4 Project development and alternatives

This chapter describes the various alternatives and options for the project that were considered during the project development process. It explains how and why the preferred option was selected and describes the different route, bridge, approach road, intersection and Thompson Square urban design options considered.

Director General's requirements	Where addressed
An analysis of feasible alternatives to the carrying out of the project and project justification, including: An analysis of alternatives/options considered having regard to the project objectives (including an assessment of the environmental costs and benefits of the project relative to alternatives and the consequences of not carrying out the project), and the provision of a clear discussion of the route development and selection process, the suitability of the chosen alignment and whether or not the project is in the public interest.	Chapter 4 – Describes the alternatives considered. Chapters 3 and 11 – Provide the justification for the project.

4.1 Options development and selection process

This section presents a summary of the process followed to develop, assess and select options for various components of the project including:

- The route (or alignment) of the replacement bridge.
- The approach roads and intersections.
- The bridge type.
- The design of Thompson Square.

It also provides information on when input on the options was sought from community, stakeholder groups and government agencies during the process. An integrated design approach was taken for the development of the project, involving engineers, urban designers and architects working collaboratively with environmental and heritage specialists. This approach complemented the input process from external stakeholder groups. The environmental sensitivities and constraints of Windsor and its surrounding areas have been taken into account in the design development process, with adverse impacts avoided or minimised in design to the greatest extent practicable.

Detailed information on the specific options for each of the project components is presented in **Section 4.2** to **Section 4.6**.

Project development and options assessment was staged and is summarised in **Section 4.1.1** to **Section 4.1.5**) provide more detail on each of the stages.

The stages of project development were:

- *Stage 1* - Identification of alternatives for a river crossing at Windsor and development of route options and project objectives.
- *Stage 2* - Short-listing of route options and further investigation and assessment against project objectives and criteria.
- *Stage 3* - Selection of a preferred route option.
- *Stage 4* - Development, assessment and selection of options for the existing Windsor bridge.
- *Stage 5* - Development, assessment and selection of options for the approach roads and intersection types.
- *Stage 6* - Development, assessment and selection of options for the bridge type.
- *Stage 7* - Development, assessment and selection of options for the urban design of Thompson Square and the shared pathway.

4.1.1 Development of alternatives and options for a river crossing at Windsor

In recognition of the need to address the deteriorating condition of the existing Windsor bridge, the NSW Government announced in June 2008 that it would provide funding to rehabilitate or replace this important river crossing. Four alternatives were identified for the river crossing at Windsor including:

- Do nothing and continue to maintain the existing bridge – This option would involve doing nothing except continuing the ongoing regular maintenance of the existing Windsor bridge.
- Refurbishment of the existing bridge – this alternative would involve temporarily closing the existing bridge and refurbishing elements of the bridge and approach roads to meet current design standards where possible.
- Bypass of Windsor – this alternative would involve constructing one or more bridges and associated roads to bypass the town centre of Windsor.
- Replacement bridge – this alternative would involve constructing a replacement bridge either up or downstream of the existing bridge, with traffic still being able to access the town centre directly.

RMS subsequently began investigating potential route options and, in July 2009, ten potential options were identified: two for refurbishment of the existing bridge, two for a bypass of Windsor and six for a replacement bridge. While two bypass options were identified, it was recognised that a bypass would substantially exceed the project budget. However bypass options were further developed to provide a comparison to other alternatives.

The do nothing alternative was not investigated further as it was not considered feasible because of the high costs associated with maintaining the existing bridge, the high vehicle usage and its inherent safety and flood immunity design issues. In the short to medium term, the existing bridge would further deteriorate resulting in load limits for heavy vehicles to be imposed – and eventually either total closure of the bridge to all vehicles or failure of the bridge in a flood event. Also any growth in traffic would result in further congestion and capacity issues.

The ten options considered are listed in **Table 4-1** and shown in **Figure 4-1**. Further information on each of the options is provided in **Section 4.3**.

A detailed options assessment report was prepared by RMS (RTA, 2011), which presented information on the location, performance, potential environmental impacts and costs/benefits of each option. Project objectives and criteria were also developed to allow an assessment of each of the options.

In 2011 the options assessment report was presented to the community, stakeholder groups and government agencies and their feedback on the options was obtained. The issues raised during the consultation process were documented in Chapter 6, the "Windsor Bridge over the Hawkesbury River Options Report" (RTA, 2011) and the "Windsor Bridge over the Hawkesbury River Report on Community Consultation" (RTA, 2009), which are available on the RMS website (www.rms.nsw.gov.au/roadprojects).

The Heritage Council of NSW was consulted in 2009 and identified option 9 – Refurbishment of the existing bridge as its preferred option. Their second preferences were the bypass options of Windsor (options 6 and 8). They also recommended that detailed heritage investigations and a Statement of Heritage Impact would be required especially for those options that impacted Thompson Square.

Based upon feedback from the consultation process on the options, RMS short-listed and further developed three options, namely:

- Option 1 - Replacement high-level bridge via Old Bridge Street, Windsor.
- Option 2 - Replacement low-level bridge via Old Bridge Street, Windsor.
- Option 6 - Bypass of Windsor via a new bridge parallel to Palmer Street, Windsor and a new bridge over South Creek.

Additional preliminary investigations were undertaken to assess the relative advantages and disadvantages of each short-listed option, how each option performed against the project objectives and to identify opportunities to improve project outcomes. The results of preliminary investigations were used in the development and refinement of short-listed project options and ultimately in the selection of the preferred option for the project.

The preliminary investigations considered potential adverse impacts and benefits in relation to historic heritage, Aboriginal heritage, traffic and transport, landscape and town character, and socio-economic outcomes. Construction impacts and costs were also considered.

4.1.2 Assessment of short-listed route options against project objectives

From the original six project objectives, additional criteria (as identified in Chapter 3, **Section 3.4**) were developed by RMS to provide a more comprehensive assessment of short-listed options. A comparison of each of the short-listed options against the original project objectives and criteria is provided in **Table 4-2**. The 'base case' or 'do-nothing' alternative was also assessed for comparative purposes only. The base case would include the current schedule of maintenance works required to address on-going structural deterioration of the existing bridge. Further detail on the consequences of the base case is provided in **Section 3.2**.

As shown in **Table 4-2,** option 1 performed well in terms of safety, flood immunity and long term community needs. It would increase the area of consolidated open space within Thompson Square, provide an opportunity to reinstate the typical Macquarie era grid street layout and improve the relationship between open space and the river. Option 1 also offered the best value for money. However option 1 would have a significant impact on historic heritage as it would directly impact the Thompson Square Conservation Area and remnants of the 19th century Windsor wharf. It would also have considerable visual impact from within and outside Thompson Square.

Option 2 had similar benefits to option 1, however, it would not provide an improvement in flood immunity. It would also have a significant impact on historic heritage as it would directly impact the Thompson Square Conservation Area and remnants of the 19th century Windsor wharf and have considerable visual impact from within and outside Thompson Square.

Option 6 performed well in terms of safety, traffic and transport efficiency. Option 6 would not affect the Thompson Square Conservation Area, however would have visual impacts upon other heritage items such as the Tebbutt's Peninsula House group and the Observatory. Option 6 performed poorly, however, in terms of amenity impacts on previously unaffected residential areas, increased flooding risks, and would have amenity and recreational impacts on Governor Phillip Park. The cost of option 6 was substantially higher than the other options as two bridges and a longer length of approach roads would be required.

4.1.3 Selection of the preferred route option

The selection of the preferred option by RMS was based on consideration of transport needs, heritage impacts, environmental impacts and engineering and cost constraints. The decision on the preferred option was made by considering:

- The performance of each option against the project objectives.
- The relative advantages and disadvantages of each option.
- Information on the potential impact of each option, including biophysical, heritage, community and socio-economic impacts.
- Community and government agency issues, as identified in community and agency consultation.

Option 1 (new high-level downstream bridge) was identified by RMS as the preferred option for the project. This option was found to perform best in terms of value for money and would perform well in relation to most of the project objectives (refer to **Table 4-2**).

While RMS selected option 1 as the preferred option for the replacement bridge it was recognised that there is significant opposition to this option within parts of the community (eg. Community Action for Windsor Bridge) and the Heritage Council of NSW. This opposition was due to its potential impacts on the heritage values of the Thompson Square Conservation Area and the heritage character of Windsor. While the Heritage Council of NSW and parts of the community support a bypass such as option 6, other sections of the community and the Hawkesbury City Council support option 1.

To minimise the potential heritage impacts of option 1 and to develop urban design and landuse outcomes that minimise amenity impacts and provide opportunities for use of this historic precinct, RMS undertook further refinement of the preferred option including:

- Identifying a bridge type that can be designed to minimise visual impacts and is sympathetic to the historic vistas.
- Reducing the bulk and height of the bridge and approach roads as much as possible while still retaining its functionality.
- Reducing the amount of land required in Thompson Square for the bridge and approach roads.
- Developing urban design and landuse principles and plans to minimise amenity impacts and provide opportunities for future uses of Thompson Square in conjunction with key stakeholders.

Further consultation was undertaken with the Heritage Council of NSW in 2010 on option 1. While the Heritage Council of NSW reinforced its preference for a bypass option, it identified design and mitigation measures which would need to be considered in further development of option 1. These measures were further reiterated in consultation undertaken in 2011 and included (Heritage Council of NSW letters dated 9 September 2011 and 28 October 2011):

- Urban design input, detailed design review and further heritage advice must be obtained which will allow modifications to be explored that would lower the intervention and impacts on Thompson Square'.
- Consideration should be given to reduction of the overall bulk and scale of the road embankments and increasing the permeability of the structure to prevent the imposition of a solid barrier across Thompson Square.'
- Comprehensive archaeological investigations' to identify the potential archaeological resource to identify impacts and inform detailed design'.
- Specific heritage impacts arising from construction and operation of option 1 as a result of vibration, demolition, archaeological disturbance, altered historical arrangements and access, changes to the landscape and vistas and architectural noise treatment of buildings on the State Heritage Register require assessment.

The Heritage Council of NSW concerns and requirements have been used to guide the further development of design and environmental impact assessment of the project. The design requirements are further discussed in the following sections, which included urban designers, architects and heritage specialists working collaboratively to assist the design process.

The NSW Office of Environment and Heritage (OEH) were also consulted in 2011 on potential impacts of option 1 on Aboriginal heritage and they noted that:

- The project is located "within a highly sensitive archaeological landscape feature with the potential to contain some of the oldest surviving evidence of Aboriginal life along the Hawkesbury River and in NSW" (OEH letter dated 31/10/11).
- "The alluvial terrace in the location of the proposed bridge is therefore of potentially very high [Aboriginal cultural heritage] significance" (OEH letter dated 31/10/11).

These OEH comments were reflected in the Director General's requirements for the project and have been addressed in the Aboriginal heritage impact assessment for this EIS (see **Section 7.2**).

4.1.4 Development, assessment and selection of options for the existing Windsor bridge

The existing Windsor bridge is listed on the RMS Heritage and Conservation Register as an item of State significance and has been in use for over 130 years since opening in 1874. Both community and other stakeholders such as the Heritage Council of NSW have sought for the existing bridge to be retained for pedestrians and cyclists if the refurbishment option was not the preferred option. The alternative option to retaining the existing bridge would be to demolish it. The advantages of retaining the existing bridge would include:

- Retaining a Section 170 RMS Heritage and Conservation Register listed heritage item which forms part of the heritage vistas and values of Windsor.
- Proving an additional pedestrian and cyclist link between Windsor township and Macquarie Park.

The disadvantages of retaining the existing bridge would include:

- Substantial ongoing and escalating maintenance costs as the bridge further deteriorates. While the removal of vehicles from the bridge may reduce maintenance costs in the short term, in the longer term these would be substantial as the piers and steel reinforcing in the concrete corrodes further.
- Risk to the replacement bridge if the existing bridge fails in a flood event. A failure may result in sections of the existing bridge being washed downstream causing direct physical damage to the replacement bridge. Debris from the failed bridge may also lodge underneath the replacement bridge, impeding floodwaters and causing stresses that the replacement bridge may not be designed to handle. Both scenarios could result in substantial damage to or failure of the replacement bridge.
- Increased flooding upstream of the bridges. Preliminary modelling indicates that two bridges would result in increased flooding upstream especially for floods up to the 1 in 5 year flood event. This would result in increased property damage and costs for flood mitigation works.

Hawkesbury City Council were also consulted on retaining the existing bridge and indicated that they do not want to own or maintain the existing bridge.

Based on the advantages and disadvantages of retaining the bridge, RMS decided that it was not feasible to retain the existing bridge especially due to the risk of damage to the replacement bridge and upstream flooding impacts. Therefore the preferred option for the existing bridge would be to demolish it once the new bridge is complete.

4.1.5 Development, assessment and selection of options for the approach roads and intersection types

A series of design workshops were held to further refine the design of approach roads and intersections. Attendees at these workshops included bridge and road engineers, environmental planners, heritage architects, heritage advisers, urban designers and RMS personnel. One of the key outcomes in relation to the approach roads was a reduction in the design speed from 60 kilometres per hour to 50 kilometres per hour which allowed the bridge height to be decreased, reducing its visual impact.

A number of different intersection types and lane configurations were assessed for existing and future traffic scenarios including:

- For the northern intersection:
  - Traffic lights.
  - Single lane roundabout.
  - Dual lane roundabout.
- For the southern intersection:
  - Maintain the existing roundabout.
  - Traffic lights.

The conclusions of the additional traffic modelling were that for the northern intersection a dual lane roundabout was the preferred intersection type and for the southern intersection, traffic lights were identified as the preferred option.

4.1.6 Options development, assessment and selection of a bridge type

Potential options for the bridge form were examined through a series of project team workshops and design reviews. A “Bridge Form Alternatives” report (SKM, 2012a) was produced, detailing the types of bridges considered and their advantages and disadvantages relative to key design criteria. Apart from the standard bridge design criteria relating to functionality, capacity and durability, there were a number of additional key criteria considered in comparing and assessing the bridge form options. These criteria included the ability to withstand immersion by flood waters, visual appearance, cost, construction impacts on Thompson Square, number of piers and other environmental risks and design issues.

The eight bridge form options that were considered for the replacement bridge included:

- Precast concrete plank with composite cast in situ concrete deck bridge.
- Incrementally launched bridge.
- Cast in situ balanced cantilever bridge.
- Arch bridge (with arch under the deck).
- Arch bridge (with arch above the deck).
- Truss bridge.
- Cable stayed bridge.
- Concrete cast in situ bridge.

To assist with the selection of the preferred bridge form, a Bridge Options Review Workshop was held in January 2012. The workshop involved assessing and scoring the alternative bridge form options in terms of environmental and technical criteria (See **Table 4-3**). Workshop participants included bridge and road engineers, environmental planners, heritage architects, heritage advisers, urban designers and RMS personnel. Input from the community focus group established for the project and the NSW Government Architect and an independent third party architect was also sought before making a decision on the preferred bridge option.

Based on the combined outcomes of the Bridge Options Review Workshop and input from the community focus group, the incrementally launched bridge was found to be the preferred bridge form. Key factors in the selection of this bridge form included its:

- Lower visual impact and ability to be architecturally enhanced.
- Relatively small number of piers in comparison to some of the other options.
- Ability to be constructed and launched from the northern bank, which would minimise construction impacts on Thompson Square.

4.1.7 Development, assessment and selection of options for the urban design of Thompson Square

Urban design principles were developed to guide the design process for the bridge replacement project, including Thompson Square. A series of options for the Thompson Square parkland were developed based on these principles. The options were primarily based upon around the location of paths and stairways to provide access to and around the Thompson Square parkland as well as the shared pathway across the replacement bridge.

The project team met with Hawkesbury City Council officers in March 2012 to present and discuss the possible options for the Thompson Square parkland. Feedback from Hawkesbury City Council on 3 April 2012 was incorporated into the Thompson Square options assessment. Input was also sought from the community focus group on the different options.

Based upon the community group and Hawkesbury City Council feedback, a preferred option was selected. This consisted of a shared path along the western side of the replacement bridge and two sets of stairways on either side of the Thompson Square parkland to link new and existing paths to The Terrace.

4.2 Route options development

4.2.1 Overview of route options

In July 2009 RMS identified ten potential options for a river crossing at Windsor: two options involving the refurbishment of the existing bridge, two options involving a bypass of Windsor and six for a new replacement bridge. The ten options are listed in **Table 4-1** and shown in **Figure 4-1**. Further information on each of the alternatives is provided in **Section 4.2.2**. The other option would be the ‘do nothing’ or ‘base case’ option, however as discussed in Chapter 3 this was not considered a feasible option due to the poor and deteriorating condition of the existing bridge and its critical function in providing a crossing of the Hawkesbury River at Windsor.

Table 4-1 Route options considered

Option	Route option type	Name
Option 1	New bridge	New downstream high-level bridge via Old Bridge Street, Windsor
Option 2	New bridge	New downstream low-level bridge via Old Bridge Street, Windsor
Option 3	New bridge	New bridge immediately upstream of existing bridge
Option 4	New bridge	New bridge at Baker Street, Windsor
Option 5	New bridge	New bridge at Kable Street, Windsor
Option 6	Bypass	New bridge parallel to Palmer Street, Windsor and new bridge over South Creek
Option 7	New bridge	New bridge at Palmer Street, Windsor via Court Street and North Street
Option 8	Bypass	New bridge at Pitt Town Bottoms
Option 9A	Refurbishment	Refurbishment of existing bridge to provide a 2 lane crossing
Option 9B	Refurbishment	Refurbishment of existing bridge to provide a 3 lane crossing

Apart from the refurbishment options, all other options included removing the existing bridge as the costs to repair and maintain the existing bridge would be substantial even if its use was limited to pedestrians and cyclists only. Even if repaired, the existing bridge would still have a limited lifespan due to the considerable corrosion of the iron piers below the water line and the spalling of the bridge girders. Additionally if the existing bridge failed during a flood event it may cause physical damage to a new downstream bridge or to other downstream structures such as Windsor wharf. Debris from the failed existing bridge might also be captured by a new downstream bridge, impeding floodwaters and causing stresses that result in the failure of the new bridge.

4.2.2 Description of the route options and performance against objectives

This section describes each of the ten options considered for the river crossing at Windsor, including a broad assessment against the project objectives and criteria (as defined in **Section 3.4**). The route options considered are shown in **Figure 4-1**.

Option 1 – New downstream high-level bridge via Old Bridge Street

Option 1 involves replacing the existing bridge with a new high-level bridge along the alignment of Old Bridge Street, around 35 metres downstream of the existing bridge. The southern approach to the new bridge would be via the existing alignment of Old Bridge Street on the eastern side of the Thompson Square parkland, with the existing roundabout at George Street retained in the short-term and converted to traffic lights in the future. On the northern bank of the river, a new approach road would be constructed to connect the new bridge with the existing intersection of Freemans Reach Road and Wilberforce Road. A new intersection would be constructed to manage traffic at this busy location.

Option 1 meets many of the project objectives and criteria including:

- Flood immunity – This option would provide an improved and appropriate level of flood immunity in consideration of the surrounding road network.
- Pedestrian and cyclist connections – Better and safer connections to Macquarie Park and The Terrace for pedestrian and cyclist access would be provided with this option.
- Efficient connection for local traffic - The option would provide the most direct route from Windsor Road to Freemans Reach Road via the existing road corridor and maintain direct access into the Windsor township.
- Land acquisition – The amount of land acquired for option 1 would be low in comparison to other options.
- Cost and return on investment – This option would have a low cost in comparison to other replacement options and a higher benefit cost ratio (BCR greater than 14) in comparison to option 6 (BCR about eight).

The project objectives and criteria that option 1 performs poorly against would be minimising impacts on heritage and the character of the local area. Option 1 would have a significant impact on historic heritage as it would directly impact the Thompson Square Conservation Area and remnants of the 19th century Windsor wharf. It would also have substantial visual impacts within Thompson Square and for views to and from Windsor along the Hawkesbury River.

While some heritage impacts would be unavoidable, this option would also provide an opportunity to increase the area of Thompson Square parkland and connections to surrounding areas. Specifically, by removing the existing bridge approach road that runs through the Thompson Square parkland, it would consolidate the currently divided open space and improve pedestrian connections to the river. This increase and reconfiguration of the open space, in conjunction with the urban design and landscaping treatments and heritage management measures described in this EIS, would provide an opportunity to increase the area for public use and address the heritage values of the area.

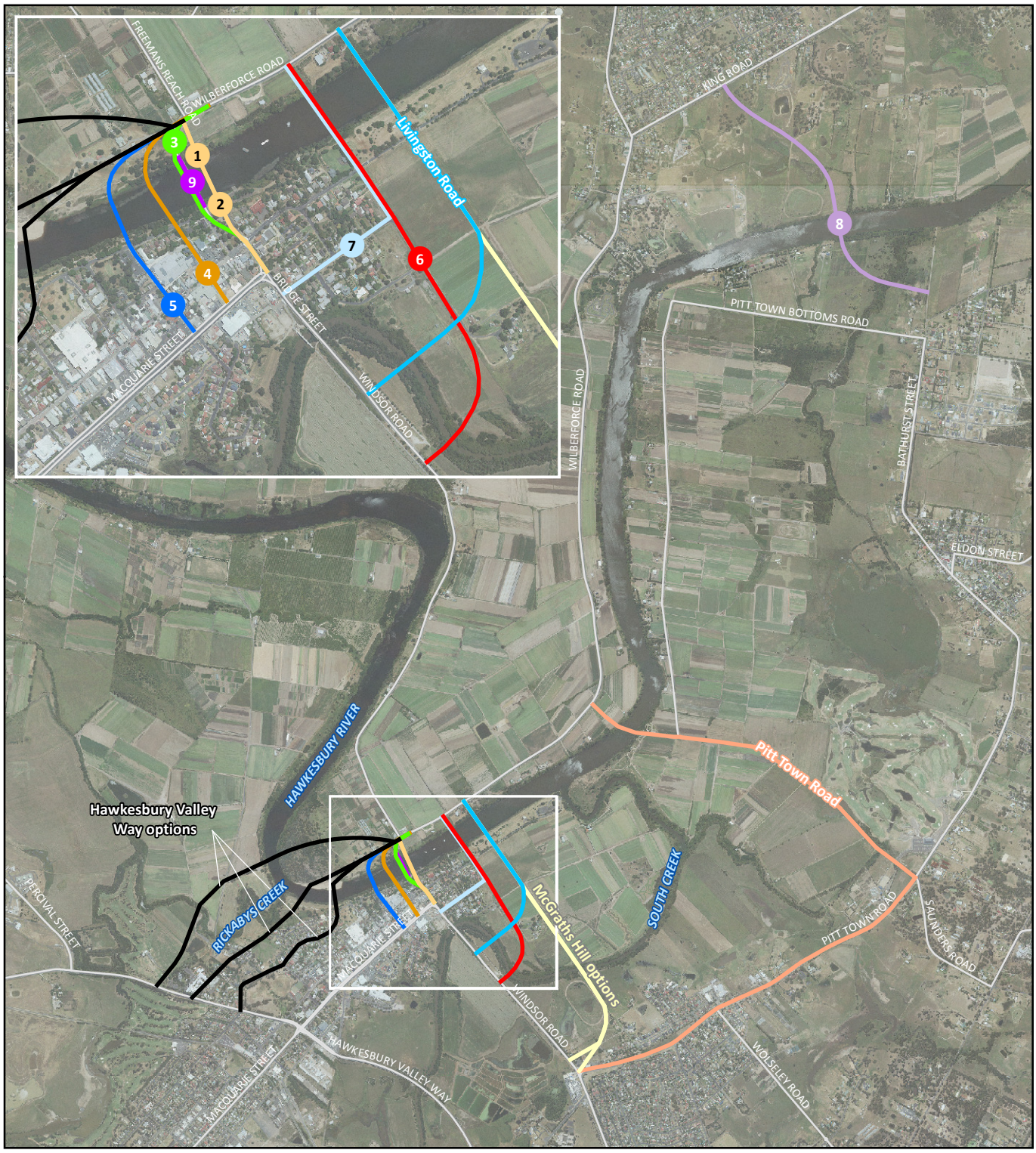
Option 2 – New downstream low-level bridge via Old Bridge Street

As for option 1, option 2 would involve providing a replacement bridge along the alignment of Old Bridge Street, around 35 metres downstream of the existing bridge. The primary difference between option 1 and 2 would be in the height of the replacement bridge, with option 2 involving a low-level bridge in contrast to the high-level bridge of option 1.

This option would be similar to option 1 in terms of meeting project objectives and criteria, with a couple of notable differences. Direct impacts on heritage would be similar to option 1, although the low-level bridge would have a lesser visual impact on the overall heritage character of the Windsor township. However the low-level of the bridge would not have flood immunity to match the flood immunity of the approach roads and hence would not provide any improvement in access during minor flood events. Additionally, this option prevents an extension of The Terrace under the new bridge to allow access of vehicles to Windsor Wharf.

The need to provide a crossing that matches the flood immunity of the surrounding roads is one of the project objectives and the failure of option 2 to meet this objective is a disadvantage.

Figure 4-1 | Windsor Bridge replacement options



Indicative only – subject to detailed design

LEGEND

Bridge replacement options

RMS options

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9

Community options

- Hawkesbury Valley Way options
- Livingston Road
- McGraths Hill options
- Pitt Town Road

Major road

GDA 1994 | MGA Zone 56

A4 1:36,000

0 1

Kilometre

AUSIMAGE SKM

Option 3 – New bridge immediately upstream of existing bridge

Option 3 would replace the existing bridge with a new bridge that primarily follows the existing alignment of Bridge Street through Thompson Square, around 10 metres upstream of the existing bridge. This option would maintain the existing roundabout at George Street and the current alignment of Bridge Street. It would create a curved bridge that meets the existing alignment of Wilberforce Road. Advantages of option 3 with respect to the project objectives include:

- Pedestrian and cyclist connections – Better and safer connections to Macquarie Park and The Terrace for pedestrian and cyclist access would be provided with this option.
- Efficient connection for local traffic - The option would provide a direct route from Windsor Road to Freemans Reach Road via the existing road corridor and maintain direct access into the Windsor township.
- Land acquisition – The amount of land acquired for option 3 would be low in comparison to other options.
- Cost and return on investment – This option would have one of the lowest costs, and higher return on investment, although it would cost more than option 1 and would have a lower benefit cost ratio.

While option 3 meets many of the project objectives and criteria, it would create significant disruptions to traffic and the community during construction due to the proximity of the replacement bridge to the existing bridge. These disruptions would potentially include closing the existing bridge for up to three months during construction of the new bridge, which would require traffic to be diverted to the Richmond Bridge (about a 20 kilometre road detour). Option 3 would have higher impacts on the heritage values of the Thompson Square Conservation Area compared to options 1 and 2 as it would encroach on the Doctors House as well as having similar visual impacts on historic vistas. Unlike option 1 and 2, option 3 would not provide the opportunity to improve Thompson Square parkland by uniting the currently bisected parkland.

Option 4 – New bridge at Baker Street

Option 4 involves replacing the existing bridge with a new bridge along the alignment of Baker Street, Windsor. The new bridge would be around 70 metres upstream of the existing bridge and would connect Baker Street to existing roads in Macquarie Park on the northern bank of the Hawkesbury River. Advantages of this option with respect to the project objectives include:

- Providing improved bridge flood immunity.
- Improving pedestrian and cyclist access and safety across the bridge to Macquarie Park.

However it would not meet many of the other project objectives and criteria such as:

- Traffic and transport efficiency – The high volumes of traffic using the bridge would need to use Baker Street and cross George Street to access Macquarie Road. This would cause local congestion and poor traffic performance.
- Meeting long-term community needs - The high volumes of traffic using Baker Street would have negative impacts on the business and shopping environment, background noise levels and pedestrian safety. There would also be the loss of recreational space in Macquarie Park and additional land may need to be acquired along Baker Street.
- Impact on the heritage and character of the local area – Baker Street contains heritage listed buildings and the heritage vista of this relatively quiet street would be negatively impacted.
- Cost effectiveness and affordable – This option would be more expensive than some other options due to land acquisition and longer approach roads.

This option would split the town centre in half resulting in a high severance impact.

Option 5 – New bridge at Kable Street

Option 5 is similar to option 4 and involves replacing the existing bridge with a new bridge along the alignment of Kable Street, Windsor. The new bridge would be around 170 metres upstream of the existing bridge and would connect to existing roads in Macquarie Park on the northern bank.

As for option 4, option 5 would meet some of the project objectives (including providing improved bridge flood immunity and improved pedestrian access and safety across the bridge) but it would score poorly against many of the other project objectives and criteria such as:

- Traffic and transport efficiency – The high volumes of traffic using the bridge would need to use Kable Street and cross George Street to access Macquarie Road. This would cause local congestion and poor traffic performance.
- Meeting long-term community needs - The high volumes of traffic using Kable Street would have negative impacts on the business and shopping environment, background noise levels and pedestrian safety. There would also be the loss of recreational space in Macquarie Park.
- Impact on the heritage and character of the local area – Kable Street contains heritage listed buildings and the heritage vista of this relatively quiet street would be negatively impacted.
- Cost effectiveness and affordable – This option would be more expensive than some other options due to land acquisition and longer approach roads.

This option would split the town centre in half resulting in a high severance impact.

Option 6 – New bridge parallel to Palmer Street and new bridge over South Creek

Option 6 would involve replacing the existing bridge with a new bridge around 400 metres downstream of the existing bridge. Option 6 would include a new signalised T-intersection on Windsor Road north of Pitt Town Road, a bridge over South Creek, a 1.2 kilometre road parallel to Palmer Street and through Governor Phillip Park, a new bridge over the Hawkesbury River and a new T-intersection on Wilberforce Road. This option would meet many of the project objectives and criteria including:

- Providing improved bridge flood immunity.
- Improved traffic and transport efficiency – It would provide an efficient regional traffic connection with minimal delays and queues.
- Protecting the built heritage of the town and its setting – through avoiding heritage impacts on Thompson Square Conservation Area and surrounding heritage buildings.
- Minimising property access impacts – There would be no properties which would experience a deterioration in permanent access.

While this option meets many project objectives, it would not achieve other project objectives and criteria such as:

- Cost effective and affordable outcomes – This would be one of the most expensive options with a capital cost of about double that of options 1 and 2. It would far exceed the budget allocated to the project and the cost of the option does not provide value for money in comparison to other options despite the positive aspects associated with this option.
- Noise impacts – While there would be a reduction in noise impacts on the already exposed sensitive receivers around Thompson Square, there would be new noise and amenity impacts on residents living near Palmer Street, who are not currently exposed to noise from busy roads.
- Local traffic access – The efficiency of local traffic connections to the township of Windsor would be reduced.
- Impacts on recreational areas – The recreational amenity of Governor Philip Park would be impacted and there may be impacts on boating activities that are held regularly in the waters directly adjacent to Governor Philip Park. Access to Windsor Wharf by larger boats would be affected due to the height restrictions of the downstream bridge.
- Impacts on Aboriginal and historic heritage - This option was not preferred by Aboriginal stakeholders due to its potential impact on cultural and archaeological sites. However it should be noted that no detailed studies on potentially impacted sites have been undertaken. There would also be a number of heritage listed buildings potentially impacted such as the Tebbutt's Peninsula House group and the Observatory.

Option 6 would have a negative impact on residents who live along the route of the new bridge approach road and have chosen their location of residence on the basis that it is not on a busy road. The lifestyles of these residents have the potential to be impacted by the construction and operation of the new road.

Option 7 – New bridge at Palmer Street via Court Street and North Street

Option 7 would involve replacing the existing bridge with a new bridge at the end of Palmer Street. Traffic would access Palmer Street and the new bridge via Court and North Streets. A new signalised intersection would be installed at the corner of Windsor Road and North/Court Street, establishing the southern approach route to the bridge and a new T-intersection would be installed where the bridge connects to Wilberforce Road. This option would meet some of the project objectives and criteria including:

- Providing improved bridge flood immunity.
- Protecting the built heritage of the town and its setting – through avoiding heritage impacts on Thompson Square and surrounding heritage buildings.

While this option meets a number of the project objectives, it would not achieve other project objectives and criteria such as:

- Increased noise impacts – While there would be a reduction in noise impacts on the already exposed sensitive receivers around Thompson Square, there would be new noise and amenity impacts on residents living along Palmer, Court and North Streets, who are not currently exposed to busy roads.
- Reduction in local traffic access – The efficiency of local traffic connections to the township of Windsor would be reduced.
- Impacts on recreational areas – Recreational amenity of Governor Philip Park would be impacted and there may be impacts on boating activities that are held regularly in the waters directly adjacent to Governor Philip Park. Access to Windsor Wharf by larger boats would be affected due to the height restrictions of the downstream bridge.
- Impacts on Aboriginal and historic heritage - This option was not preferred by Aboriginal stakeholders due to its potential impact on cultural and archaeological sites. However it should be noted that no detailed studies on potentially impacted sites have been undertaken. There would also be heritage impacts, in particular on the North Street Conservation Area and Court House. These may include direct impacts from construction activities (eg. vibration, road widening) and amenity impacts from the operation and visual appearance of the road.

Option 8 – New bridge at Pitt Town Bottoms

Option 8 would involve replacing the existing bridge with a new bridge located at Pitt Town Bottoms and connecting to Wilberforce, around six kilometres downstream of the existing bridge. There would be no bridge crossing of the Hawkesbury River at Windsor if this option was implemented.

From the southern approach, traffic would be diverted down Pitt Town Road at the intersection with Windsor Road and would travel along Pitt Town Road onto Bathurst Street and Punt Road. A new viaduct or low embankment would be provided to extend Punt Road across Bardenarang Creek and the adjacent Hawkesbury River floodplain. On the northern bank of the Hawkesbury River, the bridge would intersect with King Road at a T-intersection. Traffic would turn left (westbound) into King Road and intersect with Wilberforce/Singleton Road at the existing T-intersection at Wilberforce. The new bridge would not provide pedestrian access given the isolation of the crossing from populated areas.

Option 8 meets some of the project objectives and criteria, including providing improved bridge flood immunity and minimising impacts on historic heritage in Windsor. This option does not meet some key project objectives and criteria including:

- Providing an efficient connection for local traffic – This option would remove the historical direct link between the southern and northern sides of the river at Windsor and result in a nine kilometre detour of the Windsor township. This would have adverse effects on local residents and businesses, as well as significantly changing the character of Windsor.
- Impacts on recreational areas - Establishment of new in-water structures (bridge pylons) in a part of the river used extensively by recreational boaters for high-speed water skiing activities.
- Impact on heritage – heritage vistas and historic heritage items in the Pitt Town area would be impacted. The location also has significance as a place of contact between the Aboriginal community and European explorers.
- Cost effective and affordable outcomes – This would be the most expensive option with a capital cost of about three times that of options 1 and 2. It would far exceed the budget allocated to the project and would not provide value for money.

Option 9A & 9B – Refurbishment of existing bridge

Refurbishing the existing bridge would require extensive works to achieve current road design standards and stabilise the structural deterioration. The refurbishment option comprises two sub-options (option 9A and option 9B) corresponding to different refurbishment methods.

Option 9A – Refurbishment of existing bridge to provide a two lane crossing

Option 9A would:

- Not require the removal or the replacement of the existing bridge deck.
- Retain the existing narrow lane widths on the current bridge.
- Replace the bridge joints, concrete the bridge deck, install deck drainage and beams and add additional steel girders between the existing concrete beams. The cast iron piers would require strengthening by concrete encasement.
- Close the existing bridge for three months during the refurbishment.

Option 9B – Refurbishment of existing bridge to provide a three lane crossing

Option 9B would:

- Remove and replace the existing bridge deck and existing superstructure. The rubble in the existing cast iron casings would be drilled out and replaced with a reinforced concrete infill to create permanently cased bored piles.
- Refurbish the bridge superstructure to include a head stock, beams and decking that would accommodate a wider road platform.
- Require closing the bridge for twelve months during the refurbishment.

Both options would have only minor heritage impacts on Thompson Square. However, these options are not preferred as they do not meet key project objectives and criteria. In particular, it is not considered to be cost-effective, with the cost of refurbishing the existing bridge for a 25 year life span likely to exceed $18 million (for option 9A), not including the community costs that would be incurred during the refurbishment period as a result of closure of the bridge and the need for road detours. Furthermore, refurbishing the existing structure would not improve its flood immunity. Traffic access during flood events would remain unchanged from existing conditions and the bridge would continue to be exposed to the same level of flood damage.

Community options

As a result of the display of the initial ten options developed by RMS and through the community focus group, a number of additional options were suggested by community stakeholders.

Livingston Road options

These options are a variation of option 6. One alternative suggested begins with a new signalised T-intersection on Windsor Road, north of Pitt Town Road, to then travel east by a new bridge across South Creek. It then runs parallel and to the east of Palmer Street along intended Livingston Road, proceeding to a new bridge over the Hawkesbury River, intersecting with Wilberforce Road at a T-intersection. Another variation on this option (McGraths Hill option) had a road starting at the Pitt Town Road and Windsor Road intersection or near to it, a bridge crossing South Creek and then a similar route to the route described above.

These options would have similar performance in meeting the project objectives and criteria as option 6 but would have the benefit of reducing impact on properties closer to Palmer Street. However, these options would not meet the project criterion to minimise the impacts on recreational areas as they would have greater impact on the boating activities which are regularly held in the waters directly adjacent to Governor Philip Park and would also split Governor Philip Park in half. A single span bridge across the Hawkesbury River was also suggested by the community to mitigate impacts on boating activities (the Sustainable Bypass option). While this would mitigate some of the impacts on recreational boating, the cost of a single span bridge would be substantial and would not be justified.

In response to this suggestion, RMS made a concerted effort to address some of the concerns by slightly modifying option 6 during the detailed options assessment in 2011. Accordingly, the option 6 route was marginally shifted to the eastern side of Palmer Street and direct access to Palmer Street was removed. A small landscape mound was proposed between the new alignment and Palmer Street to minimise traffic noise. This would to some extent meet the intention of the Livingston Road proposal as raised in the community response. However, the other issues such impacts on Governor Phillip Park, impacts on boat users and the overall cost of this option would still not be addressed.

Pitt Town Bottom Road option

This option begins at the intersection of Pitt Town Road and Windsor Road, then travels east along the existing alignment of Pitt Town Road/Pitt Town Bottom Road and then across the Hawkesbury River to intersect with Wilberforce Road. However, while this option would meet the project objectives and criteria for traffic and transport efficiency and historic heritage impacts, it would not meet other project objectives and criteria relating to Aboriginal heritage, flood immunity, property acquisition and local pedestrian and traffic access. This option would also substantially exceed the project budget.

Hawkesbury Way option

Three potential options were identified with bridges proposed upstream of the existing bridge and access provided from Hawkesbury Valley Way. Two of the options would begin at the intersection of Freemans Reach Road and Wilberforce Road with a road through Macquarie Park, a bridge across the Hawkesbury River from Macquarie Park to Howe Park and then a connection to The Hawkesbury Way via either The Terrace and Moses Street or across Primrose Place, Greenway Crescent and Rum Corps Lane. While these two options would meet project objectives for heritage by maintaining heritage values of Thompson Square, neither would meet other project objectives and criteria with respect to impacts on recreational areas and from noise.

A third option would similarly begin at the intersection of Freemans Reach Road and Wilberforce Road, but would follow a different alignment through the centre of Macquarie Park instead of spanning the beach areas as proposed in the former two variants. The alignment would then cross the Hawkesbury River from Macquarie Park to Deerubbun Park. While the river is narrow at this location the bridge structure would be need to begin from within Macquarie Park due to the topography and geology of the eastern bank. The alignment would continue almost parallel with the access road for the playing field car park, cross Rickabys Creek on a second bridge crossing and extend between a resort and a golf club to connect with Hawkesbury Valley Way at a new intersection.

While this third Hawkesbury Valley Way option would meet project objectives for heritage and safety, it is anticipated to only partially meet the traffic objective unless a number of additional significant improvements were made to the surrounding traffic network.

The community stakeholders who suggested the Hawkesbury Valley Way options also proposed an alternative option for refurbishment of the existing Windsor bridge. The scope of refurbishment proposed under this option differed from that proposed under options 9A and 9B above. It would employ different strengthening methods that would allow the bridge to be retained for light vehicles only. Refurbishment under this option would be less expensive than options 9A and 9B, however like those options it would necessitate temporary closures of the bridge.

Benefits to traffic efficiency and pedestrian safety within Windsor would be expected due to a reduction in the number of vehicles travelling through the area and impacts on Thompson Square and the existing Windsor bridge would be reduced. However, the option would impact on the local character of the area along the proposed route, including a number of recreational areas and businesses. Further, it would not meet the cost objective, with high costs associated with two bridge structures and considerable property acquisition. Significant adjustments to the surrounding road network would also be required and these could included new traffic signals, road widening with associated property acquisitions, bridge rehabilitation/replacement, utility adjustments and adjustments to drainage.

Bridge Road tunnel option

This option would involve a tunnel under George Street, connecting Bridge Street between the area south of Macquarie Street and the southern approach road to the new bridge. “Cut and cover” construction would be likely to be required, involving extensive widening of Bridge Street. This would necessitate the acquisition and demolition of most properties on Bridge Street between Macquarie Street and the Hawkesbury River.

While this option would meet the project objective to improve safety for motorists, pedestrians and cyclists by creating a grade separated crossing of George Street, it would not improve traffic efficiency. Substantial traffic impacts are anticipated as a result of changes in the operation of Macquarie Street intersection. An alternative option involving removing vehicle access between George Street and Bridge Street may reduce the amount of acquisition and demolition required but would result in an unacceptable reduction in traffic efficiency at this intersection and on surrounding roads. Further, construction activities would require extensive road closures in the area, including the Windsor bridge over the Hawkesbury River for around two years. This would impact local and regional traffic, placing additional traffic loads on the North Richmond crossing of the Hawkesbury River.

The option would also not meet heritage, flood and cost objectives. Direct impacts on numerous heritage items along Bridge Street would be anticipated as well as subsurface archaeological impacts. It is estimated that the cost of a tunnel would be significantly more than the cost of the project.

4.2.3 Consultation, assessment and selection of the preferred route option

Information on details, impacts and costs of each of the options were presented to the community, stakeholder groups and government agencies to obtain feedback. Further details of the issues raised during the consultation process can be found in Chapter 6 of this document the “Windsor Bridge Options Report” (RTA, 2011) and the “Community Consultation Report” (RTA, 2009a), which are available on the RMS website (www.rms.nsw.gov.au/roadprojects).

While RMS did not request that the community nominate a preferred option, many of the submissions identified one or more preferred options for the replacement bridge. The three most preferred options were options 1, 2 and 6. However, many submissions were opposed to options 1 and 2 because of their potential impact on Thompson Square and the heritage values and vistas of Windsor. Many submissions were opposed to option 6 due to new amenity impacts on previously unaffected residential areas and the potential economic impacts of a bypass of the town centre.

Following the community information sessions, a government agency workshop was held to consider the issues and concerns relating to each option. The workshop was held on 18 September 2009 and was attended by Hawkesbury City Council, the then NSW Maritime (now RMS), the Heritage Branch of the NSW Office of Environment and Heritage, and the Government Architects Office. The workshop participants identified project objectives, considered the positive and negative aspects of each option and identified opportunities to improve project outcomes, particularly in terms of visual amenity and urban design, heritage, traffic and impacts on the Windsor community. The workshop participants recommended that options 3, 4, 5, 7, 8 and 9 not be considered further as they did not meet one or more of the project objectives. They also recommended that further work on short-listed option 1, 2 and 6 were required before a preferred option could be recommended.

Given that there is little or no support for the other options (ie options 3, 4, 5, 7, 8 and 9), they were not further developed and are not further discussed in the EIS.

A comparison of each of the short-listed options against the project objectives and criteria is provided in **Table 4-2**).

While option 1 was selected as the preferred option for the replacement bridge by RMS, it is recognised that there is significant opposition to this option within parts of the community and from the Heritage Council of NSW due to its potential impacts on the heritage values of Thompson Square and the heritage character of Windsor. To minimise these potential impacts and to develop urban design and landuse outcomes that enhance the amenity and use of this historic precinct, RMS has undertaken further development of the preferred option which is discussed in the following sections.

4.3 Road and approach road alignment and intersection options

A series of design workshops were held to further refine the preferred option, including the design of approach roads and intersections. Attendees at these workshops included bridge and road engineers, environmental planners, heritage architects, heritage advisers, urban designers and RMS personnel. One of the major focuses of the design workshops was to minimise the impact of the preferred option for the replacement bridge on the:

- Heritage values of Thompson Square and its surrounds.
- Heritage vistas from the Windsor township and from the northern bank of the Hawkesbury River.

It was agreed at the workshops that the two main methods for achieving these outcomes were to:

- Lower the bridge and approach road relative to the surrounding landforms to minimise the visual intrusiveness of the replacement bridge (see **Section 4.3.1)**.
- Select a bridge type that was designed to be sympathetic to its surrounding heritage environment (refer to **Section 4.4** for discussion of bridge options considered).

The second focus of the workshops was to identify the preferred options for the intersections where the new bridge and approach roads connect to the existing road network. The preliminary concept design developed by RMS identified that:

- The southern approach road intersection (at the corner of Old Bridge Street and George Street) would remain a roundabout until growth in traffic numbers required the installation of traffic lights to maintain an acceptable level of service.
- The northern approach road intersection (at the intersection of the northern bridge approach road, Macquarie Park access road, Freemans Reach Road and Wilberforce Road) would have traffic lights controlling movements.

These intersection types were reviewed and changed as part of developing a more detailed concept design (see **Section 4.3.2**).

Table 4-2 Performance of the options against the project objectives

Objectives (in bold) and component criteria	Performance against the project objectives			
	1	2	6	Do nothing
To improve safety for motorists, pedestrians and cyclists				
Meets the various design codes	★★	★★	★★	
Meets a road speed of 60 km/h*	★★	★★	★★	
Ensures pedestrian safety	★★	★★	★★	★
To improve traffic and transport efficiency				
Minimises queue length/delays	★★	★★	★★★★	
Improves performance of road network	★★	★★	★★	
Enables two heavy vehicles to pass on the bridge without waiting	★★	★★	★★	
Improves load capacity of the crossing to meet current load standards	★★	★★	★★	
To improve the level of flood immunity				
Provides a crossing that has a higher level of flood immunity than the existing bridge	★★★	★★	★★	
Provides a crossing with a flood immunity that is compatible with the surrounding approach roads	★★★★	★★	★★	
To meet long term community needs				
Provides an efficient connection for local traffic	★★★	★★★	★★	★★
Provides an efficient connection for regional traffic	★★	★★	★★★★	★
Provides a pedestrian and cyclist connection to surrounding locations	★★★	★★★	★★	★★★
Minimises impacts on recreational spaces	★★	★★	★★	★★
Minimises impacts of noise	★★★	★★★	★	★★★
Minimises impacts to businesses and the shopping environment	★★	★★	★★	★★
Minimises impacts on property access	★★	★★	★★★★	★★★★
Minimises need for acquisition	★★★	★★★	★★	★★★★
Provides a 100 year life span for the bridge	★★	★★	★★	
To minimise the impact on heritage and the character of the local area				
Minimises impact on Aboriginal and non-Aboriginal heritage and conservation areas			★★	★★
Protects the town built heritage and its setting	★	★	★★★	★★★
Minimises visual impact and impacts on the character of local area	★	★	★★	★★★
To be a cost effective and an affordable outcome				
Provides a cost effective solution - capital cost	★★★	★★★	★	★★★★
Provides a cost effective solution - maintenance	★★★	★★★	★★★	
Provides a cost effective solution - investment on return	★★★	★★★	★★★	
Minimises the impact of construction in regards to length and timing	★★★	★★★	★★★	★★

Worse performance				Better performance
	★	★★	★★★	★★★★

*Note: The design speed limit was changed to 50 kilometres per hour to allow a reduction in the height of the bridge (see **Section 4.3.1**).

4.3.1 Bridge and road alignment options

To lower the bridge and approaches relative to surrounding landforms (while still improving its flood immunity) required a modification to one of the primary design criteria for the project, namely the design speed for the replacement bridge. Reducing the design speed from 60 kilometres per hour to 50 kilometres per hour would allow the southern approach road through Thompson Square to be lowered closer to the existing ground levels. This would still meet road safety requirements and improve flood immunity. Workshop participants agreed this modification should be considered to minimise the impacts of the project on the heritage values and vistas of Thompson Square and Windsor.

Based upon this recommendation from the design workshop participants, RMS revised the design speed for the replacement bridge to 50 kilometres per hour. It was also considered that a lower design speed limit would be more appropriate given that the speed limit along many of Windsor's streets is 50 kilometres per hour. The reduction of the design speed to 50 kilometres per hour allowed the southern approach road through Thompson Square to be lowered compared to a design based upon 60 kilometres per hour. The change in the height of the replacement bridge as a result of lowering design speed limit is shown in **Figure 4-2**.

Further reductions in the height of the new bridge and approach road were investigated but were not considered to be feasible, as there needs to about 3.6 metres of under bridge clearance on the southern side to allow small coaches, service vehicles and emergency vehicles to access Windsor Wharf. While The Terrace could be lowered to achieve the required clearance under the replacement bridge this was considered undesirable due to the potential disturbance of terrestrial and maritime archaeological sites and a steeper access road the wharf car park.

4.3.2 Intersection options

The RMS preliminary concept design proposed a signalised intersection at the northern end of the replacement bridge and retaining the existing roundabout at the southern end of the replacement bridge (ie the corner of Bridge and George Streets). This roundabout would eventually be replaced by traffic lights when growth in traffic numbers resulted in an unacceptable level of service at the intersection.

These intersection types were reviewed during the design development process to:

- Ensure that they provided an acceptable level of service both when the replacement bridge was initially opened and into the future.
- Assess new traffic information collected in early 2012.
- Identify the optimal intersection type in terms of traffic and pedestrian safety.

A number of different intersection types and lane configurations were assessed for existing and future traffic scenarios including:

- For the northern intersection:
  - Traffic lights.
  - Single lane roundabout.
  - Dual lane roundabout.
- For the southern intersection:
  - Maintain the existing roundabout.
  - Traffic lights.

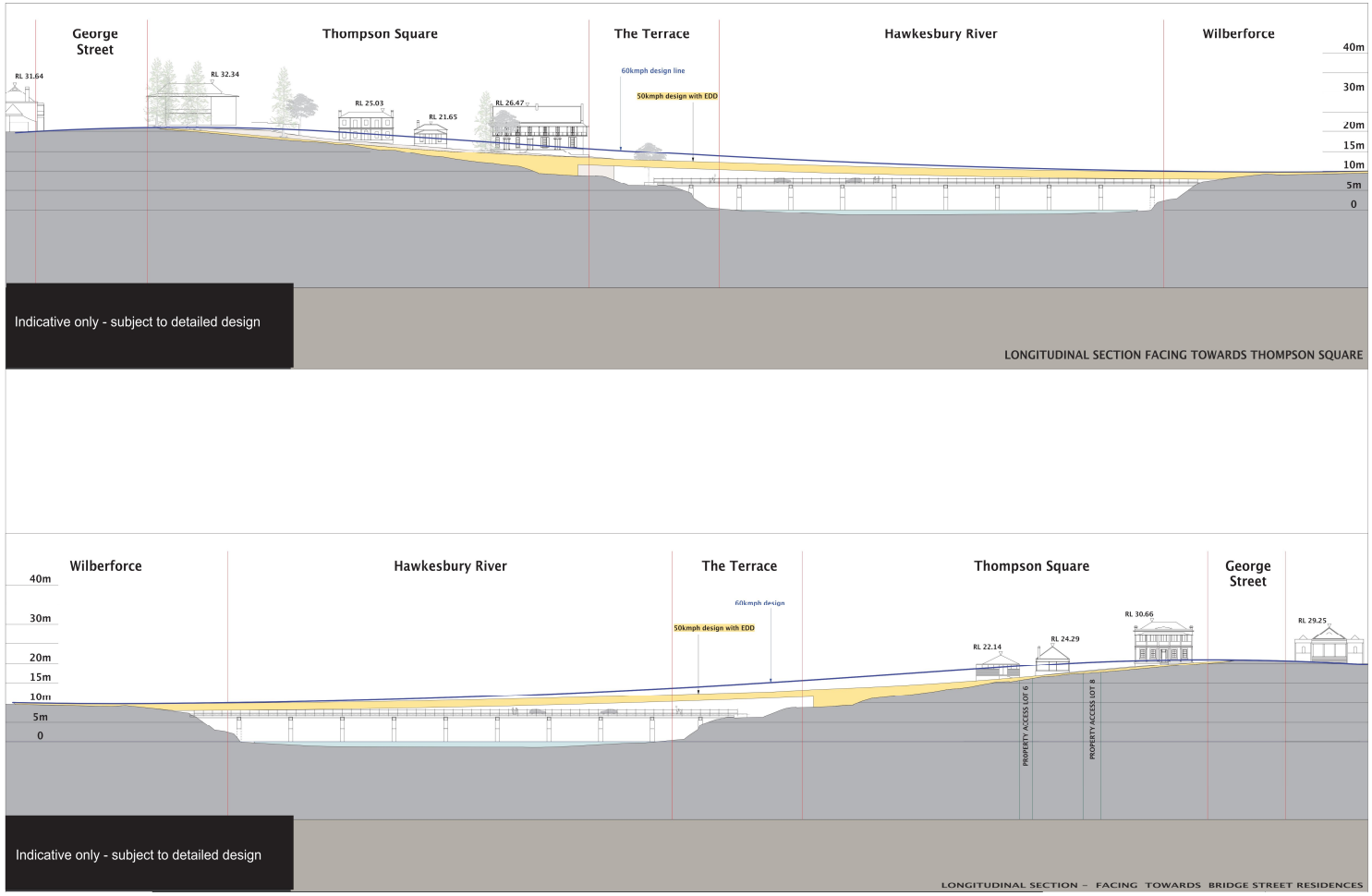


Figure 4-2 Replacement bridge elevations for 60 and 50 kilometre per hour design speed limits

The conclusions of the additional traffic modelling were that for the northern intersection a dual lane roundabout was the preferred intersection type. While traffic lights would provide similar traffic outcomes to a dual lane roundabout, operating and maintaining traffic lights in the floodplain adjacent to the bridge was undesirable and costly as they would be subject to frequent immersion by floodwaters. While a dual lane roundabout would require more land than traffic lights it would be cheaper both to construct and maintain in the longer term. A single lane roundabout would not provide an acceptable level of service especially for morning peak traffic from Wilberforce Road.

The roundabout would also act as a traffic calming device as motorists enter the 50 kilometres per hour zone. It also provides a visual entry point into the township of Windsor.

For the southern intersection, traffic lights were identified as the preferred option, rather than maintaining the existing roundabout in the short term. Traffic lights would result in improved levels of service for traffic from all directions in all peak periods. The provision of a signalised intersection at the corner of Bridge and George streets also addresses the concern of pedestrian safety raised during community consultation. The existing roundabout has no designated pedestrian crossings of Bridge/Old Bridge Street at the intersection, making access across this intersection difficult and dangerous. With a signalised intersection, pedestrian crossing of the intersection would be catered for and made safer. This was considered an important outcome as most of the local hotel accommodation and Governor Phillip Park is located on the eastern side of Windsor and pedestrian traffic from this area is required to cross Bridge/Old Bridge Street for direct access to the Windsor town centre.

4.4 Bridge options

A series of preliminary concept designs for the replacement bridge were developed to determine a preferred bridge type for the replacement bridge. Based on advice from the heritage architect and urban designers, it was considered desirable to have a straight (rather than curved) bridge option as perpendicular to the river banks as possible. This allowed consideration of a wide range of bridge types. Eight bridge options were considered:

- Bridge option 1 - Precast concrete plank with cast in situ concrete deck bridge.
- Bridge option 2 - Incrementally launched bridge.
- Bridge option 3 - Cast in situ balanced cantilever bridge.
- Bridge option 4 - Arch bridge (with arch under the deck).
- Bridge option 5 - Arch bridge (with arch above the deck).
- Bridge option 6 - Truss bridge.
- Bridge option 7 - Cable stayed bridge.
- Bridge option 8 – Concrete cast in situ bridge.

4.4.1 Assessment criteria for bridge options

Apart from the standard bridge design criteria relating to functionality, capacity and durability, there were a number of additional key criteria considered in comparing and assessing the bridge options. These criteria were as follows:

- The suitability of the bridge type to undergo regular immersion by flood waters - some bridge types were found to be unsuitable for regular immersion by flood waters for the following reasons:
  - Some bridge types (eg cantilever bridges) would be buoyant (ie have a tendency to float) because of the presence of voids in the superstructure. This would result in unacceptable stresses on other elements of the bridge and increase the risk of failure.
  - Some bridge types (eg arch bridges) would potentially capture significant quantities of flood debris, resulting in increased stress on other elements of the bridge and greater maintenance requirements.
  - Some bridge types (eg truss bridges) would need to be constructed predominately of materials that are not suitable for regular immersion, such as steel (which would undergo increased corrosion with regular immersion).
- The visual appearance of the bridge, including:
  - The ability of the bridge type to reflect the heritage values of Windsor.
  - The bulk and direct visual impact of the bridge type on heritage vistas.
- Number of piers in the river – minimising the number of piers in the river was considered beneficial for boating and other water-based recreational activities as well as minimising visual impact.
- Construction impacts on Thompson Square – some bridge types would require greater disturbance or use of Thompson Square during construction.
- Other environmental risks – some bridge types would take longer to build or pose greater environmental risks during construction. This is specifically of concern for the project due to the higher possibility of the bridge undergoing immersion by flood waters during the construction period.
- Other issues – such as the complexity of design and construction, ability to accommodate services, maintainability and flexibility in road geometry.
- Cost – some bridge types were considerably more expensive than other options.

4.4.2 Assessment of bridge options

Each of the eight bridge options and their relative performance against the assessment criteria are described in greater detail in the following sections and summarised in **Table 4-3**.

Table 4-3 Relative performance of bridge structure options against key criteria

Criteria	Bridge structure options							
	Precast concrete plank bridge	Incrementally launched bridge	Balanced cantilever bridge	Arch bridge (under the deck)	Arch bridge (above the deck)	Truss bridge	Cable stayed bridge	Concrete cast in situ bridge
Flood performance operation	★★★★	★★★		★		★		★★★
Impact on flood levels	★★	★★						★
Bridge aesthetics	★	★★★	★	★★★★	★★	★	★	★★★★
Compatibility to Windsor		★★	★	★★★	★			★★★★
Impact on vistas/views		★★★	★	★★★	★★			★★★★
Abutment built form	★★	★	★	★★	★★	★★	★★★	★★★
Enhances water-based activities	★	★★	★★★	★★★	★★★	★★	★★	★★
Design/construct complexity	★★★★	★★★	★	★	★	★		★
Construction impact Thompson Square	★★	★★★		★★	★★	★★★	★	
Construction period	★★★★	★★★	★★	★★	★★	★★★	★	★★
Flood performance construction	★★★	★★		★	★	★★		
Maintainability	★★★★	★★	★★★	★	★★	★		★★
Flexibility in road geometry	★★★	★	★★	★★	★★	★	★	★★★★
Ability to include services		★★★	★★★★	★★	★	★★	★★	★★
Flexibility for future changes	★★★	★	★★	★		★		★★
Cost	★★★★	★★★	★	★★	★★	★★★		★★

Worse performance				Better performance
	★	★★	★★★	★★★★

Bridge option 1 - Precast concrete plank with composite cast in situ concrete deck

This form of bridge is the most common bridge type in NSW – and could be constructed either using the standard RMS 18 metre spans or the Queensland style 26 metre spans. The bridge superstructure consists of precast concrete planks which are placed from pier to pier. The bridge deck and other elements of the superstructure are then cast in situ once the planks have been placed. An example of this type of bridge is shown in **Figure 4-3**.

Figure 4-3 Example of a precast concrete plank bridge (Adelong Bridge, NSW)

The main advantages of this bridge option would be:

- Excellent flood performance.
- Cost – the lowest cost bridge type to construct and maintain in comparison to other options.
- Flexibility – able to vary the horizontal and vertical alignment.
- Minimal design and construction risks.

The main disadvantages of this bridge options would be:

- Higher number of piers – because the length of the planks are limited, a higher number of piers (five) would be required in comparison to other options. However the number of piers would be lower than the existing bridge.
- Limited opportunities to ensure that the visual appearance of the bridge would be sympathetic to heritage vistas and values of Windsor in comparison to other bridge types. While the parapets (ie the sides of the bridge deck) would be able to be architecturally treated, the underside of the bridge cannot be modified.

Bridge option 2 - Incrementally launched bridge

This type of bridge is constructed by setting up a casting bed on one side of the river, casting segments of the bridge and then 'pushing' (ie launching) each new segment across the alignment on to the piers. A typical span would be about 30 metres and the superstructure and other elements of the bridge are incorporated into each segment. An example of this type of bridge is shown in **Figure 4-4**.

Figure 4-4 Example of an incrementally launched bridge (Corowa, NSW)

The main advantages of this bridge option would be:

- Good flood performance.
- Lower visual impact – There would be opportunities to include architectural features within the bridge superstructure - and the underside of the bridge is uncluttered and uncomplicated resulting in reduced visual impact on the heritage vista and values of Windsor.
- Reduced construction impacts in Thompson Square – the casting bed and most other equipment associated with the construction would be located on the northern bank, minimising construction impacts on Thompson Square.
- Only four piers in the river would be required because 30 metre spans are achievable.

The main disadvantages of this bridge option would be:

- Flexibility – the ability to vary the horizontal and vertical alignments would be limited.
- The abutments of this type of bridge would be more visually prominent than some other types of bridges.
- Cost – this type of bridge would cost about 50 per cent more than a plank bridge.

Bridge option 3 – Cast in situ balanced cantilever bridge

This type of bridge can have large spans (up to 65 metres) and consequently would require only two piers in the river (see **Figure 4-5**). The bridge is constructed from one or more piers with the deck and superstructure cast in situ in equal lengths either side of the pier. Generally the superstructure depth at the piers is significant, tapering to a smaller depth in the middle of the span.

Figure 4-5 Example of an in situ balanced cantilever bridge (Brunswick, NSW)

The main advantage of this bridge option would be:

- Lower number of piers – because 60 metre spans are achievable, only two piers would be required in comparison to other options.

The main disadvantages of this bridge option would be:

- Poor flood performance – the bridge superstructure would be typically buoyant – though measures could be incorporated into the design and construction to minimise buoyancy. Also the relatively deep superstructure at the piers would result in substantial horizontal forces on the bridge during immersion in flood events and may cause increased flood levels upstream.
- Visual appearance – the superstructure would be visually prominent and would not be sympathetic to the historic vistas and values of Windsor.
- Construction risk – this type of bridge would be slow to construct and the main construction areas would be located directly over the river. The combination of these factors increase environmental risks such as water pollution if flood events were to occur during construction.
- Cost – this bridge would be expensive to construct.

Bridge option 4 - Arch bridge (with arch under the deck)

Typically this type of bridge would be constructed by attaching steel or precast concrete arches to the piers and then adding additional structural support. The deck and other bridge elements would then be cast in situ. Two piers in the river would be required for support. An example of bridge type is shown in **Figure 4-6**.

Figure 4-6 Example of an Arch Bridge with arch under deck (Yelgun, NSW)

The main advantages of this bridge option would be:

- Lower number of piers – only two piers would be required for this bridge type.
- Visual appearance - there would be substantial opportunities to include architectural features within the bridge superstructure which would be sympathetic to the heritage vista and values of Windsor.

The main disadvantages of this bridge option would be:

- Poor flood performance – the relatively deep superstructure would result in substantial horizontal forces on the bridge during immersion in flood events and the bridge would be prone to collect flood debris.
- Cost – this would be one of the highest cost bridge types to construct in comparison to other options. As this type of bridge is relatively uncommon, there are substantial risks in design and construction costs.
- Construction risk – this type of bridge would be slow to construct and the main construction areas would be located directly over the river. The combination of these factors increase environmental risks such as water pollution if flood events were to occur during construction.

Bridge option 5 - Arch bridges (with arch above the deck)

The features and construction of this type of bridge are very similar to Option 4, except the arches extend above the bridge deck and the bridge deck is suspended from the arches. An example of this type of bridge is shown in **Figure 4-7**.

Figure 4-7 Example of an arch bridge with arch above deck (Coffs Harbour, NSW)

The main advantage of this bridge type would be the lower number of piers. Because 100 metre spans would be achievable, only one pier would be required in the river for this bridge type.

The main disadvantages of this bridge option would be:

- Poor flood performance – the relatively large cross-sectional area would result in substantial horizontal forces on the bridge during immersion in flood events and the bridge would be prone to collect flood debris.
- Visual appearance – the arches over the deck would be visually prominent and would not be sympathetic to the heritage vistas of the area.
- Cost – one of the highest cost bridge types to construct in comparison to other options. As this type of bridge is relatively uncommon, there would be substantial risks in design and construction costs.

Bridge option 6 - Truss bridges

An example of this type of bridge is the Iron Cove Bridge in Sydney (see **Figure 4-8**). Steel trusses would be assembled on the bank and then floated and lifted into place between piers. A concrete deck would be then cast in situ. Two piers in the river would be required.

Figure 4-8 Example of a truss bridge (Iron Cove Bridge, Sydney)

The main advantages of this bridge option would be:

- Lower number of piers – because 47 metre spans would be achievable, only two piers would be required in comparison to other options.
- Lower construction impact on Thompson Square – the trusses would be assembled on the northern bank, avoiding impacts on Thompson Square.

The main disadvantages of this bridge option would be:

- Poor flood performance – the trusses on the bridge would be prone to collect flood debris. Also as the trusses would be steel, the maintenance costs would be higher in comparison to other types of bridges.
- Visual appearance – the trusses over the deck would be visually prominent and would not be sympathetic to the heritage vistas of the area.

Bridge option 7 - Cable stayed bridge

A cable stayed bridge would consist of two towers with cables from the top of towers supporting a concrete deck. Two piers in the river would be required. An example of a cable stayed bridge is presented in **Figure 4-9**.

Figure 4-9 Example of a cable stayed bridge (ANZAC Bridge, Sydney)

The main advantage of this bridge type would be the lower numbers of piers. Because large spans are achievable, only two piers would be required.

The main disadvantages of this bridge options would be:

- Poor flood performance – the cables would be prone to collect flood debris and the deck would become unstable during immersion.
- Visual appearance – the towers over the deck would be visually prominent and would not be sympathetic to the heritage vistas of the area.
- Cost – one of the highest cost bridge types to construct in comparison to other options.

Bridge option 8 – Cast in situ concrete bridge

This type of bridge can take many forms and would be only limited by the ability to place formwork to allow the casting to take place. It is likely that only two piers would be required.

Figure 4-10 Example of a cast in-situ bridge (Emigrant Creek, Sydney)

The main advantages of this bridge option would be:

- Lower number piers – because large spans are achievable, only two piers would be required.
- Visual appearance – there would be opportunities to include architectural features within the bridge superstructure to make the bridge form sympathetic to the heritage vistas and values of Windsor.

The main disadvantages of this bridge type would be:

- Cost – one of the highest cost bridge types to construct in comparison to other options.
- Environmental risk – due to the need to provide extensive formwork (and potentially temporary piles in the river), there is a risk of damage to or loss of the formwork and resulting water pollution if the bridge construction site was to experience immersion during a flood event.
- Construction impacts on Thompson Square – there would be considerable disturbance and loss of use of Thompson Square during construction.

4.4.3 Selection of the preferred bridge structure type

To assist with the selection of the preferred bridge structure type, a Bridge Options Review Workshop was held in January 2012. The workshop involved assessing and scoring the alternative bridge structure options in terms of environmental and technical criteria (See **Table 4-3**). Workshop participants included bridge and road engineers, environmental planners, heritage architects, heritage advisers, urban designers and RMS personnel. Input from the community focus group established for the project was also sought before making a decision on the preferred bridge option.

Bridge structure types with bulky or prominent superstructures were found to perform poorly in terms of their ability to withstand flood events and their adverse visual impacts. These bridge structure types included the balanced cantilever (bridge option 3), arch (bridge option 4 and 5), truss (bridge option 6) and cable stayed bridges (bridge option 7). Workshop participants agreed that these bridge structure types were not suitable for the replacement bridge at Windsor.

Three bridge structure types were found to be potentially suitable for the Windsor bridge replacement, namely the cast in situ concrete bridge (bridge option 8), the Queensland style plank bridge (bridge option 1) and the incrementally launched bridge (bridge option 2). Of these three structural types, the cast in situ concrete bridge (bridge option 8) was found to have the greatest flexibility in visual appearance but significant disadvantages that ruled it out as the preferred option (namely high cost, construction risk and construction impacts on Thompson Square). The Queensland style plank bridge (bridge option 1), while considered to have significant benefits (namely cost and ease of construction) was also ruled out because of the limited scope for architecturally improving the visual appearance of this structure type, combined with the relatively high visual prominence of the structure and large number of piers.

Based on the combined outcomes of the Bridge Options Review Workshop and input from the community focus group, the incrementally launched bridge (bridge option 2) was found to be the preferred bridge structure option. Key factors in the selection of this bridge option included its:

- Lower visual impact and ability to be architecturally enhanced.
- Relatively small number of piers in comparison to some of the other options.
- Ability to be constructed and launched from the northern bank, which would minimise construction impacts on Thompson Square.

4.5 Thompson Square options

In selecting option 1 as the preferred option for the bridge alignment, it was recognised that it would adversely impact the significance of the State Heritage Register-listed Thompson Square heritage conservation area and the overall historic vistas and values of Windsor. To minimise these potential impacts substantial effort has been invested in developing appropriate design and environmental management measures to minimise the visual impact of the project. A preliminary concept plan for the future consolidation and reinvigoration of Thompson Square and adjacent areas as a community space that reflects the important historical values of the area has been developed with feedback from Hawkesbury City Council and the community focus group. It is recognised that further work and input from stakeholder groups would be required before a plan for the area can be finalised.

4.5.1 Thompson Square options

Historical context

The heritage values and uses of Thompson Square are an important context to the development and assessment of any modifications to the area. These are summarised below:

- Thompson Square has been and is the primary location for accessing the Hawkesbury River within the Windsor township since its development as the Green Hills settlement. The physical access and vistas from Thompson Square to the river are essential to maintain.
- Thompson Square has been and is the primary location for crossing the Hawkesbury River. In the past it has also been a location for wharves to ship and receive goods when river transport was the principal means of moving large quantities of heavy goods. Crossing of the river pre-1874 was via a ferry or punt crossing and post 1874 via the bridge. Consequently a road from George Street to either the wharves or the bridge has been a constant feature of Thompson Square, although the alignment, size and layout of roads in Thompson Square has varied considerably over 200 years. The current alignment bisecting the square into two triangular segments was established in 1934.
- The Government Precinct, from which Thompson Square evolved was the focus of much of the early development of the township of Windsor, with many important buildings surrounding the square, such as the barracks, Governor's cottage and granary. Many of the original buildings predating or built in the Macquarie period were demolished and the land was redeveloped between 1840 and 1880. However, many of these replacement buildings still exist and are included in the Thompson Square Conservation Area State heritage listing. As the town grew the focus of development moved westward and more important buildings were located away from Thompson Square. However, as noted above, Thompson Square still remained the most important local link to the river, the wharves and to northern side of the river either via a punt or bridge.

A full description of the historic heritage of the study area is provided in **Section 7.1**.

Existing condition

Open space in Thompson Square is currently diagonally bisected by the southern approach road to the existing Windsor bridge. The approach road is located in a cut (up to five metres deep) and safe pedestrian access across the approach road is only possible via two sets of substandard stairs under the first span of the bridge. There are also a number of other local roads in the Thompson Square heritage conservation area including Old Bridge Street, The Terrace, Thompson Square road and carparks.

The Thompson Square upper parkland is about 500 square metres in size. It is predominately grassed parkland with about 14 medium to large trees, some picnic benches and seats, and civic memorials. The park is used by tourists and locals generally to eat lunch or for short rest periods. Events are also held in the park regularly, such as bands playing on the weekend or public holidays and as part of the annual Windsor Jazz and Blues Festival. However the amenity of the park is impacted by noise and exhaust emissions from vehicles using the existing Windsor bridge approach road and George Street.

The Thompson Square lower parkland contains a small sloping grassed area, about 10 medium to large trees and a car park. This area is not extensively used as it is on the eastern side of the existing Windsor bridge approach road and is difficult to access on foot from the town centre. It is also impacted by vehicles using the existing Windsor bridge approach road.

Buildings on the western side of the square are accessed along Thompson Square road, while the two on the eastern side and the recently upgraded wharf use the Old Bridge Street alignment.

Opportunities with preferred bridge alignment option

Locating the bridge and approach roads on the eastern side of the Thompson Square parkland provides opportunities to improve the size, amenity, appearance and use of the green space with Thompson Square. The approach road to the existing Windsor bridge would be removed, the cutting backfilled and landscaped to provide additional green space and connect the two existing sections of the Thompson Square parkland. Uninterrupted pedestrian and cyclist access would be able to be provided along The Terrace to the wharf. Access from the new pedestrian/cyclist path across the replacement bridge to the town centre would also need to be provided.

Hawkesbury City Council has also developed a concept landscape masterplan for the southern river bank (including Thompson Square parkland) and have identified potential uses for a redeveloped Thompson Square parkland. Hawkesbury City Council would be responsible for maintaining the Thompson Square parkland in the future.

Urban design principles and development of concept alternatives

In response to the significant heritage and social values of Thompson Square, urban design principles were developed to guide the design process for the bridge replacement project, including Thompson Square. These are:

- Protect and interpret the heritage values of Thompson Square and Windsor in general.
- Maximise the available open space in Thompson Square by minimising the road corridor footprint.
- Define a preferred form and character for Thompson Square based on a range of appropriate uses.
- Enhance access around and through Thompson Square.
- Improve the amenity of Thompson Square and the surrounding areas.

A series of options for the Thompson Square parkland were developed based on these principles and are presented in **Table 4-4**. To achieve the objectives stated above, the focus in considering the best outcome for Thompson Square was on access both into and around the square. The options generated focussed on the location and alignment of the shared path associated with the replacement bridge and access to the river foreshore via The Terrace.

The shared path along Thompson Square and across the new bridge is an integral component of the project as it provides a safe and improved pedestrian and cyclist link between the recreational areas on both sides of the Hawkesbury River. While components of the shared path extend outside of Thompson Square, the design of the square considered a number of potential path crossings. As such, the shared path consideration process has been described as part of the Thompson Square considerations.

The minimum recommended width for a shared path is 2.4 metres and apart from the bridge, the minimum width of all paths would be 2.4 metres. A three metre wide shared path has been proposed for the bridge to cater for the higher speeds travelled by cyclists due to the slope of the bridge deck. The width of the shared path along the bridge will be reviewed during detailed design, with narrower widths further considered. Alternative locations for the shared path were investigated to minimise the width and visual impact of the bridge. Options included:

- Constructing a separate pedestrian and cyclist bridge and path.
- Suspending the pedestrian and cyclist path under the bridge.
- Retaining the existing bridge to provide pedestrian and cyclist access.
- Constructing a shared path on the eastern side of the project (option E).
- Constructing a shared path on the western side of the project (option B).

The first option was not considered viable because of cost, potential upstream flooding impacts and the visual impacts of a second bridge. The second option was not viable due to the visual impact of a suspended walkway and potential flooding damage to the path during immersion. The option to retain the existing bridge was considered in **Section 4.1.4**.

While option E (shared path on eastern side of the project, refer to **Table 4-4**) locates the shared path outside of Thompson Square parkland and provides a greater area of green space, the additional area of green space in the parkland would be unusable as it would be directly adjacent to the southern approach road and subject to high noise levels from passing traffic. A path along the eastern side of the southern approach road would be steep in places (eight per cent grade) and would not provide a direct linkage from the bridge to The Terrace and to the lower parts of Thompson Square parkland. Also two crossings of the project alignment, one at the George Street/Bridge Street intersection and the other under northern bridge abutment, would be required with a path along the eastern side of the project.

Option B was considered the preferred option for Thompson Square, recognising that further consultation and design development would be required. Option B was preferred over other alternatives as it would maximise the amount of green space within Thompson Square, efficiently accommodate pedestrian and cyclist movements and would provide the most flexibility for future uses of Thompson Square.

Secondary footpaths through the square and other parts of the square have not been fully explored as the detailed design of the final form of Thompson Square would require further input from Hawkesbury City Council and other stakeholders. Access for people who are mobility impaired between George Street, The Terrace and the river foreshore would be by using Thompson Square road, past the Doctor's House to The Terrace. For the purposes of the EIS and for further consultation the design of option B was further developed and is presented in **Figure 4-11**.

All options for Thompson Square provide opportunities to incorporate interpretation of the human history of Windsor into their fabric, along with the bridge approaches by selection of finishes for built structures, visual and other sensory devices and more traditional signage and naming.

4.5.2 Other urban design options

Other urban design aspects of the project for which options were developed and considered included:

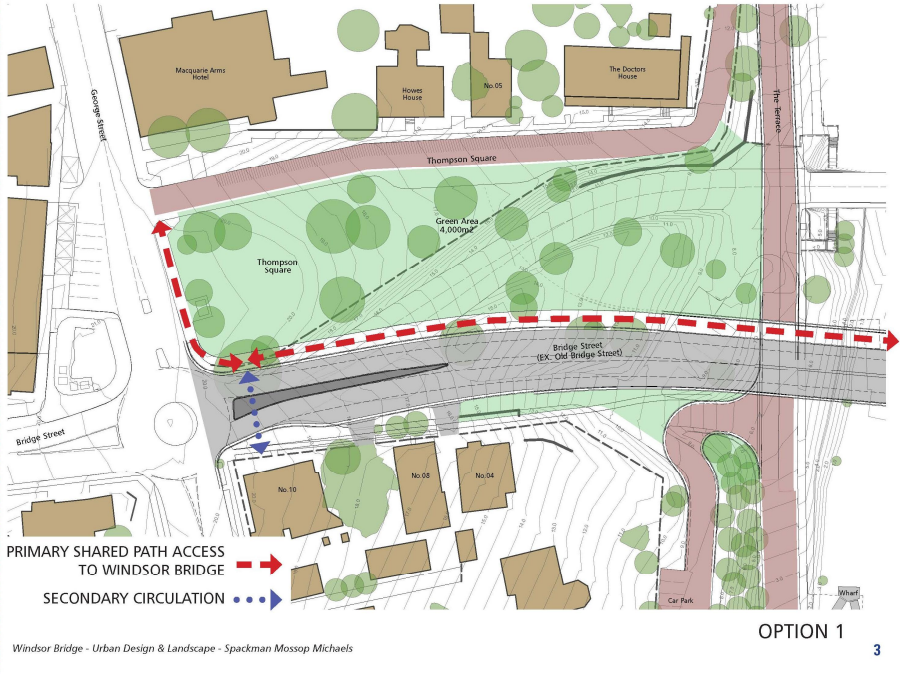
- The landscaping and pedestrian/cyclist pathways on the northern bank.
- Pier design of the replacement bridge.
- Other elements of the bridge including soffits, barriers etc.

Additional information on these options can be found in the Visual Amenity, Urban Design and Landscaping working paper (Working paper 5 – Volume 3). These would be further refined during the detailed design process.

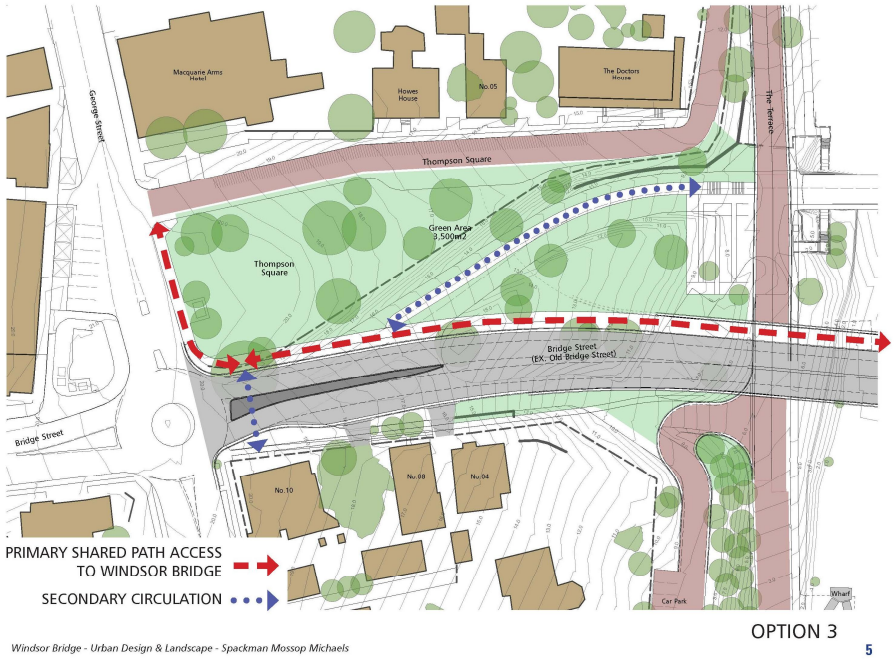
4.6 Consideration of the principles of Ecologically Sustainable Development

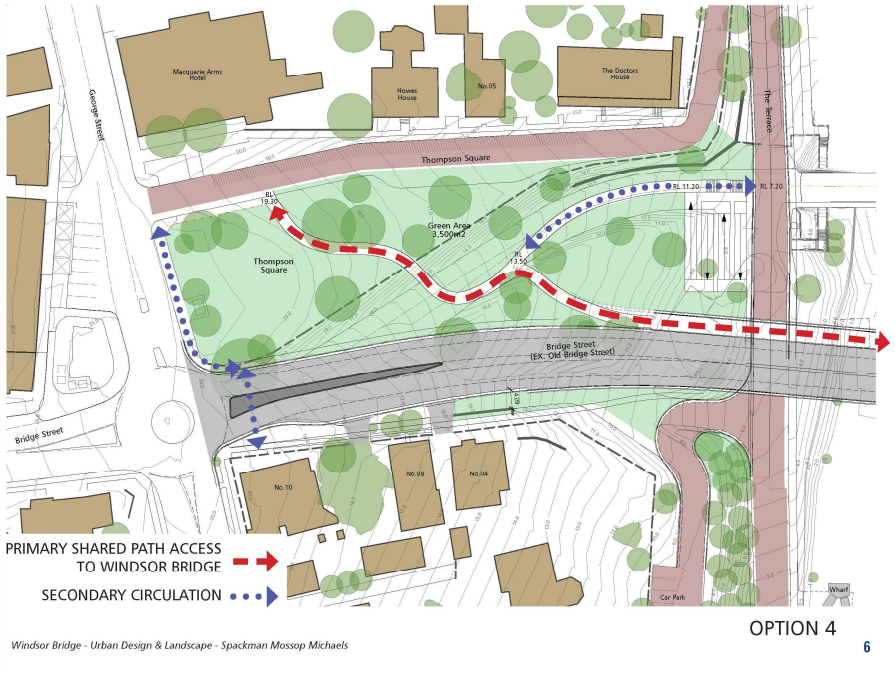
The environmental, social, engineering and cost factors considered in the options selection process and project development, as summarised in this chapter of the EIS, are consistent with consideration of the principles of Ecologically Sustainable Development (ESD). Consideration of ESD would continue during the detailed design process, including further refining the design of the bridge and Thompson Square to further minimise potential impacts. The principles of ESD would also be incorporated in construction through the development and implementation of environmental management measures, should the project be approved. ESD is considered in further detail as part of the justification for the project in Chapter 11.

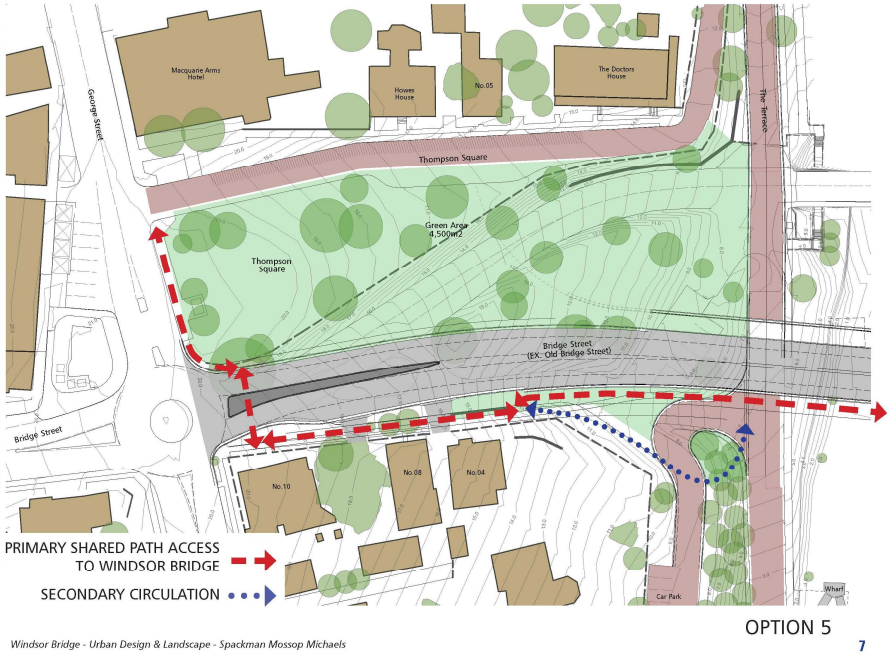
Table 4-4 Urban design options for Thompson Square open space

Option	Design	Description and Assessment
A		**Description** This option would consist of a single shared path along the new alignment of Bridge Street – which would join with the existing path along George Street. No additional paths or stairways would be provided in the Thompson Square parkland. **Advantages** 1) The shared path provides a logical and direct connection to the bridge from the George Street and Bridge Street intersection. 2) Uninterrupted green open space in Thompson Square is provided. This is helped by aligning the path with the edge of the square. 3) The shared path alignment is easily constructed adjacent to the roadway reducing the construction footprint in Thompson Square. 4) The shared path provides a suitable alignment for both pedestrians and cyclists. **Disadvantages** 1) This creates a relatively steep grade (up to eight per cent) down to the bridge, which is not desirable for mobility impaired access. 2) The access from the area around the intersection on George Street, near the Macquarie Arms Hotel, to the bridge, is not direct. 3) The footpath on the eastern side of the square between Bridge Street and the adjoining properties would not be suitable for mobility impaired access.

Option	Design	Description and Assessment
B		**Description** This option would consist of a single shared path along the new alignment of Bridge Street – which would join with the existing path along George Street. Landscaped stairways from the Bridge Street shared path to The Terrace and from Thompson Square road to The Terrace would also be provided. **Advantages** 1) The stairs adjacent to the bridge abutment provide direct access to The Terrace and the river foreshore and assist in integrating the bridge abutment into the Square. 2) Stairs adjacent to the retaining wall next to the Doctor's House would provide access for pedestrians from the road in the square down to The Terrace and river foreshore. 3) The shared path provides a logical and direct connection to the bridge from the George Street and Bridge Street intersection. 4) Contiguous green open space in Thompson Square would be provided. This is helped by aligning the path with the edge of the square. 5) The shared path alignment is easily constructed adjacent to the roadway reducing the construction footprint in Thompson Square. 6) The shared path provides a suitable alignment for both pedestrians and cyclists. **Disadvantages** 1) This option does not improve access for mobility impaired people to The Terrace and the river, over that described in option 1 or the current situation. 2) This creates a relatively steep grade (up to eight per cent) down to the bridge, which is not desirable for mobility impaired access. 3) The access from the area around the intersection on George Street, near the Macquarie Arms Hotel, to the bridge, is not direct. 4) The footpath on the eastern side of the square between Bridge Street and the adjoining properties would not be suitable for mobility impaired access.

Option	Design	Description and Assessment
C		**Description** This option would consist of a single shared path along the new alignment of Bridge Street – which would join with the existing path along George Street. A secondary path would be provided basically along the alignment of the existing approach road to a series of ramps to provide mobility impaired access to The Terrace. **Advantages** 1) The secondary path provides direct access through the Square to The Terrace and to the river foreshore. 2) The secondary path provides opportunity to interpret the heritage alignment of the existing Bridge Street approach to the bridge through Thompson Square. 3) The shared path provides a logical and direct connection to the bridge from the George Street and Bridge Street intersection. 4) The shared path alignment is easily constructed adjacent to the roadway reducing the construction footprint in Thompson Square. 5) The shared path provides a suitable alignment for both pedestrians and cyclists. **Disadvantages** 1) A secondary path cuts across the Square disrupting the contiguous green open space between George Street and The Terrace. 2) A secondary path would require complex grading in order to meet mobility impaired access guidelines. 3) The ramp access on the secondary path adjacent to The Terrace both physically and visually separates The Terrace from the square. 4) This creates a relatively steep grade (up to eight per cent) down to the bridge and this is not desirable for mobility impaired access. 5) The access from the area around the intersection on George Street, near the Macquarie Arms Hotel, to the bridge, is not direct. 6) The footpath on the eastern side of Bridge Street and the adjoining properties will not be suitable for mobility impaired access.

Option	Design	Description and Assessment
D		**Description** This option would consist of a curved shared path through the middle of the Thompson Square parkland. A secondary path would be provided from the shared path along the alignment of the existing approach road to a series of ramps to provide mobility impaired access to The Terrace. **Advantages** 1. A shared path provides more direct access to the George Street intersection near the Macquarie Arms Hotel. 2. Pedestrian and cyclist amenity is improved as it is partially located within the square and away from traffic on Bridge Street. 3. Both paths provide some opportunity to interpret the earlier/historic alignments of roads through the square. 4. The secondary path provides more direct access through the square to The Terrace and the river foreshore. **Disadvantages** 1. Direct shared path access is not provided to the George and Bridge Street intersection to avoid duplicating the shared path in Thompson Square. 2. The shared path alignment is not in a typical location being away from the roadside and therefore may be disorienting for new path users. 3. The shared and secondary paths cut across the square disrupting the green open space between George Street and The Terrace. 4. The shared path alignment is less easily constructed away from the roadway increasing the construction footprint into the Square. 5. Both paths would require complex grading to meet mobility impaired access guidelines. 6. The ramp access on the secondary path adjacent to The Terrace physically and visually separates The Terrace from the square and takes up substantial space.

Option	Design	Description and Assessment
E		**Description** The shared path along Bridge Street and the replacement bridge would be on the eastern side. There would be no paths or ramps in Thompson Square green space. **Advantages** 1. The shared path maximises the use of an area of the road corridor which would be underutilised due to the need for a curved road alignment on the approach to the bridge. 2. The shared path provides a logical and direct connection to the bridge from the George Street and Bridge Street intersection. 3. The uninterrupted green open space in the square is maximised by aligning the path with the eastern edge of the square. 4. The shared path alignment is easily constructed adjacent to the roadway minimising the construction footprint. 5. Access to and from the properties on the eastern side of the square across Bridge Street is helped by this alignment of the shared path. 6. The shared path provides a suitable alignment for both pedestrians and cyclists. **Disadvantages** 1. The relatively steep grade (up to eight per cent) down to the bridge is not desirable for providing mobility impaired access. 2. Access from the area around the intersection on George Street, near the Macquarie Arms Hotel, to the bridge, is not direct and requires people to cross the George and Bridge Streets intersection. 3. Access to Macquarie Park on the northern foreshore requires crossing under the bridge at the abutment. 4. Access for mobility impaired people down to The Terrace and River foreshore is restricted to the road on the western edge of the square (past the Doctor's House).

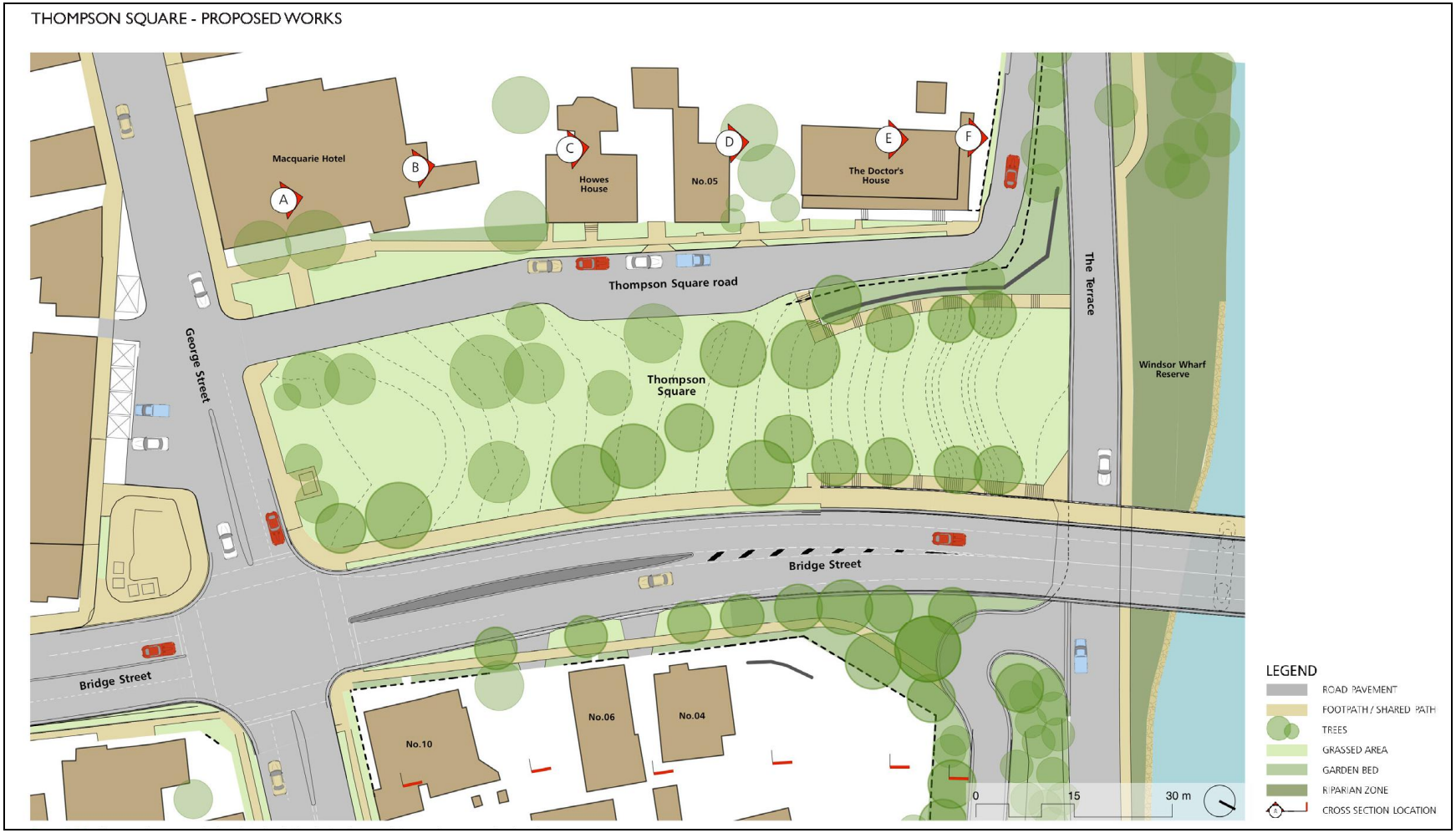


Figure 4-11 Further development of option B

4.7 Confirmation of the preferred option for the project

The preferred option for the project comprises the following:

- Replace the existing Windsor bridge with a new downstream high-level bridge via the alignment of Old Bridge Street (option 1).
- Provide an incrementally launched bridge structure (bridge option 2).
- Minimise bridge height and vertical elevation of the bridge access road in Thompson Square to reduce visual impacts on Thompson Square while still providing sufficient under-bridge clearance for service vehicles to access Windsor Wharf along The Terrace.
- Replace the roundabout at the intersection of George Street and Bridge Street with traffic signals and construct a new dual lane roundabout at the intersection of Freemans Reach Road, Wilberforce Road, Macquarie Park access road and the northern bridge approach road.
- Rehabilitate Thompson Square based on option B – recognising that further consultation is required.
- Rehabilitate and landscape other areas of the project impacted by construction.
- Demolish the existing Windsor bridge.

In comparison to other options, the preferred option for the project performs best in terms of value for money and satisfies the majority of project objectives (refer to **Table 4-2**). The selected bridge option and southern approach road alignment would also minimise the option's potential visual and construction impacts on the Thompson Square parkland. The replacement bridge would have improved flood immunity, would allow access along The Terrace for buses, emergency and service vehicles, and would provide improved pedestrian access both across the river and along the southern bank.

In comparison to the other options, adverse impacts on community amenity and traffic flows during the construction period would be relatively minor and there would be no significant long-term changes in access to Windsor for local residents or through traffic. The new bridge would maintain the existing, historic linkage between the northern and southern sides of the Hawkesbury River at Windsor and the continuity of Thompson Square as a link to the river and a civic park.

The main adverse effects of the preferred option would be impacts on historic heritage, including direct and visual impacts on Thompson Square Conservation Area, the character of its open space and surrounding heritage buildings, and buried archaeological evidence, with potential for flow-on effects on the character and amenity of the Windsor township. Additional issues include the potential for traffic noise and vibration impacts associated with the change in location and height of the bridge, as well as changed access arrangements for two properties on Old Bridge Street. These impacts have been considered in design and options development - and would be further mitigated and/or managed using the measures identified in this EIS. These measures include:

- Detailed management and conservation measures to avoid, minimise and mitigate impacts on historic heritage.
- Urban design and landscaping treatments to integrate the new bridge with the existing environment and maximise the potential benefits to public open space, community amenity and the character of Windsor.

It should be recognised that Thompson Square has been and is the primary location for crossing the Hawkesbury River and also in the past, a location for wharves to ship and receive goods when river transport was the principal means of moving large quantities or heavy goods. Crossing of the river pre-1874 was via a ferry or punt crossing and post 1874 via the bridge. Consequently a road from George Street to either the wharves or the bridge has been a constant feature of Thompson Square, although the alignment, size and layout of roads in Thompson Square has varied considerably over 200 years. The current alignment was established in 1934.

One of the benefits of the preferred option is that it removes the existing bridge approach road through the Thompson Square parkland, creating a larger area of consolidated open space in this location. This increase in consolidated parkland, in conjunction with the proposed urban design and landscaping treatments and the proposed heritage management and conservation measures, provides an opportunity to improve some of the amenity aspects of the area for public use consolidating the currently divided open space and improve pedestrian connections to the river. This increase and reconfiguration of the open space, in conjunction with the urban design and landscaping treatments and heritage management measures described in this EIS, would provide an opportunity to increase the area for public use and address the heritage values of area.

The adverse impacts of the preferred option are considered justified in view of the need for the project and the alternative options available. If the bridge is not refurbished or replaced, its structural condition will continue to deteriorate with age. This will lead to increasing maintenance costs in the short term and ultimate closure of the bridge in the long term when ongoing maintenance can no longer provide an adequate level of traffic safety. This would result in the loss of an important bridge crossing of the Hawkesbury River, with impacts on local and regional connectivity. Existing bridge users would need to use alternative river crossing points, resulting in increased travel times and adverse effects on the local economy of Windsor.

The preferred option, including the chosen alignment for the replacement bridge, minimises the substantial changes to traffic conditions and access arrangements that would be associated with other options. In particular, it avoids:

- The need to close the existing bridge during the construction period, which would be required intermittently during construction for option 3 (new bridge immediately upstream of existing bridge) and for the duration of the construction period for option 9A and B (refurbishment of the existing bridge).
- Impacts on residential areas that currently do not experience high levels of traffic and associated amenity impacts (options 4, 5, 6, 7 and 8 and community options – Livingston Road, Pitt Town Bottom Road and Hawkesbury Way).
- Loss of parking and major changes in road access within the Windsor township (which would occur in the cases of options 4 and 5 and community option – Bridge Street tunnel).
- Impacts on existing boating activities (which are likely to occur in the cases of options 6, 7 and 8 and community options – Livingston Road and Pitt Town Bottom Road).
- Closures of the bridge during low level flood events (which would occur in the cases of option 2 and 9).

The proposed flood immunity level of the new bridge and the proposed number of traffic lanes would be compatible with the approach roads and surrounding traffic routes. Higher levels of flood immunity would not be justified given that access would still be limited by the flood immunity of the approach roads that traverse the Hawkesbury floodplain. Similarly, the width of the bridge and corresponding traffic lane numbers would be limited by the capacity of the intersections and access roads within the township.

The replacement of the existing bridge at Windsor would clearly be in the public interest as the existing bridge does not meet safety and traffic requirements. With high future traffic growth predicted due to increased urban development in the townships on the northern bank of the Hawkesbury River, traffic and safety issues would increase. The existing Windsor bridge has reached the end of its design life and the only long-term cost effective option would be to build a new replacement bridge.

The preferred option for the replacement bridge and other elements of the project are described in detail in **Chapter 5**.