Beveridge North West Designs and Costings

Beveridge North West PSP Infrastructure Designs and Costings

V181662

Prepared for
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D04	25.07.19	Addressing VPA comments	Viraj Abeykoon	
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1 Introduction

The Victorian Planning Authority (VPA) in consultation with Mitchell Shire Council is in the process of preparing the Beveridge North West Precinct Structure Plan (PSP). The area of the PSP is bounded by Camerons Lane to the south, Hume Freeway to the east and Old Sydney Road to the west. The northern boundary of the site is approximately 3km from Camerons Lane. The land is currently predominantly farmland and the western portion of the site encompasses a section of Kalkallo creek.

Cardno was engaged by the VPA on 08 February 2019 to conduct an analysis on several of the proposed transport infrastructure elements of the PSP and to subsequently cost these items. The nominated infrastructure items and relevant analysis include;

> 3D concept design for 2 road sections (RD-03, part of RD-04);
> 3D concept design for 5 intersections (IN-02, IN-05, IN-06, IN-07, IN-11);
> 2D concept design for 2 intersections (IN-03, IN-04)
> Benchmark costing for 2 road sections (RD-01, RD-02, part of RD-04)
> Benchmark costing for intersections (IN-01, IN-09, IN-10, IN-12, IN-13)
> 1 bridge concept design (BR-02).
> Benchmark costing for 2 bridges (BR01, BR03)

3D design tasks have been undertaken to inform ideal conceptual road geometry and to inform earthworks quantities for costings only. The design effort therefore reflects the tasks required to obtain the above information and no further road traffic or intersection modelling (e.g.- SIDRA modelling) or detailed design work has been undertaken. For elements with 3D design tasks, relevant road and intersection templates from the benchmark infrastructure costings project were utilised for costing purposes.

For the remaining items, quantities were extracted from the bespoke documents prepared by Cardno for this project and where applicable, rates from the Benchmark Infrastructure report (version D08, date 11 April 2019) were utilised to determine final costs. The benchmark infrastructure items were developed with P50 and P90 estimated rates. The P50 Estimates and P90 Estimates denote that there is a 50% chance and 90% chance respectively of meeting the total actual project cost, based on the analysis conducted within the Benchmark Infrastructure Costing project. The modelling was undertaken using a Monte-Carlo analysis. The rates were later indexed to inflation, taken from ABS data up to July 2018. For this current report, prices were again indexed to rates current as of June 2021. For a summary of the cost estimates, please see Estimate summary.

Cardno was also engaged to undertake a site visit and to provide advice on the geology of the area (refer appendix A). The recommendations in this report are based on the following inputs provided to Cardno by the VPA.

Input	Reference	Date
Melbourne Water Flood Levels	FW Beveridge North West - Kalkallo Creek.msg	13.02.2019
GTA traffic report	GTA Traffic Modelling report - 10 December 2018 – Final.pdf	03.08.2018
VPA alignment - Roads	Multiple files	17.07.2018
LiDAR survey 1	BNW lidar.zip	17.07.2018
VPA alignments - Bridge	Bridges_edit.zip	08.03.2019
LiDAR survey 2	Multiple files	14.03.2019
LiDAR survey 3	Multiple files	15.03.2019

Following the initial issue of this report a stakeholder meeting was held on 21.05.2019. Feedback from stakeholders have been accommodated in this latest issue of the report.

Cardno was later engaged by the VPA on numerous occasions to make the following variations:

- **15 June 2020:** Redesign RD-03 to be a 80km/h ultimate design speed road & update costings.
- **27 July 2020:** Review the nominated infrastructure items in light of a Jacobs report highlighting significant sodic soil present in the area, refer to Appendix D. The Jacobs report commented on certain measures required in order to safeguard newly constructed items from the effects of erosion. Cardno's responses/actions are summarised in section 6.
- **04 June 2021**: Prepare three concept alignment design options and costings of an extension to the RD-03 arterial. The general alignments were derived by the VPA in response to the Beveridge North-West panel report dated October 2020 which required VPA to address Hanna Swamp onto the road alignments.
- **20 September 2021:** Prepare an updated conceptual design and costings for extension of RD-03 (western arterial) and update existing conceptual designs and costings and summary report. Further refinement of sodic soil cost estimates was requested in order to take to a panel hearing.

Further details of the project are outlined in the sections below and stakeholder comments received for infrastructure components where appropriate are also summarised within these sections.

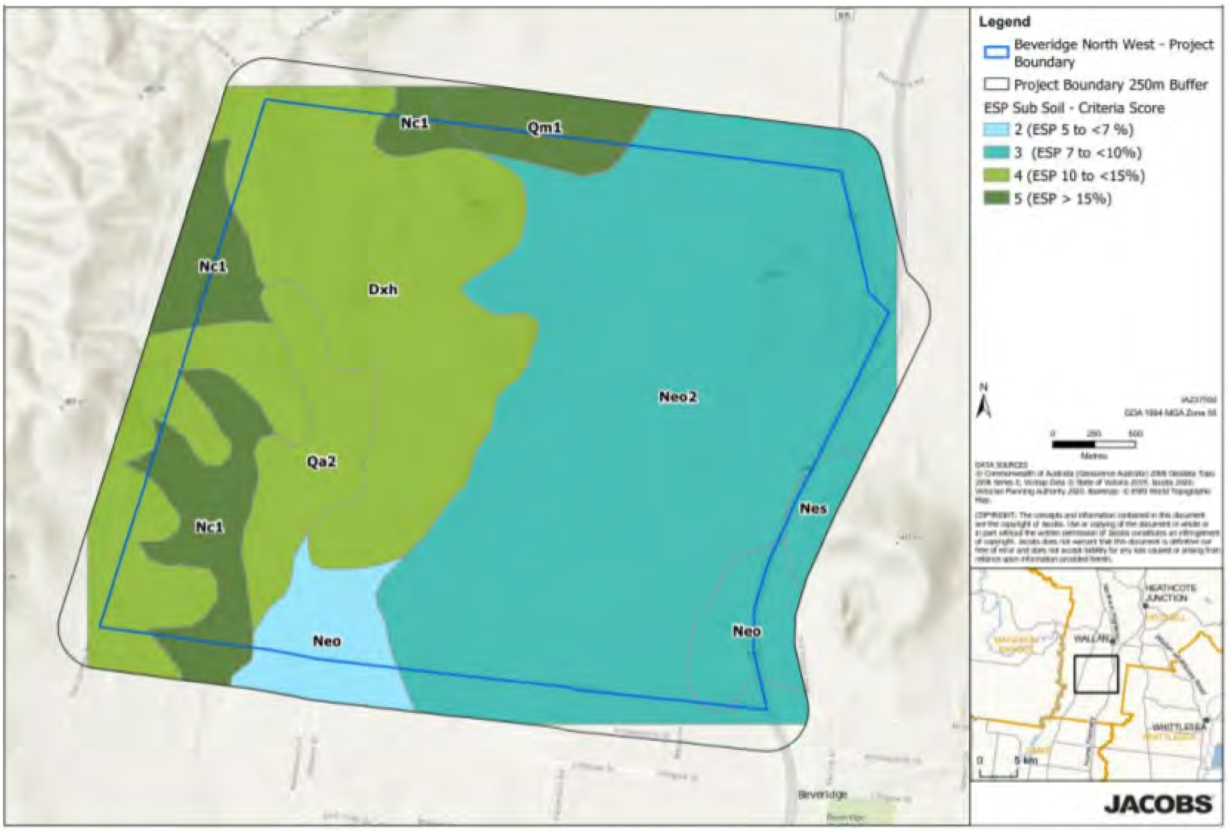
2 Sodic Soil Methodology

Cardno was engaged by the VPA on 27 July 2020 to review the nominated infrastructure items in light of a Jacobs report highlighting significant sodic soil present in the area. The Jacobs report commented on certain measures required in order to safeguard newly constructed items from the effects of erosion. A copy of the Jacobs report on sodic soil presence in the area can be found in Appendix D.

It is important to note that these costings were completed in the absence of site testing, and thus the measures to negate the influence of sodic soil were robust and conservative. However, it is not the intention of the methodology or derived costs to replace recommendations that would come from specific site testing.

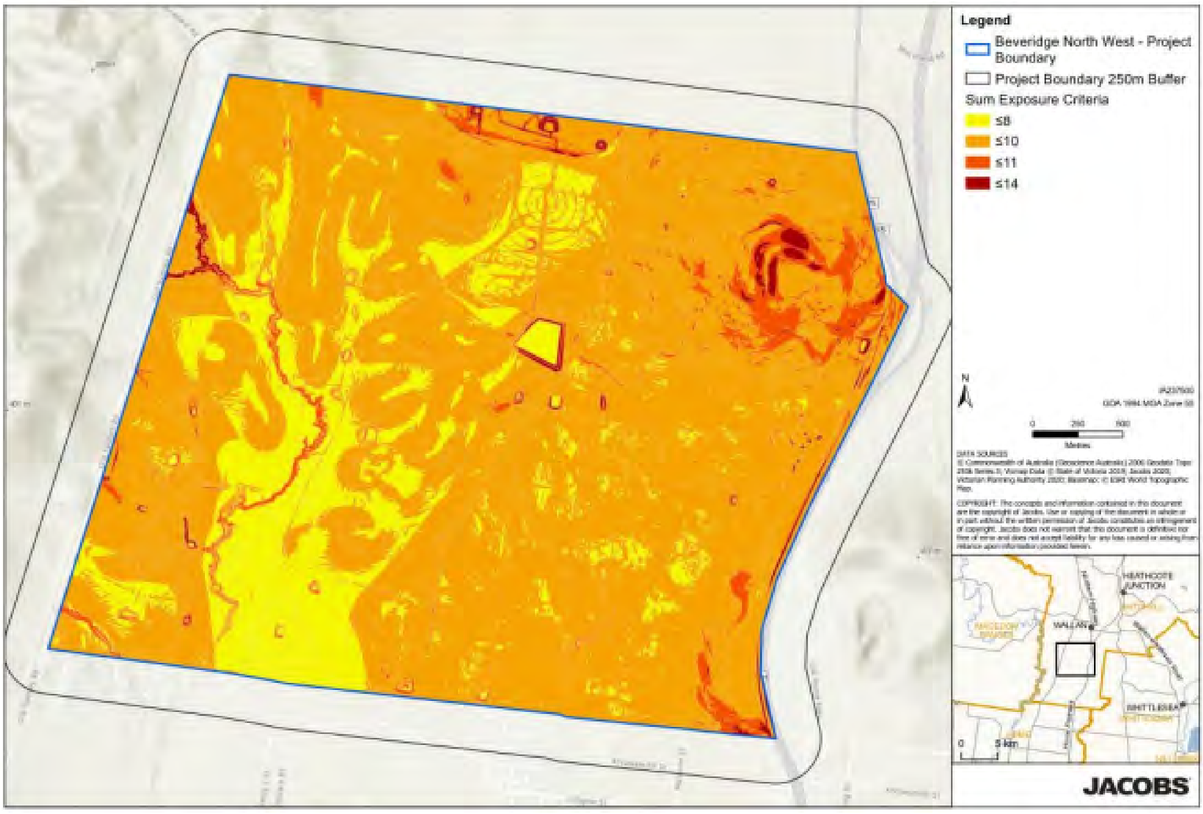
Upon review of the Jacobs report, the entire site is affected by the presence of sodic soils, but particularly so in the western portion of the site. Figure 2-1 below shows the estimated subsoil sodic content:

Figure 2-1 Mean sodic soil content across PSP



Areas identified as having a high sensitivity of erosion are soils around creek beds, high gradients where earthworks will be considerable and increased speed of runoff and areas where water can congregate. Figure 2-2 below shows an extract of the sum of the sensitivity criteria across the site:

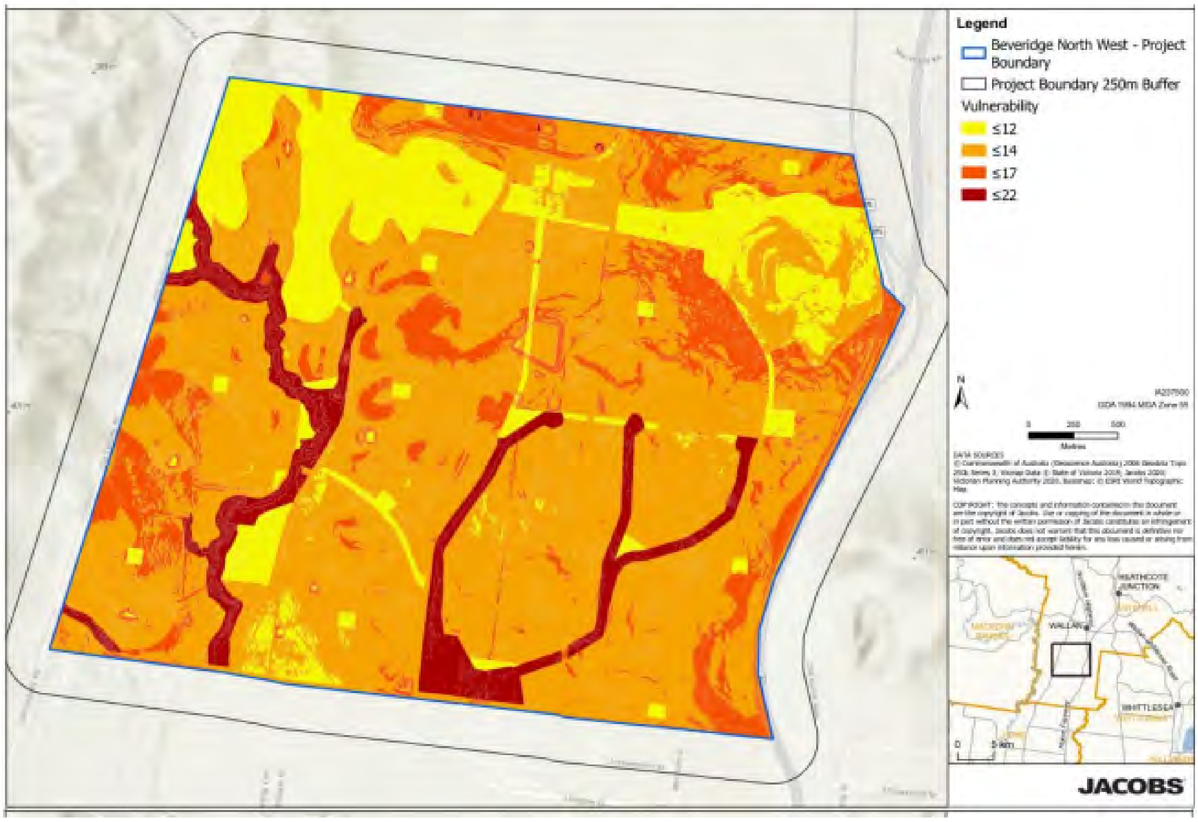
Figure 2-2 Summary of sensitivity criteria as per Jacobs report



Areas in the PSP were also analysed for vulnerability during construction. It was deemed that all areas for infrastructure works were of a high category for exposure due to the disturbance caused during construction.

Figure 2-3 below gives an overview of the site from a construction vulnerability perspective:

Figure 2-3 Vulnerability Construction Phase



The methodology derived to provide for sodic soil measures needed to take account for the overall sodic soil levels of the site but also pay attention to the risks on the western section, particularly in the vicinity of the Kalkallo Creek beds. The following measures below were taken to negate the effects of sodic soils on the proposed infrastructure items. Cardno's internal resources were consulted in determining the methodology of costing the management measures. Appendix D gives an overall plan view and table including Jacobs comments of measures taken in the PSP.

Across entire site:

- Provision of 200mm capping layer underneath pavement area;
- Use of batter protection matting for 1:4 batters to prevent erosion;
- Allowance for erosion protection treatment for utilities (street lighting);
- Inefficiency cost for staging of works to minimising disturbance of soil;
- Provision of lime stabilisation 0.5m behind BOK in addition to boxed out area due to increased risk of sodic soil erosion;
- Geotextile mat to prevent concrete items from erosion;
- Provision of soil stabilisation using gypsum to topsoil and 150mm of earth beneath topsoil.

Western section of site: (RD-03 & associated intersections)

- Conducted a high-level drainage analysis to determine swale requirements and to subsequently price in suitable erosion protection measures. Costed swale lining material as rip-rap for this item;
- Rock protection (for areas near creek);

Application of methodology

The items indicated above have been applied to both the bespoke infrastructure designs and benchmark items. For bespoke items, values were taken from designs, and therefore a higher degree of accuracy was attained. In some cases, this led to significantly different results than if benchmark values had been used. For instance, 3D-modelled intersections produced more reliable estimates of batter areas, which could then be used for batter protection calculations.

When applying these measures to benchmark costings, standard dimensions were used to produce rational estimates. For example, erosion protection for streetlight cabling was based on the lengths of each intersection leg.

A table summary of application of sodic soil contingencies across benchmark and bespoke intersections is shown below:

Table 2-1 – Sodic soil contingency application

Sodic soil contingency	Unit	Application to bespoke items	Application to benchmark items
200mm capping layer	m2	Equal to the sum of pavement area and stabilized section behind kerb.	Equal to the sum of pavement area and stabilized section behind kerb.
Batter protection matting	m2	Measured surface area of batters	Assumed surface area of batters equal to length of kerb multiplied by 4m batters (along edges of kerb to existing surface).
Utility erosion protection (lighting)	m	Length of kerbs	Length of kerbs
Inefficiency contingency for staging of works	m2	Assumed $0.80 per m2 of site preparation	Assumed $0.80 per m2 of site preparation
Lime stabilization for soil up to 0.5m BOK.	m2	Equal to the sum of pavement area and stabilized section behind kerb.	Equal to the sum of pavement area and stabilized section behind kerb.
Geotextile mat to prevent concrete items from erosion	m2	Area of mat for drainage: 1m width excavation multiplied by pipe length. Area of mat for SUP: Area of shared user path	Area of mat for drainage: 1m width excavation multiplied by pipe length. Area of mat for SUP: Area of shared user path
Provision of soil stabilisation using gypsum to topsoil and 150mm of earth beneath topsoil	m2	All areas not treated by lime to be stripped and filled in with 4% concentration gypsum.	All areas not treated by lime to be stripped and filled in with 4% concentration gypsum.
Costed swale lining material as rip-rap for this item, poat drainage analysis.	m2	Swale width calculated as ~5m as per concept rational method drainage analysis, multiplied by road length to get rip-rap required.	Not applied
Rock protection (for areas near creek);	m2	Area of batters facing Kalkallo Creek	Not applied

3 Results of Preliminary Cost Estimates

3.1 Estimate summary

Results of the cost estimates are outlined in the table below. For further details of the cost estimates refer to appendix C (cost sheets).

Results of the estimation process (rounded up to the nearest thousand) are outlined in the tables below. Refer to Appendix C for full price extraction data and quantities. The P50 Estimates and P90 Estimates denote that there is a 50% chance and 90% chance respectively of meeting the total actual project cost, based on the analysis conducted within the Benchmark Infrastructure Costing project.

The costs identified below have been arrived at using the indexed P50/P90 rates as of June 2021 from the Benchmark Infrastructure Report – version D08 (11 April 2019), with the exception of BR-02.

Bespoke infrastructure items with full 3D design are shown in Table 3-1 – 3D infrastructure costings. Bespoke project costs varied from benchmark costs primarily due to earthworks and different pavement areas. As previously noted, this also allowed a more accurate incorporation of sodic soil measures.

Table 3-1 – 3D infrastructure costings

Project	Description	Reference material	P50Estimate ($ Excl GST)	P90Estimate ($ Excl GST)
RD-03 Sec.1	North-South Primary Arterial Road 123m	V181662-CI-DG-2001-2002	712,000	800,000
RD-03 Sec.2	North-South Primary Arterial Road 402m	V181662-CI-DG-2004-2005	2,532,000	2,843,000
RD-03 Sec.3	North-South Primary Arterial Road 64m	V181662-CI-DG-2007	437,000	494,000
RD-03 Sec.4 (alignment 3B)	North-South Secondary Arterial Road 2357m	V181662-CI-DG-2009-2015	14,817,000	16,515,000
RD-04	North-South Secondary Arterial Road 1296m	V181662-CI-DG-2011-2012	7,291,000	8,123,000
IN-02	Secondary-Connector intersection	V181662-CI-DG-2014	4,577,000	5,145,000
IN-05	Primary-Connector intersection	V181662-CI-DG-2003	8,243,000	9,286,000
IN-06	Primary-Connector intersection	V181662-CI-DG-2006	8,957,000	10,143,000
IN-07	Primary-Connector intersection	V181662-CI-DG-2008	6,287,000	7,131,000
IN-11	Secondary-Connector intersection	V181662-CI-DG-2013	5,690,000	6,427,000

A comparison table has also been prepared for these bespoke roads and intersections against their benchmark equivalents.

Table 3-2 – 3D infrastructure cost comparisons

Project	Benchmark Item No.	Benchmark Cost ($P90)	Estimated Cost ($P90)	Departures
RD-03 Sec.1	Item 1	593,000	800,000	Higher subgrade preparation allowance Higher earthworks requirements Sodic soil allowances
RD-03 Sec.2	Item 1	1,940,000	2,843,000	
RD-03 Sec.3	Item 1	309,000	494,000	
RD-03 Sec.4-B	Item 2	10,312,000	16,515,000	
RD-04	Item 1	5,670,000	8,123,000	As above & rock excavation allowance
IN-05	Item 7	4,674,000	9,286,000	Higher subgrade preparation allowance Larger area of works Higher earthworks requirements Sodic soil allowances
IN-06	Item 7	4,674,000	10,143,000	
IN-07	Item 13	3,962,000	7,131,000	
IN-11	Item 9	4,310,000	6,427,000	As IN-05 & rock excavation allowance
IN-02	Item 15	3,549,000	5,145,000	As IN-07/12 and; existing pavement removal allowance Higher cost for wider SUP Sodic soil allowances

Sodic soil items were also added to benchmark items as required, based on standard dimensions and given values, as previously noted.

There were few changes made to existing benchmark items. However, all items had an updated landscaping methodology. Instead of using a more expensive rate, incorporating more advanced landscaping, a cheaper rate was used, which only accounted for topsoil seeding. Unlike the previous landscape item, topsoil seeding was applied to all surfaces of within the road reserve that were not already covered. Typically, this resulted in lower overall landscaping cost, for both benchmark and bespoke items.

Benchmark items and 2D designs are shown in Table 3-3 – 2D and benchmark infrastructure costings.

Table 3-3 – 2D and benchmark infrastructure costings

Project	Description	Reference material	P50Estimate ($ Excl GST)	P90Estimate ($ Excl GST)
BR-01	Interim secondary bridge arterial road	V181544-CI-DG-2032	18,437,000	21,749,000
BR-02	Pedestrian Bridge	V181662-ST-0010	283,000	324,000
BR-03	Ultimate connector road bridge	V181544-CI-DG-2034	6,478,000	7,603,000
CU-01	RCP 1200DN Secondary Arterial - Interim	V181544-CI-DG-2043	256,000	297,000
RD-01	Secondary arterial road	V181544-CI-DG-2002	3,016,000	3,347,000
RD-02	Secondary arterial road	V181544-CI-DG-2002	6,541,000	7,269,000
IN-01	Secondary-Secondary intersection	V181544-CI-DG-2011	7,998,000	8,962,000
IN-03	Primary-Connector intersection	V181544-CI-DG-2009	10,693,000	12,038,000
IN-04	Primary-Connector intersection	V181544-CI-DG-2009	8,917,000	10,062,000
IN-08	Secondary-Secondary intersection	V181544-CI-DG-2011	8,075,000	9,047,000
IN-09	Secondary-Secondary intersection	V181544-CI-DG-2011	8,075,000	9,047,000
IN-10	Secondary-Connector intersection	V181544-CI-DG-2013	5,406,000	6,094,000
IN-12	Secondary-Connector intersection	V181544-CI-DG-2013	5,222,000	5,877,000
IN-13	Secondary-Connector intersection	V181544-CI-DG-2013	5,396,000	6,082,000

A comparison table has also been prepared for these amended benchmark and 2D items against their original benchmark equivalents. Note that this table is only shown for the roads and intersections, which changes due to the sodic soil updates and other amendments to come from the Jacobs report.

Cost differences are due to sodic soil items, including the increased subgrade preparation allowance, with other items noted in the departures column. 2D concept designs are also noted.

Table 3-4 – 2D and benchmark infrastructure cost comparisons

Project	Benchmark Item No.	Benchmark Cost ($P90)	Estimated Cost ($P90)	Departures
CU-01	Item 31	287,000	297,000	Rate changes due to rock gabions
RD-01	Item 2	2,196,000	3,347,000	Sodic soil allowances
RD-02	Item 2	4,703,000	7,269,000	Sodic soil allowances Allowance for rock removal
IN-01	Item 8	6,134,000	8,962,000	Sodic soil allowances Allowance for rock removal
IN-03	Item 6 (no direct equivalent)	6,940,000	12,038,000	Sodic soil allowances V181662-TR-SK-0018 used as basis, allowance for rock removal, rock armoring on LHS
IN-04	Item 7	4,674,000	10,062,000	Sodic soil allowances V181662-TR-SK-0019 used as basis, allowance for rock removal
IN-08	Item 8	6,134,000	9,047,000	Sodic soil allowances Allowance for rock removal
IN-09	Item 8	6,134,000	9,047,000	Sodic soil allowances Allowance for rock removal
IN-10	Item 9	4,310,000	6,094,000	Sodic soil allowances Allowance for rock removal
IN-11	Item 9	4,310,000	5,877,000	Sodic soil allowances Allowance for rock removal
IN-13	Item 9	4,310,000	6,082,000	Sodic soil allowances Allowance for rock removal

4 Site visit

As part of the early project scope, a site visit was undertaken on 06 March 2019. Locations of the infrastructure projects Cardno was engaged to analyse were observed during the site visit. Notable general items from the site visit are discussed in the section below. Other items noted during the site visit specific to the infrastructure projects are discussed within the individual sections for these infrastructure items.

4.1 Shared use path location

The VPA have indicated that the current informal path along the western edge of Old Sydney Road will be upgraded so that a formal path is created in the same location. The current informal path is an unpaved dirt track and has litter scattered along certain locations.

Figure 4-1 Current status of informal path

The grades of the current informal paths across certain sections were also noted to be very steep. Based on Nearmap vertical data, the grades across these sections appear to be in the order of 10%-20%.

Figure 4-2 Steep grades along certain sections of the path

In addition to the above, another significant issue noted during the site visit was the series of highly eroded sections at low points along the length of the track. The current terrain west of the path slopes and drains towards the path. Old Sydney Road which is east of the path is additionally largely built above the path. At the low points of the path, there appears to be insufficient/ no crossing drainage allowing the surface flows from the west to drain under the road to the east. As a result, large ponds are created at these sections leading to significant erosion and soft subgrade issues.

Figure 4-3 Significantly eroded sections and inundations at low points along the path

4.2 Rock outcrops

The visit showed that the North-East corner of the site appeared to have frequent rock outcrops. This signifies a shallow depth to the Basalt rock expected over this section of the site. Further details of the terrain are discussed in the geotechnical section of the report (Appendix A). This terrain condition is expected to impact intersection IN-12 and road section RD-04.

Figure 4-4 Rock outcrops at RD-04 and IN-12

5 Bespoke costings analysis - Road projects

Details of the analyses of the transport (road) projects are outlined in this section.

Cardno has conducted a 3D modelling exercise over two road sections (RD-03 and RD-04). In addition to conducting the 3D modelling for RD-03 and RD-04, the road alignments provided by the VPA were also adjusted to meet the required geometry standards. The costings for these infrastructure items were to be based on findings from the above investigations. Further details of the analysis are outlined in the sections below.

A summary of the design parameters followed are provided in the tables below, and are in accordance with Austroads Guide to Road Design Part 3.

5.1.1 Horizontal alignment

Table 5-1 Horizontal design parameters

Description	Specification	Criteria 1	Criteria 2	Criteria 3
Operating Speed V 60km/h; *Design Speed V 70km/h* - RD-04				
Minimum curve length	AGRD part 3 Table 7.7	V60	100m	
Frictional Factor (Cars)	AGRD Part 3 Table 7.5	V60	0.24	
Minimum curve radius (6% super, Trucks)	AGRD Part 3 Equation 5	V60	94m	
Minimum Radii 3% adverse cross fall (New roads)	AGRD Part 3 Table 7.12	V60	220m	0.16 (friction factor)
Minimum straight between reverse curves (0.7V) (Design speed based)	AGRD Part 3 Section 7.5.3	V70	49m	
Minimum straight between broken back curves (V) (Design speed based)	AGRD Part 3 Section 7.5.2	V70	70m	
Maximum deflection angle, no curve	AGRD Part 3 Table 7.7	V60	2 Lane	1º

Table 5-2 Horizontal design parameters

Description	Specification	Criteria 1	Criteria 2	Criteria 3
Operating Speed V 80km/h; *Design Speed V 80km/h* - RD-03				
Minimum curve length	AGRD part 3 Table 7.7	V80	180m	
Frictional Factor (Cars)	AGRD Part 3 Table 7.5	V80	Des max 0.16	Abs max 0.26
Minimum curve radius (6% super, Trucks)	AGRD Part 3 Equation 5	V80	280m	Max side friction 0.13
Minimum Radii 3% adverse cross fall (New roads)	AGRD Part 3 Table 7.12	V80	660m	Max side friction 0.11
Minimum straight between reverse curves (0.7V) (Design speed based)	AGRD Part 3 Section 7.5.3	V80	56m	
Minimum straight between broken back curves (V) (Design speed based)	AGRD Part 3 Section 7.5.2	V80	80m	
Maximum deflection angle, no curve	AGRD Part 3 Table 7.7	V80	0.5deg	

5.1.2 Vertical alignment

The vertical design parameters relevant to the concept design are provided in the table below.

Table 5-3 Vertical design parameters

Operating Speed V 60km/h; *Design Speed V 70km/h* - RD-04				
Maximum grades	AGRD part 3 Table 8.3	Flat	6%	
Minimum grade	AGRD Part 3 Table 8.5	Minimum	0.5%	
	AGRD Part 3 Table 8.5	Desirable	1%	
Minimum vertical curve length (New construction)	AGRD Part 3 Table 8.10	V60	40m	
Minimum straight between broken back curves (0.4V)	AGRD Part 3 Section 8.6.6	V60	24m	
Maximum grade change without vertical curve	AGRD Part 3 Table 8.12	V60	0.8%	
Minimum Sag K value	AGRD Part 3 Figure 8.9	V60	6 –10	
Desirable minimum crest K value (Design speed based)	AGRD Part 3 Table 8.7	V70	Rt=2.0s	19.1

Table 5-4 Vertical design parameters

Operating Speed V 80km/h; *Design Speed V 80km/h* - RD-03				
Maximum grades	AGRD part 3 Table 8.3	Flat	6%	
Minimum grade	AGRD Part 3 Table 8.5	Minimum	0.5%	
	AGRD Part 3 Table 8.5	Desirable	1%	
Minimum vertical curve length (New construction)	AGRD Part 3 Table 8.10	V80	60m	Single carriageway
Minimum straight between broken back curves (0.4V)	AGRD Part 3 Section 8.6.6	V80	32m	
Maximum grade change without vertical curve	AGRD Part 3 Table 8.12	V80	0.6%	

Minimum Sag K value	AGRD Part 3 Figure 8.9	V80	10 – 17	
Desirable minimum crest K value (Design speed based)	AGRD Part 3 Table 8.7	V80	Rt=2.0s	29.3

The appropriate sight distances for the concept design have been checked in accordance with the requirements of Austroads Part 3 Geometric design.

Table 5-5 Sight distance criteria

Description	Specification	Criteria 1	Criteria 2	Criteria 3
Operating Speed V 60km/h; *Design Speed V 70km/h* - RD-04				
Driver Reaction time (Rt)	AGRD part 3 5.2.2	2.0 sec		
Coefficient of Deceleration (Car)	AGRD Part 3 Table 5.5	0.46		
Car Stopping Sight Distance (SSD) – no grade correction	AGRD Part 3 Table 5.5	V70	Rt=2.0s	92m
Operating Speed V 80km/h; *Design Speed V 80km/h* - RD-03				
Driver Reaction time (Rt)	AGRD part 3 5.2.2	2.0 sec		
Coefficient of Deceleration (Car)	AGRD Part 3 Table 5.5	0.36		
Car Stopping Sight Distance (SSD) – no grade correction	AGRD Part 3 Table 5.5	V80	Rt=2.0s	117m
General criteria				
Eye Height	AGRD Part 3 Table 5.1	1.1m Cars	2.4m Truck	
Eye location	AGRD Part 3 Table 5.1	Centre of lane		
Object height	AGRD Part 3 Table 5.1	0.0m ASD		
	AGRD Part 3 Table 5.1	0.2m SSD		
	AGRD Part 3 Table 5.1	0.65m MGSD		

In addition to the above, the following cross-falls were adopted for the road cross sections.

Description	Specification	Criteria 1	Criteria 2	Criteria 3
Interim road cross fall		3%		
Verge and SUP cross fall		2%		
Ultimate land reserve		As appropriate depending on the existing surface grade		
Batters	AGRD	Cut	Earth	Max. 4:1
	AGRD	Fill	Earth	Max. 4:1

5.2 Road RD-03

Road RD-03 is a North-South secondary arterial road connecting intersections IN-03 through to the intersection on the Northern PSP boundary. Cardno was engaged to conduct a 3D modelling exercise for approximately 3000m of RD-03 between intersection IN-04 and the Northernmost intersection, IN-08. Road centreline grading was conducted between the midpoint of intersection IN-04 (CH-00) and the midpoint of IN-08 (CH-3120.132). Benchmark road section Item 2 has been applied over the extents of the road (excluding 190m of secondary arterial intersection legs of IN-04, and excluding the entire intersections extents for IN-05, IN-06 and IN-07). The lengths of the road sections between individual intersections are;

> RD-03 section 1 (between IN-04 and IN-05) – 123m;

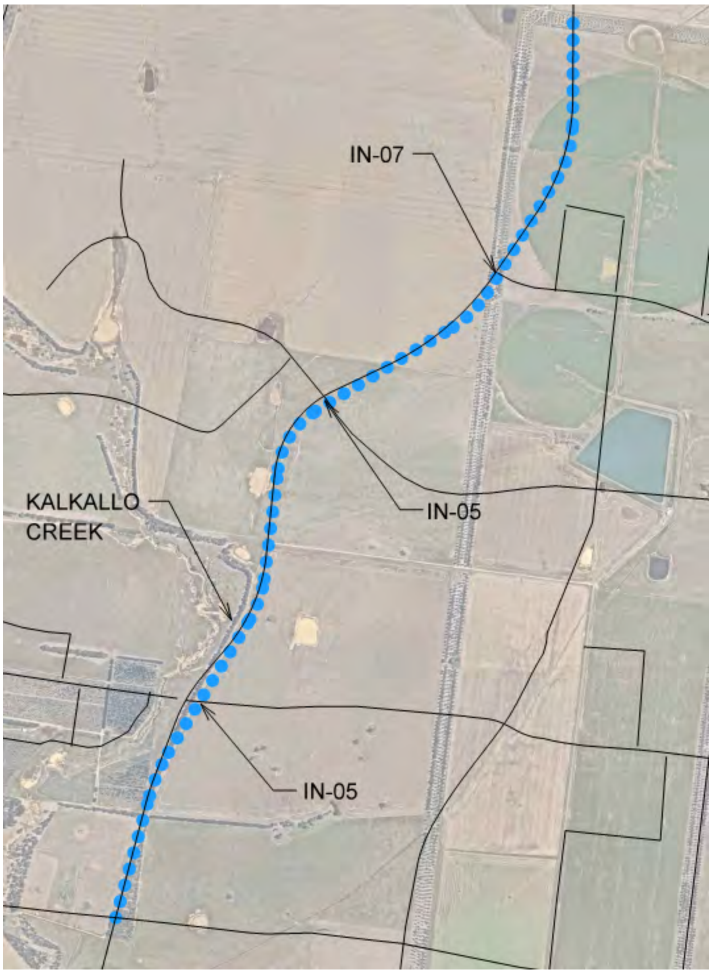
> RD-03 section 2 (between IN-05 and IN-06) – 402m;

> RD-03 section 3 (between IN-06 and IN-07) – 64m;

> RD-03 section 4 (between IN-07 and Northern PSP boundary intersection) – 241m.

The alignment of the road has been adjusted to accommodate the required horizontal geometry for the design speed of the road and to provide ideal geometry for the intersection approaches as per Austroads Guide to Road Design Part4A. As a result, the road centreline has been shifted from the original VPA provided alignments allowing the intersecting legs to be as close to 90º as possible and to have any curved horizontal alignments located at a substantial distance from the intersection as possible. Existing surface profiles from the provided LiDAR data have also been given a thorough consideration in proposing the road geometry.

Figure 5-1 Road 03 centreline refinement



Key changes and points as a result of the above exercise include;

> Shifting the location of intersection IN-05 and section of the road to the East by 30m from the original VPA road alignments. This change is proposed to improve the intersection geometry for IN-05;

> Providing road geometry to accommodate adverse cross fall at 3.0%.

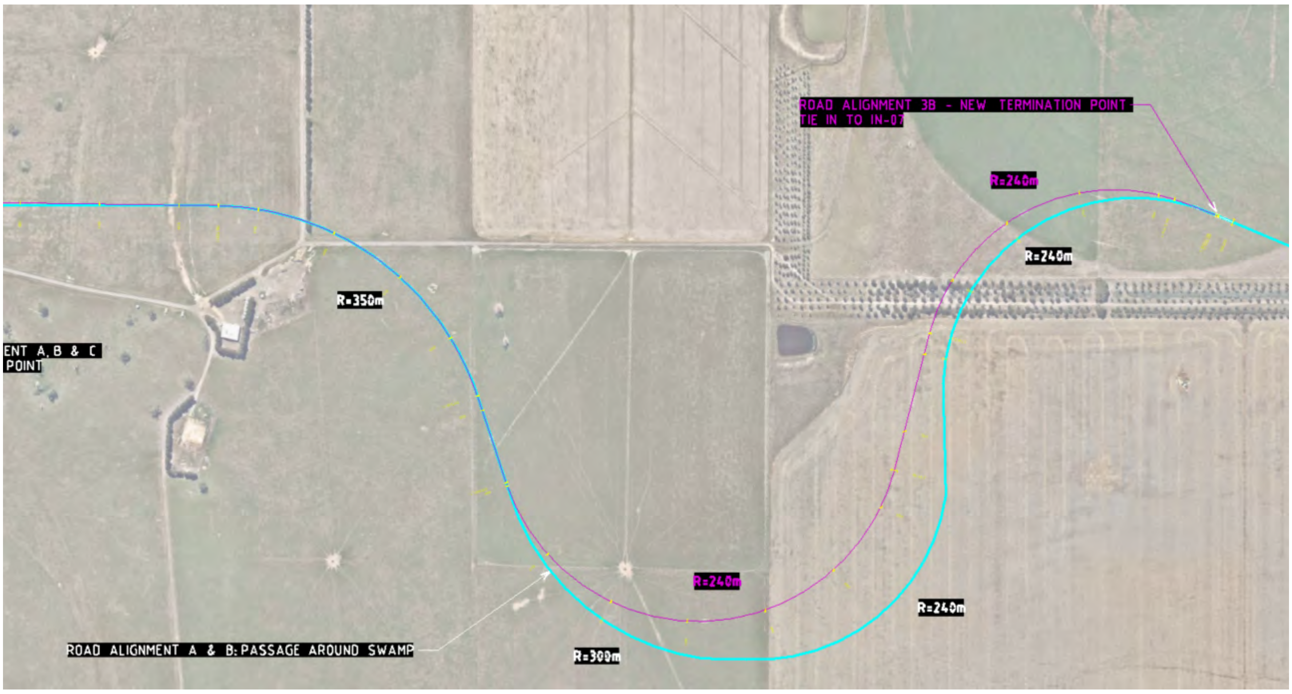
Cardno upon consultation from the VPA on 15 June 2020 redesigned RD-03 to 80km/h. This resulted in a marginal change to the horizontal and vertical alignments of the road and associated intersections. The costings for the road and intersections were updated accordingly.

Upon consultation with the VPA, Cardno removed RD-03 section 4 and IN-08, replacing it with alignment 3B as detailed in the variation dated 20 September 2021. More information on topographical features and sight distance constraints led to the optimisation of the alignment 3B control line including the connection to the existing RD-03 at the northern extremity of IN-07 and the general alignment from the previous variation dated 4 June 2021.

The alignment of RD-03b was selected to maintain ground above and avoid the flat plain identified as Hanna Swamp by following the LiDAR contours area as identified in the received LiDAR information.

The IN-08 cost remains due to an intersection requirement along the length of RD-03B, the physical location of IN-08 is yet to be confirmed. Refer to the figure below for a sketch of RD-03B refinement:

Figure 5-2 Road 03-B centreline refinement



Further details of the geometry of the road is outlined within the Geometric Plans in Appendix C of the report.

Costings for the road have been conducted based on the cost sheet for benchmark item 2. Item 2 cost sheet has been adjusted on a pro-rata basis to suit the individual lengths of RD-03 road sections between intersections. Earthworks quantities within the cost sheets have been informed by the 3D modelling exercise conducted. In addition, as specified in the geology study (refer appendix A) due to the proximity of the road to Kalkallo Creek there is a susceptibility for tunnel erosion to occur. In order to address this issue, it is expected that subgrade stabilisation works is required over the extent of the road as outlined in section 8.2.1 of the geotechnical report (Appendix A). The costings have been adjusted to reflect this necessity by allowing for subgrade preparation over the entire extent of RD-03 works.

Following discussions with stakeholders, an allowance has also been made to construct a culvert in the northern section of RD-03 (section 4). Benchmark item 31 has been adopted for costing purposes.

5.2.2 Hanna Swamp

Cardno were engaged by the VPA on 04/06/2021 to prepare three concept alignment design options and costings of the Beveridge Northwest Western arterial shown in Figure 7-1 The general alignments were derived by the VPA in response to the Beveridge North-West panel report dated October 2020 which required VPA to address Hanna Swamp onto the road alignments.

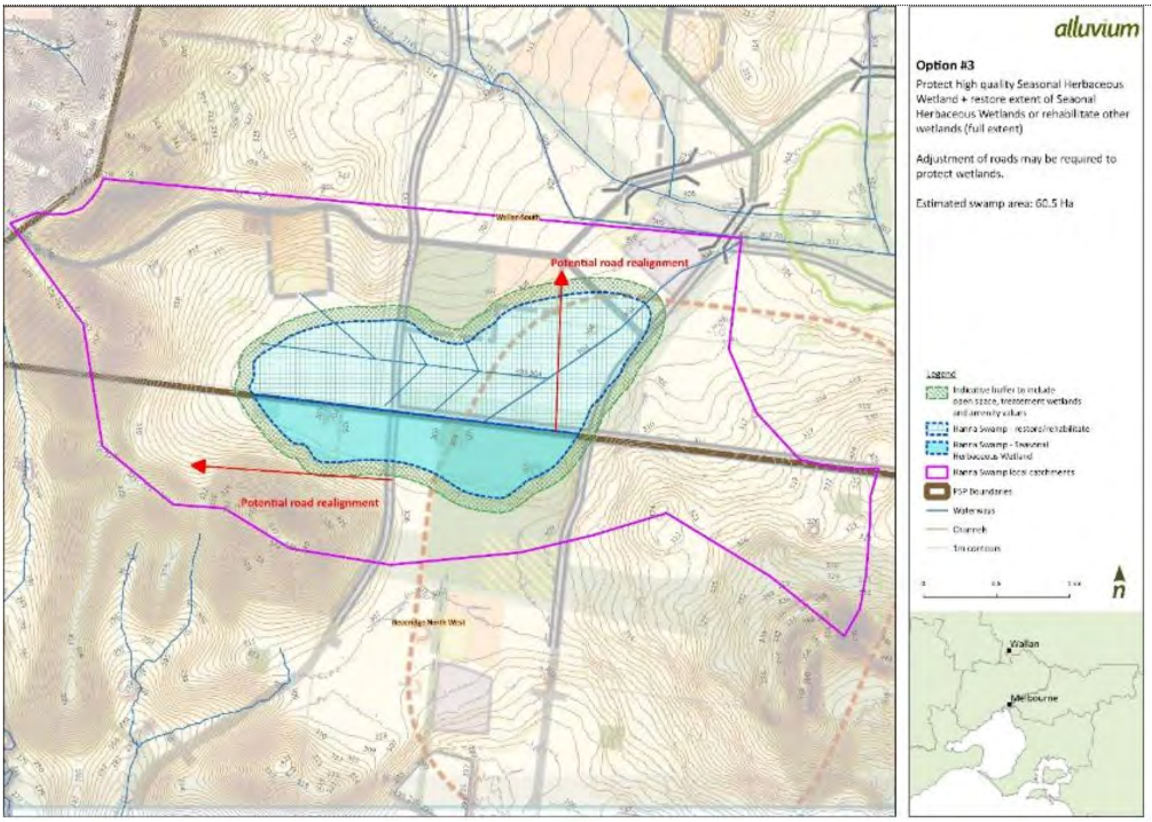
The purpose of the design exercise was for Cardno to determine design alignments that conformed to Australian Standards in line with the general alignments specified by the VPA. Once these were finalised, Cardno were to ascertain the most cost-effective alignment which kept construction impact to a minimum in Hanna Swamp, as detailed by the Alluvium Hanna Swamp Investigation Report dated May 2021. Each alignment option has been split onto two sections: The Beveridge Northwest PSP and Wallan South PSP. The description of the three road alignments are as follows:

1. Road Alignment 3-A – Through the saddle on the hilltops
2. Road Alignment 3-B – ‘S’ curve against the hilltops and around Hanna Swamp
3. Road Alignment 3-C – Through Hanna Swamp

Figure 5-3 Road alignment options with Hanna Swamp extents

Cardno has made assumptions on the Hanna swamp extents based on information from the aforementioned Hanna Swamp Investigation Report, shown in Figure 2. A conservative approach has been undertaken to preserve the swamp by minimising construction effects on open space, treatment wetlands and amenity values.

Figure 5-4 Retaining full extents of Hanna Swamp



5.2.3 Design Alignments

The following assumptions have been undertaken to create the concept alignment plan for all three options:

- 3.5m lane widths resulting in a total road width of 7m which conforms to AGRD Part 3: Geometric Design standards;
- The alignment options only consist of control lines and all other civil design elements such as kerb lines and line marking were considered outside the scope of works;
- The design sketch with dimensions provided conform to the Australian Guide to Road Design (AGRD) horizontal design standards;
- No existing utility infrastructure to be determined along the vicinity of the proposed road alignments as per DBYD analysis;
- Expectation that the proposed road alignments are considered to be an urban secondary arterial road;
- Operating speed of 80km/hr throughout the length of the road;
- Minimum horizontal radius value of 240m with maximum 6% vertical grades which conforms to AGRD Part 3: Geometric Design standards;
- Sodic soil conditions and associated requirements have assumed to be the same as those for the original proposed alignment indicated in Cardno's previous submissions as RD03-3 and RD03-4. The current sodic soil protections include erosion protection for 1:4 batters and lime stabilisation.

The three alignment options were determined using LiDAR contour information, Hanna Swamp extents based on the Alluvium report and horizontal/vertical requirements under AGRD Part 3: Geometric Design. All three alignment options commence at IN-06 on RD-03 from Cardno's previous submissions and terminate at the approximate tie-in shown on the VPA brief. The concept layout sketch has been provided highlighting each alignment option including the approximate dimensions.

5.2.4 Comparison of Costings

The following assumptions have been undertaken for all three alignment options in developing the costing estimates:

- Each alignment option will be costed as a single entity, without dividing costing between Beveridge Northwest PSP and Wallan South PSP;
- Costing does not include any intersections on these road segments. Thus, costing will assume each option is a single uninterrupted segment;
- Total pavement depth is 0.635m as per the VPA Benchmark Infrastructure Report developed by Cardno in April 2019;
- Subgrade preparation is determined as 20% of arterial road pavement;
- Concrete works consist of no cycle paths or traffic islands and only assumed to have a 3m shared user path on one side of the road;
- Drainage works consists of 525mm diameter pipes along the length of the road with 450mm diameter pipe across the road width for every 50m segments of road length;
- Landscaping works assumes tree planting on each side of the road for every 10m of road length and topsoil with seeding for 23m of landscaping width as per the road cross section;
- Street lighting to be used throughout the length of road and erosion protection for lighting cables is used for each side;
- Regulatory Signage are based on 60m segments of road length.

The costing is completed without the use of 3D modelling software in estimating the earthworks quantities. Earthworks have been determined by a boxing calculation and a flat rate contingency calculated prorate using the length of road. Costing spreadsheets have followed the same format as previous spreadsheets developed for Beveridge Northwest.

Unit rates for the costing analysis have matched those of the earlier iterations of this costing, many of which have been derived from the Benchmark Infrastructure Project which were developed using a Monte Carlo probability-based simulation providing two confidence levels in P50 and P90. This denotes that there is a 50% probability that the estimates will cover the actual cost for P50 and a 90% probability that the estimates will cover the actual cost for P90. Therefore, by adopting benchmark rates the confidence of the probability-based approach can be brought over to this project.

For cost elements that are not present in the benchmark project, Cardno has developed rates from previous work on Beveridge Northwest.

Using the assumptions stated in Section 2, costings were produced for each alignment and have been separated onto two sections in Beveridge Northwest and Wallan South PSP. Alignment 3-B would have the longest length of road of approximately 3550m around the hilltops and Hanna Swamp. Despite a realignment of option 3-A through the gentlest slope, it remained the most expensive option due to earthworks requirements. Overall, alignment 3-C was deemed to be the most cost-effective despite sub-grade strengthening works and erosion protection. This is due to the reduced alignment length and required earthworks in comparison to the other options.

5.2.5 Road Alignment 3-A

The following assumptions have been incorporated for road alignment 3-A in developing the costing estimates

> Siteworks/Earthworks
  - 100% rock allowance has been assumed on the hilltops on Beveridge Northwest PSP
  - 20% rock allowance has been assumed outside the hilltops on Wallan South PSP
  - Increased rates for bulk earthworks, rock allowance and erosion protection for the rolling terrain on Beveridge Northwest PSP due to the increased uncertainty of earthworks requirement for this alignment.

> Road Pavement
  - Lime stabilisation usage is limited as basaltic soil has a low susceptibility of erosion. Refer to Section 8.2.1 of the VPA Desktop Geotechnical Investigation for proposed Beveridge Northwest PSP developed by Cardno.

> Drainage
  - A swale lining – rip-rap catchment drainage analysis has been undertaken on the Beveridge

Northwest PSP where it is assumed that the catchment only occurs on the right-hand side of the road. Only the largest catchment is considered to determine the total swale perimeter.

> Miscellaneous
  - 20% contingency for the delivery of this project due to the rolling terrain through the hilltops and uncertainty of earthworks for Beveridge Northwest PSP.

5.2.6 Road Alignment 3-B

The following assumptions have been incorporated for road alignment 3-B in developing the costing estimates

> Siteworks/Earthworks
  - 20% rock allowance has been assumed throughout the length of the road
  - Erosion protection has a unit rate of $12/m for the length of the road

> Road Pavement
  - Lime stabilisation usage is limited as basaltic soil has a low susceptibility for erosion. Refer to Section 8.2.1 of the VPA Desktop Geotechnical Investigation for proposed Beveridge Northwest PSP developed by Cardno.

> Drainage
  - No catchment area for this alignment option based on the LiDAR contour information. Thus, no catchment drainage analysis required.
  - Drainage culverts to be included along the road length between the hilltops and the swamp for Beveridge Northwest PSP which is determined to be 950m. This will accommodate the flow of water onto Hanna Swamp from the hilltops. Assumed 650mm box culverts at $6,000 per 50m of road length.
  - Drainage culverts not included for the road length on Wallan South PSP based on the LiDAR contour information.

> Miscellaneous
  - 15% contingency for the delivery of this project due to the flat terrain around the hilltops and around the swamp.

5.2.7 Road Alignment 3-C

The following assumptions have been incorporated for road alignment 3-C in developing the costing estimates

> Siteworks/Earthworks
  - 20% rock allowance has been assumed throughout the length of the road
  - Erosion protection has a unit rate of $12/m for the length of the road due to the flat terrain

> Road Pavement
  - Lime stabilisation is prescribed as alluvial soil and clay which has a high susceptibility of erosion through Hanna Swamp. Refer to Section 8.2.1 of the VPA Desktop Geotechnical Investigation for proposed Beveridge Northwest PSP developed by Cardno.
  - 1m depth of subgrade preloading fill required for the road length along Hanna Swamp of around 600m (230m for Beveridge Northwest PSP and 370m for Wallan South PSP) to stabilize the soil conditions

> Drainage
  - No catchment area required for this alignment option based on the LiDAR contour information. Thus, no catchment drainage analysis required.

> Miscellaneous
  - 15% contingency for the delivery of this project due to the flat terrain going through the swamp;
  - This option requires an extended period of time to stabilize the subgrade using preloaded fill.

5.3 Road RD-04 – Patterson Road

Road RD-04 'Patterson Road' is a North-South secondary arterial road connecting intersections IN-09 through to IN-14 of the Beveridge North West PSP. Cardno was engaged only to conduct a 3D modelling exercise for approximately 400m. However, modelling for approximately 530m of RD-04 between intersection IN-09 and IN-10 has been conducted. This was necessary to ensure the functionality of the intersection IN-10. Vertical profiles for the modelled road are provided in the appendix of the report. RD-04 costings are however only based on a length of 237m (excluding intersection IN-09 and IN-10 leg portions from the above 530m). The benchmark road section item 2 has been applied over the remaining extent of the road.

The alignment of the road has been adjusted to accommodate the required horizontal geometry for the design speed of the road. Existing surface profiles from the provided LiDAR data have also been considered in the proposed road geometry. In addition to the above, as part of addressing the stakeholder comments, the alignment has also been adjusted such that the entirety of RD-04 road works would be to the west of the adjacent property boundary. In order to minimise the footprint of RD-04, earthworks batter gradients have been steepened to 25%. The batters will also need erosion protection. These have been assumed to be geotechnically stable for the purposes of this report (and not need retaining walls etc) but this would need confirming during design development.

Figure 5-5 Road 04 centreline refinement

Key changes to the VPA alignments as a result of the above exercise include;

> Providing road geometry to accommodate adverse cross fall at 3.0%;

Further details of the geometry of the road is outlined within the Geometric Plans in Appendix C of the report.

Costings for this road have also been conducted based on the cost sheet for benchmark item 2. This cost sheet has been adjusted on a pro-rata basis to suit the lengths of RD-04. Earthworks quantities for the cost sheets have been informed by the 3D modelling exercise. In addition, findings from the geology study have been incorporated within the costings. To accommodate the expected basalt deposits at the location of RD-04 and rock outcrops noted during the site visit an allowance has been made for rock excavation within costings and increasing the finished design level to minimise rock cutting.

6 Bespoke costings analysis - Intersection projects

Details of the analyses of the transport projects are outlined in this section.

6.1 Intersection IN-02

Intersection IN-02 is a ‘T intersection’ between Camerons Lane (secondary arterial road) and a future connector boulevard street. Camerons Lane is an existing road with its own PSP cross section (a slight variation of the standard secondary arterial road cross section - including the full shared path width and a small nature strip within the ICP funded reserve). As instructed by the VPA all future widening is expected to take place to the north with no changes to the southern road reserve. The connector road alignment has also been shifted to accommodate all road works to the east of the property boundary.

A 3D modelling exercise has been conducted using benchmark intersection item 09 as the basis and the earthworks quantities have been based on this. Slight adjustments were made to benchmark item 9 to accommodate the changes to the standard cross section.

The geology study also showed that this intersection is located at an area where basalt deposits can be expected (refer appendix A). Therefore, the costings have been adjusted by including an additional allowance for rock excavation at this location.

6.2 Intersections IN-05, IN-06 and IN–11

Intersections IN-05, IN-06 are Primary-Connector cross intersections and IN-12 is a Secondary-Connector cross intersection. A preliminary 3D modelling exercise has been conducted for these intersections using benchmark intersection item 9 as the basis. The earthworks for these intersections have been informed by the aforementioned 3D modelling exercise. The IN-05 & IN-06 costings were slightly updated when RD-03 was redesigned to be a 80km/h road.

Notable items that have affected costs for intersection 12 include basalt deposits as outlined in the geology study (refer appendix A) and the rocky terrain for IN-12 as noted in section 2.2. In addition, thick vegetation was noted at the location for this intersection as well. Costs for clearing these trees can be captured as part of the site preparation line item. No planning due diligence for flora/fauna issues has been carried out within our scope.

Additionally, IN-12 has been shifted south approximately 40m from the VPA alignment to avoid the ridge in the proximity of the intersection.

6.3 Intersection IN – 07

Intersections IN-07 is a Secondary-Connector T intersection. Similar to the previously discussed intersections, a 3D modelling exercise has been conducted using benchmark intersection item 15 as the basis and the earthworks quantities have been based on this. The costing was slightly updated when RD-03 was redesigned to be a 80km/h road.

It was noted during the site visit that a line of trees exists at the current location of IN-07. A portion of these trees will need to be removed as part of construction of the intersection legs. No significant costs are expected however, and this task can be captured by the line item ‘site preparation’ of the cost sheets. Environmental due diligence will need to be exercised however at a future date when more refined designs are available.

Figure 6-1 Vegetation at the location of IN-07

7 Bridge projects

Cardno was engaged to concept design and cost a pedestrian bridge crossing across Kalkallo Creek (BR-02). The proposed pedestrian bridge over Kalkallo Creek has been designed using AS5100:2017 and the Austroads guide to road design Part 6A – Paths for Walking and Cycling.

Using LiDAR data provided by the VPA, and the approximate location shown in the Beveridge North West Precinct Structure Map, the span for the pedestrian bridge has been determined to be 13m.

The 1% AEP flood level of 264.03mAHD provided by Melbourne Water is shown with the contour of the creek bed mapped by the LiDAR survey. The flood level results in a clearance to the bridge soffit of 1977mm.

A partial barrier fence has been nominated due to the fall risk associated with the bridge height.

Prestressed precast concrete planks have been nominated for the construction of the bridge as they allow for a shorter construction time and avoid temporary propping/scaffolding in the creek bed. The precast deck is to sit on an in-situ reinforced concrete abutments. The abutments are supported by two 450 diameter bored piers.

Costing for the project was carried out using Rawlinson Construction Handbook 2019, costings directly from suppliers and similar past projects Cardno have been involved with. Within the costings an allowance has been made to connect to adjoining street and park networks (75m per bridge approach).

8 Benchmark costings analysis – roads and intersections

In addition to the bespoke infrastructure items described above, multiple infrastructure items were developed from the earlier Benchmark Infrastructure Report.

Roads developed from benchmark items were RD-01, RD-02 and part of RD-04. Costings were developed on a pro-rata basis to suit the specific length of each road.

Intersections developed from benchmark items included IN-01, IN-09, IN-10, IN-11 and IN-13.

The above infrastructure followed benchmark costings closely, but added additional items where required due to sodic soil and other environmental factors, such as rock excavation.

9 Safety in Design

Safety in Design (SiD) and best practice design principles and standards have been considered in the development of the project design to capture the stakeholders and maintenance requirements.

SiD Section 28 of the Occupational Health and Safety (OHS) Act 2004, provides a duty of care for designers of building's and structures or part thereof to ensure that hazards and risks that may exist in the design of a workplace are eliminated or controlled at the design stage, so far as is reasonably practicable. It requires that the building or structure or part thereof is designed, so far as is reasonably practicable, to be safe and without risk to people using it as a workplace for a purpose for which it was designed.

A SiD risk assessment has been conducted by the design team as part of the initial concept design works. This is provided for consideration of the stakeholders and maintenance personnel, as per Table below;

Table 9-1 Safety in Design Risk Assessment – Primary Controls

Item	Hazard	Risk	Controls	Level of Risk
1.0 Construction Phase				
1.1	Existing traffic diversion	Vehicle impact	VicRoads traffic guidelines	Moderate

1.2	In ground and overhead services	Service strike	Identification and location of services and standover by provider	Moderate
1.3	Unknown ground conditions in excavations	Require special equipment and specific excavation methods to be utilised.	Mechanical plant to operate under approved SWMS	High
1.4	Poor pavement condition	Extent of full depth construction or overlay increases area affected in road	Site specific traffic management plan to be prepared by Contractor and approved by Council / DOT etc	High
1.5	Install traffic signal conduits in carriageway	Vehicle impact / road closure	VicRoads traffic guidelines and agreed shut down provision	Moderate
1.6	Lack of visibility around temp works	Traffic accident	VicRoads traffic guidelines	Low
1.7	Narrow working lanes restricting access and plant exceeding working area	Vehicle impact with plant or personnel	Site Safety management plan to be prepared by Contractor	Moderate
1.8	Vulnerable road users movement around construction works	Pedestrian and Vehicle impact	Site safety specific management plan to be prepared by Contractor and approved.	Moderate
1.9	Tree removal	Crushing, impact	Certified arborist and site fencing to be established	Moderate
1.10	Contaminated ground	Toxic / poisoning or workers	Contaminated Land management plan to be prepared by contractor and also SWMS. and approved.	Moderate
1.11	Visibility of works at night	Traffic accident	Existing lighting and temporary lighting as per VicRoads traffic guidelines	Moderate
	(Hazards associated with typical roadworks contract including slips, trips, falls, trenches, debris, etc. in and adjacent to the construction works are not covered here where these are covered by normal working practice controls and safety management plans to be provided by the Contractor)			

2.0 Operation & Maintenance Phase				
2.1	Use of pedestrian crossing	Traffic accident where pedestrians cross at undesignated crossing	Crossing configuration to deter unlawful crossing	Moderate
2.2	Proximity of pedestrians and cyclists adjacent to traffic lane	Vehicle/pedestrian traffic accident	Pedestrians and cyclists on designated paths and separated from traffic lane	Moderate
2.3	Bus stop location conflict with vehicle & cycle movements	Vehicle/cyclist traffic accident	Location and treatment of bus stop in consultation with PTV	Low
2.4	Cyclists turning at traffic signals	Vehicle/cyclist traffic accident	Cross at signalised crossing points	Moderate
2.5	Traffic signal repair / maintenance	Workers exposed to live traffic	VicRoads traffic guidelines	Moderate
2.6	Road lighting repair / maintenance	Workers exposed to live traffic	VicRoads traffic guidelines	Moderate
2.7	Services pit access	Manual handling, falling, crushing, restrictive & confined space	VicRoads standard products with agreed lifting procedures	Low

2.8	Drainage blocked	Flooding on highway causing loss of control of vehicles	Drainage capacity provided and highway pits designed to minimise blockage. Roading authority to manage maintenance regime	Low
3.0 Demolition Phase				
3.1	Contaminated material	Harm to personnel handling contaminated material	Avoid use of material that could be harmful to remove	Low

Table 9-2 Safety in Design Risk Matrix to Determine Level of Risk

CONSEQUENCE \ LIKELIHOOD	Rare (E)	Unlikely (D)	Possible (C)	Likely (B)	Almost Certain (A)
Catastrophic (5)	High	High	Extreme	Extreme	Extreme
Major (4)	High	High	High	Extreme	Extreme
Moderate (3)	Low	Moderate	High	High	Extreme
Minor (2)	Low	Low	Moderate	Moderate	High
Insignificant (1)	Low	Low	Low	Moderate	Moderate