



Denmark Link Road

Between Garfield Road West, Riverstone
and the Westminster Street bridge,
Schofields

Options report

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Abbreviations

ABS	Australian Bureau of Statistics
ASS	Acid sulphate soils
EP&A Act	<i>NSW Environmental Planning and Assessment Act 1979</i>
FM Act	<i>NSW Fisheries Management Act 1994</i>
LALC	Local Aboriginal Land Council
NWGC	North West Growth Centre
PACHCI	Procedure for Aboriginal Cultural Heritage Consultation and Investigation
SWGC	South West Growth Centre
TSC Act	<i>NSW Threatened Species and Conservation Act 1995</i>

Executive summary

Background

Roads and Maritime Services (Roads and Maritime) is working with the NSW Department of Planning and Environment, Transport for NSW and Blacktown City Council to implement the North West Growth Centre (NWGC) Road Network Strategy. Options are being investigated under this Strategy to include a road connection between Garfield Road West in Riverstone and Westminster Street at Schofields. The connection would be introduced as a short-term interim measure to reduce traffic congestion in Riverstone pending a medium-term plan to develop Bandon Road and Schofields Road, and a long-term plan to replace the Richmond railway line level crossing in the Riverstone town centre with a four-lane overpass, and upgrade Garfield Road between Richmond Road and Windsor Road.

Proposal need

The NWGC is expected to be developed over the next 15 to 20 years. Its development will rely on improving the road infrastructure in the area. This is being developed under the NWGC Road Network Strategy as confirmed by Roads and Maritime in July 2015. The Strategy includes plans for five links that would provide connectivity between Richmond Road to Windsor Road. Each link would include a grade-separated crossing of the Richmond rail line.

Currently there are only two locations to cross the Richmond railway line in the NWGC; a level crossing in the Riverstone town centre and a bridge crossing at Westminster Street. These two crossings currently experience traffic congestion and delays.

The most congested of the two crossings is in the Riverstone town centre as it is used by local, regional and heavy vehicle traffic, with about 900 vehicles crossing it between 5 pm and 6 pm during the week. At these volumes, the amount of traffic exceeds the capacity the road was designed to carry, which is the cause of the congestion and delays. A number of accidents have also occurred locally over the past few years as a result of these traffic volumes in the area.

Roads and Maritime is currently planning the short, medium and long-term projects needed to implement the NWGC Road Network Strategy, all of which are subject to funding. The medium-term development of Bandon Road and Schofields Road and the long-term development of Garfield Road would address the ultimate development needed to support the NWGC. However, some short-term work is needed to reduce traffic congestion in and around Riverstone. One of the short-term solutions is to construct a link road that connects Garfield Road West to the Westminster Street bridge. This proposed link road would reduce the traffic congestion experienced in the Riverstone town centre and on Garfield Road caused by the Richmond railway line level crossing at Riverstone.

The objectives for the link road are to:

- Improve traffic flows by providing an alternative connection between Garfield Road West and the Westminster Street bridge
- Provide a north-south local road running parallel to, and on the western side of the Richmond rail line
- Provide infrastructure that complements the planned long-term proposed upgrade of the area.

Secondary objectives are to:

- Provide a safe environment for all road users
- Minimise adverse operational environmental and social impacts
- Avoid any change to the flood risk in the area
- Improve amenity, accessibility and efficiency for all road users.

Purpose of the report

This report details the process of identifying, comparing and selecting a preferred option for a local link road between Garfield Road West, Riverstone and the Westminster Street bridge at Schofields. The proposal would connect Garfield Road West at Denmark Road and the Westminster Street bridge at Schofields.

This report has analysed the constraints and issues associated with each of the options and identified a preferred option for community consultation.

Issues

Riverstone is located in an area where development is constrained by a range of traffic and transport, engineering and environmental values and issues. A preliminary review of information locally has identified the following issues and concerns that would influence how the proposal is developed:

- The residential development in the area
- Richmond Park off Creek Street, which contains playing and sports fields that are used and valued by the community
- The aquatic and fish habitat of Eastern Creek and the ecological value associated with the areas around Eastern Creek
- The high flood risk associated with Eastern Creek
- The risk of soil erosion and encountering saline soils during construction
- The presence of two endangered ecology communities locally in the form of Shale plains and alluvial woodland
- The area's historic occupation by Aboriginal communities and their reliance upon, and use of, Eastern Creek
- The community values and resources in the Riverstone town centre
- The presence of various underground water, sewer, telephone and optical fibre utilities and aboveground low-voltage transmission lines in the area.

Options

Three strategic corridor options for a proposed link road between Garfield Road West, Riverstone and the Westminster Street bridge, Schofields were identified and a preferred corridor was selected. From this preferred corridor five options were developed in the preferred corridor and these are described below.

Corridor options

In 2014, an Interim Traffic Management Measures Report was prepared to look at a possible range of solutions that could provide an alternative link road for local traffic to avoid traveling through the Riverstone town centre. Three general corridors were identified that involved the extension of West Parade and a new connection point into Garfield Road West either via Denmark Road (corridor 1), Creek Street (corridor 2) or Carlton Street/Trevithick Street (corridor 3) (refer to figure 1-2).

The Interim Traffic Management Measures Report identified that the Creek Street and Carlton Street/Trevithick Street corridors would connect into Garfield Road West too far east. Both intersections would be affected by traffic queuing back from the railway level crossing along Garfield Road West at Riverstone. The Denmark Road corridor was considered to be a sufficient distance to minimise being affected by the congestion on Garfield Road West. Also, connecting to Garfield Road West at the Denmark Road intersection would have the benefit of forming a through-connection to the planned Riverstone West spine road in the future. For this reason Denmark Road was selected as the preferred corridor option.

Proposal options

Having determined that the preferred corridor was via Denmark Road, a series of options were developed within the corridor to:

- Link into Garfield Road West at the Denmark Road intersection
- Upgrade West Parade south of Trevithick Street and connect into Bridge Street at the Westminster Street bridge
- Provide a route that would be safe for local traffic to use
- Avoid the riparian (river corridor) habitat of Eastern Creek wherever possible.

On this basis, the following options were identified:

- Option A is an indirect route via Creek Street and Carlton Street and would use a number of existing unnamed roads and tracks to form a link road. It contains nine turns
- Option B is a connection via the whole length of Denmark Road before making a 90-degree turn and following a new section of road running parallel to Trevithick Street. It then connects into West Parade via a new intersection
- Option C is a similar design to Option B except the road would tie-back into the existing intersection of West Parade and Trevithick Street to avoid creating a new intersection on West Parade
- Option D is a similar design to Option B except a curved link would be created to link back into West Parade instead of using a T-intersection
- Option E is a similar design to Option D except a second curve would be created to link into Denmark Road. This would create an s-curve.

Options evaluation

The options were evaluated against the issues and constraints to reach the following conclusions:

- The corridor along Denmark Road remains the preferred option as it would minimise the risk of being affected by, or interfering with, the traffic queuing into and out of the Riverstone town centre on Garfield Road West
- The southern options (Option B to Option E) are preferred over Option A given that they provide a more direct route. They therefore provide a better design outcome against the proposal's objectives
- The southern options (Option B to Option E) would provide slightly better travel times between Garfield Road West and Westminster Street bridge, therefore being preferred by road users
- The preferred option would need to be carefully designed to ensure its impact on local residents is minimised
- Traffic safety is a key design issue and a concern for the community. There are opportunities to provide intersections under Option B and Option C that would introduce traffic calming controls by forcing drivers to slow down
- As the southern options (Option B to Option E) are more removed from the residential areas this would reduce the road's operational noise impact
- The southern options (Option B to Option E) provide solutions that would reduce impacts on existing local traffic by upgrading the road away from the residential area. Instead, new sections of dedicated link road would be created. Also, certain options make good use of the existing intersections (Option B and Option C) or provide improved connections into West Parade (Option D and Option E) and Denmark Road (Option E) by using curved links.

The southern options (Option B to Option E) have some disadvantages and potential environmental impacts, including the need to build in the floodplain and near a river corridor. Property acquisition would also be required to build these options and this may also result in land division and impacts on land use. These perceived impacts could be avoided or minimised in developing the concept design and preparing the environmental assessment.

The preferred option

The evaluation concludes that southern options (Option B to Option E) would provide better community and social outcomes than Option A. Of the southern options, the preferred option outcome has to refer back to the proposal's objectives and the understanding of the community's needs and requirements. As such, the preferred option would need to:

- Provide a link road from Denmark Road through to Westminster Street bridge. A connection to Garfield Road West at Denmark Road would provide sufficient separation from the Garfield Road railway level crossing to allow local motorists to choose to use the link road instead of Garfield Road
- Provide a through connection on West Parade running parallel to the Richmond railway line with a connection to Denmark Road to allow people to continue to travel along West Parade once the link road is constructed
- The link road should be consistent with the ultimate long-term road network in the NWGC
- Deliver a proposal that is safe for road users and the local community this would be carried out by a preference to create a local link road instead of a higher-speed 'bypass'
- Impacts on Eastern Creek, its river corridor habitat and floodplain, as well the endangered ecological communities that occur locally should be minimised

- Put the intersection of Denmark Road and the proposed link road as far away from Eastern Creek as is practical to minimise the flood exposure
- Provide connection to West Parade and Carton Street to provide access for locals.

These considerations and the proposal's objectives would be best-met by Option B as it would:

- Reduce congestion and delays that are currently being experienced on Garfield Road East and West caused by the Richmond railway line level crossing in the Riverstone town centre. Providing a straight alignment for the link road with appropriate intersections that would provide local motorists with a good alternative to using the Garfield Road level crossing
- Minimise operational, environmental and social impacts by avoiding the most populated area including Riverstone Park (an area of playing fields), while also reducing the need to buy or divide properties
- Provide a preferential outcome that minimises ecological, land use and flood affects
- Support the short-term need to reduce traffic congestion in the area, while providing a link road that would be consistent with the long-term road network
- Provide a traffic calming outcome due to the inclusion of additional intersections forcing traffic to slow down.

The next steps

Before finalising the preferred option, Roads and Maritime propose to carry out a number of follow-on actions that include:

- Work with Blacktown City Council and the NSW Department of Planning and Environment to develop the Denmark Link Road based on Option B
- Seek feedback from the community on the link road based on Option B. This feedback would then be used to inform the development of a concept design and to carry out an environmental assessment.

Figure ES-1: Preferred Option

DENMARK LINK ROAD

ROADS AND MARITIME SERVICES



Option B

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1. Introduction

This section describes the purpose of the report in the context of the proposal.

1.1 Background

1.1.1 The North West Growth Centre and the NWGC Road Network Strategy

In 2005, the NSW Government released its strategy to develop Sydney in light of the expected population growth across the metropolitan area over the next 15 to 20 years (forward of 2015). This was based on the development of two principal growth centres; the North West Growth Centre (NWGC) and the South West Growth Centre (SWGC). The NWGC focusses on the corridor north-west of the M7 Motorway to Richmond. Presently, about 6,000 people live in the defined NWGC boundary that is expected to increase to 200,000 over the next two-to-three decades. This will be supplemented by job creation in the area, where it is expected that 40,000 people will work in four key industrial precincts: Riverstone, Box Hill, Riverstone West and Marsden Park (Industrial).

Riverstone is located centrally in the NWGC and is both part of, and surrounded by, several growth centre development precincts (refer to figure 1-1). Each precinct is being 'released' and developed in stages. To date, the Marsden Park and Marsden Park (Industrial) precincts have been rezoned, released and (partially) developed. This has been supplemented by the upgrade of Richmond Road north of the M7 Motorway. Another nine precincts have been rezoned and released for development (refer to section 2.3.5).

Given its position, Riverstone is an integral part of the NWGC and its future development. The majority of the existing 6,000 residents in the NWGC live in and around Riverstone, which also includes an important industrial area. The expected population growth and development of local employment hubs will result in a marked increase in traffic, which will affect Riverstone and in particular Garfield Road. In 2014, Roads and Maritime developed the NWGC Road Network Strategy. This Strategy has been updated to include the location of the proposed Denmark Link Road and is shown on figure 1-1. This Strategy identified key corridors and roads in the area that will be affected by NWGC development. It also sets objectives and targets for improving the road infrastructure to allow for the area's growth.

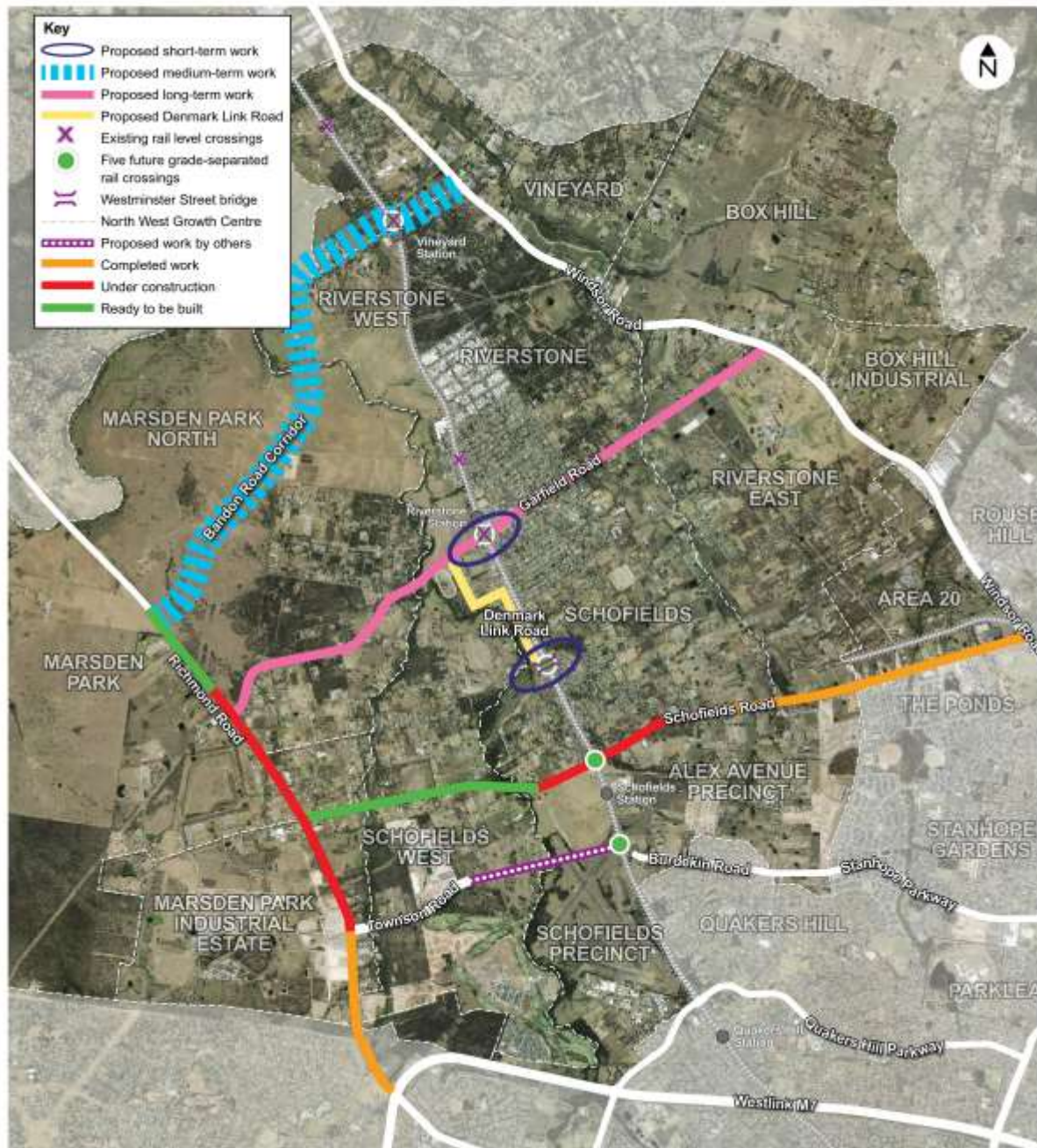
Part of the NWGC Road Network Strategy focusses on Riverstone, its central location and its role in the development of the NWGC. The strategy notes that the Richmond railway line is currently a key constraint in the road network as there are only two crossing points in the area: Garfield Road (via a rail level crossing in the centre of Riverstone) and Westminster Street (via a bridge over the Richmond railway line in Schofields).

Garfield Road is an existing classified road managed by Roads and Maritime that provides a connection between Richmond Road and Windsor Road via the Richmond railway line level crossing at Riverstone. For its design and capacity Garfield Road carries a high volume of traffic and a high number of heavy vehicles (about 23 per cent). This is because it is the only road in the area that provides a direct link between Richmond Road and Windsor Road. The traffic converges on the Richmond railway line level crossing in Riverstone leading to congestion and long delays during the morning and afternoon peak periods as well as at other times of the day. These delays are expected to increase with the development of the NWGC if safeguards and management measures are not carried out.

The only other existing crossing of the Richmond railway line in the NWGC is at Westminster Street in Schofields. This is the only bridge that crosses over the rail line. Traffic is also delayed crossing this bridge,

particularly during the afternoon peak period as a result of the limited turning opportunities for vehicles waiting on the bridge to enter Railway Terrace.

Figure 1-1 North West Growth Centre, development precincts and the road network strategy



Source: Roads and Maritime, 2015

The NWGC Road Network Strategy would reduce the congestion issues in Riverstone while improving connectivity between Richmond Road and Windsor Road via Garfield Road. This Strategy is set within the wider context of the program objectives, the following of which are relevant to this proposal:

- Provide a road network within the NWGC to support the State Government's urban land release strategy through the provision of increased road capacity to meet existing and future traffic and transport growth
- Improve road and train-user safety by providing the required infrastructure necessary to ultimately close/remove four existing level crossings at: Garfield Road at Riverstone; north of King Street at Riverstone; Bandon Road at Vineyard; and Level Crossing Road at Vineyard

- Reduce travel times between Richmond Road and Windsor Road
- Reduce the number of heavy vehicle movements through and near the Riverstone town centre
- Reduce congestion and delays across the Garfield Road rail level crossing
- Provide a strategy that caters for bus services across the region, contributes to increased bus (and rail) travel mode shares and reduces the reliance on private vehicle travel as the NWGC expands
- Deliver benefits for pedestrians, cyclists and less mobile people in terms of accessibility, connectivity, safety and amenity as part of the short, medium and long term program
- Enhance flood evacuation access across the area consistent with State Emergency Service flood evacuation planning.

1.1.2 Proposal background

The NWGC Road Network Strategy highlights a range of short, medium and long-term solutions for upgrading the road network to ensure the development of the NWGC is supported (refer to figure 1-1). The Strategy will be delivered over the next two decades to coincide with the area's development, subject to funding. A key short-term solution is based on the commitment to work with "Blacktown City Council to develop local strategies to improve traffic flow within the Riverstone town centre and access to the Westminster bridge".

The medium and long-term strategies focus on improving west-east connectivity between Richmond Road and Windsor Road by identifying the need for five grade separated crossings of the Richmond rail line. This includes the construction of Bandon Road and completion of Schofields Road in the medium-term and the upgrade of Garfield Road in the long-term including the Garfield Road overpass of the rail line.

A short-term solution to alleviate traffic congestion at the Richmond level crossing and along Garfield Road through the Riverstone town centre is also needed. This report considers one of the short-term solutions. This would be achieved by linking Garfield Road West via Denmark Road and Bridge Street (near Westminster Street bridge and West Parade) 'the proposal'. This has been considered by Roads and Maritime and they have identified five possible options that are described in detail in section 5.3.

1.2 Purpose of this report

This report details the five options developed by Roads and Maritime to alleviate congestion in the Riverstone town centre. It supplements an independent Interim Traffic Management Measures Report prepared in November 2014. This report:

- Explains why the proposal is needed, including its context and setting (refer to Chapter 2)
- Establishes a study area that covers the extent of the existing environmental constraints and issues described under each heading in Chapter 4 (refer to Chapter 1 and Figure 1-2)
- Documents the community consultation that has taken place to date and the planned future consultation that will take place to develop the proposal's concept design (refer to Chapter 3)
- Describes the corridor and options development process (refer to Chapter 5)
- Describes how the preferred corridor was selected (refer to Chapter 5)
- Compares and assesses the traffic and transport, engineering and environmental values and issues associated with each option (refer to Chapter 6)
- Confirms and justifies which of the options are preferred (refer to Chapter 6 and Chapter 7)
- Outlines the next steps for developing the preferred option (refer to Chapter 7).

1.3 Factors and aspects considered

The report considers traffic and transport, engineering and environmental values and issues within the local area. The factors that have been considered in this report have been guided by a number Roads and Maritime and Austroads documents, specifically:

- EIA Guidelines, Environmental Assessment Procedure, Project Review of Environmental Factors (EIA-P05-2) (Roads and Maritime, 2014)
- Guide to Road Safety (eight parts) (Austroads, 2002)
- Guide to Road Design (eight parts) (Austroads, 2009)
- Guide Supplements
 - Road Design (eight parts) (Roads and Maritime, 2011)
 - Asset Management (eight parts) (Roads and Maritime, 2011)
 - Pavement Technology (10 parts) (Roads and Maritime, 2013)
 - Road Safety (nine parts) (Roads and Maritime, 2011)
 - Transport Planning (one part) (Roads and Maritime, 2011)
 - Traffic Management (13 parts) (Roads and Maritime, 2013).

These documents specify the principal factors and aspects that must be considered when assessing, designing and developing a road project in NSW. Chapter 4 describes their relevance and context in detail.

1.4 Study limits

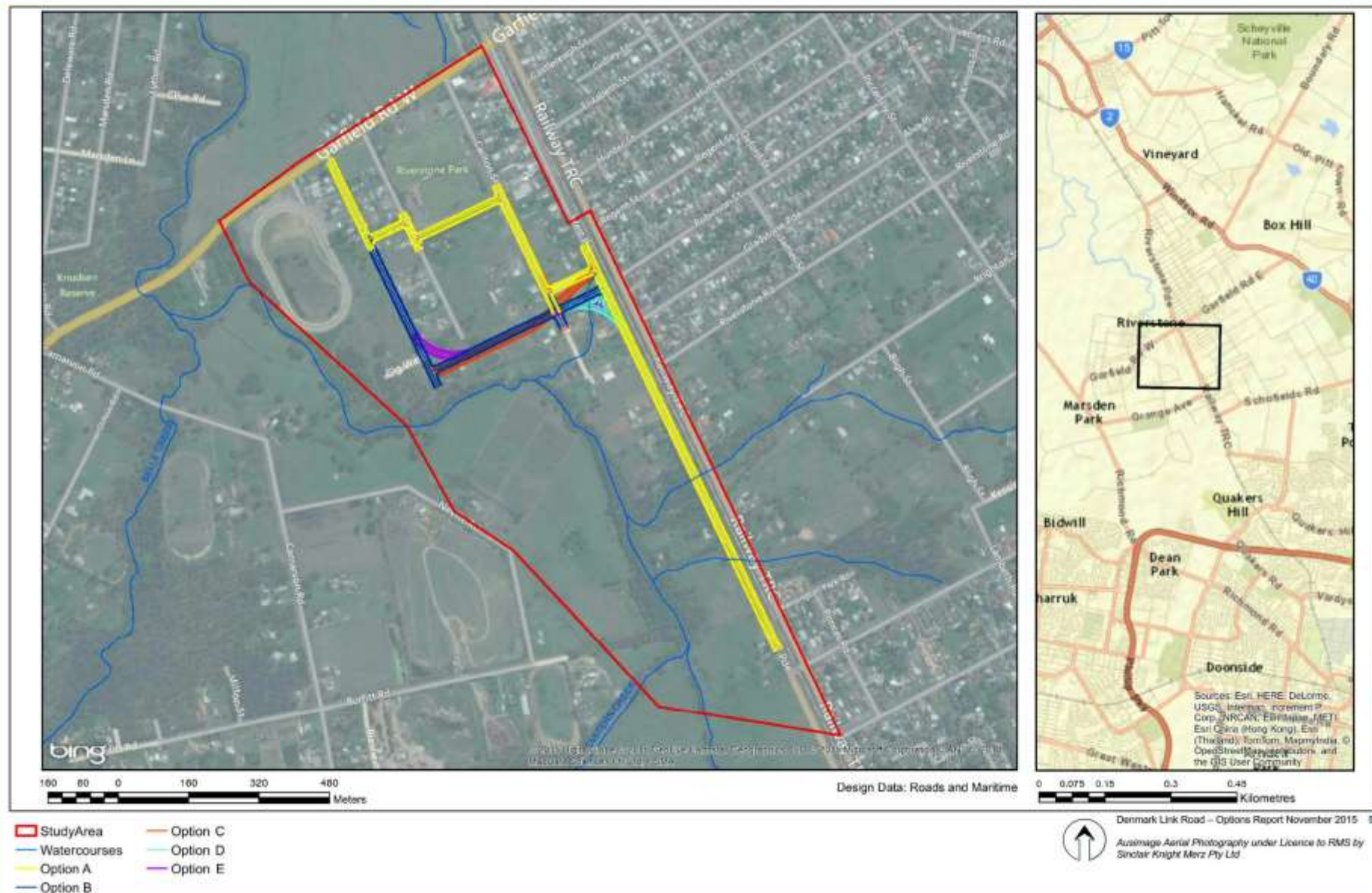
An area of about 88 hectares was considered in preparing this report. It covers a maximum area extending about two kilometres in all directions beyond the limit of the five options that are considered in this report (refer to section 5.3). A smaller area (the options footprint) was also adopted to map the detail of the constraints and issues associated with the options considered in this report (refer to figure 1-2).

1.5 Common terms

The following terms have been used throughout this report:

- The 'proposal' refers to the work described as the Link Road from Garfield Road West to the Westminster Street bridge
- The 'corridor options' refer to three strategic point-A to point-B corridors between Garfield Road West to Westminster Street as defined in an Interim Traffic Management Measures Report published in November 2014 by Parsons Brinckerhoff
- The 'preferred corridor' refers to the connection between the Garfield Road West/Denmark Road intersection and Westminster Street bridge that was confirmed in November 2014 following the recommendations of the Interim Traffic Management Measures Report (refer to section 5.2)
- The 'options' refer to five routes developed within the 'preferred corridor' as defined in section 5.3
- The 'preferred option' refers to the option selected following the analysis
- The 'study area' relates to an 88 hectare area extending about two kilometres in all directions beyond the limit of the 'preferred corridor'
- The 'options footprint' is the combined full extent of all five options considered in this report.

DENMARK LINK ROAD



2. Project need and strategic context

2.1 Statement of project need

As described in chapter 1, the NWGC population is expected to increase over the coming years as more people come to live and work in the area. Without providing the appropriate transport and road infrastructure, the existing roads will not be able to meet the expected additional traffic. As a result, traffic congestion is predicted to get worse, which may lead to associated traffic delays and access, journey time and road safety impacts.

Presently, the road network is constrained as there are only two crossing bridge points over the Richmond rail line, one in the Riverstone town centre and the second at Westminster Street, Schofields

The NSW Government has developed a Road Network Strategy for the (NWGC). The Network Strategy improves east-west connectivity between Richmond Road and Windsor Road by proposing five grade separated crossings of the Richmond railway line and the upgrade and construction of a number of link roads. This strategy has been displayed to the public in November 2014 and responds to the work of multiple Government agencies and the community. The five bridges are proposed at:

- Burdekin Road in Quakers Hill (planned)
- Westminster Street bridge at Schofields (existing with limited capacity)
- Schofields Road at Schofields (in progress)
- Garfield Road in Riverstone (currently a level crossing)
- Bandon Road in Vineyard (currently a level crossing).

The strategy also describes how the above connections should be prioritised, which reflects the planned release of land for development in the NWGC. The Garfield Road upgrade is a long-term priority that needs to be implemented to coincide with the release of the surrounding development and employment precincts. However, in the short-term Riverstone would continue to be affected by the regional growth and development of the NWGC; the effects of which will be increased pressure and congestion in the town centre. As such, a short-term strategy has been developed, which comprises:

- Working with Blacktown City Council to develop local strategies to improve traffic flow within the Riverstone town centre and access to Westminster Street bridge
- Begin planning for the Bandon Road underpass/link between Richmond Road and Windsor Road
- Work with the NSW Department of Planning and Environment and Blacktown City Council to reserve a road corridor along Garfield Road between Richmond Road and Windsor Road for future widening.

This proposal responds to the first action of the short-term strategy by looking to improve traffic flows within Riverstone.

2.1.1 Existing traffic conditions

The Interim Traffic Management Measures report (Parsons Brinckerhoff, 2014) describes the traffic conditions associated with the study area.

Traffic volumes

During the morning peak period between 8am and 9am:

- About 850 vehicles travel along Garfield Road West
- About 650 vehicles travel along Garfield Road East
- About 600 vehicles use the Westminster Street bridge.

During the afternoon peak period between 5pm and 6pm:

- About 900 vehicles travel along Garfield Road West
- About 700 vehicles travel along Garfield Road East
- About 650 vehicles use the Westminster Street bridge.

Heavy vehicles

The roads in the study area carry a disproportionately high percentage of heavy vehicles:

- Up to 20 per cent of the traffic on Garfield Road West are heavy vehicles
- Up to 13 per cent of the traffic on Garfield Road East are heavy vehicles
- Up to 15 per cent of the traffic on Riverstone Parade are heavy vehicles
- About three per cent of the traffic using Westminster Street are heavy vehicles despite the rail bridge being limited to carrying five tonnes.

The above figures compared to other roads in the area where heavy vehicles only account for up to eight per cent of the traffic. The high heavy vehicle count adds to the congestion and these delays on Garfield Road.

Existing congestion and traffic delay

One of the main reasons for the proposal is the congestion that is currently experienced in the Riverstone town centre due to the constraints of the rail level crossing and the volume and composition of the traffic as described above. This not only affects Garfield Road but it has a wider impact on Riverstone Parade, Garfield Road East and Railway Terrace.

Congestion can be measured in terms of the amount of time each vehicle is delayed at an intersection. It can also be measured in terms of an intersection's performance. This is called the 'level of service' and it describes the traffic conditions on a given section of road. The level of service is graded from A to F where 'level of service A' represents free flowing uninterrupted conditions and 'level of service F' indicates over-capacity heavily congested conditions. Typically, roads are considered congested where the 'level of service' falls below D. The average delay per vehicle is a product of the level of service. The lower the level of service the longer it takes for traffic to travel along a road. Correspondingly, when it takes traffic more than about a minute (60 seconds) extra to travel along a section of road due to the high volumes of traffic the road is considered congested.

Table 2.1 shows that the existing delays and level of service during the morning and afternoon peak periods on the above four roads as they intersect. It is clear that this intersection and the approach roads are characteristic of roads that are congested, and in the case of Garfield Road West and Riverstone Parade, 'gridlocked'.

Table 2.1 Existing intersection performance

Intersection approach	Morning week day peak period (8am to 9am)		Afternoon week day peak period (4pm to 5pm)	
	Average delay per vehicle (seconds)	Level of Service	Average delay per vehicle (seconds)	Level of Service
Garfield Road West	184	F	85	F
Riverstone Parade	94	F	108	F
Garfield Road East	55	D	57	E
Railway Terrace	55	D	77	F
Level of service A: Good operation B: Good with acceptable delays C: Satisfactory D: Operating near capacity E: At capacity with excessive delays F: Unsatisfactory with excessive queuing				

The above modelled data were supplemented by site observations in 2014 that noted the development of eastbound traffic queues on Garfield Road West. In particular, traffic on Garfield Road West on the approach to the Riverstone town centre queues back to about Denmark Road in the morning peak period and it queues out of Riverstone in the afternoon peak period as far as Creek Street.

2.1.2 Traffic growth and future road network performance

It is predicted that without an upgrade to the road network, traffic congestion and travel delays would become notably worse. This would further restrict and delay traffic from being able to access, exit or move through the area. This is due to the roads in the area were never designed or expected to cope with the volumes of traffic that would be generated from the development of the NWGC.

2.1.3 Road safety

There were 13 crashes with no fatalities in Riverstone between 2010 and 2014, the majority of which were on the Garfield Road West approach to the intersection. There is no clear accident causality and they occurred throughout the day under a range of weather conditions; however speed and fatigue were contributing factors (Roads and Maritime, 2014)

There were eight crashes with no fatalities around Bridge Street between 2008 and 2014, six of which occurred at the intersection with Railway Terrace caused by turning traffic (Roads and Maritime, 2014).

2.1.4 Public transport

Buses operate along Garfield Road West and Railway Terrace. Table 2.2 describes the service provisions.

Table 2.2 Bus stops and services

Road	Bus stop location	Bus service	
		Number	Weekday frequency
Garfield Road West	Between Denmark Road and Creek Street (eastbound)	757	Hourly 5am to 6pm
	Riverstone Park (westbound)	757	
Railway Terrace	Riverstone Station (interchange)	661, 662, 746, 757, N71, T74 and T75	661, 662, 746 are not routed through core of the study area
	Hunter Street and Regent Street (southbound)	T74 and T75	Half hourly 5am to 11pm
	Gladstone Parade and Riverstone Road (southbound)	T74 and T75	
	Gladstone Parade and Riverstone Road (northbound)	T74	
	Kensington Park Parade (southbound)	T74 and T75	
	Kensington Park Parade (northbound)	T74 and T75	
Riverstone Road	Southbound	T75	

The Richmond railway line (T1 Western Line) also provides a connection between Richmond and Central Station, with the link then extending to Hornsby and Berowra. Trains leave from and arrive at Riverstone Station every half hour during the week between 4.30am and 11.15pm.

2.1.5 Pedestrians and cyclists

There are no dedicated cycle provisions along any of the main roads in the area. Few of the roads and streets have dedicated footpath provisions with the exception of Railway Terrace, where there is a footpath off the eastern kerb along its length. Within the Riverstone town centre there are footpath provisions adjacent to both kerbs.

2.1.6 Flood immunity

The study area is flood prone (refer to section 4.2) due to it being located on low-lying land in the Eastern Creek catchment. Sections of road in the area have not been designed to increase their flood immunity and they flood regularly as a result.

2.2 Proposal objectives

The proposal's objectives are defined by the need to address existing traffic and access issues to support the development of the NWGC. The proposal's principal objectives are to:

- Improve traffic flow by providing an alternative local connection between Garfield Road West, Riverstone and the Westminster Street bridge, Schofields
- Provide a north-south local road running parallel to, and on the western side of, the Richmond rail line
- Provide infrastructure that complements the planned long-term proposed road network upgrade.

These principal objectives are supplemented by the following secondary objectives:

- Provide a safe environment for all road users
- Minimise adverse operational environmental and social impacts
- Avoid any change to the flood risk in the area
- Improve amenity, accessibility and efficiency for all road users.

2.3 Strategic planning and policy framework

The proposal is supported by the aims and direction of a number of strategic planning documents:

- North West Subregional Strategy (Department of Planning and Environment, 2007)
- National Road Safety Strategy for Australia, 2011 – 2020 (Australian Transport Council, 2011)
- Road Safety Strategy for NSW 2012 – 2021 (NSW Transport for NSW, 2008 (as amended))
- North West Growth Centre Structure Plan (Department of Planning and Environment, 2010)
- Riverstone Precinct Plan (Department of Planning and Environment, 2010 (as amended))
- Schofields Precinct Plan (Department of Planning and Environment, 2012 (as amended))
- NSW 2021: A Plan to Make NSW Number One (NSW Department of Premier and Cabinet, 2011)
- NSW State Infrastructure Strategy (NSW Department of Premier and Cabinet, 2012)
- NSW Long Term Transport Master Plan (Transport for NSW, 2012)
- A Plan for Growing Sydney (NSW Department of Planning and Environment, 2014)
- North West Growth Centre Road Network Strategy (Roads and Maritime, 2014).

2.3.1 North West Subregional Strategy

The North West Subregional Strategy implements the Sydney Metropolitan Strategy across the north-west region. A key direction of the above strategy is the connection of the NWGC to the regional road network. The strategy acknowledges that the existing road network in the region will suffer from congestion, capacity and maintenance issues and travel-demand challenges as the area's population increases. In response, the Strategy recognises the need to provide relief in and around Riverstone. While the long-term objective includes for the upgrade of Garfield Road as the mechanism to achieve this, the short-term objective recognises the need to provide a traffic diversion around Riverstone to relieve the town centre. This would be achieved through the proposal and the preferred option will be one that can clearly demonstrate achieving this over the next three years.

2.3.2 National Road Safety Strategy for Australia, 2011 – 2020

The National Road Safety Strategy for Australia 2011 – 2020 is a 10 year strategy to reduce the number of serious injuries and fatalities on Australian roads by 30 per cent by 2020 from 2011 levels. Four specific road safety actions or interventions have been identified to achieve this target. They are supported by immediate and future additional actions. Of these four actions, the creation of 'safe roads' will be a central consideration for the proposal. The aim of 'safe roads' is to reduce the crash risk and severity of injury if a crash does occur through the appropriate design and maintenance of roads and roadsides. Safety is a fundamental consideration, and the option selection and design will need to demonstrate that the aims of the National Road Safety Strategy for Australia 2011-2020 are achieved by delivering a design that demonstrably contributes to the safe roads target.

2.3.3 Road Safety Strategy for NSW 2012 – 2021

The Road Safety Strategy for NSW 2012 – 2021 supports the National Road Safety Strategy for Australia 2011 – 2020 by outlining the State's commitment to reduce the road fatality and injury rate by 30 per cent by 2021 from 2012 levels. Of the initiatives identified in the Strategy those of relevance to this proposal are:

- Elevating road safety work across the State
- Elevating safety-in-design, construction and maintenance
- Addressing serious injury trends
- Focussing on high-risk road users including pedestrians, cyclists, motorcyclists and vulnerable age groups
- Reducing the number of crashes on the road.

The expansion and development of the NWGC means that there will be more traffic in the area. Inherently this means that the accident risk will increase. Any road infrastructure improvements would be implemented under a safety-in-design strategy. The focus for this proposal will be to ensure that any option provides for a safe geometric design and that it does not present a tie-in risk from the perspective of intersection turning movements.

2.3.4 North West Growth Centre Structure Plan

The North West Growth Centre Structure Plan provides the strategic blueprint for the detailed planning and release of each precinct in the NWGC. Since being prepared and released in 2010, the NSW Department of Planning and Environment has developed specific Precinct Plans as discussed in section 2.3.5.

The Structure Plan reinforces the overall objectives of the growth centres in streamlining the supply of greenfield land for urban development and to coordinate the delivery of infrastructure through the NSW Department of Planning and Environment. Under the Structure Plan there is a focus on relieving congestion in the Riverstone town centre which will be achieved in the long-term by upgrading Garfield Road. This proposal will need to support and facilitate the long-term outcome for upgrading Garfield Road, while offering the best short-term solution for improving traffic conditions in the Riverstone town centre.

2.3.5 Precinct Plans

The Structure Plan also establishes 16 precincts that make up the NWGC. To date:

- Eleven precincts have been rezoned to allow for their development
- Three precincts are undergoing precinct planning
- Two precincts are yet to be released for planning.

The study area covers three precincts: Riverstone and Schofields, which have been rezoned and released for development, and Schofields West, which is yet to be rezoned and released. In the Riverstone and Schofields precincts, a range of core development and conservation interests have been identified that reflect the area's current land uses, and conservation and socioeconomic interests. Table 2.3 summarises these in the order of the priority for each precinct.

Table 2.3 Precinct plan and core development and conservation interests

Precinct plan	Core development and conservation interests	
Riverstone	Aboriginal heritage	Playing fields
	Biodiversity certification	Industrial development
	Bush fire management	Traffic and transport management.
	Flood risk and water cycle management	
Schofields	Flood risk and water cycle management	Primary utilities
	Aboriginal heritage	Land capability, salinity and contamination
	Biodiversity	Noise and vibration
	Bushfire management	Non-Aboriginal heritage
	Demographics and social infrastructure	Odour

Both plans recognise the current issues and interests in each precinct. These include the importance of conserving development interests in the Riverstone town centre, the ecological and Aboriginal heritage values and flood risk of Eastern Creek, and the plans to introduce residential development in both precincts. The proposal will need to avoid impacting on the conservation interests in the precincts, while supporting and enhancing the development interests.

2.3.6 NSW 2021: A Plan to Make NSW Number One

NSW 2021: A Plan to Make NSW Number One is the NSW Government's 10 year strategic business plan. It sets priorities for action and guides resource allocation to deliver economic growth and critical infrastructure throughout the State. It emphasises delivering an efficient and effective transport system to relieve congestion, improve safety and expand road corridor capacity. The proposal would help achieve the following goals outlined in the Plan:

- Goal 7: Reduce travel time
- Goal 9: Improve customer experience with transport services
- Goal 10: Improve road safety.

The comparison of options and selection of a preferred option will need to identify how it best achieves these goals.

2.3.7 NSW State Infrastructure Strategy

The NSW State Infrastructure Strategy identifies and prioritises the delivery of critical public infrastructure over a 20-year period ending in 2032. The Strategy shares links with other State infrastructure plans such as the A Plan for Growing Sydney (refer to section 2.3.9). Roads and Maritime has considered the road infrastructure in the NWGC as critical infrastructure needed to support the area's development. The proposal would improve the road infrastructure by alleviating congestion and enabling the area's development. It would also support the delivery of new infrastructure and the maintenance of an existing asset; two key components of the State Infrastructure Strategy.

2.3.8 NSW Long-Term Transport Master Plan

The Long-Term Transport Master Plan provides the framework for delivering an integrated, modern transport system across NSW over the next 20 years. It identifies transport actions and investment priorities over the short, medium and long-term that have emerged in response to six identified transport challenges:

- Integrating transport services
- Getting Sydney moving again
- Sustaining growth in Greater Sydney
- Providing essential access to regional NSW
- Supporting efficient and productive freight
- State-wide actions.

The Master Plan responds to these challenges through setting actions, two of which are 'modernising the transport system' and 'maintaining important road and public transport assets'. The Master Plan specifically identifies the need for transport improvements in the NWGC aligned with the five strategic links described in section 2.1. The objective of these improvements is to support the economic development of the area while committing to alleviating congestion at identified pinch points. The proposal is part of the overall response to the above objectives and the commitments to develop the NWGC. The selection of a preferred option therefore needs to be consistent with the objectives of the Long Term Transport Master Plan both generally and specifically in relation to the NWGC.

2.3.9 A Plan for Growing Sydney

A Plan for Growing Sydney extends to 2036. It sets out the long-term framework to develop Sydney on the global stage based on integrated 'radical' public transport links and cross-regional transport connections, which would support economic development. A focus is providing the required network capacity to relieve and prevent congestion over the next two decades.

The Plan reinforces the estimated population growth over the next two decades and the need to establish the growth centres to accommodate about 30 per cent of the new housing needed for the 1.7 million people that will move to Sydney over this period.

A main concept of the above Plan is pinch point and congestion alleviation. The proposal is a direct short-term response to this concept and the associated traffic management objectives of the above Plan. The selection of the preferred corridor was based on providing the best outcome in terms of alleviating traffic congestion in the Riverstone town centre. The preferred option therefore, needs to support this by providing the greatest reduction in travel time delays and improvement in level of service while also minimising environmental impacts and delivering value for money.

2.3.10 North West Growth Centre Road Network Strategy

The North West Growth Centre Road Network Strategy was developed in parallel with the precinct plans described in section 2.3.5. A principal objective is to identify strategic crossing points over the Riverstone railway line to effectively manage traffic and heavy vehicle movements in the NWGC. The five crossing points are described in section 2.1. In addition to the five crossing points the Strategy:

- Addresses community feedback
- Supports the immediate needs and long-term impacts of the NWGC
- Was developed based on the findings of a traffic and transport study (refer to section 5.1)
- Had input from Department of Planning and Environment, Transport for NSW, Blacktown City Council, Hawkesbury City Council and the Member of Parliament for Riverstone.

The Strategy also highlights a range of short-term, medium-term and long-term solutions for upgrading the road network, one of which is to 'develop local plans to improve traffic flow within the Riverstone town centre and access to Westminster Street bridge'.

Roads and Maritime also consulted with the community on the Strategy, the outcome of which is described in Chapter 3. The selected preferred option would need to address the short-term needs to relieve congestion in Riverstone and respond to community feedback. The Strategy was confirmed by the State Government in July 2015.

2.4 Summary

The development and evaluation of options, and the selection of a preferred option, needs to respond to the proposal's need and strategic context in order to:

- Deliver the proposal's objectives
- Provide an effective road network that meets the development needs of the NWGC over the short-to-long-term
- Ensure safety-in-design
- Reduce the risk of traffic-related accidents
- Reinforce and support the long-term outcome for upgrading Garfield Road
- Avoid impacting on the area's environmental values
- Support and enhance the area's development interest
- Alleviate congestion, reduce travel times and improve the level of service in the area
- Invest in the area's road network as it supports the development of critical infrastructure
- Respond to community feedback on the proposed strategy
- Support the approach of integrating transport services, sustaining the growth and development of the NWGC, and providing access to regional NSW.

3. Community and stakeholder involvement

This chapter outlines the proposal's communication and stakeholder engagement plan as well as the consultation carried out with relevant stakeholders to date.

3.1 Community involvement

In November 2013 Roads and Maritime commenced consultation on the removal of the Railway level crossing at Riverstone. As a result of the community feedback, Roads and Maritime reviewed its proposal and undertook a traffic study of the entire NWGC that led to the development of the NWGC Road Network Strategy. Over the past two years several community updates and information sessions have been held, all of which have been used to seek feedback. Table 3.1 summarises the community consultation to date.

Table 3.1 Community consultation overview

Date	Publication
November 2013	Removal of the Railway Level Crossing at Riverstone: Community Consultation Report
August 2014	Riverstone Railway Crossing: Community Consultation Report
	North West Growth Centre and Riverstone Traffic Study: Summary Report
November 2014	Proposed Road Network Strategy for the North West Growth Centre: Community Update
July 2015	Road Network Strategy for the North West Growth Centre: Community Consultation Report
	NWGC Road Network Strategy: Confirmed by the State Government
	New Traffic Lights at the Intersection of Westminster Street and Railway Terrace, Schofields: Notification Letter

Roads and Maritime has committed to ongoing consultation with regards to this proposal and the wider medium and long-term development strategies for the provision and upgrade of road infrastructure within the NWGC.

3.1.1 November 2014 to July 2015

Roads and Maritime had received 23 comments in response to the proposed NWGC Road Network Strategy that was publicised to the community in the November 2014. These responses were analysed, reviewed and responded to in a community consultation report issued in July 2015. The 23 comments were received in response to a consultation campaign involving the distribution of about 17,000 copies of the update within and surrounding the NWGC. This was supplemented by a doorknocking campaign of residents and businesses on Garfield Road East, Garfield Road West (near the Riverstone town centre), Castlereagh Street, Loftus Street, Victoria Street and Bandon Road in November 2014.

In line with the community feedback, Roads and Maritime decided to continue to develop the individual proposals that collectively form the short, medium and long-term upgrade of the road infrastructure in the NWGC. This specifically includes:

- Short-term: improving traffic flows within the Riverstone town centre and access to the Westminster Street bridge at Schofields
- Medium-term: planning for the upgrade of Bandon Road and Schofields Road
- Long-term: planning for upgrade of Garfield Road between Richmond Road and Windsor Road.

3.2 Government agency and stakeholder involvement

As noted above, the NWGC Road Network Strategy has been developed by Roads and Maritime in consultation with the NSW Department of Planning and Environment, Transport for NSW and Blacktown City Council. These agencies continue to work closely together to identify, develop, refine and improve the development outcome for the NWGC.

3.3 Aboriginal stakeholder involvement

The proposal will be considered against the Roads and Maritime Procedure for Aboriginal Cultural Heritage Consultation and Investigation (PACHCI, Roads and Maritime, 2011). This procedure is generally consistent with the Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010 (NSW Department of Environment, Climate Change and Water, 2011). It comprises four stages, of which stage one confirms if there is a potential risk and the remaining stages include for Local Aboriginal Land Council (LALC) consultation.

At this point in time, Roads and Maritime has not completed any of the PACHCI stages. However, in 2015 a brief review identified Aboriginal heritage values and archaeological potential in the area. The recommendation following this is that the PACHCI process is adopted once the preferred option is finalised. This will determine the need to consult with Deerubbin LALC and other interested Aboriginal stakeholders.

3.4 Utility and service providers

A preliminary utility investigation was prepared to support this report. This involved consulting utility provider records to identify the presence, location, density, routing and sensitivity of the utilities in the area. Utility-providers have not been directly consulted at this stage, however once the preferred option is finalised, the next stage would involve meeting and consulting with the owners of likely affected utilities and services. Section 4.13 describes the utility search results.

3.5 Further consultation

The community will be asked to provide comments on the preferred option. Further consultation will also take place when the concept design is being developed. The key stakeholders that are likely to be most interested in the proposal are:

- | | |
|--|---|
| ■ NSW Department of Planning and Environment | ■ Bicycle NSW |
| ■ NSW Transport for NSW | ■ Greater Blacktown Business Chamber |
| ■ Sydney Trains | ■ Deerubbin Local Aboriginal Land Council |
| ■ Blacktown City Council | ■ Emergency services |
| ■ NSW Environment Protection Authority | ■ Utility providers |
| ■ NSW Office of Environment and Heritage | ■ Landowners, residents and local businesses. |

4. Issues

This chapter describes the issues that may constrain development in the study area. Supporting figures, prepared by Hills Environmental, are provided at the end of this chapter.

4.1 Landform, Geology and Soils

4.1.1 Landform

The study area's topography has been partly modified and is relatively flat. It is undulating and varies in height from about 10 metres to 25 metres above Australian Height Datum (refer to figure 4-1). Locally the topography is influenced by Eastern Creek which causes the land to gradually fall towards the west and south towards the watercourse. This has created a notable floodplain (refer to section 4.2). The topography would have some influence on the required earthworks and the requirement to either cut into the landscape or raise (fill) the road level; however the local height variation is not significant to require substantial earthworks.

Summary of issues

The following are potential issues that may constrain development:

- **Engineering:** cut and fill requirements due to the undulating topography.

4.1.2 Geology and soils

Geology

As shown on Penrith 1:100 000 Geological Sheet 9030 (Clark & Jones, 1991) (refer to figure 4-2) the area's surficial geology comprises:

- Quaternary deposits (sediments) broadly west of the alignment of Creek Street
- Bringelly Shales broadly east of the alignment of Creek Street.

Quaternary deposits

Quaternary deposits (sediments) are likely to have variable composition, engineering properties and depths. They have limited engineering and reuse potential. They can support road construction, however they often need additional engineering treatments. They also require large shallow batter slopes where a road is constructed in cutting or on fill. For example, any batter slopes in the area would typically need to be about three metres wide for every one metre increase or decrease in the height of the road compared to the surrounding land (Roads and Maritime, 2015). The sediments are also affected by the water table. This may result in the need to either flatten (requiring additional land take) or steepen (requiring less land take) the slopes depending on localised ground conditions. This would be confirmed through a geotechnical site investigation of the local area. The sediments are also typically erosive meaning that dust propagation, erosion and sediment controls would need implementing during construction.

Bringelly shales

Bringelly shales are a composite of carbonaceous claystone, claystone, laminate (small scale sequence of fine layers that occurs in sedimentary rocks) and fine-to-medium grained lithic sandstone (sandstone that contains sand grains from other eroded rocks). Bringelly shale strata can also occasionally contain coal and tuff (a porous rock that is usually formed by the compaction and cementation of volcanic ash or dust).

This composition affects the shale's physical properties and they often have a low strengths meaning they have limited engineering and reuse potential. They are often only suitable as general fill and incapable of supporting road construction without additional engineering treatments.

Batter slopes would typically need to be about two metres wide for every one metre increase or decrease in the height of the road compared to the surrounding land (Roads and Maritime, 2015). The shales can be erosive depending on their clay content. This may require the batter slopes to be flatter (requiring more land take) or steeper (requiring less land take) to provide erosion protection or additional engineering stability. Dust propagation, erosion and sediment controls would need implementing during construction.

Soil landscape

There are two soil landscapes in the area as recorded on Soil Landscapes of the Penrith 1:100,000 Sheet 9030 (Bannerman & Hazelton, 1990) (refer to figure 4-3):

- The South Creek soil landscape broadly west of the alignment of Creek Street
- The Blacktown soil landscape broadly east of the alignment of Creek Street

South Creek

These soils are deep-layered sediments over bedrock or relict (soils that contain features developed under different soil forming conditions than those at present). They are common to the active floodplains and drainage networks of the Cumberland Plain, including Eastern Creek. They erode easily and often result in streams becoming partially or fully blocked by sediment.

Blacktown

These soils are shallow-to-moderately deep and comprise red, brown and yellow podzols (zonal soil developed under coniferous or mixed forests in warm-temperate climates). They are either formed on crests and upper slopes, and well drained areas (red and brown podzols) or on lower slopes and in drainage depressions (yellow podzols). They are moderately reactive (ie their volume is affected by changes in moisture content) and highly plastic, which means they need additional engineering treatments to be stable, however they do not erode easily.

Summary of issues

The following are potential issues that may constrain development:

- **Engineering and environmental:** poor physical and engineering properties associated with the geology and soil in the area. Wide batter slopes or retaining walls may be required through both the quaternary deposits associated with the western side of the option footprint and the Bringelly shale associated with the eastern side of the footprint. The extent of any engineering treatments would depend on the height of the road above or below the surrounding area and the road's depth relative to the water table. It would also affect the required land take, or invite the need to include partial or full retaining walls as an alternative, which can be costly.

- **Engineering:** poor physical and engineering properties associated with the geology and soil in the area. This would potentially mean that additional engineering treatments would be required to provide suitable conditions to lay the road foundations on. It may also mean that any excavated materials could only be reused as general fill.
- **Environmental:** the quaternary deposits and the South Creek soils, and the high clay-content Bringelly shales erode easily. This means that they may cause a dust dispersion and erosion and sediment control issue during construction.

4.1.3 Acid Sulfate Soils

Acid sulfate soils (ASS) are soils that contain iron sulphides, which produce sulphuric acid when exposed to oxygen in air. They are typically present in lowland coastal areas and do not occur around Riverstone (Australian Soil Resource Information System, accessed September 2015).

4.1.4 Salinity

Saline soils occur where there is a build-up of salts in the soil surface and groundwater in non-irrigated areas. While naturally occurring, the build-up of excess salt can affect the soil quality, native vegetation, biodiversity, crops and water quality. Termed 'dryland salinity' this typically occurs where brackish groundwater rises to the surface. The water is either taken up by plants or evaporates and leaves the salt deposits behind. The soils around Eastern Creek are highly saline while the soils elsewhere in the study area are moderately saline (Department of Infrastructure, Planning and Natural Resources, 2003).

Summary of issues

The following are potential issues that may constrain development:

- **Engineering:** the requirement for additional corrosion protection and concrete treatment
- **Environmental:** the creation of saline conditions during construction and its impact on soil quality, native vegetation, biodiversity values, crops and water quality.

4.1.5 Contamination

Contaminated land: records

While there are two sites on the NSW Environment Protection Authority contaminated land record in the Blacktown local government area neither are within the study area.

Contaminated land: development history

The study area has been under agricultural and residential use for over 150 years. There is no light or heavy industry locally. The only potential contamination sources would be from:

- The operation of the railway (adjacent to West Parade), an activity that is associated with generating hydrocarbons, heavy metals and asbestos
- Agricultural activities (south of Denmark Road, Creek Street and Carlton Street) that can create pesticide and fertiliser washout.

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** encountering and mobilising dispersed metals and hydrocarbons adjacent to the Richmond rail line, leading to human health, water quality and biodiversity impacts
- **Environmental:** encountering and mobilising washed out fertilisers and pesticides south of Denmark Road, Creek Street and Carlton Street leading to water quality and biodiversity impacts.

4.2 Hydrology and Flooding

The entire study area falls within the Eastern Creek catchment, with Eastern Creek being located about 60 metres west of the limit of the footprint of the options. There is also an unnamed creek (a tributary of Eastern Creek) in the area near Trevithick Street. The catchment is subject to flooding as confirmed by Blacktown City Council's flood mapping (accessed September 2015) (refer to figure 4-4) that highlights the:

- High flood risk associated with the majority of the study area
- Moderate flood risk associated with the area to the east around West Parade.

Summary of issues

The following are potential issues that may constrain development:

- **Engineering:** the potential flood risk and inundation by constructing a road in a floodplain. Additional engineering treatments may be required. Should the road be engineered to provide flood immunity, its height would need increasing relative to the floodplain. This may require volumes of fill and extensive batter slopes or a more costly engineering solution
- **Environmental:** construction in the floodplain would affect runoff and surface water flow patterns. The final road may also act as a barrier in the floodplain which could affect drainage and surface water supply. This could have wider agricultural, flood risk or biodiversity impacts
- **Environmental:** the need to cross an unnamed creek at Trevithick Street (which flows into Eastern Creek) and the potential for runoff impacts to affect Eastern Creek.

4.3 Biodiversity

The study area includes residential development, playing fields, agricultural land and the Eastern Creek river (riparian) corridor. With the exception of the river corridor, the other land uses limit the area's ecological value. This preliminary assessment is based on a desk-based review of available records. No field verification has been carried out at this stage.

4.3.1 Certified land

In 2008 the State Government carried out an exercise of mapping the ecological values of the NWGC in order to identify areas that needed safeguarding and areas that could be developed. This was supplemented by a commitment to provide offset (replacement) habitat for areas that would be developed. However, certain environments, including river corridors and their associated riparian habitat were all identified as needing to be safeguarded as they could not be easily offset. Legislation was then passed at the State and Commonwealth level to certify land for its development and clearance. This allows development to take place without the need to follow the usual legislative processes and requirements as a strategic offset has

been made by the State Government. Only a small portion of the options footprint is located on certified land (the south eastern section close to West Parade), and the majority of area falls outside of the certification process (refer to figure 4-5).

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** construction on non-certified land, and the need to follow legislative processes, with the aim of avoiding any impact on threatened flora and fauna, communities and habitat.

4.3.2 Threatened flora

There are eight threatened plant species records within 10 kilometres of the study area (Atlas of NSW Wildlife, 2015) (refer to figure 4-6). No species have been recorded in the study area. The closest record is about 400 metres from the intersection of Garfield Road West and Denmark Road. It is for grevillea (*Grevillea juniperina* sbsp. *juniperina*), which is listed as vulnerable at the State level (ie under the NSW *Threatened Species and Conservation Act, 1995* (TSC Act)).

Other non-threatened flora will occur within the area, some of which may be native and endemic. While they hold no legal protected status they may provide habitat for threatened fauna while also providing other ecological function or value.

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** presence of grevillea, unknown threatened flora and other endemic and native species that may be impacted or lost under the proposal.

4.3.3 Threatened fauna and migratory species

There are 26 threatened fauna species and 34 migratory species records within 10 kilometres of the study area (Atlas of NSW Wildlife, 2015 and Protected Matters Search, 2015) (refer to figure 4-6). No species have been recorded in the study area. The closest records are about 200 metres and 500 metres east of Carlton Road. Respectively, these are for giant burrowing frog (listed as vulnerable at the State level) and the green and golden bell frog (listed as endangered at the State level).

Other non-threatened fauna will occur within the area, some of which may be native and endemic. While they hold no legal protected status they may provide and important ecological function or value.

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** presence of unrecorded threatened fauna and other endemic and native species that may be impacted by the proposal.

4.3.4 Key fish habitat

Key fish habitat comprises aquatic environments that are important to the 'sustainability of recreational and commercial fishing industries, the maintenance of fish populations generally and the survival and recovery of threatened aquatic species' (NSW *Fisheries Management Act 1994* (FM Act)). Eastern Creek forms a key fish habitat due to its function in maintaining fish populations in the area.

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** indirect impacts on Eastern Creek that would affect its values as a key fish habitat. This could include accidental spillages or leaks, sediment discharge (refer to section 4.1.2), unattenuated road runoff to the creek, changes in water flow patterns due to needing to engineer the road in the floodplain, and direct impacts to riparian habitat.

4.3.5 Endangered ecological communities

Despite the study area being under residential and agricultural land use, there are areas of remnant vegetation and woodland that include:

- Shale plains woodland, located around Eastern Creek
- Alluvial woodland, located around Eastern Creek.

Table 4.1 describes the protected status of each woodland community. Figure 4-7 shows their location in the study area. These woodland communities are also likely to support other native and endemic flora and fauna.

Table 4.1 Endangered ecological communities

Vegetation	Potential endangered ecological community equivalent	TSC Act status	EPBC Act status
Shale plains woodland	Cumberland Plains Woodland in the Sydney Basin bioregion	Critically endangered	Critically endangered
Alluvial woodland	River-flat eucalypt forest on coastal floodplains of the NSW North Coast, Sydney Basin and south east corner bioregions	Endangered	Not listed

Source: *Native Vegetation Maps of the Cumberland Plain, Western Sydney* (NSW National Parks and Wildlife Service, 2002).

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** an impact on an endangered ecological community would be notable and should be avoided.

4.4 Socioeconomic and land use

The socioeconomic environment covers: local and regional population and demographics; social characteristics; social infrastructure (ie community facilities, services and networks), local businesses; the local and regional economy; and community values (ie socioeconomic aspects that people hold important to their quality of life and wellbeing).

4.4.1 Population and demographics

There are about 6,000 people that live in the growth centre, many of which are located in Riverstone and the surrounding area. Table 4.2 shows the key demographic information about this population as taken from census data (Australian Bureau of Statistics, 2011)

Table 4.2 Social and economic demographics

Category	Sub-category	Characteristics
Social characteristics		
Population and demography	Population	6,191
	Average Age	35
	Cultural diversity	Australia: 81%, England: 2%, New Zealand: 2%, Malta: 1%, Italy: 1%
Families and housing	Families	77%
	Home ownership	66%
Travel to work	Car travel and public transport use	77%
Economic characteristics		
Income	Average income	\$559 AUD per week for 2011
	Employment	Full-Time: 61%, Part-Time: 27%

Source: Adapted from the 2011 Census QuickStats (ABS, 2011)

A review of the statistics reflects that 77 per cent of people in the area use cars or public transport to travel to work. They rely on road access and the ability to travel into the Riverstone town centre either by car or on bus, as evidenced by the traffic congestion during the peak periods (refer to Chapter 2). With the planned development of the NWGC the population is expected to increase to 200,000 within the next two decades. This will affect house prices. It will also affect average incomes, and the age and demographics of the community including the average age and cultural diversity. It will also affect how people travel around the area.

As this proposal is part of a short-term measure to assist with the development of the NWGC; in its own right it would not have an additional contribution to the above expected population, economic and demographic changes over the next two decades. In the short-term the proposal would affect the existing community in the area by alleviating delayed travel times and facilitating movement through the area for the local population.

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** social benefit to local traffic as their travel times will be improved due to avoiding the need to travel through the Riverstone town centre
- **Environmental:** social benefit to the population and community of Riverstone by reducing the volumes of traffic travelling through the town centre. This would have an amenity benefit and may also improve commuter travel times
- **Environmental:** social impact for the people living within the study area that would be exposed to more traffic including potential road safety issues that would need to be addressed through the design.

4.4.2 Social infrastructure and local business

Table 4.3 lists the social infrastructure in the area.

Table 4.3 Social infrastructure and local businesses within the preferred corridor

Characteristics	Location
Education facilities	
Riverstone Public School	Elizabeth Street
Casuarina School	100 Garfield Road East
Norwest Christian College	Regent Street & McCulloch Street
Riverstone High School	71 McCulloch Street
Health, emergency and aged care services	
Riverstone Family Medical Practice	10 Pitt Street
Sport, recreation and cultural facilities	
Riverstone Park	Garfield Road West
Riverstone Trotting Track	Garfield Road West
1 st Riverstone Scouts Hall	Carlton Street
Riverstone Bowling Club	44-52 Riverstone Parade
Riverstone Schofields Memorial Club	23 Market Street
Community support services	
Riverstone Neighbourhood Centre & Community Aid Service Corporation	Park Street
Transport facilities	
Bus Stop	Garfield Road West (near Creek Street)
Bus Stop	Garfield Road West (near Carlton Street)
Local businesses	
West End City Motors	7 Garfield Road West
Knights Garage	1 Carlton Street
TAB Riverstone Sportsman's Hotel	Garfield Road West

The users of the above facilities and local business owners may be affected by the proposal's construction. Their amenity, enjoyment and use of the above facilities may also be affected.

There may be short periods of restricted access to these above facilities and businesses during construction.

Operationally, the impacts would be as a result of there being more traffic promoted to use the link road, which could also affect the amenity, use and enjoyment of the above facilities. There may be some economic benefit to the few businesses in the study area from passing trade. Businesses in the Riverstone town centre may be marginally adversely affected through a loss of passing trade, although access to the town centre itself would be improved by the proposal.

The other social impact would be the required property acquisition needed to construct the proposal. This could either take the form of partial or full acquisition, as well as the potential to sever and sub-divide land.

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** temporary loss of user enjoyment and amenity of various social facilities during construction, potentially affecting Riverstone Park, Riverstone Trotting Track and 1st Riverstone Scout Hall
- **Environmental:** loss in user enjoyment and the amenity of various social facilities due to the increased traffic promoted to use the link road once it is operational
- **Environmental:** perceived operational loss of passing trade (refer to Chapter 3) due to traffic avoiding travelling through the Riverstone town centre
- **Environmental:** potential partial or full property acquisition or land severance and sub-division to accommodate the proposal.

4.4.3 Local and regional economy

The local economy benefits from the residents in the area that rely on the use of local shops, pubs, general practitioners, dentists and other facilities. The other important economic value in the area is the industrial area on the outskirts of Riverstone that is a source of local employment and income. Agriculture also contributes to the local economy. The proposal may affect businesses during construction and once the link road is operational. In addition, the footprint of the options crosses land that is being used for small scale agricultural purposes. This may result in land use severance and land parcel isolation, which is the reduced ability to farm the land due to loss, isolation or severance.

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** agricultural land severance caused by the road and potential land parcel isolation. This would potentially reduce agricultural land quality and viability, which could have a wider socioeconomic impact.

4.4.4 Community values

The community values in the area are likely to include:

- The local character, historic values, landmarks, open spaces and natural areas
- Local amenity, provided by the historic value of the Riverstone town centre and the wider social facilities (such as the playing fields) on the outskirts
- Local employment in Riverstone and at the industrial area on the outskirts
- Community safety and security
- Liveability and access to social support and community facilities, noting the likely need for many residents to travel to access these facilities
- Access and connectivity, especially for the commuting population and local businesses.

The above values may be compromised during construction and operation. The disruption, delays and access restrictions during construction may affect the amenity and character of the area, while also affecting travel times and liveability issues. This is however, likely to be mainly restricted to the property owners along Denmark Road and West Parade. It would have a limited impact on the majority of Riverstone's population as the proposal is located off the main roads in the area.

During the operational phase, the link road would affect the local character of the area, which may give rise to safety concerns, liveability issues and effects on the area's amenity. Again, this would be focussed on the property owners along the alignment. Conversely however, directing traffic away from Riverstone may improve the community values for a larger number of people that live within area as they would experience lower levels of traffic in the town centre.

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** short-term impacts on the area's community values during construction due to disruption, delays and access restrictions affecting amenity and character, travel times, and liveability
- **Environmental:** operational impacts on the area's community values giving rise to safety concerns, liveability issues and effects on the area's amenity
- **Environmental:** benefits to the community values in the Riverstone town centre by diverting traffic to use the link road.

4.5 Non-Aboriginal heritage

There is one known locally significant historic heritage item within the study area and one unlisted item of archaeological potential (refer to figure 4-8).

- Hebe Farm located off Bridge Street (Lot 1, DP 527115) about 20 metres west of West Parade (listed under the Blacktown City Council Local Environmental Plan 2015)
- John Schofields/Gillingham Farm located about 50 metres west of West Parade (of recognised archaeological potential) (The Schofields Precinct: Non-Indigenous Heritage Assessment, Godden Mackay Logan, 2011).

Non-Aboriginal heritage item

The NSW Heritage Inventory Statement of Significance describes Hebe Farm as:

‘A fine example of a late colonial country homestead. It was built by the Dawson family, some of whose members worked at the iron foundry on Cockatoo Island (probably where the iron columns on Hebe Farm were made) and was later the residence of their relatives, the Bliss family’.

Archaeological potential

John Schofields/Gillingham Farm (adjacent to Hebe Farm) represents an early and mid-nineteenth rural pastoral enterprise. Its archaeological potential has been affected by recent earthworks for a residential subdivision. The site and its curtilage is located outside of the footprint of any of the options such that it would not be affected by the proposal.

The study area has also been under development for the past 150 years. This includes residential and agricultural land uses. Consequently, the potential for discovering unexpected archaeology during construction cannot be discounted.

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** potential impacts on the context and setting of Hebe Farm during construction
- **Environmental:** potential impacts on the context and setting of Hebe Farm during operation through the increased volumes of traffic on West Parade
- **Environmental:** potential for encountering unexpected archaeology during construction due to the area's development history.

4.6 Aboriginal heritage

There are four recorded Aboriginal heritage sites and finds in the study area (Aboriginal Heritage Information Management System, 2015):

- An open campsite (ref: 45-5-0210) located about 150 metres west of Denmark Road
- An isolated find (non-d (ref: 45-5-2528) located in the above open campsite
- A non-disclosed item (ref: 45-5-2821) located about 150 metres west of Denmark Road. The site has been heavily disturbed and does not warrant preservation
- An open site and non-disclosed artefact (ref: 45-5-4266) located about 50 metres west of Bridge Street.

None of the above sites are located within the footprint of any of the options, and as such they are unlikely to be impacted by the proposal. However, the area was occupied by the Dharug people who were known to widely use the land as well as occupying the fringes of Eastern Creek and Bells Creek (Roads and Maritime, 2014). Until further assessment and investigation is carried out it is assumed that there would be chance of encountering unexpected Aboriginal archaeology across the area.

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** potential for encountering unexpected Aboriginal archaeology during construction.

4.7 Noise and vibration

There are a number of noise and vibration sensitive receivers within the study area. They include: residents along Denmark Road, Creek Street, Carlton Street, Trevithick Street, West Parade, Bridge Street, Westminster Street and Railway Terrace. Other sensitive receivers locally include:

- Riverstone Park located between Creek Street and Carlton Street (an active recreational area)
- Commercial businesses primarily on the eastern side of the road on Creek Street
- The scout hall located at 7 Carlton Street (active recreational area).

These receivers may be exposed to adverse construction noise and vibration. They would also be likely affected by the increased traffic volumes in the area once the link road is open to local traffic. However, there may be an improvement by removing local traffic from Garfield Road West. This may have a beneficial operational noise impact to residents and the community in the Riverstone town centre.

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** construction noise impacting sensitive receivers (residents, users of the playing fields, commercial businesses and users of the scout hall)
- **Environmental:** construction vibration impacts leading to amenity issues or cosmetic building damage
- **Environmental:** potential for operational noise impacts due to the increased volumes of traffic using the link road. Equally, potential benefit due to the reduction of traffic on Garfield Road West and through the Riverstone town centre.

4.8 Air quality

The above noise and vibration sensitive receivers would also be sensitive to dust and vehicle emissions. The soils and geology erode easily (refer to section 4.1.2), which adds to the risk for dust generation during construction.

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** construction dust generation leading to amenity impacts on sensitive receivers (residents, users of the playing fields, commercial businesses and users of the scout hall)
- **Environmental:** construction vehicle emissions leading to amenity issues
- **Environmental:** potential for receivers to become more exposed to traffic-generated pollutants due to the increased volumes of traffic promoted to use the link road.

4.9 Landscape character and visual

The area's landscape character and visual setting is influenced by the topography and land uses in the area. The northern section is characterised by well-spaced plots and low-rise single residential dwellings. These frame the existing roads in the area however, the wider landscape is not contained or restricted. This allows a strong connection between the residential areas and the surrounding agricultural land, interspersed by remnant vegetation and woodland. This provides a semi-rural setting that can be referenced by the existing land patterns, field boundaries and land uses (pastoral, arable and grazing).

There are two distinct natural components in the landscape: Eastern Creek to the west and Hebe Park, west of Railway Terrace. Eastern Creek frames and contains the landscape to the west providing a clear distinction between the built and agricultural land uses and the natural riparian environment. Hebe Park also represents an area of retained remnant woodland that provides a distinct reference point in the landscape.

Finally, the Riverstone railway line is raised to about two metres above the surrounding land through the study area. It contains and frames the landscape to the east. It provides a point of physical and visual severance in the landscape restricting views out of the study area or view into the study area from Railway Terrace.

The residents, commercial properties and other amenity land uses in the area (refer to section 4.4) are all visual receivers and their location relative to the proposal would determine their sensitivity. The introduction of traffic into the area and the creation of the link road would affect the area's local landscape character and more notably the streetscape of the exiting local roads. The main effect would be a loss reduction in the semi-rural character and values in the area. Residents and other visually-sensitive land users would also be adversely affected by the introduction of the link road, principally due to the increased traffic passing through the area.

Summary of issues

The following are potential issues that may constrain development:

- **Environmental:** temporary impacts on the area's landscape character during construction leading to a loss of amenity
- **Environmental:** temporary visual impacts during construction due to the work area, construction activity and earthworks
- **Environmental:** operational impacts on the area's landscape character, which may result in a loss of semi-rural characteristics as a result of the introduction of traffic through the study area
- **Environmental:** operational visual impact to sensitive receivers through the increase in traffic promoted to use the link road and the presence of new road infrastructure.

4.10 Utilities and services

A search of the area (dial before you dig) was undertaken to confirm the provisional location of key utilities. It identified assets owned by: Sydney Water; Endeavour Energy; Jemena; National Broadband Network (NBN); and Telstra, which confirmed the presence of the following above and belowground utilities:

- Sydney Water: A belowground mains sewer that runs along Carlton Road
- Sydney Water: Belowground potable water pipelines that run along Denmark Road, Creek Street, Trevithick Street and West Parade
- Endeavour Energy: Aboveground low-voltage transmission lines along Creek Street

- Telstra/NBN Co: Telephone and optical fibre cables located along Denmark Road, Creek Street and Carlton Street

No gas pipelines (Jemena assets) were recorded locally.

Summary of issues

The following are potential issues that may constrain development:

- **Engineering:** the need to avoid, divert and relocate utilities during construction including belowground optical fibre cables, telephone lines, mains sewers and potable water pipelines and aboveground low-voltage transmission lines.

4.11 Traffic and transport

4.11.1 Traffic volumes

Section 2.1.1 describes the existing traffic conditions in the area.

It is predicted that about 20 percent of the traffic in the area would use the link road as an alternative during the weekday peak periods (Parsons Brinckerhoff, 2014) once completed with about equal numbers of vehicles travelling in each direction. The road capacity would be designed to accommodate this traffic.

4.11.2 Intersection performance

The modelling (Parsons Brinckerhoff, 2014) also predicts that the intersections at Garfield Road West and Denmark Road and West Parade and Westminster Street (including the intersection with Railway Terrace) would continue to perform with delays (less than one minute) and levels of service (above level of service D) (refer to section 2.1 for further discussion on these terms).

4.11.3 Travel times

The proposal offers the ability for local traffic to avoid the Riverstone town centre. The difference between the options would affect the overall saving in travel times, which would depend on route length, the type of intersection adopted, the number of turning movements and number of intersections along the route. Chapter 5 and Chapter 6 describe this in more detail.

4.11.4 Other traffic and transport issues

The study area comprises a number of local and informal roads that would need to be upgraded to support the proposal. It would also require land and property acquisition (refer to section 4.4). The design of each option would also effect on road safety outcomes as described in Chapter 5 and Chapter 6. In some cases, there may be changes to access for some properties with delays resulting from increased passing traffic. While this is the case, the increased journey times would be marginal as described in Chapter 6.

Summary of issues

The following are potential issues that may constrain development:

- **Traffic and transport:** increased traffic using the link road once it is operational
- **Traffic and transport:** reduced traffic travelling through the Riverstone town centre once the link road is operational
- **Traffic and transport:** improved travel times both for local traffic using the link road and the residual traffic on Garfield Road West
- **Traffic and transport:** a perceived safety risk due to routing traffic through local roads
- **Traffic and transport:** impacts to access for properties along the proposal route.

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Figure 4-2: Geology

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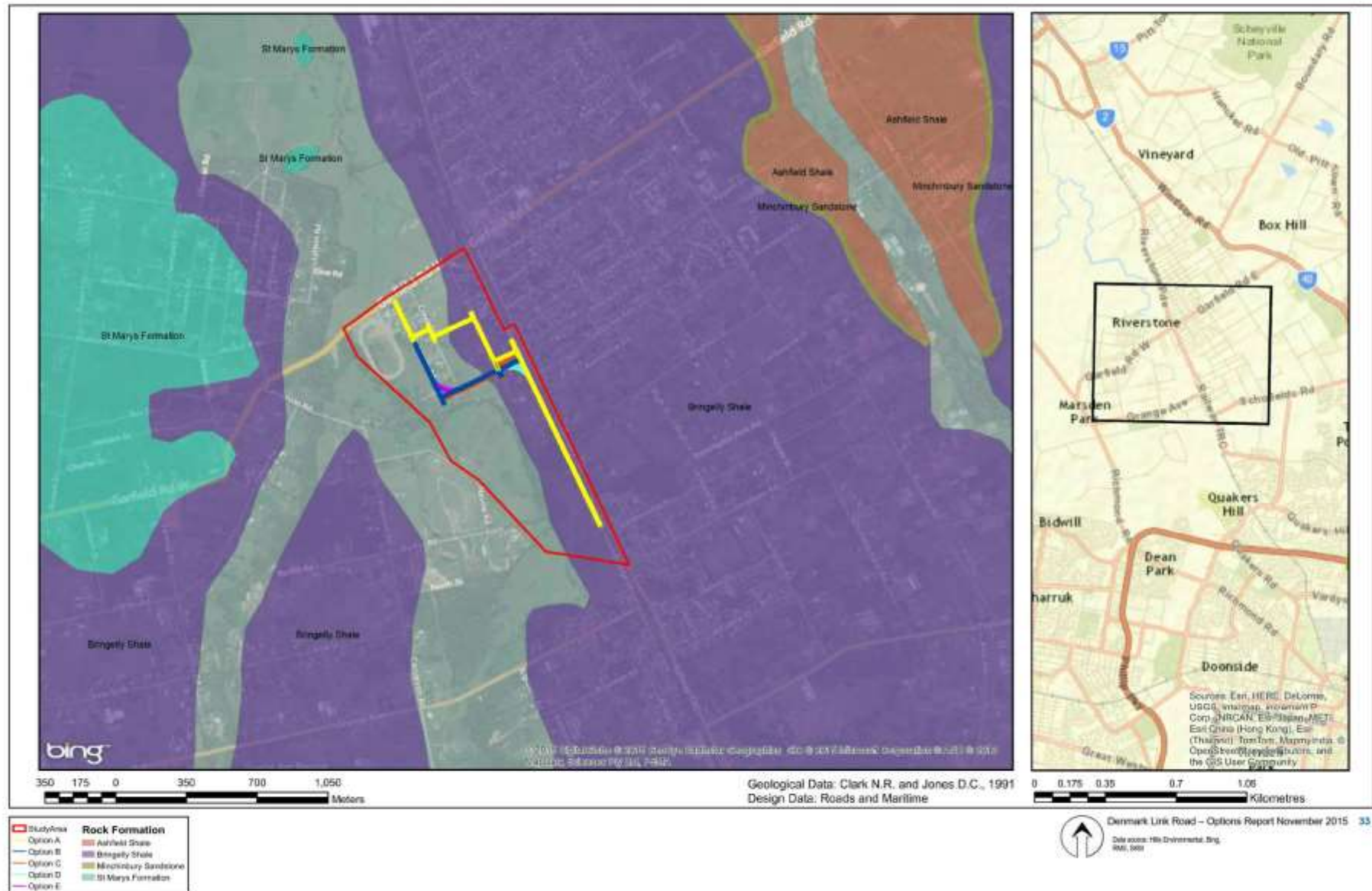


Figure 4-3: Soils

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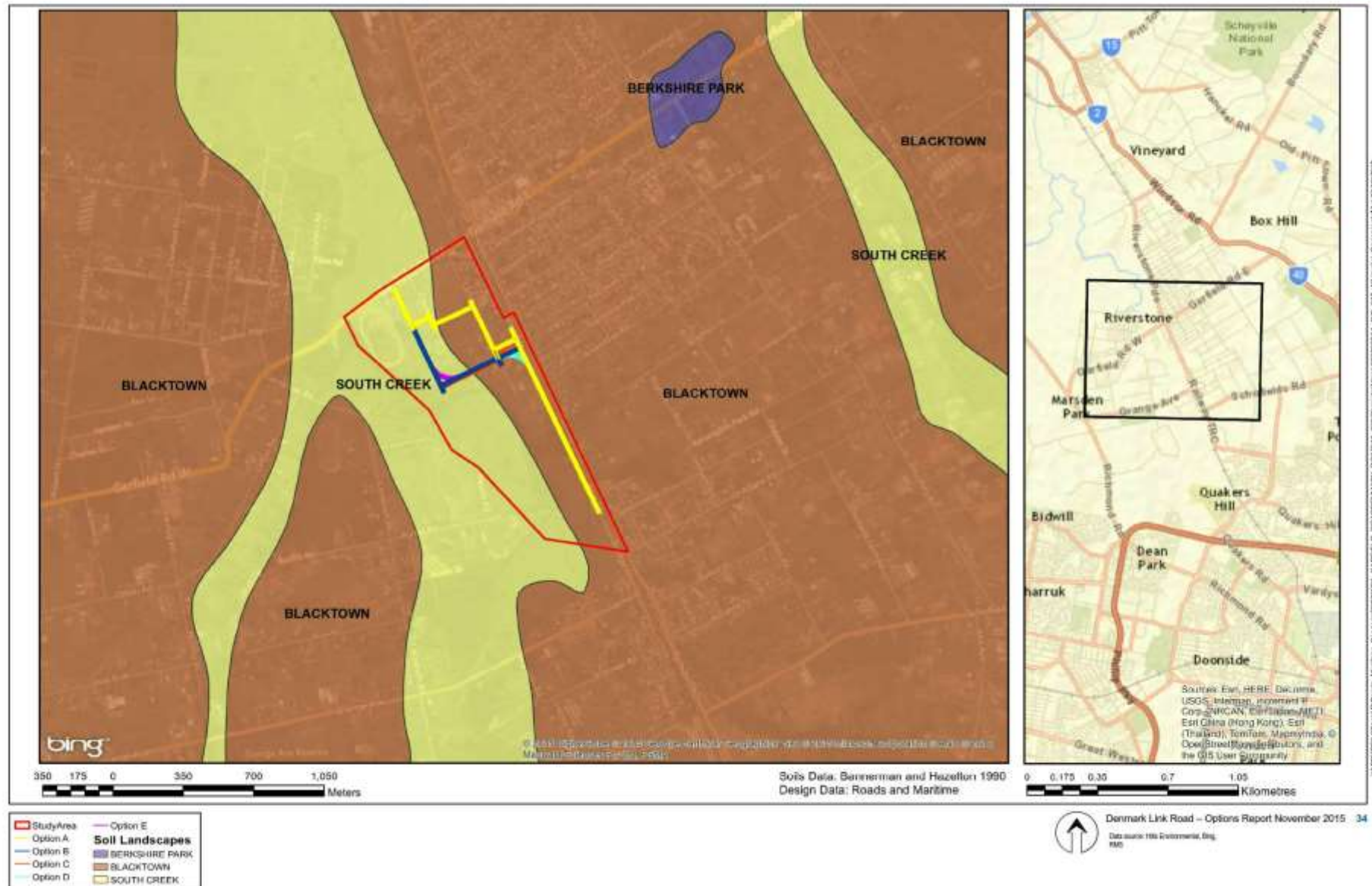


Figure 4-4: Flood Mapping

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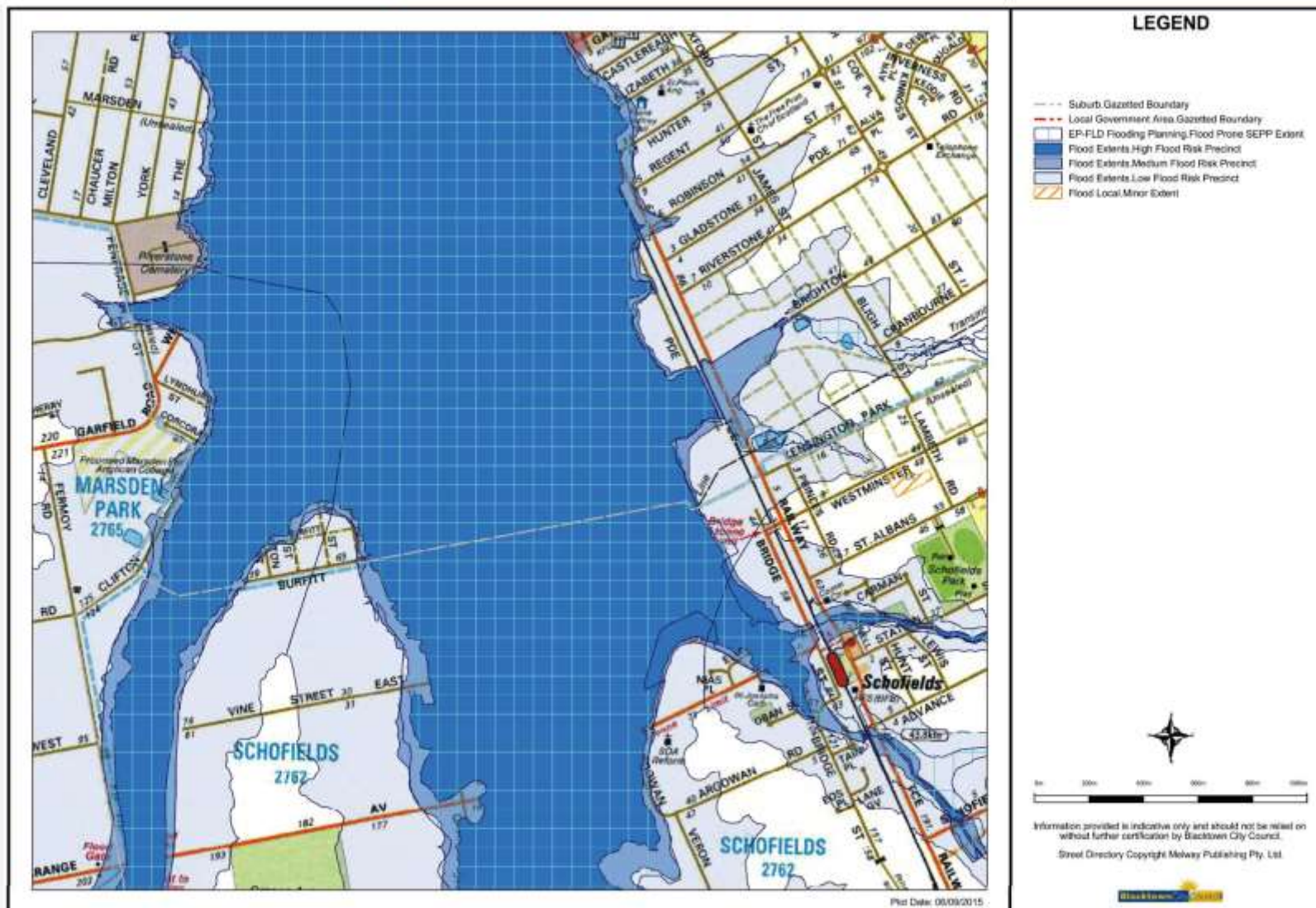


Figure 4-5: Biocertified lands

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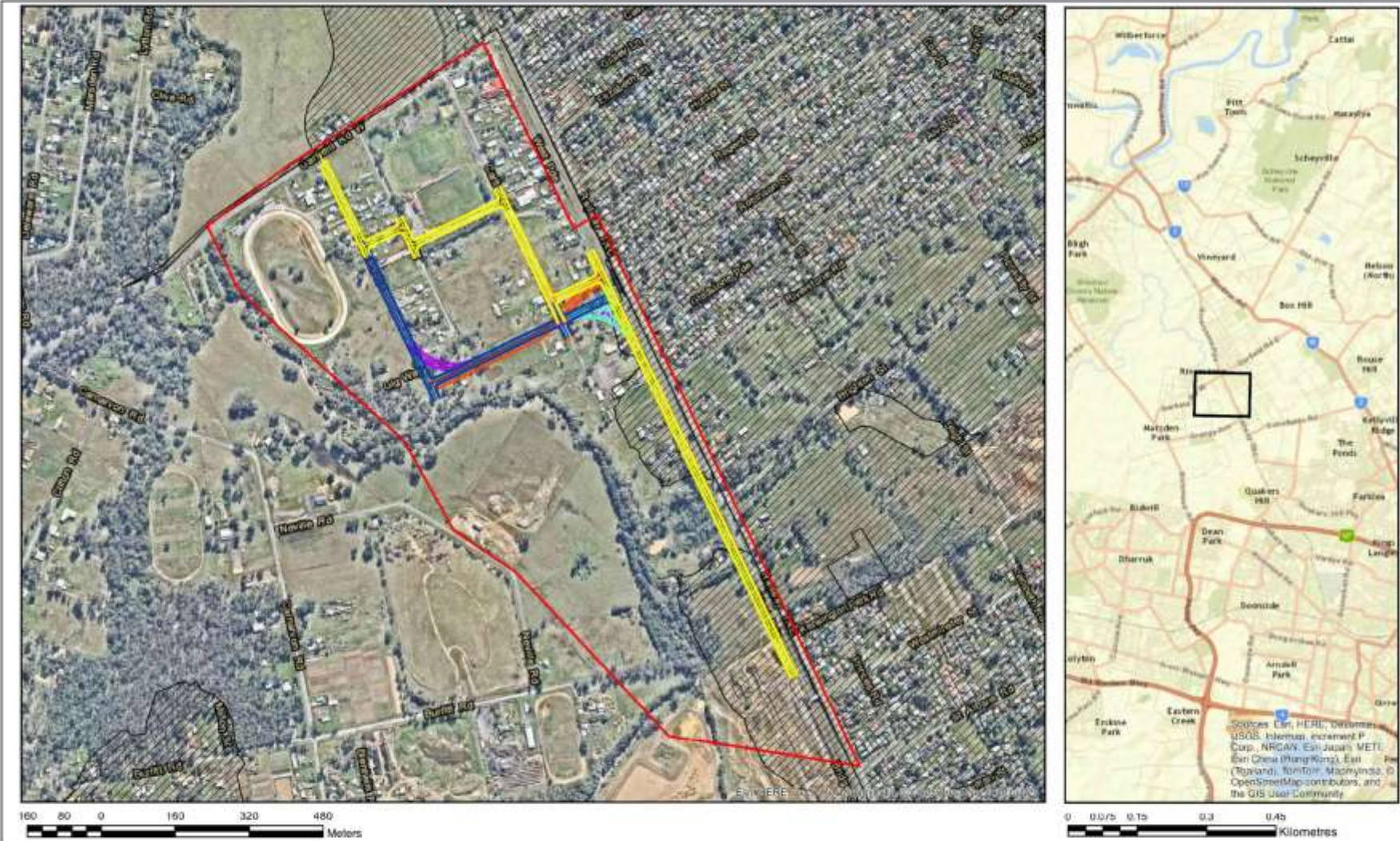


Figure 4-6: Threatened Species

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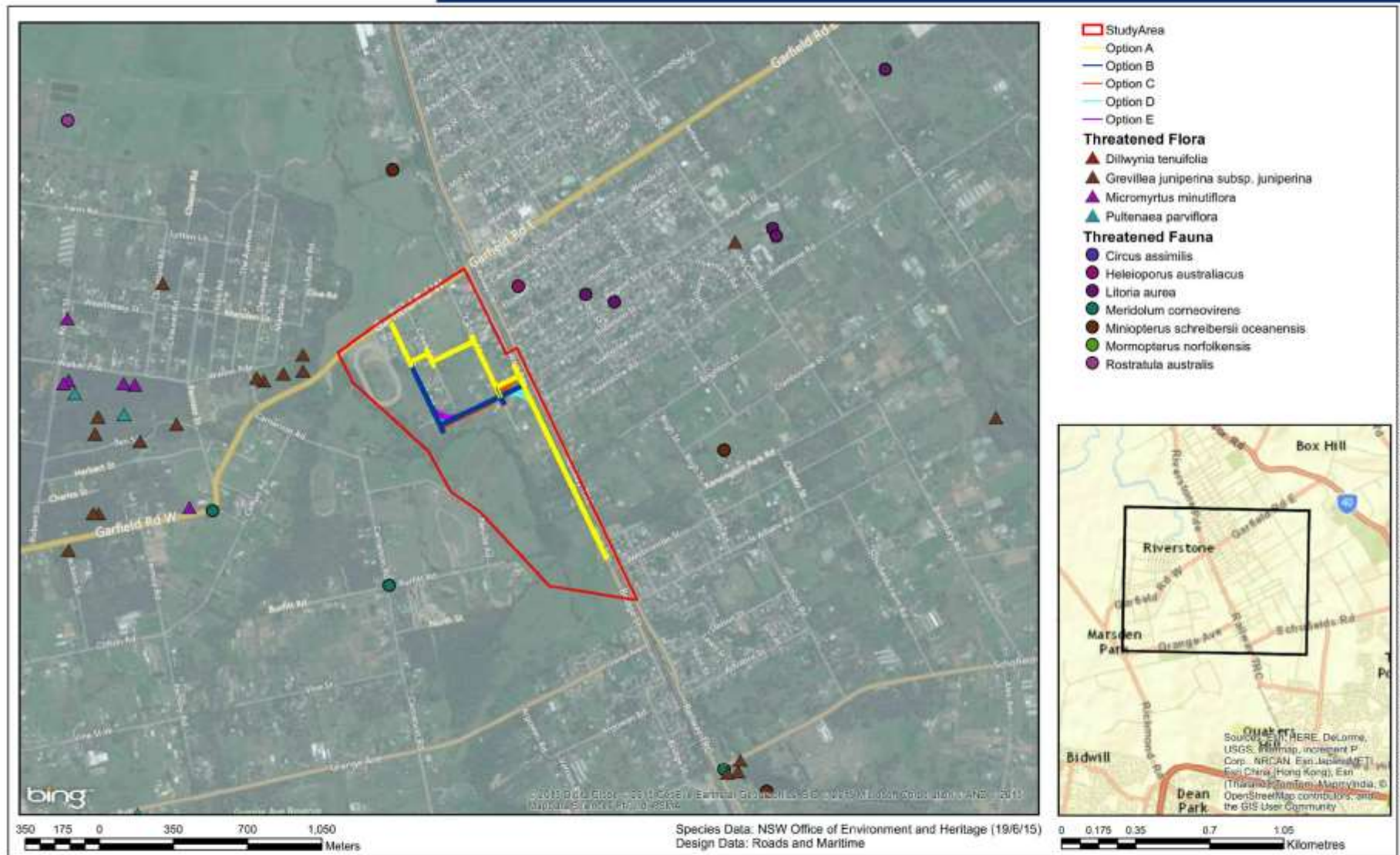


Figure 4-7: Ecological Communities

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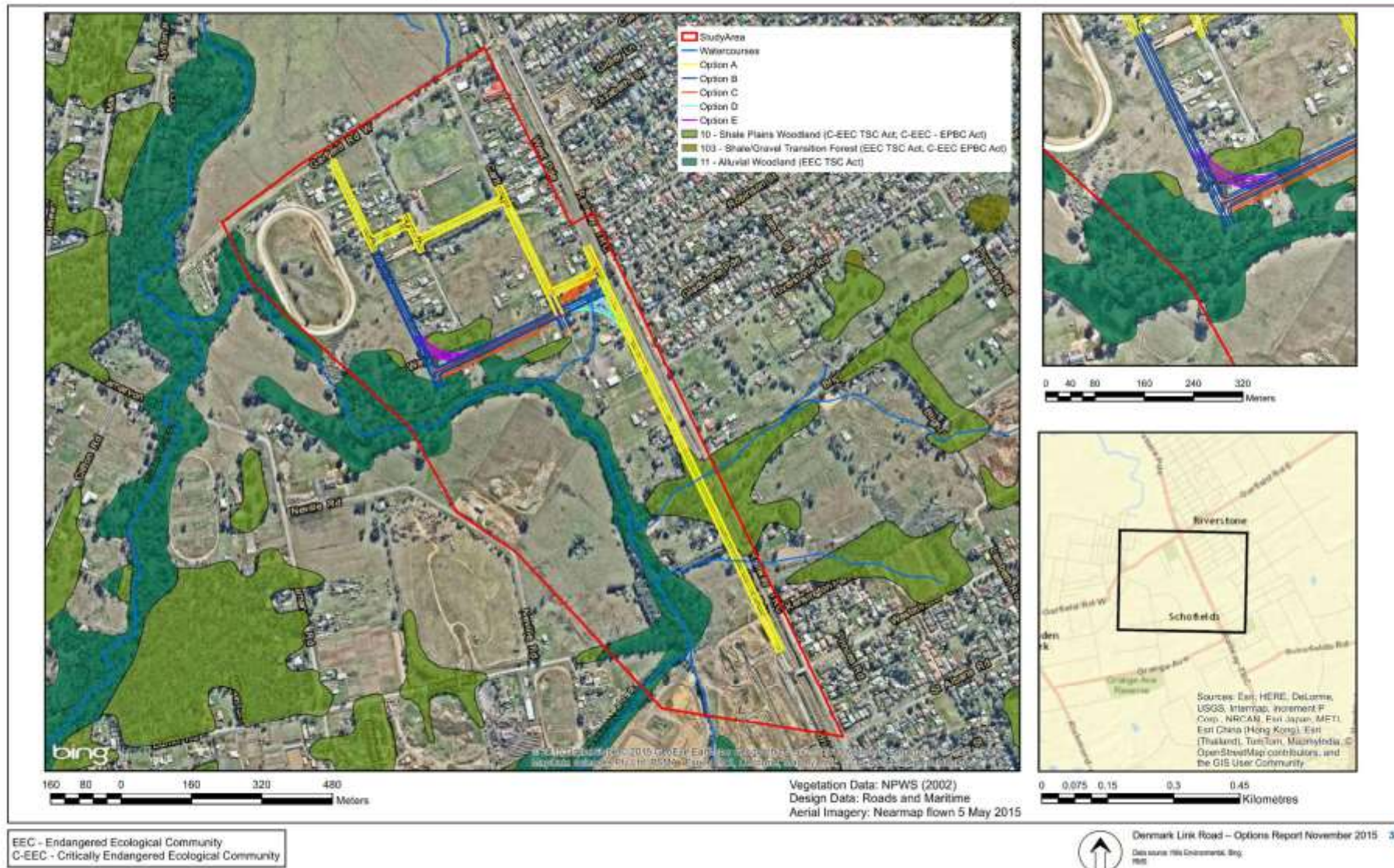
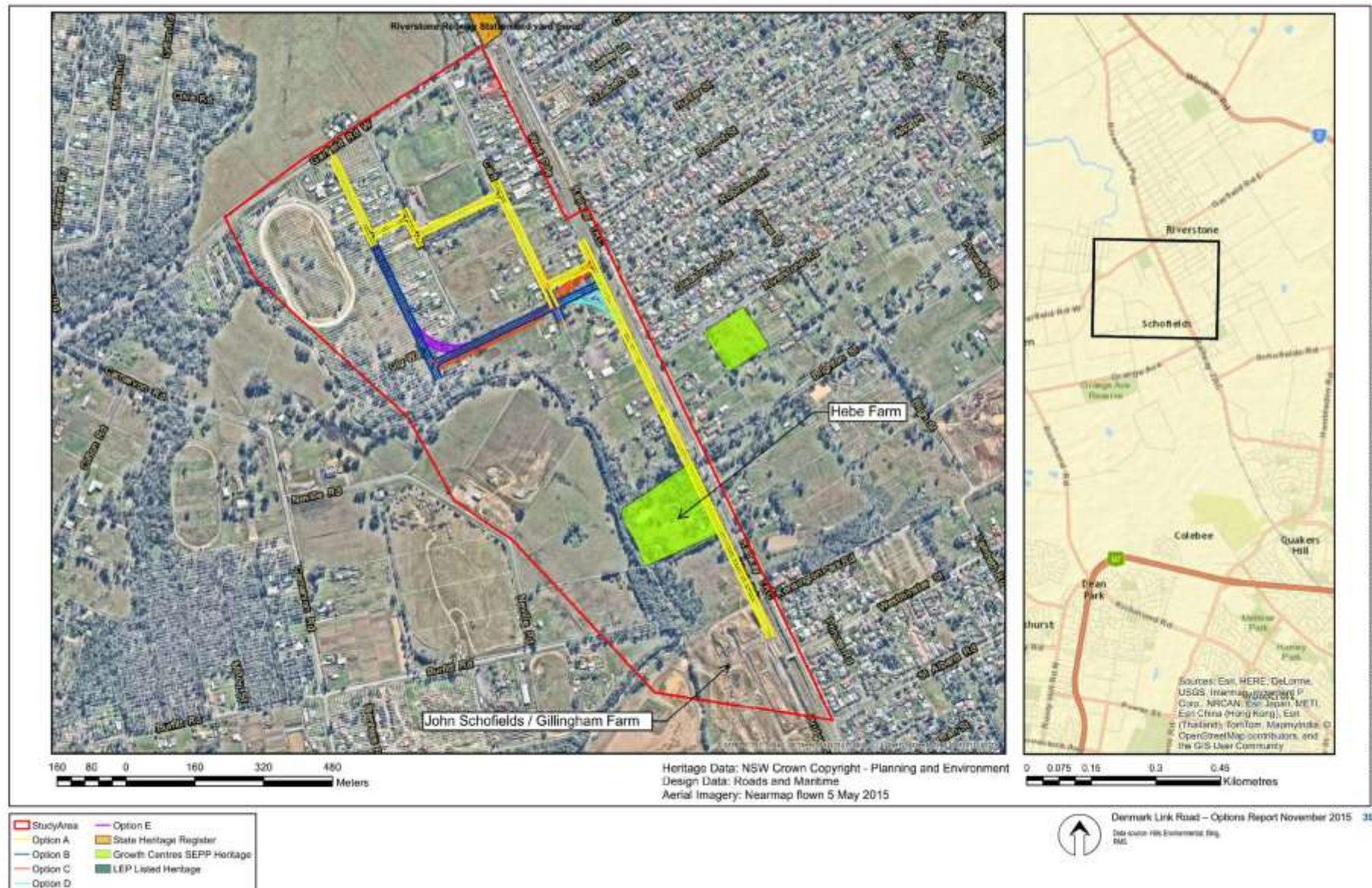


Figure 4-8: Non-Aboriginal Heritage

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5. Options development

This chapter describes how the proposed corridors were identified and the rationale for selecting a preferred corridor. It also describes the five options that have been identified and developed based within the preferred corridor.

5.1 Corridor options development process

As described in Chapter 2 and Chapter 3 there is a medium-term proposal to upgrade Bandon Road between Richmond Road and Windsor Road. There is also a long-term proposal to replace the railway level crossing in the Riverstone town centre with a grade-separated bridge to improve safety, reduce congestion and improve travel times. However as noted in the NWGC Road Network Strategy, the development of the grade-separated bridge would only be provided once the NWGC is about 75 per cent developed. In the interim, the Riverstone town centre would continue to be affected by high traffic congestion and a disproportionately high number of heavy vehicles.

Consequently, Roads and Maritime has identified and developed traffic and transport solutions that could be implemented over the short-term (three years), medium-term (five-to-10 years) and long-term (greater than 10 years). These solutions are based on current growth rates and their construction would be subject to funding.

The short-term solutions were informed by traffic modelling and looked at addressing the congestion issues in the Riverstone town centre while the railway level crossing remained open. This resulted in a strategy being developed that focused on providing improved access in the area. One Strategic objective was to include a link road that would connect Garfield Road West to the Westminster Street bridge via one of the three access points as shown on figure 5-1. The purpose of the link road would be to provide an additional route for local vehicles crossing the Richmond railway line without contributing to the congestion at the level crossing in the Riverstone town centre. It would also provide an alternative connection in the event of an incident occurring on the Richmond railway line affecting the rail level crossing. The location of the connection point into Garfield Road West is important. If it is too close to the existing railway level crossing on Garfield Road it could have a counter effect by potentially increasing congestion.

Moving the intersection west would reduce the likelihood that traffic from the link road could interfere with the traffic approaching the Riverstone town centre. The offered solutions; Carlton Street, Creek Street and Demark Road would also allow traffic wishing to use the Westminster Street bridge to leave Garfield Road West earlier and therefore, avoid adding to the congestion in the Riverstone town centre. It was also identified early in the assessment process that moving the intersection as far west as possible would reduce the likelihood that local traffic waiting to use the link road would be affected by traffic on Garfield Road West.

Table 5.1 summarises the advantages and disadvantages of each of the corridors.

Table 5.1 Corridor options

Option	Advantages	Disadvantages
A new link road between Denmark Road and West Parade (Yellow option on figure 5-1)	- About 450 metres from the level crossing - About 2,000 metres to the Westminster Street bridge - Least likely to be affected by queuing on Garfield Road West - Connects with the future Riverstone West spine road	There is associated property acquisition
A new link road between Creek Street and West Parade (Blue option on figure 5-1)	- About 360 metres from the level crossing - About 1,900 metres to Westminster Street bridge	- Route is adjacent to existing playing fields - The intersection of Creek Street and Garfield Road West is already affected by traffic queuing on the approach to the Riverstone town centre - Does not connect with the future Riverstone West spine road
A new link road between Carlton Street/Trevithick Street and West Parade parallel to Garfield Road West (Purple option on figure 5-1)	- About 140 metres from the level crossing - About 1,200 metres to Westminster Street bridge - Uses existing roads where possible - Minimal requirement for property acquisition	- Route is adjacent to existing playing fields - The intersection of Carlton Street and Garfield Road West is already affected by traffic queuing on the approach to the Riverstone town centre - Does not connect with the future Riverstone West spine road

Table 5-1 shows the advantages and disadvantages of providing a link road corridor down Carlton Street, Creek Street or Denmark Road. Based on these considerations, it was concluded that the Denmark Road corridor is the preferred corridor as it would provide sufficient distance from the existing Richmond railway line level crossing in the Riverstone town centre and would be less likely to be affected by traffic queues on Garfield Road West. Also this corridor would complement the planned signalised intersection at Westminster Street to provide a safe access to Riverstone West precinct.

While the Denmark Road corridor was considered as the preferred solution, it was also recognised that this corridor would have its impacts, which include: increasing the volume of traffic on Denmark Road and West Parade; requiring property acquisition; the potential need to rearrange property accesses in certain locations; and potential to impact upon biodiversity and heritage conservation values.

Figure 5-1: Corridor Options



- Carlton Street/Trevithick Street
- Creek Street
- Denmark Road



5.2 Options development objectives

With the Denmark Road corridor confirmed as the preferred corridor, a suite of options were developed that take into account the design requirements and objectives for the proposal.

It was recognised that the following design requirements needed to be common to all options:

- To tie into Garfield Road West at the Denmark Road intersection
- To upgrade West Parade east of Trevithick Street and to connect into Bridge Street at the Westminster Street bridge
- To provide a route that would be safe for local traffic use
- To avoid riparian (river corridor) habitat wherever possible.

It was on this basis that five options were identified, which are discussed in more detail in the following section. The options currently represent connections between two fixed points. They include no design details other than a point-A to point-B alignment from Garfield Road West to Railway Terrace. The design, configuration, alignment, width and other engineering details are not confirmed at this stage.

5.3 Options

The five options are described below and shown on figure 5-2a to figure 5-2e.

5.3.1 Option A

Option A (refer to figure 5-2a) would provide a less direct connection between Denmark Road and West Parade along Denmark Road, then north on an unnamed existing track that connects to Creek Street before making a right and left turn onto a second unnamed existing track located to the south of Riverstone Park. The route would then turn right onto Carlton Street, left onto Trevithick Street and right onto West Parade. This option would involve the upgrade of the two unnamed streets/tracks. It would also need traffic priorities to be set on Creek Street, Carlton Street and Trevithick Street to promote traffic flows along the route to favour the link road over other local traffic access.

5.3.2 Option B

Option B (refer to figure 5-2b) would provide a connection between Denmark Road and West Parade travelling along the length of Denmark Road before making a 90-degree left-turn and following a new road that runs parallel to Trevithick Street. The new road section would connect into West Parade south of Trevithick Street. This option would include the construction of intersections, at the end of Denmark Road, Carlton Street (formed across an existing section of road) and at West Parade. It would also require traffic priority to be set on Carlton Street and West Parade to favour the use of the link road.

5.3.3 Option C

Option C (refer to figure 5-2c) would follow a similar alignment to Option B. It would differ just to the south of Carlton Street where it would deviate generally north-west to a tie-in point at the existing intersection of Trevithick Street and West Parade. As with Option B, it would involve the creation of a new intersection at the end of Denmark Road, and Carlton Street while traffic would use the existing intersection at Trevithick Street and West Parade. As with Option B, the new section of road would intersect Carlton Street and West Parade intersections to favour link road.

5.3.4 Option D

Option D (refer to figure 5-2d) would follow a similar alignment to Option B. Its only difference to Option B is the tie-in to West Parade. This would be achieved by creating a tight 90-degree curve that would deviate from Carlton Street and tie into West Parade opposite Gladstone Parade. This option would avoid needing to create or use an intersection on West Parade and would therefore assist in improving journey travel times. However, creating the curve would truncate West Parade and restrict traffic from being able to travel along its full length. Traffic would need to divert onto Carlton Street and turn right onto Trevithick Street before turning left onto the truncated section of West Parade. This option would include a new intersection with Carlton Street.

5.3.5 Option E

Option E (refer to figure 5-2e) would follow a similar alignment to Option D. Its only point of difference from Option D is its tie into Denmark Road. This alternative removes the proposed intersection at the end of Denmark Road and replaces it with another curve to create an s-curve link. This would avoid needing to create or use an intersection either on West Parade or Denmark Road. Traffic would still need to divert onto Carlton Street and Trevithick Street to be able to continue to use West Parade. A sub-option of this would be to create an intersection on the curve to connect back into West Parade to avoid traffic needing to use the above streets. This sub-option is not shown on figure 5-2e. This option includes a new intersection with Carlton Street.

Figure 5-2a: Option A

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- Option A
- Option B
- Option C
- Option D
- Option E

Figure 5-2b: Option B

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- Option A
- Option D
- Option B
- Option E
- Option C

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Figure 5-2c: Option C

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- Option A
- Option B
- Option C
- Option D
- Option E

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Figure 5-2d: Option D

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- Option A
- Option B
- Option C
- Option D
- Option E

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Figure 5-2e: Option E

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- Option A
- Option B
- Option C
- Option D
- Option E

6. Options evaluation

This chapter evaluates the options by comparing their relative merits and issues. This is described below.

6.1 Overview

As described in Chapter 5, the options evaluation process started by identifying the need for the proposal, which was then followed by the identification and development of three corridors to deliver the proposal. From these three corridors, a preferred corridor was selected that would use Denmark Road. Five options were investigated within the Denmark Road corridor. This process is described under the 11 stages below. This report is being prepared in response to the output of Stage 10 and to assist with presenting the preferred option to the community under Stage 11.

- **Strategic corridor options development**
 - ▶ Stage 1: development of preliminary strategic corridor options
 - ▶ Stage 2: review of preliminary strategic corridors to confirm how easy they would be to construct
 - ▶ Stage 3: refinement of the strategic corridor options
 - ▶ Stage 4: evaluation of the refined strategic corridor options in a workshop
 - ▶ Stage 5: further refinement of the strategic corridor options and selection of preferred option.
- **Proposal options development**
 - ▶ Stage 6: development of proposal options within the preferred corridor
 - ▶ Stage 7: review of proposal options to confirm how easy they would be to construct
 - ▶ Stage 8: refinement of the proposal options
 - ▶ Stage 9: evaluation of the refined proposal options in a workshop
 - ▶ Stage 10: further refinement of proposal options including design considerations
 - ▶ Stage 11: presentation of the preferred proposal option to the community, for comment

6.2 Options evaluation process

Chapter 4 identifies the traffic and transport, environmental, and engineering issues associated with the options footprint. The following section provides a comparison of the options based on the likelihood of the issue becoming a constraint to development (likelihood) and the consequence of the constraint becoming a material consideration (magnitude). This approach to assessment is consistent with the Australian Standard AS 31000:2009 on Risk Management (Standards Australia, 2009). It has been applied to previous options analysis on other projects of a similar scope. It is also a recognised method to rate proposal impacts as described in review of environmental factor documents. Table 6.1 describes the ratings/rankings that have been applied to compare the options. The table only describes adverse risk outcomes.

Note 1: The rankings have been taken forward into Table 6.2. They have been abbreviated to the letters shown in brackets in the risk ranking column of the table below.

Table 6.1 Adverse risk evaluation criteria

Risk ranking	Likelihood	Magnitude
Very High (VH)	Certain	Extreme: Permanent and catastrophic risk/impacts on the environment or population; large impact area; reportable incident to external agency; large fines and prosecution; operational constraints; substantial community concern. Engineering impacts that cannot be accommodated in the design.
High (H)	Likely	Major: Permanent and detrimental risk/impacts on the environment or population; large impact area; reportable incident to external agency; may result in large fines and prosecution; operational constraints; high level of community concern. Engineering solutions that are atypical, non-standard, non-routine or costly.
Medium (M)	Possible	Moderate: Substantial temporary or minor long term detrimental risk/impacts on the environment or population; moderate impact area; reportable incident to external agency; action required by reportable agency; community interested. Engineering solutions that are standard and typical however potentially costly and may have a notable impact on the receiving environment
Low (L)	Unlikely	Minor: Detrimental risk/impacts on the environment or population; small impact area; reportable incident internally; no operational constraints; some local community interest. Engineering solutions that are standard, low cost and fit within the context and setting of the local environment.
Very Low (VL)	Exceptionally unlikely	Negligible: Measurable yet immaterial risk/impact on the environment or population, restricted impact area, no reportable outcomes, no material operational constraints, limited community interest. Typical engineering solutions.
N/A	Not applicable	No impacts. There are no impacts associated with the risk, as the risk may not exist within the option footprint or be highly unlikely to exist
Unknown (U)	Unknown	Unknown: The impacts associated with the risk are unknown as the risk may or may not exist and can only be confirmed through additional site investigation.
Very Low (+VL)	Certain	Negligible: The benefit is perceptible and would have some positive outcome for very few people, or environmental values.
Low (+L)	Likely	Minor: Measurable benefit to the environment or society, localised impact area, positive outcome to people living immediately adjacent to the road, some community value
Medium (+M)	Possible	Moderate: Benefit to the local community or local environmental values, moderate impact area, positive outcome to people living in Riverstone, measureable community value
High (+H)	Unlikely	Major: Benefit to the regional community or regional environmental values, large impact area, positive outcome across the NWGC, measurable regional value
Very High (+VH)	Exceptionally unlikely	Extreme: Benefit to the State or Nation or State or national environmental values, major impact area, positive outcome across Sydney, measurable State value.

6.3 Options evaluation

Table 6.2 compares the merits and issues associated with each option relative to the factor/aspect being considered.

Note: This table uses the precautionary principle and assesses the risk based on a high level review of information.

Table 6.2 Options evaluation

Issues and constraints	Options (A to E) and risk rankings (refer to Table 6-1)					Issue and discussion
	A	B	C	D	E	
Landform, Geology and Soils						
Landform: undulating topography	L	L	L	M	M	Issue: engineering: cut and fill requirements due to the undulating topography Discussion: the area is gently undulating which would limit the required extent of earthworks for each option. That said, the land does generally fall away to Eastern Creek which would potentially result in the need for additional fill associated with all options except Option A. The engineering alignment of Option D and Option E may also require the implementation of batter slopes to accommodate the curves, which makes Option B or C the favoured of the southern options.
Geology and soils: low quality and strength geological and soil landscape conditions	L	L	L	M	M	Issue: engineering and environmental: wide batter slopes associated with the quaternary deposits (found generally to the west of Creek Street) and the Bringelly shale (found generally east of Creek Street). This would depend on the height of the road above or below the surrounding area. It would also depend on the local erosive character of the geology and the road’s depth relative to the water table. It would also affect the required land take or invite the need to include partial or full retaining walls as an alternative, which can be costly. Discussion: consistent with the discussion above, Option D and Option E are more likely to either require the construction of batter slopes or retaining walls to accommodate the curves. This would require additional land take or cost over the other options. Again Option B or Option C are the favoured options.

Issues and constraints	Options (A to E) and risk rankings (refer to Table 6-1)					Issue and discussion
	A	B	C	D	E	
Geology and soils: low quality and strength geological and soil landscape conditions	M	M	M	M	M	Issue: engineering: poor physical and engineering properties associated with the geology and soil in the area. This would potentially mean that additional engineering treatments would be required to provide suitable conditions to lay the road foundations on. It would also mean that any excavated materials could only be reused as general fill. Discussion: the geology and soil landscape divides broadly along the alignment of Creek Street. To the west are the deposits associated with Eastern Creek (ie quaternary sediments and the South Creek soil landscape) while to the east are the regional deposits of Bringelly Shale and the Blacktown soil landscape. The ground deposits either erode easily or are of low engineering quality. Given the likely greater extent of excavation, engineering and earthworks associated with Option E it is evaluated as the least favourable option, however all options would be exposed to similar risks.
Geology and soils: geology and soils that are subject to erosion.	L	L	L	L	M/L	Issue: environmental: the quaternary deposits, high clay-content Bringelly shales and the South Creek soils erode easily. This means that they may cause a dust dispersion, erosion and sediment control issue during construction. Discussion: Option A is likely to require less erosion and sediment control compared to the other options as it crosses the Blacktown soil landscape (which does not erode as easily), however this would depend on the depth of the soil locally and the depth of excavation, both of which are unconfirmed at this point. Option E crosses an erosive landscape and is likely to require the most excavation, engineering and earthworks. As such it is the least favoured option.
Salinity						
Salinity: presence of highly and moderately saline soils	M/L	M	M	M	M	Issue: engineering: the requirement for additional corrosion protection and concrete treatment. Discussion: salinity and saline soils are an issue for all options. The risk is inherently greater for the options that would be predominantly constructed closer to Eastern Creek, namely all options except Option A. The need for corrosion protection and engineering treatment is therefore consistent except in the case of Option A.
	L	M/L	M/L	M/L	M/L	Issue: environmental: creation of saline conditions during construction could impact on soil quality, native vegetation, biodiversity, crops and water quality. Discussion: consistent with the above evaluation, all options except Option A have a higher inherent risk of impacting on saline soils. However, the environmental risk of encountering and managing saline soils is considered to be lower than the need to include corrosion protection and concrete treatment. This is because the likelihood of impact is less.

Issues and constraints	Options (A to E) and risk rankings (refer to Table 6-1)					Issue and discussion
	A	B	C	D	E	
Contamination						
Existing and historic land uses: Richmond railway line	U	U	U	U	U	Issue: environmental: encountering and mobilising dispersed metals and hydrocarbons adjacent to the Richmond rail line, leading to human health, water quality and biodiversity impacts. Discussion: all options require the use of West Parade, which is located parallel and close to the rail line. The construction of the curves close to West Parade under Option D and Option E may require more earthworks close to the rail line, and as such there would be a greater inherent risk for encountering/mobilising contaminants with these options. While the likelihood of such an impact occurring is low due to the low mobility of the associated contaminants, the risk is ultimately unknown without further site investigation.
Existing and historic land uses: agricultural land	N/A	L	L	L	L	Issue: environmental: encountering and mobilising washed out fertilisers and pesticides (south of Denmark Road, Creek Street and Carlton Street) leading to water quality and biodiversity impacts. Discussion: locally, the land along the Eastern Creek corridor is currently used for agriculture. This includes the land between the end of Denmark Road, Creek Street, Carlton Street and Eastern Creek. All options except Option A would cross this land therefore increasing the risk of encountering/mobilising washed out fertilisers and pesticides. This risk would be likely avoided under Option A.
Hydrology and flooding						
Flood risk: high and moderate flood risk	M	H	H	H	H	Issue: engineering: the potential flood and inundation risk by constructing a road on a floodplain meaning that additional engineering treatments may be required. Also, the road may need engineering to provide some flood immunity by increasing its height relative to the floodplain. This may require increased volumes of fill or batter slopes (refer to section 4.1.2). Discussion: the area’s flood risk is divided around West Parade. On the higher ground close to the railway line there is a moderate flood risk while everywhere else there is a high flood risk. It is also assumed (however not reflected in the flood mapping) that the land closer to the creek floods more regularly (as it is lower) than the other areas in the high-risk flood zone. All options would involve some work in the high-risk zone, however Option A would require the least development in this zone. For the remaining options, flood immunity would need to form part of the design. Note: given the short-term role of the link road it would be designed to achieve a lower level of flood immunity protection.

Issues and constraints	Options (A to E) and risk rankings (refer to Table 6-1)					Issue and discussion
	A	B	C	D	E	
Flood risk: high and moderate flood risk	M	H	H	H	H	Issue: environmental: construction on the floodplain may affect runoff and surface water flow patterns. The final road may also act as a barrier in the floodplain which could affect drainage and surface water supply. This could have wider agricultural, flood risk or biodiversity impacts. Discussion: an additional effect of constructing in the floodplain and the need to include flood immunity in the design is that this could affect surface water flows, drainage and subsequent environmental impacts. This risk would present for all options however, it would be slightly lower for Option A given its location.
Creek: a tributary of Eastern Creek	L	M	L	M	M	Issues: environmental: the need to cross two unnamed creeks and the potential for runoff impacts to affect Eastern Creek. Discussion: all options with the exception of Option A and Option C would need to cross two unnamed creeks. While the ecological value of this creek is unknown, it connects directly into Eastern Creek, which is known to have high ecological value. Therefore, there is a risk to the water quality and ecological values of both watercourses.
Biodiversity						
Certified land: presence of non-certified land along the Eastern Creek riparian corridor	N/A	N/A	N/A	N/A	N/A	Issue: environmental: construction on non-certified land and the need to follow legislative processes, with the aim of avoiding any impact on threatened flora and fauna, communities and habitat. Discussion: the majority of the study area is on non-certified land adjacent to Eastern Creek. As such, the usual biodiversity assessment and protective legal provisions would apply during the proposal's construction and operation. This issue should not influence the decision on which option is selected.
Threatened flora: residual potential for threatened flora	U	U	U	U	U	Issue: environmental: presence of grevillea, unknown threatened flora and other endemic and native species that may be impacted or lost under the proposal. Discussion: the presence of any threatened flora in the area could only be confirmed through further site investigation work. However, the risk would be inherently greater with options that require the most land take from vegetated areas, which would favour Option A over the other options and Option B and Option C of the southern options.
Threatened fauna: residual potential for threatened fauna	U	U	U	U	U	Issue: environmental: presence of unknown threatened fauna and other endemic and native species that may be impacted or lost under the proposal. Discussion: the presence of any threatened fauna in the area could only be confirmed through further site investigation work. However, the risk would be inherently greater with the options that require the most land take from vegetated areas, which would favour Option A over the other options and Option B and Option C of the southern options.

Issues and constraints	Options (A to E) and risk rankings (refer to Table 6-1)					Issue and discussion
	A	B	C	D	E	
Key fish habitat: the designation of Eastern Creek as Key Fish habitat	L	M/L	M/L	M/L	M/L	Issue: environmental: direct impacts to Eastern Creek and indirect impacts that would affect its values as a key fish habitat due to accidental spillages or leaks. Discussion: as all options, with the exception of Option A, are located about 60 metres from Eastern Creek, this would limit the potential for direct impacts on the creek itself, but may still affect the adjacent riparian habitat (considered further below). With regards to spills and leaks, the road configuration and geometry of all options would be designed to ensure they are safe, therefore this aspect has not been evaluated. Note: Option A is about 150 metres from the creek.
	L	L	L	L	L	Issue: environmental: indirect impacts on Eastern Creek that would affect its values as a key fish habitat due to road runoff to the creek. Discussion: the proposal would create new impermeable area. This would be greatest for Option E given the construction of the curves. It would be lowest for Option A. Option E is also closer to the creek, which would increase the risk of impacting on the watercourse. A secondary impact would be the quality of the runoff, which would be affected by the volumes of traffic using the road. While all options are expected to carry similar volumes of traffic, the fact that the southern options (Option B to Option E) are closer to the creek means that the risk for more concentrated runoff to enter the creek would be greater. Note: That said it is assumed that standard drainage designs can be employed to minimise this risk.
	N/A	M	M	M	M	Issue: environmental: indirect impacts on Eastern Creek that would affect its values as a key fish habitat as a result of changes in water flow patterns due to needing to engineer the road in the floodplain, and direct impacts to riparian habitat. Discussion: the need to construct all options in the floodplain and close to the creek (with the exception of Option A) introduces the risk of affecting water flow patterns. Note: It is assumed that cross drains would be included in the design to maintain lateral flows towards the creek to reduce this risk however the risk cannot be fully mitigated via such controls.
Endangered ecological communities: presence of shale plains and alluvial woodland	N/A	M	M	H	H	Issue: environmental: an impact on an endangered ecological community would be notable and should be avoided. Discussion: Shale plains woodland and alluvial woodland are both associated with the Eastern Creek corridor. All options with the exception of Option A would have some impact on alluvial woodland. However, Option D and Option E, that adopt the curve, would also impact on an area of remnant shale plain woodland. As both communities are protected, and shale plains woodland is critically endangered, the impact may be notable. Therefore, Option B or Option C of the southern options are favoured.

Issues and constraints	Options (A to E) and risk rankings (refer to Table 6-1)					Issue and discussion
	A	B	C	D	E	
Socioeconomic and land use						
Social benefit: reduced congestion and traffic volumes	M+	M+	M+	M+	M+	Issue: environmental: social benefit to the population and community of Riverstone by reducing the volumes of traffic travelling through the town centre. This would have an amenity benefit and may also improve commuter travel times. Discussion: the volumes of traffic reassigned and diverted from the Riverstone town centre is predicted to be broadly consistent under all options.
Social impact: people exposed to more traffic on the link road	L	L	L	L	L	Issue: environmental: social impact for the people living within the study area that would be exposed to more traffic. Road safety issues would need to be considered in the development of the concept design. Discussion: Option A includes a route that passes close to the scout hut and Riverstone Park, both of which are used by children. There are also a number of residential properties along the alignment of each option, principally towards the western end. All options would need to cross a number of intersections, with Option E including the least number of intersections (two compared to four intersections with Option B and Option C). Note: all options will be required to achieve a safety-in-design outcome and would be subject to stringent independent design safety audits. As such, this risk would managed under all options.
Social infrastructure: presence and use of social infrastructure	M	L	L	L	L	Issue: environmental: temporary loss of user enjoyment and amenity of various social facilities during construction, potentially affecting Riverstone Park, Riverstone Trotting Track and the scout hall. Discussion: the key social infrastructure in the area includes Riverstone Park located between Creek Street and Carlton Street and the scout hall on Carlton Street. The amenity and enjoyment of these facilities would be most affected by constructing Option A.
Social infrastructure: presence and use of social infrastructure	M	VL	VL	VL	VL	Issue: environmental: potential loss of user enjoyment and amenity of social facilities due to the increased traffic promoted to use the link road. Discussion: the main social infrastructure affected by the proposal would be Richmond Park. Option A would affect the context, setting, use and enjoyment of the park, extending to concerns about the increased traffic in the area. As such, this is considered the less favourable option. The other options are unlikely to have any material operational impact on the playing fields.

Issues and constraints	Options (A to E) and risk rankings (refer to Table 6-1)					Issue and discussion
	A	B	C	D	E	
Social infrastructure: local businesses	N/A	N/A	N/A	N/A	N/A	Issue: environmental: potential loss of passing trade due to traffic avoiding travelling through the Riverstone town centre. Discussion: all options would serve to reassign traffic to avoid the Riverstone town centre. However, it is considered that the businesses in Riverstone mainly serve the local community. They are unlikely to gain any substantial income from passing trade as their customers are more likely to purposefully plan to shop there. Therefore, none of the options are evaluated as having an impact on passing trade in the Riverstone town centre.
Social infrastructure: properties and land use	VL	L	L	L	M	Issue: environmental: potential partial or full property acquisition or property severance and sub-division to accommodate the proposal. Discussion: all options would require some property acquisition, however this would be less for Option A. Of the southern options, Option C, by tying back into Trevithick Street, would reduce the impact of property acquisition. The greatest impacts come under Option E due to the creation of the two curves.
Agricultural land: key land use in the area	N/A	M/L	M/L	M	M	Issue: environmental: agricultural land severance caused by the road and potential land parcel isolation. This would potentially reduce agricultural land quality. Discussion: there is a range of small scale agricultural activity in the preferred corridor between Western Parade and Eastern Creek. The land is used pastorally and for crops and is not farmed by one single landowner. All options except Option A would have some impact on the use of this land. This would be potentially greater for Option D and Option E as they are likely to require more land take. As such, Option B and Option C are favoured of the southern options.
	N/A	M/L	M/L	M	M	Issue: environmental: issues of runoff and accidental spillage during construction or once the road is operational that may affect agricultural land quality, which may have an economic impact. Discussion: there would be a risk of runoff impacts during construction and once the link road is operational that could affect the quality of the agricultural land. Again this would be potentially greatest for Option D and Option E given that they would create the largest impermeable area. This favours Option B and Option C of the southern options. Option A would have the lowest risk.
Community values: defined by the people that live and work in the area and the social infrastructure (refer to section 4.4.4)	M	L	L	L	L	Issue: environmental: short-term impacts on the area's community values during construction due to disruption, delays and access restrictions affecting amenity and character, travel times, and liveability. Discussion: all options would result in some short-term disruption during construction. This would mostly affect the residents close to Garfield Road West on Denmark Road and would be common to all options. However as Option A also passes through the more populated areas in the footprint and it therefore considered to have the greatest risk of impacting community values during construction.

Issues and constraints	Options (A to E) and risk rankings (refer to Table 6-1)					Issue and discussion
	A	B	C	D	E	
	M	L	L	L	L	Issue: environmental: operational impacts on the area's community values. Discussion: the proximity of Option A to key social infrastructure in the area is likely to have the greatest effect on community values. Option A would also disrupt the connectivity within the study area, which may affect the identified community values. The remaining options would also have adverse effects on community values although the impacts would be lower as their alignments avoid the more populated area of the footprint.
	L+	M+	M+	M+	H+	Issue: environmental: benefits to the community values in the Riverstone town centre by diverting traffic to use the link road. Discussion: the predicted volumes of traffic reassigned and diverted from the Riverstone town centre is predicted to be broadly consistent under all options. It is expected that the best options in terms of improved travel times is Option E as it does not include two intersections. This may also attract more people to use the link road.
Non-Aboriginal heritage						
Non-Aboriginal heritage item: Hebe Farm about 20 metres west of West Parade.	N/A	N/A	N/A	N/A	N/A	Issue: environmental: potential impacts on the heritage context and setting of Hebe Farm during construction. Discussion: all options would involve upgrading West Parade close to Hebe Farm. At this stage, the upgrade requirements are not known however it would involve using the existing road and may involve marginal widening and/or drainage and kerb improvements. As such, it would be unlikely to affect the farm's context of setting. However, there may be some short-term amenity noise impacts at this property during construction (refer to the noise and vibration heading below).
	N/A	N/A	N/A	N/A	N/A	Issue: environmental: potential impacts on the context and setting of Hebe Farm during operation through the increased volumes of traffic on West Parade. Discussion: while all options use West Parade, the farm is sufficiently far from the road that its context or setting would not be likely affected by the proposed work, with the possible exception of operational noise (refer to the noise and vibration heading below).
Non-Aboriginal potential: given the area's development and land use history	U	U	U	U	U	Issue: environmental: potential for encountering unexpected archaeology during construction due to the area's development history. Discussion: without further investigation it is not possible to determine if there is a greater inherent risk with one option over another. At this stage the risk is unknown for all options.

Issues and constraints	Options (A to E) and risk rankings (refer to Table 6-1)					Issue and discussion
	A	B	C	D	E	
Aboriginal heritage						
Aboriginal potential: given the area's occupation and use by Aboriginal communities	U	U	U	U	U	Issue: environmental: potential for encountering unexpected Aboriginal archaeology during construction due to the area's development history. Discussion: without further investigation it is not possible to determine if there is a greater risk with one option over another. All options except Option A pass close to Eastern Creek, which has a higher potential for Aboriginal archaeological finds (refer to section 4.6) At this stage the however risk is unknown for all options.
Noise and vibration						
Sensitive receivers: due to the proximity of residents, commercial properties and recreational areas	M	M/L	M/L	M/L	M	Issue: environmental: construction noise impacting sensitive receivers (residents, users of the playing fields, commercial businesses and users of the scout hall). Discussion: the construction of all options would affect noise sensitive receivers. The greatest density of receivers is on Denmark Road near Garfield Road West, which is common to all options. However, as Option A is located in the more populated area of the footprint it is considered the least favoured option. Also, Option E would likely take the longest to construct, which would affect adjacent receivers for a longer duration.
	M	M/L	M/L	M/L	M	Issue: environmental: construction vibration impacts leading to amenity issues or cosmetic building damage. Discussion: there is the potential for construction vibration impacts to occur under all options. This risk would ultimately depend on the selection and use of construction equipment as well as the separation distance between where the equipment is used and adjacent properties. As above, Option A passes through the most populated area of the footprint and is therefore the least favoured, while Option E would likely take the longest to construct and it would potentially involve more engineering work.

Issues and constraints	Options (A to E) and risk rankings (refer to Table 6-1)					Issue and discussion
	A	B	C	D	E	
	M	L	L	M	M	Issue: environmental: potential for operational noise impacts due to the increased volumes of traffic promoted to use the link road. Equally potential benefit due to the reduction of traffic on Garfield Road West and through the Riverstone town centre. Discussion: operational noise impacts would be a product of the change in traffic volumes, change in road alignment and how close receivers are to the road. There needs to be a 50 per cent reduction in traffic to offset a 50 per cent decrease in distance between the road and sensitive receivers. As such, separation distance is the most influential factor affecting noise impacts. Given that all options would carry similar volumes of traffic, Option A would have the greatest operational impact given that it passes close to the most populated area in the footprint. While Option D and Option E pass closer to receivers than the remaining two options. Further assessment and development of feasible and reasonable noise management controls would be required for all options.
Air quality						
Sensitive receivers: due to the proximity of residents, commercial properties and recreational areas	L	VL	VL	VL	L	Issue: environmental: construction dust generation leading to amenity impacts on sensitive receivers (residents, users of the playing fields, commercial businesses and users of the scout hall). Discussion: all options would generate dust, and given that the soils and geology in the area are susceptible to erosion, there is no one option that is considered more favourable than another. Option E would potentially involve more earthworks and it would involve a longer construction program which makes it the least favoured. Option A passes through the most populated area of the footprint, increasing the potential for amenity impacts. Note: While dust is a concern, its dispersion would be managed during construction and it does not materially influence the choice of option.
	N/A	N/A	N/A	N/A	N/A	Issue: environmental: construction vehicle emissions leading to amenity issues for the above receivers. Discussion: while the proposal would be constructed using a range of vehicles and other emissions-generating equipment this would be likely insufficient to have any amenity impact on receivers locally.
	N/A	N/A	N/A	N/A	N/A	Issue: environmental: potential for the above receivers to become more exposed to traffic-generated pollutants due to the increased volumes of traffic promoted to use the link road. Discussion: Sydney's air quality is classified as good-to-very-good (NSW Environment Protection Authority, 2015) and typically many orders of magnitude below the air quality goals set under the Air Quality National Environmental Protection Measure that are based on international health and amenity standards. The increased volumes of traffic promoted to use the link road are unlikely have a material impact on the local air quality.

Issues and constraints	Options (A to E) and risk rankings (refer to Table 6-1)					Issue and discussion
	A	B	C	D	E	
Landscape character and visual amenity						
Landscape character: value of the semi-rural environment and the important components that contribute to this	L	L	L	L	L	Issue: environmental: temporary impacts on the area’s landscape character during construction leading to a loss of amenity. Discussion: all options would involve construction work in the area. It is considered that all options, except Option A, would have a similar temporary effect on the area’s amenity given that the work would take place on land that is currently open and exposed. Option A that would be constructed in a more developed part of the footprint. Overall however, the scale of the work is unlikely to have a major influence or outcome of the area’s landscape values.
	L	M	M	M	M	Issue: environmental: operational impacts on the area's landscape character, which may result in a loss of semi-rural characteristics as a result of the introduction of traffic through the study area. Discussion: all options would result in the introduction of new road infrastructure into the area. This would be most notable for the options that involve the construction of a new section of road at the end of Denmark Road. Also, as the footprint of Option E is likely bigger than the other options in this location, this may have the greatest influence on the area’s landscape characteristics. Conversely, Option A represents a formalisation of existing tracks and roads in the area over the construction of a new section of road, which means that this option is favoured.
Visual sensitivity: due to the proximity of residents, commercial properties and recreational areas	L	L	L	L	L	Issue: environmental: temporary visual impacts during construction due to the work area, construction activity and any earthworks. Discussion: the visual impact of Option A may be potentially greatest given its location close to sensitive receivers. However, the magnitude of the visual impact with Option A is likely to be less than the construction of a new section road across open land proposed under all other options. As such, all options are likely to have a similar temporary visual impact during construction.
	L	M	M	M	M	Issue: environmental: operational visual impact to sensitive receivers through the increase in traffic promoted to use the link road and the presence of new road infrastructure. Discussion: operational visual impacts will be affected by how close and how sensitive receivers are to the road and traffic. Option A is likely to result in fewer effects from introduction of the road (as the road already exists at this location), however it will result in visual impacts from the introduction of traffic in the most populated area of the footprint. All other options would result in a number of receivers having new sections of road introduced into their viewscape, in addition to traffic running closer to them. This is considered a worse outcome than the traffic that would be introduced under Option A.

Issues and constraints	Options (A to E) and risk rankings (refer to Table 6-1)					Issue and discussion
	A	B	C	D	E	
Utilities and services						
Utility provisions: presence of aboveground and belowground utilities	M	M/L	M/L	M/L	M/L	Issue: engineering: the need to avoid, divert and relocate utilities during construction including belowground optical fibre cables, telephone lines, mains sewers and potable water pipelines and aboveground low-voltage transmission lines. Discussion: water, sewer and optical fibre utilities are present throughout the area and would be encountered under all options. Under Option A low-voltage overhead power lines may also be affected. Further detailed searches would be needed and a concept design would need developing that describes the extent of impact and depth of excavation to fully appreciate the likely risks.
Traffic and transport						
Traffic volumes: due to the reassignment of traffic onto the link road	L+	M+	M+	M+	H+	Issue: traffic and transport: traffic promoted to use the link road once it is operational. Discussion: all options would increase the traffic volumes in the area. While it is predicted that all options would reassign similar volumes of traffic onto the link road, it is anticipated that people would be less likely to use Option A due to its indirect route and most likely to use Option E due to the improved travel times. However Option E is likely to encourage higher vehicle speeds that could potentially conflict with surrounding land uses.
						Issue: traffic and transport: reduced traffic travelling through the Riverstone town centre once the link road is operational. Discussion: all options would result in reduced traffic through the Riverstone town centre. However, it is considered that Option E would attract more traffic than the other options as a result of enhanced traffic flow through the ‘curves’.
Travel times: due to improvements introduced by the link road	L+	M/L+	M/L+	M+	M+	Issue: traffic and transport: improved travel times for local traffic using the link road and the residual traffic on Garfield Road West. Discussion: travel times are affected by the posted speed limit, the distance of the route, number of intersections and the nature of the turning movements dictated by the road geometry. In general, shorter routes are quicker than longer ones. Option D and Option E are about 100 metres shorter than the other options. This is too marginal to have any material effect however Option E is expected to be a slightly more efficient route given the use of curves.

Issues and constraints	Options (A to E) and risk rankings (refer to Table 6-1)					Issue and discussion
	A	B	C	D	E	
Road safety: due to residential properties, families in the area, and the playing fields.	M	L+	L+	M+	H+	Issue: traffic and transport: Safety risk due to reduced route legibility as a result of routing traffic through local roads. Discussion: in terms of driver certainty and safety, Option A with nine turns introduces a number of potential conflicts and driver uncertainty and is likely to have a negative impact. This would also encourage drivers to bypass Denmark Road and turn down Carlton Street to use the link road, which could cause increased traffic congestion on Garfield Road West (refer to section 5.1). Conversely, Option D and Option E might be considered slightly safer for motorists due to the reduced number of intersections, but worse against the socioeconomic impact of creating a high-speed route and the risk it would present to the local community as described above under the corresponding heading.
Properties access: as obtained directly from the road in the area	N/A	N/A	N/A	N/A	N/A	Issue: traffic and transport: Access delays for people entering and leaving their properties while waiting for passing traffic. Discussion: while all options would create some delay to people accessing and leaving their driveway it is likely that during the peak periods there would be no more than five or six vehicles travelling along the link road every minute. This would have no material impact on people needing to wait a few seconds before being able to enter or leave their property.

6.4 Options evaluation summary

Table 6.3 summarises the advantages and disadvantages associated with each option identified through the assessment.

Table 6.3 Options evaluation summary

Option	Advantages	Disadvantages
Option A	■ Uses existing tracks and roads. ■ Requires the least property acquisition. ■ On balance has the lowest likely impact to biodiversity and heritage values. ■ Does not encourage high-speed through traffic due to the number of turns forcing traffic to slow down in comparison to Option D and Option E.	■ Creates a very convoluted route with up to nine turning movements. ■ Traffic routes through the most populated part of the area. ■ Has the potential to increase traffic congestion on Garfield Road West due to motorists wanting to turn right on Carlton Street, or exiting from Carlton Road, due to the number of turning movements travelling from Denmark Road. ■ Actively creates driver uncertainty due to the number of turning movements. ■ Is likely the slowest route. ■ The number of turns and slow progress would potentially deter drivers from using the link road. ■ Would require traffic management priorities to be set where the route intersects with Carlton Street and Creek Street, which may disadvantage local traffic. ■ It is not consistent with the proposal objectives.
Option B	■ Minimal property acquisition needed. ■ Has less social and residential impact over Option A being located away from the populated area of the footprint along Denmark Road. ■ Provides a traffic calming outcome due to the inclusion of additional intersections forcing traffic to slow down. ■ Potential for a reduced operational noise impact compared to Option A due to being the farther away from sensitive receivers along Carlton Street.	■ More property acquisition than Option A. ■ Results in the need to cross the unnamed creek near Trevithick Street. ■ Requirement to construct in the main part of the floodplain. ■ Requirement to construct close to/within the Eastern Creek riparian corridor. ■ Creates an additional intersection near the Trevithick Street and West Parade intersection. ■ Increased risk of Aboriginal heritage impacts.

Option	Advantages	Disadvantages
Option C	■ Slightly reduced property acquisition compared to Option B by tying back into Trevithick Street. ■ Has less social and residential impact over Option A being located away from the populated area of the footprint along Denmark Road. ■ Provides traffic calming due to the use of intersections forcing traffic to slow down. ■ Potential for a reduced operational noise impact due to being the farther away from sensitive receivers near Garfield Road. ■ Potential to use part of Trevithick Street removing the need to construct an additional intersection with West Parade.	■ More property acquisition than Option A. ■ Requirement to construct in the main part of the floodplain. ■ Requirement to construct close to/within the Eastern Creek riparian corridor. ■ Increased risk of Aboriginal heritage impacts. ■ Potential closure of part of West Parade or Trevithick Street that would become redundant.
Option D	■ Has no impact on Trevithick Street. ■ Improves travel time. ■ Provides for an effective tie into West Parade through the use of a curve. ■ Has less social and residential impact over Option A being located away from the populated area of the footprint. ■ Potential for less operational noise impact due to being the farther away from sensitive receivers. ■ Provides traffic calming due to the creation of an intersection at the southern end of Denmark Road forcing traffic to slow down. ■ Potential for a reduced operational noise impact due to being the farther away from sensitive receivers.	■ Potential speed management issue by including curve, which removes the need for people to slow down. ■ Requires the construction of two intersections close to each other on Trevithick Street and Creek Street. ■ More property acquisition required. ■ Requirement to construct in the main part of the floodplain. ■ Requirement to construct close to/within the Eastern Creek riparian corridor. ■ Increased risk of Aboriginal heritage impacts. ■ Requirement to truncate West Parade increasing people's journey times that want to travel its length. ■ Requirement to cross the unnamed creek adjacent to Trevithick Street.
Option E	■ Has no impact on Trevithick Street. ■ Would result in the quickest travel time for people by removing two intersections, introducing curves and not including an intersection back into West Parade. ■ Provides for a smooth flow of traffic	■ Potential speed management issue by including two curves, which removes the need for people to slowdown. ■ Requirement to construct two intersections close to each other on Trevithick Street and Creek Street. ■ Requirement to construct in the main part

Option	Advantages	Disadvantages
	along the Link Road by reducing the need to stop at intersections. - Improved geometry between West Parade and Denmark Road. - Has less social and residential impact being located away from the populated area in the north of the footprint. - Slightly reduced impact on the riparian corridor of Eastern Creek. - Potential for the lowest operational noise impact compared to the options due to being the farthest away from sensitive receivers.	of the floodplain. - Increased risk of Aboriginal heritage impacts. - Highest potential property acquisition of all the options. - Requirement to cross the unnamed creek adjacent to Trevithick Street. - Requirement to truncate West Parade increasing people's journey times that want to travel its length. - Has more property acquisition than Option A, B or C.

6.5 Preferred option

The evaluation concludes that the southern options (Option B to Option E) would provide better community and social outcomes than Option A. Of the southern options, the preferred option has to refer back to the proposal's objectives and the understanding of the community's needs and requirements. As such, the preferred option would need to:

- Provide a link road from Denmark Road through to Westminster Street bridge. A connection at Denmark Road would provide sufficient separation from the Garfield Road railway level crossing to allow local motorists to choose to use the link road instead of Garfield Road
- Provide a through-connection on West Parade running parallel to the Richmond railway line with a connection to Denmark Road to allow people to continue to travel along West Parade once the link road is constructed
- Be consistent with the ultimate long-term road network in the NWGC
- Deliver a proposal that is safe for road users and the local community as it would create a local link road instead of a higher-speed 'bypass'
- Minimise impacts on Eastern Creek, its riparian habitat and floodplain, as well the endangered ecological communities that occur locally
- Minimise the flood exposure risk by keeping the link road as far away from Eastern Creek as possible
- Provide connection to West Parade and Carton Street to provide access for locals.

The southern options (Option B to Option E) are not without their disadvantages and potential environmental impacts, which include the need to construct on the floodplain and in a riparian corridor. Property acquisition would also be required to construct these options and this may also result in subsequent land severance and land uses impacts.

It is anticipated that many of the risks at this early stage would be avoided or minimised during development of the concept design. The residual environmental issues that would be more difficult to avoid or mitigate would be the need to construct the road within the Eastern Creek floodplain, the potential impact and loss of Shale plains woodland and alluvial woodland, property loss and severance, and the road's operational noise impact.

While this is the case, the southern options (Option B to Option E) are assessed as providing a better community and social outcome than Option A. They are also better aligned to the proposal's objectives and they support the objectives of the strategic planning policy as discussed in Chapter 2. On this basis, Option A is discounted. Of the southern options (Option B to Option E), the preferred option should be selected based on it meeting the proposal's objectives and understanding community needs and requirements. Based on these considerations it is concluded that Option B (shown in figure 6-1) would provide the best outcome as it would:

- Reduce congestion and delays that are currently being experienced on Garfield Road East and Garfield Road West caused by the Richmond railway line level crossing in the Riverstone town centre
- Provide a straight alignment for the link road with appropriate intersections that would provide local motorists with a good alternative to Garfield Road
- Minimise operational environmental and social impacts by avoiding the most populated areas including Riverstone Park (an area of playing fields), while also reducing property acquisition and severance
- Provide a preferential outcome that minimises ecological, land use and flood affects
- Support the short-term need to reduce traffic congestion in the area, while providing a link road that would be consistent with long-term road network.
- Provide a traffic calming outcome due to the inclusion of additional intersections forcing traffic to slow down.

Figure 6-1: Preferred Option

DENMAKR LINK ROAD

ROADS AND MARITIME SERVICES



Option B

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7. Conclusions and next steps

The evaluation of options to provide a link road to connect Garfield Road West at the Denmark Road intersection, Riverstone to the Westminster Street bridge, Schofields has considered a range of traffic and transport, environmental and engineering issues. The outcome of this process is a preferred option (Option B) that would comprise:

- A right turn bay from Garfield Road West to connect with Denmark Road and improve existing Denmark Road.
- A 90-degree left-turn via an intersection at the end of Denmark Road that would follow a new road that runs parallel to Trevithick Street
- A new intersection into West Parade to the south of Trevithick Street
- The introduction of two new additional intersections, the first at Carlton Street (formed across the existing intersection of the Carlton Street) the second at the West Parade south of Trevithick Street.
- Setting traffic priority at Carlton Street and West Parade to favour the use of the link road
- Extension of West Parade to connect with Bridge Street near the Westminster Street bridge at Schofields.

Introducing a new link road would provide an effective short-term solution to alleviate traffic congestion in the Riverstone town centre by avoiding the need to cross the Garfield Road railway level crossing at Riverstone. The preferred option (Option B) is considered to provide the best solution to address the proposal's objectives.

Option B would:

- Support the short-term need to reduce traffic congestion and delays that are currently being experienced on Garfield Road caused by the Richmond railway line level crossing in the Riverstone town centre
- Provide a local alternative road connection for motorists to use the Westminster Street bridge instead of the Richmond railway line level crossing in the Riverstone town centre
- Provide a link road from Denmark Road through to the Westminster Street bridge and therefore it would provide sufficient separation from the Garfield Road railway level crossing to allow local motorists to choose to use the link road instead of Garfield Road
- Provide a through connection on West Parade running parallel to the Richmond railway line with a connection to Denmark Road to allow people to continue to travel along West Parade once the link road is constructed
- Be consistent with the ultimate long-term road network
- Deliver a proposal that is safe for road users and the local community as it would create a local link road instead of a higher-speed 'bypass'
- Minimise impacts on Eastern Creek, its riparian habitat and floodplain, as well as endangered ecological communities that occur locally
- Minimise the flood exposure risk by keeping the link road as far away from Eastern Creek as possible
- Provide connection to West Parade and Carlton Street to provide access for locals
- Provide infrastructure that complements the proposed future Riverstone West spine road
- Provide a safe environment for all road users by creating a low-speed local road connection

- Minimise operational environmental and social impacts by avoiding the most populated area including Riverstone Park (an area of playing fields), while also reducing property acquisition and severance
- Provide a traffic calming outcome due to the inclusion of additional intersections forcing traffic to slow down.

Before finalising the selection of the preferred option Roads and Maritime propose to carry out community consultation. Community comments will be incorporated in finalising the preferred option that will be used to prepare the concept design and environmental assessment to obtain project approval.

References

- Australian Bureau of Statistics, 2011. *Quickstats*. [Online]
- Australian Transport Council, 2011. *National Road Safety Strategy for Australia, 2011 - 2020*
- Austroads, 2000. *Road Runoff and Drainage: Environmental Impacts and Management*,
- Austroads, 2002. *Guide to Road Safety (eight parts)* (Austroads, 2002)
- Austroads, 2009. *Guide to Road Design (eight parts)* (Austroads, 2009)
- Bannerman, S. M. & Hazelton, P. A., 1990. *Soil Landscapes of the Penrith 1:100,000 Sheet*, Sydney: Soil Conservation Service of NSW.
Canberra: Austroads.
- Clark, N. R. & Jones, D. C., 1991. *Penrith 1:100 000 Geological Sheet 9030*, Sydney: Conservation.
- Department of Environment and Climate Change, 2008. *Managing Urban Stormwater: Soils and Construction. Volume 2D. Main Road Construction*. Sydney: Department of Environment and Climate Change.
- Department of Environment and Climate Change, 2009. *Interim Construction Noise Guideline*. 1st ed. Sydney: Department of Environment and Climate Change.
- Department of Environment, Climate Change and Water, 2010. *Due Diligence Code of*
- Department of Infrastructure, Planning and Natural Resources, 2003. *Salinity Potential in Western Sydney - Map*, Sydney: Department of Infrastructure, Planning and Natural
- Department of Planning and Environment, 2007. *North West Subregional Strategy*
- Department of Planning and Environment, 2010. *North West Growth Centre Structure Plan*
- Department of Planning and Environment, 2010. *Riverstone Precinct Plan*
- Department of Planning and Environment, 2012. *Schofields Precinct Plan*
- Godden Mackay Logan, 2011. *Schofields Precinct –Non-Indigenous Heritage Assessment*, s.l.: Draft Report for Department of Planning.
- Landcom, 2006. *Managing Urban Stormwater: Soils and Construction. Volume 1*. 4th ed. *Modelling and Assessment of Air*, Sydney: NSW Department of Environment and
- NSW Department of Environment and Conservation, 2005. *Approved Methods for the*
- NSW Department of Environment and Conservation, 2006. *Assessing vibration: a technical guideline*, Sydney: NSW Department of Environment and Conservation.
- NSW Department of Environment, Climate Change and Water, 2011. *NSW Road Noise Policy*, Sydney: NSW Department of Environment, Climate Change and Water.
- NSW Department of Planning and Environment, 2014. *A Plan for Growing Sydney*
- NSW Department of Premier and Cabinet, 2011. *NSW 2021: A Plan to Make NSW Number One*

NSW Department of Premier and Cabinet, 2012. NSW State Infrastructure Strategy

NSW National Parks and Wildlife Service, 2002. *Native Vegetation Maps of the Cumberland Plain, Western Sydney*, Sydney: NSW National Parks and Wildlife Service.

NSW Transport for NSW, 2008. Road Safety Strategy for NSW 2012 – 2021

Parsons Brinckerhoff, 2014. Interim Traffic Management Measures Report

Roads and Maritime, 2011a. *Roads and Maritime Services procedure for Aboriginal cultural heritage consultation and investigation*. Sydney: Roads and Maritime Services.

Roads and Maritime, 2011b. *Technical Guideline for Environmental Management of Construction Site Dewatering*, s.l.: Unpublished.

Roads and Maritime, 2011c. *Technical Guideline Temporary stormwater drainage*

Roads and Maritime, 2013a. *Environmental Impact Assessment Guidance Note EIA- N04 Guidelines for landscape character and visual impact assessment*, s.l.: Unpublished.

Roads and Maritime Services, 2013b. *Removal of the railway level crossing at Riverstone - Community consultation report*, Sydney: Roads and Maritime Services.

Roads and Maritime Services, 2014a. *Riverstone Railway Crossing - Community*

Roads and Maritime Services, 2014b. *North West Growth Centre and Riverstone Corridor Traffic Study - Summary Report*, Sydney: Roads and Maritime Services.

Roads and Maritime, 2014c. North West Growth Centre Road Network Strategy

Roads and Maritime Services, 2015a. EIA Guidelines, environmental assessment procedure, project review of environmental factors, roads (EIA-P05-2) (Road and Maritime, 2014)

Roads and Maritime Services, 2015b. *Road Network Strategy for the North West Growth Centre - Community Consultation Report*, Sydney: Roads and Maritime Services.

Roads and Maritime, 2015c. Connections between Garfield Road West and Westminster Street, Riverstone, Preliminary Environmental Investigation

Roads and Traffic Authority, 2001. *RTA Environmental Noise Management Manual*. 1st ed. Sydney: Roads and Traffic Authority.

Roads and Traffic Authority, 2009. *Beyond the Pavement: RTA Urban Design Policy*,

Transport for NSW, 2012. NSW Long Term Transport Master Plan

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