Appendix A

Options Analysis Report
Options development report

M1 improvements, Picton Road to Bulli Tops

June 2017
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1. Introduction

The M1 Princes Motorway between Picton Road and Bulli tops is a four lane road separated by a central median with a speed limit of 100km/h.

The M1 in this location has challenging topography with sections of the road having steep hills that range between grades of seven to 10 per cent. There are also a number of tight curves along the road that combined with the steep grades make it difficult for heavy vehicles to maintain a constant speed.

In addition to its role as a commuter route between the Illawarra and Sydney, the M1 has an important access and transport function for freight between Port Kembla and Sydney (including South West Sydney). The M1 provides the only A-double and B-double access route into the Illawarra from the north.

In 2014 the M1 between Picton Road and Bulli tops recorded traffic volumes of around 37,000 vehicles per day. These traffic volumes include a large proportion of heavy vehicles, which make up around 13 per cent of the daily traffic volume or around 4800 heavy vehicles per day. The increase in heavy vehicles on the M1 due to the expansion of Port Kembla and increased colliery operations places additional pressure on the route.
1.1 Background

In 2009 Roads and Maritime Services (then RTA) began investigating the performance of the M1 between Picton Road and Bulli Tops. The purpose of the investigations were to gain an understanding of the issues along this route and how these may be contributing to road safety and traffic efficiency concerns reported in this location.

The *Mt Ousley Road/Southern Freeway Traffic Modelling – Final Report* identified a number of concerns with the performance of the M1. It provided guidance on the potential traffic benefits of providing additional lanes and recommended up to six climbing lanes (three in each direction) to be provided through this section. The recommended lanes were proposed on the steeper sections as this would provide the greatest overall network benefits.
In 2009 Roads and Maritime completed one of the northbound climbing lanes as an 1800m on-load to the M1 at Bulli Tops.

In 2013 Roads and Maritime received funding for another northbound climbing lane / acceleration lane located from the intersection of the M1 and Picton Road. This lane was finalised and open to traffic in 2014.

In 2015 Roads and Maritime received additional funding to investigate the remainder of the climbing lanes. This was linked to an $84 million joint New South Wales Government and Australian government funding commitment for improvements on the M1.

1.2 Purpose of the report
The purpose of the report is to outline the steps taken to arrive at a preferred option for the M1 improvements project. Specifically this report:

- identifies the project objectives;
- summaries the project issues and constraints;
- summarises the options assessment criteria;
- discusses the preferred option development.

1.3 Project objectives
Before starting any design work, Roads and Maritime identified a number of project objectives. These objectives, ensure projects are developed to address site specific challenges.

The purpose of this project project is to improve travel efficiency and road safety on the M1 Princes Motorway between Picton Road and Bulli Tops. The project objectives developed for the project are to:

- improve travel time and efficiency through additional lane capacity;
- improve road safety through enabling enhanced separation of slower moving and faster moving vehicles;
- provide for safe road and utility maintenance and access;
- increase reliability of access into and out of the Illawarra region and Port Kembla including for general freight, larger restricted access vehicles and high performance freight vehicles.

Roads and Maritime also places a high priority on achieving quality project outcomes from a customer, time, budget, environmental and work health and safety perspective. These factors are fundamental to design development, options evaluation and selection.
2. Preliminary option selection

As part of the early investigation into the proposed improvements, Roads and Maritime considered a number of alternative treatments that might help meet the project objectives. Roads and Maritime also revisited the base or ‘do minimum’ option to better understand the issues associated with this section of the M1.

2.1 Do minimum

The existing route includes a range of steep hills, including sections that range between grades of 7.5 per cent and 10.2 per cent. A number of the existing curves, particularly toward the south of the project do not meet the design goals for the posted travel speed. This creates travel efficiency and road safety concerns particularly given the combination of grades and crests. Tight curves ranging from a 300 metre radius to 399 metre radius are present on sections of the route, which is well below the goal of a 460 metre radius curve.

Other issues experienced on this section of the M1 include the lack of drainage across the median which can result in aquaplaning risk or the creation of excessive spray, and the lack of appropriate facilities for carrying out maintenance in a high speed, high traffic environment.

Given the road safety and traffic performance of the road is unchanged under a do minimum option Roads and Maritime did not consider this to be a viable alternative as it would not meet the project objectives.

2.2 Technology

‘Point-to-point’ speed cameras
The road safety and traffic efficiency issues experienced on this section of the M1 are generally associated with the steep and winding topography of the road rather than heavy vehicles exceeding the speed limit. Although point-to-point cameras could be used to help regulate the speed of heavy vehicles, the introduction of this system would not improve the grade or poor alignment of the road. As this system would not help meet the project objectives it was not considered a viable standalone option for further investigation. A point-to-point speed camera system is already on place over the project extent.

Environmental response technology
Fog and rainfall have been identified as factors influencing safety along the M1. Although environmental response technology such as fog detectors may provide some benefit in these conditions they would not address the ongoing road safety and traffic performance issues on the route created by the road’s alignment. As this system would not help meet the project objectives it was not considered a viable standalone option for further investigation.

‘Smart Motorways’, Variable Speed Limiting and Intelligent Transport Systems
Roads and Maritime completed an early review to understand the likely requirements to achieve Smart Motorways technology such as a combination of the systems described above
and variable speed limiting on the M1. These systems require significant infrastructure and management items including:

- vehicle detection systems, which are in-pavement detection 'loops' installed in each lane of the road at (typically) 500 metre intervals;

- Lane Use Management Systems (LUMS) which are overhead gantries, typically spanning the full width of a motorway with lane use signs above each lane. Associated with each gantry is a combined maintenance bay and breakdown bay, emergency telephones, telecommunications and power access points, and space for the gantry footings and supports;

- variable speed limit signs, typically installed on the LUMS gantries;

- Closed Circuit Television (CCTV), ideally installed to provide an 'end-to-end' vision for staff managing the Motorway length. To ensure this, CCTV cameras are placed on LUMS gantries, as well as on additional CCTV pole mounts, to provide full roadway length coverage;

- Variable Message Signs (VMS), ideally these would be installed to supplement any existing VMS. Locations may be stand alone or installed on LUMS gantries;

- communications and power. All of the Intelligent Transport Systems infrastructure requires cabling to provide power and communications. Power and communications are typically required in separated underground conduits, with access pits for service and maintenance located at appropriate and safe locations.

Although incorporating Smart Motorways technology into the M1 improvements is likely to provide road safety and traffic benefits in the longer term, retro fitting the system into the existing route under traffic would come at a significant cost and create substantial delays to traffic during its construction and implementation. The system would also be constructed along the existing route (on-alignment) so would not address the alignment constraints, enhance the separation between light and slower moving heavy vehicles or address the ongoing maintenance concerns with the route. As this system would not help meet the project objectives it was not considered a viable standalone option for further investigation.

### 2.3 Climbing lanes

In line with the 2015 funding announcement of $84 million for improvements on the M1, Roads and Maritime continued investigations into the four remaining climbing lanes recommended as part of the 2009 study. The lanes, located between Picton Road and Bulli Pass included:

- a northbound lane from Cataract Creek, around 1300m in length;
- a northbound lane from Bellambi Creek, around 2200m in length;
- a southbound lane near Bulli Pass, around 2300m in length;
- a southbound lane from Cataract Creek, around 1500m in length.
As part of these investigations, Roads and Maritime considered lessons learned from the completion of the first two climbing lanes including a range of traffic management, worker safety and constructability issues.

In particular, issues raised during the construction of the Picton Road/M1 acceleration lane led Roads and Maritime to further consider the risks of carrying out similar works over other sections of the M1 Princes Motorway, and potentially on both sides of the road at the same time as may be required by the proposal.

As a result of the lessons learned, Roads and Maritime identified the need to not only ensure the climbing lanes would meet the adopted project objectives, but also to progress the design and environmental investigations considering a number of specific issues including:

- road safety implications of adding additional lanes on the outside of an existing substandard curve;
- road surface drainage issues from additional road pavement (including the need for new drainage in the median);
- environmental issues;
- Aboriginal and non-Aboriginal heritage matters;
- soils and water management issues;
- utility constraints;
- constructability and construction staging;
- traffic management and impact;
- cost;
- safety of workers and motorists during construction.

A review of the proposed climbing lanes against these criteria identified a number of concerns. These included:

- the need for extensive construction activities on the existing road surface from a major overlay across current traffic lanes. The overlay would be required to ensure road safety and drainage performance (particularly related to aquaplaning). Additional width for two additional lanes, a wider median and suitable width for construction staging would also be required;
- issues with relocating traffic, removing and relocating the centre median barrier, and providing a safe working space behind shoulder barriers;
- safety concerns around additional weaving movements for traffic around the worksite. A proposal to join the two northbound climbing lanes across Bellambi Creek bridge was proposed to reduce the amount of weaving in high speed environments improving safety;
- Limited options for the location of the two northern lanes between Bellambi Creek and Bulli Pass - to avoid expensive utility relocations, property acquisition and environmental impact, the climbing lanes would need to fit between power transmission infrastructure and also maintain access to nearby landholdings including; WaterNSW, NSW National Parks and Wildlife estate (Illawarra Escarpment State Conservation Area) and Wollongong Coal, by these land owners and other
emergency services, agencies and utilities, particularly the NSW Rural Fire Service, Endeavour Energy and TransGrid.

In addition to the above, the development of the design demonstrated a difficulty in providing a safe location for transitioning from three lanes back to two. This was worsened by steep grades and substandard curves on the route.

3. Further options development

Roads and Maritime considered that the above issues were likely to affect the ability to meet the safety, maintenance and constructability objectives for the project and as such, the climbing lanes should not be progressed any further. This led to the need to investigate alternative design solutions for this section of the route. These were mostly desktop investigations and were mostly design led with cost and other impacts considered at a broad strategic level.

3.1 Criteria

In determining alternative options for future investigation, Roads and Maritime considered a number of broad criteria. These included:

**Traffic**
Options that had the greatest potential to reduce the steep grades of the route and improve the alignment (i.e. improve the curves) were identified. These options would likely achieve the broader travel time improvements on the route, reduce the weaving interactions between light and heavy vehicles by reducing the speed differences between vehicle types, and were seen to have the greatest benefit.

**Road safety**
The difference in the travel speeds between light and heavy vehicles as well as the existing road alignment are factors that influence road safety. Options that improved the alignment and allowed for safe merge locations at the end of overtaking or climbing lanes were considered for further investigation.

**Environment**
Roads and Maritime considered the information from the environmental investigations for the project to help guide the options selection process. Options that could reduce the potential project footprint, particularly in environmentally sensitive areas while achieving the project objectives were prioritised.

**Constructability**
Building upgrades on roads with high traffic volumes such as the M1 can lead to safety concerns for both workers and road users. Construction under traffic also requires mitigation such as speed reductions that can impact travel times and create delays for large periods
during construction. Options that had the potential to minimise these interactions and reduce the need for speed reductions were considered in the design development.

**Property impacts**
Options that had the potential to minimise property impacts including acquisition were considered in the design development.

**Cost**
Options that would minimise the need for expensive utility relocation and reduce earthworks including limiting spoil etc. were considered for future investigation.

Designs that best addressed the above criteria and were expected to meet the project objectives were prioritised for consideration in the options selection process.

### 3.2 Design Criteria

In considering alternative options, the following minimum criteria were identified:

- typically 3.5 metre lanes unless otherwise required for heavy vehicle tracking;
- 3.0 metre wide outside shoulders;
- median width of up to 2.5 metres for drainage and gutters;
- median barrier full length (other than emergency crossovers);
- longitudinal drainage (including median drainage) as required;
- providing for future Smart Motorways/Managed Motorways infrastructure;
- typical road furniture such as barriers, fences and maintenance accesses as required;
- Overall design to facilitate a general 100 kilometres per hour posted speed environment.

### 3.3 Options considered

Roads and Maritime considered a number of potential options. These included:

**Tunnel Options**
Tunnel options over a length of 400 metres were not considered to be economically feasible for this project. Three potential tunnel options with maximum grades of three per cent, six per cent and eight per cent were considered. No tunnel lengths below 580 metres could be found and a maximum length of 1,252 metres was identified. While likely traffic efficiency benefits would be high, funding would be outside the available scope. These options were not further progressed.

**Large scale realignment of the M1**
A large scale realignment to provide an 1800 metre radius curve between Picton Road interchange and Bellambi Creek was considered. This option could be built mostly outside the existing route (off-alignment), which would address the majority of the constructability and worker safety issues identified during development. The option would remove the tight curves on the existing section of road improving road safety and traffic efficiency. However, early investigations found that this option would have over 2,000,000 m³ of earthwork and
cuttings over 40 metres deep. The option would also have a larger project area with potentially greater environmental impacts. Given this and the expected high costs associated with the earthworks, this option was not progressed further.

**Minor to major realignments on the M1**

A number of smaller scale realignments were considered through this section. Although addressing some of the project objectives each of these options included a number of challenges and were therefore not progressed. These included:

- an option realigning the existing road to produce a minimum curve radius of 460 metres and to provide for a 100km/h design speed. While a mostly built beside or on the existing route (on-alignment) this still involved considerable work off-alignment. It also had significantly unbalanced earthworks, requiring major importation of fill, and extensive construction under traffic, leading to high costs and risks;
- an option largely on-alignment with a minimum 600 metre radius curves. This option also involved major earthworks, large areas of construction under traffic and some lengths of grades worse than the current alignment (up to 13.2 per cent versus the existing alignment at 10.2 per cent worst case);
- an option providing for a minimum curve radius of 600 metres with minor realignments. South of Bellambi Creek this required major cuts (34 metres deep) and fills (29 metres), with sections of steep grades up to 12.3 per cent. North of Bellambi Creek cuts of 18 metres and 26 metres and fills of 51 metres deep were required. While minimising works under traffic, the earthwork balances created by this option result in major costs. North of Bellambi Creek major impacts to utilities would also be unavoidable adding to the complexity and cost of construction;
- an option providing for a 600 metre minimum curve radius but allowing for a major realignment. This option required a set of major cuts along the project length (depths of 36 metres, 51 metres, 31 metres) and major fills (20 metres, 33 metres, 34 metres, 37 metres). While the improved alignment would likely result in excellent efficiency and road safety performance, the costs and likely environmental impacts associated with this option were considered prohibitive. It would also be difficult to stage the construction given the location of the realigned areas.

4. **Staging options**

While the investigations outlined above did not identify a viable option for further development, the improved understanding of the site area, potential alignments and estimated construction costs led to the consideration of a staged approach for the project and its delivery (building the project in two stages).

The staging option considered a mixed ‘on-alignment and off-alignment’ design at the southern end of the project (Stage 1), and a mostly ‘on-alignment’ design at the northern end of the project (Stage 2).

Bellambi Creek formed a natural boundary for the staging due to likely stage lengths, potential construction costs and other known delivery risks (e.g. the likely need for acquisition of section of the Illawarra Escarpment State Conservation Area for the stage north of Bellambi Creek). A range of specialist studies that had previously been considered for the full project scope were used where appropriate to progress the single stage investigations.
4.1 Stage 1

Once a staged approach had been proposed, Roads and Maritime identified the southern stage would be best considered as Stage 1 (i.e. constructed first) as it:

- could be achieved for the available funding of $84 million;
- does not require potential revocation from the NSW National Parks Estate (time delays and other risks and associated with revocation);
- currently has a poorer standard of geometric design than the ‘northern stage’;
- has a poorer crash performance than the ‘northern stage’.

On-alignment / Off-alignment investigations

Investigations into Stage 1 identified an early on-alignment / off-alignment arrangement. This included:

- a new section to the east of the existing route at the top of Picton Hill;
- additional lanes on the existing alignment each side of the Cataract Creek straight (also known as ‘the Big Dipper’);
- a new alignment between the Big Dipper and Bellambi Creek;
- five lanes over the existing Bellambi Creek bridge (three northbound and two southbound).

Based on broad earthwork cut/fill ratios and general strategic cost estimating, an on-alignment / off-alignment option for Stage 1 would be achievable for the funding profile. A number of designs with minor variations were developed for the above option and included designs where:

- the on-alignment portion was centred over the existing median lane, and included works east and west of the existing route on the Cataract straight or ‘Big Dipper’;
- the carriageway would be split to separate old and new alignments;
- different curves were examined to achieve safer tie-ins to the existing alignment and where undercutting could be minimised etc.

Roads and Maritime considered the best performing design option, based on the project’s objectives, risks, environmental impacts and funding profile was a design that included:

- work to the east of the existing alignment only;
- minimum 460 metre radius curves;
- a northern boundary immediately south of Bellambi Creek.

This is the design that was assessed as the preferred option in the REF (figure 7.1).
5. **Next Steps**

Subject to environmental and planning approvals, Roads and Maritime will finalise the concept design and expects to start detailed design in second half of 2017. Roads and Maritime will continue to consult with relevant stakeholders and agencies throughout the design phase.

Subject to project approval, the construction of Stage 1 would start in 2018 and be delivered over two years.

The design for Stage 2 (Bellambi Creek to Bulli Tops) is continuing. A number of options have been considered for a mostly on-alignment approach. A variety of curve designs are being investigated for the poorest-performing curve at the northern end, as are investigations into the crossing of Bellambi Creek.