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WOLGAN VALLEY ACCESS ROAD – ALIGNMENT OPTIONS ASSESSMENT REPORT

OCTOBER 2023

ALIGNMENT OPTIONS ASSESSMENT REPORT

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Wolgan Valley Access Road – Alignment Options Assessment Report

Lithgow City Council

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REV	DATE	DETAILS
A	26/10/2023	Draft issue

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Acknowledgement of Country

WSP acknowledge the Traditional Custodians of the land on which the project is located, and the land on we are working, the Mulgoa, Cabrogal and Cannemegal people of the Darug language group, and their continuing connection to culture, community and country. We pay our respect to Elders past, present and future.

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1 PROJECT UNDERSTANDING AND SCOPE

1.1 INTRODUCTION

Lithgow City Council (Council) has engaged WSP to provide assistance with finding an alternative long-term resilient access route into the Wolgan Valley. The existing access from Castlereagh Highway via Wolgan Road has been subject to many rockfalls and landslips. The road remains closed due to slope instability within the approximately 2 km section of Wolgan Road descending from the Wolgan Gap lookout. Refer to Figure 1-1 which is a map showing the extent of Wolgan Road from the junction with Castlereagh Highway west of Lithgow, up to Newnes.

The Wolgan Valley includes private residences, farms and tourist destinations, including Emirates One & Only, a luxury resort located near the Wolgan River. The Newnes area grew out of the Commonwealth Oil Shale Company operations at Newnes Junction. The ruins of the shale oil mine processing are a popular attraction to this day.

Wolgan Valley is formed by the Wolgan River in mountainous country. The river flows generally east, joining the Capertee River, and then becomes the Colo River. The Wolgan Valley includes sections of Wollemi National Park, Gardens of Stone National Park and the UNESCO declared Greater Blue Mountains World Heritage Area.

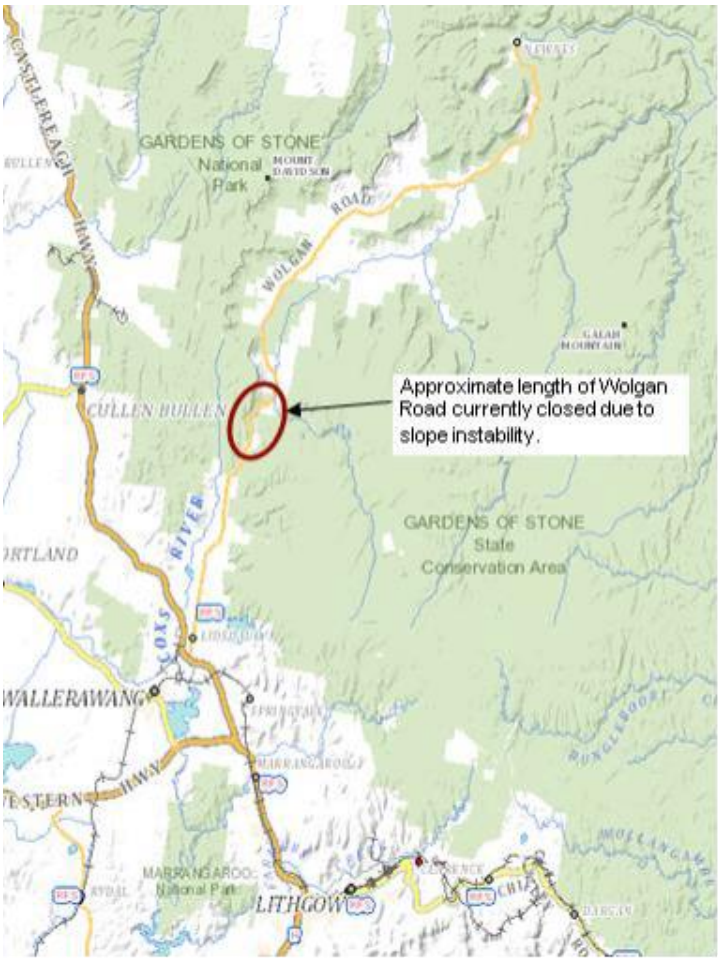


Figure 1-1 - Project Overview – Location of Wolgan Road and project site

1.2 DEVELOPMENTS SINCE ROAD CLOSURE

Wolgan Road was closed to traffic in November 2022 by Council due to the high risk of harm resulting from continued slope instability. Council engaged Public Works to construct an interim alternate access road along the eastern side of the Wolgan Gap based closely on the route of an existing historic track known as the Donkey Steps. This access has been used by four-wheel drive vehicles since January 2023 in accordance with Council's Donkey Steps Emergency Bypass Route Access Strategy Plan (Council Ref. P-FY20231791, Version 5).

This access has provided some relief by allowing restricted access for residents but is not suitable as a permanent all vehicle access solution in replacement of the original (now closed) road on the western side of the valley.

Council previously commissioned WSP to look at a long-term strategy to provide new access that would cater for expected traffic types and numbers, would be safe and resilient to use and would be cost effective to construct and maintain. In response to this, WSP has produced two reports to establish the location of a future new access road into the Wolgan Valley. The first report considered the constraints that would inform a future corridor study. These constraints included geotechnical slope risk, ecology, waterways, utilities, and heritage. The second report identified three corridors that could contain a future access road. The corridors were spatially diverse, covering a route across the Newnes plateau from Lithgow, a route south from Glen Davis and a route within the existing Wolgan Gap valley. An assessment of these corridors against a range of engineering, cost and environmental criteria found that the eastern side of the Wolgan Gap valley offered a preferred location for a new access road.

1.3 SCOPE OF WORKS AND METHODOLOGY

In November 2022, WSP prepared a high-level constraints study (refer to report PS129742-SYD-GEO-REP-101 REV 00) to identify and discuss the key constraints that would need to be considered when choosing an alternative route into the Wolgan Valley. That stage of the study, shaded green in Figure 1-2 below, was the first stage of a route assessment process that would initially identify a preferred corridor and then a preferred new route within that corridor.

In December 2022, WSP prepared a Corridor Assessment Report (refer to report PS129742-SYD-GEO-REP-102). This report considered and compared three primary corridors for a new access to the Wolgan Valley and identified a preferred corridor for a new access road to be developed. This study stage is shown in yellow in Figure 1-2 below.

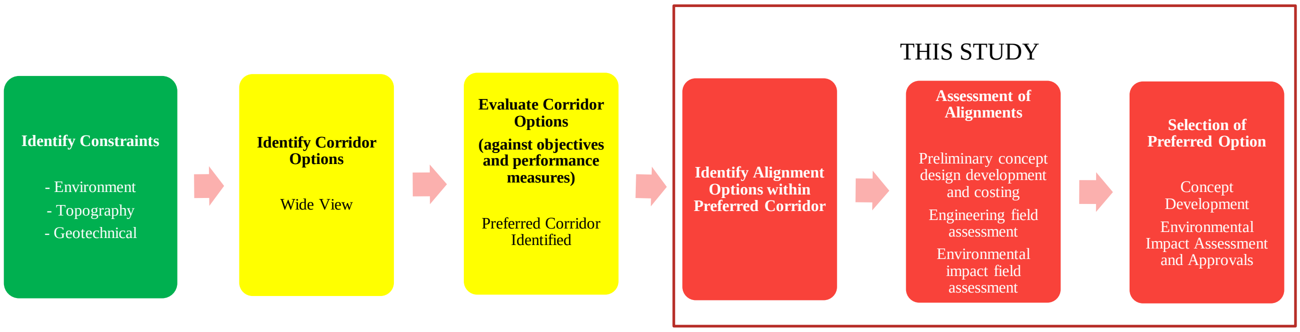


Figure 1-2: Route Assessment Process

The Southern Corridor was identified as a preferred corridor, being preferred on ecology impact, aboriginal heritage impact, visual impact, route length, slope hazard susceptibility, resilience and cost.

The next stage of the development of a new permanent access into the Wolgan Valley is to determine the best route through the preferred corridor. The scope herein covers undertaking sufficient investigations to determine key constraints that will inform alignment design followed by engineering design and costing to determine a preferred alignment. The approach is based on 3 phases:

- Phases 1 and 2 – Alignment Options Assessment and Investigations/Data Acquisition:
  - Alignment Options Assessment: development of design concepts for three potential road alignments within the preferred corridor to a level of detail sufficient to enable comparison of each alignment against high-level engineering, environment, and cost factors.
  - Investigations and Data Acquisition: assembly of the required design data, agreement of design criteria and identification of key inputs required for the Alignment Options Assessment:
    - Investigations and Data Acquisition undertaken by WSP:
      - Geotechnical desktop assessment
      - Ecological site assessment and constraints mapping to inform design requirements relating to sensitive habitat and species within the preferred corridor.
      - Identification of the recorded locations of known utility assets from BYDA data with respect to the alignment options (fibre optic survey to be provided by Council)
      - Location of key watercourses and drainage lines which will need to be conveyed across the road within the preferred corridor.
      - Determination of property boundaries, land ownership and occupation
    - Investigations and Data Acquisition undertaken by Council in consultation with WSP.
      - Design speed and maximum superelevation. The design speed may vary according to topography between the gentler lower slopes and the steeper upper section of the valley.
      - Design vehicle to be accommodated on the road.
      - Typical road cross sections including features such as benches, road furniture, drainage elements and indication of where width for potential for future pavement widening exists.
      - Maximum grade
      - Maximum channel flow width into traffic lane and associated ARI event
      - Relevant Council standard details that need to be included, (e.g., spacing of breakdown bays)
      - Determination of criteria to be adopted in the multi-criteria analysis of three alignments within the preferred corridor which will be considered by Council in identifying a preferred alignment to be advanced to concept design.
      - Extension of the previous heritage surveys undertaken by Council to cover the footprint of the alignment options and map areas of significance to avoid impacts where possible.
  - A Project Risks and Opportunities and HSiD workshop (to be scheduled before the final issue of this report) will be held during the Alignment Options Assessment phases to identify, agree and document project and Safety in Design risks and opportunities which will be updated during the design development.
- Phase 3 – Preliminary Concept Design of Preferred Alignment. It will include:
  - Design development process
  - Adopted Design Criteria with reference to the Basis of Design
  - Methods of calculation and analysis
  - Constructability
  - Land ownership
  - Environmental and heritage status of the corridor through which the alignment passes.

- Planning approval process
- Procurement strategies and risks.
- Geophysical survey along preferred alignment and further investigations.

1.3.1 PROJECT KEY DELIVERABLES

Two (2) design delivery phases:

- Alignment Options Assessment – components: Geotechnical Assessment, Road Alignment, Drainage, Pavements, Road Furniture, Bridges and Structures, Cost Estimate (North Projects) and HSiD Risk Register
- Concept Design of Preferred Alignment – components: Geotechnical Assessment, Road Alignment, Drainage, Pavements, Road Furniture, Bridges and Structures and Cost Estimate (North Projects).

1.4 PROJECT OBJECTIVES

The objectives for the project are detailed below:

- Produce Concept Design of the new Wolgan Valley permanent access road suitable for all vehicle access in replacement of the original (now closed) road on the western side of the valley.
- Maintain historic track known as the Donkey Steps.

1.5 DEFINITIONS AND ABBREVIATIONS

Table 2 – Abbreviations Used Within this Report

Abbreviation.	Description
AEP	Annual Exceedance Probability
CH	Chainage
HSiD	Health and Safety in Design
km/h	Kilometres per hour

2 INITIAL OPTION DEVELOPMENT

2.1 ROAD ALIGNMENT

2.1.1 DESIGN CRITERIA

For the initial option development, input was sought from Council on design parameters including maximum grade and design vehicle (i.e., the length of vehicle that needs to be accommodated).

The preferred maximum gradient used by Council is 15% (17% maximum). WSP adopted a preferred gradient of 10% where achievable and a maximum grade of 15%. The flatter grades allow more efficient travel allowing vehicles to use a higher gear and therefore less fuel when climbing out of the valley and reducing brake wear on downhill travel.

A single unit truck (12.5m length) was adopted as the design vehicle, i.e., the size of vehicle that can remain within its lane on tight curves. The 19m semi-trailer was used as a check vehicle, which could utilise the inner shoulder for tighter turns such as the switchback curves.

2.1.2 GENERAL DESIGN CRITERIA

Based on the above discussion, the values in Table 2-1 were adopted as a compromise between cost and a reasonable level of operational service based on the anticipated traffic volumes. Horizontal curves will typically require speed advisory signs to ensure safe operation. The combination of steep terrain, road grades and curvature will impact the necessary message to road users to use caution. In addition, the entry curves to the upper section of the road have been chosen to progressively reduce in radius to safely slow traffic when entering the more tightly curved upper section.

Table 2-1 – General road design criteria

Design value	Required value
Posted Speed	50 & 40km/h*
Average Annual Daily Traffic (AADT)	~100 v.p.d.
Design Vehicle	Single Unit Truck (12.5m)
Checking Vehicle	Semi-Trailer (19m)

*Advisory speed signage required for all horizontal and vertical geometry.

2.1.1 CROSS SECTION

The typical cross section adopted is detailed in Table 2-2 and Figure 2-1 below. Normal lane widths were adopted in preference to a narrower 3.3m lane. This is due to the need to apply lane widening on many of the curves to accommodate the design vehicle within the lane. The lane widening would override many sections of narrower lane and hence any advantage in cost would be lost.

Table 2-2 – Cross section design criteria

Design elements	Minimum design requirement
Number of through lanes each direction	1
Design lane width	3.5 m

Design elements	Minimum design requirement
Offside shoulder width	1.0 m
Verge width	1.5 m
Cut batter slope	1H:1V – Desirable 0.5H:1V – Minimum
Fill batter slope	1H:1V - Desirable

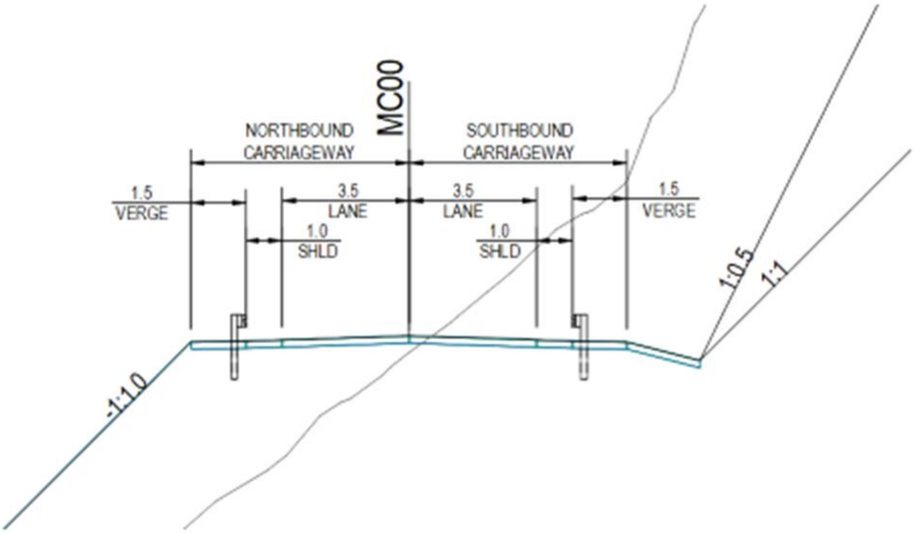


Figure 2-1 – Typical Cross Section Adopted

2.1.1 HORIZONTAL AND VERTICAL CONSIDERATIONS

The Wolgan Valley presents a significant challenge for the geometric alignment of an access road, due to the elevation difference of 260 meters between the head (southern) and floor (northern) ends of the valley. Due to this elevation change, an overall road length of around 2,600 meters (minimum) is required to achieve an average grade of 10% down the vertical profile of the access road. The instantaneous grade varies between 0% (at vertical curves) and 15% (absolute maximum). Grades were eased at the location of the switch backs to avoid creating excessive gradients on the inner edge of the curve due to the shorter distance the inner edge traverses to achieve the same elevation change as the outer edge of the curve.

The other key geometric constraint for the access road is the slope grade within the valley. A steep rock face exists at the top of the eastern side of the valley with slopes reducing towards the valley floor. The observed slopes in the valley are around 1H:0.8V at the steep rock face and flattens to 1H:2.2V at the lower areas for the alignment switch backs. There is significant undulation that occurs across the gullies and ridges which necessitate a balance of cut and fill spilling from the alignment while maintaining suitable vertical smoothness. Each option to overcome these topographic challenges are explained below, with key details around the differences between each option. Tight horizontal curves following the valley gullies and ridges have been incorporated into the geometry to efficiently limit earthworks. To increase the length of road and hence limit the maximum gradients, two switch backs (otherwise known as hair pin turns) were adopted to allow the road to reverse direction and increase the road length. In most cases the switchbacks were on absolute minimum curve radii (R10) to limit the extent of cut and fill batter.

Nine strategic alignments were developed with most of them located on the eastern side of the valley where acceptable slope stability was highlighted in the previous corridor study. Thes are described in Table 2-3 in the following section.

2.2 INITIAL DEVELOPMENT OF STRATEGIC DESIGNS

2.2.1 GENERAL PRINCIPLES OF ROUTE ALIGNMENTS

As mentioned earlier, WSP aimed to create a route length of around 2.6km between Wolgan Gap at the southern end of the valley and the existing road to the North adjacent to the Wolgan River. This length of new road would provide an average gradient close to 10%. The topography of the site is reflected by a steeper upper slope between RL920 and RL760 including steep upper rock bluffs and a flatter section of lower slope extending from RL760 to RL720. All route options needed to traverse the steep upper slope to reach the more accommodating slopes in the lower valley. To create acceptable gradients in the upper slopes, the options needed to include a switch back to create a longer section of road over which to change height without encroaching on the less desirable north facing slopes.

2.2.2 INITIAL OPTIONS AND SIFTING PROCESS

A suite of options was developed based on the design criteria listed in 2.1.1 above and the general principles in 2.2.1 above. Each initial option was subject to a high-level sifting process to determine which three options should proceed to the detailed assessment phase. Each of the options were developed and workshopped with the design team and assessed from an alignment and geotechnical viewpoint. These two design disciplines provided the initial differentiators to facilitate the high-level option sifting process. Options that had merit but contained some undesirable elements were refined to mitigate these shortcomings. The refinements typically comprised:

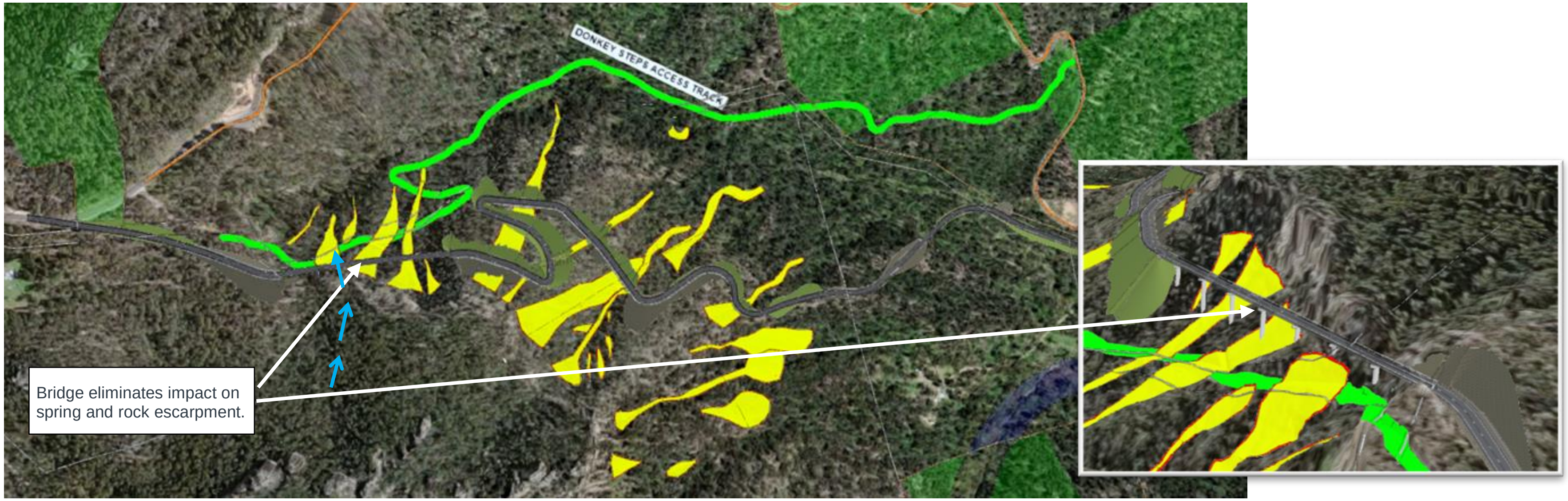
- Relocation of switchback curves to avoid areas with higher levels of slope risk.
- Easing of gradients at the switch back locations to improve driveability.
- Realignment to eliminate high fill and cut batters.
- Substitution of bridge structure in place of earthworks to limit impacts on natural features or excessive batter slopes.
- Incorporating retaining walls to minimise earthworks extents.

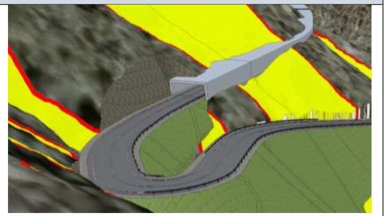
Table 2-3 below shows the initial description of all the initial alignment options that were developed and subject to the initial sifting process by the design team to determine which selected three final options would be taken forward for assessment.

Table 2-3 - Initial Options Assessment

	Status	Description and Key References	Benefits/Disadvantages
Option 1	Discontinued	This initial option explores a “no structure” approach by looking at the resultant cut and fill embankments encountered while keeping the road alignment as close to the eastern valley wall as possible: • The alignment stays to the east of the Donkey Steps and cuts into the existing ground as it departs from the head of the valley. The cutting goes through an existing major water course and seep. The cutting runs across the escarpment above the Donkey Steps. As the grade drops the cutting continues around northeast to a switch back. • The main switch back spills to the other side of the natural rock abutment on the eastern wall. A bridging structure is required to cross the Wolgan River at the valley floor, joining the existing Wolgan Road at the bottom of the valley.	Cons: • The horizontal geometry necessary to keep the alignment in a close balance with the existing valley slopes. • The cut through the watercourse and seep causes. The cut takes out the entire escarpment above the Donkey Steps. The cut slopes are 0.5:1 It has been decided to close this option to further development due to the major cuts at the beginning of the decent.
			

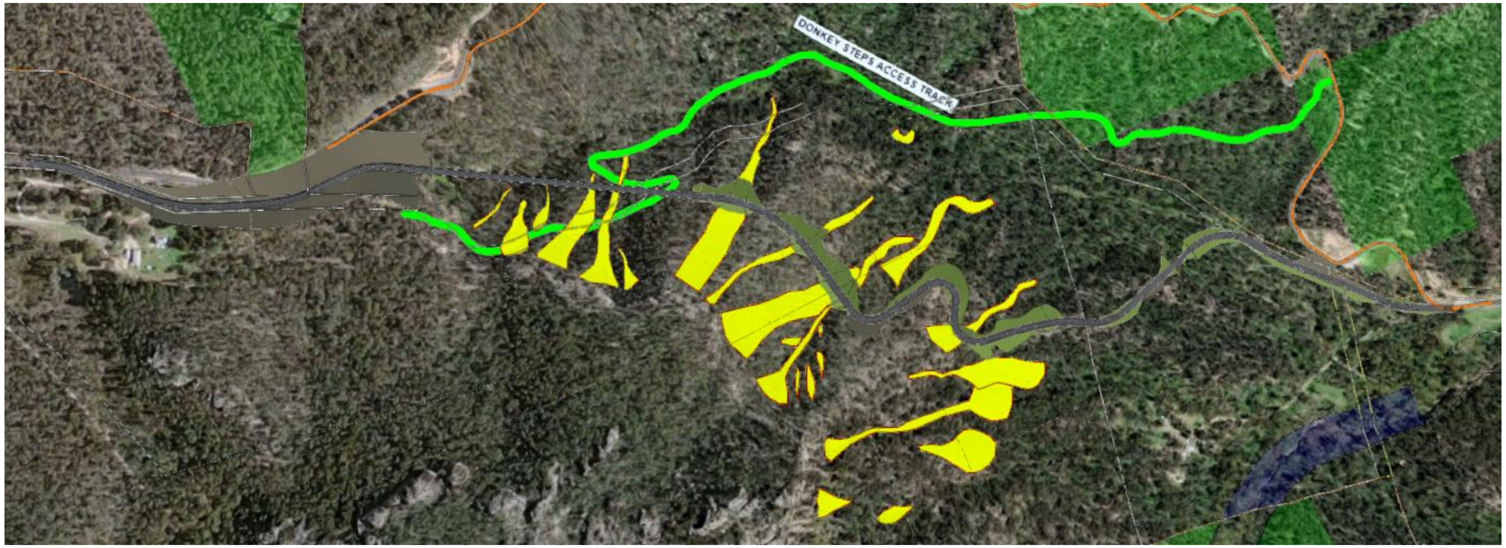
	Status	Description and Key References	Benefits/Disadvantages
Option 2	**Viable Option**	This option incorporates a bridge at the head of the valley to avoid the cut batter impacts on the vertical bluffs above the road and excessive fill batters below the road which would cover the Donkey Steps Track. The bridge also offers a better standard of alignment for the upper section. The alignment enters the valley to the East of the Donkey Steps, in a large cut then into a 270m bridge structure on a 10% grade located against the eastern valley cliff edge; and continues in cut below the escarpment. Vertical profile is lower than Alignment Option 1 and the upper switch back is located further south, prior to the next gully which included unfavourable slope risk. A bridge is required to convey the road across the Wolgan River in the valley floor. Beyond the bridge the option joins the existing Wolgan Road at the bottom of the valley.	Option 2 offers an efficient combination of route length and gradient. Upper bridge avoids impact on vertical bluffs and excessive fill batters impacting on Donkey Steps track. The track could remain operational during construction and could provide construction access.

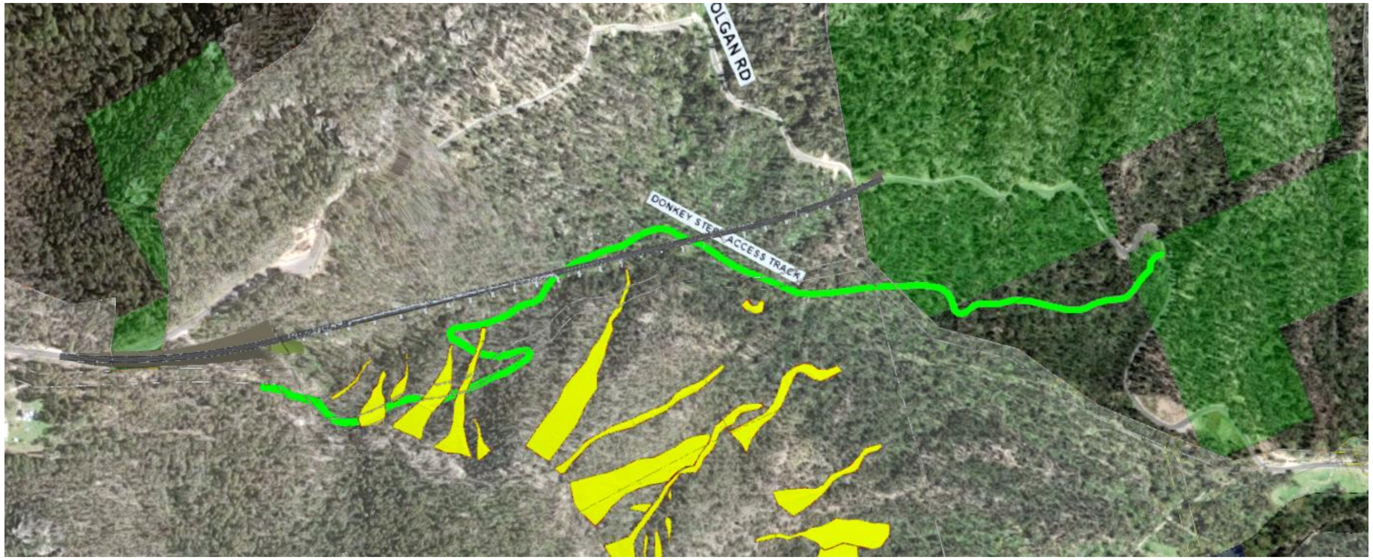


	Status	Description and Key References	Benefits/Disadvantages
Option 2 Buried Tunnel	Discontinued	Similar alignment and grading to Option_2 with a cut and cover tunnel section added in the upper section. The purpose was to explore whether a cut and cover tunnel could provide protection for slips above the road and allow watercourses to pass over, rather than under the road. By its nature the option would sit primarily in cut, with minimal fill batters and walls.	Further analysis of the slope risk suggested that the risk of ongoing minor slips would not justify the cost of the cut and cover tunnel sections. 
Option 3	**Viable Option**	This option keeps to the west of the Donkey Steps in a cut then onto a 370m long bridge on a 10% grade which would carry the route over the Donkey Steps onto its eastern side. The road then continues along in cut below the escarpment. There are 2 switch backs with 10m radius. These switch backs have the grades reduced to 1% through the switch back. The grade after the first switch back is increased to 15%. A bridge would be required to cross the Wolgan River at the valley floor, joining the existing Wolgan Road at the bottom of the valley.	As with Option 2, Option 3 offers an efficient combination of route length and gradient. Upper bridge avoids impact on vertical bluffs and excessive fill batters impacting on Donkey Steps track. The track could remain operational during construction and could provide construction access.
			

	Status	Description and Key References	Benefits/Disadvantages
Option 4	Discontinued	The option was created to examine whether the adoption of lower design standards such as reduced lane width and tighter curve radii would offer significant benefits. The adoption of the lower standard of alignment would provide a route located to the East of the donkey steps to avoid needing a bridge structure.	The cut through the Water course and seep causes. The cut takes out the entire escarpment above the Donkey Steps. It has been decided to close this option to further development due to the major cuts and minimum design standard the beginning of the decent and minimum design standards considered.
			

	Status	Description and Key References	Benefits/Disadvantages
Option 5	**Viable Option**	This option is to the west of the Donkey Steps in a very large cut up to 50m deep. This deep cut allows the bridge to be much lower in the valley floor. The bridge is approximately 400m long at 10% grade crossing over the Donkey Steps. The deep cut also means the upper levels of the road are at a much lower elevation that with Alignment Options 2 and 3. The grade on the lower section is 15% and the lower elevation of this option means that only partial switch backs are needed and the radii of these is a more relaxed 30m. A bridge is required to cross the Wolgan River at the valley floor as with other options before Alignment Option 5 joins the existing Wolgan Road at the bottom of the valley.	The route sits at a lower elevation on the eastern slopes of the valley which may reduce the visual impact. The switchback curvature is less severe as with other similar options (i.e., Alignment Options 2 and 3). Alignment Option 5 would require a diversion to the Donkey Steps access at the top of the valley to accommodate the deep cutting associated with this option.

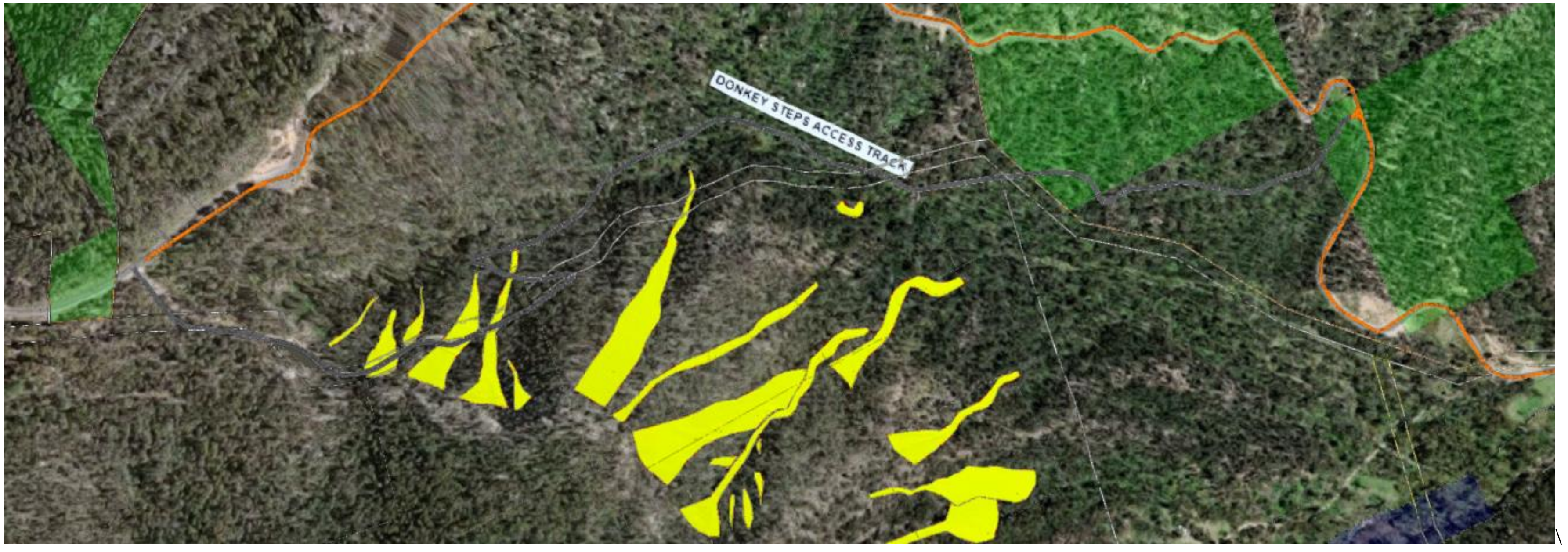


	Status	Description and Key References	Benefits/Disadvantages
Option 6	Discontinued	This option again is located west of Donkey Steps, initially in a cut then onto a long straight bridge 935m long joining to the existing Wolgan Road on the western side of the valley. The bridge would have significant height with a maximum pier height of 80-90m.	Alignment Option 6 is substantially a bridge solution which would be much more costly to construct. The option would be less subject to ongoing slips due to being located on structure with clearance below for debris to pass. There is a safety concern given the relatively straight bridge connecting to a section of existing road with tight curvature which could result in run off road type accidents.
			

	Status	Description and Key References	Benefits/Disadvantages
Option 6A	Discontinued	This option again is west of donkey steps in a cut then into a long \ bridge 1220m long joining into the Wolgan Road at the bottom of the valley. The bridge is very high with a max pier height of 70-80m.	Alignment Option 7 is substantially a bridge solution which would be much more costly to construct. The option would be less subject to ongoing slips due to being located on structure with clearance below for debris to pass.
			

	Status	Description and Key References	Benefits/Disadvantages
Option 7	Discontinued	This option was investigated to present an option that utilised a lower maximum gradient to test the impact on road length. The grades are generally 6% with a max of 8%. There are 6 switch backs on the alignment. Retaining walls would be required between the switch backs in the upper section however these could possibly be designed out if greater separation of the alignments was achieved.	This option achieved its objective of providing a flatter average grade which would facilitate vehicle operations. The flatter grades were achieved at the expense of increasing the length of road, which in turn would result in a slower journey time and construction cost. This is compounded by the six tight switchback curves which would require speed reductions to negotiate safely. Therefore, the benefits of the flatter grade would be lost in comparison to steeper, shorter routes with fewer switchback turns.

	Status	Description and Key References	Benefits/Disadvantages
Option 8	Discontinued	Existing Donkey Steps track without improvement. Grades up to 35% on the upper section and 20% - 25% elsewhere. This option was a “Do Nothing” option.	The curvature, gradient and cross section is suitable for 4WD passenger vehicles and specialist single unit trucks. It retains an elevated level of safety risk that would not be acceptable for a permanent access road.



	Status	Description and Key References	Benefits/Disadvantages
Option 8A	Discontinued	Upgrade to the existing Donkey Steps route. Add deeper cut at top then a bridge 115m long. Lengthen the first switch back to reduce the grade in that section.	The improvements help reduce the grade to around 26% however the remainder of the Donkey Steps track would retain the steep grades and tight curvature hence the investment in bridging the upper section would not translate into a wider improvement. The remaining alignment, as with Option 8, is not considered suitable as a permanent access road.
			

	Status	Description and Key References	Benefits/Disadvantages
Option 9	Discontinued	This Alignment option is similar to options 2 and 3 and it would require the Donkey Steps to be diverted onto a bench so it could remain in operation.	Disadvantage of impacting Donkey Steps track.
			

2.3 OUTCOME OF INITIAL OPTION SIFTING

Option 1 was not taken forward due to the impact of the upper level cutting on the natural escarpment and the length of fill batter which would block the Donkey Steps track.

Option 2 was developed based on Option 1 but with a bridge to avoid the challenging earthworks associated with Option 1 and was further refined to improve driveability and avoid an area north of the upper switchback that was subject to higher risk slope instability. Option 2 was the initial option taken forward for assessment.

Option 3 was developed to enter the valley to the West of the Donkey Steps track instead of to the East of the Donkey steps as with Option 2. The remainder of Option 3 is similar to Option 2. It was taken forward to compare against Option 2.

Option 4 adopted an absolute minimum cross section and curvature to gauge impact on the upper escarpment. The benefits were not deemed sufficient to offset the reduced cross section and curvature which would potentially impact safety and operation of the road. Option 4 was not taken forward.

Option 5 entered the valley to the West of the Donkey Steps track similar to Option 3 but at a lower elevation by cutting much deeper than Option 3. This lower grading allowed the switch backs to be reduced in severity and enabled the alignment to traverse lower sections of the steep slope compared to Options 2 and 3. These positive features of Option 5 made it worthwhile taking forward for comparison with Option 2 and Option 3.

Options 6 and **Option 6A** comprised long bridges extending from the top of the valley and intercepting the existing closed road on the west side of the valley at different locations. Both options were likely to be costly, given the length of bridge and pier heights. Being predominantly located on bridge, they would have less exposure to ongoing slips and associated maintenance. Neither option was taken forward.

Option 7 benefitted by having a lower average grade but at the expense of a much greater route length to achieve the lower grade. The six switch backs would be challenging to negotiate, especially for heavy vehicles. Given these disadvantages, this option was not taken forward.

Option 8 (Existing Donkey Steps) and **Option 8A** (refined Donkey Steps) were not taken forward. Both options retained sections of narrow cross section and steep grades rendering them unsuitable as long-term options. Upgrading would necessitate closure of the route to traffic and a long detour via the Old Coach Road while the access was closed.

Option 9 enters the valley close to the Donkey Steps Track between Option 2 and Option 3. It would require the Donkey Steps to be diverted onto a bench so it could remain in operation. Given its similarity to Option 2 and Option 3 and the disadvantage of impacting the existing track, Option 9 was not taken forward.

The initial sifting process resulted in three viable options to take forward for further assessment. These are, **Options 2, 3 and 5**. All meet the design criteria and follow the eastern slopes of the valley and rejoin Wolgan Road at the valley floor.

3 DESCRIPTION OF SHORTLISTED OPTIONS

3.1 ROAD ALIGNMENT

3.1.1 ALIGNMENT OPTION 2

This option explores an initial bridging structure at the head of the valley to smooth the horizontal and vertical undulations in the alignment which result from the eroded gullies present in the steep cliff face. Development of the design has been undertaken to introduce a significant cutting at the head of the valley which results in a lower overall alignment. Refinements were also made to move the upper switchback further south to avoid a gully which contained a significant slope hazard.

— Alignment stays to the East of the Donkey Steps, with a bridge structure launched against the eastern valley cliff edge.

— Vertical profile is higher than Option 3 but is able to return the switch back prior to the next gully over around the natural rock abutment in the valley, while still achieving a similar average grade.

3.1.1.1 BENEFITS

— Lower overall alignment. The landing onto the eastern wall of the valley is significantly lower than trying to maintain a maximum downgrade while commencing from the head of the valley.

— Switch backs avoid many of the identified slip failure zones on the eastern valley wall.

Table 3-1 – Design values Option 2

Design values	**Value achieved**	**Notes**
Vertical Grade	15% (Maximum)	117m section between the two switch backs. Vertical flattening has been incorporated through the switch backs to aid resultant cross fall.
Vertical Curve	K = 3 (Crest) K = 2.5 (Sag)	Located at the approach and departure of the horizontal switch backs, in an area of low operational speed.
Length of Vertical Curve	Min. 17.5m	Located at the approach and departure of the horizontal switch backs, in an area of low operational speed.
Horizontal Curve Radius	65m (min.) generally. 10m at horizontal switch backs.	
Horizontal Curve Length	~16m (min.) generally. ~30m at horizontal switch backs.	
Crossfall	3% (adverse) standard. Max. 6% superelevation.	Where superelevation transitions are not achievable between adjacent horizontal curves, one-way crossfall may extend along the tangents.

3.1.2 ALIGNMENT OPTION 3

This option explores a 300m long initial bridging structure at the head of the valley; launching from the western side of the Donkey Steps access, crossing over the Donkey Steps, and landing on the initial ridge on the eastern wall of the valley (similar to other options).

- 300m long initial bridging structure launching from approximately 5m of cut from the head of the valley.
- Vertical profile that is slightly lower than Option 2 when landing the bridge on the eastern wall of the valley.

3.1.2.1 BENEFITS

- Lower alignment due to the higher angle approach to the eastern valley wall, by launching a longer bridge on the western side of the Donkey Steps.
- Avoids significant cutting of the eastern wall of the Wolgan Valley, preserving the rock face, and bridges over many of the potential slip failure zones.

Table 3-2 - Design values Option 3

Design values	Value achieved	Notes
Vertical Grade	15% (Maximum)	440m section following the switch backs, to tie into the existing Wolgan Valley Road on the floor of the valley.
Vertical Curve	K = 2.8 (Crest) K = 3.0 (Sag)	Located at the approach and departure of the horizontal switch backs, in an area of low operational speed.
Length of Vertical Curve	Min. 25m	Located at the approach and departure of the horizontal switch backs, in an area of low operational speed.
Horizontal Curve Radius	65m (min.) generally. 10m at horizontal switch backs.	
Horizontal Curve Length	~35m (min.) generally. ~30m at horizontal switch backs.	
Crossfall	3% (adverse) standard. Max. 6% superelevation.	Where superelevation transitions are not achievable between adjacent horizontal curves, one-way crossfall may extend along the tangents.

3.1.3 ALIGMENT OPTION 5

This option explores an initial, significant cutting of ~45m into the head of the valley to achieve a reduction in launching height for the top structure. A single bridge structure crosses over the Wolgan Valley floor, the Donkey Steps and lands further down the first ridge line on the eastern side of the valley, lower than the prior two options. No horizontal switch backs have been incorporated higher on the eastern valley wall, different from the first two options.

3.1.3.1 BENEFITS

- Lower alignment due to the 45m cutting into the head of the Wolgan Valley.
- Avoids switchbacks higher up the valley wall, and only a single crossing over the identified slip zones. Switchbacks have larger radii and less turn angle than Options 2 and 3
- Highest overall quality of horizontal and vertical geometry, however there is a 635 length of 15% vertical grade.

Table 3-3- Design values Option 5

Design values	Value achieved	Notes
Vertical Grade	15% (Maximum)	Two sections, the main being a 635m section following the bridge landing on the first ridge of the eastern valley wall.
Vertical Curve	K = 15 (Crest) K = 15 (Sag)	
Length of Vertical Curve	Min. 75m	
Horizontal Curve Radius	56m (min.) generally. 30m & 40m at horizontal switch backs.	
Horizontal Curve Length	~16m (min.) generally. ~30m at horizontal switch backs.	
Crossfall	3% (adverse) standard. Max. 6% superelevation.	Where superelevation transitions are not achievable between adjacent horizontal curves, one-way crossfall may extend along the tangents.

3.1.4 ROAD FURNITURE

3.1.4.1 ROAD SIGNAGE

Appropriate regulatory, guide and information signs would be provided to complete a suite of road furniture. The regulatory signage would include steep grade, curve advisory, stopping bay signage. Guide signage would advise on key destinations and distance. Information signage would potentially cover road condition or access restrictions.

3.1.4.2 SAFETY BARRIERS

Given the curvature, steep terrain and grades, road safety barriers will be provided wherever the road is supported on a fill batter or retaining wall. Safety barriers are not required next to cut batters. Safety barriers proposed for the options would be steel W Beam type above fill batters and Rigid Concrete Barriers on retaining walls (Figures Figure 3-1Figure 3-2).

Figure 3-1 – Flexible Safety Barriers (Wolgan Road)

Figure 3-2 – Rigid Concrete Barrier

3.1.5 ROAD SAFETY

The safe operation of the new Wolgan Road access will be influenced by several factors including the design itself and the physical environment through which the road passes.

3.1.5.1 SAFE ROAD DESIGN

MITIGATION FOR ROAD CURVATURE

Considering the road design itself, it needs to be acknowledged that the geometric alignment is of a generally lower standard due to the need to fit the alignment into the existing terrain so that construction cost is reasonable. The closer the alignment fits the terrain, leads to less earthworks and retaining walls. The design approach has been to offer a balance between construction cost and operating speed which is related to road curvature. When considering safety, the presence of multiple curves on a section of road is not necessarily unsafe since drivers (assisted by appropriate speed advisory signage) would adjust their speed to negotiate the road safely. What is more important is the transition from straighter sections of road into more tightly curved sections. The Wolgan Road has a relatively straight approaches at both ends which allow free speeds of around 80km/h. On the northern approach from Lithgow there is a straight section 400m long before a curve of around 130m radius as depicted in Figure 3-3 and the southern approach has two curves of around 150m and 220m radius, as shown in Figure 3-4, although both have deviation angles of less than 10 degrees, which allows a higher operating speed.

Figure 3-3 – Northern Approach to The Valley

Figure 3-4 – Southern Approach (Road Since Sealed)

The safe design approach is to progressively tighten the road curvature as vehicles enter the new road so that drivers can progressively adjust to a lower speed. Braking in the downhill (northbound) direction will be increased due to grade effects. Maintaining adequate friction resistance on the road surfacing will be important. road signage will pay a key role in providing visual warning to drivers of the curve advisory speeds and the steep gradients however these will not assist in differentiating between the options.

OPTION 2 NORTHBOUND

The critical curve is the R85m left curve at the start of Bridge 01which follows a gentle R650m right curve. The R85 m curve is in a cutting which will help define the tighter radius. Bridge 1 is located on a R200m right curve which leads to a R80m right curve and R150 right curve leading into the R20m left switchback curve.

OPTION 2 SOUTHBOUND

The critical curve southbound is a R85m left curve preceded by a gentle R250 right curve with small deviation angle. This curve defines the start of the steeper winding section of road to the summit.

OPTION 3 NORTHBOUND

The critical curve southbound is a R100m right curve preceded by a n approx. R100 left curve (existing curve). The preceding curve has a smaller deflection angle which will provide initial slowing for the subsequent right curve. Bridge 1 is on a R1200m curve on a downhill grade where travel speeds will increase until the R160 right curve and R100m left curve before the R20m first switch back curve. The progressive curve tightening from R1200 > R160 > R100m with small deviation angles will slow vehicles before the switchback curve.

OPTION 3 SOUTHBOUND

The critical curve southbound is a R85m left curve preceded by a gentle R250 right curve with small deviation angle. This design is identical to Option 2.

OPTION 5 NORTHBOUND

The critical curve southbound id the R100 right curve leading on to Bridge 1. This is preceded by two R200m left curves and a R200m right curve with moderate deviation angles which allow a progressive slowing of approaching vehicles. Beyond Bridge 1which is located on a straight section, there is a R200m left curve with large deviation angle before the R40m left switchback curve.

OPTION 5 SOUTHBOUND

The southbound approach alignments are as per Option 2.

BREAKDOWN FACILITIES

The typical road section adopted provides a compromise between safety and cost. The shoulders do not have sufficient width to allow a broken-down vehicle to park clear of the traffic lane. To mitigate this and improve safety, emergency stopping bays will be provide at nominal 500m spacings on both sides of the road. The actual locations would be chosen to minimise earthworks and/or retaining walls. The bay dimensions would be 2.5m wide over a 20m length, sufficient to hold one semi-trailer. A 20m lead in/lead out taper would be provided at each end. Since the normal shoulder is 1.0m wide, this entails widening the shoulder a further 1.5m. Consideration can be given to these bays having a double function as both emergency stopping and short duration parking bays allowing visitors to the area to enjoy the views of the surrounding terrain and rivers.

SAFETY BARRIERS

Refer to section 3.1.4.2.

SAFETY RAMPS

The steep downhill grades raise the need to consider safety in the event vehicles suffer brake failure or overheating. In addition to the locally widened shoulders every 500m to allow vehicles to stop clear of traffic if necessary. Consideration has been given to safety ramps (arrestor beds) for out of control vehicles, in particular heavy vehicles. Safety ramps typically contain a depth of uncompacted gravel into which an out of control vehicle can be steered and be brought to a halt in an emergency, refer to Figure 3-5 for an example of a safety ramp used in NSW. The proposed Wolgan Road route would benefit from two safety ramps. The first would be located at the upper switchback (Ramp 1) and the second at the lower switchback (Ramp 2) as shown on Figure 3-6. These two locations cover critical locations prior to the upper and lower switchback curves (the two tightest curves on the routes).

Figure 3-5 – Example of safety ramp (Mt Victoria)

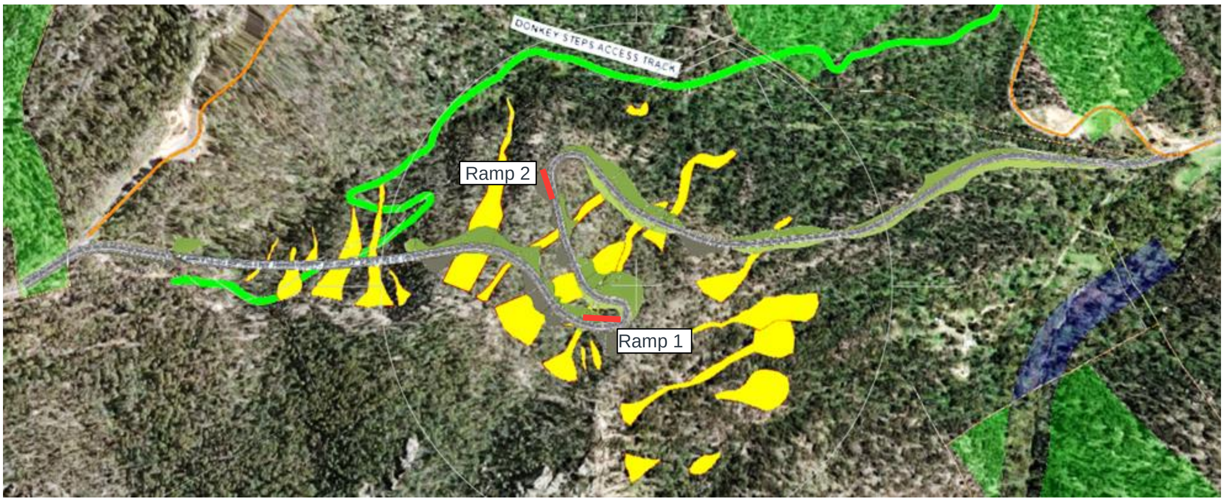
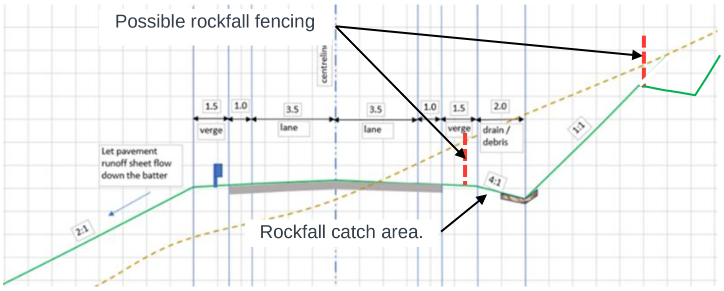


Figure 3-6 – Proposed Locations for Safety Ramps

3.1.5.2 SAFETY WITHIN THE PHYSICAL ENVIRONMENT

ROCKFALL MITIGATION

The primary safety risk related to the physical environment remains slope stability risk. The eastern slopes of the Wolgan Valley offer less instability risk than the western slopes that are traversed by the existing (closed) road. Notwithstanding this, the cross section design incorporates a deeper table drain adjacent to the uphill slope to provide a catch area to contain minor rockfalls and debris spills which might otherwise reach the traffic lane.



Slope risk is further discussed in Section 3.2 where a quantifiable measure of slope risk will be used in the assessment section.

Figure 3-7 – Design Elements to Address Rockfalls

Flooding is not considered to be a significant risk to the route options since the valley has a relatively small catchment area and the majority of the route is well above flood level. A bridge is proposed for the waterway crossing in the valley floor, hence adequate capacity will be available to convey flood flows. Flooding therefore will not be a differentiator between the options.

BUSHFIRE SAFETY

It is acknowledged that the 2019-2020 summer resulted in extensive bushfires in the hills surrounding the Wolgan Valley. The majority of the routes constructed on earthworks will still be susceptible to bushfires, however compared to the existing road, where trees overhang the carriageway, the landscape restoration strategy would aim to maintain a clear buffer of 20m on either side of the carriageway to large trees. Where the road was located on bridge structure would be of lesser risk.

Whilst the direct impact from fire can be reduced by providing a tree buffer, the impact of smoke blanketing the road and reducing visibility would continue to affect the safe passage of vehicles.

Figure 3-8– Bushfire Risk on Existing Road

3.1.1 ROAD AMENITIES

Wolgan Road provides access not only to the local community but also serves as a tourist and visitor access into the Wolgan Valley with high end destinations such as the Emirates One & Only resort, The Camping ground and historic ruins at Newnes and 4wd tracks in the surrounding forests. The route from Wolgan Gap to the southern end of the valley, traversed by these options offers opportunities to stop and view the vistas.

It is possible to allow use of the emergency stopping bays as short-term parking bays for opportunistic photo stops. In addition, the location of the upper switchback might provide a viewing opportunity and parking area for a more formalised stopping location. Below are two images taken from the BIM model which shows views to the North from Option 5 (in

Figure 3-9) and Option 2 and 3 at a higher elevation (in

Figure 3-10). The Wolgan River flows along the base of the range in the right background. Parking facilities could either be a stopping bay or a widened shoulder/verge area, subject to adequate sight distance and a safe road crossing point.

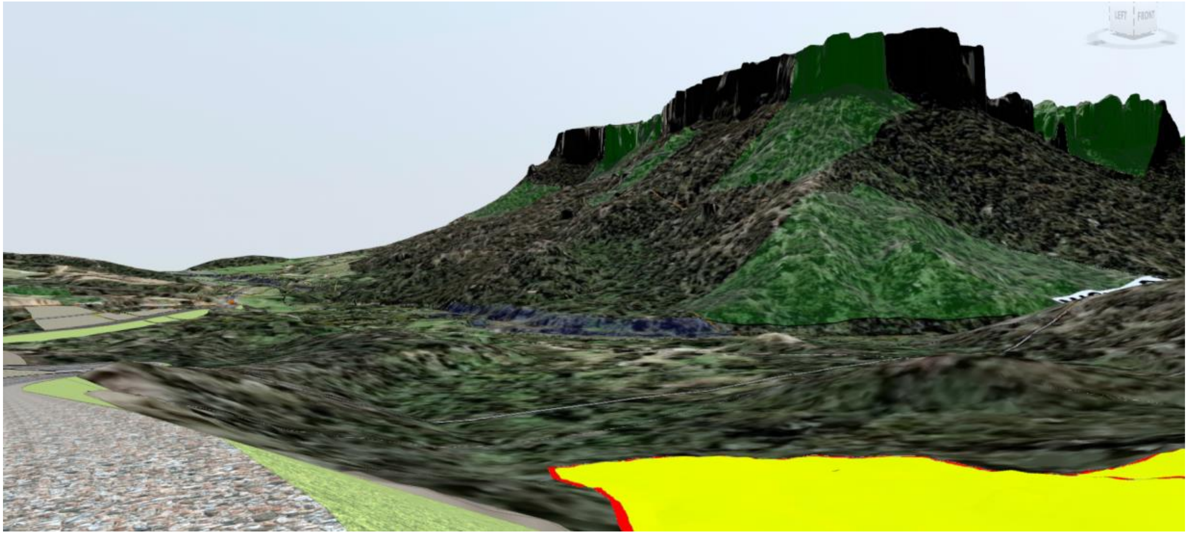


Figure 3-9 – Potential Parking and Viewpoint (Option 5)

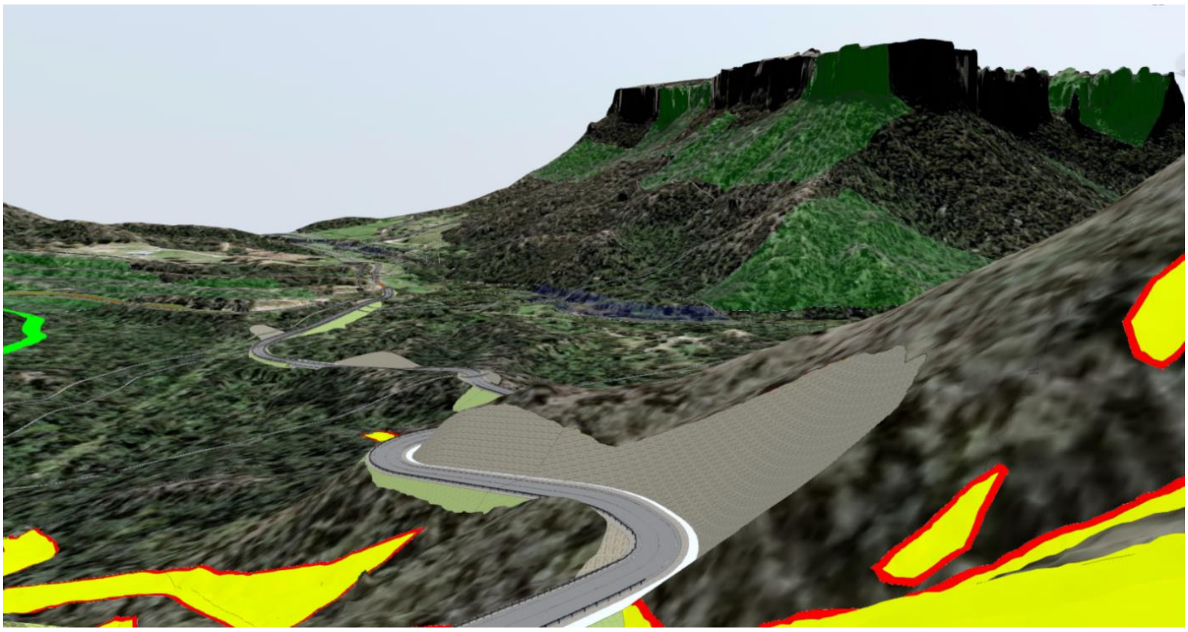


Figure 3-10 – Potential Stopping and Viewpoint (Option 2 & 3)

3.2 GEOTECHNICAL

3.2.1 INTRODUCTION

In November 2022, Council identified a need to investigate options to replace an approximately 2 km length of the existing Wolgan Road and move towards providing e a new Wolgan Valley Access Road which would avoid an area of slope hazard which exposed road users to an unacceptable loss of life risk (WSP 2023a, WSP 2023b). A Route Constraints Study was prepared by WSP in December 2022 which included a review of physical constraints to accessing Wolgan Valley and preliminary slope hazard susceptibility mapping of Wolgan Valley (WSP 2022a). Subsequent to the Route Constraints Study a Corridor Assessment Report was prepared which included comparison of the slope hazard susceptibility of six potential corridors to access Wolgan Valley (WSP 2022b). Of those six corridors, the Southern Corridor was favoured based on an assessment that considered cost, engineering and environment criteria (WSP 2022b). The Southern Corridor recorded the lowest slope hazard susceptibility score of the six corridors assessed.

As discussed in Section 1.1 of this report, three alignment options within the Southern Corridor have been considered and refined (herein as Option 2, Option 3 and Option 5 in accordance with Section 2.3 of this report). A comparison of the slope hazard susceptibility (Section 1.1.1) and geotechnical engineering challenges (Section 1.1.2) associated with each of the three options is provided and herein. The characteristics used for the slope hazard susceptibility assessment were chosen based on the geological setting and local geomorphology (WSP 2022a). A preliminary geological model has been developed based on regional geological data derived from publicly available coal mining borehole information, cored boreholes undertaken along the existing Wolgan Road, geological maps, detailed aerial photogrammetry and LiDAR, and field-based mapping along Wolgan Road and the Donkey Steps temporary Access Road. Based on that preliminary geotechnical model, the three option alignments have been assessed against anticipated ground conditions.

Further detailed investigation will be required to confirm local surface and subsurface geological and geomorphological conditions (including the presence, nature, extent and activity of existing landslides). It is envisaged that such investigation will be undertaken during future design development stages for the preferred alignment. Determination of the location, nature and extent of that investigation should be undertaken with consideration of the potential interaction of the preferred road alignment and its engineered form (e.g., horizontal and vertical alignment, cut and fill orientations and magnitudes) and engineered elements (e.g., retaining walls) with those geological and geomorphological conditions.

3.2.2 GEOTECHNICAL SLOPE HAZARD SUSCEPTIBILITY

The slope hazard susceptibility zoning developed for the Route Constraints Study has been applied to the three short listed alignment options. The approximately 2 km length of Wolgan Road which is bypassed by the three short listed alignment options has also been zoned to allow for risk comparison. The following characteristics which influence slope hazard susceptibility are considered in calculating the slope hazard susceptibility score.

1. Slope angle
2. Maximum individual cliff-line height
3. Slope aspect/orientation
4. Presence of colluvium
5. Presence of water courses/drainage lines
6. Presence of Narrabeen Group cap rock at cliff line
7. Presence of coal measures
8. Evidence of past rock fall and topple.
9. Evidence of past landslide

The susceptibility zoning of the area through which the existing portion of Wolgan Road to be bypassed and the three alignment options assessed is shown visually in Figure 3-11 below.

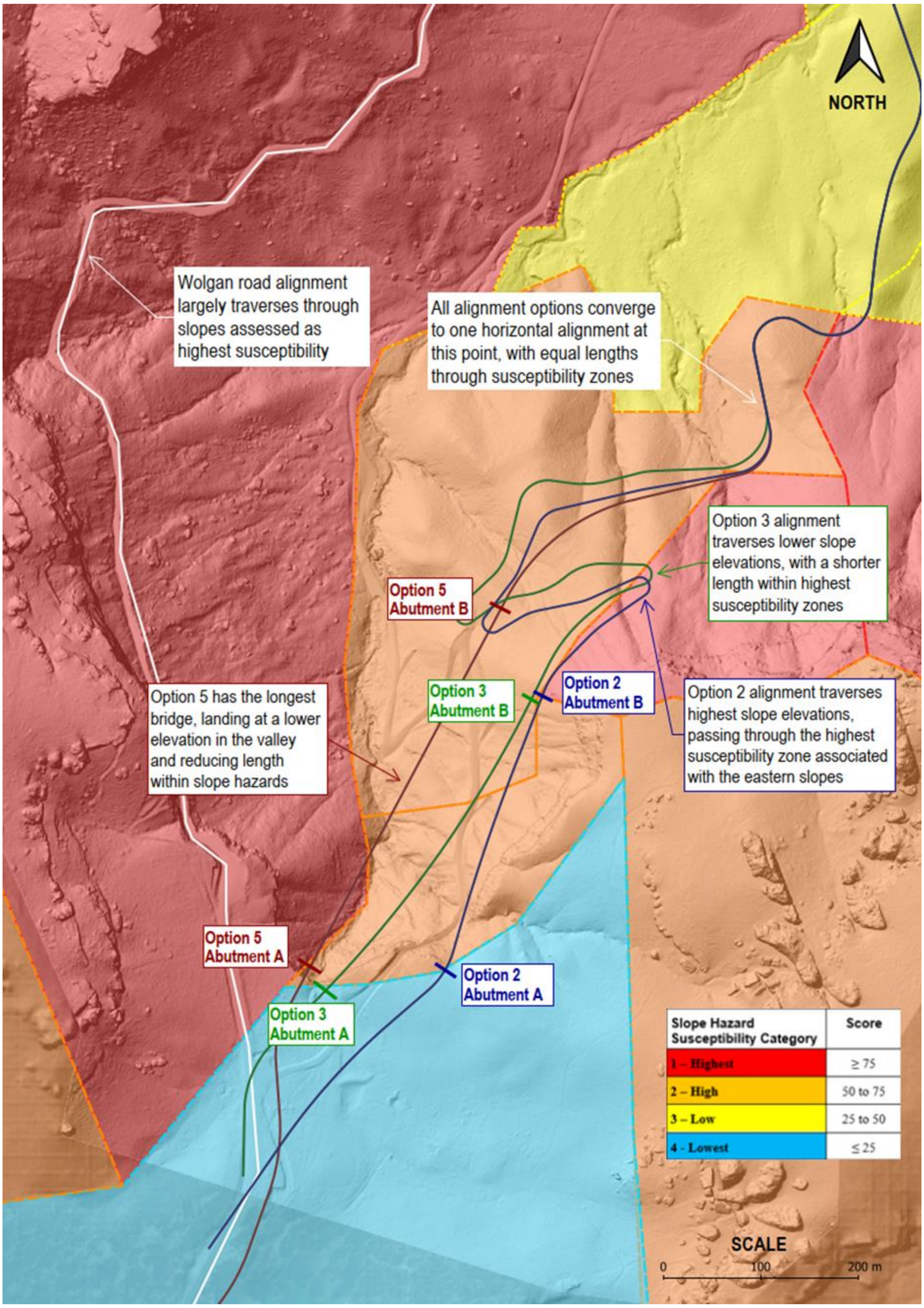


Figure 3-11 - Slope hazard susceptibility traversed by alignment Option 2, 3, 5 and existing Wolgan Road (to be bypassed)

The slope hazard susceptibility zoning results in a weighted slope hazard susceptibility score with a possible range of 0 to 100 in the categories of Table 3-4 below, which a higher score indicating increasing hazard. The basis of the susceptibility scoring is described in detail within the Corridor Assessment Report (WSP 2022b).

Table 3-4 - Slope hazard susceptibility Zoning categories

Category	Score [1]
1 – Highest	≥ 75
2 – High	50 to 75
3 – Low	25 to 50
4 - Lowest	≤ 25

Notes: [1] – Refer to report PS129742-SYD-GEO-REP-101, (WSP, 2022a) for scoring basis and details

For the purposes of comparison of the three options for a new Wolgan Valley access road, the slope hazard susceptibility approach was applied to individual segments of the three alignment options and then the scores combined to achieve a weighted score for the overall alignment option based on the alignment length. Where lengths of particular design elements avoid slope hazards (i.e., bridge spans sufficiently elevated and offset from the surrounding terrain) a slope hazard score of 0 was applied for those lengths.

In similar slope hazard susceptibility conditions, relatively longer alignments will expose road users to greater slope risk. As such the weighted slope hazard susceptibility scores for each option have been normalised against the longest alignment (i.e., in this case the length of existing Wolgan Road to be bypassed). The results of the slope hazard susceptibility comparison are presented in Table 3-5.

Table 3-5 - Slope Hazard Susceptibility scores for Option 2, 3, 5 and the existing portion of Wolgan Road to be bypassed

Option1	Weighted hazard score	Length (km)	Length factor	Slope hazard susceptibility score[2] normalised for length of alignment
Option 2	33	2.53	0.86	28
Option 3	33	2.53	0.86	28
Option 5	26	2.45	0.83	21
Existing Wolgan Road (to be bypassed)	73	2.96	1.00	73

Notes: [1] – Refer to Section 3.1of this report for a description of the alignment options.

[2] – The individual alignment option Weighted Score is normalised against the longest alignment (i.e., Slope Hazard Susceptibility Score = Weighted Score × Length Factor, where Length Factor = Option Length ÷ Longest Option Length).

As shown in Table 3-5, Option 5 has been assessed as the least susceptible to slope hazards of the three proposed new alignment options. The existing portion of Wolgan Road to be bypassed is calculated to be significantly more susceptible than any of the three proposed alignment options assessed. Key differences which influence the relative slope hazard susceptibility scores of each of the alignments are assessed as follows:

1. Overall length of alignment
2. Length of bridges which avoids slope hazard.
3. Length of alignment within high slope hazard susceptibility zones.

As can be seen in Figure 3-11, the existing portion of Wolgan Road is situated almost entirely within Category 1 hazard susceptibility zones, is the longest alignment and does not contain any bridge sections. The Option 5 alignment (i.e., the lowest slope hazard susceptibility scoring alignment) by comparison is the shortest alignment and contains the longest bridge section avoiding a significant length of slope hazard. Option 2 and Option 3 alignments have similar lengths, approximately similar lengths of bridge, approximately similar alignments with respect to hazard susceptibility traversed and result in the same slope hazard susceptibility scores.

3.2.3 COMPARISON OF GEOTECHNICAL ENGINEERING CHALLENGES

Each of the three alignment options traverse terrain which is challenging from a geotechnical engineering viewpoint in consideration for modern road construction standards. Historic road construction methods in similar terrain would sometimes comprise side cast cut to filling with very steep longitudinal grades and very short radius horizontal curves. Some of the geotechnical challenges include.

1. Existing landslides and debris cones.
2. Variable thicknesses and composition of colluvium.
3. Variable bedrock stratigraphy including the presence of coal seams.
4. Variably orientated and very steep slopes.

Items 1 to 4 above are addressed generally without considering engineering details (e.g., generally including cut, fill and retaining wall locations and heights) within the slope hazard susceptibility comparison outlined in Section 3.2.2. However, the nature and location of engineering elements (e.g., retaining walls) including their form, extent and position are an additional factor which will influence the magnitude of the geotechnical challenges for each option.

The road design of the three alignment options is discussed in detail in Section 3.1.1 to 3.1.3 of this report. For the purpose of this alignment option assessment and comparison a preliminary 45 º cut envelope has been adopted. However, in accordance with *Austroads: Guide to Road Design Part 3*, cuttings will require cut benches, the width, spacing and positioning of which will need to be determined during future design development for the preferred alignment. Final cut batter slopes will also need to be determined during future design development in consideration of the nature and extent of temporary and/or permanent support which may be adopted. As a minimum, rockfall catch fences should be allowed for at the lowest bench height. However, additional landslide risk mitigation measures may also be required depending on the nature of the final design, target residual risk and any specific geotechnical conditions that are identified. Budgets for on-going maintenance, repair and replacement should also be considered when deciding the type, location and extent of risk mitigation measures adopted for the preferred alignment.

Geotechnically, the three shortlisted alignment options can be sub-divided into four broad sections with respect to geotechnical challenges and complexity, as shown in **Error! Reference source not found.**. In summary each option incorporates the following:

SECTION 1 (SHADED ORANGE IN FIGURE 2) - SOUTHERN APPROACH FROM WOLGAN ROAD TO BRIDGE LAUNCH INTO THE VALLEY:

This section is dominated by cutting and commences the descent into the valley from the plateau. Maximum cut heights range between options from 8 m to 50 m and cut lengths range between options from 120 m to 580 m.

SECTION 2 (UNSHADED IN FIGURE 2) - A BRIDGE DECK SECTION:

Bridge deck lengths range from 270 m to 395 m (details of bridge options are provided in Section 3.3. 2).

SECTION 3 (SHADED RED IN FIGURE 2) - A SECTION OVER STEEP AND VERY STEEP VALLEY SLOPES:

This section of the route is considered the most challenging portion of the alignment from a geotechnical and constructability perspective. The alignment is required to descend more than 100m of elevation, across steep terrain containing variable thicknesses of landslide prone colluvial material, existing landslide features, significant drainage paths, and springs. In this area the upper portion of the alignment (i.e., leading to the switchbacks which are a feature of Option 2 and Option 3 but not Option 5) is situated below an eastern upper escarpment which is a source for landslide and rockfall from above. In this section there are 4 cuttings in each option (up to a maximum height of 25 m) and between five and seven areas of fill (up to an approximate maximum of 25m height for the option of a sub-vertical reinforced soil retaining wall). It has been assumed at this stage that retaining walls are likely to be adopted through this section rather than engineered fill batters due to the following:

- In many locations typical 2H:1V (i.e., 2 Horizontal to 1 Vertical, or approximately 26o) compacted fill embankment profiles will 'chase' the slope downhill without intersection with natural surface.
- Due to the slope of the terrain, even relatively steep engineered and reinforced fill embankments at say 1H:1V slopes will result in large embankment foundation footprints, complex terracing requirements for foundation preparation and a potential need for temporary support of the existing slopes and excavated terraces in order to safely construct the embankments.
- It is anticipated that retaining walls would typically have a relatively smaller foundation footprint and less complex terracing required for foundation excavation.

SECTION 4 (SHADED GREEN IN FIGURE 2) - A VALLEY FLOOR SECTION:

The alignments converge to follow similar horizontal alignments within this section over typically moderate or gentle slopes. Within this section, each option incorporates 3 embankment fills to a maximum height of 13 m, 3 (for Option 5) to 4 (Option 2 and 3) cuttings to a maximum batter height of 9 m, and all options include a one single span bridge over the creek. Based on currently available information, 2H:1V cut and fill batters are typically considered geometrically feasible in this section.

In general terms, Section 3 is currently considered the most geotechnically challenging. Within Section 3, the central switch backs, which require cut and fill at multiple levels across the same slope area, will present temporary (i.e., construction stage) and permanent stability challenges and will likely require both temporary and permanent slope support. Section 4 is currently considered the least geotechnically challenging due to the typically gentle or moderate slopes.

The number and location of bridge piers within Section 2 has only been determined at a high level of detail at this stage. The nature and location of those structures will need to be reviewed against the ground and sub-surface conditions during future design development to identify geotechnical challenges. However, Section 2 is not currently envisaged to present the same magnitude of geotechnical challenges as Section 3.

Section 1 is currently considered to present a level of geotechnical challenge intermediate to Section 3 and Section 4. The level of geotechnical challenge presented by Section 1 varies between alignment options due to the significant differences in cut depth and length, as well as differences in the positioning of the proposed cuts (as shown Figure 3-12).

To aid comparison of the alignment options, a ranking has been undertaken of the inferred level of geotechnical challenge each alignment option faces. This comparison was based on assessment of a total of eight parameters associated with inferred ground and subsurface conditions and the engineered form and engineering elements of alignment Option 2, Option 3 and Option 5. The assessment criteria adopted for those parameters is described in Table 3-6.

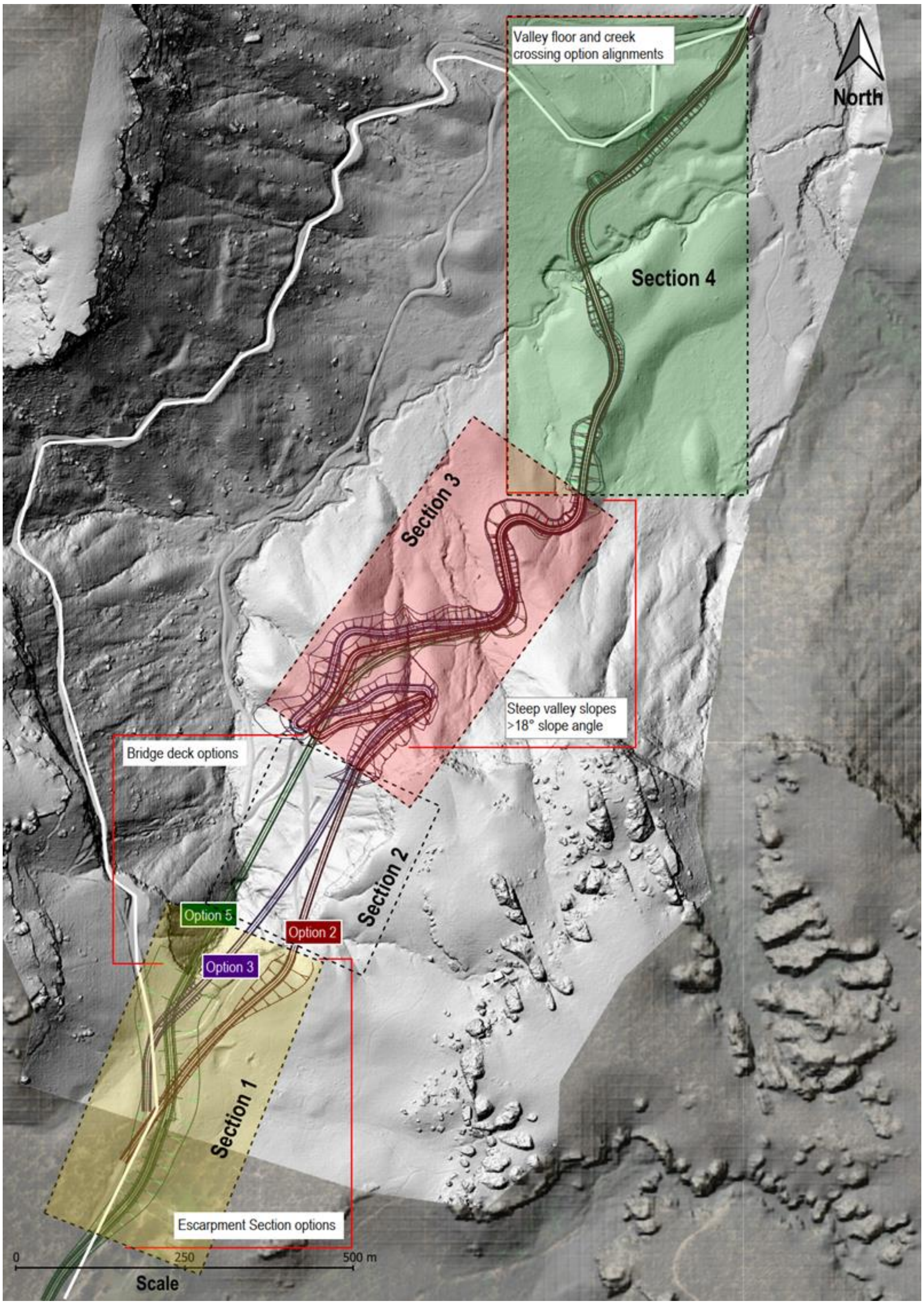


Figure 3-12 – Overview of engineering features of alignment Option 2, Option 3 and Option 5.

The three shortlisted options have been assessed and ranked 1 (best), 2 (intermediate) or 3 (worst) for the eight geotechnical challenge parameters of Table 3 6. The total scores (i.e., the sum of the rank scores for each parameter) were normalised against the highest possible score of 24 (i.e., the theoretical result for an alignment if it scored a rank value of 3 for each of the eight parameters). Thus, the lowest scoring alignment is assessed as facing the least geotechnical engineering challenges within this comparison.

The comparative rankings for each parameter and result out of a possible maximum of 100 for alignment Options 2, Option 3 and Option 5 are presented in Table 3 7.

Table 3-6 - Parameters adopted for comparison of geotechnical challenges of Option 2, Option 3 and Option 5 alignments

Parameter		Potential influence	Assessment criteria
1	Proximity of coal seams to cut floor/ foundation.	Potential for increased seepage and 'poorer' (e.g., lower CBR value) foundation conditions where coal seams and associated 'finer' grained strata (e.g., shale) are encountered compared to granular soil and/or sandstone.	Relative length (i.e., ranking alignment options from least to most) of total cut floor and fill foundations inferred to be within ±5m of coal seams.
2	Quantity of rock excavation.	Rock excavation inferred to typically entail a slower excavation rate, higher cost, and increased environmental challenges (e.g., vibration, noise and dust) than a similar volume of soil.	Relative quantity (i.e., ranking alignment options from least to most) of inferred rock excavation based on preliminary geotechnical model.
3	Length of retaining walls	Retaining walls will typically have increased material requirements and costs (including construction stage testing and inspection) than an equivalent length of un-reinforced compacted fill embankment.	Relative length (i.e., ranking alignment options from least to most) of walls.
4	Length of retaining wall > 10m in height	The load which high retaining walls will place on existing slopes will present relatively greater challenges than low walls.	Relative length (i.e., ranking alignment options from least to most) of walls > 10 m in height.
5	Length of cuts	Cuts typically involve slower production rates and greater temporary and permanent support requirements than the same length of 'at grade' construction.	Relative length (i.e., ranking alignment options from least to most) of walls.
6	Length of cuts > 15m	High cuts will require multiple benches and may require more extensive cut face support or relatively wide footprints (depending on the cut batter envelopes adopted).	Relative length (i.e., ranking alignment options from least to most) of cuts > 15 m in height.
7	Length of cuts with steep slopes above crest	Where cuts are situated below steep natural slopes (compared to being situated below gentle terrain for example) there is typically an increased risk of instability of the cut, a potential increased need for slope stabilisation of the natural slope above the cut crest and a potential increased need for landslide protection (e.g., rock fall catch fences) on the cut slope, its benches and/or at its toe.	Relative length (i.e., ranking alignment options from least to most) of cuts with steep, very steep or extreme natural slopes or cliffs above their crest (i.e., where upslope angles are >18°in accordance with the terminology of AGS Geoguide LR2).
8	Length of cuts encountering coal seams within their cut face.	Where coal seams are encountered within the cut face, they may be associated with areas of increased seepage and/or instability. Relatively more shallow cut batter angles and/or more cut support may be required along with the potential for management of increased and/or concentrated zones of seepage.	Length of cutting that are inferred to encounter coal seams within the cutting face which may require protection or reinforcement.

Table 3-7 - Comparison of relative magnitude of inferred Geotechnical Challenges for alignment Options 2, 3 and 5

Parameter	Option 2 rank	Option 3 rank	Option 5 rank
1 Proximity of coal seams to cut floor/foundation.	2	3	1
2 Quantity of rock excavation.	2	1	3
3 Length of retaining walls	2	3	1
4 Length of retaining wall > 10m in height	3	2	1
5 Length of cuts	2	1	3
6 Length of cuts > 15m	2	1	3
7 Length of cuts with steep slopes above crest	3	2	1
8 Length of cuts with coal seams in their cut face.	2	1	3
Sum of Ranks	**18**	**14**	**16**
Normalised Score[2]	**75**	**58**	**67**
Overall Ranking	**3**	**1**	**2**

Notes: [1] – Refer to Table 3 for a description of the assessment parameters 1 to 8 inclusive.

[2] – Calculated as the sum of ranks for the 8 parameters divided by 24 and multiplied by 100

As shown in Table 3 7, the comparative assessment results in Option 3 being calculated as the ‘least’ geotechnical challenging with a score of 58, following by Option 5 with a score of 67, followed by Option 2 with a score of 75. The results of are influenced by the following alignment characteristics and differences between the three options:

— Option 5 commences with a long and high cut in Section 1 (approximately 580 m long with a maximum height of approximately 50 m). Thus Option 5 is ranked third with respect to quantity of rock excavation, length of cuts, length of high cuts and length of cuts with coal seams within their face. Option 5 has the longest bridge section (approximately 390 m long) and is the shortest of the three alignment options which contributes to it being ranked first with respect to length of retaining walls, length of high retaining walls and length of cuts with steep slopes above the crest. In addition to the length of the bridge section and overall length, the elevation of the bridge section with respect to the stratigraphy also contributes to Option 5 being ranked first with respect to proximity of coal seams to the foundation floor.

— Option 3 commences with a relatively smaller cut in Section 1 (approximately 8 m maximum height) than Option 2 (approximately 30 m maximum height). That influences Option 3 being ranked first for quantity of rock excavation, length of cuts, length of high cuts and length of coal seams within cut faces whereas Option 2 is ranked second for those parameters. As shown on Figure 3 12, within Section 3 the horizontal alignment of Option 3 is situated relatively further to the west and thus downslope than Option 2. That influences Option 3 being ranked second with respect to length of cuts with steep slopes above their crest and length of high retaining wall, whereas Option 2 is ranked third for those parameters.

— Option 3 has a more elongated switch back section in Section 3 of the alignment which influences Option 3 being ranked third for length of retaining walls whereas Option 2 is ranked second for that parameter. The elevation at which Option 3 enters cut and fill sections influences its third ranking for proximity of coal seams to the cut floor or fill foundation (Option 2 is ranked second for that parameter).

3.2.4 SUMMARY OF GEOTECHNICAL COMPARISON OF OPTION 2, OPTION 3 AND OPTION 5

Alignment Option 2, Option 3 and Option 5 have been compared as described in Section 3.2.2 and Section 3.2.3 for their relative slope hazard susceptibility and the inferred geotechnical challenges. The results of those comparisons are as follows.

- Alignment Option 5 is the least susceptible to slope hazard but the middle rank (i.e., between Option 2 and Option 3) for overall geotechnical challenges.
- Alignment Option 3 is the least geotechnically challenging but equally susceptible to slope hazard as Option 2.
- Alignment Option 2 is the most geotechnically challenging and equally susceptible to slope hazard as Option 3.

Assessment of a preferred alignment will need to include cost, engineering and environmental factors considerations which were not considered in this geotechnical review. The slope hazard susceptibility and geotechnical engineering challenges presented by the three alignment options assessed here should form part of the overall preferred route selection process.

3.2.5 REFERENCES

- Wolgan Valley Access road – Route Constraints Study, WSP, November 2022, Report #PS129742-SYD-GEO-REP-101-REV0 (WSP 2022a)
- Wolgan Valley Access road – Corridor Assessment Report, WSP, December 2022, Report #PS129742-SYD-GEO-REP-102-REV0 (WSP 2022b)
- Review of Wolgan Gap Slope Hazards, WSP, January 2023, Report #PS129742-SYD-REP-GEO-REP-001-REV0 (WSP, 2023a)
- Slope Risk Assessment Update 2022 – Domain 1 and 2, February 2023, Report #PS129742-SYD-REP-GEO-REP-002-REV0 (WSP, 2023b)
- Australian GeoGuide LR2 – Landslides, Australian Geomechanics, Vol 42, March 2007
- Austroads Guide to Road Design Part 3 Geometric Design, Austroads, 2021

3.3 BRIDGES AND STRUCTURES

The structural options developed and presented in this report have been based on the relevant Australian Standards, in conjunction with TfNSW specifications. In general order of precedence, the design criteria are listed below.

- TfNSW standards and specifications (including Bridge Technical Directions)
- AS 5100 – 2017 Bridge Design Code, with latest amendments
- Other relevant Australian Standards (e.g., AS 1170, AS 2159)

The design loads, forces and load effects applied to the structures are assumed as follows:

- SM1600 and HLP400 traffic loading to AS 5100.2
- Traffic barrier performance level: Medium
- No of design lanes: 2

3.3.1 STRUCTURE REQUIREMENTS

All alignments assessed require similar structural solutions. While each alignment varies slightly at each structure, the overall structural options are similar for all options. Hence the structures for each alignment option are discussed under one heading with influences from different alignments included within that heading.

3.3.1.1 BRIDGE NO. 1 (VIADUCT)

The first bridge at the entry to the valley is a significant structure that will traverse from the top of the escarpment and land on the talus ridge slope partway down. The alignment of each bridge is summarised in Table 3-8.

Table 3-8 – Bridge No. 1 (Viaduct) Alignment considerations.

ALIGNMENT FEATURE	ALIGNMENT OPTION		
	Alignment Option 2	Alignment Option 3	Alignment Option 5
Bridge Length (≈m)	270	370	395
Indicative max height (≈m)	23	45	40
Horizontal Alignment	2000m radius curve	1200m radius curve	Straight
Vertical Alignment	10% grade	10% grade	10% grade
Below Bridge	Steep sloping terrain transverse to road	Steep sloping terrain transverse to road	Crosses gulley / Wolgan River tributary at a skew with steep slopes into the valley

It is not considered the differences in road alignment will have a fundamental impact on the bridge type selected, only influence the cost and complexity of the construction.

Several bridge Structure types have been assessed, with the most feasible three options for this bridge are presented for consideration in the Table 3-9. The structure types presented have been simplified to suit all three alignment options for the ease of comparison. These options will require further investigation as the alignment and design develop.

Table 3-9 – Structural Options, Bridge No. 1 (Viaduct)

CRITERIA	BRIDGE OPTION 1 SUPER-T GIRDER	BRIDGE OPTION 2 INCREMENTALLY LAUNCHED	BRIDGE OPTION 3 HAUNCHED BALANCED CANTILEVER
Overall Length and Span Arrangement	<u>*Alignment Option 2*</u> 7 No. spans with overall length 266m 38m typical spans <u>*Alignment Option 3*</u> 10 No. spans with overall length 370m	<u>*Alignment Option 2*</u> 5 No. spans with overall length 270m 60m typical spans, 45m end spans <u>*Alignment Option 3*</u> 7 No. spans with overall length 390m	<u>*Alignment Option 2*</u> 4 No. spans with overall length 270m 80m typical spans, 55m end spans <u>*Alignment Option 3*</u> 6 No. spans with overall length 380m

CRITERIA	BRIDGE OPTION 1 SUPER-T GIRDER	BRIDGE OPTION 2 INCREMENTALLY LAUNCHED	BRIDGE OPTION 3 HAUNCHED BALANCED CANTILEVER
	37m typical spans *Alignment Option 5* 11 No. spans with overall length 396m 36m typical spans	60m typical spans, 45m end spans *Alignment Option 5* 7 No. spans with overall length 390m 60m typical spans, 45m end spans	70m typical spans, 50m end spans *Alignment Option 5* 6 No. spans with overall length 400m 75m typical spans, 50m end spans
Cross Section Type	Type 5 (1815 mm deep) super-T girders with composite 200mm thick cast-in-place concrete deck. 5 girders per span. 9.0m width between barrier faces, with asphaltic concrete wearing surface and waterproofing membrane.	Single 3.0m constant depth concrete box girder. 9.0m width between barrier faces, with asphaltic concrete wearing surface and waterproofing membrane.	Single haunched concrete box girder, 3.0m depth at mid-span and 4.5m depth at piers. 9.0m width between barrier faces, with asphaltic concrete wearing surface and waterproofing membrane.
Articulation	Restrained elastomeric bearings at piers and abutments. Fabricated steel finger plate expansion joints at both abutments. Continuous deck (link slabs) over piers. Lateral restraint blocks at each pier and abutment.	Guided pot bearings at piers and abutments. Fabricated steel finger plate expansion joints at both abutments. Box girder continuous over piers.	Guided pot bearings at piers and abutments. Fabricated steel finger plate expansion joints at both abutments. Box girder continuous over piers.
Piers	**All Piers Reinforced concrete columns.** *Alignment Option 2* 6 Piers Tallest pier ~ 28m *Alignment Option 3* 9 Piers Tallest pier ~ 38m *Alignment Option 5* 10 Piers Tallest pier ~ 34m	**All Piers Reinforced concrete columns.** *Alignment Option 2* 4 Piers Tallest pier ~ 28m *Alignment Option 3* 6 Piers Tallest pier ~ 38m *Alignment Option 5* 6 Piers Tallest pier ~ 34m	**All Piers Reinforced concrete columns.** *Alignment Option 2* 3 Piers Tallest pier ~ 28m *Alignment Option 3* 5 Piers Tallest pier ~ 38m *Alignment Option 5* 5 Piers Tallest pier ~ 34m

CRITERIA	BRIDGE OPTION 1 SUPER-T GIRDER	BRIDGE OPTION 2 INCREMENTALLY LAUNCHED	BRIDGE OPTION 3 HAUNCHED BALANCED CANTILEVER
Pier Foundation	Pile cap with bored reinforced concrete piles, or, Pad footing with rock anchors	Pile cap with bored reinforced concrete piles, or, Pad footing with rock anchors	Pile cap with bored reinforced concrete piles, or, Pad footing with rock anchors
Abutments	Bored reinforced concrete piles. RSW at Abutment B.	Bored reinforced concrete piles. RSW at Abutment B.	Bored reinforced concrete piles. RSW at Abutment B.
Utilities and Drainage	Provision of conduits for services. Deck scuppers and piped drainage.	Provision of conduits for services. Deck scuppers and piped drainage.	Provision of conduits for services. Deck scuppers and piped drainage.
Hydrology and Hydraulics*	No defined creek. Piers to avoid gully locations.	No defined creek. Piers to avoid gully locations.	No defined creek. Piers to avoid gully locations.
Design Issues	Proven design methodology, less complex.	Proven design methodology, more complex.	Proven design methodology, more complex.
Construction Issues	Proven technology, less complex. Less site construction with use of precast girders. Transport and crane lift from ground level not considered feasible given steep terrain. Alternative span by span erection using an overhead travelling gantry likely.	Proven technology, requires specialised equipment, more geometry control and construction accuracy. Easier access to Abutment A. Launching downhill (10% grade) presents safety and control challenges. Launching uphill from Abutment B feasible but presents accessibility challenges. Launching gantry nose and equipment required.	Proven technology, requires specialised equipment, more geometry control and construction accuracy. More site construction with cast-in-place box girder segments. Travelling form.
Safety in Design	Longest exposure to working at heights. Girder erection, placement of concrete deck, installation of barriers.	Shortest exposure to working at heights. Box segments match-cast behind abutment.	Intermediate exposure to working at heights. Box girder cast in place using travelling form.
Environmental	Most number of piers	Intermediate number of piers	Least number of piers
Geotechnical	Most number of piers increases risk of impact from rock fall	Intermediate number of piers and intermediate risk level. (with respect to landslide).	Least number of piers reduces risk (with respect to landslide).

CRITERIA	BRIDGE OPTION 1 SUPER-T GIRDER	BRIDGE OPTION 2 INCREMENTALLY LAUNCHED	BRIDGE OPTION 3 HAUNCHED BALANCED CANTILEVER
	and/or interaction with landslide zones.		
Durability	Reinforced concrete structure, 100 years design life. Replaceable joints and bearings.	Reinforced concrete structure, 100 years design life. Replaceable joints and bearings.	Reinforced concrete structure, 100 years design life. Replaceable joints and bearings.
Maintenance	Replaceable joints and bearings. *Alignment option0 2* 70 elastomeric bearings to replace. *Alignment Option 3* 100 elastomeric bearings to replace. *Alignment Option 5* 110 elastomeric bearings to replace	Replaceable joints and bearings. *Alignment Option 2* 12 pot bearings *Alignment Option 3* 16 pot bearings *Alignment Option 5* 16 pot bearings	Replaceable joints and bearings. *Alignment Option 2* 10 pot bearings *Alignment Option 3* 14 pot bearings *Alignment Option 5* 14 pot bearings

** Alignment Option 5 crosses a tributary of Wolgan River. This would need to be considered in the pier placement.*

All options above are considered to be feasible. Further investigation, including detailed geotechnical site investigations, refinement of the road alignment, accessibility assessment and constructability review, is required before a preferred option can be identified. The haunched concrete box girder (Bridge Option 3), for Alignment Option 2, has been selected to develop concept sketches that are presented in Appendix B

3.3.1.2 BRIDGE NO. 2

There is a second bridge towards the bottom of the valley, crossing a Wolgan River Tributary. All alignment options are similar at this point with the estimated overall bridge length between 35m to 45m. Being much lower in the valley, the terrain is much flatter and access to the pier and abutment is easier compared to Bridge No. 01. The location of Bridge 2 lends itself to a precast concrete girder option. With the hydraulic requirements as yet defined, there are two main options for this structure, a single span structure with deeper girders or a two-span structure utilizing shallower girders if a greater bridge length is required.

A single span structure could utilise either Type 5 (1815mm deep) super-T girders span up to 37m between bearings or should hydraulics allow a reduced bridge length Type 4 (1515mm deep) super-T girders span up to 33m between bearings.

Should a greater bridge length be required due to hydraulics, or transportation requirements of girders dictate, a 2-span option utilising Type 4 (1515mm deep) super-T girders (or shallower) could be utilised to meet site requirements.

Concept sketches of a single span Type 5 Super T girder for this bridge are presented in Appendix B. The bridge superstructure consists of 4 No. Type 4 (1815mm deep) super-T girders per span, a composite 200mm thick cast-in-place deck slab with asphaltic concrete wearing surface and waterproofing membrane. The girders are to be supported on laminated elastomeric bearings sitting on reinforced concrete abutment sill beams. Both abutment sill beams are supported on bored, cast-in-place reinforced concrete piles. Strip seal expansion joints would be provided at each abutment.

3.3.2 RETAINING WALLS

Significant volumes of earth fill would be required to support the road if battered embankment slopes are used. On the downside of the road, the embankment footprint would be substantial as the battered slope chases the ground surface down into valley. An alternate solution to minimise both earth fill and footprint impact would be to support the road using retaining walls. Each alignment option requires a different lengths and heights of retaining walls. The basic wall requirements of each option are summarised in Table 3-10.

Table 3-10 – Basic Retaining Wall Requirements

RETAINING WALL REQUIREMENTS	ALIGNMENT OPTION		
	Alignment Option 2	Alignment Option 3	Alignment Option 5
Indicative maximum visible height	23m	27m	20m
Approximate length of retaining wall required	911m	1074m	586m
Approximate face area	8,749m^2	9,848m^2	4,484m^2

Given the maximum visible retained height of fill is between 20m and 27m for the alignment options, the most feasible retention solution would be the use of a Reinforced Soil Wall (RSW). A RSW utilises precast facing panels, select backfill and straps that extend back through the backfill to engage the soil block to behave as a mass gravity element. A traffic barrier will be required above the wall. Medium Performance Level bridge barriers are anticipated. An indicative example of a RSW cross section in sloping terrain is shown in Appendix B.

The design of the RSW walls will be influenced by a number of factors including.

- The level and slope of natural and retained ground surface above and below the structure.
- Subsurface conditions at wall locations, (e.g., bedrock levels, presence of coal seams, proximity to existing landslide material, zones of seepage and/or soft ground).
- Design surcharge loadings (including landslide debris impact and/or static load from accumulation between maintenance periods).
- Design geometric requirements for maintenance (e.g., access ramps to the area below or above the wall).

Due to the steep terrain and landslide prone colluvial material through which alignment Options 2, 3 and 5 pass, temporary and permanent slope support will likely be required in some areas to enable wall construction and achieve long-term performance requirements. Further geotechnical investigation will be required to develop the RSW design concepts for the preferred alignment Option.

3.4 DRAINAGE

The design standards, key methodology and parameters associated with drainage design are outlined below.

3.4.1 DRAINAGE DESIGN CRITERIA

The preliminary high-level drainage has been prepared based on the following standards and guideline:

- Australian Rainfall and Runoff: A guide to Flood Estimation (Geoscience Australia, 2019)

— Austroads Guide to Road Design Part 5A (2023)

— Lithgow City Council Guidelines for Civil Engineering Design and Construction for Development.

Table 3-11 shows the proposed drainage design criteria and technical inputs to be applied where possible. The criteria were obtained from Austroads and Lithgow CC guidelines.

Table 3-11 – Key Drainage Design Criteria

PARAMETER	VALUE
Min Pipe Cover	600mm (Austroads Part 5A Table 6.1) for rigid pipes, at road carriageways and other areas subject to regular vehicle traffic.
Flow Width	The following flow width (10-Year ARI event) requirements have been adopted for spacing of pits in accordance with Austroads Guide to Road Design Part 5A Table 5.1 and RMS supplement 17.053: • 0.75 m encroachment into travel lane where number of trafficable lanes is one in any one direction and posted speed limit exceeds 70 km/h. • 1m encroachment into travel lane where number of trafficable lanes is one in any one direction and posted speed limit is less than 70 km/h. • Maximum gutter flow width to 2.5m (Lithgow City Council Guidelines for Civil Engineering Design). Where a kerbside trafficable lane is less than 3.5m, the additional width is to be subtracted from the allowable spreads.
Design Average Recurrence Interval (ARI) for Drainage	10-Year ARI storm event (Austroads Part 5 Table 4.3) for non-local road elements. 10-Year ARI storm event for bridge drainage (RMS R11 2018). 100-Year ARI (1% AEP) storm event design for transverse drainage with freeboard. 100-Year ARI (1% AEP) storm event design for scour protection. For conservatism, open channels have been designed to the 10% AEP storm event with consideration to Austroads Guide to Road Design Part 5B.
Min Pipe Diameter	Minimum pipe size of 375mm for longitudinal drainage based on Austroads Part 5A Section 6.5.2 and RMS supplement 17.053. Minimum pipe size of 450mm for new transverse drainage pipe.
Min Pipe Grade	1:200 (0.5%) based on RMS Supplement 17.053 Section 6.5.4
Min Kerb Grading	0.3% based on Austroads Part 5A Section 5.4.5.
Min. Pipe Strength Class (Reinforced Concrete or Fibre Reinforced Concrete)	Class 4 (longitudinal) pipe.
Maximum Pit Spacing	Max 100-120m spacing for pipe diameters less than 1800mm (Austroads Part 5A Section 6.3.1). Maximum spacing between any two consecutive pits is 85m (Lithgow City Council Guidelines Civil Engineering Design).

PARAMETER	VALUE
Min Self-Cleaning Velocity for Pipes	0.6 m/s pipe flow velocity apply to the 1-Year ARI design storm (Austroads Part 5A Table 6.2).
Pipe Velocity of Flow	In steep terrain, the pipe velocity of flow should not be greater than the maximum velocity of 6.0m/s under pipe full conditions. (Austroads Part 5A Section 6.5.4) – This might be impossible as existing velocity in the steep terrain area is already high.
Pit Blockage Factors	50% for sag pits (Austroads Part 5A Table 5.4). 20% for on-grade pits (Austroads Part 5A Table 5.4). For transverse pipe culverts with hydraulic design capacity less than or equal to 600 mm diameter, or 600 mm height for box culverts, a blockage factor of 50% should be applied.
Channel Lining	Channel lining types have been selected based on the velocities in the scour design event (1% AEP), with the following maximum allowable limits: ▪ Vegetated (typically grassed) < 1.7m/s; ▪ Rock = 1.7-3.5m/s; and ▪ Concrete > 3.5m/s.

3.4.2 RAINFALL DATA

Design Intensity Frequency Duration (IFD) data and storm temporal patterns have been derived from the Australian Bureau of Meteorology (BOM) website. The IFD data in Table 3-12 has been used to derive design rainfall events for use in the hydrological analysis of the drainage design. Data is based on coordinates Latitude -33.313405, Longitude 150.114620.

Table 3-12 – Rainfall Depths (mm/h), Frequency and Duration (min)

DURATION (MIN)	ANNUAL EXCEEDANCE PROBABILITY (AEP)						
	63.20%	50%	20%	10%	5%	2%	1%
1	102	115	155	183	211	249	279
2	83.5	93.1	125	147	168	196	218
3	77.4	86.4	116	136	156	183	203
4	73	81.6	110	129	148	174	194
5	69.2	77.5	104	123	141	166	185
10	55	61.7	83.4	98.5	114	135	151
15	45.6	51.3	69.3	82	94.8	112	126
20	39.1	43.9	59.4	70.3	81.3	96.5	108
25	34.3	38.5	52.1	61.6	71.3	84.5	94.9
30	30.7	34.3	46.4	54.9	63.5	75.3	84.5
45	23.5	26.3	35.4	41.8	48.3	57	64
60	19.2	21.5	28.8	34	39.2	46.3	51.9

DURATION (MIN)	ANNUAL EXCEEDANCE PROBABILITY (AEP)						
	63.20%	50%	20%	10%	5%	2%	1%
90	14.4	16.1	21.5	25.3	29.1	34.3	38.3
120	11.8	13.1	17.4	20.5	23.5	27.6	30.9
180	8.85	9.84	13	15.3	17.5	20.6	23
270	6.71	7.46	9.87	11.6	13.2	15.5	17.3
360	5.55	6.17	8.17	9.56	11	12.9	14.4
540	4.28	4.77	6.34	7.43	8.54	10	11.2
720	3.58	4	5.34	6.27	7.23	8.53	9.53
1080	2.79	3.13	4.22	4.99	5.79	6.85	7.66

3.4.3 DRAINS MODEL PARAMETERS

The following DRAINS parameters listed in Table 3-13 were assumed for the hydrological modelling:

Table 3-13 - DRAINS Model Parameters

Description	Value
Pervious Area Depression Storage	5mm
Impervious Area Depression Storage	1mm
Road Area Imperviousness	100%
Soil Type	3 (or C) slow infiltration rates
Pipe Roughness Coefficient (Colebrook-White)	0.6
Concrete Pipe Roughness N	0.013
Headwall Entrance Loss Factors, K Entry Value	0.5

3.4.4 DRAINAGE DESIGN

For purposes of the culvert drainage assessment Option 3B (walled) and 5 have been used.

3.4.4.1 CULVERT DESIGN

To maintain the existing flow conditions, the existing transverse flow paths have been identified and culvert crossings or catch drains used to channel and transfer flows. For larger catchments (creek/major drainage line), the construction of a bridge is recommended.

The estimated culvert sizes are based on the peak 1% AEP storm event flows from DRAINS. These sizes may be refined at further design stages subject to survey or design changes. For transverse pipe culverts with hydraulic design capacity less than or equal to 600 mm diameter, or 600 mm height for box culverts, a blockage factor of 50% have been applied.

Each alignment option has its own construction challenges, for example slope instability can be an issue due to the steep 1:1 slope cut, and appropriate slope treatments and engineering measures are required. The culvert outlet might discharge to an embankment batter slope or out of a retaining wall, depending on the height of the road or the batter slope. See section 3.4.6 for the types of culvert discharge arrangement that can be used for different situations, this will be further investigated during the next stage.

Table 3-14 shows the potential number of bridge structures and transverse crossings for each option. This is an estimation based on the preliminary road designs, natural surface survey, and the catch drains diversion.

Table 3-14 – Potential Number of Bridge Structures and Transverse Crossings for Each Option

Design option	Estimated no. of bridge structures	Estimated no. of transverse crossings
Alignment Option 2	2	10
Alignment Option 2B Walled	2	10
Alignment Option 3	2	13
Alignment Option 3B Walled	2	13
Alignment Option 5	2	9

Option 2, 3 and 5 have considered the above issue by constructing a bridge on the eastern valley side to avoid cutting into the steep escarpment cliffs at the top of the valley.

3.4.4.2 PRE AND POST DEVELOPMENT FLOW COMPARISON (ESTIMATED CULVERT SIZES)

A pre and post overland catchment flows comparison have been carried out to see the differences. The post approached flows have increased due to the proposed batters and road areas.

Table 3-15 shows the pre / post flows; a list of transverse crossings or bridge structures identified in Alignment Option 5.

Table 3-15 – Pre and post catchments flows comparison for Option 5 gully locations.

	PRE DEVELOPMENT			POST DEVELOPMENT					
POINT OF INTEREST	PRE CATCHMENT (m2)	AREA (Ha)	1% AEP FLOW (m3/s)	POST CATCHMENT (m2) grassy rock area and paved road	AREA (Ha)	POST CATCHMENT (m2) paved road only	AREA (Ha)	% GRASSY ROCK AREA	1% AEP FLOW (m3/s)
1	3842.300	0.38	0.11	15460.700	1.55	576.200	0.06	3.73	0.73
2	18536.000	1.85	0.53	22356.300	2.24	610.000	0.06	2.73	1.06
3	93891.300	9.39	2.68	108761.700	10.88	789.000	0.08	0.73	5.23
4	248.200	0.02	0.01	5333.700	0.53	305.000	0.03	5.72	0.25
5	1064.000	0.11	0.03	5472.400	0.55	881.900	0.09	16.12	0.24
6	817.000	0.08	0.02	4053.000	0.41	939.500	0.09	23.18	0.17
7	6802.000	0.68	0.19	12322.100	1.23	676.000	0.07	5.49	0.57
8	373.000	0.04	0.01	1016.000	0.10	148.700	0.01	14.64	0.04
9	40166.200	4.02	1.14	44743.400	4.47	1252.800	0.13	2.80	2.12

3.4.4.3 CULVERTS DISCHARGE ARRANGEMENT

Batter chutes would be adopted to convey concentrated flows (e.g., longitudinal pipe outlets) down the embankment batter slopes to the receiving environment or to a channel and thereby minimise the risk of erosion of the batter slope. This outlet would be used in the embankment batter slope option designs, see

Figure 3-13 and

Figure 3-14 for details.

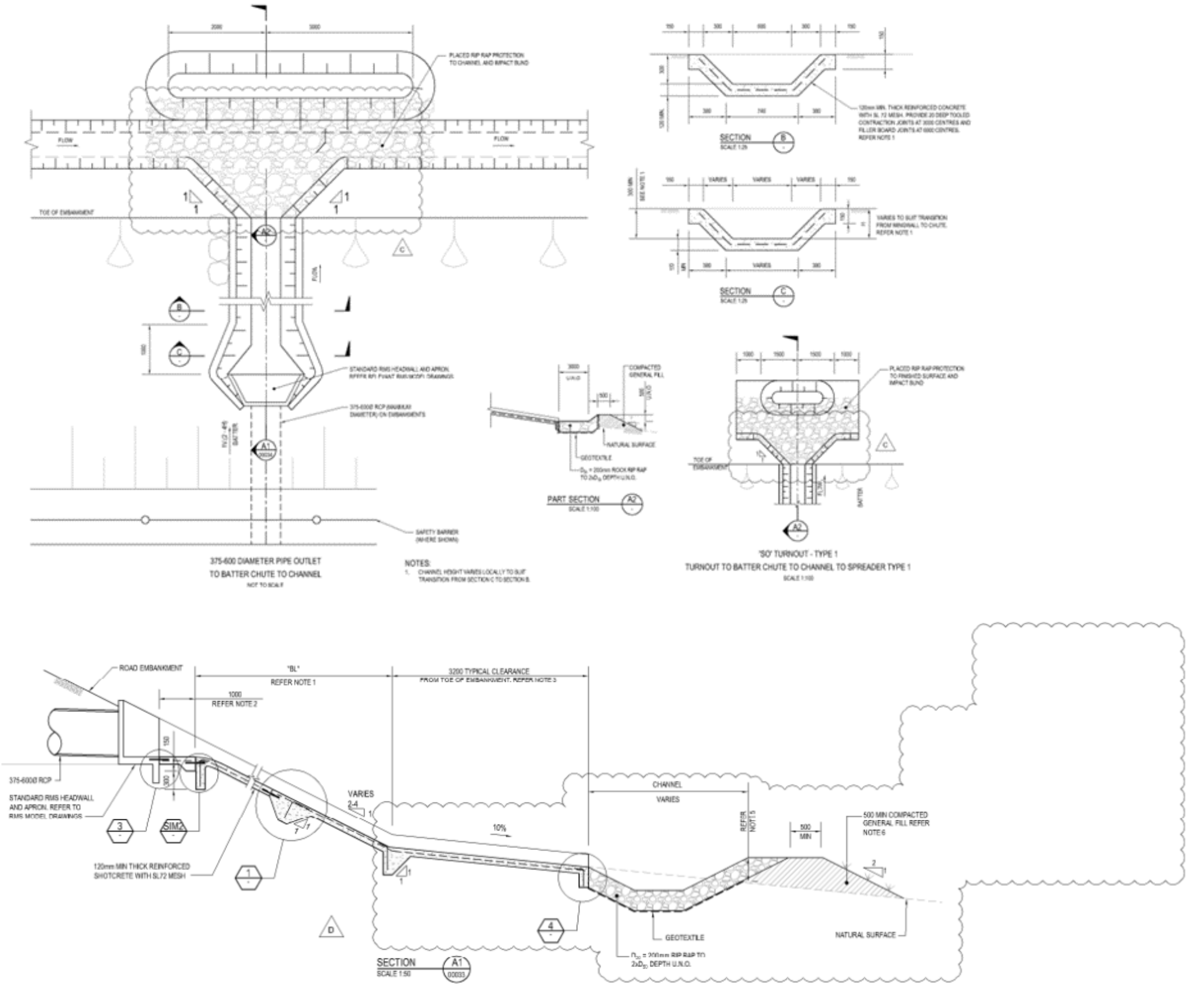


Figure 3-13 - Pipe Outlet to Batter Chute Details

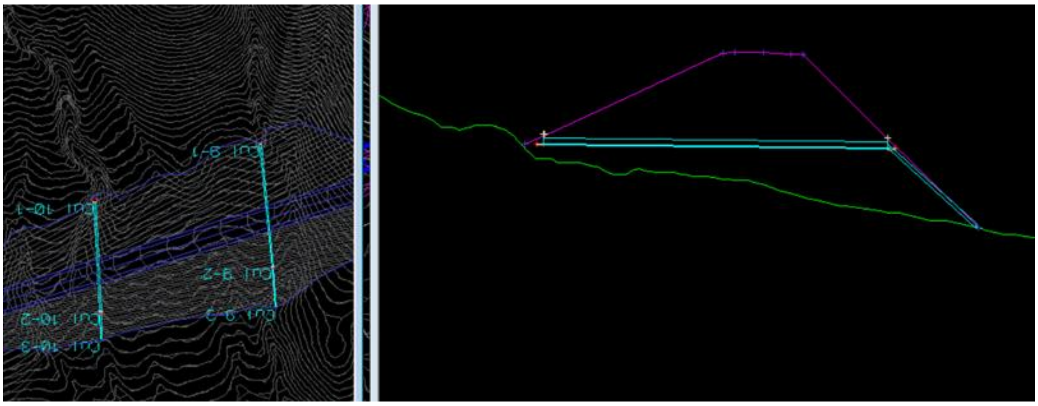


Figure 3-14 - Pipe Outlet to Batter Chute in 12d Plan and Section Views

Drop pit with downpipe at retaining wall is use for Option 2B (Walled) and Option 3B (Walled), see

Figure 3-15 and

Figure 3-16 for details.

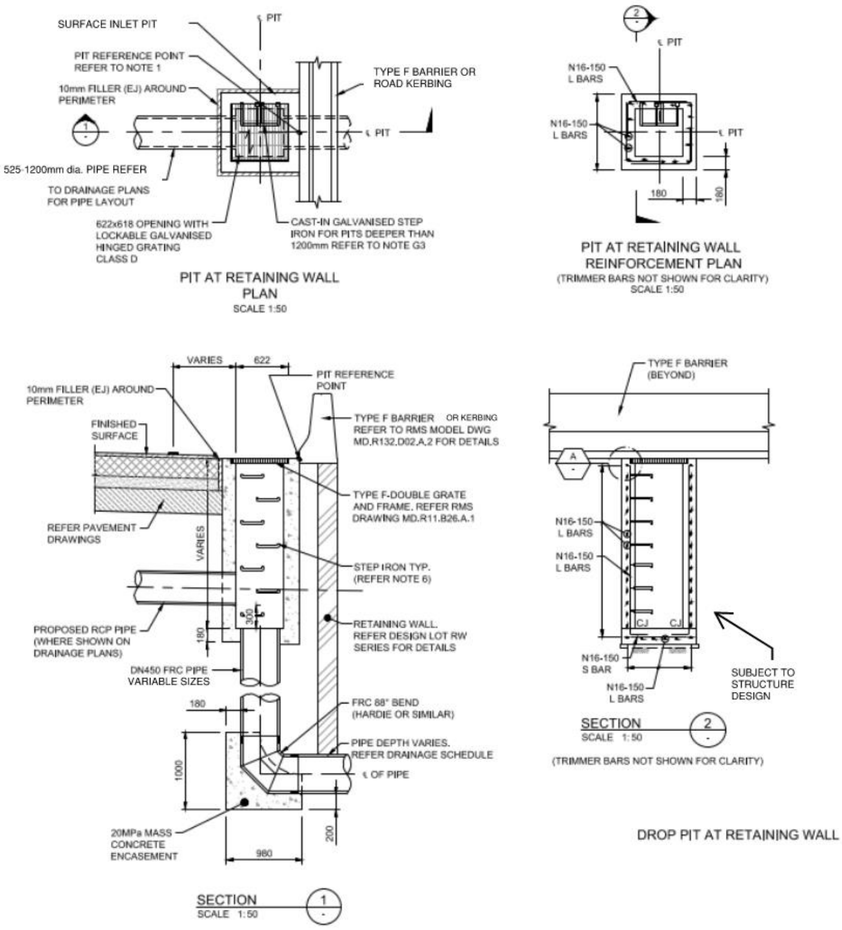


Figure 3-15 - Pipe Outlet to Drop Pit with Downpipe at Retaining Wall

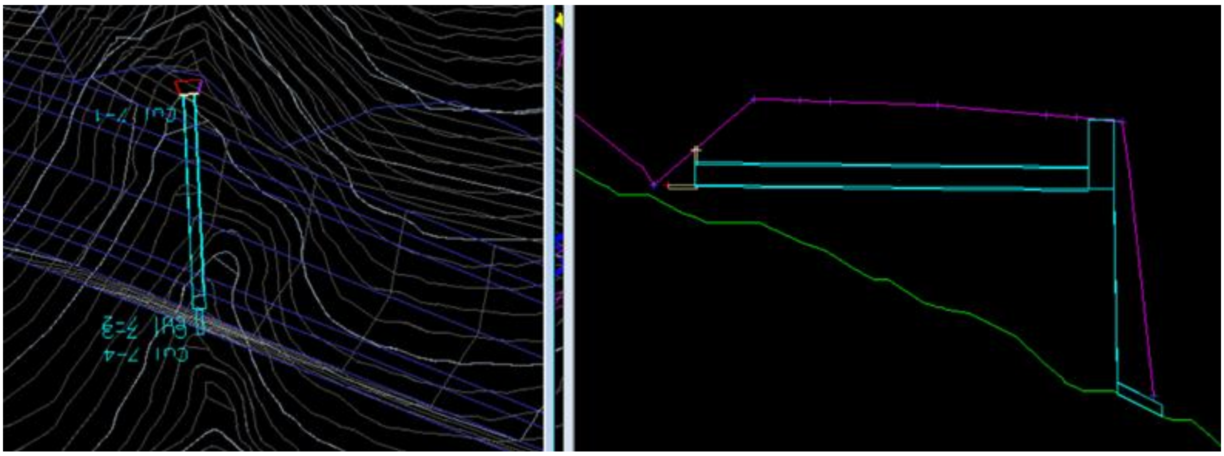


Figure 3-16 - Pipe Outlet to Drop Pit with Downpipe at Retaining Wall in 12d Plan / Section Views

3.4.5 ROAD SURFACE DRAINAGE

The proposed Wolgan Road is mostly a crowned road with a normal crossfall of 3%, the crown may transition to a one-way crossfall. Option 2, 3 and 05 comprises embankment and cut batters similar to

Figure 3-17. There are two scenarios where the pavement runoff can sheet flow down the fill embankments if:

- Batter Slope 1(V) to 2(H) Max. embankment height – 0m
- Batter Slope 1(V) to 4(H) Max. embankment height – 4.0m

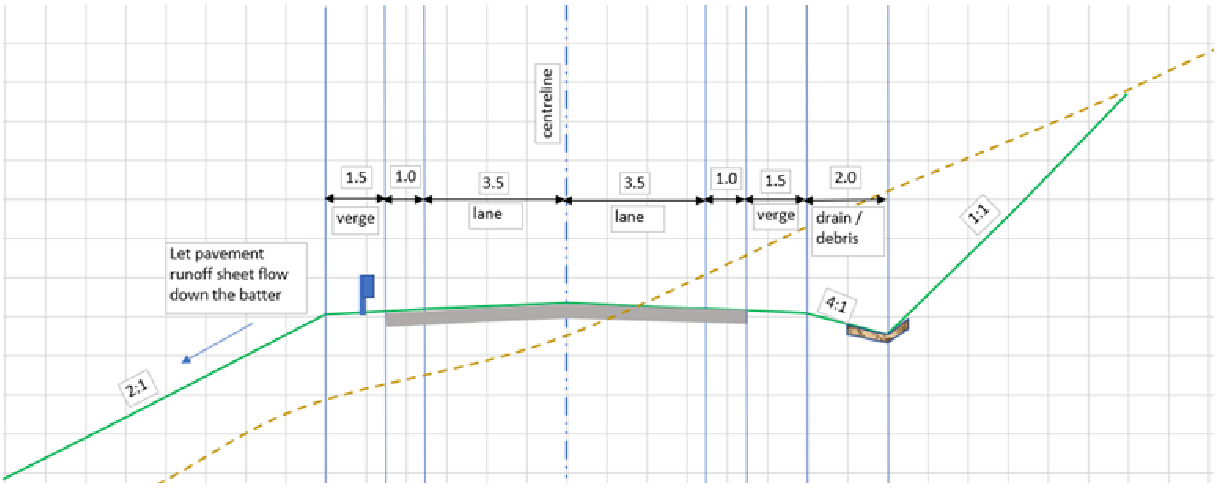


Figure 3-17 - Pavement Runoff Sheet flow Down the Fill Embankments.

If the fill embankment is steeper than above batter slopes, then a retaining wall design is preferred. For retaining wall design, the pavement runoff is capture in surface inlet with a drop pit at the termination point, through retaining wall to the scour protection before discharging to the natural channel/drainage line. See Figure 3-18 and section 3.4.4.3 drop pit at retaining wall design for further details.

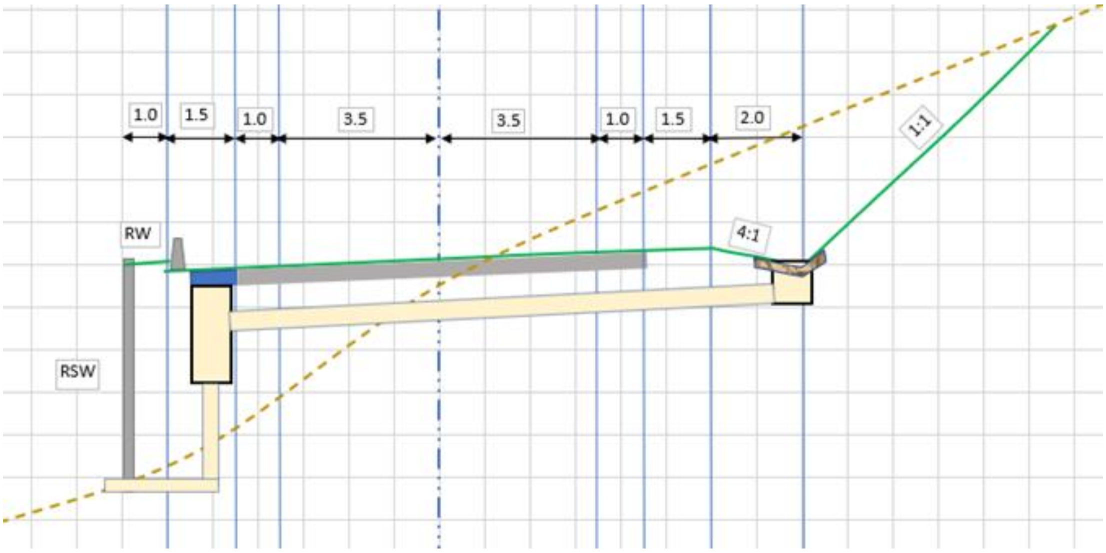


Figure 3-18 - Drop Pit at Retaining Wall

SO kerbs and turnout with batter chutes can be installed where pavement runoff cannot sheet flow down the embankments. The longitudinal road grades varying from 5 to 12%, the standard SO kerb can hold 0.12 m^3/s to 0.18 m^3/s flows without overtopping. The spacing of turnouts to suit grade, turnout capacity and prevent turnout jumping (excess velocity) would be developed at detailed design. The water discharges out the SO turnouts as shown in

Figure 3-19.

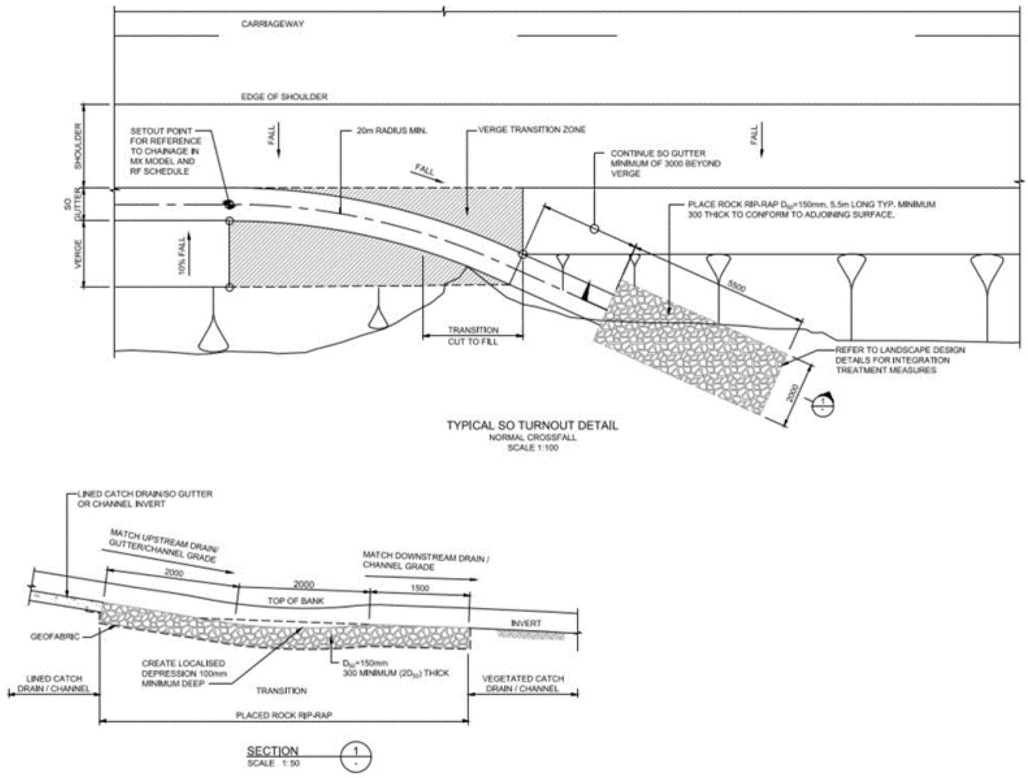


Figure 3-19 – SO Turnout with Batter Chute

3.4.6 CHANNELS TO CAPTURE CUT FACE RUNOFF

Catch drains are proposed to be constructed above the cut crest to divert surface runoff from the overlying contributing catchment above away from the cut face below, shown in

Figure 3-20. In erodible soils, it is preferable for the catch drain in cut to take the form of a low mound along the top of the batter. The catch drain will return these flows to the natural environment at the nearest practicable point of discharge either side of the cut or discharge to the proposed culvert, with consideration of the stability of the cut flank.

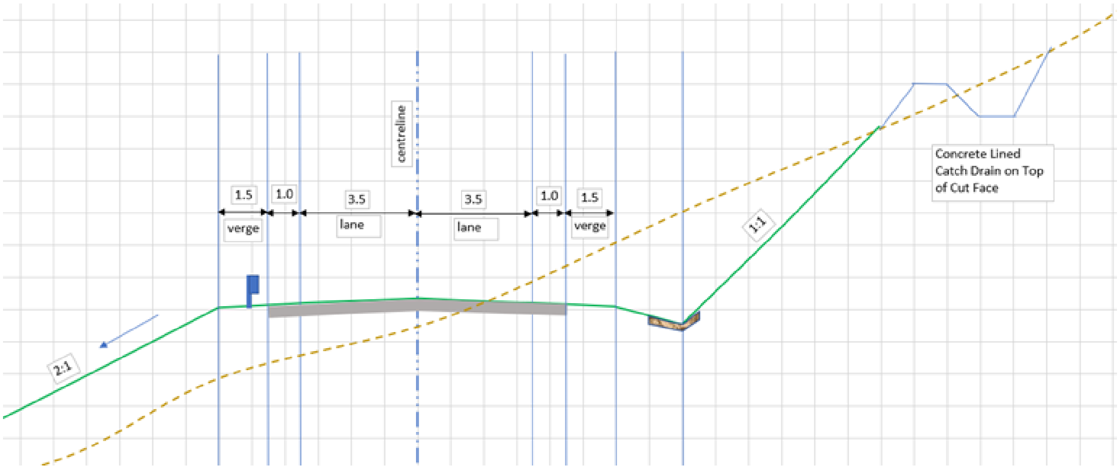


Figure 3-20 – Catch Drains in Cut Along the Top of The Batter as a Drain

Roadside channels are proposed to capture runoff from cuts shown in Figure 3-21, as it could be difficult to construct the catch drains above cuts due to the steep terrain. Vegetated lined channels can convey and treat runoff directly from the pavement surface and adjoining overland catchment area before discharge to the receiving environment at an appropriate location. Some WQ polishing would be provided as water passes through the vegetated channel. However, if flow velocities are high and the slopes are steeper than 4%, then rock lined or concrete lined channels would be required. Flows in the roadside channel would be intercepted at interval by an RSG pit and transferred across the road to a discharge point.

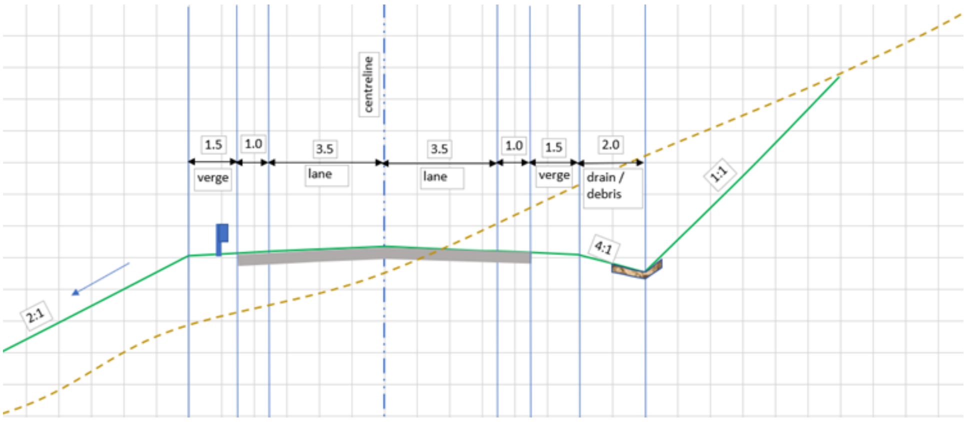


Figure 3-21 – Capture Cut Face Runoff – Table Drain Proposed Next to The Road

Berm (bench) drains are proposed to be incorporated on intermediate benches of cut faces to intercept runoff from the cut face above and/or cut dewatering sub-horizontal drains and return it to the natural environment, shown in Figure 3-22. Where this is not practical, discharge is to be provided via batter chutes to areas below which also eventually discharge to the receiving watercourse. Berm drains are located to mitigate erosion of cut faces with further development of the berm drain layout being undertaken in conjunction with design development incorporating safety in design, geotechnical and alignment requirements during the next design stage.

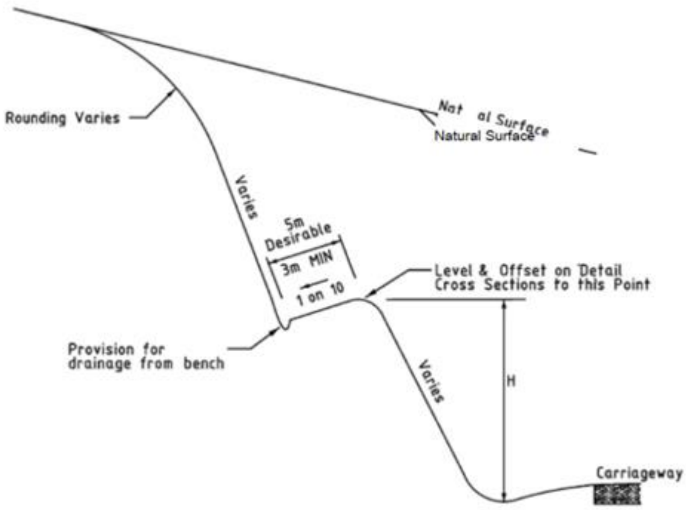


Figure 3-22 – Bench Drain Constructed on a Batter (Austroads Part 5B Guideline)

3.4.7 BRIDGE DRAINAGE

3.4.7.1 SURFACE DRAINGE

Generally, drainage from bridge scuppers will be conveyed by a suspended carrier pipe under the bridge if required. The carrier pipes will discharge at suitable location down the bridge piers. Bridge scuppers are provided at both low side of the bridge carriageways where required. Scupper spacing is designed to meet the flow width requirements for 10-Year ARI storm event. Bridge piers are located away from the natural channels.

If the 10-Year ARI storm event flow width is contained within the shoulder the length of the bridge and as such, no scuppers are required. The preliminary scuppers spacing calculation shows no scuppers would be required for the

Options 2, 0 walled, 3 and 3 walled road bridge arrangements as flow can be carried across the deck within the shoulder with one-way crossfall of 3% and approximately pavement width of 9m.

However, scuppers would be required for Option 5 as the one-way crossfall have reduced to 0.7% so the flow widths will exceed the allowable width. Provision of long drainage pits immediately upstream and downstream of the bridge would capture flows for transfer to outlets at the bridge abutments.

3.4.7.2 SCOUR PROTECTION

Scour protection will be assessed for all open channels and drainage outlets at the next stage. Scour protective measures are provided at culvert outlets and in open channels where required to minimise erosion and scour as a result of stormwater. Scour protection is provided in accordance with Austroads and designed for the 1% AEP storm event. Tailwater levels have been set as free draining in the DRAINS hydraulic analysis to confirm the worst-case pipe velocities.

Constructing scour protection to reduce flows to standard velocities may not be feasible due to the steep topography and large rock sizes. The localised reduction of velocity at an outlet to suit rock sizes may be overly conservative as flow will simply re-accelerate downstream. Re-use of existing drainage lines (possible already cut to rock) and investigation may provide a more realistic design treatment. Appropriate outlet treatments will be investigated further during the next stage.

3.4.8 LEVEL SPREADERS

Level spreaders are often provided at the end of a catch drain or channel in order to transition the accumulated flow into a more dispersed sheet flow. The drain or channel is “turned out” along the natural contour to provide an extended flat section with rock scour protection whereby the flow momentum and velocity are reduced to allow the water to spill down the natural vegetated slope below in a dispersed fashion.

3.4.9 ASSUMPTIONS AND LIMITATIONS

The design of the drainage system is based on the following assumptions and limitations:

- The topographic survey is available for Donkey steps and Wolgan Valley, but it does not cover the full extent of the catchments. For this high-level assessment, the bigger catchments have been assumed when it is beyond the extent. Further topographic survey will be requested during the next design stage.
- The existing drainage survey was not available; therefore, it was not checked for hydraulic capacity. It is assumed the unsurveyed existing system is separate and do not interact with the proposed drainage network.
- Some proposed pits might be deeper than 3.5 m due to the steep batter slopes and vertical alignments, or to provide adequate pipe cover. In this high-level assessment, the deep pits were not structurally designed.
- Catchment area and slopes have been derived based on the road design model and existing surface data in the form of LiDAR data.
- Catchment impervious percentages, runoff coefficients and time of concentration have been determined based on recommendations in the prescribed standards, past engineering experience and judgement from google earth. It is assumed the overland catchments are mostly grassy pervious area, although it might look rocky in some places, water can still penetrate through. Pervious grassed % area and impervious paved % area is used in DRAINS programme to determine the flow.
- It is assumed that the existing drainage lines are free flowing (due to grade), the tailwater level is set as discharging freely.
- No classified fish habitat waterways within the project limit of works.
- No stormwater quality improvement devices and spill containment devices have been proposed.
- Aquaplaning will be addressed separately under the roads and alignment package during design stage.

3.4.10 RISK AND RECOMMENDATIONS (SAFETY)

- No road safety audit undertaken in this alignment optioning.
- No accidental spill management was considered as the development is not near a water supply area.
- Potential high outlet flow velocities when the drainage pipes are steep or due to the large approach catchment flows, might cause the soil at downstream outlet to erode. Due to the natural terrain the velocity will be high, so the post developed velocity is unlikely to be lower. However, soil erosion can be minimised by ensuring flow velocities are maintained below critical values with appropriate pipe grade.
- Benching on fill and cut batters is not shown at this stage but would be included to limit the batter flow paths and control scour.

3.5 PAVEMENT OPTIONS

3.5.1 GEOTECHNICAL INPUTS

At this stage, there is no formal input from Geotech in relation to the subgrade California Bearing Ratio (CBR) to be adopted for pavement design. Therefore, a conservative subgrade CBR value of 3% has been adopted. In addition, the subgrade material has been considered as non-expansive behaviour.

3.5.2 TRAFFIC DATA

Traffic count information has been provided to WSP as shown in Table 3-17 below. Based on the data provided, the following has been calculated or assumed to obtain the design traffic loading:

- Traffic data survey: 15 December 2021 to 23 May 2022;
- Data collection year: 2022 (from traffic data);
- Analysis start year: 2025 (assumed);
- AADT: 95 (assumed bidirectional);
- Percentage of heavy vehicles: 9.64%;
- Annual growth factor: 1.0%;
- NHVAG = 2.1 (calculated from traffic data);
- ESA/HVAG = 0.9 (assumed based on Austroads Part 2, 2012 for rural roads).

No Traffic Loading Distribution (TLD) has been provided. However, the axle load proportions have been calculated using TfNSW Pavement traffic loading spreadsheet based on the traffic data provided where the following can be presented:

Table 3-16 – Traffic Data

SAST	SADT	TAST	TADT	TRDT	QADT
0.4616	0.3724	0.0151	0.1299	0.021	0

It should be noted that the suggested TLD for rural areas in the TfNSW Supplement to Austroads Part 2 might be excessive to represent the low traffic volume as expected on Wolgan Road.

Due to the absence of a project TLD, the following traffic multipliers have been adopted based on Austroads:

- SAR5/ESA: 1.1;

- SAR7/ESA: 1.6;
- SAR12/ESA: 12.

Based on the above, the design traffic loading calculated is: 1.60x10E+05 DESA or 1.78x10E+05 HVAG

Traffic calculations are included in Appendix A.

Table 3-17 - Traffic Counts

KM/H	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7	CLASS 8	CLASS 9	CLASS 10	CLASS 11	CLASS 12
10-20	29		3	4	1							
20-30	106	2	19	3	2							
30-40	339	22	36	9	6					6		
40-50	1155	68	108	11	5	4	3			11	2	
50-60	2716	168	195	30	3	5	4	3		8	2	
60-70	4055	163	298	61	9	10	5	4		1	1	
70-80	3119	75	263	86	16	5	10	6				
80-90	1214	12	113	31	3	1	5	7	2			
90-100	315		21	8			1					
100-110	43		1	1	1							
110-120	11											
120-130	1											
130-140	2											
140-150												
150-160												
TOTAL	13105	510	1057	244	46	25	28	20	2	26	5	0
%	0.869724	0.033847	0.070149	0.016193	0.003053	0.001659	0.001858	0.001327	0.000133	0.001726	0.000332	0

3.5.3 DESIGN METHODOLOGY AND PAVEMENT PROFILE OPTIONS

At this stage, a final road design alignment is not available. However, it has been noted that the proposed road will be composed of steep grades and small radius turns in certain sections.

The proposed pavement profile options listed below are intended for initial discussion. The design has been based on a 40-year design life in accordance with *TfNSW Supplement to Austroads Part 2* and adopted TfNSW Specifications.

Table 3-18 – Pavement Option A: Unbound Granular Material With Sprayed Seal Wearing Course

LAYER	THICKNESS
Single/Single Seal 14mm (C170 binder)	N/A
Prime (AMC0)	-
Dense graded basecourse (DGB) Class 2 (traffic category "D")	210mm
Selected material zone	300mm
Subgrade (CBR ≥ 3%)	-

Pavement Option A shown above is suggested to be adopted in sections of the alignment where there are no small radius turns and steep slopes such as beyond Ch2000. This is because a sprayed seal wearing course is not able to resist the shear forces generated by tight turns and steep grades. As sprayed seal is cheaper than asphalt, Council might be able to save construction costs.

Table 3-19 – Pavement Option B: Unbound Granular Material With Thin Asphalt Wearing Course

Layer	Thickness
AC14 (C450 binder)	50mm
7mm low cutter seal (C170 binder)	-
Prime (AMC0)	-
Dense graded basecourse (DGB) Class 2 (traffic category "D")	210mm
Selected material zone	300mm
Subgrade (CBR ≥ 3%)	-

Pavement Option B provides an asphalt wearing course which is more expensive than a sprayed seal. Asphalt as a material is suitable to withstand shear forces in steep grades and tight radius turns. For uniformity of the wearing course in the asset, Council might consider an asphalt wearing course over the full extent of the proposed new road.

The feasibility of using a paver and compaction roller in areas of steeper grades will need to be confirmed. Auxiliary plant might be required to pull the paver or manual compaction might be required in steep sections which may extend construction timeframe.

Rigid pavement shown in Pavement Option C is suitable for construction on steep grades and areas of tight curvature. However, it should be noted that anchor beams will be required to restrict horizontal slab movements and this would increase construction costs. Caution should be adopted when using the profile above as WSP adopted a simplified TLD to calculate the PCP slab thickness based on the maximum legal road limits allowed for each axle type. If rigid pavement is to be considered, WSP suggests a review of the proposed profile above with a conservative TLD.

Table 3-20 – Pavement Option C – Plain Concrete Pavement (Austroads Non-Compliant)

Layer	Thickness
Plain concrete pavement base (PCP)	230mm
7mm low cutter seal (C170 binder)	-
Dense graded basecourse (DGB) Class 2 (traffic category "D")	125mm
Selected material zone	300mm
Subgrade (CBR ≥ 3%)	-

Pavement Option C provides an Austroads non-compliant rigid pavement profile where an unbound granular material has been adopted as subbase instead of bound material. This can be justified due to the low traffic volume expected on Wolgan Road. This profile can provide some cost savings to Council but further discussions are required to understand risks involved.

Table 3-21 – Bridge Deck

Layer	Thickness
AC14 (C450 binder)	50mm
AC10 (C450 binder)	30mm
10mm Sprayed Seal (S45R)	-
Quick dry prime emulsion (CRS 170/60)	-
Bridge deck	-

A standard bridge deck profile for TfNSW projects is shown above.

3.5.4 PROPOSED PAVEMENT FOR COSTING PURPOSES

Pavement Option c, comprising plain concrete on a DGB layer will be costed for the initial options selection.

All pavement profiles calculations are included in Appendix C.

3.6 PROPERTY IMPACTS

3.6.1 BASIS OF ASSESSMENT

This section focusses on impact to property and lands from each option. The measurements exclude an apparent road reserve which runs from the Wolgan Road at Wolgan gap down the valley and rejoins Wolgan Road. The existing section of Wolgan Road does not appear to sit within an identified road reserve. Land ownership has not been explored at this stage and the areas measured are based on the preliminary designs and hence may change once earthworks footprints are derived in more detail.

3.6.2 MEASURED LAND REQUIREMENTS

OPTION 2

Land is required from four lots (excluding a section of apparent road reserve at both ends of the deviation). A total indicative area of 78,330m2 is required and is summarised in Table 3-22 below.

Table 3-22 – land requirements Option 2

LOT	AREA	COMMENTS
DP751636	13,580m^2	Refer Figure 3-23. Existing road reserve not included.
DP1055079	51,200m^2	Refer Figure 3-24
DP751666 11C	11,830m^2	Refer Figure 3-25. Existing road reserve not included.
DP751666 10D	1,720m^2	Refer Figure 3-25. Existing road reserve not included.
Total area	**78,330 m^2**	

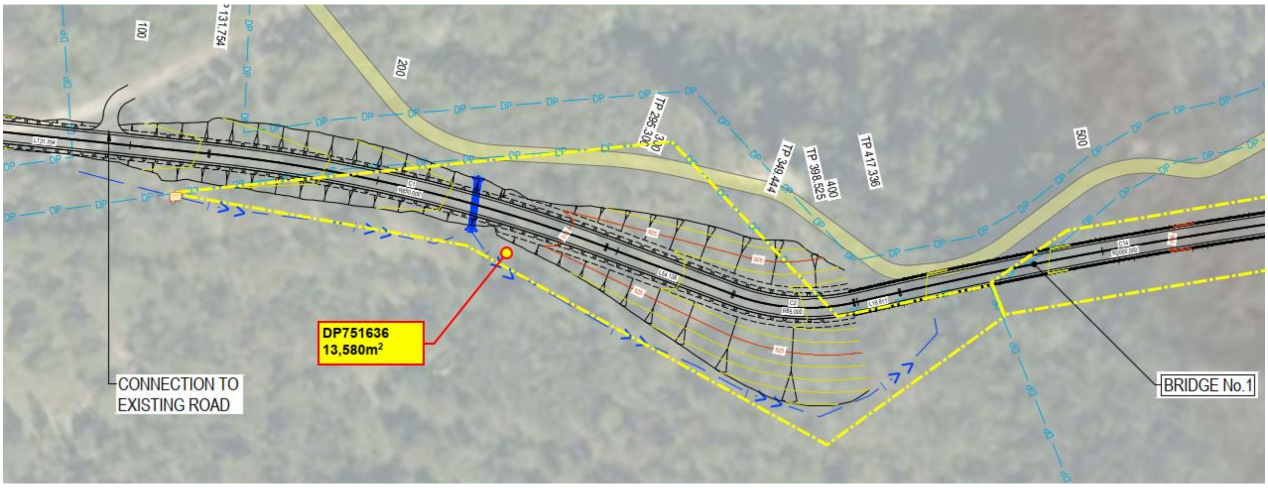


Figure 3-23 – Option 2 land requirement south

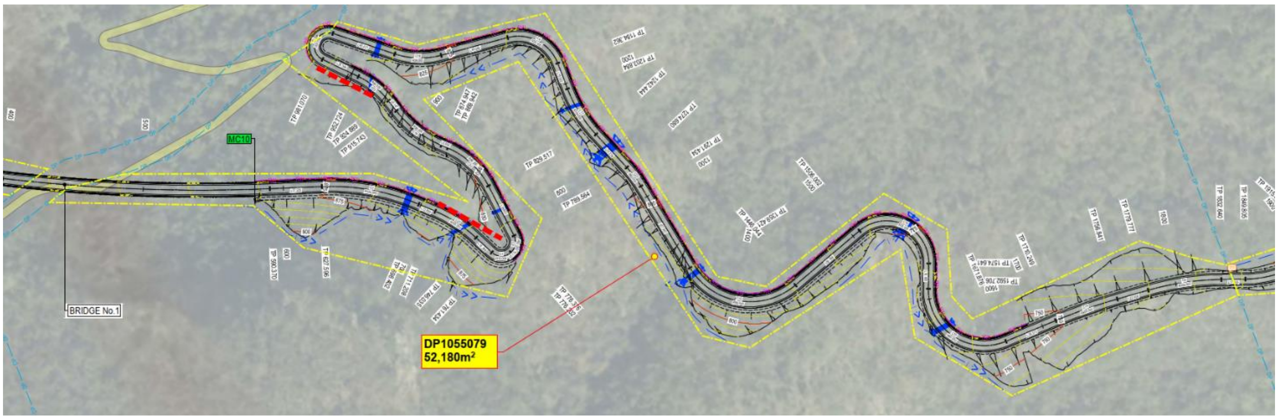


Figure 3-24 - Option 2 land requirement centre

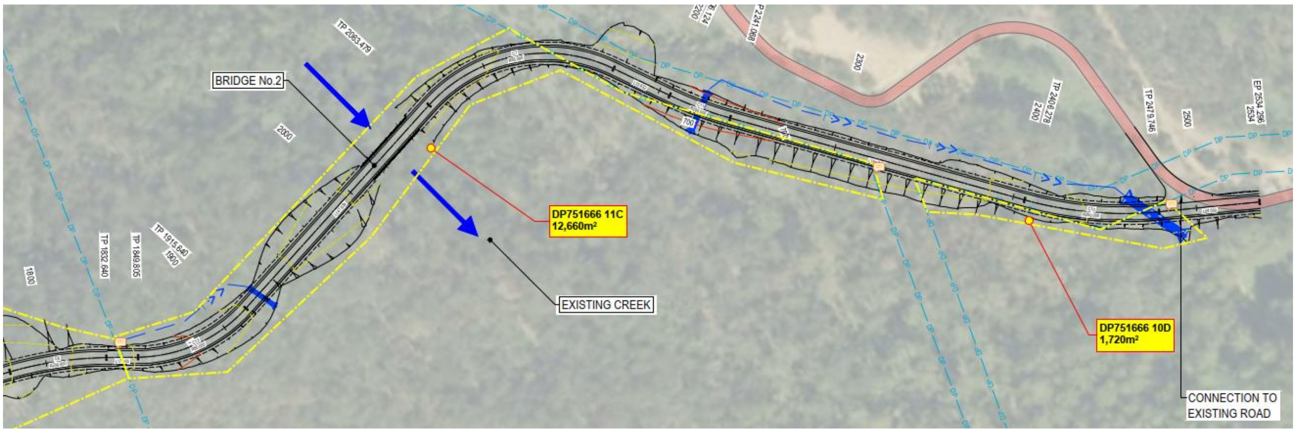


Figure 3-25 - Option 2 land requirement north

OPTION 3

Land is required from four lots (excluding a section of apparent road reserve at both ends of the deviation). A total indicative area of 77,040m^2 is required and is summarised in Table 3-23 below. This is similar to the area required for Option 2.

Table 3-23 – land requirements Option 3

LOT	AREA	COMMENTS
DP1055080	10,480m^2	Refer Figure 3-26. Measured to assumed Wolgan Rd road reserve
DP1055079	52,180m^2	Refer Figure 3-27
DP751666 11C	12,660m^2	Refer Figure 3-28. Existing road reserve not included.
DP751666 10D	1,720m^2	Refer Figure 3-28. Existing road reserve not included.
Total area	**77,040 m^2**	

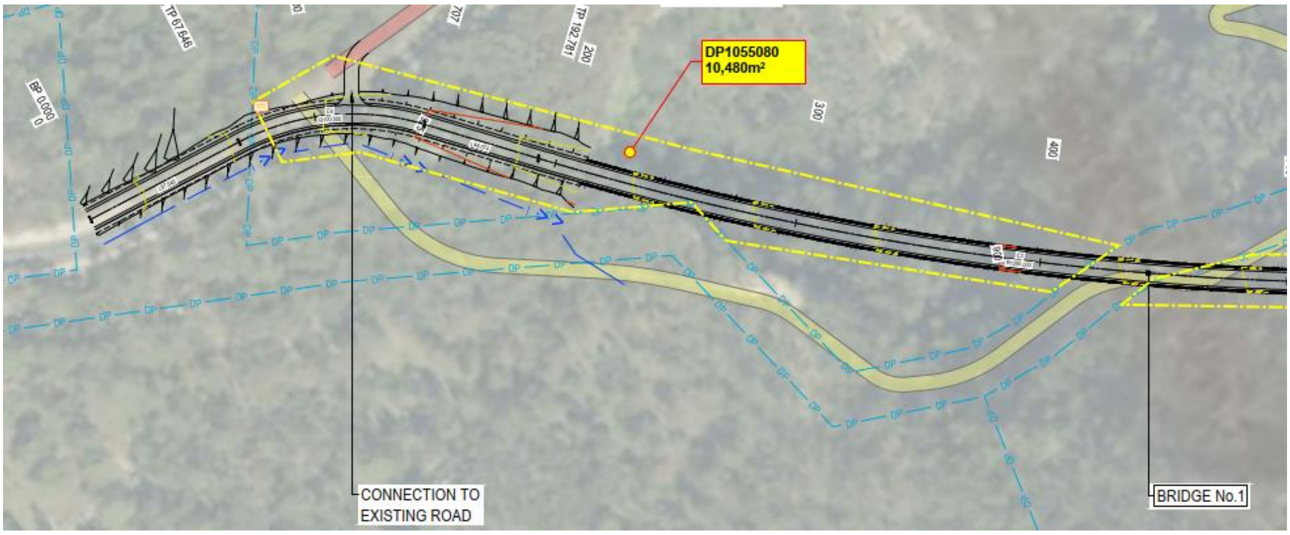


Figure 3-26 - Option 3 land requirement south

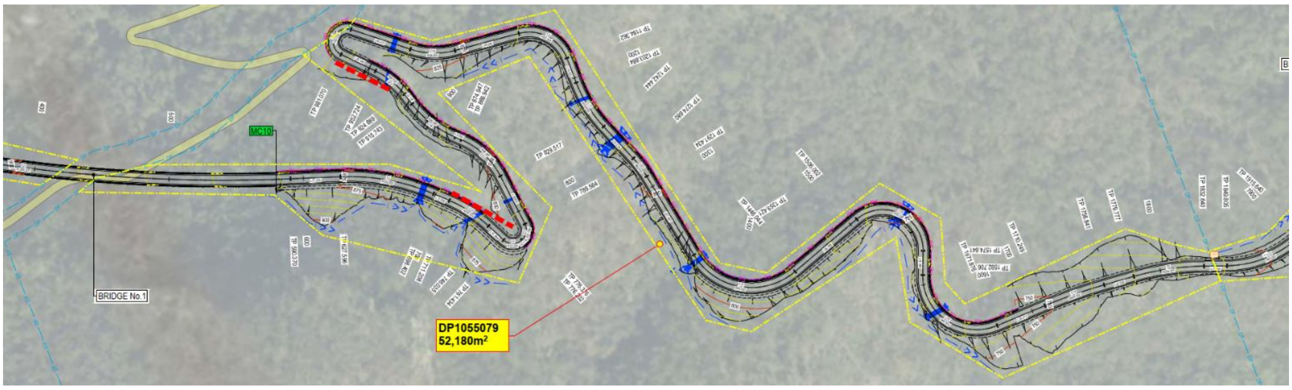


Figure 3-27 - Option 3 land requirement centre

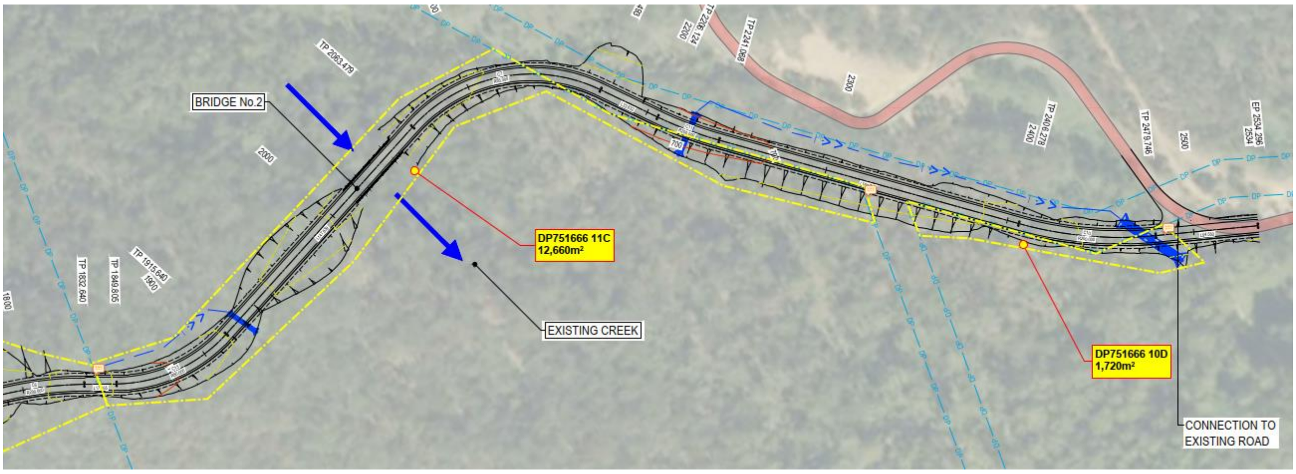


Figure 3-28 - Option 3 land requirement north

OPTION 5

Land is required from six lots (excluding a section of apparent road reserve at the northern end of the deviation). The measured areas at the southern end include the existing Wolgan Rd road reserve, which does not follow the route of Wolgan Road but deviates to the East. This deviated road reserve is excluded from the areas listed in Table 3-24. A total indicative area of 89,310m^2 is required and is summarised in Table 3-24 below. This area is around 15% greater than the area required to construct Option 2 and Option 3.

Option 5 would also require diversion of two roads. The existing property access serving 'Wolgan View' would be severed by the deep cutting, hence a diversion of the access further south would be needed.

Access to the existing lookout at Wolgan Gap on the original road would require diverting around the western side of the cutting to a new intersection with Wolgan Road. Both are shown as blue dashed lines in Figure 3-29.

Table 3-24 – land requirements Option 3

LOT	AREA	COMMENTS
DP1026540	6,220m^2	Refer Figure 3-29. May include part Wolgan Rd road reserve. Allowance for road diversion included.
Gardens of Stone State Conservation Area	3,690m^2	Refer Figure 3-29. May include part Wolgan Rd road reserve. Allowance for road diversion included.

LOT	AREA	COMMENTS
DP751636	7,520m^2	Refer Figure 3-29. Existing road reserve not included
DP1055080	24,820m^2	Refer Figure 3-29. May include part Wolgan Rd road reserve. Allowance for road diversion included.
DP1055079	32,820m^2	Refer Figure 3-30
DP751666 11C	12,520m^2	Refer Figure 3-31. Existing road reserve not included.
DP751666 10D	1,720m^2	Refer Figure 3-31. Existing road reserve not included.
Total area	**89,310 m^2**	

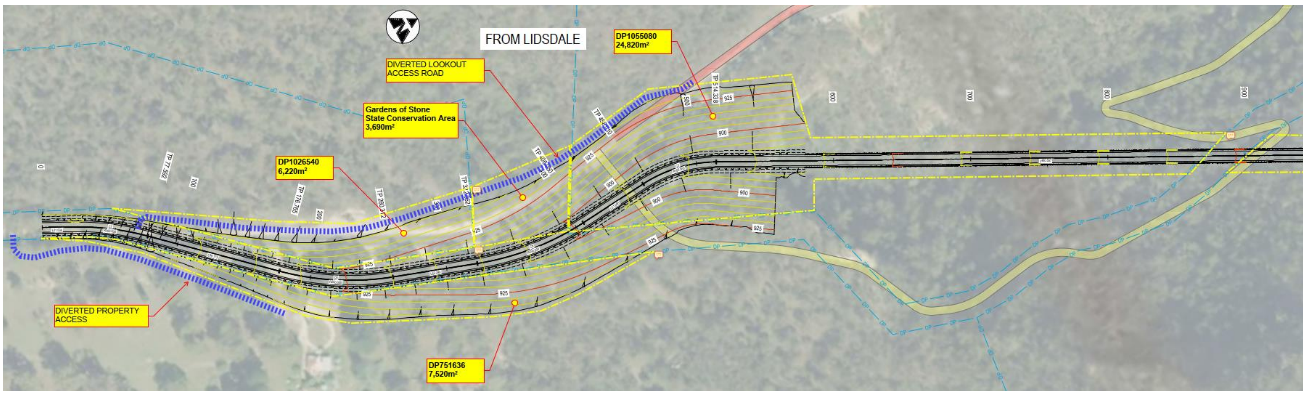


Figure 3-29 - Option 5 land requirement south

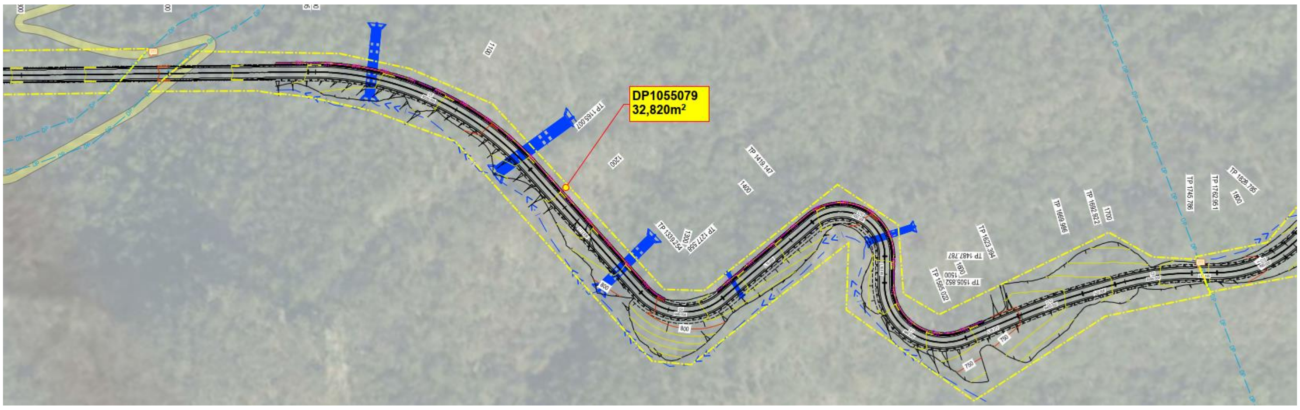


Figure 3-30 - Option 5 land requirement centre

Figure 3-31 - Option 5 land requirement north

3.7 ABORIGINAL HERITAGE

3.7.1 THIS SECTION IS YET TO BE COMPLETED

3.8 ECOLOGY

3.8.1 THIS SECTION IS YET TO BE COMPLETED

3.9 VISUAL IMPACTS

3.9.1 VIEWPOINT SELECTION

The visual impacts have been investigated based on three viewpoints. Two being residences and the third being from Wolgan Road prior to starting the climb to the top of the valley. The location of the viewpoints is shown below in Figure 3-32 below, and the snips of each option, which were taken from the BIM model, are as close to observers' eye height as possible.

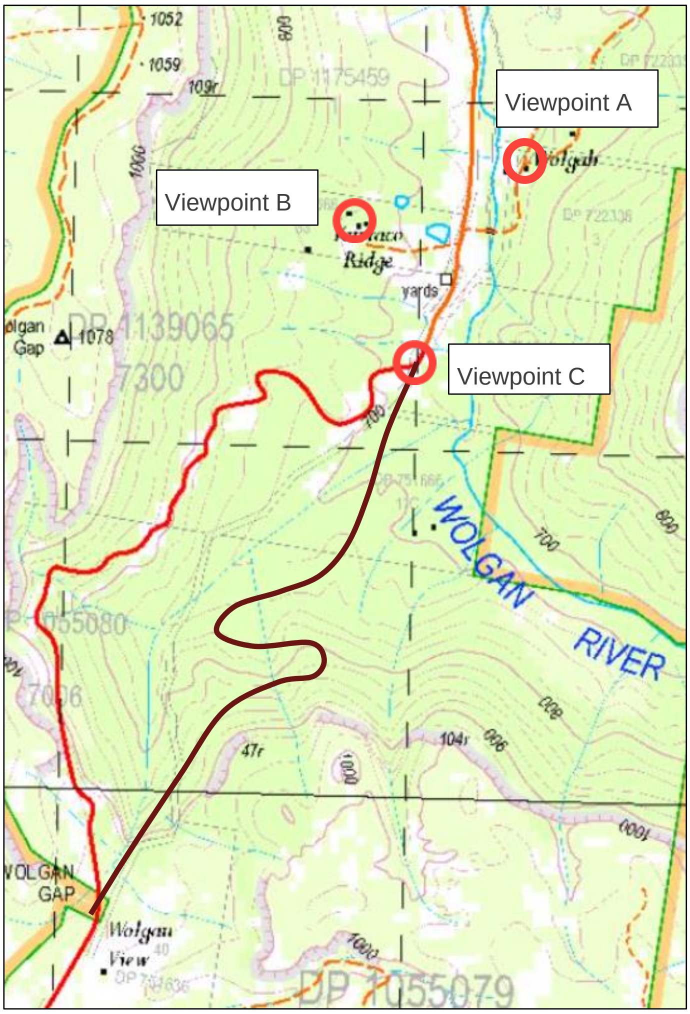


Figure 3-32 – Locations Used to Create Viewpoints

The three viewpoints selected cover residences at the northern end of the valley and drivers view heading southbound from the point where the new route would divert from the existing road. The bottom of the valley was selected as the majority of the length of each shortlisted option can be seen from the northern end of the valley. There are no residences at the top of the valley that have a clear view of the options, and any drivers eye views are limited to the road section immediately ahead hence the location where differentiation could be achieved is from the northern end of the valley, looking south towards Wolgan Gap.

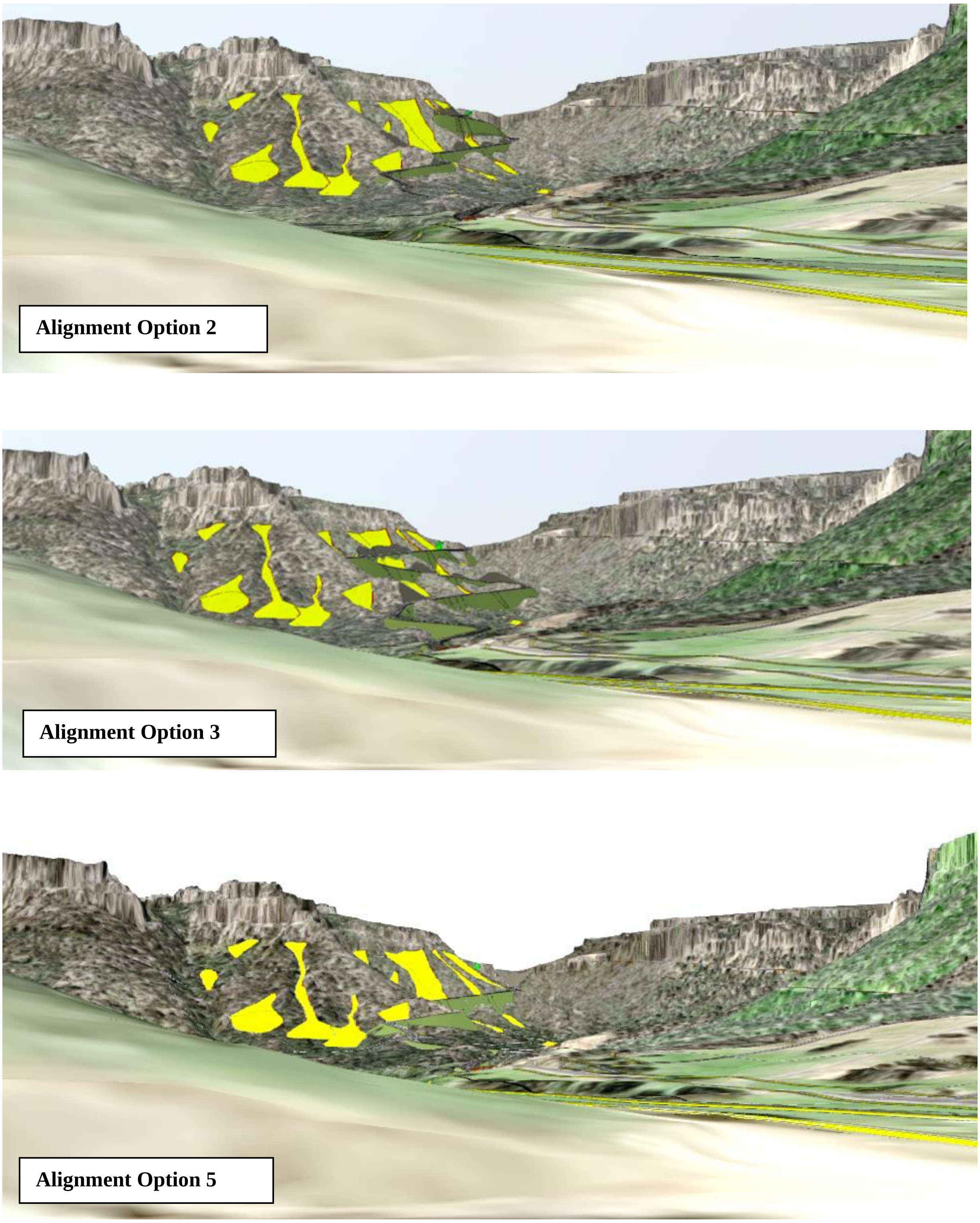


Figure 3-33 – Viewpoint A: Visual Impacts (Alignment Options 2, 3 and 5)

From viewpoint A (Wolgah Farm) Alignment Option 3 has the greatest visual impact with the majority of the route visible. Alignment Option 2 is slightly less visible, forming a narrower route corridor when viewed from this point, but has a large fill batter associated with the upper level turnback. Alignment Option 5 presents the lowest impact as part of the route is located beyond the top of the valley and in not seen. The remainder of Alignment Option 5 is visible on the lower slopes and less noticeable.

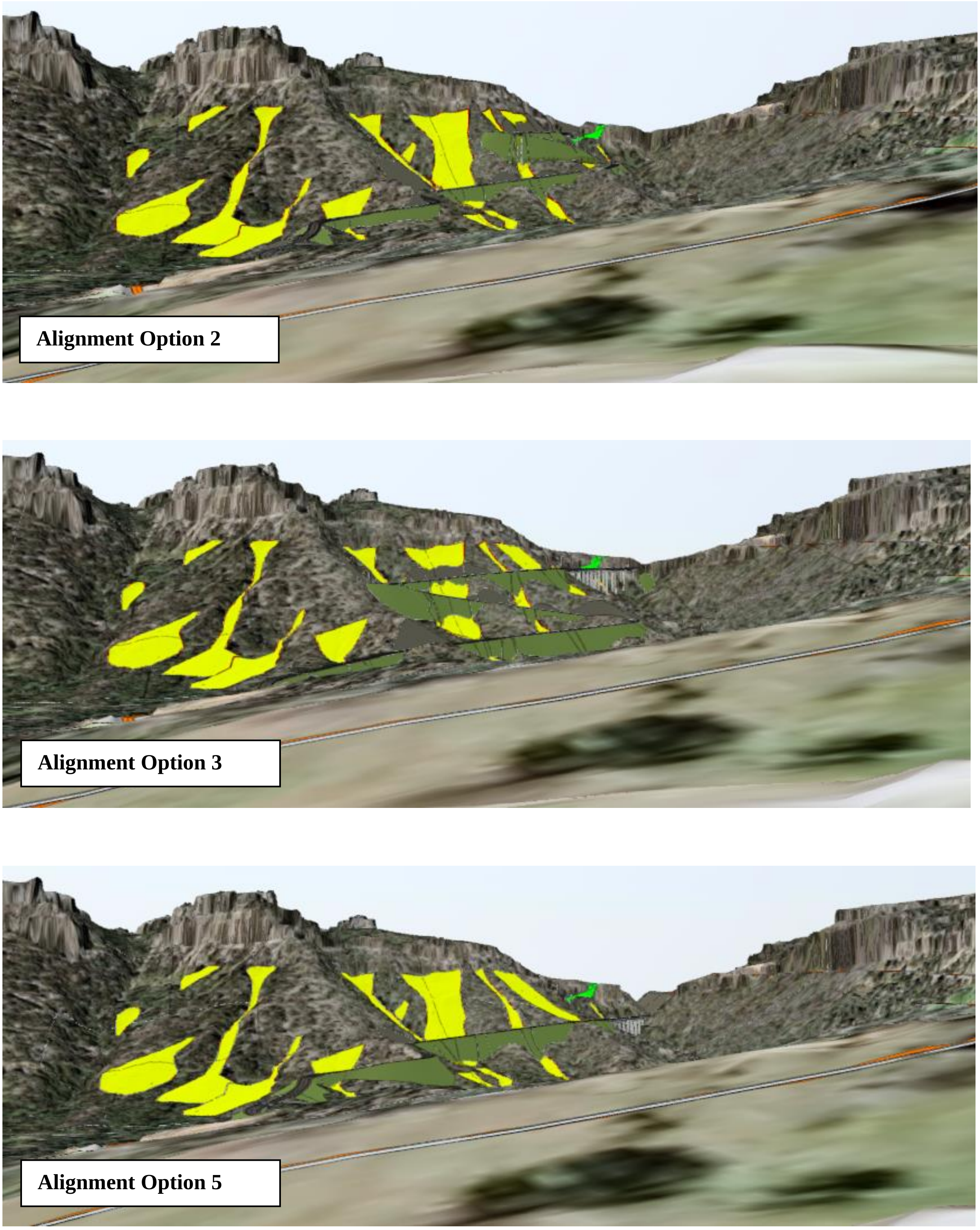


Figure 3-34 –Viewpoint B – Visual Impacts (Alignment Options 2, 3 And 5)

From viewpoint B (Kurraco Ridge Farm), again Alignment Option 3 has the largest visual impact due to the greater length of the switchback visible. Alignment Option 2 presents a smaller length of switchback to the viewer and is an improvement on Alignment Option 3. Alignment Option 5, by starting the cut beyond the valley, crosses the eastern valley slopes at a lower level resulting in a reduced visual impact.

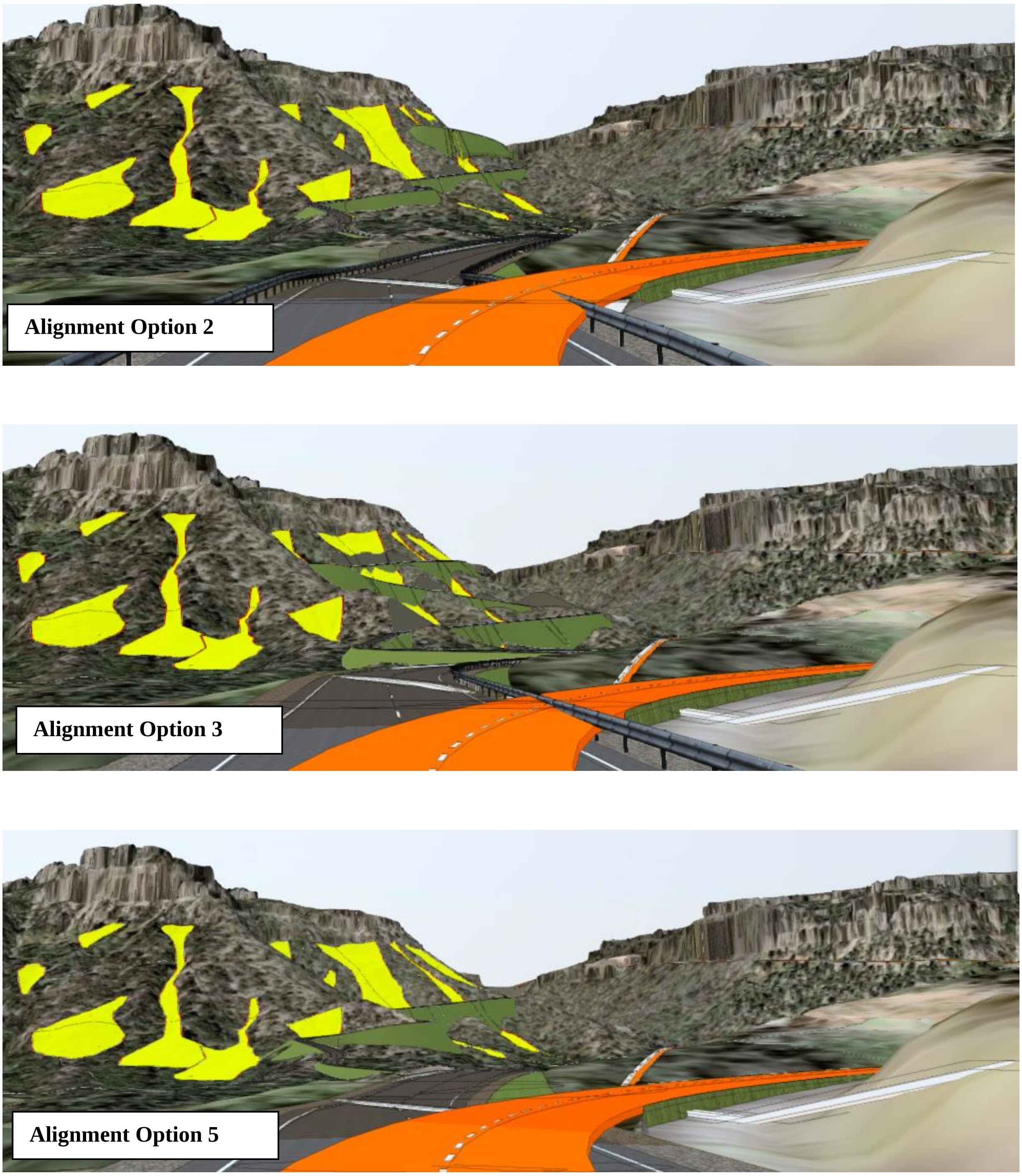


Figure 3-35 –Viewpoint C – Visual Impacts (Alignment Options 2, 3 And 5)

From viewpoint C (Southbound point of deviation), Alignment Option 3 again has the largest visual impact due to the greater length of the switchback visible in the centre of the view. Alignment Option 2 presents a smaller length of switchback to the viewer and remains as an improvement on Alignment Option 3. Alignment Option 5, by starting the cut beyond the valley, crosses the eastern valley slopes at a lower level resulting in a reduced visual impact.

4 OPTIONS ASSESSMENT

4.1 ASSESSMENT METHODOLOGY

In this section, the three shortlisted options are subject to an assessment process to examine the benefits and disbenefits of each option. The assessment process comprised three primary criteria and sub criteria, comprising:

4.1.1 ENGINEERING CRITERIA, COMPRISING THE FOLLOWING SUB CRITERIA:

- Road Gradient, route length and curvature (alignment quality)
- Geotechnical slope risk
- Geotechnical challenges
- Safety
- Resilience
- Constructability
- Operation and Maintenance.

4.1.2 ENVIRONMENTAL CRITERIA COMPRISING THE FOLLOWING SUB CRITERIA

- Property Impact
- Impact on Aboriginal Heritage
- Ecological Impact
- Visual Impact

4.1.3 COST

A simple ranking system was adopted where the number assigned indicates the preference of each option. Therefore, on any assessment criteria, a score of 1 indicates the option is preferred, a score of 2 means the option is second best and a score of 3 indicates the option is least preferred on that assessment criteria.

4.2 ENGINEERING ASSESSMENT

4.2.1 ROAD GRADIENT, ROUTE LENGTH AND CURVATURE

Considering curvature, Option 2 has 21 separate curves, Option 3 has 22 curves and Option 5 has 15 curves. In terms of curve severity (radius and deviation angles) Options 2 and 3 are broadly similar and Option 5 has larger curve radii.

Comparing gradient, Option 2 has an initial 10% grade to the first switch back and 15% between switchbacks. Option 3 has a short length of 14% grade before the first switchback and 12% grade between switchbacks. In the lower section, Option 3 has a combination of 12%, 4% and 15% grades whereas Option 2 has a constant 15% grade for 828m over the same section. Option 5 has an initial 15% grade from the top and then a 10% grade across Bridge 01. It then transitions to a 15% grade over the next 636m and a steeper grade (6%) across bridge 02. By comparison Options 2 and 3 have 3% grades over this section.

Comparing route length, Options 2 and 3 are 2534m long whilst Option 5 is 2447m long. However, if a constant start point is used to make like for like comparisons, Option 2 would be 2780m in length and Option 3 2880m in length.

Table 4-1 – Summary Assessment of Road Gradient, Route Length and Curvature

OPTION	SUMMARY COMPARISON	RANKING
Alignment Option 2	Similar number of corves to Option 03. The combinations of grade and length of grade are largely similar between options. Second shortest route length.	2
Alignment Option 3	Number and severity of curves is similar to Option 2. The combinations of grade and length of grade are largely similar between options. Longest route length.	3
Alignment Option 5	Fewer and less severe curves compared to Options 2 and 3. The combinations of grade and length of grade are largely similar between options Shortest overall route length.	1

4.2.2 GEOTECHNICAL ASSESSMENT

The geotechnical risks and challenges have been presented in Section 3.2. The comparative assessment was based on two criteria:

- Slope hazard susceptibility, based on slope angle, orientation, presence of undesirable strata and watercourses and evidence of past instability, and
- Geotechnical challenges, considering extents of retaining wall, cuttings, challenging strata, quantity of rock excavation.

The results are presented in Table 4-2 and in

Table 4-3.

Table 4-2 – Summary Assessment of geotechnical slope hazard

OPTION	SUMMARY COMPARISON	RANKING
Alignment Option 2	Option 2 and Option 3 alignments have similar lengths, approximately similar lengths of bridge, approximately similar alignments with respect to hazard susceptibility traversed and result in the same slope hazard susceptibility scores	2
Alignment Option 3		2
Alignment Option 5	Option 5 by comparison is the shortest alignment and contains the longest bridge section avoiding a significant length of slope hazard.	1

Table 4-3– Summary Assessment of geotechnical challenges

Option	Summary comparison	Ranking
Alignment Option 2	Option 2 has a larger initial cutting compared to Option 3 (approximately 30 m maximum height) hence Option 2 is ranked second for quantity of rock excavation, length of cuts, length of high cuts and length of coal seams within cut faces, whereas Option 2 is ranked third with respect to length of cuts with steep slopes above their crest and length of high retaining walls. Option 2 is ranked second for length of retaining walls. (Option 2 is ranked second for that	3

Option	Summary comparison	Ranking
	parameter). Option 2 is ranked second for proximity of coal seams to the cut floor or fill foundation.	
Alignment Option 3	Option 3 has a relatively smaller cut in Section 1 (approximately 8 m maximum height) than Option 2. That influences Option 3 being ranked first for quantity of rock excavation, length of cuts, length of high cuts and length of coal seams within cut faces. Within Section 3 the horizontal alignment of Option 3 is situated relatively further to the west and thus downslope than Option 2 so Option 3 is ranked second with respect to length of cuts with steep slopes above their crest and length of high retaining wall. Option 3 has a more elongated switch back section in Section 3 of the alignment which influences Option 3 being ranked third. The elevation at which Option 3 enters cut and fill sections influences its third ranking for proximity of coal seams to the cut floor or fill foundation.	1
Alignment Option 5	Option 5 is ranked third with respect to quantity of rock excavation, length of cuts, length of high cuts and length of cuts with coal seams within their face. Option 5 also has the longest bridge section (approximately 390 m long). It is the shortest of the three alignment options which contributes to it being ranked first with respect to length of retaining walls, length of high retaining walls and length of cuts with steep slopes above the crest. In addition to the length of the bridge section and overall length, the elevation of the bridge section with respect to the stratigraphy also contributes to Option 5 being ranked first with respect to proximity of coal seams to the foundation floor	2

4.2.3 SAFETY

The safety assessment considers the discussion on road safety in Section 3.1.5. From that section, the key differentiator was the arrangement of curves withing each option to ensure drivers progressively slow their speed as they enter the steeper curved section of each option from each direction. Whilst all options are considered safe, there are some key differences between option alignments.

Table 4-4 – Summary Assessment of road safety

OPTION	SUMMARY COMPARISON	RANKING
Alignment Option 2	Option 2 and Option 3 have similar alignments for the upper section and are identical from around Ch1400 onwards. Option 2 bypasses the existing curve on Wolgan Road and presents drivers with a tighter R85 curve just prior to Bridge 01. At the lower end of Bridge 01, Option 2 has a sharper R80 curve followed by a R150 curve prior to the first switchback.	3
Alignment Option 3	From the South, Option 3 is considered to present a better approach to the new section of road starting with a R100m curve immediately after an existing curve to slow vehicles. At the lower end of Bridge 01, the alignment has a better combination of curves starting with R160 then R100 before the first switchback. Option 3 is therefore preferred compared to Option 2	2

OPTION	SUMMARY COMPARISON	RANKING
Alignment Option 5	Option 5 shares the same alignment in the lower section to Option 2 and Option 3. Fron the South, Option 5 presents a controlled tightening of curvature with three R200 curves prior to a R100 curve leading on to Bridge 01. Beyond Bridge 01, Option 5 has a superior alignment using R40 and R30 curves as switchbacks compared to the R10 curves with greater deviation angles used in Options 2 and 3. Option 5 offers potentially the safest alignment of the three options and is the preferred option on safety grounds	1

4.2.4 RESILIENCE

Resilience is a measure of the roads ability to function throughout and maintain its function or recover quickly from adverse events. The key risks being heavy rainfall events and slips during operation of the road. Regarding the latter event, all options are expected to perform with a similar level of resilience since culverts will be sized for the expected flows, channels will incorporate scour resistant linings and culvert outlets will incorporate scour protection measures. The differences in exposure to ongoing slope stability risks is discussed in Section 3.2.2 Geotechnical slope hazard susceptibility. The determining factors used to compare options are:

- Overall length of alignment
- Length of bridges which avoids slope hazard.
- Length of alignment within high slope hazard susceptibility zones

Table 3-5 summarises the relevant slope hazard risk for each option, and this is discussed below in Table 4-5.

Table 4-5 - Summary Assessment of Route Resilience

OPTION	SUMMARY COMPARISON	RANKING
Alignment Option 2	Option2 and Option 3 were found to have similar route lengths and similar bridge lengths and both traverse largely similar sections of the eastern slopes so both were ranked the same in terms of slope risk	2=
Alignment Option 3		2=
Alignment Option 5	Option 5 has the shortest overall length, longest bridge (avoiding slip risk) and has the least exposure to slope instability	1

4.2.5 CONSTRUCTABILITY

Constructability has been based on access for bridge and earthworks construction, amount of retaining wall, length/height of bridges and earthworks volumes. An assessment of locations for construction compounds and materials storage has not been undertaken.

Access for construction for all options is from the existing Wolgan Road, but since Wolgan Road beyond Wolgan Gap is closed, the main access point will be from the South. Suitable plant will be able to use the Donkey Steps track for access to construct Bridge 01piles and piers. All options would allow a connection between the Donkey Steps track and option close to the upper switchback curve on the Donkey Steps track.

Regarding retaining walls, with reference to Table 3-10, Option 3 requires the greatest area and length of wall, followed by Option 2. Option 5 has around half the area and length of wall. Retaining walls are costly compared to cut/fill earthworks.

Considering bridges and with reference to Table 3-8, Bridge 1 is of similar length and height for Option 3 and 5. Bridge 1 in Option 2 has a shorter length and has a lower maximum height. Bridge 2 is similar for all options.

A comparison of earthworks volumes is to provide some measure of the efficiency of each option in providing a route requiring least earthmoving effort.

Table 4-6 – Summary Assessment of Constructability

OPTION	SUMMARY COMPARISON	RANKING
Alignment Option 2		
Alignment Option 3		
Alignment Option 5		

4.2.6 OPERATION AND MAINTENANCE

This assessment topic covers the post construction phase to determine whether there is an option which delivers a better operational or maintenance outcome for Council and road users. Parts of operations and maintenance have been considered in other sections. For instance, the assessment or road curvature and gradient also covers the amenity value i.e., how enjoyable the road is to use. The geotechnical slope hazard assessment has a bearing on the likelihood that batters will need ongoing maintenance. Road length has an impact on pavement and linemarking maintenance costs if other parameters are equal such as same pavement type. This assessment is therefore based on slope risk, quality of the alignment and length of road.

Option 2 was second equal with Option 3 based on slope risk. Option 5 was rated highest. On road length and quality of alignment, Option 1 was ranked highest on both topics. On route length, Option 3 is slightly longer than Option 2 and would therefore attract a slightly higher maintenance effort than Option 2. Both Option 2 and 3 have a similar quality of road alignment.

Table 4-7 – Summary assessment of operation and maintenance

OPTION	SUMMARY COMPARISON	RANKING
Alignment Option 2	Second equal on alignment quality and slope risk, second on route length.	2
Alignment Option 3	Second equal on alignment quality and slope risk, third on route length.	3
Alignment Option 5	Best on slope risk, road length and quality of alignment	1

4.3 ENVIRONMENTAL ASSESSMENT

It should be noted that any option will be subject to a rigorous environmental assessment through an EIS or REF process and that the assessment is to assist in comparing the environmental benefits and disbenefits of the three shortlisted options as part of a Preferred Option selection process.

4.3.1 PROPERTY IMPACTS

In Section 3.6, a review of land required for each option was undertaken. The results show that Options 2 and 3 have similar areas of land required, whereas Option 5 requires around 15% more land. In addition, Option 5 would require relocation of one property access and a section of the old Wolgan Road route. A summary of the relative comparison is shown in Table 4-8 below.

Table 4-8 – Summary Assessment of property impacts

OPTION	SUMMARY COMPARISON	RANKING
Alignment Option 2	Total land area required = 78,330m^2	1=
Alignment Option 3	Total land area required =77,040m^2	1=
Alignment Option 5	Total land area required = 89310m^{2}5. One access diversion and on minor road diversion	3

4.3.2 IMPACT ON ABORIGINAL HERITAGE

This section is yet to be completed.

Table 4-9 – Summary assessment of aboriginal heritage

OPTION	SUMMARY COMPARISON	RANKING
Alignment Option 2		
Alignment Option 3		
Alignment Option 5		

4.3.3 ECOLOGY IMPACTS

This section is yet to be completed.

Table 4-10 – Summary Assessment of ecology

OPTION	SUMMARY COMPARISON	RANKING
Alignment Option 2		
Alignment Option 3		
Alignment Option 5		

4.3.4 VISUAL IMPACT

Visual impact of the options was determined in Section 3.6 of this report. Three locations were used to assess views of each option as described in section 3.9.1 earlier. The results of the impact assessment are recorded in Table 4-11 below.

Table 4-11 – Summary assessment of visual impact

OPTION	SUMMARY COMPARISON	RANKING
Alignment Option 2	Option 2 consistently presented a lesser visual impact compared to Option 3, due to a reduced length of road visible between the upper and lower switchbacks	2

OPTION	SUMMARY COMPARISON	RANKING
Alignment Option 3	Option 3 consistently presented the greatest visual impact due to the length of route visible against the eastern slopes of the valley	3
Alignment Option 5	Option 5 presented the least visual impact due to part of the route being hidden beyond the top of the valley, and the remainder of the route lying at a lower elevation on the eastern slope of the valley	1

Further to this, each option was considered for a possible location of a parking and viewing area, given the attractive vistas. The potential viewpoints for Alignment Option 2 and Option 3 offered a slightly improved viewpoint than Alignment Option 5 given the higher elevation.

4.4 ASSESSMENT CONSOLIDATION

This section is yet to be completed.

4.4.1 CONSOLIDATION OF ENGINEERING ASSESSMENT

OPTION	GRADIENT, LENGTH & CURVATURE	GEOTECHNICAL SLOPE HAZARD	GEOTECHNICAL CHALLENGES	SAFETY	RESILIENCE	CONSTRUCTABILITY	OPERATION & MAINTANANCE	TOTAL SCORE	RANKING
Alignment Option 2	2	2=	3	3	2=				
Alignment Option 3	3	2=	1	2	2=				
Alignment Option 5	1	1	2	1	1				

4.4.2 CONSOLIDATION OF ENVIRONMENTAL ASSESSMENT

OPTION	PROPERTY	HERITAGE	ECOLOGY	VISUAL	MEAN SCORE	RANKING
Alignment Option 2	1=			2		
Alignment Option 3	1=			3		
Alignment Option 5	3			1		

4.4.3 SUMMARY OF COST ASSESSMENT

OPTION	P90 COST	P50 COST	RANKING
Alignment Option 2			
Alignment Option 3			
Alignment Option 5			

APPENDIX A

ALIGNMENT OPTIONS DRAWINGS

Drawing Index

APPENDIX B

STRUCTURAL DRAWINGS

APPENDIX C

PAVEMENT CALCULATIONS

WSP ANZ

DESIGN TRAFFIC CALCULATION SHEET

CALCULATION METHOD

Reference Guide	Austroads Guide to Pavement Technology Part 2, 2017
Growth Type	Linear

PROJECT INFO

Project:	Wolgan Road
Location:	NSW
TLD Data Source:	Traffic count

CALCULATION CONSTANTS

Data Collection Year	2022	Traffic count
Analysis Start Year	2025	Assumed
Years to Grow Data	3	
Design Period (Years)	40	Assumed
Annual Growth Rate (%)	1.0%	Assumed
Cumulative Growth Factor	49	Austroads Eqn 31

TRAFFIC SPECTRUM INFO

AADT at Data Collection	95	Traffic count
AADT at Analysis Start	98	
%HV	10%	Traffic count
Directional Factor (%)	50%	Assumed
Lane Distribution Factor (%)	100%	Austroads Table 7.3
HV/Day	5	
NHVAG	2.10	Austroads Table E.1
NDT	**1.78E+05**	Austroads Eqn 35

LOAD EQUIVALENCY

ESA/HVAG	0.90	Assumed for rural
ESA/HV	1.9	
ESA/Day	9	

DESIGN TRAFFIC RESULTS

DESA	1.60E+05	Austroads Eqn 37
WMAPT	20	
NDT (Limit)	4.00E+08	Austroads Eqn 38

COMMENTS

PAVEMENT TRAFFIC LOADING 2 - CLASSIFICATION COUNT RESULTS

Input Details

Project title : Wolgan Road

Analysis by : WSP
Analysis date : 10 July 2023

Count station : Wolgan Road
Count period : 15 Dec 2021 to 23 May 2022

Count duration : 159 day(s)

Vehicle count :

Class	Count
1	13,105
2	510
3	1,057
4	244
5	46
6	25
7	28
8	20
9	2
10	26
11	5
12	0
13	0

Analysis Details

PTL2 design filename :
PTL2 software version : 1C (December 2021)
Design reference : Austroads Guide AGPT02-17

Results

%HV - Heavy Vehicles : 9.6%

Axle-Pairs/Vehicle : 1.04

Bin 13 error : 0.0%

ADT (during count) : 99 Axle-Pairs
95 Vehicles

Av. passenger cars / HV 2.09

N_{HVAG} : 2.10 HVAG/HV

	SAST	SADT	TAST	TADT	TRDT	QADT
HVAG proportions :	0.4616	0.3724	0.0151	0.1299	0.0210	0.0000

```
CIRCLY  - Version 6.0 (12 April 2021)

Job Title: Wolgan Road

Damage Factor Calculation

Assumed number of damage pulses per movement:
   Combined pulse for gear (i.e. ignore NROWS)

Traffic Spectrum Details:

   Load   Load                    Movements
   No.    ID
    1     ESA750-Full             1.60E+05

Details of Load Groups:

   Load   Load                   Load                  Load            Radius     Pressure/    Exponent
   No.    ID                     Category              Type                       Ref. stress
    1     ESA750-Full            ESA750-Full           Vertical Force     92.1     0.75          0.00

   Load Locations:
   Location    Load                   Gear           X           Y      Scaling      Theta
   No.         ID                     No.                               Factor
    1          ESA750-Full             1          -165.0        0.0    1.00E+00       0.00
    2          ESA750-Full             1           165.0        0.0    1.00E+00       0.00
    3          ESA750-Full             1          1635.0        0.0    1.00E+00       0.00
    4          ESA750-Full             1          1965.0        0.0    1.00E+00       0.00

Layout of result points on horizontal plane:
   Xmin:  0   Xmax:  165   Xdel:  165
   Y:     0

Details of Layered System:

   ID: Wolgan Road Title: Wolgan Road

   Layer  Lower    Material               Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F           Eh          vh
    1     rough    Gran_350               Aniso.     3.50E+02   0.35      2.59E+02    1.75E+02    0.35
    2     rough    subsltCB15             Aniso.     1.50E+02   0.35      1.11E+02    7.50E+01    0.35
    3     rough    Sub_CBR3               Aniso.     3.00E+01   0.45      2.07E+01    1.50E+01    0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.  Traffic
   No.             ID                                Constant   Exponent  Multiplier
    2     top      subsltCB15             EZZ         0.009300   7.000     1.600
    3     top      Sub_CBR3               EZZ         0.009300   7.000     1.600

   Reliability Factors:
   Project Reliability: Austroads 95%
   Layer  Reliability  Material
    No.   Factor        Type
    2       1.00       Subgrade (Selected Material)
    3       1.00       Subgrade (Austroads 2004)

   Details of Layers to be sublayered:
   Layer no.  1:  Austroads (2004) sublayering
   Layer no.  2:  Austroads (2004) sublayering

Results:

   Layer  Thickness  Material               Load                    Critical      CDF
   No.               ID                     ID                      Strain
    1      200.00    Gran_350                            n/a                      n/a
    2      300.00    subsltCB15             ESA750-Full              1.49E-03     6.79E-01
    3        0.00    Sub_CBR3               ESA750-Full              1.41E-03     4.63E-01
```

Rigid Pavement Design Calculation Sheet

Date: 10-Jul-23
Project: Wolgan Road

Designer: WSP
Location: NSW

Design Details

Pavement Type:	PCP
CRC/Dowelled Joints:	No
Concrete Shoulders:	No
Source of Load Data:	Client
Design Period (Years):	40
Design Traffic (HVAG):	1.78E+05
Design Reliability (%):	95.0%
Load Safety Factor:	1.30
Load Multiplication Factor:	1.00
Minimum Base Thickness:	150
Concrete Shoulder Factor (F2):	0.06
TRIAL BASE THICKNESS (mm):	**210**

Compressive Strength f'_c (MPa):	36
Flexural Strength f'_{cf} (Mpa):	4.5
UZM Thickness (mm):	0
SMZ Thickness (mm):	300
Subgrade CBR (%):	3
UZF CBR (%):	0
SMZ CBR (%):	15
Design Subgrade CBR (%):	5.3
Subbase Type:	Bound Material
Subbase Thickness:	125
Effective CBR:	27

Equivalent Erosion and Stress Factors

Axle Group	SAST	SADT	TAST	TADT	TRDT	QADT
% of Each Axle Group	46%	37%	2%	13%	2%	0%
Equivalent Stress	0.91	1.47	0.91	1.23	0.92	0.92
Stress Ratio Factor	0.20	0.33	0.20	0.27	0.20	0.20
Erosion Factor	2.34	2.94	3.06	3.06	3.10	3.10

Damage Analysis

Axle Group	SAST	SADT	TAST	TADT	TRDT	QADT
Fatigue (%)	0.0%	46.4%	0.0%	0.0%	0.0%	0.0%
Erosion (%)	0.7%	14.0%	8.0%	4.1%	0.2%	0.0%

	TOTAL DAMAGE	RESULT
Fatigue Analysis:	46%	ACCEPTED
Erosion Analysis:	27%	ACCEPTED

Load (kn)	SAST %	SADT %	TAST %	TADT %	TRDT %	QADT %
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
30	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
40	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
60	100.0000	0.0000	0.0000	0.0000	0.0000	0.0000
70	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
80	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
90	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
100	0.0000	100.0000	0.0000	0.0000	0.0000	0.0000
110	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
120	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
130	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
140	0.0000	0.0000	100.0000	0.0000	0.0000	0.0000
150	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
160	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
170	0.0000	0.0000	0.0000	100.0000	0.0000	0.0000
180	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
190	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
200	0.0000	0.0000	0.0000	0.0000	100.0000	0.0000
210	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
220	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
230	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
240	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
260	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
270	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
280	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
290	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
310	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
320	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
330	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
340	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
350	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
360	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
370	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
380	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
390	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	100.0000	100.0000	100.0000	100.0000	100.0000	0.0000
% of Each Group	0.4616	0.3724	0.0151	0.1299	0.0210	0.0000

Rigid Pavement Design Calculation Sheet

Date: 10-Jul-23
Project: Wolgan Road

Designer: WSP
Location: NSW

Design Details

Pavement Type:	PCP	Compressive Strength f'_c (MPa):	36
CRC/Dowelled Joints:	No	Flexural Strength f'_{cf} (Mpa):	4.50
Concrete Shoulders:	No	UZM Thickness (mm):	0
Source of Load Data:	Client	SMZ Thickness (mm):	300
Design Period (Years):	40	Granular Thickness (mm):	125
Design Traffic (HVAG):	1.78E+05	Subgrade CBR (%):	3
Design Reliability (%):	95.0%	UZF CBR (%):	0
Load Safety Factor:	1.30	SMZ CBR (%):	15
Load Multiplication Factor:	1.00	Granular Subbase(CBR (%):	80
Minimum Base Thickness:	150	Design Subgrade CBR (%):	9.3
Concrete Shoulder Factor (F2):	0.06	Effective CBR:	9.3
TRIAL BASE THICKNESS (mm):	220		

Equivalent Erosion and Stress Factors

Axle Group	SAST	SADT	TAST	TADT	TRDT	QADT
% of Each Axle Group	46%	37%	2%	13%	2%	0%
Equivalent Stress	0.90	1.49	0.90	1.31	0.98	0.98
Stress Ratio Factor	0.20	0.33	0.20	0.29	0.22	0.22
Erosion Factor	2.31	2.91	3.09	3.09	3.14	3.14

Damage Analysis

Axle Group	SAST	SADT	TAST	TADT	TRDT	QADT
Fatigue (%)	0.0%	59.8%	0.0%	0.0%	0.0%	0.0%
Erosion (%)	0.5%	11.5%	9.9%	5.1%	0.3%	0.0%

	TOTAL DAMAGE	RESULT
Fatigue Analysis:	60%	ACCEPTED
Erosion Analysis:	27%	ACCEPTED

Load (kn)	SAST %	SADT %	TAST %	TADT %	TRDT %	QADT %
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
30	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
40	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
60	100.0000	0.0000	0.0000	0.0000	0.0000	0.0000
70	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
80	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
90	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
100	0.0000	100.0000	0.0000	0.0000	0.0000	0.0000
110	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
120	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
130	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
140	0.0000	0.0000	100.0000	0.0000	0.0000	0.0000
150	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
160	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
170	0.0000	0.0000	0.0000	100.0000	0.0000	0.0000
180	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
190	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
200	0.0000	0.0000	0.0000	0.0000	100.0000	0.0000
210	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
220	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
230	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
240	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
260	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
270	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
280	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
290	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
310	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
320	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
330	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
340	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
350	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
360	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
370	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
380	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
390	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	100.0000	100.0000	100.0000	100.0000	100.0000	0.0000
% of Each Group	0.4616	0.3724	0.0151	0.1299	0.0210	0.0000

ABOUT US

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