Title: Starkey Street Pedestrian Bridge, Forestville

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File Name: Starkey Street Pedestrian Bridge, Forestville Options Report

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### Glossary of terms and abbreviations

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<tr>
<th>Term</th>
<th>Meaning</th>
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<tr>
<td>BCR</td>
<td>Benefit cost ratio – the ratio of the present value of future net benefits to the present value of capital and ongoing maintenance costs.</td>
</tr>
<tr>
<td>BRT</td>
<td>Bus rapid transport</td>
</tr>
<tr>
<td>CBD</td>
<td>Central business district</td>
</tr>
<tr>
<td>ISEPP</td>
<td>State Environmental Planning Policy (Infrastructure) 2007</td>
</tr>
<tr>
<td>LGA</td>
<td>Local government area</td>
</tr>
<tr>
<td>LTTMP</td>
<td>Long Term Transport Master Plan</td>
</tr>
<tr>
<td>NBHCaNE</td>
<td>Northern Beaches Hospital Road Connectivity and Network Enhancement (Project)</td>
</tr>
<tr>
<td>REF</td>
<td>Review of environmental factors</td>
</tr>
<tr>
<td>Roads and Maritime</td>
<td>NSW Roads and Maritime Services</td>
</tr>
<tr>
<td>SHOROC</td>
<td>Shore Regional Organisation of Councils</td>
</tr>
<tr>
<td>Transport for NSW</td>
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Executive summary

Background

Roads and Maritime Services is planning to deliver major road works in Frenchs Forest to support the opening of the Northern Beaches Hospital in 2018 and the anticipated development of a specialised healthcare precinct in the surrounding area.

Investigations related to these upgrades identified localised traffic capacity constraints on Warringah Road west of Frenchs Forest, in Forestville.

Roads and Maritime has carried out further investigations aimed at addressing traffic congestion in Forestville, identifying measures to remove and reduce traffic constraints, and providing a road network solution with long-term benefits.

This Options Report outlines the problems within the network and design options identified, developed and evaluated to resolve the problems. It also identifies a preferred solution for the proposal, a pedestrian bridge over Warringah Road at Starkey Street.

Proposal need and objectives

The Frenchs Forest road network has a number of complex interdependencies that can have different effects on particular sub-precincts and downstream locations, such as at Starkey Street.

In the morning peak period, Warringah Road plays a central role, where traffic is predominantly heading west. This, coupled with traffic joining Warringah Road along the corridor, places great stress on particular locations.

Capacity constraints and interactions like bus loading, pedestrian crossings and side-road traffic, effect intersections some distance away.

In the evening peak period, Warringah Road plays a similar central role with traffic predominantly travelling east.

The overall objective is to provide a traffic solution that is complementary to the Northern Beaches Hospital Road Connectivity and Network Enhancement Project by enhancing transport efficiency on Warringah Road.

The specific proposal objectives are to:

- Maximise the efficiency of westbound traffic in the morning peak and eastbound traffic in the evening peak along Warringah Road
- Minimise delays on Warringah Road
- Allow for road-based public transport
- Improve road safety
- Minimise environmental and community impacts
- Optimise the urban design and landscape outcome to complement the surrounding natural, built and community environment
- Provide value for money.

The traffic analysis indicated that the intersection at Starkey Street produced the most significant delays for through traffic and, in particular, that the signalised pedestrian crossing exacerbates congestion.
Development of options

Roads and Maritime developed the following design options for evaluation:

- Option 1: ‘do nothing’ (base case). Maintain the existing road configuration along Warringah Road within Forestville and retain the existing pedestrian crossing arrangements at the Starkey Street traffic signals
- Option 2: Pedestrian bridge over Warringah Road at Starkey Street and widening of Starkey Street
- Option 3: Pedestrian bridges over Warringah Road at Starkey Street and at Brown Street
- Option 4: Pedestrian bridge over Warringah Road at Starkey Street without widening of Starkey Street.

Evaluation of options

Roads and Maritime first evaluated the options using traffic modelling to assess intersection and network performance.

SIDRA modelling analysed the performance of intersections along Warringah Road and within Forestville. VISSIM network performance modelling was undertaken for a base year (2012) and two future years (2021, 2036) for the morning and evening peak periods.

The modelling showed benefits to traffic movement and efficiency across the network for Options 2 to 4.

Environmental and community constraints were identified to facilitate further evaluation. These included property impacts, accessibility, and amenity.

A Value/Risk Management Workshop was held on 3 September 2014 to evaluate the proposed options and to identify the preferred option.

Roads and Maritime then assessed the risks associated with the preferred option and developed mitigation measures to address the most severe risks identified.

An economic analysis was also undertaken for each option. This showed that:

- The base case (Option 1) was not justifiable
- All other options would provide a benefit and would be economically justifiable
- Option 4 (pedestrian bridge at Starkey Street) has the highest benefit relative to cost by a considerable margin.

Preferred option

Option 4 was selected as the preferred option as it would best meet the proposal objectives with the least impacts.

This proposal would involve:

- Installing a new pedestrian bridge over Warringah Road to the east of Starkey Street
- Removing the signalised pedestrian crossing of Warringah Road at Starkey Street
- Relocating the existing eastbound bus stop from 60 metres west of Starkey Street, to the east of Starkey Street, next to the pedestrian bridge entry
- Providing a defined pathway through the car park to the pedestrian bridge entry and bus stop.
This option best meets the proposal objectives as it would:

- Provide more “green time” for through traffic on Warringah Road by removing the signalised pedestrian crossing
- Improve the efficiency of westbound traffic by seven to 13 kilometres per hour in the morning peak along Warringah Road at Forestville
- Reduce the average delay per vehicle on Warringah Road in both the morning and evening peaks by about 79 seconds in the morning and 32 seconds in the evening
- Support improvements to road-based public transport on Warringah Road by improving traffic capacity
- Improve road safety by separating pedestrians from a busy main road, and reducing the risk of unsafe road crossing
- Minimise the amount of property acquisition required
- Provide an optimal urban design and landscape outcome that complements the surrounding natural, built and community environment
- Provide the best value for money of all the improvement options considered.

The proposal would also have some unavoidable impacts, including:

- Changing the visual amenity by introducing a new pedestrian bridge
- The acquisition of some property to accommodate the bridge
- A loss of car parking spaces in the car park on the southern side of Warringah Road servicing a church, Memorial Hall and Senior Citizens Centre to accommodate the bridge.
1 Introduction

1.1 Background to the proposal

Roads and Maritime Services (Roads and Maritime) is planning road upgrades to support the opening of the Northern Beaches Hospital in 2018 and anticipated future development, including a specialised healthcare precinct, in the surrounding area.

It has also been investigating complementary works to enhance these major road works, largely concentrated on the Warringah Road corridor.

The traffic investigation for the Northern Beaches Hospital Road Connectivity and Network Enhancement (NBHRCaNE) Project identified that localised traffic capacity constraints occur along the length of Warringah Road to the west of Forest Way, including the following intersections:

- Warringah Road at Starkey Street/Ferguson Street, Forestville
- Warringah Road at Brown Street/Currie Road, Forestville.

The traffic investigation also identified that there are negative effects on the network caused by traffic banking back from west of Forest Way.

In the morning peak period, Warringah Road plays a central role, with most traffic travelling west. This, coupled with traffic joining Warringah Road along the corridor, places great stress on particular locations. In the evening peak period, Warringah Road plays a similar central role with traffic predominantly travelling east.

Impediments to the continuous flow of traffic on Warringah Road west of Forest Way (often some distance away) can affect the efficiency of travel through the Wakehurst Parkway and Forest Way intersections. These impediments include both traffic incidents and regular activities such as bus loading, pedestrians crossing, and entry of side-road traffic.

The traffic investigation found that in future, these issues could be experienced over longer periods of the day. It also identified that effective accommodation of local traffic will be important to the management of regional through-traffic, and that this would be a key issue to longevity of the network.

1.2 Study area

The broader study area for the investigation is a 1.5 kilometre segment of the Warringah Road corridor west of Forest Way at Frenchs Forest to Arthur Street at Forestville, including Brown Street/Currie Road and Starkey Street/Fergusson Street.

The two intersections are about 400 metres apart. The study focussed on the area around these two intersections (Figure 1.1).

Potential traffic improvements were tested over the wider, five-kilometre long section of Warringah Road between Arthur Street, Forestville and Government Road, Beacon Hill.
1.3 Purpose of report

The purpose of this report is to:

- Outline the problems in this part of the network
- Provide the context for the identification, development and evaluation of options to meet the proposal objectives
- Provide a clear description of the option identification process and justification for the evaluation methodology
- Describe the options identified
- Identify the preferred option and provide justification for its selection with reference to meeting the proposal objectives.
2 Proposal need

2.1 Background

Investigations to support current and planned road upgrade projects in the Frenchs Forest area have identified that the local network has a number of complex interdependencies that can have different effects on particular sub-precincts and downstream locations.

In the morning peak period, Warringah Road plays a central role, with most traffic travelling west. This, coupled with traffic joining Warringah Road along the corridor, places great stress on particular locations.

Capacity constraints and interactions such as bus loading, pedestrian crossings and side-road traffic effect intersections some distance away.

In the evening peak period, Warringah Road plays a similar central role with traffic predominantly travelling east.

A major contributing factor to the level of congestion experienced along Warringah Road is the high volume of east-west traffic.

In addition, the following issues and constraints have been identified at the Starkey/Fergusson and Brown/Currie intersections as causing the most significant traffic impacts:

- Static queuing to the east for morning westbound traffic manifests itself at the Starkey Street/Ferguson Street intersection and banks back past Forest Way, where slow-moving rolling queues form as far away as Allambie Road
- In the evening peak, eastbound traffic flow is impeded at the Arthur Street and Starkey Street signals with eastbound rolling queues leading up to Forest Way also forming
- There is limited side-road access to Warringah Road with demand from westbound entry from the northern side, and eastbound entry from the southern side
- About one hundred pedestrians per hour in the morning peak use the pedestrian crossing at Starkey Street to use buses, shops, community facilities and schools
- Twenty-three pedestrians per hour use the pedestrian crossings at Brown Street to access buses and schools
- The regular call up of pedestrian phases can cause cumulative impacts. Each time pedestrians cross Warringah Road it halts traffic for 30 seconds (including inter-green time)
- The loading and unloading of passengers at bus stops can cause considerable difficulties for traffic flow in the kerbside lane although use of the existing westbound arrangement at Starkey Street (left turn lane works well).

2.2 Regional context

2.2.1 Demographic profile

The proposal is in Forestville, in Warringah Local Government Area (LGA) on Sydney’s Northern Beaches, about 16 kilometres north of the Sydney CBD. The Warringah LGA
covers about 1560 square kilometres and has a population of about 141,000. In 2011, the suburb of Forestville had 7835 residents living in 2918 dwellings with an average of 2.8 persons per household.

The main mode of transport is by private vehicle. In 2011, each dwelling had an average of 1.7 motor vehicles, which is similar to the Greater Sydney average of 1.6.

Public transport in the region is limited to buses, generally making use of Warringah Road, which is the main thoroughfare from Dee Why/Brookvale/Manly through to Chatswood and the Sydney CBD.

Table 2.1 summarises the key demographic and travel characteristics for the Warringah LGA and, where available, provides similar information for Greater Sydney.

Table 2.1 Key demographic and travel characteristics for Warringah LGA

<table>
<thead>
<tr>
<th>Characteristic*</th>
<th>Warringah LGA</th>
<th>Greater Sydney</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>140,741</td>
<td>–</td>
</tr>
<tr>
<td>Household size</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Age breakdown:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-17 years</td>
<td>23.6%</td>
<td>22.9%</td>
</tr>
<tr>
<td>18-59 years</td>
<td>56.0%</td>
<td>59.1%</td>
</tr>
<tr>
<td>60+ years</td>
<td>20.4%</td>
<td>18.0%</td>
</tr>
<tr>
<td>Unemployment rate</td>
<td>3.5%</td>
<td>5.7%</td>
</tr>
<tr>
<td>Population in employment</td>
<td>72,287</td>
<td>–</td>
</tr>
<tr>
<td>Population work and live in the same LGA</td>
<td>59.1%</td>
<td>–</td>
</tr>
<tr>
<td>Car ownership (cars per household)</td>
<td>1.7</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Commuting mode share:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Warringah LGA</th>
<th>Greater Sydney</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>61.6%</td>
<td>58.3%</td>
</tr>
<tr>
<td>Train</td>
<td>2.0%</td>
<td>13.8%</td>
</tr>
<tr>
<td>Bus</td>
<td>13.2%</td>
<td>5.8%</td>
</tr>
<tr>
<td>Tram or ferry</td>
<td>0.3%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Bicycle</td>
<td>1.0%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Walked only</td>
<td>3.1%</td>
<td>4.1%</td>
</tr>
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</table>

* Source: 2011 ABS Census (Community Profile)

2.2.2 Land use and zoning

Land use within the study area (refer Figure 2.1) is predominantly low-density residential, comprising one to two storey dwellings. There are also a number of multi-storey high density residential developments such as at the southwest corner of the Warringah Road/Starkey Street intersection. A number of these are ‘seniors living’ (over 55 years) developments.

Non-residential land uses include commercial/business, educational, community facilities, places of worship, and public open space.

The Forestville neighbourhood shopping centre is the largest commercial facility in the study area, located south of Warringah Road between Starkey Street and Darley Street. Other
Land use in the study area

Figure 2.1
commercial/business activity is largely concentrated around Cook Street and Currie Road extending south and east of Warringah Road. There are also other small businesses, like the Forest Animal Hospital (a 24-hour veterinary surgery), in the study area.

There are four educational facilities in the study area:

- Forestville Primary School (off Darley Street, south of Warringah Road at the western end of the study area)
- Our Lady of Good Council Early Learning Centre (off Currie Road, east of Warringah Road)
- Forestville Montessori Primary School (off Brown Street, west of Warringah Road)
- Aspect Vern Barnett Primary School (off Cook Street, south of Warringah Road).

The local catchments for these facilities straddle the Warringah Road corridor.

Community facilities include a public library (off Darley Street) and a community hall (off Starkey Street). There are three small public open space areas in the study area. There are two reserves off Epacris Street (west of Warringah Road) and Casuarina Reserve in the southwest of the study area, off Bushland Avenue.

Forestville Park is a major public open space area to the east of the study area. There are various access routes from Forestville, principally Currie Road and Cook Street. Gwarra Reserve is at the end of Ferguson Street and backs on to Garigal National Park, west of the study area.

Starkey Street serves as a key route to Killarney Heights.

Land use in the immediate vicinity of the Warringah Road/Starkey Street/Ferguson Street intersection includes:

- A high density residential development (southwest corner of intersection)
- Single storey residences (northwest corner)
- Forest Animal Hospital (northeast corner)
- Public car park (southeast corner)

At the Warringah Road/Brown Street/Currie Road intersection, land use in the immediate vicinity is single storey residential (southwest, northwest, northeast corners) and commercial/business (southeast corner).

The land either side of Warringah Road is largely zoned R2 Low Density Residential under the Warringah Local Environmental Plan 2010. Other zones within the study area include:

- IN2 Light Industrial, located south/east of Warringah Road on both sides of Cook Street
- B2 Local Centre, located southwest of the Warringah Road/Starkey Street intersection
- RE1 Public Recreation, located variously in the area including within/adjacent to the Local Centre zone.

Warringah Road is zoned SP2 Infrastructure. Other roads are zoned the same as the zones in which they are located.
2.3 Existing road network

Warringah Road (A38) is an arterial road corridor providing a major east/west corridor from Brookvale/Dee Why to Chatswood and provides connection to the Sydney CBD.

Warringah Road has a six lane carriageway configuration with a wide central median. It has eight sets of signalised intersections (at an average spacing of 500 metres) to accommodate pedestrian crossing opportunities and traffic accessing Warringah Road. A number of these, and some unsignalised intersections, have auxiliary right turn bays allowing access to side streets. The major intersections of Starkey Street, Forest Way and Wakehurst Parkway also have auxiliary left turns.

The speed limit on Warringah Road is generally 70 kilometres per hour. There is a 40 kilometres per hour school zone between Cook Street and Woodside Grove at Forestville.

Lane widths are relatively narrow, typically 3.1 metres, which is below the optimal arterial lane width of 3.5 metres. Turning lanes are approximately 3.0 metres wide.

The horizontal alignment is generally straight. Where it does bend, the curve radius is greater than the minimum radius of 150 metres for the 70 kilometres per hour speed limit.

The terrain is slightly hilly, but the road gradient is within the desirable maximum of four to six per cent for that speed zone.

Parking is prohibited on both sides of Warringah Road.

The daily traffic volume on Warringah Road west of Forest Way is in the order of 80,000 vehicles.

It is designated as a tertiary freight route, with heavy freight vehicles comprising around 3.5 per cent of peak traffic. It is also designated as a Higher Mass Limit road.

There are three intersections on Warringah Road within the study area:

- Brown Street/Currie Road (four-way signalised intersection)
- Cook Street (three-way unsignalised intersection – right turn out not viable in peak periods)
- Starkey Street/Ferguson Street (four-way signalised intersection).

Signalised pedestrian crossings on Warringah Road are provided at the:

- North-eastern side of Brown Street/Currie Road intersection
- Western side of Starkey Street/Ferguson Street intersection.

Right-hand turns are not permitted into Ferguson Street or Brown Street from Warringah Road for westbound traffic. Right turns into Starkey Street are restricted from 6am to 10am, with the exception of buses.

Figure 2.2 and Figure 2.3 illustrate the current permitted vehicle turning movements and their respective volumes for the morning peak at the Starkey Street/Ferguson Street intersection with Warringah Road and the Brown Street/Currie Road intersection with Warringah Road. The figures also illustrate the level of pedestrian usage (shown in green) during this period.
Figure 2.2  Starkey Street/Ferguson Street/Warringah Road intersection peak morning traffic and pedestrian volumes

Figure 2.3  Currie Road/Brown Street/Warringah Road intersection peak morning traffic and pedestrian volumes
2.4 Traffic activity

Daily traffic volumes and patterns

The volume of traffic on Warringah Road west of Forest Way is in the order of 80,000 vehicles per day. The two-hour morning peak traffic volumes throughout the corridor are provided in Figure 2.4. This shows steadily increasing levels of westbound traffic from east to west.

Figure 2.4 Current two-hour morning peak traffic volumes (2012 model)

The daily pattern of activity on Warringah Road (Figure 2.5) is fairly constant in terms of traffic volume. The morning peak periods are much the same throughout the working week, while the evening peak steadily increases from Monday to Thursday and splits on Fridays. The Saturday peak is of a similar magnitude to the weekday peaks.

Location: Warringah Rd, E Daines Parade, Beacon Hill, 21-27 February 2011 – Source RISS

Figure 2.5 Daily traffic activity on Warringah Road
Traffic signals coordination

The traffic signals coordination plan for the Warringah Road corridor is shown in Figure 2.7. It shows substantial segments of roadway operate inter-dependently. Within the Forest District, the Warringah Road/Wakehurst Parkway intersection dominates other intersections.
2.5 Travel speeds

The Key Roads Performance Report (Roads and Maritime, 2013) outlines how well the road network in Greater Sydney is performing during morning and evening peak periods, as determined using global positioning system (GPS) surveys of the routes.

The most recent report (June 2013) provides trip times calculated using weekday traffic information from 1 March 2013 to 31 May 2013 (excluding public holidays). Average speeds on key routes in the Northern Beaches are summarised in Table 2.2 with the subject route Warringah Road (Frenchs Forest to Roseville) shaded.

Table 2.2 Average peak period speeds on selected major Northern Beaches routes

<table>
<thead>
<tr>
<th>Route</th>
<th>Distance (km)</th>
<th>AM peak inbound average speed (km/h)</th>
<th>PM peak outbound average speed (km/h)</th>
</tr>
</thead>
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<tr>
<td>Warringah Road (Frenchs Forest–Roseville)</td>
<td>7.1</td>
<td>39</td>
<td>32</td>
</tr>
<tr>
<td>Warringah Road (Frenchs Forest–Brookvale)</td>
<td>5.3</td>
<td>33</td>
<td>27</td>
</tr>
<tr>
<td>Forest Way</td>
<td>6.0</td>
<td>34</td>
<td>45</td>
</tr>
<tr>
<td>Mona Vale Road</td>
<td>20.1</td>
<td>42</td>
<td>41</td>
</tr>
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<td>Pittwater Road (Mona Vale–Brookvale)</td>
<td>10.4</td>
<td>24</td>
<td>30</td>
</tr>
<tr>
<td>Pittwater Road (Balgowlah–Brookvale)</td>
<td>5.8</td>
<td>22</td>
<td>25</td>
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<tr>
<td>Military Road–Spit Road–Manly Road</td>
<td>6.6</td>
<td>20</td>
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Roads and Maritime undertook speed surveys along Warringah Road between Woodlands Road and Government Road on 21 and 22 May 2013. The surveys recorded travel times and speeds, and encompassed a total of 58 survey runs during the two-hour morning and two-hour evening peak periods.

The survey results are summarised in Table 2.3. Starkey Street is about midway between the first two locations (shaded) in the table.

The results of the Warringah Road speed surveys indicate the variability of peak period average travel speeds along this section of Warringah Road. The survey results indicate that speeds during the morning peak period are generally slower in both directions compared with the evening peak period. Key slow points are the eastbound approach to Forest Way and the westbound approach to Wakehurst Parkway.
### Table 2.3 Average peak period travel speeds (km/h) on sections of Warringah Road

<table>
<thead>
<tr>
<th>Time period</th>
<th>Woodlands Rd–Starkey St</th>
<th>Starkey St–Altona Ave</th>
<th>Altona Ave–Forest Way</th>
<th>Forest Way–Hilmer St</th>
<th>Hilmer St–Wakehurst Pkwy</th>
<th>Wakehurst Pkwy–Allambie Rd</th>
<th>Allambie Rd–Government Rd</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>730m</td>
<td>680m</td>
<td>760m</td>
<td>500m</td>
<td>260m</td>
<td>850m</td>
<td>920m</td>
<td>4700m</td>
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<tr>
<td><strong>Eastbound morning peak</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>7–8am</td>
<td>44</td>
<td>33</td>
<td>13</td>
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<td>38</td>
<td>43</td>
<td>46</td>
<td>20</td>
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<tr>
<td>8–9am</td>
<td>49</td>
<td>45</td>
<td>26</td>
<td>35</td>
<td>32</td>
<td>37</td>
<td>38</td>
<td>32</td>
</tr>
<tr>
<td>Average</td>
<td>47</td>
<td>39</td>
<td>20</td>
<td>36</td>
<td>41</td>
<td>38</td>
<td>42</td>
<td>26</td>
</tr>
<tr>
<td><strong>Eastbound evening peak</strong></td>
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<tr>
<td>4–5pm</td>
<td>43</td>
<td>55</td>
<td>25</td>
<td>44</td>
<td>37</td>
<td>38</td>
<td>38</td>
<td>34</td>
</tr>
<tr>
<td>5–6pm</td>
<td>31</td>
<td>33</td>
<td>16</td>
<td>34</td>
<td>30</td>
<td>31</td>
<td>31</td>
<td>25</td>
</tr>
<tr>
<td>Average</td>
<td>37</td>
<td>44</td>
<td>21</td>
<td>39</td>
<td>49</td>
<td>34</td>
<td>35</td>
<td>30</td>
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<td><strong>Westbound morning peak</strong></td>
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<td></td>
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<tr>
<td>7–8am</td>
<td>53</td>
<td>29</td>
<td>32</td>
<td>35</td>
<td>21</td>
<td>6</td>
<td>31</td>
<td>15</td>
</tr>
<tr>
<td>8–9am</td>
<td>49</td>
<td>45</td>
<td>41</td>
<td>33</td>
<td>36</td>
<td>19</td>
<td>38</td>
<td>24</td>
</tr>
<tr>
<td>Average</td>
<td>51</td>
<td>37</td>
<td>37</td>
<td>34</td>
<td>29</td>
<td>13</td>
<td>35</td>
<td>20</td>
</tr>
<tr>
<td><strong>Westbound evening peak</strong></td>
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<td></td>
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<tr>
<td>4–5pm</td>
<td>48</td>
<td>23</td>
<td>64</td>
<td>52</td>
<td>44</td>
<td>33</td>
<td>43</td>
<td>37</td>
</tr>
<tr>
<td>5–6pm</td>
<td>50</td>
<td>30</td>
<td>56</td>
<td>44</td>
<td>43</td>
<td>15</td>
<td>40</td>
<td>28</td>
</tr>
<tr>
<td>Average</td>
<td>49</td>
<td>23</td>
<td>60</td>
<td>49</td>
<td>44</td>
<td>24</td>
<td>42</td>
<td>33</td>
</tr>
</tbody>
</table>


### 2.6 Road safety

Table 2.4 provides a summary of crash data for Warringah Road (10 metres east of Darley Street to 10 metres west of Cook Street), Starkey Street (Warringah Road to Violet Avenue and Ferguson Street (Warringah Road to Epacris Avenue) between 1 July 2008 and 30 June 2013. The table shows data for all crashes recorded, including crashes involving pedestrians.

The data shows crashes related to congestion are common, including rear-end collisions, head-on collisions, intersection crashes, and collisions associated with opposing vehicles turning, parallel lanes turning, U-turns, lane changes, vehicles leaving driveways, and overtaking. The majority of crashes are associated with cars and light trucks. A relatively small number involved pedestrians.
Table 2.4: Crash types for Warringah Road in the vicinity of Starkey Street, 1 July 2008 to 30 June 2013

<table>
<thead>
<tr>
<th>Casualty crashes per km per year</th>
<th>All vehicles</th>
<th>Pedestrians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of fatal crashes</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Number of fatalities</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Number of casualties</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>Total number of casualty crashes</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>Total number of non-casualty crashes</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL CRASHES</td>
<td>35</td>
<td>5</td>
</tr>
</tbody>
</table>

2.7 Public transport demand and performance

There is no rail service on the Northern Beaches and the closest train station connected to bus services is Chatswood, nine kilometres to the west. The other notable transport hub is at Manly (about 10 kilometres away), which has ferry services. Buses are the primary mode of non-car travel servicing the area (Department of Premier and Cabinet 2012b).

Bus routes

Bus routes operating in the broad vicinity of the study area are listed with their destinations in Table 2.5 (Sydney Buses) and Table 2.6 (Forest Coach Lines). Currently there are eight bus routes operated by Sydney Buses and 13 bus routes operated by Forest Coach Lines (shown in Figure 2.8). The majority of buses travel towards Chatswood and Sydney CBD in the morning peak with the reverse occurring in the evening peak.

Forest Coach Lines - Killarney Heights shuttle loop

Starkey Street is a main access road for Killarney Heights, which is situated to the south of Warringah Road. The 278 bus service runs along Starkey Street before terminating south of the Warringah Road/Starkey Street intersection. After making a final stop on Starkey Street, buses use the driveway in front of the Memorial Hall as a turning facility prior to layover on Starkey Street. Many passengers walk to the local area or transfer, via the car park, to buses along Warringah Road to reach their destinations.

Table 2.5 Sydney Buses services

<table>
<thead>
<tr>
<th>Route</th>
<th>Service and destinations</th>
</tr>
</thead>
<tbody>
<tr>
<td>136</td>
<td>Daily service between Manly and Chatswood</td>
</tr>
<tr>
<td>137</td>
<td>Weekday limited stop service between Bantry Bay and Chatswood</td>
</tr>
<tr>
<td>142</td>
<td>Daily between Allambie and Manly</td>
</tr>
<tr>
<td>169</td>
<td>Daily between Manly and Sydney CBD</td>
</tr>
<tr>
<td>173</td>
<td>Weekday peak hour service between Narraweena and Milsons Point</td>
</tr>
<tr>
<td>E66</td>
<td>Weekday peak hour express service between Allambie and Sydney CBD</td>
</tr>
<tr>
<td>E69</td>
<td>Weekday peak hour express service between Manly and Sydney CBD</td>
</tr>
<tr>
<td>L60</td>
<td>Weekday peak hour limited stop service between Mona Vale and Chatswood</td>
</tr>
<tr>
<td>Route</td>
<td>Service and destinations</td>
</tr>
<tr>
<td>-------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>260</td>
<td>Weekday peak hour service between Terrey Hills and North Sydney</td>
</tr>
<tr>
<td>270</td>
<td>Daily service between Terrey Hills and Sydney CBD</td>
</tr>
<tr>
<td>271</td>
<td>Daily service between Austlink Business Park (Belrose) and Sydney CBD</td>
</tr>
<tr>
<td>274</td>
<td>Weekday peak hour service between Davidson and Sydney CBD</td>
</tr>
<tr>
<td>276</td>
<td>Weekday school hours service between Belrose and Warringah Mall</td>
</tr>
<tr>
<td>278</td>
<td>Weekday peak hour and weekend service between Killarney Heights and Chatswood</td>
</tr>
<tr>
<td>279</td>
<td>Weekday services between Frenchs Forest and Chatswood</td>
</tr>
<tr>
<td>280</td>
<td>Daily service between Warringah Mall and Chatswood</td>
</tr>
<tr>
<td>281</td>
<td>Daily service between Davidson and Chatswood</td>
</tr>
<tr>
<td>282</td>
<td>Daily afternoon service between Davidson/Belrose and Chatswood</td>
</tr>
<tr>
<td>283</td>
<td>Daily service between Belrose and Chatswood</td>
</tr>
<tr>
<td>284</td>
<td>Daily service between Duffys Forest and Chatswood</td>
</tr>
<tr>
<td>L70</td>
<td>Weekday peak hour limited stop service between Terrey Hills and Sydney CBD</td>
</tr>
</tbody>
</table>
Figure 2.8 Forest Coach Lines bus routes within and around Forestville

Bus performance

In 2012, prior to the Long Term Transport Master Plan, a study was commissioned by Roads and Maritime into potential short and medium term bus priority measures for the Warringah Road corridor. As part of these investigations, bus travel surveys were commissioned to...
identify the bus travel speed performance of services in this vicinity. The survey recorded travel times for Route 136 between Roseville and Dee Why, and Route 280 between Chatswood and Allambie Heights, during the major direction of travel in the morning and evening peak periods. The survey results are summarised in Table 2.7.

Table 2.7  Warringah Road peak hour bus travel speeds, 2012

<table>
<thead>
<tr>
<th>Bus route</th>
<th>Morning peak – westbound Average travel speed</th>
<th>Evening peak –eastbound Average travel speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>136</td>
<td>22.9 km/h</td>
<td>28.2 km/h</td>
</tr>
<tr>
<td>280</td>
<td>12.5 km/h</td>
<td>20.9 km/h</td>
</tr>
</tbody>
</table>

The targeted average speeds for bus services were 20 to 25 kilometres per hour over the length of the bus route. The target was generally met with the exception of Route 280. This route, which runs along Warringah Road between Allambie Road and Forest Way, had travel speeds below the target. The service was much slower than the published timetable. The delays were mostly due to congestion, particularly at:

- Warringah Road and Allambie Road intersection – about eight minutes delay
- Rabbett Street intersection – about three minutes delay
- Warringah Road – about two minutes delay from general congestion.

The bus travel surveys and analysis also identified slow points on the bus network by analysing GPS data collected from buses tracked through Roads and Maritime’s Public Transport and Priority System (PTIPS). Bottlenecks were noticeable at:

- Forest Way/Naree Road intersection
- Warringah Road and Forest Way intersection
- Frenchs Forest Road and Wakehurst Parkway intersection
- Warringah Road and Starkey Street intersection.

The westbound Starkey Street bus stop serves 200 to 300 passengers in the morning period. A similar number of passengers use the eastbound bus stop in the evening period. The bus stops are not indented from the kerbside lane. The high volume of pedestrian traffic across Warringah Road generated by the bus stops results in high use of the signalised pedestrian crossing during peak periods.

Pedestrian crossing demand

Signalised pedestrian crossings are provided at the Starkey Street/Fergusson Street/Warringah Road intersection and the Currie Road/Brown Street/Warringah Road intersection. Current levels of pedestrian crossing demand in the morning peak are provided in Figure 2.2 and Figure 2.3.

Generally the walking speed of pedestrians is between 0.8 metres and 1.2 metres per second. This equates to pedestrians typically requiring about 20 to 25 seconds to cross six to seven lanes and median of Warringah Road, resulting in a 30 second pedestrian cycle (including inter-green time).

This is a constraint to traffic flows on Warringah Road.
The following intersection usage characteristics have also been noted:

- The close location of two schools to the Brown Street/Currie Road intersection generates pedestrian demand including large numbers of parents escorting young children and prams.

- The Starkey Street/Ferguson Street crossing attracts a wide cross-section of pedestrians including people accessing the nearby shops, schools and community centre.
3 Strategic context

3.1 NSW 2021: A Plan to Make NSW Number One

*NSW 2021: A Plan to Make NSW Number One (NSW 2021)* (Department of Premier and Cabinet 2011) is the NSW Government’s 10 year strategic business plan that sets priorities for action and guides resource allocation to deliver economic growth and critical infrastructure.

NSW 2021 places emphasis on investing in and delivering an efficient and effective transport system including delivering road infrastructure that will relieve congestion, improve travel times, improve road safety and enhance and expand capacity on road corridors.

The proposal to improve traffic flow along the Warringah Road corridor is consistent with NSW 2021, as it would improve safety and reduce congestion.

3.2 The State Infrastructure Strategy 2012-2032

*The State Infrastructure Strategy 2012-2032* (State Infrastructure Strategy) developed by Infrastructure NSW is a strategy that identifies and prioritises the delivery of critical public infrastructure to drive productivity and economic growth (Infrastructure NSW 2012). Infrastructure NSW’s assessment of the State’s existing infrastructure highlighted critical deficiencies in urban road capacity with the Bureau of Transport and Regional Economics (2007) estimating that congestion in Sydney would cost the NSW economy $8 billion annually by 2020. The State Infrastructure Strategy identifies strategic infrastructure options to meet the challenges of population growth across NSW.

The proposal is consistent with the State Infrastructure Strategy, as it would deliver an improvement to Warringah Road that would contribute to meeting future traffic growth and transport requirements in Greater Sydney.

In November 2014 the State Government released *Rebuilding NSW – State Infrastructure Strategy 2014*. This complements the State Infrastructure Strategy and identifies specific infrastructure projects and initiatives to strengthen the NSW economy.

3.3 NSW Long Term Transport Master Plan

The *NSW Long Term Transport Master Plan* (LTTMP) (Transport for NSW 2012) establishes the framework to deliver an integrated, modern transport system by identifying NSW’s transport actions and investment priorities over the next 20 years. The LTTMP identifies that over the next 20 years, Sydney’s population is forecast to increase from 4.3 million to 5.6 million. By 2031, the number of trips made around the city each day will increase by 31 per cent from 16 million to 21 million trips, placing greater demands on road, rail and bus networks. Road congestion is currently estimated to have a cost of about $5.1 billion (or nearly $1100 for every person living in Sydney) each year. By 2020, the costs of congestion are expected to rise to $8.8 billion a year.

The LTTMP proposes a coordinated and integrated approach to meeting these transport challenges. Actions outlined in the plan include a program of work to expand capacity on Sydney’s most congested corridors. A medium to long-term action to deliver targeted
investment and efficiency improvements on the arterial road network is relevant to the proposal.

The LTTMP identifies 46 strategic transport corridors across the Greater Metropolitan Area, that represent travel demands between centres in Metropolitan Sydney and areas where high concentrations of travel demand occur during peak periods on all travel modes.

The transport corridor connecting Dee Why and Chatswood through Forestville is identified as one of these strategic transport corridors. The LTTMP identifies that on Warringah Road between Frenchs Forest and Brookvale, the average travel speed in the morning peak is about 32 kilometres per hour. Forecast for strong growth in car traffic over the next 20 years means that road congestion will increase unless action is taken.

The proposal is consistent with the LTTMP as it would facilitate improved traffic flow along a strategic transport corridor.

The LTTMP identifies the road corridor along Warringah Road between Dee Why and Chatswood as having the potential to be expanded as part of the Strategic Transit Network.

This may include a Northern Beaches Bus Rapid Transit along the Warringah Road Corridor. Warringah Road, between Chatswood and Dee Why, is also proposed to be part of the core bus network by 2031. The proposal would support such an initiative.

### 3.4 Draft Metropolitan Strategy for Sydney to 2031

The *Draft Metropolitan Strategy for Sydney to 2031* (Draft Metropolitan Strategy) (NSW Government 2013) was released for public comment in March 2013 and sets the framework and strategic planning foundation for Sydney’s housing and job growth to 2031 to inform the final Metropolitan Strategy.

The Draft Metropolitan Strategy is being delivered in conjunction with the LTTMP and State Infrastructure Strategy to fully integrate planning for housing and employment with the delivery of extensive transport and infrastructure. The Draft Metropolitan Strategy recognises Sydney as highly networked with more frequent connections into and through the Global Economic Corridor, and between the Sydney CBD and Parramatta.

The Draft Metropolitan Strategy identifies that the Warringah Road corridor between Brookvale and Dee Why to Chatswood provides an important connection from the northern suburbs into the Global Economic Corridor. The road corridor is identified as having potential for a Transit Network Expansion.

Objective 25 of the Draft Metropolitan Strategy focuses on improving access to major employment hubs such as Chatswood. The proposal is consistent with this objective as it would facilitate improved traffic flow along a strategic transport corridor.

**North Subregional Strategy**

The Draft Metropolitan Strategy contains detailed advice for all six sub-regions to provide a direction for sub-regional planning including metropolitan priorities. The proposal is located within the North Subregion which includes the Warringah, Pittwater, Manly, Hornsby, and Ku-ring-gai LGAs.

One of the objectives of the North Subregional Strategy is to improve connections to the Global Economic Corridor via North Sydney and cross-regional links with Chatswood via
Brookvale/Dee Why. The proposal is consistent with this objective as it would facilitate improved traffic flow along the Warringah Road corridor between Chatswood and Dee Why.

3.5 Northern Beaches Regional Action Plan

The *Northern Beaches Regional Action Plan* (Department of Premier and Cabinet 2012b) outlines the initiatives and strategies to be pursued by the NSW Government to meet its election commitments. It requires agencies to plan for and facilitate connectivity to, from and across the region so that people spend less time in their cars commuting to work.

The plan states that ‘residents of the Northern Beaches region rely heavily on private vehicles and public buses to commute to work and for travel to retail and recreation places. The geography of the region presents a challenge to solving the congestion issues faced by the Northern Beaches community on major transport routes’.

The proposal is consistent with the *Northern Beaches Regional Action Plan* as it would improve travel times on Warringah Road for both private vehicles and public transport.

3.6 Sydney’s Bus Future

*Sydney’s Bus Future* (Transport for NSW 2013b) sets out the NSW Government’s overall plan to deliver fast and reliable bus services for customers in Sydney. Based on the integrated approach outlined in the LTTMP, it outlines how the bus network would be redeveloped to bring simpler, faster and more efficient services. It identifies three tiers of bus routes in the network:

- **Rapid service routes**, forming the backbone of the bus network with fast and reliable bus travel between key centres
- **Suburban service routes**, consisting of a mix of timetabled and frequent, ‘turn-up-and-go’ type services that do not require timetables
- **Local service routes** comprising timetabled services with stops every 400 metres or so.

A total of 13 rapid transit routes have been identified that would have stops generally at intervals of 800-1000 metres.

*Sydney’s Bus Future* also outlines investment in bus priority infrastructure to support fast and reliable bus journeys. This includes adopting a staged approach to introducing bus rapid transit (BRT) on key corridors, beginning with investigations along key high-growth corridors. These include two corridors on the Northern Beaches.

Targets for additional bus services that include Warringah Road include:

- **Direct connections** that will link the Northern Beaches to major centres such as Chatswood, St Leonards and Macquarie Park, including more than 50 new suburban services operating very weekday to connect Manly to Chatswood via Brookvale and the proposed Frenchs Forest Hospital
- **Thirty additional services** on Eastern Valley Way connecting Belrose to the Sydney CBD, supported by new bus priority measures.

The proposal would support these targets as it would improve travel times on Warringah Road.
3.7 Northern Beaches Bus Rapid Transit Study

The Northern Beaches Bus Rapid Transit (BRT) Pre-Feasibility Study (Transport for NSW 2012b) identifies a number of corridor options to provide BRT services in the Northern Beaches. Two corridors were investigated:

- A north–south corridor linking Mona Vale with the CBD via the Pittwater Road–Spit Road–Military Road corridor
- An east–west corridor linking Dee Why and Chatswood via Warringah Road.

The proposal would support the implementation of a BRT along the Warringah Road corridor through improvements to traffic flow.

3.8 Northern Beaches Transport Action Plan

The NSW Government is investing in a number of transport improvements as part of the Northern Beaches Transport Action Plan (Transport for NSW 2014). Transport improvements in the vicinity of the proposal that are part of the plan include:

- More frequent bus services for the area, with buses starting earlier and finishing later during the week and on weekends; these include expanding bus services along Route 136 (Chatswood to Manly) and Route 271 (Terrey Hills to Sydney CBD)
- Kerbside BRT providing more reliable ‘turn up and go’ bus services between Chatswood and Manly, incorporating new bus bays, upgraded intersections, road lanes and bridges to improve traffic flow and bus travel
- Major road improvements around the Northern Beaches Hospital at Frenchs Forest
- Development of an all day, seven days a week public transport network.

Investigations into a number of significant transport improvement proposals are also part of the action plan. These include a feasibility study on a Northern Beaches motorway tunnel between the Spit Bridge and Warringah Freeway. The proposal would support the implementation of improved transport services along the Warringah Road corridor through the improvement of traffic flow on Warringah Road.

3.9 Shaping Our Future

Shaping Our Future is the overarching integrated strategy for the Shore Region of Councils (SHOROC) geographical region. It outlines the infrastructure and policy priorities so that member councils can lobby with a united voice for investment, as well as bring together projects that are more effectively or efficiently delivered in partnership by the councils.

Shaping Our Future outlines how the SHOROC councils will work together with other levels of government, business and the community to address critical challenges for the region, now and into the future.

SHOROC supports bus priority/BRT initiatives on the Dee Why to Chatswood link in response to existing road congestion and growth targets. The proposal is compatible with these objectives.
4 The proposal

4.1 Proposal objectives

The overall objective for the proposal is to provide a traffic solution that is complementary to the NBHRCaNE Project through enhancing transport efficiency along the Warringah Road corridor through Forestville.

The specific proposal objectives are to:

- Maximise the efficiency of westbound traffic in the morning peak along the Warringah Road corridor
- Minimise delays to the Warringah Road corridor
- Allow for road-based public transport
- Maintain and improve road safety
- Minimise environmental and community impacts
- Optimise the urban design and landscape outcome to complement the surrounding natural, built and community environment
- Provide value for money.

4.2 Proposal overview

The Frenchs Forest area currently experiences substantial levels of traffic congestion. With the planned opening of the Northern Beaches Hospital in 2018, the anticipated development of a specialised healthcare precinct in the surrounding area and the proposed introduction of BRT along Warringah Road, traffic demand is expected to increase.

A number of localised traffic capacity constraints have been identified along Warringah Road in the Forestville area that contribute to issues in the wider road network.

In addition to the high volumes of east-west traffic, contributing factors to capacity constraints include:

- Traffic entering and exiting to and from side streets, particularly at signalised intersections where east-west traffic is halted
- Locations where there are high levels of signalised pedestrian crossing demand
- Bus stops during the loading and unloading of passengers.

Roads and Maritime carried out targeted investigations to identify operational and physical improvements that would remove the worst of the constraints to through traffic on Warringah Road west of Forest Way peak periods.

Roads and Maritime was focussed on:

- Increasing green time at traffic signals for vehicles travelling on Warringah Road by eliminating or shortening the green and inter-green time for other movements
- Removing constraints to the flow of traffic on Warringah Road movement by better managing side-road activity and reducing the impact of loading and unloading of passengers at bus stops.
4.3 Proposal constraints and considerations

The study area predominantly comprises low-density residential development with pockets of other land uses that have influenced the development of options.

The existing at-grade pedestrian crossings provide important connectivity for pedestrians across Warringah Road accessing the Forestville neighbourhood shopping centre, the Forestville Senior Citizens Centre, and schools such as the Forestville Montessori School on Warringah Road north of Brown Street. It is important that this connectivity and provision of safe pedestrian passage is maintained.

The proximity of the Forestville Senior Citizens Centre means that accessibility will be an important consideration for any options explored. For the pedestrian bridge options, this will impact the inclusion of ramps, stairs and lifts. Consideration will also need to be given to the provision of alternative access if, for some reason, access is temporarily restricted (e.g. lift breakdown).

The preferred option must not preclude longer-term transport solutions from being implemented in the future, for example an upgrade of Starkey Street, or additional work to Warringah Road to provide a BRT route.

The car park at the Starkey Street/Warringah Road intersection provides parking for people using the nearby community hall, the senior citizens centre and the church. Development of options that impact the car park will need to minimise the loss of car parking spaces.

There are various utilities (Telstra, Optus, Ausgrid, Jemena, Verizon and Sydney Water), both above ground and underground in Starkey Street and along Warringah Road. There is often a significant cost associated with the relocation of utilities. Where practicable, options would need to avoid affecting utilities, and where this is not practicable, minimise the extent of impact.

The Killarney Heights buses (Forest Buses Route 278) use the driveway in front of the Memorial Hall as a turning facility prior to layover on Starkey Street. All options need to accommodate this bus service and provide for its turning arrangements.
5 Option analysis and evaluation

5.1 Description of options

The traffic analysis identified that the Warringah Road/Starkey Street intersection produces the most significant delays for through traffic, and in particular, the signalised pedestrian crossing exacerbates the congestion. In view of this, the following options have been developed for evaluation:

- Option 1: Do nothing (base case)
- Option 2: Pedestrian bridge over Warringah Road at Starkey Street and widening of Starkey Street
- Option 3: Pedestrian bridges over Warringah Road at Starkey Street and Brown Street
- Option 4: Pedestrian bridge over Warringah Road at Starkey Street without widening Starkey Street.

The key features of each option are described in the following sections with an analysis of each identifying potential benefits and impacts. The pedestrian bridge at Starkey Street and removal of the at grade pedestrian crossing (Option 4) are common to all build options.

5.1.1 Option 1: Do nothing (base case)

This option would maintain the existing road configuration along Warringah Road within Forestville and retain the existing pedestrian crossing at the Starkey Street intersection.

5.1.2 Option 2: Pedestrian bridge over Warringah Road and widening of Starkey Street

The key features of this option are:

- Install a new pedestrian bridge over Warringah Road to the east of Starkey Street
- Remove the existing at grade pedestrian crossing of Warringah Road west of Starkey Street
- Relocate the existing eastbound bus stop from 60 metres west of Starkey Street, to east of Starkey Street next to the pedestrian bridge entry
- Widen the eastern side of Starkey Street between Warringah Road and Nicholas Avenue to provide an additional right turn lane; this would include a 0.5 metre median about 60 metres in length with a gap to allow local bus services to turn around via the existing car park
- Revise the lane marking of the existing centre lane (currently through traffic movements only) to provide for a right turn as well as through traffic movements
- Retain the current configuration of the existing left turn only lane
- Relocate the footpath and grassed verge on the eastern side of Starkey Street to accommodate widening
- Provide defined pathway through the car park to the pedestrian bridge entry and bus stop
• Reconfigure affected property accesses on eastern side of Starkey Street
• Relocate affected utilities.

This option included a variant (Option 2A) comprising a shorter additional right turn lane with the taper commencing about 60 metres back from the Warringah Road intersection.

5.1.3 Option 3: Pedestrian bridges over Warringah Road at Starkey Street and Brown Street

The key features of this option are:
• Install two new pedestrian bridges over Warringah Road: one to the east of Starkey Street and one either north or south of Brown Street
• Remove the existing at-grade pedestrian crossings on Warringah Road at Starkey Street and Brown Street
• Relocate the existing eastbound bus stop from 60 metres west of Starkey Street, to east of Starkey Street next to the pedestrian bridge entry
• Provide a defined pathway through the car park to the pedestrian bridge entry and bus stop.

5.1.4 Option 4: Pedestrian bridge over Warringah Road at Starkey Street without widening of Starkey Street

The key features of this option are:
• Install a new pedestrian bridge over Warringah Road, east of Starkey Street
• Remove the existing at-grade pedestrian crossing of Warringah Road at Starkey Street
• Relocate the existing eastbound bus stop from 60 metres west of Starkey Street, east of Starkey Street next to the pedestrian bridge entry
• Provide a defined pathway through the car park to the pedestrian bridge entry and bus stop.

5.2 Traffic modelling

Roads and Maritime assessed the performance of each option by completing an iterative, intersection-based traffic analysis using intersection modelling software (SIDRA Version 6.1) and a network-based traffic analysis using VISSIM\(^1\).

The latter was undertaken to assess wider network performance relative to local network performance (i.e. within the study area). This was necessary to identify potential reductions in wider network performance at the expense of improved local network performance.

Intersection performance was assessed for the base case (year 2012). Network performance considered the same base year and the following two future scenarios (including the upgrades proposed as part of NBHRCaNE Project):
• 2021: 18 per cent traffic growth over 2012 levels

\(^1\) VISSIM is a microscopic, discrete time, behaviour-based multipurpose traffic simulation program developed in Germany by PTV. VISSIM is capable of simulating complex road networks and providing aggregated performance measures of options and forecast scenarios.
• 2036: 24 per cent traffic growth over 2012 levels.

Modelling examined both morning (7am to 9am) and afternoon (4pm to 6pm) peak periods.

The base case for network modelling adopted the preferred underpass option for the NBHRCaNE Project.

The results of the traffic modelling are summarised as follows.

**Intersection-based traffic analysis**

All build options would result in a large improvement to travel speeds, generally doubling the estimated current eastbound speed from 11.3 kilometres per hour to 22.5–26.7 kilometres per hour, depending on the option.

A corresponding halving of travel time is also forecast. The improvement in performance would occur without any material impact on the functioning of side streets, which would maintain current levels of delay and queues.

In absolute terms of performance (highest to lowest), the order is Option 2, Option 3, then Option 4.

However, this order changes when the estimated costs of the options are taken into account. Option 4 is the most cost-effective, with Options 2 and 3 providing only marginal improvements in performance relative to additional cost (see section 5.3 for further information).

**Network-based traffic analysis**

The following observations were noted:

• The results of the VISSIM modelling generally confirmed the findings of the intersection-based modelling

• All build options would meet the main proposal objectives of maintaining a continuous flow of traffic along Warringah Road while considering the operational function of side streets

• Benefits to traffic movement and efficiency of movement would be experienced across the network and have positive knock-on effects

• All build options would deliver very similar results in terms of network and Warringah Road corridor travel speed and travel delay

• Individual build options perform relatively better over different years and between morning and afternoon conditions, however in absolute terms, Option 2 slightly outperforms Option 3 which in turn slightly outperforms Option 4.

Option 4 is considered to provide the best value in terms of increased corridor travel speed. The provision of a second bridge at Brown Street (Option 3) or the widening of Starkey Street (Option 2) would deliver some additional, relatively smaller benefits, but at higher proportionate costs and impacts.

### 5.3 Economic modelling

As part of the traffic modelling and options analysis, a microsimulation modelling approach was used to inform the economic analysis of the network-wide traffic modelling performance measures.
The four options have been modelled in VISSIM for the years 2021 and 2036 for both morning and evening peak periods and an economic assessment carried out consistent with Principles and Guidelines of Economic Appraisal of Transport Investment and Initiatives (Transport for NSW 2013a).

The modelled impacts of the improvement scenarios were compared to the forecast base case network to identify the network-wide implications of effects on queuing and related measurable parameters such as travel distance, travel time and number of stops.

The economic analysis showed that all three options are economically justifiable. However, Option 4 has the highest benefit relative to cost by a considerable margin and is therefore the least risky proposition from an investment perspective.

5.4 Urban design

The following key landscape contextual notes were identified for consideration during design of the proposal:

- Warringah Road is a key local arterial road connecting Northern Beaches residents with Chatswood to the west and beaches to the east
- Warringah Road’s character is that of an urban parkway, tree lined and with low built form
- The Starkey Street intersection forms a key gateway into Killarney Heights and the Centre Shopping Village in Forestville, and standard wayfinding signage is present
- Nearby community facilities are important site attributes that contribute to the local community and Warringah Shire
- The bus stop on Warringah Road is a key regional bus stop and is used for special event bus travel
- The Community Centre parking area is an important hub for community usage, including parking for community facilities and as a bus stop interchange
- The Forest Animal Hospital and Norfolk Island pine tree are well established local landmarks
- Native plant species located along road verges, in the corner garden bed and around existing community buildings contribute to the character of the area.

Based on the site analysis and landscape contextual considerations, urban design objectives and principles were developed to inform development of options and assist identification of a preferred option. These are presented in Table 5.1 and depicted graphically in the urban design strategy plan provided in Appendix A.
<table>
<thead>
<tr>
<th>Objective</th>
<th>Principles</th>
</tr>
</thead>
</table>
| 1. Retain and reinforce the urban parkway character of Warringah Road    | • Ensure that the parkway character of Warringah Road is retained through the retention of existing trees and the planting of new trees wherever possible  
• Carefully locate built elements and footpaths to avoid the need to remove existing trees or prevent the planting of new trees |
| 2. Reinforce the bushland character of the area                          | • Retain the informal bush character of nearby garden beds through replanting of any cleared areas or newly created garden beds with locally occurring indigenous trees, shrubs, ground cover and grass species  
• New street tree planting should be locally occurring indigenous species  
• Reinforce the definition of the intersection through strategic landscape measures such as revegetating impacted areas where applicable  
• Minimise impacts to existing vegetation and utilise it as green buffers/visual foils to new built form, and urban infrastructure |
| 3. Deliver an integrated approach to traffic management including pedestrian, cycle and public transport | • Provide/retain user-friendly pedestrian crossings at Warringah Road and Starkey Street  
• Ensure easy and safe connectivity to public transport modes, particularly bus stops along Warringah Road and community shuttle pickups in the Community Centre car park and to community and retail facilities on Starkey Street  
• Provide improved bicycle facilities including secure bicycle parking with easy access to the existing bus stop |
| 4. Retain the privacy and amenity for residents, and commercial exposure for local businesses and community facilities in the immediate area | • Utilise existing vegetation as visual screening within new developments to retain vegetative character and minimise visual impacts. Screening should take the form of a visual foil and vegetative screening wherever possible as opposed to walls, solid panels and other similar materials  
• Provide visual screening for adjacent properties, particularly to the Forest Animal Hospital and adjacent residents on Ferguson Street and Walkom Avenue  
• Retain clear sightlines to the Forest Animal Hospital and community facilities. Consider means of highlighting the Forest Animal Hospital to westbound traffic on Warringah Road |
| 5. Define the gateway to Killarney Heights and the Centre Shopping Village | • Retain the informal bush character of nearby garden beds through replanting of any cleared areas or newly created garden beds with locally occurring indigenous shrub, ground cover and grass species  
• Reinforce the character of the intersection through strategic landscape measures such as revegetating impacted areas where applicable and planting of new trees  
• Rationalise wayfinding signage as part of an overhaul of signage at the intersection aimed at reducing clutter and providing clear messages to the road user |
### Objective

<table>
<thead>
<tr>
<th>Objective</th>
<th>Principles</th>
</tr>
</thead>
</table>
| 6. Retain a clear structural framework for the streetscape, wayfinding and functionality of the precinct | • Rationalise wayfinding signage as part of an overhaul of signage at the intersection aimed at reducing clutter and providing clear messages to the road user  
• Integrate any pedestrian bridge structure within the landscape setting and ensure logical pathway connections to existing footpaths and building entries  
• Integrate any pedestrian bridge design with other future pedestrian bridges and consider existing pedestrian bridges along the corridor between Arthur Street, Forestville to the west and Wakehurst Parkway in the east |
| 7. Design integrated urban infrastructure/landscape design elements that allow the landscape to dominate and built forms to recede | • Use existing vegetation as visual screening within new developments to retain green character and minimise visual impacts. Screening should take the form of vegetative screening wherever possible as opposed to walls, solid panels and other similar materials  
• Integrate the proposal within the landscape setting and ensure logical pathway connections  
• Any pedestrian bridge design should be in accordance with Roads and Maritime guidelines and consist of clean, streamlined forms and not be overly fussy in terms of detailing. Materials and colours should be recessive in order to allow the existing landscape to dominate with selected architectural highlight colours to express dramatic forms or features of the bridge |

### 5.5 Evaluation of options

Value management is a development process used by Roads and Maritime to bring together technical experts and key stakeholders to develop a way forward for large infrastructure projects.

A Value/Risk Management workshop was held on 3 September 2014 to evaluate the proposed options and to identify the preferred option. Risks associated with the preferred option were then assessed and mitigation measures developed to address the most severe risks identified.

The workshop was facilitated by an external party and involved stakeholders and representatives from:

- Roads and Maritime Services
- URaP (traffic consultants)
- Warringah Council
- Transport for NSW
- SMEC (environmental consultants)
- Spackman Mossop Michaels (urban design consultants).

The purpose of the workshop was to update stakeholders about the problems identified on the network and the design options developed. The intention was to select a preferred
option, to identify the risks associated with the preferred option and to develop mitigation measures to address the most severe risks identified.

In the course of the workshop, participants revisited and confirmed the overall and specific proposal objectives to be achieved.

The workshop used a structured process to ensure that key issues were identified and the preferred solution meets essential service level requirements and community expectations.

The session was characterised by a strong commitment to innovation, collaboration and teamwork. The process was focussed on confirming the agreed proposal objectives and ensuring the option implemented is aligned with those objectives.

The Value Management and risk assessment process followed the following stages:

- Information phase – provided background context to the proposal and description of the options developed to date
- Options analysis phase – used to gain an understanding of the underlying issues and constraints with the potential to impact the options being considered
- Options evaluation phase –
  - Considered each of the available options in more detail to identify the option that could best met proposal objectives
  - Led to a preferred option that could to be presented to the Major Projects Review Committee and could progress to detailed design
- Creative phase – provided a platform for a general brainstorming of wide-ranging ideas to improve overall functionality and value as well as achieving the proposal objectives in the context of the constraints and issues discussed earlier in the workshop
- Judgement phase – assessed the ideas for option improvement generated in the creative phase in terms of practicality, viability and cost effectiveness; each idea was discussed and rated using the following criteria:
  - Recommended for implementation
  - Good idea – needs further investigation
  - Not practical
- Risk identification /strategy development – identified the issues that had the potential to create a negative impact on any aspect of the preferred option for the proposal. After identification, each risk was reviewed and assessed in terms of the likelihood of it occurring and the level of impact that would result from such an occurrence. Strategies were then developed to mitigate risks before responsibilities and timeframes were agreed.

Analysis of options involved a collaborative identification and discussion of the potential benefits and impacts for each option. The preferred option was selected through a consensus decision.

The following aspects were considered when identifying the benefits and impacts for each option:

- Socio-economic impacts during construction and operation such as potential property acquisition and construction impacts on neighbouring properties
• Environmental impacts during construction and operation such as potential vegetation clearing, noise, air quality, changes to the visual landscape and heritage impacts,
• Safety and accessibility requirements for all potential users (pedestrians, mobility impaired users, cyclists and all motor vehicles types), including lighting requirements.

Options were evaluated against the objectives (refer Section 4.1) with potential benefits and impacts identified. The outcomes of this are discussed as follows for each option.

5.5.1 Option 1: Do nothing (base case)

Proposal objectives
Option 1 would not achieve any transport efficiency improvement on Warringah Road. This option does not meet the proposal objectives.

Potential benefits
There are no benefits associated with this option.

Potential impacts
There would be no change to the existing situation and congestion would continue to be a considerable issue on Warringah Road.

Summary
Given the existing poor performance of public transport reliability on this route, and the considerable congestion experienced in the westbound morning peak and eastbound evening peak, Option 1 was considered to be unacceptable.

5.5.2 Option 2: Pedestrian bridge over Warringah Road and widening of Starkey Street

Proposal objectives
This option would meet all proposal objectives with the exception of minimising environmental and community impacts (relative to other options).

Potential benefits
Option 2 would:
• Increase traffic efficiency out of Starkey Street by providing additional storage for right turning traffic
• Provide greatest westbound traffic benefit on Warringah Road through additional green time associated with removing the at-grade pedestrian crossing
• Improve safety for pedestrians by separating pedestrians from Warringah Road traffic, rationalising bus stops, and integrating pedestrian desire lines into urban design outcomes.

Option 2A (shorter widening length of Starkey Street) would have similar potential benefits to Option 2 but with lower capital costs and fewer property impacts.
Potential impacts

Option 2 would have the following potential impacts:

- Provision of a new pedestrian bridge over Warringah Road to the east of Starkey Street would require:
  - Partial acquisition of one property to the north of Warringah Road
  - Removal of a number of car park spaces in the car park on the southern side of Warringah Road, with the potential consequent impact of shifted demand for car parking elsewhere in the local area
- Property acquisition impact would be the second worst of all options
- Longest construction time – negative impact on the surrounding community
- Greatest impact on surrounding environment including reduced amenity from removal of street trees for work in Starkey Street
- Largest built infrastructure footprint, therefore likely largest construction footprint
- Greatest impact on utilities.

Option 2A would have similar potential impacts to Option 2, but with slightly reduced traffic efficiency outcomes and a smaller impact footprint.

Summary

Option 2 would meet all proposal objectives. It would provide the greatest relative benefit to traffic exiting from Starkey Street, however, this is not a primary consideration with regard to the proposal objectives. This option would have the largest relative footprint due to the road widening works in Starkey Street.

The total cost for this option sits in the middle of the three build options, being about 0.7 times the total cost of Option 3 and about 1.4 times the total cost of Option 4.

5.5.3 Option 3: Pedestrian bridges over Warringah Road at Starkey Street and Brown Street

Proposal objectives

This option would meet all proposal objectives with the exception of minimising environmental and community impacts (relative to other options).

Potential benefits

Option 3 would:

- Provide the second-best westbound traffic benefit on Warringah Road through the removal of two at-grade pedestrian crossings
- Improve safety for pedestrians by separating them from Warringah Road traffic, rationalising bus stops, and integrating pedestrian desire lines into urban design outcomes
- No road works would be required, which would reduce impacts on traffic during construction.
Potential impacts

Option 3 would:
- Have a major impact on utilities (second highest when compared with other build options)
- Have the highest requirement for property acquisition, potentially including full acquisition of some properties
- Have a major impact on surrounding environment (second worst when compared with other build options)
- Cause the greatest change to visual amenity through the introduction of two new pedestrian bridges into the landscape
- Have the highest ongoing maintenance costs.

Summary

This option has the greatest property impacts, particularly with regard to the Brown Street/Currie Road pedestrian bridge. It would also have the greatest relative impact on visual amenity.

This option would have fewer impacts on utilities than Option 2, because it would not involve the widening of Starkey Street.

This option has the highest total cost of the three build options and is about 1.4 times more costly than Option 2 and 1.9 times more costly than Option 4.

5.5.4 Option 4: Pedestrian bridge over Warringah Road at Starkey Street without widening of Starkey Street

Proposal objectives

This option would meet all proposal objectives with the exception of minimising environmental and community impacts relative only to the do nothing option.

Potential benefits

Option 4 would:
- Improve safety for pedestrians by separating them from Warringah Road traffic, rationalising bus stops, and integrating pedestrian desire lines into urban design outcomes
- Have the smallest requirement for property acquisition, with only one property affected
- Provide the greatest incremental traffic improvement for the lowest cost
- Have the smallest visual impact (only one new built element introduced into the landscape)
- Have the smallest impact footprint when compared with other build options
- Have the smallest impact on utilities
- Be the fastest to construct – reducing the potential impact on surrounding community
- Be the most cost effective to build and maintain
- Provide greatest flexibility for accommodating future enhancements in the area.
Option 4 would:

- Provide the lowest westbound traffic benefit on Warringah Road of the three build options (however in relative terms, there is no material difference)
- Require partial property acquisition on the northern side of Warringah Road (veterinary clinic) and potentially impact on a local feature tree
- Require the removal of a number of car park spaces in the car park on the southern side of Warringah Road, causing displacement of car parking into local area.

Summary

Option 4 would have the lowest overall impacts of the build options considered and is best able to meet the proposal objectives.

While it would provide the lowest westbound traffic benefit on Warringah Road in absolute terms, in relative terms, there is no material difference between Option 4 and Options 2 and 3 with regard to traffic improvements.

5.6 Preferred option

Through the evaluation process detailed previously, Option 4 (pedestrian bridge over Warringah Road at Starkey Street) was selected as the preferred option that would best meet the objectives of the proposal with the fewest impacts. The plan for this option is provided in Appendix B.

This option meets the objectives by:

- Improving the efficiency of westbound traffic by seven to 13 kilometres per hour in the morning peak along Warringah Road at Forestville by removing the signalised pedestrian crossing at Starkey Street and providing an increase in ‘green time’
- Reducing the average delay per vehicle on Warringah Road by about 79 seconds in morning and 32 seconds in the evening
- Supporting improvements to road-based public transport on Warringah Road by improving traffic capacity
- Improving road safety by separating pedestrians from a busy main road and reducing the risk of unsafe road crossing
- Minimising the amount of property acquisition required
- Providing the best value for money of all the options considered.

Unavoidable impacts are:

- Changed visual amenity by introducing a new pedestrian bridge
- The requirement for some property acquisition, which would impact the Forest Veterinary Hospital (noting that the current design does not directly impact on the building)
- The removal of car parking spaces in the car park to the south east of the intersection, which services the Memorial Hall and Senior Citizens Centre.
Overall, Option 4 would provide the most appropriate response to address congestion on Warringah Road in Forestville in a timely and effective manner.

It is anticipated that construction of the pedestrian bridge could predominantly be undertaken offline and/or outside of peak traffic periods, and would therefore have minimal impact on traffic.

Preliminary photomontages have been developed for the preferred option and are provided in Appendix C.
6 Next steps

6.1 Risk assessment
As part of the workshop process, Roads and Maritime completed a risk assessment to assess the potential impacts of the proposal and identify strategies to manage risks.

The workshop also identified the level of residual risk for each issue and assigned responsibilities for management and mitigation of risks.

It was recognised that circumstances can, and often do change. Therefore, it was agreed that all risk items would be reviewed regularly to determine changing risk profiles.

The risk register will be used as a management tool during subsequent stages of the proposal.

6.2 Consultation
Roads and Maritime agreed with Value/Risk Management Workshop participants to develop a consultation plan, in conjunction with Warringah Council.

This options report is available on the Roads and Maritime website. Concurrently, a community update on the proposal was prepared and distributed in December 2014.

The environmental assessment for the proposal (see Section 6.4) will be placed on public exhibition and Roads and Maritime will invite comments and feedback.

Roads and Maritime will consider all feedback as part of its determination process and document its response in a Submissions Report. The determination will include specific commitments to mitigate and manage impacts associated with the proposal.

Roads and Maritime will consult affected landowners about the required property acquisition. Once the project is approved to proceed, acquisition will be undertaken in accordance with the Land Acquisition (Just Term Compensation) Act 1999 and the process outlined in Roads and Maritime’s Land Acquisition Information Guide (Roads and Maritime 2012).

6.3 Concept design
Roads and Maritime is progressing the design of the preferred option.

An urban design specialist will be involved to ensure appropriate consideration is given to urban design issues and to facilitate the most practicable and cost effective urban design outcome.

6.4 Environmental assessment
Roads and Maritime will prepare an environmental assessment to examine the likely and potential impacts associated with construction and operation of the proposal.

Based on the current level of understanding of the proposal and related issues, the assessment would likely include specialist technical studies addressing:

- Noise and vibration
Visual impacts and urban design issues.

The proposal will be assessed under Part 5 of the *Environmental Planning and Assessment Act 1979* through the effect of State Environmental Planning Policy (Infrastructure) 2007 (ISEPP). Clause 94 of the ISEPP permits development on any land for the purpose of a road or road infrastructure facilities to be carried out by or on behalf of a public authority without consent.

Given the relatively small scale of the proposal and that the associated impacts are anticipated to be of a low to medium magnitude, the environmental assessment will comprise a Review of Environmental Factors (REF). The REF would be placed on public exhibition in the first half of 2015 and will involve a formal submissions and response process.
References


Transport for NSW (2012b) *Northern Beaches Bus Rapid Transit (BRT) Pre-Feasibility Study*, June 2012, Sydney, NSW.


Transport for NSW (2013b) *Sydney’s Bus Future*, December 2013, Sydney NSW.


Appendix A
Urban design strategy plan
Urban Design Objectives and principles

Based on the site analysis and landscape contextual considerations, a series of urban design objectives and principles have been developed in order to guide the design proposal for the bridge and its connectivity to the immediate area:

01. Retain and reinforce the urban parkway character of Warringah Road
   a. Ensure that the parkway character of Warringah Road is retained through the retention of existing trees and the planting of new trees wherever possible
   b. Carefully locate built elements and footpaths to avoid the need to remove existing trees or prevent the planting of new trees

02. Reinforce the bushland character of the area
   a. Retain the informal bush character of nearby garden beds through replanting of any cleared areas or newly created garden beds with locally occurring indigenous tree, shrub, ground cover and grass species
   b. New street tree planting should be of a locally occurring indigenous species
   c. Reinforce the definition of the intersection through strategic landscape measures such as revegetating impacted areas where applicable
   d. Minimise impacts to existing vegetation and utilise it as green buffers to new built form and urban infrastructure

03. Deliver an integrated approach to traffic management including pedestrian, cycle and public transport
   a. Provide pedestrian friendly pedestrian crossings at Warringah Road and Starkey Street carpark and to community and retail facilities on Starkey Street
   b. Ensure easy and safe connectivity to public transport modes, particularly bus stops along Warringah Road and community shuttle pickups in the Community Centre
c. Provide improved bicycle facilities including secure bicycle parking with easy access to the existing bus stop at Jamieson Square and the new footbridge

04. Retain the privacy and amenity for residents and commercial exposure for local businesses and community facilities in the immediate area
   a. Utilise existing vegetation as visual screening within new developments to retain vegetative character and minimise visual impacts. Screening should take the form of vegetative screening wherever possible as opposed to walls, solid panels and other similar materials
   b. Provide visual screening for adjacent properties, particularly to the Forest Animal Hospital and adjacent residents on Ferguson Street and Walkom Avenue
   c. Retain clear sightlines to the Forest Animal Hospital and community facilities. Consider means of highlighting the Forest Animal Hospital to west bound traffic on Warringah Road

05. Define the gateway to Killarney Heights and the Centre Shopping Village
   a. Retain the parkway character of Warringah Road through the retention of any cleared areas or newly created garden beds with locally occurring indigenous shrub, ground cover and grass species
   b. New street tree planting should be of a locally occurring indigenous tree, shrub, ground cover and grass species
   c. Provide improved bicycle facilities including secure bicycle parking with easy access to the existing bus stop at Jamieson Square and the new footbridge

06. Retain a clear structural framework for the streetscape, wayfinding and functionality of the pedestrian
   a. Rationalise wayfinding signage as part of an overhaul of signage at the intersection aimed at reducing clutter and providing clear messages to the road user
   b. Integrate the footbridge design with other future footbridges and consider existing footbridges along the corridor between Arthur Street, Forestville to the west and Wakehurst Parkway in the east

07. Design integrated urban infrastructure/landscape design elements that allow the landscape to dominate and built forms to recede
   a. Utilise existing vegetation as visual screening within new developments to retain green character and minimise visual impacts. Screening should take the form of vegetative screening wherever possible as opposed to walls, solid panels and the like
   b. Integrate the footbridge structure within the landscape setting and ensure logical pathway connections to existing footpaths and building entries
   c. The footbridge design should be in accordance with RMS guidelines and consist of clean, streamlined forms and not be overly fussy in terms of detailing. Materials and colours should be recessive in order to allow the existing landscape to dominate with selected architectural highlight colours to express dramatic forms or features of the bridge
Appendix B
Strategic design plan for preferred option
STARKEY STREET - OPTION 4
PEDESTRIAN BRIDGE AT STARKEY STREET ONLY

NOTES
1. PEDESTRIAN BRIDGE FOOTPRINT SHOWN IS INDICATIVE ONLY AND MAY CHANGE DURING DETAIL DESIGN.
Appendix C

Preliminary photomontages of preferred option
Note
1. THIS 3D VISUALISATION IS AN ARTISTS SKETCH ONLY FOR THE PURPOSE OF DISCUSSION.
2. FINAL DESIGN, LOCATION AND FINISHES OF THE BRIDGE SUBJECT TO CHANGES DURING DETAILED DESIGN.
NOTE:
1. THIS 3D VISUALISATION IS AN ARTISTS SKETCH ONLY FOR THE PURPOSE OF DISCUSSION.
2. FINAL DESIGN, LOCATION AND FINISHES OF THE BRIDGE SUBJECT TO CHANGES DURING DETAILED DESIGN STAGE.