing submissions from the public exhibition should then be submitted to the Director-General of the Department of Infrastructure, Planning and Natural Resources. This report and the draft LEP will then be considered by the Minister who may make a Local Environmental Plan.



Source: Environment Planning and Assessment Act 1979

Figure 8.1: Process for LEP Preparation

9. Conclusions and Recommendations

9.1 Summary and Conclusions

The study has investigated a range of possible public transport uses for the F6 corridor. Options have been considered for both the alignment of the corridor and the mode which would best meet the needs of the population. It was not the intention of the brief to identify a sole mode for implementation at this stage, but rather to identify a preferred mode or modes, to provide a basis for decision making on the continued reservation of land for public transport purposes and the extent of residual land which may result.

The study has considered a range of options which include alignments within the F6 reservation and one that makes use of adjacent streets for public transport. The range of modes considered for use in the corridor included heavy rail, light rail and busways. Each mode was assessed in conceptual design terms with regards alignment, cross sectional width and station locations. For the purposes of this strategic study and because of their similar performance characteristics light rail and busways were grouped together as medium capacity modes for demand assessment purposes. Broad order of cost estimates were developed for each option. The options are summarised as:-

- Heavy Rail – there are two options, both linking to the Cronulla Line at Miranda and running via the F6 reservation. One option is to connect to the Illawarra Line near Sydenham and the other option connects to the Airport Line west of the International Airport station;
- Light Rail and Busway – starting from Miranda and running via the F6 reservation to link to Sydenham Station and/or the International Airport station; and
- Light Rail and Busway – starting from Miranda and running on-street, generally parallel to the F6 reservation to link to Sydenham Station and/or the International Airport station.

The medium capacity modes showed the best potential to attract passengers within the 2020 timeframe for this study with demands in the order of 4,000 peak direction passengers in the peak two hours. Within the two basic options, operation in an exclusive corridor was found to attract marginally more peak direction passengers. However, the on-street option attracted more contra-peak passengers and also has the potential for closer integration with the community.

These modes also exhibited least cost per passenger in comparison to heavy rail with the on-street option being the lowest cost overall in terms of passenger and capital costs. Table 9.1 summarises the cost per passenger for each mode and alignment option.

Table 9.1: Cost per Passenger for Various Modes and Options at Forecast Patronage

Mode/Option Description	Total Cost per Passenger
Heavy rail	$50.00
Light rail in exclusive corridor	$9.20
Bus in exclusive corridor	$3.80
Light rail on street	$9.00
Bus on street	$2.70

Heavy rail's high cost can be attributed to its high capital cost and relatively low patronage, which is below that which would support heavy rail within the 2020 timeframe for this study. However, when considering the requirement to reserve land within the corridor for future public transport the vision should be beyond 2020. The Illawarra Line is reaching capacity towards the end of the next decade and RailCorp's patronage forecasts for the South Coast and Illawarra Lines have shown the need for additional lines, including potential metro lines in this corridor and other parts of the metropolitan area. In this regard it is considered that any change to the F6 corridor reservation should not preclude the potential for future development of a high capacity mode and to this end an alignment width of 40 metres has been recommended.

A major challenge for the medium capacity system will be integration with the existing rail system. Whether the alignments connect with the Illawarra line at Sydenham or the Airport line there are potential problems in finding seats on already congested trains. Further studies should look closely at the potential for extension of these options towards the city and in this regard extensions via the Airport towards Green Square and the city may offer the best opportunities.

This study has found that within the next 10 to 20 years a medium capacity mode could fulfil an effective public transport role in increasing the level of public transport use in the corridor. These findings point to the need to consider the staged development of public transport services in the corridor. In principle, a staged approach could include:

1. Preservation of the option to provide for long term needs by establishing a reservation capable of meeting the needs of a heavy or metro style rail line. In this way the potential to develop other, lower capacity systems would also be protected.

2. In the short term, rationalise the existing bus network to develop high quality, high frequency, feeder services to existing Illawarra line stations, Sydney Airport and the CBD. The proposed initiatives under the *Review of Bus Services in NSW (March 2004)* could provide the basis for this rationalisation.

3. Through this rationalisation process progressively develop a strategic bus service *which* mirrors the proposed corridor (similar routes are referred to in *Review of Bus Services in NSW)*. Provide a high quality service at minimum levels service of 10 to 15 minutes in peak periods. In addition, consider improving catchment coverage by adjusting the service to use Chuter Avenue instead of the "one sided" route along General Holmes Drive.

4. The strategic bus routes should be structured to take advantage of developments along the corridor. For example, consideration should be given to taking advantage of provisions within the Cooks Cove development for priority access to the airport across the Cooks River.

5. Develop priority systems on existing roads and where appropriate make use of the reserved exclusive public transport corridor to by-pass points of congestion.

6. Put in place a strategy to progressively develop a medium capacity transport system over the full corridor. This could be focused on either side of the Georges River in the initial stages of development and include connections to key transport nodes such as Rockdale and Miranda.

7. This strategy should firstly, fully investigate and recommend the most effective medium capacity mode (light rail, bus rapid transit system or other mode) to serve this corridor. The strategy should include a schedule for development of the corridor over the next 10 to 20 years.

9.2 Recommendations

The following key recommendations are made:-

- establish a reservation 40 metres wide to preserve the potential to develop a high capacity mode in the long term;
- undertake detailed network and patronage studies and a robust financial/economic assessment to confirm the most appropriate medium capacity mode and technology to serve the corridor;
- develop the engineering design, geotechnical studies and environmental assessment for the selected mode to confirm the reservation boundary to enable residual lands to be appropriately zoned for other uses.
- Undertake a detailed road network assessment of the selected public transport system including addressing potential by-pass opportunities (e.g. Miranda Town Centre) and their potential land requirements; and
- develop a detailed implementation strategy for progressive development of high quality public transport services in the F6 Corridor.

Future Actions

This study has addressed a wide range of issues associated with the development of a public transport system within the F6 corridor. The strategic nature of the study has highlighted the need for a range of additional studies and actions required to assist decision making with regards the ultimate medium capacity mode and the final reservation of the corridor lands. These future actions should include:-

- detailed public transport feasibility and operations study. The study scope should include:

- a more detailed patronage assessment (based on the current assessment) to focus on the passenger needs in the catchment and to support final decision making on the most appropriate mode for the corridor;
- determination of the long term medium capacity mode best suited to meeting the passenger needs within the corridor;
- engineering feasibility study to develop an optimum long term alignment and staging plan;
- traffic studies to identify the interaction with the road network and necessary works to establish public transport priority;
- public transport operations plan which integrates all modes within the corridor; and
- detailed staging strategy for the progressive implementation of the public transport strategy.

The above scope could be undertaken as a single feasibility study or managed as a series of sequential studies.

- Land use and urban design studies should be undertaken at an appropriate stage to address the most appropriate use for residual lands and to identify the urban design solutions for future station locations and the corridor in general.
- In order to improve the level of confidence for the definition of the future reservation the following activities should be undertaken:
  - obtain more detailed survey of the study area. We have established that digital aerial photography is available that will allow the generation of DTM mapping to 2 metre contours and an ortho-rectified aerial photo base with 0.3 metre pixels;
  - obtain a more accurate definition of the corridor boundary by obtaining the corridor coordinates from the RTA and plotting this on the cadastral base (the RTA has advised that it may require up to two years to acquire this data); and
  - undertake sufficient field investigations to allow zoning of the corridor in terms of environmental constraints, geotechnical conditions and flooding.

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