



Shire of Denmark

Denmark East Development Precinct

Phase 1 – Options Analysis



October 2016

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- Appendix A – RAV classifications
- Appendix B – Design drawings
- Appendix C – Key biological constraints maps
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Glossary

ARI	Average recurrence interval
ASD	Approach sight distance
'as of right'	An 'as of right' vehicle means a truck or semi-trailer less than 19 m in length that is allowed to travel on any public road
DAA	Department of Aboriginal Affairs
DEDP	Denmark East Development Precinct
DER	Department of Environment Regulation
DotEE	Department of the Environment and Energy
DoW	Department of Water
DPaW	Department of Parks and Wildlife
EPBC	Environmental Protection and Biodiversity Conservation Act
GSDC	Great Southern Development Commission
LPS	Local Planning Strategy
MCA	Multi-criteria assessment
MNES	Matters of national environmental significance
MRWA	Main Roads Western Australia
PCG	Project Control Group
PEC	Priority ecological community
PRM	Probabilistic Rational Method
RAV	Restricted access vehicles (refer to Appendix A)
SISD	Safe intersection sight distance
TEC	Threatened ecological community
WACAD	West Australian College of Agriculture, Denmark
WIR	Water Information Reporting
WoNS	Weeds of national significance

1. Introduction

1.1 Background

Through the Royalties for Region's "Growing our South Initiative", the Shire of Denmark has received funding to provide a second crossing of the Denmark River, to upgrade approximately 6.5 km of local roads and to support the delivery of an industrial estate adjacent to McIntosh Rd.

The Denmark East Development Precinct project seeks to provide a second bridge crossing over the Denmark River primarily to accommodate local traffic movements for residents living to the north of the town's Central Business District. A road connection from Scotsdale Road to the Denmark-Mt Barker Road and South Coast Highway provides improved east-west connectivity for the community and will reduce travel distances for residents moving between Denmark, Albany, Mount Barker and beyond. In addition, the new bridge will provide an alternate access for the Denmark community in the event of a fire or an emergency.

The project is a joint initiative of the State Government (53%) the Shire of Denmark (30%) and LandCorp (17%), with the project planning and delivery overseen by a Great Southern based Project Control Group. Construction will be undertaken progressively, and is expected to be fully completed by June 2018.

1.1.1 Project overview

Within the Great Southern Regional Blueprint (GSDC, 2015), the need for a second crossing of the Denmark River and the production of "general industrial" lots were listed as high regional priorities. The Shire of Denmark submitted a funding request through the Royalties for Region's "Growing our South Initiative", and subsequently the Minister for Regional Development and Lands announced that the funding request was successful on 4 March 2016, with the State Government committing over \$7 million to the project.

The Denmark East Development Precinct (DEDP) project seeks to:

1. Provide a second bridge crossing over the Denmark River in close proximity to the town centre,
2. Construct, upgrade or ensure fitness of purpose of approximately 6.5 kilometres of East River Road and McIntosh Road,
3. Modify and upgrade existing road intersections, and
4. Facilitate the development of stage one (six lots) of the McIntosh Road industrial estate by LandCorp.

The industrial estate is required to be accessible to road-trains from Denmark-Mt Barker Rd, via an approved RAV (restricted access vehicle) class 4 network, with route access denied between the southern boundary of the industrial estate and South Coast Highway. The Denmark-Mt Barker Road is a RAV 5 approved network, and the South Coast Highway is an approved RAV 4 network.

The section of the proposed road network to the west of the Denmark-Mt Barker Road will be constructed for "as of right" vehicles (i.e. including semi-trailers up to 19 m) only, for use by locals and tourists as a local connecting road. Refer to the vehicle classifications in Appendix A.

As shown in Figure 1 and Figure 2, land uses in the vicinity of the proposed Denmark East Development Precinct study area include public infrastructure (airstrip and waste transfer station), educational facilities (Western Australian College of Agriculture, Denmark and the

Golden Hill Steiner School), conservation areas, rural living lots, rural activities, tourism accommodation and wineries.

It is anticipated that construction of the eastern component of the project will be undertaken during the summer of 2016/17 and the western component during the summer of 2017/18. The McIntosh Road industrial development will also be constructed during the summer of 2017/18.

To construct a road network that is suitable for the intended traffic demands, new sections of road will need to be built, existing roads will require widening or reconstructing and drainage systems will need to be adjusted. Following the receipt of the relevant clearing permits, some level of vegetation removal will be required to improve road safety and accommodate new road works. The Shire of Denmark has been issued new bridge number 5390 by Main Roads Western Australia (MRWA) and it is proposed to construct a new concrete and/or steel bridge over the Denmark River, aiming to minimise vegetation clearance. The Denmark River is a recorded aboriginal heritage site and the design shall accommodate Aboriginal cultural and heritage values.

1.2 Project objectives

LandCorp and the Shire of Denmark are committed to demonstrating high quality design and sustainability initiatives in the delivery of the DEDP project, to promote environmental, cultural and engineering best practice and to encourage economic opportunities for Denmark that are integrated into the cultural and natural landscape. The following key benefits have been identified for the project:

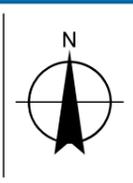
- An entry / exit point to a housing development totalling approximately 700 lots, recognised in Denmark's Local Planning Strategy and Local Planning Scheme as a significant northward urban expansion of the Denmark town site.
- Improved economic opportunities in Denmark, through the attraction of new industrial uses and commercial businesses,
- Improved employment opportunities in the industrial area and during construction,
- Diversification of the economy,
- Facilitation of private investment,
- Managing community risks associated with fire and accident on the existing Denmark Bridge:
 - The proposed bridge would provide a critical additional exit route for Denmark residents and visitors, responding to the risk assessment from MRWA that concludes that the likelihood of a major risk event is "almost certain" and that the consequences would be "Major" (MRWA, 2015).



Page size A3

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50



LEGEND

- Town
- Survey Area
- Major Road
- Mnor Road



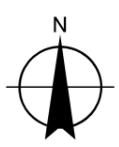
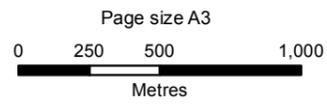
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Denmark East Development Precinct

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Revision	0
Date	13 Oct 2016

Locality

Figure 1

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 Data source: Geoscience Australia: GeoData Topo 250k Series III, Landsat Imagery; MRWA: Roads - 20140723; LandCorp: Study Area - 20160726. Created by: ateeney



LEGEND

- | | | | |
|--------------------------------|--------------------------------|-------------|----------------|
| Threatened Flora | Priority 2 - Poorly Known Taxa | Road | Nature Reserve |
| Priority 1 - Poorly Known Taxa | Priority 3 - Poorly Known Taxa | Watercourse | State Forest |
| Priority 4 - Rare Taxa | Survey Area | Waterbody | Timber Reserve |



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Denmark East Development Precinct

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Biological Context

Figure 2

1.3 Project team

The DEDP Project is being delivered by the Shire of Denmark and overseen by the Project Control Group (PCG) (comprising representatives from the Shire of Denmark, LandCorp and the Great Southern Development Commission). LandCorp has been appointed as the project manager and is also the Principal for the procurement and management of all services and for ensuring the objectives of the project are delivered.

For planning and design purposes, LandCorp has appointed a multidisciplinary team to investigate and analyse the development options. The project team includes the following consultancies:

- GHD – Environmental consultant (flora and fauna),
- GHD – Engineer (civil and structural), including geotechnical engineering,
- 35 Degrees South – Surveyor, and
- Brad Goode & Associates – Aboriginal Heritage Consultant.

1.4 Purpose of this report

The purpose of this report is to document GHD's investigations into the feasibility of various alignment options for the road network and Denmark River bridge crossing. Using the inputs from studies by GHD and others, this report analyses the various alignment options against a range of assessment criteria, endorsed by the Project Control Group. Based on this analysis, a short list of preferred road and bridge alignments is described to inform consultation with the Denmark community.

1.5 Scope and limitations of this study

The scope of work for this initial feasibility study includes the following elements:

- Review of existing plans, data and other information, familiarisation with site characteristics, and existing engineering facilities.
- Investigate and define key risks and other aspects in relation to the potential route options. Confirm the project objectives, major constraints, relevant environmental, social and cultural conditions/obligations, community concerns and potential problems.
- Prepare and maintain a project delivery program and project budget.
- Undertake preliminary design of the Denmark–Mt Barker Road and East River Road intersection (RAV 4 classification) to identify land resumption requirements.
- Liaise with the project team, key stakeholders (MRWA, Department of Water, DAA, DER, Western Power, etc.) and the PCG to provide engineering, geotechnical, hydrological and traffic advice and input on route options and overall project development.
- Provide a plan of the preferred road alignment(s) overlaying an aerial photograph for use in public consultation.
- Prepare a Phase 1 Report incorporating all of the above in a concise document, covering all aspects of the project concept and investigative work, plus the rationale for the route selection, to assist in community engagement.

This report: has been prepared by GHD for LandCorp and the PCG members and may only be used and relied on by LandCorp and the PCG members for the purpose agreed between GHD and the LandCorp and PCG members as set out in section 1.4 of this report. GHD otherwise disclaims responsibility to any person other than LandCorp and the PCG members arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

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2. Project constraints

The Denmark East Development Precinct project is subject to several constraints – environmental, cultural heritage, physical, social, regulatory and financial. Some of the key issues considered in this feasibility study are outlined below.

2.1 Aboriginal heritage

This project is subject to the requirements of the West Australian *Aboriginal Heritage Act 1972*. Hence, to inform the assessment of route alignment and river crossing options, a Site Identification Aboriginal Heritage Survey was conducted by Brad Goode & Associates Pty Ltd (Goode & Harris, 2016).

An initial search of the Department of Aboriginal Affairs (DAA) sites and places register returned one registered Aboriginal site within the development area as of 7 July 2016. In terms of its significance Site ID 22081 Denmark River is a sacred site of spiritual, mythological and cultural significance, as well as a past and present resource for Aboriginal people. A specific mythology has been recorded about the creation of the river by the green python called *Mardjit*, who in turn was created in the Porongurup Ranges by the *Waugal* serpent who created the Swan River, connecting the *Mardjit* with Uluru. The *Mardjit* moved southwards creating water holes and rivers, including the Denmark River before coming to rest at a place called Quaranup. The Denmark River was also reported to demarcate the boundary between the *Minang* People of the south coast and the *Bibbulmun* People from the west, who both used the river as a traditional walking path. The river provided the Noongar people travelling along the route with food and water, as well as bush medicine and goods for trade, and enabled them to continue carrying out their roles as caretakers of Aboriginal Land or *Noongar Boojara*. This included carrying out ceremonies or Lore along their route, and traditional customary practices such as burning, hunting and the collection of different items for trade at coastal gatherings. Consultation with representatives of the Wagyl Kaip WC1998/070 Native Title Claim reported no other ethnographic sites of significance within the project area (Goode & Harris, 2016).

The site (Site ID 22081 Denmark River) was determined to be directly affected by the project. However, the Wagyl Kaip WC1998/070 Native Title Claim group members consulted are willing to support a section 18 of the *Aboriginal Heritage Act* (AHA) for ministerial consent to use the land located within the DAA registered site, Site ID 22081 Denmark River, to conduct the required geotechnical drilling, bridge and construction work (Goode & Harris, 2016).

From a cultural heritage perspective, it was reported that there was no preference for the location of the bridge as there will be negligible effect on the flow of the river and the associated sacred beliefs held for the river. However, two options (Option 3E, followed by Option 3B – refer to Section 3.4) were identified as preferred over other options, due to other values held by the group, primarily relating to minimising environmental impact from vegetation clearing.

- Of the two options, Option 3E is slightly preferred due to its not requiring the removal of a particularly large and mature Karri tree. Should an independent arborist survey find this tree is unable to survive long term due to white ants, then Option 3B would be equally weighted to Option 3E, due to the site being previously disturbed by an old bridge at that site.

The representatives of the Wagyl Kaip WC1998/070 Native Title Claim were willing to consent to the project providing bridge pylons are not located in the river, that the bridge abutments are as far back from the water as possible and that the environmental impact is minimised. This would involve the engagement of Noongar monitors during clearing at the site, minimising siltation and maintaining the social amenity of the area.

The group also suggested that the new bridge be named ‘Kwoorabup’, the Noongar name for the Denmark River (Goode & Harris, 2016).

2.2 Flora and fauna

The survey area is approximately 68.5 ha in area and includes a broad area of land between Scotsdale Road and the Denmark River and the road reserve and adjacent land along East River Road and McIntosh Road between the Denmark-Mt Barker Road and South Western Highway. A 200 m section north and south along the Denmark Mt Barker Road from East River Road was also surveyed. Refer also to Figure 2.

The biological assessment involved a desktop review and three separate field surveys, including a winter flora and fauna survey, spring flora and fauna survey and spring nocturnal fauna survey. Fauna surveys also included the use of movement sensitive cameras in key locations.

2.2.1 Key biological aspects

The key biological aspects and constraints identified for the survey area are summarised in Table 1.

Table 1: Key biological aspects within the survey area

Biological values	Constraints identified
Remnant vegetation	The three pre-European vegetation types mapped by Beard (1979) are represented by at least 32% remaining at the Local Government, bioregional and Western Australian scales.
Conservation significant vegetation types	No vegetation representative of Threatened or Priority Ecological Communities was recorded or is considered likely to be present.
Riparian vegetation	Vegetation associated with riparian/ wetland zones was recorded within the survey area and includes: <ul style="list-style-type: none"> — Karri forest over tall to medium shrubland over sedges — <i>Melaleuca preissiana</i>, <i>Homalospermum firmum</i> and <i>Kunzea ericifolia</i> shrubland — <i>Evandra aristata</i>, <i>Anarthria prolifera</i> and <i>Leptocarpus tenax</i> sedgeland — <i>Tremulina tremula</i>, <i>Mesomelaena tetragona</i> and <i>Lepidosperma pubisquameum</i> sedgeland
Conservation significant flora species	One record of a Priority 4 flora species, <i>Laxmannia jamesii</i> , was recorded during the surveys. The likelihood of occurrence identified an additional 25 conservation significant species which may occur within the survey area but, during at least two surveys over the area, none were recorded.

Biological values	Constraints identified
Conservation significant fauna species	<p>The field surveys and camera trapping identified five conservation significant species: Baudin's and the Forest Red-tailed Black Cockatoos (EPBC Act listed), the Southern Brush-tailed Phascogale (Vulnerable, Wildlife Protection Act), the Water Rat, a Priority 4 species and the Quenda, a Priority 5 species.</p> <p>The likelihood of occurrence assessment identified eight conservation significant species which are considered likely to occur within the survey area. Of these, two species are listed under the EPBC Act (Carnaby's Black Cockatoo and Western Ring-tailed Possum). However, thorough searching and camera trapping did not indicate the presence of the possum.</p>
Black Cockatoo habitat	<p>Approximately 45 ha of suitable foraging and roosting habitat was recorded throughout the survey area in the Eucalyptus and <i>Allocasuarina</i> woodland habitats. 902 potential breeding trees were recorded within the survey area, of which 40 trees were recorded as having hollows: 8 trees having 9 large hollows, 8 trees had 10 medium hollows and 28 trees had 43 small hollows.</p> <p>The timing of the September survey was within the breeding season of all species. A Baudin's Black Cockatoo was recorded as nesting within a large hollow in a Redgum in the western section of the survey area and one Forest Red-tailed Black Cockatoo was recorded sitting in the entrance to a hollow.</p>
Southern Brush-tailed Phascogale habitat	<p>Species was recorded during the survey and is known from the local area and region. Primarily uses all of the drier woodland (20.7 ha) as habitat in the survey area. The remainder of the habitat may be utilised opportunistically as a foraging/hunting resource or for dispersal.</p>

2.2.2 Federal environmental approvals and referrals

With regard to the *Environmental Protection and Biodiversity Act (EPBC Act)*, the following recommendations are provided, based on a preliminary assessment of key biological constraints for the survey area (not the impact area).

Table 2: Referral under the EPBC Act

Matters of National Environmental Significance	Species/ community	Assessment of referral requirement
Threatened species (flora) and ecological communities	None identified from July/September assessment.	Not required.

Matters of National Environmental Significance	Species/ community	Assessment of referral requirement
Threatened species (fauna)	Baudin's Black Cockatoo were recorded feeding and breeding in the survey area.	Referral will depend on the final impact area and quality of impacted habitat.
Threatened species (fauna)	Carnaby's Black-Cockatoo are likely to be present.	Referral will depend on the final impact area and quality of impacted habitat.
Threatened species (fauna)	Forest Red-tailed Black-Cockatoo were recorded feeding in the survey area and sitting in a nest hollow.	Referral will depend on the final impact area and quality of impacted habitat.
Threatened Species (fauna)	Chuditch are potentially present.	Referral unlikely to be required. No Chuditch were recorded during either the field surveys or camera survey.
Western Ring-tailed Possum	Western Ring-tailed Possums are potentially present.	Referral unlikely to be required. Not identified in daytime and night-time surveys, or motion sensor cameras. No dreys (resting and nesting platforms) recorded.
Listed Migratory Species	None present – no species were recorded from the survey area during the July or September 2016 surveys.	

2.2.3 Western Australian approvals

Referral under Part IV of *Environmental Protection Act 1986* is not considered necessary, as the impacts are primarily associated with flora and fauna, which can be considered under Part V of the Act (Native Vegetation Clearing Permit).

The Federal and Western Australian governments have entered into a bilateral agreement under the EPBC Act relating to environmental assessment (assessment bilateral agreement). Specifically, this agreement now includes the clearing permit assessment process under Part V Division 2 of the EP Act. Under the assessment bilateral agreement, if a native vegetation clearing permit is required and the clearing will have or is likely to have an impact on a Matter of National Environmental Significance (MNES), the assessment of the clearing application including the potential impacts to the MNES can be conducted by the DER or Department of Minerals and Petroleum under delegation.

Four fauna species listed under the EPBC Act (MNES) and Wildlife Conservation Act were recorded within the survey area during the field surveys, and a further seven fauna species listed under the Acts were considered likely to occur, as they are known from the area and suitable habitat is present for them.

As such, any clearing permit application should assess the significance of any potential impacts of the proposed clearing area on these aspects, and the assessment of the potential impacts to the MNES can be assessed by DER under the bilateral agreement.

Key biological constraints for the survey area are mapped and shown in Appendix C.

2.3 Land assembly

During this assessment the proposed route alignments have been limited to existing road reserves, where possible. However, some options would require the acquisition of land for a new road reserve. Of these alignments, it has been assumed that it would be preferable to use Crown reserves as opposed to acquiring private property. Where acquisition of land would be unavoidable, the use of private land was rated much lower than the use of Crown reserves.

Acquisition of agricultural land has been kept to a minimum. Where it does occur, the aim has been to restrict roads to the outer edges of the property or to reinstate access to usable portions of alienated land wherever possible. This would be done through the use of cattle underpasses or acquisition of boundary sections.

Overall, the route assessment process has attempted to minimise both the impacts on land uses and the acquisition of land.

2.4 Geotechnical

2.4.1 Available data

No historical geotechnical data has been identified in the immediate vicinity of the site. Review of existing information on the area has been based on the 1,250:000 scale regional geology map (Mt Barker-Albany) published by the Geological Survey of Western Australia.

2.4.2 Regional geology

The regional geological map indicates that the site is underlain by the geological units listed in Table 3 and shown in Figure 3. Where indicated to be present, the Qa, Qc and Czl are surficial units expected to be underlain by gneiss (Pnb) bedrock. The thicknesses of the superficial units are not indicated on the geological map.

Table 3: Regional geology

Geological unit	Unit description
Alluvium (Qa)	Clay, silt, sand and gravel. Depositional extent not shown on the geological map, but expected to occur in, and along the banks of watercourses.
Colluvium (Qc)	Sand, silt, clay.
Laterite (Czl)	Massive and pisolitic deposits; includes both in-situ and clastic types interbedded with sandstone.
Quartz-feldspar-biotite Gneiss (Pnb)	Compositionally layered gneiss, includes amphibolite and mafic granulite layers; granoblastic fabric. The surface of the Gneiss unit could be weathered, to an extent where it exhibits soil like properties. The degree of weathering would be expected to be variable, both laterally and with depth.

2.4.3 Regional groundwater

No historical groundwater data has been identified in the immediate vicinity of the site. A search (AECOM, 2016) of the DoW Water Information Reporting (WIR) database was undertaken to identify groundwater bores and surface water monitoring points within a 4 km radius of the Project Area. Four groundwater monitoring bores and four surface water sampling points were identified within a 4 km radius of the Project Area. There are no registered groundwater

monitoring bores or surface water monitoring points located within the Project Area boundary. Due to the distance of those bores from the Project Area, it is unlikely that groundwater in those bores will be impacted by activities undertaken within the Project Area.

2.4.4 Geotechnical assessment

Subsurface Profiles

The proposed road alignments are expected to traverse areas predominantly underlain by colluvium (Qc) and laterite (Czl). Local areas underlain by gneiss (Pnb) are also indicated to be present, as indicated in Figure 3.

Geotechnical Conditions

Table 4 identifies typical geotechnical-related design and construction issues associated with each geological unit.

Table 4: Geotechnical design and construction issues

Anticipated geological unit	Colluvium (Qc)	Laterite (Czl)	Gneiss (Pnb)
Anticipated excavation conditions	Excavation (i.e. into sand, silt, clay) would generally be expected to be within the capacity of conventional earth moving plant. Ripping or rock breaking may be required where the underlying bedrock is present at shallow depth or outcrops at surface, although this risk is assessed as low based on the nominal depth of excavation envisaged.	Pisolitic deposits expected to be excavatable using conventional earth moving plant. Where massive, excavation is likely to require ripping or rock breaking within low strength and / or highly fractured zones. Rock blasting is unlikely, but should not be discounted, within areas of low strength and / or massive (i.e. few natural discontinuities) zones.	Expected to be within the capacity of conventional earthmoving plant where weathered at near surface to exhibit soil like properties (i.e. completely to extremely weathered). Likely to require ripping or rock breaking within low strength, and / or highly fractured zones. Rock blasting is unlikely, but should not be discounted, within areas of low strength and / or massive (i.e. few natural discontinuities) zones.
Pavement subgrade conditions	Generally suitable as a pavement subgrade. Subgrade performance is dependent on the material composition, and is likely to be variable due to the inherent material properties. High fines (i.e. clay and silt) content could present difficult handling / compaction difficulties and trafficability conditions during construction.	Suitable as a pavement subgrade, but may be difficult to grade within areas of low strength and / or massive zones.	Dependent on extent and depth of weathering profile. Where weathered to exhibit soil like properties, subgrade performance will be dependent on the material composition. May be difficult to grade within areas of low strength and / or massive zones.

Anticipated geological unit	Colluvium (Qc)	Laterite (Czl)	Gneiss (Pnb)
Re-use of excavated soils for pavement construction	Unlikely to be suitable for pavement sub-base or base course if deficient in coarse (i.e. gravel sized) particles as indicated by the regional geology map. Likely to be suitable for use as general fill.	Suitable for use in pavement construction, but may require careful selection and processing to fulfil material grading requirements.	Highly weathered, low strength or better gneiss suitable for use in pavement construction, but may require careful selection and processing to fulfil material grading requirements. Completely to extremely weathered gneiss only likely to be suitable for use as general fill.
Suitability of bridge sites	Similar subsurface conditions indicated for all bridge locations under consideration. Foundation performance would depend on the strength and compressibility characteristics of the surficial colluvial (and alluvial) deposits and depth to the underlying bedrock.	-	-

2.4.5 Conclusions

The various road alignment options being considered are expected to traverse an area predominantly underlain by colluvium, with gneiss locally present at surface as indicated in Figure 3. In general, geological conditions within the study area are indicated to be similar.

2.4.6 Further geotechnical investigation

On selection of the preferred road alignment, a targeted intrusive investigation is recommended for the characterisation of site conditions to inform the design and management of key geotechnical risks. Broadly, the proposed scope of work is outlined below:

- Site walkover of the preferred road alignment option(s) to assess local geotechnical conditions, confirm scope of site investigation and identify potential site constraints that may restrict access of plant / equipment,
- Test pitting (backhoe or equivalent) at selected locations
- Geotechnical boreholes at the bridge site over the Denmark River,
- Geotechnical borehole at the culvert on the Agricultural College (WACAD) creek line,
- Laboratory testing of representative soil and rock samples to allow material characterisation and determination of engineering properties, and
- Preparation of a geotechnical investigation report to outline the findings of the investigation and recommendations for geotechnical and pavement design.

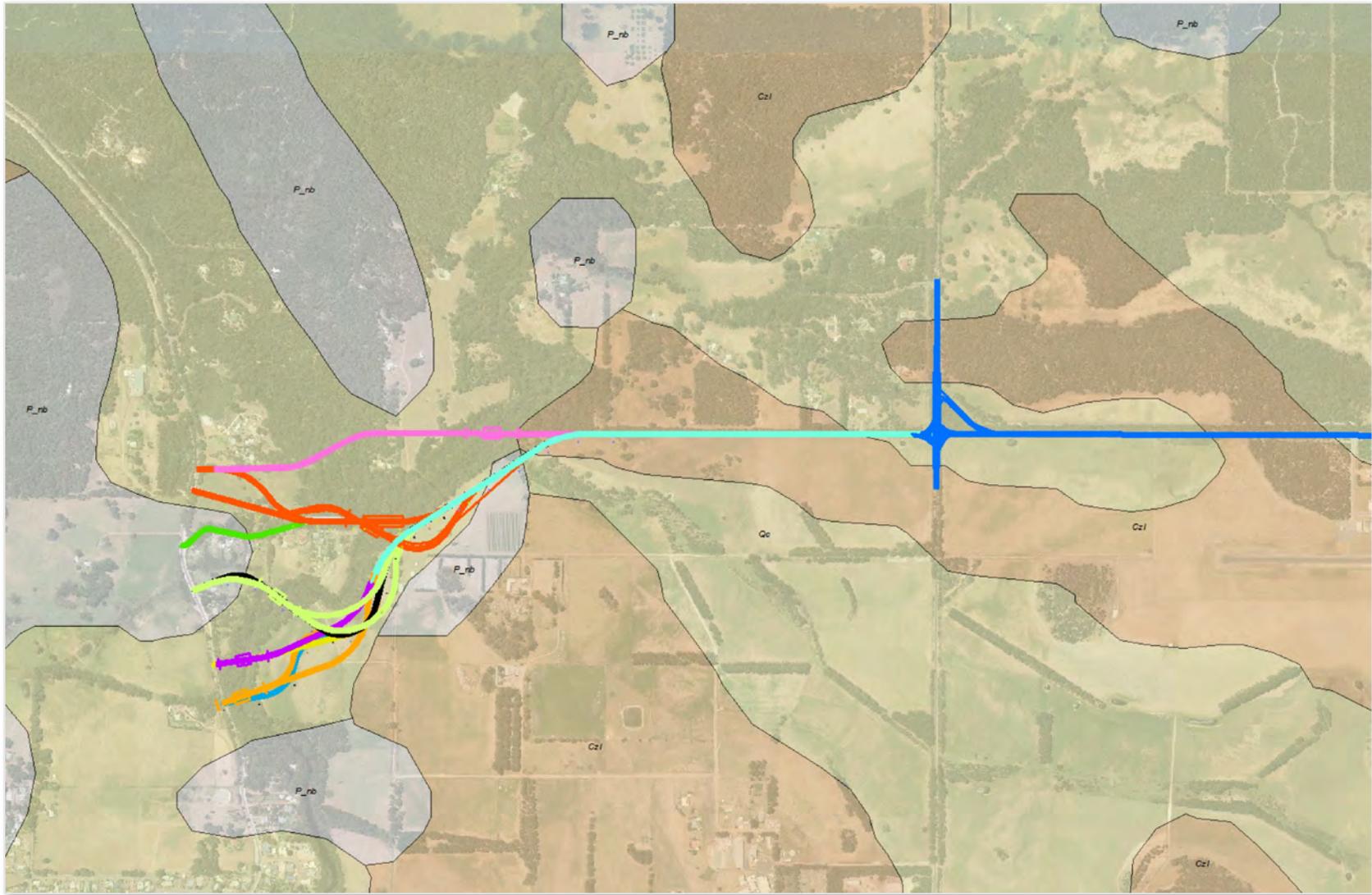


Figure 3: Regional geology

2.5 Hydrology

The possible locations of the proposed Denmark River crossing start just to the south and downstream of the confluence of Scotsdale Brook and Denmark River. In particular, there are two water supply dams at a further 2 km north and upstream of the confluence. Both of these dams, namely the Denmark Dam and Quickup Dam, discharge into the Denmark River.

The total upstream catchment draining to the confluence is approximately 638 km², of which 518 km² and 33 km² of largely uncleared forested catchment contribute runoff to the Denmark Dam and Quickup Dam respectively. The remainder of the upstream catchment (totalling some 86 km²) is drained via Scotsdale Brook.

A Department of Water (DoW) stream gauging station (Site Ref. 603021) just 300 m south of the Scotsdale Brook confluence provides continuous historical measurements of the streamflow and has been operational since 1997. Figure 4 presents the daily mean streamflow rates and depths that were recorded at the gauging station.

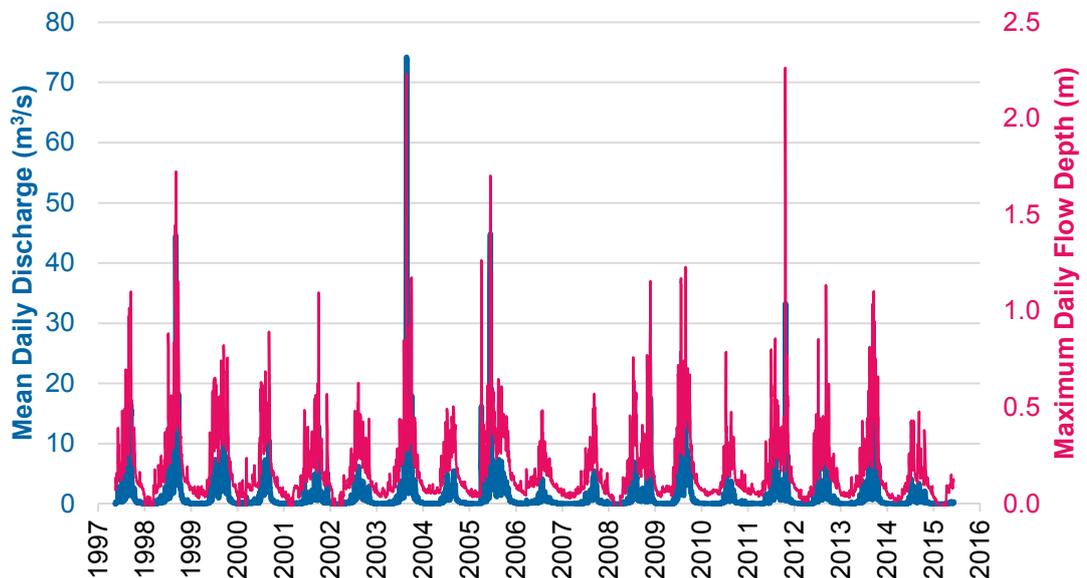


Figure 4: Historical stream discharge and flow depths at Denmark River

The historical records indicate a highly seasonal discharge pattern, with high discharge rates in winter. Throughout the 18-year operational period, the maximum recorded depth at the station was 2.263 m, which occurred in 23 Oct 2011. Future bridge crossing at this location will need to ensure that the lower deck provides the requisite clearance to the maximum water level.

Given the relatively short operational period of the DoW stream gauging station, the maximum recorded flow depth should not be taken as the absolute worst-case scenario. Further, it should be noted that water levels in the river could be highly influenced by the upstream dams' operations, which might not rigidly follow previous years' discharge trends and magnitudes.

2.6 Community concerns

The Denmark East Development Precinct, and the associated river crossing are documented in the Shire of Denmark's Local Planning Strategy (LPS), which provides the vision to guide the future growth of the Shire for the next 20 years. Following extensive community consultation, the LPS was adopted by Council at the Special Meeting of Council held on 4 October 2011 and endorsed by the Western Australian Planning Commission on 22 May 2012.

Following the approval of the *Royalties for Regions* funding, preliminary consultation specifically for this project was also undertaken in March 2016, and has been on-going throughout this study. Of the comments received during the LPS consultation process and the preliminary consultation for this project, the following summarises the high level areas of concern:

- Proposed location of the bridge and road infrastructure,
- Protection of the Kwoorabup Trail, both during and post construction and improving future access to the Trail ,
- Impact on existing flora and fauna,
- Increased east-west traffic movement leading to greater noise and safety issues, particularly with small children and the existing bus pick-up/drop-off,
- Impacts to residents on upgraded roads due to purchased land and safety issues,
- The movement of industrial traffic through the urban environment,
- Addressing existing intersection safety issues, and
- Effects of proposed bridge on the floodway and potential for upgrade works of existing drains.

These concerns have been considered during the multi-criteria assessment (refer to Section 4). Further, throughout the consultation process there have been several suggestions of alternate routes made by the community. Several of these options have been included for assessment in this study.

2.6.1 Kwoorabup Trail

The 4.6 km Kwoorabup Walk Trail runs along the eastern bank of the Denmark (Kwoorabup) River from East River Rd to Kwoorabup Community Park and the town centre. During initial community consultation for this project, the importance of having potential route alignments avoid the Kwoorabup Trail, maintaining access along and to Kwoorabup Trail, including during construction, was specifically highlighted.

The proposed bridge includes a 2.0 m wide cycle path, and it is intended that this will be connected to Kwoorabup Trail to provide another pedestrian/cycle access across the river and to connect residents on the western side of the river to the trail.

2.7 West Australian College of Agriculture, Denmark (WACAD)

Being a substantial landholder on the eastern side of Denmark River, the WACAD will be significantly impacted by the proposed Denmark East Development Precinct. Hence, they are a critical stakeholder in this feasibility study, and it is important to understand their operations and their economic contribution to the Denmark community.

2.7.1 Operations of the WACAD

The WACAD provides the knowledge and skills for future farmers to operate within state, national and international markets. It embraces modern technology in the delivery of farming operations and the recently commissioned rotary dairy is an example of the use of that technology. The WACAD is also required to operate as a diversified farming unit, providing experiences to students in dairying, broad-acre farming, animal husbandry, viticulture and other operations.

Located on the eastern periphery of the Denmark town site, the WACAD has common boundaries with a range of urban land uses (rural living, industrial, residential, civic purposes, public recreation and community infrastructure) and it is under continual pressure to relinquish land for non-agricultural purposes. The continual erosion of the WACAD's land holdings will impact on its capacity to maintain its primary activity of providing a quality educational experience for its students.

The WACAD has previously relinquished 12 ha of land for the Denmark East Development Precinct project for the establishment of the McIntosh Road industrial subdivision. The WACAD may be prepared to relinquish additional land on its north western boundary to provide for the extension of East River Road through to a river crossing at the old bridge site (Option 3B – refer Section 3.4.2), but is reluctant to provide unconditional support to any land release option.

However, the WACAD has indicated it is not supportive of the creation of any new road network(s) that would isolate pasture (particularly river flats) or restrict stock movements between pasture and the rotary dairy. The WACAD will oppose any activities that will diminishes the amount of quality grazing land available to maintain the stocking levels needed to sustain the operations of the WACAD.

2.7.2 Economic and financial impacts of WACAD operations

The WACAD currently contributes approximately \$4.7 million per annum to the local economy in staff wages and approximately \$1.5 million in purchases of local goods, services and trades. The students contribute to the local economy through such activities as visits to the doctor and purchases of chemist items, the purchase of clothes, shoes, toiletries and snack foods, as well as participation in local sporting activities. Parents and family members stay in local accommodation and purchase meals and sundry items at the beginning, middle and end of each term, as well as other special occasions (for example the school ball); that expenditure would exceed \$3,000 per annum per family. A multiplier of around three is associated with this additional spending and positions the WACAD as a major driver in Denmark's economy.

2.8 Project funding

The DEDP project is a joint initiative of the State Government (53%) the Shire of Denmark (30%) and LandCorp (17%). The business case for *Royalties for Regions* funding estimated the breakdown of project costs shown in Table 5. The Shire of Denmark is committed to delivering this project within this budget.

Table 5: Project funding breakdown

Element	Budget *
Eastern Precinct roads (inc. Denmark-Mt Barker Rd / East River Rd intersection)	\$3.1 million
Western Precinct bridge and culvert	\$3.4 million
Western Precinct roads	\$2.1 million
Total	\$8.6 million

* Excluding land acquisition and consultancy fees (surveys, design, etc.), adjustments required to servicing infrastructure, etc.

2.9 Regulatory compliance and approvals

In addition to engineering design approvals by the Shire of Denmark, several state and federal agencies and organisations are required to be notified of the proposed works and included in the planning process. Among these are:

- Regulatory approval:
 - Western Australian Department of Aboriginal Affairs, with regards to consent to alter or interfere with a registered site (Denmark River) under the *Aboriginal Heritage Act 1972*,
 - Department of Water (DoW) with regards to interference with the watercourse bed and banks, and floodway impacts on the Denmark River, and
 - Western Australian Department of Environment Regulation (DER), with regards to vegetation clearing and fauna impacts under the *Environmental Protection Act 1986*, and
 - Federal Department of the Environment and Energy (DotEE), depending on the assessment of a Significance Test against Matters of National Environmental Significance under the *Environment Protection and Biodiversity Conservation Act 1999*.
- Non-regulatory approval:
 - MRWA with regards to bridge, intersection, speed limits and RAV4 route approval, and
 - Utility providers (e.g. Western Power, Water Corporation) within proximity of the proposed works, with regards to service impacts and/or relocations.

For the new bridge, MRWA only require that the bridge design meets Australian Standard AS 5100 and that they are part of the formal review process. This will include a formal letter requesting review services and a project timeline to ensure all deadlines are met. A 15% design review report outlining the scope of the new works is required to be sent to MRWA for review prior to further design. Similarly, 85% and 100% designs are required to be sent for review by MRWA. Once MRWA has accepted these an electronic copy of the final signed drawings will be sent to MRWA.

3. Options development

For the purposes of developing a preferred route alignment, the DEDP project is divided into three sections, as shown in Figure 5 and Figure 10:

1. Eastern Precinct – from the DEDP Industrial Area on McIntosh Rd, connecting to Denmark-Mt Barker Rd (RAV4 route),
2. Western Precinct – from Denmark-Mt Barker Rd to the eastern bank of Denmark River (local traffic only), and
3. Denmark (Kwoorabup) River crossing – with connecting intersection to Scotsdale Rd (local traffic only).

Based on the *Royalties for Regions* business case and suggestions from the community, several route alignment options have been considered in each of these precincts. In addition, a number of options have been developed for the critical intersection of East River Rd and Denmark-Mt Barker Rd.

3.1 Eastern Precinct

The Eastern Precinct comprises the area between Denmark-Mt Barker Road and McIntosh Road to the Industrial Area. Two options for access to the proposed Industrial Area – Option 1A and Option 1B – were assessed and are identified in Figure 5.

3.1.1 Option 1A

Heading east, Option 1A predominantly follows the existing pavement of East River Road, then connects to McIntosh Road with a sweeping curve to the south allowing for improved RAV4 access. The option requires that East River Road be marginally widened. A preliminary concept horizontal alignment has been developed with a larger curve radius to allow for RAV4 access. In several instances this brings the road shoulder within close proximity to or onto of the boundary of the road reserve on both East River Road and McIntosh Road.

Following consultation with affected property owners on East River Rd (16 September 2016), the preliminary concept design was refined to align with the existing fire break east from Sheoak Drive. This allows the existing road to be decommissioned and revegetated, with private access driveways retained for the four affected properties on the northern side of East River Rd. This refined alignment, shown in Figure 6, impedes on the north-east corner of Crown Allotment 8027 (Denmark Airport reserve), but maximises the extent of buffering vegetation between private residences and the RAV4 route.



Figure 5: Eastern Precinct route alignment options



Figure 6: Eastern Precinct – Option 1A

In detail design, further consideration will be given to the intersections with the Denmark Airport driveway and Sheoak Drive. Similarly, incorporation of the existing McIntosh Road to the north to the large radius entry to East River Road must be undertaken. This requires the clearing of vegetation to enable safe sight lines for traffic coming from the north.

3.1.2 Option 1B

Option 1B requires the creation of a new road reserve between Denmark-Mt Barker Road and the western edge of the Industrial Area, bisecting WACAD land (Lots 555 and 556), south of Denmark Airport. Although closer to the proposed Industrial Area, Option 1B requires the acquisition of a large amount of WACAD land between Denmark-Mt Barker Road and McIntosh Road.

As Lot 555 will be bisected with the selection of Option 1B, consideration must also be given to the method of access (vehicles and livestock) between the northern and southern sections of the property by the WACAD. An additional intersection would also be created on Denmark-Mt Barker Road.

Under Option 1B, it would be possible to avoid sealing McIntosh Rd (as proposed in the *Royalties for Regions* business case).

3.2 Denmark-Mt Barker Road / East River Road intersection

The intersection at Denmark-Mt Barker Road and East River Road needs to be modified to allow for RAV4 classed vehicles. It will also create a delineation between the eastern (heavy vehicle) and western (local traffic only) areas of the project. The upgraded intersection will also encourage MRWA to reduce the posted speed limits on Denmark-Mt Barker Rd, thereby reducing current safety concerns with this approach to town.

Under MRWA intersection guidelines for RAV routes (MRWA, 2013) (MRWA, 2016), two configurations have been considered:

1. Staggered T intersection, and
2. Roundabout.

Both options provide safe access for north/south bound heavy vehicles turning east onto East River Rd, as well as westbound heavy vehicles turning north/south onto Denmark-Mt Barker Rd. The two intersection options also provide safe passage for 'as of right' vehicles travelling in any direction in traffic with heavy vehicles.

3.2.1 Option 1 – Staggered T

Compliant with MRWA guidelines, a left-right staggered T intersection onto Denmark-Mt Barker Road has been proposed in this option. The eastern approach on East River Rd has been designed within the existing road reserve on the north-east corner. The western approach on East River Rd is shifted south onto WACAD land to provide sufficient storage between the two intersections on Denmark-Mt Barker Rd for RAV4 (27.5 m long) vehicles. Side-by-side turn pockets on Denmark-Mt Barker Rd, have been used to minimise the impact to the adjacent land. However, this pushes the road shoulder close to the boundaries of the road reserve on both sides. A painted median separating turn pockets has not been included. Should MRWA request this a 1 m wide section of pavement will be required and will extend the earthworks over the road reserve property boundaries on both sides. The exact impact to the adjacent properties cannot be assessed until the 3D modelling is undertaken during detail design.

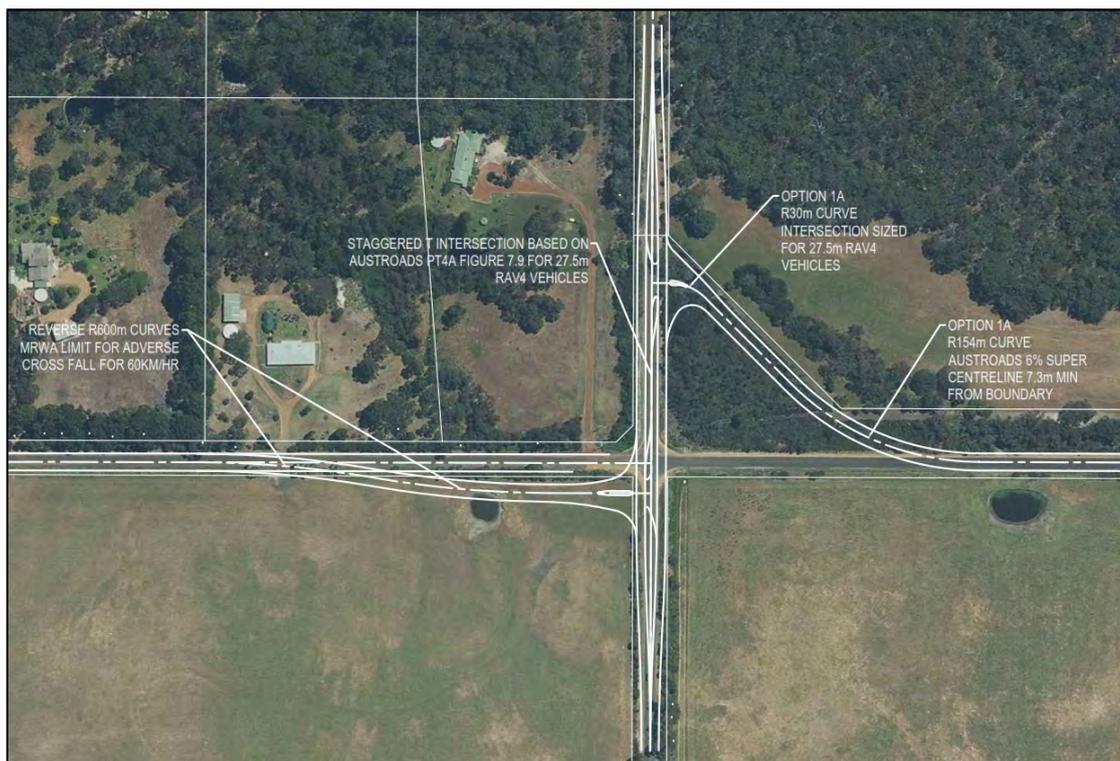


Figure 7: Staggered T intersection option (preliminary design)

3.2.2 Option 2

In this option a roundabout to accommodate RAV4 vehicles at the intersection has been considered. The proposed roundabout conforms with Austroads Guide to Road Design Part 4B, with carriageway width extrapolated from Table 4.3 using a central island radius of 20 m and a 27.5 m RAV4 vehicle.

Option 2 East

Under this variation the roundabout is offset 20 m to the east, such that Denmark-Mt Barker Rd will be required to be realigned. East River Rd will maintain its current alignment. This option eliminates any impact to the private land (Lot 15) on the north-western corner of the intersection and minimises the amount of land to be acquired from the WACAD.

Option 2 South

The south variation of the roundabout offsets East River Road to the south by 23.5 m to avoid Lot 15 on the north-western corner. Denmark-Mt Barker Road will maintain its current alignment.

This option will require minimal land clearing (on the north-eastern corner), with the majority of land acquired from the WACAD.

During detail design, the southern alignment will require special consideration to incorporate the driveway access for privately-held Lot 15.

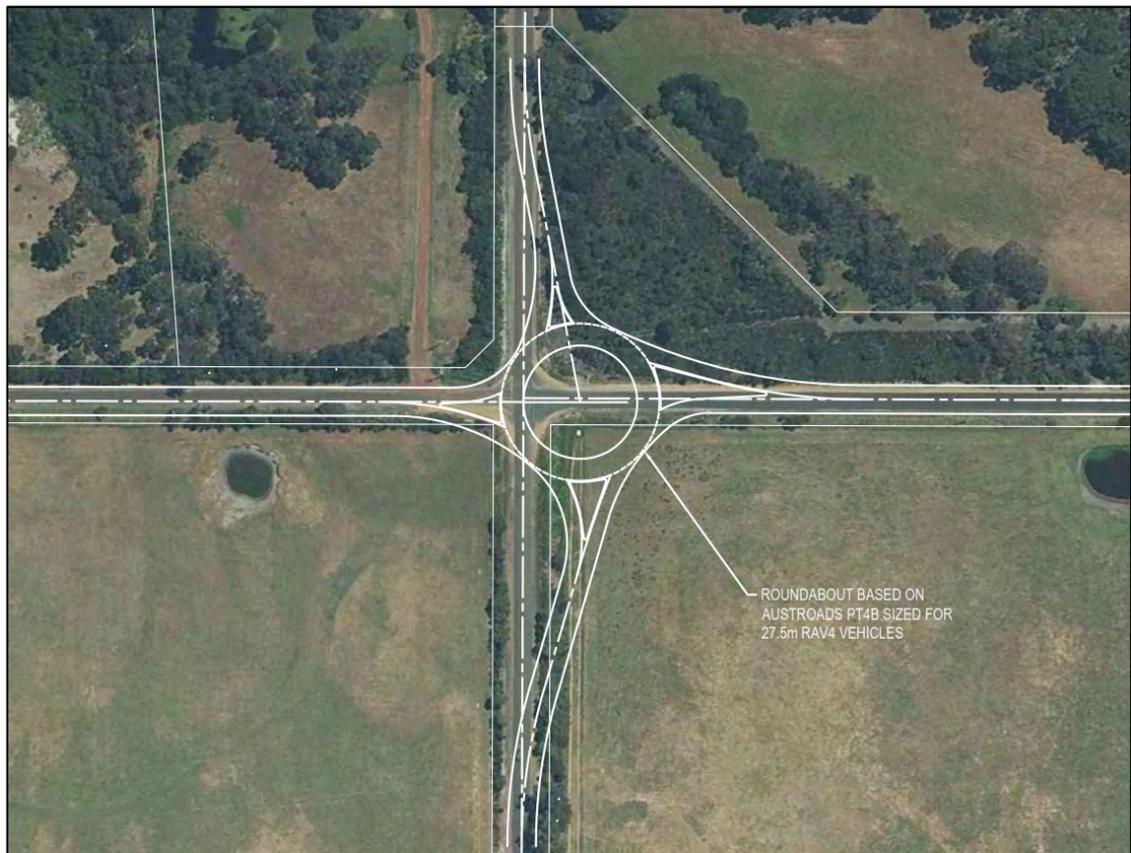


Figure 8: East roundabout intersection option (preliminary design)



Figure 9: South roundabout intersection option (preliminary design)

3.2.3 Land requirements

A summary of the land acquisition requirements for the intersection options is shown in Table 6.

The staggered T intersection makes best use of the existing road reserve. However, the north-eastern corner is heavily vegetated and would require (partial) clearing to accommodate both the staggered T intersection and the eastern roundabout option.

These land requirements are only based on two-dimensional design and no allowance has been made for the batter spillage and drainage.

Table 6: Summary of land acquisition requirements for the intersection

Land owner	Staggered T	Roundabout	
		Option 2 East	Option 2 South
WACAD (Lots 8197, 555)	3,040 m ² (3,000 + 40 m ²)	2,320 m ² (40 + 2,280 m ²)	6,170 m ² (2,550 + 3,620 m ²)
Private (Lot 15)	N/A	N/A	N/A

3.2.4 Sight distance

Preliminary investigations indicate that when heading south along Denmark-Mt Barker Road, the safe intersection sight distance (SISD) is only achieved for 60 km/hr (due to a crest in the road north of the intersection). The safe approach sight distance (ASD) is not achieved at the start of the diverge for the intersection widening heading south at 60 or 70 km/hr. The ASD however is achieved at the actual intersection location.

When approaching the intersection on East River Rd, SISD is achieved for both legs of the staggered T at 70 km/hr.

In comparison, the physical presence of a roundabout will provide a traffic calming feature and maintain the existing sightlines. For the East option, ASD is achievable at 70 km/hr.

3.2.5 Comparison of Option 1 and 2

A brief comparison of the advantages and disadvantages is included in Table 7 below.

Table 7: Summary of advantages and disadvantages of intersection options

Intersection	Advantages	Disadvantages
Staggered T intersection	<p>Provide clear separation between the heavy vehicle route and the residential traffic in the western precinct.</p> <p>Does not require the installation of lighting at the intersection.</p> <p>Removes portion of East River Road and the visual corridor down the road.</p> <p>Forces traffic to slow or stop at intersection.</p> <p>Retains traffic flow for trucks on Denmark-Mt Barker Road.</p>	<p>Requires large amount of clearing of vegetation on the road reserve.</p> <p>On the eastern approach, sight lines are obscured for southbound traffic due to the substandard crest.</p> <p>Potentially requires some private land to incorporate road shoulder (to be confirmed during detail 3D design).</p> <p>ASD not achieved at start of widening.</p>
Roundabout	<p>East option requires less land.</p> <p>Provides a physical structure to slow traffic speed on all approaches.</p> <p>Provides better sight lines.</p> <p>Possibly improve traffic flow at Tulley Rd intersection to the north.</p>	<p>Requires relocation of major power supply lines.</p> <p>South option greatly encroaches into WACAD land.</p> <p>Additional cost of required street lighting and associated impacts on adjacent residents.</p>

These two options are to be presented for community consultation to help inform a preferred solution.

3.3 Western Precinct

The Western Precinct comprises three options between the eastern bank of Denmark River and Denmark-Mt Barker Road: Option 2A in the north along the existing East River Rd reserve, Option 2B immediately south of the existing road reserve, and Option 2C in line with Option 1B further to the south.



Figure 10: Western Precinct and Denmark River crossing route alignment options

3.3.1 Option 2A

This option proposes an upgrade of the existing East River Road, with a 1.1 km extension from its current end point, south-west through WACAD land, adjacent to the existing riparian river reserve. This assumes that the existing East River Road will be upgraded within the confines of the current road reserve. The road would then be extended in a new road reserve that runs parallel to the Denmark River reserve, requiring approximately 1 hectare of WACAD land (excluding areas affected by road batters), before crossing at a newly constructed bridge.

This option requires a minimum amount of WACAD land to be purchased on the north-western boundary of the property. This option is the only Western Precinct option conditionally supported by the WACAD. The land obtained from the WACAD would be predominantly pasture and therefore substantially reduce the requirement for clearing of native vegetation.

Option 2A would likely result in lower maintenance and construction costs than other proposed options as there is little proposed additional road reserve. Residents would see an improvement in conditions to the entrances to their property, however the area in general would experience an increase in traffic. Therefore, appropriate speed restrictions would need to be implemented for the area, particularly near the residential sections.



Figure 11: Western Precinct – Option 2A

The relocation of existing utilities will be considered at the detailed design stage. Access to private properties during construction will need to be managed.

3.3.2 Option 2B

Based on a suggestion from the community, this option proposes to duplicate the existing East River Road, by building a new road within cleared land between the Denmark River and Denmark-Mt Barker Road to the south of the current reservation of East River Road. East River Road would be maintained in perpetuity as a local service road for residents while the main through traffic would be directed to the new southern route. Residents have highlighted that the western end of the (existing) East River Rd could be opened to the public for walk trails, while the low speed limit of a local service road would allow for a safer pedestrian environment.

This option would see the existing roadside vegetation maintained, with minimal clearing of land required for the new road as it is located on existing pastureland. However, a significant section of WACAD land would need to be acquired. This would amount to approximately 4 hectares of

their northern paddock between the Denmark River and Denmark-Mt Barker Road. This would negatively impact the WACAD. The proposed location of the route has an economic value, is of high educational value to the WACAD and forms part of the future plans of the WACAD.

3.3.3 Option 2C

Option 2C would also see the construction of a new road to the south of East River Road from the Denmark River across to Denmark-Mt Barker Road. This would form a more direct route from the McIntosh Road Industrial Estate for Denmark residents if constructed, as a continuation of Option 1B. This would require the purchase of approximately 10 hectares of WACAD land. As the land is predominantly pastureland, little clearing of native vegetation would be required.

The proposed route would bisect the WACAD into several segments, preventing ready access to their northern pastures and significantly impacting the functionality of the WACAD and the safety of their students and livestock. This option would also economically affect the WACAD as the recent addition of the dairy would be separated from its paddocks. Provision of stock crossings under the road may be applicable provided the road height can accommodate this.

Construction would generate farm operational difficulties as access must be maintained between the WACAD dairy and all paddocks. Additional temporary access routes could be implemented but with further loss of WACAD land. Little impact would be felt by residents during the construction process except for additional construction traffic on the surrounding roads.

3.4 Denmark (Kwoorabup) River crossing

The river crossing section of this project connects the end of the Western Precinct (i.e. Options 2A, 2B or 2C) across the Denmark River to an intersection with Scotsdale Rd, somewhere between Golden Hill Steiner School to the north, and Hillview Chalet to the south. Five options have been considered for the location of the bridge over the Denmark (Kwoorabup) River: Options 3A, 3B and 3C, 3D, 3E and 3F.

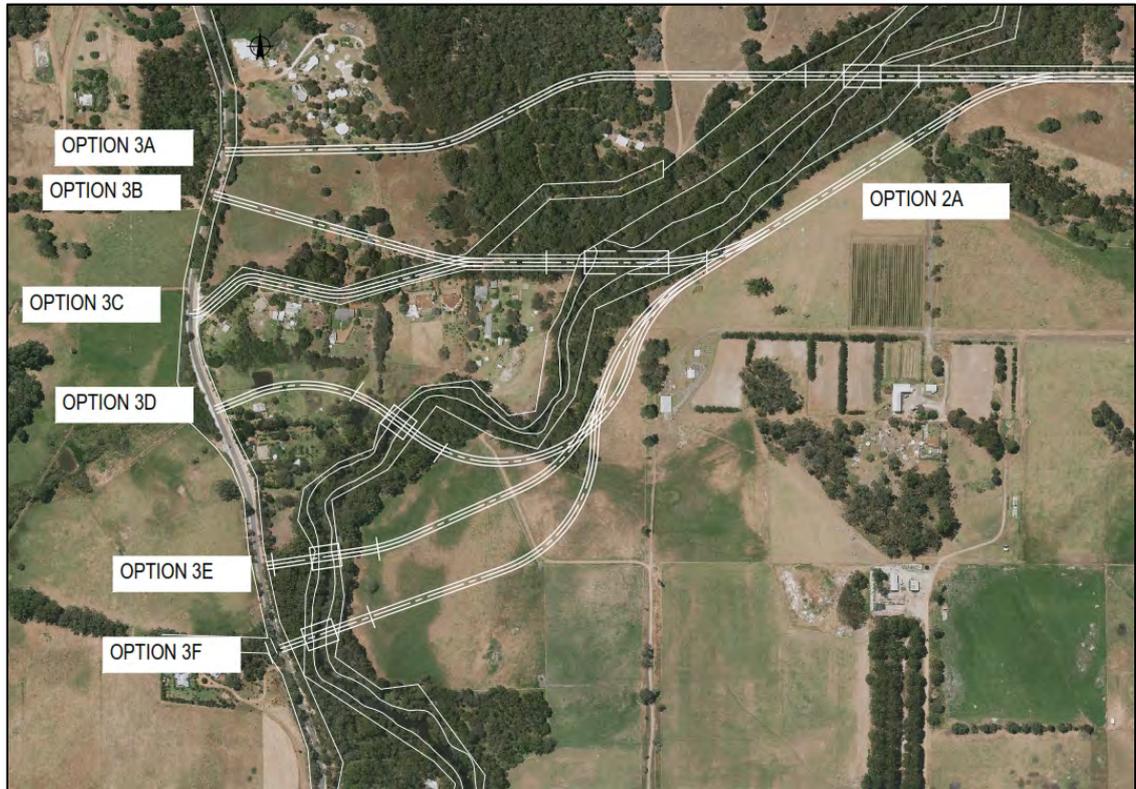


Figure 12: Denmark River crossing options

3.4.1 Option 3A

Option 3A crosses the Denmark River to the north as a direct east-west continuation of East River Road before skirting the Golden Hill Steiner School and joining Scotsdale Road. The route allows for a maximum speed of 60 km/hr and would require a 40 km/hr zone adjacent to the school.

This route will also require a second crossing over Scotsdale Brook, acquisition of private property (Lot 5, 114, 115 and 116 on Riche Rd) and significant clearing of riparian native vegetation.

The lot adjoining the southern boundary of the Golden Hill Steiner School (Lot 1) is owned by Shire of Denmark, is zoned for Special Rural purposes and accommodate the proposed route alignment.



Figure 13: Denmark River crossing Option 3A route

3.4.2 Option 3B

Option 3B crosses the river and could connect to the unconstructed section of the eastern end of the existing Riverbend Lane road reserve, at the site of an historical timber bridge crossing, before continuing on west-north-west through Lot 1 to a new intersection with Scotsdale Rd. All sections of the route allow for a maximum design speed of 60 km/hr (posted at 50 km/h).

Connections will need to be maintained with Riche Rd, and possibly Riverbend Lane, to allow for continued residential and commercial access. The Riverbend Caravan Park operates at the eastern end of Riverbend Lane. However, the proposed alignment of Option 3B results in gradients in excess of the maximum longitudinal gradient of 10% as recommended by the Shire of Denmark (SoD, 2008, p. Section 11.3) on side roads. The maximum gradient of Riche Road following the current alignment is 13.67%. As a potential alternative route, Riche Road could run parallel to the Option 3B route before intersecting at CH200 (refer to Appendix B for design drawings). However, a crest immediately to the east of the alternative Riche Rd intersection interrupts the sight lines, and will need to be flattened to achieve SISD. This will be undertaken during detailed design.

A driveway has also been shown to provide access to the Riverbend Caravan Park, with an approach grade of 7.3%. Although this is less than the Shire of Denmark 10% grade requirement, the sight lines are to be checked during detailed design. Further design work would be undertaken to determine the optimum access arrangements for Riche Road and the Riverbend Caravan Park.

The business case for *Royalties for Regions* funding identified Option 3B as the “preferred alignment”, and it represents one of the preferred locations from the Aboriginal Heritage survey (refer Section 2.1). However, there are some significant community concerns associated with the level of clearing that would be required, particularly for a number of mature karri and marri trees. An arborist has examined the large Marri tree at the junction of Riche Road and Riverbend Lane and reported that a large cross section of the trunk of the tree is degraded by decay and termite damage and the tree is not structurally viable.

Performance of the bridge during flood events will also need to be considered, as well as impacts to the flow of the river.



Figure 14: Denmark River crossing Option 3B route

3.4.3 Option 3C

Option 3C crosses the river in the same location as that proposed in Option 3B however, the western approach would follow the existing Riverbend Lane, as opposed to crossing through Lot 1.

This option will utilise the existing pavement within the road reserve and will not require the purchase of further land, minimising capital costs and maintenance costs. However, this will require the widening of the existing road and result in the removal of several significant trees and clearing of native vegetation.

While the majority of the route allows for a speed limit of 60 km/hr, one tight curve close to Scotsdale Road is limited to 40 km/hr, reducing the capacity for the future road to operate as a local connector.



Figure 15: Denmark River crossing Option 3C route

3.4.4 Option 3D

Option 3D proposes a crossing point further to the south, with the eastern approach through WACAD summer grazing paddocks, before crossing the river and traversing Reserve 47104 (Lot 1116, held by Department of Water) and (privately held) Lot 46 to intersect with Scotsdale Road.

This option runs parallel to the river reserve within the WACAD land. There would be the alienation of a portion of WACAD land between the new road reserve and the river reserve under this option. While it is possible for underpasses to be incorporated for access to these areas, the land could rather be bought and incorporated into the river reserve.

Acquisition of (privately held) Lot 46 on Scotsdale Road is necessary for this option to be implemented.

Very few significant trees are within the proximity of this route, however the acquisition of WACAD and private land is a significant drawback.

The use of 180 m radius curves and 6% superelevation allow for speeds of 70 km/hr along this route.



Figure 16: Denmark River crossing Option 3D route

3.4.5 Option 3E

Similar to Option 3D, Option 3E follows the south-west extension of East River Road across WACAD summer grazing paddocks, crossing the river and traversing Crown Reserve 12995 (Lot 124) to an intersection with Scotsdale Rd.

Option 3E requires less clearing of native vegetation and significant trees, and it represents one of the preferred locations from the Aboriginal Heritage survey (refer Section 2.1). However, with steep banks on the western side of the river, the bridge height and required abutment embankments and/or retaining walls will be significant.

Approximately 2 hectares of WACAD land would be isolated between the new road and the river reserve. This can either be bought and incorporated into the river reserve or have a cattle underpass built, provided the road elevation can allow for this. The loss of this highly fertile land would be a significant impact to the WACAD.

The design comprises sections of 60 and 70 km/hr speed zones.

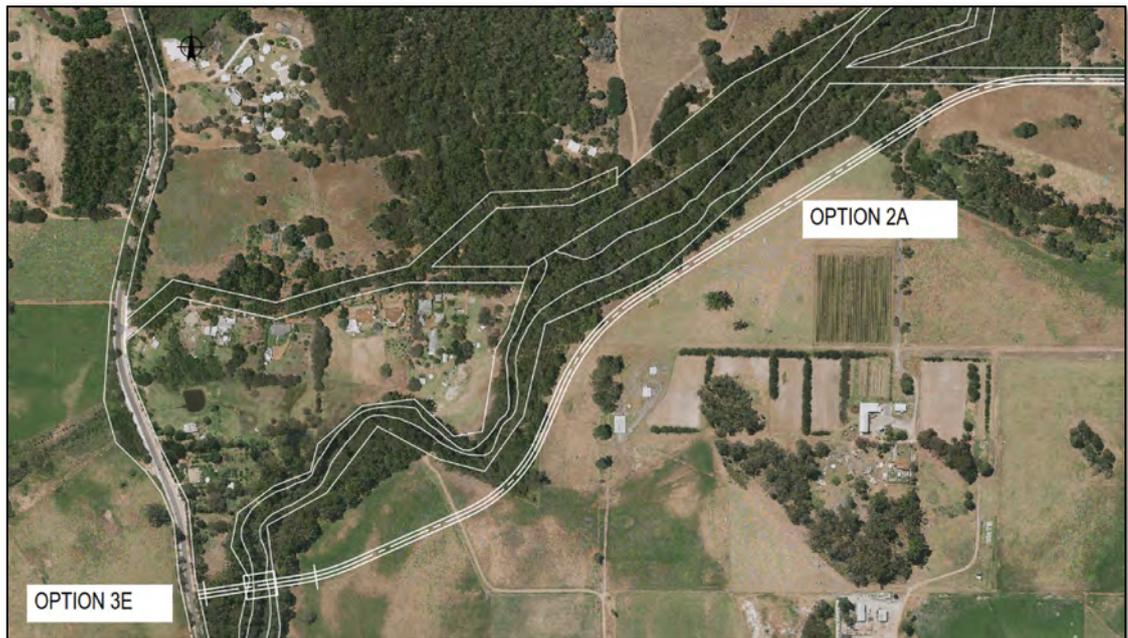


Figure 17: Denmark River crossing Option 3E route

3.4.6 Option 3F

Option 3F follows a similar route to Option 3E with the bridge crossing further to the south. The bridge is located within 50 m of the Scotsdale Road intersection. As with Option 3E, the steep banks on the western side of the river will result in significant bridge height and abutment embankments and/or retaining walls.

The proposed route isolates approximately 4.7 hectares of WACAD land between the river and the proposed road. Provided the road height allows, cattle underpasses could be built to accommodate this.

This option requires minimal clearing of land. However, several significant trees are within close proximity of the proposed road. This option is the least favoured of the options by the WACAD.



Figure 18: Denmark River crossing Option 3F route

3.5 Typical road cross-sections

For the purposes of preliminary design and costing, the following typical road cross-sections have been adopted:

RAV4 route

As shown in Figure 19 below, typical cross section utilised for the RAV4 concept road design is 2 × 3.5 m lanes, 2 × 0.5 m sealed shoulders and 2 × 0.5 m unsealed shoulders for a total formation width of 9 m. This would allow for the movement of passenger vehicles and trucks up to 27.5 m in length along the road.

Local traffic 'as of right'

Shire of Denmark has advised that they are willing to reduce the road formation width from west of the Denmark Mt-Barker Road to Scotsdale Road to 8 m formation (i.e. 2 × 3.5 m lanes, 2 × 0.5 m unsealed shoulders), to minimise the need for roadside vegetation clearing. This would allow for the movement of passenger vehicles and non-RAV trucks (e.g. semi-trailers less than 19 m in length, short B-doubles less than 20 m in length) along the road. Refer to Appendix A for RAV vehicle classifications.

Bridge

According to the Australian Standards AS 5100, the minimum shoulder width on the bridge should be 0.6 m. Total width between kerbs is thus:

- 0.6 m shoulder + 2 × 3.5 m lanes + 0.6 m shoulder, plus
- 2.5 m wide shared path (min. 2 m clear width excluding kerbs).
- **Total = 10.7 m**

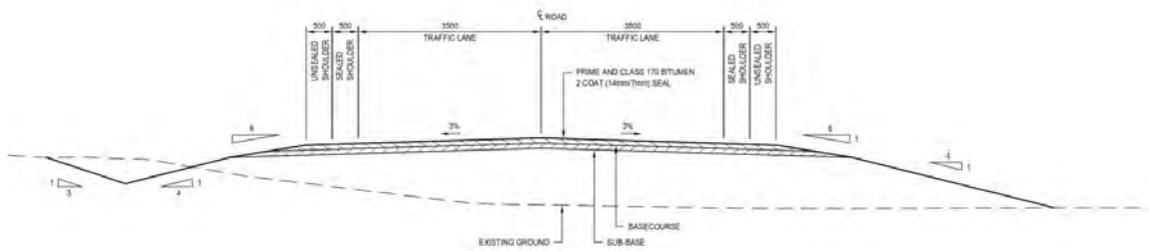


Figure 19: Typical road cross section for RAV4 route

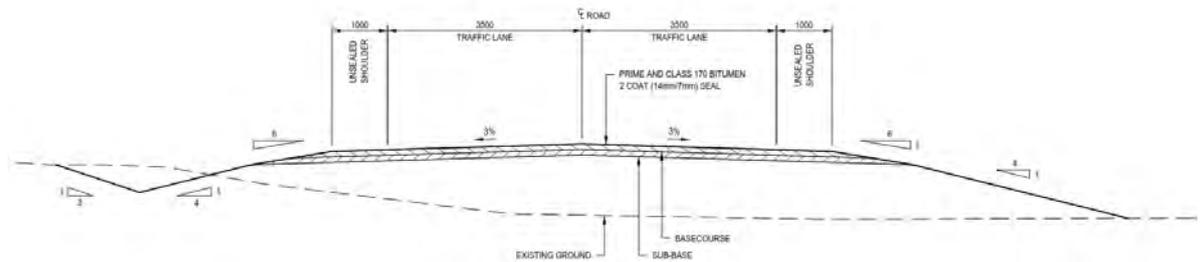


Figure 20: Typical road cross section for Western Precinct

3.6 Preliminary flood assessment

The existing hydrology of the Denmark River is described in Section 2.5. Outlined below is a preliminary assessment of flood water levels at the five proposed river crossing locations.

3.6.1 Indicative peak discharge estimates

The peak discharge from the upstream catchment was estimated using the Probabilistic Rational Method (PRM) as described in the *Australian Rainfall and Runoff* (IEAust, 1987). The design equations for the “WA South West Region, Jarrah forest with loamy soils” were used. Based on an assessment of the catchment hydrological characteristics, the time of concentration and proportion of cleared land were estimated to be about 75.5 hours and 30% respectively. These parameters were used as inputs into the PRM, yielding the peak discharges listed in Table 8.

It should be noted that, due to the presence of two dams in the upstream catchment, the use of the PRM is considered inadequate and likely to overestimate the peak discharges significantly. Consequently, the reported values in Table 8 should be considered to be highly indicative and not reflective of the actual flood conditions. It is recommended that the peak discharges are further refined in future stages of the project through a flood frequency analysis, as well as a more rigorous assessment of the catchment hydrology.

Table 8: Upstream catchment peak discharge

Storm event	Peak discharge (m ³ /s)
2-year ARI	34.0
5-year ARI	61.9
10 year ARI	89.0
20 year ARI	127.5
50-year ARI	184.9
100-year ARI	296.0

3.6.2 Existing water levels

Flood levels for various bridge crossings were carried out using HEC-RAS, which is a river analysis system capable of performing one and/or two-dimensional hydraulic calculations for a full network of natural and constructed channels. The geometry of the river was characterised using recently surveyed cross sections. The expected water levels at various recurrence intervals for these proposed bridge crossings are as shown in Figure 21 to Figure 25.

These water levels have been used to inform the multi-criteria assessment of the river crossing options. Depending on the preferred option for detail design, further refinement of this flood assessment will be necessary.

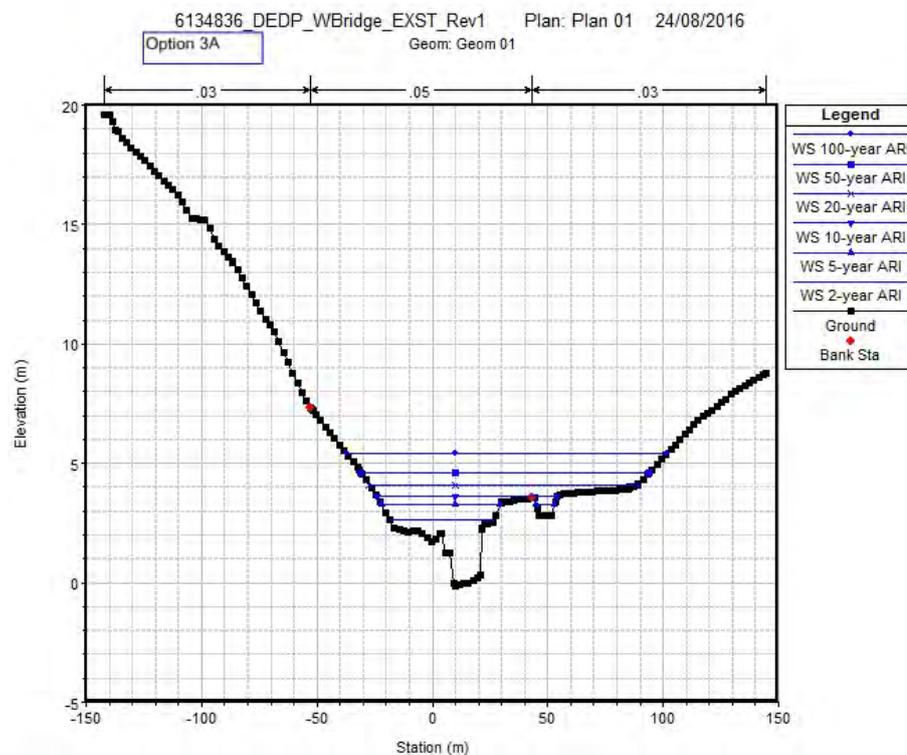


Figure 21: Option 3A water level for various recurrence intervals

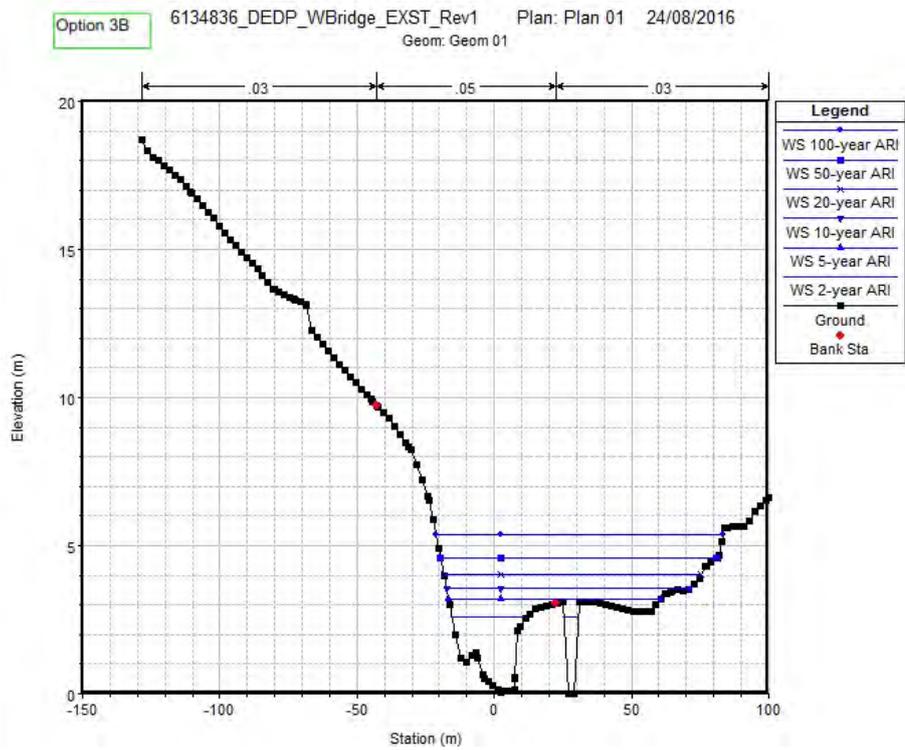


Figure 22: Option 3B water level for various recurrence intervals

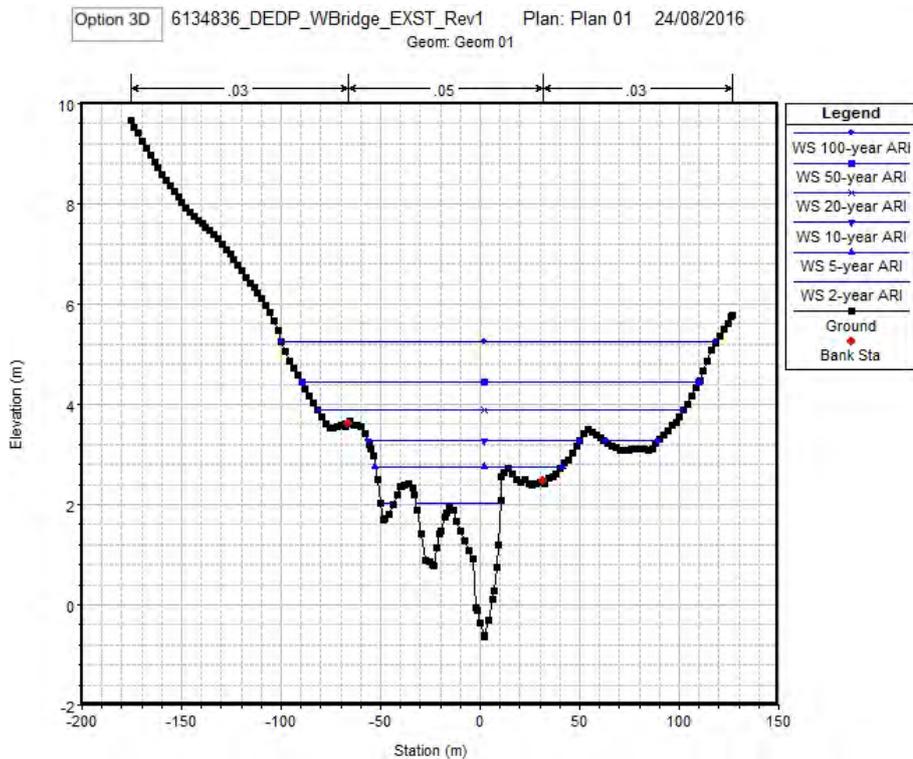


Figure 23: Option 3D water level for various recurrence intervals

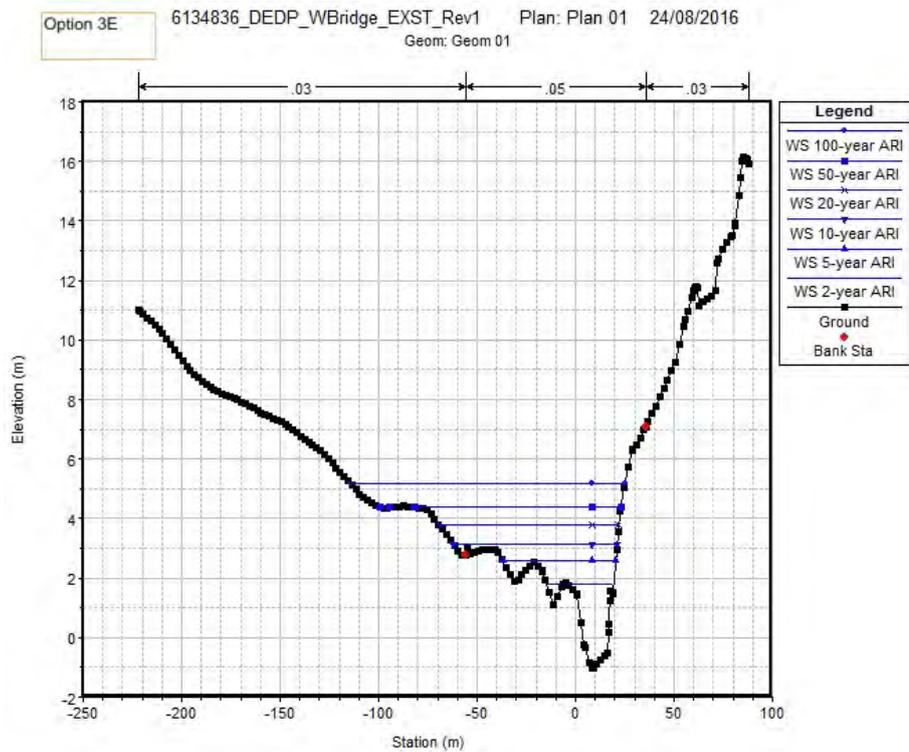


Figure 24: Option 3E water level for various recurrence intervals

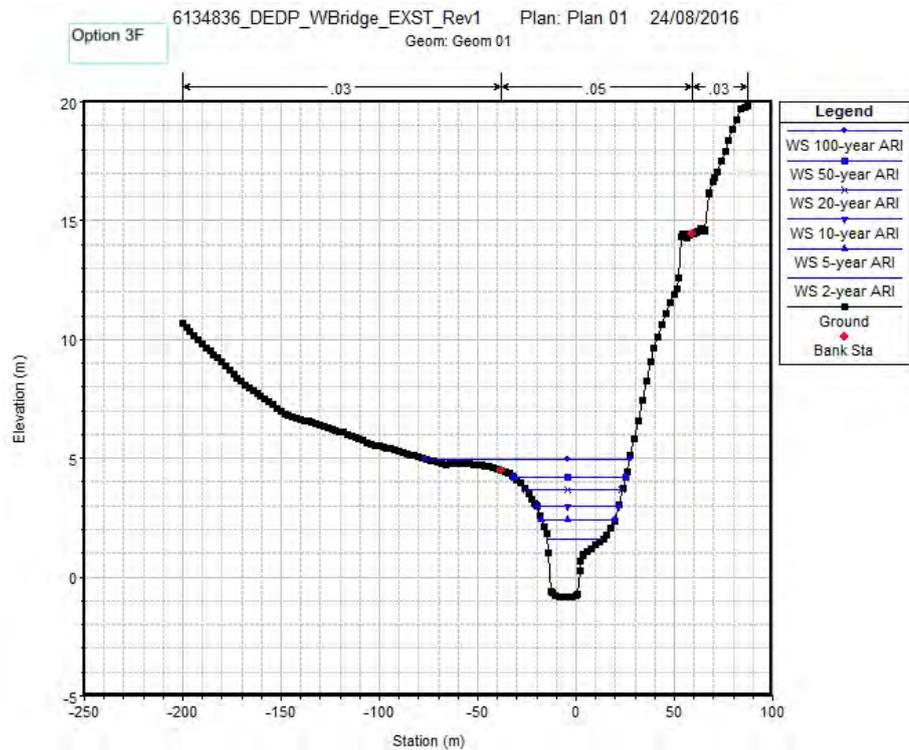


Figure 25: Option 3F water level for various recurrence intervals

Based on MRWA guidance for minor regional roads, the proposed bridge crossing should accommodate at least a **20 year ARI** flood event. Based on preliminary design of the various crossing options at natural terrain, the bridge deck for Options 3D, 3E and 3F easily meet this criterion, and will be well above the 100 year ARI flood level.

However, for Options 3B and 3C, following the natural terrain (i.e. at the same level as the original bridge), the bridge deck would potentially be submerged during a 10 year ARI flood event, which is unacceptable. Hence, this option will require the bridge deck to be lifted to achieve the required flood clearance, including allowance for structural depth of the bridge and suitable freeboard.

The road/bridge(s) design for Option 3A has not been modelled for vertical alignment, hence it has not been assessed for flood level clearance at this point. If Option 3A becomes a preferred route alignment, this modelling would be done in the next phase of design.

4. Multi-criteria assessment

To advance the selection of preferred route alignments, the options for the Eastern Precinct, Western Precinct and River crossing have been considered using a weighted multi-criteria assessment (MCA). The MCA framework was developed in consultation with the Project Control Group (PCG), and is described in detail below.

The assessment of each option was then initially undertaken by GHD, based on the findings of environmental and cultural heritage studies, as well as the preliminary engineering design undertaken in developing the options (refer Section 3). This initial assessment was then reviewed, discussed and confirmed with the Project Control Group.

4.1 Assessment criteria

The assessment criteria were formulated by GHD and LandCorp and are designed to cover the key project risks and constraints (refer Section 2). The criteria are classified under four main categories:

- Physical criteria:
 - Land acquisition and assembly,
 - General (extent of) vegetation clearance,
 - Significant tree clearing,
 - Fauna disturbance, and
 - Visual/amenity intrusion.
- Social criteria:
 - Cultural heritage compatibility,
 - Impacts on residents, and
 - Impact on the WACAD.
- Financial criteria:
 - Costs due to bridge length for the various alignments,
 - Capital costs for the overall project (inc. land acquisition), and
 - On-going maintenance costs.
- Engineering criteria:
 - Constructability,
 - Impact on floodway,
 - Intersection safety, and
 - Traffic (road) safety.

4.2 Weighting

Each of the 15 assessment criteria identified in Section 4.1 were assigned a weighting reflecting their importance to the project. The weighting exercise was undertaken with the PCG using a simple pairwise comparison technique, where two criteria are directly compared against one another – the more important or preferred criterion is rated '1', the less important or non-preferred criterion is rated '0'.

- For example, if it was necessary to choose between an option that had better outcomes for “vegetation clearance” versus an option that had better outcomes for “intersection safety”, which one would you choose?

Each criterion was compared against the others and the more important or preferred option for each pair marked as ‘1’. The sum of positive ‘1’ values for each criterion then provides a weighting for that particular criterion. The results are shown in Table 9 below.

Table 9: Assessment criteria weighting

Assessment criteria		Weighting	Assessment criteria		Weighting
Physical (21.2%)	Land assembly	1.9 %	Financial (19.2%)	Bridge length	5.8 %
	Vegetation clearance	2.9 %		Capital costs	5.8 %
	Significant tree clearing	10.6 %		On-going maintenance costs	7.7 %
	Fauna disturbance	3.8 %	Engineering (34.6%)	Constructability	4.8 %
	Visual intrusion	1.9 %		Impact on floodway	5.8 %
Cultural heritage compatibility	13.5 %	Intersection safety		12.5 %	
Social (25.0%)	Impact on residents	3.8 %		Traffic safety	11.5 %
	WACAD impacts	7.7 %	Total		100%

Note:

Compare the horizontal criterion vs the vertical criterion. If the horizontal criterion is preferred, mark it as '1'. If the vertical criterion is preferred, mark it as '0'. Black squares are the inverse value of the reciprocal white square.

	Land assembly	Vegetation clearance	Significant tree clearing	Fauna disturbance	Visual intrusion	Cultural heritage compatibility	Impacts on residents	Agricultural College impacts	Bridge length	Capital costs	On-going maintenance costs	Constructability	Impact on floodway	Intersection safety	Traffic safety	Rank
Land assembly		0	0	1	1	0	0	0	0	0	0	0	0	0	0	14
Vegetation clearance	1		0	1	1	0	0	0	0	0	0	0	0	0	0	13
Significant tree clearing	1	1		1	1	0	1	1	1	1	1	1	1	0	0	4
Fauna disturbance	1	0	0		0	0	0	1	0	0	0	1	1	0	0	11
Visual intrusion	0	0	0	1		0	0	0	1	0	0	0	0	0	0	14
Cultural heritage compatibility	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1
Impacts on residents	1	1	0	1	1	0		0	0	0	0	0	0	0	0	11
Agricultural College impacts	1	1	0	0	0	0	1		1	1	1	1	1	0	0	5
Bridge length	1	1	0	1	0	1	1	0		0	0	0	1	0	0	7
Capital costs	1	1	0	1	1	0	0	0	1		1	0	0	0	0	7
On-going maintenance costs	1	1	0	1	1	0	1	1	1	0		1	0	0	0	5
Constructability	1	1	0	0	1	0	1	0	0	1	0		0	0	0	10
Impact on floodway	1	1	0	0	1	0	1	0	0	0	1	1		0	0	7
Intersection safety	1	1	1	1	1	0	1	1	1	1	1	1	1		1	2
Traffic safety	1	1	1	1	1	0	1	1	1	1	1	1	1	0		3

4.3 Options assessment

Each option was qualitatively assigned a rating on how well it met the assessment criteria. The rating scores are from 0 to 4, where 0 does not meet the criteria and 4 best meets the criteria.

Table 10: Rating scale used in multi-criteria analysis of options

Rating	Description
0	Fatal flaw
1	Remotely meets criteria/ weakly consistent
2	Partially meets criteria/ moderately consistent
3	Substantially meets criteria/ strongly consistent
4	Best meets criteria/ fully consistent

The full assessment is shown in Table 11 and the results in Figure 26 below.

Table 11: Multi-criteria assessment

		Options												
		Eastern Precinct		Western Precinct			Denmark River Crossing							
		1A	1B	2A	2B	2C	3A	3B	3C	3D	3E	3F	Option Description	
		East River Rd - existing road reserve	New road reserve through 'Lot 556 / Reserve 26565' (WACAD)										Eastern Precinct Road - (from McIntosh Rd to Denmark-Mt Barker Rd):	
				Existing East River Rd reserve	Duplicate East River Rd (towards the south)	New road reserve through ' Lot 8197 / Reserve 26565' (WACAD)							Western Precinct Road - (from Denmark-Mt Barker Rd to Denmark River):	
							Other (further north)	Northern Crossing	Northern crossing	Central northern crossing	Central Southern Crossing	Southern crossing	Bridge Crossing:	
	Weighting:						Via Lot 1	Via Lot 1	Via Riverbend Lane	Through Lot 46	Through 'Reserve 12995'	Through 'Reserve 12995'	Western Connection to Scotsdale Rd:	
Assessment Criteria	Physical													
	Land assembly	1.9%	3	0	4	1	0	1	4	4	0	1	1	
	Vegetation clearance (general)	2.9%	2	3	3	4	3	1	2	1	2	3	4	
	Significant tree clearing	10.6%	2	4	2	4	4	1	2	1	4	3	3	
	Fauna disturbance	3.8%	2	4	3	4	4	2	3	1	4	3	3	
	Visual intrusion	1.9%	4	1	4	2	1	3	3	2	2	1	1	
	Social													
	Cultural heritage compatibility	13.5%	N/A	N/A	N/A	N/A	N/A	1	3	1	1	4	1	
	Impacts on residents	3.8%	3	4	2	3	4	2	2	1	1	3	4	
	WACAD impacts	7.7%	4	0	4	1	0	4	3	3	1	0	0	
	Financial													
	Bridge length (+/- 30 m)	5.8%	N/A	N/A	N/A	N/A	N/A	1	3	3	3	3	3	
	Capital costs	5.8%	3	4	3	1	1	1	4	4	1	2	2	
	On-going maintenance costs	7.7%	4	1	4	2	2	1	3	3	2	2	2	
	Engineering													
Constructability	4.8%	4	3	4	3	2	1	2	2	2	3	3		
Impact on floodway	5.8%	N/A	N/A	N/A	N/A	N/A	2	1	1	4	4	4		
Intersection safety	12.5%	4	3	4	2	3	2	2	1	2	3	3		
Traffic safety	11.5%	3	3	3	4	2	3	3	1	3	3	3		
TOTAL		100.0%	2.42	2.01	2.47	2.01	1.75	1.76	2.62	1.72	2.23	2.75	2.41	

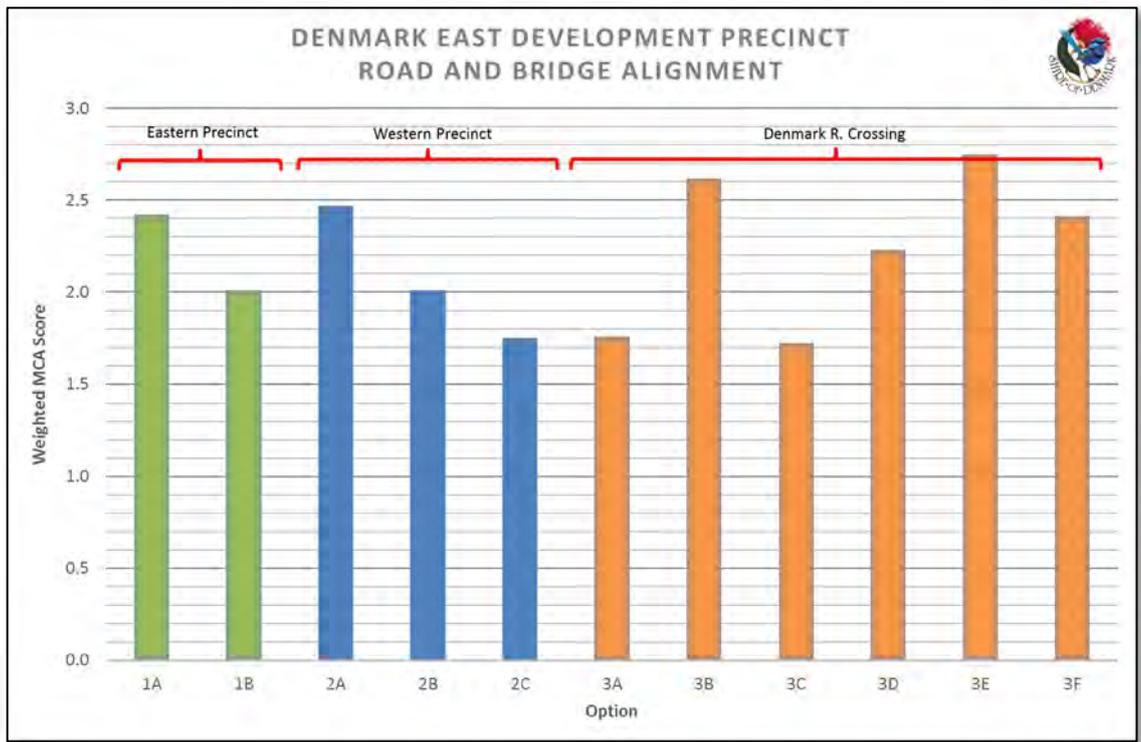


Figure 26: Multi-criteria assessment results

4.4 Preferred options

Table 12 summarises the major reasoning for the preferred alignment(s) in each section of the DEDP project.

Table 12: Preferred option summary

Section	Preferred options	Reasoning
Eastern Precinct	Option 1A	<p>By largely following the existing road alignment, this option requires much less land to be acquired, having negligible impacts on the WACAD. Similarly, this option will have lower long term maintenance costs than an additional new road servicing only industrial traffic. Visual impacts will be minimised by largely following the existing road reserves. Capital costs are expected to be within the budget of the original business case.</p> <p>Option 1B also suffers from 'fatal flaws' in the costly acquisition of significant land from WACAD, and being highly disruptive impacts to their farm operations.</p>

Section	Preferred options	Reasoning
Western Precinct	Option 2A	By following the existing road alignment, this option requires much less land to be acquired and impacts the WACAD to a much lesser degree. The on-going maintenance costs will be much lower than maintaining a second road and the visual impact and intersection safety is much better than other options. Capital costs are expected to be within the budget of the original business case.
Denmark (Kwoorabup) River Crossing	Option 3B or Option 3E	<p>Option 3B was identified as the “preferred alignment” in the original business case, and the site of a previous bridge crossing. It requires minimal land to be acquired and is expected to be within budget on capital costs.</p> <p>Option 3E is the preferred site identified in the Aboriginal Heritage survey (refer Section 2.1) and would have a limited impact on the floodway. With appropriate design, minimal vegetation and fauna disturbance will occur. However, this option potentially suffers from a ‘fatal flaw’ as it requires acquisition of WACAD land, and impacts their farm operations.</p> <p>-----</p> <p>Option 3A scores poorly due mainly to the extra cost of a second bridge crossing over Scotsdale Brook, the additional vegetation clearing required, and the impacts to privately held land.</p> <p>Option 3C is discounted due to difficulty of extra traffic traversing Riverbend Lane, and the substantial clearing of mature trees that would be required for road widening.</p> <p>Option 3D has some advantages (mainly minimal clearing), but is not preferred due to impacts on private land holdings, the WACAD and some concerns about achieving satisfactory sight distances at the intersection with Scotsdale Rd.</p> <p>Option 3F is very similar to 3E, but is less preferred in the Aboriginal Heritage survey.</p>

Based on this multi-criteria assessment, the preferred options have been further advanced into preliminary design. In particular, the options for the river crossing are further developed to help inform the community consultation process.

5. Preliminary design

5.1 Eastern Precinct – Option 1A

Option 1A is the preferred option for the Eastern Precinct. This option will require some acquisition of land through the Denmark Airport reserve (Crown Allotment 8027). Due to the high radius curves required for long RAV4 vehicles some land will be required to be cleared. Some existing driveways will require to be extended to meet the new alignment while designs are required for Sheoak Dr and McIntosh Rd (north) intersections.

Following endorsement by Shire of Denmark Council, detail design for this option will commence in October 2016, with construction activity scheduled to occur from January 2017.



Figure 27: Preferred option for the Eastern Precinct

5.2 Western Precinct – Option 2A

Option 2A, as identified in Figure 28, is the preferred option for the Western Precinct.

Although some land acquisition will be required at the south-western extent, Option 2A requires the minimum acquisition of land. The majority of the works will be undertaken in the existing road reserve of East River Road, which will minimise the capital costs and the ongoing maintenance costs. No significant constructability issues are known at present. However, the operation of the farm and maintaining property access will require management solutions during the construction phase.

Where possible, the upgrade will be kept to the southern side of the East River Road, thereby minimising the need to clear existing significant trees on the northern boundary. However, this will be constrained by existing power lines on the southern edge of the road reserve. Some relocation may be necessary. The typical road cross-section shown in Figure 20 will be adopted to minimise clearing, and emphasise the character of the road as a local connecting road.



Figure 28: Preferred option for the Western Precinct

The south-west extension of the road through WACAD land will occupy existing pastureland, further reducing the need to clear vegetation. Incorporation of existing residential driveways and WACAD access roads will be undertaken during detail design.

Following endorsement by Shire of Denmark Council, detail design for this option will commence in early 2017, with construction activity scheduled to occur from October 2017.

5.3 Denmark (Kwoorabup) River crossing

Options 3B and 3E are the more preferred options for the river crossing. The proposed horizontal alignments are shown in Figure 29.



Figure 29: Preferred Denmark River crossings

5.3.1 Option 3B

The bridge level for Option 3B has been preliminarily set to accommodate a 20-year ARI flood event. To ensure that the flow of the river is minimally impacted, a 30 m span bridge is proposed. Considerable extra retaining walls will be required on the north-east side of the bridge, to prevent embankments entering the river running parallel to the bridge. Further retaining walls will be required on the north-west side as the modelled earthworks would fill Scotsdale Brook. Retaining walls will also be placed on the southern side of both eastern and western approaches to minimise spill of earthworks and reduce the extent of clearing. On the western approach, the southern retaining walls are required to fit within the existing road reserve, and avoid impacting the adjacent Riverbend Caravan Park property.

The proposed road level is approximately 2.4 m higher than the existing bridge on Riche Road over Scotsdale Brook. Direct grade from edge to edge is 9.8% but will be considerably steeper if rounding curves are applied, as the sight distance between the two is only 24.6 m.

The design utilises a mix of 60 and 70 km/hr sections, with 70 km/hr being utilised east of the bridge. Posted speed is recommended to be 50 km/hr.

Earthworks are proposed as 1 in 4 cut and fill slopes, with a 0.6 m deep table drain at 1 in 6. This follows MRWA standards. Preliminary design modelling is shown in Appendix B.

Following community consultation and if endorsed by Shire of Denmark Council, detail design for this option will commence in early 2017, with construction activity scheduled to occur from Spring 2017. Particular detail design items that will require further development are:

- Connections between bridge cycle path and Kwoorabup trail on eastern side of Denmark River (including during construction),
- Connection of bridge cycle path through to Scotsdale Rd and any cross-over with Riche Rd and/or Riverbend Lane,
- Access and intersection configuration for Riche Rd (including during construction),
- Access and connectivity (if required) to Riverbend Lane (including during construction) and adjoining properties,
- Exact alignment of western approach through Lot 1 to optimise intersection sight lines, and redevelopment potential,
- Detail hydrological modelling to confirm expected flood levels, required bridge clearance and impacts to upstream water level,
- Structural bridge design, with consideration of constructability and material selection (i.e. concrete vs steel).

5.3.2 Option 3E

Due to the terrain on the western approach to Option 3E, the proposed bridge level will be well clear of a 100-year ARI flood event. Similar to Option 3B, a 30 m span bridge is proposed. On the eastern approach significant retaining walls will be required to prevent excessive spill of embankments, minimise clearing of significant trees and reduce the extent of land required from the WACAD. Similar treatments may also be required on the western approach, but this will need to be reviewed during detail design.

The proposed earthworks are 1 in 4 cut and fill slopes with a 0.6 m deep table drain at 1 in 6. The design of Option 3E also uses a combination of 60 and 70 km/hr speed limits, with 70 km/hr being utilised east of the bridge from CH260. Posted speed is recommended to be 50 km/hr. This alignment runs along the side of the hill which has a similar slope to the 1 in 4 earthworks.

This leads to large earthwork batters. Earthworks may need to be steepened, but the safety aspects of this need are yet to be determined.

Preliminary design modelling is shown in Appendix B.

A DoW gauging station is located on the southern side of the river within the section that would be potentially alienated from the WACAD. Along with the implementation of potential cattle underpasses for WACAD farm operations, an at-grade side track could be provided for access to the gauge station.

Following community consultation and if endorsed by Shire of Denmark Council, detail design for this option will commence in early 2017, with construction activity scheduled to occur from Spring 2017. Particular detail design items that will require further development are:

- Connections between bridge cycle path and Kwoorabup trail on eastern side of Denmark River (including during construction),
- Connection of bridge cycle path through to Scotsdale Rd,
- Exact alignment of eastern approach through WACAD land to minimise disruption to farm operations (including during construction),
- Cattle/vehicle underpass(es) and intersection with internal gauging station / farm access road,
- Detail hydrological modelling to confirm expected flood levels and impacts to upstream water level,
- Structural bridge design, with consideration of constructability and material selection (i.e. concrete vs steel).

5.4 Budget estimate

Table 13 provides the preliminary estimates of the costs for the preferred scenarios. These estimates must be treated as indicative only, as there is presently insufficient design detail to confirm quantities for all elements of the project.

Table 13: Budget estimate

Element	Budget ¹	Scenario 1 (inc. Option 3B)	Scenario 2 (inc. Option 3E)
Eastern Precinct	\$3.1 million	Option 1A: \$3.6 million ^{2,7}	Option 1A: \$3.6 million ^{2,7}
Western Precinct (inc. roads and bridge)	\$2.1 million + \$3.4 million	Option 2A + Option 3B: 2A road - \$0.8 million ^{3,7} 3B road - \$1.3 million ^{4,7} 3B bridge - \$3.2 million ⁵ Total - \$5.3 million	Option 2A + Option 3E: 2A road - \$0.8 million ^{3,7} 3E road - \$2.2 million ^{4,6,7} 3E bridge - \$4.1 million ⁵ Total - \$7.1 million
Total	\$8.6 million	\$8.9 million	\$10.7 million

See notes overpage:

- ¹ Excluding land acquisition and consultancy fees (surveys, design, etc.), adjustments required to servicing infrastructure, etc.
- ² Includes widening of East River Rd to Sheoak Drive, new road from Sheoak Drive to McIntosh Rd, sealing of McIntosh Rd south to the industrial estate, and \$400,000 allowance for the Denmark-Mt Barker Rd / East River Rd intersection. Lighting costs may be an additional \$100,000.
- ³ Includes widening of existing East River Rd west from Denmark-Mt Barker Rd, and allowance for minor culverts for residential driveway accesses.
- ⁴ Includes \$150,000 allowance for WACAD culvert.
- ⁵ Excludes general site mobilisation, preliminaries, overheads and superintendence.
- ⁶ Includes \$400,000 allowance for WACAD cattle underpass.
- ⁷ Excludes relocation of power lines, if required.

5.5 Project delivery program

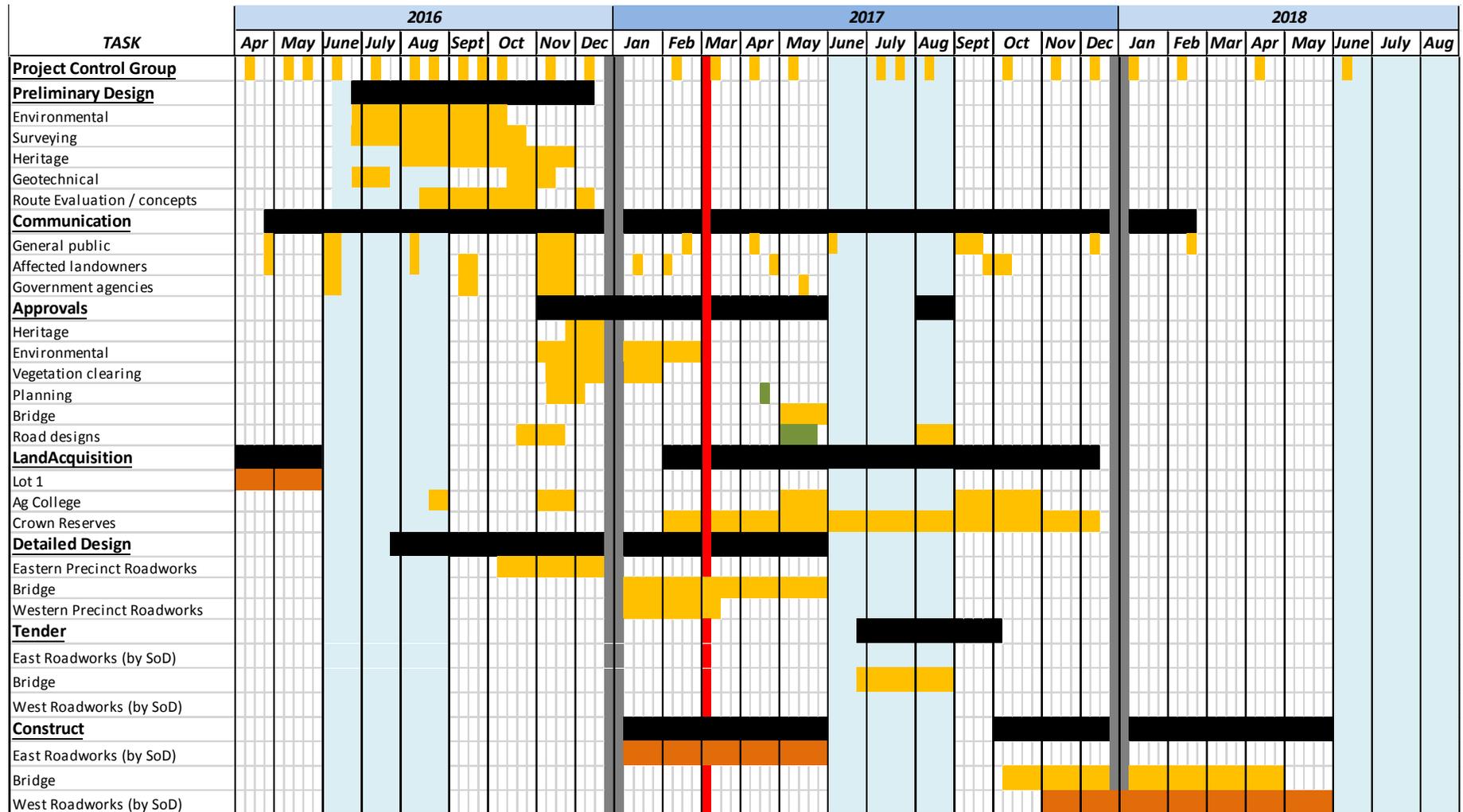


Figure 30: Delivery program

6. Recommendations

Shown in Table 14 is a summary of the recommended options for each key area of the DEDP road alignment.

Table 14: Alignment recommendations

Area	Recommended option
Eastern Precinct	Develop Option 1A for detail design.
Intersection of Denmark-Mt Barker Rd and East River Rd	<p>A staggered T intersection and roundabout are both viable options.</p> <p>Further community consultation is recommended to help inform the final intersection decision by Council.</p>
Western Precinct	Develop Option 2A for detail design.
Denmark (Kwoorabup) River crossing	<p>Option 3B and Option 3E are viable options.</p> <p>Further community consultation is recommended to help inform the final alignment decision by Council.</p>

Appendices

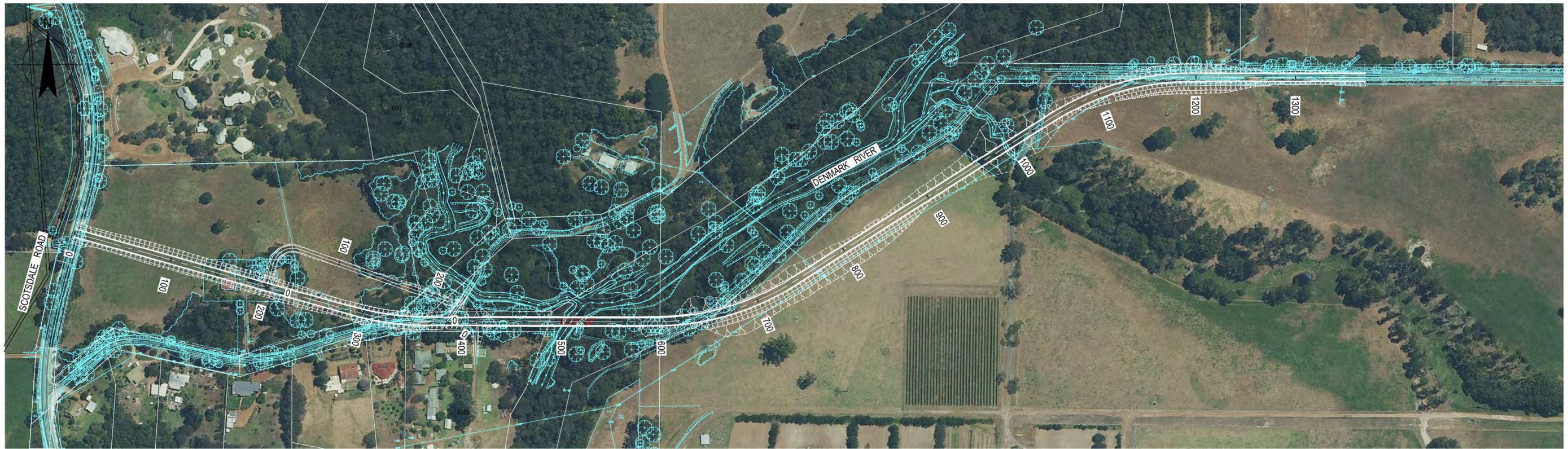
Appendix A – RAV classifications

VEHICLE DESCRIPTION AND CONFIGURATION CHART (RAV) – PRIME MOVER, TRAILER COMBINATIONS EXAMPLES						Axle Spacing Table	Length (m)	Mass (T) Maximum Permitted Mass	Height (m) (1 = see NOTES)	Axle Groups	RAV Network
Category 1	(A) PRIME MOVER, SEMI TRAILER TOWING A PIG TRAILER 	(B) PRIME MOVER TOWING AN OVERHEIGHT SEMI TRAILER 	(C) SHORT B-DOUBLE 	(D) TWINSTEER PRIME MOVER TOWING SEMI TRAILER 		(A) (B) (C) (D)	≤20 ≤19 ≤20 ≤19	50 42.5 50 47.5	≤4.6 (4) ≤3.5 (5) ≤4.6 (4) ≤4.6 (4)	4 3 4 3	Network 1
Category 2	(A) PRIME MOVER, SEMI TRAILER TOWING A PIG TRAILER 	(B) PRIME MOVER TOWING SEMI TRAILER 	(C) B-DOUBLE 	(D) SHORT B TRIPLE 	(E) CAR CARRIER SEMI TRAILER 	(A) (B) (C) (D) (E)	≤27.5 ≤20 ≤27.5 ≤27.5 ≤25	65.5 42.5 67.5 87.5 42.5	≤4.6 (4) ≤3.5 (5) ≤4.6 (4) ≤4.6 (4) ≤4.6 (4)	4 3 4 5 3	Network 2
Category 3	(A) PRIME MOVER, SEMI TRAILER TOWING A DOG TRAILER 					(A)	≤27.5	84	≤4.6 (4)	5	Network 3
Category 4	(A) PRIME MOVER, SEMI TRAILER TOWING 6 AXLE DOG TRAILER 					(A)	≤27.5	87.5	≤4.6 (4)	5	Network 4
Category 5	(A) PRIME MOVER, SEMI TRAILER TOWING A DOG TRAILER 	(B) PRIME MOVER, SEMI TRAILER TOWING A DOG TRAILER AND CONVERTER DOLLY 	(C) B-DOUBLE TOWING A CONVERTER DOLLY 	(D) B-TRIPLE 		(A) (B) (C) (D)	>27.5, ≤36.5 >27.5, ≤36.5 >27.5, ≤36.5 >27.5, ≤36.5	84 84+d 67.5+d 84	≤4.6 (4) ≤4.6 (4) ≤4.6 (4) ≤4.6 (4)	5 6 5 5	Network 5
Category 6	(A) PRIME MOVER, SEMI TRAILER TOWING 6 AXLE DOG TRAILER 	(B) B-TRIPLE 	(C) PRIME MOVER SEMI TRAILER TOWING A 6 AXLE TRAILER & CONVERTER DOLLY 			(A) (B) (C)	>27.5, ≤36.5 >27.5, ≤36.5 >27.5, ≤36.5	87.5 87.5 87.5+d	≤4.6 (4) ≤4.6 (4) ≤4.6 (4)	5 5 6	Network 6
Category 7	(A) PRIME MOVER, TOWING SEMI TRAILER AND B DOUBLE 	(B) B-DOUBLE TOWING A DOG TRAILER 				(A) (B)	>27.5, ≤36.5 >27.5, ≤36.5	107.5 107.5	≤4.6 (4) ≤4.6 (4)	6 6	Network 7
Category 9	(A) PRIME MOVER, SEMI TRAILER TOWING 2 X DOG TRAILERS 	(B) PRIME MOVER, SEMI TRAILER TOWING A DOG TRAILER AND CONVERTER DOLLY 	(C) B DOUBLE TOWING A DOG TRAILER 	(D) PRIME MOVER, SEMI TRAILER TOWING A B-DOUBLE 		(A) (B) (C) (D)	>36.5, ≤53.5 >36.5, ≤53.5 >36.5, ≤45 >36.5, ≤45	120.5 84+d 107.5 107.5	≤4.6 (4) ≤4.6 (4) ≤4.6 (4) ≤4.6 (4)	7 6 6 6	Network 9
Category 10	(A) PRIME MOVER, SEMI TRAILER TOWING 2 X 6 AXLE DOG TRAILERS 	(B) B-DOUBLE TOWING A CONVERTER DOLLY CONNECTED TO 2 SEMI TRAILERS 	(C) PRIME MOVER, SEMI TRAILER TOWING B TRIPLE 	(D) B-DOUBLE TOWING 2 DOG TRAILERS 	(E) DOUBLE ROAD TRAIN TOWING B-DOUBLE TRAILERS 	(A) (B) (C) (D) (E) (F)	>36.5, ≤53.5 >36.5, ≤53.5 >36.5, ≤53.5 >36.5, ≤53.5 >36.5, ≤53.5 >36.5, ≤53.5	127.5 127.5 127.5 147.5 147.5 87.5+d	≤4.6 (4) ≤4.6 (4) ≤4.6 (4) ≤4.6 (4) ≤4.6 (4) ≤4.6 (4)	7 7 7 8 8 6	Network 10

1. Operators using a category of RAV outlined in this document must operate that RAV in accordance with the OPERATING CONDITIONS and only on the network specified.
 2. These diagrams are a visual indication of the vehicle only.
 3. Operators must refer to the OPERATING CONDITIONS for the full vehicle description.

4. The height of the vehicle can exceed 4.3 m but MUST NOT exceed 4.6 m when it is:
 (i) built to carry livestock or; (ii) carrying a crate to carry livestock or; (iii) carrying vehicles on more than one deck or;
 (iv) carrying a multi modal container or; (v) carrying a large indivisible item or; (vi) When operating with an appropriately licenced over height curtain side or pantechonicon trailer.
 5. Maximum height of Pig Trailer only.

Appendix B – Design drawings



PLAN
SCALE 1:2000

V.P.I. No.1
CHA 0.000
ELE. 16.652
LVC ****
K ∞

V.P.I. No.2
CHA 8.551
ELE. 16.550
LVC 10
K -1246/100

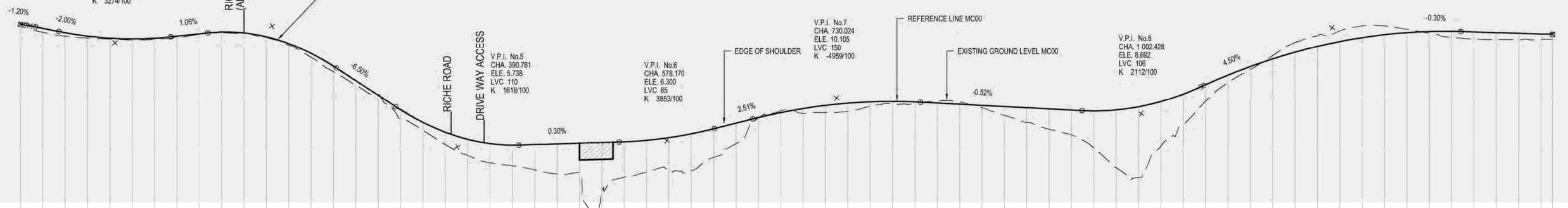
V.P.I. No.3
CHA 84.522
ELE. 15.031
LVC 100
K 3274/100

V.P.I. No.4
CHA 225.005
ELE. 16.513
LVC 115
K -1522/100

THIS CURVE MUST BE FLATTENED
TO ACHIEVE SISID IF THE RICHE ROAD
ALTERNATIVE ACCESS IS ADOPTED

V.P.I. No.9
CHA 1 173.171
ELE. 16.375
LVC 230
K -4792/100

V.P.I. No.10
CHA 1 370.288
ELE. 15.784
LVC ****
K ∞



PROFILE
SCALE H 1:2000 V 1:200

STATION	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500	520	540	560	580	600	620	640	660	680	700	720	740	760	780	800	820	840	860	880	900	920	940	960	980	1000	1020	1040	1060	1080	1100	1120	1140	1160	1180	1200	1220	1240	1260	1280	1300	1320	1340	1360	1370																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
DESIGN TO GROUND LEVEL DIFFERENCE	0.000	-0.361	-0.301	0.172	-0.074	-0.106	-0.094	-0.086	0.044	-0.064	-0.001	-0.046	-0.139	-0.366	-0.507	-0.349	-0.068	0.815	-0.708	-1.083	-1.443	-1.717	-1.852	-2.286	-2.690	-2.709	-4.491	-3.148	-2.850	-2.970	-3.302	-2.565	-1.816	-0.043	-0.172	-0.449	0.637	-0.754	-0.405	-0.210	-0.112	-0.156	-0.203	-0.209	-0.801	-1.329	-1.811	-2.223	-3.290	-5.166	6.313	-3.957	-2.695	-1.478	-0.662	0.266	-0.297	-0.876	-0.960	-0.956	-1.050	-0.794	-0.291	-0.147	0.537	-0.635	-0.623	-0.571	-0.478																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
DESIGN LEVEL	16.652	16.321	15.928	15.620	15.437	15.276	15.437	15.616	15.827	15.987	15.902	15.555	14.945	14.072	12.596	11.638	10.338	9.044	7.920	7.043	6.413	6.031	5.886	5.945	6.005	6.065	6.125	6.188	6.222	6.580	6.903	7.348	7.849	8.348	8.789	9.149	9.429	9.627	9.746	9.783	9.740	9.639	9.535	9.431	9.327	9.201	9.030	8.930	8.780	8.648	8.539	8.310	8.120	7.946	7.744	7.544	7.344	7.144	6.944	6.744	6.544	6.344	6.144	5.944	5.744	5.544	5.344	5.144	4.944	4.744	4.544	4.344	4.144	3.944	3.744	3.544	3.344	3.144	2.944	2.744	2.544	2.344	2.144	1.944	1.744	1.544	1.344	1.144	0.944	0.744	0.544	0.344	0.144	-0.056	-0.256	-0.456	-0.656	-0.856	-1.056	-1.256	-1.456	-1.656	-1.856	-2.056	-2.256	-2.456	-2.656	-2.856	-3.056	-3.256	-3.456	-3.656	-3.856	-4.056	-4.256	-4.456	-4.656	-4.856	-5.056	-5.256	-5.456	-5.656	-5.856	-6.056	-6.256	-6.456	-6.656	-6.856	-7.056	-7.256	-7.456	-7.656	-7.856	-8.056	-8.256	-8.456	-8.656	-8.856	-9.056	-9.256	-9.456	-9.656	-9.856	-10.056	-10.256	-10.456	-10.656	-10.856	-11.056	-11.256	-11.456	-11.656	-11.856	-12.056	-12.256	-12.456	-12.656	-12.856	-13.056	-13.256	-13.456	-13.656	-13.856	-14.056	-14.256	-14.456	-14.656	-14.856	-15.056	-15.256	-15.456	-15.656	-15.856	-16.056	-16.256	-16.456	-16.656	-16.856	-17.056	-17.256	-17.456	-17.656	-17.856	-18.056	-18.256	-18.456	-18.656	-18.856	-19.056	-19.256	-19.456	-19.656	-19.856	-20.056	-20.256	-20.456	-20.656	-20.856	-21.056	-21.256	-21.456	-21.656	-21.856	-22.056	-22.256	-22.456	-22.656	-22.856	-23.056	-23.256	-23.456	-23.656	-23.856	-24.056	-24.256	-24.456	-24.656	-24.856	-25.056	-25.256	-25.456	-25.656	-25.856	-26.056	-26.256	-26.456	-26.656	-26.856	-27.056	-27.256	-27.456	-27.656	-27.856	-28.056	-28.256	-28.456	-28.656	-28.856	-29.056	-29.256	-29.456	-29.656	-29.856	-30.056	-30.256	-30.456	-30.656	-30.856	-31.056	-31.256	-31.456	-31.656	-31.856	-32.056	-32.256	-32.456	-32.656	-32.856	-33.056	-33.256	-33.456	-33.656	-33.856	-34.056	-34.256	-34.456	-34.656	-34.856	-35.056	-35.256	-35.456	-35.656	-35.856	-36.056	-36.256	-36.456	-36.656	-36.856	-37.056	-37.256	-37.456	-37.656	-37.856	-38.056	-38.256	-38.456	-38.656	-38.856	-39.056	-39.256	-39.456	-39.656	-39.856	-40.056	-40.256	-40.456	-40.656	-40.856	-41.056	-41.256	-41.456	-41.656	-41.856	-42.056	-42.256	-42.456	-42.656	-42.856	-43.056	-43.256	-43.456	-43.656	-43.856	-44.056	-44.256	-44.456	-44.656	-44.856	-45.056	-45.256	-45.456	-45.656	-45.856	-46.056	-46.256	-46.456	-46.656	-46.856	-47.056	-47.256	-47.456	-47.656	-47.856	-48.056	-48.256	-48.456	-48.656	-48.856	-49.056	-49.256	-49.456	-49.656	-49.856	-50.056	-50.256	-50.456	-50.656	-50.856	-51.056	-51.256	-51.456	-51.656	-51.856	-52.056	-52.256	-52.456	-52.656	-52.856	-53.056	-53.256	-53.456	-53.656	-53.856	-54.056	-54.256	-54.456	-54.656	-54.856	-55.056	-55.256	-55.456	-55.656	-55.856	-56.056	-56.256	-56.456	-56.656	-56.856	-57.056	-57.256	-57.456	-57.656	-57.856	-58.056	-58.256	-58.456	-58.656	-58.856	-59.056	-59.256	-59.456	-59.656	-59.856	-60.056	-60.256	-60.456	-60.656	-60.856	-61.056	-61.256	-61.456	-61.656	-61.856	-62.056	-62.256	-62.456	-62.656	-62.856	-63.056	-63.256	-63.456	-63.656	-63.856	-64.056	-64.256	-64.456	-64.656	-64.856	-65.056	-65.256	-65.456	-65.656	-65.856	-66.056	-66.256	-66.456	-66.656	-66.856	-67.056	-67.256	-67.456	-67.656	-67.856	-68.056	-68.256	-68.456	-68.656	-68.856	-69.056	-69.256	-69.456	-69.656	-69.856	-70.056	-70.256	-70.456	-70.656	-70.856	-71.056	-71.256	-71.456	-71.656	-71.856	-72.056	-72.256	-72.456	-72.656	-72.856	-73.056	-73.256	-73.456	-73.656	-73.856	-74.056	-74.256	-74.456	-74.656	-74.856	-75.056	-75.256	-75.456	-75.656	-75.856	-76.056	-76.256	-76.456	-76.656	-76.856	-77.056	-77.256	-77.456	-77.656	-77.856	-78.056	-78.256	-78.456	-78.656	-78.856	-79.056	-79.256	-79.456	-79.656	-79.856	-80.056	-80.256	-80.456	-80.656	-80.856	-81.056	-81.256	-81.456	-81.656	-81.856	-82.056	-82.256	-82.456	-82.656	-82.856	-83.056	-83.256	-83.456	-83.656	-83.856	-84.056	-84.256	-84.456	-84.656	-84.856	-85.056	-85.256	-85.456	-85.656	-85.856	-86.056	-86.256	-86.456	-86.656	-86.856	-87.056	-87.256	-87.456	-87.656	-87.856	-88.056	-88.256	-88.456	-88.656	-88.856	-89.056	-89.256	-89.456	-89.656	-89.856	-90.056	-90.256	-90.456	-90.656	-90.856	-91.056	-91.256	-91.456	-91.656	-91.856	-92.056	-92.256	-92.456	-92.656	-92.856	-93.056	-93.256	-93.456	-93.656	-93.856	-94.056	-94.256	-94.456	-94.656	-94.856	-95.056	-95.256	-95.456	-95.656	-95.856	-96.056	-96.256	-96.456	-96.656	-96.856	-97.056	-97.256	-97.456	-97.656	-97.856	-98.056	-98.256	-98.456	-98.656	-98.856	-99.056	-99.256	-99.456	-99.656	-99.856	-100.056	-100.256	-100.456	-100.656	-100.856	-101.056	-101.256	-101.456	-101.656	-101.856	-102.056	-102.256	-102.456	-102.656	-102.856	-103.056	-103.256	-103.456	-103.656	-103.856	-104.056	-104.256	-104.456	-104.656	-104.856	-105.056	-105.256	-105.456	-105.656	-105.856	-106.056	-106.256	-106.456	-106.656	-106.856	-107.056	-107.256	-107.456	-107.656	-107.856	-108.056	-108.256	-108.456	-108.656	-108.856	-109.056	-109.256	-109.456	-109.656	-109.856	-110.056	-110.256	-110.456	-110.656	-110.856	-111.056	-111.256	-111.456	-111.656	-111.856	-112.056	-112.256	-112.456	-112.656	-112.856	-113.056	-113.256	-113.456	-113.656	-113.856	-114.056	-114.256	-114.456	-114.656	-114.856	-115.056	-115.256	-115.456	-115.656	-115.856	-116.056	-116.256	-116.456	-116.656	-116.856	-117.056	-117.256	-117.456	-117.656	-117.856	-118.056	-118.256	-118.456	-118.656	-118.856	-119.056	-119.256	-119.456	-119.656	-119.856	-120.056	-120.256	-120.456	-120.656	-120.856	-121.056	-121.256	-121.456	-121.656	-121.856	-122.056	-122.256	-122.456	-122.656	-122.856	-123.056	-123.256	-123.456	-123.656	-123.856	-124.056	-124.256	-124.456	-124.656	-124.856	-125.056	-125.256	-125.456	-125.656	-125.856	-126.056	-126.256	-126.456	-126.656	-126.856	-127.056	-127.256	-127.456	-127.656	-127.856	-128.056	-128.256	-128.456	-128.656	-128.856	-129.056	-129.256	-129.456	-129.656	-129.856	-130.056	-130.256	-130.456	-130.656	-130.856	-131.056	-131.256	-131.456	-131.656	-131.856	-132.056	-132.256	-132.456	-132.656	-132.856	-133.056	-133.256	-133.456	-133.656	-133.856	-134.056	-134.256	-134.456	-134.656	-134.856	-135.056	-135.256	-135.456	-135.656	-135.856	-136.056	-136.256	-136.456	-136.656	-136.856	-137.056	-137.256	-137.456	-137.656	-137.856	-138.056	-138.256	-138.456	-138.656	-138.856	-139.056	-139.256	-139.456	-139.656	-139.856	-140.056	-140.256	-140.456	-140.656	-140.856	-141.056	-141.256	-141.456	-141.656	-141.856	-142.056	-142.256	-142.456	-142.656	-142.856	-143.056	-143.256	-143.456	-143.656	-143.856	-144.056	-144.256	-144.456	-144.656	-144.856	-145.056	-145.256	-145.456	-145.656	-145.856	-146.056	-146.256	-146.456	-146.656	-146.856	-147.056	-147.256	-147.456	-147.656	-147.856	-148.056	-148.256	-148.456	-148.656	-148.856	-149.056	-149.256	-149.456	-149.656	-149.856	-150.056	-150.256	-150.456	-150.656	-150.856	-151.056	-151.256	-151.456	-151.656	-151.856	-152.056	-152.256	-152.456	-152.656	-152.856	-153.056	-153.256	-153.456	-153.656	-153.856	-154.056	-154.256	-154.456	-154.656	-154.856	-155.056	-155.256	-155.456	-155.656	-155.856	-156.056	-156.256	-156.456	-156.656	-156.856	-157.056	-157.256	-157.456	-157.656	-157.856	-158.056	-158.256	-158.456	-158.656	-158.856	-159.056	-159.256	-159.456	-159.656	-159.856	-160.056	-160.256	-160.456	-160.656	-160.856	-161.056	-161.256	-161.456	-161.656	-161.856	-162.056	-162.256	-162.456	-162.656	-162.856	-163



PLAN

SCALE 1:2000

V.P.I. No.1
CHA. 0.000
ELE. 15.681
LVC ∞
K ∞

V.P.I. No.2
CHA. 8.682
ELE. 15.382
LVC 10
K 2278/100

V.P.I. No.7
CHA. 1 270.688
ELE. 16.376
LVC 230
K -4792/100

V.P.I. No.8
CHA. 1 467.780
ELE. 15.784
LVC ∞
K ∞

2.5m x 2.5m PROPOSED
CATTLE UNDERPASS

V.P.I. No.4
CHA. 610.000
ELE. 11.880
LVC 95
K -4780/100

V.P.I. No.5
CHA. 815.083
ELE. 10.170
LVC 60
K 19068/100

V.P.I. No.6
CHA. 1 099.921
ELE. 8.692
LVC 106
K 2112/100

2.5m x 2.5m PROPOSED
CATTLE UNDERPASS

V.P.I. No.3
CHA. 280.000
ELE. 7.842
LVC 100
K 2408/100

EDGE OF SHOULDER

REFERENCE LINE MC00

EXISTING GROUND LEVEL MC00

-3.44%

-3.00%

1.15%

-0.83%

-0.52%

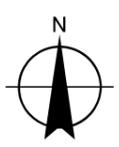
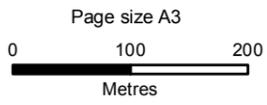
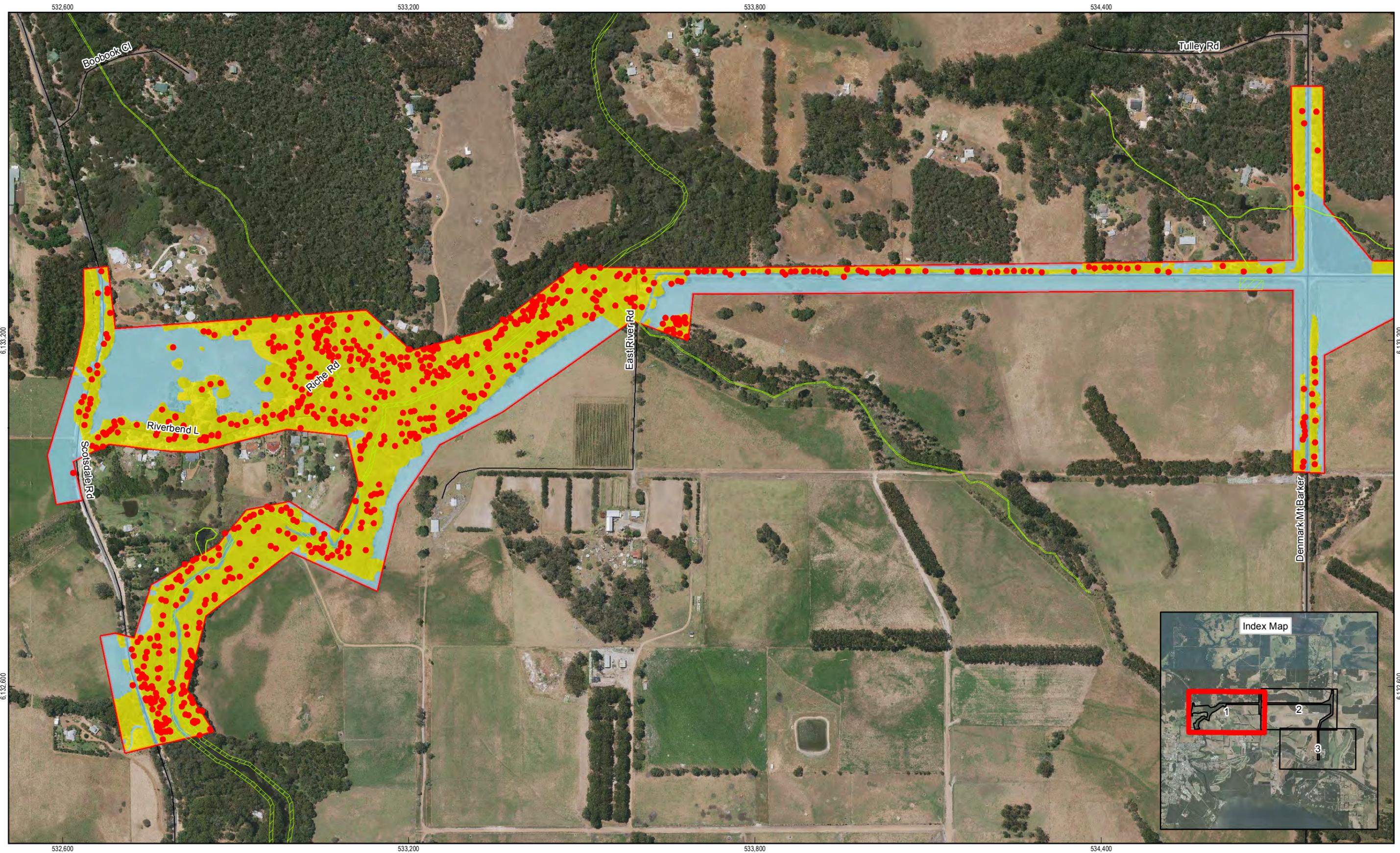
4.50%

-0.30%

DATUM=-2.000

DESIGN TO GROUND LEVEL DIFFERENCE	0.032	2.447	5.102	9.043	11.818	11.641	8.972	6.713	6.135	5.287	4.048	2.751	1.616	0.838	0.483	0.046	-0.237	-0.270	-0.217	0.173	0.752	1.136	1.124	1.161	0.635	0.230	-0.024	-0.012	-0.065	0.057	0.354	0.674	0.890	0.907	0.667	1.227	1.955	0.990	-0.176	0.086	0.976	1.259	1.862	2.302	3.509	5.346	6.345	3.715	2.601	1.348	0.597	0.213	-0.390	-0.883	-1.032	-1.006	-1.048	-0.730	-0.229	0.192	0.554	0.639	0.614	0.559	0.466																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
DESIGN LEVEL	15.681	15.042	14.442	13.842	13.242	12.642	12.042	11.442	10.842	10.242	9.642	9.063	8.629	8.362	8.260	8.325	8.535	8.765	8.996	9.227	9.457	9.688	9.919	10.150	10.380	10.611	10.842	11.072	11.303	11.532	11.761	11.990	12.219	12.448	12.677	12.906	13.135	13.364	13.593	13.822	14.051	14.280	14.509	14.738	14.967	15.196	15.425	15.654	15.883	16.112	16.341	16.570	16.799	17.028	17.257	17.486	17.715	17.944	18.173	18.402	18.631	18.860	19.089	19.318	19.547	19.776	20.005	20.234	20.463	20.692	20.921	21.150	21.379	21.608	21.837	22.066	22.295	22.524	22.753	22.982	23.211	23.440	23.669	23.898	24.127	24.356	24.585	24.814	25.043	25.272	25.501	25.730	25.959	26.188	26.417	26.646	26.875	27.104	27.333	27.562	27.791	28.020	28.249	28.478	28.707	28.936	29.165	29.394	29.623	29.852	30.081	30.310	30.539	30.768	30.997	31.226	31.455	31.684	31.913	32.142	32.371	32.600	32.829	33.058	33.287	33.516	33.745	33.974	34.203	34.432	34.661	34.890	35.119	35.348	35.577	35.806	36.035	36.264	36.493	36.722	36.951	37.180	37.409	37.638	37.867	38.096	38.325	38.554	38.783	39.012	39.241	39.470	39.699	39.928	40.157	40.386	40.615	40.844	41.073	41.302	41.531	41.760	41.989	42.218	42.447	42.676	42.905	43.134	43.363	43.592	43.821	44.050	44.279	44.508	44.737	44.966	45.195	45.424	45.653	45.882	46.111	46.340	46.569	46.798	47.027	47.256	47.485	47.714	47.943	48.172	48.401	48.630	48.859	49.088	49.317	49.546	49.775	50.004	50.233	50.462	50.691	50.920	51.149	51.378	51.607	51.836	52.065	52.294	52.523	52.752	52.981	53.210	53.439	53.668	53.897	54.126	54.355	54.584	54.813	55.042	55.271	55.500	55.729	55.958	56.187	56.416	56.645	56.874	57.103	57.332	57.561	57.790	58.019	58.248	58.477	58.706	58.935	59.164	59.393	59.622	59.851	60.080	60.309	60.538	60.767	60.996	61.225	61.454	61.683	61.912	62.141	62.370	62.599	62.828	63.057	63.286	63.515	63.744	63.973	64.202	64.431	64.660	64.889	65.118	65.347	65.576	65.805	66.034	66.263	66.492	66.721	66.950	67.179	67.408	67.637	67.866	68.095	68.324	68.553	68.782	69.011	69.240	69.469	69.698	69.927	70.156	70.385	70.614	70.843	71.072	71.301	71.530	71.759	71.988	72.217	72.446	72.675	72.904	73.133	73.362	73.591	73.820	74.049	74.278	74.507	74.736	74.965	75.194	75.423	75.652	75.881	76.110	76.339	76.568	76.797	77.026	77.255	77.484	77.713	77.942	78.171	78.400	78.629	78.858	79.087	79.316	79.545	79.774	80.003	80.232	80.461	80.690	80.919	81.148	81.377	81.606	81.835	82.064	82.293	82.522	82.751	82.980	83.209	83.438	83.667	83.896	84.125	84.354	84.583	84.812	85.041	85.270	85.499	85.728	85.957	86.186	86.415	86.644	86.873	87.102	87.331	87.560	87.789	88.018	88.247	88.476	88.705	88.934	89.163	89.392	89.621	89.850	90.079	90.308	90.537	90.766	90.995	91.224	91.453	91.682	91.911	92.140	92.369	92.598	92.827	93.056	93.285	93.514	93.743	93.972	94.201	94.430	94.659	94.888	95.117	95.346	95.575	95.804	96.033	96.262	96.491	96.720	96.949	97.178	97.407	97.636	97.865	98.094	98.323	98.552	98.781	99.010	99.239	99.468	99.697	99.926	100.155	100.384	100.613	100.842	101.071	101.300	101.529	101.758	101.987	102.216	102.445	102.674	102.903	103.132	103.361	103.590	103.819	104.048	104.277	104.506	104.735	104.964	105.193	105.422	105.651	105.880	106.109	106.338	106.567	106.796	107.025	107.254	107.483	107.712	107.941	108.170	108.399	108.628	108.857	109.086	109.315	109.544	109.773	110.002	110.231	110.460	110.689	110.918	111.147	111.376	111.605	111.834	112.063	112.292	112.521	112.750	112.979	113.208	113.437	113.666	113.895	114.124	114.353	114.582	114.811	115.040	115.269	115.498	115.727	115.956	116.185	116.414	116.643	116.872	117.101	117.330	117.559	117.788	118.017	118.246	118.475	118.704	118.933	119.162	119.391	119.620	119.849	120.078	120.307	120.536	120.765	120.994	121.223	121.452	121.681	121.910	122.139	122.368	122.597	122.826	123.055	123.284	123.513	123.742	123.971	124.200	124.429	124.658	124.887	125.116	125.345	125.574	125.803	126.032	126.261	126.490	126.719	126.948	127.177	127.406	127.635	127.864	128.093	128.322	128.551	128.780	129.009	129.238	129.467	129.696	129.925	130.154	130.383	130.612	130.841	131.070	131.299	131.528	131.757	131.986	132.215	132.444	132.673	132.902	133.131	133.360	133.589	133.818	134.047	134.276	134.505	134.734	134.963	135.192	135.421	135.650	135.879	136.108	136.337	136.566	136.795	137.024	137.253	137.482	137.711	137.940	138.169	138.398	138.627	138.856	139.085	139.314	139.543	139.772	140.001	140.230	140.459	140.688	140.917	141.146	141.375	141.604	141.833	142.062	142.291	142.520	142.749	142.978	143.207	143.436	143.665	143.894	144.123	144.352	144.581	144.810	145.039	145.268	145.497	145.726	145.955	146.184	146.413	146.642	146.871	147.100	147.329	147.558	147.787	148.016	148.245	148.474	148.703	148.932	149.161	149.390	149.619	149.848	150.077	150.306	150.535	150.764	150.993	151.222	151.451	151.680	151.909	152.138	152.367	152.596	152.825	153.054	153.283	153.512	153.741	153.970	154.199	154.428	154.657	154.886	155.115	155.344	155.573	155.802	156.031	156.260	156.489	156.718	156.947	157.176	157.405	157.634	157.863	158.092	158.321	158.550	158.779	159.008	159.237	159.466	159.695	159.924	160.153	160.382	160.611	160.840	161.069	161.298	161.527	161.756	161.985	162.214	162.443	162.672	162.901	163.130	163.359	163.588	163.817	164.046	164.275	164.504	164.733	164.962	165.191	165.420	165.649	165.878	166.107	166.336	166.565	166.794	167.023	167.252	167.481	167.710	167.939	168.168	168.397	168.626	168.855	169.084	169.313	169.542	169.771	170.000	170.229	170.458	170.687	170.916	171.145	171.374	171.603	171.832	172.061	172.290	172.519	172.748	172.977	173.206	173.435	173.664	173.893	174.122	174.351	174.580	174.809	175.038	175.267	175.496	175.725	175.954	176.183	176.412	176.641	176.870	177.099	177.328	177.557	177.786	178.015	178.244	178.473	178.702	178.931	179.160	179.389	179.618	179.847	180.076	180.305	180.534	180.763	180.992	181.221	181.450	181.679	181.908	182.137	182.366	182.595	182.824	183.053	183.282	183.511	183.740	183.969	184.198	184.427	184.656	184.885	185.114	185.343	185.572	185.801	186.030	186.259	186.488	186.717	186.946	187.175	187.404	187.633	187.862	188.091	188.320	188.549	188.778	189.007	189.236	189.465	189.694	189.923	190.152	190.381	190.610	190.839	191.068	191.297	191.526	191.755	191.984	192.213	192.442	192.671	192.900	193.129	193.358	193.587	193.816	194.045	194.274	194.503	194.732	194.961	195.190	195.419	195.648	195.877	196.106	196.335	196.564	196.793	197.022	197.251	197.480	197.709	197.938	198.167	198.396	198.625	198.854	199.083	199.312	199.541	199.770	200.000	200.229	200.458	200.687	200.916	201.145	201.374	201.603	201.832	202.061	202.290	202.519	202.748	202.977	203.206	203.435	203.664	203.893	204.122	204.351	204.580	204.809	205.038	205.267	205.496	205.725	205.954	206.183	206.412	206.641	206.870	207.099	207.328	207.557	207.786	208.015	208.244	

Appendix C – Key biological constraints maps



LEGEND

- Roads
- ▨ Riparian and River Habitat
- Constraint**
- ▭ Low
- ▭ Medium
- ▭ High
- ▭ Survey Area

Page size A3
 Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 50



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 Denmark East Development Precinct

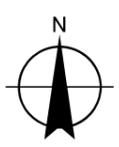
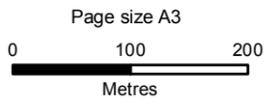
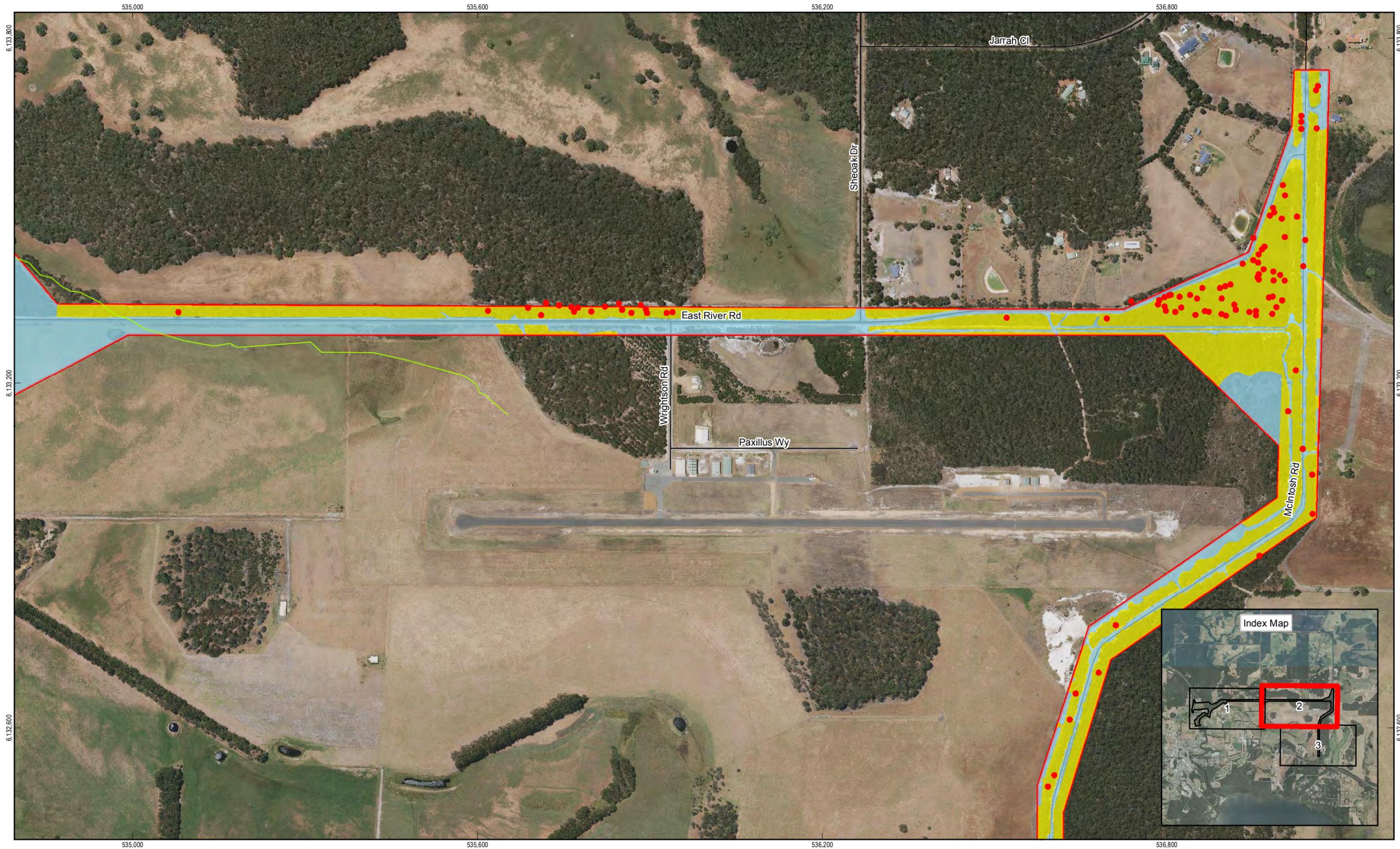
Biological Constraints

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 Revision 0
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Sheet 1 of 3

Figure 6

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 Data source: GHD: Constraints, Riparian Habitat - 20160815; Landgate: Aerial Photography - Virtual Mosaic; MRWA: Roads - 20140723; LandCorp: Study Area, 20160726. Created by: mmikkonen



LEGEND

- Roads
- ▨ Riparian and River Habitat
- Constraint**
- ▭ Low
- ▭ Medium
- ▭ High
- ▭ Survey Area

Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 50



LandCorp
 Denmark East Development Precinct

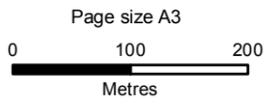
Biological Constraints

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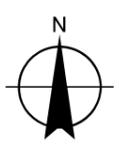
Sheet 2 of 3

Figure 6

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 Data source: GHD: Constraints, Riparian Habitat - 20160815; Landgate: Aerial Photography - Virtual Mosaic; MRWA: Roads - 20140723; LandCorp: Study Area, 20160726. Created by: mmikkonen



Page size A3
 Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 50



LEGEND

- Roads
- ▨ Riparian and River Habitat
- Constraint**
- Low
- Medium
- High
- ▭ Survey Area



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 Denmark East Development Precinct

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Biological Constraints

Sheet 3 of 3
 Figure 6

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 Data source: GHD: Constraints, Riparian Habitat - 20160815; Landgate: Aerial Photography - Virtual Mosaic; MRWA: Roads - 20140723; LandCorp: Study Area, 20160726. Created by: mmikkonen

Appendix D – References

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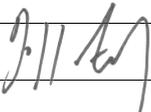
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