REGIONAL ROADS VICTORIA

SEPTEMBER 2021

BEAUFORT BYPASS ENVIRONMENT EFFECTS STATEMENT

FLORA AND FAUNA IMPACT ASSESSMENT

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Beaufort Bypass Environment Effects Statement
Flora and Fauna Impact Assessment

Regional Roads Victoria

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ABBREVIATIONS

BoM	Bureau of Meteorology
CALP	Catchment and Land Protection Act 1994
CF	Construction Footprint
CIAA	Cumulative Impact Assessment Area
GHCMA	Glenelg Hopkins Catchment Management Authority
DAWE	Department of Agriculture, Water and the Environment
DELWP	Department of Environment, Land, Water and Planning
DoEE	Department of Environment and Energy
EE Act	Environment Effects Act 1978
EES	Environment Effects Statement
EnSym	Environmental Systems Modelling Platform
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EVC	Ecological Vegetation Class
EVC BCS	Ecological Vegetation Classes Bioregional Conservation Status
FFG Act	Flora and Fauna Guarantee Act 1988
GAP CLoSR	General Approach to Planning Connectivity from Local Scales to Regional
GIS	Geographic Information System
MNES	Matters of National Environmental Significance
NVR report	Native Vegetation Removal report
PMST	Protected Matters Search Tool
SCO	Specific Controls Overlay
SBV	Strategic Biodiversity Value
VBA	Victorian Biodiversity Atlas
VTWBC	Victorian Temperate Woodland Bird Community
VVP	Victorian Volcanic Plain

EXECUTIVE SUMMARY

INTRODUCTION

WSP Australia Pty Limited (WSP) was engaged by Regional Roads Victoria (RRV) to prepare the Environment Effects Statement (EES) and associated technical reports to support the selection of an alignment for a future Bypass of Beaufort (the 'Project'). On securing further funding for construction, RRV proposes to construct a new duplication section of the Western Highway to bypass Beaufort, linking completed sections of the Western Highway duplication to the east and west of the town. The EES has assessed four proposed alignments and contributed to the options assessment prepared by RRV to determine the preferred alignment. This report outlines and compares the ecological impacts of each of the proposed alignments and provides detailed impact assessment and proposed mitigations for the preferred C2 alignment.

The objective of this study is to address the EES Scoping Requirements through detailing the ecological values of the study area (including significant values), assessing the ecological impacts of the alignments and outlining a mitigation strategy for the project when it reaches the construction phase. This report identifies the significant ecological values within the study area listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act); Flora and *Fauna Guarantee Act 1988* (FFG Act) and the Victorian Rare or Threatened Species Advisory Lists.

STUDY AREA

The study area is located within Pyrenees Shire Council and extends for approximately 9 km from the eastern end to the western end of the Beaufort township, to the north of the town. The four proposed bypass corridor options cross a patchwork of landscapes including rural and agricultural freehold land, privately owned land, state forests and bushland reserves, private mine tenements and local road reserves.

The majority of the study area falls within the Central Victorian Uplands bioregion with two small areas in the east covered by the Victorian Volcanic Plain bioregion. The study area contains several creeks with the largest being Yam Holes Creek. There are also many seasonal wetlands and farm dams scattered through the study area, particularly along the Yam Holes Creek valley system.

SCOPING REQUIREMENTS

The *Scoping Requirements for Beaufort Bypass Project Environment Effects Statement* (DELWP 2016) (Scoping Requirements) set out the specific environmental matters to be investigated and documented in the EES, which informs the scope of this assessment.

The following matters of the Scoping Requirements are relevant to the flora and fauna impact assessment:

EES evaluation objective

Biodiversity: *To avoid and minimise adverse effects on native vegetation, as well as habitat for threatened flora and fauna species and ecological communities, including those listed under the FFG Act, and address offset requirements for predicted losses consistent with relevant policy.*

Environmental management framework: *To provide a transparent framework with clear accountabilities for managing environmental effects and hazards associated with construction and operation phases of the proposed project, in order to achieve acceptable environmental outcomes.*

METHODS

LITERATURE AND DATABASE REVIEW

To determine the ecological values and potential constraints, a database search and literature review was undertaken. Relevant and available documents were reviewed for information on past land uses, presence of vegetation communities as well as flora and fauna. Databases were searched for records of threatened and other significant species within a 10 km radius of the centre of the study area including:

- Victorian Biodiversity Atlas (VBA)
- Birdlife Australia Birdata extract
- Protected Matters Search Tool
- Victorian Aquatic Fauna Database.

Due to the history of consideration for upgrade works to the Western Highway a number of previous ecological and environmental studies have been undertaken within or near the study area. A short review of these studies has been undertaken and information from those reports used where relevant.

FIELD SURVEYS

- Field surveys to determine the significant values present including:
  - Targeted threatened flora surveys, vegetation mapping and tree surveys were undertaken between September 2016 and January 2018. In addition, survey data conducted in 2015 (WSP | Parsons Brinckerhoff 2016b) has been incorporated into the results.
  - The fauna surveys for terrestrial and aquatic species were undertaken between November 2016 and March 2021. In addition, survey data conducted in 2015 (WSP | Parsons Brinckerhoff 2016b) has been incorporated into the results.

EXISTING CONDITIONS

- Assessment of existing conditions including consolidation of records and likelihood of occurrence and habitat assessment to establish baseline conditions to apply to risk and impact assessments.

RISK ASSESSMENT

- Risk assessment, identifying risks to biodiversity values and controls to guide the impact assessment.

IMPACT ASSESSMENT

- Values in The *Assessor's handbook - Applications to remove, destroy or lop native vegetation (the Handbook)* (DELWP 2017b) were used to determine the lower and higher values of native vegetation.
- Detailed assessment of impacts upon ecological values, including native vegetation, significant species, threatening processes, threatened and listed communities and ecological character, with reference to relevant legislation and policy.
- A cumulative impacts assessment was undertaken for all alignment options.
- Assessment of current and future levels of connectivity for wildlife in response to the project (Lechner et al. 2019).
- Development of a recommended impact avoidance and mitigation strategy for the project, based on the outcomes of the risk assessment and impact assessment, and identification of the required mitigation measures for significant species.

LEGISLATION

The following State and Commonwealth legislation informed the framework for assessment, assessment of impacts and prescription of mitigations for the Beaufort Bypass.

ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

The construction and operation phase of the project has the potential to impact on a number of Matters of National Environmental Significance (MNES) under the EPBC Act.

A 'significant impact' is defined under the EPBC Act as 'an impact that is important, notable, or of consequence, having regard to its context or intensity' (Department of the Environment 2013). If a project is likely to have a significant impact on one of the nine MNES, the 'action' must be referred to the Commonwealth Department of Agriculture, Water and the Environment (DAWE). This 'referral' is then released to the public for comment.

Two of the nine matters are relevant to the study area: 'nationally threatened species and ecological communities' and 'migratory species'.

Based on the analysis of impacts of the preferred C2 alignment, with the mitigation proposed, only Golden Sun Moth is considered to have a moderate or high likelihood of a significant impact. For the remaining MNES, mitigation is expected to avoid or reduce impacts such that they will not be significantly impacted.

The project was referred to the Australian Government Minister for the Environment (the Minister) on 19 January 2021. The project was referred on the basis of potential impacts to two MNES; listed species and communities and migratory species. A decision on the referral on 24 February 2021 stated that the proposed action is a controlled action under section 75 of the EPBC Act. Based on the information available in the referral, it was considered that the proposed action is likely to have a significant impact on but not limited to Golden Sun Moth. As such, the EPBC Act Environmental Offsets Policy (DSEWPaC 2012a) will apply as residual impacts on Golden Sun Moth remain significant, even after mitigation.

The project will be assessed by accredited assessment under the *Environmental Effects Act 1978.*

ENVIRONMENT EFFECTS ACT 1978

Under Victoria's *Environment Effects Act 1978* (EE Act), projects that could have a 'significant effect' on Victoria's environment can be referred for consideration under the requirements of an Environment Effects Statement (EES). This Act applies to any public works 'reasonably considered to have or be capable of having a significant effect on the environment'. The Minister for Planning is the responsible authority for assessing whether this Act applies.

On 22 July 2015, the Minister for Planning determined that an EES would be required under the EE Act to assess the potential environmental effects of the project. The EES allows stakeholders to understand the likely environmental effects of the project and how they would be managed.

FLORA AND FAUNA GUARANTEE ACT 1988

The FFG Act was established to provide a legal framework for enabling and promoting the conservation of all Victoria's native flora and fauna, and to enable management of potentially threatening processes. One of the main features of the Act is the listing process, whereby native species and communities of flora and fauna, and the processes that threaten native flora and fauna are listed in the schedules of the Act. This assists in identifying those species and communities that require management to survive and identifies the processes that require management to minimise the threat to native flora and fauna species and communities within Victoria.

A permit from DELWP is required to 'take' listed flora species that are 'protected flora' from public land. A permit is not required under the FFG Act for private land, unless listed species are present and the land is declared 'critical habitat' for the species. Protected flora are all listed species, species which belong to listed communities, and other species which have been included on the protected flora list, managed by the DELWP. A permit to take Protected Flora will be required the project. Changes to the FFG Act by the *Flora and Fauna Guarantee Amendment Act 2019* have implications for the project including the changes to the Protected Flora list, Threatened List and the obligation on public authorities including Regional Roads Victoria, to consider potential biodiversity impacts.

GUIDELINES FOR THE REMOVAL, DESTRUCTION OR LOPPING OF NATIVE VEGETATION

The *Guidelines for the Removal, Destruction or Lopping of Native Vegetation* (Guidelines 2017) (DELWP 2017e) have been designed to manage the risk to Victoria's biodiversity associated with the removal of native vegetation. The Guidelines have been incorporated into the Victoria Planning Provisions and all Planning Schemes. The assessment pathways are classified as:

- Basic – limited impacts to biodiversity
- Intermediate – could impact on large trees, endangered EVCs and/or sensitive wetlands or coastal areas
- Detailed – could impact large trees, endangered EVCs, sensitive wetlands and coastal areas and could significantly impact on habitat for rare and threatened species.

The project will be assessed under the Detailed pathway and require native vegetation offsets calculated in accordance with the Guidelines 2017.

WILDLIFE ACT 1975

The *Wildlife Act 1975* is the primary legislation in Victoria for the protection of wildlife. The Act requires that wildlife research (including fauna salvage and translocation) is regulated through a permit system, which is managed by the DELWP. Any persons involved in fauna removal, salvage capture or relocation of fauna during mitigation measures must hold a current Management Authorisation under the *Wildlife Act 1975*.

Fauna salvage and relocation will be required for the project.

CATCHMENT AND LAND PROTECTION ACT 1994

Under the CaLP Act declared noxious weeds are categorised depending on their known and potential impact and specific circumstances for each region. The CaLP Act provides the legislative framework to prevent the unlawful transport and spread of declared noxious weeds. The study area supports six regionally controlled (C), eight restricted (R) and no regionally prohibited (P) weeds. It is the responsibility of the landowner to control these weeds on their property and on adjacent roadside reserves. Six of these weed species are also listed as Weeds of National Significance by the Australian Government.

Most of the significant weeds were recorded along roadsides and private land in the study area. Controlling their spread during construction will be required.

EXISTING CONDITIONS

FLORA

A total of 471 vascular plant species were recorded in the study area during the field surveys, combined with other studies and VBA records, of which 350 (74%) were native and 121 (26%) introduced species.

SIGNIFICANT FLORA SPECIES

Nine significant flora species have been recorded in the study area during surveys in 2015–2018, many of which were not previously recorded prior to studies for the Beaufort Bypass including:

- Matted Flax-lily *Dianella amoena* (EPBC Act and FFG Act listed; endangered in Victoria) – **new record for region**
- Floodplain Fireweed *Senecio campylocarpus* (rare in Victoria) – **new record for region**
- Ben Major Grevillea *Grevillea floripendula* (EPBC Act and FFG Act listed; vulnerable in Victoria)
- Yarra Gum *Eucalyptus yarraensis* (rare in Victoria)
- River Swamp Wallaby-grass *Amphibromus fluitans* (EPBC Act) – **new record for region**
- Pale-flower Cranesbill *Geranium sp. 3* (rare in Victoria) – **new record for region**
- Rosemary Grevillea *Grevillea rosmarinifolia* (rare in Victoria)
- Ornate Pink Fingers *Caladenia ornata* (EPBC Act and FFG Act listed; vulnerable in Victoria) – **new record for region**
- Emerald-lip Greenhood *Pterostylis smaragdyna* (rare in Victoria).

One species Rough Wattle *Acacia aspera subsp. parviceps* (rare in Victoria) was not found during surveys, despite repeated searches, but was previously recorded in the Victorian Biodiversity Atlas (VBA) in the Snow Gums Bushland Reserve in 1993.

VEGETATION AND THREATENED ECOLOGICAL COMMUNITIES

There are extensive areas of cleared land throughout the study area in a mosaic with large patches of native vegetation, unimproved pasture with >25% perennial native vegetation and areas of plantations. Seventeen Ecological Vegetation Classes (EVCs) were mapped within the study area, the majority of which are considered endangered within the Central Victorian Upland and/or Victorian Volcanic Plain bioregions.

Two EPBC Act listed critically endangered ecological communities, *Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains* and *White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Grasslands* were mapped in the study area. One FFG Act community, *Victorian Temperate Woodland Bird community*, was also recorded.

FAUNA

A total of 160 native fauna species were recorded in the study area across all survey programs conducted by WSP, GHD 2015 and previous records from the VBA.

SIGNIFICANT FAUNA SPECIES

Six significant fauna species have been recorded in the study area during surveys in 2015–2018:

- Golden Sun Moth (EPBC Act and FFG Act listed; critically endangered in Victoria) – **new record for study area**
- Brown Toadlet (FFG Act listed; endangered in Victoria)
- Brush-tailed Phascogale (FFG Act listed; vulnerable in Victoria)
- Brown Treecreeper (near threatened in Victoria)
- Brolga (FFG Act listed; vulnerable in Victoria)
- Eastern Long-necked Turtle (data deficient in Victoria).

Despite not being recorded during current surveys for this assessment, there are records from previous studies and the VBA within the study area for a further 15 significant fauna species. Of these species, six have been assessed as highly likely to occur based on the availability of suitable habitat in parts of the study area. This includes the following:

- Growling Grass Frog (EPBC Act and FFG Act listed; endangered in Victoria)
- Powerful Owl (FFG Act listed; vulnerable in Victoria)
- Little Galaxias – closely related Dwarf Galaxias (EPBC Act and FFG Act listed)
- Painted Honeyeater (EPBC Act and FFG Act listed; vulnerable in Victoria)
- Hardhead (vulnerable in Victoria)
- Diamond Firetail (FFG Act listed; near threatened in Victoria).

Fauna habitat values within the study area include:

- wetlands throughout the Yam Holes Creek floodplain
- woodlands and forests along roadsides
- scattered trees throughout some agricultural areas
- forested hills throughout Camp Hill State Forest, Snow Gums Bushland Reserve and private land throughout the study area
- native and derived grasslands
- ecological connectivity throughout the study area includes extensive core areas, some stepping stones and a network of terrestrial and waterway linkages throughout the study area. The terrestrial linkages on roadsides, rail corridors and all linear reserves as well as the waterway linkages provide important functions throughout the otherwise moderate to heavily cleared landscapes in lower lying areas along Yam Holes Creek.

IMPACT ASSESSMENT FOUR ALIGNMENT OPTIONS

The impact assessment of the four options allowed for comparison of the specific impacts that would likely result from the project.

ALIGNMENT OPTION FOOTPRINTS

The EES includes consideration of two main alignment options, each with two variations, and the selection and approval of a preferred bypass alignment.

The four route options are identified as:

- Option (A0)
- Option (A1)
- Option (C0)
- Option (C2).

CONSTRUCTION IMPACT FOOTPRINT

For the purpose of the impact assessment of the four options, a nominal construction impact footprint was determined by using the outer limit of the road functional design for each alignment. The footprint includes pavement surfaces, batters, cuttings, and bridges with a 10 m buffer either side of the design, as advised by RRV, to account for the construction of the road. Approximate total construction footprint widths range from 100–150 m, with wider sections at interchanges. The construction footprint is used to determine the extent of the impacts for native vegetation, trees, fauna habitat and communities.

Tree Protection Zone (TPZ) impacts were considered for any large trees in close proximity (15 m) to the current construction footprint. Any tree with >10% TPZ impact was considered lost for the purpose of the current assessment. Feature survey and arborist assessments are recommended during the detailed design phase to allow more detailed determination of impacts on all trees and to inform detailed impact minimisation on trees.

The definition of the construction footprint is intended to provide a realistic indication of likely impacts at the functional design phase.

NATIVE VEGETATION

Native vegetation was assessed using the classifications of 'patch' and 'scattered tree' under *Guidelines for the removal, destruction or lopping of native vegetation* (hereafter Guidelines 2017) (DELWP 2017e). The total amount of mapped EVCs (i.e. patches only) assumed impacted for each alignment are 58.15 ha (A0), 57.80 ha (A1), 58.88 ha (C0) and 47.06 ha (C2). There is a clear distinction between the impacts on native vegetation on the alignment options, with C0 having the highest impact, followed closely by A0 and A1. C2 clearly has lower levels of impacts on native vegetation. There is a similar trend with the FFG Act listed Victorian Woodland Bird Community where A0, A1, C0 have similar impacts (ranging between 37.59 and 38.43 ha) and C2 has the lowest impact (31.56 ha).

The results of the assessment using the *Assessors Handbook* highlighted a similarity in Strategic Biodiversity Value (SBV) score across all four alignment options. The breakdown of native vegetation according to Ecological Vegetation Class Bioregional Conservation Status (EVC BCS) showed more variation across each alignment. Option C2 was identified as having the lowest impact on total native vegetation loss at 49.54 ha. Alignment C2 also had the lowest impact on endangered EVCs.

NATIVE TREES

For impacts on large trees in patches and large and small scattered trees assessed as per the Guidelines 2017, alignment A0 has the highest number of trees proposed for removal (396 trees, with the majority (98%) of those large trees). This is followed by A1 with 374 trees, then C0 with 322 trees. The alignment with the lowest tree impacts is C2 with 317 trees. Whilst C2 has the lowest tree impact, all alignments would remove a significant number of large trees.

THREATENED ECOLOGICAL COMMUNITIES

Three alignments A0, A1, and C2 would have a low level (0.06 ha) of impact on the EPBC Act listed community Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains, whereas C0 would impact 2.58 ha. This is potentially a significant impact under the EPBC Act. Alignments A0 and C0 may have significant impacts on the EPBC Act listed community White box – Yellow Box – Blakely's Red Gum Grassy Woodland, whereas alignment A1 would have a substantially lower impact (0.65 ha) and C2 would not directly impact any of this community. Impacts to the FFG Act listed Victorian Woodland Bird Community are described under Native Vegetation above.

SIGNIFICANT SPECIES

Flora – impacts are based on actual records:

- No impact on the following flora species is expected as there are no recorded individuals recorded within any alignments: Emerald-Lip Greenhood, Floodplain Fireweed, Ben Major Grevillea, Pale-Flower Cranesbill, Rosemary Grevillea and Rough Wattle.
- There may be impacts on the following species, depending on the proposed road alignment as these species have been recorded within the 250 m wide study alignments: Matted Flax-Lily, Yarra Gum, River Swamp Wallaby-grass and Ornate Pink Fingers. For both Matted Flax-Lily and River Swamp Wallaby-grass, the alignments with the highest to lowest level of impact in order are C0 then similar for A0, A1 and C2. For Yarra Gum, all alignments may impact on similar numbers (two to three trees each). For Ornate Pink Fingers, both A0 and A1 have the greatest impact, whereas C0 and C2 avoid all records.

Fauna – impacts are based on habitat within the construction footprint:

- Waterbird habitat: Only alignment C0 has the potential to impact high-quality waterbird habitat (1.23 ha). The impact on potential medium-quality waterbird habitat is also greatest for alignment C0 at 3.00 ha, followed by alignment A0, C2 and A1 with 2.00 ha, 0.71 ha and 0.58 ha respectively.
- Woodland habitat: The potential impact to woodland bird habitat is lowest for alignment C2 at 29.25 ha, whilst impacts for alignments A0, A1 and C0 are comparable, ranging between 34.67 ha to 35.29 ha.
- Growling Grass Frog habitat: The potential impact area (high and medium quality habitat combined) is highest for alignment C0 at 2.88 ha. Impacts for alignments A0, A1 and C2 are comparable, ranging between 0.81 ha and 1.24 ha. Potential impact areas of Growling Grass Frog terrestrial habitat, defined as a 200 m buffer from aquatic habitat (DEWHA 2009c), are smallest for alignment C0 at 62.23 ha (high and medium quality combined). This is closely followed by alignments A0, A1 and C2 which have a potential terrestrial habitat loss of 65.23 ha, 69.02 ha and 77.84 ha respectively.
- Brown Toadlet habitat: The potential impact area is below 2 ha for alignments A0, A1 and C2. Alignment C0 is likely to have the biggest impact with a potential loss of 3.20 ha of Brown Toadlet habitat.
- Arboreal mammal habitat: The potential area of impact (high and medium quality combined) is anticipated to be smallest for alignment C2 at 15.06 ha. The anticipated impact associated with alignment A0, A1 and C0 are comparable, ranging between 20.37 ha and 22.39 ha.
- Golden Sun Moth habitat: The potential area of impact (combined confirmed habitat and high and low quality potential habitat) is comparable across all alignments; 13.91 ha (C2), 14.06 ha (A1) 15.47 ha (C0) and 15.48 ha (A0). It is worth noting that alignment A0 has the largest impact on confirmed Golden Sun Moth habitat at 3.28 ha, while the impact on confirmed Golden Sun Moth habitat for alignments A1, C0 and C2 ranges between 1.40 ha and 1.73 ha.
- Little Galaxias: The potential impacts are similar across all four alignments, each intersecting between 5 and 7 creek crossings which are mapped as areas of potential habitat. The only exception is alignment C0 which also intersects one large wetland.

ECOLOGICAL CONNECTIVITY IMPACTS

An initial connectivity assessment was undertaken in GIS by using definitions including core area, stepping stones, nodes and corridors, to produce a digital interpretation of structural connectivity. Alignments A0, A1 and C0 were found to have similar total impacts on structural connectivity, with C2 having a lower impact. A0 and A1 would impact the highest amounts of core area, whereas C0 and C2 impact on considerably less, with C2 impacting the least amount of core area. Impacts on nodes are low across all alignments. Impacts on stepping stones are similar for A0 and A1, however, C0 would have double the impact as the A alignments and C2 has the highest impacts on stepping stones. Terrestrial and wetland and riparian corridors are relatively similar across all alignments with exception of C0 which has more than double the impacts than other alignments on wetland and riparian corridors.

Following this, WSP commissioned experts at the University of Nottingham (UoN) to undertake a more indepth assessment of current and future levels of connectivity for wildlife in response to the proposed bypass. The assessment used state-of-the-art modelling approaches to assess the potential effect of the bypass on landscape connectivity for five different conservation targets (i.e. species) which were selected to represent a diversity of species that occur in the study area. The connectivity modelling assessment found that all four alignment options reduced the connectivity in the landscape which is a combined result of habitat loss for the construction of the bypass and the creation of barriers to movement. Overall, alignment option C2 was modelled to have the least impact on connectivity for three of the conservation targets. For the remaining two conservation targets, the differences between the four alignments on connectivity was likely to be negligible.

THREATENING PROCESSES

The project has the potential to exacerbate several threatening processes listed under the EPBC Act or FFG Act. For all alignments, the project involves the loss of large trees and native vegetation which increases habitat fragmentation and may advantage Noisy Miners and Red Foxes. Clearing may also provide opportunities for weeds and soil pathogens to establish within the area and can increase the amount of sediment run off and toxic substances entering waterways resulting in wetland loss and/or degradation. Most of these will be managed through standard controls. Some vegetation clearing is unavoidable.

When comparing alignment options, the total number of EPBC Act threatening processes which are applicable to each alignment are the same. Regarding FFG Act threatening processes, alignment C2 ranks second, with 17 of the 28 threatening processes being applicable to the alignment.

CUMULATIVE IMPACTS

Cumulative impact assessments aim to consider the effects of effects of multiple actions or impacts on the environment. An assessment of cumulative impacts was undertaken for specific threatened species and ecological communities determined to have a moderate or higher likelihood of occurrence within the Beauport Bypass study area. The assessment was carried out for each of the four Beaufort Bypass alignment options in conjunction with four other projects currently underway or completed within a 20 km radius, an area defined as the Cumulative Impact Assessment Area (CIAA). The additional projects included in the assessment are outlined below:

- Stage 1 of the Western Highway Upgrade (Burrumbeet to Beaufort)
- Stage 2A of the Western Highway Upgrade (Beaufort to Buangor)
- Stage 2B of the Western Highway Upgrade (Buangor to Ararat & Buangor Bypass); and
- Stockyard Hill Wind farm.

In addition to the CIAA, the assessment considered the impacts at three other spatial scales including the State of Victoria, the Central Victorian Uplands Bioregion and the Victorian Volcanic Plains Bioregion.

The results of the analysis indicated that the combined impacts of the five projects within the CIAA were unlikely to result in a significant cumulative impact on any of the species or communities included in the assessment. However, the combined impacts of the five projects could potentially result in a minor cumulative impact on native vegetation and on some species. Those likely to be impacted by the Beaufort Bypass include; Yarra Gum, Brolga, Brown Toadlet and Golden Sun Moth.

OPTIONS ASSESSMENT

An options assessment was completed by RRV for the project, which assessed alignment options A0, A1, C0 and C2 against the customised set of criteria.

The alignment scoring scenarios show that the best performing option is the C2 Alignment, while the worst performing options are the A0 and C0 Alignments. The primary drivers for this outcome were due to the C2 alignment having the:

- lowest amount of total native vegetation clearance
- least impact on threatened ecological communities identified under the EPBC Act and FFG Act
- least impact on wildlife corridors, particularly the core habitat areas
- lowest amount of native vegetation with high conditions to be removed by Ecological Vegetation Class (EVC) Bioregional Conservation Status
- lowest potential impacts on known or registered sites of Aboriginal and historic heritage significance
- smallest number of dwellings within 100 m, 200 m and 300 m of the alignment corridor.

IMPACT ASSESSMENT PREFERRED ALIGNMENT

Following the selection of the preferred alignment through the options assessment process, detailed flood modelling has been undertaken to provide a more thorough assessment of impacts, complement and support the options assessment process and to further inform the extent and duration of surface water impacts. The modelling has enabled further assessment of flora and fauna impacts resulting from changes to the surface water regime. Refinement of the construction footprint has also been developed post options assessment, to include creek realignments to account for modelled surface water impacts, refinements in design and ensure the full extent of flora and fauna impacts are documented. The revised C2 construction footprint includes a 5 m buffer around the creek realignments, which were not included in the indicative early construction footprints for options assessment, meaning that it is a slightly larger area than that assessed previously (and reported on above). The impact totals are therefore different in the preferred alignment section to what was quoted for C2 during the options assessment.

NATIVE VEGETATION AND TREES

The total amount of mapped EVCs (i.e. patches only) assumed impacted for the preferred C2 alignment (November 2020 refined construction footprint) is 47.950 ha.

The preferred alignment C2 (November 2020 refined construction footprint) impacts 327 large trees in patches, 21 large scattered trees and seven small scattered trees, defined and assessed as per the Guidelines 2017.

THREATENED ECOLOGICAL COMMUNITIES

The preferred alignment C2 would have a low level (0.312 ha) of impact on the EPBC Act listed community Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains. The preferred alignment C2 would not directly impact White box – Yellow Box – Blakely's Red Gum Grassy Woodland. Impacts to the FFG Act listed Victorian Temperate Woodland Bird Community are calculated as 32.800 ha.

SIGNIFICANT SPECIES

Four threatened flora species were recorded within the study area for the C2 alignment. Two species are listed under the EPBC Act. Of the species recorded, one Yarra Gum, one Matted Flax-lily and one patch of River Swamp Wallaby-Grass are likely to require removal based on the current construction footprint.

The following fauna species have been recorded as impacted as a result of the preferred C2 alignment.

Wetland Birds:

- The C2 footprint will impact 1.52 ha of medium quality wetland bird habitat, no direct impacts on high quality wetland habitat is proposed.

Woodland birds:

- The C2 footprint impacts 32.800 ha of woodland habitat which could potentially impact woodland bird species.

Amphibians:

- Growling Grass Frog: There are likely to be impacts to 0.281 ha of high quality aquatic potential habitat and 17.285 ha of associated terrestrial habitat, as well as 1.132 ha of moderate quality aquatic potential habitat with 68.179 ha of associated terrestrial habitat (excluding overlap with potential terrestrial habitat associated with high quality aquatic). Potential terrestrial habitat is conservatively estimated using a 200 m buffer of potential aquatic habitat.
- Brown Toadlet: 1.680 ha of potential habitat for Brown Toadlet will be impacted based on the current construction footprint.

Fish:

- Little Galaxias does not have a known permanent population within the C2 alignment, however, has a high likelihood of occurrence within the alignment in Yam Holes Creek and its tributaries, particularly during flood events. The current construction footprint intersects 2.011 km of waterways that could be potential habitat for this species and would require seven creek crossings.

Arboreal mammals:

- The construction footprint is likely to impact 6.985 ha of moderate quality habitat for Brush-tailed Phascogale and 15.598 ha of high-quality habitat (Total: 22.583 ha).

Invertebrates:

- Based on the current construction footprint, 1.672 ha of confirmed Golden Sun Moth habitat is likely to be impacted along with 9.431 ha of higher quality potential habitat and 2.822 ha of lower quality potential habitat.

LOSS OF CONNECTIVITY

The preferred C2 alignment will have the least negative impacts on connectivity of the proposed alignments assessed, however, substantial impacts are still likely without mitigation. An impact severity of High is attributed to loss of connectivity without mitigation.

OTHER IMPACTS

Other impacts assessed in this report include:

- mortality and injury of wildlife during construction and operation
- habitat degradation from increased disturbance due to:
  - noise impacts
  - light impacts
  - visual disturbance
- habitat degradation from physical changes including:
  - weeds and disease
  - rubbish
  - erosion, sedimentation, and water pollutants
  - hydrological changes (surface water, groundwater unlikely to be affected)
  - air quality and dust.

Highest potential impacts without mitigation include surface water changes, and injury and mortality of fauna, however mitigation for all assessed potential impacts except for groundwater will be required.

THREATENING PROCESSES

Threatening processes identified within the assessment of the four options remain applicable to the preferred C2 alignment.

CUMULATIVE IMPACTS

Cumulative impacts identified within the assessment of the four options remain applicable to the preferred C2 alignment.

AVOIDANCE, MINIMISATION, MITIGATION AND OFFSETS

There is considerable native vegetation and fauna habitat known to support Commonwealth and Victorian listed species and communities within and adjacent to the current alignment options. The preferred alignment selection and design within the alignment will be based on avoiding and minimising impacts on vegetation and fauna habitat where possible.

A range of measures are provided in this report which aim to avoid, reduce and/or mitigate potential impacts to threatened species and their habitat identified within the report. Detailed design of mitigation measures will be required once the preferred alignment is approved and as part of the detailed design phase for the project.

AVOID AND MINIMISE

A key tenet of the Guidelines 2017 is the requirement to *avoid and minimise* impacts to native vegetation; this principal is also common to relevant legislative instruments such as the EPBC Act and the FFG Act. The principal is that priority should be given to avoidance, then minimisation, then mitigation, and lastly offsetting, and that this process should be considered early in the design of the project.

The process to avoid and minimise impacts through the functional design development, preliminary planning and options analysis (detailed in Section 10.1) included:

- road corridor analysis to consider a range of feasible alternatives by incorporating engineering design principles with constraints and environmentally sensitive areas. This utilised Trimble Quantum planning software tool (http://www.trimble.com/Alignment/Index.aspx) along with workshops to optimise assumptions made
- development of new alignments (C alignments) to provide alignment option to minimise impacts through areas such as Camp Hill State Forest
- modification of alignment options to avoid all known occurrences of Ben Major Grevillea plants and all previous Guidelines 2013 modelled Ben Major Grevillea habitat, as this is one of the most significant species in the study area
- modification of alignment to avoid a number of wetlands, areas of threatened ecological communities and threatened species habitat
- micro-alignment of functional designs in several areas to avoid and minimise impacts to isolated paddock trees (or scattered trees).

It is anticipated that there will continue to be opportunities to further avoid and minimise impacts during subsequent detailed design and pre-construction phases of the project. Contractual arrangements, once the project receives funding would incentivise further avoidance and minimisation of impacts for contracting parties, throughout the construction phase. Further opportunities to avoid and minimise impacts are identified in this report.

MITIGATION MEASURES

The mitigation measures provided in the report have been tailored in response to the identified impacts. The measures have been developed to mitigate specific impacts to species and communities listed under the EPBC Act and FFG Act, native vegetation (Guidelines 2017), flora, vertebrate fauna and invertebrate fauna listed under the relevant DELWP Advisory lists, and wildlife protected under the *Wildlife Act 1975*.

The mitigation measures include both standard construction and operation controls established by RRV, with additional detail or additional measures targeted to the specific significant values associated with the C2 alignment (November 2020 refined construction footprint).

A range of innovative solutions (informed by current research and expert opinion), to mitigate the less direct impacts of the project (habitat fragmentation, light, noise, etc.) have been presented for the preferred C2 alignment. Appropriate mitigation strategies will take place and target species for each specific location/type of structure including barrier structures, wildlife crossing structures and structures for waterway connectivity, a land bridge, open span bridges, fauna-sensitive lighting, habitat creation, landscaping and revegetation, and measures during construction.

RESIDUAL IMPACTS

Following the implementation of the identified mitigation measures, residual impacts for the flora and fauna identified in the assessment range from low to high subject to nature, extent and duration of impact on the identified flora and fauna.

Direct impacts to vegetation and habitat resulting from construction have high residual impacts. Whereas identified impacts during operation, related to connectivity, noise and vibration, light pollution, visual impacts and physical habitat disturbance and modification are low when identified mitigation measures are implemented.

Residual impacts to fauna are highly dependent on the mobility and habitat of the specific fauna species. There is currently expected to be a high residual impact on Golden Sun Moth the extent of unavoidable removal of confirmed and high quality potential habitat. There is expected to be low residual impacts on the remaining terrestrial and aquatic flora and fauna species and ecological communities following implementation of the detailed mitigation measures.

With the measures recommended in the Surface Water Impact Assessment (WSP 2021) and in this report, the residual impact of changes in surface water hydrology on aquatic vegetation and habitat is likely to be low.

OFFSETS

STATE OFFSETS

State offsets will be required for native vegetation and habitat under the Guidelines 2017. Based on the current (November 2020) refined construction footprint for the preferred C2 alignment, 2.041 general habitat units are likely to be required, as well as species offsets for three species:

- 27.002 specific units of habitat for Ben Major Grevillea, *Grevillea floripendula*
- 32.250 specific units of habitat for Emerald-lip Greenhood, *Pterostylis smaragdyna*
- 28.002 specific units of habitat for Rough Wattle, *Acacia aspera subsp. parviceps.*

The offset will also need to protect 348 large trees.

The feasibility to secure all state offsets are considered likely given the confirmed availability through offset brokers and extent of modelled habitat coverage. Offsets need to be secured prior to commencement of construction.

FEDERAL OFFSETS

Based on the information available in the referral under the EPBC Act, it was considered that the proposed action is likely to have a significant impact on but not limited to Golden Sun Moth. As such, the EPBC Act Environmental Offsets Policy (DSEWPaC 2012a) will apply as residual impacts on Golden Sun Moth remain significant, even after mitigation.

The impact on Golden Sun Moth habitat is estimated to be 13.925 ha. The feasibility to secure offsets for Golden Sun Moth are considered likely given the confirmed availability through offset brokers and extent of modelled habitat coverage. Once an offset site/s are identified and confirmed, and the values confirmed in the EPBC Offset Calculator with DAWE, a Site Offset Management Plan will need to be prepared and sent to DAWE for endorsement. Offsets need to be secured prior to commencement of construction.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the following people and organisations:

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- John Vranjic and Mark Bourne (the then Department of the Environment and Energy, Ecological Communities Section) for review of Commonwealth listed communities.
- Inka Veltheim – PhD Candidate (Brolga study), Federation University.
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- Tim D'Ombrain, Biodiversity Services Pty Ltd for provision of biodiversity assessment reports.
- Ray Draper – ecological consultant, Central Highlands Environmental Consultancy.
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1 INTRODUCTION

Regional Roads Victoria (RRV), formerly VicRoads, proposes to construct a new freeway section of the Western Highway to bypass the town of Beaufort (the project), linking completed sections of the Western Highway duplication to the east and west of Beaufort.

On 22 July 2015, the Minister for Planning determined an Environment Effects Statement (EES) would be required under the *Environment Effects Act 1978* (EE Act) to assess the potential environmental effects of the project. The EES includes consideration of four alternative alignments and selection of a preferred bypass alignment which identifies the land to be reserved for the future construction. The EES process provides for identification and analysis of the potential environment effects of the project and the means of avoiding, minimising and managing adverse effects. It includes public involvement and allows stakeholders to understand the likely environmental effects of the project and how they will be managed.

This flora and fauna impact assessment addresses the Biodiversity EES scoping requirements and assesses impacts on flora and fauna from the project.

1.1 PROJECT BACKGROUND

The Western Highway is the primary road link between Melbourne and Adelaide. It serves interstate trade between Victoria and South Australia and is a key transport corridor through Victoria's west. Over 6,500 vehicles utilise the Western Highway, west of Ballarat each day. Of these 6,500 vehicles, 1,500 are classed as commercial heavy vehicles. These traffic volumes are expected to increase to approximately 7,500 by 2025 and 9,500 by 2040.

RRV have identified the need to upgrade the Western Highway from Ballarat to Stawell to:

- improve road safety at intersections
- improve safety of access to adjoining properties
- enhance road freight efficiency
- reduce travel time
- provide better access to local facilities
- improve roadside facilities.

As part of planning studies commissioned by the Commonwealth and State Governments, bypass route options around the town of Beaufort have been considered to meet the objectives identified by RRV and the National Land Transport Network's Nation Building Program.

The project would include construction of a dual carriageway, connections to major intersecting roads, interchanges to connect Beaufort to the Western Highway at the eastern and western tie-in points, several waterway crossings, an overpass of the Melbourne-Ararat rail line, and intersection upgrades at local roads and provision for service roads as required.

1.2 PROJECT OBJECTIVES

The objectives of the project are to:

- improve road safety and maintain the functionality of Beaufort's road network
- improve freight movement and efficiency across the road network
- improve Beaufort's amenity by removing heavy vehicles
- improve access to markets and the competitiveness of local industries.

2 PROJECT DESCRIPTION

The project would comprise of an 11 km freeway standard bypass to the north of the township of Beaufort, connecting the two recently duplicated sections of the Western Highway to the east and west of Beaufort. The project would be constructed under a Design and Construction or Construction contract administered by a superintendent at RRV/MRPV, following a competitive tender process. Department of Transport would manage and maintain the asset.

2.1 FREEWAY STANDARD BYPASS

The project proposes to connect the duplicated sections of the Western Highway to the east and west of Beaufort via the Option C2 bypass to the north of Beaufort that avoids Snowgums Bushland Reserve and cuts through Camp Hill. The bypass would include the following key components:

- designed as a freeway standard bypass
- approximately 11 km long
- designed to 120 km/hr and sign posted to 110 km/hr for its entirety
- two tie-in interchanges
- one road over rail bridge
- waterway crossings
- diamond interchange to connect with the local road network
- two to three overpass bridge structures over the local road network.

2.2 INTERCHANGES

The project proposes interchanges at the following locations:

- tie-in points to existing Western Highway at the eastern and western ends of the bypass
- diamond interchange at existing local road network connection (Beaufort-Lexton Road).

2.3 BRIDGES AND CULVERTS

The route option would have bridge structures at the following locations:

- road over rail bridge structure for the Melbourne-Ararat rail line
- several waterway bridge structures over Yam Holes Creek
- overpass bridge structures for the existing local road network:
  - Main Lead Road
  - Beaufort-Lexton Road (diamond interchange)
  - Racecourse Road
  - Back Raglan Road.

2.4 ALIGNMENT DESCRIPTIONS

Four alignment options, referred to as Options A0, A1, C0 and C2, were assessed in order to identify a preferred bypass (see Figure 2.1). Following extensive community consultation and technical assessments, Option C2 was selected as the preferred route.

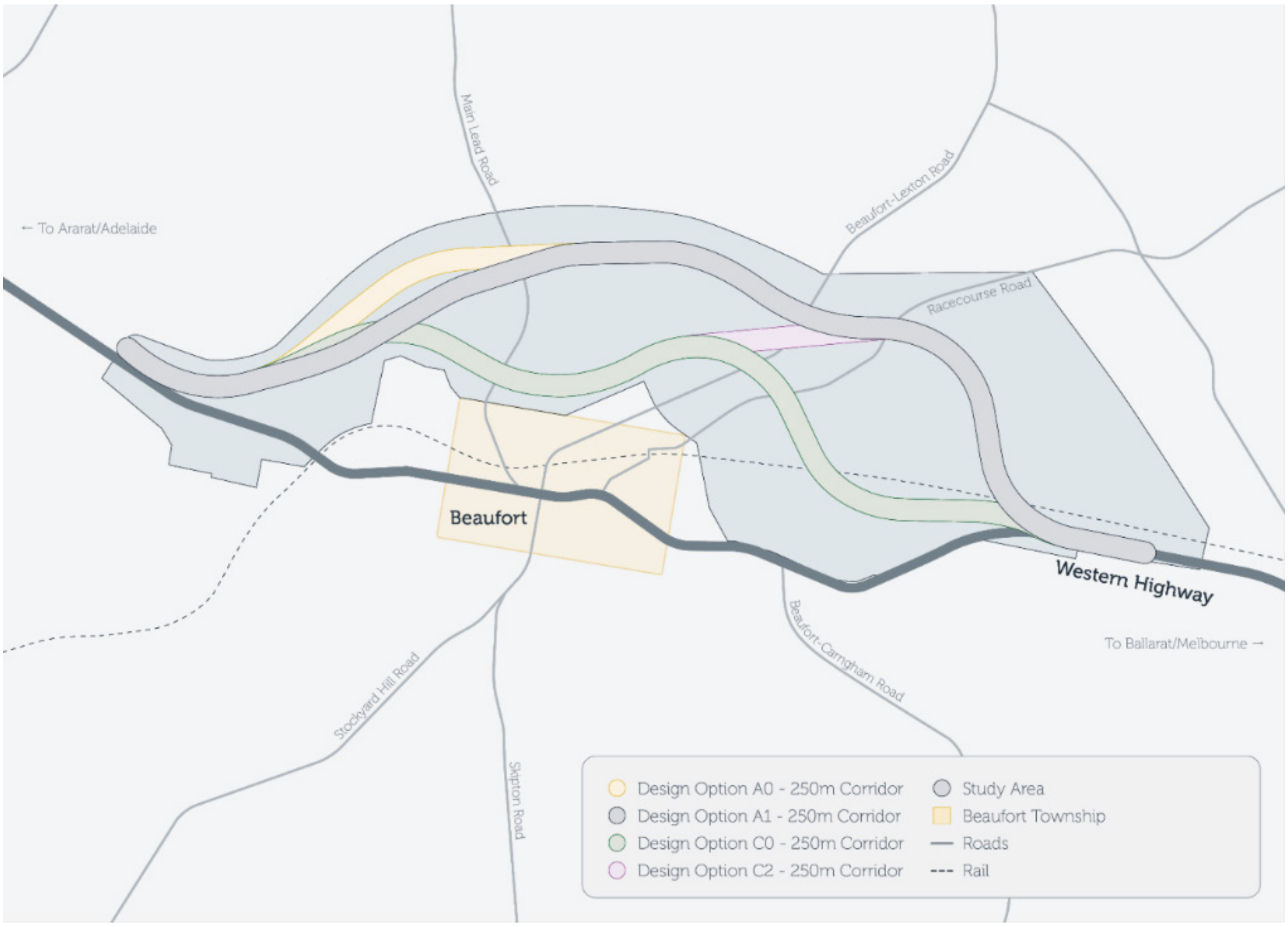


Figure 2.1 Beaufort Bypass alignment options and study area

2.4.1 *OPTIONS ASSESSED*

2.4.1.1 OPTION A0

The A0 bypass alignment is 11.2 km in length and is the northern most bypass option (see Figure 2.2). From the western tie-in point, approximately 3 km from the Beaufort township, this alignment curves north – north east, where there will be a west-facing, half diamond interchange to maintain access to private properties and the township via the existing Western Highway. The alignment passes over Main Lead Road then climbs through the State Forest north of Camp Hill. From here it descends to a full diamond interchange at Beaufort-Lexton Road, which will provide access to the north and south of the township, before re-joining the Western Highway at its eastern extent, approximately 4.5 km from Beaufort. An outbound exit ramp at the eastern interchange will allow for eastern access to Beaufort via the existing Western Highway. Bridges will pass over Main Lead and Racecourse Roads, as well as over the Melbourne-Ararat train line. The main areas of fill occur at bridge and interchange locations with a large cut section north of Camp Hill.

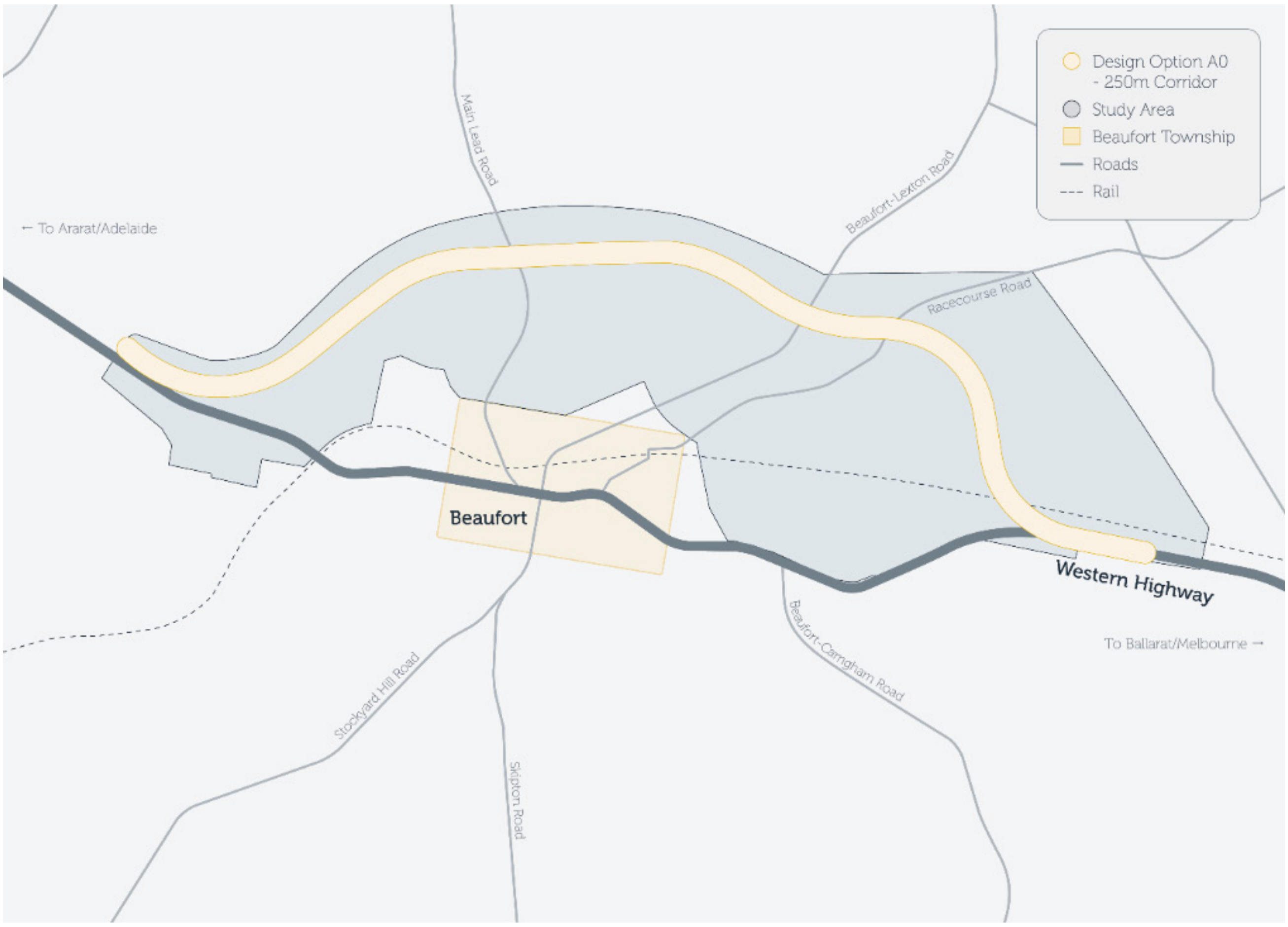


Figure 2.2 Beaufort Bypass A0 alignment option

2.4.1.2 OPTION A1

The A1 bypass alignment option is 11.1 km in length (see Figure 2.3). Approximately 3 km from the Beaufort township, this alignment deviates north-east from the Western Highway, staying slightly south of option A0 until a point east of Main Lead Road, where it re-joins the A0 alignment. There will be a west-facing, half diamond interchange at the western tie-in to maintain access to private properties and the township of Beaufort via the existing Western Highway, and a full diamond interchange at Beaufort-Lexton Road to maintain north-south access. The A1 alignment will re-join the Western Highway approximately 4.5 km to the east of the township. An outbound exit ramp at the eastern interchange will allow for eastern access to Beaufort via the existing Western Highway. Bridges will pass over Main Lead and Racecourse Roads, as well as over the Melbourne-Ararat train line. The main areas of fill occur at bridge and interchange locations, with cuts north-east of Back Raglan Road, and north of Camp Hill.

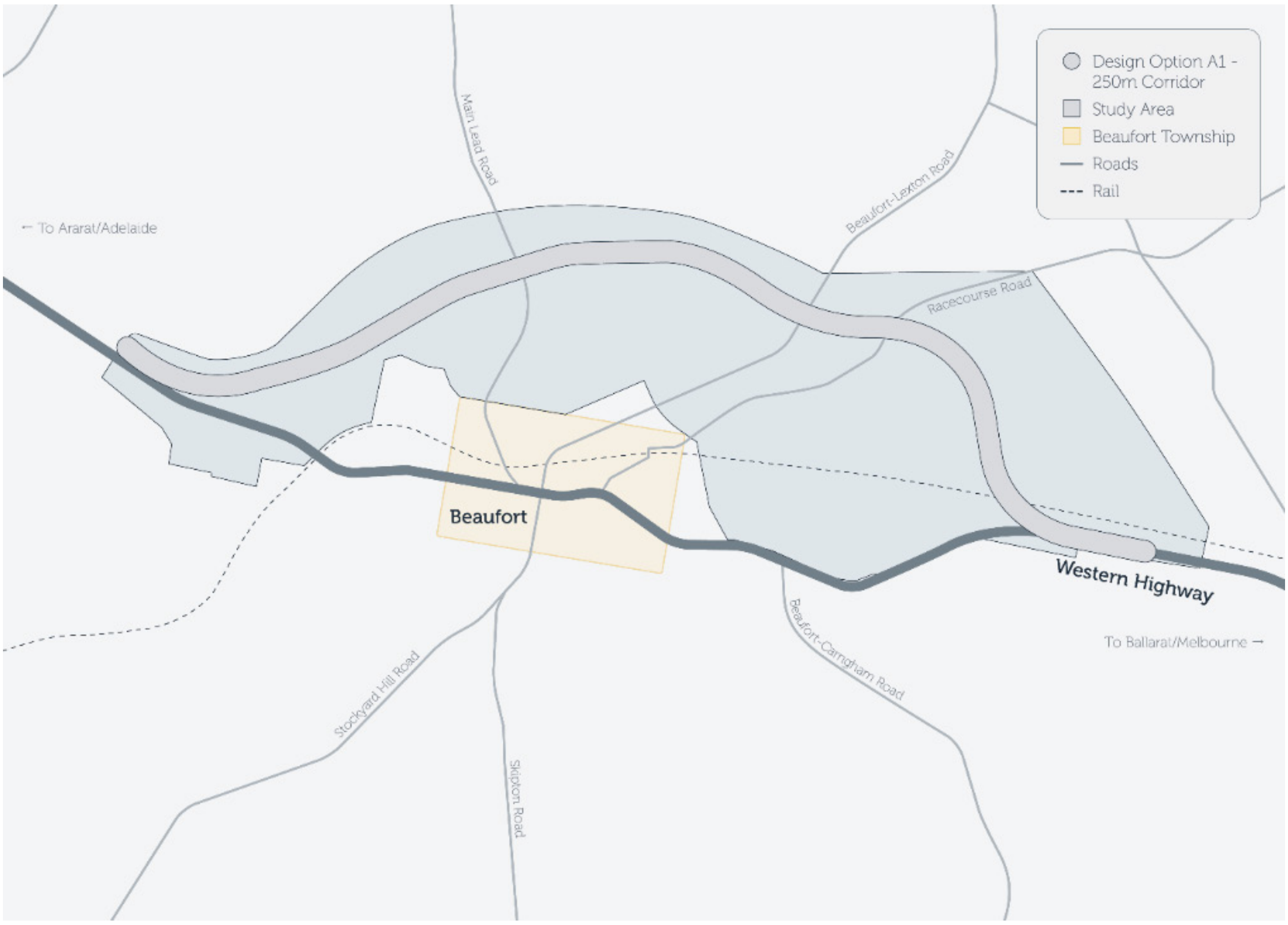


Figure 2.3 Beaufort Bypass A1 alignment option

2.4.1.3 OPTION C0

The southernmost option, C0, is approximately 10.6 km in length from the west to east tie-in points of the Western Highway (see Figure 2.4). Access to the Beaufort township via the existing Western Highway will be maintained by a west -facing, half diamond interchange in the west. The C0 option follows the A0 option from the western tie-in point, approximately 3 km from the Beaufort township, before deviating at Back Raglan Road in a more easterly direction almost parallel to the existing Western Highway. This option passes close to the north of Camp Hill, with some cut and fill required in this section, before curving south-east to a full diamond interchange at Beaufort-Lexton Road, providing north-south access. The C0 alignment will re-join the Western Highway approximately 4.5 km to the east of the township. Bridges will pass over Main Lead and Racecourse Roads, as well as over the Melbourne-Ararat train line. The main areas of fill occur at bridge and interchange locations, with the largest cut and fill areas north and north-east of Camp Hill.

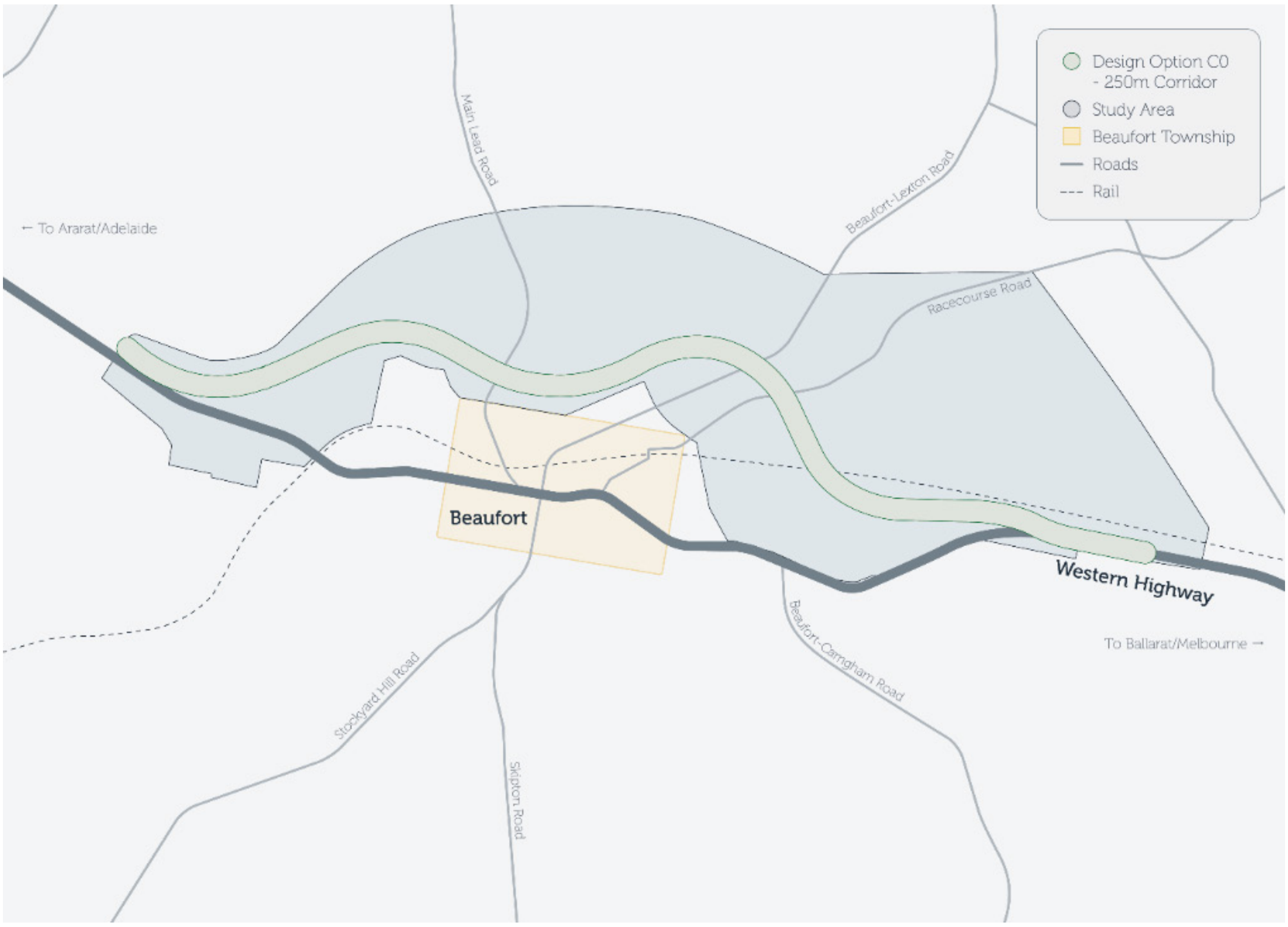


Figure 2.4 Beaufort Bypass C0 alignment option

2.4.2 *PREFERRED ALIGNMENT*

2.4.2.1 OPTION C2

Option C2 is 11 km in length and is a hybrid between the A0 and the C0 options (see Figure 2.5). It follows the C0 option from the western tie-in point (approximately 3 km from the Beaufort township) until Beaufort-Lexton Road, where it continues in an easterly direction and joins the A0 alignment near Racecourse Road. The C2 alignment will re-join the existing Western Highway at the eastern tie-it point, approximately 4.5 km from the township. At the western extent, access to Beaufort via the existing Western Highway will be maintained by a half diamond interchange, and there will be a full diamond interchange over Beaufort-Lexton Road. Access to Beaufort via the existing Western Highway at the eastern approach will be maintained by an outbound exit ramp at the eastern interchange. Again, bridges will pass over Main Lead and Racecourse Roads, as well as over the Melbourne-Ararat train line. The main areas of fill occur at bridge and interchange locations, with the largest cut and fill areas north and north east of Camp Hill.

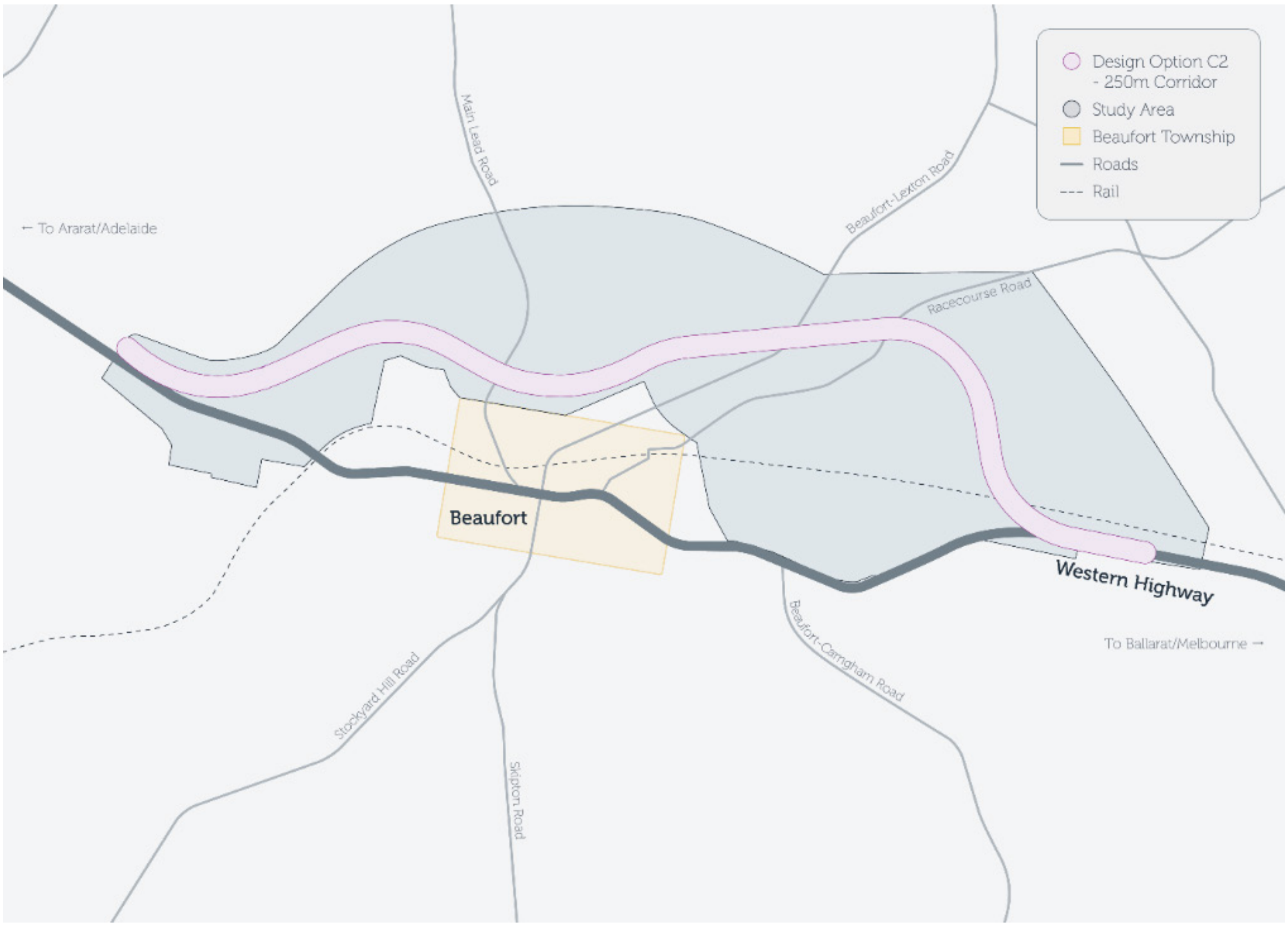


Figure 2.5 Beaufort Bypass C2 alignment option

2.5 PROJECT CONSTRUCTION

The following construction sub-sections describe the construction activities for the project. Construction of the bypass is expected to take two years and commence once construction funding and approvals are obtained.

2.5.1 CONSTRUCTION ACTIVITIES

Construction activities would include:

- preconstruction site delineation and compound setup, which may include (but not be limited to) tree clearance and vegetation lopping/removal, and establishment of construction site(s) and access tracks
- establishment of environmental and traffic controls
- route clearance and relocation and/or protection of utilities
- construction drainage and sediment and erosion control mitigation
- general earthworks:
  - excavation of a cut including stripping of topsoil and placement of fill
  - import, export and stockpiling of fill
  - treatment of contaminated soil or removal of hazardous material, if required
- development of structures, interchanges, batters, drainage and pavement
- development of ancillary infrastructure:
  - noise barriers
  - lighting
  - safety barriers
  - line marking
- landscaping and site reinstatement.

2.6 OPERATIONS AND MAINTENANCE

Operations and maintenance of the project would be consistent with current practices and standards, including the VicRoads' *Roadside Management Strategy* (2011).

Key objectives include:

- asset management of:
  - landscaped areas
  - stormwater drains
  - bridges and culverts
  - road pavement
  - signage
  - barriers
  - line marking
- enhancement of transport safety, efficiency and access
- protection of environmental and cultural heritage values
- management of fire risk
- preservation and enhancement of roadside amenity
- routine and life cycle maintenance activities throughout operations
- monitoring and management of areas of environmental sensitivity such as water bodies and wildlife corridors.

3 EES SCOPING REQUIREMENTS

The *Scoping Requirements for Beaufort Bypass Project Environment Effects Statement* (DELWP 2016b) (Scoping Requirements) have been prepared by DELWP on behalf of the Minister for Planning. The Scoping Requirements set out the specific environmental matters to be investigated and documented in the EES, which informs the scope of the EES technical studies. The following matters of the Scoping Requirements are relevant to the flora and fauna impact assessment:

EES EVALUATION OBJECTIVE

Biodiversity: *To avoid and minimise adverse effects on native vegetation, as well as habitat for threatened flora and fauna species and ecological communities, including those listed under the FFG Act, and address offset requirements for predicted losses consistent with relevant policy.*

Environmental management framework: *To provide a transparent framework with clear accountabilities for managing environmental effects and hazards associated with construction and operation phases of the proposed project, in order to achieve acceptable environmental outcomes.*

Table 3.1 EES scoping requirements – Flora and fauna

SCOPING REQUIREMENTS SUB-SECTION	MATTERS TO BE ADDRESSED	RELEVANT ASSESSMENT	ADDRESSED IN THIS ASSESSMENT
Key Issues	Loss or degradation of native vegetation and habitat for threatened species and communities, including those listed under the FFG Act and DELWP Advisory List.	Flora and fauna impact assessment	✓
	Degradation to local and downstream ecology of aquatic environments.	Flora and fauna impact assessment Surface water impact assessment	✓
	The impact of the road bypass on wildlife movement within continuous vegetation linkages.	Flora and fauna impact assessment	✓
Priorities for characterising the existing environment	Characterise the distribution and quality of biodiversity values that could be affected by the proposed project, including remnant native vegetation, large old trees, terrestrial and aquatic habitat for threatened species and patterns of wildlife movement in the area.	Flora and fauna impact assessment	✓
	Accurately identify remnant vegetation on private and public road reserves using the current definition of native vegetation as outlined in the Victorian Native Vegetation Clearing Guidelines.	Flora and fauna impact assessment	✓
	Identify the existence or likely existence of any threatened species or communities listed under the FFG Act and DELWP Advisory List.	Flora and fauna impact assessment	✓

SCOPING REQUIREMENTS SUB-SECTION	MATTERS TO BE ADDRESSED	RELEVANT ASSESSMENT	ADDRESSED IN THIS ASSESSMENT
	Identify any potentially threatening processes that could result from the proposed project under the FFG Act and any declared weeds or pathogens.	Flora and fauna impact assessment	✓
	This characterisation is to be informed by relevant databases, literature and appropriate seasonal or targeted surveys. In the absence of positive identification of listed species, but where suitable habitat is identified, a precautionary approach to the further investigation of their occurrence should be applied, where practicable.	Flora and fauna impact assessment	✓
Design and mitigation measures	Identify potential and proposed alignment and design alternatives, as well as mitigation measures which could avoid or minimise significant effects on biodiversity values, including native vegetation, large old trees and any listed threatened ecological communities or flora and fauna species.	Flora and fauna impact assessment	✓
	Assessment of the expected or predicted effectiveness of mitigation measures, within the proposed alignment, any statutory or policy basis for the mitigation measures, the proponent's ability to implement these measures as well as monitoring and auditing of effectiveness of the proposed mitigation measures.	Flora and fauna impact assessment	✓
	Assessment of the cumulative effect on biodiversity values and extent of remaining remnant vegetation on a regional scale and the effectiveness of the proposed mitigation measures in addressing regional ecological effects.	Flora and fauna impact assessment	✓
	Identify mitigation measures to avoid or reduce negative impacts on the environment including wildlife movement and connectivity (e.g. suitable fencing and overhead or under-road wildlife crossings including in relation to bridges for waterway crossings).	Flora and fauna impact assessment	✓
Assessment of likely effects	Assess the likely direct and indirect effects of each alignment alternative on wildlife movement and biodiversity values, including native vegetation, large old trees, listed threatened flora and fauna species and ecological communities, including those listed under the FFG Act and DELWP Advisory List.	Flora and fauna impact assessment	✓
Approach to manage performance	Identify proposed offset measures to address requirements for alternatives that may be implemented, in accordance with the Permitted Clearing of Native Vegetation Biodiversity Assessment Guidelines (2013) and the relevant requirements of the Pyrenees Planning Scheme.	Flora and fauna impact assessment	✓
	Provide an offset strategy to address these requirements for the final alignment options examined in the EES, to identify feasibility and availability of offsets.	Flora and fauna impact assessment	✓

SCOPING REQUIREMENTS SUB-SECTION	MATTERS TO BE ADDRESSED	RELEVANT ASSESSMENT	ADDRESSED IN THIS ASSESSMENT
	Identify any additional, proposed measures to manage residual effects on biodiversity values during construction of the proposed project, as part of the EMF.	Flora and fauna impact assessment	✓
	Commit to undertake appropriate management plans.	Flora and fauna impact assessment	✓

4 METHODOLOGY

4.1 STUDY AREA

4.1.1 DEFINITIONS

The terminology utilised throughout the current technical assessment relating to the study area and alignment options is defined below.

Study area: The study area for the Beaufort Bypass EES project includes approximately 1,800 ha of land north of the Beaufort township, which contains the four bypass options assessed in this report. During the development stages of the alignment options, the study area was assessed to determine potential environmental impacts and constraints to individual alignment options.

Alignment options: Alignment options (A0, A1, C0 and C2) refer to the four selected bypass options assessed within the study area. Each alignment option consists of a 250 m corridor in which the specific bypass option has been designed. Each alignment option, unless otherwise stipulated, is the area assessed for direct and indirect impacts resulting from the construction, operation and maintenance of the project during the options assessment process.

Nominal construction footprint (alignment options assessment only): An early nominal construction footprint developed using a 10 m buffer off all road design drawings including earthworks. A nominal construction footprint was defined for each option to allow for the comparison of potential direct impacts on fauna and vegetation.

Construction footprint (preferred alignment): For the preferred alignment (C2) an updated construction footprint was defined for calculation of impacts. This footprint, dated November 2020, is the area within which impacts on ecological values are assumed to occur. This is different from the early nominal footprint defined for the comparison of the four alignments as it includes areas required for refinements in design and creek realignments, calculated using a 5 m buffer off the creek realignment area. See figure below.

Project area (preferred alignment only): Also termed the Specific Controls Overlay (SCO). The project area is slightly different from the 250 m alignment option corridor described above, as it has been widened slightly in some areas from the original C2 alignment option to include all potential impacts of the project. It has a minimum of 30 m buffer from the functional design edge. A 300 ha footprint for construction and ancillary facilities for the project, within which the construction footprint occurs. Significant ecological values (including native vegetation and habitat for MNES) outside the construction footprint but within the project area will be protected by No-Go Zones.

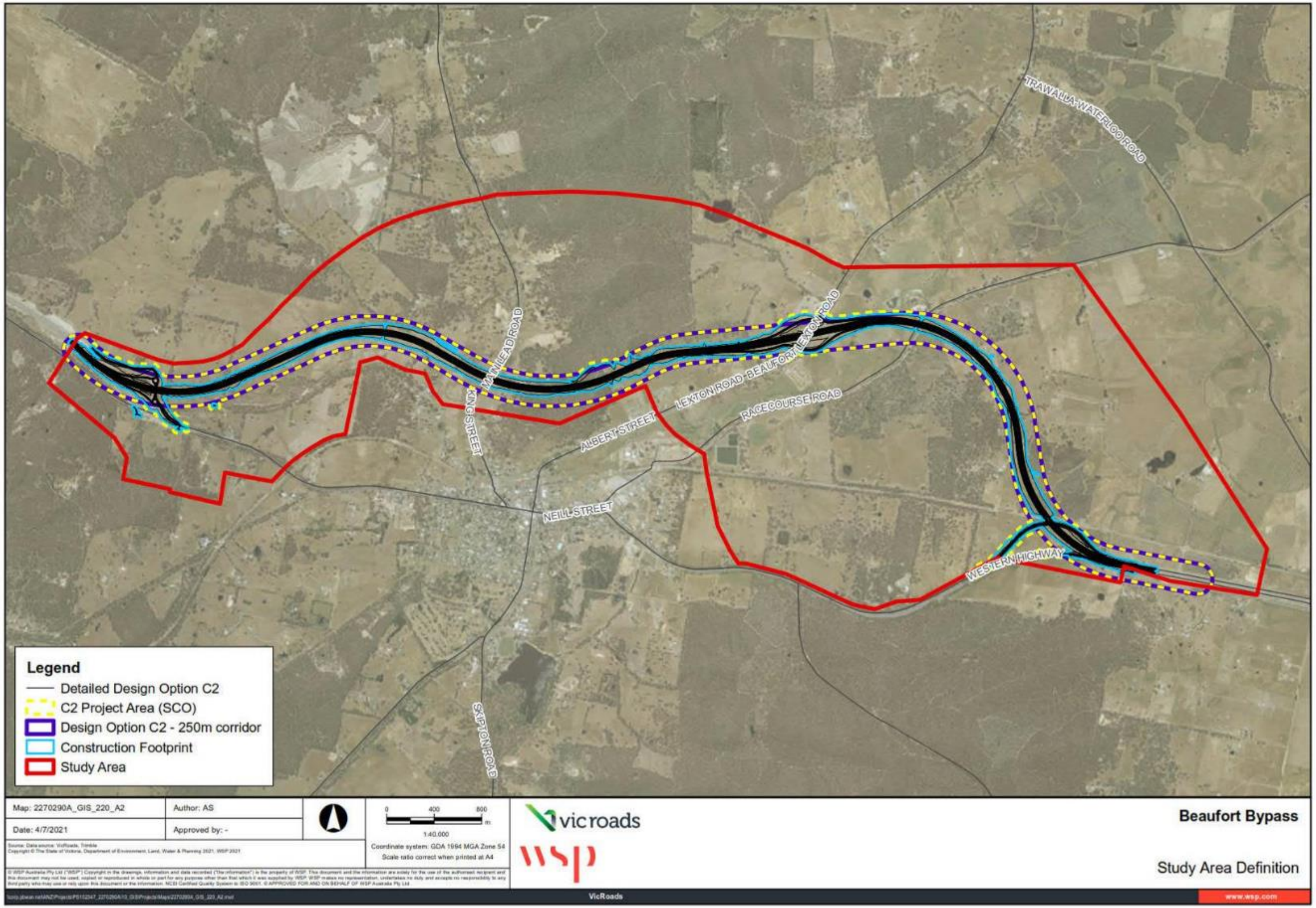


Figure 4.1 Study area and other relevant areas

4.2 PERSONNEL

Table 4.1 Contributors and their roles

NAME	QUALIFICATIONS	ROLE
Nic McCaffrey	BSc (Natural Resource Management)	Principal Ecologist – Ecology lead, botanical survey lead, lead report preparation, spatial data management
Samantha Vertucci	BSc	Senior Ecologist – flora survey and reporting
Danelle Scicluna	BSc	Ecologist – flora survey and reporting
Rob Gration	M. Wildlife Management (Habitat), Post Graduate Certificate in Applied Science (Wildlife Ecology/Management), Dip Applied Science (Natural Resource Management)	Principal Ecologist, EcoAerial – Terrestrial fauna survey lead, report preparation
John McGuckin	BSc	Principal Aquatic Ecologist, Streamline Research – field work and report preparation
Dr Rodney van der Ree	PhD	National Technical Executive – zoology, mitigation measures.
Dr Alex Lechner	PhD	Associate Professor, Landscape Ecologist, University of Nottingham Malaysia
Tanya Bangel	BSc (Hons)	Ecologist – flora survey and vegetation mapping
Mark Shepherd	BSc	Senior Ecologist – flora survey and vegetation mapping
Justin Pegg	BSc	Senior Ecologist – flora survey, vegetation mapping and EnSym analysis
Zoë Steven	BSc (Hons), Master of Environment	Senior Ecologist – flora survey and vegetation mapping
Matt Clancy	BSc (Hons)	TactEcol Consulting Pty Ltd – zoologist, frog surveys 2020
Bruce Edley	BSc	TactEcol Consulting Pty Ltd – zoologist, frog surveys 2020
Matt Brown	Diploma GIS Spatial Sciences	Senior GIS Consultant – mapping and spatial data management
Kerry Gassner		Document control and Word Processing

4.3 CONSULTATION

Prior to the commencement of any fieldwork, a guidance document named *Beaufort Environment Effects Statement - Flora and Fauna Impact Assessment: Survey Methods and Timing* (WSP | Parsons Brinckerhoff 2016a) was prepared to provide an overview of the proposed survey methods and timing for the surveys, as much as site conditions and seasonal conditions warranted. This was reviewed and commented on by key staff in RRV and DELWP with those comments incorporated into the survey design. The methods proposed were designed to meet requirements under relevant environmental legislation and policy, as well as the then *Draft scoping requirements for the Beaufort Bypass Project Environment Effects Statement – Biodiversity*.

There has also been consultation with staff from RRV, DELWP, National Herbarium of Victoria, Department of Agriculture, Water and the Environment (DAWE), and others. The Ecological Communities Section of DAWE were consulted for advice on EPBC Act listed threatened ecological communities.

4.4 NOMENCLATURE AND IDENTIFICATION

Scientific and common names of flora and terrestrial and aquatic fauna species used in this document follow the Victorian Biodiversity Atlas (DELWP 2018e). Common names are used in this report for a plant or animal species followed by the scientific names in italics. Subsequent references may cite common names only. Introduced species are identified within the text with an asterisk before the scientific name, for example Greater Quaking-grass **Briza maxima*.

Terrestrial fauna species identifications were aided by the following field guides and reference material; mammals (Van Dyck & Strahan 2008), evidence of mammals (Triggs 1996), birds (2014) and bird calls (MyDigitalEarth 2017), reptiles(Wilson & Swan 2003), frogs (Tyler & Knight 2009) and frog calls (Glenelg Hopkins CMA date unknown).

The Little Galaxias is a recently described species and is one of two taxa that were formerly described as the Dwarf Galaxias *Galaxiella pusilla*. Records of the Dwarf Galaxias for all waters west of Melbourne are now categorised as Little Galaxias *Galaxiella toourtkoourt* (Coleman, Hoffmann & Raadik 2015).

Names used for Yam Holes Creek tributaries in the Beaufort Flood Study (Water Technology 2008) have been adopted in this report. From east to west the Yam Holes Creek tributaries are referred to as Cumberland, Cemetery and Ding Dong respectively. It is noted that locally Cumberland Creek is sometimes also referred to, in other literature, as Garibaldi Creek.

4.5 EXISTING CONDITIONS ASSESSMENT

4.5.1 DATABASE AND LITERATURE REVIEW

To determine the ecological values and potential constraints, a database search and literature review was undertaken. Relevant and available documents were reviewed for information on past land uses, presence of vegetation communities as well as flora and fauna. Relevant databases were searched for records of threatened species within a 10 km radius of the centre of the study area.

This review was used to prepare a list of threatened flora and fauna species, ecological communities, migratory species and any significant habitat previously recorded or predicted to occur in the study area and the broader locality (listed and preliminary listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and *Flora and Fauna Guarantee Act 1988* (FFG Act)). The following sources of information were consulted:

- The Department of Environment, Land, Water and Planning (DELWP) NatureKit (DELWP 2018d)
- The Victorian Biodiversity Atlas (VBA) (DELWP 2018e) – 10 km radius of the study area
- Birdlife Australia Birdata extract – 10 km radius of the study area
- Victorian Aquatic Fauna Database (DSE 2010b)

- Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) Protected Matters Search Tool – 10 km radius of the study area (DoEE 2019)
- The Commonwealth Department of the Environment Species Profile and Threats Database
- Victorian Rare or Threatened Species Advisory Lists (DEPI 2014; DSE 2009, 2013)
- Guidelines for the Removal, Destruction or Lopping of Native Vegetation (DELWP 2017e)
- Native Vegetation Information Management System (DELWP 2020a)
- Vegetation Quality Assessment Manual (DSE 2004)
- BioSites (DELWP 2014), wetlands and any significant roadside studies
- Publicly available reports
- Reports provided by RRV
- Aerial imagery to determine habitat extents and linkages
- Relevant legislation, government policy and strategies
- Publicly available geospatial datasets.

4.5.1.1 PREVIOUS SURVEYS AND ASSESSMENTS

Due to the locality's recent history of investigations for potential freeway bypass and other Western Highway upgrades, several ecological and environmental studies have been undertaken within or near the study area. A short review of these studies has been undertaken to provide context to the current study area. Two key studies have been used as a background to further progress surveys in this report:

- Western Highway Bypass Project – Beaufort. Stage 1 – Flora, Fauna and Aquatic Assessment (GHD 2015)
- Threatened Species Targeted Assessments Beaufort Bypass (WSP | Parsons Brinckerhoff 2016b).

4.5.2 FLORA SURVEY

Field surveys for threatened flora species were undertaken using a suite of methods specific to each of the targeted species. The likely presence of threatened species was determined through an assessment of suitable habitat in the study area. The survey design aimed to survey potential habitat throughout the study area in the most appropriate season acknowledged in the relevant literature or survey guidelines.

4.5.2.1 TARGETED THREATENED FLORA SPECIES SURVEYS

Field surveys for threatened flora species were undertaken using a combination of search methods where relevant. The main survey or sampling techniques used were:

- Random meander: a technique involves targeting a particular (or several) threatened plant species and traversing areas of suitable habitat in no set pattern (Cropper 1993).
- Parallel line traverses: traverses across suitable habitat using set distances apart (Cropper 1993).
- Stratified meander: combines traversing suitable habitat using a timed meander within a stratified grid-cell survey design (McCaffrey, NB et al. 2014).

For some selected flora species, population demographic surveys have been undertaken where this data was relevant for population estimates, and hence impact estimation as well as management implications.

The survey design was based on relevant State and Commonwealth survey guidelines as well as other relevant references including the following:

- Management of Endangered Plants (Cropper 1993)
- Pest Plant Mapping & Monitoring Protocol (Parks Victoria 2007)
- Survey Guidelines For Australia's Threatened Orchids (Department of Environment 2013)
- Site examination for threatened and endangered plant species – for timed meander technique (Goff, Dawson & Rochow 1982) and stratified meander (McCaffrey, NB et al. 2014)
- Monitoring Plant and Animal Populations (Elzinga et al. 2001).

Where possible, the targeted surveys were undertaken in the most appropriate season acknowledged in the relevant literature or survey guidelines for that species.

4.5.2.2 SURVEY EFFORT

Targeted threatened flora surveys were undertaken over a number of visits to maximise the detection of a range of species. These surveys were undertaken for threatened plants that were assessed as having a moderate or greater likelihood of occurrence, based on known distributions and habitat types present within the study area, as identified in (WSP | Parsons Brinckerhoff 2016b). Table 4.2 below outlines the survey method used, based on existing survey techniques in published literature, where available. Additional species recommended for targeted surveys by DELWP staff based on DELWP's Species Distribution Modelling for Guidelines 2013 (the initial native vegetation policy at the start of the study) included Slender Mint-bush *Prostanthera saxicola var. bracteolata* , Clover Glycine *Glycine latrobeana*, Pale Swamp Everlasting *Coronidium gunnianum*, Austral Crane's-bill *Geranium solanderi var. solanderi s.s*, Pale-flower Crane's-bill *Geranium sp. 3*, Arching Flax-lily *Dianella sp. aff. longifolia (Benambra)* and Golden Cowslips *Diuris behrii*. These species and any other potentially present species were targeted for detection during surveys in 2016 and 2017.

The Spring season in 2016 was generally wetter and colder than average and as such, many flora species were delayed in their response to typical seasonal climatic conditions. Targeted surveys were adapted to suit these differences and in particular, many wetlands throughout the study area were much easier to determine the vegetation type in 2016 compared to the much drier season in 2015. Some additional targeted surveys were undertaken in 2017 and 2018.

Table 4.3 also shows the flora survey effort by property. Property identifiers are shown on Figure 4.2.

STRATIFIED MEANDER SURVEY FOR BEN MAJOR GREVILLEA

To provide a high degree of transparency and certainty for the survey effort for Ben Major Grevillea, a unique approach combining two published methods was used. This method used 'stratified meander' technique (McCaffrey, NB et al. 2014) to determine time spent in each grid combined with the level of 'detectability' or probability of detection (Garrard et al. 2015). This method was presented at the ANET Conference in April 2018 and further details can be found at https://www.eianz.org/document/item/4443.

Table 4.2 Summary of survey effort for flora species

SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS	THREATENED SPECIES SURVEY GUIDELINES OR SUGGESTED APPROACH	SUGGESTED SEASONALITY AND SURVEY TIMING	SURVEY METHOD	SURVEY DATES																														
						12/09/2016	13/09/2016	14/09/2016	15/09/2016	16/09/2016	19/10/2016	20/10/2016	21/10/2016	30/11/2016	1/12/2016	2/12/2016	15/12/2016	16/12/2016	14/02/2017	15/02/2017	16/02/2017	17/02/2017	20/06/2017	21/06/2017	22/06/2017	8/07/2018	20/09/2017	26/09/2017	18/10/2017	19/10/2017	15/11/2017	9/01/2018	17/01/2018	23/01/2018	24/01/2018	31/01/2018
Acacia aspera subsp. parviceps	Rough Wattle	r	Surveys can be undertaken anytime of the year	Flowers July – October (RBGV 2020)	Random meander	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Amphibromus fluitans	River Swamp Wallaby-grass	VU	Surveys are best undertaken whilst the species is flowering. Mature flowers are required for identification (TSSC 2008b)	November to March (Walsh & Entwistle 1994)	Random meander									X	X	X	X	X	X	X	X	X									X	X	X	X	X	X
Amphibromus pithogastrus	Plump Swamp Wallaby-grass	e L	As above for River Swamp Wallaby-grass	November to March (Walsh & Entwistle 1994)	Random meander									X	X	X	X	X	X	X	X	X									X	X	X	X	X	X
Amphibromus sinuatus	Wavy Swamp Wallaby-grass	v	As above for River Swamp Wallaby-grass	November to March (Walsh & Entwistle 1994)	Random meander and possibly parallel line traverses									X	X	X	X	X	X	X	X	X										X	X	X	X	
Caladenia versicolor and other Caladenia spp.	Candy Spider-orchid	VU e L	Surveys can only be undertaken whilst the species is flowering (Backhouse & Jeanes 1995)	September to November (Backhouse & Jeanes 1995)	Random meander and possibly parallel line traverses	X	X	X	X	X	X	X	X														X	X	X	X						
Coronidium gunnianum	Pale Swamp Everlasting	v	Surveys best undertaken when in flower in November to April	November to April	Random meander and parallel line traverses through suitable habitat areas	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						X	X	X	X	X	X	X	X		
Dianella amoena	Matted Flax-lily	EN e L	Detectability increases when in flower (Nic McCaffrey pers. obs.) which is generally October to April (Carter, O 2010), however can be detected when not in flower	October to April	Stratified meander and/or Parallel line traverses	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dianella sp. aff. longifolia (Benambra)	Arching Flax-lily	v	Most detectable when in flower however can be surveyed and identified any time of the year	November to December	Survey method and similar habitat areas searched for Matted Flax-lily also applied to Arching Flax-lily	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Diuris behrii	Golden Cowslips	v	Surveys can only be undertaken whilst the species is flowering (Backhouse & Jeanes 1995)	September to November	Survey method and similar habitat areas searched for Spiral Sun-orchid and Candy Spider-orchid also applied to Golden Cowslips	X	X	X	X	X	X	X	X														X	X	X	X						
Eucalyptus yarraensis	Yarra Gum	r	Surveys can be undertaken anytime of the year	anytime	Random meander	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS	THREATENED SPECIES SURVEY GUIDELINES OR SUGGESTED APPROACH	SUGGESTED SEASONALITY AND SURVEY TIMING	SURVEY METHOD	SURVEY DATES																														
						12/09/2016	13/09/2016	14/09/2016	15/09/2016	16/09/2016	19/10/2016	20/10/2016	21/10/2016	30/11/2016	1/12/2016	2/12/2016	15/12/2016	16/12/2016	14/02/2017	15/02/2017	16/02/2017	17/02/2017	20/06/2017	21/06/2017	22/06/2017	8/07/2018	20/09/2017	26/09/2017	18/10/2017	19/10/2017	15/11/2017	9/01/2018	17/01/2018	23/01/2018	24/01/2018	31/01/2018
Geranium solanderi var. solanderi s.s	Austral Crane's-bill	v	Can only be identified when in flower, typically October to January	October to January	Stratified meander and/or Parallel line traverses	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					X	X	X	X	X	X	X	X	X	X
Geranium sp. 3	Pale-flower Crane's-bill	r	Can only be identified when in flower, typically October to January	September to January	Stratified meander and/or Parallel line traverses	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					X	X	X	X	X	X	X	X	X	X
Glycine latrobeana	Clover Glycine	VU v L	Most readily observed when in flower	October to December (RBGV 2020)	Stratified meander and/or Parallel line traverses	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					X	X	X	X	X	X	X	X	X	X
Grevillea floripendula	Ben Major Grevillea	VU v L	Detection and identification of this species is possible with or without flowers – survey anytime of the year. Use guidelines in (Carter, O, Murphy & Downe 2006)	September to November (Carter, O, Murphy & Downe 2006)	Stratified meander and/or Parallel line traverses	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pimelea spinescens	Spiny Rice Flower	CR e L	Transect surveys should be undertaken when the plant is in flower (April to August) at any location containing suitable habitat for the spiny rice-flower (Department of Environment Water Heritage and the Arts 2009a)	April to August although can still be detectible in September depending on the season	Random meander and parallel line traverses	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					X	X	X	X	X	X	X	X	X	X
Prostanthera saxicola var. bracteolata	Slender Mint-bush	r	Unlikely to be present as the nearest location is near Maryborough, over 50 km north. However targeted surveys for other species aimed to encompass this species	September to December	Random meander and parallel line traverses	X	X	X	X	X	X	X	X	X	X	X	X	X									X	X	X	X	X					
Pterostylis smaragdyna	Emerald-lip Greenhood	r	Surveys can only be undertaken whilst the species is flowering. Flowering can extend to late September, depending on the season	June to August (RBGV 2020) but may extent to end of September (see note preceding table on seasonal conditions)	Random meander and parallel line traverses	X	X	X	X	X																	X	X	X							
Senecio campylocarpus	Floodplain Fireweed	r	Surveys can only be undertaken when the species is flowering. Mature achenes are required for identification	November to March (Belcher R.O. & Albrecht D.E. 1994)	Random meander and parallel line traverses									X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X

SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS	THREATENED SPECIES SURVEY GUIDELINES OR SUGGESTED APPROACH	SUGGESTED SEASONALITY AND SURVEY TIMING	SURVEY METHOD	SURVEY DATES																														
						12/09/2016	13/09/2016	14/09/2016	15/09/2016	16/09/2016	19/10/2016	20/10/2016	21/10/2016	30/11/2016	1/12/2016	2/12/2016	15/12/2016	16/12/2016	14/02/2017	15/02/2017	16/02/2017	17/02/2017	20/06/2017	21/06/2017	22/06/2017	8/07/2018	20/09/2017	26/09/2017	18/10/2017	19/10/2017	15/11/2017	9/01/2018	17/01/2018	23/01/2018	24/01/2018	31/01/2018
Senecio psilocarpus	Swamp Fireweed	VU v	Surveys can only be undertaken when the species is flowering. Mature achenes are required for identification	November to March (Belcher R.O. & Albrecht D.E. 1994)	Random meander and possibly parallel line traverses									X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X
Thelymitra matthewsii	Spiral Sun-orchid	VU v L	Found in open forests and woodlands, often where there has been soil disturbance such as road verges (Duncan 2010). Use guideline (Department of Environment 2013)	August – September (and possibly October) – flowers early for *Thelymitra* species (Backhouse & Jeanes 1995).	Random meander	X	X	X	X	X																X	X	X	X	X						
Xerochrysum palustre	Swamp Everlasting	VU v L	Surveys are best undertaken whilst the species is flowering. Use guideline (Carter, O, Walsh, N. 2011)	November to March (Carter, O, Walsh, N. 2011)	Random meander and parallel line traverses through suitable swamp habitat areas									X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X

<u>Conservation Status used in the table above</u>:

Conservation Status in Australia (EPBC Act): CR = Critically Endangered, EN = Endangered, VU = Vulnerable.

Conservation Status in Victoria (Vic Advisory List): e = Endangered, v = Vulnerable, r = Rare

Status under the Flora and Fauna Guarantee Act 1988: L = Listed as threatened

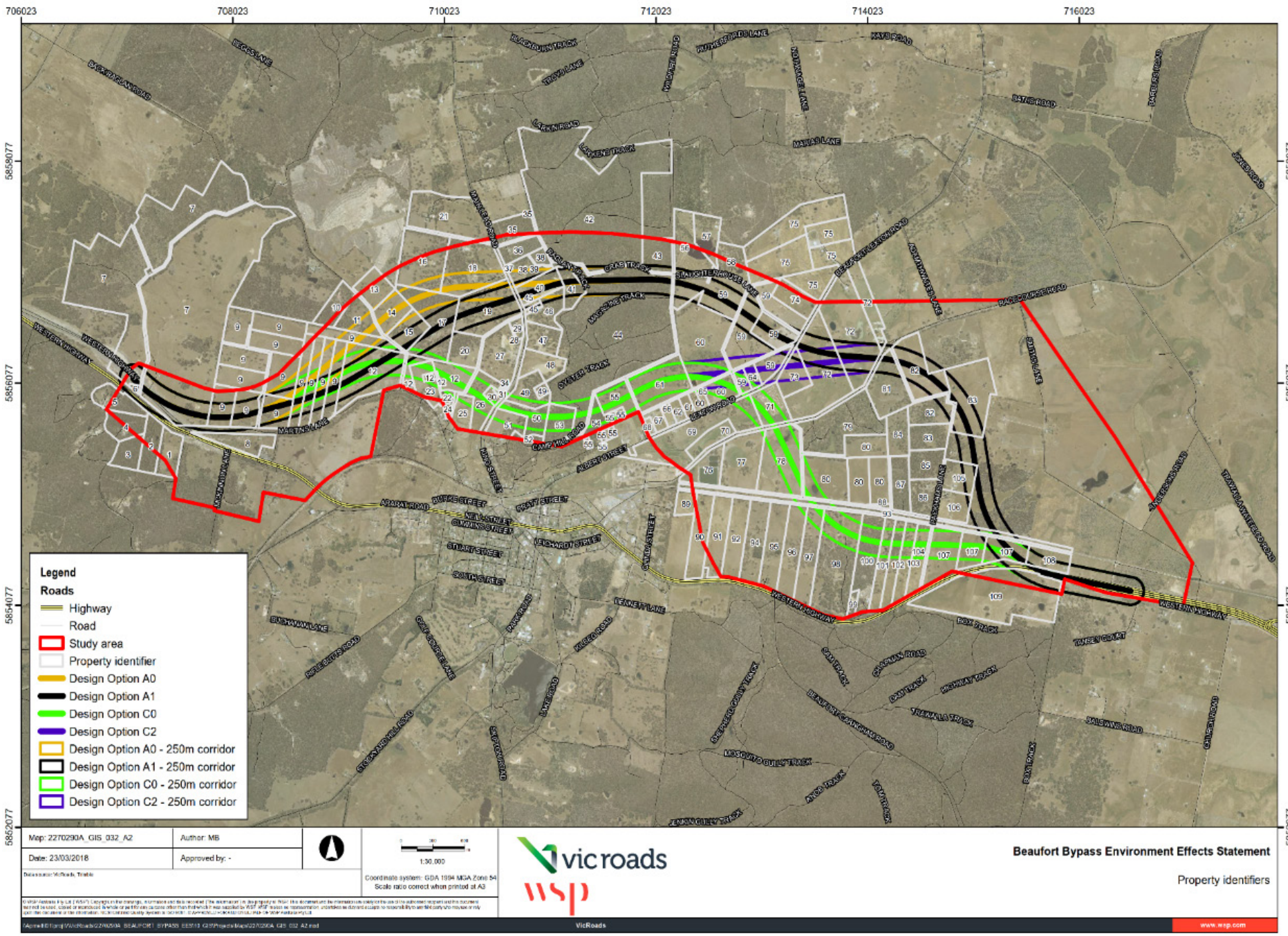


Figure 4.2 Property identifiers

Table 4.3 Summary of targeted threatened flora and searches by properties

DATES OF TARGETED SURVEY	SPECIES TARGETED	VEGETATION TYPE SEARCHED WITHIN STUDY AREA^	TYPE OF SURVEY EFFORT
12-16 September 2016	Earlier flowering target species included Spiral Sun-orchid *Thelymitra mathewsii, Pterostylis smaragdyna,* spider-orchids *Caladenia* spp. (and other early flowering orchids), *Acacia aspera subsp. parviceps, Diuris behrii and Pimelea spinescens* Yarra Gum *Eucalyptus yarraensis*	Roadsides Smiths Lane, Racecourse Road, Beaufort-Lexton Road, Back Raglan Road, Martins Lane Properties 50, 53, 79, 81, 82, 83, 85, 87, 86, 94, 95, 96, 97, 98, 100 Western Highway (western section from rail crossing to new freeway)	Random meander and parallel line traverses
19-21 October 2016	Early to mid-Spring flowering orchids (e.g. *Diuris behrii, Caladenia* spp.) Pale-flower Cranesbill *Geranium sp. 3*	Properties: 1,2, 4, 8, part of property east of 8, part of the rail corridor near 8 (from over the fence), 17, 18, two properties east of 1, Western Highway (eastern section near electrical substation) Revisit properties 87, 17, 18, 4, Martins Lane (part) Revisit some areas of Camp Hill State Forest	Random meander and parallel line traverses
30 November to 2 December 2016	Focused on surveying in wetland areas throughout the majority of the study area as the water levels had dropped throughout the swamps and the climate was conducive to good plant growth and flowering Conducted targeted surveys for threatened wetland flora species including Swamp Everlasting, Swamp Fireweed, River Swamp wallaby-grass, Plump Swamp Wallaby-grass and Floodplain Fireweed	Properties: 69, 70, 71, 72, 76, 78, part of property east of 8, property along Smiths Lane	Targeted meander through zonation of wetlands
15 & 16 December 2016	Ben Major Grevillea Late flowering orchids	Intact Heathy Dry Forest, Grassy Dry Forest and complexes through Camp Hill State Forest See further detail below	Stratified meander survey method

DATES OF TARGETED SURVEY	SPECIES TARGETED	VEGETATION TYPE SEARCHED WITHIN STUDY AREA^	TYPE OF SURVEY EFFORT
14-17 February 2017	Survey of the rail corridor were undertaken from Smiths Lane to Racecourse Road and either side of the crossing of the Western Highway. Targeted threatened grassy woodland species such as Matted Flax-lily Ben Major Grevillea	Intact grassland and grassy woodland habitats along the rail corridor Intact Heathy Dry Forest, Grassy Dry Forest and complexes through Camp Hill State Forest	Random meander and parallel line traverses
20-22 June 2017	Survey for large trees in remnant patches and scattered trees Incidental surveys for winter flowering orchids (e.g. helmet orchids) and other plants which can be identified in most seasons (e.g. Matted Flax-lily)	Most properties in the three corridors from Camp Hill State Forest to the eastern end of the study area	Random meander and parallel line traverses
20 September 2017 26 September 2017 18-19 October 2017 15 November 2017	Targeted surveys for early to mid-Spring targeted orchids, mostly through unsurveyed areas. Repeat visits through those areas in 2017 Survey for large trees in remnant patches and scattered trees and refine native vegetation mapping	Through Camp Hill State Forest (new alignments), previous surveyed areas and parts of the rail corridor Tree surveys through remaining areas of Camp Hill State Forest and some western properties	Random meander and parallel line traverses
8-9 January 2018 23 & 24 January 2018 17 January 2018 31 January 2018	Survey for large trees in remnant patches and scattered trees and refine native vegetation mapping	Mostly throughout western and central properties	Random meander and parallel line traverses
5-7 June 2019	Survey for large trees in remnant patches and scattered trees	Nine additional sites located within the Beaufort Bypass study to account for alignment design alterations. Refer to Figure 4.3 below	Random meander and parallel line traverses

^ *Properties outlined in Figure 4.2 above*

4.5.2.3 FLORA HABITAT MAPPING

Flora habitat mapping was undertaken for the following species which were considered likely to occur within the study area:

- Matted Flax-lily
- Floodplain Fireweed
- Ben Major Grevillea
- Yarra Gum
- River Swamp Wallaby-grass
- Pale-flower Cranesbill
- Rosemary Grevillea
- Ornate Pink Fingers.

Mapping potential habitat is a common and standard industry practice method to identify areas where species may occur based on habitat attributes. Potential habitat for flora species identifies areas which may be suitable but not necessarily present could possibly require a number of years of survey effort across every square meter to determine 'absence', particularly for cryptic and less predictable orchid species.

For some species, some further levels of habitat suitability (e.g. low, medium and/or high) were determined. Some species were mapped as just one category where there was less specific information on habitat available and where there are broader habitat requirements.

In addition, DELWP's Species Distribution Modelling (SDM) was used as a base layer for display, however, this was not relied on for determining any site-specific habitat needs or determining areas to target for surveying as many SDMs are not particularly reliable at a site-based scale (e.g. 1:10,000) and in some cases do not have any modelled data for the study area. This is likely due to not having been previously recorded in the study area or broader region (e.g. Ornate Pink Fingers, River Swamp Wallaby-grass).

4.5.2.4 PLANT IDENTIFICATION

Flora species that could not be identified in the field were recorded to the nearest possible family or genera. These were then collected and identified as per protocols of the Flora and Fauna Guarantee permit (10007800) for the collection of plant material.

4.5.3 VEGETATION ASSESSMENTS

4.5.3.1 DETERMINATION OF ECOLOGICAL VEGETATION CLASSES

An Ecological Vegetation Class (EVC) is a unit of consistent vegetation displaying broadly similar botanical characteristics reflecting consistent environmental and structural conditions (Oates & Taranto 2001). EVCs include a benchmark for the characteristics of the vegetation type in its mature, natural, (pre-1750) state (DEPI 2013a). Field validation (or ground-truthing) of the DELWP modelled vegetation layer NV2005_EVCBCS (DELWP 2018d) was undertaken to determine the site specific classification of the vegetation structure, floristics, wetland formations, dominant canopy species, native diversity and condition. NV2005_EVCBCS was mapped with a focus on terrestrial vegetation and broader wetland types and has not been updated to include published wetland EVCs. Specific wetland EVCs were assessed using EVCs developed for the Index of Wetland Condition by (Frood 2009) and (DELWP 2016a). Mapping undertaken in (GHD 2015) and (WSP | Parsons Brinckerhoff 2016b) was used in combination with NV2005_EVCBCS.

Terrestrial and wetland EVCs and trees were originally mapped according to the *Permitted Clearing of native vegetation: biodiversity assessment guidelines* (Guidelines 2013) (DEPI 2013a). However, these regulations were changed on 12 December 2017 via Planning Scheme Amendment VC138. Guidelines 2013 was effectively replaced by *Guidelines for the removal, destruction or lopping of native vegetation* (Guidelines 2017) (DELWP 2017e), with exception of the 12-month transition period. The main difference between the two policies affecting the definition of native vegetation are:

- ‘remnant patch’ changed to ‘patch’
- one of the definitions of patch requires that three or more trees to form a continuous canopy as opposed to Guidelines 2013 which required ‘any area with three or more native canopy trees where the canopy foliage cover is at least 20 per cent of the area’
- inclusion of any mapped wetland included in the Current wetlands map.

The classification of native vegetation used in Guidelines 2017 are:

Patch – a patch of native vegetation is:

- an area of vegetation where at least 25 per cent of the total perennial understorey plant cover is native, or
- any area with three or more native canopy trees where the drip line of each tree touches the drip line of at least one other tree, forming a continuous canopy, or
- any mapped wetland included in the Current Wetland map, available in DELWP systems and tools.

Scattered tree – a scattered tree is:

- a native canopy tree that does not form part of a patch.

Any vegetation mapping using the Guidelines 2013 definition was adapted to Guidelines 2017.

All vegetation mapping was undertaken using a Dell rugged tablet computer with Quantum GIS and a Garmin GLO Bluetooth GPS with GLONASS which receives position information from both the GPS and GLONASS satellite constellations, enabling greater position accuracy.

Mapping for vegetation impacts used in EnSym analysis was undertaken by mapping around the edge of the tree canopy of all trees to be removed, in accordance with *Assessor’s Handbook – Applications to remove, destroy or lop native vegetation (the Handbook)* (DELWP 2017b).

4.5.3.2 REVEGETATION CATEGORISATION

Revegetation is extensive at some sites within the study area, and this can have different implications and exemptions under planning laws and other biodiversity legislation. So that these exemptions and implications may be assessed for revegetation in the study area, the categories detailed in Table 4.4 were used.

Where possible, groups or rows of planted trees were lumped into revegetation polygons.

Table 4.4 Revegetation categories used for mapping

REVEGETATION/PLANTING MAPPING CATEGORY	DESCRIPTION	PLANNING IMPLICATIONS
Site Indigenous	Indigenous to a local area. Described by (Pyšek, Richardson & Williamson 2004) and adopted by (Royal Botanic Gardens Melbourne 2016), defined as ‘taxa that have originated in a given area without human involvement or that have arrived there without intentional or unintentional intervention of humans from an area in which they are native’	There are certain exemptions under all Victorian Planning Schemes, Clause 52.17 ‘planted vegetation’ where “native vegetation that is to be removed, destroyed or lopped that was either planted or grown as a result of direct seeding. This exemption does not apply to native vegetation planted or managed with public funding for the purpose of land protection or enhancing biodiversity unless the removal, destruction or lopping of the native vegetation is in accordance with written permission of the agency (or its successor) that provided the funding
Non-indigenous Victorian Native	Non-indigenous to the local area but native to Victoria (e.g. Mahogany Gums, Giant Honey-myrtle). Defined in Victorian Planning Provisions – Definitions – Clause 72 as *‘Plants that are indigenous to Victoria, including trees, shrubs, herbs, and grasses’*	If vegetation is not exempt as above, or if a schedule to a planning overlay specifies, it may require a permit for removal
Non-indigenous Australian Native	Non-indigenous Australian native plants or vegetation (non-indigenous to Victoria) (e.g. Sugar Gums)	Usually do not require a permit for removal, unless a planning overlay stipulates that all vegetation removal requires a permit, but are identified to show these have not been overlooked
Plantation	Plantations such as Blue Gum plantations, vineyards and fruit trees	Usually do not require a permit for removal unless there are special protections
Exotic	Planted and rogue pines trees and willows	Usually do not require a permit for removal unless there are special protections (e.g. heritage overlays)

4.5.3.3 HABITAT HECTARE ASSESSMENTS

Habitat Hectare assessments were undertaken to determine the condition of the vegetation in the context of the local area and the relevant bioregions. This methodology is outlined in *Vegetation Quality Assessment Manual-Guidelines for applying the Habitat Hectares scoring method* (DSE 2004). The Habitat Hectare method involves making visual qualitative and quantitative assessments on various characteristics of native vegetation according to established criteria that are set against an optimum benchmark. This process aims to establish the condition of native vegetation through an objective and repeatable methodology using working documents (benchmark data and field assessment score sheets) that are uniformly applied across Victoria.

In summary, this process begins with the identification of the EVC. Each EVC has a benchmark of optimal values which are found on DELWP's website (DELWP 2018b). Site assessments are undertaken using the DSE *Vegetation Quality Field Assessment Sheet* (Version 1.3 October 2004) from (DSE 2004). Further to the site condition criteria, the Habitat Hectare process also requires an assessment of the site in a landscape context (DSE 2004).

If a site meets or exceeds all benchmark criteria it will receive a total score of 100, which is a total of the above condition and landscape scores in pristine undisturbed condition. However, in many cases in the urban-influenced ecosystems, sites receive a score less than 60, due to their relatively high level of modification. The final habitat score is presented as a percentage and then converted to a score out of 1.00.

Areas defined as a 'patch' were subject to Habitat Hectare assessments. According to the Location Map accessed via Native Vegetation Information Management System (NVIM) (DELWP 2020a), the majority of the site is covered by a mix of Location 1 and 2 with small areas of Location 3. However, as the quantity of patches and scattered trees proposed for removal was likely to be over 0.5 ha, a detailed assessment pathway was likely required and therefore a Habitat Hectare assessment was undertaken on all patches. See Section 6 for more detail.

For some wetland EVCs there was no Habitat Hectare EVC benchmark, therefore the most similar available EVC benchmark for the bioregion was used, as per (DSE 2004). Typically Bioregion Conservation Status is derived from (DELWP 2018b). However, several EVCs did not have a published conservation status, therefore a status in a nearby bioregion was used. Where this wasn't available, conservation status from (Frood & Papas 2016) was used.

Site condition scoring for all patches was undertaken in the field. Landscape context was assessed by estimating vegetation coverage estimates using aerial imagery using GIS, as per (DSE 2004).

4.5.3.4 APPLICATION OF DELWP'S ASSESSOR'S HANDBOOK ON NATIVE VEGETATION

The *Assessor's Handbook – Applications to remove, destroy or lop native vegetation (the Handbook)* (DELWP 2017b) outlines additional biodiversity values that can be considered for avoidance and minimisation along with the application of the *Guidelines 2017*. Appendix 1D of *the Handbook* contains four tables describing native vegetation values which can be interpreted in tabular format or in geographic format. The tables used in this assessment include the following:

- Table 6. Other values of native vegetation
- Table 7. Biodiversity values of native vegetation considered in all assessment pathways
- Table 8. Additional biodiversity values considered in the Intermediate and Detailed Assessment Pathway
- Table 9. Additional biodiversity value of native vegetation considered in the Detailed Assessment Pathway.

The application of *the Handbook* involved using the values in these tables to determine the lower and higher values of native vegetation data mapped in the field. Using GIS, the lower and higher values were quantified in hectares for each alignment so that a comparison could be made.

A review from DELWP resulted in a revision of the methodology. The subsequent application of the Assessor's Handbook aimed to further distinguish lower and higher values of native vegetation such as considering Strategic Biodiversity Value (SBV) and Ecological Vegetation Class Bioregional Conservation Status (EVC BCS). For further information regarding the methodology adopted to assess each value, refer to tables 1-4 of the assessment, provided in Appendix L.

4.5.4 TREE SURVEY

Tree surveys were conducted to provide the information required to provide sufficiently detailed data to compare alignment options. As such, the surveys focused on collecting information regarding large trees, and the information required to estimate native vegetation losses and offset requirements as per the Guidelines 2017. The relevant tree definitions are provided in Table 4.5 below.

Table 4.5 Tree assessment criteria

ELEMENT	DEFINITION	REFERENCE
Scattered tree	A native canopy tree that does not form part of a patch. A scattered tree can be a large or a small tree.	*Guidelines for the removal, destruction or lopping of native vegetation* (DELWP 2017e)
Large tree within a patch	A native canopy tree with a Diameter at Breast Height (DBH) greater than or equal to the large tree benchmark for the relevant bioregional EVC (DELWP 2018b), contained within a patch.	*Guidelines for the removal, destruction or lopping of native vegetation* (DELWP 2017e)
Large tree	A native canopy tree with a Diameter at Breast Height (DBH) greater than or equal to the large tree benchmark for the relevant bioregional EVC. A large tree can be either a large scattered tree or a large tree contained within a patch.	*Guidelines for the removal, destruction or lopping of native vegetation* (DELWP 2017e)
Small tree	A native canopy tree with a Diameter at Breast Height (DBH) less than the large tree benchmark for the relevant bioregional EVC.	*Guidelines for the removal, destruction or lopping of native vegetation* (DELWP 2017e)
Large old tree	Defined as "trees of key long-lived dominant species – greater than a certain diameter at 1.3 m above ground level – as specified in the relevant EVC benchmark" this term is no longer used and is considered synonymous with 'large scattered tree' or a 'large tree within a patch' above.	*Scoping Requirements for the Beaufort Bypass Project under the Environment Effects Act 1978* (DELWP 2016b)
Canopy Tree	Canopy Tree is a mature tree (i.e. it is able to flower) that is greater than 3 metres in height and is normally found in the upper layer of the relevant vegetation type.	*Guidelines for the removal, destruction or lopping of native vegetation* (DELWP 2017e)

Given some of the previous issues with assessing large trees in other sections of the Western Highway projects (VicRoads 2016b) (report reviewed in Section 6.1), it was considered of high importance to ensure that all large trees were surveyed in the field. Surveying all trees on foot was proposed to significantly minimise the issues associated with sampling and extrapolation of tree numbers that led to the issues referred to above. Due to the large number of trees throughout the 1825 ha study area, tree surveys focused on assessing the 250 m wide alignment corridor and the trees at interchanges (i.e. the locations where impacts may occur outside of the alignment corridors due to new or upgraded interchange). All large trees in patches and all scattered trees in these areas were recorded. The location of some large trees outside of the current alignments reflect some assessments of previous alignment options.

Metrics used for each tree assessed are outlined in the table below. A small number of tree DBHs had to be estimated in the field due to safety concerns or other physical reasons (e.g. base of tree in blackberry patch). These are all labelled 'estimated in field' in Appendix E.

Most tree location points were collected using a Garmin GLO Bluetooth Global Navigation Satellite System (GNSS) with GPS and GLONASS reception, reported as having 3–4 m accuracy. Some waypoints were collected using a Garmin Montana 650t, with GPS and GLONASS reception. The accuracy of GNSS signals deteriorates under tree canopies, even with differential GPS units, however the position accuracy and precision is considered adequate for impact assessment evaluation.

Once the project moves into a detailed design phase, a feature survey and an arborist assessment is highly recommended to assess all trees above 10 cm DBH (not just large trees in patches and scattered trees) in close proximity (15 m buffer) to the construction footprint. This is not a requirement of the Guidelines 2017, however this will allow detailed impact minimisation to be undertaken and allow for the accurate assessment of TPZ impacts as part of the detailed design phase.

Table 4.6 Metrics used to measure and record tree data

METRICS	DESCRIPTION
ID	Unique identifier
Scientific name	Trees identified to species level; names consistent with the Victorian Biodiversity Atlas
Common name	Common names consistent with the Victorian Biodiversity Atlas
DBH	Diameter at Breast Height in centimetres measured at 1.3 metres above ground level.
CBH	Circumference at Breast Height in centimetres measured at 1.3 metres above ground level; as per (DELWP 2017e)
Size	Large or small tree, as per definitions in Table 4.5
Category	Scattered tree (ST) or Large Trees in Patches (CT). CT is the definition from EnSym
Method	Measured in field with DBH tape or estimated in field (for only six trees due to access to tree trunks)
GPS Accuracy	Recorded by handheld GNSS receiver (accuracy +/- 4 m) or occasionally determined from aerial photography (when only one tree)
Date	Date recorded
Assessor	Assessors
HBT	Hollow bearing trees – where there was evidence of tree hollows
X	Latitude geographic coordinate
Y	Longitude geographic coordinate

To account for alignment design alterations, additional tree surveys were conducted in 2019 at nine sites within the Beaufort study area (Refer to Figure 4.3).

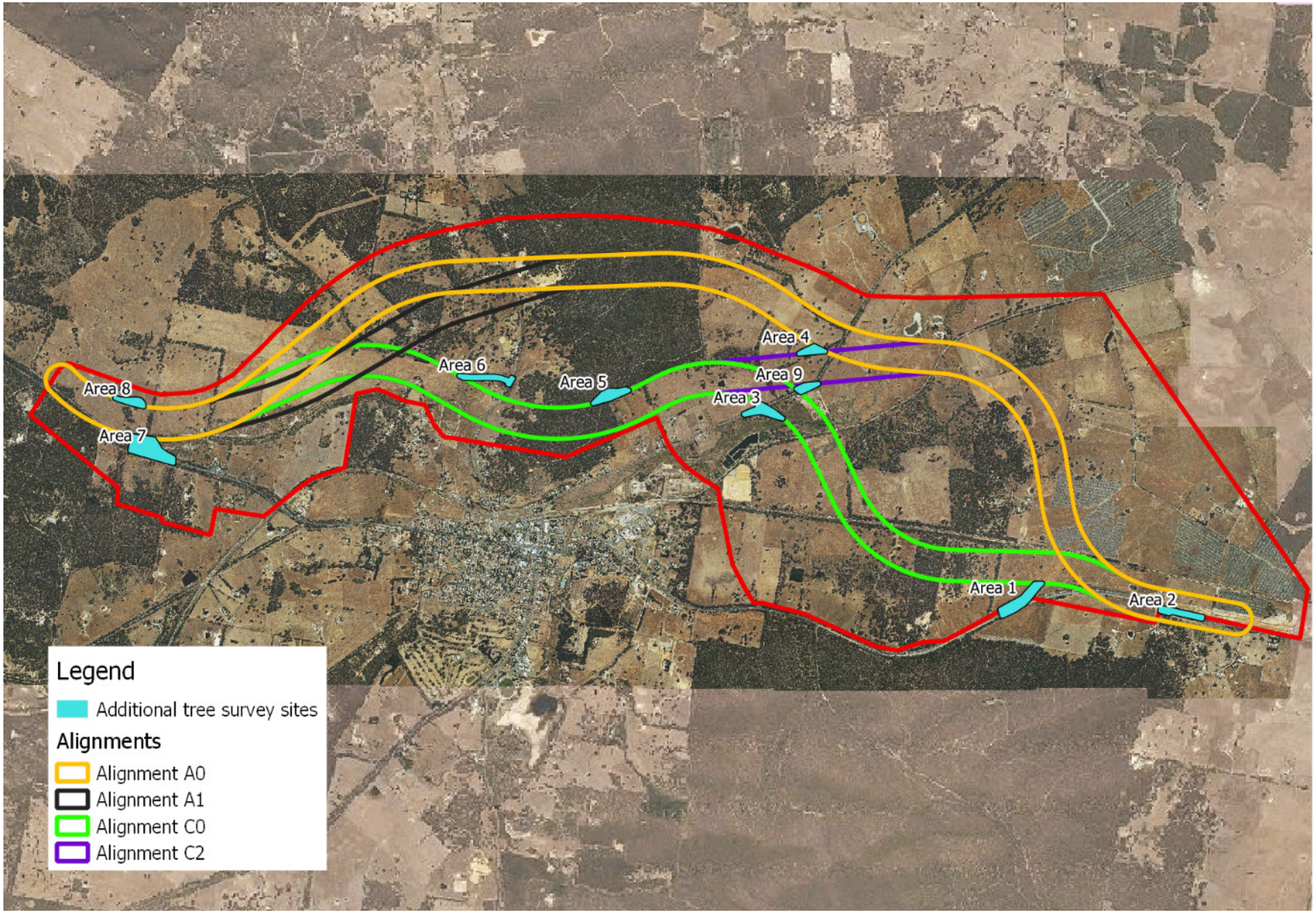


Figure 4.3 Additional tree survey sites

4.5.5 THREATENED VEGETATION COMMUNITIES

Four EPBC Act and three FFG Act listed communities were considered possibly present within the study area. These included:

EPBC Act communities:

- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland
- Natural Temperate Grassland of the Victorian Volcanic Plain
- Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains
- Grassy Eucalypt Woodland of the Victorian Volcanic Plain.

FFG Act threatened communities:

- Western (Basalt) Plains Grasslands Community
- Western Basalt Plains (River Red Gum) Grassy Woodland
- Victorian Temperate Woodland Bird Community.

There is no specific criteria which determines the presence of FFG Act communities except for an informal method of comparing site characteristics and floristics with community descriptions in *Characteristics of Threatened Communities – Flora and Fauna Guarantee Act 1988 – Threatened List* (DELWP undated).

The majority of vegetation surveys of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains were assessed in a 'wet phase' in mid spring and early summer 2016, which are considered optimum conditions. This is otherwise known as seasonal, annual filling. In seasons or years with lower rainfall during a 'dry phase', most plants remain dormant and underground as seeds or underground propagules (such as tubers), thus making identification of this community difficult (Goulburn Broken CMA 2015). Survey times and effort are shown below in Table 4.7.

Table 4.7 Summary of targeted threatened vegetation assessments

DATES OF TARGETED SURVEY	COMMUNITY TARGETED	VEGETATION TYPE SEARCHED WITHIN STUDY AREA	TYPE OF SURVEY EFFORT
19-21 October 2016	White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Properties: 1,2, 4, 8, part of property east of 8, part of the rail corridor near 8 (from over the fence), 17, 18, two properties east of 1, Western Highway (eastern section near electrical substation) Revisit properties 87, 17, 18, 4, Martins Lane (part)	Targeted meander through zonation of wetlands
30 November to 2 December 2016	Focused on surveying in wetland areas throughout the majority of the study area as the water levels had dropped throughout the swamps and the climate was conducive to good plant growth and flowering Target Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	Properties: 69, 70, 71, 72, 76, 78, part of property east of 8, property along Smiths Lane	Targeted meander through zonation of wetlands

DATES OF TARGETED SURVEY	COMMUNITY TARGETED	VEGETATION TYPE SEARCHED WITHIN STUDY AREA	TYPE OF SURVEY EFFORT
15 & 16 December 2016	Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	Between Racecourse Road and Beaufort-Lexton Road	Targeted meander through zonation of wetlands
14-17 February 2017	White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	Intact grassland and grassy woodland habitats along the rail corridor. Alluvial-terraces Herb-rich Woodland through Camp Hill State Forest	Random meander and parallel line traverses
20-22 June 2017	Incidental surveys for White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Properties in the eastern end of the study area	Random meander
20, 26 September 2017 18-19 October 2017 15 November 2017	Incidental surveys for White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Through Camp Hill State Forest (new alignments), previous surveyed areas and parts of the rail corridor Tree surveys through remaining areas of Camp Hill State Forest and some western properties	Random meander and parallel line traverses

4.5.6 QUADRAT SURVEYS

Quadrat data used to support the assessment of patches of native vegetation against determination criteria for the EPBC Act listed communities. These were assessed by undertaking 20 x 20 m flora quadrats to evaluate the scientific determination criteria for:

- Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains (TSSC 2012b)
- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland.

Six quadrats, three in each community, were undertaken in representative across the study area in patches of each community in order to validate species composition. Quadrat data was collected to sample communities throughout the study area, independent of the alignments. In addition, two quadrats with Ben Major Grevillea were undertaken to characterise the typical floristics found associated with Ben Major Grevillea. See Figure 4.4 and Appendix A for quadrat data.

Quadrats were conducted to sample the floristics according to a modified version of the Braun-Blanquet system from 1951, described in (Specht 1981):

Table 4.8 Quadrat cover abundance methodology

COVER VALUE	COVER OF FOLIAGE/BRANCH	NUMBER OF INDIVIDUALS
+	<5%	< 10 individuals
1	<5%	>10 individuals
2	5–25%	Any number
3	25–50%	Any number
4	50–75%	Any number
5	75–100%	Any number

Codes used to identify quadrats are:

— BMG – Ben Major Grevillea
— SHW – Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains
— WYBGW – White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland.

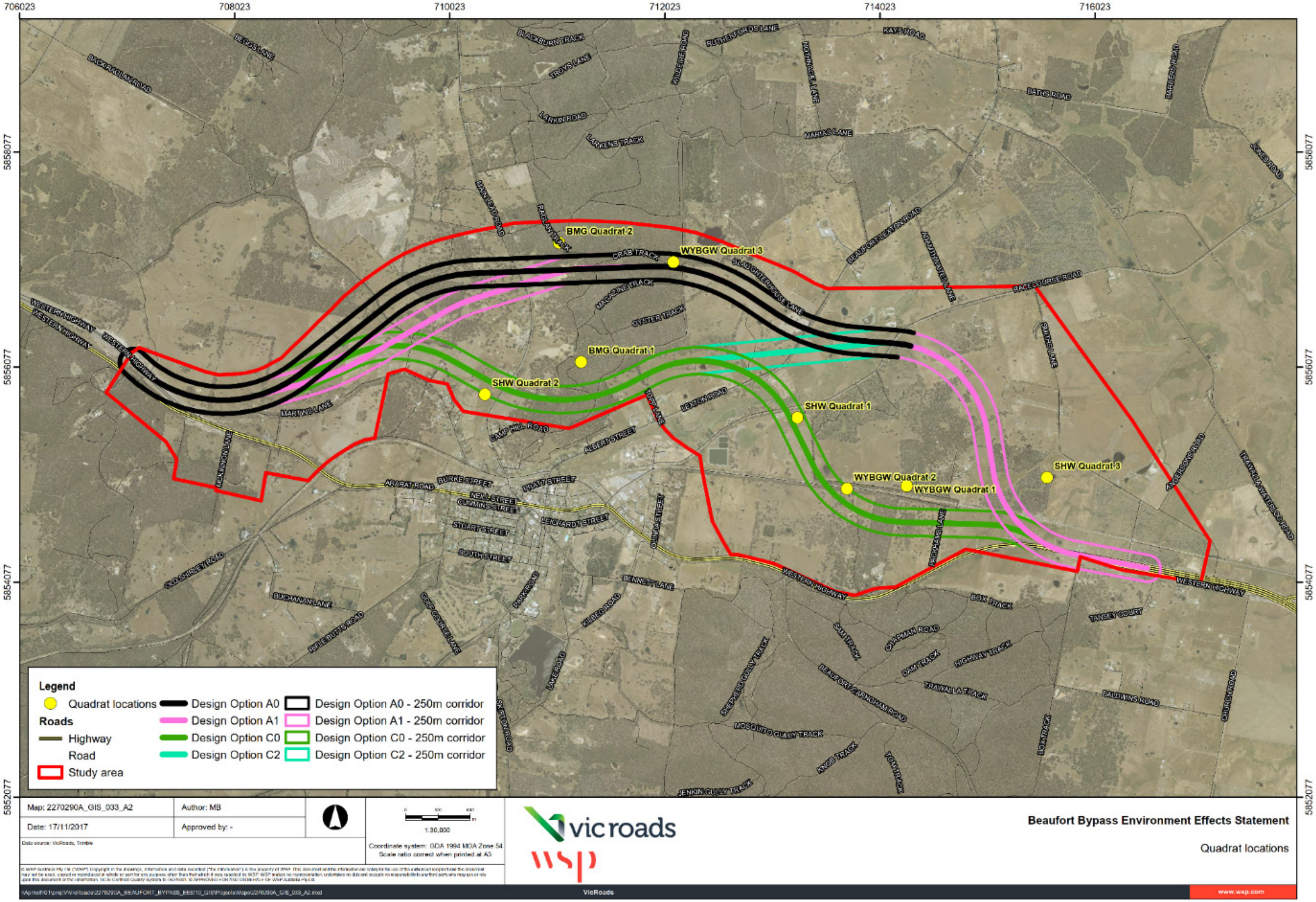


Figure 4.4 Quadrat locations

4.5.7 FAUNA SURVEY

4.5.7.1 TARGETED SURVEYS FOR THREATENED FAUNA

Field surveys for threatened species were undertaken using a suite of methods specific to each of the targeted species.

The methods deployed do not allow for determining population demographics, however, may be used as an activity index to be assessed against studies in other regions with similar habitat. The comparison of this data can then be used to draw conclusions on potential impacts and management implications.

The survey design was based on relevant State and Commonwealth survey guidelines. The following guidelines are considered: the *'best practice'* and formed the basis of the surveys undertaken:

- Arthur Rylah Institute, Camera Trapping Survey Guidelines (Nelson J.L. and Scroggie M.P. 2009)
- Survey guidelines for Australia's threatened frogs (DEWHA 2010a)
- Survey guidelines for Australia's threatened birds (DEWHA 2010b)
- Significant Impact Guidelines for the Critically Endangered Golden Sun Moth (Synemon plana) (DEWHA 2009b)
- Survey guidelines for Australia's threatened reptiles: Guidelines for detecting reptiles listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999 (DSEWPC 2011)
- Survey guidelines for detecting mammals listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (DEWHA 2011)
- Biodiversity Precinct Structure Planning Kit (DSE 2010a)
- Addressing Welfare Concerns When Observing and Trapping Vertebrate Fauna (Gration 2010)
- Flora and Fauna Survey Assessment Documents (Melbourne Water 2011).

Field assessments were undertaken in the most appropriate season acknowledged in the above literature/survey guidelines. Only those species with a Moderate or high likelihood of occurrence were targeted during surveys. The survey methods deployed for each species is provided below.

GROWLING GRASS FROG & BROWN TOADLET

Surveys were conducted at five wetland sites within the study area and ten wetland reference sites were surveyed for a minimum of two visits per site, as per *Survey guidelines for Australia's threatened frogs: Guidelines for detecting frogs listed as threatened under the EPBC* Act (DEWHA 2010c) and *Significant impact guidelines for the vulnerable growling grass frog (Litoria raniformis)* (DEWHA 2009c).

Nocturnal call playback was undertaken: calls were broadcasted using a portable MP3 player and amplified through a megaphone. The advertisement call of male Growling Grass Frog and Brown Toadlet was played for two minutes to elicit a response from any adult males, followed by quiet listening for several minutes.

Surveys were conducted during suitable climatic conditions on 30/11/2016 and 1/12/2016. Targeted surveys (diurnal and nocturnal) were conducted throughout and adjacent to the study area. A systematic search for Growling Grass Frog and Brown Toadlet was undertaken using spotlights or head torches including the surrounding terrestrial habitat within 10 metres of all waterbodies. In addition, a survey was undertaken on 16/01/2017. Brown Toadlets typically call in Autumn but can be detected in other times of the year such as summer by direct observations. Brown Toadlet were previously recorded in spring in 2015 (WSP | Parsons Brinckerhoff 2016b) (Appendix O) and as such were surveyed for during Growling Grass Frog survey times. Brown Toadlet are cryptic species and can be difficult to survey for in autumn if conditions are too dry or cold.

Sites were prioritised to assess potential habitat areas not previously covered in the targeted surveys in 2015 (WSP | Parsons Brinckerhoff 2016b), with exception of high-quality wetlands within and close to Snow Gums Bushland Reserve.

Additional surveys were conducted in 2020 at fifteen wetland, creek and dam sites within the study area and one wetland reference site. Sites sampled covered a number of sites previously surveyed in 2015 and 2016, as well as some new sites – survey locations are shown in Figure 4.7. These sites were surveyed for a minimum of two visits per site across three nights 3/11/2020, 18/11/2020 and 25/11/2020 during optimal climatic conditions.

Nocturnal call playback was undertaken: calls were broadcasted using a portable MP3 player and amplified through a megaphone. Call playback will involve a two minute calling period followed by a 30 second listening period, repeated once followed by spotlighting/visual searches along wetland/dam edges. The entire edge of small dams were surveyed and larger sites were sampled.

BRUSH-TAILED PHASCOGALE & SQUIRREL GLIDER

To survey for Brush-tailed Phascogale and Squirrel Glider, 25 hair funnels traps (hair-tubes) and three infra-red motion detection cameras were deployed on 2 December 2016 in additional areas not previously covered in the 2015 surveys (WSP | Parsons Brinckerhoff 2016b), Appendix O and shown on Figure 4.5. Hair funnel traps comprised a mixture of small (40 mm) and large (90 mm) hair-tubes which were placed on hollow bearing trees across the study area. Hair-tubes and cameras were retrieved on 16 December 2016, equating to 14-trap days/nights. Hair analysis was subsequently undertaken by a company named Scats About. In addition, spotlight surveys were also carried out on the 16 January 2017. Refer to Figure 4.6 for camera and hair funnel locations.

Additional surveys using remote cameras were undertaken for Brush-tailed Phascogale and Squirrel Glider in late summer and early autumn of 2021.

A total of 47 cameras were deployed across the study area on 18 and 19 February 2021 and left for three and a half weeks before being collected on 15 and 16 March 2021. Camera surveys utilised Reconyx Hyperfire infrared cameras, placed approximately 2–3 m above ground on hollow bearing trees in habitat considered most likely to support both species. An inaccessible bait station containing oats, peanut butter and honey was used and trees were sprayed with diluted honey at the time of deployment. Areas surveyed included Camp Hill State Forest, private property and roadsides. Refer to Figure 4.7 for camera locations. Following the camera surveys, the images collected were analysed for the presence of the two target species. Given that both species are nocturnal, image analysis was limited to night photos and focused on determining the presence of the target species and other nocturnal species on each night.

Elliot trapping was also undertaken for Brush-tailed Phascogale and Squirrel Glider in 2021. Surveys were conducted over four nights between 14 and 18 March 2021 in which 36 Elliot traps were attached to hollow bearing trees and baited with a ball of oats, peanut butter and honey. Trees were also sprayed with diluted honey at the start of trapping and again on the second day. Elliot trap locations are shown in Figure 4.7. Traps were checked early each morning for the presence of captured animals which were identified and sexed. Other features of interest were also recorded such as the females reproductive condition, teeth condition and general observations about the individual's health. After processing, each trap was reset, baited if necessary and reinstalled for the next night. Each trap was left open for the duration of the survey unless an individual animal was caught on two consecutive nights, in which case the trap was closed.

POWERFUL OWL

Powerful Owl call-playback and spotlighting surveys were undertaken at three locations within the study area on in the 2015 surveys (WSP | Parsons Brinckerhoff 2016b), Appendix O (Figure 4.5) and again on 15 and 17 March 2021 (refer to Figure 4.7). Surveys involved broadcasting a pre-recorded Powerful Owl call at up to ~110% of natural call volume for two minutes using a megaphone. Call-playback was followed by two minutes of quiet listening for a response. This was repeated three times at each location, followed by a five minute period of spotlighting in the surrounding area to check for the presence of owls that are attracted by the calls but are not vocalising. Any fauna observations were recorded, along with the weather conditions at the time of survey.

GOLDEN SUN MOTH

Surveys were undertaken when the commencement of the flight season was confirmed by the Victorian DELWP endorsed Golden Sun Moth email group. This notifies email list members during the Golden Sun Moth flight season as to when they are observed flying at reference sites and other sites across Victoria. Within the flight season, surveys were undertaken when conditions met those stipulated in the *Significant Impact Guidelines for the Critically Endangered Golden Sun Moth (Synemon plana)* (DEWHA 2009b) as this is when male moths are most likely to be flying and therefore, are most detectable. Preferred survey conditions include;

- warm to hot day, generally above 20°C
- clear or mostly cloudless sky relatively still winds
- surveys undertaken between 10:00 am and 3:00 pm.

The Golden Sun Moth surveys targeted areas identified as potential habitat (see Figure 4.6), which were not surveyed in 2015 (WSP | Parsons Brinckerhoff 2016b) (Appendix O) and shown on Figure 4.5. These sites were then investigated by Rob Gration to determine if these would be suitable for habitat based on grass species present, biomass cover and proximity to other records. In a number of cases, the sites which had been initially identified as potential habitat were determined to be unlikely to support Golden Sun Moth, based on the conditions in 2016–2017.

A local Beaufort reference site was established at Property 18 as Golden Sun Moth was first identified at the site in (WSP | Parsons Brinckerhoff 2016b). The reference site was visited prior to commencing surveys. Sites were surveyed until either a population (defined as 5 or more moths) was detected or until four surveys, spaced at least 1 week apart, had been completed (population assumed to be absent). In the survey season 2016/2017, four repeat surveys were not required as a population was identified and mapped as habitat or initial investigations deemed the sites inappropriate for Golden Sun Moth habitat. Refer to Figure 4.6 below for the location of Golden Sun Moth survey sites.

Table 4.9 Golden Sun Moth habitat investigations in 2016–2017

SITE	HABITAT	NOTES FOR SURVEY
Reference site	Low, open treeless grassland dominated by wallaby-grasses *Rytidosperma spp*. with 10-20% cover.	Golden Sun Moth observed at this site in 2015 by WSP.
Site 1	Low, open treeless grassland dominated by Kangaroo Grass *Themeda triandra* and wallaby-grasses *Rytidosperma spp*. with >50% cover.	Inspected twice but discarded as potential habitat due to high biomass levels.
Site 2	Low, open treeless grassland dominated by wallaby-grasses *Rytidosperma spp*. with 10-20% cover.	Identified as a potential habitat site.
Site 3	Low, open treeless grassland dominated by wallaby-grasses *Rytidosperma spp*. with 10-20% cover.	Identified as a potential habitat site due to its open grassland condition.
Site 4	Low, open treeless grassland dominated by Kangaroo Grass *Themeda triandra* and wallaby-grasses *Rytidosperma spp*. with >50% cover.	Identified as a potential habitat site due to its open grassland condition. Disregarded as potential habitat due to high biomass levels.
Site 5	Low, open treeless grassland dominated by Kangaroo Grass *Themeda triandra* and wallaby-grasses *Rytidosperma spp*. with >50% cover.	Identified as a potential habitat site due to its open grassland condition. Disregarded as potential habitat due to high biomass levels.
Site 6	Low, open treeless grassland dominated by wallaby-grasses *Rytidosperma spp*. with 10-20% cover.	Identified as a potential habitat site due to its open grassland condition.

SITE	HABITAT	NOTES FOR SURVEY
Site 7	Low, open treeless grassland dominated by Kangaroo Grass *Themeda triandra* with varying cover from 10-20% on the upper slopes to higher levels on the lower slopes.	Identified as a potential habitat site due to its open grassland condition. Not surveyed due to habitat falling outside current alignments.
Site 8	Low, open treeless grassland dominated by Kangaroo Grass *Themeda triandra* and wallaby-grasses *Rytidosperma spp*. with >50% cover.	Identified as a potential habitat site due to its open grassland condition. Disregarded as potential habitat due to high biomass levels.
Site 9	Low, open treeless grassland dominated by wallaby-grasses *Rytidosperma spp*. with 10-20% cover.	Golden Sun Moth observed at this site in 2015 by WSP.
Site 10	Low, open treeless grassland dominated by wallaby-grasses *Rytidosperma spp.* and exotic grasses with >50% cover.	Identified as a potential habitat site due to its open grassland condition. Disregarded as potential habitat due to high biomass levels.

In 2018 there was a ‘bumper season’ for Golden Sun Moth, where many Golden Sun Moths were detected across Victoria, evidenced through the DELWP endorsed Golden Sun Moth email group. This included some sites where Golden Sun Moth had not previously been recorded including Beaufort. In December 2018, two incidental surveys from roadsides were undertaken at several sites in the study area, and as such habitat mapping was updated.

GOLDEN SUN MOTH HABITAT ASSESSMENTS

Golden Sun Moth habitat assessments were intended to map known or potential habitat based on descriptions in DEWHA (2009a). Categories were determined and mapped in conjunction with survey findings from the 2017 survey results. Habitat areas were updated following incidental surveys in 2018.

Preferred habitat in the study area is dominated by native grasses including Kneed Wallaby-grass *Rytidosperma geniculatum,* Copper-awned Wallaby-grass *Rytidosperma fulvum,* Kangaroo Grass *Themeda triandra* and Common Wallaby-grass, *Rytidosperma caespitosum.* See Section 6.6.2.12 for details on Golden Sun Moth habitat mapping.

STRIPED LEGLESS LIZARD

Striped Legless Lizards were considered to have a low likelihood of occurrence (WSP | Parsons Brinckerhoff 2016b) (Appendix O) due to the lack of suitable habitat and records near the study area. However, a small area of grassland was identified along the Western Highway 350 m north-east of Packhams Lane as potentially supporting some Striped Legless Lizard habitat. A small survey was proposed which was intended to be opportunistic and not a full survey program, due to the low likelihood of occurrence. As such, two tile grids (layout of 50 tiles at 5 m spacing, five rows of 10) were placed along the Western Highway (see Figure 4.6). Given the small amount of potential habitat identified (0.5 ha), the use of only two grids was considered adequate for the survey, being in accordance with the survey guidelines in the Referral guidelines for the vulnerable Striped Legless Lizard *Delma impar* (DSEWPaC 2011a), which state that two tile arrays are required for sites less than two hectares in size.

No other areas were identified in (WSP | Parsons Brinckerhoff 2016b) as providing potential habitat. This was largely due to the lack of basalt-derived soils across most of the study area (refer Section 6.3.1), the heavy agricultural use of much of the land (cropping and pasture improvement) and the lack of connectivity with historic areas of natural grassland.

The survey method was based on, but did not strictly comply with, the *Survey guidelines for Australia’s threatened reptiles: Guidelines for detecting reptiles listed as threatened under the EPBC Act 1999* (DSEWPaC 2011c) and the referral guidelines (DSEWPaC 2011a) but the method was adequate for reasons explained below.

The tile grids were placed on 15 September 2016. The tile grids were checked six times when the weather was fine and the temperature was under 20ºC. The tile grids could not be placed earlier in the year due to the timing of the project award in late August 2016. Checking dates were 20/10/2016, 1/12/2016, 17/01/2017, 1/05/2017, 23/06/2017 and 19/09/2017 (immediately prior to removal). The number of checks is lower than the 10 recommended checks in the guidelines and largely did not line up with the peak survey season for the species, which is spring. However, the approach adopted is adequate because of the extended length of the survey period. This means that, if the species was present at the grids, it is very likely that some sign of them would have been detected (i.e. skin sloughs). The ecologists undertaking the survey have extensive experience identifying the species and differentiating its skin sloughs from other similar species (such as Olive Legless Lizard *Delma inornata*).

Photo 4.1 One of the two Striped Legless Lizard tile grid sites surveyed by WSP

Further Striped Legless Lizard habitat assessment and targeted survey has been undertaken since these surveys were completed. Results, as presented in '*Striped Legless Lizard habitat assessment'* (Cardno 2020a) *and 'Targeted Survey for Striped Legless Lizard'* (Cardno 2020b) are discussed in this report where relevant.

The scope of Cardno's work included a habitat assessment to inform survey locations and targeted tile surveys for Striped Legless Lizard. The habitat assessment focused on a 250 m corridor of the C2 alignment and included a desktop and field based component. The desktop assessment identified five sites that required further field-based investigation which was undertaken on 30 July, 2 August and 16 October 2019. Each site was assessed visually for habitat features associated with Striped Legless Lizard and potential habitat was mapped.

Based on the habitat assessment, four tile grids consisiting of 50 tiles each were installed across two sites within and adjacent to the C2 alignment on 30 July 2019 (refer to Figure 4.7). Tile grids were left for approxaimtely 2.5 months before tile checks commenced in mid October 2019. Eight tile checks were undertaken fortnightly and then weekly between October 2019 and January 2020 (refer to Table 4.11). The timing of these surveys coincided with the peak active period for Striped Legless Lizard (i.e. when they are most likely to be detected if present) and the surveys were completed in accordance with Commonwealth Survey Guidelines (DSEWPaC 2011c).

An additional site west of Main Lead Road was identified as potential habitat by Cardno but was unable to be surveyed. This area was not surveyed by WSP due to the distance from previous records and lack of natural grassland.

WATERFOWL AND OTHER WATERBIRDS (BROLGA & EASTERN GREAT EGRET)

Incidental observations of waterbirds at waterbodies within and adjacent to the study area were undertaken between November 2016 – July 2017.

SUMMARY OF FAUNA SURVEY EFFORT

Refer also to Appendix O for targeted survey report in 2015 (WSP | Parsons Brinckerhoff 2016b) which has additional survey data results.

Table 4.10 Summary of 2016-2017 survey effort for fauna species

SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS	THREATENED SPECIES SURVEY GUIDELINES	SUGGESTED SEASONALITY AND SURVEY TIMING	SURVEY METHOD	SURVEY DATES																								
						20/10/2016	22-23/11/2016	30/11/2016	1/12/2016	2/12/2016	3/12/2016	4/12/2016	5/12/2016	6/12/2016	7/12/2016	8/12/2016	9/12/2016	10/12/2016	11/12/2016	12/12/2016	13/12/2016	14/12/2016	15/12/2016	16/12/2016	16/01/2017	17/01/2017	1/05/2017	23/06/2017	19/09/2017	1/12/2017
Ardea modesta	Eastern Great Egret	vu L			Incidental Observations			X																	X	X				
Delma impar	Striped Legless Lizard	VU en L	(DSEWPaC 2011c)	Surveys primarily undertaken during the active period of the species (between September and May)	Tile Surveys	X			X																	X	X	X	X	
Galaxiella toourtkoourt	Little Galaxias	VU en L	(DSEWPaC 2011b)	Anytime of the year, however this can depend on water volumes at the time of surveys	Dip netting		X																							
Grus rubicunda	Brolga	vu L		Anytime of the year, however this can depend on water volumes at the time of surveys	Incidental Observations			X																	X	X				
Litoria raniformis	Growling Grass Frog	Vu en L	(DEWHA 2010c)	November-December in temperate, southern regions under optimum weather conditions; that is, warm and windless	Call playback, active search and incidental survey			X	X																X					
Petaurus norfolcensis	Squirrel Glider	en L		Spring - Autumn	Hair Tubes, Camera Traps and Spotlighting					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
Phascogale tapoatafa	Brush-tailed Phascogale	vu L		Summer - Autumn	Hair Tubes, Camera Traps and Spotlighting					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
Pseudophryne bibronii	Brown Toadlet	en L		Summer - Autumn	Call playback, active search and incidental survey			X	X																X					
Synemon plana	Golden Sun Moth	CR cr L	(DEWHA 2009b):	Late October to early January	Active Search																		X		X					X

<u>Conservation Status used in the table above:</u>

Conservation Status in Australia (EPBC Act): CR = Critically Endangered, VU = Vulnerable.
Conservation Status in Victoria (Vic Advisory List): cr = Critically Endangered, en = Endangered, vu = Vulnerable
Status under the Flora and Fauna Guarantee Act 1988: L = Listed as threatened

Table 4.11 Summary of 2019–2021 survey effort for fauna species

SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS	THREATENED SPECIES SURVEY GUIDELINES	SUGGESTED SEASONALITY AND SURVEY TIMING	SURVEY METHOD	SURVEY DATES																																							
						16/10/2019	29/10/2019	11/11/2019	22/11/2019	29/11/2019	6/12/2019	13/12/2019	16/01/2020	3/11/2020	18/11/2020	25/11/2020	18/02/2021	19/022021	20/02/2021	21/02/2021	22/02/2021	23/02/2021	24/02/2021	25/02/201	26/02/2021	27/02/2021	28/02/2021	1/03/2021	2/03/2021	3/03/2021	4/03/2021	5/03/2021	6/03/2021	7/03/2021	8/03/2021	9/03/2021	10/03/2021	11/03/2021	12/03/2021	13/03/2021	14/03/2021	15/03/2021	16/03/2021	17/03/2021	18/03/2021
Delma impar	Striped Legless Lizard	VU en L	(DSEWPaC 2011c)	Surveys primarily undertaken during the active period of the species (between September and May)	Tile Surveys	X - Cardno	X - Cardno	X - Cardno	X - Cardno	X - Cardno	X - Cardno	X - Cardno	X - Cardno																																
Litoria raniformis	Growling Grass Frog	Vu en L	(DEWHA 2010c)	November-December in temperate, southern regions under optimum weather conditions; that is, warm and windless	Call playback, active search and incidental survey									X	X	X																													
Ninox strenua	Powerful Owl	Vu L	(Department of Sustainability and Environment 2011)	Surveys can be conducted at any time of the year, although it's recommend to avoid January and February.	Call-playback and Spotlighting																																					X		X	
Petaurus norfolcensis	Squirrel Glider	en L	–	Spring - Autumn	Camera Traps												X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
					Elliot Traps																																				X	X	X	X	X
Phascogale tapoatafa	Brush-tailed Phascogale	vu L	–	Summer - Autumn	Camera Traps												X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
					Elliot Traps																																				X	X	X	X	X

<u>Conservation Status used in the table above:</u>

Conservation Status in Australia (EPBC Act): VU = Vulnerable
Conservation Status in Victoria (Vic Advisory List: en = Endangered, vu = Vulnerable
Status under the Flora and Fauna Guarantee Act 1988: L = Listed as threatened

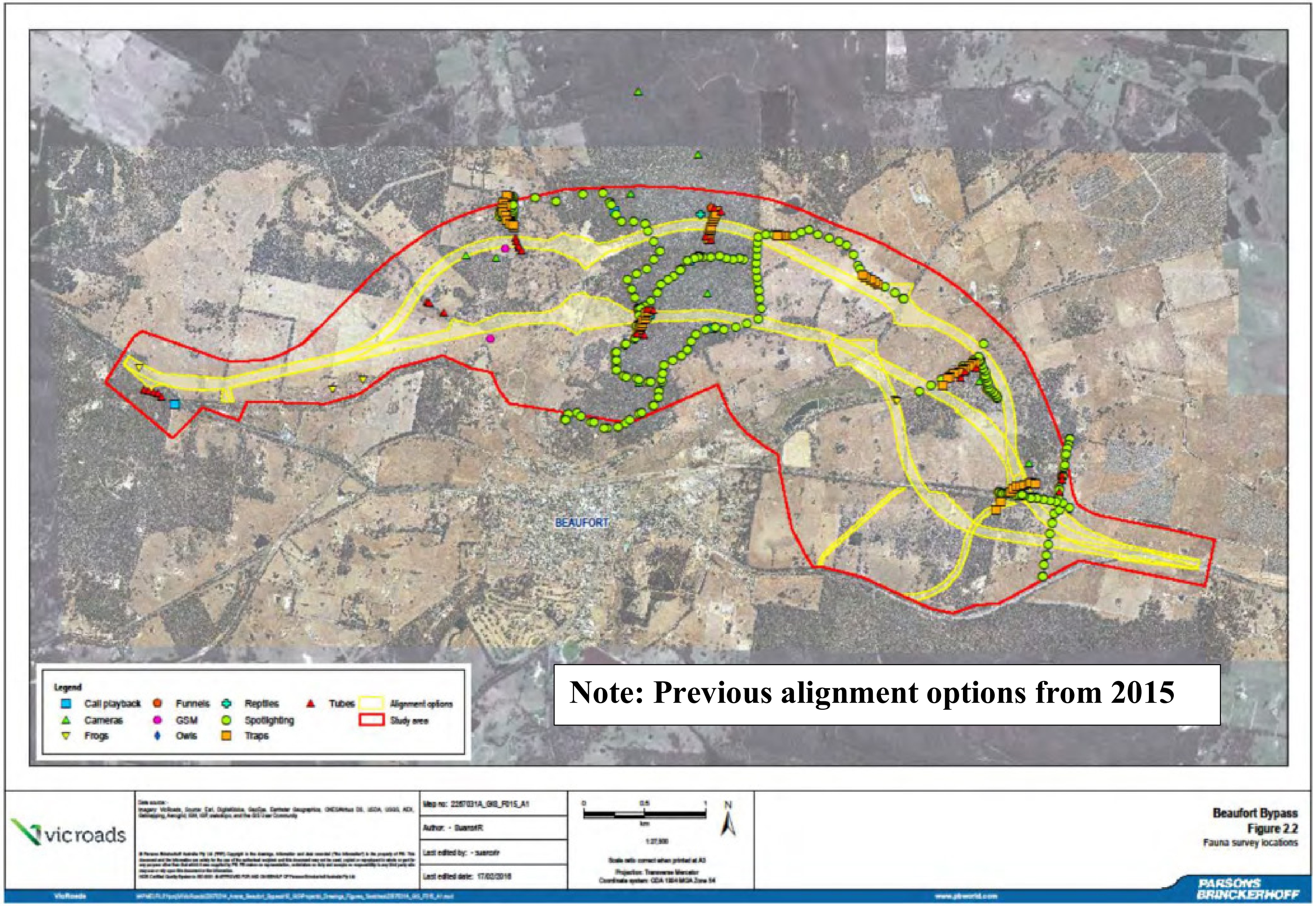


Figure 4.5 2015 fauna survey effort (WSP | Parsons Brinckerhoff 2016b) – refer also to Appendix O for targeted survey report – note previous alignment options

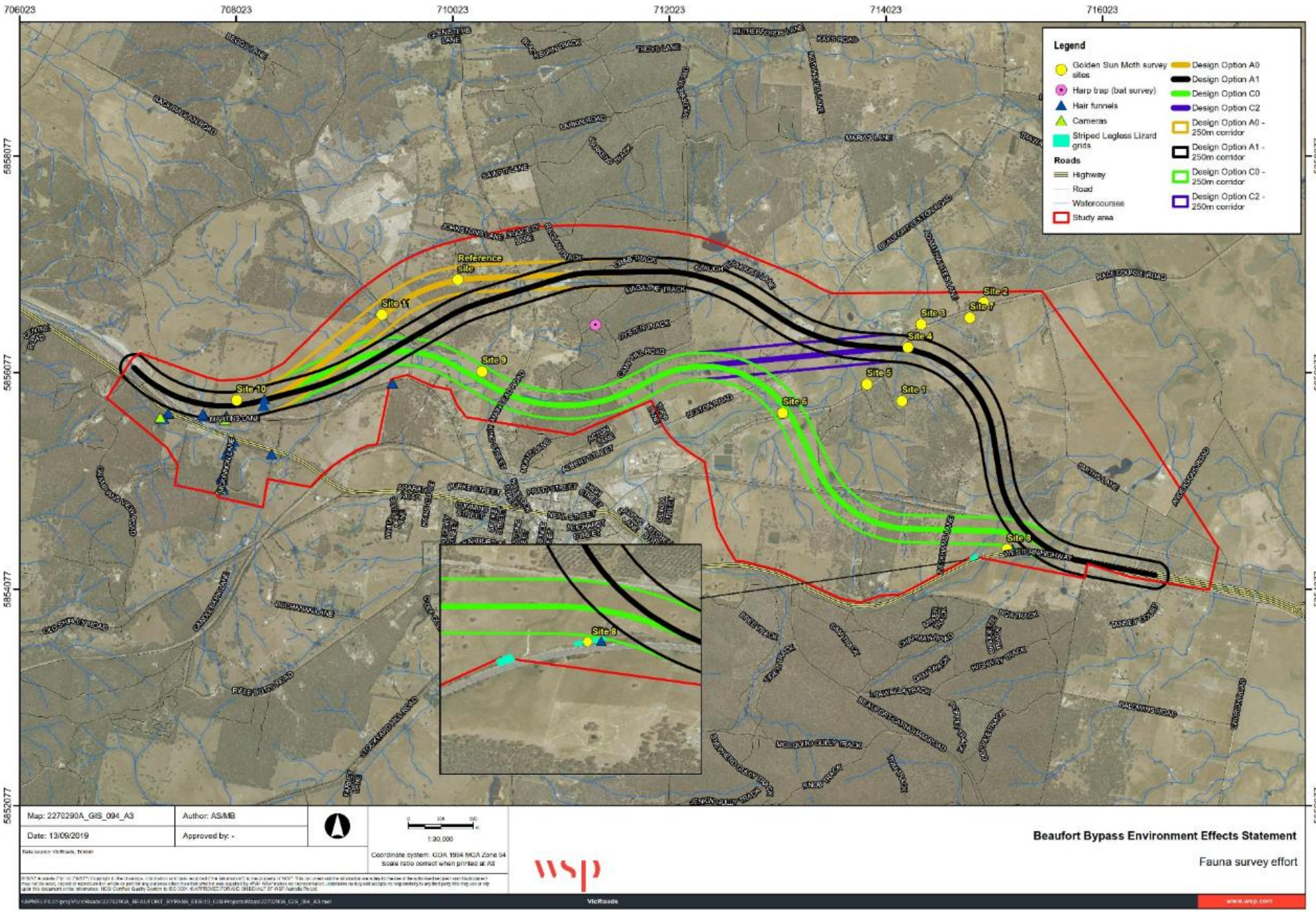


Figure 4.6 2016–2017 fauna survey effort

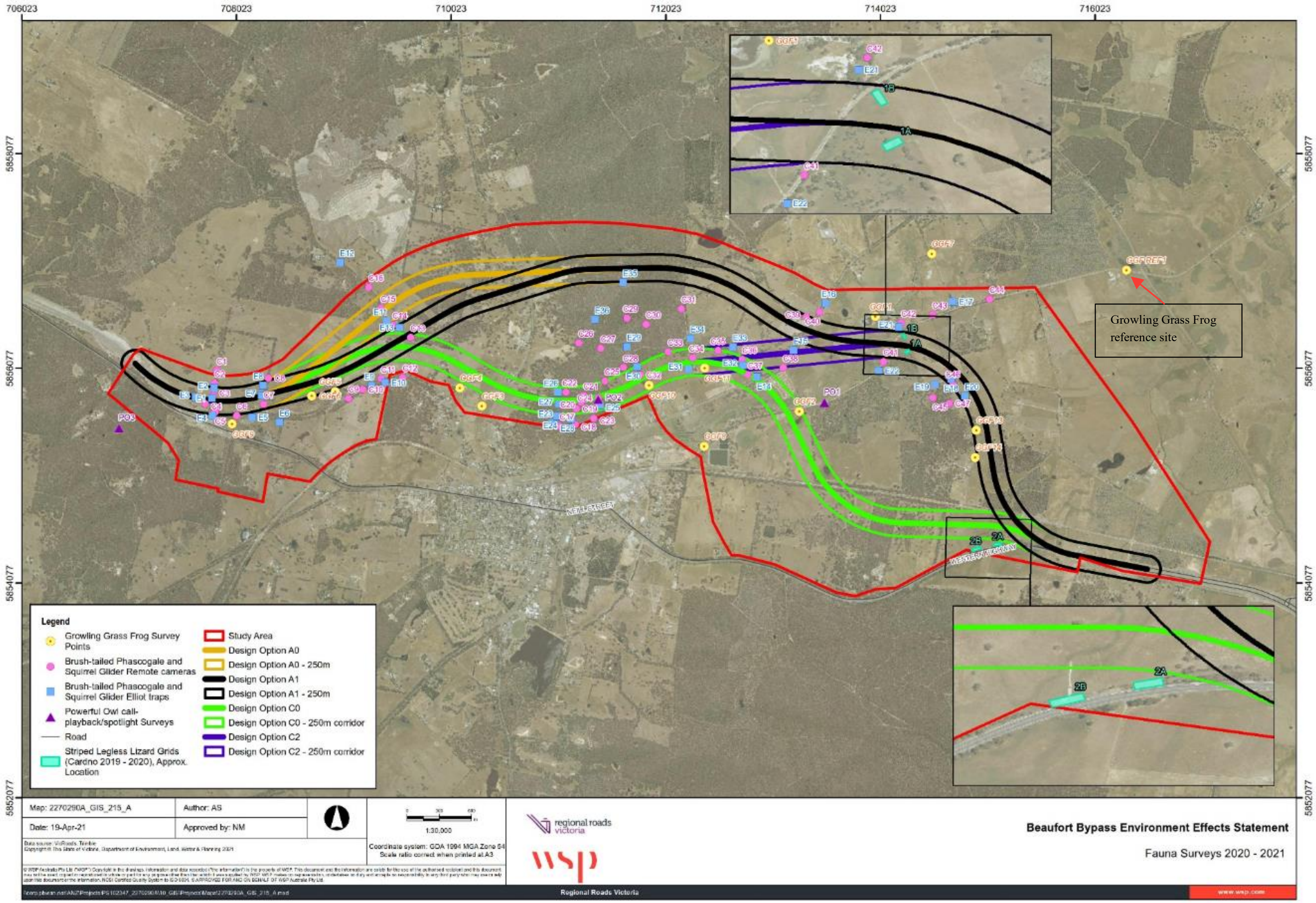


Figure 4.7 2019–2021 fauna survey effort

4.5.7.2 AQUATIC FAUNA ASSESSMENT

A desktop review, targeted survey, and likelihood of occurrence was undertaken for aquatic fauna by Streamline Research. The methodology is detailed in the following sections.

DESKTOP REVIEW

A desktop review was completed, including analysis of VBA records and records in the Victorian Aquatic Fauna Database (DSE 2010b), as well as a review of past surveys including:

- Western Highway Bypass Project – Beaufort Stage 1 – Flora, Fauna and Aquatic Assessment (GHD 2015)
- Environmental Effects Statement referral for the Beaufort Bypass – update to flora and fauna information Ecology Partners Pty Ltd (2014)
- Threatened species Targeted Assessments (WSP | Parsons Brinckerhoff 2016b).

SURVEY SPECIES

Only one species was targeted in this aquatic fauna investigation, the Little Galaxias. The species was recommended for further survey following the 2015 aquatic fauna study (WSP | Parsons Brinckerhoff 2016b). As the Little Galaxias has only recently been described (Coleman, Hoffmann & Raadik 2015) there is currently no formal national or state categorisation of the species. However, as the species represents 60% of the known range of the Dwarf Galaxias (Coleman, Hoffmann & Raadik 2015) it should, at a minimum, be considered to have the conservation significance of the Dwarf Galaxias. The Dwarf Galaxias is listed as 'Vulnerable' under the EPBC Act, is listed under the FFG Act and 'Endangered' on the Victorian Advisory List for threatened fauna.

The Little Galaxias is only known to occur to the west of Melbourne and in South Australia. In close vicinity to Beaufort, the species has been recorded just east of the study area in Yam Holes Creek (DELWP 2018e).

A second nationally threatened fish species, the Yarra Pygmy Perch *Nannoperca obscura* was formerly considered worthy of a targeted survey (Ecology Partners Pty Ltd 2014; WSP | Parsons Brinckerhoff 2016b), but was not considered in this investigation. An unconfirmed record of the species in Mt. Emu Creek at Trawalla in 2010 has not been validated. As there is no historical record of the Yarra Pygmy Perch in Mt. Emu Creek (DELWP 2018e), the species is unlikely to be found in any of the waterways within the Beaufort Bypass study area.

FISH SURVEY SITE SELECTION

Unlike past aquatic investigations (GHD 2015; WSP | Parsons Brinckerhoff 2016b), this investigation targeted waterways in which the Little Galaxias had been recorded and habitats which the species could be expected to occupy.

The early 2015 investigation (GHD 2015) concentrated upon watercourses found along roads, most of which were dry at the time of assessment. The late 2015 study (WSP | Parsons Brinckerhoff 2016b) targeted the expected alignment routes for the Beaufort Bypass but again found that most waterways were dry.

Winter and spring rain in 2016 meant that reaches of Yam Holes Creek and many floodplain wetlands had filled with water. Although there had not been flooding, connectivity between waterways may have provided conditions suitable for the spread of the Little Galaxias into the study area, as occurred following the January 2011 flood.

The Little Galaxias survey was conducted on 22-23 November 2016 by John McGuckin. The main creeks targeted were Yam Holes Creek and minor tributaries Cumberland, Cemetery and Ding Dong Creeks. As the Little Galaxias has been recorded in Mt. Emu Creek, a nearby connecting creek, it too was targeted as part of this investigation even though it was outside of the Beaufort Bypass study area. Yam Holes Creek floodplain wetlands were also examined, as these could potentially provide a permanent source of water that could support a Little Galaxias population.

Yam Holes Creek was walked between Racecourse Road and Beaufort-Lexton Road with many locations within the creek and floodplain wetlands sampled for the Little Galaxias. Yam Holes Creek is seasonally flooded but tends to reduce down to pools in drier seasons. Minor tributaries were surveyed but as they all appear to be seasonal, therefore fewer survey locations were examined.

Sampling utilised dip netting, a technique which is ideal for the capture of Little Galaxias. Dip netting also allows for the visual identification of young of the year that would be overlooked using other sampling techniques. Use of unbaited traps and electrofishing may be useful for the capture of other fish species but have limited use in the capture of Little Galaxias (John McGuckin pers. comm.). In the Survey Guidelines for Threatened Fish, *Guidelines for detecting fish listed as threatened under the EPBC Act 1999* (DSEWPaC 2011b), there are a range of survey methods available including dip netting, overnight traps and electrofishing. While it states traps have proven highly effective, it does not discount the use of other methods and they are only guidelines not specifications. Additionally, in most instances the water depth was insufficient to set fyke nets.

In total, 40 locations were surveyed for Little Galaxias (see Figure 4.8). Twenty-four locations were surveyed in Yam Holes Creek, eight in tributaries, six in floodplain wetlands, one in a farm dam and one in Mt. Emu Creek. The one farm dam surveyed was suspected to have held permanent water since 2011 and was observed spilling into Yam Holes Creek.

Topographical map references of each location are listed in Appendix H and photographs of each location are provided in Appendix I.

Surveys in 2016 were a supplement to two other aquatic ecology surveys undertaken in 2014 by GHD (GHD 2015) and WSP | Parsons Brinckerhoff in 2015 (WSP | Parsons Brinckerhoff 2016b). Bait traps were used by WSP | Parsons Brinckerhoff in 2015. Previous surveys in 2014 and 2015 did not detect Little Galaxias.

In situ water quality field measurements were made with a TPS 90-FLT multimeter. This water quality instrument measures pH, conductivity, temperature, dissolved oxygen and turbidity. Each of the parameters were calibrated and water quality monitoring was conducted in accordance with NATA protocols.

Property access was requested and granted for all the waterway locations surveyed in this study.

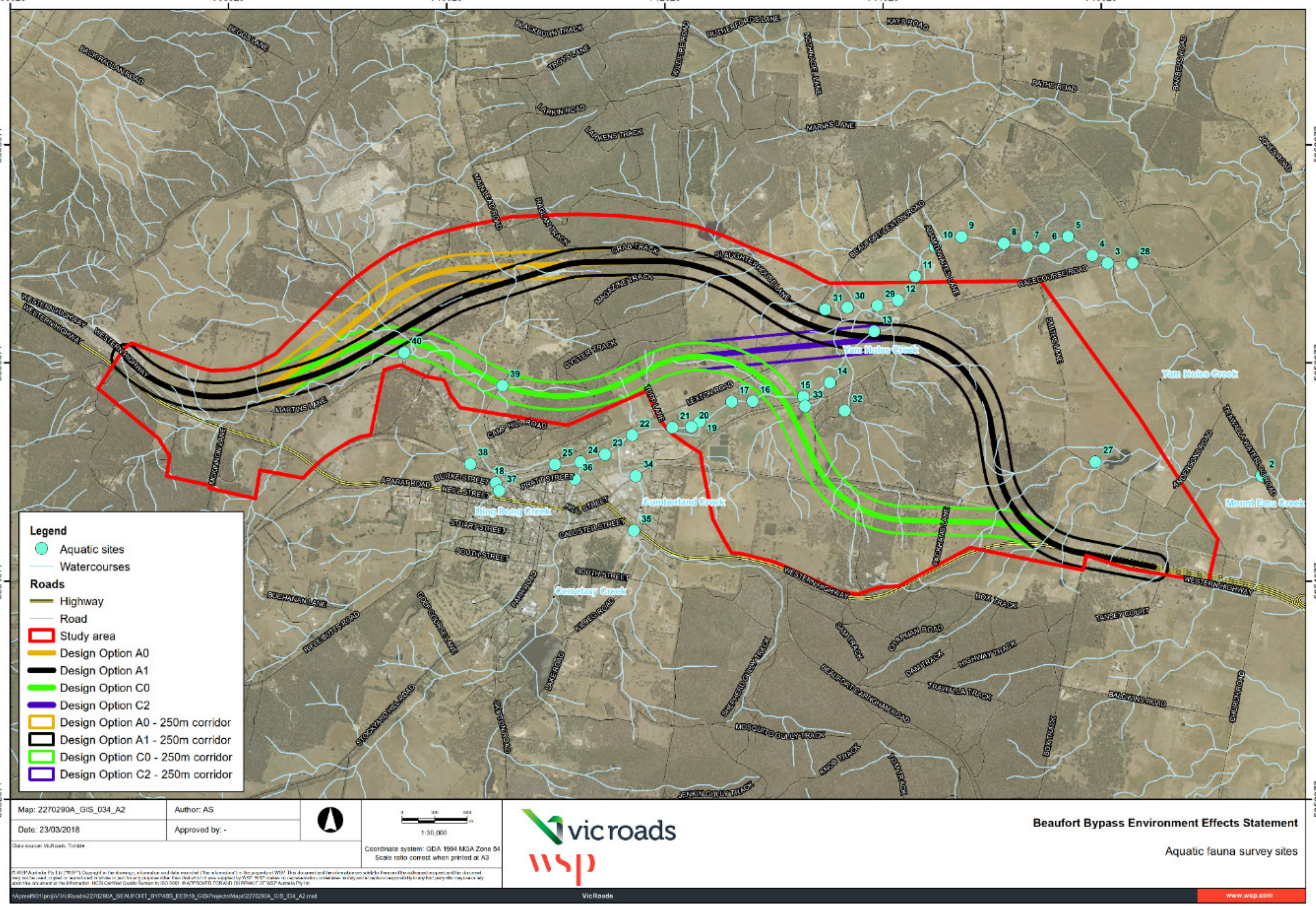


Figure 4.8 Fish survey sites

4.5.7.3 FAUNA HABITAT MAPPING

The mapping of potential habitat is a common and standard industry practice method to identify areas where a species may occur based on habitat attributes. For each species, WSP sampled the potential habitat area and also utilised EVC mapping and aerial photography. Habitat mapping and categories were refined based on the results of targeted surveys, where relevant. Several fauna species in the study area are highly mobile across the landscape and the habitat mapping method is more useful than targeted survey to determine the possible range of their movements during their foraging, territorial and breeding behaviour.

DELWP's Species Habitat Distribution Models (V4) (SHDM) (DELWP 2012) was examined in the habitat assessment and mapping process, however, this was not relied on for determining site-specific habitat needs or determining areas to target for surveying. This is because many SHDMs are not reliable at a site-based scale (e.g. 1:10,000) and for some species there is no modelled data for the study area.

Fauna habitat mapping was undertaken for the following species:

- Growling Grass Frog
- Brown Toadlet
- Waterfowl and other waterbirds (Brolga & Eastern Great Egret)
- Victorian Temperate Woodland Bird Community (FFG Act listed community)
- Arboreal mammals such as Brush-tailed Phascogale
- Golden Sun Moth
- Little Galaxias – main waterways and wetlands – excluding minor tributaries.

Potential habitat for some species was mapped using only one category where there was less specific information on habitat available or where the species has broader habitat requirements. For some species, further levels of habitat quality (e.g. low, medium and/or high) were also mapped. More detailed definitions and methods on habitat categories used are provided below.

Table 4.12 Provides the characteristics used to map final habitat categories for different species/guilds within the study area, taking into account all survey results

SPECIES/GROUP	HABITAT CATEGORIES AND DEFINITIONS USED IN THIS REPORT
Growling Grass Frog	Growling Grass Frog is usually found in water bodies such as lagoons, swamps, lake and farm dams (Clemann & Gillespie 2012) with submerged, emergent and floating vegetation still or slow-moving water (Robertson, Heard & Scroggie 2002). Growling Grass Frog depends on aquatic habitats for breeding and a range of terrestrial habitat for foraging and shelter (Clemann & Gillespie 2012). Terrestrial habitats including woodland and forest are also used by Growling Grass Frog during the breeding season where individuals use dense ground vegetation, rocks, logs and other woody debris as refuge sites during dispersal (Pyke 2002), sometime considerable distances from waterbodies (Clemann & Gillespie 2012). **Aquatic habitat** — **High quality potential aquatic habitat** is defined as those with preferred habitat characteristics described above which are areas favoured for breeding. — **Moderate quality potential aquatic habitat** is defined as sites which have some characteristics of high quality sites but may lack some or a number of key features. These sites include farm dams with lower levels of emergent, submerged or floating vegetation, or with steep sided banks, sites which lack permanent water, and isolated dams with fewer connections to favoured sites but may have high levels of emergent, submerged and floating aquatic vegetation. **Terrestrial habitat** Terrestrial habitat is used for dispersal, foraging and overwintering and are defined as a buffer of 200 m surrounding aquatic habitat in the significant impact guidelines (DEWHA 2009c). — **High quality** terrestrial habitat surrounds the high quality aquatic/breeding habitat. — **Moderate quality** terrestrial habitat surrounds the moderate quality aquatic/breeding habitat.
Brown Toadlet	Brown Toadlet usually breeds following heavy summer rains with eggs laid in small depressions (Tyler & Knight 2009) near water that will later be flooded (ARC 2020). The habitat of Brown Toadlet is typically dry forest, woodland, shrubland and grassland where they shelter in moist depressions and soaks such as drainage lines and small dams. Due to the wide variety of habitats that this species may inhabit, only one category of habitat was defined and mapped: **'potential habitat'**. There are a number of wetlands, drainage lines and drains within the study area which provide potentially suitable habitat characteristics for the Brown Toadlet.
Water birds	Habitat for wetland birds were broadly defined into two categories: **High quality** — Larger and more intact waterbodies with longer inundation hydroperiods. — Higher likelihood of use for breeding, foraging and roosting of waterbirds such as Brolga. **Moderate quality** — Smaller waterbodies and wetland areas typically with shorter inundation hydroperiods. — Lower likelihood of use for breeding, foraging and roosting of waterbirds such as Brolga.

SPECIES/GROUP	HABITAT CATEGORIES AND DEFINITIONS USED IN THIS REPORT
Woodland birds	One category of habitat was defined for woodland birds: **'Woodland habitat'**. The Victorian Temperate Woodland Bird Community is listed under the FFG Act. It is defined as a suite of bird species which has declined significantly, mainly associated with drier woodlands on the slopes and plains north of the Great Dividing Range (DELWP undated). Given the broad definition above, the majority of the woodland and forest EVCs within the study area have been mapped as Victorian Temperate Woodland Bird Community.
Arboreal mammals	The Brush-tailed phascogale *Phascogale tapoatafa* is a nocturnal tree dwelling marsupial that inhabits a range of environments with a preference for dry sclerophyll forest with sparse groundcover (DSE 2003). Given that the majority of woodland and forest EVCs meet this broad definition, most treed EVCs in the study area is potential habitat for Brush-tailed phascogale, mapped in the following two categories: **High quality potential habitat** — Habitat mapped as high quality where larger, intact remnants were present and where there have been confirmed records. **Moderate quality potential habitat** — Habitat mapped as moderate quality are where there are more fragmented remnants were present without confirmed records.
Little Galaxias	Little Galaxias inhabits swamps, wetlands, shallow lakes, billabongs, small creeks and artificially created drainage lines in landscapes of low elevations (7–376 m) (Coleman, Hoffmann & Raadik 2015). Habitats are mostly shallow (0.5–1.5 m) with still to low water velocities with partial to moderate levels of shading (Bray 2019). The species has frequently been captures in waters which have dense native aquatic vegetation, particularly emergent and submergent aquatic species (Coleman, Hoffmann & Raadik 2015). In the study area, potential habitat has been mapped across most of the deeper and more permanent reaches of Yam Holes Creek and its tributaries. Some of the potential habitat meets the favoured characteristics described above (e.g. through parts of Yam Holes Creek between Racecourse Road and Beaufort-Lexton Road) whereas some areas appear less suitable (e.g. west of Back Raglan Road) where the creeks are channelised with little surrounding vegetation or permanent pools of water for refuge. However, these channelised creeks may still be useful for dispersal of the species throughout the landscape.

SPECIES/GROUP	HABITAT CATEGORIES AND DEFINITIONS USED IN THIS REPORT
Golden Sun Moth	The habitat categories and typical characteristics are described below. **'Confirmed habitat'** Patches which supported Golden Sun Moth as recorded in this study during surveys. These are typically patches of native grassland or treeless grassy woodland dominated by wallaby grasses *Rytidosperma spp*. and spear grasses *Austrostipa spp*. with open inter-tussock spaces (DEWHA 2009a). Patches of habitat usually support high proportion of Golden Sun Moth feed species with optimum biomass levels. **'Higher quality potential habitat'** Patches of preferred habitat, as described above and in DEWHA (2009a), where surveys have not confirmed the presence of Golden Sun Moth. The patch may have the following characteristics: — supports a high proportion of Golden Sun Moth feed species (roughly above 25%) — supports optimal biomass levels — supports suboptimal proportion of feed species or suboptimal biomass levels but is contiguous with or very close to confirmed habitat. **'Lower quality potential habitat'** Patches with elements of habitat such as scattered wallaby grasses with higher levels of exotic herbs and grasses and/or less available inter-tussock spaces. The patch may have the following characteristics: — Golden Sun Moth have not been recorded — supports a proportion Golden Sun Moth feed species although it may be suboptimal (roughly less than 25%) — supports suboptimal biomass levels — is not located close to confirmed habitat. **'Not mapped as habitat'** — Golden Sun Moth have not been recorded — none or very low proportion of Golden Sun Moth feed species (roughly less than 5%) — recently ploughed/cropped — wetlands — heavily treed vegetation without open grassy areas.

4.5.7.4 DETERMINATION OF CONNECTIVITY IN THE LANDSCAPE

Ecological connectivity is characterised by habitat features in a fragmented or heterogeneous landscape that physically link other features, especially when they link discrete areas of habitat occupied by a particular species or community (e.g. patches) (Doerr et al. 2014). Determination of existing connectivity in the landscape can be done by using a number of different methods (Hargrove, Hoffman & Efroymson 2005; Lechner et al. 2017; O'Malley & Lechner 2017; PAUL, R. & D. 2008).

INITIAL CONNECTIVITY ASSESSMENT

A simplified method was initially used to create a digitally constructed map of structural connectivity based on *Ecological Connectivity Plan for the South-east region of Melbourne* (McCaffrey, N & Henry 2010).

The determination of existing connectivity in the landscape was undertaken in GIS by using definitions in (McCaffrey, N & Henry 2010) combined with DELWP's dataset NV_2005_QUAL_LC to produce a digital interpretation of structural connectivity. NV_2005_QUAL_LC is the layer for the modelled output of Landscape Context (LC). LC constitutes 25 points based on the Habitat Hectares method (DSE 2004). This incorporates aspects of landscape ecology including patch size, neighbourhood (the total coverage of vegetation/habitat within the surrounding area at different distances from a site) and proximity to core area (areas greater than 50 ha). The types of connectivity identified in the landscape for the purposes of this study include the following types of habitat:

- **Core areas** – large patches of native vegetation and/or fauna habitat which are >50 ha, generally with a higher LC score of >10.50 ha is the size threshold used for the Habitat Hectare method, which is defined as *"any patch of native vegetation greater than 50 ha regardless of type, quality or tenure"* (DSE 2004). Secondly, it is used to define habitats that functionally control population spatial structure (Martin and Benda 2004).
- **Nodes** – medium-sized patches of native vegetation, defined by LC scores of 9–12, generally 20–50 ha in size.
- **Stepping stones** – smaller-sized patches of native vegetation defined by LC scores of <9. Stepping stones are one or more separate patches of habitat in the intervening space between ecological isolates, that provide resources and refuge that assist animals to move through the landscape (Bennett 2003).
- **Terrestrial corridors** – linear links of native vegetation. Linear patterns were identified by eye. Minimum width was determined by pixel display size, which shows patches of vegetation >20 m wide. These corridors are typically a linear strip of vegetation that provides a continuous (or near continuous) pathway between two habitats.
- **Wetland and riparian corridors** – linear links of existing wetlands, watercourse, drainage line with or without native vegetation.

DETAILED CONNECTIVITY ASSESSMENT

As part of the EES, WSP later commissioned the University of Nottingham (UoN) Malaysia to undertake a more in depth assessment of current and future levels of connectivity for wildlife in response to the proposed bypass titled *Wildlife Connectivity Impact and Mitigation Assessment* (Lechner et al. 2019). The study, provided in Appendix M, set out to address the following scoping requirements:

- characterise the distribution and quality of biodiversity values that could be affected by the proposed project, including remnant native vegetation, large old trees, terrestrial and aquatic habitat for threatened species and patterns of wildlife movement in the area
- assess the likely direct and indirect effects of each alignment alternative on wildlife movement and biodiversity values, including native vegetation, large old trees, listed threatened flora and fauna species and ecological communities, including those listed under the FFG Act and DELWP Advisory List
- identify mitigation measures to avoid or reduce negative impacts on the environment including wildlife movement and connectivity (e.g. suitable fencing and overhead or under-road wildlife crossings including in relation to bridges for waterway crossings).

Associate Professor Alex Lechner and colleagues from the Landscape and Conservation Lab in the School of Environmental and Geographical Sciences at the University of Nottingham analysed the current and future levels of connectivity for the four alternative alignment designs using spatially-explicit state-of-the-art modelling approaches known as the General Approach to Planning Connectivity from Local Scales to Regional (GAP CLoSR). This framework was developed by Professor Lechner and others and has been employed on projects globally to assess levels of connectivity under different scenarios. The framework also helps identify key locations in the landscape that are critical to maintaining or restoring connectivity and prioritising landscape restoration activities. The method behind this approach is spatially complex. It involves a series of GIS processing steps to create land cover maps that inform the connectivity assessment. A simplistic overview to this approach is shown as a visual schematic in Figure 4.9.

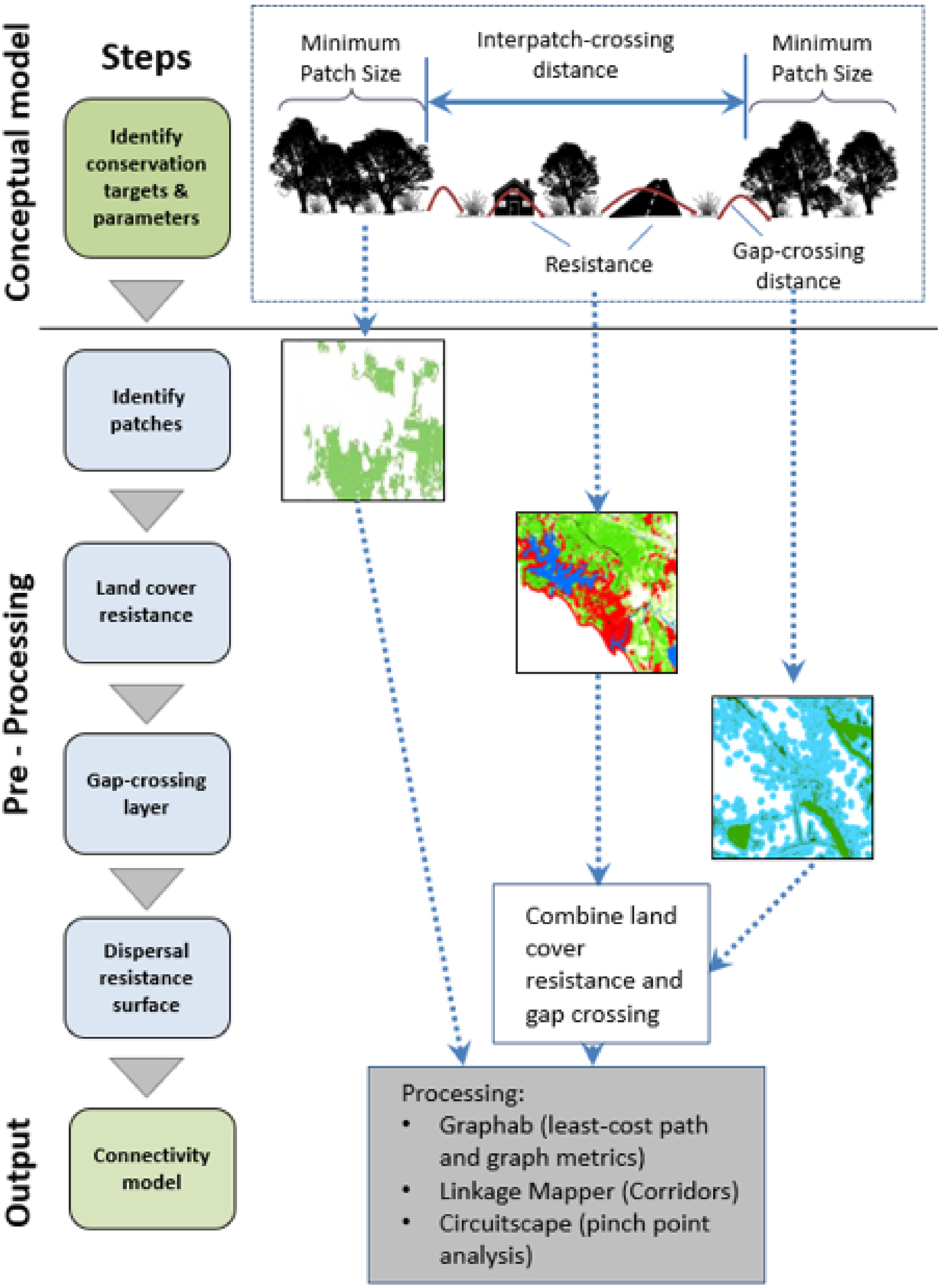


Figure 4.9 Schematic diagram identifying the steps taken to complete the connectivity assessment

The first step involved determining the spatial extent that would be used. The study area used in the EES was extended by a two-kilometre buffer for use in the connectivity assessment to include portions of woodland in the north, southeast and southwest of the town. Doing so enabled the study to assess connectivity at the landscape scale.

Next was the determination of the species or communities that would be used in the study, referred to as conservation targets. For inclusion, the study required the chosen conservation targets to have available data regarding habitat distribution and dispersal characteristic parameters (i.e. minimum habitat patch size). In addition, the conservation targets needed to consist of species or groups of species with a range of habitat preferences and movement capabilities to 'represent' a diversity of species occurring in the study area. Together, WSP and the UoN team decided on five conservation targets. The rational for their inclusion is provided in Table 4.13 below. The habitat preferences and movement capabilities of each of these targets was then characterized using data from the published literature and expert opinion where such data was not available.

Table 4.13 Each conservation target, the group they represent and their habitat and dispersal characteristics

CONSERVATION TARGETS	SPECIES OR FAUNA GROUPS	HABITAT AND DISPERSAL CHARACTERISTICS
Woodland Birds	Tree cover sensitive birds	Native woody vegetation (dominant remnant ecosystem within the study area), tree cover sensitive. Representative of the "average species" dispersal characteristics (cf. Lechner & Lefroy, 2014).
Short-beaked Echidna	Ground-dwelling mammal	Ground-dwelling mammal, woody-vegetation dependent. Representative of long dispersers.
Brush-tailed Phascogale	Arboreal mammal	Small arboreal mammal, woody-vegetation dependent. Representative of long dispersers.
Growling Grass Frog	Amphibian	Wetland amphibians. Representative of short dispersers.
Golden Sun Moth	Invertebrate	Grassland. Representative of short dispersers.

The UoN team then created a land cover map for current scenario modelling. This was achieved by using a combination of remote sensing land cover mapping and GIS processing of a range of GIS datasets. The resultant land cover map accounted for areas of native and non-native woody vegetation, roads, rail lines, pasture and open spaces, waterways and residential developments.

The connectivity was characterised and modelled for each conservation target using modelling methods which simulate how animals move through the landscape based on their movement ecology and habitat preferences, and how they respond to anthropogenic land cover. These layers were then combined and used as inputs for the connectivity models which generated least-cost paths, least-cost corridors and pinch points for each conservation target. This enabled the assessment of current connectivity in the landscape without the bypass.

Assessing the impacts of each alignment on connectivity was achieved by comparing the current scenario with the modelled connectivity of each bypass design option (A0, A1, C0 and C2). The impacts were visually analysed, and quantified using mathematically derived metrics, to assess how each alternative design option fragmented the conservation target's landscape.

Finally, the effectiveness of realistic options for wildlife crossing structures were evaluated for the preferred alignment option C2. WSP provided UoN with the indicative locations of nine canopy rope bridges (for Brush-tailed Phascogale) and one vegetated landbridge (for woodland birds, Echidna and Brush-tailed Phascogale) along the alignment. These were positioned at locations where tree cover was lost for the construction of the bypass and at locations on the functional designs that were conducive to the construction of that type of crossing structure. Modelling software was then used to calculate the increase in connectivity associated with the addition of these mitigation structures. Improvements in connectivity for the Growling Grass Frog was not assessed because it was assumed that the identification of crossing structures would inevitably choose the waterways and that all waterways would include structures that allowed movements of the frogs. However, the absence of using this for modelling does not equate to effective mitigation; the efficacy of connecting Growling Grass Frog populations depends on the specific design of the crossing structures and habitat created either side to maximise the crossing probability, which is covered in Section 10.4.2.4 of this report. The efficacy of connectivity for Growling Grass Frog was not able to be modelled at the time. Golden Sun Moth was not assessed for effectiveness of connectivity as the design of effective crossing structures for Golden Sun Moth are not known and cannot be modelled at the time.

In summary, the modelling of connectivity provided an objective, repeatable and transparent approach to evaluating the impacts of each of the proposed alignment options on wildlife movement and the relative benefits of the inclusion of crossing structures for woodland dependent species. For more information on the methodology used in the wildlife connectivity impact and mitigation assessment refer to Appendix M.

4.5.8 LIKELIHOOD OF OCCURRENCE

As with most biological assessments, the presence or absence of a particular species cannot be definitively determined during a relative short survey timeline. For this study, the likelihood of occurrence of threatened and migratory species and populations was determined based on the criteria shown in Table 4.14 below. This method identifies the habitat requirements of the species, outcomes of a habitat assessment and habitat connectivity in conjunction with Victorian Biodiversity Atlas and Protected Matters Search Tool records.

Table 4.14 Likelihood of occurrence criteria for threatened flora and fauna species

LIKELIHOOD	DESCRIPTION
Low	Species considered to have a low likelihood of occurrence include species not recorded during the field surveys that fit one or more of the following criteria: — have not been recorded previously in the study area and surrounds and for which the study area is beyond the current distribution range — rely on specific habitat types or resources that are not present in the study area — are considered locally extinct — are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded.
Moderate	Species considered to have a moderate likelihood of occurrence include species not recorded during the field surveys that fit one or more of the following criteria: — have infrequently been recorded previously in the study area and surrounds — use habitat types or resources that are present in the study area, although generally in a poor or modified condition — are unlikely to maintain sedentary populations, however, may seasonally use resources within the study area opportunistically during variable seasons or migration — are cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded.
High	Species considered to have a high likelihood of occurrence include species not recorded that fit one or more of the following criteria: — have frequently been recorded previously in the study area and surrounds — use habitat types or resources that are present in the study area, that are abundant and/or in good condition within the study area — are known or likely to maintain resident populations surrounding the study area — are known or likely to visit the site during regular seasonal movements or migration.
Recorded	Any threatened species recorded during field surveys.

4.5.9 PERMITS

All relevant WSP staff are covered under the Victorian *Flora and Fauna Guarantee Act 1988* Permit to take/keep protected flora purposes of identification and lodging herbarium specimens (permit no. 10007800, now updated to 10009535). Also, all relevant WSP staff are covered under the Standard Operating Procedures approved by the former Department of Economic Development, Jobs, Transport and Resources, Wildlife and Small Institutions Animal Ethics Committee approval (08.17, now 06.20) and Victorian *Wildlife Act 1975* Research Permit (permit no. 10007800, now 10009535).

Terrestrial fauna surveys in 2016 were undertaken by Rob Gration under the approval of the former Department of Economic Development, Jobs, Transport and Resources, Wildlife and Small Institutions Animal Ethics Committee approval (04.16) and Victorian *Wildlife Act 1975* Research Permit (Permit No. 10007972).

The aquatic fauna survey was undertaken by John McGuckin in accordance with the following approvals and permits held by Streamline Research:

- Department of Environment and Primary Industries Research Permit (RP1072).
- Department of Environment and Primary Industries Flora and Fauna Guarantee Act 1988 Permit To Take/Keep Protected Fish (10007420).
- Former Department of Economics, Development, Jobs, Transport and Resources Wildlife and small Institutions Animals Ethics Committee approval (01.13).
- Former Department of Economics, Development, Jobs, Transport and Resources Wildlife and small Institutions Animals Ethics Scientific Procedures Fieldwork Licence (SPFL1090).

4.6 RISK ASSESSMENT

As outlined in the *Ministerial Guidelines for Assessment of Environmental Effects* (DSE 2006) (Ministerial guidelines) and the final *Scoping Requirements for the Beaufort Bypass Project EES (2016)*, a risk-based approach was adopted for the EES studies to assess potential risks and direct a greater level of effort at investigating matters that pose relatively higher risk of adverse environmental effects.

The project defines impact and risk as:

- environmental impact is described as any change to the environment as a result of a project activities
- the project adopts the definition of environmental risk proposed by the Ministerial guidelines, that: "e*nvironmental risk reflects the potential for negative change, injury or loss with respect to environmental assets*". This approach correlates with ISO 31000: 2018, which defines risk as "*the effect of uncertainty of [environmental] objectives*". Both definitions reflect the fact that risk is normally expressed in terms of the likelihood of a change occurring and the consequence of that change.

The purpose of the environmental risk assessment (ERA) was to provide a systematic approach to further assessing the project's impacts, whether they be environmental, social or economic. It articulated the probability of an incident with environmental effects occurring and the consequential impact to the environment.

Through undertaking a risk assessment, hazards and risks were identified, analysed and evaluated, and appropriate mitigation measures developed to ensure that both the project and RRV's objectives are met. Through establishing a rigorous assessment, a wide range of variables may be considered and the risk of the project to the environment may be controlled and reduced through implementation of appropriate avoidance and mitigation measures.

The risk assessment is a critical part of the EES process as it guides the level and range of impact assessment work required, identifies further assessment work which may be required following the review of results at the risk workshop, and facilitates a consistent approach to risk assessment across the various disciplines.

4.6.1 RISK IDENTIFICATION

To effectively and comprehensively recognise all potential risks to the project, it was necessary to identify impact pathways for the project. An impact pathway is the cause and effect pathway or relationship that exists between a project activity (or aspect) and environmental segment. The ERA describes how aspects of design, construction, operation and maintenance interact with assets, values and uses.

Environmental impacts were identified under two categories:

- Primary environmental impacts: impacts that were directly attributable to project activities, following a cause and effect formula where an activity results in an impact to an environmental segment or value, such as land clearing resulting in vegetation impacts.
- Secondary environmental impacts: environmental impacts that arise as a direct outcome of implementing a risk response in mitigating a primary environmental impact.

4.6.2 RISK ANALYSIS

With risks identified for each discipline, industry best practice and standard mitigation controls intrinsic to the project were identified, including requirements under relevant sections of the VicRoads Standard Specifications, EPA guidelines and Government environmental management policies.

4.6.3 RISK EVALUATION

The risk assessment criteria that were used for determining the significance of risks of the project are a product of likelihood and consequences factors for project-related environmental risks. These tools are shown below in Table 4.15.

Table 4.15 Risk assessment matrix

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

The risk evaluation criteria were adapted from the risk matrix set out in the VicRoads Environmental Sustainability toolkit.

All risks should be reassessed at regular intervals during all phases of the project, from the development of the EES to Operation and Maintenance, to ensure they are still applicable, that controls are appropriate and effective and that they reflect most recent outcomes of specialist technical studies.

Based on the project objectives and context, a draft set of project-specific and appropriate assessment, likelihood and consequence criteria were developed.

The likelihood categories are used as a guide for evaluating risk shown below in Table 4.16.

Table 4.16 Likelihood categories

RARE (A)	UNLIKELY (B)	POSSIBLE (C)	LIKELY (D)	ALMOST CERTAIN (E)
Less than once in 12 months OR 5% chance of recurrence during course of the contract	About once in 6 months OR 10% chance of recurrence during course of the contract	About once in 4 months OR 30% chance of recurrence during course of the contract	About once in 2 months OR 50% chance of recurrence during course of the contract	About once in a month OR 100% chance of recurrence during course of the contract
The event may occur only in exceptional circumstances	The event could occur but is not expected	The event could occur	The event will probably occur in most circumstances	The event is expected to occur in most circumstances
It has not happened in Victoria but has occurred on other road projects in Australia.	It has not happened regionally but has occurred on other road projects in Victoria	It has happened in the Beaufort region	It has happened on an adjoining section of the Western Highway	It has happened on more than one of the adjoining Western Highway projects OR It has happened multiple times on an adjoining Western Highway project.

Consequence criteria have been developed for the project in consultation with technical specialists. The result is a discipline and aspect-specific set of consequence descriptors used to define what would be considered an Insignificant, Minor, Moderate, Major and Catastrophic consequence associated with a risk event.

Table 4.17 Biodiversity and habitat environmental risk assessment consequences descriptors

ASPECT	INSIGNIFICANT	MINOR	MODERATE	MAJOR	CATASTROPHIC
Project impacts threatened species	Negligible impact on species or species' habitat (e.g. for EPBC Act or FFG Act listed species this may be an indirect or temporary impact on <0.005% of remaining species' habitat in Victoria*).	Minor impact on species or species' habitat (e.g. for EPBC Act or FFG Act listed species this may be loss or permanent impact on <0.005% of remaining species habitat in Victoria with no direct impact on important or critical local habitat).	Moderate impact on species or species' habitat (e.g. for EPBC Act or FFG Act listed species this may be 0.005–1% loss of remaining species' habitat in Victoria, or <0.005% of important or critical local habitat).	Major impact on species or species' habitat (e.g. for EPBC Act or FFG Act listed species this may be 1–5% of remaining habitat in Victoria** or 0.005–1% loss of important or critical local habitat).	Catastrophic impact on species or species' habitat (e.g. for EPBC Act or FFG Act listed species this may be >5% loss of remaining species' habitat in Victoria or 1–5% loss of important or critical local habitat).
Project impacts EPBC Act listed Migratory fauna species	Population change not detectable. Negligible impact to habitat.	Minor impact to habitat for a migratory species. No impact to important habitat.	Moderate impact to habitat for a migratory species. Minor impact to important habitat.	Major impact to habitat for a migratory species. Moderate impact to important habitat.	Catastrophic impact to habitat for a migratory species. Major impact to important habitat.
Project impacts fauna protected under the *Wildlife Act 1975*	Minor temporary increase in mortality of protected fauna.	Moderate temporary or minor long term increase in mortality of protected fauna.	Substantial temporary or moderate long term increase in mortality of protected fauna.	High long term increase in mortality of protected fauna.	Very high long term increase in mortality of protected fauna.
Project impacts native vegetation	Negligible impacts on an EVC of high or very high conservation significance Or Total native vegetation loss <2 ha.	Loss of <1 ha of an EVC of high or very high conservation significance from the region (based on the total area of an EVC from the bioregion) OR Total native vegetation loss <5 ha.	Loss of 1–10 ha of an endangered EVC or an EVC of high or very high conservation significance OR Total native vegetation loss 5–10 ha.	Loss of 10–20 ha of an endangered EVC or an EVC of high or very high conservation significance from the region OR Total native vegetation loss 10–30 ha.	Loss of >20 ha of an endangered EVC or an EVC of high or very high conservation significance OR Total native vegetation loss >30 ha.

ASPECT	INSIGNIFICANT	MINOR	MODERATE	MAJOR	CATASTROPHIC
Project impacts threatened ecological community	No measurable permanent impacts on the extent of a listed threatened community.	Minor impact. For a community of high significance or in good condition this may be loss of <0.5 ha of an EPBC Act listed community or <1 ha of an FFG Act listed community.	Moderate impact. For a community of high significance or in good condition this may be loss of 0.5–2 ha of an EPBC Act listed community or 1–5 ha of an FFG Act listed community.	Major impact. For a community of high significance or in good condition this may be loss of 2–5 ha of an EPBC Act listed community or 5–10 ha of an FFG Act listed community.	Catastrophic impact. For a community of high significance or in good condition this may be loss of >5 ha of an EPBC Act listed community or >10 ha of an FFG Act listed community.
Project impacts large remnant trees	Loss of <5 large remnant trees.	Loss of 6–20 large remnant trees.	Loss of 21–100 large remnant trees.	Loss of 101–300 large remnant trees.	Loss of >300 large remnant trees.
Fragmentation of fauna habitat	No measurable impact on habitat connectivity. Alignment does not intercept or reduce any existing wildlife corridors or habitat linkages.	Minor impact on habitat connectivity. E.g. No fragmentation of core habitat but a minor reduction in the width of a major wildlife corridor or intercepting of 1–2 small habitat linkages.	Moderate impact on the quantity and extent of habitat connectivity. E.g. Minor fragmentation of core habitat, reduction in the width of a major wildlife corridor, or intercepting of 3–4 minor habitat linkages.	Major impact on the quantity and extent of habitat connectivity. E.g. Fragmentation of core habitat, considerable reduction in the width of a major wildlife corridor, or intercepting of 5 minor habitat linkages.	Catastrophic impact on the quantity and extent of habitat connectivity. E.g. Substantial fragmentation of core habitat or wildlife corridors, or intercepting of 6 or more minor habitat linkages.
Project impacts aquatic or floodplain habitat and aquatic ecosystem function	No detectable changes in aquatic or floodplain habitats, no restriction to fish passage	Short-term (i.e. construction only) isolated and localised detectable changes in aquatic or floodplain habitats in the study area, minor restriction of fish passage during construction period.	Short-term detectable local changes in aquatic or floodplain habitats, fish passage obstructed during construction period.	Permanent detectable local changes in aquatic or floodplain habitats OR Short-term detectable regionally-significant changes. Fish passage permanently restricted.	Permanent detectable changes in aquatic or floodplain habitats that are significant regionally. Fish passage permanently obstructed.

* This number is based on the 0.005 ha trigger for species habitat loss which triggers species offsets under the *Guidelines for the removal, destruction or lopping of native vegetation* (DELWP 2017).

** This number is based on the EES *Referral criteria for individual potential environmental effects*

Risks will be rated separately for each discrete option as each will have a distinct profile of type and extent of environmental impacts. Feasibility of possible mitigation measures may also change between alignment options, thus impacting the risk rating.

For all risks ranked Medium, High or Extreme in the Initial Risk rating, additional controls were identified to further reduce risk and risk ratings were reassessed accordingly (referred to as Residual Risk). Additional controls specify management measures over and above those considered as Standard Controls to ensure the residual risk is effectively avoided or mitigated to as low as reasonably practicable.

4.6.4 RISK ASSESSMENT WORKSHOP

The risk workshop was a multi-disciplinary exercise, with attendance from risk specialists, WSP project team and designers, discipline leads and RRV representatives.

The purpose of the risk workshop was to finalise the draft risk by reviewing and standardising the risk scores and adding further risks identified as part of the preliminary investigations already undertaken. A cross-disciplinary review of mitigation measures was also conducted to ensure any controls did not impact on other environmental aspects.

See Appendix P for outcomes of the ERA process.

4.7 IMPACT ASSESSMENT

4.7.1 OPTIONS ASSESSMENT

For the purpose of the initial impact assessment on the four proposed alignments, a nominal/indicative construction impact footprint was determined by using the outer limit of the road functional design for each alignment. The footprint includes pavement surfaces, batters, cuttings, and bridges with a 10 m buffer either side of the design, as advised by RRV, to account for the construction of the road. The 10 m buffer was used for the options assessment.

Approximate total construction footprint widths range from 100–150 m, with wider sections at interchanges. The construction footprint was used to determine the extent of the potential impacts on native vegetation, trees, fauna habitats and communities. The location of individual flora species is known and can, in some circumstances, be avoided with road design, however the total alignment corridor was used for comparing potential impacts at the early options assessment stage as the functional designs are not set.

Tree Protection Zone (TPZ) impacts were considered for any trees in close proximity (15 m) to the current construction footprint. Any tree with >10% TPZ impact was considered lost for the purpose of the assessment. Feature survey and arborist assessment will allow more detailed determination of impacts, and inform detailed impact minimisation, at the detailed design stage.

The indicative construction footprints were intended to provide a realistic indication of potential impacts at the functional design phase, however it is noted that detailed design may result in a revised area of impact.

4.7.2 ASSESSMENT OF PREFERRED ALIGNMENT (C2)

The impact assessment for the chosen alignment was undertaken using an updated construction footprint (November 2020). The refined construction footprint was developed using a further 5 m buffer off creek realignments where these are proposed outside the 10 m wide buffer of the design. Calculations of creek realignment impacts were not undertaken for the other alignments.

For the preferred alignment assessment, the updated construction footprint was used to calculate impacts on native vegetation, and all threatened species and ecological communities.

The construction footprint provides a realistic indication of the maximum extent of likely impacts for the reference design, however it is noted that detailed design may result in a revised area of impact. Any changes are likely to result in lower impacts on ecological values as the footprint is refined, as they will need to take into consideration the project's No-go Zones.

4.7.3 CUMULATIVE IMPACTS

Cumulative impacts were assessed separately. See Section 7.10.2 for the cumulative impact assessment methodology.

4.8 MITIGATION

Mitigations for identified impacts were developed by discipline specialists in consultation with RRV. All identified mitigations developed for the project have been informed by specialist experience with proven feasible control measures for major civil infrastructure projects, industry best practice measures and regulatory measures defined by State, Commonwealth and International Government agencies.

Mitigations for the project were developed throughout the impact assessment process to inform the residual impacts of the preferred alignment, which are detailed in Section 11.

4.9 OPTIONS ASSESSMENT

The alignment refinement for the Beaufort Bypass has been undertaken in three distinct phases since project inception. These are discussed in the *Beaufort Bypass Options Assessment Report* as:

- Phase 1 – Concept alignment development
- Phase 2 – Option development and assessment
- Phase 3 – Identification of preferred alignment.

This options assessment method section considers the Phase 3 assessment and details the process for selection of the preferred alignment.

The Phase 3 assessment considered four alignment options to select the preferred alignment, utilising a customised comparative options assessment to rank each option against the following areas:

- Biodiversity
- Catchment values and hydrology
- Cultural heritage (Aboriginal and Historic)
- Social and Community
- Amenity
- Landscape and Visual.

Multiple scoring scenarios and sensitivity testings were undertaken against each option to ensure the environmental, social, heritage and economic assessment criteria aligned with the EES evaluation objectives. The scoring framework developed sought to ensure a wholistic decision-making process was undertaken, and that no single scoring or sensitivity scenario would be the primary determining factor in the identification and selection of the preferred alignment.

Weightings for the assessment included the application of six scenarios and sensitivity tests to eliminate bias of specific environmental constraints. These scenarios included:

- Scenario 1: Apply a score of 1 to 4 from least to highest impact
- Scenario 2: Alignment with highest number of least impact scores
- Scenario 3: Apply a score of 1 to the highest impact and the subtract the percentage difference between alignments
- Scenario 4: Apply a score of 1 to least impact and then add the percentage difference between remaining alignments
- Scenario 5: As per Scenario 3, but minus criteria that can be mitigated
- Scenario 6: As per Scenario 4, but minus criteria that can be mitigated.

The sensitivity tests included:

Scoring sensitivity scenario 1:

- Options with the lowest impact and other options within 5% of the lowest impact are apportioned a score of one point and a green light.
- Options within 5–20% of the lowest impact option are apportioned a score of zero points and an amber light.
- Options with an impact of 20% or greater than the lowest impact option are apportioned a score of minus one and a red light.

Scoring sensitivity scenario 2:

- Options with the lowest impact and other options within 5% of the lowest impact are apportioned a score of one point and a green light.
- Options within 5–25% of the lowest impact option are apportioned a score of zero points and an amber light.
- Options with an impact of 25% or greater than the lowest impact option are apportioned a score of minus one and a red light.

Scoring sensitivity scenario 3:

- Options with the lowest impact and other options within 5% of the lowest impact are apportioned a score of one point and a green light.
- Options within 5–15% of the lowest impact option are apportioned a score of zero points and an amber light.
- Options with an impact of 15% or greater than the lowest impact option are apportioned a score of minus one and a red light.

The assessment process included an iterative process with RRV, the Technical Reference Group (TRG), legal and discipline specialists to refine the assessment environmental risk workshops and develop a customised assessment matrix. The suite of assessment criteria are detailed within the *Beaufort Bypass Options Assessment Report.*

4.10 ASSUMPTIONS AND LIMITATIONS

The results are indicative of the environmental conditions at the time of assessment, including the presence or otherwise of species. Site conditions, including the presence of threatened species, can change with time.

A common limitation of ecological surveys is the short time period over which they are undertaken and the lack of seasonal sampling, which can lead to lack of detection of some species. WSP ecologists have conducted surveys over multiple years and across different seasons to compensate for this as far as practicable.

The likely presence of threatened fauna species was determined primarily through habitat assessment and examination of records from the broad locality, which is a conservative approach. It ensures that difficult-to-detect species are appropriately considered.

Most species records are sourced from the field data collected by WSP and the VBA as all records are verified by an expert reviewer. However, in some cases, additional desktop searches and information rely on third party data, which cannot always be verified.

For the examination of fauna habitat connectivity, the following limitations are relevant:

- The assessment mostly focused on native vegetation and did not include areas of revegetation. Revegetation, native plantations, and even exotic vegetation can provide connectivity for native species. However, as the value of this vegetation for connectivity is considered lower, these categories were not included in the assessment.
- Individual trees are not currently included in the assessment of connectivity. Individual trees, particularly isolated paddock trees, can be of disproportionately high value to wildlife (Fischer, Stott & Law 2010). They provide hotspots of resources for invertebrates, birds, and bats, and may act as a stop-over point for some birds. However, because of the limited faunal groups supported, they are not included in the model. Loss of scattered trees is considered as a separate impact.
- Large areas of mostly treeless native vegetation are not included, apart from habitat mapping for Golden Sun Moth which did include treeless vegetation. Treeless native vegetation can provide important habitat and connectivity for native species, particularly grassland species. As the suite of species supported by large areas of (usually degraded) treeless native vegetation will be less than that supported by woodland and forest communities, they have not been included in the model.

For providing a broad quantitative comparison of connectivity impacts between alignments, these limitations are considered to be acceptable.

5 LEGISLATION

This section assesses the project against the Commonwealth and State legislation, policies and guidelines relevant to the flora and fauna assessment for the preferred alignment C2.

5.1 COMMONWEALTH LEGISLATION

5.1.1 *ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 (EPBC ACT)*

The *EPBC Act* is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places defined in the Act as matters of national environmental significance (MNES). There are nine matters of national environmental significance to which the EPBC Act applies, these are:

- World heritage sites
- National heritage places
- Wetlands of international importance (often called 'Ramsar' wetlands after the international treaty under which such wetlands are listed)
- Nationally threatened species and ecological communities
- Migratory species
- Commonwealth marine areas
- Nuclear actions
- The Great Barrier Reef Marine Park
- a water resource, in relation to coal seam gas development and large coal mining development.

A 'significant impact' is defined under the EPBC Act as 'an impact that is important, notable, or of consequence, having regard to its context or intensity' (Department of the Environment 2013). If a project is likely to have a significant impact on one of the nine MNES, the 'action' must be referred to the Commonwealth Department of Agriculture, Water and the Environment (DAWE). This 'referral' is then released to the public for comment.

At least two out of the nine matters are relevant to the study area. This includes nationally threatened species and ecological communities and migratory species. The MNES with the potential to be affected by the proposed development are discussed in the following sections.

5.1.2 *DECISION ON REFERRAL*

The project was referred to the Australian Government Minister for the Environment (the Minister) on 19 January 2021. The project was referred on the basis of potential impacts to two MNES; listed species and communities and migratory species.

The threatened species and communities listed in the referral are:

- Growling Grass Frog
- Golden Sun Moth
- Little Galaxias
- Painted Honeyeater
- River Swamp Wallaby-grass
- Matted Flax-lily
- Ben Major Grevillea
- Ornate Pink Fingers
- Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains

- White box – Yellow box – Blakely's Red Gum Grassy Woodland.
- Migratory species including Latham's Snipe.

As stated in the referral, the only EPBC Act listed species considered likely to be significantly impacted by the project (preferred alignment, with mitigation) was Golden Sun Moth.

A decision on the referral on 24 February 2021 stated that the proposed action is a controlled action under section 75 of the EPBC Act. The referral has been accepted under section 74A of the EPBC Act for staged developments. Based on the information available in the referral, it was considered that the proposed action is likely to have a significant impact on but not limited to Golden Sun Moth. As such, the EPBC Act Environmental Offsets Policy (DSEWPaC 2012a) will apply as residual impacts on Golden Sun Moth remain significant, even after mitigation.

The project will be assessed by accredited assessment under the *Environmental Effects Act 1978.*

5.1.2.1 MIGRATORY SPECIES

Fourteen migratory species were listed on the PMST as potentially occurring in the study area. Of these species, two are also listed as threatened on the Victorian Advisory list and had records in the VBA within 10 km of the study area; Curlew Sandpiper *Calidris ferrunginea* and Latham's Snipe *Gallingo hardwickii*. Only one migratory bird, Latham's Snipe, is considered likely to occur in the study area as there are a number of seasonal wetlands present.

The likelihood of significant impact to Latham's Snipe is considered to be low for the preferred alignment because the habitat present does not meet the definition of 'important habitat' for this species. In addition, many other wetlands are available within the local area and the species distributes across a wide range of south and eastern Australia. The Latham's Snipe significant impact criteria assessment for the preferred alignment is provided in Appendix Q.

5.1.2.2 THREATENED SPECIES AND ECOLOGICAL COMMUNITIES

THREATENED FLORA

Four EPBC Act listed plant species were recorded within the study area; River Swamp Wallaby-grass *Amphibromus fluitans*, Ornate Pink Fingers, *Caladenia ornata*, Mated Flax-lily Dianella *amoeana* and Ben Major Grevillea *Grevillea floripendula*. Two additional EPBC Act listed plant species were considered moderately likely to occur but were not located during field assessments so have since been re-assessed as having a low likelihood of occurrence.

The preferred alignment avoids all records of Ornate Pink Fingers and Ben Major Grevillea. There are two records of Matted Flax-lily and River Swamp Wallaby-grass within the preferred alignment. However, the revised construction footprint will impact only one plant/clump of Matted Flax-lily and only one record of River Swamp Wallaby-grass, recorded in a 300 m^2 section of a dam.

No EPBC Act listed flora species are likely to be significantly impacted by the project (preferred alignment) with the mitigation proposed. The mitigation has largely been developed to avoid direct impacts on retained threatened flora (i.e. through No-go Zones and pre-clearing surveys) and to avoid or substantially minimise indirect impacts such as from dust, increased weeds, etc. The full significant impact assessments for the preferred alignment (based on the updated construction footprint) are provided in Appendix Q.

THREATENED FAUNA

One EPBC Act listed fauna species, Golden Sun Moth *Synemon plana*, was recorded in the study area during the most recent targeted surveys and another, Painted Honeyeater *Grantella picta*, has been recorded by a local landholder. Two other EPBC Act listed fauna species, Little Galaxias *Galaxiella toourtkoourt* and Growling Grass Frog *Litoria raniformis*, are considered moderately likely to occur due to their potential to recolonise the potential habitat present, although were not recorded during targeted surveys. The Striped Legless Lizard has been reduced to a low likelihood of occurrence based on the survey results, the paucity of local records, and the potential habitat present, and is therefore unlikely to be impacted by the project.

The significant impact assessments for the preferred alignment provide the full suite of mitigation proposed for each species. Based on this assessment, the only EPBC Act listed species considered likely to be significantly impacted by the project (preferred alignment, with mitigation) is Golden Sun Moth. For the remaining species, mitigation is expected to avoid or reduce impacts such that they will not be significantly impacted. The mitigation has largely been developed to avoid direct impacts on retained threatened fauna habitat and avoid or substantially minimise indirect impacts such as from dust, increased weeds, etc. The full significant impact assessments for the preferred alignment (based on the updated construction footprint) are provided in Appendix Q.

THREATENED ECOLOGICAL COMMUNITIES

According to the PMST, five threatened ecological communities were modelled as potentially occurring within the study area:

- Grassy Eucalypt Woodland of the Victorian Volcanic Plains
- Grey Box Grassy Woodlands and Derived Native Grasslands of South-eastern Australia
- Natural Temperate Grassland of the Victorian Volcanic Plain
- Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains
- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland.

Two of these were recorded during the site assessments: Seasonal herbaceous Wetlands and White Box Box-Yellow Box – Blakely's Red Gum Grassy Woodland. With the implementation of suitable mitigation measures, neither of these communities are likely to be significantly impacted by the project (preferred alignment). The mitigation has largely been developed to avoid direct impacts on retained threatened ecological communities through measures such as No-go Zones and sediment and erosion controls, and avoid or substantially minimise indirect impacts such as from dust, increased weeds, surface water changes etc. Refer to Appendix Q for the full significant impact assessments for the preferred alignment (based on the updated construction footprint).

5.1.2.3 THREATENING PROCESSES

A Key Threatening Process includes any process that threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community. There are 21 listed Key Threatening Processes of which 13 were determined to be relevant to the Project. An assessment against the relevant Commonwealth listed Key Threatening Processes was completed for the project (preferred alignment) and determined the following:

- The preferred alignment will result in 50.7 ha of native vegetation clearing.
- The project may advantage Noisy Miners *Manorina melanocephala* in some areas.
- The project is unlikely to increase rabbit and feral cat populations or feral pig numbers or impacts (if present). Similarly, the preferred alignment is unlikely to substantially increase red fox populations in the area. However, the creation of new roads through intact vegetation can create opportunities for foxes to more easily access habitat. The more intact habitats in the study area are relatively open already, however, there may be patches that are more susceptible to fox incursion.
- The Project is unlikely to result in an increase in escaped garden plants.
- The type of disturbance associated with the construction of road pavement can result in a window of opportunity for weeds and soil pathogens such as Phytophthora *Phytophthora cinnamomii*. Appropriate hygiene controls will need to be implemented to prevent introduction and spread. Similarly, appropriate hygiene controls will be required to prevent the spread of Chytrid fungus when moving equipment in and out of the area.
- Road construction will cause greenhouse gas emissions but unlikely to an extent that would result in significant impacts to habitat.

5.2 STATE LEGISLATION, REGULATION AND POLICY

5.2.1 *ENVIRONMENT EFFECTS ACT 1978*

Under Victoria's *Environmental Effects Act 1978* (EE Act), projects that could have a 'significant effect' on Victoria's environment can be referred for consideration under the requirements of an Environmental Effects Statement (EES). This Act applies to any public works 'reasonably considered to have or be capable of having a significant effect on the environment'. The Minister for Planning is the responsible person for assessing whether this Act applies.

On 22 July 2015, the Minister for Planning determined that an EES would be required under the *Environment Effects Act 1978* to assess the potential environmental effects of the project. The EES allows stakeholders to understand the likely environmental effects of the project and how they would be managed.

Section 3 of this report outlines the *Scoping Requirements for the Beaufort Bypass Project under the Environment Effects Act 1978* (DELWP 2016b).

5.2.2 *FLORA AND FAUNA GUARANTEE ACT 1988*

The FFG Act was established to provide a legal framework for enabling and promoting the conservation of all Victoria's native flora and fauna, and to enable management of potentially threatening processes. One of the main features of the Act is the listing process, whereby native species and communities of flora and fauna, and the processes that threaten native flora and fauna are listed in the schedules of the Act. This assists in identifying those species and communities that require management to survive and identifies the processes that require management to minimise the threat to native flora and fauna species and communities within Victoria.

A permit from DELWP is required to 'take' listed flora species that are 'protected flora' from public land. A permit is not required under the FFG Act for private land, unless listed species are present and the land is declared 'critical habitat' for the species. Protected flora are all listed species, species which belong to listed communities, and other species which have been included on the protected flora list, managed by the DELWP. A permit to take Protected Flora will be required the project.

Under the FFG Act, a permit from DELWP is also required to 'take' (to kill, injure, disturb or collect) listed flora species that are members of protected taxa from public land (this does not apply to private land unless listed species are present and the land is declared 'critical habitat' for the species). Protected flora are:

- plants that have been declared to be protected under section 46 of the FFG Act
- plants that are listed as threatened under section 10 of the FFG Act
- plants that belong to communities that are listed as threatened under section 10 of the FFG Act.

For the preferred C2 alignment, a permit under the FFG Act will be required for the removal of one Matted Flax-lily plant which occurs on public land (Back Raglan Road). In addition, the removal of any non-threatened flora on the Protected Flora list or any plant members of the FFG Act-listed community Victorian Temperate Woodland Bird Community which occur on public land will require a permit under the FFG Act. The only plant found in the Victorian Temperate Woodland Bird Community which occurs in the study area is River Red-gum.

5.2.2.1 THREATENED COMMUNITIES

One community listed under the FFG Act, Victorian Temperate Woodland Bird Community, was recorded in the study area. This community is defined by the suite of birds inhabiting the area, usually associated with drier woodlands on the slopes and plains north of the Great Dividing Range. The majority of the woodland and forest EVCs have been mapped as Victorian Temperate Woodland Bird Community within the study area. The permit requirement to impact on this community is stated in the section above.

5.2.2.2 THE FLORA AND FAUNA GUARANTEE AMENDMENT ACT 2019

In August 2019, the Victorian Parliament passed changes to amend the FFG Act to provide for a modern and strengthened framework for the protection of Victoria's biodiversity. The amendments took effect on 1 June 2020, with further changes under the Act yet to be enacted. Key changes to the Act potentially relevant to the project include changes to the Protected Flora list and the Threatened List and 'public authority duty'.

There is now an obligation on public authorities including Regional Roads Victoria, to consider potential biodiversity impacts when exercising their functions (set out in new section 4B). The types of potential impacts on biodiversity that should be considered are also specified, these include: long and short term impacts, detrimental and beneficial impacts, direct and indirect impacts, cumulative impacts and potentially threatening processes. These potential impacts have been addressed in Section 7 and 9 of this report.

The changes to the Protected Flora list and the Threatened List includes the Conservation Status Assessment Project. This project has been underway for over a decade and will be enacted through the FFG Act reforms. The aim of this project is *"to deliver a Single Operational List of threatened species in accordance with the Common Assessment Method (CAM) Memorandum of Understanding"*. Currently there are three lists (EPBC Act, FFG Act and Victorian Advisory Lists) with many inconsistencies. The assessment process is based on International Union for Conservation of Nature (IUCN) guidelines which uses five criteria to evaluate if a taxon belongs in a threatened category (e.g. Endangered, Vulnerable etc). The assessments use a rigorous approach with a combination of software, expert evaluation, review and public consultation. The set of assessments will become the new FFG Act Threatened List (See Table 5.1 and Table 5.2 for changes to relevant species listings).

There are a number of rare and threatened flora and fauna which have been assessed as a part of the Conservation Status Assessment Project, some of which are not currently FFG Act listed. Once enacted, a review of the changes to and implications of the Protected Flora and Threatened List is recommended. It is likely that more FFG Act listed species will need a Permit to Take Protected Flora. This may also affect the need for management plans, translocation requirements and other implications. There are no transition arrangements under the new changes to the FFG Act.

The following tables list the species of relevance to the project which have a provisional new listing.

Table 5.1 Flora species with provisional new listings

COMMON NAME	CURRENT CONSERVATION STATUS			PROVISIONAL NEW LISTING[1]
	EPBC ACT	FFG ACT	VIC ADV	
Ben Major Grevillea	Vulnerable	Listed	Vulnerable	Critically Endangered
Emerald-lip Greenhood			Rare	Endangered
Floodplain Fireweed			Rare	Endangered
Matted Flax-lily	Endangered	Listed	Endangered	Critically Endangered
Ornate Pink Fingers	Vulnerable	Listed	Vulnerable	Endangered
Pale-flower Cranesbill			Rare	Endangered
River Swamp Wallaby-grass	Vulnerable			NA
Rosemary Grevillea			Rare	Invalid
Rough Wattle			Rare	Endangered
Yarra Gum		Rejected	Rare	Critically Endangered

(1) From the Conservation Status Assessment Project (https://www.environment.vic.gov.au/conserving-threatened-species/conservation-status-assessment-project)

Table 5.2 Fauna species with provisional new listings

COMMON NAME	CURRENT CONSERVATION STATUS			PROVISIONAL NEW LISTING[1]
	EPBC ACT	FFG	VICTORIAN ADVISORY LIST	
Amphibians				
Growling Grass Frog	Vulnerable	Listed	Endangered	Vulnerable
Brown Toadlet		Listed	Endangered	Endangered
Birds				
Australasian Shoveler			Vulnerable	Vulnerable
Baillon's Crake		Listed	Vulnerable	Least Concern
Blue-billed Duck		Listed	Endangered	Vulnerable
Brolga		Listed	Vulnerable	Endangered
Brown Treecreeper		Nominated	Near Threatened	NA
Diamond Firetail		Listed	Near Threatened	Vulnerable
Eastern Great Egret		Listed	Vulnerable	Data Deficient
Emu			Near Threatened	NA
Hardhead			Vulnerable	Vulnerable
Latham's Snipe	Migratory	Nominated	Near Threatened	NA
Musk Duck			Vulnerable	Least Concern
Painted Honeyeater	Vulnerable	Listed	Vulnerable	Vulnerable
Pied Cormorant			Near Threatened	NA
Powerful Owl		Listed	Vulnerable	Vulnerable
Speckled Warbler		Listed	Vulnerable	Endangered
Fish				
Little Galaxias	Vulnerable	Listed	Endangered	Endangered
Insects				
Golden Sun Moth	Critically Endangered	Listed	Critically Endangered	Vulnerable
Mammals				
Brush-tailed Phascogale		Listed	Vulnerable	Vulnerable
Squirrel Glider		Listed	Endangered	Vulnerable

(1) From the Conservation Status Assessment Project

5.2.2.3 THREATENING PROCESSES

An assessment of listed threatening processes was undertaken for each of the alignment options (See Section 7.11.2.3). The threatening process of most relevance to the C2 alignment are:

- habitat fragmentation as a threatening process for fauna in Victoria
- invasion of native vegetation by Blackberry
- invasion of native vegetation by environmental weeds
- loss of hollow bearing trees from Victorian native forests
- wetland loss and degradation as a results of change in water regime, dredging, draining, filling and grazing.

5.2.3 GUIDELINES FOR THE REMOVAL, DESTRUCTION OR LOPPING OF NATIVE VEGETATION

The *Guidelines for the Removal, Destruction or Lopping of Native Vegetation* (Guidelines 2017) (DELWP 2017e) have been designed to manage the risk to Victoria's biodiversity associated with the removal of native vegetation. These Guidelines were released in December 2017 to replace the former native vegetation removal Guidelines 2013 (DEPI 2013a). The assessment pathways are now classified as:

- Basic – limited impacts to biodiversity.
- Intermediate – could impact on large trees, endangered EVCs and/or sensitive wetlands or coastal areas.
- Detailed – could impact large trees, endangered EVCs, sensitive wetlands and coastal areas and could significantly impact on habitat for rare and threatened species.

The assessment pathway is determined by the extent and location of the impacts. All locations within Victoria are classified as following:

- Location 3 – includes locations where the removal of less than 0.5 ha of native vegetation could have a significant impact on habitat for a rare or threatened species.
- Location 2 – includes locations that are mapped as endangered EVCs and/or sensitive wetlands and coastal areas that are not included in Location 3.
- Location 1 – includes all remaining locations.

Table 5.3 Determining the assessment pathway

EXTENT OF NATIVE VEGETATION	LOCATION CATEGORY		
	Location 1	**Location 2**	**Location 3**
Less than 0.5 ha and not including any large trees	Basic	Intermediate	Detailed
Less than 0.5 ha and including one or more large trees	Intermediate	Intermediate	Detailed
0.5 ha or more	Detailed	Detailed	Detailed

The project will be assessed under the Detailed pathway and requires native vegetation offsets calculated in accordance with the Guidelines 2017 as there is well over 0.5 ha of vegetation in all Location categories.

ALL ASSESSMENT PATHWAYS

Application requirements for all applications for a permit to remove native vegetation involve the following (where relevant to the project):

- Information about the vegetation to be removed including:
  - the assessment pathway and reason for the assessment pathway. This includes the location category of the native vegetation to be removed. See paragraph above
  - a description of the native vegetation to be removed accounted for as per the Guidelines. See Section 1.1. Maps showing the native vegetation and property in context and vegetation to be removed as accounted for by the Guidelines. See Appendix K and EnSym reports in Appendix F
  - the offset requirement, determined in accordance with the Guidelines. See Section 12.
- Topographic and land information relating to the native vegetation to be removed. See Section 6.3. Topography of the land for alignment C2 is low-lying terrain throughout Yam Holes Creek valley, gently undulating rolloing hills to the west of Yam Holes Creek and hilly to steep terrain in the Camp Hill area.
- Recent, dated photographs of the native vegetation to be removed. See Section 6.4.1 for examples of vegetation, some of which will be removed.
- Details of any other native vegetation approved to be removed, or that was removed without the required approvals within 5 years of the permit application. Not applicable.
- An avoid and minimise statement. See Section 5.2.3.1.
- An offset statement providing evidence that an offset that meets the offset requirements for the native vegetation to be removed has been identified, and can be secured in accordance with the Guidelines. See Section 12.

ADDITIONAL APPLICATION REQUIREMENTS FOR APPLICATIONS IN THE DETAILED ASSESSMENT PATHWAY

A site assessment report of the native vegetation to be removed, including:

- A habitat hectare assessment of any patches of native vegetation, including the condition, extent (in hectares), Ecological Vegetation Class and bioregional conservation status. Section 6.4.2.
- The location, number, circumference (in centimetres measured at 1.3 metres above ground level) and species of any large trees within patches. Section 6.4.5.
- The location, number, circumference (in centimetres measured at 1.3 metres above ground level) and species of any scattered trees, and whether each tree is small or large. Section 6.4.5.
- Information about impacts on rare or threatened species habitat, including:
  - the relevant section of the Habitat importance map for each rare or threatened species requiring a species offset. Section 9.1.3 and Section 12
  - for each rare or threatened species that the native vegetation to be removed is habitat for, according to the Habitat importance maps:
    - the species' conservation status. Section 9.1.3 and Section 12
    - the proportional impact of the removal of native vegetation on the total habitat for that species. Section 9.1.3
    - whether their habitats are highly localised habitats, dispersed habitats, or important areas of habitat within a dispersed species habitat. Section 12 and EnSym reports in Appendix F.

5.2.3.1 STATEMENT ON AVOIDANCE AND MINIMISATION

The three-step approach (avoid, minimise, offset) is the key policy in relation to the removal of native vegetation to achieve no net loss to biodiversity as a result of the removal, destruction or lopping of native vegetation. Avoidance and minimisation has been considered in the project to date where possible, as per the Assessor's Handbook (DELWP 2017a). The Assessor's Handbook requires that the proponent demonstrates avoidance and minimisation in the following ways:

- any strategic level planning over the study area
- site level planning
- that no feasible opportunities exist to further avoid and minimise impacts on native vegetation without undermining the key objectives of the proposal.

STRATEGIC LEVEL PLANNING

The avoidance and minimisation of impacts to native vegetation have been considered throughout all phases of the project from the inception to the options analysis. A summary of measures taken include:

- road corridor analysis to consider a range of feasible alternatives by incorporating engineering design principles with constraints and environmentally sensitive areas.
- consideration of new alignments to minimise impacts through areas such as Camp Hill State Forest
- modification of alignments to avoid known occurrences of Ben Major Grevillea
- modification of alignments to avoid a number of wetlands, threatened ecological communities and threatened species habitat
- micro-alignment of the design options in several areas to avoid and minimise impacts to isolated paddock trees (or scattered trees)
- the preferred alignment selected (C2) has the lowest impacts to native vegetation of the four proposed

SITE LEVEL PLANNING

Once the preferred alignment was chosen, a detailed exploration of measures to avoid and minimise impacts on native vegetation included the following summarised points:

- design modifications to reduce impacts on specific trees or areas of habitat such as locally steepened batters, use of retaining walls and kerb and channelling, installation of safety barriers and realigning drainage and culverts to avoid impacts
- citing of laydowns, site offices, temporary access tracks, relocation of utility services etc within the construction footprint or outside of native vegetation and habitat, as identified on Appendix K, No-go Zone map. Given the amount of cleared pasture in the study area, this is highly feasible
- development project-wide No-go Zones which maps all native vegetation and fauna habitat outside the construction footprint to ensure it is not impacted during construction (see Appendix K, No-go Zone map)
- use of bridges instead of culverts to avoid and minimise in-stream impacts.

Further details on measures to avoid and minimise impacts on native vegetation is provided in Section 10.1.

FURTHER AVOIDANCE AND MINIMISATION OF DIRECT IMPACTS

Once the project is awarded to build, further refinement during detailed design will likely present scope for further avoidance and minimisation of impacts to native vegetation.

5.2.3.2 ASSESSOR'S HANDBOOK EVALUATION

Native vegetation values in Appendix 1D of the *Assessor's handbook - Applications to remove, destroy or lop native vegetation* (DELWP 2017a) (the Handbook) outline other values to be considered for avoidance and minimisation with the application of DELWP's *Guidelines for the removal, destruction or lopping of native vegetation 2017*. This is enacted through Clause 12 of all Victorian Planning Schemes.

Appendix 1D contains four tables of relevance (Tables 6, 7, 8 and 9) which can be interpreted in tabular format or in geographic format. For the purposes of evaluating lower and higher values in the Tables 6, 7, 8 and 9 for the comparison of alignments, we undertook the following tasks:

- use the values in Tables 6, 7, 8 and 9 of the *Assessor's handbook* as to determine lower and higher values against native vegetation data mapped in the field by WSP as a part of the *Flora and Fauna Impact Assessment for the Beaufort Bypass EES*
- summarise the quantities in hectares of lower and higher values for each alignment.

The results of this is summarised in Section 7.11.3.2 and Appendix L for the full *Assessor's Handbook* assessment of all alignment options.

5.2.4 WILDLIFE ACT 1975

The *Wildlife Act 1975* is the primary legislation in Victoria for the protection of wildlife. The Act requires that wildlife research (including fauna salvage and translocation) is regulated through a permit system, which is managed by the DELWP.

Section 42 of the Wildlife Regulations 2013 states that a person must not damage, disturb or destroy any wildlife habitat unless that person is authorised to damage, disturb or destroy wildlife habitat under any Act. According to DELWP, destruction of wildlife habitat for this project will be approved through the *Planning and Environment Act* so the project would be exempt from Section 42.

As there are numerous large trees within the proposed construction footprint, pre-clearing surveys and fauna removal and salvage is highly recommended prior to removal. Any persons involved in fauna removal, salvage capture or relocation of fauna during mitigation measures must hold a current Management Authorisation under the *Wildlife Act 1975*. Fauna management during construction is discussed in Section 10.4.3.1.

5.2.5 CATCHMENT AND LAND PROTECTION ACT 1994

5.2.5.1 DECLARED NOXIOUS WEEDS

The study area supports a number of weeds that are declared noxious under the *Catchment and Land Protection Act 1994* (CaLP Act). Plants occurring on this list are known to or have the potential to result in detrimental environmental and/or economic impact.

Under the CaLP Act declared noxious weeds are categorised into four groups depending on their known and potential impact and specific circumstances for each region. These categories are:

- State Prohibited Weeds (S) – Plants that do not occur in Victoria but would pose a significant threat if they did invade. If found, they are to be eradicated with responsibility falling on the Victorian Government.
- Regionally Prohibited Weeds (P) – Weeds that are not widely distributed in a region but are capable of spreading further. Land owners, including public authorities such as Regional Roads Victoria responsible for managing land must take all reasonable steps to eradicate Regionally Prohibited weeds on their land.
- Regionally Controlled Weeds (C) – Invasive plants that are usually widespread in a region. Ongoing control measures are required to prevent their spread. Land owners, including public authorities responsible for managing land, must take all reasonable steps to prevent growth and spread of Regionally Controlled weeds on their land.

- Restricted Weeds (R) – Plants that pose an unacceptable risk of spreading in this state and are a serious threat to another State or Territory. Trade in these weeds and their propagules, either as plants, seeds or contaminants in other materials is prohibited.

The field survey identified that the study area supports six regionally controlled (C), eight restricted (R) and no regionally prohibited (P) weeds from (DEDJTR 2017). These weeds are listed in Table 5.4. Six of these weed species are also listed as Weeds of National Significance (WoNS) by the Australian Government.

Table 5.4 Declared noxious weeds occurring within the study area

SCIENTIFIC NAME	COMMON NAME	CALP ACT STATUS	WONS
**Allium triquetrum*	Angled Onion	R	
**Allium vineale*	Crow Garlic	R	
**Asparagus asparagoides*	Bridal Creeper	R	Yes
**Asphodelus fistulosus*	Onion Weed	C	
**Chondrilla juncea*	Skeleton Weed	C	
**Cirsium vulgare*	Spear Thistle	R	
**Crataegus monogyna*	Hawthorn	R	
**Cytisus scoparius*	English Broom	R	Yes
**Foeniculum vulgare*	Fennel	R	
**Genista monspessulana*	Montpellier Broom	R	Yes
**Lycium ferocissimum*	African Box-thorn	C	Yes
**Rosa rubiginosa*	Sweet Briar	C	
**Rubus fruticosus spp. agg.*	Blackberry	C	Yes
**Ulex europaeus*	Gorse	C	Yes

The CaLP Act has legislative requirements for weed management to ensure that reasonable precautions are taken to ensure that vehicles, machinery or equipment used for maintenance or construction be free from seeds of any noxious weed seeds or propagules.

RRV and their contractors undertaking construction works for the proposed Beaufort Bypass will need to take all reasonable steps to eradicate regionally prohibited weeds, prevent the growth and spread of regionally controlled weeds and prevent the spread of and as far as possible eradicate established pest animals. Weed control measures are discussed in Section 10.4.7.1.

The preferred alignment will likely cross some of the locations of some CaLP Act weeds and as such will need to adhere to specific measures to limit the spread of these weeds. Specific measures to manage this risk may include wash-down procedures to remove weed seeds and soil from plant and equipment and measures to contain runoff from spoil and prevent spread of soil into native vegetation in the rail corridor adjacent to the study area. Such measures with be detailed in an Environmental Management Plan (or similar) for the works. Develop and implement measures to avoid the spread, or introduction of weeds and pathogens during construction, including vehicle and equipment hygiene. Weed and pathogen controls should be implemented through the CEMP.

5.3 LOCAL POLICY

The *Planning and Environment Act 1987* provides the legal framework for the operation of Victoria's planning system, commonly referred to as *the Planning Scheme*. Sections of the Pyrenees Planning Scheme of relevance to ecological matters are discussed below.

Most of the C2 alignemnt is covered by Farming Zone (FZ), along with Camp Hill which is a Public Conservation and Resource Zone (PCRZ). Other smaller zones that intersect alignment C2 include: Public Use Zone – Transport (PUZ4), Road Zone – Category 1 (RDZ1), Rurual Conservation Zone (RCZ) and Rural Living Zone (RLZ).

There are four planning overlays of relevance to ecological maters that intersect the preferred alignment. These include; a narrow section of Vegetation Protetion Overly – Schedual 1 (VPO1), Floodway Overlay (FO), Land Subject to Inundation Overlay (LSIO) and Bushfire Management Overlay (BMO).

The VPO occurs along Beaufort Lexton road and is for Roadside Grassland Protection and Conservation. A planning permit is required to remove, destroy or lop native vegetation in this area. More detail about the planning zones and ovelays is provided in the *Beaufort Bypass Environment Effects Statement – Planning And Land Use Impact Assessment* (WSP 2020b).

5.3.1 REVEGETATION

There is no site indigenous revegetation proposed for removal in the C2 construction footprint, but 0.21 ha of site indigenous revegetation occurs within the Specific Controls Overlay (SCO).

6 EXISTING CONDITIONS

6.1 LITERATURE REVIEW

Previous ecological assessments of the study area and surrounds which were reviewed have been summarised below.

DESKTOP FLORA AND FAUNA ASSESSMENT OF THE WESTERN HIGHWAY, BURRUMBEET TO STAWELL, VICTORIA (ECOLOGY PARTNERS PTY LTD 2008)

Ecology Partners Pty. Ltd. was commissioned by VicRoads to undertake a desktop flora and fauna assessment for the duplication of the Western Highway between Burrumbeet and Stawell (through Beaufort). Biological databases maintained by the Department of Sustainability and Environment (DSE) were reviewed, including the Atlas of Victorian Wildlife and Flora Information System. The presence of EVCs within the wider study area was reviewed using DSE's Biodiversity Interactive Map. A search was completed using the EPBC Act Protected Matters Search Tool. A rapid landscape field assessment was also completed across two days to broadly record the vegetation communities and condition within the study area.

In the locality of Beaufort, the assessment identified the potential for endangered EVCs as well as records and potential habitat for nationally and state listed flora and fauna species. The report determined that a referral under the EPBC Act would likely be required and that detailed flora and fauna assessment and Habitat Hectare analysis would be needed to calculate losses and offset requirements.

FLORA, FAUNA AND NET GAIN ASSESSMENT OF THE PROPOSED WESTERN HIGHWAY DUPLICATION, BURRUMBEET TO BEAUFORT, VICTORIA (ECOLOGY PARTNERS PTY LTD 2010B)

Ecology Partners undertook a flora, fauna, and net gain assessment for VicRoads for the Burrumbeet to Beaufort section of the Western Highway Duplication (not including the Beaufort Bypass). This included a review of databases and mapping, and a field survey to document fauna and flora species, remnant native vegetation patches, and significant communities. They also undertook a Net Gain assessment.

Ecology Partners determined that the study area supported Valley Grassy Forest and Plains Grassland between Beaufort and Trawalla, and Plains Grassland and Plains Grassy Wetland between western Trawalla and Burrumbeet. All seven of the proposed alignments assessed in the study intersected with remnant patches of these EVCs. Three species listed as vulnerable under the EPBC Act were recorded, all at Mt Emu Creek: Growling Grass Frog, Dwarf Galaxias (now split into Little Galaxias – refer to section 4.4 of this report), and Yarra Pygmy Perch. The report determined that Mt Emu Creek is of national conservation significance and that both the eastern and western portions of the study area are at least of state significance.

Targeted surveys for both flora and fauna were recommended.

TARGETED FLORA, FAUNA & AQUATIC SURVEYS OF THE WESTERN HIGHWAY UPGRADE: BURRUMBEET TO BEAUFORT (ECOLOGY PARTNERS PTY LTD 2010C)

Following on from (Ecology Partners Pty Ltd 2010b), Ecology Partners were commissioned by VicRoads to undertake targeted surveys for flora, and terrestrial and aquatic fauna within multiple alignment options for the proposed duplication of the Western Highway between Burrumbeet and Beaufort. Targeted survey was undertaken in summer and winter for threatened flora. Targeted fauna surveys were conducted for the Growling Grass Frog, Golden Sun Moth, Dwarf Galaxias (now split into Little Galaxias – refer to section 4.4 of this report), and Yarra Pygmy Perch.

Two state significant flora species were recorded during the summer survey: Rosemary Grevillea and Wavy–swamp Wallaby–grass, and one was recorded during the winter survey: Emerald–lip Greenhood. Two threatened fauna species were recorded: Growling Grass Frog and Dwarf Galaxias, both species listed under the EPBC Act and FFG Acts.

DETAILED FLORA AND FAUNA STUDY – WESTERN HIGHWAY PROJECT – ARARAT TO STAWELL, VICTORIA (ECOLOGY PARTNERS PTY LTD 2010A)

Ecology Partners Pty Ltd was commissioned by VicRoads to undertake a flora, fauna and Net Gain assessment of alignment options for the proposed duplication of the Western Highway between Ararat and Stawell. The study included background review and a field assessment to documenting fauna and flora species, remnant native vegetation patches, and significant communities in the study area. A Net Gain assessment was also undertaken. The study determined that the vegetation within the study area was predominantly Grassy Woodland between Ararat and Great Western with large areas of Plains Grassy Woodland and Heathy Woodland between Great Western and Stawell.

One state significant (Brown Treecreeper) and one regionally significant fauna species (Black-chinned Honeyeater), were recorded during the survey. Targeted survey was recommended for the numerous threatened flora and fauna species with the potential to occur within the study area. A preferred alignment was identified based on the Habitat Hectares assessment and the potential for threatened species to occur along the alignments.

ALIGNMENT OPTIONS REPORT BEAUFORT BYPASS – WESTERN HIGHWAY (BECA 2012)

In 2012, BECA developed alignment options for the proposed bypass around Beaufort. This included a preliminary assessment of their impacts upon various values, including ecological values. Four options to the south and five options to the north of Beaufort were assessed in the report. The assessment of ecological 'criteria' was informed by (Ecology Partners Pty Ltd 2008) and DSE habitat mapping.

The report determined that some alignment options would have a significantly larger impact upon areas of threatened EVC than others. It also determined that all alignment options would impact on the habitat of threatened native fauna. Additional detailed survey including a Habitat Hectares assessment was recommended.

WESTERN HIGHWAY PROJECT: SECTION 2, BEAUFORT TO ARARAT, VICTORIA IMPACT ASSESSMENT REPORT – FLORA, FAUNA AND ECOLOGICAL COMMUNITIES (ECOLOGY AND HERITAGE PARTNERS PTY LTD 2012A)

Ecology and Heritage Partners (EHP) undertook a flora, fauna and Net Gain assessment of three alignment options for Section two of the Western Highway Project between Beaufort and Ararat. This was required as part of the EES process for the project. The study included background review, flora, fauna, and Net Gain Assessment, targeted flora assessment, and targeted fauna assessment (both terrestrial and aquatic).

One threatened flora species (Spiny Rice-flower), two threatened communities (Natural Temperate Grassland of the Victorian Volcanic Plain, and Grassy Eucalypt Woodland of the Victorian Volcanic Plain), and five significant fauna species (Dwarf Galaxias, Golden Sun Moth, Brown Toadlet, Brown Treecreeper, and Baillon's Crake) were recorded. Potential habitat for two other threatened fauna species (Powerful Owl and Brush-tailed Phascogale) was also noted. An assessment of the ecological impact of each potential alignment option was completed. The assessment determined that the Project would have a significant impact upon MNES (Golden Sun Moth and the two listed communities). A referral had already been submitted and a controlled action determination had resulted. Net Gain offset requirements for each of the potential alignments and proposed mitigation measures for the project were provided.

WESTERN HIGHWAY PROJECT: SECTION 3, ARARAT TO STAWELL, VICTORIA. BIODIVERSITY AND HABITAT IMPACT ASSESSMENT REPORT – FLORA, FAUNA AND ECOLOGICAL COMMUNITIES (ECOLOGY AND HERITAGE PARTNERS PTY LTD 2012B)

EHP was commissioned by VicRoads to prepare a flora, fauna, and Net Gain assessment of several alignment options for Section 3 of the Western Highway Project between Ararat and Stawell. This was required as part of the EES process for the project. The study included background review, flora, fauna, and Net Gain Assessment, targeted flora assessment, and targeted fauna assessment (both terrestrial and aquatic).

Significant flora species recorded included the Trailing Hop-bush (EPBC Act vulnerable), Emerald-lip Greenhood, and Rising Star Guinea-flower, as well as numerous species of regional significance. Significant fauna species recorded included Golden Sun Moth (EPBC Act critically endangered) as well as state- significant species (Brush-tailed Phascogale, Brown Toadlet, Brown Treecreeper, and Barking Owl), and several regionally-significant species. One significant community, Victorian Temperate Woodland Bird Community, was also recorded.

A final alignment was identified and the assessment determined that this alignment would have a significant impact upon MNES. A referral had already been submitted and a controlled action determination had resulted. It also determined that the final alignment would necessitate the clearance of 116.62 ha of Very High conservation significance vegetation and 16.52 ha of High conservation significance vegetation.

WESTERN HIGHWAY PROJECT SECTION 2: BEAUFORT TO ARARAT. ENVIRONMENT EFFECTS STATEMENT (VICROADS 2012B)

An EES for the Beaufort to Ararat section of the Western Highway Project was prepared by VicRoads for submission in 2012. The duplication alignment commences at the railway crossing west of Beaufort and extends for 38 kms to Heath Street, Ararat. The EES responds to the Scoping Requirements issued by the Minister for Planning in September 2011. It provides the outcomes of investigations, the alignment options that were investigated, the predicted environmental effects, and the proposed management measures for the Project. The sections of most relevance to ecological values are Chapters 13. Biodiversity and Habitat, 20. Matters of NES, and 21. Environmental Management Framework.

WESTERN HIGHWAY PROJECT SECTION 3: ARARAT TO STAWELL. ENVIRONMENT EFFECTS STATEMENT (VICROADS 2013B)

An EES for the Ararat to Stawell section of the Western Highway Project was prepared by VicRoads for submission in 2013. The duplication alignment commences about 3 km from the Ararat Town Centre and terminates about 3 km from the Stawell Town Centre. The EES responds to the Scoping Requirements issued by the Minister for Planning in September 2011. It provides the outcomes of investigations, the alignment options that were investigated, the predicted environmental effects, and the proposed management measures for the project. The sections of most relevance to ecological values are Chapters 13. Biodiversity and Habitat, 20. Matters of NES, and 21. Environmental Management Framework.

ENVIRONMENT EFFECTS STATEMENT REFERRAL FOR THE BEAUFORT BYPASS – UPDATE TO FLORA AND FAUNA INFORMATION (ECOLOGY PARTNERS PTY LTD 2014)

A letter was prepared by Ecology and Heritage Partners Pty Ltd for VicRoads, detailing the outcomes of a desktop review of the flora and fauna values of the Beaufort Bypass alignment options. Two primary alignments were assessed (B4 and B5), broken down into different sections. The study included a review of databases for flora and fauna records, review of previous ecological assessments completed for other sections of the Western Highway Project, quantification of EVCs within each alignment section and investigation of EVCs outside of the alignments (based on broad-scale DEPI mapping only), and provision of additional information to inform an EES referral. No field survey was completed.

The report preliminarily identified numerous threatened species with the potential to occur within the alignments and be affected by the project, as well as EVCs of conservation significance likely to be lost. With regard to EPBC Act listed communities, the letter identified the likely occurrence of Natural Temperate Grassland of the Victorian Volcanic Plain and Grassy Eucalypt Woodland of the Victorian Volcanic Plain, and the potential occurrence of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains and White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland.

WESTERN HIGHWAY BYPASS PROJECT – BEAUFORT. STAGE 1 – FLORA, FAUNA AND AQUATIC ASSESSMENT (GHD 2015)

GHD undertook a Stage 1 study for VicRoads for the Beaufort Bypass. The study area encompassed an area of approximately 1,141 ha to the north of the township of Beaufort (including alignments B4-A, B4-B and B5). The study included: desktop review of ecological databases, review of previous documents, and rapid field assessment in spring. No targeted surveys for rare or threatened species were undertaken. EVC mapping was completed at a course scale.

Five different EVCs were identified as well as three mosaics comprising two EVCs. The majority of the EVCs which were mapped within the study area are classified as depleted, with smaller areas also mapped as Endangered, Vulnerable or Least Concern. No listed threatened flora species were recorded during the rapid survey. One EPBC Act migratory species (Rainbow Bee-eater) and three DELWP Advisory List bird species were recorded.

Targeted surveys for seven listed flora species and five listed fauna species were recommended. This included Candy Spider-orchid, Matted Flax-lily, Trailing Hop-bush, Clover Glycine, Ben Major Grevillea, White Sunray, Spiral Sun-orchid, Golden Sun Moth, Striped Legless Lizard, Growling Grass Frog, Brown Toadlet and Brush-tailed Phascogale. The study identified likely wildlife corridors within the study area. This study informed the EES referral for the project, submitted in May 2015. A decision from the Minister for Planning was received on 22 July 2015 that an EES is required for the project.

THREATENED SPECIES TARGETED ASSESSMENTS BEAUFORT BYPASS (WSP | PARSONS BRINCKERHOFF 2016B)

Informed by GHD 2015, WSP undertook targeted surveys for threatened flora and fauna in November and December 2015 and provided a report to VicRoads in 2016. The results of these surveys and as well as additional surveys by WSP and subconsultants undertaken for the current study have informed the current understanding of the existing environmental condition of the alignments.

Five significant flora species were identified: Ben Major Grevillea (EPBC Act and FFG Act), Matted Flax-lily (EPBC Act and FFG Act), River Swamp Wallaby-grass (EPBC Act), Yarra Gum (rare in Victoria), and Snow Gum (of local significance). Three threatened ecological communities listed under the EPBC Act were identified: White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland, Natural Temperate Grassland of the Victorian Volcanic Plain, and Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains. Five FFG Act threatened fauna species were recorded: Brown Toadlet, Brush-tailed Phascogale, Squirrel Glider, Brolga and Golden Sun Moth (also listed under the EPBC Act). In addition, Brown Treecreeper (listed as near threatened in Victoria) was also recorded along with areas assessed as meeting the Victorian Temperate Woodland Bird Community listed under the FFG Act.

UNDERESTIMATION OF LARGE OLD TREES WITHIN THE ENVIRONMENT EFFECTS STATEMENT – WESTERN HIGHWAY DUPLICATION SECTION 2: BEAUFORT TO ARARAT (VICROADS 2016B)

In March 2016, VicRoads produced a report to document the sequence of events that lead to the severe underestimation of large old trees (LOTs) associated with Section 2 of the Western Highway duplication project between Beaufort and Ararat. It is noted that this was a methodological issue – the underestimation occurred across all options being assessed. It is also noted that the construction phase controls provided for the differences between methodology and detailed construction phase requirements, the planning scheme controls required all vegetation to be removed to be offset. However, VicRoads intends understanding what occurred to develop key learnings and capitalise on improvement opportunities to avoid similar scenarios in the future. VicRoads also acknowledged that 221 LOTs were misinterpreted as an absolute maximum, rather than a comparison of differences between options. The report found that the underestimation could be attributed to several factors, including a poor understanding of the stated limitations of the data, and a dismissal of these limitations. The report suggested several recommendations to avoid similar situations in the future. These included: undertaking counts of individual LOTs at the appropriate stage of the planning process; ensuring technical experts are given adequate opportunity to review and provide feedback on the final draft of an EES before it is released for exhibition; and exercising caution in reviewing sampling strategies that attempt to estimate LOTs across large areas. VicRoads acknowledged that it should ensure it understands the sampling strategies used and is comfortable with them being fit-for-purpose before supporting their adoption.

STRIPED LEGLESS LIZARD HABITAT ASSESSMENT' (CARDNO 2020A) AND 'TARGETED SURVEY FOR STRIPED LEGLESS LIZARD' (CARDNO 2020B)

This was conducted by Cardno in 2019/2020. Tiles placed in four tile arrays within and adjacent to the C2 alignment in July 2019 with tile checks at a fortnightly intervals, increasing to weekly checks which took place from October 2019 to January 2020. Surveys detected Eastern Three-lined Skink, Little Whip Snake, Brown Snake and Garden Skink but did not detect Striped Legless Lizard. Surveys were conducted in line with the EPBC Act guidelines for Australia's threatened reptiles. See Section 6.6.2.22 for more details on results.

THREATENED SPECIES MANAGEMENT PLAN – WESTERN HIGHWAY PROJECT SECTION 2B: BUANGOR TO ARARAT (MRPV 2020C)

A Threatened Species Management Plan was prepared by MRPV for species listed under the EPBC Act and/or the FFG Act. This included Spiny Rice-flower, Button Wrinklewort, Dwarf Galaxias, Golden Sun Moth and Brown Toadlet. The plan outlines the anticipated impact of the project on each of the species as well as the management and monitoring required before, during and after construction. Measures and advice for three Victorian Advisory listed species, Emerald-lip Greenhood, Golden Cow-slip and Yarra Gum, is also provided in the management plan. The plan also outlines mitigation and monitoring requirements pertaining to erosion and sediment control, use of fuels and chemicals, contaminated soils and materials, air quality and waste and resource use.

NATIVE VEGETATION MANAGEMENT PLAN – WESTERN HIGHWAY PROJECT SECTION 2B: BUANGOR TO ARARAT (MRPV 2020A)

A Native Vegetation Management Plan for the Buangor to Ararat portion of the Western Highway Project was prepared by MRPV as a requirement of the proposed Incorporated Document in the Ararat Planning Scheme. Section 2B of the Project was assessed as impacting a total of 43.758 hectares of native vegetation and 262 trees consisting of 179 Large Old Trees (LOTs) in patches and 83 scattered trees. As a result of the vegetation loss, biodiversity and habitat objectives and indicators were developed for the project to guide environmental performance during construction. These objectives and indicators are stipulated in the Native Vegetation Management Plan for the project and include some of the following items; minimising native vegetation loss and impacts to threatened species, implementation and regular surveillance of No-go Zones, environmental monitoring and monthly reporting by the construction contractor and the development of a weed management program and hygiene practices to alleviate risks associated with invasive species, pathogens and disease.

NATIVE VEGETATION OFFSET MANAGEMENT PLAN – WESTERN HIGHWAY PROJECT SECTION 2B: BUANGOR TO ARARAT (MRPV 2020B)

MRPV prepared a Native Vegetation Offset Management Plan which describes the native vegetation losses associated with the construction of the Stage 2B Western Highway Project and the required offsets that have either been secured or have been sourced and are in the process of being secured. Adjustments to No-go Zones based on the final design for the project substantially reduced the anticipated impacts to trees and thus also reduced the offset target required. This variation was approved by DELWP in August 2019.

The Native Vegetation Offset Management Plan stipulates that the offsets are to be provided in the Victorian Volcanic Plains (VVP) and Central Victorian Uplands (CVU) bioregions. An updated Native Vegetation Offset Management Plan is to be provided to DELWP following the securing and allocation of all offsets for the project.

6.2 STUDY AREA DESCRIPTION

The study area, shown on Figure 6.2, is located within Pyrenees Shire Council and extends for approximately 9 km from the eastern end to the western end of the Beaufort township, to the north of the town. It includes the four alignment options as provided by RRV. The study area occurs across a patchwork of landscapes including rural and agricultural freehold land, privately owned land, state forests and bushland reserves, private mine tenements, and roadsides. Areas of public tenure include Snowgums Bushland Reserve, Camp Hill State Forest, Camp Hill Recreation Reserve, Beaufort Trotting Track, Beaufort Blue Light Motorcycle Club, Beaufort Gun Club, Beaufort Wastewater Treatment Plant, local road reserves and rail corridors.

The study area supports a number of native vegetation types including grassy woodlands, grassy and heathy forests as well as several wetland vegetation types including grassy and sedgy wetlands. There are extensive areas of cleared land throughout the study area and current alignments, some of which support modified native vegetation or unimproved pasture with perennial native vegetation. Additionally, there are many scattered trees, of which many are considered large trees. Previous land use in the study area has included extensive agricultural use, gold mining activities, rural living, timber plantations, rubbish tips and transportation corridors.

The majority of the study area falls within the Central Victorian Uplands (CVU) bioregion with smaller areas covered by the Victorian Volcanic Plain (VVP) bioregion in two eastern areas (DELWP 2018d). The study area supports several permanent and ephemeral creeks with the largest being Yam Holes Creek. There are also a number of seasonal wetlands scattered through the study area, particularly along the Yam Holes Creek valley system.

6.3 LOCAL CONDITIONS

6.3.1 GEOLOGY

A Soils and Geology Impact Assessment was undertaken by WSP for the project, this section briefly summarises the geology of the study area as per the Soils and Geology Impact Assessment report (WSP 2020d).

The study area largely consists of Pyrenees and Beaufort formations that make up the hills surrounding the town of Beaufort and alluvial material situated in drainage lines and floodplains associated with the ephemeral Yams Holes Creek and its tributaries. The general topography within the study area is undulating, with sloping hills to the east and west of Beaufort and to the north, steeper areas throughout Camp Hill State Forest, resulting in an elevation range between <300 m and 460 m.

The Soils and Geology Impact Assessment report (WSP 2020d) and the Aboriginal Cultural Heritage Impact Assessment (Archaeology At Tardis 2020) both identified five geological units that underlie the study area; Alluvium, Incised alluvium, Beaufort Formation, White Hills Gravel and Pyrenees Formation.

The geology of Yam Holes Creek and its tributaries within the study area is predominately Quaternary alluvium, consisting of gravel, sand and silt derived from erosion of the surrounding environment. Given the young phase of fluvial deposition, the soil profile that has developed is thin, consisting of a silt A_1 Horizon that overlies a sandy silt A_2 horizon and a clay subsoil. To the south of Yam Holes Creek in the eastern region of the study area, and further upstream in the western region of the study area, the geology unit is identified as Incised Alluvium. Deposited during the Pilocene – Pleistocene age, this older geological unit is comprised from the same constituents as above except it contains ferricrete, an erosion resistant layer of sedimentary rock, and the soil profile that has developed in these locations are deeper.

Camp Hill State Forest is located in the centre of the study area and supports a dense patch of native forest. The Beaufort Formation geological unit, which underlies Camp Hill State Forest, is at least 1–1.5 km thick. It consists primarily of siltstone with interbedded mudstone, sandstone and black shale sediments which were originally deposited in a horizontal bed along the sea floor in the Middle - late Cambrian Period. The soil profile that has developed on the Beaufort Formation consists of a sandy silt A_1 and A_2 horizon with ironstone concretions at the base and a clay subsoil. Along with Camp Hill State Forest, the Beaufort Formation geological unit underlies other regions within the study area, particularly in the east.

Snowgums Bushland Reserve is located off Racecourse Road, approximately 4km east from the Beaufort township and in the east of the study area. There are two geological units which underlie this area: Incised Alluvium (described above) and White Hills Gravel. The latter is a heavily eroded remanent of a geological unit which was once an extensive outcrop within the central parts of the study area. The nature and distribution of the geological unit across Victoria suggests that it was deposited in the Late Cretaceous to Eocene during a catastrophic and widespread flooding event. Near the study area, the White Hills Gravel is likely to primarily consist of rounded white vein quartz with some sandstone and quartzite clasts derived from the surrounding hills of Beaufort and Pyrenees Formation. The soil profile which has developed includes a silty sand A_1 horizon, a rocky silty sand A_2 horizon and a grey clay subsoil with gravel weathering up from the underlying beds.

The western and eastern edges of the study area are underlain by Pyrenees Formation which consists of sandstone and organic rich mudstone deposits from the Middle Cambrian to Early Ordovician Period. The formation is sandy and is estimated to have a maximum thickness of 2.5 km. The soil profile that has developed consists of a silty sand A_1 horizon, a sandy silt A_2 horizon with iron concretions at its base and a mid-brown clay subsoil.

6.3.2 CLIMATE

Historical and current climate information for Beaufort and the surrounding region was obtained from the Australian Government Database, Bureau of Meteorology (BoM). The weather conditions at Beaufort and the surrounding regions are typically dry in summer with mean minimum temperatures of 10.6°C, mean maximum temperatures of 24.3°C and a mean monthly rainfall of 42.1 mm. Winter months comprise of mean minimum temperatures of 3.6°C, mean maximum temperatures of 10.8°C and a mean monthly rainfall of 68.9 mm (Bureau of Meteorology 2018). Most rainfall in Beaufort is received during the months of May to November with an average annual rainfall of approximately 679 mm (Bureau of Meteorology 2018).

Figure 6.1 below shows monthly average rainfall (mm) according to records from the Beaufort Station (No. 89005) between 1882 and 2018. The Beaufort Station is located 2.4 km from the Beaufort township (latitude: 37.25°S, longitude: 143.37°E). Average minimum and maximum temperatures per month are also shown, depicted by the grey and orange bars respectively. Due to unavailable temperature data from the Beaufort Station, temperature averages are taken from the Ballarat Aerodrome Station (No. 89002) which is located 37.2 km from Beaufort (latitude: 37.51° S Longitude: 143.79° E). Temperature averages are based on records between 1908 and 2018.

It is worth noting that the months of June – October 2015 had below average rainfall levels leading up to the 2015 targeted flora and fauna surveys in November 2015. Comparatively, September 2016 when the studies for this report commenced, Beaufort received 191.2 mm of rainfall, a substantial amount more than the 51.2 mm received in September 2015 and the historical average of 70.4 mm (Bureau of Meteorology 2018).

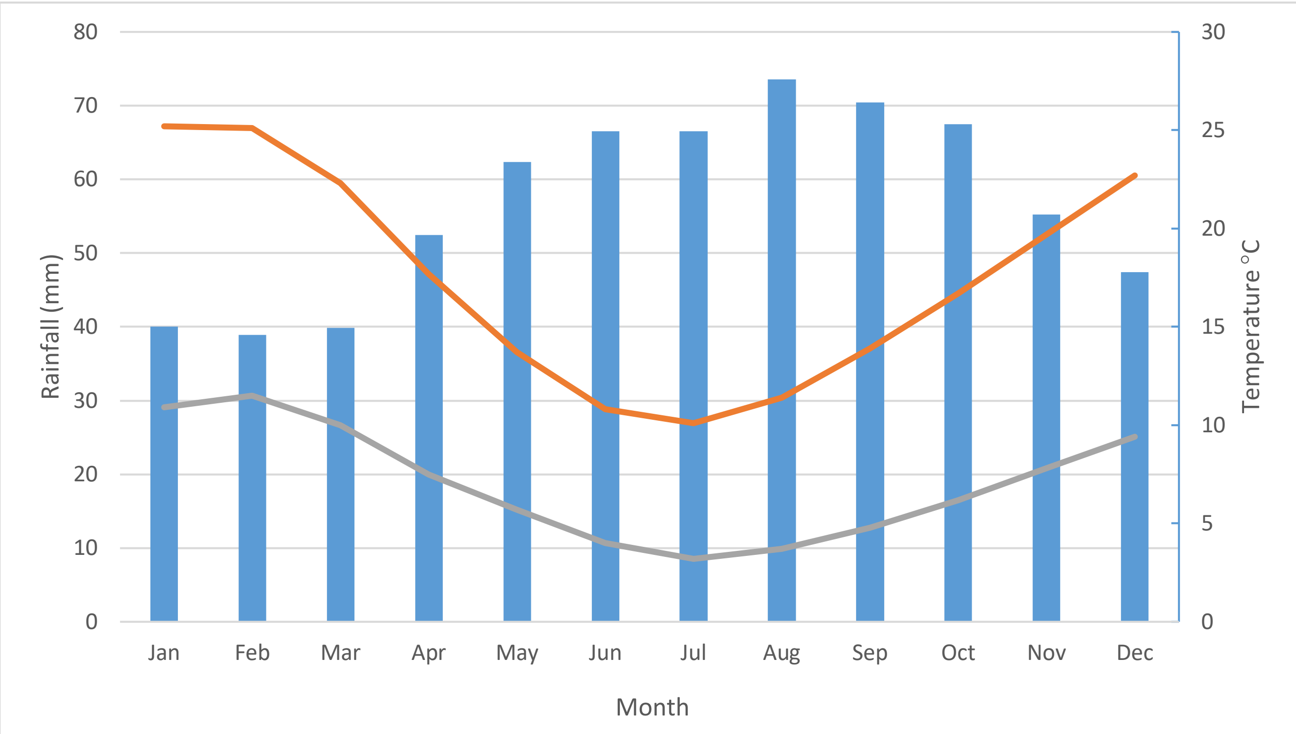


Figure 6.1 Average monthly rainfall (mm) and minimum and maximum temperatures (°C) in Beaufort and the surrounding regions

6.3.3 LANDSCAPE CONTEXT

The study area includes large areas of agricultural land, plantations and fragmented native vegetation. The study area also includes extensive areas of native vegetation, some of which has high ecological significance. It also supports patches of remnant vegetation, scattered remnant trees, drainage lines, and roadside revegetation, all of which provide habitat and connectivity for fauna. Areas of private and public land within the study area are shown on Figure 6.2. Note that key areas of ecological significance generally occur on public land, such as Camp Hill State Forest.

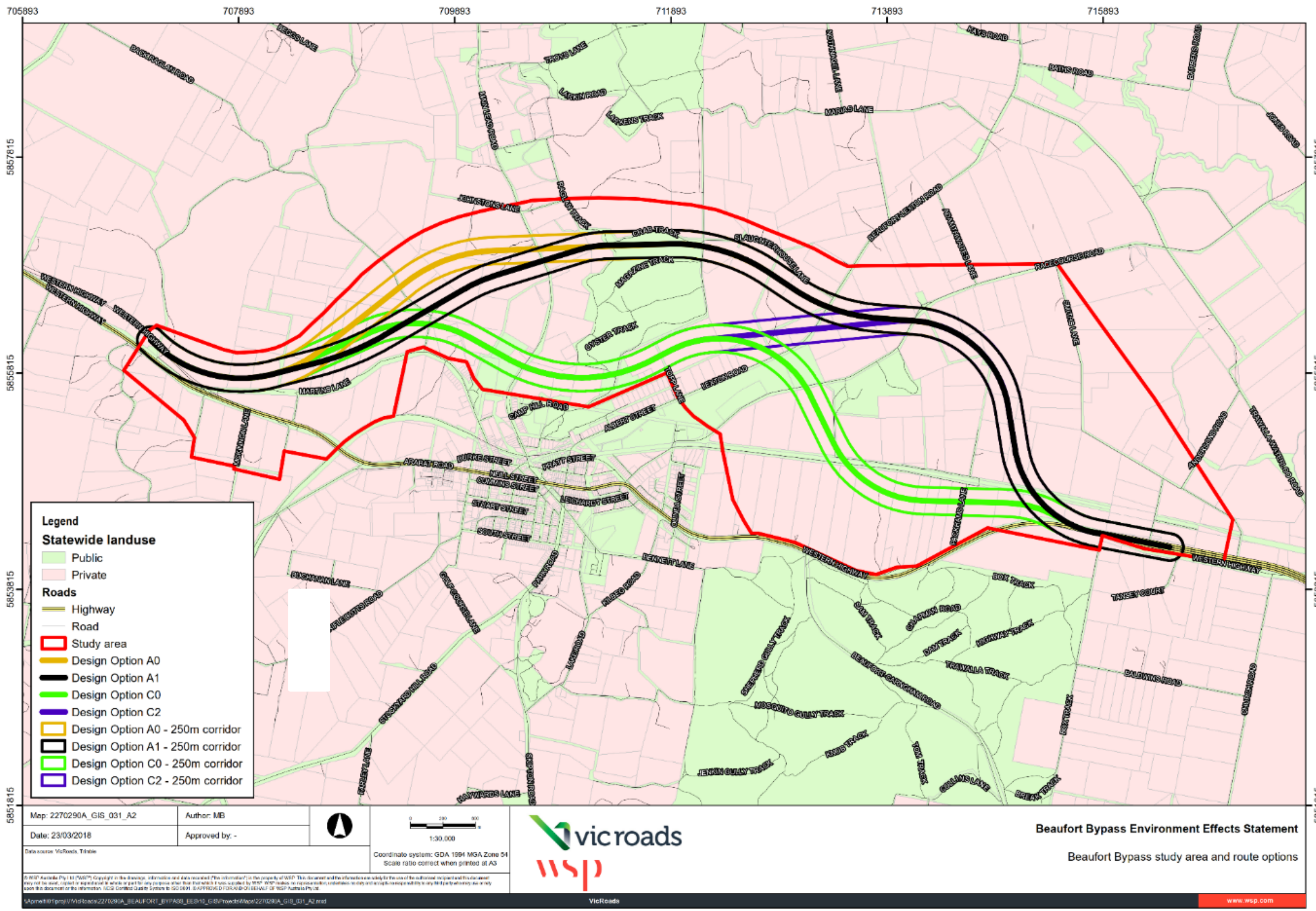


Figure 6.2 Beaufort Bypass study area and route options

6.4 VEGETATION

Sixteen EVCs were mapped within the study area which comprises 919 ha of combined native vegetation out of a total 1825 ha study area (Appendix K). The EVCs and corresponding conservation significance and extent within the study area are summarised in Table 6.2 below. Brief descriptions are provided in Section 6.4.1. Several EVCs mapped are indicative of either FFG Act or EPBC Act listed ecological communities as outlined in the table. Further assessment of threatened communities is provided in Section 6.4.3.

There are extensive areas of cleared land throughout the study area and current alignments, of which some supports modified native vegetation or unimproved pasture with >25% perennial native vegetation. Additionally, there are many scattered trees, of which a large proportion are large old trees. Trees are addressed in greater detail in Section 6.4.5.

A number of areas of revegetation, mostly Blue Gum plantations, were mapped in the study area. The revegetation map layer also includes exotic planted vegetation such as pines.

Several wetlands in DELWP's legacy dataset Wetlands 1994 and DELWP's Current Wetlands layer occur in the study area (Figure 6.3). Some of these were observed to still be present in the study area and have been mapped as EVCs and, where applicable, the EPBC Act listed Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plain. Several Biosites from the now decommissioned databases BioSite 25 and Biosite 100 occur in the study area, mostly along road and rail corridors (Figure 6.3).

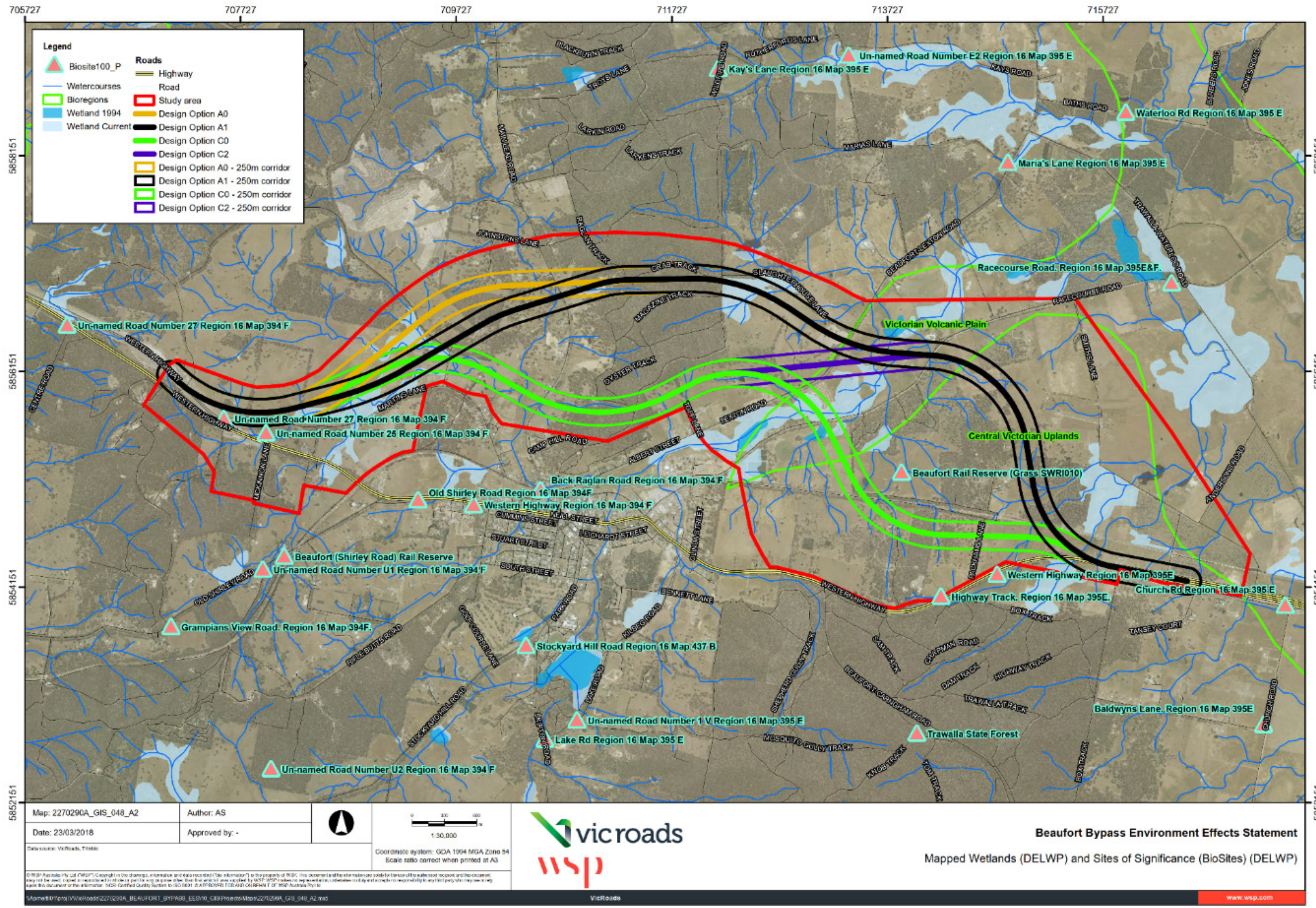


Figure 6.3 Mapped wetlands (DELWP) and Sites of Significance (BioSites) (DELWP)

6.4.1 VEGETATION DESCRIPTIONS

Sixteen EVCs (including complexes) were recorded within the study area. These are described in Table 6.2 and mapped in Appendix K. Several treeless patches of native vegetation were mapped in the study area and these were typically ascribed the closest EVC, often with reference to the pre-industrial vegetation spatial dataset NV1750_EVC. These were often found along roadsides where trees had been removed and in unimproved pasture where the understorey was relatively intact.

Each EVC is assigned a conservation status which is specific for the bioregion in which it occurs. These conservation statuses are categorised by DELWP as follows:

Table 6.1 EVC conservation status descriptions

CONSERVATION STATUS	STATUS CODE	DESCRIPTION^
Endangered	E	Contracted to less than 10% of former range; OR Less than 10% pre-European extent remains; OR Combination of depletion, degradation, current threats and rarity is comparable overall to the above: — 10 to 30% pre-European extent remains and severely degraded over a majority of this area; or — naturally restricted EVC reduced to 30% or less of former range and moderately degraded over a majority of this area; or — rare EVC cleared and/or moderately degraded over a majority of former area.
Vulnerable	V	10 to 30% pre-European extent remains; OR Combination of depletion, degradation, current threats and rarity is comparable overall to the above: — greater than 30% and up to 50% pre-European extent remains and moderately degraded over a majority of this area; or — greater than 50% pre-European extent remains and severely degraded over a majority of this area; or — naturally restricted EVC where greater than 30% pre-European extent remains and moderately degraded over a majority of this area; or — rare EVC cleared and/or moderately degraded over a minority of former area.
Depleted	D	Greater than 30% and up to 50% pre-European extent remains; OR Combination of depletion, degradation and current threats is comparable overall to the above and: — greater than 50% pre-European extent remains — and moderately degraded over a majority of this area.
Rare	R	Rare EVC (as defined by geographic occurrence) but neither depleted, degraded nor currently threatened to an extent that would qualify as Endangered, Vulnerable or Depleted.
Least Concern	LC	Greater than 50% pre-European extent remains and subject to little to no degradation over a majority of this area.

^Descriptions are provided by DELWP's Bioregion and EVC Benchmark website https://www.environment.vic.gov.au/biodiversity/bioregions-and-evc-benchmarks

Table 6.2 Ecological Vegetation Classes, conservation status and equivalent communities listed under EPBC Act and FFG Act

EVC NO.	EVC NAME	BIOREGION CONSERVATION STATUS CENTRAL VICTORIAN UPLANDS (CVU) (DELWP 2018B)	BIOREGION CONSERVATION STATUS VICTORIAN VOLCANIC PLAIN (VVP) (DELWP 2018B)	WETLAND EVC BIOREGION CONSERVATION STATUS CVU (FROOD & PAPAS 2016)	WETLAND EVC BIOREGION CONSERVATION STATUS VVP (FROOD & PAPAS 2016)	FFG ACT COMMUNITY EQUIVALENT †	EPBC ACT COMMUNITY EQUIVALENT †
67	Alluvial Terraces Herb-rich Woodland	Endangered	Endangered	NA	NA	Can be indicative of Temperate Woodland Bird Community	Can form White Box - Yellow Box – Blakely's Red Gum Grassy Woodland where Yellow Box is co-dominant and meets other criteria
306	Aquatic Grassy Wetland	EVC not listed in CVU – use Endangered status from VVP	Endangered	Vulnerable	Endangered	No	Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains
653	Aquatic Herbland	EVC not listed in CVU – use Endangered status from VVP	Endangered	EVC not listed in CVU	Endangered	No	Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains
308	Aquatic Sedgeland	EVC not listed in (DELWP 2018b) – use Endangered status from Aquatic Herbland	EVC not listed in (DELWP 2018b) – use Endangered status from Aquatic Herbland	EVC not listed in CVU	Endangered	No	NA – Contra-indicated from Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains as species-poor EVCs are excluded
656	Brackish Herbland	EVC not listed in Central Victorian Uplands – use Endangered status from VVP	Endangered	EVC not listed in CVU	Endangered	No	No

EVC NO.	EVC NAME	BIOREGION CONSERVATION STATUS CENTRAL VICTORIAN UPLANDS (CVU) (DELWP 2018B)	BIOREGION CONSERVATION STATUS VICTORIAN VOLCANIC PLAIN (VVP) (DELWP 2018B)	WETLAND EVC BIOREGION CONSERVATION STATUS CVU (FROOD & PAPAS 2016)	WETLAND EVC BIOREGION CONSERVATION STATUS VVP (FROOD & PAPAS 2016)	FFG ACT COMMUNITY EQUIVALENT †	EPBC ACT COMMUNITY EQUIVALENT †
68	Creekline Grassy Woodland	Endangered	Endangered	NA	NA	Can be indicative of Temperate Woodland Bird Community	No
22	Grassy Dry Forest	Depleted	Depleted	NA	NA	Can be indicative of Temperate Woodland Bird Community	No
175	Grassy Woodland	Endangered	Endangered	NA	NA	Can be indicative of Temperate Woodland Bird Community	Can form White Box - Yellow Box – Blakely's Red Gum Grassy Woodland where Yellow Box is co-dominant and meets other criteria
20	Heathy Dry Forest	Least Concern	Least Concern	NA	NA	Can be indicative of Temperate Woodland Bird Community	No
320	Heathy Dry Forest/ Grassy Dry Forest Complex	Complexes not listed in (DELWP 2018b). Use status for highest status – Grassy Dry Forest - Depleted	Complexes not listed in (DELWP 2018b). Use status for highest status – Grassy Dry Forest - Depleted	NA	NA	Can be indicative of Temperate Woodland Bird Community	No

EVC NO.	EVC NAME	BIOREGION CONSERVATION STATUS CENTRAL VICTORIAN UPLANDS (CVU) (DELWP 2018B)	BIOREGION CONSERVATION STATUS VICTORIAN VOLCANIC PLAIN (VVP) (DELWP 2018B)	WETLAND EVC BIOREGION CONSERVATION STATUS CVU (FROOD & PAPAS 2016)	WETLAND EVC BIOREGION CONSERVATION STATUS VVP (FROOD & PAPAS 2016)	FFG ACT COMMUNITY EQUIVALENT †	EPBC ACT COMMUNITY EQUIVALENT †
125	Plains Grassy Wetland	Endangered	Endangered	Endangered	Endangered	No	Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains
767	Plains Grassy Wetland/ Brackish herbland Complex	Complexes not listed in (DELWP 2018b). Use status for Plains Grassy Wetland (endangered)	Complexes not listed in (DELWP 2018b). Use status for Plains Grassy Wetland (endangered)	EVC not listed in Central Victorian Uplands	Endangered	No	Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains
755	Plains Grassy Wetland/ Aquatic Herbland Complex	Complexes not listed in (DELWP 2018b). Use status for Plains Grassy Wetland (endangered)	Complexes not listed in (DELWP 2018b). Use status for Plains Grassy Wetland (endangered)	EVC not listed in Central Victorian Uplands	Endangered	No	Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains
55	Plains Grassy Woodland	Endangered	Endangered	NA	NA	Can be indicative of Temperate Woodland Bird Community	Grassy Eucalypt Woodland of the Victorian Volcanic Plain
647	Plains Sedgy Wetland	Endangered	Endangered	EVC not listed in Central Victorian Uplands	Vulnerable	No	Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains

EVC NO.	EVC NAME	BIOREGION CONSERVATION STATUS CENTRAL VICTORIAN UPLANDS (CVU) (DELWP 2018B)	BIOREGION CONSERVATION STATUS VICTORIAN VOLCANIC PLAIN (VVP) (DELWP 2018B)	WETLAND EVC BIOREGION CONSERVATION STATUS CVU (FROOD & PAPAS 2016)	WETLAND EVC BIOREGION CONSERVATION STATUS VVP (FROOD & PAPAS 2016)	FFG ACT COMMUNITY EQUIVALENT †	EPBC ACT COMMUNITY EQUIVALENT †
821	Tall Marsh	EVC not listed in Central Victorian Uplands. Closest bioregion is Victorian Riverina which is very far from study area. Use status Endangered in (Frood & Papas 2016)	EVC not listed in VVP. Closest bioregion is Victorian Riverina which is very far from study area. Use status Endangered in (Frood & Papas 2016)	EVC not listed in Central Victorian Uplands	Endangered	No	No – Contra-indicated from Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains
47	Valley Grassy Forest	Vulnerable	Vulnerable	NA	NA	Can be indicative of Temperate Woodland Bird Community	Can form White Box - Yellow Box – Blakely's Red Gum Grassy Woodland where Yellow Box is co-dominant and meets other criteria

† Equivalence to FFG Act and EPBC Act communities as assessed by criteria in Section 6.4.3 Threatened vegetation communities

EVC 67 ALLUVIAL TERRACES HERB-RICH WOODLAND

Open woodland to 15 m high on broad alluvial plains and ephemeral drainage lines throughout the study area. Typically occurs on alluvial deposits overlying heavier clay soils. In the study area, this EVC has been mapped in association with Creekline Grassy Woodland but differs where it occurs on broad alluvial plains as opposed to low-gradient ephemeral to intermittent drainage lines. It is also mapped in association with Valley Grassy Forest but differs where vegetation occurs on broad valleys off defined alluvial plains. Also Valley Grassy forest tends to have a higher shrub layer. Mapping of this EVC in the Beaufort area is challenging, particularly as Alluvial Terraces Herb-rich Woodland has likely been overestimated in EVC modelling and Valley Grassy Forest underestimated (Biodiversity Services 2016).

Most common over storey species in the study area are Yellow Box *Eucalyptus melliodora* and Candelbark *E. rubida* with occasional Manna Gum *Eucalyptus viminalis* near Main Lead Road. Typically this EVC has River Red Gum *Eucalyptus camaldulensis*, however, there are very few River Red Gum in the study area. The shrub layer is typically sparse with occasional Blackwood *Acacia melanoxylon.*

The ground layer is usually diverse with herbs and grasses, particularly at more intact sites or sites with higher moisture but this EVC has suffered a severe history of disturbance from mining, grazing and timber cutting (Commonwealth of Australia 1999).

Dominant species found in the study area include Weeping Grass *Microlaena stipoides*, Grey Tussock-grass *Poa sieberiana,* Copper-awned Wallaby-grass *Rytidosperma fulvum and* Kneed Wallaby-grass *Rytidosperma geniculatum,* Kangaroo Grass *Themeda triandra,* Chocolate Lily Arthropodium strictum s.l., Kidney-weed *Dichondra repens,* Common Wheat-grass *Elymus scabrus*, Common Bog-sedge *Schoenus apogon,* Yellow Rush-lily *Tricoryne elatior* and Scented Sundew *Drosera aberrans.*

Typical weeds found in this EVC in the study area include Squirrel-tail Fescue **Vulpia bromoides,* Flatweed **Hypochaeris radicata*, Montpellier Broom **Genista monspessulana*, Spear Thistle **Cirsium vulgare*, Sweet Briar **Rosa rubiginosa* and Sweet Vernal-grass **Anthoxanthum odoratum*.

EVC 653 AQUATIC HERBLAND

Semi-permanent to seasonal wetland vegetation, lacking woody species, dominated by herbaceous aquatic species (Frood 2009). Often occurring in association with other wetland EVCs where it occurs in deeper, more frequently inundated parts of wetlands. Indicator species found in the study area include Running Marsh-flower *Ornduffia reniformis,* Common Water-ribbons *Cycnogeton procerum s.s.,* Upright Water-milfoil *Myriophyllum crispatum,* Common Spike-sedge *Eleocharis acuta,* River Buttercup *Ranunculus inundates,* Small River Buttercup *Ranunculus amphitrichus,* Red Water-milfoil *Myriophyllum verrucosum* and White Purslane *Montia australasica.* Typical weeds include Hairy Hawkbit * *Leontodon saxatilis subsp. saxatilis,* Yorkshire Fog **Holcus lanatus,* Curled Dock **Rumex crispus* and Water Buttons **Cotula coronopifolia.*

Distributed in a number of natural wetlands throughout the study area as well as formed drainage lines and farm dams.

EVC 308 AQUATIC SEDGELAND

Species-poor vegetation dominated by one to several species of robust inundation-tolerant rhizomatous sedges, with vegetative growth extending into virtually permanent water. Indicator species typically include Tall Spike-sedge *Eleocharis sphacelata* with occasional Common Reed *Phragmites australis,* Australian Sweet-grass *Glyceria australis,* and Common Spike-sedge *Eleocharis acuta.*

Distributed in several wetlands and farm dams throughout the study area.

EVC 656 BRACKISH HERBLAND

Short herbland dominated by species tolerant of mildly saline conditions and intermittent inundation. Indicator species include Streaked Arrowgrass *Triglochin striata,* Nodding Club-sedge *Isolepis cernua.* Typical weeds include Buck's-horn Plantain **Plantago coronopus,* Spiny Rush **Juncus acutus subsp. acutus* and Water Buttons **Cotula coronopifolia.*

Limited distribution in the study area in low lying areas along Martins Lane where salinity discharge is evident.

EVC 68 CREEKLINE GRASSY WOODLAND

Eucalypt-dominated woodland to 15 m with occasional shrub layer over a mostly grassy/sedgy to herbaceous ground-layer. Occurs on low-gradient ephemeral to intermittent drainage lines, typically on fertile colluvial/alluvial soils on a wide range of suitably fertile geological substrates. Typically, this EVC is dominated by River Red Gum *Eucalyptus camaldulensis*. However, it appears all River Red Gums in the study area, particularly along the eastern parts of Yam Holes Creek where Creekline Grassy Woodland was identified, are planted. This is over a ground layer dominated by robust sedges such as Poong'ort *Carex tereticaulis* and Tall Sedge *Carex appressa* and rushes *Juncus spp*. There are many weeds in this EVC which typically include Yorkshire Fog **Holcus lanatus,* Curled Dock **Rumex crispus* and Blackberry * *Rubus fruticosus spp. agg.*

EVC 22 GRASSY DRY FOREST

Occurs on a variety of gradients and altitudes and on a range of geologies, typically on Pyrenees Formation and White Hills gravel geologies in the study area. Grassy Dry forest usually occurs on gentle to steep slopes, often lower down a slope gradient between Heathy Dry Forest (higher slope, ridgelines) and Valley Grassy Forest (in valley floors). The overstorey is dominated by a low to medium height forest of eucalypts to 20 m tall, sometimes resembling and open woodland with a secondary, smaller tree layer including a number of wattle species. The understorey usually consists of a sparse shrub layer of medium height. Ground layer dominated by a high diversity of drought-tolerant grasses and herbs.

Most common over storey species in the study area are Bundy *Eucalyptus goniocalyx s.l.,* Red Stringybark *Eucalyptus macrorhyncha,* Broad-leaf Peppermint *Eucalyptus dives,* Narrow-leaf Peppermint *Eucalyptus radiata s.l.* and Messmate *Eucalyptus obliqua* (on sheltered aspects). There is a sparse shrub layer with occasional Cherry Ballart *Exocarpos cupressiformis* however repeated burning can encourage dense stands of Narrow-leaf Bitter-pea *Daviesia leptophylla* Commonwealth of Australia (1999).

The ground layer dominated by Silvertop Wallaby-grass *Rytidosperma pallidum,* Common Rapier-sedge *Lepidosperma filiforme,* Common Raspwort *Gonocarpus tetragynus,* Ben Major Grevillea *floripendula,* Wattle Mat-rush *Lomandra filiformis subsp. coriacea,* Milkmaids *Burchardia umbellata,* Button Everlasting *Coronidium scorpioides s.s.,* Veined Spear-grass *Austrostipa rudis subsp. rudis,* Stony Fireweed *Senecio phelleus,* Black-anther Flax-lily *Dianella admixta,* Variable Stinkweed *Opercularia varia* and Common Rice-flower *Pimelea humilis.*

Weeds are typically sparse but often include Large Quaking-grass **Briza maxima* and Delicate Hair-grass **Aira elegantissima.*

There was a note in the West Victoria Comprehensive Regional Assessment Report - Volume Two Commonwealth of Australia (1999) on the difficulty of assigning Grassy Dry Forest and Heathy Dry Forest separately in the Beaufort region due to the altered fire regimes and other disturbances such as past clearing and timber cutting which can cause the grassy/heathy understorey to vary over time. Mapping the differences between Grassy Dry Forest and Heathy Dry Forest proved difficult in the study and as such Heathy Dry Forest/Grassy Dry Forest Complex has been assigned outside the study alignments.

This EVC was mapped across the study area. There is an extensive patch throughout Camp Hill State Forest that spans from the northern study area boundary to the south. Other large patches occur in the western extent of the study area, south of the Western Highway, and in the east of the study area where a large patch occurs west of Packhams Lane.

EVC 175 GRASSY WOODLAND

A variable open eucalypt woodland to 15 m tall over a diverse ground layer of grasses and herbs. The shrub component is usually sparse. It occurs on sites with moderate fertility on plains or undulating hills on a range of geologies.

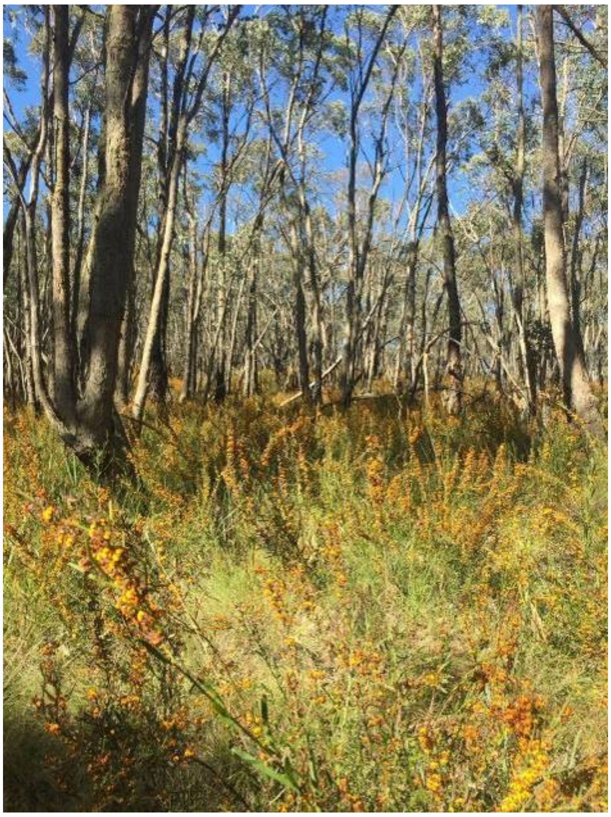
Most common over storey species in the study area are Yellow Box *Eucalyptus melliodora,* Scentbark *Eucalyptus aromaphloia,* Candelbark *Eucalyptus rubida* with Snow Gum *Eucalyptus pauciflora* or Yarra Gum *Eucalyptus yarraensis.* The shrub layer is typically dominated by Hedge Wattle *Acacia paradoxa,* Black Wattle *Acacia mearnsii* and Blackwood *Acacia melanoxylon* with occasional Cherry Ballart *Exocarpos cupressiformis*.

The ground layer is dominated by grasses and herbs particularly Fibrous Spear-grass *Austrostipa semibarbata,* Veined Spear-grass *Austrostipa rudis subsp. rudis,* Weeping Grass *Microlaena stipoides,* Kangaroo Grass *Themeda triandra* and wallaby grasses *Rytidosperma spp.* Herbs include Chocolate Lily *Arthropodium strictum s.l.,* Kidney-weed *Dichondra repens,* Bulbine Lily *Bulbine bulbosa,* Blue Grass-lily *Caesia calliantha,* Yellow Rush-lily *Tricoryne elatior,* Scented Sundew *Drosera aberrans,* Button Everlasting *Coronidium scorpioides s.s.,* Black-anther Flax-lily *Dianella admixta,* Stinking Pennywort *Hydrocotyle laxiflora,* Common Woodrush *Luzula meridionalis,* Variable Plantain *Plantago varia and* Australian Buttercup *Ranunculus lappaceus.*

Typical weeds found in this EVC in the study area include Flatweed **Hypochaeris radicata*, Large Quaking-grass **Briza maxima*, Montpellier Broom **Genista monspessulana*, Spear Thistle **Cirsium vulgare*, Squirrel-tail Fescue **Vulpia bromoides*, Sweet Briar **Rosa rubiginosa* and Sweet Vernal-grass **Anthoxanthum odoratum*.

Grassy Woodland EVC occurs in small fragmented patches across the study area with larger patches occurring in Snowgums Bushland Reserve.

EVC 20 HEATHY DRY FOREST



Grows on shallow, rocky skeletal soils on Pyrenees Formation and White Hills gravel geologies in the study area on a range of landforms from gently undulating hills to exposed aspects on ridge tops and steep slopes at a range of elevations. The overstorey is a low, open eucalypt forest to 20 m tall. The understorey is dominated by a low layer of ericoid-leaved shrubs including heaths and peas with a low cover of graminoids.

Most common over storey species in the study area are Bundy *Eucalyptus goniocalyx s.l.,* Red Stringybark *Eucalyptus macrorhyncha,* Broad-leaf Peppermint *Eucalyptus dives,* Narrow-leaf Peppermint *Eucalyptus radiata s.l.* and Messmate *Eucalyptus obliqua* (on sheltered aspects). The mid-storey and shrub layer typically includes Spreading Wattle *Acacia genistifolia,* Hedge Wattle *Acacia paradoxa,* Narrow-leaf Bitter-pea *Daviesia leptophylla,* Gorse Bitter-pea *Daviesia ulicifolia,* Grey Parrot-pea *Dillwynia cinerascens s.l.,* Common Beard-heath *Leucopogon virgatus* and Daphne Heath *Brachyloma daphnoides*.

The ground layer dominated by Common Rapier-sedge *Lepidosperma filiforme*, Common Raspwort *Gonocarpus tetragynus*, Ben Major Grevillea *Grevillea floripendula*, Wattle Mat-rush *Lomandra filiformis subsp. coriacea*, Silvertop Wallaby-grass *Rytidosperma pallidum*, Milkmaids *Burchardia umbellata*, Button Everlasting *Coronidium scorpioides* s.s., Veined Spear-grass *Austrostipa rudis subsp. rudis*, Stony Fireweed *Senecio phelleus*, Black-anther Flax-lily *Dianella admixta*, Variable Stinkweed *Opercularia varia* and Common Rice-flower *Pimelea humilis*.

Weeds are typically sparse but often include Large Quaking-grass **Briza maxima* and Delicate Hair-grass **Aira elegantissima.*

There was a note in the Commonwealth of Australia (1999) on the difficulty of assigning Grassy Dry Forest and Heathy Dry Forest separately in the Beaufort region due to the altered fire regimes and other disturbances such as past clearing and timber cutting which can cause the grassy/heathy understorey to vary over time. Mapping the differences between Grassy Dry Forest and Heathy Dry Forest proved difficult in the study and as such Heathy Dry Forest/Grassy Dry Forest Complex has been assigned outside the study alignments.

This EVC was mapped as fragmented patches across the study area, with a larger patch just east of Snowgums Bushland Reserve.

EVC 306 AQUATIC GRASSY WETLAND

Seasonal wetland on plains, dominated by rhizomatous to stoloniferous floating grasses, in association with mainly aquatic species (Frood 2009). Turf grassland under drier conditions. Typically treeless in the study area, dominated by River Swamp Wallaby-grass *Amphibromus fluitans,* Common Water-ribbons *Cycnogeton procerum s.s.,* Common Spike-sedge *Eleocharis acuta,* Australian Sweet-grass *Glyceria australis,* Upright Water-milfoil *Myriophyllum crispatum,* Red Pondweed *Potamogeton cheesemanii* with White Purslane *Montia australasica* and Poison Lobelia *Lobelia pratioides* ondrier edges. Typical weeds found in this EVC are aquatics such as Thread Water-starwort **Callitriche brutia subsp. brutia* and Water Buttons **Cotula coronopifolia.* Limited to two locations, one along Racecourse Road and another swamp along Smiths Lane.

EVC 125 PLAINS GRASSY WETLAND

Grassy-herbaceous wetland on fertile lowland plains which are typically species-rich on the outer verges when relatively intact. Plains Grassy Wetland can represent complexes between several other wetland EVCs, as described below.

Indicator species found in the study area include Brown-back Wallaby-grass *Rytidosperma duttonianum,* Common Swamp Wallaby-grass *Amphibromus nervosus,* Australian Sweet-grass *Glyceria australis,* Common Spike-sedge *Eleocharis acuta,* Common Blown-grass *Lachnagrostis filiformis s.l.,* River Swamp Wallaby-grass *Amphibromus fluitans,* Centella *Centella cordifolia*, Reed Bent-grass *Deyeuxia quadriseta* and occasional Floodplain Fireweed *Senecio campylocarpus.* Typical weeds include Yorkshire Fog **Holcus lanatus,* Curled Dock **Rumex crispus* and Brown-top Bent **Agrostis capillaris.*

Limited distribution in the study area in low lying areas along Martins Lane, Racecourse Road and Smiths Lane where it occurs in association with related wetland EVCs Aquatic Grassy Wetland, Plains Sedgy Wetland and complexes listed below.

EVC 755 PLAINS GRASSY WETLAND/AQUATIC HERBLAND COMPLEX

Contains the structural dominants of Plains Grassy Wetland with aquatic herbs also prevalent. Indicator species include Australian Sweet-grass *Glyceria australis,* Common Water-ribbons *Cycnogeton procerum s.s.,* Upright Water-milfoil *Myriophyllum crispatum,* Red Pondweed *Potamogeton cheesemanii* and White Purslane *Montia australasica.*

Only mapped in one wetland in the study area along Racecourse Road in association with Aquatic Grassy Wetland.

EVC 767 PLAINS GRASSY WETLAND/BRACKISH HERBLAND COMPLEX

Contains the structural dominants of Plains Grassy Wetland in association with herbaceous species characteristics of Brackish Herbland. Indicator species include Australian Sweet-grass *Glyceria australis,* Brown-back Wallaby-grass *Rytidosperma duttonianum,* Streaked Arrowgrass *Triglochin striata,* Nodding Club-sedge *Isolepis cernua* and Floating Club-sedge *Isolepis fluitans.* Typical weeds include Buck's-horn Plantain **Plantago coronopus,* Spiny Rush **Juncus acutus subsp. acutus* and Water Buttons **Cotula coronopifolia.*

Limited distribution in the study area in low lying areas along Martins Lane where salinity discharge is evident, as well as an area along Racecourse Road west of the sewage treatment plant.

EVC 55 PLAINS GRASSY WOODLAND

An open eucalypt woodland to 15 m tall occurring on typically fertile geologies and soil types on flat or undulating plains. Typically this EVC has River Red Gum *Eucalyptus camaldulensis*, however there are very few River Red Gum in the study area and the only patch of Plains Grassy Woodland in the study area appears to be older, planted River Red Gum in one patch between Racecourse Road and Beaufort – Lexton Road. This has an over storey of River Red Gum with a sparse grassy understorey dominated by exotic pasture grasses with scattered wallaby grasses *Rytidosperma spp.*

EVC 647 PLAINS SEDGY WETLAND

Occurs in seasonally wet depressions, typically associated with fertile, silty, peaty or heavy clay soils. Primarily sedgy-herbaceous vegetation, sometimes with scattered or fringing eucalypts. A range of aquatic herbs can be present, and species-richness is mostly relatively low to moderate but higher towards the margins. Indicator species in the study area include Poong'ort *Carex tereticaulis,* Tall Sedge *Carex appressa,* Common Spike-sedge *Eleocharis acuta*, Flecked Flat-sedge *Cyperus gunnii subsp. gunnii,* Broom Rush *Juncus sarophorus,* Reed Bent-grass *Deyeuxia quadriseta,* River Buttercup *Ranunculus inundatus,* Swamp Starwort *Stellaria angustifolia subsp. angustifolia* (in higher quality patches) and occasional Floodplain Fireweed *Senecio campylocarpus.* Typical weeds include Sweet Vernal-grass **Anthoxanthum odoratum,* Flatweed **Hypochaeris radicata,* Yorkshire Fog **Holcus lanatus,* Curled Dock **Rumex crispus* and Blackberry * *Rubus fruticosus spp. agg.*

Distributed along wet depressions in the Yam Holes Creek Valley.

EVC 821 TALL MARSH

Wetland dominated by tall emergent graminoids, typically in thick, species poor swards. The structure is variously rushland, sedgeland or reedbed, in association with other wetland EVCs. Indicator species in the study area include Common Reed *Phragmites australis,* Australian Sweet-grass *Glyceria australis,* Common Spike-sedge *Eleocharis acuta,* Upright Water-milfoil *Myriophyllum crispatum* and rushes *Juncus spp.* Typical weeds include Toowoomba Canary-grass **Phalaris aquatic,* Blackberry **Rubus fruticosus spp. agg.,* Clustered Dock **Rumex conglomeratus* and Yorkshire Fog **Holcus lanatus.*

Limited distribution in the study area in low lying areas along Racecourse Road west of the sewage treatment plant.

EVC 47 VALLEY GRASSY FOREST

Woodland to open forest to 25 m tall with a variety of eucalypts but usually dominated by species which prefer moist or fertile conditions over a sparse shrub layer. It usually grows on fertile, well-drained colluvial or alluvial soils in valley floors or gently undulating slopes on colluvial or alluvial geology. Altitude is usually less an 600 m with most areas around 400 m in the study area.

Most common over storey species in the study area are Yellow Box *Eucalyptus melliodora* and Candelbark *E. rubida* with occasional Messmate *Eucalyptus obliqua,* Snow Gum *Eucalyptus pauciflora* or Yarra Gum *Eucalyptus yarraensis.* Bundy *Eucalyptus goniocalyx* can occur in drier sites along a gradient into Grassy Dry Forest. The shrub layer is typically dominated by Hedge Wattle *Acacia paradoxa* and Blackwood *Acacia melanoxylon* with occasional Cherry Ballart *Exocarpos cupressiformis*.

The ground layer usually carries a high diversity of herbs and grasses, particularly at more intact sites or sites with higher moisture. Dominant species found in the study area include those found in Quadrats 1-3 (WYBGW Quadrat 1-3) Weeping Grass *Microlaena stipoides*, Grey Tussock-grass *Poa sieberiana,* Silvertop Wallaby-grass *Rytidosperma pallidum*, Five-awned Spear-grass *Pentapogon quadrifidus*, Common Wheat-grass *Elymus scabrus*, and wallaby grasses Common Wallaby-grass *Rytidosperma caespitosum,* Hill Wallaby-grass *Rytidosperma erianthum and* Weeping Wallaby-grass *Rytidosperma penicillatum. Herbs include* Chocolate Lily Arthropodium strictum s.l., Kidney-weed *Dichondra repens,* Bulbine Lily *Bulbine bulbosa,* Blue Grass-lily *Caesia calliantha,* Button Everlasting *Coronidium scorpioides s.s.,* Black-anther Flax-lily *Dianella admixta,* Scented Sundew *Drosera aberrans,* Stinking Pennywort *Hydrocotyle laxiflora,* Common Woodrush *Luzula meridionalis,* Variable Plantain *Plantago varia and* Australian Buttercup *Ranunculus lappaceus.*

Typical weeds found in this EVC in the study area include Flatweed **Hypochaeris radicata*, Large Quaking-grass **Briza maxima*, Montpellier Broom **Genista monspessulana*, Spear Thistle **Cirsium vulgare*, Squirrel-tail Fescue **Vulpia bromoides*, Sweet Briar **Rosa rubiginosa* and Sweet Vernal-grass **Anthoxanthum odoratum*.

Valley Grassy Forest usually occurs in association with Grassy Dry Forest and Heathy Dry Forest (NCCMA 2019) but can be a transitional EVC and form mosaics with Alluvial Terraces Herb-rich Woodland and Grassy Woodland.

Distributed along valley floors and smaller creek valleys in the Yam Holes Creek Valley.

6.4.2 HABITAT HECTARE RESULTS

The following table is a summary of the Habitat Hectare results which are provided in full in Appendix D and mapped in Appendix K. A total of 1042 polygons of native vegetation were scored across the study area. This includes all four of the alignment options. A comparison of impacts across the different alignments is provided in Section 7.1.

Table 6.3 Summary of Habitat Hectare data across the study area

ECOLOGICAL VEGETATION CLASS	COUNT OF PATCHES	AVERAGE OF SITE SCORE	AVERAGE OF LANDSCAPE CONTEXT	AVERAGE OF FINAL SCORE	STANDARD DEVIATION OF FINAL SCORE
Alluvial Terraces Herb-rich Woodland	76	36.9	14.6	51.5	15.8
Aquatic Grassy Wetland	11	49.9	8.5	58.5	5.5
Aquatic Herbland	110	32.5	12.3	44.9	11.8
Aquatic Sedgeland	10	52.6	12.6	65.1	7.8
Brackish Herbland	5	38.1	16.0	53.8	3.8
Creekline Grassy Woodland	24	16.7	16.9	33.6	1.5
Grassy Dry Forest	113	38.4	15.8	54.1	13.9
Grassy Woodland	119	32.9	9.3	42.2	16.3
Heathy Dry Forest	48	37.0	15.2	52.2	13.7
Heathy Dry Forest/Grassy Dry Forest Complex	39	44.9	18.8	63.7	2.9
Current Wetland (DELWP layer) with modelled score	121	0.0	15.0	15.0	3.1
Plains Grassy Wetland	46	34.7	9.5	44.2	15.4
Plains Grassy Wetland/Aquatic Herbland Complex	10	53.0	8.0	61.0	0.0
Plains Grassy Wetland/Brackish Herbland Complex	15	35.0	15.5	50.2	5.0
Plains Grassy Woodland	3	19.0	7.0	26.0	0.0
Plains Sedgy Wetland	39	29.6	14.2	43.8	15.7
Tall Marsh	4	34.0	14.0	48.0	2.3
'Treeless' Alluvial Terraces Herb-rich Woodland	16	21.3	15.0	36.3	6.9
'Treeless' Grassy Dry Forest	31	9.2	15.5	24.6	6.0
'Treeless' Grassy Woodland	52	16.4	9.3	25.8	8.8
'Treeless' Heathy Dry Forest	16	8.1	16.0	24.1	1.0
'Treeless' Valley Grassy Forest	10	16.5	15.2	31.7	6.7
Valley Grassy Forest	124	38.8	14.3	53.1	11.3

6.4.3 THREATENED ECOLOGICAL COMMUNITIES

Two EPBC Act listed threatened ecological communities were recorded within the study area:

- Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plain
- White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Grasslands.

The above two EPBC Act communities were identified in (WSP | Parsons Brinckerhoff 2016b). Further field surveys have expanded the known range of these communities.

Two other EPBC Act listed ecological communities, Grassy Eucalypt Woodland of the Victorian Volcanic Plain and Natural Temperate Grassland of the Victorian Volcanic Plain, have been assessed as not occurring within the study area. Grassy Eucalypt Woodland of the Victorian Volcanic Plain was not found in the study area. Natural Temperate Grassland of the Victorian Volcanic Plain was originally mapped in (Ecology Partners Pty Ltd 2010c) and adopted in (WSP | Parsons Brinckerhoff 2016b), however upon further assessment (see Section 6.4.3.4), is no longer considered to occur in the study area.

Further assessment of the above four EPBC Act listed communities is provided in the following sections.

One FFG Act threatened community was recorded: the Victorian Temperate Woodland Bird Community. The Victorian Temperate Woodland Bird Community is addressed in the fauna section in Section 6.6.4.

6.4.3.1 WHITE BOX-YELLOW BOX-BLAKELY'S RED GUM GRASSY WOODLAND AND DERIVED NATIVE GRASSLAND

White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland ('Box-gum grassy Woodland') is listed as a critically endangered ecological community under the EPBC Act. The ecological community can occur either as woodland or derived native grassland (i.e. grassy woodland where the tree overstorey has been removed). Box-gum Grassy Woodland was previously widespread across the slopes and tablelands of the Great Dividing Range throughout Queensland, New South Wales, Australian Capital Territory and Victoria.

To be listed as endangered under the EPBC Act, the vegetation must be consistent with the criteria outlined in the National Recovery Plan for White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland (DECCW 2011). White Box and Blakely's Red Gum are typically found north of the Great Dividing Range not in the study area which is south of the Great Dividing Range, so just Yellow Box could be part of this community in this area. The first criterion in the National Recovery Plan is:

> *"Is, or was the most common overstorey species White Box and/or Yellow Box and/or Blakely's Red Gum (and/or Western Grey box and/or Coastal Grey Box in the Nandewar Bioregion)?"*

This community can be difficult to determine from other grassy woodland communities with a component of Yellow Box in the canopy. Therefore, as a guide and in consultation with the Federal Department of the Environment, Ecological Communities Section, the above criterion was further assessed using the following:

- for Yellow Box to be the most common overstorey species, we assumed it had to have over 50% total composition of the tree canopy cover; OR
- to be co-dominant, we assumed Yellow Box should have equal or greater total composition of the tree canopy cover shared over multiple species (e.g. Yellow Box 30%, Candlebark 30%, Snow Gum 25%).

A single patch of Valley Grassy Forest along the rail corridor was identified as meeting the scientific determination criteria and assessed in the preliminary assessment (WSP | Parsons Brinckerhoff 2016b). The assessment is reproduced in Appendix A (Q1). This is consistent with the recovery plan which indicates that Valley Grassy Forest in the Central Victorian Uplands can meet the criteria for Box-Gum Grassy Woodland. Additionally, this assessment was provided to the Department of the Environment and Energy, Ecological Communities Section who informally agreed with the determination (23 February 2016).

With more detailed surveys in 2016–2017, several other patches were identified in the Snow Gums Bushland Reserve, Camp Hill State Forest, along Martins Lane, private land on Racecourse Road and close to the rail corridor.

Three sample floristic quadrats were undertaken in different patches to assist in assessing the patches against scientific determination criteria. Quadrat data is found in Appendix A. An assessment of each plot against the scientific determination criteria is provided in Table 6.4. In accordance with this assessment, all three patches meet the criteria for the community.

Table 6.4 Assessment of White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland

SCIENTIFIC DETERMINATION CRITERIA	Q1 – VALLEY GRASSY FOREST ALONG RAIL CORRIDOR (NORTH)	Q2 – VALLEY GRASSY FOREST ALONG RAIL CORRIDOR (SOUTH)	Q3 – ALLUVIAL TERRACES HERB RICH WOODLAND CAMP HILL
Is, or was the most common overstorey species White Box and/or Yellow Box and/or Blakely's Red Gum (and/or Western Grey box and/or Coastal Grey Box in the Nandewar Bioregion)?	Yes – dominant species was Yellow Box with some Messmate.	Yes – Yellow Box (>50% of cover) is co-dominant with Candlebark and in some areas Snow Gum.	Yes – Yellow Box co-dominant with Bundy and Candlebark.
Does shrub cover comprise less than 30 percent cover?	Yes – there are patches of Hedge Wattle which overall provide less than 30 percent shrub cover.	Yes – there are patches of Hedge Wattle which overall provide less than 30 percent shrub cover.	Yes – Some Blackwood is present but less than 30% overall shrub cover.
Does the patch have a predominantly native ground layer with at least 50 percent of the perennial vegetation cover in the ground layer is made up of native species?	Yes - the ground cover is over 50% native comprised of a combination of Wallaby grasses, Spear grasses and Tussock grass.	Yes – the introduced weed cover varies from 10–40 percent cover, with a dominance of annual weed grasses such as **Briza maxima* which is not considered in the cover assessment. There are also woody weeds including **Rosa rubiginosa, *Genista monspessulana and *Rubus fruticosus spp. agg*. Which constitute 10–20 percent cover overall.	Yes – the ground cover is over 50% native comprised of a combination of Wallaby grasses, Spear grasses and Weeping grass.
Is the patch 0.1 ha (1,000 m^2) or greater in size?	Yes – the patch this quadrat was in was much greater than 0.1 ha.	Yes – both sides of the rail form part of much larger remnant native vegetation patches much greater than 0.1 ha.	Yes – the patch this quadrat was in was much greater than 0.1 ha.

SCIENTIFIC DETERMINATION CRITERIA	Q1 – VALLEY GRASSY FOREST ALONG RAIL CORRIDOR (NORTH)	Q2 – VALLEY GRASSY FOREST ALONG RAIL CORRIDOR (SOUTH)	Q3 – ALLUVIAL TERRACES HERB RICH WOODLAND CAMP HILL
Are there 12 or more native understorey species present within the patch (excluding grasses). There must be at least one important species. See list of species at: http://www.environment.gov.au/epbc/publications/box-gum.html	3 Important species with over 12 native understorey species.	Yes – patch characteristically dominated by *Dianella admixta, Helichrysum scorpioides, Chrysocephalum apiculatum, Gompholobium huegelii, Pimelea curviflora, Rytidosperma spp. Austrostipa semibarbata and Austrostipa pubinodis.* Refer to plot data (3 important species).	1 Important species with over 12 native understorey species.
If there are not the characters as above, is the patch 2 ha or greater in size	n/a – meets criteria above.	n/a – meets criteria above.	n/a – meets criteria above.
If the answer is 'yes' to the question above, does the patch have an average of 20 or more mature trees per hectare, or is there natural regeneration of the dominant overstorey eucalypts?	n/a – meets criteria above.	n/a.	n/a – meets criteria above.
Summary: patch meets criteria for listed threatened community	Yes.	Yes.	Yes.

Photo 6.1 Area of EPBC Act listed White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland community on property 87

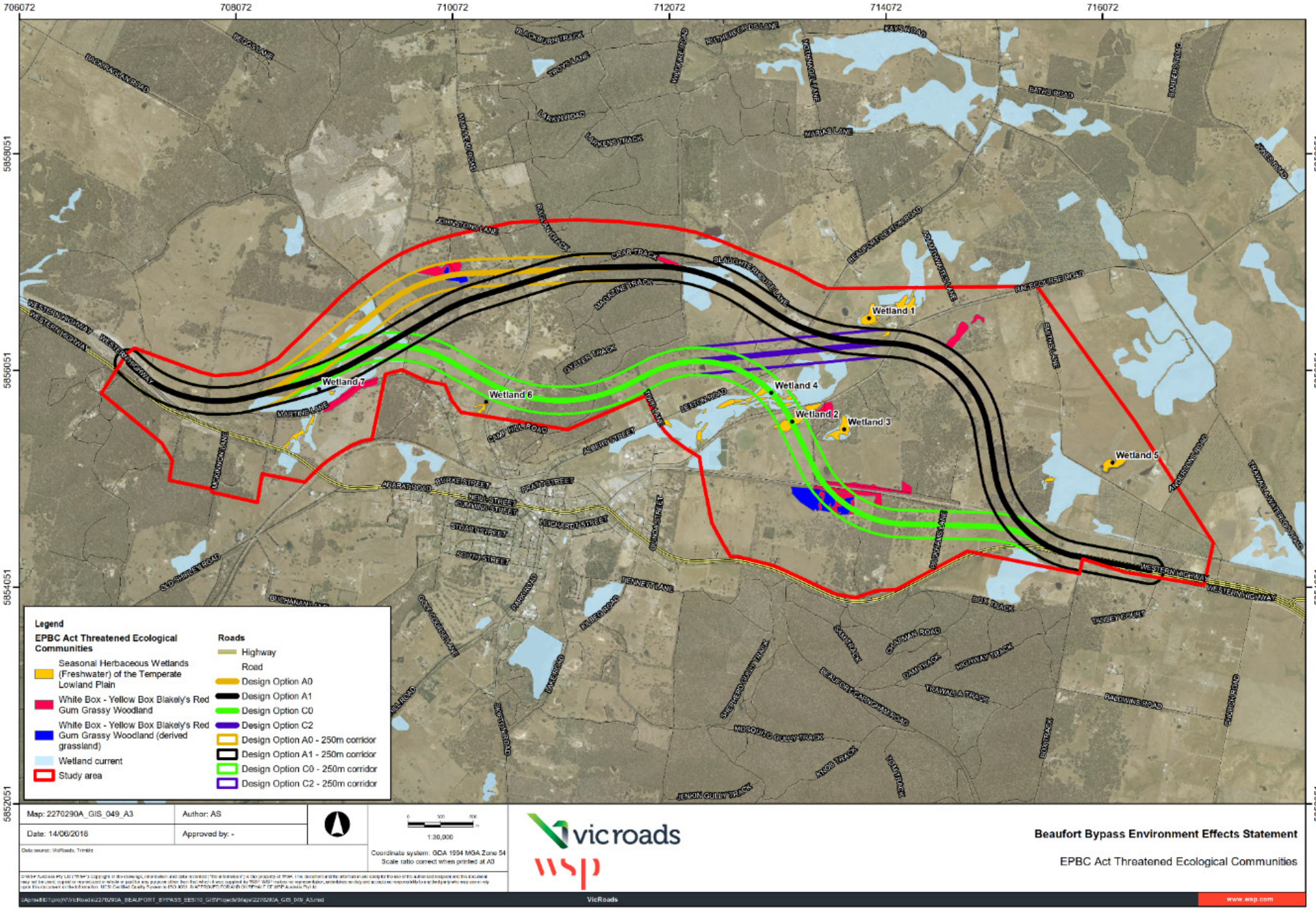


Figure 6.4 EPBC Act Threatened Ecological Communities and significant wetlands

6.4.3.2 SEASONAL HERBACEOUS WETLANDS (FRESHWATER) OF THE TEMPERATE LOWLAND PLAINS

The community Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains (Seasonal Herbaceous Wetlands) is listed as a critically endangered ecological community under the EPBC Act. These are freshwater wetlands which are typically inundated on a seasonal basis through rainfall then dry out over summer (WSP 2020a). The vegetation structure is treeless and dominated by herbs, grasses and sedges and includes flora, fauna and micro-organisms present in both wet and dry periods.

There are a number of key diagnostic characteristics and condition thresholds which define if a wetland meets the listing of Seasonal Herbaceous Wetlands. Further details on the determination criteria can be found in (TSSC 2012b). Several wetlands in the study area, particularly in the Yam Holes Creek valley were assessed against the criteria in (WSP | Parsons Brinckerhoff 2016b), with most intact patches meeting the diagnostic characteristics and condition thresholds. This assessment was provided to the Department of the Environment, Ecological Communities Section who informally agreed with the determination (23 February 2016). The most widespread wetland Ecological Vegetation Class was Plains Sedgy Wetland (Ecological Vegetation Class 647) which is known to correspond with Seasonal Herbaceous Wetlands.

With more detailed surveys in 2016–2017, a number of other patches were identified throughout the study area (Figure 6.4).

Three floristic quadrats were undertaken in different patches to assist in assessing the patch against scientific determination criteria. All areas mapped meet the required condition thresholds to be included as part of the community. (Quadrat data is found in Appendix A including the assessment of this plot data against the community condition thresholds).

The main wetland systems determined as Seasonal Herbaceous Wetlands are found in the following locations:

- extensive areas along the Yam Holes Creek and valley between Racecourse Road and Beaufort-Lexton Road
- south of Racecourse Road and within the Snow Gums Bushland Reserve
- north of Smiths Lane
- between Martins Lane and Western Highway.

Further details on wetlands including Seasonal Herbaceous Wetlands is provided in Section 6.4.4.

Photo 6.2 Areas of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains: (left) *Carex tereticaulis* dominated wetland, synonymous with Plains Sedgy Wetland (EVC 647) behind motorbike track (right) Aquatic Herbland (EVC 653) in a large wetland along Yam Holes Creek

6.4.3.3 GRASSY EUCALYPT WOODLAND OF THE VICTORIAN VOLCANIC PLAIN

Grassy Eucalypt Woodland of the Victorian Volcanic Plain is listed as a critically endangered ecological community under the Commonwealth *EPBC Act*. The community is dominated by River Red Gums (or some other listed eucalypts) with a ground layer of native tussock-forming perennial grasses along with a number of herbs and small shrubs or subshrubs. Grassy Eucalypt Woodland is confined to the Victorian Volcanic Plain as it is limited to quaternary basalt substrates.

There were only two minor patches (0.56 and 0.03 ha) of planted River Red Gum along Yam Holes Creek which qualified as EVC Plains Grassy Woodland but were too low in condition or size, respectively, to meet the criteria for Grassy Eucalypt Woodland of the Victorian Volcanic Plain. One patch located close to the large wetland between Beaufort-Lexton Road and Racecourse Road was assessed in Table 6.5 against the diagnostic characteristics and condition thresholds in (TTSC 2008).

Table 6.5 Assessment against Commonwealth criteria for Grassy Eucalypt Woodland of the Victorian Volcanic Plain

DETERMINATION CRITERIA	PATCH DESCRIPTION	CRITERIA MET Y/N?
The minimum patch size for the listed ecological community is 0.5 hectare	The patch assessed was 0.56 ha, the other was too small for consideration (0,03 ha).	Yes
One or more of the following native grass genera accounts for at least 50% of native perennial ground layer cover; *Themeda, Rytiodosperma*, *Austrostipa*, *Poa* and/or *Microlaena*	The patch contained scattered *Rytiodosperma spp*. and *Microlaena stipiodes* however the estimated combined cover of native grasses was approximately 20% of the total perennial ground cover. The remainder of the ground cover was introduced species such as **Dactylis glomerata* and **Phalaris aquatica*.	No – next step
If native grasses account for less than 50% of the perennial ground cover then: At least 50% of the ground layer vegetative cover is represented by native dryland forbs during spring-summer; OR	The patch did not contain any dryland native herbs.	No – next step
Perennial weeds comprise less than 70% of the ground layer vegetative cover; OR	Perennial weeds present in the patch include **Dactylis glomerata*, **Avena spp*. and **Phalaris aquatica.* The estimated combined cover of these weed species is 80%.	No – next step
If weeds comprise more than 70% of the ground layer vegetative cover, then the patch must have more than 10 perennial native species per 100 m^2 AND a density of at least 3 large trees per hectare.	There are less than 10 perennial native species and no large trees.	No
OVERALL ASSESSMENT		**DOES NOT MEET CRITERIA**

6.4.3.4 NATURAL TEMPERATE GRASSLAND OF THE VICTORIAN VOLCANIC PLAIN

Natural Temperate Grassland of the Victorian Volcanic Plain (Natural Temperate Grassland) is listed as a critically endangered ecological community under the Commonwealth EPBC Act. The community is dominated by a ground layer of native tussock-forming perennial grasses along with a number of herbs and small shrubs or subshrubs. Trees and large shrubs are sparse to absent.

There are a number of diagnostic characteristics and condition thresholds which generally are based on features which apply all year round. Further details on the determination criteria can be found in (TSSC 2008a).

Natural Temperate Grassland was originally mapped in (Ecology Partners Pty Ltd 2010c) and adopted in (WSP | Parsons Brinckerhoff 2016b) in an area in the eastern end of the Western Highway on the northside of the highway. However, more consideration of the diagnostic characteristics has been undertaken and it is no longer considered that this community is present or would have been present in the past.

The study area occurs in a transition area from the Central Victorian Uplands into the Victorian Volcanic Plain bioregion, indicated by the change in geology and a flatter landscape. The vegetation in this area appears to be treeless remnants of Valley Grassy Forest which transitions to Grassy Woodland to the east. There are a number of trees nearby, including some Candlebarks, Yellow Box and Snow Gums and some planted non-indigenous natives and Monterey Pines **Pinus radiata*. This indicates that the tree layer has likely been removed in the past. Additionally, there are no basalt soils in the area. As such, it is not considered that this area meets the diagnostic characteristics for Natural Temperate Grassland. This assessment was provided to the Department of the Environment, Ecological Communities Section who provided some further assessment advice which assisted with the determination (12 May 2017).

6.4.4 WETLANDS

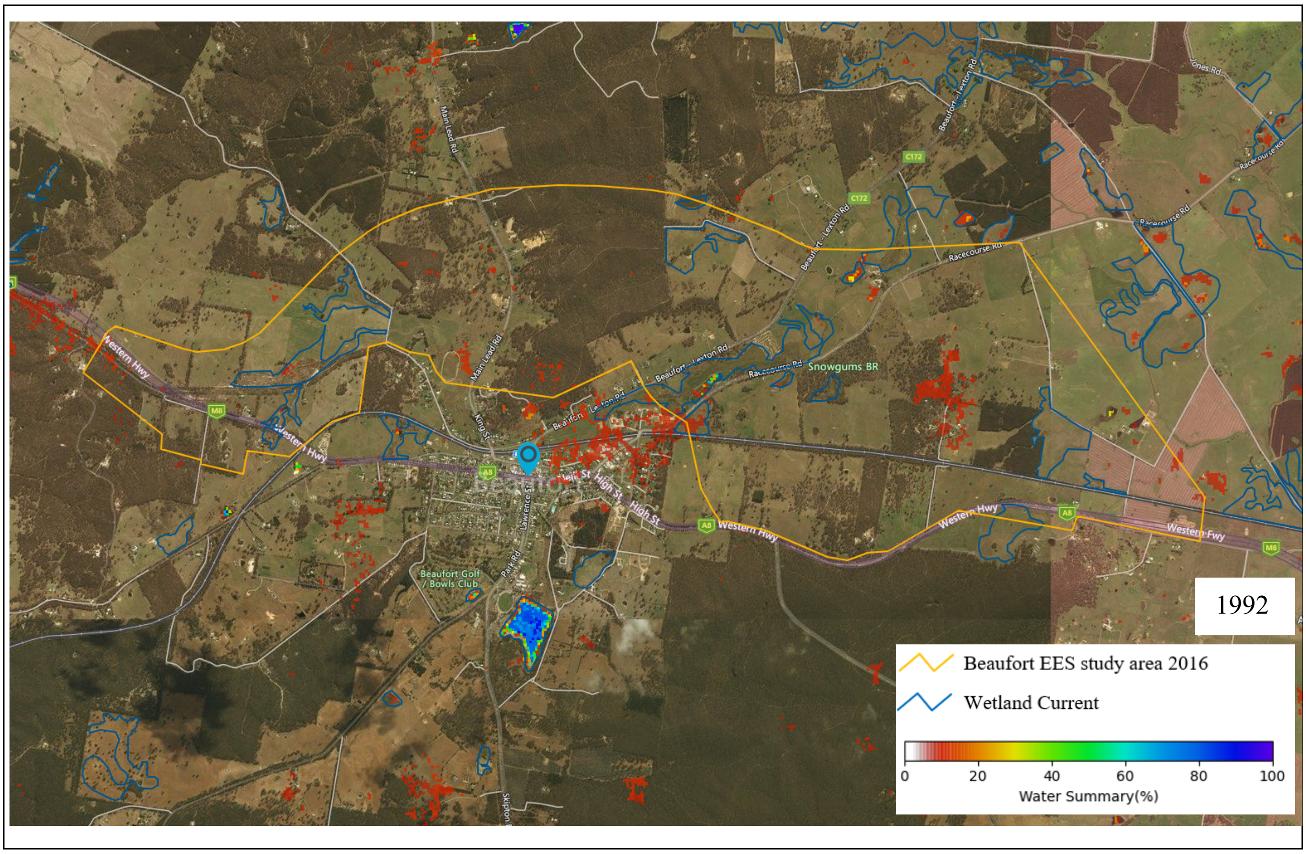
Wetlands in the study area are seasonal, palustrine wetlands, that is, they are typically inundated by seasonal rainfall events in the cooler months and generally dry out by late summer (Goulburn Broken CMA 2015). Palustrine wetlands are inland, non-riverine and typically include swamps, marshes, meadows and peatlands in the Victorian classification of wetlands (DELWP 2016c). Inundation of seasonal wetlands are fed by rainfall as the main water source and are not dependent on connections to riverine systems (TSSC 2012b). There may be some instances where seasonal wetlands are influenced by groundwater (TSSC 2012b), however in the study area, there is low permeable silts and clays in the Quaternary alluvial sediments that underlie drainage lines and floodplains meaning the interaction with surface and groundwater is likely to be low (see Section 7.7.4).

Historically, wetlands in the study area occurred along the floodplains of the Yam Holes Creek valley, as deduced from Victorian Wetland Inventory (Pre-European) (DELWP 2020b), which mapped the extent of wetlands in Victoria prior to European settlement. Past land use history including alluvial and deep lead gold mining, agriculture, draining and channelization of creeks and wetlands lead to the alteration of hydrology and extent of wetlands. In 1947, it appears much of this landscape transformation had taken place (Department of Lands and Survey 1947), Figure 6.7. Whilst many wetlands remain, particularly in clusters along the Yam Holes Creek valley floor, some are no longer evident from field-based evaluation (e.g. Current Wetlands) backed up by multi-decadal satellite evidence using Water Observations from Space – see text below. More recent changes to the catchment and water quality and volume have been from the construction of the sewage treatment plant on Racecourse Road and a number of pivot irrigation systems which discharge treated sewer water across the floodplain. Some of these changes have resulted in longer periods of inundation (hydroperiod) to some wetlands which would have previously dried out in late summer (e.g. Wetland 1).

The Current Wetland layer, formally titled Victorian Wetland Inventory (Current) or Wetland_Current metadata name in the Data.Vic portal, can sometimes have mapped wetlands in the Current Wetland database which are clearly not present. There is a process under the Guidelines 2017 for excluding Current Wetlands. Excluding wetlands does need to consider not just wetland vegetation and fauna habitat (or lack of) at suitable times (eg after periods of adequate seasonal rainfall), but also key wetland drivers and variables including geomorphology, hydrology and climate. Another relevant consideration is that wetlands <1 ha are not included in the database due to the small scale and difficulty to determine shoreline definition in the original inventories in the 1980s and early 1990's (eg. (Corrick 1981) – see more detail in *Index of Wetland Condition Conceptual framework and selection of measures* (DSE 2005). Whilst removal of Current

Wetland layers is not proposed in this report, it is important to note that there is recognition that the Current Wetland database does not always reflect site conditions, as evident at Beaufort.

Water Observations from Space (WOFS) (https://maps.dea.ga.gov.au/) is a continent-scale map of surface water and provides images and mapped data showing where water has been seen in Australia from 1987 to the present. WOFS has been compiled using multi-decadal archive of Landsat satellite data. An indication of surface water in context with the Current Wetland layer can be seen WOFS using annual water observations in high rainfall years in 1992, 2010 and 2016 on the figures below.



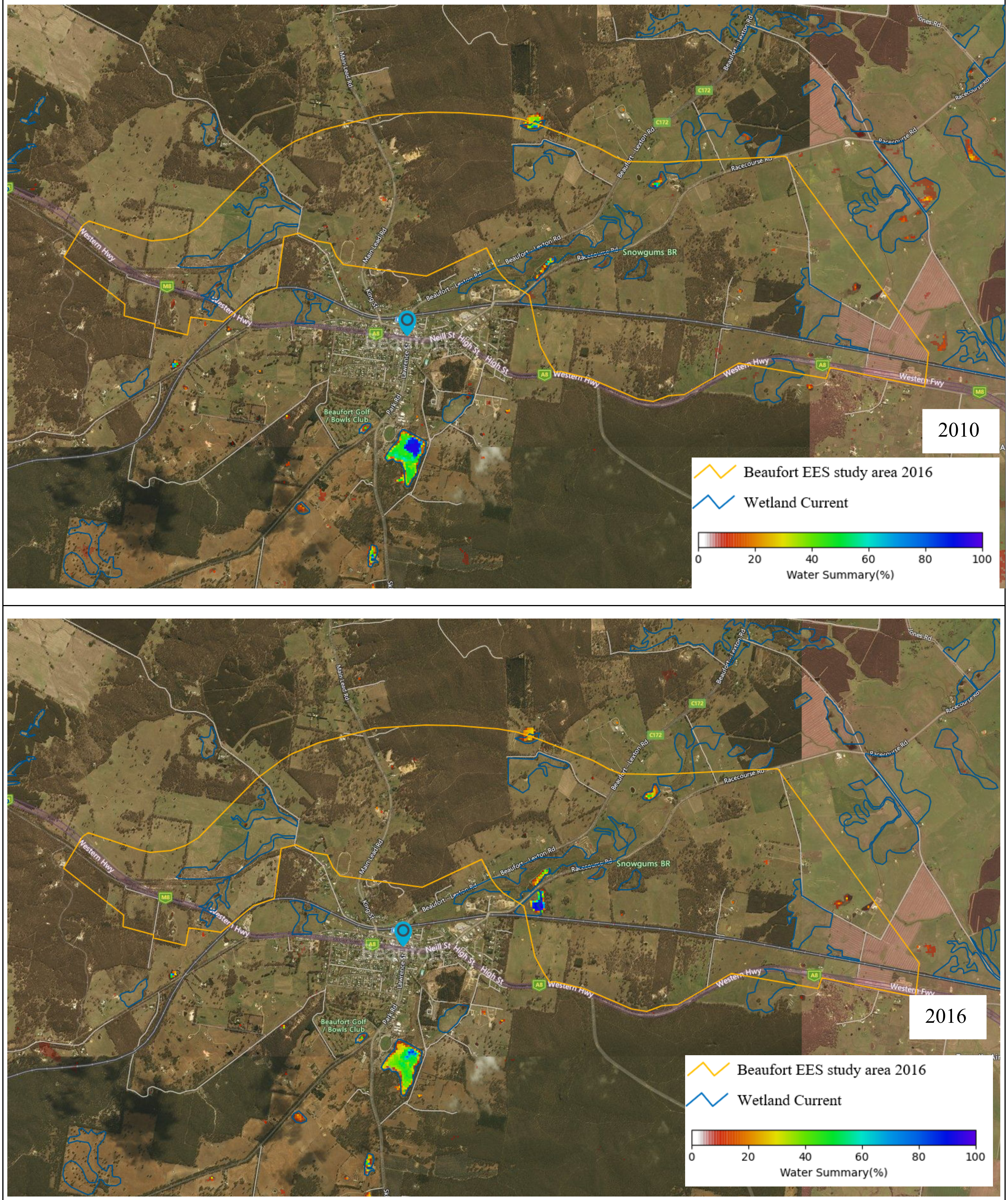


Figure 6.5 Water Observations from Space (Geoscience Australia 2021) – annual water observations in high rainfall years in 1992, 2010 and 2016.

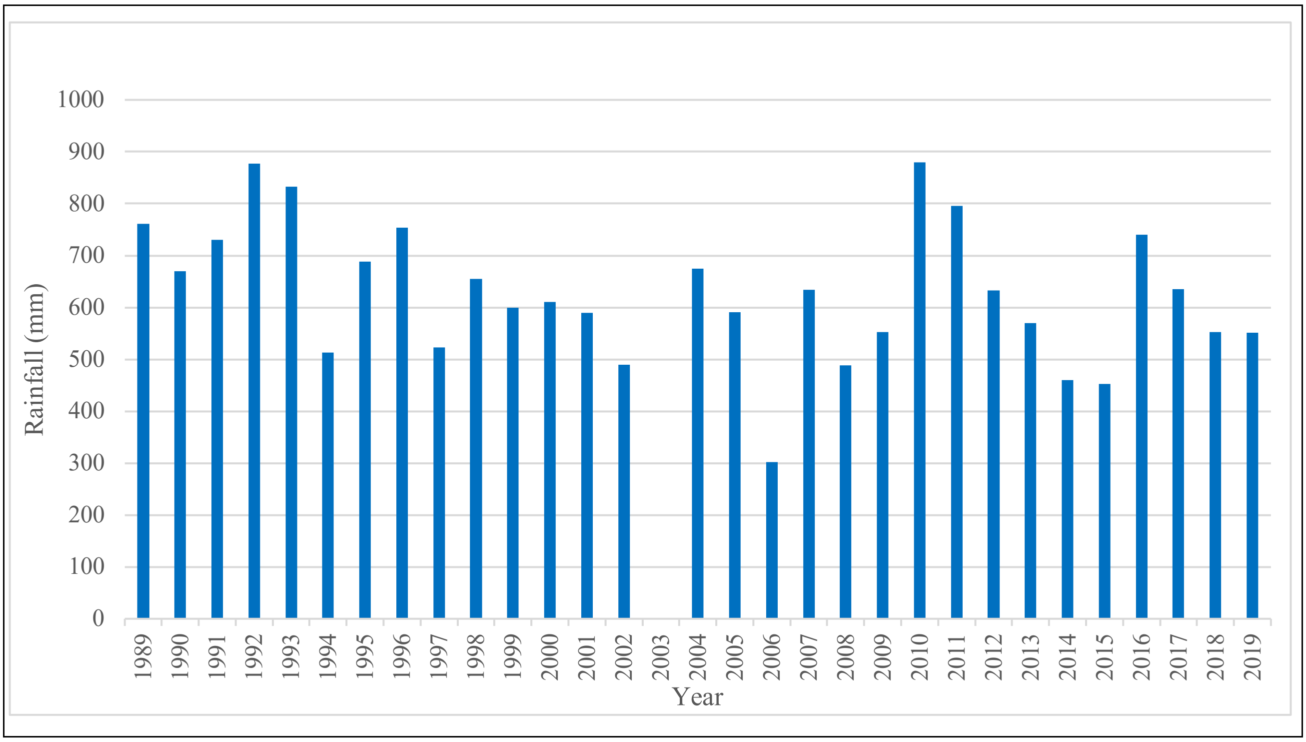


Figure 6.6 Annual rainfall climate data for Ballarat Aerodrome Station 89002 (Bureau of Meteorology 2021)

For the purposes of this assessment, all wetlands within the study area were categorised into high, moderate and low value shown on the summary map below Figure 6.8 with more detailed maps in Appendix K based on the categories in the table below.

Subjective value categories for 'wetland values' were derived from Corangamite Wetland Inventory (Centre for Environmental Management 2005) used for wetland quality ratings. Wetland 'condition' ratings were derived from ratings used in the Index of Wetland Condition Assessment Procedure (DELWP 2018c). Wetland 'physical form' and 'water regime' considerations were derived from (DELWP 2018c; DSE 2005). Table 6.6 provides an an evaluation of all Current Wetlands within and close to the study area and a summary of their ecological values.

Table 6.6 Wetland value categorisation

WETLAND VALUE	DEGREE OF MODIFICATION	VEGETATION	CONDITION (HABHA SCORES)	HABITAT ATTRIBUTES	PHYSICAL FORM	WATER REGIME
High value	Intact – low level of modification	Seasonal Herbaceous Wetlands under EPBC Act Areas mapped as wetland EVCs Areas mapped as 'Current Wetland'	Good to excellent Typically >40%	Identified habitat for a range of wetland dependent flora and fauna including numerous threatened species. Records of numerous threatened species.	Naturally occurring	Seasonal

WETLAND VALUE	DEGREE OF MODIFICATION	VEGETATION	CONDITION (HABHA SCORES)	HABITAT ATTRIBUTES	PHYSICAL FORM	WATER REGIME
Moderate value	Medium levels of modification	Areas mapped as wetland EVCs Areas mapped as 'Current Wetland'	Moderate to good Typically 20-40%	Identified and potential habitat for a range of wetland dependent flora and fauna including numerous threatened species	Naturally occurring and dams	Seasonal, semi-permanent (dams)
Low value	Highly modified	No areas mapped as wetland EVCs Areas mapped as 'Current Wetland'	Poor Typically <20%	Lesser areas of potential habitat for a range of wetland dependent flora and fauna. Wetland buffers for birds and frogs. May provide some food resources for fauna and temporal values through longer periods of inundation.	Modified from natural form by artificial channels, dams and artificial waterbodies.	Intermittent to episodic in paddock areas, artificial areas tend to be permanent. Tend to be affected by drains, pivot irrigation and water treatment plants.

A description of all wetlands found within the study area are described in Table 6.7 and located in Figure 6.4 above.

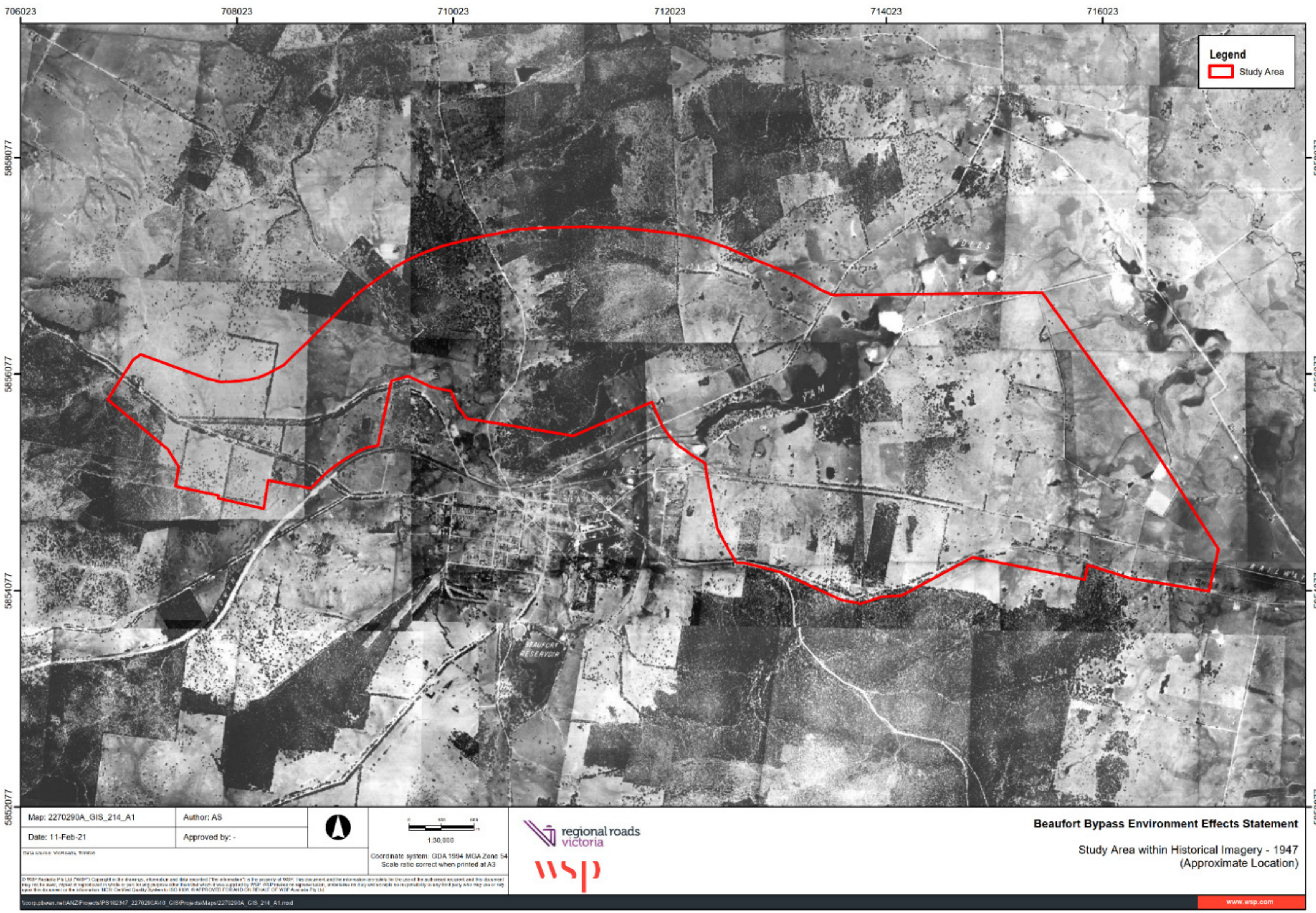


Figure 6.7 Historical aerial imagery from 1947 (Department of Lands and Survey 1947)

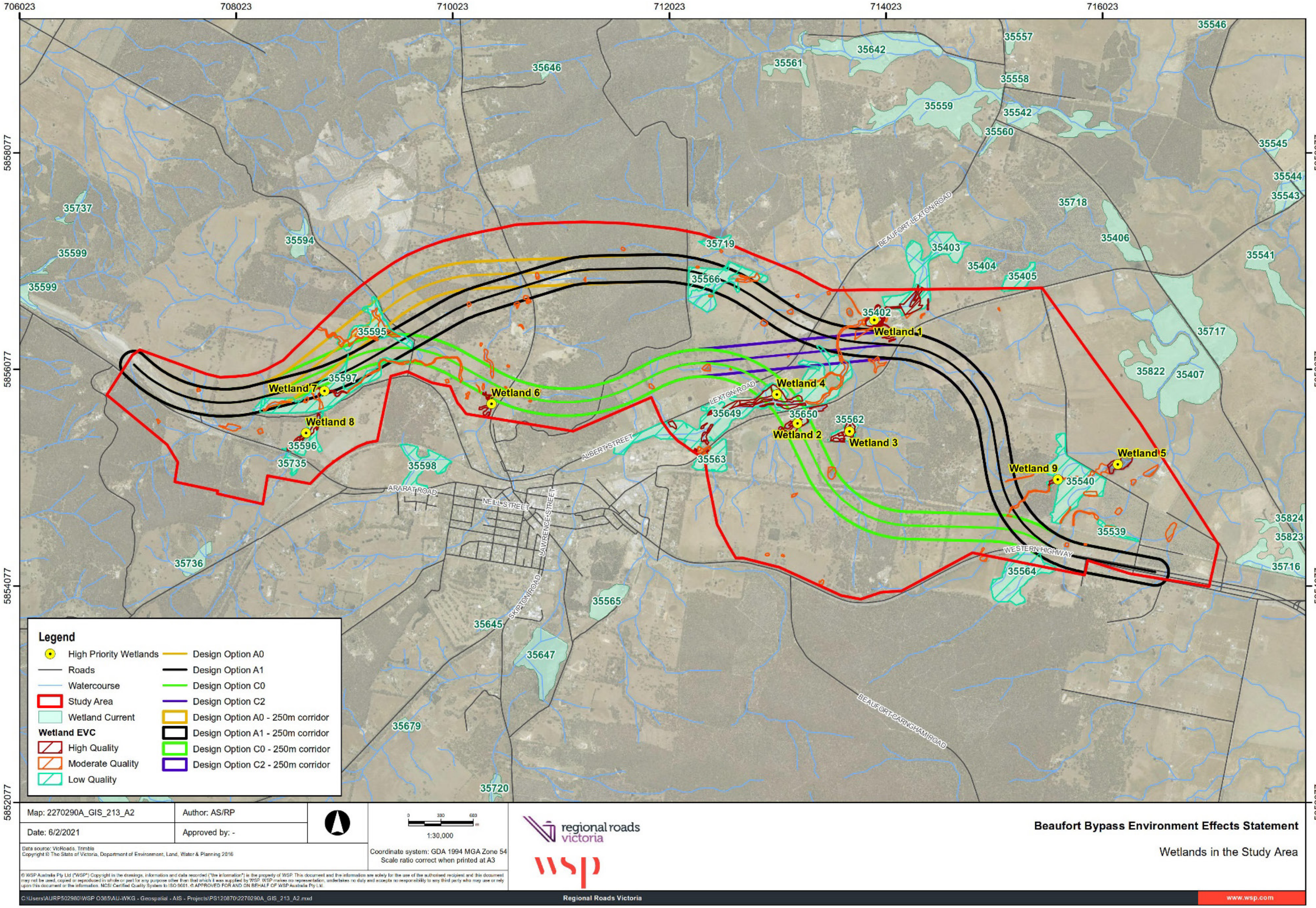


Figure 6.8 Wetland value categories in the study area

Table 6.7 Description of the all Current Wetlands found within the study area

WETLAND NO.	WETLAND CHARACTERISTICS	ECOLOGICAL VALUES
Western Highway – western end to Back Raglan Road	**Gently undulating terrain, mostly open, cleared agricultural land.**	**Typical wetland EVCs in this area are reflective of the elevated salinity, including Brackish Herbland and Plains Grassy Wetland/Brackish Herbland Complex, both are endangered EVCs in CVU and VVP bioregions. Highly modified stream with numerous dams through an agricultural landscape. Riparian vegetation along the minor drainage lines is generally absent except within close proximity to dams or gentler sloping areas. Area north of Martins Lane previously affected by dryland salinity – planting surrounding wetland undertaken approximately two decades ago.**
35596 (includes High value wetland 8)	Seasonal wetland likely surface water fed. Not assessed in 2015 as it was outside the study area at the time. Flooded in September 2016. Surrounding area susceptible to salinity.	Potential Moderate habitat for wetland birds including Brolga in the High value wetlands. Potential habitat for Eastern Long-necked Turtle. Potential habitat for Growling Grass Frog (mostly in High value wetland areas). Potential habitat for Brown Toadlet, mostly in High and value wetland areas. Suboptimal stream habitat for Little Galaxias in that there are few areas with instream aquatic plants, creeks with low shade which typically mostly dry out over summer. High value areas meet definition of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains. Contains the following wetland EVCs: Plains Grassy Wetland, Aquatic Herbland and Aquatic Sedgeland. Areas of Low value wetland which are dominated by grazed pasture.

WETLAND NO.	WETLAND CHARACTERISTICS	ECOLOGICAL VALUES
35597 (includes High value wetland 7)	Seasonal wetlands likely surface water fed. Dry in 2015. Flooded in September 2016. Half to ¾ full in spring 2017. Dry in Jan 2018. Deepest point ~0.2 m. Surrounding area susceptible to salinity.	Potential Moderate habitat for wetland birds including Brolga in the High and Moderate value wetlands. Potential habitat for Eastern Long-necked Turtle. Potential habitat for Growling Grass Frog (mostly in High value wetland areas). Potential habitat for Brown Toadlet, mostly in High and Moderate value wetland areas. Suboptimal stream habitat for Little Galaxias in that there are few areas with instream aquatic plants, channelised creeks with low shade which typically mostly dry out over summer. High value areas meet definition of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains. Contains the following wetland EVCs: Brackish Herbland and Plains Grassy Wetland/Brackish Herbland Complex. Large areas of Low value wetland which are dominated by cropped land, pasture or plantation previously affected by dryland salinity – planting surrounding wetland undertaken approximately two decades ago.
35595	Mostly a damp area rather than seasonal wetland. No wet count in WOFS during high flood years.	Potential Moderate habitat for wetland birds including Brolga in the Moderate value wetlands. Limited habitat for Eastern Long-necked Turtle. Limited potential habitat for Growling Grass Frog (mostly in Moderate value wetland areas). Potential habitat for Brown Toadlet, mostly in Moderate value wetland areas. Suboptimal stream habitat for Little Galaxias in that there are few areas with instream aquatic plants, channelised creeks with low shade which typically mostly dry out over summer. Contains the following EVC treeless Creekline Grassy Woodland. Large areas of Low value wetland which are dominated by cropped land and pasture.

WETLAND NO.	WETLAND CHARACTERISTICS	ECOLOGICAL VALUES
35735	Seasonal wetland likely surface water fed. Mostly a dry area rather than seasonal wetland, possibly upstream part of wetland 35595 cut for the development of the Western Highway. No wet count in WOFS during high flood years.	Little to no habitat for wetland birds, constrained to the dam at the north of the wetland. Limited habitat for Eastern Long-necked Turtle. Limited to no habitat for Growling Grass Frog or Brown Toadlet, constrained to the dam at the north of the wetland. Suboptimal stream habitat for Little Galaxias Does not contain wetland EVCs. Vegetation mapped as Alluvial Terraces Herb-rich Woodland and Grassy Dry Forest. Low value wetland covers wetland area.
Back Raglan Road to Main Lead Road	**Gently undulating terrain, mostly open, cleared agricultural land and low-lying swampland and post-mined landscape north of the Beaufort Trotting Training Track.**	**Typical wetland EVCs in this area are Plains Grassy Wetland and Plains Sedgy Wetland, both endangered EVCs in CVU and VVP bioregions. Highly modified stream through agricultural area, consisting of one main channelized stream with numerous crisscrossing drainage lines. Modified stream and landscape north of racecourse.**
No Wetland No. (includes High value wetland 6)	Complex of wetlands to the east of the Beaufort Trotting track Seasonal wetland likely surface water fed. Dry in 2015. Flooded in September 2016. Half to ¾ full in spring 2017. Deepest point ~0.2 m	Potential but limited habitat for wetland birds in the High and Moderate value wetlands. Potential habitat for Eastern Long-necked Turtle. Potential moderate habitat for Growling Grass Frog (mostly in High value wetland areas). Potential habitat for Brown Toadlet, mostly in High and Moderate value wetland areas. Suboptimal stream habitat for Little Galaxias in that there are few areas with instream aquatic plants, channelised creeks with low shade which typically mostly dry out over summer. River Swamp Wallaby-grass and Floodplain Fireweed present in High value wetland areas. High value areas meet definition of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains. Contains the following wetland EVCs: Plains Grassy Wetland and Plains Sedgy Wetland.

WETLAND NO.	WETLAND CHARACTERISTICS	ECOLOGICAL VALUES
Main Lead Road to Beaufort-Lexton Road	**Moderately undulating to steep terrain, with a mix of native forested hills and cleared agricultural land.**	**Typical wetland EVCs in this area are Aquatic Herbland (endangered) and Aquatic Sedgeland (vulnerable) in the CVU bioregion. Wetlands in this section are mostly small dams. Riparian vegetation typically narrow being at the top of the catchment, with a few areas having broader riparian, forested vegetation at lower, gentler gradients.**
35566	Mostly a dry area rather than seasonal wetland with damp areas constrained to the drainage line. No wet count in WOFS during high flood years.	Potential Moderate habitat for wetland birds including Brolga in the Moderate value wetlands. Limited habitat for Eastern Long-necked Turtle. Limited potential moderate habitat for Growling Grass Frog (in Moderate value wetland areas). Potential habitat for Brown Toadlet, mostly in Moderate value wetland areas. Suboptimal stream habitat for Little Galaxias in that there are few areas with instream aquatic plants, channelised creeks with low shade which typically mostly dry out over summer. Contains the following wetland EVC: Aquatic Herbland. Large areas of Low value wetland which are dominated by pasture.
35719	Created dam	Potential but limited habitat for wetland birds. Limited habitat for Eastern Long-necked Turtle. Limited to no habitat for Growling Grass Frog. Potential habitat for Brown Toadlet around dam edges. No habitat for Little Galaxias. Does not contain native vegetation mapped as EVCs. Dominated by large areas of Low value wetland which are dominated by dam.

WETLAND NO.	WETLAND CHARACTERISTICS	ECOLOGICAL VALUES
Beaufort-Lexton Road to Racecourse Road	**Gently undulating terrain, mostly open, cleared grazing and irrigated pasture and low-lying swampland.**	**Typical wetland EVCs in this area are Plains Sedgy Wetland, Plains Grassy Wetland and Aquatic Herbland, all endangered EVCs in CVU and VVP bioregions. Highly modified stream through agricultural area, consisting of one main channelized stream with several drainage lines. A number of High and Moderate values wetlands in this area.**
35649 (includes High value wetland 4)	Shallow wetland/floodplain along channelised part of Yam Holes Creek. Flooded in September 2016. Very shallow to damp soil in summer 2017. Seasonal wetland likely surface water fed with overflow from creek in flood events and sewer treatment plant.	Potential Moderate habitat for wetland birds including Brolga in the High value wetlands. Potential habitat for Eastern Long-necked Turtle. Potential habitat for Growling Grass Frog in High and Moderate value wetland areas. Potential habitat for Brown Toadlet, mostly in High and Moderate value wetland areas. Stream habitat for Little Galaxias. Marginal vegetation but meets definition of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains. Contains the following wetland EVC: Plains Sedgy Wetland. Large areas of Low value wetland which are dominated by pasture, grazed crown land and irrigated pasture.
35650 (includes High value wetland 2)	Mostly dry in Nov 2015, full in Spring/summer 2016 and 2017. Seasonal wetland likely surface water fed. Deepest point ~1.5 m.	Potential High habitat for wetland birds including Brolga in the High value wetlands. Potential habitat for Eastern Long-necked Turtle. Potential habitat for Growling Grass Frog in High value wetland areas. Potential habitat for Brown Toadlet, mostly in High value wetland areas. Wetland habitat for Little Galaxias. River Swamp Wallaby-grass present in High value wetland areas. Meets definition of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains. Contains the following wetland EVCs: Aquatic Sedgeland, Plains Grassy Wetland/Aquatic Herbland Complex and Aquatic Grassy Wetland. Ecological values cover all of Current Wetland.

WETLAND NO.	WETLAND CHARACTERISTICS	ECOLOGICAL VALUES
35562 (includes High value wetland 3)	Shallow wetland, mostly dry in Nov 2015, full flooded in September 2016, in drawdown in spring 2017. Deepest point ~0.5 m. Seasonal wetland likely surface water fed.	Potential High habitat for wetland birds including Brolga in the High value wetlands. Potential habitat for Eastern Long-necked Turtle. Potential habitat for Growling Grass Frog in High value wetland areas. Potential habitat for Brown Toadlet, mostly in High value wetland areas. Wetland habitat for Little Galaxias. River Swamp Wallaby-grass present in High value wetland areas. River Swamp Wallaby-grass and Floodplain Fireweed present in High value wetland areas. Meets definition of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains Contains the following wetland EVC: Plains Sedgy Wetland. High ecological values cover all Current Wetland.
35563	Sewer Treatment Plant was expanded across half of this wetland in 2014-15. Part of wetland extent susceptible to salinity.	Limited habitat for wetland birds in the Moderate value wetland areas. Potential habitat for Eastern Long-necked Turtle. Potential moderate habitat for Growling Grass Frog in Moderate value wetland areas. Potential habitat for Brown Toadlet, mostly in Moderate value wetland areas. No habitat for Little Galaxias. Minor area meets definition of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains Contains the following wetland EVCs: Plains Grassy Wetland/Brackish Herbland Complex, Tall Marsh anf Aquatic Grassy Wetland.

WETLAND NO.	WETLAND CHARACTERISTICS	ECOLOGICAL VALUES
35402 (includes High value wetland 1)	At least 3/4 full in summer 2015, 2016, 2017. Flooded in September 2016. Likely surface water fed, possibly fed from pivot irrigator nearby. Deepest point ~2 m.	Potential High habitat for wetland birds including Brolga in the High value wetlands. Potential habitat for Eastern Long-necked Turtle. Potential High habitat for Growling Grass Frog in High value wetland areas. Potential habitat for Brown Toadlet, mostly in High value wetland areas. Wetland habitat for Little Galaxias. River Swamp Wallaby-grass present in High value wetland areas. River Swamp Wallaby-grass present in High value wetland areas. Meets definition of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains Contains the following wetland EVCs: Plains Grassy Wetland, Aquatic Sedgeland and Aquatic Herbland. High ecological values cover all Current Wetland.
35403	Shallow wetland/floodplain along channelised part of Yam Holes Creek. Seasonal wetland likely surface water fed with overflow from creek in flood events and sewer treatment plant from pivot irrigators. Outer areas do not have wet count in WOFS during high flood years.	Potential Moderate habitat for wetland birds including Brolga in the High value wetlands. Potential habitat for Eastern Long-necked Turtle. Potential Moderate habitat for Growling Grass Frog in High value wetland areas. Potential habitat for Brown Toadlet, mostly in High value wetland areas. Stream habitat for Little Galaxias. Marginal vegetation but meets definition of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains. Contains the following wetland EVC: Plains Sedgy Wetland and Creekline Grassy Woodland (mostly areas planted with River Red Gum). Large areas of Low value wetland which are dominated by pasture, grazed land and irrigated pasture.
35404	Seasonal wetland likely surface water fed. Not assessed in field as this is outside study area.	Potential habitat for wetland birds including Brolga, Eastern Long-necked Turtle, Growling Grass Frog, Brown Toadlet. Habitat for Little Galaxias unlikely as there is no defined creekline evident. Extent of native wetland vegetation unknown.

WETLAND NO.	WETLAND CHARACTERISTICS	ECOLOGICAL VALUES
35405	Seasonal wetland likely surface water fed. Not assessed in field as this is outside study area.	Potential habitat for wetland birds including Brolga, Eastern Long-necked Turtle, Growling Grass Frog, Brown Toadlet. Habitat for Little Galaxias unlikely as there is no defined creekline evident. Extent of native wetland vegetation unknown.
Racecourse Road to Western Highway – eastern end	**Low lying to hilly terrain, with a mix of native forested hills and cleared agricultural land.**	**Typical wetland EVCs in this area are Plains Grassy Wetland, Aquatic Grassy Wetland and Aquatic Herbland, all endangered EVCs in CVU and VVP bioregions. Also a large area mapped as Current Wetland with little to no native vegetation. Riparian vegetation along the minor drainage lines is generally absent except within close proximity to dams or gentler sloping areas.**
35540 (includes High value wetland 9)	Not assessed in 2015 as it was outside the study area at the time. Flooded in September 2016. Seasonal wetland likely surface water fed. No wet count in WOFS during high flood years.	Potential but limited habitat for wetland birds in the High and Moderate value wetlands. Potential habitat for Eastern Long-necked Turtle. Potential but limited Moderate habitat for Growling Grass Frog (mostly in High value wetland areas). Potential habitat for Brown Toadlet, mostly in High value wetland areas. Limited to no habitat for Little Galaxias. River Swamp Wallaby-grass present in High value wetland areas. Small areas of High value areas meet definition of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains. Contains the following wetland EVCs: Plains Grassy Wetland and Aquatic Herbland. Large areas of Low value wetland which are dominated by pasture and grazed land.

WETLAND NO.	WETLAND CHARACTERISTICS	ECOLOGICAL VALUES
No Wetland No. (includes High value wetland 5)	Not included in 2015 study area. Flooded in September 2016. Half to ¾ full in spring 2017. Seasonal wetland likely surface water fed.	Potential High habitat for wetland birds in the High value wetlands. Potential habitat for Eastern Long-necked Turtle. Potential High habitat for Growling Grass Frog in High value wetland areas. Potential habitat for Brown Toadlet, mostly in High value wetland areas. Limited to no habitat for Little Galaxias. River Swamp Wallaby-grass present in High value wetland areas. Meets definition of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains. Contains the following wetland EVCs: Aquatic Grassy Wetland and Aquatic Herbland.
35564	Seasonal wetland likely surface water fed. Partially assessed in field as most of this wetland is outside study area. Mostly a dry area rather than seasonal wetland. No wet count in WOFS during high flood years.	Potential but limited habitat for wetland birds, constrained to the dam at the north of the wetland. Limited habitat for Eastern Long-necked Turtle. Limited to no habitat for Growling Grass Frog or Brown Toadlet. No habitat for Little Galaxias. Does not contain native vegetation mapped as EVCs. Low value wetland covers entire wetland area. Dominated by pasture and grazed land.
35539	Seasonal wetland likely surface water fed.	Potential but limited habitat for wetland birds in the Moderate value wetlands. Potential habitat for Eastern Long-necked Turtle. Potential but limited Moderate habitat for Growling Grass Frog in Moderate value wetland areas. Potential habitat for Brown Toadlet, mostly in Moderate value wetland areas. No habitat for Little Galaxias. Contains the following wetland EVCs: Plains Grassy Wetland and Aquatic Herbland.

6.4.5 TREES

A total of 2036 trees including large trees, small trees and dead trees have been recorded within the study area, with a focus on scattered trees and trees in patches within the 250 m wide study alignment corridors. The location of some large trees outside of the current alignments is based on assessments and data from previous alignments and is included for reference. A summary breakdown of the trees and categories is provided in the table below. Note that 105 of the recorded trees were small trees within patches. There is no legislative requirement to record small trees in patches and so they are omitted from the summary table below. A full list of all 2036 trees recorded is provided in Appendix E and mapped in Appendix K. The comparison of tree impacts for each alignment is in Section 7.1.2.2.

Thirteen eucalypt species were recorded in tree surveys with dominant species being Candlebark, Messmate Stringybark, Scentbark and Yellow Box. Interestingly, there are very few River Red-gum found within the study area, reflected in the table below. This is in contrast to the surrounding landscape to the east and west on the Victorian Volcanic Plain. In summary, the highest concentration of large trees is typically in remnants on roadsides (e.g. Racecourse Road), rail corridor, private land with patches and paddock trees and to a lesser extent, public land in the Camp Hill State Forest.

To account for alignment design alterations, additional tree surveys were conducted in 2019 at nine sites within the Beaufort study area (Refer to Figure 4.3). The results of these additional surveys are displayed below in Table 6.9 and a total summary of all trees recorded (except for small trees in patches) is presented in Table 6.8.

Table 6.8 Summary of tree species and categories recorded in the study area, mostly within the four alignments

COMMON NAME	SCIENTIFIC NAME	LARGE TREES WITHIN PATCHES	SCATTERED TREES	
			LARGE	SMALL
Broad-leaf Peppermint	*Eucalyptus dives*	10		
Bundy	*Eucalyptus goniocalyx*	48		
Candlebark	*Eucalyptus rubida*	302	21	4
Eucalypt	*Eucalyptus spp.*	3		2
Manna Gum	*Eucalyptus viminalis*	8	5	
Messmate Stringybark	*Eucalyptus obliqua*	198	5	1
Narrow-leaf Peppermint	*Eucalyptus radiata*	12	4	
Red Stringybark	*Eucalyptus macrorhyncha*	40	11	9
River Red-gum	*Eucalyptus camaldulensis*		3	1
Scentbark	*Eucalyptus aromaphloia*	535	20	1
Snow Gum	*Eucalyptus pauciflora*	4		
Swamp Gum	*Eucalyptus ovata*	1		
Unknown	Unknown		1	
Yarra Gum	*Eucalyptus yarraensis*	10		
Yellow Box	*Eucalyptus melliodora*	526	40	24
Dead	Dead	66	7	9
Subtotals		1763	117	51
Total		**1931**		

Table 6.9 Trees recorded within the additional nine tree survey sites

ROW LABELS	TREES IN PATCHES		SCATTERED TREES	
	LARGE	SMALL	LARGE	SMALL
Area 1	11	–	–	–
Area 2	6	–	–	–
Area 3	17	1	1	2
Area 4	18	1	10	6
Area 5	13	–	–	–
Area 6	1	–	1	1
Area 7	23	2	–	–
Area 8	–	–	–	–
Area 9	6	–	–	–
Grand Total	**95**	**4**	**12**	**9**

6.5 FLORA

6.5.1 FLORA SPECIES RECORDED

A total of 471 vascular plant species have been recorded in the study area. This total includes the field surveys completed for this study, combined with the other relevant studies, and the VBA records. Of the 471 species, 350 (74%) are native and 121 (26%) introduced species.

Nine significant flora species were detected during field surveys, with one further species that has previously been recorded within the study area but was not recorded during surveys (Rough Wattle *Acacia aspera* subsp. *parviceps*), as detailed in Table 6.10. Further information on each of these significant species is provided in the following section.

The full list of flora species recorded in the study area, tabulated by source, is included as Appendix A.

Table 6.10 Summary of the significant flora species recorded within the study area

COMMON NAME	SCIENTIFIC NAME	EPBC ACT	FFG ACT	VICTORIAN ADVISORY LIST	SURVEY RESULT SUMMARY 2015 – 2017 AND PREVIOUS RECORDS
Ben Major Grevillea	*Grevillea floripendula*	Vulnerable	Listed	Vulnerable	A number of new locations found
Emerald-lip Greenhood	*Pterostylis smaragdyna*			Rare	Several new locations found
Floodplain Fireweed	*Senecio campylocarpus*			Rare	Several plants found – new records for region. Specimens to herbarium.
Matted Flax-lily	*Dianella amoena*	Endangered	Listed	Endangered	Several plants found – new records for region. Specimens to herbarium.
Ornate Pink Fingers	*Caladenia ornata*	Vulnerable	Listed	Vulnerable	Several plants found – new records for region.

COMMON NAME	SCIENTIFIC NAME	EPBC ACT	FFG ACT	VICTORIAN ADVISORY LIST	SURVEY RESULT SUMMARY 2015 – 2017 AND PREVIOUS RECORDS
Pale-flower Cranesbill	*Geranium sp. 3*			Rare	Several plants found – new records for region. Specimens to herbarium.
River Swamp Wallaby-grass	*Amphibromus fluitans*	Vulnerable			Several plants found – new records for region. Specimens to herbarium.
Rosemary Grevillea	*Grevillea rosmarinifolia*			Rare	One area appears remnant/non-planted
Rough Wattle	*Acacia aspera subsp. parviceps*			Rare	Not located during 2016–2017 surveys but has been previously recorded within the study area in 1993 (VBA) and several more records within the 10 km buffer.
Yarra Gum	*Eucalyptus yarraensis*		Rejected for listing as threatened; taxon ineligible	Rare	A number of new records found

6.5.2 SIGNIFICANT FLORA SURVEY RESULTS AND HABITAT

6.5.2.1 BEN MAJOR GREVILLEA

Ben Major Grevillea *Grevillea floripendula* is a spreading decumbent to semi-prostrate shrub that can grow up to 1m tall. It is restricted to a small area north of Beaufort to Ben Major State Forest and grows in dry open forests on shallow quartzitic soils (Walsh & Entwistle 1996). There are two forms of Ben Major Grevillea: the Ben Major form is mostly prostrate with shallowly divided leaves and flowers with a red tinge; the Musical Gully form grows to 1m tall, is shrubbier and has more deeply divided leaves with flowers variable in colour (Carter, O, Murphy & Downe 2006). The Ben Major form occurs in Ben Major State Forest, and the Musical Gully form occurs elsewhere north of Beaufort, including Camp Hill State Forest and Musical Gully State Forest. Only the Musical Gully form occurs in the study area.

Ben Major Grevillea is typically found on higher, north-facing ridges throughout the Camp Hill State Forest and Musical Gully State Forest (Nick Jeshencko pers. obs.). Targeted searches were conducted throughout intact Heathy Dry Forest, Grassy Dry Forest and related Ecological Vegetation Class complexes, mostly through Camp Hill State Forest and intact private land sites between Camp Hill State Forest and Musical Gully State Forest. Other private properties supporting relatively intact vegetation in the east and west of the study area were also searched for this species whilst conducting surveys for other threatened species.

Detection and identification of this species is possible with or without flowers/seeds as it has distinct morphological characters (e.g. deeply lobed, rigid leaves), different to most other flora species in the study area. Therefore, detection of this species was not influenced by seasonal factors.

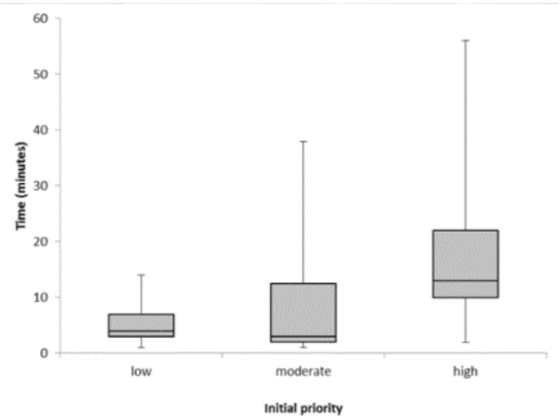
Many records in the VBA, occurring as individual data points and from monitoring data, are located in the study area. Each of the previous recorded occurrence points were visited in 2015, 2016 and 2017 by WSP. During targeted searches, approximately 65 new locations supporting a number of individual Ben Major Grevillea plants were found in the Camp Hill State Forest which were not previously recorded in the VBA.

A forest burn occurred in late 2017 between corridors A0 and C0, in a location where there are many Ben Major Grevillea.


Photo 6.3 Ben Major Grevillea in Camp Hill State Forest. Leaf form (left) and flower (right)

STRATIFIED MEANDER RESULTS

In total 137 grids, one hectare in size, were covered (=137 ha coverage). The average times spent in each grid determined by the initial priority were as follows: low priority – 4.9 minutes, moderate priority – 7.6 minutes, and high priority – 17.7 minutes.



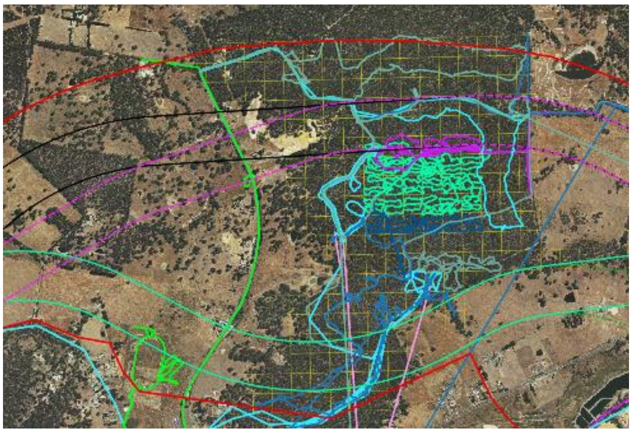


Figure 6.9 Boxplot of times spent surveying each 1ha grid by initial priority (left), and example of search area covered with GPS track data (blue and pink lines) (right)

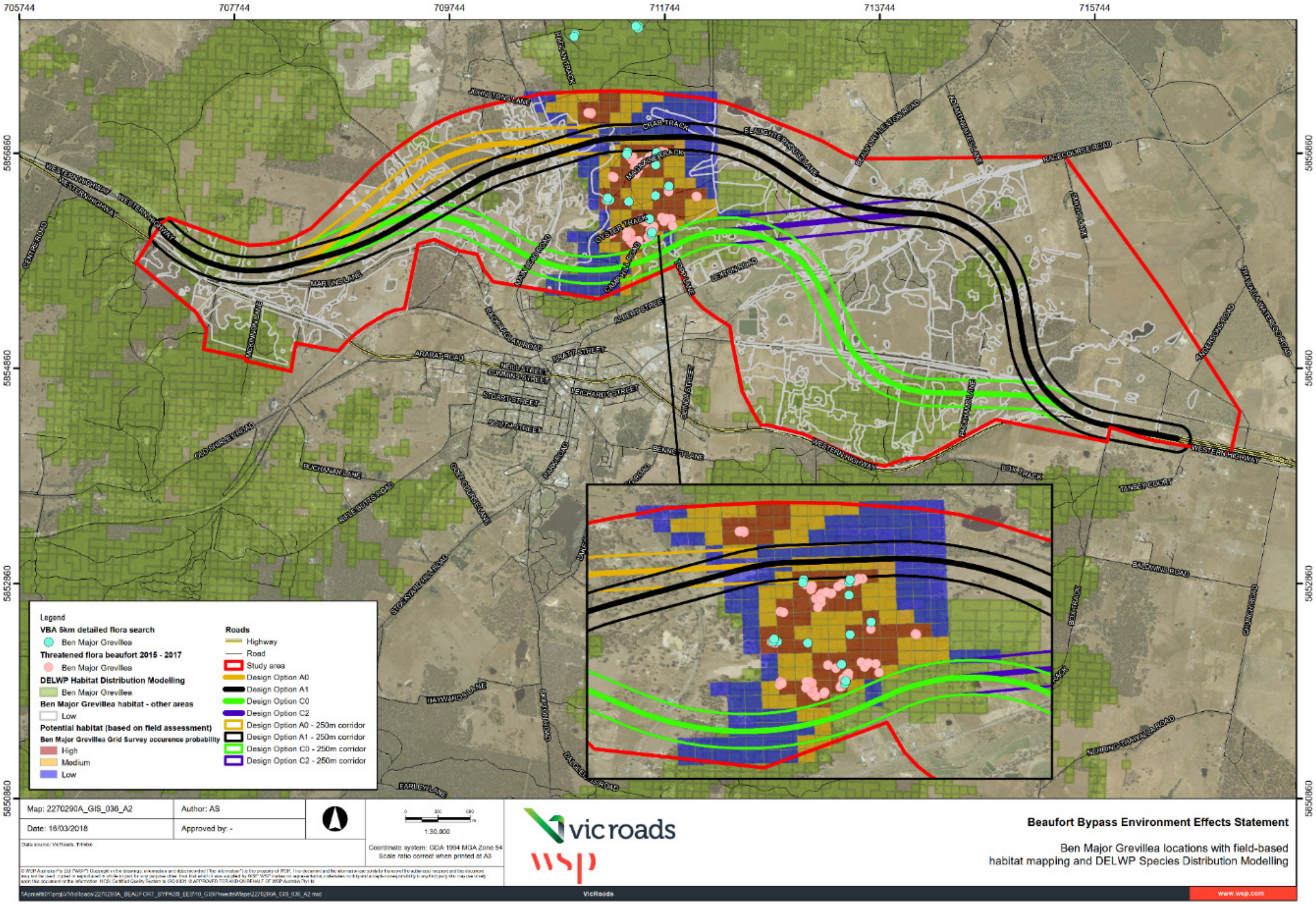


Figure 6.10 Ben Major Grevillea locations with field-based habitat mapping and DELWP Species Distribution Modelling

6.5.2.2 EMERALD–LIP GREENHOOD

The Emerald-lip Greenhood *Pterostylis smaragdyna* is a flowering plant in the orchid family. A number of Emerald–lip Greenhood orchids were recorded either side of the Western Highway between Beaufort-Carngham Road and Packhams Lane, on the south edge of property 98 in *Targeted Flora, Fauna & Aquatic Surveys of the Western Highway Upgrade: Burrumbeet to Beaufort* (Ecology Partners Pty Ltd 2010c). Targeted searches for this species were undertaken in September 2016 in the same area but failed to detect any individuals. Surveys undertaken in September 2017 along Western Highway and in Camp Hill State Forest located several individuals.

There is a record of the closely related Green-striped Greenhood *Pterostylis chlorogramma* found in the Camp Hill State Forest area in a later release of VBA data, not in previous search data. This record from 1993 was from within 400 m of Emerald–lip Greenhoods recorded in this study. Due to the known confusion with allied taxa (RBGV 2020), it is plausible that one or more taxa are present. Collection of a specimen and submission to the National Herbarium of Victoria may help to confirm the identity of the taxa. However, as no specimens attributable to either Emerald–lip Greenhood or Green-striped Greenhood were recorded in the current alignment options, this was not necessary.

Photo 6.4 Emerald–lip Greenhood *Pterostylis smaragdyna* (left) closely related and widespread Tall Greenhood *Pterostylis melagramma* (right) on the northern side of the Western Highway between Beaufort-Carngham Road and Packhams Lane

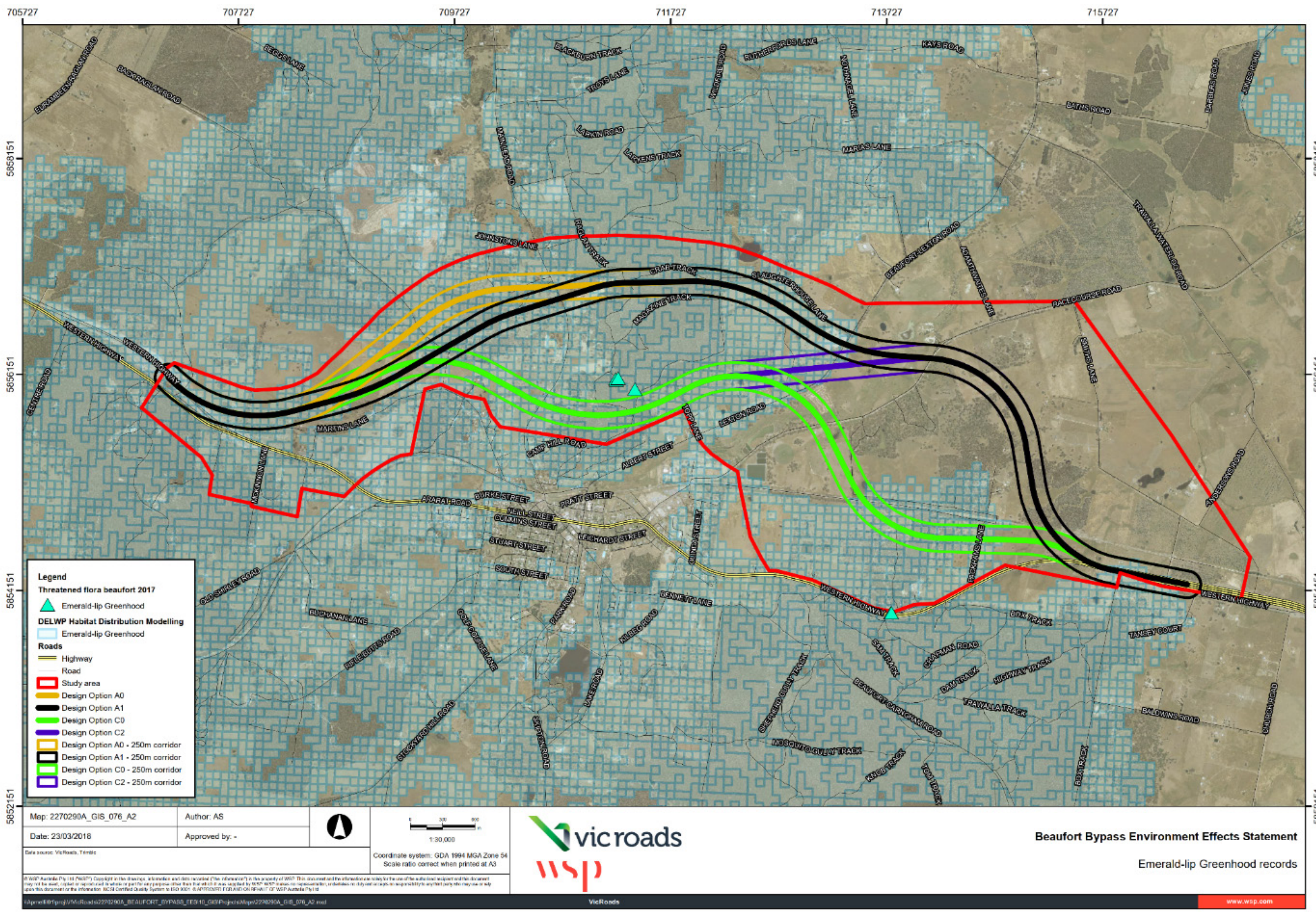


Figure 6.11 Emerald-lip Greenhood records and modelled habitat

6.5.2.3 FLOODPLAIN FIREWEED

Floodplain Fireweed *Senecio campylocarpus* is an erect perennial herb growing to 1.5 m high (RBGV 2020). It is typically found throughout central Victoria and in the north-east and is usually found in seasonally inundated areas (RBGV 2020) and creeklines. There are very few records in the region, with only one other record further east of Ballarat near Brown Hill (AVH 2017). It is likely this species is under-collected as it was described fairly recently (2004). As such, the records of this species made during the current surveys in 2016 are new for the region.

Floodplain Fireweed, shown in Photo 6.5, is similar to Cotton Fireweed *S. quadridentatus* but differs by its sparsely hairy to hairless leaves and stems (Thompson 2004) and is generally more green than grey in overall appearance. One voucher specimen (NM00362) was lodged with National Herbarium of Victoria in 2016.

In the study area, Floodplain Fireweed was mostly found in Plains Sedgy Wetland growing in drawdown zone on wetland edges and drier parts of wetland dominated by Common Sedge *Carex tereticaulis*, River Buttercup *Ranunculus inundatus* and Common Spikerush *Eleocharis acuta*. It was recorded in the Snow Gums Bushland Reserve (~50 plants), the old Beaufort racecourse (~5–10 plants) and in the rail corridor (1 plant).

Photo 6.5 Floodplain Fireweed *Senecio campylocarpus* (rare in Vic) found in wetlands in Snowgums Bushland Reserve

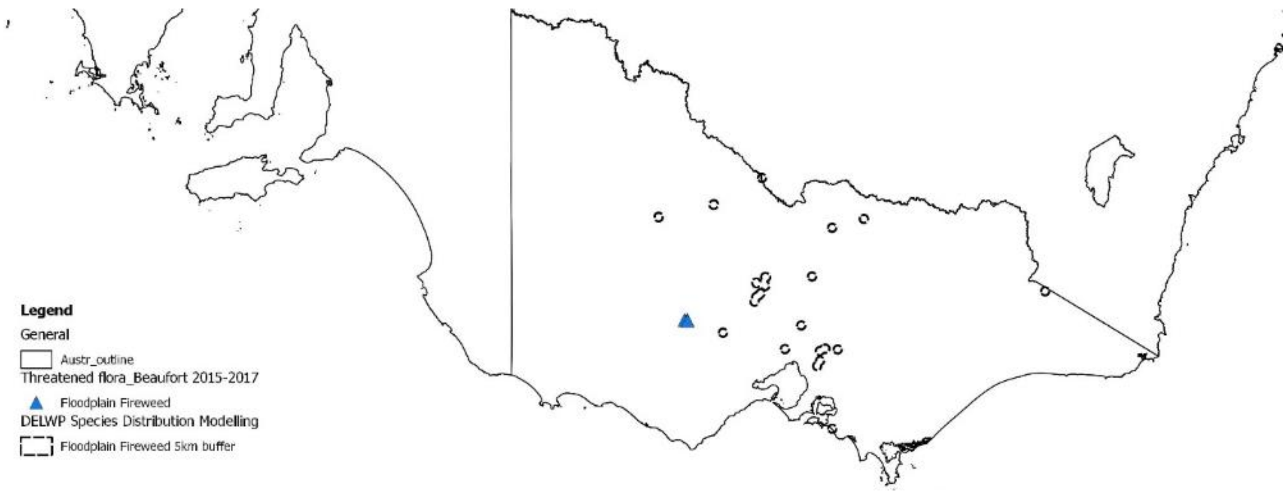


Figure 6.12 Floodplain Fireweed in context with DELWP Species Distribution Modelling

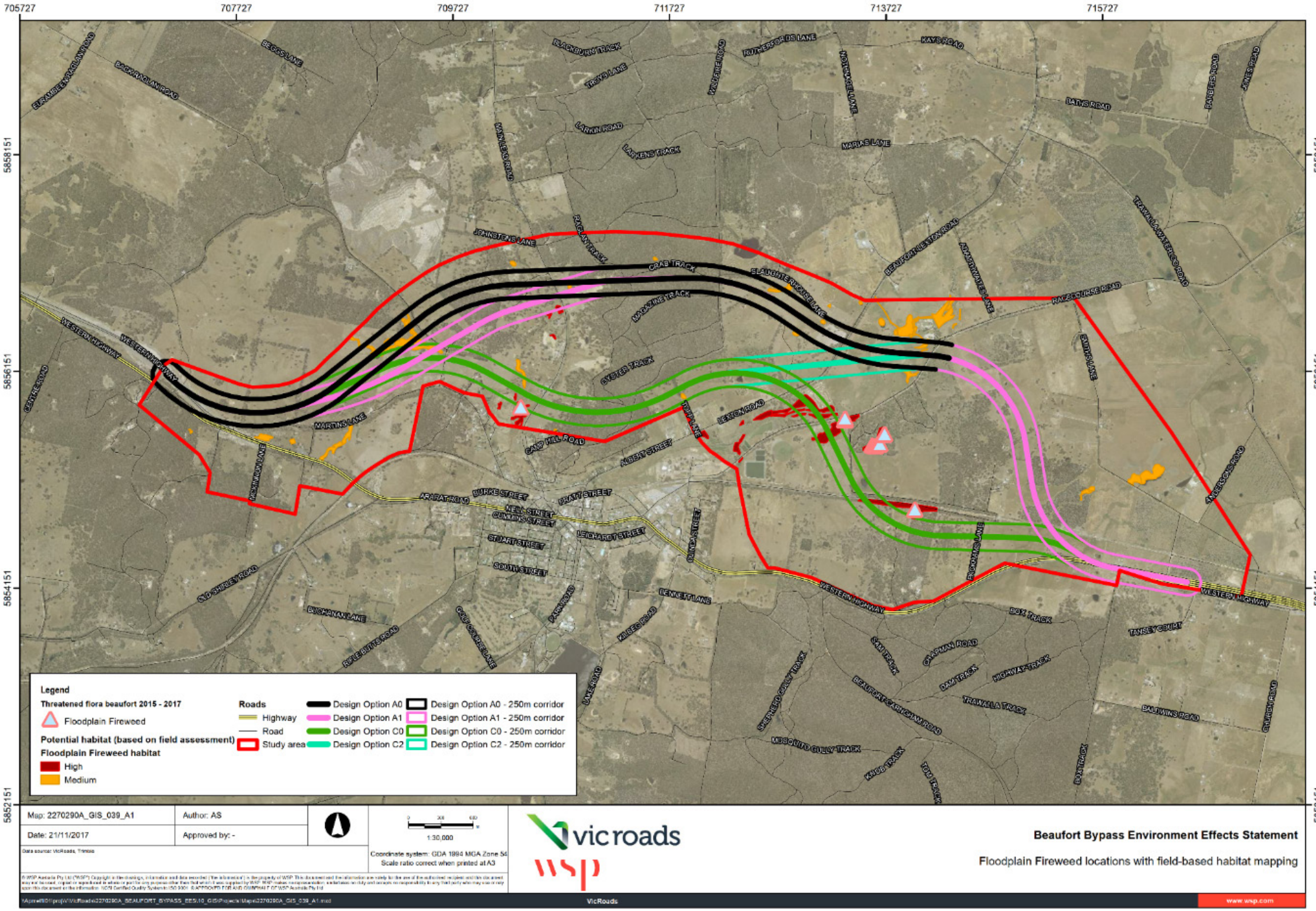


Figure 6.13 Floodplain Fireweed locations with field-based habitat mapping

6.5.2.4 MATTED FLAX-LILY

Endemic to Victoria, Matted Flax-lily *Dianella amoena* is a small, perennial, tufted lily (Carter, O 2010). Several Matted Flax-lily plants were detected in the study area. Searches were conducted primarily in the preferred Ecological Vegetation Classes: Valley Grassy Forest, Grassy Woodland and Alluvial Terraces Herb-rich Woodland with micro-site preference of remnant roadsides, rail corridors and along fence lines. Individual plants are difficult to isolate as Matted Flax-lily is rhizomatous and one plant can spread for up to 20 x 20 m with many isolated individual shoots (Carter, O 2010), however individuals often occupy a much smaller area. In a study by (North Barker Ecosystem Services 2009), they assumed that a single plant occupied 3 m^2 in larger patches. Therefore, in this study, new locations marked with a GPS are typically recorded where there are gaps in vegetative shoots of over 5 m.

Fifteen new occurrences of Matted Flax-lily were recorded in the study area, comprised of the following population clusters:

- three locations in Snow Gum Bushland Reserve (all ~2 x 1 m^2, mostly short 10 cm long leaves only)
- nine locations along the Melbourne-Adelaide rail corridor (5 plants <1 m^2, other plants ~3 m^2 each)
- one location along Beaufort-Lexton Road, near the corner of Slaughterhouse Lane (1 m^2)
- one location along Back Raglan Road (2 x 1 m^2)
- one location in private land on Racecourse Road (2 x 1 m^2).

The ability to detect this species increases when it is flowering, which is generally October to April (Carter, O 2010). However, most plants were not flowering at the time of the survey apart from the plant on the roadside at Beaufort-Lexton Road. Some plants were detected in winter 2017.

There are very few records of this species west of Ballarat recorded in the VBA, so these records are an extension to the known distribution. A voucher specimen (NM00356) with flowers was lodged with National Herbarium of Victoria in 2015 and confirmed as *Dianella amoena* in (WSP | Parsons Brinckerhoff 2016b).

Photo 6.6 Matted Flax-lily in flower (late November) along Beaufort-Lexton Road (left – flowers; right – close up of the irregularly spaced teeth along the margins; a useful identification trait when not in flower

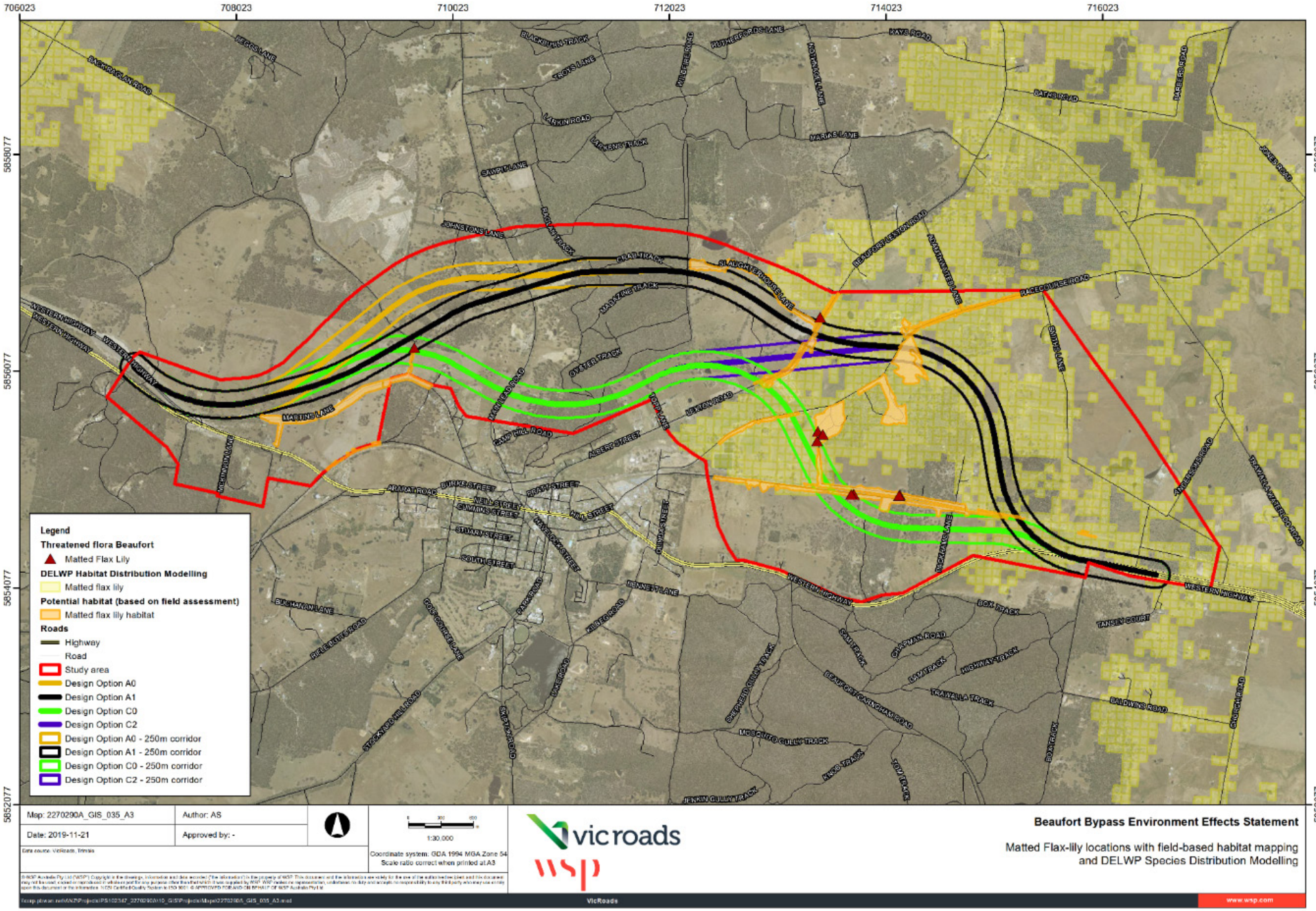


Figure 6.14 Matted Flax-lily locations with field-based habitat mapping and DELWP Species Distribution Modelling

6.5.2.5 ORNATE PINK FINGERS

Ornate Pink Fingers *Caladenia ornata* is a terrestrial orchid which grows 10–18 cm tall. Endemic to Victoria, it has previously been recorded around Stawell and in areas south west of Victoria. It grows in heathy forest on seasonally moist sandy loam (RBGV 2020). One specimen was recorded during the surveys in 2016. This is a new record with the closet records near Stawell. More individuals were recorded in October 2017 through Camp Hill State Forest and on a private land block. In some areas, where it grows with the more common Pink Fingers *Caladenia carnea*, some specimens can be difficult to assign to one species or the other (RBGV 2020). This was evident in Camp Hill State Forest where Ornate Pink Fingers were intermixed with Pink Fingers. These were separated by the presence of fused lateral sepals and a deep pink labellum. Intermediate specimens are not included in the Ornate Pink Finger records shown on Figure 6.16. A specimen collected in 2017 has been sent to the National Herbarium of Victoria for clarification of identification. It is possible that these species are hybridising in this location.



Photo 6.7 Pink Fingers *Caladenia carnea* (left), a widespread species and the similar EPBC Act orchid Ornate Pink Fingers *Caladenia ornata* (middle and right). Found on property 87. Nearest location is Stawell

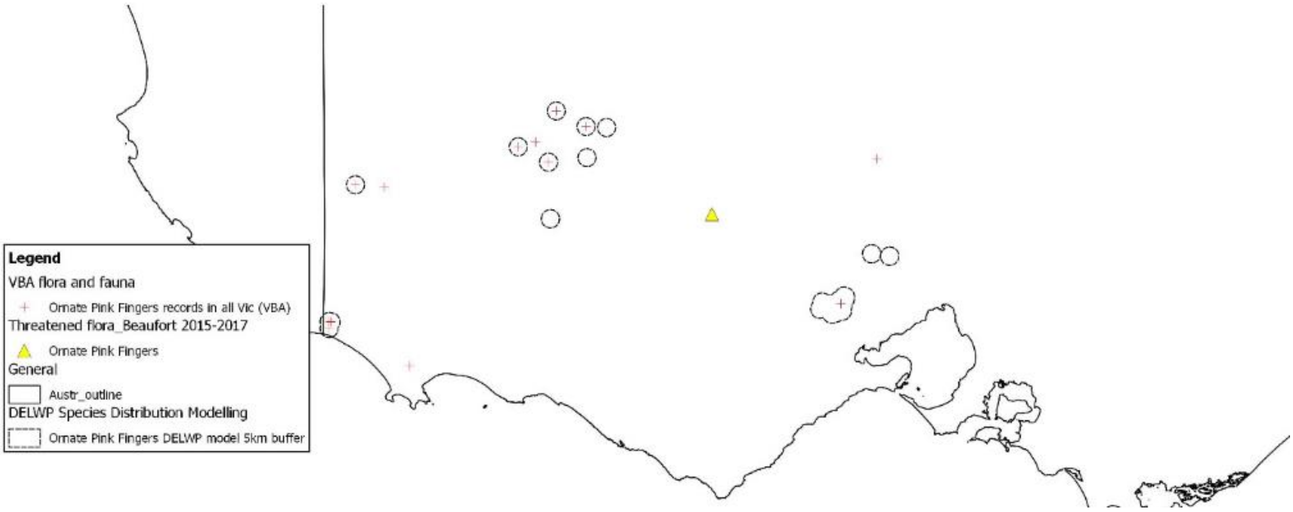


Figure 6.15 Ornate Pink Finger records with DELWP Species Distribution Modelling

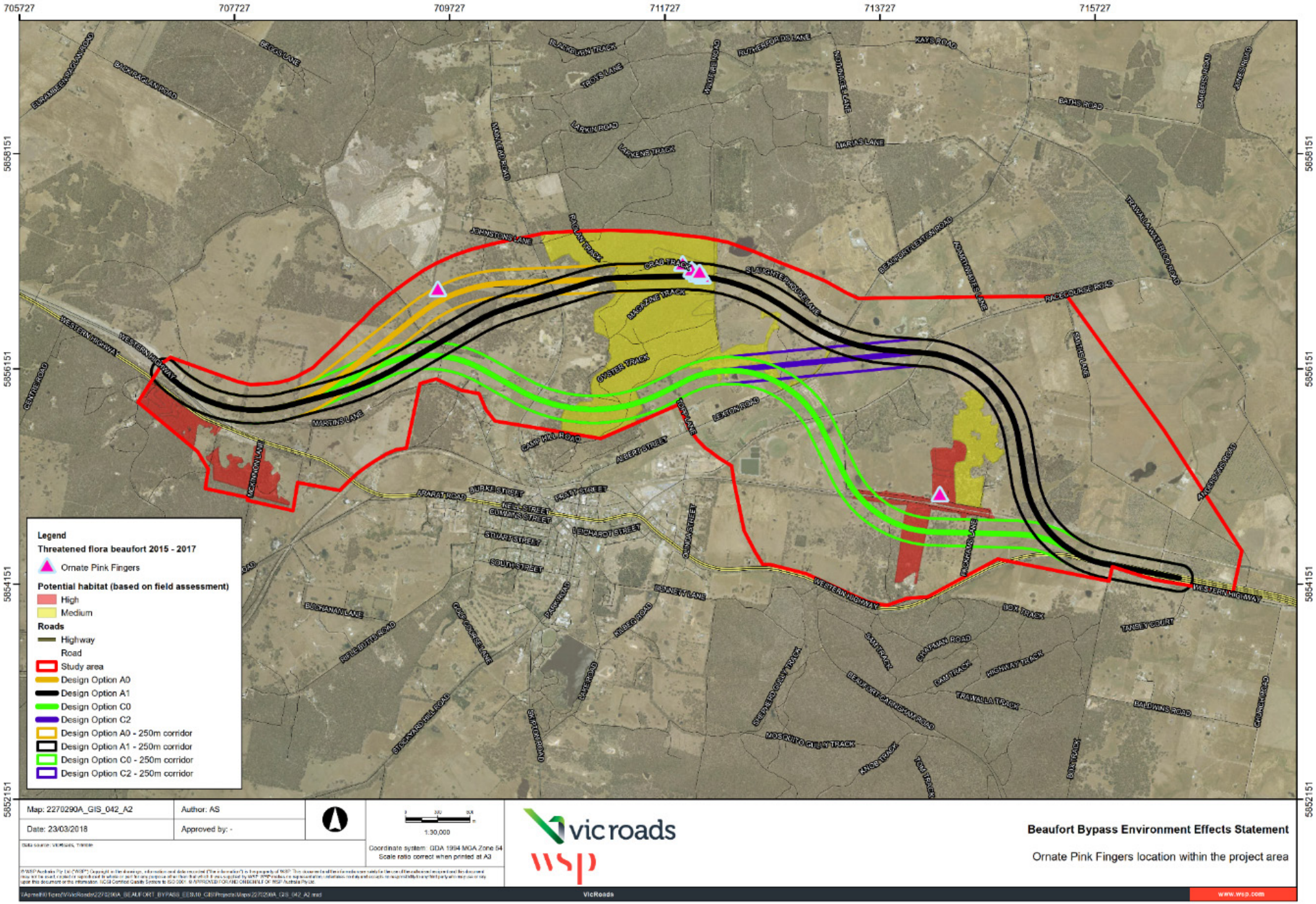


Figure 6.16 Ornate Pink Fingers locations with field-based habitat mapping

6.5.2.6 PALE-FLOWER CRANESBILL

Pale-flower Cranesbill *Geranium sp. 3* is a decumbent to ascending perennial herb with stems growing to 30 cm long (RBGV 2020). Pale-flower Cranesbill is known in central and western Victoria from Stawell, Yan Yean, Eltham, and Bonegilla areas. It is usually found in open, grassy areas of dry woodland to forest (RBGV 2020). Locations of this species found in the current surveys in 2016 are new for the region.

Two voucher specimens (NM00364 and NM00365) were lodged with National Herbarium of Victoria in 2016 and confirmed as Pale-flower Cranesbill. However, it was noted that in the absence of a taxonomic revision of the *Geranium* genus, it is difficult to confidently apply the informal taxonomy from Flora of Victoria (Walsh & Entwistle 1999) (Val Stajsic pers. comm.). The specimens sent were generally consistent with that described for Pale-flower Cranesbill (e.g. patent hairs on stems, purple dehicent lines on anther pods, pale pink flowers when fresh, three translucent lines on petals, sepals with short mucro).

In the study area, it was found in Grassy Dry Forest (property 2), a mix of Radiata Pine and native grassy understorey along the rail corridor near Martins Lane, and Valley Grassy Forest along the rail corridor (property 98). Indicative photographs of plants recorded are provided in Photo 6.8 and the locations of records are provided on Figure 6.17.

Photo 6.8 Pale-flower Cranesbill, flower, form and long, straight hairs (patent) on stem

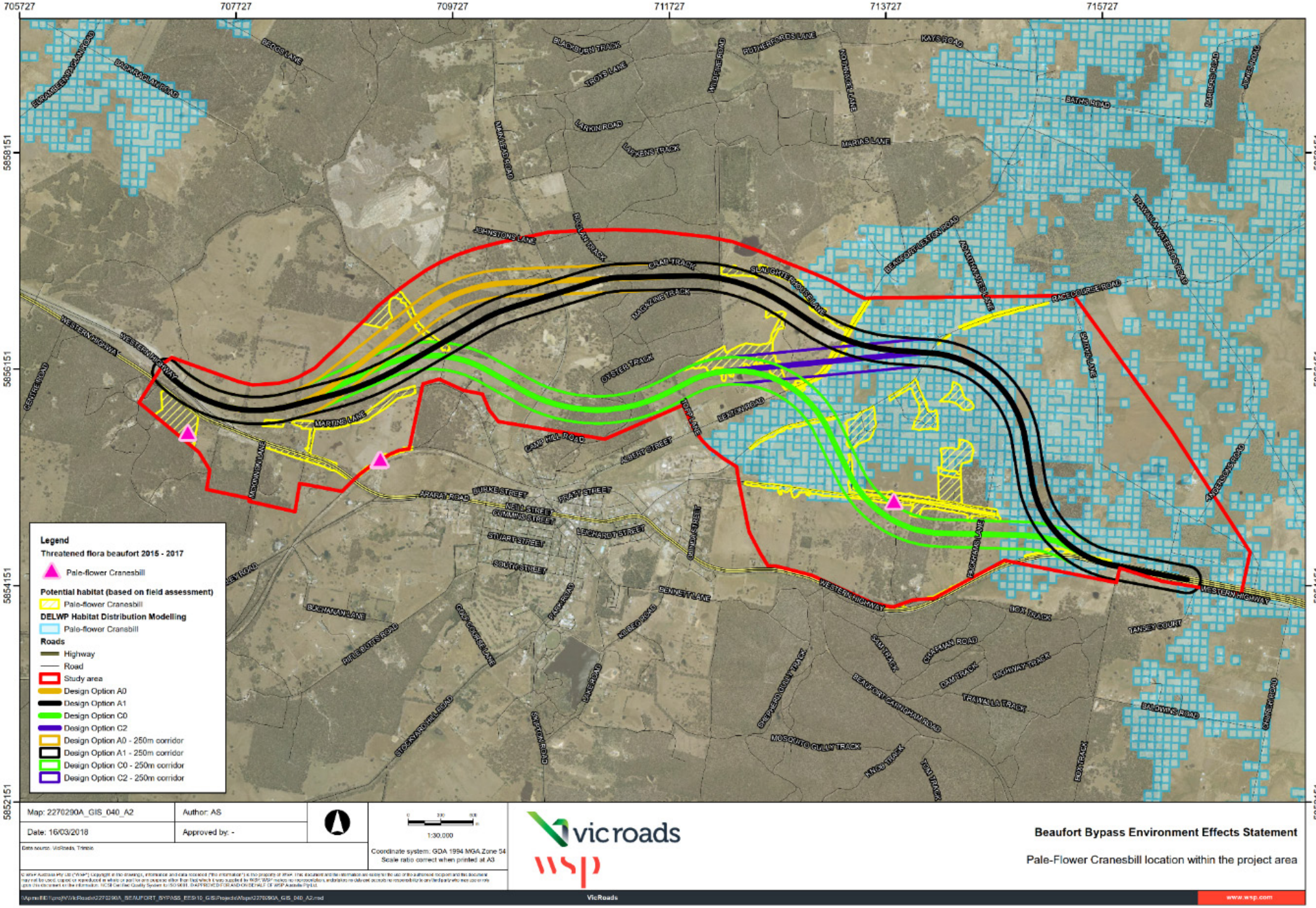


Figure 6.17 Pale-flower Cranesbill locations with field-based habitat mapping and DELWP Species Distribution Modelling

6.5.2.7 RIVER SWAMP WALLABY-GRASS

River Swamp Wallaby-grass *Amphibromus fluitans* is a rhizomatous and stoloniferous aquatic or semi-aquatic grass found across northern Victoria on the Murray River and with a scattered, uncommon distribution across southern Victoria (RBGV 2020). Prior to the targeted surveys in 2015 for the Beaufort Bypass (WSP | Parsons Brinckerhoff 2016b), there were no records of this species in the broader region.

This species, shown in Photo 6.10, can be difficult to differentiate from other *Amphibromus spp.* due to the interpretation of the key morphological characteristics through the different growth phases. These characteristics are heavily influenced by soil moisture and water depth (if growing in water). All plants recorded in the study area in 2015 were all found in the drier mud and drawdown areas of wetlands, mostly in full flower which facilitated identification. In 2016 and 2017, all plants were identified in flower, many growing in water. Two voucher specimens with seeds (NM00353 and NM00356) were lodged with National Herbarium of Victoria in 2015 and confirmed as *Amphibromus fluitans.*

In the study area, the species has mostly been found in the EVCs Aquatic Grassy Wetland, Aquatic Herbland and Plains Grassy Wetland, growing in water 0.5–1.0 m deep, wetland edges or on the floor of wetlands in drawdown phase.

Thirty-six new records of Swamp wallaby-grass have been made during current surveys in 2015–2017. The locations of these records are provided below on Figure 6.18. Most records comprised many plants, however, it is difficult to estimate numbers of individuals due to its rhizomatous form. An indicative coverage of River Swamp Wallaby-grass was mapped at each location, which covers approximately 9.24 ha within the study area. A sample of the larger populations are at the following locations:

- wetlands either side of Racecourse Road in the Yam Holes Valley
- wetland in the Snow Gums Bushland Reserve
- wetlands near Martins Lane
- wetland north of Smiths Lane
- wetlands in the upper reaches of Yam Holes Creek adjacent to Main Lead Road.

The species was also recorded in smaller populations in several smaller wetlands and dams in other parts of the study area.

There are very few records (five) west of Ballarat according to VBA, so these records are an addition to the known distribution. No DELWP Species Distribution Modelling available for River Swamp Wallaby-grass.

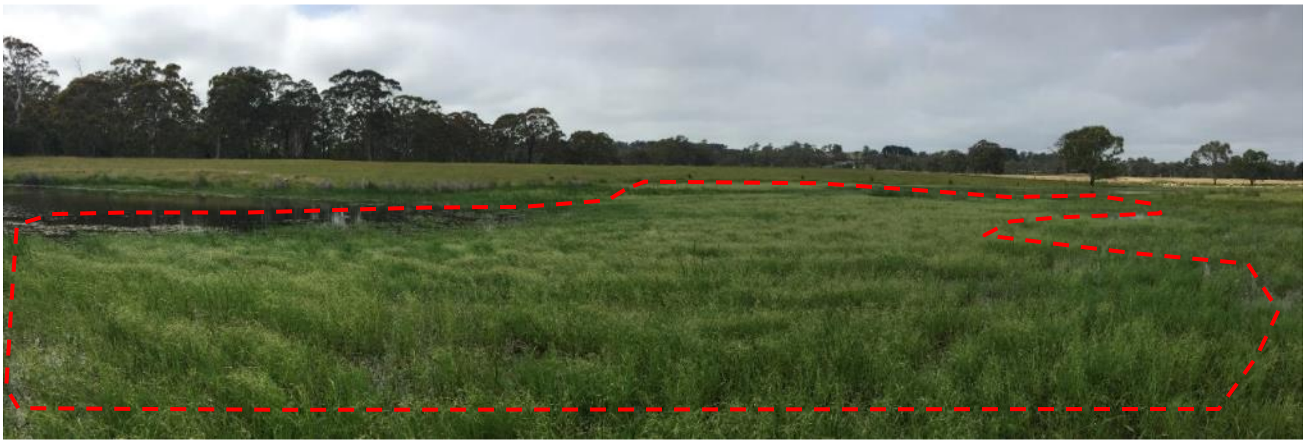


Photo 6.9 Extensive area (red hashed outlined) of EPBC listed River Swamp wallaby-grass in flower at Property 78. This is also an area assessed as EPBC listed community Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains

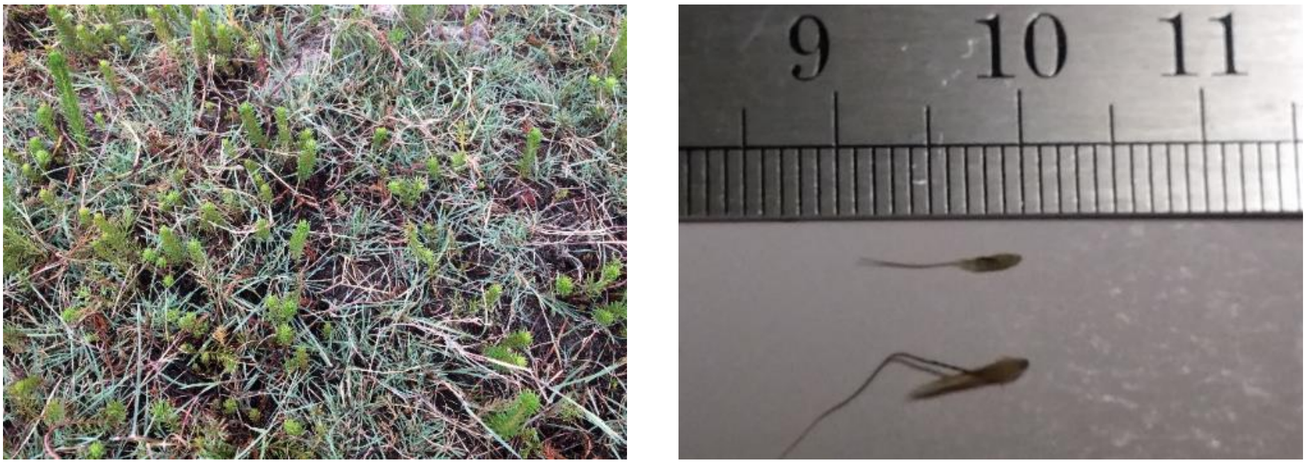


Photo 6.10 Typical stoloniferous growth form of River Swamp wallaby-grass growing amongst Upright Water-milfoil *Myriophyllum crispatum* (left) and comparison of seeds (right) – *Amphibromus fluitans* (top) *Amphibromus nervosus*, a more common, tussock forming species (bottom)

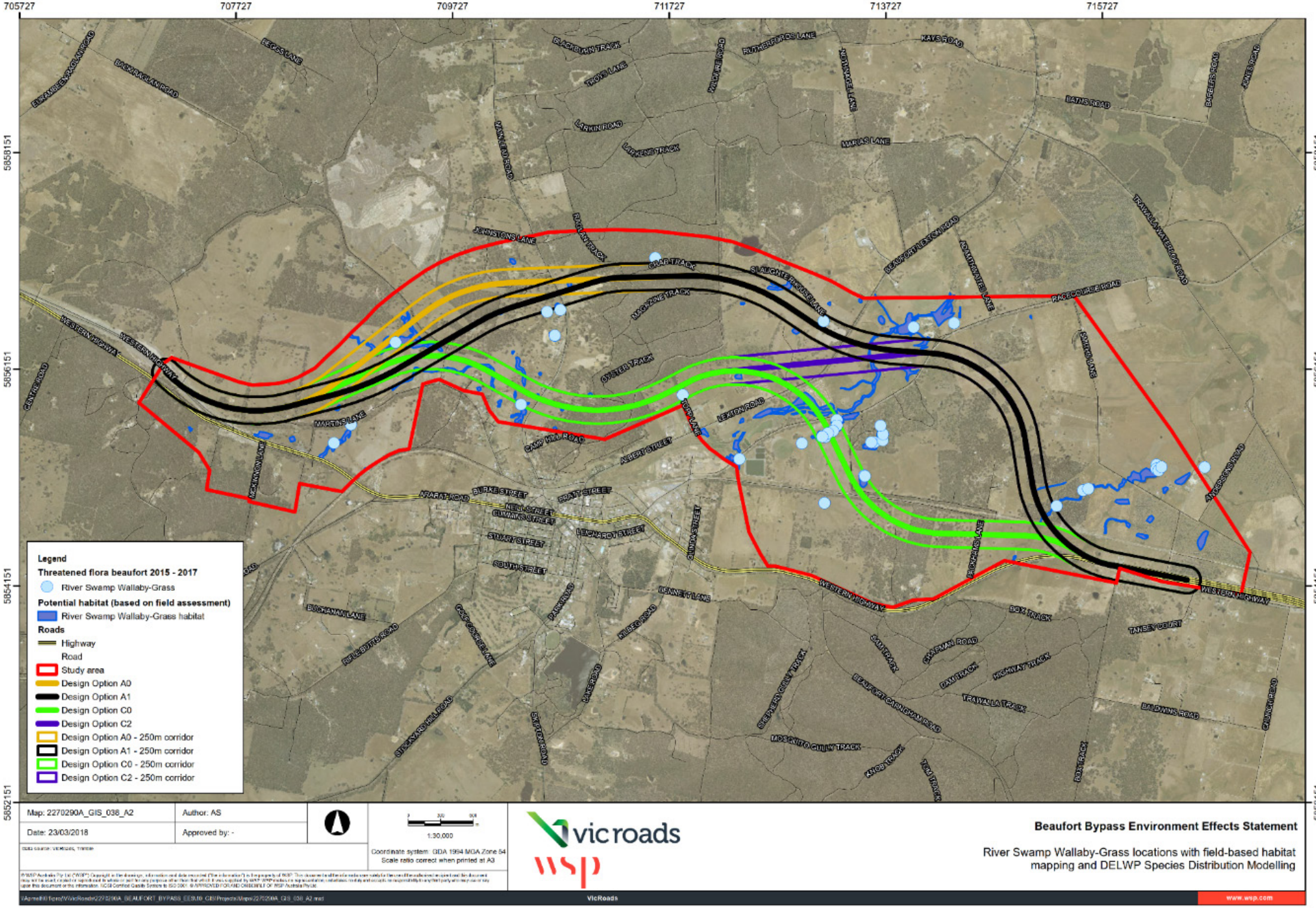


Figure 6.18 River Swamp wallaby-grass locations with field-based habitat mapping

6.5.2.8 ROSEMARY GREVILLEA

Rosemary Grevillea *Grevillea rosmarinifolia subsp. rosmarinifolia* is a compact to open shrub growing 0.3–2 m high (RBGV 2020). It has a patchy distribution around central Victoria and is frequently planted in gardens and often escapes into nearby bushland where it has been naturalised and sometimes interbreeds with indigenous species of Grevillea. Therefore, there are some difficulties associated with accurately determining the identification and status of Rosemary Grevillea. There are known natural hybrids between Rosemary Grevillea and Woolly Grevillea *Grevillea lanigera* (Olde & Marriot 1994) and also naturalised, non-indigenous Rosemary Grevillea plants (Walsh & Entwistle 1996). One of the methods for determining the rare taxon is to look for the presence of hairs on the style of the fresh flower (Savona et al. 2005). This taxon is also generally less than 1 m high, though height is not a stand-alone method for identification.

Approximately 30 plants were recorded at an old mullock heap off Racecourse Road (refer to Photo 6.11 and Figure 6.20). It is uncertain if these plants are indigenous or naturalised; however, they do have hairs on the flower style, are not much greater than 1.5 m in height, and are not far (26 km south) from modelled habitat (refer Figure 6.19). Therefore, this population is treated as the rare indigenous type. Planted specimens of Rosemary Grevillea were observed growing on private properties and bushland along the Western Highway, west of Packhams Lane. These are not considered to be indigenous.

Photo 6.11 Rosemary Grevillea flower (left) and habit (right)

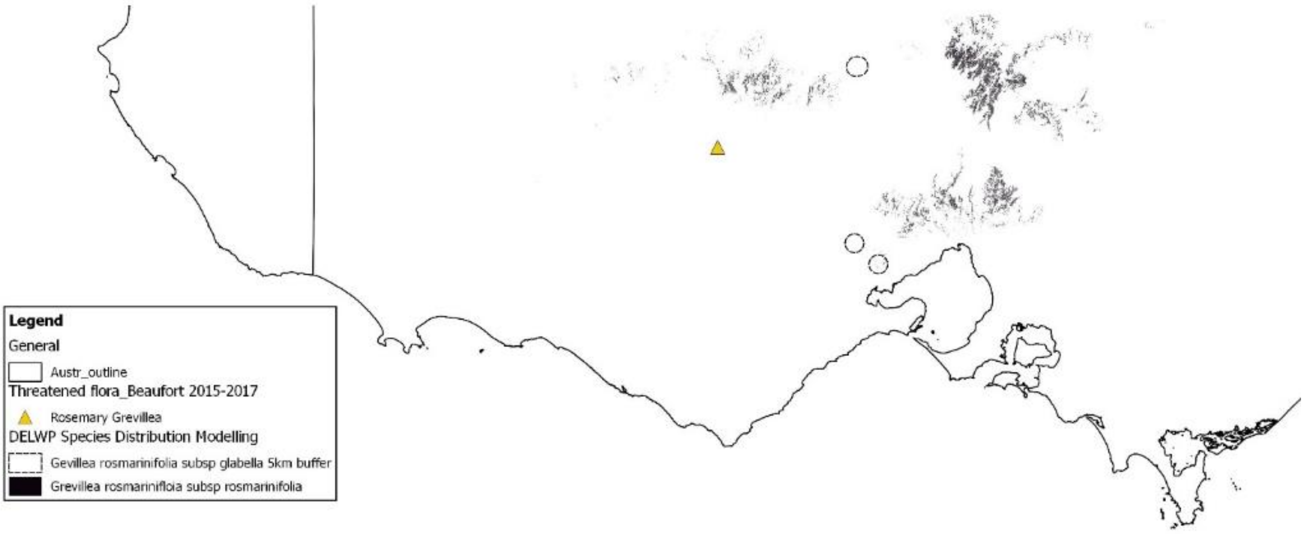


Figure 6.19 Rosemary Grevillea in context with DELWP Species Distribution Modelling

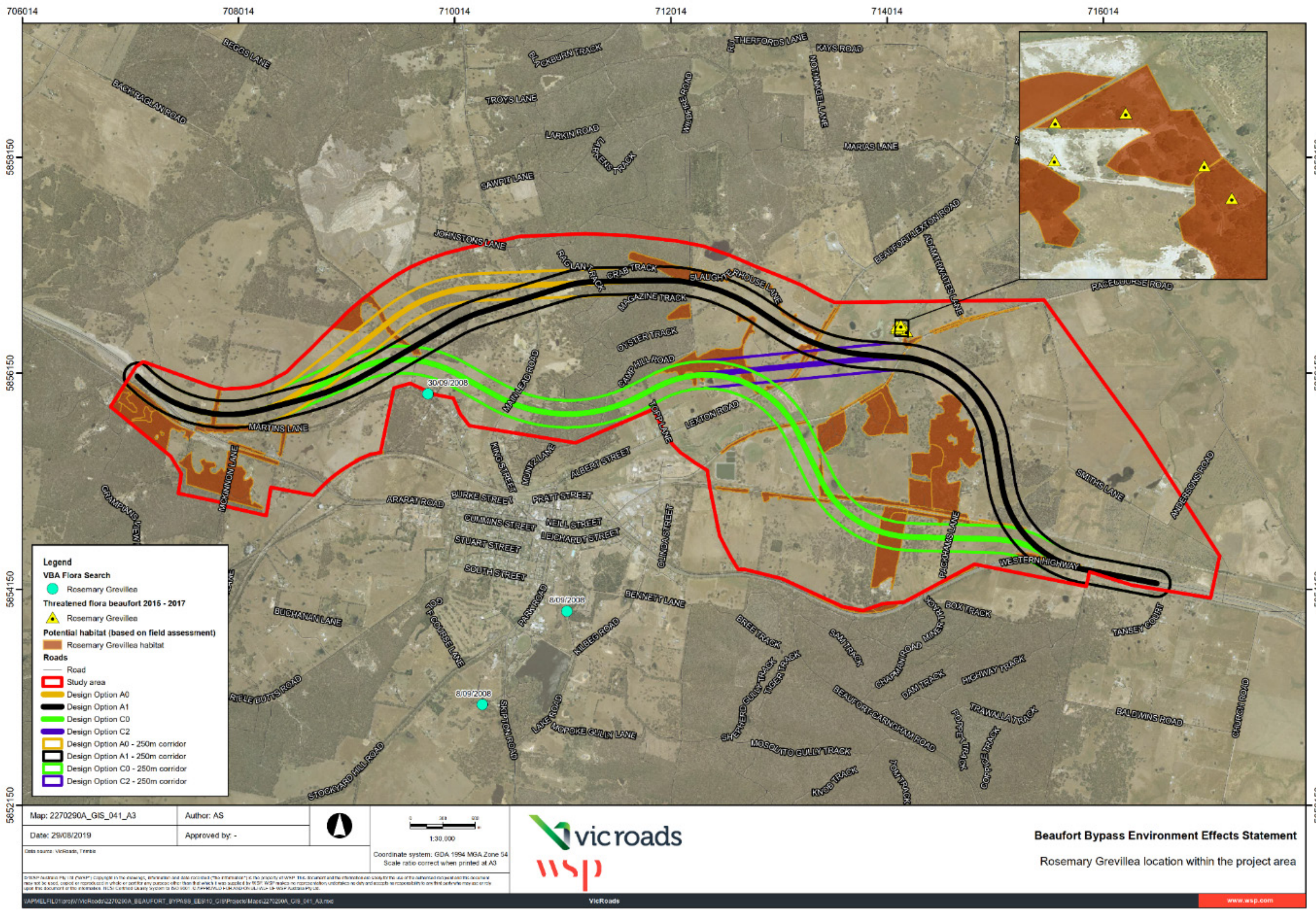


Figure 6.20 Rosemary Grevillea locations with field-based habitat mapping

6.5.2.9 ROUGH WATTLE

Rough Wattle *Acacia aspera subsp. parviceps* is a spreading, viscid shrub which grows 0.5–2 m high (RBGV 2020). The species grows in shallow soil in dry to moist open Eucalypt forest west of Melbourne in the Brisbane Ranges, Werribee Gorge and Beaufort areas (RBGV 2020).

It has previously been recorded within the study area in the Snow Gums Bushland Reserve in 1993, and there are several records just south of the study area in Trawalla State Forest. Despite repeated searches through Snow Gums Bushland Reserve and other parts of the study area, it was not recorded during surveys in 2015–2017. Given the past records, it is still considered likely to be present within the study area. Refer to Figure 6.21 below.

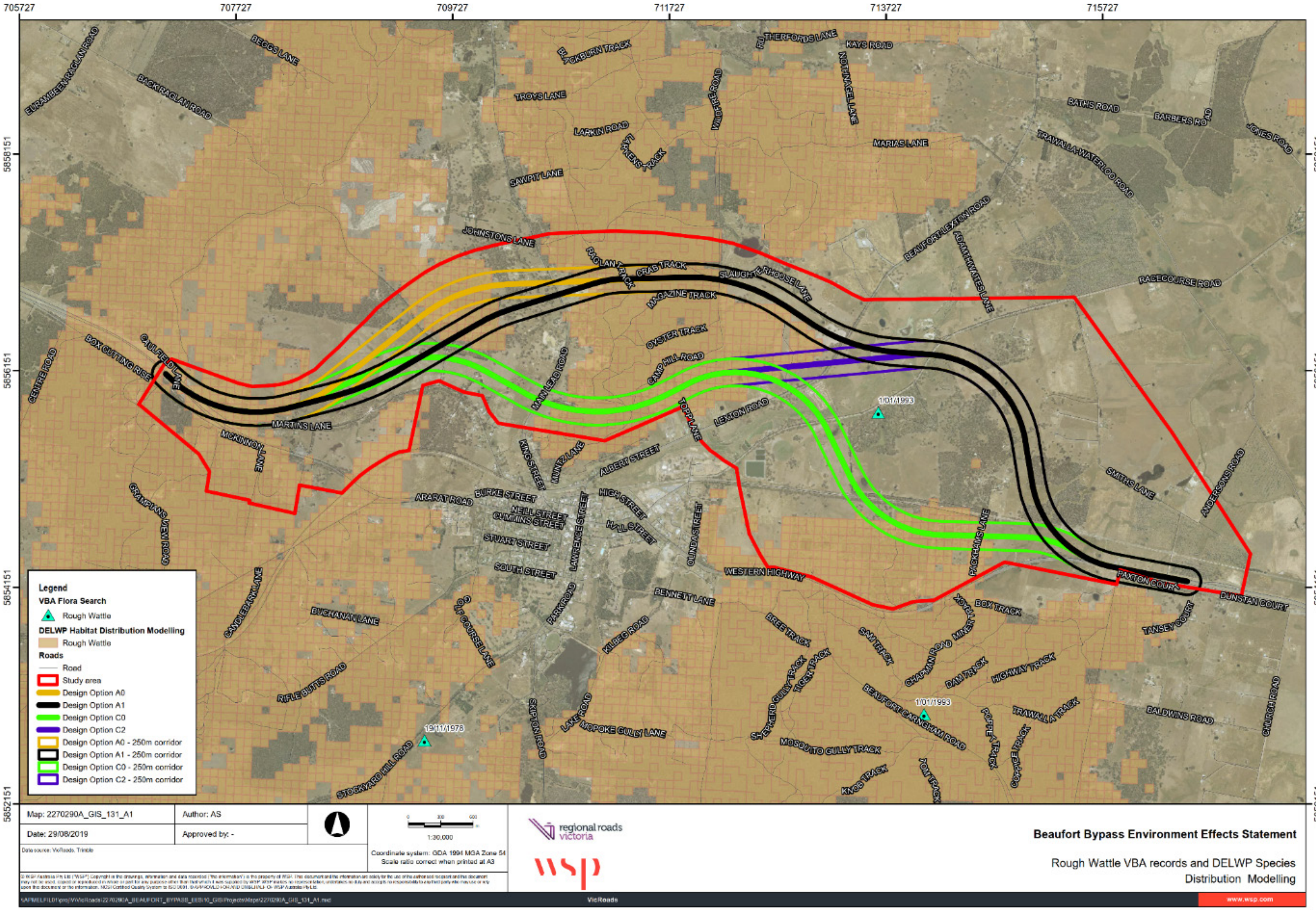


Figure 6.21 Rough Wattle VBA records and DELWP Species Distribution Modelling

6.5.2.10 YARRA GUM

Yarra Gum *Eucalyptus yarraensis* is a Eucalyptus tree found across southern Victoria from Glengarry in western Victoria to Traralgon in Gippsland (RBGV 2020). Identification of this species can be difficult, due to similarities to Swamp Gum *Eucalyptus ovata* which is common across lowland Victoria. However, it can be distinguished by more persistent rough bark, smaller leaves and smaller buds and fruits (RBGV 2020). Additionally, a boil test can readily differentiate Yarra gum from close relatives, as boiling the leaves for a few minutes releases the characteristic odour of benzaldehyde (smell of almonds or marzipan), which the others only contain in low levels (Simmons & Parsons 1999).

One VBA record occurs in the study area (DELWP 2018e), however, this tree could not be relocated in the study area during surveys in 2015–2017.

However, 31 new records of Yarra Gum were made during current surveys (2015–2017) at the following locations:

- fifteen on Martins Lane
- five on the rail corridor
- eight on Smiths Lane, including several large old trees
- one on Johnsons Lane off Main Lead Road, just outside the study area
- one in the Camp Hill State Forest area
- one on a property on Racecourse Road.

Photo 6.12 Yarra gum tree on Smiths Lane (left) fruit (middle) and leaves (right)

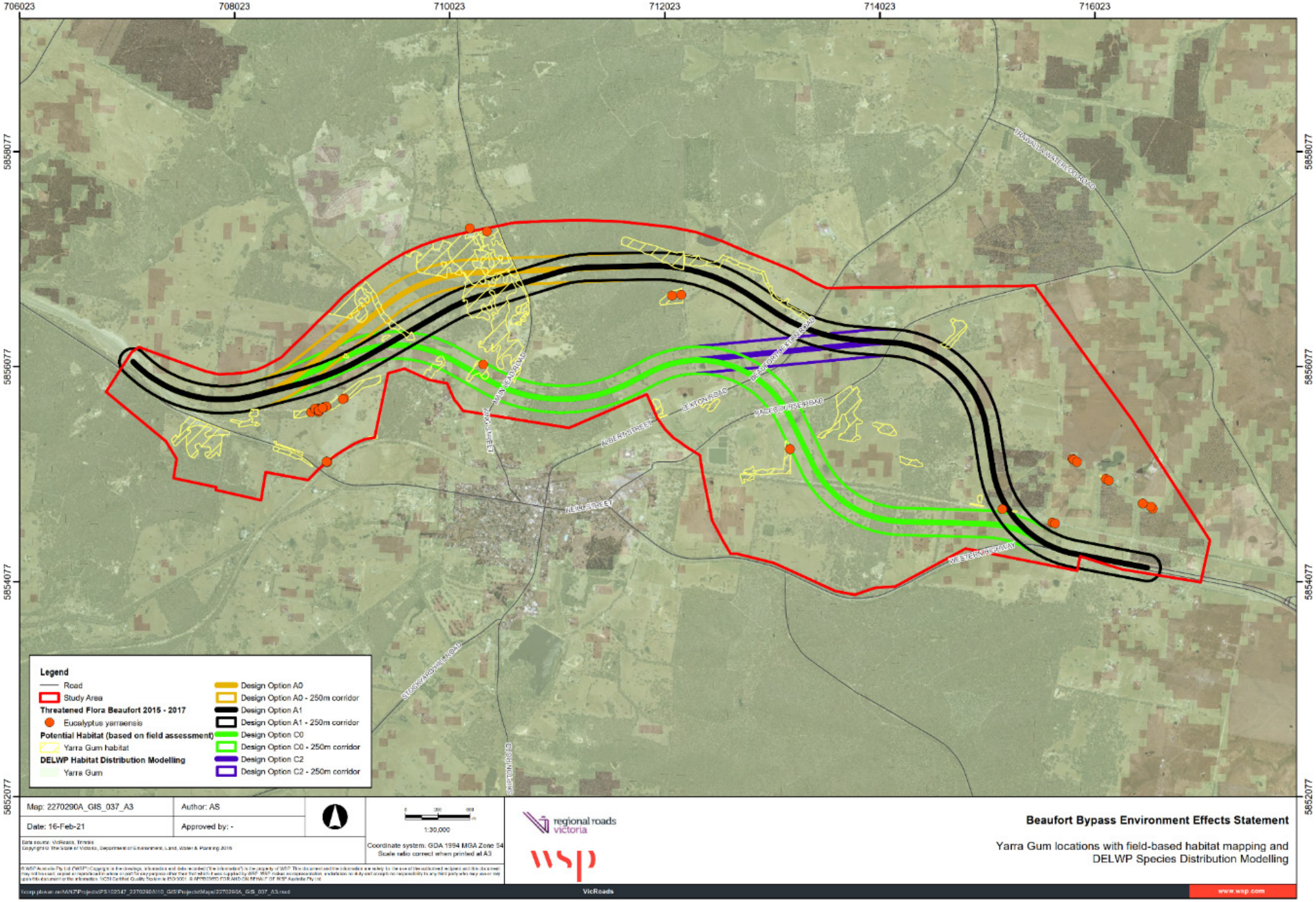


Figure 6.22 Yarra Gum locations with field-based habitat mapping and DELWP Species Distribution Modelling

6.5.3 LIKELIHOOD OF OCCURRENCE

Thirty-four flora species of state and/or national significance appeared on the database searches (PMST and VBA) within 10 km of the study area (refer to Appendix C for the full likelihood of occurrence assessment). Of these, six species were recorded and one further rated as highly likely to occur despite not being recorded during site assessments. These species are listed in Table 6.11 below.

In addition, although not identified in database searches, a further three threatened flora species were recorded within the Beaufort Bypass study area during targeted surveys (See Section 6.5.2). This included Emerald-lip Greenhood, Floodplain Fireweed and Pale-flower Cranesbill.

Table 6.11 Flora species with a moderate or higher likelihood of occurrence

COMMON NAME	CONSERVATION STATUS			VBA COUNT FROM 10 km BUFFER	LIKELIHOOD OF OCCURRENCE
	EPBC ACT	FFG ACT	VIC ADV		
Ben Major Grevillea	Vulnerable	Listed	Vulnerable	146	Recorded
Emerald-lip Greenhood			Rare	0	Recorded
Floodplain Fireweed			Rare	0	Recorded
Matted flax-lily	Endangered	Listed	Endangered	3	Recorded
Ornate Pink Fingers	Vulnerable	Listed	Vulnerable	0	Recorded
Pale-flower Cranesbill			Rare	0	Recorded
River Swamp Wallaby-grass	Vulnerable			0	Recorded
Rosemary Grevillea			Rare	4	Recorded
Rough wattle			Rare	10	Moderate
Yarra Gum		Rejected	Rare	64	Recorded

6.5.3.1 OTHER SIGNIFICANT SPECIES MODELLED TO OCCUR IN THE STUDY AREA

There are a number of flora species which are modelled to occur in the study area (DELWP Species Distribution Modelling) under the Guidelines 2013 and/or Guidelines 2017. Many of these species are unlikely to occur in the study area, due to an absence of suitable habitat, and lack of recent or nearby records. The 18 flora species triggered in the scenarios for offsets under Guidelines 2013 and Guidelines 2017 are listed in Table 6.12.

These species are collated for the various scenarios examined for each alignment option, including previous alignment options, the entire 250m wide corridor, and construction footprint. DELWP regional team had initially requested that these species be considered for surveying in 2016 due to their triggering in EnSym offset scenarios.

One other species recorded in *Targeted Flora, Fauna & Aquatic Surveys of the Western Highway Upgrade: Burrumbeet to Beaufort* (Ecology Partners Pty Ltd 2010c) was Wavy–swamp Wallaby–grass *Amphibromus sinuatus*. This species was targeted during surveys in 2016 and 2017 but was not found. Wavy–swamp Wallaby–grass was found just over 1km east of the study area along Mt Emu Creek. Other than this location, the nearest records are 16kms south-east of the study area near Carngham. The species is considered unlikely to occur in the study area.

Table 6.12 Flora species triggered by offset requirements Guidelines 2013 and Guidelines 2017 and their likelihood of occurrence

COMMON NAME	SCIENTIFIC NAME	SPECIFIC OFFSET REQUIREMENT – GUIDELINES 2013	SPECIFIC OFFSET REQUIREMENT – GUIDELINES 2017	LIKELIHOOD OF OCCURRENCE
Arching Flax-lily	*Dianella sp. aff. longifolia (Benambra)*	yes	no	**Low** Occurs in lowland plains grassland and grassy woodlands (e.g. Volcanic Plain and Riverina) as well as some higher altitudes. A recent change in the taxonomy has reverted to the synonym *Dianella longifolia var. grandis*. Nearest known record on the VBA is >30 km north near Avoca. There are also recent new records by WSP in Ararat >35 km west.
Ben Major Grevillea	Grevillea floripendula	no (avoided)	yes	**Present** Restricted to a small area north of Beaufort, from Waterloo to Ben Major Forest. Grows in dry open-forest, on shallow quartzitic soils. Several individuals in the VBA from previous surveys. A number of new locations found during studies in 2015 to 2017.
Buxton Gum	*Eucalyptus crenulata*	yes	no	**Low / n/a** Buxton Gum is a widely planted ornamental tree which is only native to the Acheron River valley and at Yering near Yarra Glen. One herbarium record from 1982 of a planted individual was recorded in the Beaufort township (AVH 2017).
Clover Glycine	*Glycine latrobeana*	yes	no	**Low** Widespread but of sporadic occurrence and rarely encountered. Grows mainly in grasslands and grassy woodlands. Despite searches during targeted searches in 2016 and 2016 in grassy woodland habitats, no Clover Glycine was detected. The nearest record is 16 km north.

COMMON NAME	SCIENTIFIC NAME	SPECIFIC OFFSET REQUIREMENT – GUIDELINES 2013	SPECIFIC OFFSET REQUIREMENT – GUIDELINES 2017	LIKELIHOOD OF OCCURRENCE
Emerald-lip Greenhood	*Pterostylis smaragdyna*	no	yes	**Present** Typically grows in drier forests and woodlands on well-drained shallow clay loam. Nearest records in VBA are near Langi Ghiran State Park, east of Ararat. Located along the Western Highway near Packhams Lane during the Burrumbeet to Beaufort VicRoads surveys (Ecology Partners Pty Ltd 2010c). Found in 2017 in the location above and new records in the Camp Hill State Forest.
Flame Grevillea	*Grevillea dimorpha*	no	yes	**Low** Endemic to the Grampians, growing in moister areas of dry sclerophyll forest or heath.
Flat Bluebell	*Wahlenbergia planiflora subsp. planiflora*	no	yes	**Low** Confined to a few collections from elevated sites in north-east Victoria and from lower altitude near Rutherglen.
Golden Cowslips	*Diuris behrii*	yes	no	**Low** Golden Cowslips *Diuris behrii* has been recorded within 3 km's of the western edge of the study area near Eurambeen. Despite searches during targeted searches in 2016 and 2016, only the closely resembling, widespread species Golden Moths *Diuris chryseopsis* was observed during three field trips.
Hairy Correa	*Correa aemula*	No	yes	**Low** Occurring in western Victoria in the Grampians and nearby mountains, where found along streams in woodland or on mountain tops. Nearest records in VBA are near Langi Ghiran State Park 24 km west.

COMMON NAME	SCIENTIFIC NAME	SPECIFIC OFFSET REQUIREMENT – GUIDELINES 2013	SPECIFIC OFFSET REQUIREMENT – GUIDELINES 2017	LIKELIHOOD OF OCCURRENCE
Large-headed Fireweed	*Senecio macrocarpus*	no	yes	**Low** Confined to remnant grasslands on basalt-derived clay soils near Melbourne west to Skipton area. There is very little specific habitat preferred by Large-headed Fireweed in the study area. The nearest record is in Ararat >35 km west.
Matted Flax-lily	*Dianella amoena*	yes	no	**Present** Occurs mainly in lowland grasslands, grassy woodlands, valley grassy forest and creeklines of herb-rich woodland. Locations of this species found in 2015 are new for the region.
Pale-flower Crane's-bill	*Geranium sp. 3*	yes	no	**Present** Pale-flower Cranesbill is known in central and western Victoria from Stawell, Yan Yean, Eltham, and Bonegilla areas. It is usually found in open, grassy areas of dry woodland to forest. Locations of this species found in the current surveys in 2016 are new for the region.
Plump Swamp Wallaby-grass	*Amphibromus pithogastrus*	yes	no	**Low** Plump Swamp Wallaby-grass *Amphibromus pithogastrus* has been recorded just over 10 km's east of the study area (AVH 2017). This wetland grass is rarely collected and limited in its distribution.
Rough Wattle	*Acacia aspera subsp. parviceps*	no	yes	**Moderate** One record from 1993 in Snow Gum Bushland Reserve from a defined area list. Not found during searches of alignments but further searches outside of alignments may find this species. A number of records from Trawalla State Forest

COMMON NAME	SCIENTIFIC NAME	SPECIFIC OFFSET REQUIREMENT – GUIDELINES 2013	SPECIFIC OFFSET REQUIREMENT – GUIDELINES 2017	LIKELIHOOD OF OCCURRENCE
Slender Mint-bush	*Prostanthera saxicola var. bracteolata*	yes	no	**Low** Slender Mint-bush *Prostanthera saxicola var. bracteolata* is scattered across Victoria in heathland, dry sclerophyll forests and woodlands, often on rocky soils (RBGV 2020). The nearest location is near Maryborough, greater than 50 km north. It is considered to have a low likelihood of occurrence in the study area.
White Sunray	*Leucochrysum albicans subsp. tricolor*	no	yes	**Low** Very rare in Victoria, the only recent collections from roadside verges near Wickliffe, Willaura, Streatham, Inverleigh and Creswick. All other collections at MEL were gathered last century, from Mt Cole, the Grampians and the Port Fairy district. Limited habitat in study area; likely would have seen during surveys if present. Easy to detect when present.
Wimmera Scentbark	*Eucalyptus sabulosa*	no	yes	**Low** Occurs from the Grampians, west to the Little Desert. Nearest known record on the VBA is approx. 53 km west of the study area, near Ararat Hills Regional Park.
Yarra Gum	*Eucalyptus yarraensis*	yes	no	**Present** Extending west from Glengarry (near Traralgon) to Melbourne and north-west to Daylesford and Ararat. A number of new records found during surveys in 2015, 2016 and 2017. One previous record in VBA prior to surveys for the Beaufort Bypass.

6.6 FAUNA

6.6.1 FAUNA SPECIES RECORDED

A total of 160 native fauna species have been recorded in the study area across all surveys by WSP and GHD 2015 and including previous records from the VBA. These records include 127 birds, nine frogs, nine native mammals, six reptiles and one invertebrate. Of these species, 15 are of conservation significance (Table 6.13).

The full list of fauna species recorded is provided in Appendix B.

Table 6.13 Significant fauna species recorded within the study area during surveys and previous records

COMMON NAME	SCIENTIFIC NAME	EPBC ACT	FFG ACT	VICTORIAN ADVISORY LIST	SURVEY RESULT SUMMARY 2015–2017 AND PREVIOUS RECORDS
Australasian Shoveler	*Anas rhynchotis*			Vulnerable	One VBA record from study area
Blue-billed Duck	*Oxyura australis*		Listed	Endangered	One VBA record from study area
Brolga	*Grus rubicunda*		Listed	Vulnerable	Recorded by WSP in targeted surveys in 2015-2017
Brown Toadlet	*Pseudophryne bibronii*		Listed	Endangered	Recorded by WSP in 2015 surveys but not the 2016/2017 surveys
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*		Nominated	Near threatened	Recorded by WSP in woodland bird survey 2015
Brush-tailed Phascogale	*Phascogale tapoatafa*		Listed	Vulnerable	Recorded by WSP by trapping 2015
Diamond Firetail	*Stagonopleura guttata*		Listed	Near threatened	Has been recorded by land owner on property in study area (WSP | Parsons Brinckerhoff 2016b)
Eastern Great Egret	*Ardea alba modesta*		Listed	Vulnerable	One VBA record from study area
Eastern Long-necked Turtle	*Chelodina longicollis*			Data deficient	Recorded by WSP by trapping 2018
Emu	*Dromaius novaehollandiae*			Near threatened	One VBA record in the study area
Golden Sun Moth	*Synemon plana*	Critically Endangered	Listed	Critically Endangered	Recorded by WSP in targeted surveys in 2015-2017 and again in 2018. Not previously recorded in the study area

COMMON NAME	SCIENTIFIC NAME	EPBC ACT	FFG ACT	VICTORIAN ADVISORY LIST	SURVEY RESULT SUMMARY 2015–2017 AND PREVIOUS RECORDS
Growling Grass Frog	*Litoria raniformis*	Vulnerable	Listed	Endangered	Most recent VBA records are from 2011. Not recorded in targeted surveys in 2015-2017 but species could recolonise under the right conditions. Recorded in reference area in 2020.
Hardhead	*Aythya australis*			Vulnerable	Recorded by GHD in 2015 surveys
Painted Honeyeater	*Grantiella picta*	Vulnerable	Listed	Vulnerable	Has been recorded by land owner on property in study area (WSP | Parsons Brinckerhoff 2016b)
Powerful Owl	*Ninox strenua*		Listed	Vulnerable	Multiple VBA records, although not recorded during targeted surveys in 2015 (WSP | Parsons Brinckerhoff 2016b)
Squirrel Glider	*Petaurus norfolcensis*		Listed	Endangered	Recorded by WSP in targeted surveys in 2015 (WSP | Parsons Brinckerhoff 2016b)

6.6.2 THREATENED FAUNA TARGETED SURVEY RESULTS AND HABITAT

This section details the results of the targeted fauna surveys and provides a description of the known or potential habitat for the species with a moderate or higher likelihood of occurrence within the study area (refer Section 6.6.3). Note: woodland bird habitat is considered synonymous with the Temperate Woodland Bird ecological community (Section 6.6.4), and habitat for these species has not been mapped separately. Not all Species Distribution Models have been provided, however, for most key species, past and recent records and Species Distribution Models are mapped.

6.6.2.1 AUSTRALASIAN SHOVELER

The Australasian Shoveler *Anas rhynchotis* is a semi-nocturnal feeding duck with a specialised bill that enables it to filter insects, crustaceans and plants from the water. Due to the specialised nature of the bill, the species foraging range is limited to open water aquatic habitats or soft mud in fertile wetlands. Whilst the Australasian Shoveler prefers open water wetlands fringed by abundant aquatic vegetation, they can also be found in estuaries and sheltered inshore waters (Birdlife 2019).

Potential wetland habitat is present within the study and across all alignment options. There are several Australasian Shoveler VBA records in the area, including three within the study area itself. One of these records is located within three of the alignment options, where C2 diverges from A0 and A1. Another is in close proximity to alignment C0 and a third is just north of alignment A0 and A1 (refer to Figure 6.23 below). Whilst the species was not recorded during 2016–2017 WSP surveys, it was recorded during GHD surveys conducted in 2015.

6.6.2.2 BAILLON'S CRAKE

The Baillon's Crake *Porzana pusilla* is a small bird part of the rail and crake family. It usually inhabits fresh or brackish wetland habitats, preferring those with fringing and floating aquatic vegetation. Wetland habitats include swamps, billabongs, lakes, reservoirs and temporarily inundated areas. Baillon's Crake forage for insects, crustaceans and small invertebrates in areas of open mud and fringing vegetation at the margins of wetlands or from floating aquatic plants.

Baillon's Crake was not recorded during surveys conducted for this project. Despite this, there is suitable wetland habitat within the study area capable of supporting this species, especially alignment C0 where high-quality waterbird habitat was mapped. In addition, recent VBA records from 2018 suggest the species is present in close proximity, recorded approximately 2 km south of the study area (refer to Figure 6.23 below).

6.6.2.3 BLUE-BILLED DUCK

The Blue-billed Duck *Oxyura australis* is a compact diving duck that feeds on aquatic vegetation and invertebrates by filtering food from mud. It is an almost entirely aquatic species, preferring deep permanent open water, within or near dense vegetation. They can be found on temperate, fresh to saline, terrestrial wetlands, as well as artificial wetlands, and nest in rushes, sedge, Lignum and paperbark Melaleuca, generally over water (Garnett & Crowley 2000).

Whilst the Blue-billed Duck was not recorded during the surveys undertaken for this project, potential wetland habitat is present within the study area and across all alignment options (refer to Figure 6.23 below). Previous VBA records, as recent as 2018, occur approximately 1.3 km south of the study area and one VBA record is located within three of the alignment options, where C2 diverges from A0 and A1.

6.6.2.4 BROLGA

The Brolga *Grus rubicunda* is an omnivorous bird and one of Australia's two crane species. It occurs across tropical northern Australia and throughout much of Queensland, New South Wales and Victoria. The Victorian Brolga population is estimated to be between 600–650 birds (DuGuesclin 2003; Moles et al. 2010). The Brolga has a large (average 232 ha) but varied home range (70ha – 523ha) (Veltheim, Inka et al. 2019), and uses a variety of habitat at different times of the year. The primary habitat during the breeding period (July – December) is freshwater meadows or shallow freshwater marshes. During the non-breeding season, they will use a variety of habitats including permanent open water (dams) and feed in pastures. Brolgas are known to pair for life and will use the same nesting sites for up to 20 years (Group 2017).

A pair of Brolgas were consistently seen at wetlands and waterbodies throughout the wider study area. Brolga were recorded during the 2015 surveys conducted by WSP (WSP | Parsons Brinckerhoff 2016b). Records of Brolga observed during this study were located within wetlands of the Yam Holes Creek valley particularly in the following key locations:

- wetlands either side of Racecourse Road
- a pair of Brolga in a dam south the Snow Gums Bushland Reserve (refer to Photo 6.13)
- wetland north of Smiths Lane

Wetlands and waterbodies within and adjacent to the study area are likely to be used on a seasonal basis for foraging and possibly for breeding. Specifically, potential high value and moderate wetland Brolga habitat was mapped throughout the Yam Holes Creek overlapping many but not all high and some moderate value wetlands, described Section 6.4.4. Section 4.5.7.3 describes high value/quality habitat for Brolga mapped larger and more intact waterbodies with longer inundation hydroperiods which have a higher likelihood of use for breeding, foraging and roosting. Moderate value/quality habitat are smaller waterbodies and wetland areas typically with shorter inundation hydroperiods which have a lower likelihood of use for breeding, foraging and roosting.

Mapped habitat and records of the species are shown on Figure 6.23. Survey details are provided in Table 6.14.

Table 6.14 Brolga surveys

DATE	TIME	LOCATION	BROLGA	TEMP (°C)	HUMIDITY (%)	CLOUD COVER
30/11/2016	1145	Dam west of Snow Gums	2	13	70	FEW
16/1/2017	0915	Dam south of Snow Gums	2	21	41	NSC
17/1/2017	1100	Wetland between Racecourse Rd and Beaufort Lexton Rd	2	19.3	43	NSC
10/1/2017, 17/2/2017	n/a	Incidental sightings of Brolga in wetlands north of Smiths Lane	n/a	n/a	n/a	n/a

Legend: NSC = No significant cloud**;** FEW = Few; SCT = Scattered; BKN = Broken; OVC = Overcast

Photo 6.13 Brolga – photo taken in study area (2016)

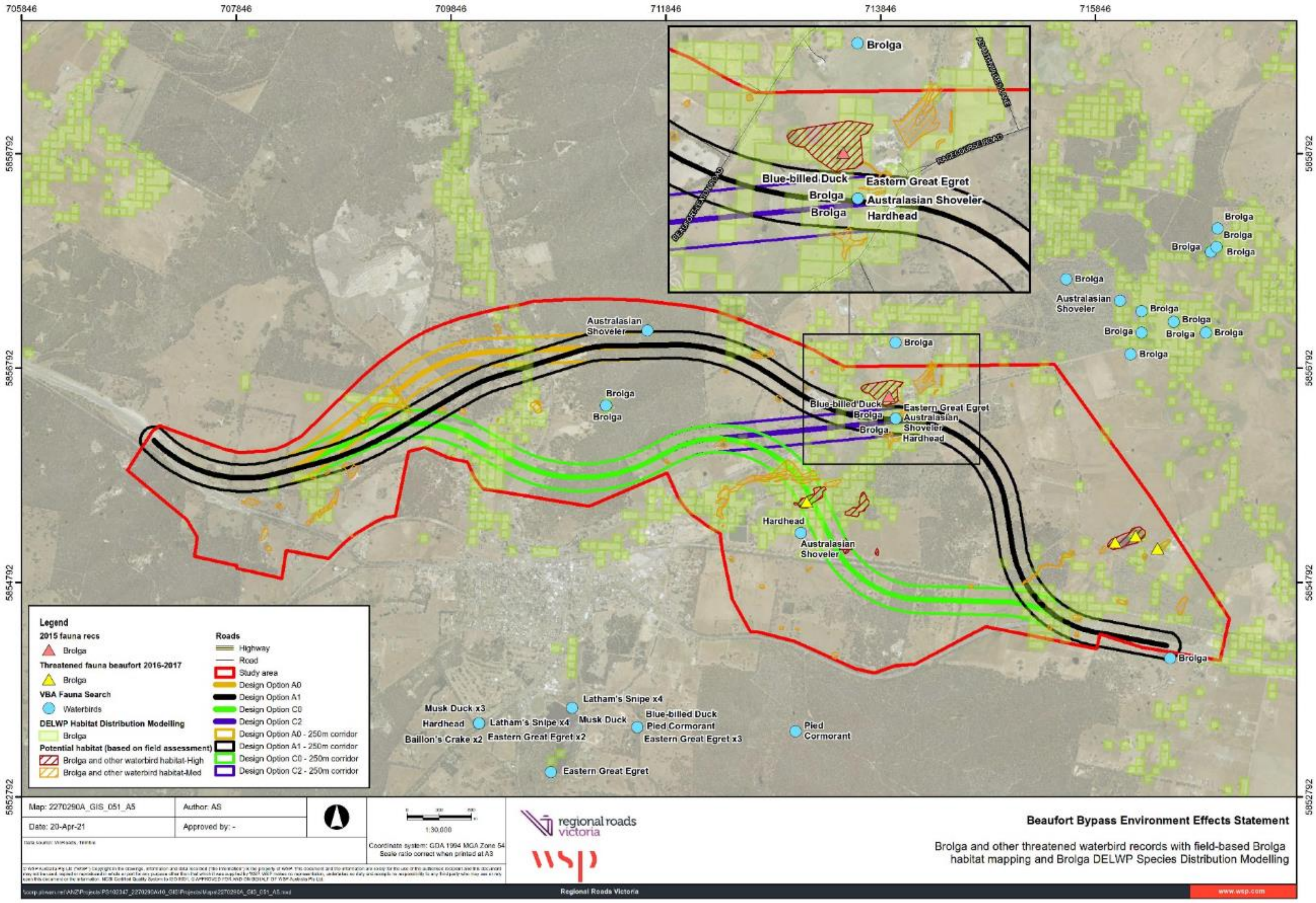


Figure 6.23 Records of Brolga and other threatened waterbirds that have a moderate or higher likelihood of occurrence with Brolga habitat mapping and DELWP Species Distribution Modelling

6.6.2.5 BROWN TOADLET

Brown Toadlet *Pseudophryne bibroni* is a small, secretive autumn-breeding frog found across most of south-east Australia. It usually breeds following heavy summer rains with eggs laid in small depressions (Tyler & Knight 2009) near water that will later be flooded (ARC 2020). The habitat of Brown Toadlet is typically dry forest, woodland, shrubland and grassland where they shelter in moist depressions and soaks such as drainage lines and small dams. There are a number of drainage lines and waterbodies within/or adjacent to the study area which provide these habitat characteristics. Declines of Brown Toadlet have been noticed over the past decade or so although robust populations have been recorded in western Victoria (Heatwole & Rowley 2018).

Habitat for Brown Toadlet has been mapped in the study area. Additionally, the species was recorded during previous surveys conducted in 2015 (WSP | Parsons Brinckerhoff 2016b) and surveys for the Western Highway duplication from Beaufort to Ararat. Refer to Figure 6.24 below for the locations of Brown Toadlet habitat and records within the Study Area.

No Brown Toadlet were recorded (seen or heard) during the surveys conducted for this species and Growling Grass Frog (2016–2017), however, it is considered that they are still present in the study area.

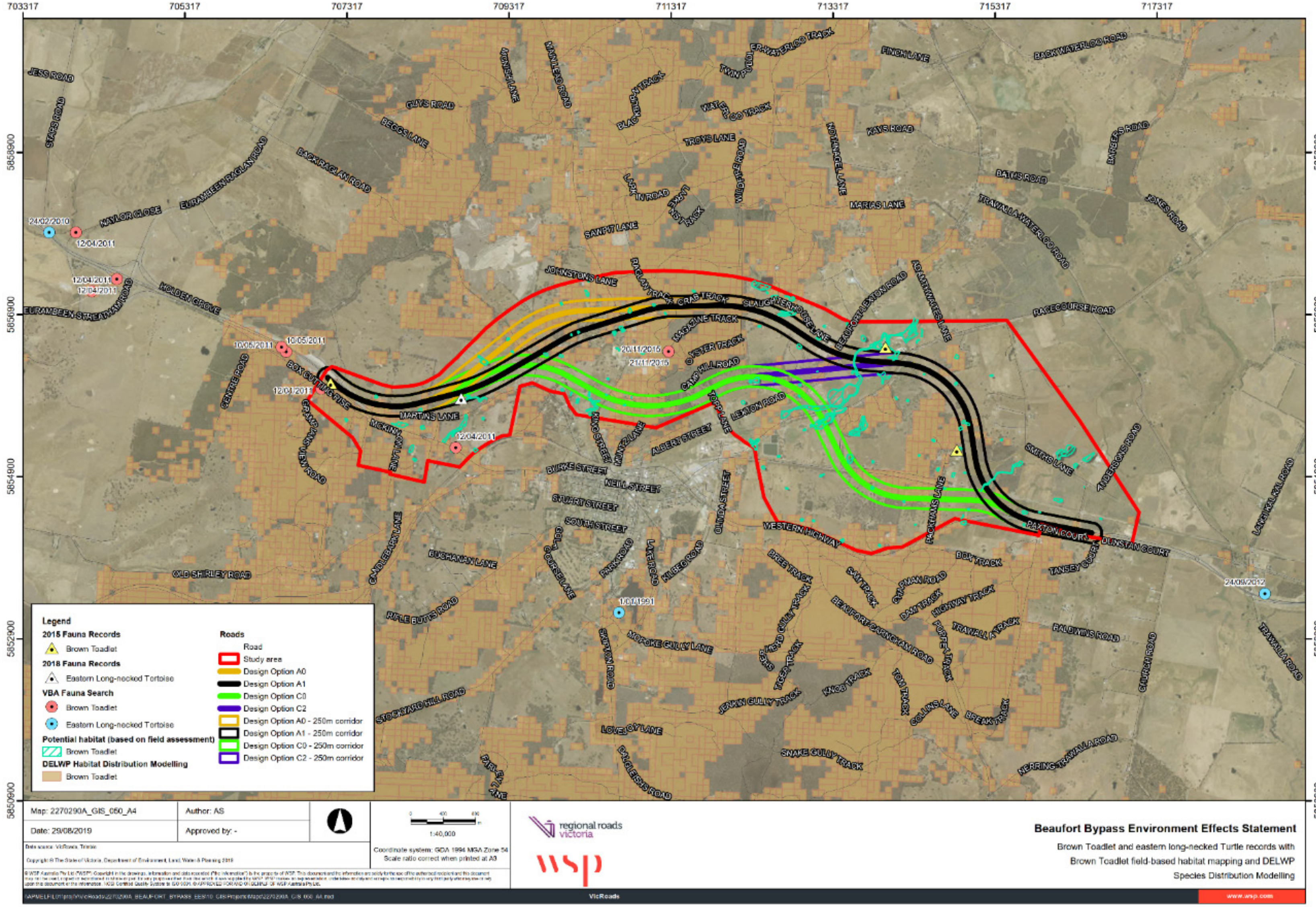


Figure 6.24 Brown Toadlet and Eastern Long-necked Turtle records with Brown Toadlet field-based habitat mapping and DELWP Species Distribution Modelling

6.6.2.6 BROWN TREECREEPER

The Brown Treecreeper (south-eastern ssp.) *Climacteris picumnus victoriae* is the largest of Australia's treecreeper birds. It is found in eucalypt woodlands and dry open forests of the inland slopes and plains inland of the Great Dividing Range. It mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts and nests in tree hollows (Department of Environment and Conservation 2005). The Brown Treecreeper climbs up tree trunks and branches in search for food under loose bark and in cavities, but it often spends just as much time foraging on the forest ground where it gathers insects and other invertebrates from amongst the leaf litter (Birdlife Australia 2019a). The Brown Treecreeper is one of the 24 species that makes up the FFG Act listed Victorian Temperate Woodland Bird Community (refer to Section 6.6.4).

Within the study area, potential habitat for this species has been mapped as Victorian Temperate Woodland Bird Community. All four alignments intersect patches of this community which occur in areas such as Camp Hill State Forest, road reserves and private property within and adjacent to all the alignment options.

There are several VBA records for this species within the area, eight of which are located within the study area itself. In addition, the species was recorded in a patch of habitat in the north-west end of the study area, just north of alignment A0, during the 2015 surveys conducted by WSP (WSP | Parsons Brinckerhoff 2016b).The extent of potential habitat, mapped as Victorian Temperate Woodland Bird Community and the records for this species are shown below in Figure 6.32.

6.6.2.7 BRUSH-TAILED PHASCOGALE & SQUIRREL GLIDER

The Brush-tailed phascogale *Phascogale tapoatafa* is a nocturnal tree dwelling marsupial that inhabits a range of environments with a preference for dry sclerophyll forest with sparse groundcover. The Brush-tailed Phascogale forages in trees, particularly rough barked Eucalypts, feeding on invertebrates and nectar, and builds its nests in hollow branches and stumps (Menkhorst, P & Knight 2004). The Squirrel Glider *Petaurus norfolcensis* is a nocturnal marsupial with distinctive membranes of skin between their front and hind legs that enable them to glide between trees. They are omnivorous mammals, feeding primarily on insects but also on pollen, nectar, sap and eggs. Similarly to the Brush-tailed Phascogale, the Squirrel Glider inhabits dry sclerophyll forest environments, usually on inland slopes and near riverine corridors (Menkhorst, P & Knight 2004).

Potential habitat for Brush-tailed Phascogale and Squirrel Glider is present within all four alignment options where they intersect areas of mature native vegetation i.e. Camp Hill State Forest, road reserves and, private property within and adjacent to all the alignment options. Note that there is no Species Distribution Model coverage for Squirrel Glider in this location.

Both Brush-tailed Phascogale and Squirrel Glider were initially recorded during the 2015 surveys (WSP | Parsons Brinckerhoff 2016b), shown in Figure 6.25. However, hair tube, camera trap and spotlight surveys conducted in 2016 and 2017 did not record either species (see Table 6.15, Table 6.16 and Table 6.17).

Recently though, camera surveys and Elliot trapping undertaken in 2021 recorded multiple sightings and captures of Brush-tailed phascogale. Across the 47 cameras, there were 92 occurrences of Brush-tailed Phascogale. A majority of these occurred within Camp Hill State Forest or on private properties that were located in close proximity. Other nocturnal mammals recorded on camera included Sugar Gliders, Feathertail Gliders, Brushtail and Ringtail Possums, Antechinus, Microbats and one exotic species, Black Rat (see photos in Table 6.20). In addition, six Brush-tailed Phascogales were captured at four different Elliot trap locations during the survey period. One phascogale was recorded within Camp Hill State Forest itself, the other five were recorded in adjacent private properties that were contiguous with Camp Hill State Forest. There was also strong evidence to suggest that Brush-tail Phascogale was present along Back Ragland Road (E12). This closed but empty trap contained long dark hairs, small scat and a strong scent that had previously been identified when Elliot traps contained Phascogales (refer to bottom right photo in Table 6.21). Eighteen Sugar Gliders were the only other species to be captured during Elliot trap surveys. Refer to Table 6.18, Table 6.19 and Figure 6.26 and Figure 6.27 for detailed results of the 2021 surveys.

Unlike the Brush-tailed Phascogale, Squirrel Gliders were not detected during 2021 surveys. It is possible that the the Squirrel Glider initially recorded during the 2015 surveys was a misidentified Sugar Glider given that the nerest VBA records occur near Ararat over, 41 km north-west of the study area (DELWP 2021). However, Squirrel Gliders are cryptic and their population densities are low (Menkhorst, PW 1996). As such, the lack of records during the current study does not imply that they are not present.

The tables and photographs below detail the outcomes of all the surveys that have been undertaken by WSP from 2016–2021.

Table 6.15 2016 Hair tube survey results

DATE	LOCATION	SPECIES
2/12/2016 – 16/12/2016	McKinnon Lane	No valid hairs collected
2/12/2016 – 16/12/2016	Old Western Highway	No valid hairs collected
2/12/2016 – 16/12/2016	Martins Lane	No valid hairs collected

Table 6.16 2016 Camera trap survey results

DATE	LOCATION	SPECIES
2/12/2016 – 16/012/2016	Cam 1. McKinnon Lane	–
2/12/2016 – 16/012/2016	Cam 2. Old Western Highway	Eastern Grey Kangaroo
2/12/2016 – 16/012/2016	Cam 3. Martins Lane	–

Table 6.17 2017 Spotlight survey results

DATE	TIME	LOCATION	SPECIES	TEMP (°C)	HUMIDITY (%)	CLOUD COVER
16/01/2017	2130 – 2230	Spot 4	Sugar Glider; Brushtail Possum & Tawny Frogmouth	21	41	No significant cloud

Table 6.18 2021 Elliot trap survey results

ELLIOT TRAP NUMBER	DATE	SPECIES	SEX	ANIMAL WEIGHT (G)	FEMALE REPRODUCTIVE CONDITION	TAIL TIP COLOUR	UPPER INCISOR WEAR	NOTES
E23	15/03/2021	Sugar Glider	F	115	Lactating	White	2.5	
E24	15/03/2021	Phascogale	F	132	First year female	-	N/A	Teeth not worn, pouch under-developed and tail base bony. No injuries.
E32	15/03/2021	Phascogale	M	182	-	-	NA	
E14	15/03/2021	Sugar Glider	F	135	Recently bred	Grey/black	3	
E22	15/03/2021	Sugar Glider	F	125	Recently bred	White	3	
E23	16/03/2021	Sugar Glider	M	135	-	Grey/black	3	
E24	16/03/2021	Phascogale	M	190	-	-	N/A	Tail quite bony. No injuries.

ELLIOT TRAP NUMBER	DATE	SPECIES	SEX	ANIMAL WEIGHT (G)	FEMALE REPRODUCTIVE CONDITION	TAIL TIP COLOUR	UPPER INCISOR WEAR	NOTES
E29	16/03/2021	Phascogale	M	207	-	-	N/A	No injuries
E14	16/03/2021	Sugar Glider	F	140	Recently bred	Grey/black	3	
E22	16/03/2021	Sugar Glider	M	92	-	Grey/black	1.5	
E5	17/03/2021	Sugar Glider	M	165	-	White	2.5	Tiny nick on upper margin of the left ear
E23	17/03/2021	Sugar Glider	F	120	Lactating	White	2.5-3	
E28	17/03/2021	Sugar Glider	M	127	-	White	1.5	
E14	17/03/2021	Sugar Glider	F	147	Recently bred	Grey/black	2.5-3	
E22	17/03/2021	Sugar Glider	M	123	-	Grey/black	2.5 to 3	
E3	18/03/2021	Sugar Glider	M	163	-	Grey/black	3	
E5	18/03/2021	Sugar Glider	F	130	Adult not breeding	Grey/black	2.5	
E23	18/03/2021	Sugar Glider	F	123	Lactating	White	1.5-2	
E24	18/03/2021	Phascogale	M	200	-	-	N/A	
E28	18/03/2021	Sugar Glider	M	135	-	White	1	
E34	18/03/2021	Phascogale	M	214	-	-	N/A	
E29	18/03/2021	Sugar Glider	M	152	-	Grey/black	2.5-3	
E15	18/03/2021	Sugar Glider	F	145	Carrying young	White	2	One jelly-bean size pouch young
E22	18/03/2021	Sugar Glider	F	120	Recently bred	White	3	

Upper incisor wear - adopted from (Suckling 1984)

1-2 No appreciable wear

2-3 Slight to moderate wear, sometimes cracked

3-3.5 Moderately-heavy wear, often cracked

3.5-4 Very heavy wear, uslly cracked

Table 6.19 2021 Camera trap survey results

CAMERA POINT	BRUSH-TAILED PHASCOGALE OBSERVATIONS	FEATHERTAIL GLIDER OBSERVATIONS	SUGAR GLIDER OBSERVATIONS	BRUSHTAIL POSSUM OBSERVATIONS	RINGTAIL POSSUM OBSERVATIONS	ANTECHINUS SPP. OBSERVATIONS	BLACK RAT OBSERVATIONS	MICROBAT OBSERVATIONS	UNIDENTIFIED MAMMAL OBSERAVATIONS	SOUTHERN BOOBOOK OBSERVATIONS	TAWNY FROG MOUTH OBSERVATIONS
C1											
C2		1	15		18						
C3			15	6		1	9				
C4			18								
C5			17	4	8						
C6			21		2						
C7			22								
C8			13	16							
C9	1		6				2			1	
C10			10								
C11			6								
C12		1	4				5		2		
C13			5								
C14			1								
C15			1								
C16	2		19	1							
C17	3		19	4							
C18	4			7				1			
C19	6		12	3							
C20	1		2								
C21											
C22	3		3	6							3
C23	9		9	9							
C24			3			1			1		

CAMERA POINT	BRUSH-TAILED PHASCOGALE OBSERVATIONS	FEATHERTAIL GLIDER OBSERVATIONS	SUGAR GLIDER OBSERVATIONS	BRUSHTAIL POSSUM OBSERVATIONS	RINGTAIL POSSUM OBSERVATIONS	ANTECHINUS SPP. OBSERVATIONS	BLACK RAT OBSERVATIONS	MICROBAT OBSERVATIONS	UNIDENTIFIED MAMMAL OBSERAVATIONS	SOUTHERN BOOBOOK OBSERVATIONS	TAWNY FROG MOUTH OBSERVATIONS
C25	13		5	1		2					
C26		2	4	2		1					
C27	11		16								
C28			10								
C29	1		11			7					
C30	2		7								
C31	4		12	1							
C32	5		9		1	3			1		
C33	1		9	2							
C34	3		7						1	1	
C35	3		1								
C36	10										
C37	3	1	15								1
C38	1		5								
C39	4		1								
C40											
C41			18								
C42			12				3		1		
C43			9								
C44			23								
C45			2								
C46	2	1	7								
C47			17								
Grand Total	**92**	**6**	**421**	**62**	**29**	**15**	**19**	**1**	**6**	**2**	**4**

Table 6.20 Photos from the 2021 camera surveys

	
Brush-tailed Phascogale - captured on 13/03/21 (C33)	Feathertail Glider – captured on 19/02/21 (C12)
	
Brushtail Possum – captured 22/02/21 (C8)	Sugar Glider – captured 14/03/21 (C33)
	
Southern Boobook Owl – captured on 24/02/21 (C34)	Tawny Frogmouth – captured on 28/02/21 (C22)

Table 6.21 Photos from the 2021 Elliot Trap Surveys

	
Female Brush-tail Phascogale caught in Elliot trap E24 on 15/03/21 (left) and being processed (right)	
	
Releasing a Sugar Glider captured at Site E22 near Snowgums Woodland Reserve	Elliot trap (E12) was closed but empty and contained dark hair, similar to that of a Brush-tailed Phascogale tail, small scat and a strong scent indicative of Brush-tailed Phascogale presence at this site.

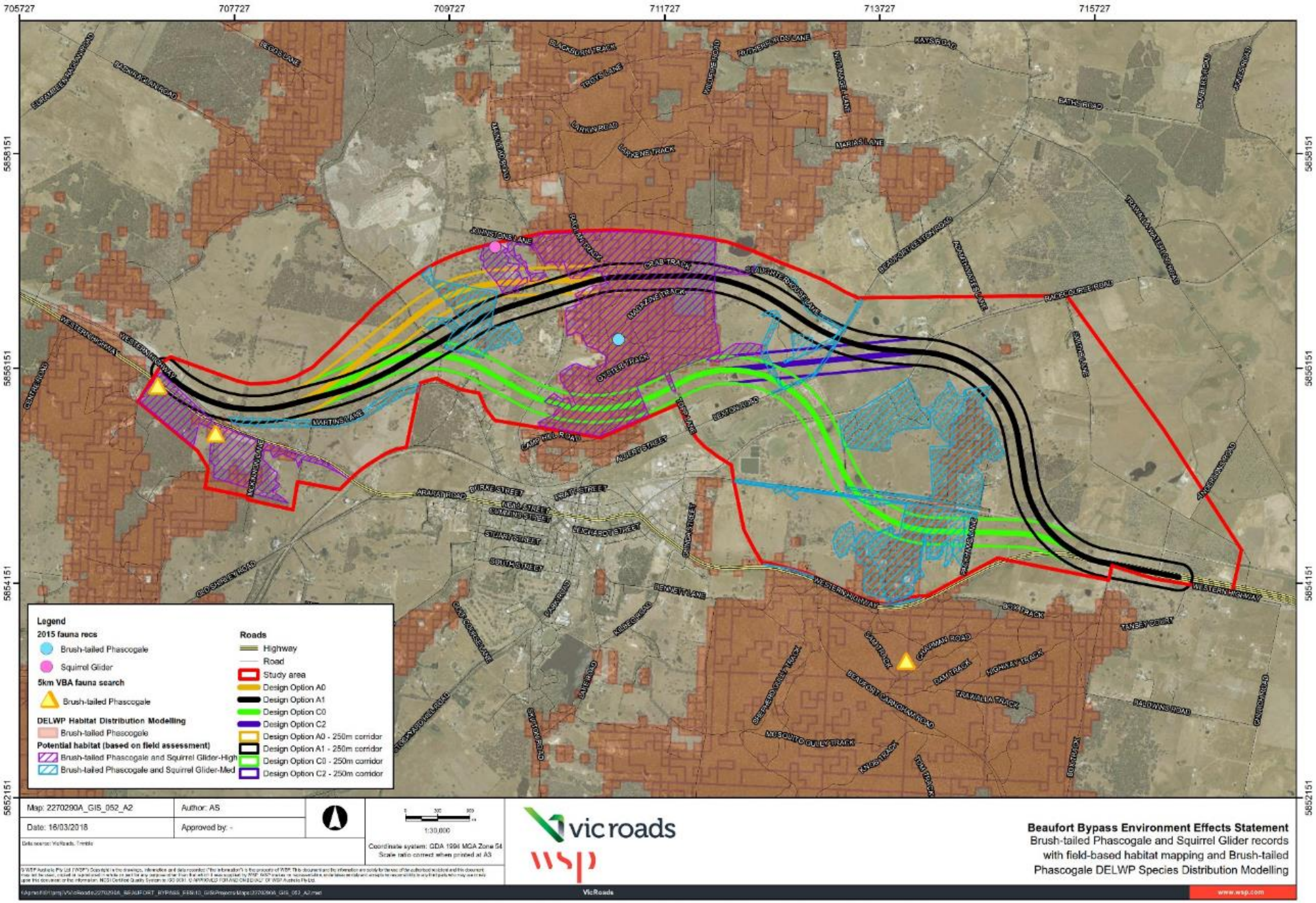


Figure 6.25 2015 survey results for Brush-tailed Phascogale and Squirrel Gliders. Records shown with field-based habitat mapping and Brush-tailed Phascogale DELWP Species Distribution Modelling

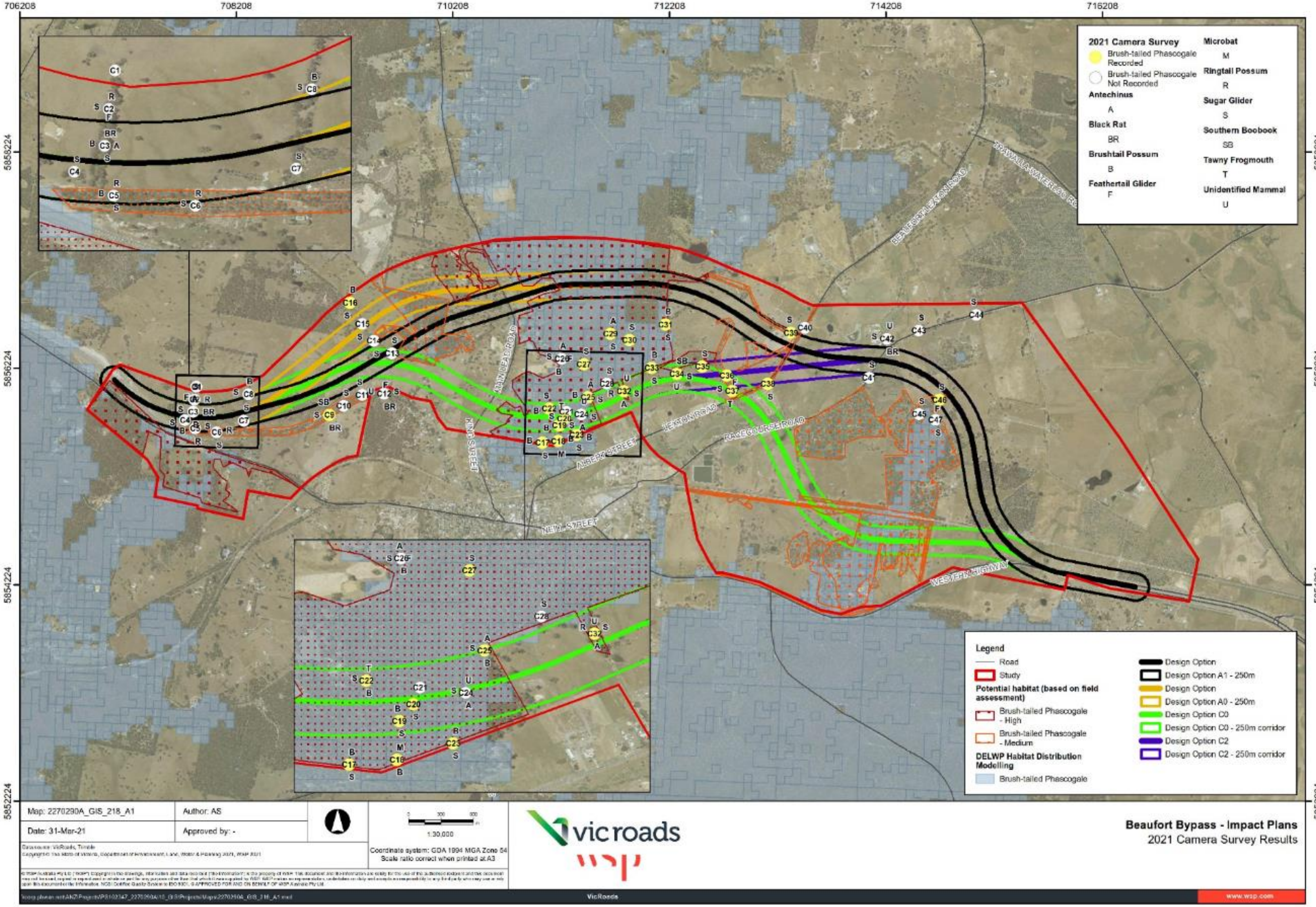


Figure 6.26 2021 camera trapping results for Brush-tailed Phascogale and Squirrel Gliders. Records shown with field-based habitat mapping and Brush-tailed Phascogale DELWP Species Distribution Modelling

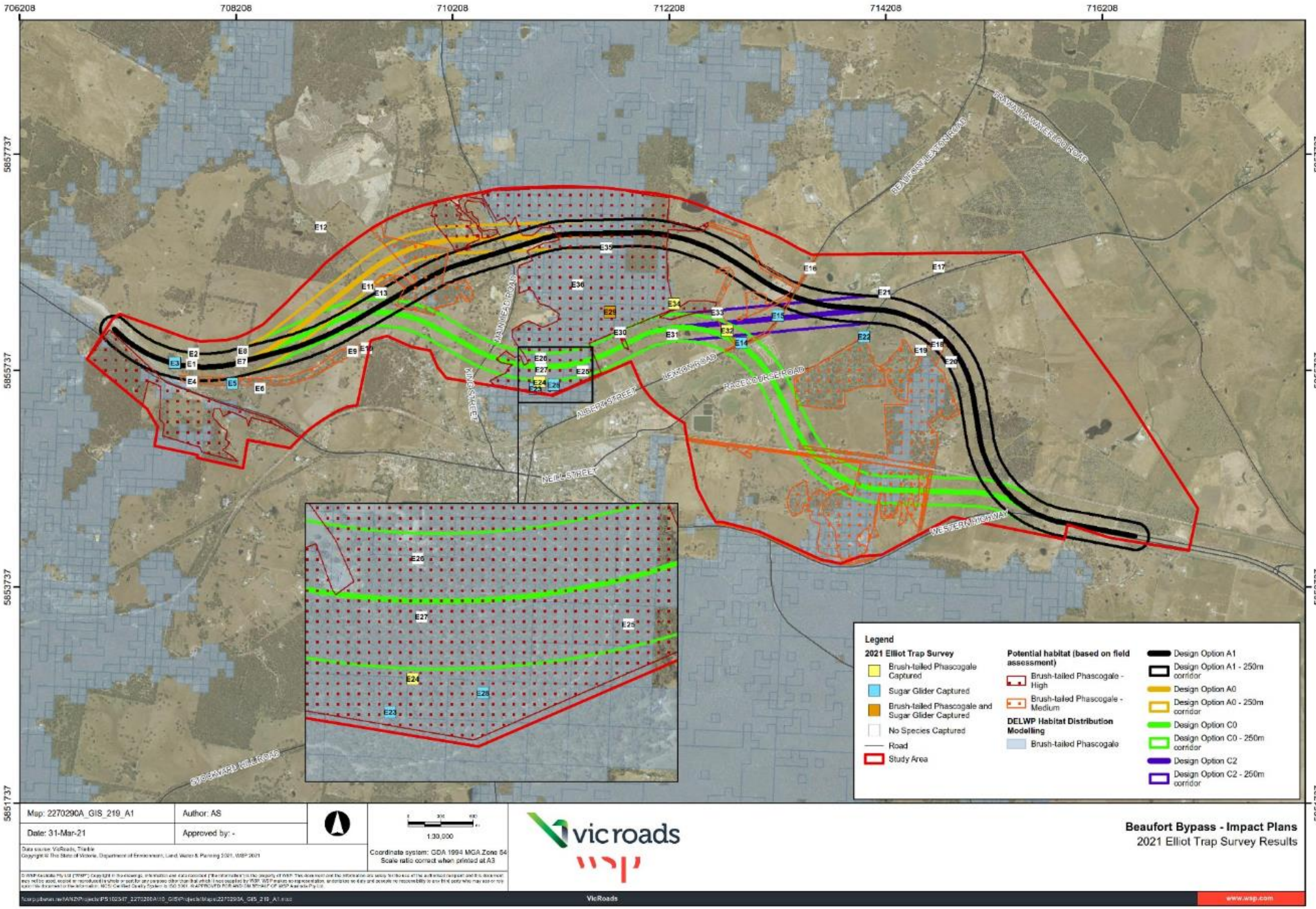


Figure 6.27 2021 Elliot trapping results for Brush-tailed Phascogale and Squirrel Gliders. Records shown with field-based habitat mapping and Brush-tailed Phascogale DELWP Species Distribution Modelling

6.6.2.8 DIAMOND FIRETAIL

The Diamond Firetail *Stagonopleura guttata* is as small woodland bird that is endemic to south-eastern Australia. It occurs in a range of eucalypt dominated communities with a grassy understorey including woodland, forest and Mallee. Firetails nest in trees and bushes, and forage on the ground, largely for grass seeds and other plant material, but also for insects (Blakers, Davies & Reilly 1984; Read 1994). The Diamond Firetail is one of the 24 species that makes up the FFG Act listed Victorian Temperate Woodland Bird Community (refer to Section 6.6.4).

Within the study area, potential habitat for this species have been mapped as Victorian Temperate Woodland Bird Community. Such habitat exists across the entire study area, in Camp Hill State Forest, road reserves and private property within and adjacent to all the alignment options (refer to Figure 6.32 below).

The species has not been recorded during surveys for this project. Although unconfirmed, a local landowner has provided reasonably reliable records of Diamond Firetail on their property, located in the north of the study area, west of Camp Hill State Forest on Johnston's Lane (Johnston, H. pers. comm. Nov 2015).

6.6.2.9 EASTERN GREAT EGRET

Eastern Great Egret *Ardea alba modesta* is a large bird, commonly found throughout Australia. They prefer shallow water, particularly when flowing, but may be seen on any watered area, including damp grasslands. While fish make up the majority of a Great Egrets diet, they also feed on molluscs, amphibians, aquatic insects and small reptiles. Great Egrets can be seen alone or in small flocks, often with other egret species, and roost at night in groups (Birdlife, 2019).

No Eastern Great Egrets were recorded during any of the current or previous surveys conducted for this project. However, potential wetland habitat is present within the study area and a VBA search has returned Eastern Great Egret records from 2019, located approximately 1.3 km south of the study area. There are also VBA records of the species within three of the alignment options, where C2 diverges from A0 and A1 (refer to Figure 6.23 above).

6.6.2.10 EASTERN LONG-NECKED TURTLE

The Eastern Long-necked Turtle or Eastern Snake-necked Tortoise *Chelodina longicollis* is a species of turtle that inhabits a wide variety of freshwater habitats across eastern Australia including wetlands, rivers, dams and lakes. Whilst they can move overland in search for new habitats, the Eastern Long-necked Turtle spends most of its time in aquatic environments where it feeds on aquatic invertebrates, tadpoles and small fish (Australian Museum 2019)

One shell of a dead Eastern Long-necked Turtle was found in wetlands north of Martins Lane in January 2018 (refer to Figure 6.24 above). Previous surveys in 2015, 2016, 2017 and 2018 undertaken throughout wetlands across the study area for flora and fauna assessments had not recorded Eastern Long-necked Turtle. Therefore, it is likely that the species occurs in low numbers in the area.

Photo 6.14 Shell of Eastern Long-necked Turtle recorded in study area near Martins Lane (2018)

6.6.2.11 EMU

Endemic to Australia, the Emu *Dromaius novaehollandiae* is the country's tallest bird. A highly nomadic bird, Emu's have an extensive distribution across the mainland occurring from coastal regions through to higher elevations where they inhabit sclerophyll forests, savanna woodlands and open country environments. They are mostly found in flat undulating lands but also on timbered ridges, tablelands and moderately hilly terrain (Marchant & Higgins 1990). Emu's are omnivorous, feeding on seeds and shoots, fruit, insects and small animals (Birdlife 2019). Emu's have a tendency to nest in areas of extensive cover where disturbance is infrequent, avoiding areas frequently disturbed by human activity (Marchant & Higgins 1990). Given the species wide distribution, habitat for the emu was not mapped. Whilst the species was not recorded during surveys, there are two previous VBA records along the southern study area boundary (shown on Figure 6.32) and there is suitable habitat within the study area to support this species.

6.6.2.12 GOLDEN SUN MOTH

The Golden Sun Moth *Synemon plana* is as medium sized day-flying moth that occurs in New South Wales, Australian Capital Territory and Victoria. Habitat for the Golden Sun Moth includes areas which have, or once had, native grasslands or grassy woodlands (including derived grasslands) and includes degraded grasslands that are dominated by introduced Chilean Needlegrass *Nassella neesiana*. Inter-tussock space is also an important habitat characteristic required for Golden Sun Moth (Department of Environment Water Heritage and the Arts 2009b).

Golden Sun Moth was first identified in the Beaufort region in 2015 (WSP | Parsons Brinckerhoff 2016b). Surveys conducted in 2017 and 2018 did not observe Golden Sun Moth flying at the properties where they were observed in 2015. However, a population was recorded at three new locations along Racecourse Road (see Table 6.22). Records of Golden Sun Moth during the current study were located along fencelines close to Racecourse Road and occurred in treeless grassy paddocks dominated by native grasses including Kneed Wallaby-grass *Rytidosperma geniculatum,* Copper-awned Wallaby-grass *Rytidosperma fulvum,* Kangaroo Grass *Themeda triandra* and Common Wallaby-grass, *Rytidosperma caespitosum.* These are typically patches of native grassland or treeless grassy woodland dominated by wallaby grasses *Rytidosperma spp*. and spear grasses *Austrostipa spp*. with open inter-tussock spaces (DEWHA 2009a). These patches were typically close to the treed roadside vegetation and preferred habitat with a high proportion of Golden Sun Moth feed species with optimum biomass levels tended to drop off approximately 30m away from fences where annual grasses replaced preferred habitat.

The records from 15 December 2016 were on a windy day with winds up to 30km (Ballarat weather station), which are usually too high to detect Golden Sun Moth. As such, they were flying low to the ground in unimproved pasture adjacent to grassy woodland remnants along Racecourse Road.

Incidental surveys in 2018 on 7 and 12 December 2018 recorded a number of Golden Sun Moth in previous and new locations, reflecting the 'bumper season' where a number of locations of Golden Sun Moth were found in areas across Victoria not previously recorded, evidenced through the DELWP endorsed Golden Sun Moth email group. Areas of mapped habitat within the study area were classified according to categories in Table 4.10 and are shown on the map in Figure 6.28 below. Habitat areas were updated following incidental surveys in 2018. These areas contain treeless grassy paddocks dominated by native grasses including Kneed Wallaby-grass, Copper-awned Wallaby-grass, Kangaroo Grass and Common Wallaby-grass, also consistent with preferred habitat (DEWHA 2009a).

Surveys by Practical Ecology on 22/11/2018 and 1/12/2018 on the private property west of Site 10 on Figure 6.28 recorded many Golden Sun Moth (Paul Guest and Lincoln Kern pers. comm.), further confirming extensive habitat mapped in this area.

Table 6.22 Active search and incidental records 2015–2018

DATE	TIME	SITE	COUNT	TEMP C	HUMIDITY (%)	WIND SPEED	OBSERVER
29/11/2015		Site 9	20 male	22	-	17 km N	RG
30/11/2015	11:00 - 11:35	Reference site	1 male	23	-	11 km SSW	RG
30/11/2015	11:00 - 11:35	Reference site	30 male	23	-	11 km SSW	RG
30/11/2015	11:00 - 11:35	Reference site	1 male	23	-	11 km SSW	RG
15/12/2016	11:00 - 2:00	Site 2	3 male	18.4	39	30 km/SE	NM
15/12/2016	11:00 - 2:00	Site 2	2 male	18.4	39	30 km/SE	NM
15/12/2016	11:00 - 2:00	Site 2	1 male	18.4	39	30 km/SE	NM
15/12/2016	11:00 - 2:00	Site 2	5 male	18.4	39	30 km/SE	NM
15/12/2016	11:00 - 2:00	Site 2	2 male	18.4	39	30 km/SE	NM
15/12/2016	11:00 - 2:00	Site 3	1 male	18.4	39	30 km/SE	NM
15/12/2016	11:00 - 2:00	Site 3	1 male	18.4	39	30 km/SE	NM
15/12/2016	11:00 - 2:00	Site 6	1 male	18.4	39	30 km/SE	NM
16/1/2017	1400 - 1430	Site 1	None recorded	30	22	14 km/NNW	RG
16/1/2017	1215 - 1240	Reference site	None recorded	27	28	16 km/NNW	RG
1/12/2017	10:30 – 1100	Reference site	None recorded	21	41	3 km/NNW	RG
1/12/2017	1100 - 1135	Site 1	None recorded	21	41	3 km/NNW	RG
1/12/2017	1150 - 1125	Site 2	None recorded	21	41	11 km/SSW	RG
7/12/2018	12:00 - 2:00	Site 11	2 male	34.6	15	30 km NNW	SV
7/12/2018	12:00 - 2:00	Site 3	1 male	34.6	15	30 km NNW	SV
7/12/2018	12:00 - 2:00	Site 3	1 male	34.6	15	30 km NNW	SV
7/12/2018	12:00 - 2:00	Site 3	1 male	34.6	15	30 km NNW	SV
7/12/2018	12:00 - 2:00	Site 10	3 male	34.6	15	30 km NNW	SV
7/12/2018	12:00 - 2:00	Site 10	2 male	34.6	15	30 km NNW	SV
7/12/2018	12:00 - 2:00	Site 10	1 male	34.6	15	30 km NNW	SV
7/12/2018	12:00 - 2:00	Site 10	1 male	34.6	15	30 km NNW	SV
7/12/2018	12:00 - 2:00	Site 11	4 male	34.6	15	30 km NNW	SV
7/12/2018	12:00 - 2:00	Site 11	3 male	34.6	15	30 km NNW	JU
7/12/2018	12:00 - 2:00	Site 10	2 male	34.6	15	30 km NNW	JU
7/12/2018	12:00 - 2:00	Site 10	6 male	34.6	15	30 km NNW	JU
7/12/2018	12:00 - 2:00	Site 10	3 male	34.6	15	30 km NNW	JU
7/12/2018	12:00 - 2:00	Site 10	6 male	34.6	15	30 km NNW	JU
7/12/2018	12:00 - 2:00	Site 3	2 male	34.6	15	30 km NNW	JU
7/12/2018	12:00 - 2:00	Site 3	2 male	34.6	15	30 km NNW	JU
7/12/2018	12:00 - 2:00	Site 3	3 male	34.6	15	30 km NNW	JU
12/12/2018	3:00 - 3:30	Site 10	1 female	30.3	30	28 km NNE	JP

Photo 6.15 Golden Sun Moth male on private land along Racecourse Road (left) and female Golden Sun Moth near Martins Lane (right)

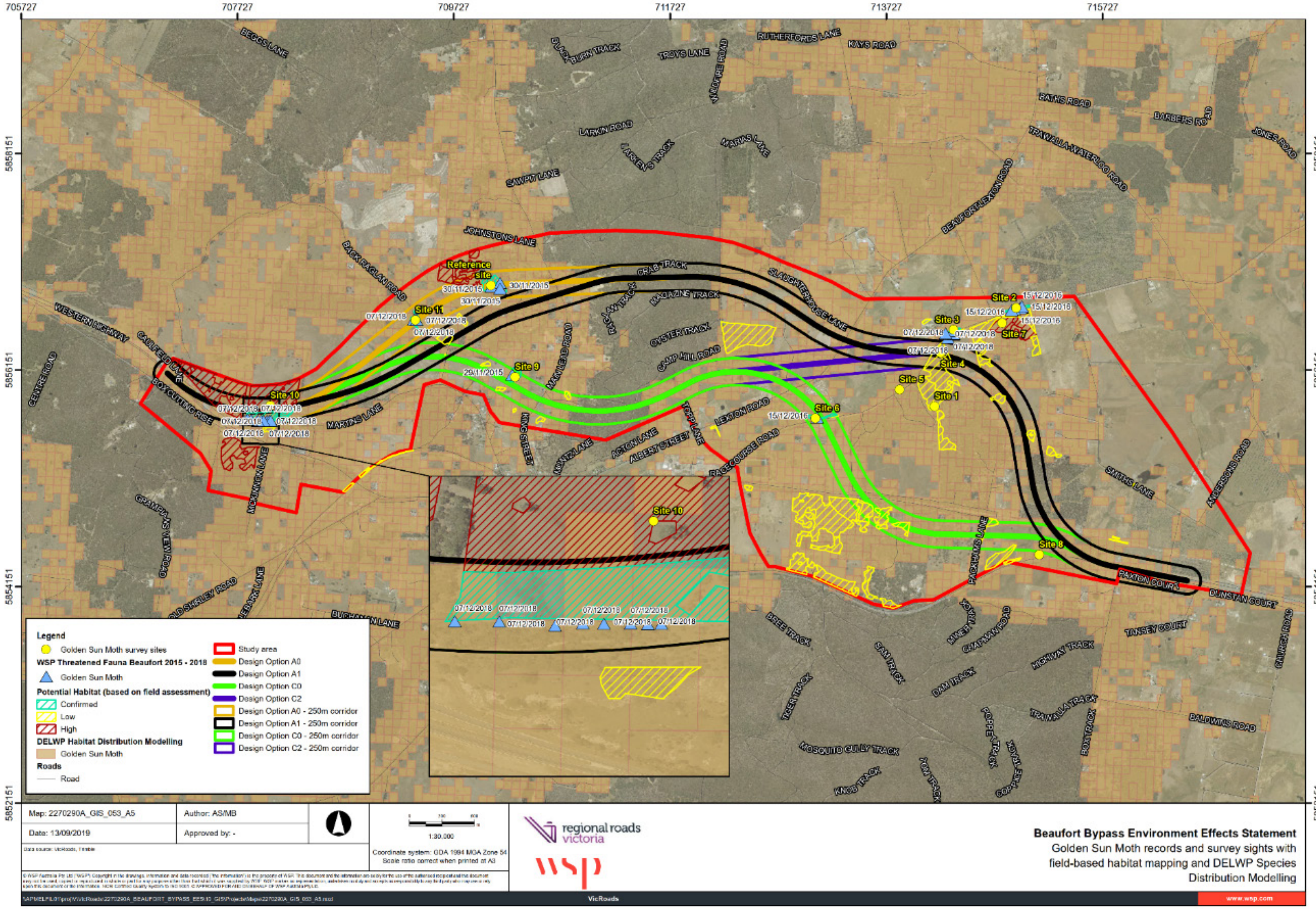


Figure 6.28 Golden Sun Moth records and survey sites with field-based habitat mapping and DELWP Species Distribution Modelling

6.6.2.13 GROWLING GRASS FROG

The Growling Grass Frog *Litoria raniformis* is a ground-dwelling frog that occurs across south-eastern Australia, from New South Wales to Victoria, Tasmania and south-eastern South Australia. The ideal habitat characteristics for Growling Grass Frog are large and relatively permanent waterbodies, with a high proportion of emergent vegetation cover (Hamer & Organ 2006) and/or off-stream wetlands, which contain water at least periodically (DEWHA 2009c). Many of the wetlands/ waterbodies within/or adjacent to the alignments provide these habitat characteristics (refer to Figure 6.29 below). The Growling Grass Frog often prefers to occupy large, permanent waterbodies as they hold water for longer periods of time; however, the species will also breed in seasonal wetlands which typically harbour fewer tadpole predators, especially the Eastern Mosquitofish *Gambusia holbrooki* (Heard, G., Robertson & Scroggie 2004).

The non-breeding season of the Growling Grass Frog extends from May to August during which time frogs shelter in terrestrial habitats in close proximity to waterbodies, but may also overwinter some distance from water (Hero, Littlejohn & Marantelli 1991). Terrestrial habitats including woodland and forest are also used by Growling Grass Frog during the breeding season where individuals use dense ground vegetation, rocks, logs and other woody debris as refuge sites during dispersal (Pyke 2002). Movement by the Growling Grass Frog occurs within metapopulations at the broader landscape scale, where waterbodies are more likely to be occupied if they are within short dispersal distance of each other (e.g. 200 m) (Heard, Geoffrey, Scroggie & Clemann 2010). This movement is considered crucial to maintaining metapopulation dynamics at the regional level, whereby local extinction at waterbodies is less likely to occur if waterbodies exist in spatial clusters, and without barriers to movement (e.g. roads).

There are a number of Growling Grass Frog records in the VBA within or in close proximity to the study area, mostly recorded between 2000 and 2011, with a concentration of records in the Yam Holes Creek floodplain between Racecourse Road and Beaufort-Lexton Road (Figure 6.29). There are also a cluster of records in the complex of wetlands near Trawalla Road in the Mount Emu Creek and Yam Holes Creek floodplain area. Based on these records and habitat elements, as characterised in Section 4.5.7.3, habitat was mapped into medium and high categories for aquatic habitat and the terrestrial buffer of 200 m Figure 6.29. This buffer area is mapped as per guidelines in the *Significant Impact Guidelines for the Vulnerable Growling Grass Frog* (DEWHA 2009c).

No Growling Grass Frog were recorded in 2015 (WSP | Parsons Brinckerhoff 2016b), possibly due to seasonally very dry conditions. Likewise, they were not recorded during targeted surveys in 2016/2017 after many wetlands had been filled from heavy rainfall in early September 2016 which had caused widespread flooding throughout Beaufort. There have been a number of sightings of Growling Grass Frog in the Beaufort area by local ecologist Ray Draper who provided a map of indicative records to the project team in July 2018. These had a number of records from wetlands and dams in the study area in the following years: 2013, 2014, 2015, 2016, 2017 and 2018. None of these records have been entered into the VBA but have been considered in the mapping of Growling Grass Frog habitat. During surveys in 2016, other frogs recorded included Ewing's Tree Frog *Litoria ewingii*, Striped Marsh Frog *Limnodynastes peroni* and Plains Froglet *Crinia parinsignifera* which were heard calling. Victorian Smooth Froglet *Geocrinia victoriana* was recorded on a sound recorder. Survey details and results are provided below in Table 6.23.

During surveys in 2020, other frogs recorded included Plains Froglet *Crinia parinsignifera,* Common Froglet Crinia signifera, Spotted Marsh Frog *Limnodynastes tasmaniensis,* Striped Marsh Frog *Limnodynastes peronii,* Eastern Banjo Frog *Limnodynastes dumerilii,* Southern Brown Tree Frog *Litoria ewingii,* Common Spadefoot Toad *Neobatrachus sudellae.* Frogs recorded repeatedly at most sites included Plains Froglet, Common Froglet, Spotted Marsh Frog, Eastern Banjo Frog and Southern Brown Tree Frog. Striped Marsh Frog *Limnodynastes peronii* was only heard at one site and Common Spadefoot Toad was seen by spotlighting near GGF Site 3. Refer to Table 6.24 for the 2020 survey results.

Growling Grass Frog were recorded in the chosen reference site during all three surveys in 2020 but at no sites within the study area, despite surveying in ideal conditions over three nights throughout the study area. Given the habitat values and previous records, particularly in the Yam Holes Creek floodplain between Racecourse Road and Beaufort-Lexton Road, it is possible that Growling Grass Frog are still present, perhaps in low numbers, but weren't detected during surveys. However, the cumulative probability of detection of Growling Grass Frog between October to March is around 93% from two surveys (Urlus J 2017), and 74% with only one survey, so they should have been detected if they were present. It is possible they are not currently occupying habitat in the study area but have the possibility to recolonise these previously occupied sites, particularly as they are present in the complex of wetlands 900m east of the study area in wetlands connected to Yam Holes Creek. (Heard, GW & Scroggie 2009) found that there is a strong relationship between connectedness of habitat and recolonization meaning populations of Growling Grass Frog close to other populations have a higher chance of persistence and are more likely to be recolonised in the event of a local extinction. Given this understanding, it is considered that wetlands in the Yam Holes Creek floodplain between Racecourse Road and Beaufort-Lexton Road mapped as 'high quality' may support future populations. Wetlands further away and mapped as 'moderate quality' are less likely to be recolonised in future.

Population fluctuation may be due to factors such as drought, habitat degradation and changes in hydrology and water quality related to pivot irrigation along Yam Holes Creek. Chytrid fungus *Batrachochytrium dendrobatidis*, which affects frogs, may also be a contributing factor in the decline in Growling Grass Frog populations although it is possible the Beaufort population is free of Chytrid according to results of swabbing of frogs in the area (Ray Draper pers. comm.), however more research is needed to confirm this.

High quality potential aquatic habitat includes many areas considered 'high quality' wetlands in Section 6.4.4, many of which are the EPBC Act listed community Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plain. Moderate quality potential aquatic habitat cover the remainder of wetlands, dams and creeks which occur throughout the Yam Holes Creek valley and tributaries. Potential terrestrial habitat used for dispersal, foraging and overwintering covers a range of habitats and vegetation types. Terrestrial buffers surrounding most of the high quality potential aquatic habitat are dominated by exotic vegetation in pasture and to a lesser extent, treed and treeless native vegetation. Terrestrial buffers surrounding most of the moderate quality potential aquatic habitat contain a mix of exotic vegetation in crops and pasture as well as patches of treed vegetation.

Table 6.23 Call playback, active search and incidental survey results 2016-17

DATE	TIME	LOCATION	SPECIES	TEMP (°C)	HUMIDITY (%)	CLOUD COVER
30/11/2016	0915 - 0925	Wetland 1	Common Froglet Plains Froglet Ewing' s Tree Frog Striped Marsh Frog	17	57	OVC
30/11/2016	0935 - 0950	Wetland 1	Common Froglet Plains Froglet Ewing' s Tree Frog Striped Marsh Frog	17	57	OVC
30/11/2016	1350 - 1415	Wetland 3	Common Froglet Plains Froglet	19	55	OVC
30/11/2016	1450 - 1500	Wetland 6 (reference site)	Plains Froglet	22	50	OVC
30/11/2016	1645 - 1655	Wetland 14 (reference site)	Plains Froglet	24	48	OVC

DATE	TIME	LOCATION	SPECIES	TEMP (°C)	HUMIDITY (%)	CLOUD COVER
1/12/2016	0700 - 0715	Wetland 2	Victorian Smooth Froglet	13	81	NSC
1/12/2016	2125 - 2135	Wetland 15 (reference site)	Common Froglet Plains Froglet Pobblebonk	17	65	OVC
1/12/2016	2140 - 2150	Wetland 10 (reference site)	Common Froglet	17	65	OVC
16/1/2017	2240 - 2300	Wetland 3	Plains Froglet Striped Marsh Frog	21	41	NSC
16/1/2017	2310 - 2335	Wetland 1	Ewing' s Tree Frog Spotted Marsh Frog	21	41	NSC

Legend: NSC = No significant cloud**;** FEW = Few; SCT = Scattered; BKN = Broken; OVC = Overcast

Photo 6.16 Growling Grass Frog at the reference site (Ref 1) during the 2020 surveys – Photo credt: Matt Clancy

Table 6.24 Growling Grass Frog call playback, spotlighting and habitat assessment survey results – 2020

SITE NAME	SITE SURVEY NUMBER	LOCATION RECORDED (LATITUDE & LONGITUDE)	DATE	START TIME	WEATHER CONDITIONS						WATER QUALITY				SURVEY METHOD	HABITAT ASSESSMENT							SPECIES RECORDED								COMMENTS
					Temp (°C)	Wind (km/hr)	Relative Humidity (%)	Cloud Cover (%)	Rain in past 24 hours	Current Rain	Water Quality data taken	Temp	pH	Electrical Conductivity (uS)		Habitat Assessment Completed	Waterbody Type	Water level depth (metres)	Emergent Vegetation (%)	Fringing Vegetation (%)	Shelter (rocks, tussocks, logs)	Comments	Plains Froglet	Common Froglet	Spotted Marsh Frog	Striped Marsh Frog	Eastern Banjo Frog	Southern Brown Tree Frog	Common Spadefoot Toad	Growling Grass Frog	
GGF1	1	37.413247 143.418032	2020-11-03	20:52:00	25	10	29	20-40%	None	None	Yes	23.6	7.7	955	C S	Yes	Wetland	1-2	50	5	T	Floating veg 20-30% Running Marsh Flower	50+ heard	50+ heard	20+ heard		5-10 heard	1 heard		No	
REF1	1	37.408538 143.444162	2020-11-03	21:24:00	25	10	29	20%	None	None	No	-	-	-	C S	Yes	Wetland	1-2	50	30	T	Floating veg 20% Running Marsh Flower	20+ heard	20+ heard			5-11 heard	5 heard		**4 heard and seen**	
GGF2	1	37.420971 143.410311	2020-11-03	20:26:00	25	10	29	20%	None	None	Yes	23.8	7	898	C S	Yes	Wetland	1-2	30	20		30% floating	20+ heard	20+ heard	20+ heard		20+ heard	2 heard		No	
GGF3	1	37.421391 143.375965	2020-11-03	22:05:00	25	10	29	20%	None	None	Yes	15.2	6.6	373	C S	Yes	Creek	1	10	40	S			5-10 heard	1 heard			5 heard	1 seen close to site	No	
GGF4	1	37.419928 143.374245	2020-11-03	22:38:00	25	10	29	20%	None	None	No	-	-	-	C S	Yes	Drain	0.2	10	10	S	Not ideal habitat, no further surveys	5 heard	5-10 (heard				1 heard		No	Not ideal habitat, no further surveys
GGF5	1	37.420543 143.361155	2020-11-03	22:48:00	25	10	29	20%	None	None	Yes	21.5	7.7	1949	C S	Yes	Wetland	1	10	40	S			10 seen, heard				5 (heard)		No	
GGF6	1	37.420924 143.358607	2020-11-03	23:00:00	25	10	29	20%	None	None	Yes	23.6	7.4	1451	C S	Yes	Dam	1-2	5	20			5-10 heard	20+ heard	20+ heard		2 heard	5 heard		No	
GGF7	1	37.407687 143.423566	2020-11-03	23:45:00	25	10	29	20%	None	None	Yes	20.7	7.5	978	C S	Yes	Creek	1	10	50	S		20+ heard	20+ heard	5 heard		1 heard	5 heard		No	
GGF8	1	37.424365 143.400093	2020-11-04	0:00:00	25	10	29	20%	None	None	No	-	-	-	C S	Yes	Dam	1-2	20	80	P		5-10 heard	20+ heard			5 heard	5 heard		No	

SITE NAME	SITE SURVEY NUMBER	LOCATION RECORDED (LATITUDE & LONGITUDE)	DATE	START TIME	WEATHER CONDITIONS						WATER QUALITY				SURVEY METHOD	HABITAT ASSESSMENT							SPECIES RECORDED								COMMENTS
					Temp (°C)	Wind (km/hr)	Relative Humidity (%)	Cloud Cover (%)	Rain in past 24 hours	Current Rain	Water Quality data taken	Temp	pH	Electrical Conductivity (uS)		Habitat Assessment Completed	Waterbody Type	Water level depth (metres)	Emergent Vegetation (%)	Fringing Vegetation (%)	Shelter (rocks, tussocks, logs)	Comments	Plains Froglet	Common Froglet	Spotted Marsh Frog	Striped Marsh Frog	Eastern Banjo Frog	Southern Brown Tree Frog	Common Spadefoot Toad	Growling Grass Frog	
REF1	2	37.408538 143.444162	2020-11-18	21:04:00	20	9	29	20-40%	None	None	Yes	23.2	7	368	C S	Yes	Wetland	1-2	50	30	T	Floating veg 20% Running Marsh Flower	20 heard	20 heard	10 heard			5-10 heard		**2-3 heard and seen**	
GGF10	1	37.419340 143.394295	2020-11-18	21:42:00	20	9	29	<20%	None	None	No	-	-	-	C S	Yes	Dam with veg	0.5	10-20	10		Floating veg 40%		5-10 heard	5 heard	1 heard	2 heard			No	
GGF11	1	37.417788 143.399488	2020-11-18	22:03:00	20	9	29	<20%	None	None	No	-	-	-	C S	Yes	Dam	1-3	10	40		Floating 10%	20+ heard	10 heard	5-10 heard			2 heard		No	
GGF14	1	37.424728 143.427855	2020-11-18	22:30:00	20	9	29	<20%	None	None	Yes	21.6	7.4	102	C S	Yes	Dam	0.5	10	0	5%		20+ heard	1 heard			2 heard			No	
GGF13	1	37.422562 143.428354	2020-11-18	22:56:00	20	9	29	<20%	None	None	No	-	-	-	C S	Yes	Dam x 3	2-4	0-5	20-40	5%		20 heard		1 seen		1 heard	1 heard		No	
GGF9	1	37.423908 143.353194	2020-11-18	23:37:00	20	9	29	<20%	None	None	No	-	-	-	C S	Yes	Dam	2-3	20-30	30			20 heard	5 heard	5 heard		2 heard			No	Gambusia
GGF5	1	37.420543 143.361155	2020-11-19	00:30:00	20	9	29	<20%	None	None	No	-	-	-	C S	Yes	Wetland	1	10	40	S		1 heard	5 heard	10-15 heard			1 heard		No	
GGF6	2	37.420924 143.358607	2020-11-19	00:44:00	20	9	29	<20%	None	None	No	-	-	-	C S	Yes	Dam	1-2	5	20			5-10 heard	15 heard	20+ heard		2 heard			No	
GGF8	2	37.424365 143.400093	2020-11-19	01:03:00	20	9	29	<20%	None	None	No	-	-	-	C	Yes	Dam	1-2	20	80	P		5 heard	20 heard			1 heard	2 heard		No	
GGF7	2	37.407687 143.423566	2020-11-19	01:13:00	20	9	29	<20%	None	None	No	-	-	-	C S	Yes	Creek	1	10	50	S		5-10 heard	20 heard	20 heard		5 heard			No	
REF1	3	37.408609 143.444116	2020-11-19	01:23:00	20	9	29	<20%	None	None	No	-	-	-	C S	Yes	Wetland	1-2	50	30	T	Floating veg 20% Running Marsh Flower								**Yes**	Late night ref check - still calling when cooler
GGF2	2	37.421047 143.410254	2020-11-19	01:30:00	20	9	29	<20%	None	None	No	-	-	-	C S	Yes	Wetland	1-2	30	20		30% floating	5 heard	5 heard	20 heard		1 heard	5-10 heard		No	
GGF14	2	37.424817 143.427831	2020-11-25	22:34:00	24	11	41	<20%	None	None	No	-	-	-	C S	Yes	Dam	0.5	10	0	5%		20 heard		5 heard					No	Sub-optimal habitat

SITE NAME	SITE SURVEY NUMBER	LOCATION RECORDED (LATITUDE & LONGITUDE)	DATE	START TIME	WEATHER CONDITIONS						WATER QUALITY				SURVEY METHOD	HABITAT ASSESSMENT							SPECIES RECORDED								COMMENTS
					Temp (°C)	Wind (km/hr)	Relative Humidity (%)	Cloud Cover (%)	Rain in past 24 hours	Current Rain	Water Quality data taken	Temp	pH	Electrical Conductivity (uS)		Habitat Assessment Completed	Waterbody Type	Water level depth (metres)	Emergent Vegetation (%)	Fringing Vegetation (%)	Shelter (rocks, tussocks, logs)	Comments	Plains Froglet	Common Froglet	Spotted Marsh Frog	Striped Marsh Frog	Eastern Banjo Frog	Southern Brown Tree Frog	Common Spadefoot Toad	Growling Grass Frog	
GGF13	2	37.422535 143.428317	2020-11-25	22:48:00	24	11	41	<20%	None	None	Yes	23.2	8.5	78	C S	Yes	Dam x 3	2-4	0-5	20-40	5%		20 heard							No	Sub-optimal habitat
REF1	4	37.408580 143.444086	2020-11-25	23:10:00	24	11	41	<20%	None	None	No	-	-	-	C	Yes														**Yes - one heard, not very active**	
GGF1	2	37.413247 143.418032	2020-11-25	23:25:00	24	11	41	<20%	None	None	No	-	-	-	C S	Yes	Wetland	1-2	50	5	T	Floating veg 20-30% Running Marsh Flower	50+ heard	5 heard	10-20 heard			10 heard		No	
GGF2	2	37.420971 143.410311	2020-11-25	23:43:00	24	11	41	<20%	None	None	No	-	-	-	C S	Yes	Wetland	1-2	30	20		30% floating	10-15 heard	5 heard	10 heard			3 heard		No	
GGF10	2	37.419323 143.394259	2020-11-26	00:03:00	24	11	41	<20%	None	None	Yes	17.4	7.1	81	C S	Yes	Dam with veg	0.5	10-20	10		Floating veg 40%	20-30 heard	5 heard	5 heard					No	
GGF11	2	37.417857 143.399287	2020-11-26	00:15:00	24	11	41	<20%	None	None	Yes	22.3	7.4	104	C S	Yes	Dam	1-3	10	40		Floating 10%	30 heard	10 heard	20 heard			5 heard		No	
GGF9	2	37.423683 143.353386	2020-11-26	00:38:00	24	11	41	<20%	None	None	Yes	18.6	7.4	181	C S	Yes	Dam	2-3	20-30	30			3 heard	10 heard			2 heard	1 heard		No	Gambusia in dam
GGF3	2	37.421391 143.375965	2020-11-26	00:52:00	24	11	41	<20%	None	None	No	-	-	-	C S	Yes	Creek	1	10	40	S		5 heard	5 heard	10-20 heard			5 heard		No	

Survey Method: *C= Call Playback, S= Spotlight/hand searching*

Shelter: *T = Tussocks, S = Sedges, P = Phragmites*

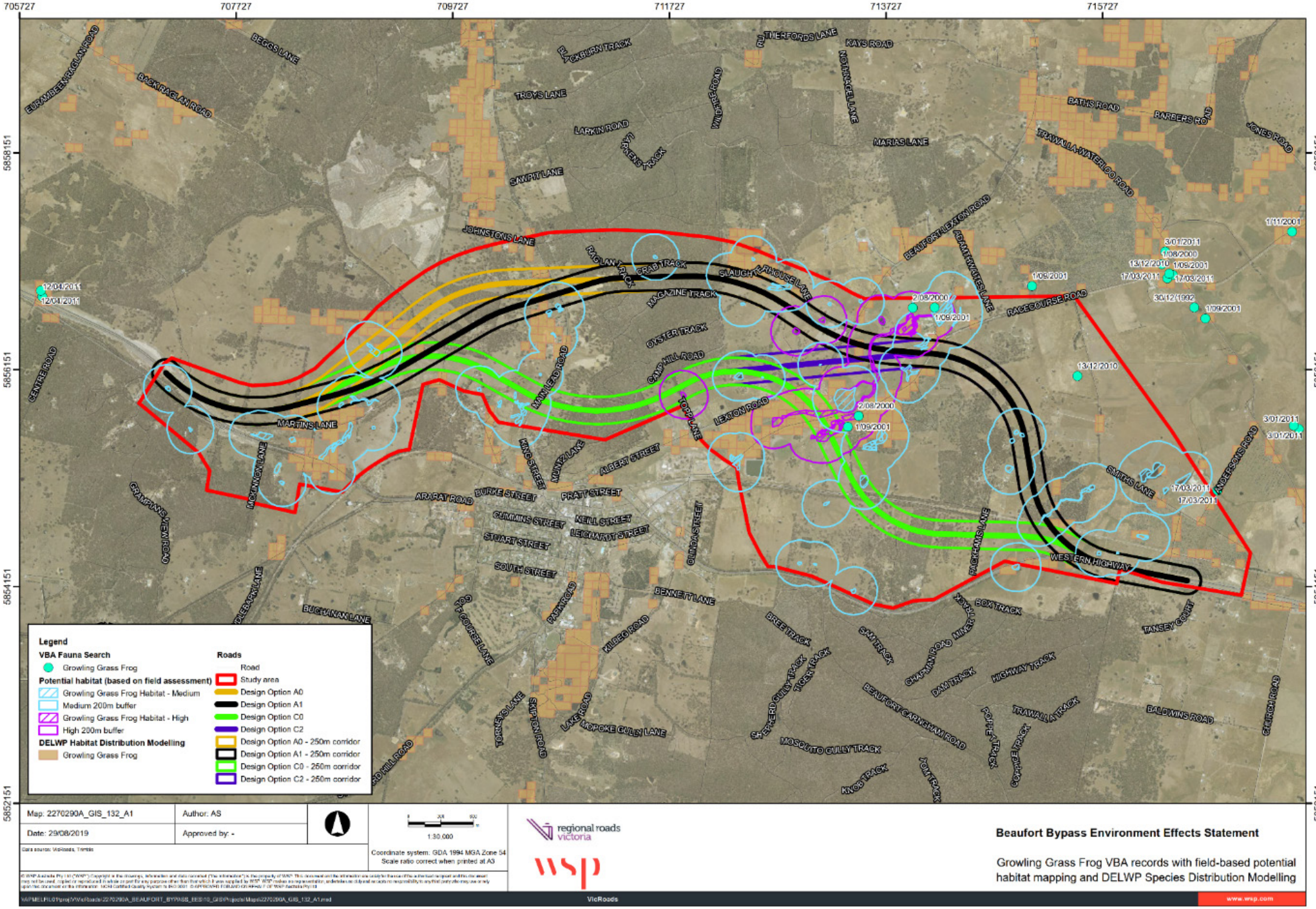


Figure 6.29 Growling Grass Frog VBA records with field-based potential habitat mapping and DELWP Species Distribution Modelling

6.6.2.14 HARDHEAD

A medium sized duck, the Hardhead *Aythya australis* is almost entirely aquatic. It prefers large, deep freshwater habitats with abundant aquatic vegetation, particularly deep swamps, lakes, creeks, billabongs and alluvial plains (Marchant & Higgins 1990). Their diet consists of aquatic plants and animals, particularly mussels and freshwater shellfish. Hardheads breed near water where there is low and thick vegetation cover (Birdlife 2019).

Potential wetland habitat of varying quality is present within the study area across all alignment options. Whilst the species was not recorded during recent surveys, the Hardhead has previously been recorded during the 2015 surveys conducted by GHD. Furthermore, there are several Hardhead VBA records in the area, including two within the study area itself (refer to Figure 6.23 above).

6.6.2.15 LATHAM'S SNIPE

A non-breeding visitor to south-eastern Australia, the Latham's Snipe *Gallinago hardwickii* is a wading bird that inhabits a variety of freshwater permanent and ephemeral wetland habitats that support low, dense vegetation. This includes swamps, flooded grasslands, heathlands and other waterbodies such as bogs, waterholes, billabongs, lagoons, lakes, creeks or river margins. Latham's Snipe can also occur in brackish and saline environments, most commonly utilised during migration, and are even regularly recorded around modified or artificial habitats including pasture, ploughed paddocks, irrigation channels, saltworks, and sewage farms (SPRAT 2019). They forage in areas of exposed mud or shallow water with some form of low dense vegetation cover, feeding on plant material, seeds, mollusks and small insects (Birdlife 2019).

The species has not been recorded during surveys. However, recent VBA records located less than 2 km south of the study area suggest that Latham's Snipe may be an occasional visitor to wetlands within the study area (refer to Figure 6.23 above).

6.6.2.16 LITTLE GALAXIAS

The Little Galaxias *Galaxiella toourtkoourt* is one of two taxa that were formerly described as the Dwarf Galaxias *Galaxiella pusilla.* Little Galaxias is endemic to south-eastern Australia (Bray 2019). The species occurs in waters which have an array of native aquatic vegetation, typically preferring swampy floodplain environments, but can also be found in creeks and rivers. The natural degree of wetland connectivity to a more permanent waterbody (such as a river or creek) may be vital to their long-term survival (particularly during extended dry conditions) and must be considered as part of the habitat requirement critical to their survival (Saddlier, Jackson & Hammer 2010).

The Little Galaxias was recorded in Yam Holes Creek near the crossing of Adamthwaite Lane in 2011 (DELWP 2017h). Subsequent investigations (GHD 2015; WSP | Parsons Brinckerhoff 2016b) failed to detect Little Galaxias. In addition, records of Little Galaxias are known for Mt Emu Creek on the Trawalla Waterloo Road in 2008 and Trawalla Road in 2006 (DELWP, 2017). The Little Galaxias has not been recorded in these areas in more recent surveys (Rhys Coleman pers. comm. 2014, (WSP | Parsons Brinckerhoff 2016b).

The fish survey in November 2015 recorded the Southern Pygmy Perch *Nannoperca australis* in Yam Holes Creek at Racecourse Road and also immediately upstream of the Ding Dong Creek junction at King Street (WSP | Parsons Brinckerhoff 2016b). The finding is of some significance as the Southern Pygmy Perch, like the Little Galaxias, requires permanent water as refugia during dry periods and the two species often occupy the same habitat. Finding of a Southern Pygmy Perch population can also lead to the finding of a Little Galaxias population.

Despite previous records, Little Galaxias was not recorded in the 2016 survey and is not expected to currently exist within the Beaufort Bypass study area. The absence of recent records from the Beaufort Bypass study area suggests that Yam Holes Creek and the other waterways sampled are not primary habitat for the Little Galaxias. However, Little Galaxias is considered to have a high likelihood of occurrence for the purposes of impact assessment as there is a reasonable likelihood that they could recolonise the catchment under suitable seasonal conditions.

Of the three fish species captured, one was a native (Southern Pygmy Perch) and two were exotic (Eastern Gambusia *Gambusia holbrooki* and Goldfish *Carassius auratus*). The Southern Pygmy Perch and the Goldfish were captured in a wetland alongside the railway, near Trawalla Waterloo Road (site 26 – refer to Figure 4.8). Elsewhere, the Eastern Gambusia was the only fish species captured. The species was recorded in many locations within Yam Holes Creek, a few wetlands and in the farm dam surveyed.

Further information regarding Little Galaxias habitat assessment is provided in Appendix H.

Table 6.25 Aquatic fauna captured in this study

SITE	WATERWAY	FAUNA CAPTURED
1	Mt. Emu Creek	no fish, freshwater shrimp
2	Yam Holes Creek	no fish
3	Yam Holes Creek	no fish
4	Yam Holes Creek	no fish
5	Yam Holes Creek	2 eastern gambusia
6	Yam Holes Creek	no fish
7	Yam Holes Creek	5 eastern gambusia
8	Yam Holes Creek	no fish
9	Yam Holes Creek	8 eastern gambusia
10	Yam Holes Creek	no fish
11	Yam Holes Creek	no fish
12	Yam Holes Creek	1 eastern gambusia
13	Yam Holes Creek	5 eastern gambusia
14	Yam Holes Creek	no fish
15	Yam Holes Creek	no fish
16	Yam Holes Creek	no fish
17	Yam Holes Creek	no fish
18	Yam Holes Creek	14 eastern gambusia
19	Yam Holes Creek	4 eastern gambusia
20	Yam Holes Creek	4 eastern gambusia-1 yabby
21	Yam Holes Creek	1 eastern gambusia
22	Yam Holes Creek	25 eastern gambusia
23	Yam Holes Creek	3 eastern gambusia
24	Yam Holes Creek	9 eastern gambusia
25	Yam Holes Creek	no fish
26	wetland	southern pygmy perch, goldfish
27	Yam Holes Creek tributary	no water

SITE	WATERWAY	FAUNA CAPTURED
28	wetland (on Yam Holes Creek second channel)	no fish
29	wetland	no fish
30	wetland	9 eastern gambusia
31	farm dam	15 eastern gambusia
32	wetland	no fish
33	wetland	no fish
34	Cumberland Creek	no water
35	Cumberland Creek	no fish -4 yabbies
36	Cemetery Creek	no fish -1 yabby
37	Ding Dong Creek	no fish
38	Yam Holes Creek tributary	no water
39	Yam Holes Creek tributary	no water
40	Yam Holes Creek tributary	no water

WATER QUALITY RESULTS

Under the draft State Environment Protection Policy (SEPP) for the Waters of Victoria (EPA 2004), the study area of the Beaufort Bypass is within the Cleared Hills and Coastal Plains Segment.

For Yam Holes Creek, water temperatures were between 16.5–31.3 ºC. The instream water temperatures were a mirror of the ambient air conditions, with warmer instream temperatures being measured on the day after the ambient air temperature was 35ºC. Cooler weather in the days that followed were reflected in cooler waterbody temperatures. Highly fluctuating water temperatures were expected to be partially due to an absence of riparian vegetation which can help regulate water temperatures on a day to day basis.

Dissolved oxygen recorded was between 1.8–6.3 mg/L. Low dissolved levels (below 5 mg/l) may be a problem to most fish species, but would not be a limiting factor for Little Galaxias, as the species can often be found in waters with oxygen levels as low as 1.0 mg/L. The pH, which ranged from 6.7 and 7.5, electrical conductivity between 455–942 S/cm and the turbidity between 4.5–30 NTU generally fit within the SEPP guidelines for acceptable instream conditions for aquatic fauna.

Overall, the water quality measurements noted in the study area are within parameters capable of supporting a Little Galaxias population. Water quality data collected during this study is presented in Appendix G.

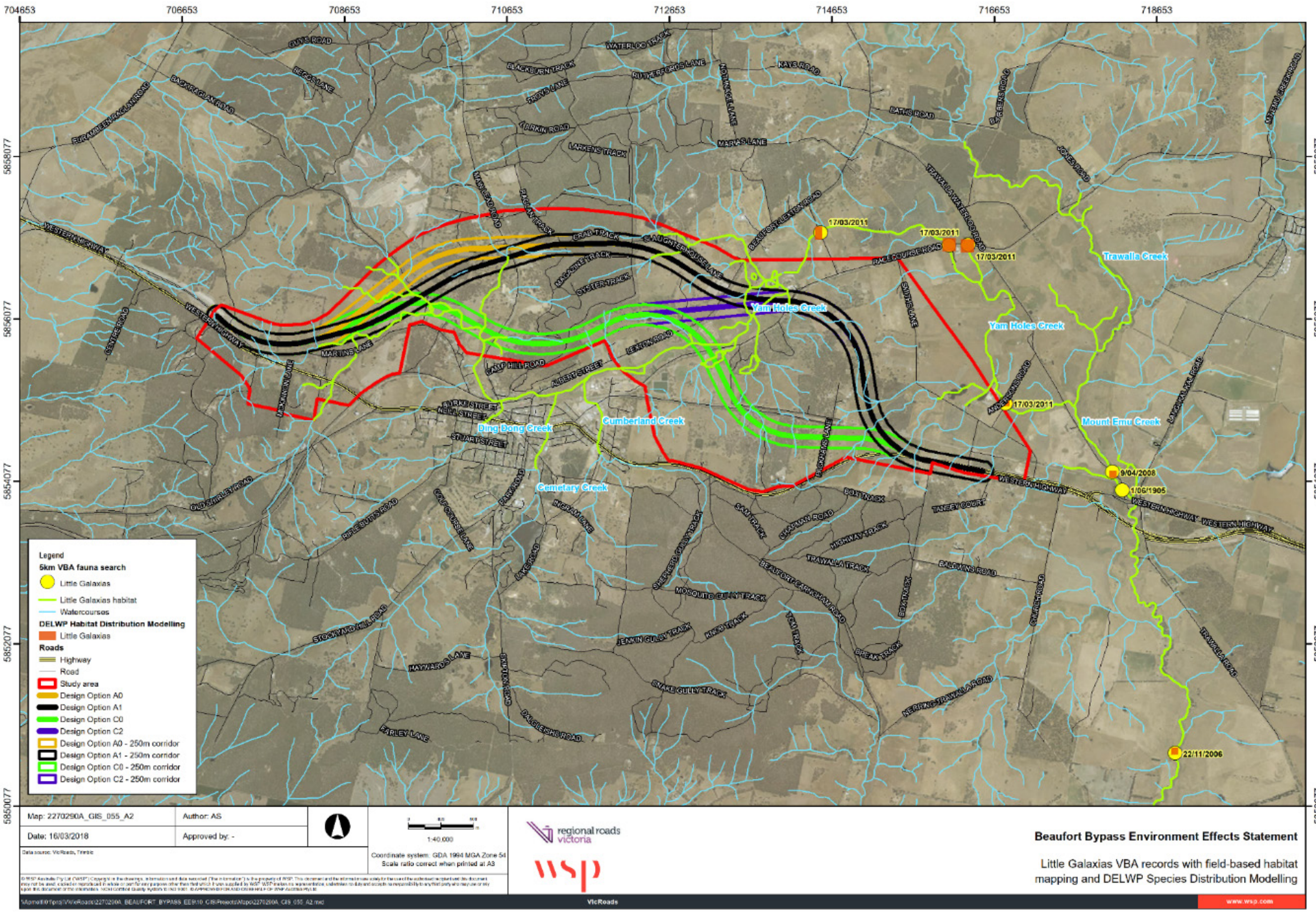


Figure 6.30 Little Galaxias VBA records with field-based habitat mapping and DELWP Species Distribution Modelling

6.6.2.17 MUSK DUCK

Endemic to Australia, the Musk Duck *Biziura lobata* is the country's largest waterfowl species. Almost entirely aquatic, they prefer large, deep, permanent expanses of water such as lakes and wetlands, with dense marginal vegetation and reed beds in which to nest (Atlas of Living Australia 2019). They also occur in estuarine habitats and sheltered inshore waters. Musk Ducks search underwater for the majority of their food, consuming aquatic insects, crustaceans, snails, shellfish, fish, frogs, ducklings and some aquatic plant seeds (Birdlife Australia 2019b).

Potential wetland habitat of varying quality is present within the study area across all alignment options. Whilst the species was not recorded during recent surveys, the Musk Duck has previously been recorded during the 2015 surveys conducted by GHD. Furthermore, there are several Musk Duck VBA records in the area, south of the project (refer to Figure 6.23 above).

6.6.2.18 PAINTED HONEYEATER

The Painted Honeyeater *Grantiella picta* is one of the most specialised honeyeater birds in Australia. The species displays seasonal north-south movements that closely correspond to the fruiting of mistletoe which constitutes a major component of the species diet. Painted Honeyeaters also eat arthropods and nectar from flowering mistletoe, eucalypts and possibly banksias. Painted Honeyeaters live in dry forest and woodland habitats. The species is more likely to occur in patches of larger vegetation, such as Camp Hill State Forest, than in strips of remnant box-ironbark woodlands, such as occur along roadsides and in windbreaks (Garnett & Crowley 2000).

The species has not been formally recorded during surveys. However, an unconfirmed, but reasonably reliable, record has been provided by a local landowner on their property (Johnston, H. pers. comm. Nov 2015). The site is located in the north of the study area, west of Camp Hill State Forest, on Johnston's Lane (refer Figure 6.32 below).

The Painted Honeyeater is one of the 24 species that makes up the FFG Act listed Victorian Temperate Woodland Bird Community (refer to Section 6.6.4).

6.6.2.19 PIED CORMORANT

A large waterbird, the Pied Cormorant *Phalacrocorax varius* is found in marine habitats including estuaries, harbours and bays. It is also found in mangroves and on large inland wetlands in eastern Australia (Birdlife 2019). Fish are the species main source of food, although the Pied Cormorant will also eat crustaceans and molluscs.

Within the study area, potential habitat consists of large expanses of water with dense marginal vegetation. The species was not recorded during surveys conducted for this project but two recent VBA records from 2018 and 2019 suggests the species presence nearby. Records are located less than 2 km south of the study area (refer to Figure 6.23 above).

6.6.2.20 POWERFUL OWL

The largest of Australia's owl species, the Powerful Owl *Ninox strenua* is endemic to eastern and south-eastern Australia, predominately occurring on the eastern side of the Great Dividing Range. The Powerful Owl typically inhabits open forests, open woodlands and sheltered gullies in wet forests with dense understoreys along watercourses. They are occasionally found in open areas near forests such as farmland, parks and suburban areas, as well as in remnant bushland patches (Birdlife Australia 2019c). Powerful Owls prey on medium to large tree-dwelling mammals, roosting birds and sometimes small ground-dwelling mammals and marsupials. They require hollow bearing trees to nest (Morcombe 2003) and their key prey is also reliant on hollow-bearing trees.

Suitable habitat for the Powerful Owl is present within the study area. Camp Hill State Forest supports many large hollow bearing trees. Some areas of road reserves and private property within and adjacent to all the alignment options may also provide suitable habitat for this species (refer Figure 6.32 in Section 6.6.4).

There have been several VBA records within the area, four of which occur within the study area itself. Of these, two records are located within three of the alignment options, where C2 diverges from A0 and A1. The other two records are located on the western end of the study area, just south of where the alignments join to the Western Highway.

The Powerful Owl has not been recorded during surveys for this project. Targeted surveys were first undertaken in November 2015 for the project (WSP | Parsons Brinckerhoff 2016b) and again in March 2021 using call playback and spotlighting. Refer to Appendix O for the detailed results of the 2015 surveys and to Table 6.26 below for the 2021 survey results.

Although the species was not recorded it is considered likely to occur at least periodically. However, based on the low number of records and lack of additional recent records in other databases (including Atlas of Living Australia and Ebird), a permanent breeding population in the study area is unlikely.

Table 6.26 Powerful Owl 2021 survey results

DATE	SITE	SURVEY START TIME	TEMP (°C)	WIND (BEAUFORT SCALE) ^	RAIN	MOON PHASE	SPECIES OBSERVED
15.03.21	PO1	8:47 PM	11.4	0	None	New Moon	No observations
15.03.21	PO2	9:19 PM	11.4	0-1	None	New Moon	Sugar Glider
15.03.21	PO3	10:02 PM	11.2	0-1	Slight drizzle	New Moon	Insectivorous Bat
17.03.21	PO1	8:40 PM	17.7	0	None	New Moon	Brushtail possum Insectivorous bat
17.03.21	PO2	9:19 PM	17.5	0-1	None	New Moon	Brushtail possum Insectivorous bat
17.03.21	PO3	9:54 PM	16.9	0	None	New Moon	Insectivorous Bat

^ Beaufort Scale: 0 = Calm, 1 = Light air

6.6.2.21 SPECKLED WARBLER

The Speckled Warbler *Chthonicola sagittata (syn. Pyrrholaemus sagittatus)* is a small woodland bird that inhabits a wide range of eucalypt dominated vegetation with a grassy understorey, often on rocky ridges or in gullies. The species feeds at ground level, foraging for seeds and insects amongst the leaf litter, and even builds domed nests on the ground (Garnett & Crowley 2000). The Speckled Warbler has been shown to decrease in abundance as woodland area decreases, and it appears to be extinct in districts where no fragments larger than 100 ha remain (Barrett, Ford & Recher 1994). Isolation of Speckled Warbler populations in small remnants increases their vulnerability to local extinction as a result of stochastic events and decreases their genetic viability in the long term (NSW Scientific Committee 2001).

A majority of the woodland and forest EVCs within the study area have been mapped as the FFG listed Victorian Temperate Woodland Bird Community, a suite of bird species which includes the Speckled Warbler (see Section 6.6.4). Despite abundant habitat in the form of unfragmented patches across Camp Hill State Forest, the species was not recorded during surveys conducted for this project. VBA records within a 10 km radius indicates that these bird species are present, with the nearest being just over 4km away from the study area (see Figure 6.32).

6.6.2.22 STRIPED LEGLESS LIZARD

The Striped Legless Lizard *Delma impar* is a Pygopodid lizard that grows to about 30 cm in length. Superficially, Pygopodids can appear snake-like, with absent forelimbs and hind limbs reduced to small flaps. Striped Legless Lizards occur in native grassland or grassy woodland habitat where there is good tussock structure and soil structure and sufficient grassy ground cover. They shelter in tussocks, soil cracks and under rocks and debris (TSSC 2016) and are not generally found in heavily treed areas. The species' distribution in Victoria is largely restricted to the southern part of the state. Many records occur in the outer suburbs north and north-west of Melbourne and extend further out to areas including Horsham and Hamilton (TSSC 2016).

No Striped Legless Lizards were observed during the tile surveys. However, three species of reptile and one amphibian were recorded. Details are provided in Table 6.27.

Upon review of the vegetation and habitat in the study area, it was determined that there is very little suitable habitat for Striped Legless Lizard based on the lack of Plains Grassland vegetation, lack of basalt-derived geology, only one record in the 10 km search area and absence of surface rocks. In addition, the grassland area identified as potential habitat is actually treeless Valley Grassy Forest, cleared for a powerline easement. It is also an area which becomes seasonally inundated or very damp in places. With the factors listed above in combination with opportunistic survey data, Striped Legless Lizards are considered to have a low likelihood of occurrence.

Photo 6.17 Little Whip Snake recorded during 2016-2017 tile surveys

This conclusion is largely supported by the results of follow-up surveys conducted for the project in 2019–2020 by Cardno (Cardno 2020b). Striped Legless Lizard was not detected at either of the two sites (i.e. four grids) identified by Cardno as potential habitat, and the species was concluded to be unlikely to occur at these sites. Four other native reptiles were recorded during surveys including two speices of snake and two species of skink. Refer to table Table 6.28 below for survey details.

A third site, located west of Main Lead Road, was identified by Cardno as potential habitat (Cardno 2020a) but was not able to be surveyed in the 2019–20 surveys. Given the availability of moderate-high potential habitat at this site, Cardno determined that Striped Legless Lizard should be considered present and that any impact to this area would have to be assessed (Cardno 2020a, 2020b). However, WSP consider this third site unlikely to support Striped Legless Lizard due to the distance from previous records, lack of natural grassland and generally low-lying, often damp area along the Yam Holes Creek valley.

Table 6.27 2016–2017 Striped Legless Lizard survey locations and results

DATE	TIME	LOCATION	SPECIES	TEMP (°C)	HUMIDITY (%)
20/10/2016		Western Highway	Garden Skink		
1/12/2016	0920	Western Highway	Three-lined Skink	15	81
17/01/2017	1100	Western Highway	Three-lined Skink Garden Skink	26	23
1/05/2017	1045	Western Highway	Three-lined Skink Garden Skink Little Whip Snake	14	74
23/06/2017	1200	Western Highway	Common Froglet Three-lined Skink	11	83
19/09/2017		Western Highway	Garden Skink		

Table 6.28 2019–2020 Striped Legless Lizard survey results (Cardno 2020b)

SURVEY NUMBER	SITE NUMBER	STRIPED LEGLESS LIZARD	EASTERN THREE-LINED SKINK	LITTLE WHIP SNAKE	BROWN SNAKE	GARDEN SKINK
1	1A	-	1			
	1B	-	4			
	2A	-	7			
	2B	-	2			
2	1A	-	1	1		
	1B	-	9		1 (juvenile)	
	2A	-	3			
	2B	-	2			
3	1A	-				
	1B	-	2		1 (juvenile)	
	2A	-	1			1
	2B	-				1
4	1A	-	2	1		
	1B	-	1			
	2A	-	6			
	2B	-	1			
5	1A	-	1			
	1B	-				
	2A	-	2			
	2B	-				1
6	1A	-	2			
	1B	-	1			
	2A	-	2			1
	2B	-	2			1
7	1A	-				
	1B	-	1			
	2A	-	5			
	2B	-	4			
8	1A	-				
	1B	-	1			
	2A	-	1			1
	2B	-	1 & 1 juvenile			

Source: Targeted Survey for Striped Legless Lizard – Beaufort Bypass (Cardno 2020b).

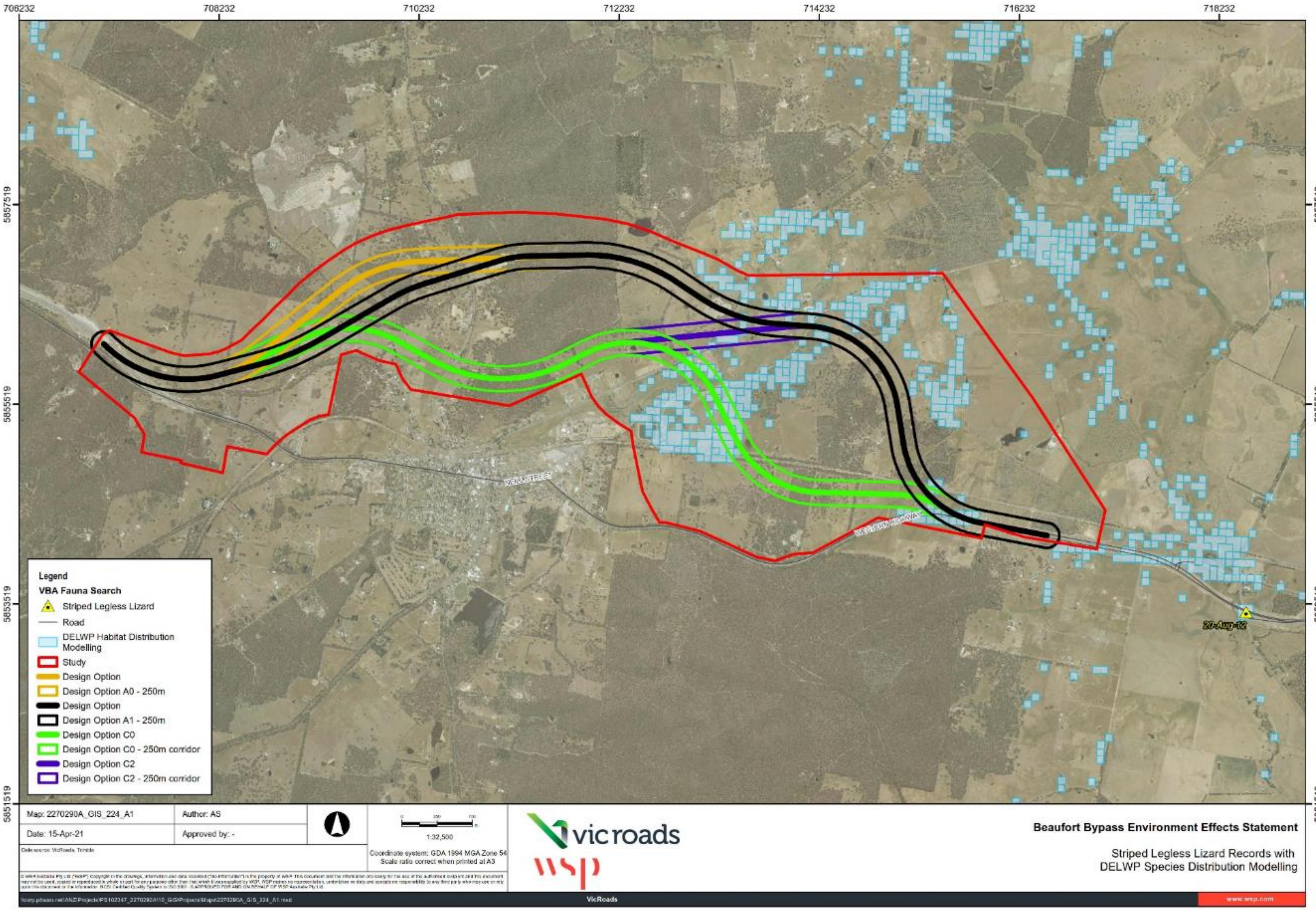


Figure 6.31 Striped Legless Lizard VBA records with DELWP Species Distribution Modelling

6.6.3 LIKELIHOOD OF OCCURRENCE

The desktop assessment identified 65 fauna species of state and/or national significance with the potential to occur within 10 km of the study area (refer to Appendix C). This includes 49 birds, one fish, seven mammals, three amphibians, one insect, and four reptiles. Of these species, 21 species were either recorded, or are considered moderately or highly likely to occur within or nearby the study area on a permanent or intermittent basis.

Although not identified in database searches, one additional species, the Squirrel Glider, was recorded within the Beaufort Bypass study area during targeted surveys conducted in 2015 (See Section 6.6.2.7). All 22 species and their conservation statuses are detailed in Table 6.29 below.

Table 6.29 Fauna species with a moderate or higher likelihood of occurrence

COMMON NAME	CONSERVATION STATUS			VBA COUNT FROM 10 km BUFFER	LIKELIHOOD (POST-SURVEYS)
	EPBC ACT	FFG	VICTORIAN ADVISORY LIST		
Amphibians					
Growling Grass Frog	Vulnerable	Listed	Endangered	35	High
Brown Toadlet		Listed	Endangered	18	Recorded
Birds					
Australasian Shoveler			Vulnerable	11	Moderate
Baillon’s Crake		Listed	Vulnerable	2	Moderate
Blue-billed Duck		Listed	Endangered	3	Moderate
Brolga		Listed	Vulnerable	270	Recorded
Brown Treecreeper		Nominated	Near Threatened	22	Recorded
Diamond Firetail		Listed	Near Threatened	1	High
Eastern Great Egret		Listed	Vulnerable	11	Moderate
Emu			Near Threatened	2	Moderate
Hardhead			Vulnerable	12	High
Latham's Snipe	Migratory	Nominated	Near Threatened	4	Moderate
Musk Duck			Vulnerable	9	Moderate
Painted Honeyeater	Vulnerable	Listed	Vulnerable	1	High
Pied Cormorant			Near Threatened	2	Moderate
Powerful Owl		Listed	Vulnerable	11	High
Speckled Warbler		Listed	Vulnerable	6	Moderate
Fish					
Little Galaxias	Vulnerable	Listed	Endangered	11	High
Invertebrates					
Golden Sun Moth	Critically Endangered	Listed	Critically Endangered	38	Recorded

COMMON NAME	CONSERVATION STATUS			VBA COUNT FROM 10 km BUFFER	LIKELIHOOD (POST-SURVEYS)
	EPBC ACT	FFG	VICTORIAN ADVISORY LIST		
Mammals					
Brush-tailed Phascogale		Listed	Vulnerable	9	Recorded
Squirrel Glider		Listed	Endangered	0	Recorded
Reptiles					
Eastern Long-necked Turtle			Data Deficient	3	Recorded

6.6.3.1 OTHER SIGNIFICANT SPECIES MODELLED TO OCCUR IN THE STUDY AREA

Like with flora, there are several fauna species which are modelled to occur in the study area (DELWP Species Distribution Modelling) under the Guidelines 2013 and/or Guidelines 2017. Three fauna species were triggered in the scenarios for offsets under Guidelines 2013 and Guidelines 2017, two of which were recorded within the study area in 2015 (refer to Table 6.30).

These species are collated for the various scenarios examined for each alignment option, including previous alignment options, the entire 250 m wide corridor, and construction footprint. The DELWP regional team had initially requested that these species be considered for surveying in 2016 due to their being triggered by EnSym offset scenarios.

Table 6.30 Fauna species triggered by offset requirements Guidelines 2013 and Guidelines 2017 and their likelihood of occurrence

COMMON NAME	SCIENTIFIC NAME	SPECIFIC OFFSET REQUIREMENT – GUIDELINES 2013	SPECIFIC OFFSET REQUIREMENT – GUIDELINES 2017	LIKELIHOOD OF OCCURRENCE
Regent Honeyeater	*Anthochaera phrygia*	No	Yes	**Low** Occurs mostly in box-ironbark forests and woodland and prefers wet, fertile sites such as along creek flats, broad river valleys and foothills. Most recent record in 1971.
Brush-tailed Phascogale	*Phascogale tapoatafa*	No	Yes	**Recorded** Largely arboreal it occurs in a range of habitats which have reliable rainfall (500–2000 mm), but has preference for open dry sclerophyll forest on ridges (up to 600 m alt) with little/sparse ground cover. Recorded in the Camp Hill State Forest area in 2015.
Brown Toadlet	*Pseudophryne bibronii*	No	Yes	**Recorded** Usually found singly under rocks and logs on slopes in grasslands or beside ditches. Found both in wet and dry sclerophyll forest. Breeding congregations usually occur in inundated grassy areas beside gutters, small creeks etc. Recorded in the study area in 2015.

6.6.4 VICTORIAN TEMPERATE WOODLAND BIRD COMMUNITY

The Victorian Temperate Woodland Bird Community is listed under the FFG Act. It is defined as a suite of bird species which has declined significantly, mainly associated with drier woodlands on the slopes and plains north of the Great Dividing Range (DELWP undated).

The 24 species in this group are Apostlebird, Barking Owl, Black-chinned Honeyeater, Brown Treecreeper, Brown-headed Honeyeater, Bush Stone-curlew, Diamond Firetail, Fuscous Honeyeater, Grey-crowned Babbler, Ground Cuckoo-shrike, Hooded Robin, Jacky Winter, Little Lorikeet, Painted Button-quail, Painted Honeyeater, Red-capped Robin, Red-tailed Black-Cockatoo, Regent Honeyeater, Speckled Warbler, Superb Parrot, Swift Parrot, Turquoise Parrot, Western Gerygone and Yellow-tufted Honeyeater. However, a number of these species are not typically found in or near the study area.

Of the 24 species on the list, two species, Brown Treecreeper and Fuscous Honeyeater, were both observed in the study area in 2015. There are unconfirmed (although reasonably reliable) records of Painted Honeyeater and Diamond Firetail by a local landowner (Johnston, H. pers. comm. Nov 2015) on their property on Johnstons Lane. There are also records of several other species in this community in the Victorian Biodiversity Atlas from within or near the study area.

Given the above, the majority of the woodland and forest EVCs within the study area have been mapped as Victorian Temperate Woodland Bird Community. The extent of this community is provided as Figure 6.32. This mapping is broad-scale and based on the EVC mapping.

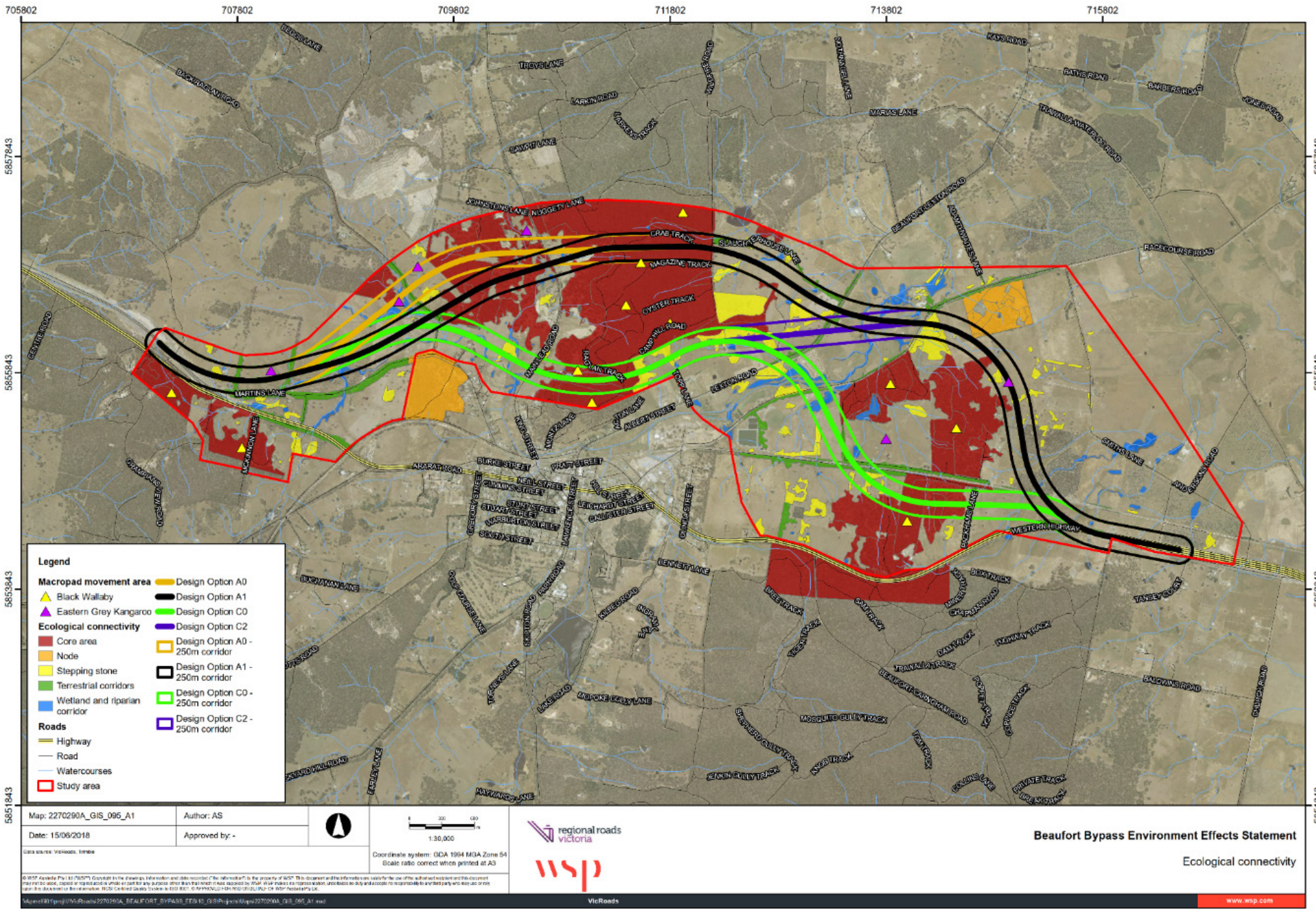


Figure 6.32 Victorian Temperate Woodland Bird Community habitat, records of birds associated with this community and records of Powerful Owl and Emu

6.6.5 HABITAT CONNECTIVITY

6.6.5.1 INITIAL CONNECTIVITY ASSESSMENT

The structural ecological connectivity assessment, presented on Figure 6.33, identifies extensive core areas, some stepping stones and a network of terrestrial and waterway linkages throughout the study area (refer to Section 4.5.7.4 for definitions). The terrestrial linkages on roadsides and rail corridors as well as the waterway linkages provide important functions throughout the otherwise moderate to heavily cleared landscapes in lower lying areas.

6.6.5.2 DETAILED CONNECTIVITY ASSESSMENT

The Wildlife Connectivity Impact and Mitigation Assessment (Lechner et al. 2019) modelled landscape connectivity for five different species (conservation targets). It assessed the current levels of connectivity within the study area and compared these to predicted levels of connectivity associated with each of the Beaufort Bypass alignment options. The results of the connectivity modelling and subsequent mitigation measure modelling are summarised below. For further details refer to The Wildlife Connectivity Impact and Mitigation Assessment in Appendix M.

CURRENT SCENARIO RESULTS

The assessment identified that, for a species with a short dispersal range, like the Golden Sun Moth, preferred habitat within the study area was highly fragmented. In comparison, for a short disperser like Growling Grass Frog, the landscape was slightly less fragmented due to the well-connected patches of habitat that extend from the centre to the east of the study area via the Yam Holes Creek system. For the Woodland Birds, which are medium dispersers, the large patches of habitat in Camp Hill State Forest and Musical Gully, to the north of the study area, are currently isolated from patches of habitat in Trawalla and Andrews State Forest which are located in the south (see example mpa of current connectivity on Figure 6.34). This is largely due to the existing roads and built up area of Beaufort as some species of woodland birds will not fly over large areas of open spaces, such as highways. In contrast, for the Echidna and Brush-tailed Phascogale which are longer-distance dispersers, the landscape is relatively unfragmented due to the presence of scattered trees and woody vegetation along minor roads that enable these species to move throughout most of the study area.

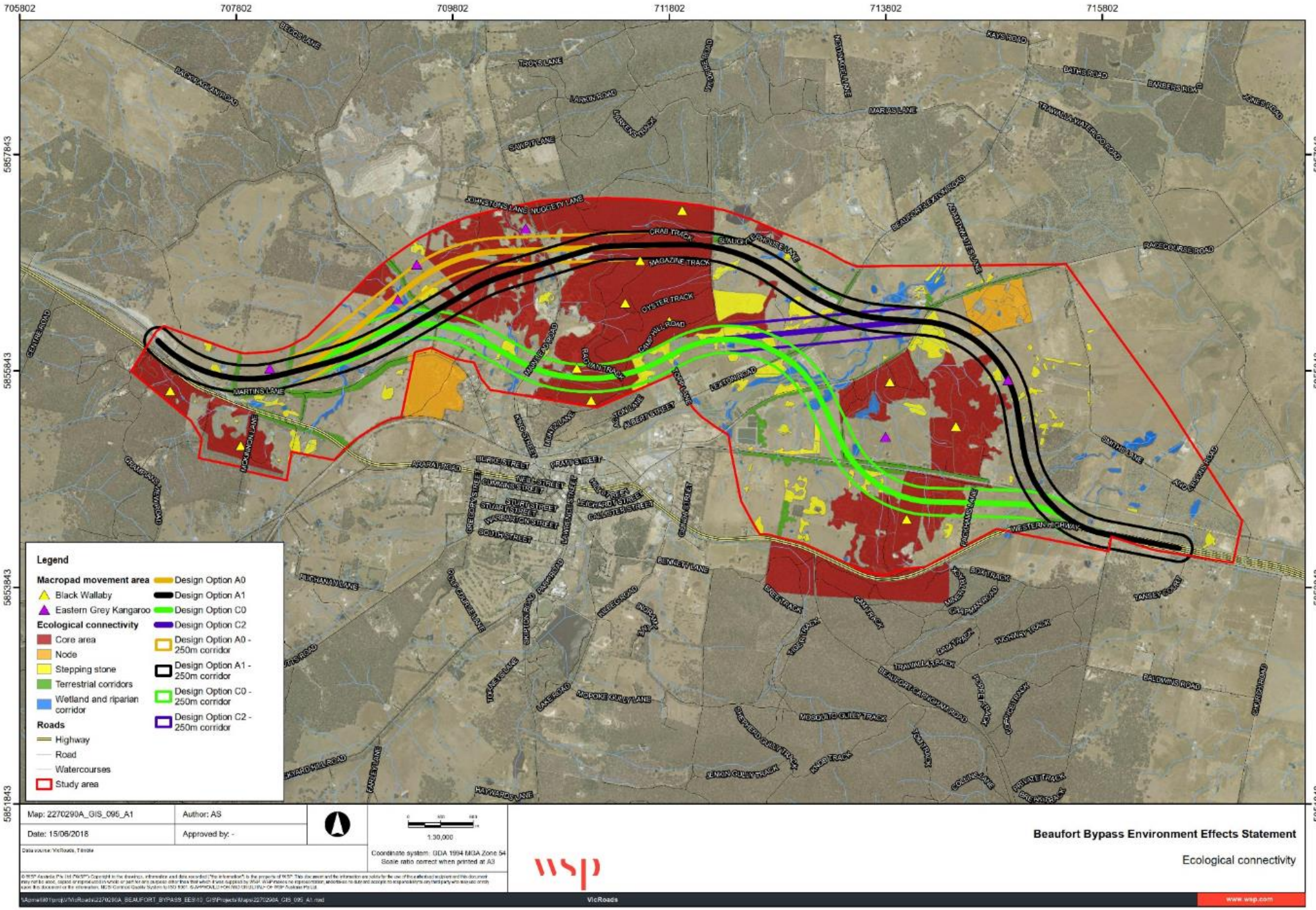


Figure 6.33 Initial ecological connectivity assessment results

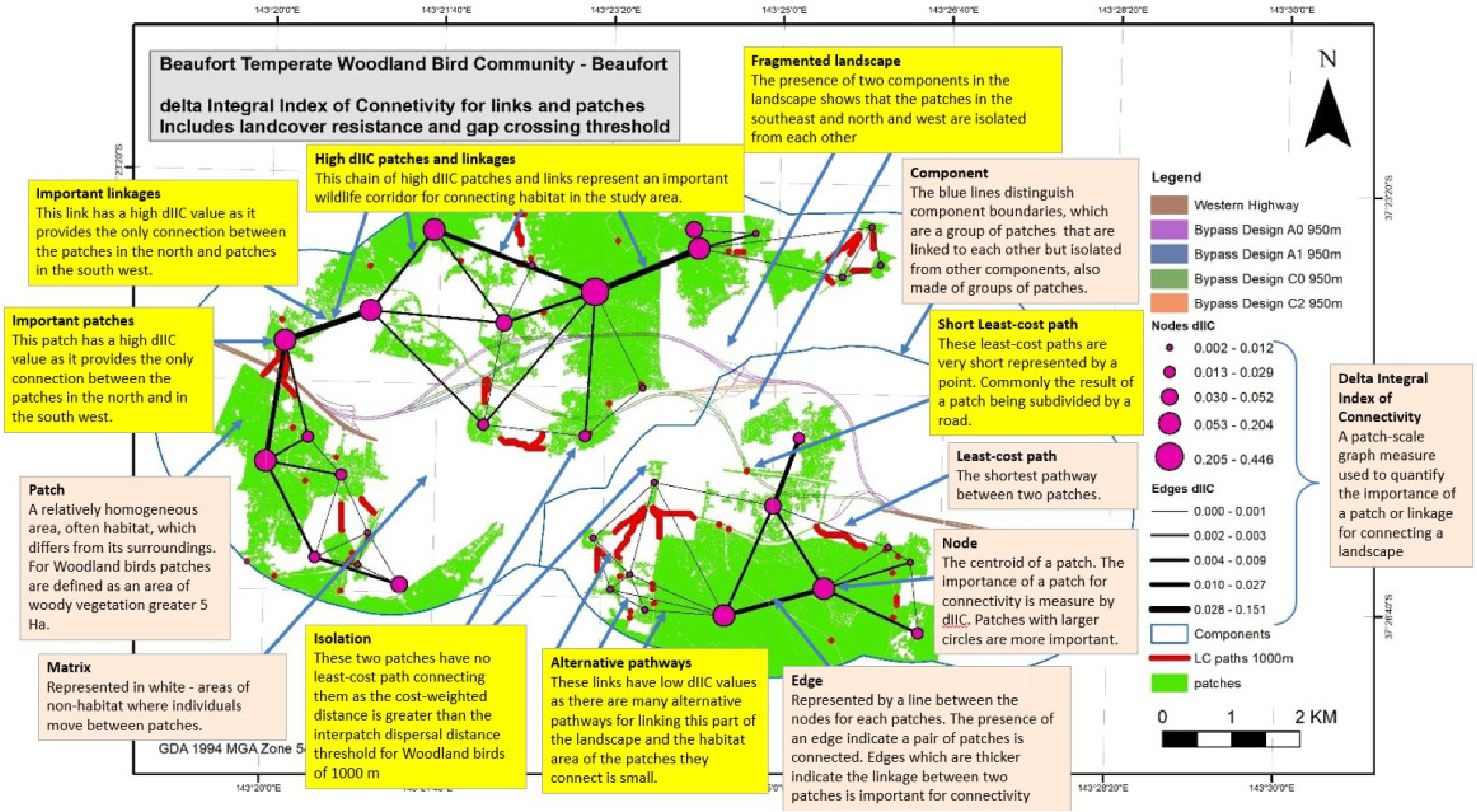


Figure 6.34 Example of current connectivity in the landscape for woodland birds – extract from (Lechner et al. 2019) in Appendix M. Important linkages and patches are denoted by thick lines and large circles respectively. The circles located at the centroid of each patch describe patch-scale graph metric values. The bypass designs are included (but not modelled) to allow for a comparison with current connectivity. Definitions are found within pink boxes and explanations within yellow boxes.

7 IMPACT ASSESSMENT – FOUR ALIGNMENT OPTIONS

The proposed construction of the Beaufort Bypass is likely to affect the local ecology in a number of ways. Impacts may be temporary, predominantly occurring during the construction phase, or ongoing for the operational phase of the bypass. The impacts can be classified as 'direct' impacts, for example the loss of vegetation through clearing for the road, and 'indirect' impacts, such as increased noise and light from the new road having flow-on effects on populations. The project may also have 'facilitated impacts' which result from actions made possible by the construction of the Beaufort Bypass, though these impacts do not necessarily arise in all circumstances and there is little to no guidance on how to assess these type of impacts. The broad types of impacts likely to be associated with this development, and the potential nature of the impacts without specific mitigation measures, are discussed in the following sections. A summary of the likely severity of impacts without mitigation is addressed at the end of this section.

In this section, the preliminary nominal construction footprint for all four alignments was used to calculate the extent of impacts. This means that for the preferred alignment (C2) the impacts will be slightly less in this section than are presented in Section 9 (Impact assessment for the preferred alignment). The full impact assessment for the preferred alignment in Section 9 was undertaken following further development of the design, including determination of clearing required for creek realignments/drainage, which has not been calculated for the other alignments. Use of the early nominal footprints allows the relative impacts of the four alignments to be compared.

Accounting for the impacts associated with constructing the road such as laydowns, site offices, temporary access tracks and relocation of utility services are not typically considered with a concept road design. This often requires specific planning for construction and landowner agreements. This typically occurs at the detailed design and pre-construction phase of a project and has not been factored into impact calculations, however there is consideration of indicative locations in Section 10.1.2.

7.1 LOSS OF VEGETATION AND HABITAT

7.1.1 *BACKGROUND*

Loss of habitat, together with habitat degradation and fragmentation, is one of the most critical impacts to native wildlife in Australia (Gleeson & Gleeson 2012). These processes reduce the ability of the land to provide necessary resources (including foraging, roosting and breeding resources) for fauna species, and increase competition between species. Clearing can also result in habitat fragmentation, discussed under section 7.2 below.

The project will require clearing of vegetation and habitat along the alignment to construct the bypass. The extent of direct vegetation/habitat loss and the impacts upon significant biodiversity values are detailed below.

7.1.2 *IMPACTS OF THE FOUR ALIGNMENT OPTIONS*

7.1.2.1 NATIVE VEGETATION AND THREATENED VEGETATION COMMUNITIES

The total amount of vegetation removal for each of the four construction footprints is listed in Table 7.1 below, separated into each EVC for remnant patches as well as Scattered Trees and Large Trees in Patches. Tree impacts have been listed in areas as per the Guidelines 2017. Numbers of individual trees impacted are provided in Section 7.1.2.2.

Table 7.1 Breakdown of impacts on EVCs in each alignment (in hectares)

EVC NO.	EVC NAME	EVC CONSERVATION STATUS	A0 (HA)	A1 (HA)	C0 (HA)	C2 (HA)
Ecological Vegetation Classes – Central Victoria Uplands Bioregion						
20	Heathy Dry Forest	Least Concern	13.70	13.70	13.68	14.27
22	Grassy Dry Forest	Depleted	20.74	22.10	25.21	20.95
47	Valley Grassy Forest	Vulnerable	0.60	0.60	4.84	0.56
67	Alluvial Terraces Herb-rich Woodland	Endangered	7.65	6.79	1.40	1.41
68	Creekline Grassy Woodland	Endangered	1.59	0.02	0	0
125	Plains Grassy Wetland	Endangered	0.73	0.83	1.04	1.01
136	Sedge Wetland^	Vulnerable	0	0	0.20	0.14
175	Grassy Woodland	Endangered	3.51	3.73	4.91	3.05
647	Plains Sedgy Wetland	Endangered			0.21	0.21
Ecological Vegetation Classes – Victorian Volcanic Plains						
22	Grassy Dry Forest	Depleted	0	0	0.43	0.15
55	Plains Grassy Woodland	Endangered	0.05	0.05	0	0
67	Alluvial Terraces Herb-rich Woodland	Endangered	0.09	0.09	0	0
125	Plains Grassy Wetland	Endangered	0.10	0.10	1.11	0.06
136	Sedge Wetland	Vulnerable	0	0	2.55	0
175	Grassy Woodland	Endangered	2.97	2.97	0.86	3.03
653	Aquatic Herbland	Endangered	0.20	0.20	0	0.26
n/a	Current Wetland (WET_0000)	Unclassified	6.23	6.63	2.44	1.97
Totals (ha)			58.15	57.80	58.88	47.06
Scattered Tree – converted to area (DELWP 2017e)						
Central Victorian Uplands			2.35	2.57	2.16	1.98
Victorian Volcanic Plains			0.35	0.35	0.07	0.49
Totals (ha)			2.70	2.92	2.23	2.48
Total (ha)			**60.85**	**60.72**	**61.11**	**49.54**
EnSym Output totals (ha)*			**62.61**	**62.55**	**62.30**	**50.70**

^ Sedge Wetland used as closest EVC to Aquatic Sedgeland

* total areas from the EnSym outputs are slightly different to totals to include canopies of trees on the edges of patches as required as per the Guidelines 2017

A Summary of EVCs proposed for removal by conservation status (not including tree losses) is provided in Table 7.2. Vegetation proposed for removal without conservation status is composed entirely of the Current Wetland layer, which forms part of the definition of ‘patch’ as per the Guidelines 2017. Areas of mapped native vegetation are cut from areas where the Current Wetland layer occur. There are extensive areas mapped as Current Wetland for which no native vegetation has been mapped during surveys for this study. This includes areas through Yam Holes Creek valley, between Back Raglan Road and Martins Lane and Slaughterhouse Lane (refer to Figure 6.3).

Large Trees in Patches are native canopy trees with a Diameter at Breast Height (DBH) greater than or equal to the large tree benchmark for the relevant bioregional EVC that is contained within a patch (DELWP 2017e). Scattered trees are native trees which do not form part of a patch. As per the Guidelines 2017, the scattered trees are broken into two size classes. Those that match the benchmark DBH for a large tree within that EVC equate to 0.07 ha and those that are considered small trees equate to 0.03 ha. The total area of both size classes of scattered trees are listed in Table 7.1 above. Any tree with >10% TPZ impact was considered lost for the purpose of the current assessment, as per the Assessors Handbook (DELWP 2018a). The number of trees impacted in each alignment are provided in Section 7.1.2.2 below.

Table 7.2 Summary of EVCs proposed for removal by conservation status (not including tree losses)

EVC CONSERVATION STATUS	A0 (HA)	A1 (HA)	C0 (HA)	C2 (HA)
Least Concern EVCs	13.70	13.70	13.68	14.27
Depleted EVCs	20.74	22.10	25.64	21.1
Vulnerable EVCs	0.6	0.6	7.59	0.7
Endangered EVCs	16.89	14.78	9.53	9.03
Unclassified – Current Wetland	6.23	6.63	2.44	1.97
Totals	**58.15**	**57.80**	**58.88**	**47.06**

Several EVCs are also consistent with three threatened vegetation communities. The breakdown of areas (in hectares) of threatened vegetation communities within the preliminary construction footprint for each alignment is provided in the table below.

Table 7.3 Breakdown of Threatened Vegetation Communities

COMMUNITY NAME	STATUS	AMOUNT IN CONSTRUCTION FOOTPRINT			
		A0	A1	C0	C2
Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	Critically Endangered under EPBC Act	0.06	0.06	2.58	0.06
White box – Yellow Box – Blakely’s Red Gum Grassy Woodland	Critically Endangered under EPBC Act	2.64	0.65	3.97	0
Victorian Woodland Bird Community	Threatened under FFG Act	38.43	38.09	37.59	31.56

7.1.2.2 TREES

The breakdown of preliminary losses of canopy trees (large trees and small scattered trees only) within the indicative construction footprint (10 m buffer on each alignment preliminary design) is provided in Table 7.4. This includes those trees which occur outside the construction footprint, but which would have >10% impact upon their Tree Protection Zone (TPZ).

A0 has the highest number of trees proposed for removal (396, with the majority (98%) of those large trees). This is followed by A1 with 374 trees, then C0 with 322 trees. The alignment with the lowest tree impacts is C2 with 317 trees. Whilst C2 has the lowest requirement for tree removal, all alignments propose to remove high numbers of large trees.

Note that this does not include impacts on small trees in patches. Whilst each alignment will also result in the loss of a considerable number of small trees in patches, these are accounted for through EVC patch impacts. However, they will need to be assessed in detail for the approved alignment during the detailed design phase by an arborist.

Table 7.4 Summary of proposed tree losses (large trees and small scattered trees only) within construction footprint per alignment option

ALIGNMENT OPTION		A0			A1			C0			C2		
COMMON NAME	SCIENTIFIC NAME	LARGE		SMALL*	LARGE		SMALL*	LARGE		SMALL*	LARGE		SMALL*
		^TP	^ST	ST	TP	ST	ST	TP	ST	ST	TP	ST	ST
Broad-leaf Peppermint	*Eucalyptus dives*							2					
Bundy	*Eucalyptus goniocalyx*	10			10			1			8		
Candlebark	*Eucalyptus rubida*	48	5	1	44	5	2	45	7	1	18	6	1
Eucalypt	*Eucalyptus spp.*	1						1			1		
Manna Gum	*Eucalyptus viminalis*	1	1			1		1	2			2	
Messmate Stringybark	*Eucalyptus obliqua*	63	1		49	1		27			42	1	
Narrow-leaf Peppermint	*Eucalyptus radiata*	3			1							1	
Red Stringybark	*Eucalyptus macrorhyncha*	3			2			5		1	2	1	
River Red-gum	*Eucalyptus camaldulensis*								1				
Scentbark	*Eucalyptus aromaphloia*	136	1		135	1		123		1	158	2	1
Snow Gum	*Eucalyptus pauciflora*							1					
Unknown	*Unknown*		1			1							
Yarra Gum	*Eucalyptus yarraensis*	2			2			1			2		
Yellow Box	*Eucalyptus melliodora*	94	3	7	100	3	5	74	8	2	50	8	2
Dead	*Dead*	11	3	1	8	3	1	12	4	2	5	4	2
Subtotals		372	15	9	351	15	8	293	22	7	286	25	6
Summary of large and small trees		387		9	366		8	315		7	311		6
Total (each alignment)		**396**			**374**			**322**			**317**		
Percentage large trees		**98%**			**98%**			**98%**			**98%**		

*Small scattered trees only. Each alignment will also result in loss of a considerable number of small trees in patches. These are partly accounted for through EVC impacts however will need to be assessed in detail for the preferred alignment. ^TP = tree in patch; ST = scattered tree

7.1.2.3 THREATENED FLORA

Some loss of significant terrestrial and wetland flora species may occur as a consequence of the proposed development. The likely impacts are described in Table 7.5 using the alignment and construction footprint (CF) to estimate losses. This allows for an initial estimate, prior to evaluation of impacts after suitable mitigation measures are applied, including the refinement of design, taking into account locations within the alignment in an effort to avoid or minimise impacts to these species.

Table 7.5 Significant flora species recorded or with the potential to occur within each alignment

COMMON NAME	SCIENTIFIC NAME	A0	A1	C0	C2
Matted Flax-lily	*Dianella amoena*	One record within alignment; none within CF	Two records within alignment; none within CF	Nine records within alignment; one within CF	Two records within alignment; one within CF
Emerald-lip Greenhood	*Pterostylis smaragdyna*	Alignment avoids all records	Alignment avoids all records	Alignment avoids all records	Alignment avoids all records
Floodplain Fireweed	*Senecio campylocarpus*	Alignment avoids all records	Alignment avoids all records	Alignment avoids all records	Alignment avoids all records
Ben Major Grevillea	*Grevillea floripendula*	Alignment avoids all records	Alignment avoids all records	Alignment avoids all records	Alignment avoids all records
Yarra Gum	*Eucalyptus yarraensis*	One record within alignment; one within CF	One record within alignment; one within CF	Two records within alignment; none within CF	Two records within alignment; one within CF
River Swamp Wallaby-grass	*Amphibromus fluitans*	Two records within alignment; one within CF covering approximately 0.25 ha	One records within alignment; one within CF covering an area approximately 0.25 ha	Three locations within alignment; two locations within CF covering an area approximately 1.02 ha	Two records within alignment; one within CF covering an area of approximately 0.05 ha
Pale-flower Cranesbill	*Geranium sp. 3*	Alignment avoids all records	Alignment avoids all records	Alignment avoids all records	Alignment avoids all records
Rosemary Grevillea	*Grevillea rosmarinifolia*	Alignment avoids all records	Alignment avoids all records	Alignment avoids all records	Alignment avoids all records
Ornate Pink Fingers	*Caladenia ornata*	Six records within alignment; four within CF	Six records within alignment; four within CF	Alignment avoids all records	Alignment avoids all records
Rough Wattle	*Acacia aspera subsp. parviceps*	No records within the study area	No records within the study area	No records within the study area	No records within the study area

7.1.2.4 THREATENED FAUNA

Habitat loss for threatened fauna species listed as threatened under the EPBC Act, FFG Act and/or the Victorian Advisory List will occur as a consequence of the proposed project.

Fourteen significant fauna species were considered to have a moderate to high likelihood of occurrence in the study area. The amount (ha) of habitat loss for each species across the different alignments is outlined in Table 7.6. The mapped habitat is based on fieldwork undertaken as a part of this project and is based on the construction footprint. The severity of all impacts on significant fauna (not just direct habitat loss) is assessed in Section 7.9.

Table 7.6 Breakdown of potential impact areas of mapped fauna species habitat within the construction footprint for each alignment option, see note below table for habitat quality definitions

HABITAT TYPE	A0	A1	C0	C2
Waterbird habitat Threatened species include Australasian Shoveler, Baillon's Crake, Blue-billed Duck, Brolga, Eastern Great Egret, Hardhead, Latham's Snipe, Musk Duck, Pied Cormorant, Eastern Long-necked Turtle	2.00 ha medium	0.58 ha medium	1.23 ha high 3.00 ha medium Total: 4.23 ha	0.71 ha medium
Woodland habitat Threatened species include Brown Treecreeper, Diamond Firetail, Painted Honeyeater, Powerful Owl, Speckled Warbler	34.94 ha	34.67 ha	35.29 ha	29.25 ha
Growling Grass Frog habitat	Aquatic Veg 0.37 ha high Aquatic Veg 0.87 ha medium Total aquatic: 1.24 ha Terrestrial 18.44 ha high Terrestrial 46.79 ha medium Total terrestrial: 65.23 ha	Aquatic Veg 0.37 ha high Aquatic Veg 0.44 ha medium Total aquatic: 0.81 ha Terrestrial 18.44 ha high Terrestrial 50.58 ha medium Total terrestrial: 69.02 ha	Aquatic Veg 2.20 ha high Aquatic Veg 0.68 ha medium Total aquatic: 2.88 ha Terrestrial 15.50 ha high Terrestrial 46.73 ha medium Total terrestrial: 62.23 ha	Aquatic Veg 0.37 ha high Aquatic Veg 0.73 ha medium Total aquatic: 1.10 ha Terrestrial 15.76 ha high Terrestrial 62.08 ha medium Total terrestrial: 77.84 ha
Brown Toadlet habitat	1.66 ha	1.25 ha	3.20 ha	1.31 ha
Arboreal mammal habitat Threatened species include Brush-tailed Phascogale	16.06 ha high 6.33 ha medium Total: 22.39 ha	13.16 ha high 8.08 ha medium Total: 21.24 ha	10.44 ha high 9.93 ha medium Total: 20.37 ha	10.44 ha high 4.62 ha medium Total: 15.06 ha

HABITAT TYPE	A0	A1	C0	C2
Golden Sun Moth habitat	3.28 ha confirmed 9.81 ha high 2.39 ha low Total confirmed and potential habitat 15.48 ha	1.40 ha confirmed 9.57 ha high 3.09 low Total confirmed and potential habitat 14.06 ha	1.73 ha confirmed 9.57 ha high 4.17 low Total confirmed and potential habitat 15.47 ha	1.49 ha confirmed 9.57 ha high 2.85 ha low Total confirmed and potential habitat 13.91 ha
Little Galaxias habitat	6 creek crossings	5 creek crossings	5 creek crossings and 1 wetland	7 creek crossings

All area in hectares (ha); High = High quality habitat, Medium = Medium quality habitat. See Section 4.5.7.3 for definitions of fauna habitat.
Note that areas of impact were not calculated for areas where the Beaufort Bypass alignments intersect with the Western highway as these sections of road have been built, therefore no habitat remains. In addition, some minor corrections in habitat boundaries have resulted in potential impact areas that vary slightly to those presented in the Cumulative Impact Assessment report which was completed by WSP in 2019 and updated in 2020 (Appendix N).

7.2 LOSS OF CONNECTIVITY

7.2.1 BACKGROUND

Clearing and construction can result in habitat fragmentation, where a patch of native vegetation may be spilt into multiple smaller patches. This effect is listed under the FFG Act as *'habitat fragmentation as a threatening process for fauna in Victoria'*. It can lead to increased 'edge effects', which is where habitat at the edge of the patch suffer more impacts from dust, noise, light and weed invasion than the middle of a single larger patch (Gleeson & Gleeson 2012). Fragmentation can also split a population of a species and cause a barrier to dispersal which can lead to smaller population sizes, inbreeding depression, greater susceptibility to environmental variation, and local extinction. Roads form a barrier or filter to the movement for certain species, particularly those that are sensitive to the noise, are slow moving (and suffer high mortality – discussed in Section 7.3) or require protective cover to move around.

7.2.2 IMPACTS OF THE FOUR ALIGNMENT OPTIONS

The fauna habitat in the study area is already fragmented to some degree, particularly through roads and historical clearing for agriculture. Nevertheless, the connectivity which currently exists among the remaining patches of native vegetation will be affected by the proposed road, especially the northerly alignments which pass through a larger patch of Camp Hill, which represents a significant sized remaining patch of native vegetation in the local area. The construction of the road may lead to road avoidance increasing isolation (and associated inbreeding as described above) or road mortality for some species. The proposed road may increase fauna injury and mortality during both the construction and the operational phase of the project, as discussed in the following sections.

The proposed road intersects smaller roads with remnant vegetation along the road corridor that could function as a regionally significant movement corridor for small woodland birds and arboreal mammals. Some species of woodland birds will not fly over large areas of open spaces such as highways. The project will add further barriers to connectivity for these species.

The ecological values most at risk of impact from habitat fragmentation and changes to wildlife movement are:

- fauna occurring in proximity to the alignment through Camp Hill State Forest, particularly Brush Tailed Phascogale, Sugar Glider, Black Wallaby other mammals and woodland birds
- fauna occurring at the waterway crossing through the Yam Holes Creek valley between Racecourse Road and Beaufort-Lexton Road, including amphibians, wetland birds and fish species
- fauna occurring at the waterway crossing through the Yam Holes Creek valley near Main Lead Road
- fauna occurring in the vicinity of Back Raglan Road and areas near Martins Lane
- macropod fauna such as Eastern Grey Kangaroo in more open and pastural areas and Black Wallaby in wooded areas
- fauna occurring in the vicinity of the remnant habitats near the railway and Packhams Lane.

7.2.2.1 BEAUFORT BYPASS IMPACT SCENARIO RESULTS

According to the modelling outputs of the bypass impact scenarios in the *Wildlife Connectivity Impact and Mitigation Assessment* (Lechner et al. 2019) (Appendix M), the four alternative alignments all reduced the connectivity in the landscape. This is a combined result of habitat loss for the construction of the bypass and the creation of barriers to movement between patches in the north and south of the study area. In addition, the response of each species to the alternative alignments varied according to their movement capabilities, most notably their ability to traverse open ground between patches of suitable habitat. For instance, the echidna is likely to be most impacted by the Bypass, regardless of alignment choice, because without mitigation the landscape will be fragmented into two isolated components. This will restrict echidna movement between habitat patches in the north and south of the study area. Overall, alignment option C2 was modelled to have the least impact on connectivity for Woodland Birds, Brush-tailed Phascogale and Echidna as the alignment has less impact on Camp Hill State Forest, a large contiguous patch of woodland habitat within the study area. In contrast, alignments A0 and A1 would bisect larger patches of habitat in Camp Hill State Forest and would have the greatest impact on connectivity, especially for woody-dependent species. The differences between the four alignments on connectivity for the Golden Sun Moth and Growling Grass Frog were likely to be negligible, with the majority of impacts on these two species likely due to loss of habitat and road mortality rather than reductions in connectivity.

The sections below summarise and contain direct extracts from Wildlife Connectivity Impact and Mitigation Assessment (Lechner et al. 2019). Refer to the detailed analysis of the impacts on connectivity in Appendix M. Impacts on connectivity of habitat for each significant species are considered in the Significant Impact Assessment (provided as Appendix J).

WOODLAND BIRDS

Connectivity and least-cost corridors is visualised for Woodland birds with explanatory comments on Figure 7.1. Firstly, the white areas in represent areas outside of the least-cost corridors. The Circuitscape analysis shows areas of high current density as warmer in colour (yellow) and low current density in cooler colours (blue). Pixels with high current density represent areas with a higher probability of a random individual moving between patches. Locations with high current density, constrained to a small number of pixels represent pinchpoints. Pinchpoints (or chokepoints) are areas where animal movement is constrained within corridors and areas with such linkages are areas that will have significant impacts on connectivity if severed. Commonly the least-cost paths and pinchpoints overlap.

There are a number of pinchpoints across the study area, but one of the more critical locations for the Woodland birds is in the larger component in the northwest where the current freeway cutting is. There are also a number of other smaller scale pinchpoints throughout the Beaufort study area.

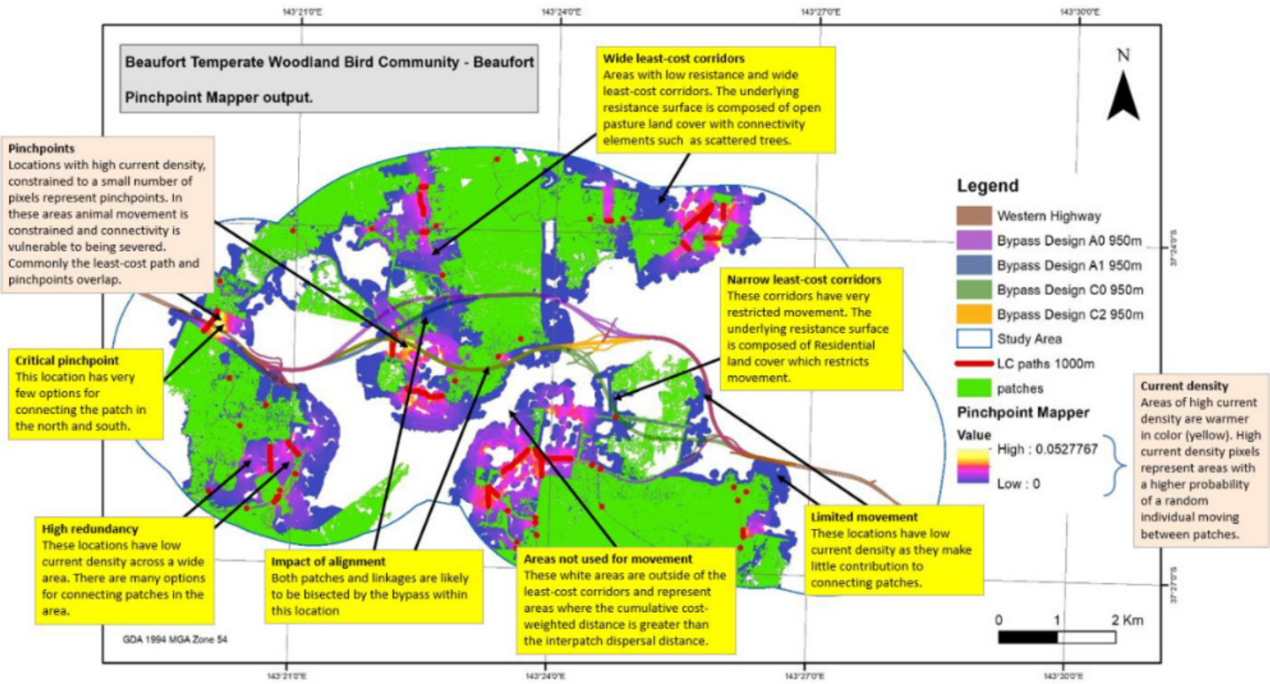


Figure 7.1 Linkage mapper and Circuitscape pinchpoint analysis of current levels of connectivity for Woodland Birds with the Western Highway and Bypass design A0, A1, C0 and C2 overlaid (extract from (Lechner et al. 2019). The bypass designs are included (but not modelled) to allow for a comparison with current connectivity. Definitions are found within pink boxes and explanations within yellow boxes

A compilation of the modelled impacts for each of the four bypass designs on connectivity for Woodland birds is summarized using graph metrics in Table 7.7. For Woodland birds, the group of patches in the north would be most affected as all four bypass designs intersect them. Bypass designs A0 and A1 resulted in more disconnected habitat patches in the central region compared to C0 and C2. Bypass design C0 is the only design which impacted the component in the southeast while design C2 appears to have the least impact on connectivity and habitat by avoiding majority of the habitat patches.

Table 7.7 Landscape-scale graph-metrics and the number of patches and links for the scenarios tested for Woodland birds overlaid (extract from (Lechner et al. 2019)

Network characteristic	Current Scenario	Future Scenario			
		Design Option A0	Design Option A1	Design Option C0	Design Option C2
Mean size of components (km^2)	12.285	12.168	12.186	12.186	12.238
Size of largest component (km^2)	15.779	15.547	15.584	15.687	15.687
Number of components	2	2	2	2	2
IIC	0.012785	0.012431 (-2.776%)	0.012049 (-5.762%)	0.012344 (-3.455%)	0.012479 (-2.395%)
Patches	34	36	36	36	35
Links	61	81	66	62	60
Total patch area (km^2)	24.569	24.336 (-0.233)	24.373 (-0.196)	24.372 (-0.197)	24.476 (-0.093)

Values in brackets refer to percentage difference compared to the current connectivity, for Integral Index of connectivity (IIC), and total patch area. IIC and total patch area are correlated, with the impacts colour coded from red, orange, yellow to green; where green means least impact and red means greatest impact.

BRUSH-TAILED PHASCOGALE

Connectivity and least-cost corridors is visualised for Brush-tailed Phascogale on Figure 7.2. This shows that Brush-tailed Phascogale are likely to utilise most of the matrix for dispersal, particularly the northern and southern areas with less connectivity through the central areas of the study area where there is less habitat.

A compilation of the modelled impacts for each of the four bypass designs on connectivity for Brush-tailed Phascogale is summarized using graph metrics in Table 7.8. The differences between the different bypass designs on the Brush-tailed Phascogale was mostly driven by the loss of habitat. Bypass design C2 had the smallest impact on habitat loss compared to A0 which dissects core contiguous habitat area in the central region. Bypass Design A0 and C2 did not change the number of patches while A1 results in the creation of two more patches. The assessment of overall IIC values show that option C2 has the least impact on Brush-tailed Phascogales with only a 0.03% decrease in IIC value versus a 9.45% decrease for bypass designs A0 and A1.

For the Brush-tailed Phascogale both visually and quantitatively it appeared as though design option C2 had the least impacts. The habitat patches are least fragmented with bypass design C2 and most fragmented with A0 and A1 based on IIC but regardless, all options will fragment habitat for Brush-tailed Phascogale.

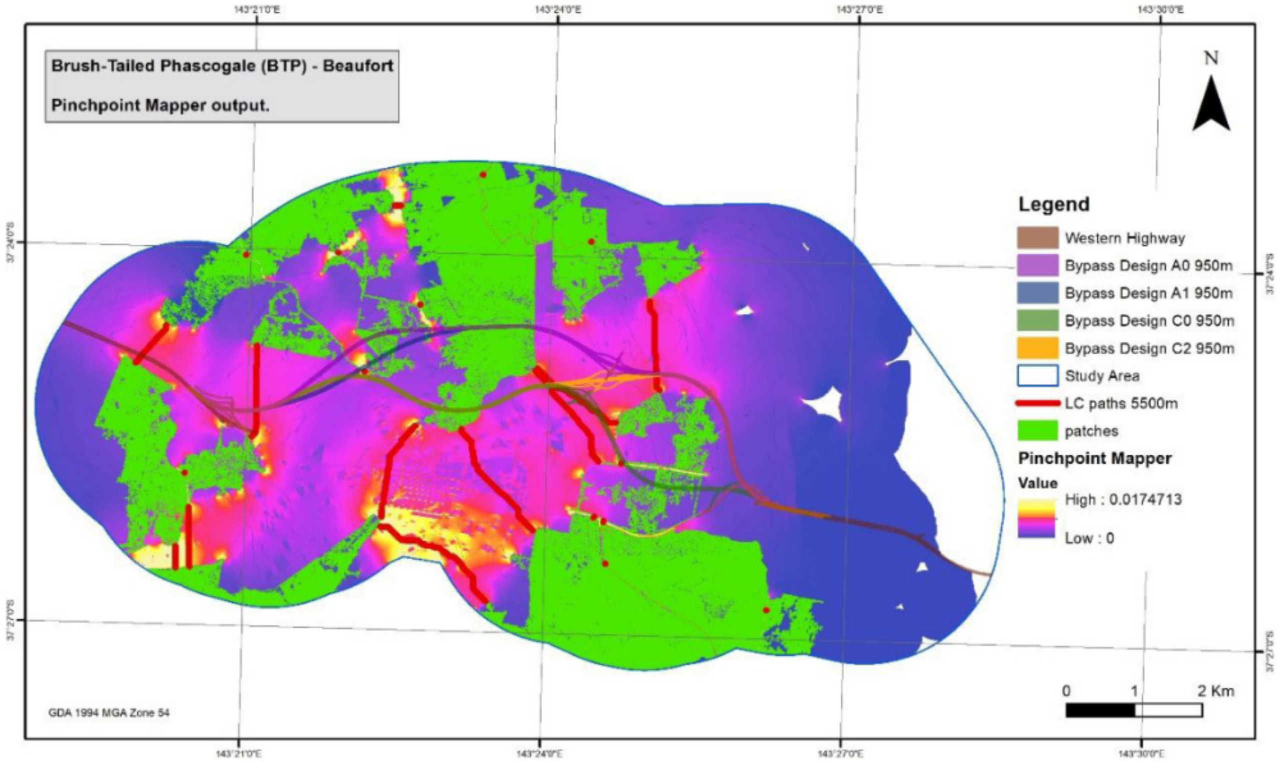


Figure 7.2 Linkage mapper and Circuitscape pinchpoint analysis of current levels of connectivity for Brush-tailed Phascogale with the Western Highway and Bypass design A0, A1, C0 and C2 overlaid (extract from (Lechner et al. 2019). The bypass designs are included (but not modelled) to allow for a comparison with current connectivity

Table 7.8 Landscape-scale graph-metrics and the number of patches and links for the scenarios tested for Brush-tailed Phascogale (extract from (Lechner et al. 2019)

Network characteristic	**Current Scenario**	**Future Scenario**			
		Design Option A0	**Design Option A1**	**Design Option C0**	**Design Option C2**
Mean size of components (km^2)	22.001	21.218	21.218	21.272	21.797
Size of largest component (km^2)	22.001	21.218	21.218	21.272	21.797
Number of components	1	1	1	1	1
IIC	0.019285	0.0174386 (-9.845%)	0.0174386 (-9.845%)	0.019494 (-1.09%)	0.019279 (-0.030%)
Patches	14	14	15	13	14
Links	31	35	36	31	33
Total patch area (km^2)	22.001	21.218 (-0.783)	21.727 (-0.274)	21.272 (-0.729)	21.797 (-0.204)

Values in brackets refer to percentage difference compared to the current connectivity, for IIC, and total patch area. IIC and total patch area are correlated, with the impacts colour coded from red, yellow, orange to green; where green means least impact and red means greatest impact

ECHIDNA

Connectivity and least-cost corridors is visualised for Echidna on Figure 7.3. Similar to the Brush-tailed Phascogale, most of the landscape is well-connected for the Echidna due to the long interpatch dispersal distances of the species.

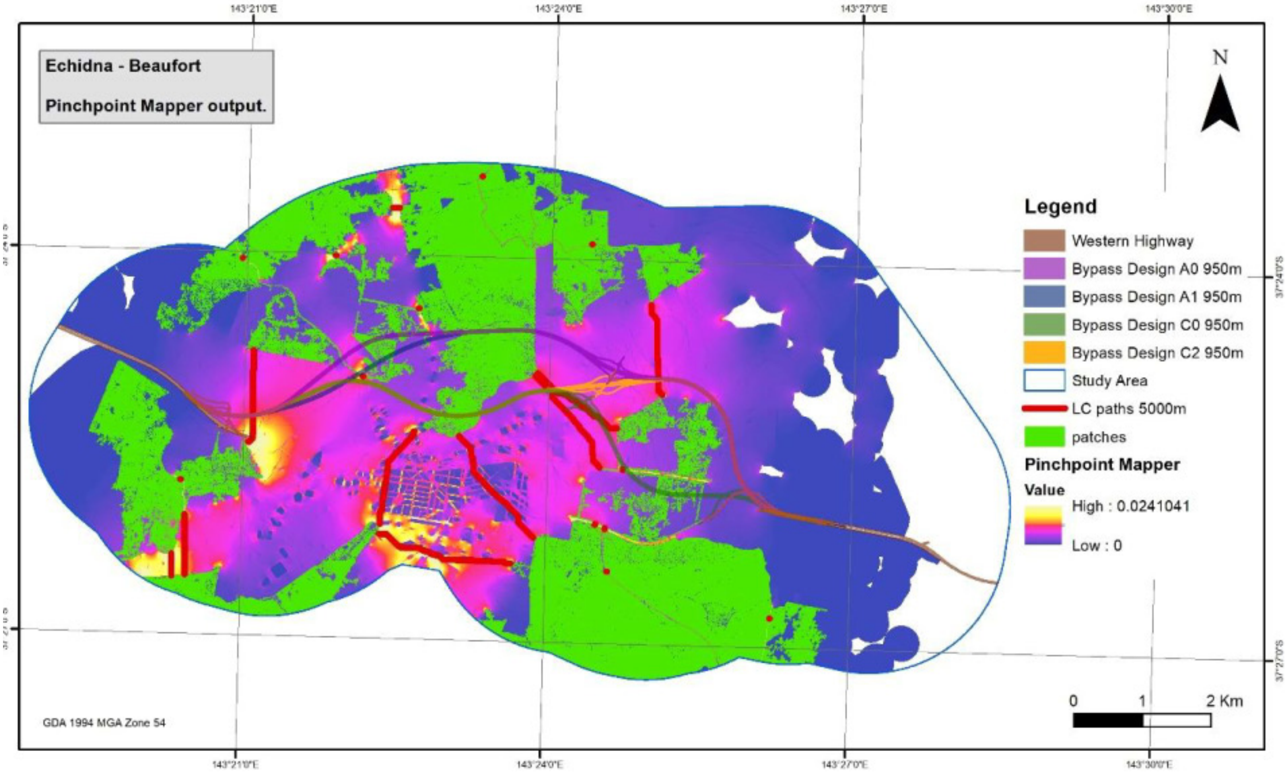


Figure 7.3 Linkage mapper and Circuitscape pinchpoint analysis for current levels of connectivity for Echidna with the Western Highway and Bypass design A0, A1, C0 and C2 overlaid (extract from (Lechner et al. 2019). The bypass designs are shown (but not modelled) to allow for a comparison with current connectivity

A compilation of the modelled impacts for each of the four bypass designs on connectivity for Brush-tailed Phascogale is summarized using graph metrics in Table 7.9. Unlike the previous two woody-dependent conservation target species, the Western Highway as a barrier to dispersal for Echidna, so regardless of bypass design the landscape will be fragmented into 2 isolated components with movement between the patches to the north and south restricted.

Habitat patches were least fragmented by bypass design C0, where the number of patches decreased by one and bypass designs A0, A1 and C2 did not change the number of patches. The decrease in total patch area was the greatest with Bypass Design A0, followed by A1, C0 and C2.

The IIC assessment shows a large decrease in the IIC value of 40% or over for all bypass designs. This is because the bypass will fragment the landscape into two components which are approximately half the total habitat area in each of them. The smallest decrease in IIC value was associated with bypass design C2 and the largest with A0.

Table 7.9 Landscape-scale graph-metrics and the number of patches and links for the scenarios tested for Echidna (extract from (Lechner et al. 2019)

Network characteristic	Current Scenario	Future Scenario			
		Design Option A0	Design Option A1	Design Option C0	Design Option C2
Mean size of components (km^2)	22.001	10.609	10.615	10.636	10.899
Size of largest component (km^2)	22.001	12.924	12.923	10.721	11.725
Number of components	1	2	2	2	2
IIC	0.019138	0.010909 (-42.994%)	0.010919 (-42.947%)	0.010933 (-42.872%)	0.011317 (-40.862%)
Patches	14	14	14	13	14
Links	29	22	22	16	19
Total patch area (km^2)	22.001	21.218 (-0.783)	21.229 (-0.772)	21.272 (-0.729)	21.797 (-0.204)

Values in brackets refer to percentage difference compared to the current connectivity, for IIC, and total patch area. IIC and total patch area are correlated, with the impacts colour coded from red to green; where green means least impact and red means greatest impact.

GROWLING GRASS FROG

Connectivity and least-cost corridors is visualised for Growling Grass Frogs on Figure 7.4. The largest component of connectivity extends from the centre of the study area to the east is composed of a chain of patches and linkages. The chain connects habitat patches to the larger patches along the eastern boundary of the study area where there are known populations of Growling Grass Frog. Figure 7.4 shows that the Growling Grass Frog is likely to be very restricted in its use of the matrix due to its short interpatch dispersal distance threshold. There are very few locations with pinchpoints present.

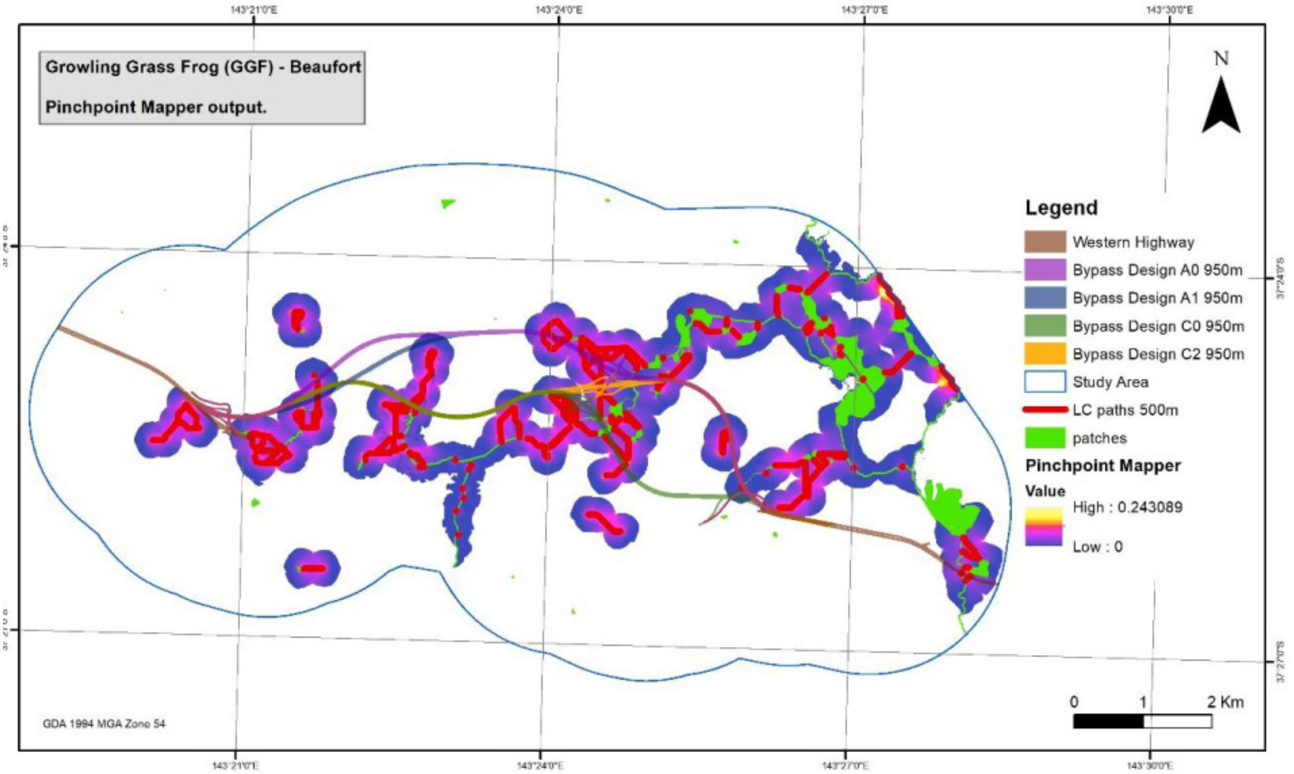


Figure 7.4 Linkage mapper and Circuitscape pinchpoint analysis of current levels of connectivity for Growling Grass Frogs with the Western Highway and Bypass design A0, A1, C0 and C2 overlaid (extract from (Lechner et al. 2019). The bypass designs are shown (but not modelled) to allow for a comparison with current connectivity

A compilation of the modelled impacts for each of the four bypass designs on connectivity for Growling Grass Frog is summarized using graph metrics in Table 7.10. The number of components increased by two with the implementation of Bypass Design A0, A1 and C0 and C2 resulted in an increase of one component from the original value. The IIC values will decrease the most with Bypass Design C2. However, the difference between the bypass designs on IIC are negligible at ~0.01%.

Table 7.10 Landscape-scale (network) graph-metrics and the number of patches for the scenarios tested for Growling Grass Frog (extract from (Lechner et al. 2019)

Network characteristic	**Current Scenario**	**Future Scenario**			
		Design Option A0	**Design Option A1**	**Design Option C0**	**Design Option C2**
Mean size of components (km^2)	0.119	0.107	0.107	0.106	0.113
Size of largest component (km^2)	2.038	2.031	2.031	2.010	2.030
Number of components	18	20	20	20	19
IIC	0.00013399	0.00013005 (-2.942%)	0.00013004 (-2.947%)	0.00013080 (-2.382%)	0.00013004 (-2.949%)
Patches	127	125	124	130	124
Links	199	184	183	199	188
Total patch area (km^2)	2.150	2.138 (-0.012)	2.142 (-0.008)	2.124 (-0.026)	2.141 (-0.009)

Values in brackets refer to percentage difference compared to the current connectivity, for dIIC, and change in area for total patch area. IIC and total patch area are correlated, with the impacts colour coded from red to green; where green means least impact and red means greatest impact.

GOLDEN SUN MOTH

Connectivity and least-cost corridors is visualised for Golden Sun Moth in Figure 7.5. The landscape for the Golden Sun Moth is characterised by a number of larger components which include one or more larger interconnected patches. The distances between most of the components within the study are much further than 200 m, and thus are unlikely to be connected based on the 200 m interpatch dispersal distance even if the intervening land cover had no resistance.

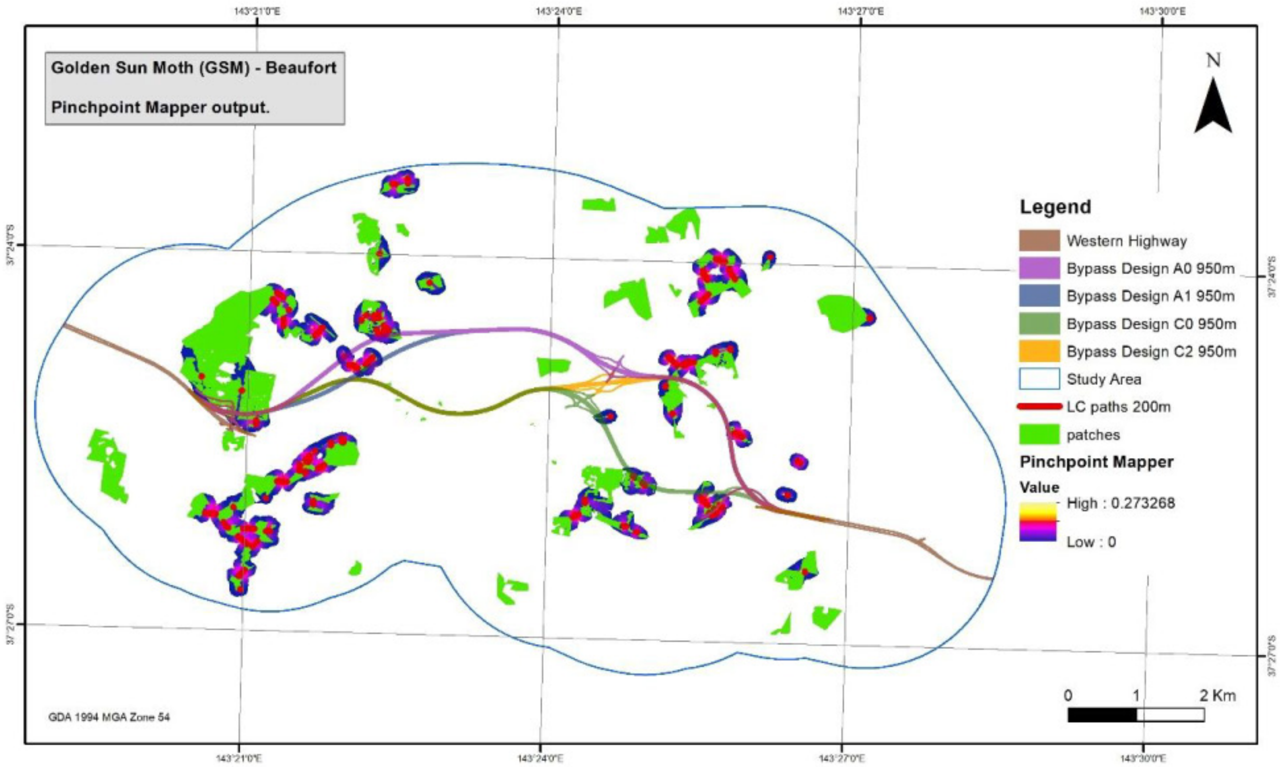


Figure 7.5 Linkage mapper and Circuitscape pinchpoint analysis for Golden Sun Moth with the Western Highway and Bypass design A0, A1, C0 and C2 overlaid (extract from (Lechner et al. 2019). The bypass designs are shown (but not modelled) to allow for a comparison with current connectivity

A compilation of the modelled impacts for each of the four bypass designs on connectivity for Golden Sun Moth is summarized using graph metrics in Table 7.11. An assessment of the change in the IIC value shows that bypass design C2 had the least impact and A1 the most. However, the differences between the different designs were very small at less than 0.1%. Overall, design C2 had the least impact quantitatively (in terms of IIC and total area) but it should be noted that all of the designs have broadly similar impacts on habitat loss and fragmentation on the Golden Sun Moth. The major difference in impacts between designs is on whether the group of patches in the north east or south east are impacted.

Table 7.11 Landscape-scale graph-metrics and the number of patches and links for the scenarios tested for Golden Sun Moth (extract from (Lechner et al. 2019)

Network characteristic	**Current Scenario**	**Future Scenario**			
		Design Option A0	**Design Option A1**	**Design Option C0**	**Design Option C2**
Mean size of components (km^2)	0.137	0.121	0.127	0.121	0.127
Size of largest component (km^2)	1.613	1.482	1.481	1.481	1.481
Number of components	39	43	41	43	41
IIC	0.00022892	0.00020258 (-11.504%)	0.00020249 (-11.546%)	0.00020271 (-11.447%)	0.00020262 (-11.488%)
Patches	118	125	124	128	123
Links	120	128	127	132	126
Total patch area (km^2)	5.359	5.205 (-0.154)	5.218 (-0.141)	5.208 (-0.151)	5.224 (-0.135)

Values in brackets refer to percentage difference compared to the current connectivity, for IIC, and total patch area. IIC and total patch area are correlated, with the impacts colour coded from red to orange, yellow and green; where green means least impact and red means greatest impact.

7.3 FAUNA INJURY AND MORTALITY

The proposed road may increase fauna injury and mortality during both the construction and the operational phase of the project, as discussed in the following sections. This is discussed in general terms across all four alignments as impacts are expected to be relatively consistent.

7.3.1 CONSTRUCTION PHASE

Mortality of wildlife during construction may occur during clearing, or during instances when wildlife strays into the construction zone (van der Ree, Smith & Grilo 2015). The potential for injury and mortality of wildlife from the project is summarised in Table 7.12 below.

Table 7.12 Summary of potential for increased injury and mortality from construction phase

ACTIVITY WITH POTENTIAL TO CAUSE MORTALITY	NATIVE ANIMALS WITH POTENTIAL TO BE AFFECTED	NATURE AND MAGNITUDE OF THE IMPACT OF THE PROJECT
Vegetation/habitat removal during construction: Removal of mature trees with hollows and dead standing trees	— Hollow-dependent bats — Hollow-nesting and canopy-nesting birds — Arboreal mammals — Arboreal reptiles — Arboreal frogs — Invertebrates	A large number of potentially hollow bearing large old trees are likely to be removed for the proposed road. Appropriate controls during construction will need to be implemented to protect arboreal mammals. The level of mortality and injury of both non-threatened and threatened species of birds, bats, arboreal mammals is likely to be lower with mitigation measures in place.
Removal of understorey, groundcover, topsoil and debris (wood, rocks, rubbish etc.)	— Small woodland birds — Ground-dwelling reptiles — Frogs — Invertebrates	Mortality of species of native (non-threatened) reptiles and frogs is likely to occur in higher numbers from vegetation (groundcover) clearance
Machinery/plant and vehicle collisions with fauna during construction	— Terrestrial, semi-aquatic and arboreal reptiles, frogs and mammals — Birds, especially waterbirds	Occasional mortality of native animals may occur during vehicle movements within the study area. This is unlikely to be a substantial risk as construction speed limits would be low.
Other causes of mortality (trenches etc)	— Terrestrial, semi-aquatic and arboreal reptiles, frogs and mammals	Without sufficient controls, mortality may result from fauna falling into trenches or sheltering in materials. This risk can be substantially reduced through stringent fauna management measures.

7.3.2 OPERATIONAL PHASE (ONGOING IMPACTS)

7.3.2.1 BACKGROUND

Many species are vulnerable to injury and mortality from roads, with the impacts on populations differing between species (Donaldson & Bennett 2004). The impacts will differ for different taxa depending on their ability to move out of the way of moving vehicles, the extent to which the species is attracted to the road, and (if a bird or bat) the height at which the species flies.

All roads have potential to result in the mortality (roadkill) of native animals. The risk of roadkill is higher where roads:

- traverse between areas of substantial animal habitat, including wildlife corridors
- are located in close proximity to natural or artificial water bodies
- contain food sources (e.g. mown grass verges, nectar-producing shrubs) which attract animals to the road edge
- have high speed limits
- provide poor visibility of wildlife (e.g. due to bends, crests and poor lighting).

A number of studies on the impacts of roads on birds in Australia provide differing information, depending on the spatial and temporal influences on bird habitats and times (e.g. breeding cycles) (Donaldson & Bennett 2004). For example, in one study, mortality was recorded at the highest levels at the intersection of roads and creeks (Brown, Brown & Pesotto 1986). Raptor species may be attracted to the carrion left on roadsides, although if sufficiently mobile, these species may experience a net benefit from increased food availability (Fahrig & Rytwinski 2009).

Amphibians and reptiles may be attracted to warm or wet roads. This group show the greatest negative effect from roads due to their relative lack of mobility and low car avoidance behaviour.

Small mammals generally show a positive or no effect, with impacts increasing with size in mammals and size of movement range, and depending on whether their predators have been affected (Fahrig & Rytwinski 2009).

The impact of introduced carnivores, specifically cats and foxes, is considered unlikely to be noticeably increased by the proposed works. Feral cats and foxes are already present in the study area. This should be taken into account when designing mitigation measures, as particular measures can be co-opted by predators and provide them an advantage, although increased predation does not seem to be an issue at most wildlife passages (Little, Harcourt & Clevenger 2002).

7.3.2.2 IMPACTS OF THE FOUR ALIGNMENTS

In the study area, mortality from the road is expected to be highest near wetlands, where the road is at grade or above, in cleared farmland areas where there are Eastern Grey Kangaroos and through Camp Hill State Forest where there are Black Wallabies, Brushtailed Phascogales and possums. All four alignments may result in considerable fauna mortality during operation of the road, without mitigation as all pass through the above habitats.

7.4 NOISE AND VIBRATION

7.4.1 BACKGROUND

A recent study has demonstrated that there is unequivocal evidence that noise is one of the factors responsible for the road-effect zone on birds (McClure, Christopher J. W. et al. 2013).

The noise from road construction and then operational traffic can be stressful, eliciting a physiological stress response, with some animals temporarily or permanently moving away from the noise. Species that remain exposed to the noise have reportedly experienced a range of responses, including reduced breeding success (Halfwerk et al. 2011; Reijnen, R & Foppen 1994) and lower survival rates, potentially such that otherwise suitable habitat is no longer occupied (Slabbekoorn & Ripmeester 2008).

There is also an increasing body of evidence demonstrating a variety of responses to anthropogenic noise in frogs, birds and other species that rely on acoustic signals (Brumm 2004; Hoskin & Goosem 2010; Parris, Kirsten M & Schneider 2008; Slabbekoorn & Ripmeester 2008). One of these impacts is masking, or where the noise interferes with the acoustic signals critical to many animal species (Halfwerk et al. 2011), including calling to attract mates, territory defence, and warning of predators. The negative effect of traffic noise on birds depends on the temporal and frequency (Hz) overlap with relevant acoustic sounds, such as their own song or calls of predators (Brumm & Slabbekoorn 2005). Most birds call to defend territory and attract mates, with much of this occurring around dawn. The impacts of traffic noise on birds can be particularly acute if this dawn 'chorus' of their calling coincides with morning peaks in traffic.

Similarly, some species of bats that rely on acoustic signals to locate their insect prey are disadvantaged close to noisy roads (Schaub, Ostwald & Siemers 2008; Siemers & Schaub 2011). A recent synthesis of the effects of traffic noise on birds suggested that masking typically occurs with noise levels between 50 and 60 dB (Dooling, RJ & Popper 2007).

There are two main components to noise which is relevant here: frequency, or pitch, which is measured in hertz (Hz); and, amplitude (also referred to as loudness), which is measured in pressure or intensity, and is expressed in decibels (dB). The decibel (dB) is a logarithmic scale that allows a wide range of values to be compressed into a more comprehensible range, typically 0 dB to 120 dB. A logarithmic scale is used in acoustic assessments because the human ear has a vast sound-sensitivity range of over a thousand billion to one dB.

7.4.1.1 CONSTRUCTION VIBRATION AND NOISE

Vibration is predominantly expected to be short term during the construction phase which involves piling works and vibratory compaction of ground surfaces. Vibration is generally considered unlikely to impact fauna, as it will be short term and has only local impacts (i.e. near the site of the machinery). However, even short-term impacts during the breeding season for threatened fauna should be avoided, where possible.

A small number of studies have shown that exposure to high-intensity construction and traffic noise can result in temporary or permanent hearing loss in animals (Brattstrom & Bondello 1983; Dooling, RJ & Popper 2007). The sound pressure level of continuous noise that induces temporary hearing loss in birds is 93–110 dB(A) and higher levels are required to potentially cause permanent loss, while levels of pulses need to exceed 125 dB(A) to permanently damage hearing in birds (Dooling, RJ & Popper 2007). However, high-intensity traffic noise is not anticipated on the Beaufort Bypass, based on the traffic estimates contained in the Traffic and Transport Report.

7.4.1.2 OPERATIONAL NOISE

Substantial variation has been shown in scientific studies in the responses of wildlife to human-generated noise and vibration, ranging from serious to non-existent in different species and situations. The main impacts on wildlife associated with noise are behavioural. Vehicle noise has been shown, particularly in some species of birds and frogs, to interfere with communication essential for reproduction. An increase in traffic noise may impact birds' ability to maintain territories, attract mates and maintain pair bonds and possibly lead to a decrease in mating success (Parris, Kirsten M & Schneider 2008). Noise may affect behaviour by causing animals to retreat from favourable habitat near noise sources, reducing time spent feeding and resulting in energy depletion and lower likelihood of survival and reproduction (Larkin 1996). These impacts will be most pronounced in species with low-frequency signals as they are likely to experience the most interference with traffic noise.

There is little information available regarding the significant species in the study area. In a study in Finland, highway construction at a wetland resulted in the abundance in wader birds breeding nearby (up to 200 m) dropping by 80%, with decline linked to road noise above 56 db (Hirvonen, H. 2001).

There have been several attempts to identify a threshold level in traffic noise above which negative impacts occur. Dooling & Popper (2007) suggested limits of 93–110 dB(A) for continuous traffic noise to prevent temporary hearing loss in birds, and pulses to not exceed 125 dB(A) to prevent permanent damage to hearing. Dooling and Popper (2007) also tentatively suggested that noise levels from roads should not exceed 50–60 dB(A) to prevent masking and other similar effects while a more recent study suggested the threshold was 49 dB(A) (Wiacek et al. 2015).

McClure et al (2013) and Ware et al. (2015) both found a significant effect to propagated road noise at 55 dB(A)Leq within a road-free landscape with a background noise level of 41 dB(A), demonstrating a maximum threshold (i.e. 55 dB(A)) that should be avoided. Unfortunately, no studies have evaluated a range of noise levels to identify where thresholds might occur, and thus the 55 dBA Leq should be considered a maximum threshold. Much lower thresholds in acceptable noise levels for all species of breeding birds in woodland (42–52 dB(A)) and open grassland (47 dB(A)) in the Netherlands were suggested by Reijnen et al. (1997). Numerous studies that compared noisy environments with quieter ones had quiet environments around the 31 L10 18 h dB(A) SPL (Parris, K. M. & Schneider 2009), and 42 dB(A) (Wiacek & Polak 2015) levels. A study of wetland birds in Finland found a negative effect where noise levels exceeded 56 dB, implying that this SPL may represent a threshold in that study (Hirvonen, Heikki 2001). An updated review by Dooling and Popper (Dooling, RJ, Popper, A.N. 2016) found that masking can occur above ambient noise levels but that, given behavioural adaptation strategies, noise guidelines in the range of 50–60 dBA would be appropriate.

From this body of evidence, and relying largely on the comprehensive reviews by Dooling and Popper (2007 and 2016), where specific information is not available regarding the sensitivities of the species of interest, traffic noise should be kept below 60 dBA. This is likely to be especially important during the morning chorus and during breeding.

Noise monitoring for the project, using nine recorders scattered around the study area, indicates that most locations that the alignments pass through have maximum noise levels between 40 and 50 $dBL_{A10,18hr}$ (with much lower 'background noise levels'). Two locations at either end of the project were found to have existing maximum noise levels above 50 $dBL_{A10,18hr}$. Both locations were where the project joins the Western Highway, with the western receiver near Martin's Lane at 57 $dBL_{A10,18hr}$ and the eastern one just north of the Western Highway at 66 $dBL_{A10,18hr}$.

7.4.2 IMPACTS OF THE FOUR ALIGNMENTS

A Noise and Vibration Impact Assessment report has been prepared for the project (WSP 2020c). The potential for noise and vibration impacts on fauna from the four alignments are assessed below.

7.4.2.1 CONSTRUCTION

Given the short-term nature of any high noise-generating activities, the impacts of construction noise on wildlife for all of the four alignments are expected to be generally minor. However, noisy and high vibration work near sensitive habitats (wetlands and woodland) from July-October inclusive may impact breeding of significant fauna species.

7.4.2.2 OPERATION

The modelled noise impacts for each alignment were examined and 10 areas of ecological sensitivity and value were examined in detail (Table 7.13). These were based on the results of a noise impacts assessment is provided in Noise and Vibration Impact Assessment (WSP 2020c). These sensitive locations include wetlands, waterway crossings and dams which provide potential or known habitat for wetland dependent species such as waterbirds and frogs (eg. Growling Grass Frog, Brolga). They also include fauna species which inhabit Victorian Temperate Woodland Bird Community (VTWBC) habitat, including Camp Hill State Forest and other smaller patches of forest/woodland habitat. Based on the recorder data (WSP 2020c) most of these ecologically sensitive receivers identified are expected to have maximum current noise levels under 50 $dBL_{A10,18hr}$, with exception of Camp Hill forest area and Yam Holes Creek valley between Beaufort-Lexton Road and Racecourse Road. From the assessment, all alignments will result in substantial noise increases (unmitigated) in some areas of habitat, including large areas of VTWBC. A0 will result in three areas with substantial impacts, A1 two areas with substantial impacts, C0 with three areas with substantial impacts and C2 with two areas with substantial impacts.

Table 7.13 Potential noise impacts

ID NUMBER (FIGURE 7.1)	1	2	3	4	5	6	7	8	9	10
Description	Martin's Ln roadside woodland/ forest	Woodland west of Back Raglan Rd	Woodland/ forest between Back Raglan Rd and Main Lead Rd	Camp Hill State Forest	Wetlands between Beaufort-Lexton Rd and Racecourse Rd	Wetlands south of Racecourse Rd	Snowgums woodland reserve	Forest north of rail line and west of Packhams Ln	Forest south of railway line, west of Packhams Ln	Wetlands east of Smiths Ln
Value*	Moderate	Moderate	High	High	High	High	High	High	High	High
Expected sensitivity to noise**	Low	Moderate	Moderate-High	Moderate-high	Moderate	High	Moderate	Moderate	Moderate	High
Anticipated impacts***										
A0	Some	Substantial	Substantial	Substantial	Some	Negligible	Negligible	Some	Negligible	Negligible
A1	Some	Negligible	Substantial	Substantial	Some	Negligible	Negligible	Some	Negligible	Negligible
C0	Some	Negligible	Some	Substantial	Negligible	Substantial	Some	Negligible	Substantial	Negligible
C2	Some	Negligible	Some	Substantial	Substantial	Negligible	Negligible	Negligible	Negligible	Negligible

ID NUMBER (FIGURE 7.1)	1	2	3	4	5	6	7	8	9	10
Comments	This vegetation is VTWBC habitat but is already impacted by noise from the Western Highway	Alignment A0 bisects this habitat, with noise impacts on the remaining patches likely	Alignments A0 and A1 bisect this habitat, with substantial impacts on remaining habitat likely. Alignments C0 and C2 will result in some increased noise along the southern edge	Cutting minimises the impact however there are still substantial increases in noise	For A0, A1 and C2, some to substantial impacts on known wetland bird and frog habitat is anticipated.	Known Brolga habitat just east of the C0 footprint would be substantially affected	For C0, wetland and habitat along the western side of Snowgums would be affected with a small area >60 dbl. Other alignments would have a negligible impact here.	Largely mitigated by a noise wall for residences	Alignment C0 bisects habitat, with noise impacts on the remaining patches likely	Alignments appear to be sufficiently far from wetland (Brolga) habitat that impacts would be negligible to minor

Definitions used in the above table

<u>Value</u>
Low: partially to highly modified and/or unlikely to regularly support threatened species
Moderate: partially modified and/or may support threatened species
High: currently unmodified and/or likely to support threatened species

*****<u>Expected sensitivity to noise</u>***
Low: already affected by noise, wildlife likely to be habituated, unlikely to support sensitive species
Moderate: somewhat affected by noise already, may still support some sensitive species
High: minimal current noise, likely to support sensitive species

****** <u>Anticipated impacts</u>***
Negligible: minimal increase in noise with none >60 dBLA10,18hr
Some: Increase in noise, although only small areas reaching >60 dBLA10,18hr
Substantial: Substantial increase in noise from likely current conditions, or a small increase affecting a large area of habitat, with areas >60 dBLA10,18hr

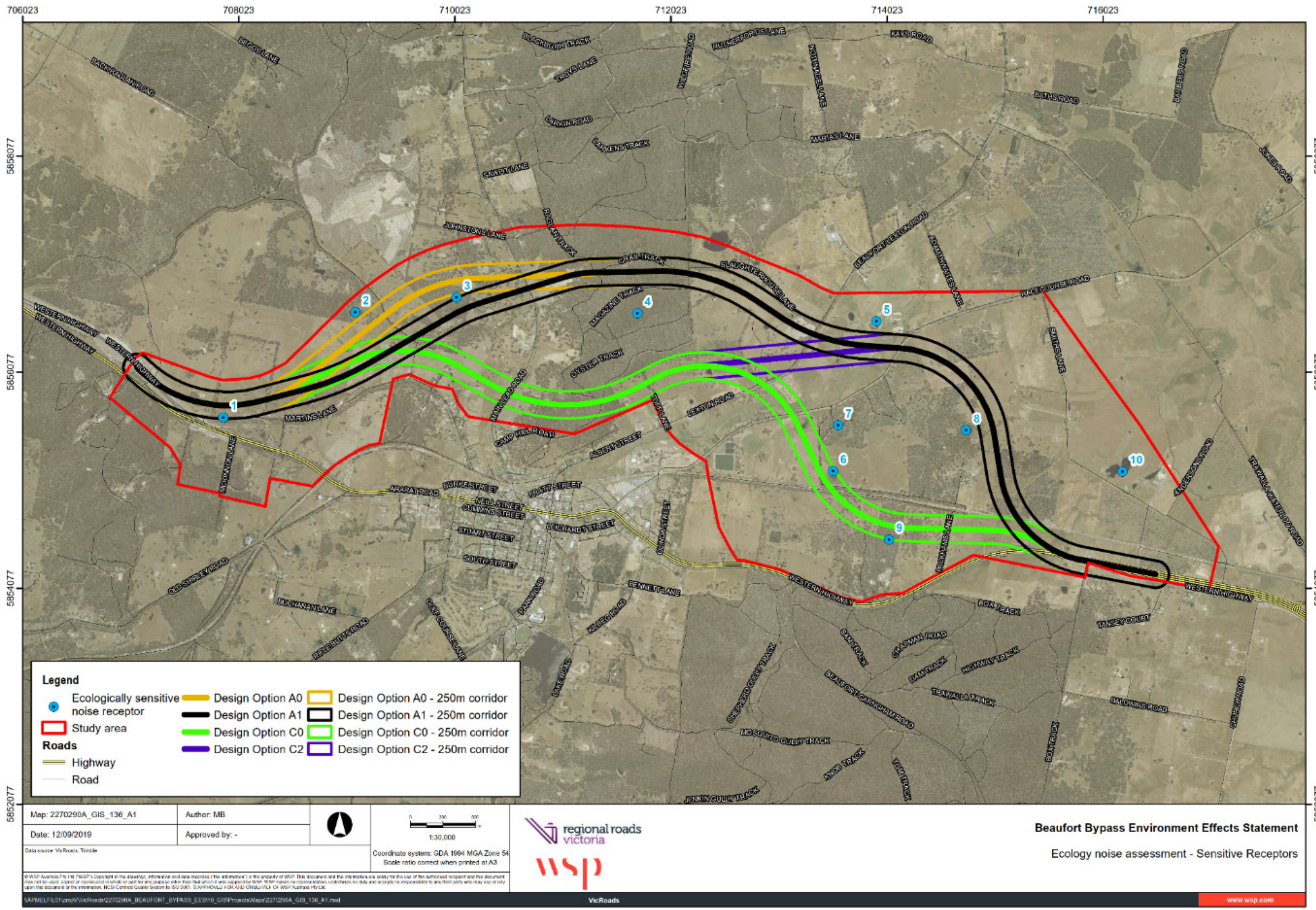


Figure 7.6 Areas of ecological sensitivity and value for noise impact evaluation

7.5 ECOLOGICAL LIGHT POLLUTION

7.5.1 BACKGROUND

Artificial light that alters the natural patterns of light and dark in ecosystems is referred to as 'ecological light pollution' (Longcore & Rich 2004). Types of ecological light pollution include chronic or periodically increased illumination, unexpected changes in illumination, and direct glare (Longcore & Rich 2004). Light pollution from the project has the potential to impact fauna during construction of the proposed bypass through use of artificial lighting for early morning or night work (if required), as well as ongoing (during the operational phase of the road) from car headlights and street lighting. Street lighting will likely be kept to a minimum, with lights at interchanges but not along the entire highway itself. With regard to construction lighting, night work is not usually permitted for construction projects. Any night works scheduled would be short-term only. Work is not expected to occur early enough that lights are required. As such, impacts from the permanent road lighting are expected to be far greater than for the temporary construction lighting.

Artificial light affects species in different ways but the main responses are:

- Disorientation – Artificial light sources may disorient night flying species including birds and bats, as well as other species such as turtles (Gleeson & Gleeson 2012). Conversely, artificial lighting may increase orientation, providing a benefit to particular species.
- Attraction – Predator species such as Magpies and Kookaburras are attracted to the lights due to the increased insect activity (Patriarca 2010), as are some species of insectivorous bats. Wading birds have also shown increased foraging success under artificial lighting (Santos et al. 2010), however, this may lead to increased predation.
- Avoidance – Some species may avoid well-lit areas due to an increased risk of predation (Longcore & Rich 2004), however, it can be difficult to separate any avoidance behaviour shown by fauna as being the result of the lighting compared to noise or a physical barrier (Gleeson & Gleeson 2012).

The above responses may affect foraging, reproduction, communication, and other critical behaviours (Longcore & Rich 2004). One of the most notable implications of light pollution is alteration of interspecific interactions (e.g. predator-prey and competitive interactions) (Longcore & Rich 2004).

7.5.2 IMPACTS

This is discussed in general terms across all four alignments as impacts are expected to be relatively consistent. Upon the projects' completion, the study area and surrounds are likely to be affected by a low level of light pollution, from dusk til dawn, during the operational phase of the project. The ecological values most at risk of impact from artificial lighting and headlights are:

- fauna occurring at the waterway crossings through the Yam Holes Creek valley between Racecourse Road and Beaufort-Lexton Road, including wetland birds
- fauna occurring at the waterway crossing through the Yam Holes Creek valley near Main Lead Road
- fauna occurring in proximity to the crossing through Camp Hill State Forest, although some light may be reduced in cuttings, and vegetation will provide shielding
- fauna occurring in the vicinity of Back Raglan Road and areas near Martins Lane
- fauna occurring in the vicinity of the remnant habitats near the railway and Packhams Lane.

The sensitive fauna receptors are likely to be largely consistent with those identified in the noise impact assessment (refer to previous section and to Section 10.4.4.2). However, for light impacts, spread of light across wetlands is expected to be a greater impact than light spread into woodland habitats. Impacts from light are expected across all four alignments.

7.6 VISUAL IMPACT

7.6.1 BACKGROUND

Closely linked to the impacts of artificial light is the visual impact of the road, a large artificial structure with moving vehicles, raised in key points above the surrounding landscape and the impact this has on fauna behaviour.

The impacts of the presence of artificial structures and car movement (as separate from noise, light and mortality impacts) are poorly known, however, it is understood that certain species, including wetland birds such as Brolga, may be affected. This may lead to decreased use of habitat nearby to the structure.

7.6.2 IMPACTS

All four alignments are likely to have some visual impact on fauna. Further assessment of potential impacts on fauna from visual impact of the project, in collaboration with the landscape and visual impact assessment team, will be required for the preferred alignment at the detailed design phase of the project.

7.7 PHYSICAL HABITAT DISTURBANCE/MODIFICATION

7.7.1 WEED INVASION AND DISEASE

7.7.1.1 BACKGROUND

The type of disturbance associated with the construction of road pavement can result in a window of opportunity for weeds and soil pathogens such as Phytophthora *Phytophthora cinnamomi* to establish. Clearing vegetation, stockpiling of materials and driving on site leaves bare ground that is particularly susceptible to colonisation by weeds or introduction of disease. Weed seeds and pathogens contained within material being used for construction or within mud from vehicles may be deposited into disturbed areas. Weed seed can also spread post construction by movement on roadside maintenance equipment like slashers. Without effective weed and disease hygiene control protocols, contaminants from construction material and un-clean vehicles have the potential to introduce a suite of avoidable impacts to ecological values on site. Through construction works, weed seed which is already present in the soil can also be brought to the surface and encouraged to germinate.

In addition, construction of a road which fragments patches of vegetation will create additional edges from which weed invasion may occur. After completion of the road, weed seed may be carried on vehicles and colonise the road edges where it can spread into nearby vegetation.

7.7.1.2 IMPACTS

The part of the study area which bisects Camp Hill State Forest currently supports a low cover of weeds due to a combination of factors including low soil fertility, lower levels of groundstorey disturbance and large areas of relatively intact vegetation. There are also relatively intact patches of vegetation in some public roadsides and private land close to the railway and Packhams Lane. The remainder of the study area is moderate to highly affected by weeds, particularly introduced pasture grasses, however, the cover of CaLP Act listed species, Weeds of National Significance, or other species regarded as highly invasive is currently generally low apart from areas along Yam Holes Creek near the sewage treatment plant which have high levels of Blackberry.

Without proper management practices during and post construction, weed and disease introduction or spread may lead to the degradation and/or loss of threatened ecological communities and a reduction in the value of habitat for threatened species. This is the case for all four alignments.

7.7.2 RUBBISH

Both the construction and operational phase of the project are expected to result in an increase in rubbish in terrestrial and aquatic habitats. Without the implantation of suitable mitigation measures, rubbish will reduce visual amenity and may have a negative impact upon habitat quality and pose a hazard to wildlife through fauna mortality within close proximity to the road alignment.

7.7.3 EROSION, SEDIMENTATION, AND WATER POLLUTANTS

7.7.3.1 BACKGROUND

Bare ground after clearing, stockpiling, earthworks, or driving vehicles and plant off-road is susceptible to erosion. Similarly, there is the potential for an increase in water pollutants in wetlands at or near the study area as a result of road construction or ongoing use of the road, through spills or run-off.

7.7.3.2 IMPACTS

The risk of erosion, sedimentation, and water pollution is highest in the Yam Holes Creek valley. Lack of appropriate erosion, sediment and pollution control may lead to the deterioration of aquatic flora and fauna, and resulting impacts to foraging wetland birds, amphibians and degradation of the relevant EVCs. This is discussed in more detail in the following section.

7.7.4 CHANGES IN GROUNDWATER AND SURFACE HYDROLOGY

7.7.4.1 GROUNDWATER

BACKGROUND

The Beaufort Bypass Groundwater Impact Assessment (WSP 2020a) identified several sensitive receptors within 2 km of the study area comprising 13 registered groundwater users (bores) and several groundwater dependent ecosystems (GDEs) (refer to Figure 7.7 and Figure 7.8). The GDEs found in the Groundwater Dependent Ecosystems Atlas (BOM 2018) for the Hopkins River catchment included:

- two aquatic GDEs consisting of:
  - Rivers: Yam Holes Creek and its tributaries including Garibaldi Creek, Mount Emu Creek and Trawalla Creek
  - Wetlands: (Unnamed wetlands)
- eight terrestrial GDEs which are categorised by the EVCs: Alluvial Terraces Herb-rich Woodland, Heathy Dry Forest, Plains Grassy Woodland, Grassy Woodland/Heathy Dry Forest Complex, Aquatic Herbland/Plains Sedgy Wetland Mosaic, Valley Grassy Forest, Creekline Grassy Woodland and Plains Grassy Wetland.

The Groundwater report (WSP 2020a) also identified several potential risks to groundwater levels and quality including:

- reduction in groundwater levels affecting existing users/sensitive receptors – such as registered and unregistered groundwater bores (water users), GDEs and surface waters systems
- spill events during construction resulting in contaminants entering groundwater
- disturbance of existing soils with elevated levels of contamination during construction resulting in mobilisation of contaminants into groundwater
- excavation of cuttings resulting in groundwater inflows during construction (and operation), leading to groundwater drawdown and changes to groundwater flow paths
- inflow of contaminated groundwater presenting OH&S and ongoing environmental compliance issues
- construction works impacting water quality in watercourses, GDE environments, and wetlands (as applicable)
- water quality impacts during operation of road.

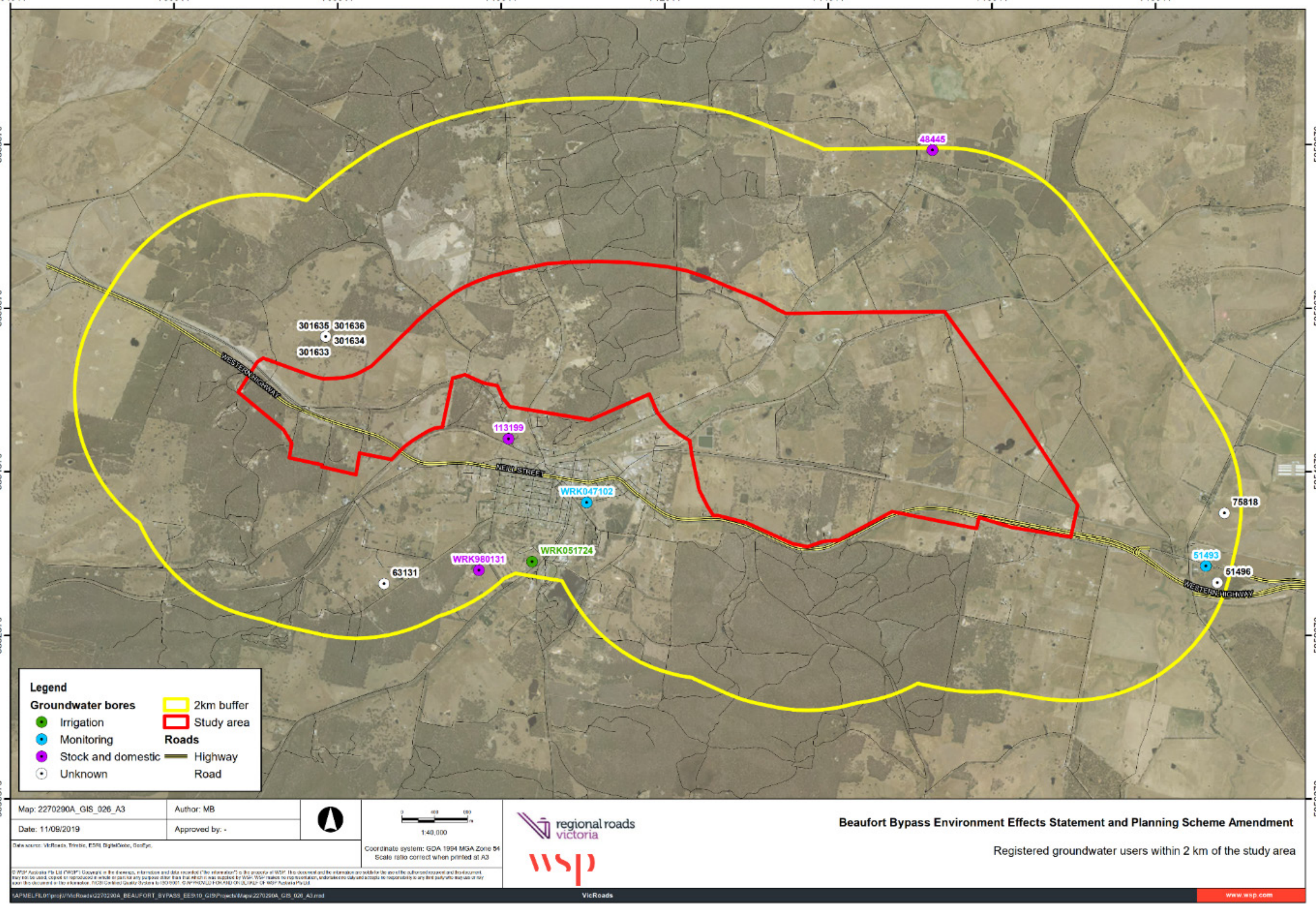


Figure 7.7 Registered groundwater users within 2 km of the study area

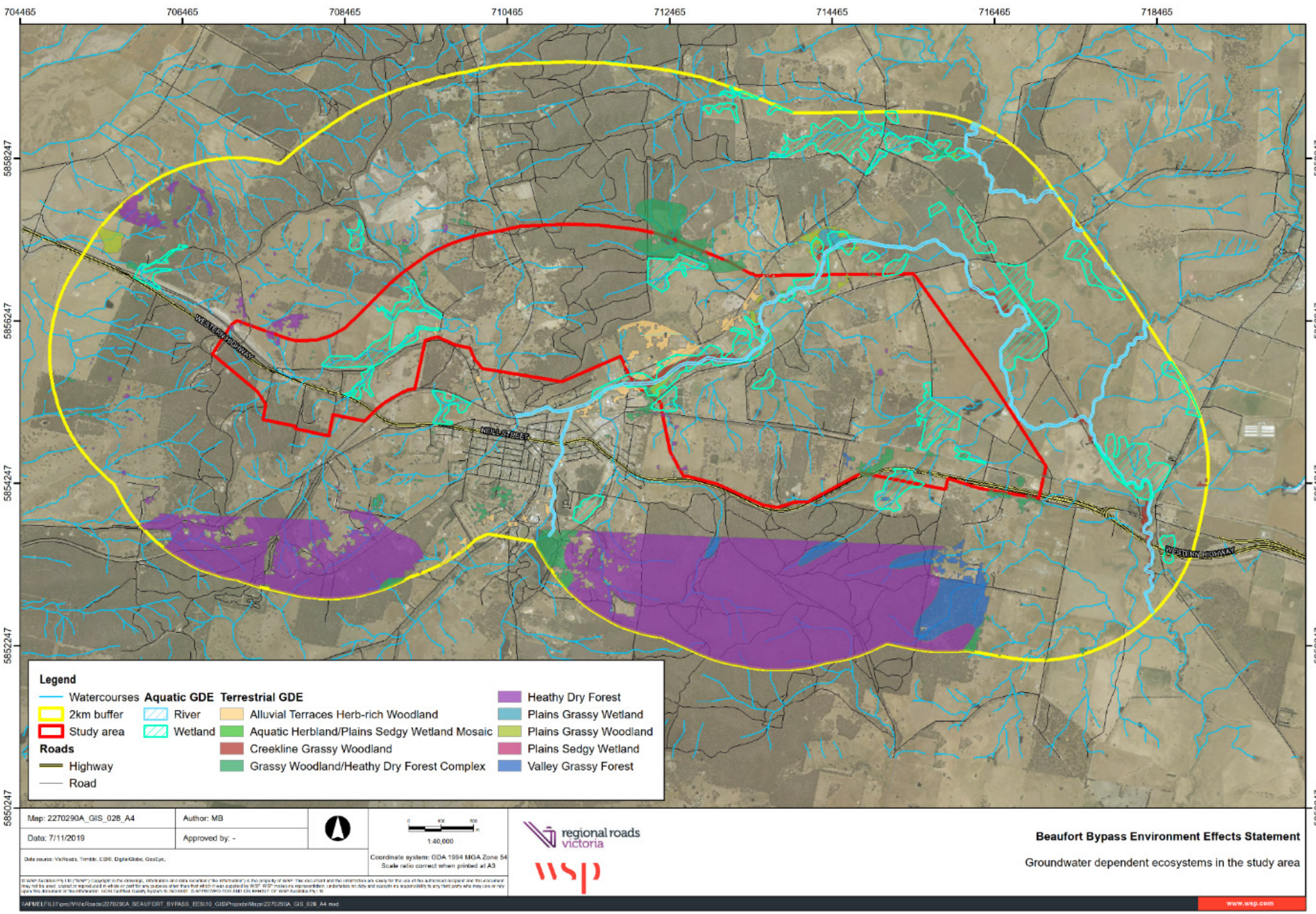


Figure 7.8 Groundwater Dependent Ecosystems in the study area

IMPACTS

The above risks can have substantial detrimental impacts upon ecological values. However, as determined through the Groundwater Impact Assessment (WSP 2020a), the overall impacts to groundwater level and quality from the proposed project are expected to be low. Where Pyrenees and Beaufort Formation geology underlies the study area, excavations for road cuttings and extraction or dewatering activities would have a negligible impact on groundwater and no additional mitigation measures outside of the standard environmental controls are required. This is largely due to the water levels within these bedrock formations being below the base of proposed cuts. Additionally, the aquitard properties of the Pyrenees and Beaufort Formation prevents the movement of groundwater and makes it an unsuitable source for construction water but also importantly the construction process will provide limited if any changes to the current relationship between surface and ground water systems.

Where Quaternary alluvial sediments underlie drainage lines and floodplains (i.e. Yam Holes Creek and tributaries) within the study area, embankment structures were determined to have the potential to impact groundwater flow where the flow is not parallel with the route alignment. However, drilling indicated that the low permeable silts and clays are largely unsaturated meaning groundwater levels are unlikely to be affected. In regards to groundwater quality, there is the potential for spills and leaks to infiltrate into the alluvial aquifer during construction and throughout ongoing road use. Impacts can be mitigated through the implementation of RRV environmental management procedures.

Some EVCs listed above (e.g. Grassy Woodland/Heathy Dry Forest Complex) are unlikely to require groundwater as a critical part of the community's survival. This is largely due to the water levels within the Pyrenees and Beaufort Formation geology bedrock formations, where these EVCs occur, being well below the depth typical of tree roots (see Soil and Geology report). EVCs occurring in low-lying areas (e.g. Alluvial Terraces Herb-rich Woodland, Valley Grassy Forest, Creekline Grassy Woodland) may benefit from groundwater but may not always be dependent. Wetland EVCs (Aquatic Herbland/Plains Sedgy Wetland Mosaic and Plains Grassy Wetland) may occur where there are groundwater fed wetlands, however, these communities can exist solely on seasonal surface water inputs, as is likely the case throughout these wetlands in the study area.

Given the above, no substantial impacts upon ecological values from changes to groundwater volumes or quality are anticipated.

7.7.4.2 SURFACE WATER

BACKGROUND

Victoria has listed *"Wetland loss and degradation as a result of change in water regime, dredging, draining, filling and grazing"* as a threatening process under the FFG Act. In a study of wetlands across Victoria in 2009–2011, key threats to the high-value wetlands included hydrology, soil disturbance, degraded water quality, reduced wetland area and altered wetland form (Papas & Moloney 2012). Demonstrated threats to the Seasonal Herbaceous Wetland community are: clearing native vegetation, altered hydrology and quality, increased fragmentation and landscape disconnection, weed invasion and inappropriate grazing (TSSC 2012a). Climate change is a potential threat to Seasonal Herbaceous Wetlands, particularly with predictions of decline in rainfall and changes to seasonal rainfall patterns (Jin, Cant & Todd 2009).

Many studies have identified that wetlands are highly susceptible to the effects of roads and road construction (Donaldson & Bennett 2004). Highway runoff has been identified as a significant source of sediment and chemical pollution affecting the quality of aquatic ecosystems (Connolly et al. 1999; Hedley 1975) and is known to affect the flow regime of streams and other hydrological systems within water catchments with roads (King & Tennyson 1984).

IMPACTS

The Surface Water Impact Assessment (WSP 2021) identified four designated waterways within the study area including Yam Holes Creek and three of its tributaries. Surface water impacts for all bypass alignments for the planning, design, construction and operation/maintenance phases were assessed. Given the early design stage of the project, the impact and mitigation assessment did not identify specific solutions but rather identified standard engineering preventative measures and principles that can be applied to mitigate adverse stormwater and flooding impacts.

Potential surface water impacts relevant to ecology include:

- changes to flooding conditions and water levels in sensitive wetlands caused by clearing of vegetation along the route alignment and cut and fill works to achieve proposed alignment design levels
- vegetation clearing, soils compaction and floodplain storage removal resulting in increased runoff rates and subsequent impacts to significant habitat both nearby the study area and further downstream
- alterations to catchment hydrology from temporary construction works such as watercourse diversion, modifications to drainage networks and pumping of surface water. Permanent features (roads, bridges and culverts) can also change the dynamic response of the catchment to excess rainfall. This may lead to changes in the natural seasonal filling and drying cycles of wetlands in the study area
- reduced water quality caused by sediment runoff during the construction phase. This has the potential to increase turbidity which, depending on the severity, may impact flora, fauna, and ecological communities that are dependent on the aquatic ecosystem
- reduced water quality caused by road runoff, accidental oil/fuel spillages and pollutant runoff generated from maintenance activities. Untreated and undiluted, these pollutants (typically consisting of sediments, hydrocarbons, nutrients and metals) may result in a deterioration of water quality in the receiving water environment and in aquatic systems further downstream.

These are further summarised in Section 10.4.7.4 of this report and within the Surface Water Impact Assessment (WSP 2021). All alignments have the potential to impact on wetlands, dams and drainage lines with wetland flora, vegetation and fauna habitat.

7.7.4.3 IMPACT ON BIODIVERSITY

Any significant changes outlined above may have flow-on effects upon waterbirds including Australasian Shoveler, Blue-billed Duck, Brolga, Eastern Great Egret, Hardhead; amphibians such as Growling Grass Frog and Brown Toadlet; and fish species including Little Galaxias. If surface water changes are not managed appropriately, the project may also affect the EPBC Act listed community Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains mapped in multiple locations throughout the study area, as well as wetland flora species Floodplain Fireweed and River Swamp Wallaby-grass.

7.7.4.4 FLOOD IMPACTS

The Surface Water Impact Assessment also included a flood impact assessment to consider how each of the four alignment options perform against the surface water objectives and to identify potential issues associated with waterway crossings. This was based on the results of initial flood modelling against project objectives and does not consider ecological impact. A summary of the findings is detailed in the Surface Water Impact Assessment (WSP 2021).

This assessment identified that flood impacts from the project relate to increased flood durations of about 1–2 hours. The assessment also found that Option A1 would have the least surface water impact. Option C2 was identified as the alignment which would have the greatest impact to surface water objectives including the highest values for:

- maximum flood width
- length of alignment within the 100 year ARI extent
- extent of ground disturbing works within 50 m of significant waterway crossings.

7.7.4.5 WETLANDS

All wetlands within the study area were categorised into high, moderate and low quality (from Section 6.4.4) with a map in that same section (Figure 6.8) showing the location of the different wetlands. These wetlands were broken into the following categories:

- High value – Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plain (EPBC Act listed community mapped in this report) and some adjacent or connected wetlands. These wetlands are listed as critically endangered ecological communities under the EPBC Act. There are overlaps between the Seasonal Herbaceous Wetlands (Freshwater) and the wetland Ecological Vegetation Classes (EVCs).
- Moderate value – All other areas mapped as wetland EVCs (mapped in this report).
- Low value – Areas mapped as 'Wetland Current' by DELWP, however vegetation mapping in the study area as a part of this report, did not map any native vegetation. Many of these areas are highly modified however may provide some food resources for fauna and temporal values through longer periods of inundation.

The following table (Table 7.14) outlines the potential impacts on each wetland from each project alignment and areas of potential impacts on all of the different wetland value types. The summary of hydraulic and qualitive impacts on surface water was used as an initial comparison. Further assessment has been undertaken in *Surface Water Impact Assessment Report* (WSP 2021) and is provided for the preferred alignment in Section 9.7.4.2.

From an ecological perspective, Option A1 impacts the largest area of mapped wetlands, closely followed by A0 and C0. C2 has considerably less overall impacts on mapped wetlands. Both A0 and A1 have the least impact on high quality wetlands, closely followed by C2. Option C0 impacts the least number of waterway crossings, and has the lowest flood width at Yam Holes Creek crossing, however, it would impact on a large area of a high quality wetland. However, overall Option C2 is the preferred option for ecology as it has the least impacts on a number of ecological parameters compared with the other options (see Section 8). Further detail on the impacts on species within wetlands is included in Section 7.1.2.4 and Section 7.9.

Table 7.14 Summary of Hydraulic and Qualitative Assessment of Surface Water Impacts to Wetlands – Surface Water Report (WSP 2021) and areas of potential impacts on quality wetlands (see Figure 6.8 for wetland locations)

WETLAND	A0	A1	C0	C2
Potential direct impacts on wetland value types (area in hectares)				
High value	0.06	0.06	3.77	0.19
Moderate value	1.10	1.19	1.31	1.45
Low value	6.30	6.71	2.47	2.00
Grand Total	**7.46**	**7.96**	**7.55**	**3.65**
Potential impacts to significant flora, fauna and ecological communities [1]				
River Swamp Wallaby-grass	Two records within alignment; one within construction footprint covering approximately 0.25 ha	One record within alignment; one within construction footprint covering an area approximately 0.25 ha	Three locations within alignment; two locations within construction footprint covering an area approximately 1.02 ha	Two records within alignment; one within construction footprint covering an area of approximately 0.05 ha
Floodplain Fireweed	Alignment avoids all records	Alignment avoids all records	Alignment avoids all records	Alignment avoids all records
Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	0.06 ha	0.06 ha	2.58 ha	0.06 ha
Waterbirds	2.00 ha	0.58 ha	4.23 ha	0.71 ha
Growling Grass Frog	Aquatic habitat: 1.24 ha Terrestrial habitat: 65.23 ha	Aquatic habitat: 0.81 ha Terrestrial habitat: 62.23 ha	Aquatic habitat: 2.88 ha Terrestrial habitat: 62.23 ha	Aquatic habitat: 1.10 ha Terrestrial habitat: 77.84 ha
Brown Toadlet	1.66 ha	1.25 ha	3.20 ha	1.31 ha
Eastern Long-necked Turtle	2.00 ha	0.58 ha	4.23 ha	0.71 ha
Little Galaxias	6 creek crossings	5 creek crossings	5 creek crossings and 1 wetland	7 creek crossings

WETLAND	A0	A1	C0	C2
Indicative significant waterway crossing (WSP 2021)				
Crossing number	16	16	14	16
Evaluation of high quality wetlands				
1 Contains the following wetland EVCs: Plains Grassy Wetland, Aquatic Sedgeland and Aquatic Herbland	Approx. 0.026 ha of wetland impacted by road embankment. Cross drainage on Yam Holes Creek (approx. 0.3 km upstream of wetland). Road drainage outfall immediately upstream of wetland. Minor loss of wetland volume due to road alignment. Offset measures to mitigate for the loss of storage to be further investigated as part of the detail design phase. Approx. 2% change to land use type and drainage characteristics of upstream catchment.	Approx. 0.026 ha impacted by embankment. Cross drainage on Yam Holes Creek (approx. 0.3 km upstream of wetland). Low point in road alignment near Yam Holes Creek. Minor loss of wetland volume due to road alignment. Offset measures to mitigate for the loss of storage to be further investigated as part of the detail design phase. Approx. 2% change to land use type and drainage characteristics of upstream catchment.	Yam Holes Creek located approx. 1.8 km upstream at wetland. Road drainage outfall located approx. 1.8 km upstream of wetland. Approx. 3% change to land use type and drainage characteristics of upstream catchment.	Approx. 0.026 ha impacted by embankment. Cross drainage on Yam Holes Creek (approx. 0.3 km upstream of wetland). Low point in road alignment near Yam Holes Creek. Minor loss of wetland volume due to road alignment. Offset measures to mitigate for the loss of storage to be further investigated as part of the detail design phase. Approx. 3% change to land use type and drainage characteristics of upstream catchment.

WETLAND	A0	A1	C0	C2
2 Contains the following wetland EVCs: Aquatic Sedgeland, Plains Grassy Wetland/Aquatic Herbland Complex and Aquatic Grassy Wetland	No change.	No change.	Approx. 1.59 ha impacted by embankment. Cross drainage located over wetland. Road drainage outfall likely to be located immediately upstream of wetland. Wetland is significantly impacted by road design. Offset measures to mitigate for impact to wetland be further investigated as part of the detail design phase. No change to catchment.	No change.
3 Contains the following wetland EVC: Plains Sedgy Wetland	No change.	No change.	Cross drainage of tributaries approx. 0.85 km upstream of wetland. Road drainage outfall to watercourse directly connected to tributary. Approx. 18% change to land use type and drainage characteristics of upstream catchment.	No change.

WETLAND	A0	A1	C0	C2
4 Contains the following wetland EVCs: Plains Sedgy Wetland	+40 mm change to 1% AEP flood level. Minor increase in flood level for 1% AEP. Investigate as part of the detailed design phase to determine if additional mitigation is required. Approx. 2% change to land use type and drainage characteristics of upstream catchment.	+40 mm change to 1% AEP flood level. Minor increase in flood level for 1% AEP. Investigate as part of the detailed design phase to determine if additional mitigation is required. Flow regime impacts due to proposed re-alignment of drainage network to be further investigated as part of the detail design phase. Approx. 2% change to land use type and drainage characteristics of upstream catchment.	-20 mm change to 1% AEP flood level. Approx. 3.71 ha impacted by embankment. Cross drainage located over wetland. Road drainage outfall likely to be located immediately upstream of wetland. Wetland is significantly impacted by road design. Offset measures to mitigate for impact to wetland be further investigated as part of the detail design phase. Approx. 3% change to land use type and drainage characteristics of upstream catchment.	+40 mm change to 1% AEP flood level. Minor increase in flood level for 1% AEP. Investigate as part of the detailed design phase to determine if additional mitigation is required. Approx. 3% change to land use type and drainage characteristics of upstream catchment.

WETLAND	A0	A1	C0	C2
5 Contains the following wetland EVCs: Aquatic Grassy Wetland and Aquatic Herbland	Cross drainage on unnamed tributary located 1.4 km upstream. Road drainage outfall immediately upstream of wetland. Realignment of tributary upstream of wetland. Likely impact to flow regime. Flow regime impacts due to proposed re-alignment of drainage network to be further investigated as part of the detail design phase. Approx. 6% change to land use type and drainage characteristics of upstream catchment.	Direct connectivity with cross drainage on unnamed approx. 1.4 km upstream of wetland. Low point in alignment near unnamed tributary. Re-alignment of tributary upstream of wetland. Likely impact to flow regime. Approx. 6% change to land use type and drainage characteristics of upstream catchment.	Direct connectivity with cross drainage on unnamed tributary located 1.2 km upstream of wetland. Approx. 4% change to land use type and drainage characteristics of upstream catchment.	Direct connectivity with cross drainage on unnamed approx. 1.4 km upstream of wetland. Low point in alignment near unnamed tributary. Re-alignment of tributary upstream of wetland. Likely impact to flow regime. Flow regime impacts due to proposed re-alignment of drainage network to be further investigated as part of the detail design phase. Approx. 6% change to land use type and drainage characteristics of upstream catchment.

WETLAND	A0	A1	C0	C2
6 Contains the following wetland EVCs: Plains Grassy Wetland and Plains Sedgy Wetland	Cross drainage on unnamed tributary located 1.7 km upstream. Road drainage outfall immediately upstream of wetland. Approx. 4% change to land use type and drainage characteristics of upstream catchment.	Direct connectivity with cross drainage on unnamed approx. 1.4 km upstream of wetland. Road drainage outfall likely to be located immediately upstream of wetland. Approx. 4% change to land use type and drainage characteristics of upstream catchment.	-30 mm change to 1% AEP flood level. Proposed cross drainage immediately upstream of wetland that provides direct connectivity with wetland. Road drainage outfall likely to be located immediately upstream of wetland. Approx. 4% change to land use type and drainage characteristics of upstream catchment.	-30 mm change to 1% AEP flood level. Approx. 0.1270 ha impacted by embankment. Proposed cross drainage immediately upstream of wetland that provides direct connectivity with wetland. Road drainage outfall likely to be located immediately upstream of wetland. Flow regime impacts and volume of wetland impacted by road design. Additional mitigation measures to be modelled as part of the detail design phase. Approx. 4% change to land use type and drainage characteristics of upstream catchment.

WETLAND	A0	A1	C0	C2
7 Contains the following wetland EVCs: Brackish Herbland and Plains Grassy Wetland/Brackish Herbland Complex	Direct connectivity with cross drainage on unnamed tributary located 1.4 km upstream of wetland. Approx. 8% change to land use type and drainage characteristics of upstream catchment.	Direct connectivity with cross drainage on unnamed tributary approx. 1.7 km upstream of wetland. Approx. 10% change to land use type and drainage characteristics of upstream catchment.	Direct connectivity with cross drainage on unnamed tributary located 1.4 km upstream of wetland. Road embankment interfaces with wetland. Flow regime impacts and volume of wetland impacted by road design. Additional mitigation measures to be modelled as part of the detail design phase. Approx. 9% change to land use type and drainage characteristics of upstream catchment.	Direct connectivity with cross drainage on unnamed tributary located 1.4 km upstream of wetland. Approx. 9% change to land use type and drainage characteristics of upstream catchment.
8 Contains the following wetland EVCs: Plains Grassy Wetland, Aquatic Herbland and Aquatic Sedgeland	No change	No change	No change	No change
9 Contains the following wetland EVCs: Plains Grassy Wetland and Aquatic Herbland	Cross drainage on unnamed tributary approx. 0.5 km upstream of wetland. Approx. 8% change to land use type and drainage characteristics of upstream catchment.	Cross drainage on unnamed tributary approx. 0.5 km upstream of wetland. Approx. 5% change to land use type and drainage characteristics of upstream catchment.	Direct connectivity with cross drainage on unnamed tributary located 0.75 km upstream of wetland. Approx. 6% change to land use type and drainage characteristics of upstream catchment.	Cross drainage on unnamed tributary approx. 0.5 km upstream of wetland. Approx. 5% change to land use type and drainage characteristics of upstream catchment.

(1) For more information about potential impacts to threatened ecological communities, flora and fauna refer to Tables 7.3, 7.5 and 7.6 respecitvely.

7.8 AIR QUALITY AND DUST

Air pollution impacts on flora and fauna are not regularly considered in ecological assessments. Although some impacts upon vegetation adjacent to the roadway from elevated nitrogen dioxide and other airborne pollutants are possible, it is unlikely that air pollutants are a substantial factor in comparison to many of the other likely effects of the road. Studies have shown that noise walls, and sometimes vegetative buffers, can reduce downwind pollutant concentrations near roads (Hagler et al. 2012; World Health Organisation 2000).

Without mitigation, dust and particulates during construction may have a temporary effect on flora and fauna, however, with standard CEMP measures, dust during construction is expected to be managed such that nearby sensitive receptors, including flora and fauna, are not substantially impacted.

7.9 SEVERITY OF IMPACTS ON SIGNIFICANT FAUNA

Table 7.15 Potential impact on threatened fauna species with a moderate or higher likelihood of occurrence within the construction footprint for each alignment option

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT WITHOUT MITIGATION MEASURES
Amphibians			
Growling Grass Frog	*Litoria raniformis*	VU L en	The Growling Grass Frog is considered likely to occur given the past records in the area. Most of the impacts are expected to occur at Yam Holes Creek floodplain between Racecourse Road and Beaufort-Lexton Road. All alignments pass through this area, therefore they will all result in the removal and fragmentation of some potential terrestrial habitat and lead to a decrease in available potential aquatic habitat for this species. Other potential impacts include barriers to movement, injury and mortality from the construction and operation phase of the project and decreased water quality of Yam Holes Creek as a result of erosion, sedimentation and pollution. The potential impact area of Growling Grass Frog aquatic habitat (high and medium quality combined) is highest for alignment C0 at 2.88 ha. Impacts for alignments A0, A1 and C2 are comparable, ranging between 0.81 ha and 1.25 ha. Minimal impact to wetland hydrology is anticipated, except for alignment C0 which passes directly through the middle of a large wetland. Potential impact areas of Growling Grass Frog terrestrial habitat were also calculated using a 200 m buffer from waterbodies as per the Significant Impact Guidelines for the species (DEWHA 2009c). In contrast to potential aquatic habitat loss, alignment C0 has the smallest area of potential terrestrial habitat loss at 62.23 ha (high and medium quality combined). This is closely followed by alignments A0, A1 and C2 which have a potential terrestrial habitat loss of 65.23 ha, 69.02 ha and 77.84 ha respectively. A Significant Impact Criteria Assessment (Appendix J) provides further information regarding the potential for significant impacts to this species across all four alignment options.

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT WITHOUT MITIGATION MEASURES
Brown Toadlet	*Pseudophryne bibroni*	L en	Despite not being recorded during the 2016–2017 targeted surveys, the Brown Toadlet was recorded during surveys conducted in 2015. Given the prior records and potential habitat mapped along Yam Holes Creek, draining lines and small dams within the study area, the species is likely to be present. All alignment options will result in some removal and fragmentation of this potential habitat for this species. Other potential impacts include physical barriers to movement and increased risk of injury and mortality from the construction and operation phase of the project. Any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species. The impact area of potential Brown Toadlet habitat is below 2 ha for alignments A0, A1 and C2. Alignment C0 is likely to have the biggest impact with a potential loss of 3.2 ha.
Birds			
Australasian Shoveler	*Anas rhynchotis*	vu	Australasian Shoveler is moderately likely to occur within the study area based on potential habitat and previous records. Some loss of open water aquatic habitats is likely across all alignments, along with potential increased mortality from road collisions. Remaining habitat may be reduced in quality by an increase in noise disturbance and light pollution. Furthermore, any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species. Only alignment C0 has the potential to impact high-quality waterbird habitat (1.23 ha). The impact on potential medium-quality waterbird habitat is also greatest for alignment C0 at 3.00 ha, followed by alignment A0, C2 and A1 with 2.00 ha, 0.71 ha and 0.58 ha respectively.
Baillon's Crake	*Porzana pusilla*	L vu	Baillon's Crake is moderately likely to occur within the study area based on available habitat and recent VBA records. Some loss of waterbird habitat is likely across all alignments, along with some disturbance related impacts associated with noise and light pollution. Any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species. Only alignment C0 has the potential to impact high-quality waterbird habitat (1.23 ha). The impact on potential medium-quality waterbird habitat is also greatest for alignment C0 at 3.00 ha, followed by alignment A0, C2 and A1 with 2.00 ha, 0.71 ha and 0.58 ha respectively.

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT WITHOUT MITIGATION MEASURES
Blue-billed Duck	*Oxyura australis*	L en	Blue-billed Duck is moderately likely to occur based on available habitat and recent VBA records from the area. Some loss of potential habitat in the form of deep, permanent and open aquatic environments is likely across all alignments. There is a risk of increased mortality from road collisions and the quality of remaining habitat may be reduced by an increase in noise disturbance and light pollution. Furthermore, any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species. Only alignment C0 has the potential to impact high-quality waterbird habitat (1.23 ha). The impact on potential medium-quality waterbird habitat is also greatest for alignment C0 at 3.00 ha, followed by alignment A0, C2 and A1 with 2.00 ha, 0.71 ha and 0.58 ha respectively.
Brolga	*Grus rubicunda*	L vu	Wetlands and waterbodies within and adjacent to the alignment options are likely to be used on a seasonal basis by Brolga for foraging and possibly breeding. Primary breeding habitat is located adjacent to options A0 and A1 and within Option C0 where a pair of Brolga was recorded. Additionally, mapped potential medium-quality habitat is present within all four alignments. Therefore, all alignments will impact potential Brolga habitat, albeit to varying degrees. Aside from habitat loss, other impacts include a heightened risk of wildlife vehicle collisions during the operational phase of the project, especially in areas located close to natural or artificial water bodies. Roads may not be a significant impediment to movement of adult birds but may affect prefledged chicks if a road is located between suitable habitats (Inka Veltheim pers. comm.). Additionally, roads may lead to a decreased use of nearby habitat as they may be sensitive to car movement and can affect pre-fledged chicks if it's located in between suitable habitats. Any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species. Only alignment C0 has the potential to impact high-quality waterbird habitat (1.23 ha). The impact area of potential medium-quality waterbird habitat is also greatest for alignment C0 at 3.00 ha, followed by alignment A0, C2 and A1 with 2.00 ha, 0.71 ha and 0.58 ha respectively.

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT WITHOUT MITIGATION MEASURES
Brown Treecreeper	*Climacteris picumnus victoriae*	N nt	The Brown Treecreeper was recorded in the study area by WSP in 2015. The largest impact to this species will result from the removal of Victorian Temperate Woodland Bird Community habitat in areas such as Camp Hill State Forest. Some impact is also expected to occur in roadside reserves and private property within and adjacent to the alignments, but to a lesser extent due to these areas being less impacted. Each alignment will result in varying degrees of potential habitat removal for this species. Other potential impacts include fragmentation of habitat, loss of connectivity, increased noise disturbance and ecological light pollution. The potential impact area to woodland bird habitat is lowest for alignment C2 at 29.25 ha, whilst impacts for alignments A0, A1 and C0 are comparable, ranging between 34.67 ha to 35.29 ha.
Diamond Firetail	*Stagonopleura guttata*	L nt	Diamond Firetail is considered highly likely to occur within the study area based on reasonably reliable records from a local Landowner. The largest impact to this species will result from the removal of Victorian Temperate Woodland Bird Community habitat at areas like Camp Hill State Forest. Some impact is also expected to occur in roadside reserves and private property within and adjacent to the alignments, but to a lesser extent due to these areas being less impacted. Each alignment will result in varying degrees of potential habitat removal for this species. Given the species ground foraging behaviour, there is an increased risk of mortality from vegetation and understory removal during construction as well as increased stresses associated with fragmentation and loss of connectivity. The potential impact area to woodland bird habitat is lowest for alignment C2 at 29.25 ha, whilst impacts for alignments A0, A1 and C0 are comparable, ranging between 34.67 ha to 35.29 ha.
Eastern Great Egret	*Ardea modesta*	L vu	Eastern Great Egret is moderately likely to occur within the study area based on available habitat and recent VBA records. Some loss of waterbird habitat is likely across all alignments, along with some disturbance related impacts associated with noise and light pollution. Any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species. Only alignment C0 has the potential to impact high-quality waterbird habitat (1.23 ha). The impact on potential medium-quality waterbird habitat is also greatest for alignment C0 at 3.00 ha, followed by alignment A0, C2 and A1 with 2.00 ha, 0.71 ha and 0.58 ha respectively.

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT WITHOUT MITIGATION MEASURES
Emu	*Dromaius novaehollandiae*	nt	Whilst there is potential habitat for the Emu within the study area, there are a low number of VBA records, resulting in the species having a moderate likelihood of occurrence. Given the distribution of the species and their ability to inhabit a variety of environments, it is likely that all alignment options will result in the loss of potential habitat. Other potential impacts would include fragmentation of habitat, loss of connectivity and increased risk of mortality from wildlife vehicle collisions during the operational phase of the project. Given the species wide distribution, the impact areas of the four alignments is not anticipated to be substantially different.
Hardhead	*Aythya australis*	vu	The Hardhead is highly likely to occur within the study area based on available habitat and previous records. Some loss of potential habitat in the form of deep, permanent and open aquatic environments is likely across all alignments. Other potential impacts include increased mortality from road collisions and reduced habitat quality from noise disturbance and light pollution. Furthermore, any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species. Only alignment C0 has the potential to impact high-quality waterbird habitat (1.23 ha). The impact on potential medium-quality waterbird habitat is also greatest for alignment C0 at 3.00 ha, followed by alignment A0, C2 and A1 with 2.00 ha, 0.71 ha and 0.58 ha respectively.
Latham's Snipe	*Gallinago hardwickii*	M N nt	Based on available potential habitat and recent VBA records from the area, Latham's Snipe is moderately likely to occur in the study area as an occasional visitor to wetlands. Some loss of potential habitat is likely across all alignments. There is a risk of increased mortality from road collisions and the quality of remaining habitat may be reduced by an increase in noise disturbance and light pollution. In addition, any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species. Only alignment C0 has the potential to impact high-quality waterbird habitat (1.23 ha). The impact on potential medium-quality waterbird habitat is also greatest for alignment C0 at 3.00 ha, followed by alignment A0, C2 and A1 with 2.00 ha, 0.71 ha and 0.58 ha respectively.

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT WITHOUT MITIGATION MEASURES
Musk Duck	*Biziura lobata*	vu	The Musk Dusk is moderately likely to occur based on available habitat within the study area and recent VBA records. Some loss of potential habitat, consisting of large expanses of water with dense marginal vegetation and reed beds, is likely to occur across all alignments. There is a risk of increased mortality from road collisions and the quality of remaining habitat may be reduced by an increase in noise disturbance and light pollution. Any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species. Only alignment C0 has the potential to impact high-quality waterbird habitat (1.23 ha). The impact on potential medium-quality waterbird habitat is also greatest for alignment C0 at 3.00 ha, followed by alignment A0, C2 and A1 with 2.00 ha, 0.71 ha and 0.58 ha respectively.
Painted Honeyeater	*Grantiella picta*	VU L vu	Whist not formally recorded in the study area, an unconfirmed but reliable record from a local landowner has constituted a high likelihood of occurrence for this species. Given the species preference for larger patches of vegetation, most of the impact will occur where an alignment intersects Camp Hill State Forest. Other potential impacts include risk of mortality from vegetation and understory removal during construction as well as increased stresses associated with fragmentation and loss of connectivity. The potential impact area to woodland bird habitat is lowest for alignment C2 at 29.25 ha, whilst impacts for alignments A0, A1 and C0 are comparable, ranging between 34.67 ha to 35.29 ha.
Pied Cormorant	*Phalacrocorax varius*	nt	The Pied Cormorant is moderately likely to occur based on available habitat within the study area and recent VBA records. Some loss of potential habitat, consisting of large expanses of water with dense marginal vegetation, is likely to occur across all alignments. There is a risk of increased mortality from road collisions and the quality of remaining habitat may be reduced by an increase in noise disturbance and light pollution. Any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species. Only alignment C0 has the potential to impact high-quality waterbird habitat (1.23 ha). The impact on potential medium-quality waterbird habitat is also greatest for alignment C0 at 3.00 ha, followed by alignment A0, C2 and A1 with 2.00 ha, 0.71 ha and 0.58 ha respectively.

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT WITHOUT MITIGATION MEASURES
Powerful Owl	*Ninox strenua*	L vu	Previous records and suitable habitat capable of supporting the Powerful Owl is present within the study area, resulting in a high likelihood of occurrence. Impacts will be heightened in woodland habitats that support large hollow bearing trees, a nesting requirement for the species. Hollow-bearing trees, with hollows of various sizes, are also required to support Powerful Owl food sources including possums and gliders. Woodland habitat supporting hollow-bearing trees includes Camp Hill State Forest. Some impact is also expected to occur in roadside reserves and private property within and adjacent to the alignments, but to a lesser extent due to these areas being less impacted. Other potential impacts include increased mortality from road collisions and reduced habitat quality from noise disturbance and light pollution. The potential impact area to woodland bird habitat is lowest for alignment C2 at 29.25 ha, whilst impacts for alignments A0, A1 and C0 are comparable, ranging between 34.67 ha to 35.29 ha.
Speckled Warbler	*Chthonicola sagittata (syn. Pyrrholaemus sagittatus)*	L vu	Based on availability of potential habitat within the study area and previous VBA records, Speckled Warbler is considered to have a moderate likelihood of occurrence. The largest impact to this species will result from the removal of potential habitat in areas like Camp Hill State Forest, roadside reserves and private property within and adjacent to the alignments. The ground-foraging nature of the Speckled Warbler makes them susceptible to mortality resulting from vegetation and understory removal during construction as well as increased stresses associated with fragmentation and loss of connectivity. The potential impact area to woodland bird habitat is lowest for alignment C2 at 29.25 ha, whilst impacts for alignments A0, A1 and C0 are comparable, ranging between 34.67 ha to 35.29 ha.

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT WITHOUT MITIGATION MEASURES
Fish			
Little Galaxias	*Galaxiella toourtkoourt*	VU L en	The Little Galaxias is not currently known to have a self-sustaining population within the study area. However, it is considered to have a high likelihood of occurrence as there is a reasonable likelihood that they could recolonise the catchment under suitable conditions, such as flood events. All alignments intersect Yam Holes Creek and smaller tributaries therefore they will all result in the loss of potential Little Galaxias habitat. Without mitigation measures, the project is also likely to result in fragmentation and habitat shading. Any significant changes in surface water hydrology may have flow on effects for this species including decreased water quality from erosion, sedimentation and water pollution. The potential impacts are similar across all four alignments, each intersecting between 5 and 7 creek crossings which are mapped as areas of potential habitat. The only exception is alignment C0 which also intersects a large wetland. A Significant Impact Criteria Assessment (Appendix J) provides further information regarding the potential for significant impacts to this species across all four alignment options.
Invertebrates			
Golden Sun Moth	*Synemon plana*	CR L cr	Golden Sun Moth have been recorded throughout the study area in grassland habitats within all alignment options. Impacts are anticipated to be highest just north of Martins Lane, near the proposed interchange with the Western Highway, where high quality Golden Sun Moth habitat was mapped and the species was recorded during 2018 surveys. Because Golden Sun Moth habitat covers parts of all the alignments, total avoidance by the construction footprint is difficult. The project is likely to lead to an increase in habitat fragmentation and present a barrier to dispersal for the species. Removal of understorey, groundcover, topsoil and debris during the construction phase is likely to result in some mortality. The impact on Golden Sun Moth habitat (confirmed, high and low quality combined) is comparable across all alignments with potential impact areas of 13.91 ha (C2), 14.06 ha (A1) and 15.47 ha (C0) and 15.48 ha (A0). A Significant Impact Criteria Assessment (Appendix J) provides further information regarding the potential for significant impacts to this species across all four alignment options.

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT WITHOUT MITIGATION MEASURES
Mammals			
Brush-tailed Phascogale	*Phascogale tapoatafa*	L vu	Previous records from 2015 surveys indicate that the species is present within the study area. Potential habitat is present within all four alignment options where they intersect areas of mature native vegetation (i.e. Camp Hill State Forest). Therefore, all alignments will result in the loss of potential Brush-tailed phascogale habitat. Brush-tailed Phascogales are most at risk of impacts associated with habitat fragmentation and changes to wildlife movement. They are also at risk of injury and mortality from the construction phase of the project, especially during the removal of hollow bearing trees, as well as the operational phase where mortality from the road is anticipated to be highest where alignments intersect Camp Hill State Forest. The potential impact area of potential Brush-tailed Phascogale habitat (high and medium quality combined) is anticipated to be smallest for alignment C2 at 15.06 ha. The anticipated impact associated with alignment A0, A1 and C0 are comparable, ranging between 20.36 ha and 22.39 ha.
Reptiles			
Eastern Long-necked Turtle	*Chelodina longicollis*	dd	One shell of a dead Eastern Long-necked Turtle was found in wetlands north of Martins Lane in January 2018. However, a lack of further records during surveys indicates that the Eastern Long-necked Turtle probably occurs in low numbers within the study area. Given that the species utilises aquatic habitats and terrestrial habitats for movement between wetlands, it is likely that all four alignments will result in the loss of some potential habitat. Other potential impacts include loss of connectivity, mortality from groundcover clearance and wildlife vehicle collisions, decreased water quality of wetlands and disorientation from artificial light pollution. Alignment C0 is the only alignment which could impact on potential high-quality aquatic habitat (1.23 ha). The impact area of potential medium-quality aquatic habitat is also greatest for alignment C0 at 3.00 ha, followed by alignment A0, C2 and A1 with 2.00 ha, 0.71 ha and 0.58 ha respectively.

Key for Conservation Status

Listing under the federal *Environment Protection and Biodiversity Conservation Act 1999*
CR = Critically Endangered, EN = Endangered, VU = Vulnerable, M = Migratory

Listing under the Flora and Fauna Guarantee Act 1988
L = listed as threatened, N = Nominated for listing as threatened,

Listed on the Victorian Advisory List of threatened species
cr = Critically Endangered, en = Endangered, vu = Vulnerable, nt = near threatened, dd = Data Deficient

7.10 CUMULATIVE IMPACTS

7.10.1 OVERVIEW

Cumulative Impact Assessments (CIA) aim to consider the effects of multiple actions or impacts on the environment (Minerals Council of Australia 2015) and are undertaken to ensure the incremental effects of multiple actions in a given area are considered and assessed holistically for their combined impact (Hegmann et al. 1999).

As part of this EES, a CIA was undertaken for all threatened species and ecological communities determined to have a likelihood of occurrence within the Beauport Bypass study area and also the CIAA. The assessment was carried out for each of the four Beaufort Bypass alignment options in conjunction with four other projects currently underway or recently completed within a 20km radius, an area agreed with DELWP and defined as the Cumulative Impact Assessment Area (CIAA). The additional projects included in the assessment are outlined below:

- Stage 1 of the Western Highway Upgrade (Burrumbeet to Beaufort)
- Stage 2A of the Western Highway Upgrade (Beaufort to Buangor)
- Stage 2B of the Western Highway Upgrade (Buangor to Ararat & Buangor Bypass); and
- Stockyard Hill Wind farm.

In addition to the CIAA, the assessment considered the impacts at three other spatial scales including the State of Victoria, the Central Victorian Uplands (CVU) Bioregion and the Victorian Volcanic Plains (VVP) Bioregion.

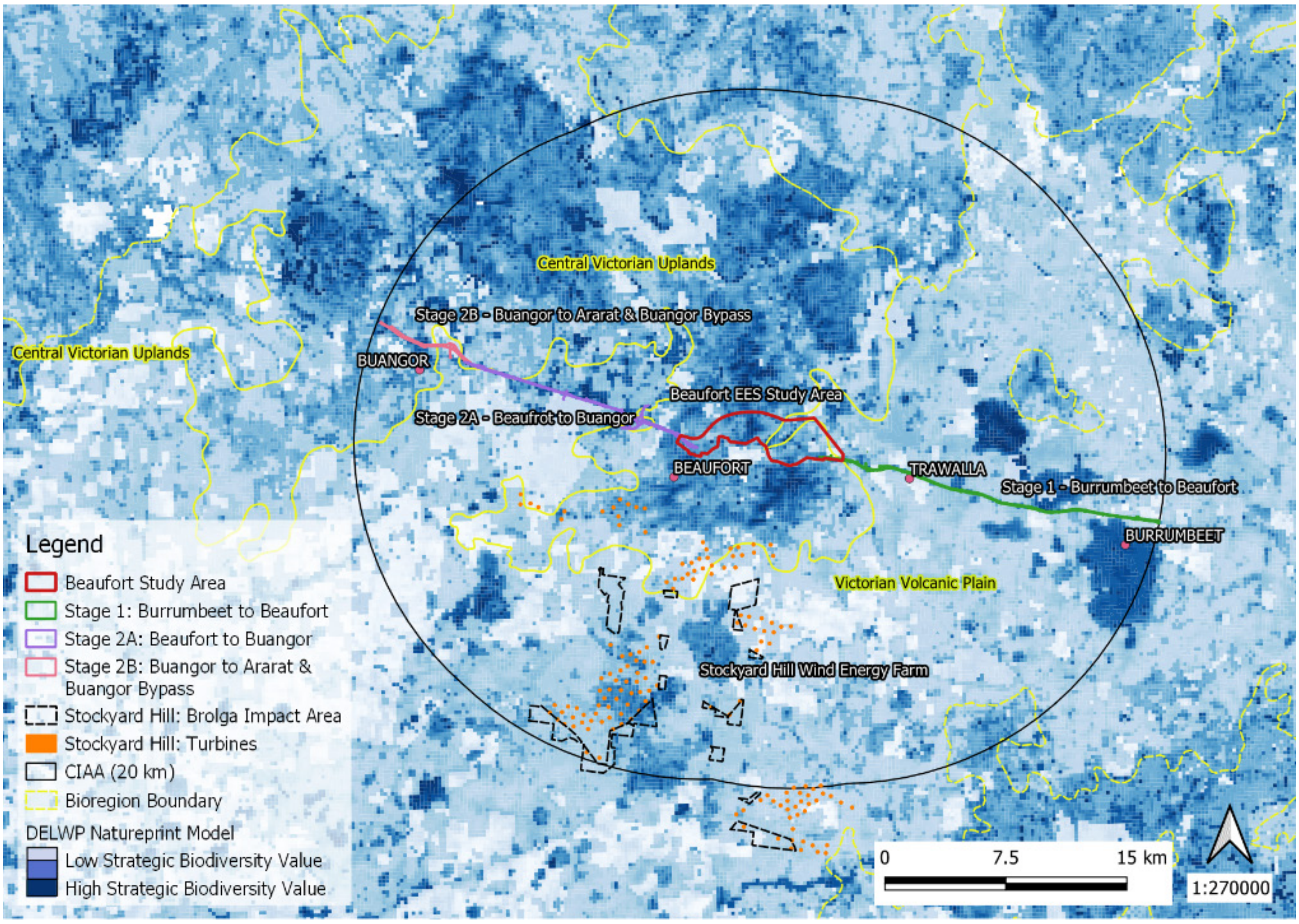


Figure 7.9 Proposed spatial boundary for cumulative impacts

All threatened species and ecological communities with a moderate or higher likelihood were assessed for inclusion, however not all could be included due a number of reasons including the lack of available modelled data or other projects not containing species or communities found in the study area. Appendix N provides detail on how species and communities that were considered for inclusion or exclusion in this CIA. The CIA was undertaken for the following species and ecological community:

- Ben Major Grevillea
- Emerald-lip Greenhood
- Matted Flax-lily
- Pale-flower Cranesbill
- Rough Wattle
- Yarra Gum
- Brolga
- Brown Toadlet
- Brush-tailed Phascogale
- Golden Sun Moth
- Growling Grass Frog
- Little Galaxias
- Powerful Owl
- Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains
- Victorian Temperate Woodland Bird Community.

7.10.2 METHODOLOGY

Analysis involved calculating the area of mapped habitat or modelled distribution of each species and ecological community within the project footprints. In the case of the Beaufort Bypass, the potential impact area across all four alignment options was calculated using mapped habitat for each species and community. For the other projects, the potential impact area was calculated using Species Distribution Models (DELWP 2017g). In the same way, analysis was also undertaken using DELWP datasets; Native Vegetation (NV2005_EVCBCS) and NaturePrint.

The potential impact areas across all five projects were tallied to provide a total cumulative impact area for each alignment. This area was then calculated as a percentage of the species distribution modelled to occur within each of the four spatial scales mentioned above. This conservative approach provides a “worst case” scenario of potential cumulative impacts to threatened species and communities as a result of multiple projects within the CIAA and allows for a direct comparison of potential impacts across each of the four Beaufort Bypass alignment options. Appendix N provides detail on methods.

The area used for alignment C2 was the nominal preliminary construction footprint, which does not include areas needed for channel realignments that are used for the preferred alignment assessment impacts in this report. This allows for a fair comparison between the four alignment options.

7.10.3 RESULTS

The results of the analysis indicated that the combined impact of the proposed bypass together with the four other projects within the CIAA were unlikely to result in a significant cumulative impact on any of the species or communities included in the assessment. However, unmitigated, the impacts of the four projects combined with impacts associated with the Beauport Bypass could potentially result in a minor cumulative impact on native vegetation and on some species, particularly those likely to be impacted by the Beaufort Bypass. This included Yarra Gum, Brolga, Brown Toadlet and Golden Sun Moth. Table 7.16 explains why the projects within the CIAA may potentially result in a minor cumulative impact (and not a significant cumulative impact) to the aforementioned species and native vegetation. The impact of alignment C2 on native vegetation is 46.40 ha which is >10 ha less than the impact associated with each of the other alignments. Alignment option C2 has the smallest area of impact on Golden Sun Moth habitat (13.65 ha) and the second smallest area of potential impact on Yarra Gum (2.21 ha), Brolga (0.71 ha) and Brown Toadlet (1.31 ha).

Table 7.16 Species with the potential to be affected by a minor cumulative impact

SPECIES	MINOR CUMULATIVE IMPACT	SIGNIFICANT CUMULATIVE IMPACT
Yarra Gum	**Yes** Up to three Yarra Gum trees may be removed from within the Beaufort Bypass study area and some impacts on modelled habitat are proposed. In addition, eight Yarra Gums were impacted by the Stage 1 Western Highway project, therefore there is potential for a minor cumulative impact on this species. The impact area for alignments A0 and A1 are similar at 7.36 ha and 7.43 ha respectively. Alignment options C0 and C2 will have considerably less impact to Yarra Gum habitat (2.15 ha and 2.21 ha respectively).	**No** The anticipated cumulative impact to this species comprises less than 1% of its distribution modelled to occur within the CIAA.
Brolga	**Yes** There is potential for a minor cumulative impact on a local Brolga population in the Yam Holes Creek Valley. Regarding the four alignment options, A1 and C2 are expected to result in the smallest areas of impact with 0.58 ha and 0.71 ha respectively. Alignment A0 will likely double the impact area (2.01 ha) while alignment C0 what result in the largest impact area at 4.22 ha.	**No** Given the small loss of Brolga habitat as a result of the Beaufort Bypass Project, the negligible difference in impact area across the four alignments (especially at a broader scale) and the large home range of the species, it appears unlikely that a significant cumulative impact on Brolga will occur as a result of impacts associated with the other projects.
Brown Toadlet	**Yes** There is potential for a minor cumulative impact on Brown Toadlet as a result of some impacts on modelled habitat proposed with all alignments, known habitat removed in the study area and some populations affected in the Stage 2B Western Highway Upgrade. Potential impacts to Brown Toadlet habitat are similar for alignments A0, A1 and C2, with the impact area ranging between 1.25–1.66 ha. Alignment C0 was calculated as having the largest impact on Brown Toadlet habitat at 3.20 ha.	**No** The anticipated cumulative impact to this species comprises less than 1% of its distribution modelled to occur within the CIAA.
Golden Sun Moth	**Yes** There is potential for a minor cumulative impact on Golden Sun Moth as a result of some impacts on modelled habitat proposed with all alignments, known habitat removed in the study area and some populations affected in the Stage 2B Western Highway Upgrade. The impact to Golden Sun Moth habitat ranged between 13.65–15.45 ha for all alignment options, with C2 having the smallest impact and A0 the largest.	**No** The anticipated cumulative impact to this species comprises less than 1% of its distribution modelled to occur within the CIAA.

SPECIES	MINOR CUMULATIVE IMPACT	SIGNIFICANT CUMULATIVE IMPACT
Growling Grass Frog	**Yes** There are some impacts on modelled habitat proposed with all alignments showing similar levels of impact, however no significant impacts using modelled data in the CIAA as a result of other projects. There are some impacts on actual mapped habitat proposed with all alignments and known habitat is likely to be removed in the Beaufort Bypass study area, along with some potential habitat at Stockyard Hill. Therefore, there is a minor cumulative impact however it appears unlikely that a significant cumulative impact on Growling Grass Frog will occur as a result of the Beaufort Bypass and other projects.	**No** The anticipated cumulative impact to this species comprises less than 3% of its distribution modelled to occur within the CIAA.
Native Vegetation	**Yes** There are some impacts on modelled native vegetation proposed with all alignments and known native vegetation removed in the Beaufort Bypass Study area. In addition, native vegetation has been/will be affected as a result of all other projects in the CIAA. Therefore, there is the potential for minor cumulative impacts resulting from the combined effect of these projects. The impact area of native vegetation is considerably less for alignment C2 at 46.40 ha while the impact area of each of the other three alignments ranged between 57.14 ha and 58.22 ha.	**No** The anticipated cumulative impact to this species comprises less than 1% of its distribution modelled to occur within the CIAA.

SPECIES	MINOR CUMULATIVE IMPACT	SIGNIFICANT CUMULATIVE IMPACT
Victorian Temperate Woodland Bird Community	**Yes** The total amount of potential cumulative impact to Victorian Temperate Woodland Bird Community (VTWBC) ranges between 128.44 to 135.31 ha. This area, which is largely based on a manipulation of modelled vegetation data, is evenly distributed across all the projects, except Stage 1 – Burrumbeet to Beaufort (potential impact calculated to be 2.45 ha). However, VTWBC was not actually found in previous assessments for Stage 1 or Stage 2A duplications. According to mapped data within the Beaufort Study area, alignment C2 intersects the least amount of VTWBC habitat (31.56 ha). There are some impacts on assumed mapped habitat for VTWBC proposed with all alignments in the context of the CIAA showing similar levels of impact, however no significant impacts using modelled data in the CIAA as a result of other projects. As there are impacts to actual mapped habitat with all alignments and known habitat will likely be removed in the Beaufort study area, there is some cumulative impact resulting from the combined effect of these projects. It is important to note that there is no layer available for VTWBC. Refer to Appendix N for limitations on using this dataset.	**No** The anticipated cumulative impact to this species comprises less than 1% of its distribution modelled to occur within the CIAA.

For the full CIA including results of all species, communities and datasets analysed, refer to Appendix N.

7.11 PRELIMINARY COMPARISON OF LEGISLATIVE IMPLICATIONS

7.11.1 ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

7.11.1.1 MIGRATORY SPECIES

Fourteen migratory species were listed on the PMST as potentially occurring in the study area but only one migratory bird, Latham's Snipe, is considered likely to occur in the study area based on previous records and available habitat.

The likelihood of significant impact on Latham's Snipe is considered to be low across all alignments because the habitat present does not meet the definition of 'important habitat' for this species. In addition, many other wetlands are available within the local area and the species distributes across a wide range of south and eastern Australia. A significant impact criteria assessment was undertaken for Latham's Snipe for all alignments (Appendix J).

Table 7.17 Summary of migratory bird impact assessment across all alignments

MIGRATORY BIRD SPECIES WITH THE POTENTIAL TO BE IMPACTED	HABITAT AT STUDY AREA	LIKELIHOOD OF OCCURRENCE AND IMPACTS
— Fork Tailed Swift *Apus pacificus*	Primarily a marine species, no habitat for this species within the study area.	Low likelihood of occurrence in study area. Not found in 10 km search area. Low likelihood of impact by all alignments.
— Common Sandpiper *Actitis hypoleucos* — Sharp-tailed Sandpiper *Calidris acuminata* — Curlew Sandpiper *Calidris ferruginea* — Pectoral Sandpiper *Calidris melanotos* — Red-necked Stint *Calidris ruficollis* — Latham's Snipe *Gallinago hardwickii* — Eastern Curlew *Numenius madagascariensis* — Common Greenshank *Tringa nebularia.*	All migratory wetland species.	All of these birds have a low likelihood of occurrence in study area with exception of Latham's Snipe which is considered moderately likely to occur in the study area. Habitat within the study area is not regarded as important habitat for Latham's Snipe. Low likelihood of significant impact by all alignments.
— White-throated Needletail *Hirundapus caudacutus* — Black-faced Monach *Monacha melanopsis* — Yellow Wagtail *Motacilla flava* — Satin Flycatcher *Myiagra cyanoleuca* — Rufous Fantail *Rufous rufifrons.*	These species are found in terrestrial habitats such as forests and open plains. Potential habitat for these species is present within the study area. However, only Satin Flycatcher and Rufous Fantail have any records within 10 km and those records are over 40 years old.	Low likelihood of occurrence in the study area. Low likelihood of impact by all alignments.

7.11.1.2 THREATENED SPECIES AND ECOLOGICAL COMMUNITIES

THREATENED FLORA

Four EPBC Act listed plant species were recorded within the study area. For each species, a preliminary significant impact assessment was completed, comparing the impact of each alignment option, based on the nominal construction footprint (refer to Appendix J). Depending on the alignment, there is the potential for significant impacts to River Swamp Wallaby-grass and Ornate Pink Fingers. The results are summarised in Table 7.18 below.

THREATENED FAUNA

Four EPBC listed fauna species were either recorded or considered likely to occur within the study area based on their potential to recolonise potential habitat. The likelihood of occurrence of one additional EPBC Act listed species, Striped Legless Lizard, was revised to low based on the results of targeted surveys, the paucity of local records, and the potential habitat present. Striped Legless Lizard is therefore unlikely to be impacted by the project.

The preliminary significant impact assessments determined that, regardless of alignment choice, a significant impact to Painted Honeyeater and Little Galaxias was unlikely to occur. However, alignment C0 has the potential to significantly impact Growling Grass Frog and alignments A0, C0 and C2 are likely to significantly impact Golden Sun Moth. Table 7.19 briefly summarises the likelihood of significant impact by alignment, with mitigation. The detailed preliminary significant impact assessments which compare alignment options (based on the nominal construction footprint) are provided in Appendix J.

Table 7.18 Summary of EPBC Act threatened flora species and potential for significant impacts (with mitigation) as a result of each alignment option

MNES	SUMMARY OF PREFERRED HABITAT	LIKELIHOOD OF OCCURRENCE AND IMPACT WITH MITIGATION			
		AO	A1	C0	C2
River Swamp Wallaby-grass *Amphibromus fluitans* EPBC Act Vulnerable	Permanent swamps, lagoons, billabongs, dams and roadside ditches. The species requires moderately fertile soils with some bare ground; conditions that are caused by seasonally-fluctuating water levels.	2 records within alignment. Potential to avoid based on road design. **Unlikely to have significant impacts.**	1 record within alignment. Potential to avoid based on road design. **Unlikely to have significant impacts.**	Multiple records within alignment including in patches of EPBC listed Seasonal Herbaceous Wetland community, likely to be a source population for dispersal. Size of patch across alignment would make avoidance difficult. **Potential for significant impacts.**	2 records within alignment. Revised construction footprint impacts one record – a 300 m^2 section of a dam supporting the species. **Unlikely to have significant impacts.**
Ornate Pink Fingers *Caladenia ornata* EPBC Act Vulnerable	Apparently endemic to Victoria where known only from the south-west in heathy forest on seasonally moist sandy loam.	Alignment passes through multiple records, some could be avoided through road design. **Potential for significant impacts.**	Alignment passes through multiple records, some could be avoided through road design. **Potential for significant impacts.**	Alignment avoids all records. **Unlikely to have significant impacts.**	Alignment avoids all records. **Unlikely to have significant impacts.**
Matted Flax-lily *Dianella amoeana* EPBC Act Endangered	Lowland grassland and grassy woodland, on well-drained to seasonally waterlogged fertile sandy loam soils to heavy cracking clays.	One record within alignment, could be avoided through road design. **Unlikely to have significant impacts.**	Two records within alignment, could be avoided through road design. **Unlikely to have significant impacts.**	Nine records within alignment, some could be avoided through road design. **Unlikely to have significant impacts.**	Two records within alignment, revised construction footprint impacts one plant/clump. **Unlikely to have significant impacts.**
Ben Major Grevillea *Grevillea floripendula* EPBC Act Vulnerable	Restricted to a small area north of Beaufort, from Waterloo to Ben Major Forest. Grows in dry open-forest, on shallow quartzitic soils.	Alignment avoids all individuals. **Unlikely to have significant impacts.**	Alignment avoids all individuals. **Unlikely to have significant impacts.**	Alignment avoids all individuals. **Unlikely to have significant impacts.**	Alignment avoids all individuals. **Unlikely to have significant impacts.**

Table 7.19 Summary of EPBC Act threatened fauna species and potential for significant impacts (with mitigation) as a result of each alignment option

MNES	SUMMARY OF PREFERRED HABITAT	LIKELIHOOD OF OCCURRENCE AND IMPACT WITH MITIGATION MEASURES			
		A0	**A1**	**C0**	**C2**
Species recorded in the study area					
Golden Sun Moth *Synemon plana* Critically Endangered	This species occurs where wallaby grasses *Rytiosperma spp*. dominate the understory, such as grassy Box-Gum Woodlands or Natural Temperate Grasslands. Larvae feed exclusively on the roots of these grasses, as well as some exotic grass species (species which are not present in the study area). Bare ground separating low tussocks of wallaby grass are key microhabitat features for the Golden Sun Moth, as courting behaviour occurs here (DEWHA 2009b).	Individuals and habitat recorded within alignment. **Likely to have significant impacts.**	Individuals and habitat recorded just outside this alignment. **Unlikely to have significant impacts.**	Individuals and habitat recorded within alignment. **Likely to have significant impacts.**	Individuals and habitat recorded within alignment. **Likely to have significant impacts.**

MNES	SUMMARY OF PREFERRED HABITAT	LIKELIHOOD OF OCCURRENCE AND IMPACT WITH MITIGATION MEASURES			
		A0	A1	C0	C2
Painted Honeyeater *Grantella picta* Vulnerable	Lives in dry forests and woodlands. Primary food is the mistletoes in the genus *Amyema*, though it will take some nectar and insects. Its breeding distribution is dictated by presence of mistletoes which are largely restricted to older trees. Less likely to be found in in strips of remnant box-ironbark woodlands, such as occur along roadsides and in windbreaks, than in wider blocks (Garnett & Crowley 2000).	Recorded by local landholder. Not detected in surveys. If present would be in low numbers and not be considered an important population for significant impact criteria. **Unlikely to have significant impacts.**	Recorded by local landholder. Not detected in surveys. If present would be in low numbers and not be considered an important population for significant impact criteria. **Unlikely to have significant impacts.**	Recorded by local landholder. Not detected in surveys. If present would be in low numbers and not be considered an important population for significant impact criteria. **Unlikely to have significant impacts.**	Recorded by local landholder. Not detected in surveys. If present would be in low numbers and not be considered an important population for significant impact criteria. **Unlikely to have significant impacts.**

MNES	SUMMARY OF PREFERRED HABITAT	LIKELIHOOD OF OCCURRENCE AND IMPACT WITH MITIGATION MEASURES			
		A0	A1	C0	C2
Species not recorded during site surveys					
Growling Grass Frog *Litoria raniformis*	The Growling Grass Frog is usually found amongst emergent vegetation such as Typha, Phragmites and Eleocharis within or at the edges of still or slow-flowing water bodies such as lagoons, swamps, lakes, ponds, and farm dams (Robinson 2003). It also occurs in irrigation channels and crops, lignum shrublands, black box and river red gum woodlands and at the periphery of rivers.	Targeted surveys were conducted for this species and none were recorded, however, they are considered ‘present’ for the purpose of impact assessment. This does intersect with minor areas of aquatic habitat, of which some could be avoided but does impact on more extensive areas of terrestrial habitat. **Unlikely to have significant impacts.**	Targeted surveys were conducted for this species and none were recorded, however, they are considered ‘present’ for the purpose of impact assessment. This does intersect with minor areas of aquatic habitat, of which some could be avoided but does impact on more extensive areas of terrestrial habitat. **Unlikely to have significant impacts.**	Targeted surveys were conducted for this species and none were recorded, however, they are considered ‘present’ for the purpose of impact assessment. This does intersect with larger areas of aquatic habitat and does impact on more extensive areas of terrestrial habitat. **Potential for significant impacts.**	Targeted surveys were conducted for this species and none were recorded, however, they are considered ‘present’ for the purpose of impact assessment. This does intersect with minor areas of aquatic habitat, of which some could be avoided but does impact on more extensive areas of terrestrial habitat. **Unlikely to have significant impacts.**
Striped Legless Lizard *Delma impar*	Inhabit both native and exotic dominant grasslands including secondary/derived grasslands.	Targeted tile surveys were conducted for this species and none were recorded. There is limited habitat available in the study area. **Low likelihood of occurrence.** **Low likelihood of impact.**	Targeted tile surveys were conducted for this species and none were recorded. There is limited habitat available in the study area. **Low likelihood of occurrence.** **Low likelihood of impact.**	Targeted tile surveys were conducted for this species and none were recorded. There is limited habitat available in the study area. **Low likelihood of occurrence.** **Low likelihood of impact.**	Targeted tile surveys were conducted for this species and none were recorded. There is limited habitat available in the study area. **Low likelihood of occurrence.** **Low likelihood of impact.**

MNES	SUMMARY OF PREFERRED HABITAT	LIKELIHOOD OF OCCURRENCE AND IMPACT WITH MITIGATION MEASURES			
		A0	**A1**	**C0**	**C2**
Little Galaxias *Galaxiella toourtkoourt*	Occurs in low flowing and still, shallow, permanent and temporary freshwater habitats such as swamps, drains, and the backwaters of streams and creeks.	Targeted surveys were conducted for this species and none were recorded, however, they are considered ‘present’ for the purpose of impact assessment. There is habitat available along Yam Holes Creek. **Unlikely to have significant impacts.**	Targeted surveys were conducted for this species and none were recorded, however, they are considered ‘present’ for the purpose of impact assessment. There is habitat available along Yam Holes Creek. **Unlikely to have significant impacts.**	Targeted surveys were conducted for this species and none were recorded, however, they are considered ‘present’ for the purpose of impact assessment. There is habitat available along Yam Holes Creek. **Unlikely to have significant impacts.**	Targeted surveys were conducted for this species and none were recorded, however, they are considered ‘present’ for the purpose of impact assessment. There is habitat available along Yam Holes Creek. **Unlikely to have significant impacts.**

THREATENED ECOLOGICAL COMMUNITIES

According to the PMST, five threatened ecological communities were modelled as potentially occurring within the study area but only two were recorded during the site assessments: Seasonal herbaceous Wetlands and White Box Box-Yellow Box – Blakely's Red Gum Grassy Woodland.

A preliminary significant impact assessment was undertaken for both threatened communities and determined that even with mitigation, alignments A0 and C0 had potential to result in significant impact on one or both communities respectively (refer to Table 7.20). The detailed preliminary significant impact assessments which compare alignment options (based on the nominal construction footprint) are provided in Appendix J.

Table 7.20 Summary of EPBC Act threatened ecological communities and potential for significant impacts (with mitigation) as a result of each alignment option

MNES	LIKELIHOOD OF OCCURRENCE AND IMPACT WITH MITIGATION MEASURES			
	A0	**A1**	**C0**	**C2**
Seasonal Herbaceous Wetlands of the Temperate Lowland Plains	0.06 ha within preliminary construction footprint. **Unlikely to have significant impacts.**	0.06 ha within preliminary construction footprint. **Unlikely to have significant impacts.**	2.58 ha within preliminary construction footprint. **Potential to have significant impacts.**	0.06 ha within preliminary construction footprint. 0.312 ha within the revised construction footprint and proposed to be impacted by the project. **Unlikely to have significant impacts.**
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	2.64 ha mapped within preliminary construction footprint. **Potential to have significant impacts**.	0.65 ha mapped within preliminary construction footprint. **Unlikely to have significant impacts.**	3.97 ha mapped within preliminary construction footprint. **Potential to have significant impacts.**	None mapped in preliminary construction footprint or revised construction footprint. **Unlikely to have significant impacts.**

7.11.1.3 THREATENING PROCESSES

An assessment of the alignment options against the relevant Commonwealth listed Key Threatening Processes is provided in Table 7.21.

Table 7.21 Threatening Processes (EPBC Act) relevant to study area

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant noisy miners (Manorina melanocephala)	Despite this species having been recorded in the area (refer to Appendix B) they are not currently abundant. It is unlikely that their existence aggressively excludes other birds from the more intact woodland and forest habitat in the study area. However, in largely cleared agricultural land, they may be impacting native fauna.	**Applicable** Alignment option, through clearing and modification of woodland and forest habitat, may advantage Noisy Miners in some areas.	**Applicable** Alignment option, through clearing and modification of woodland and forest habitat, may advantage Noisy Miners in some areas.	**Applicable** Alignment option, through clearing and modification of woodland and forest habitat, may advantage Noisy Miners in some areas.	**Applicable** Alignment option, through clearing and modification of woodland and forest habitat, may advantage Noisy Miners in some areas.
Competition and land degradation by rabbits	Rabbits occur throughout much of the study area. It is likely that their presence is resulting in competition and land degradation.	**Not Applicable** Alignment option unlikely to increase rabbit populations in the area.	**Not Applicable** Alignment option unlikely to increase rabbit populations in the area.	**Not Applicable** Alignment option unlikely to increase rabbit populations in the area.	**Not Applicable** Alignment option unlikely to increase rabbit populations in the area.
Competition and land degradation by unmanaged goats	Feral goats are not known to have been recorded in the region (VBA, ALA) and are unlikely to be affecting the study area.	**Not Applicable** Not currently relevant to the study area.	**Not Applicable** Not currently relevant to the study area.	**Not Applicable** Not currently relevant to the study area.	**Not Applicable** Not currently relevant to the study area.

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Dieback caused by the root-rot fungus (Phytophthora cinnamomi)	*Phytophthora cinnamomi* may be present in the soils of the study area but there have been no noticeable signs of dieback such as tree death. There are no known highly susceptible flora species in the study area such as grass trees.	**Applicable** The type of disturbance associated with the construction of road pavement can result in a window of opportunity for weeds and soil pathogens such as Phytophthora *Phytophthora cinnamomii*. Appropriate hygiene controls and controls regarding sourcing of materials will need to be implemented to prevent introduction and spread.	**Applicable** The type of disturbance associated with the construction of road pavement can result in a window of opportunity for weeds and soil pathogens such as Phytophthora *Phytophthora cinnamomii*. Appropriate hygiene controls and controls regarding sourcing of materials will need to be implemented to prevent introduction and spread.	**Applicable** The type of disturbance associated with the construction of road pavement can result in a window of opportunity for weeds and soil pathogens such as Phytophthora *Phytophthora cinnamomii*. Appropriate hygiene controls and controls regarding sourcing of materials will need to be implemented to prevent introduction and spread.	**Applicable** The type of disturbance associated with the construction of road pavement can result in a window of opportunity for weeds and soil pathogens such as Phytophthora *Phytophthora cinnamomii*. Appropriate hygiene controls and controls regarding sourcing of materials will need to be implemented to prevent introduction and spread.
Infection of amphibians with chytrid fungus resulting in chytridiomycosis	Chytrid Fungus is almost certainly present in the area. It may explain the decline in Growling Grass Frog populations as they are susceptible to the waterborne fungal pathogen; however, more research would be needed to confirm this.	**Applicable** Appropriate hygiene controls will be required to prevent the spread of Chytrid fungus when moving equipment in and out of the area.	**Applicable** Appropriate hygiene controls will be required to prevent the spread of Chytrid fungus when moving equipment in and out of the area.	**Applicable** Appropriate hygiene controls will be required to prevent the spread of Chytrid fungus when moving equipment in and out of the area.	**Applicable** Appropriate hygiene controls will be required to prevent the spread of Chytrid fungus when moving equipment in and out of the area.

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Land clearance	Land clearing has been extensive within the study area, mainly due to agricultural clearing. Over time, this has resulted in the loss and fragmentation of native vegetation, and a reduction in hollow-bearing trees. The remaining vegetation is therefore of especially high value.	**Applicable** Alignment will result in 62.61 ha of native vegetation clearing.	**Applicable** Alignment will result in 62.55 ha of native vegetation clearing.	**Applicable** Alignment will result in 62.3 ha of native vegetation clearing.	**Applicable** Alignment will result in 50.7 ha of native vegetation clearing.
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	Several weed species exist in the study area, six of which are considered Weeds of National Significance. It is likely that some weeds have invaded from gardens and degraded native plant and animal habitat, however, most of the weeds identified are common to pastoral areas.	**Not Applicable** Project unlikely to result in an increase in escaped garden plants.	**Not Applicable** Project unlikely to result in an increase in escaped garden plants.	**Not Applicable** Project unlikely to result in an increase in escaped garden plants.	**Not Applicable** Project unlikely to result in an increase in escaped garden plants.
Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases	It is unlikely that anthropogenic emissions of greenhouse gases have substantially affected the study area.	**Not Applicable** Road construction will cause greenhouse emissions but unlikely to an extent that would result in significant impacts to habitat.	**Not Applicable** Road construction will cause greenhouse emissions but unlikely to an extent that would result in significant impacts to habitat.	**Not Applicable** Road construction will cause greenhouse emissions but unlikely to an extent that would result in significant impacts to habitat.	**Not Applicable** Road construction will cause greenhouse emissions but unlikely to an extent that would result in significant impacts to habitat.

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Novel biota and their impact on biodiversity	This threatening process is highly relevant to the study area due to the modified and fragmented nature of the landscape. Novel biota relevant to the area includes vertebrate pests and terrestrial weeds. Refer to Appendix A and Appendix B for a full species list.	**Applicable** Road construction is likely to lead to increased weed invasion without adequate controls. The controls in VicRoads Standard Section 177 and in Section 10.4.7.1 of this report are likely to largely mitigate this risk.	**Applicable** Road construction is likely to lead to increased weed invasion without adequate controls. The controls in VicRoads Standard Section 177 and in Section 10.4.7.1 of this report are likely to largely mitigate this risk.	**Applicable** Road construction is likely to lead to increased weed invasion without adequate controls. The controls in VicRoads Standard Section 177 and in Section 10.4.7.1 of this report are likely to largely mitigate this risk.	**Applicable** Road construction is likely to lead to increased weed invasion without adequate controls. The controls in VicRoads Standard Section 177 and in Section 10.4.7.1 of this report are likely to largely mitigate this risk.
Predation by European red fox	Red Foxes occur throughout the area and have previously been recorded in low numbers near the study area (ALA, VBA). It is highly likely that they are preying on native wildlife in the study area.	**Applicable** Alignment option unlikely to substantially increase red fox populations in the area. However, the creation of new roads through intact vegetation can create opportunities for foxes to more easily access habitat. The more intact habitats in the study area are relatively open already, however, there may be patches that are more susceptible to fox incursion. This should be examined as part of the detailed design phase for the approved alignment.	**Applicable** Alignment option unlikely to substantially increase red fox populations in the area. However, the creation of new roads through intact vegetation can create opportunities for foxes to more easily access habitat. The more intact habitats in the study area are relatively open already, however, there may be patches that are more susceptible to fox incursion. This should be examined as part of the detailed design phase for the approved alignment..	**Applicable** Alignment option unlikely to substantially increase red fox populations in the area. However, the creation of new roads through intact vegetation can create opportunities for foxes to more easily access habitat. The more intact habitats in the study area are relatively open already, however, there may be patches that are more susceptible to fox incursion. This should be examined as part of the detailed design phase for the approved alignment.	**Applicable** Alignment option unlikely to substantially increase red fox populations in the area. However, the creation of new roads through intact vegetation can create opportunities for foxes to more easily access habitat. The more intact habitats in the study area are relatively open already, however, there may be patches that are more susceptible to fox incursion. This should be examined as part of the detailed design phase for the approved alignment.

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Predation by feral cats	Feral cats have not been recorded in or near the study area (VBA, ALA); however, it is highly likely that they area present. Feral cats and roaming domestic cats are likely to prey upon native fauna in the study area.	**Not Applicable** Alignment option unlikely to increase feral cat populations in the area.	**Not Applicable** Alignment option unlikely to increase feral cat populations in the area.	**Not Applicable** Alignment option unlikely to increase feral cat populations in the area.	**Not Applicable** Alignment option unlikely to increase feral cat populations in the area.
Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs	Although VBA and ALA database searches returned no result for this species in or near the study area, feral pigs may occur and be affecting habitat.	**Not Applicable** Project unlikely to increase Feral Pig numbers or impacts (if present).	**Not Applicable** Project unlikely to increase Feral Pig numbers or impacts (if present).	**Not Applicable** Project unlikely to increase Feral Pig numbers or impacts (if present).	**Not Applicable** Project unlikely to increase Feral Pig numbers or impacts (if present).
Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species	Several psittacine species occur in the study area and a proportion are likely to be affected by Psittacine Circoviral Disease. However, no endangered psittacine species are likely to regularly occur in the study area (Appendix C).	**Not Applicable** Not relevant to the study area.	**Not Applicable** Not relevant to the study area.	**Not Applicable** Not relevant to the study area.	**Not Applicable** Not relevant to the study area.
Summary of applicable threatening processes		A total of six threatening process are applicable to alignment A0.	A total of six threatening process are applicable to alignment A1.	A total of six threatening process are applicable to alignment C0.	A total of six threatening process are applicable to alignment C2.
Summary of non-applicable threatening processes		A total of seven threatening process are not applicable to alignment A0.	A total of seven threatening process are not applicable to alignment A1.	A total of seven threatening process are not applicable to alignment C0.	A total of seven threatening process are not applicable to alignment C2.

7.11.2 FLORA AND FAUNA GUARANTEE ACT 1988

7.11.2.1 THREATENED SPECIES

A total of seven fauna species listed under the FFG Act were recorded during either the WSP surveys or previous GHD surveys across the four alignment options. An additional four species that have not been recorded are still considered moderately likely to occur. Three flora species listed under the FFG Act have been located during surveys, with two additional species considered moderate to highly likely to occur.

Table 7.22 FFG Act listed species with the potential to be affected by the Project

COMMON NAME	RECORDED	VBA RECORDS IN 10 km AREA	LIKELIHOOD OF OCCURRENCE	A0	A1	C0	C2
Fauna species							
Blue-billed Duck		2	Low – nearby records over 30 years old	Unlikely	Unlikely	Unlikely	Unlikely
Brolga	WSP 2015-2017	213	Recorded	Possible	Possible	Possible	Possible
Brown Toadlet	WSP 2015	18	Recorded	Possible	Possible	Possible	Possible
Brush-tailed Phascogale	WSP 2015	9	Recorded	Possible	Possible	Possible	Possible
Diamond Firetail		1	Recorded by local landholder	Unlikely	Unlikely	Unlikely	Unlikely
Eastern Great Egret		6	Low – unlikely to be suitable habitat within study area.	Unlikely	Unlikely	Unlikely	Unlikely
Golden Sun Moth	WSP 2015-2016	38	Recorded	Possible	Unlikely	Possible	Possible
Growling Grass Frog		35	Moderate – Many records in study area and suitable habitat available	Possible	Possible	Possible	Possible
Painted Honeyeater		1	Recorded by local landholder	Unlikely	Unlikely	Unlikely	Unlikely
Little Galaxias		11	High – not found in last three surveys but may recolonise	Unlikely	Unlikely	Unlikely	Unlikely
Powerful Owl		10	High – Many records and suitable habitat available	Possible	Possible	Possible	Possible
Speckled Warbler		6	Moderate likelihood	Unlikely	Unlikely	Unlikely	Unlikely

COMMON NAME	RECORDED	VBA RECORDS IN 10 km AREA	LIKELIHOOD OF OCCURRENCE	A0	A1	C0	C2
Flora species							
Ornate Pink-fingers	WSP 2016	0	Recorded	Possible	Possible	Unlikely	Unlikely
Matted Flax-lily	WSP 2015-2017	3	Recorded	Possible	Possible	Possible	Possible
Ben Major Grevillea	WSP 2015-2017	146	Recorded	Unlikely	Unlikely	Unlikely	Unlikely

7.11.2.2 THREATENED COMMUNITIES

See Section 7.1.2.1.

7.11.2.3 THREATENING PROCESSES

Table 7.23 Threatening Processes (FFG Act) relevant to study area – assessment of all four potential alignments

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Alteration to the natural flow regimes of rivers and streams.	Some rivers and streams are present in the study area. Most notably is Yam Holes Creek, which has undergone some alteration and channelization. These changes have altered the natural flow regime of the creek.	**Not Applicable** Road design will feature a bridge over Yam Holes Creek in two areas and surface water flows would be maintained through culverts and bridge crossings.	**Not Applicable** Road design will feature a bridge over Yam Holes Creek in two areas and surface water flows would be maintained through culverts and bridge crossings.	**Not Applicable** Road design will feature a bridge over Yam Holes Creek in two areas and surface water flows would be maintained through culverts and bridge crossings.	**Not Applicable** Road design will feature a bridge over Yam Holes Creek in two areas and surface water flows would be maintained through culverts and bridge crossings.
Alteration to the natural temperature regimes of rivers and streams.	Due to the above-mentioned alterations, it is probable that the altered waterways have also experienced altered natural temperature regimes.	**Applicable** Bridge construction will shade out a section of the creek which can lead to altered temperature regimes which can affect species diversity and composition. Impacts are likely to be minor and localised.	**Applicable** Bridge construction will shade out a section of the creek which can lead to altered temperature regimes which can affect species diversity and composition. Impacts are likely to be minor and localised.	**Applicable** Bridge construction will shade out a section of the creek which can lead to altered temperature regimes which can affect species diversity and composition. Impacts are likely to be minor and localised.	**Applicable** Bridge construction will shade out a section of the creek which can lead to altered temperature regimes which can affect species diversity and composition. Impacts are likely to be minor and localised.
Collection of native orchids.	Road construction will result in some loss of orchids, however, appropriate FFG Act permits will be sought prior to their removal.	**Applicable** FFG Act permits required for loss of orchids.	**Applicable** FFG Act permits required for loss of orchids.	**Applicable** FFG Act permits required for loss of orchids.	**Applicable** FFG Act permits required for loss of orchids.

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Degradation of native riparian vegetation along Victorian rivers and streams.	Most of the native vegetation that exists along current rivers and streams within the study area has been removed.	**Not Applicable** Little to no riparian vegetation in alignment.	**Not Applicable** Little to no riparian vegetation in alignment.	**Applicable** Road construction would impact riparian vegetation around Yam Holes Creek through direct removal of shading due to bridge construction.	**Not Applicable** Little to no riparian vegetation in alignment.
Habitat fragmentation as a threatening process for fauna in Victoria.	Land clearing is prominent within the study area, mainly due to farming practices, and has resulted in habitat fragmentation. Habitat fragmentation is likely to impact certain Victorian fauna that are found in the area.	**Applicable** Road construction will increase habitat fragmentation in the area as the road passes through a significant patch of remnant vegetation.	**Applicable** Road construction will increase habitat fragmentation in the area as the road passes through a significant patch of remnant vegetation.	**Applicable** Road construction will increase habitat fragmentation as road passes through a patch of remnant vegetation. (Lesser impact than A0 and A1 due to amount of vegetation loss being smaller and toward the edge of the patch.)	**Applicable** Road construction will increase habitat fragmentation as road passes through a patch of remnant vegetation. (Lesser impact than A0 and A1 due to amount of vegetation loss being smaller and toward the edge of the patch.)
High frequency fire resulting in disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.	Risk of fire is controlled along the road. However, the construction of a road near bushland could result in increased fire frequency. For example, greater opportunity to loss cigarette butts from vehicles.	**Applicable** Alignment passes through a large patch of native forest and could result in increased fire risk. However overall risk of high fire frequency is low.	**Applicable** Alignment passes through a large patch of native forest and could result in increased fire risk. However overall risk of high fire frequency is low.	**Applicable** Alignment passes through a large patch of native forest and could result in increased fire risk. However overall risk of high fire frequency is low.	**Applicable** Alignment passes through a large patch of native forest and could result in increased fire risk. However overall risk of high fire frequency is low.

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Increase in sediment input into Victorian rivers and streams due to human activities.	Construction works involving removal of vegetation can lead to an increase in sediment run off into waterways.	**Applicable** Appropriate mitigation measures will be installed when working near waterways to prevent erosion and sedimentation of waterways.	**Applicable** Appropriate mitigation measures will be installed when working near waterways to prevent erosion and sedimentation of waterways.	**Applicable** Appropriate mitigation measures will be installed when working near waterways to prevent erosion and sedimentation of waterways.	**Applicable** Appropriate mitigation measures will be installed when working near waterways to prevent erosion and sedimentation of waterways.
Infection of amphibians with Chytrid Fungus, resulting in chytridiomycosis	Chytrid Fungus is almost certainly present in the area. It may explain the decline in Growling Grass Frog populations as they are susceptible to the waterborne fungal pathogen however more research is needed to confirm this.	**Applicable** Stringent hygiene protocols and monitoring will be required due to the high level of risk associated with earthworks, water use and soil movement in the area.	**Applicable** Stringent hygiene protocols and monitoring will be required due to the high level of risk associated with earthworks, water use and soil movement in the area.	**Applicable** Stringent hygiene protocols and monitoring will be required due to the high level of risk associated with earthworks, water use and soil movement in the area.	**Applicable** Stringent hygiene protocols and monitoring will be required due to the high level of risk associated with earthworks, water use and soil movement in the area.
Input of toxic substances into Victorian rivers and streams.	Farming practices are prominent within the study area. It is highly likely that toxic substances such as fertilisers and manure may have entered rivers and streams via run off. It is also possible that toxic substances from sources upstream may have entered rivers and streams within the study area.	**Applicable** Road construction could lead to increases in run off from contaminants such as oil and petrol.	**Applicable** Road construction could lead to increases in run off from contaminants such as oil and petrol.	**Applicable** Road construction could lead to increases in run off from contaminants such as oil and petrol.	**Applicable** Road construction could lead to increases in run off from contaminants such as oil and petrol.

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Introduction of live fish into waters outside their natural range within a Victorian river catchment after 1770.	Exotic fish species are known to occur in some waterways associated with the study area. These include Goldfish and Eastern Gambusia (Section 6.6.2.16).	**Not Applicable** Alignment option unlikely to introduce new species of live fish into waters outside of their natural range.	**Not Applicable** Alignment option unlikely to introduce new species of live fish into waters outside of their natural range.	**Not Applicable** Alignment option unlikely to introduce new species of live fish into waters outside of their natural range.	**Not Applicable** Alignment option unlikely to introduce new species of live fish into waters outside of their natural range.
Invasion of native vegetation by Blackberry *Rubus fruticosus L. agg.*	This species is present in the study area (Appendix A) and can potentially impact native vegetation. Invasion of the species may be worsened by future developments.	**Applicable** Road construction leads to increased weed spread. Weed seeds are regularly transported on vehicles and infestation levels are often higher on roads sides from where they spread into remnant forests. Road construction could result in higher level of Blackberry infestation in the region.	**Applicable** Road construction leads to increased weed spread. Weed seeds are regularly transported on vehicles and infestation levels are often higher on roads sides from where they spread into remnant forests. Road construction could result in higher level of Blackberry infestation in the region.	**Applicable** Road construction leads to increased weed spread. Weed seeds are regularly transported on vehicles and infestation levels are often higher on roads sides from where they spread into remnant forests. Road construction could result in higher level of Blackberry infestation in the region.	**Applicable** Road construction leads to increased weed spread. Weed seeds are regularly transported on vehicles and infestation levels are often higher on roads sides from where they spread into remnant forests. Road construction could result in higher level of Blackberry infestation in the region.

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Invasion of native vegetation by ‘environmental weeds’.	It is known that several weed species exist in the study area, six of which are considered Weeds of National Significance (WoNS). It is possible that, over time, these weeds have invaded and displaced native vegetation. Refer to section 5.2.5.1	**Applicable** Road construction leads to increased weed spread. Weed seeds are regularly transported on vehicles and infestation levels are often higher on roads sides from where they spread into remnant forests. Road construction could lead to additional invasive species in surrounding native forests.	**Applicable** Road construction leads to increased weed spread. Weed seeds are regularly transported on vehicles and infestation levels are often higher on roads sides from where they spread into remnant forests. Road construction could lead to additional invasive species in surrounding native forests.	**Applicable** Road construction leads to increased weed spread. Weed seeds are regularly transported on vehicles and infestation levels are often higher on roads sides from where they spread into remnant forests. Road construction could lead to additional invasive species in surrounding native forests.	**Applicable** Road construction leads to increased weed spread. Weed seeds are regularly transported on vehicles and infestation levels are often higher on roads sides from where they spread into remnant forests. Road construction could lead to additional invasive species in surrounding native forests.
Invasion of native vegetation communities by Tall Wheat-grass *Lophopyrum ponticum.*	Whilst VBA and ALA searches returned no records for this species in or near the study area, WSP surveys did record one sighting near Racecourse Road in Property 81. Despite its presence, it is unlikely that it is currently having a significant impact on native vegetation communities at the site.	**Not Applicable** Alignment option unlikely to impact as no Tall Wheat-grass populations were identified in the alignment.	**Not Applicable** Alignment option unlikely to impact as no Tall Wheat-grass populations were identified in the alignment.	**Applicable** Small population of Tall Wheat-grass near Racecourse Road. Identify during construction and minimise spread of weed to other areas.	**Applicable** Small population of Tall Wheat-grass near Racecourse Road. Identify during construction and minimise spread of weed to other areas.

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Loss of coarse woody debris from Victorian native forests and woodlands.	The study area is highly modified, having been cleared in the past predominately for farming practices. This clearing has resulted in the loss of coarse woody debris from Victorian native forests and woodlands in the area.	**Applicable** The project will result in the loss of native forests containing coarse woody debris, however, will not impact the amount of coarse woody debris in surrounding forest.	**Applicable** The project will result in the loss of native forests containing coarse woody debris, however, will not impact the amount of coarse woody debris in surrounding forest.	**Applicable** The project will result in the loss of native forests containing coarse woody debris, however, will not impact the amount of coarse woody debris in surrounding forest.	**Applicable** The project will result in the loss of native forests containing coarse woody debris, however, will not impact the amount of coarse woody debris in surrounding forest.
Loss of hollow-bearing trees from Victorian native forests.	Significant loss of hollow bearing trees has occurred due to past land management.	**Applicable** Removal of up to 396 large old trees may be required for this alignment.	**Applicable** Removal of up to 374 large old trees may be required for this alignment.	**Applicable** Removal of up to 322 large old trees may be required for this alignment.	**Applicable** Removal of up to 317 large old trees may be required for this alignment.
Loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases.	It is unlikely that anthropogenic emissions of greenhouse gases have substantially affected the study area.	**Not Applicable** Road construction will cause greenhouse emissions but unlikely to an extent that would result in significant impacts to habitat.	**Not Applicable** Road construction will cause greenhouse emissions but unlikely to an extent that would result in significant impacts to habitat.	**Not Applicable** Road construction will cause greenhouse emissions but unlikely to an extent that would result in significant impacts to habitat.	**Not Applicable** Road construction will cause greenhouse emissions but unlikely to an extent that would result in significant impacts to habitat.
Predation of native wildlife by the cat, *Felis catus.*	A VBA and ALA search returned no counts of feral cat sightings in or near the project site. However, there is a township in Beaufort and it is possible that there are feral cats and roaming domestic cats in the region which could prey upon native fauna.	**Not Applicable** Alignment option unlikely to increase feral cat populations in the area.	**Not Applicable** Alignment option unlikely to increase feral cat populations in the area.	**Not Applicable** Alignment option unlikely to increase feral cat populations in the area.	**Not Applicable** Alignment option unlikely to increase feral cat populations in the area.

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Predation of native wildlife by the introduced Red Fox *Vulpes vulpes*.	Red fox sightings have previously been recorded in low numbers near the study area (ALA, VBA). Despite the lack of records, it is highly likely that, if present, they will prey on native wildlife in the area.	**Applicable** Alignment option unlikely to increase red fox populations in the area. However, the creation of new roads through intact vegetation can create opportunities for foxes to more easily access habitat. See Section 7.3.2.1 for more detail.	**Applicable** Alignment option unlikely to increase red fox populations in the area. However, the creation of new roads through intact vegetation can create opportunities for foxes to more easily access habitat. See Section 7.3.2.1 for more detail.	**Applicable** Alignment option unlikely to increase red fox populations in the area. However, the creation of new roads through intact vegetation can create opportunities for foxes to more easily access habitat. See Section 7.3.2.1 for more detail.	**Applicable** Alignment option unlikely to increase red fox populations in the area. However, the creation of new roads through intact vegetation can create opportunities for foxes to more easily access habitat. See Section 7.3.2.1 for more detail.
Prevention of passage of aquatic biota as a result of the presence of instream structures.	There are some small weirs and other structures throughout the creeks which may prevent movement of fish species such as Little Galaxias.	**Not Applicable** Road construction unlikely to result in any additional instream structures.	**Not Applicable** Road construction unlikely to result in any additional instream structures.	**Not Applicable** Road construction unlikely to result in any additional instream structures.	**Not Applicable** Road construction unlikely to result in any additional instream structures.
Reduction in biodiversity of native vegetation by Sambar (*Cervus unicolor*).	Database searches returned no results for this species in the study area. As such, it is not considered a relevant threatening process.	**Not Applicable** Not relevant to the study area.	**Not Applicable** Not relevant to the study area.	**Not Applicable** Not relevant to the study area.	**Not Applicable** Not relevant to the study area.

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Reduction in biodiversity resulting from Noisy Miner (*Manorina melanocephala*) populations in Victoria.	Habitat modification caused by the project may advantage noisy miners over other native species by creating landscape features such as cleared 'corners' adjacent to woodland.	**Applicable** Habitat modification caused by the project may advantage noisy miners over other native species.	**Applicable** Habitat modification caused by the project may advantage noisy miners over other native species.	**Applicable** Habitat modification caused by the project may advantage noisy miners over other native species.	**Applicable** Habitat modification caused by the project may advantage noisy miners over other native species.
Reduction in biomass and biodiversity of native vegetation through grazing by the Rabbit *Oryctolagus cuniculus*.	Rabbits have previously been recorded in the area (Appendix B), however, they are mainly found in already cleared agricultural land. Currently, it is unlikely that they are having a significant impact on the biomass and biodiversity of native vegetation in the area.	**Not Applicable** Alignment option unlikely to increase rabbit populations in the area.	**Not Applicable** Alignment option unlikely to increase rabbit populations in the area.	**Not Applicable** Alignment option unlikely to increase rabbit populations in the area.	**Not Applicable** Alignment option unlikely to increase rabbit populations in the area.
Removal of wood debris from Victorian streams.	Given the history of clearing that has occurred in the study area, it is highly likely that wood debris has, at some point in time, been removed from streams.	**Not Applicable** Alignment option unlikely to impact amounts of woody debris in streams.	**Not Applicable** Alignment option unlikely to impact amounts of woody debris in streams.	**Not Applicable** Alignment option unlikely to impact amounts of woody debris in streams.	**Not Applicable** Alignment option unlikely to impact amounts of woody debris in streams.
Spread of *Pittosporum undulatum* in areas outside its natural distribution.	The species is not known to occur in the Beaufort region (VBA, ALA), therefore, is unlikely to be a relevant threatening process to the study area.	**Not Applicable** Not relevant to the study area.	**Not Applicable** Not relevant to the study area.	**Not Applicable** Not relevant to the study area.	**Not Applicable** Not relevant to the study area.

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
The spread of *Phytophthora cinnamomi* from infected sites into parks and reserves, including roadsides, under the control of a state or local government authority.	*Phytophthora cinnamomi* may be present in the soils of the study area but there have been no noticeable signs of dieback such as tree death. There are no known highly susceptible flora species such as grass trees.	**Applicable** The type of disturbance associated with the construction of road pavement, and the importation of materials can result in a window of opportunity for weeds and soil pathogens such as *Phytophthora cinnamomii*. Appropriate hygiene controls will need to be implemented to prevent introduction and/or spread.	**Applicable** The type of disturbance associated with the construction of road pavement, and the importation of materials can result in a window of opportunity for weeds and soil pathogens such as *Phytophthora cinnamomii*. Appropriate hygiene controls will need to be implemented to prevent introduction and/or spread.	**Applicable** The type of disturbance associated with the construction of road pavement, and the importation of materials can result in a window of opportunity for weeds and soil pathogens such as *Phytophthora cinnamomii.* Appropriate hygiene controls will need to be implemented to prevent introduction and/or spread.	**Applicable** The type of disturbance associated with the construction of road pavement, and the importation of materials can result in a window of opportunity for weeds and soil pathogens such as *Phytophthora cinnamomii.* Appropriate hygiene controls will need to be implemented to prevent introduction and/or spread.
Threats to native flora and fauna arising from the use by the feral honeybee *Apis mellifera* of nesting hollows and floral resources.	European honey bee or feral honeybee is present in the study area. Managed hives have been placed in the Camp Hill State Forest area from time to time.	**Not Applicable** Alignment option unlikely to increase distribution of European honey bee.	**Not Applicable** Alignment option unlikely to increase distribution of European honey bee.	**Not Applicable** Alignment option unlikely to increase distribution of European honey bee.	**Not Applicable** Alignment option unlikely to increase distribution of European honey bee.

THREATENING PROCESS	CURRENT RELEVANCE	POTENTIAL PROJECT IMPACT			
		ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Use of Phytophthora-infected gravel in construction of roads, bridges and reservoirs.	*Phytophthora cinnamomi* may be present in the soils of the study area but there have been no noticeable signs of dieback such as tree death. There are no known highly susceptible flora species such as grass trees.	**Applicable** Appropriate hygiene controls should be implemented to prevent spread of *Phytopthora* into the area.	**Applicable** Appropriate hygiene controls should be implemented to prevent spread of *Phytopthora* into the area.	**Applicable** Appropriate hygiene controls should be implemented to prevent spread of *Phytopthora* into the area.	**Applicable** Appropriate hygiene controls should be implemented to prevent spread of *Phytopthora* into the area.
Wetland loss and degradation as a result of change in water regime, dredging, draining, filling and grazing.	All alignments have the potential to impact on wetlands, dams and drainage lines with wetland flora, vegetation and fauna habitat.	**Applicable** Apply appropriate mitigation measures to maintain existing conditions wherever possible. See Section 10.4.7.4 for more detail.	**Applicable** Apply appropriate mitigation measures to maintain existing conditions wherever possible. See Section 10.4.7.4 for more detail.	**Applicable** Apply appropriate mitigation measures to maintain existing conditions wherever possible. See Section 10.4.7.4 for more detail.	**Applicable** Apply appropriate mitigation measures to maintain existing conditions wherever possible. See Section 10.4.7.4 for more detail.
Summary of applicable threatening processes		A total of 16 threatening process are applicable to alignment A0.	A total of 16 threatening process are applicable to alignment A1.	A total of 18 threatening process are applicable to alignment C0.	A total of 17 threatening process are applicable to alignment C2.
Summary of non-applicable threatening processes		A total of 12 threatening process are not applicable to alignment A0.	A total of 12 threatening process are not applicable to alignment A1.	A total of 10 threatening process are not applicable to alignment C0.	A total of 11 threatening process are not applicable to alignment C2.

7.11.3 *GUIDELINES FOR THE REMOVAL, DESTRUCTION OR LOPPING OF NATIVE VEGETATION*

7.11.3.1 PRELIMINARY NATIVE VEGETATION OFFSET COMPARISON

Preliminary Victorian state offset requirements for the proposed removal of native vegetation for each of the four alignments was undertaken based on a 10 m buffer of the indicative construction footprints. The offset requirements were then calculated using DELWP's EnSym tool (https://ensym.dse.vic.gov.au/cms/). A summary of the native vegetation removal and offset requirements is provided in Table 7.24 and with full preliminary EnSym reports for each alignment option in Appendix F. Any tree with >10% TPZ impact within proximity of the construction footprint (including the 10 m buffer) was considered lost for the purpose of the current assessment, as per the Assessors Handbook (DELWP 2018a).

Based on this assessment, the Alignment C2 early indicative construction footprint results in the least overall native vegetation impacts, the least amount of species offset units required and the least number of large trees needing to be offset.

This assessment was completed for alignment option comparison only. Offset calculations for the preferred alignment and revised construction footprint are provided in Section 12.

7.11.3.2 APPLICATION OF DELWP'S ASSESSOR'S HANDBOOK

Analyses of lower and higher values against Tables 6, 7, 8 and 9 in Appendix 1D of the *Assessors Handbook* were undertaken in Appendix L. A summary of this analysis is provided in Table 7.24. Alignment C2 results in the lowest values for all those assessed.

Table 7.24 Summary of native vegetation removal and offset requirements (including 10 m buffer on construction footprint)

	A0	A1	C0	C2
Assessment pathway	Detailed Assessment Pathway	Detailed Assessment Pathway	Detailed Assessment Pathway	Detailed Assessment Pathway
Extent including past and proposed	62.613 ha	62.546 ha	62.298 ha	50.703 ha
Extent of past removal	0.000 ha	0.000 ha	0.000 ha	0.000 ha
Extent of proposed removal	62.613 ha	62.546 ha	62.298 ha	50.703 ha
No. Large trees proposed to be removed	387	366	315	311
Location category	Location 3	Location 3	Location 2	Location 2
General offset amount	2.322 general habitat units	2.360 general habitat units	0.114 general habitat units	3.000 general habitat units
Vicinity	Glenelg Hopkins Catchment Management Authority (CMA) or Pyrenees Shire Council	Glenelg Hopkins Catchment Management Authority (CMA) or Pyrenees Shire Council	Glenelg Hopkins Catchment Management Authority (CMA) or Pyrenees Shire Council	Glenelg Hopkins Catchment Management Authority (CMA) or Pyrenees Shire Council
Minimum strategic biodiversity value score	0.514	0.512	0.469	0.499

	A0	A1	C0	C2
Species offset amount	23.088 specific units of habitat for Ben Major Grevillea, *Grevillea floripendula* 34.079 specific units of habitat for Rough Wattle, *Acacia aspera subsp. parviceps* 43.484 specific units of habitat for Emerald-lip Greenhood, *Pterostylis smaragdyna* 43.066 specific units of habitat for Wimmera Scentbark, *Eucalyptus sabulosa*	27.280 specific units of habitat for Ben Major Grevillea, *Grevillea floripendula* 32.898 specific units of habitat for Rough Wattle, *Acacia aspera subsp. parviceps* 43.820 specific units of habitat for Emerald-lip Greenhood, *Pterostylis smaragdyna* 43.136 specific units of habitat for Wimmera Scentbark, *Eucalyptus sabulosa*	29.517 specific units of habitat for Ben Major Grevillea, *Grevillea floripendula* 36.655 specific units of habitat for Large-headed Fireweed, *Senecio macrocarpus* 39.426 specific units of habitat for Emerald-lip Greenhood, *Pterostylis smaragdyna* 13.291 specific units of habitat for White Sunray, *Leucochrysum albicans subsp. tricolor* 36.607 specific units of habitat for Wimmera Scentbark, *Eucalyptus sabulosa* 32.665 specific units of habitat for Rough Wattle, *Acacia aspera subsp. parviceps*	24.913 specific units of habitat for Ben Major Grevillea, *Grevillea floripendula* 29.785 specific units of habitat for Emerald-lip Greenhood, *Pterostylis smaragdyna* 25.715 specific units of habitat for Rough Wattle, *Acacia aspera subsp. parviceps*
The total number of large trees that the offset must protect	387 large trees to be protected in either the general, species or combination across all habitat units protected	366 large trees to be protected in either the general, species or combination across all habitat units protected	316 large trees to be protected in either the general, species or combination across all habitat units protected	311 large trees to be protected in either the general, species or combination across all habitat units protected

Table 7.25 Biodiversity and other values of native vegetation impacted by each alignment option according to tables in the Assessors Handbook

VALUE	A0	A1	C0	C2
Land and water protection (ha higher value)*	53.34	53.51	53.7	39.8
Landscape values (ha higher value)*	31.9	31.42	28.25	25.5
Aboriginal heritage (ha higher value)*	17.8	18.83	16.64	11.8
Extent (ha lost)	62.61	62.55	62.30	50.70
Average condition score (ha low value, no high value)	58.15	57.80	58.88	47.06
Average Strategic Biodiversity Score (ha high score)	10.59	9.57	14.04	9.52
Large trees (number)	388	366	315	310
Endangered ecological vegetation class (ha)	11.89	9.34	8.56	5.12
Habitat for rare or threatened species	4 specific habitat units (offsets) comprised of: 1 vulnerable 3 rare Total number of species modelled: 60 rare and threatened 21 endangered and critically endangered	4 specific habitat units (offsets) comprised of: 1 vulnerable 3 rare Total number of species modelled: 60 rare and threatened 21 endangered and critically endangered	6 specific habitat units (offsets) comprised of: 2 endangered 1 vulnerable 3 rare Total number of species modelled: 54 rare and threatened 23 endangered and critically endangered	3 specific habitat units (offsets) comprised of: 1 vulnerable 2 rare Total number of species modelled: 57 rare and threatened 22 endangered and critically endangered

Green represents the lowest impact figure for each value.

8 OPTIONS ASSESSMENT AND PREFERRED ALIGNMENT SELECTION

The options assessment completed for the project assessed alignment options A0, A1, C0 and C2 against the customised set of criteria summarised in Section 4.8. The results of the options assessment and sensitivity testing are detailed in Table 8.1. As well as the score for each alignment under each scenario, a colour coding has been applied to rank the performance of the options under each scenario as follows:

- best performing alignment option: green
- second performing alignment option: yellow
- third performing alignment option: orange
- worst performing alignment option: red.

Table 8.1 Combined alignment option scenario scoring

SCENARIO	ALIGNMENT A0	ALIGNMENT A1	ALIGNMENT C0	ALIGNMENT C2
Scenario 1	128	123	126	111
Scenario 2	18	22	20	27
Scenario 3	45.85	44.89	50.01	43.95
Scenario 4	81.03	77.59	93.98	74.12
Scenario 5	24.16	22.70	27.03	19.44
Scenario 6	47.74	42.69	56.16	35.49
Sensitivity Scenario 1	-6	-3	-5	9
Sensitivity Scenario 2	-3	2	-4	11
Sensitivity Scenario 3	-11	-6	-9	5

The alignment scoring scenarios outlined in Table 8.1 show that the best performing option is the C2 Alignment, while the worst performing options are the A0 and C0 Alignments. The primary drivers for this outcome were due to the C2 alignment having the:

- lowest amount of total native vegetation clearance
- least impact on threatened vegetation communities identified under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and *Flora and Fauna Guarantee Act 1988* (FFG Act).
- least impact on wildlife corridors, particularly the core habitat areas
- lowest amount of native vegetation with high conditions to be removed by Ecological Vegetation Class (EVC) Conservation Status
- lowest potential impacts on known or registered sites of Aboriginal and historic heritage significance
- smallest number of dwellings within 100 m, 200 m and 300 m of the alignment corridor.

9 IMPACT ASSESSMENT – PREFERRED ALIGNMENT

The impacts resulting from the C2 alignment is assessed in the following sections and are based on the current construction footprint (November 2020). Refinement of the construction footprint has also been developed post options assessment (Section 7), to include creek realignments to account for modelled surface water impacts, refinements in design and ensure the full extent of flora and fauna impacts are documented. The revised C2 construction footprint includes a 5 m buffer around the creek realignments, which were not included in the indicative early construction footprints for options assessment, meaning that it is a slightly larger area than that assessed previously (and reported on above). See Figure 9.1 showing differences in design. The impact totals are therefore different in the preferred alignment section to what was quoted for C2 during the options assessment.

These impacts are the baseline and assume no mitigation measures. For each impact, an impact rating is provided as Extreme, High, Medium, Low, or Negligible. Although this is subjective, it is based on the risk evaluation framework and is used to identify the requirement for mitigation.

Further detail on how each of the factors covered below impacts flora and fauna, including literature review, is found in Section 7.

Accounting for the impacts associated with constructing the road such as laydowns, site offices, temporary access tracks and relocation of utility services are not typically considered with a concept road design. This often requires specific planning for construction and landowner agreements. This typically occur at the detailed design and pre-construction phase of a project and has not been factored into impact calculations, however there is consideration of indicative locations in Section 10.1.2.

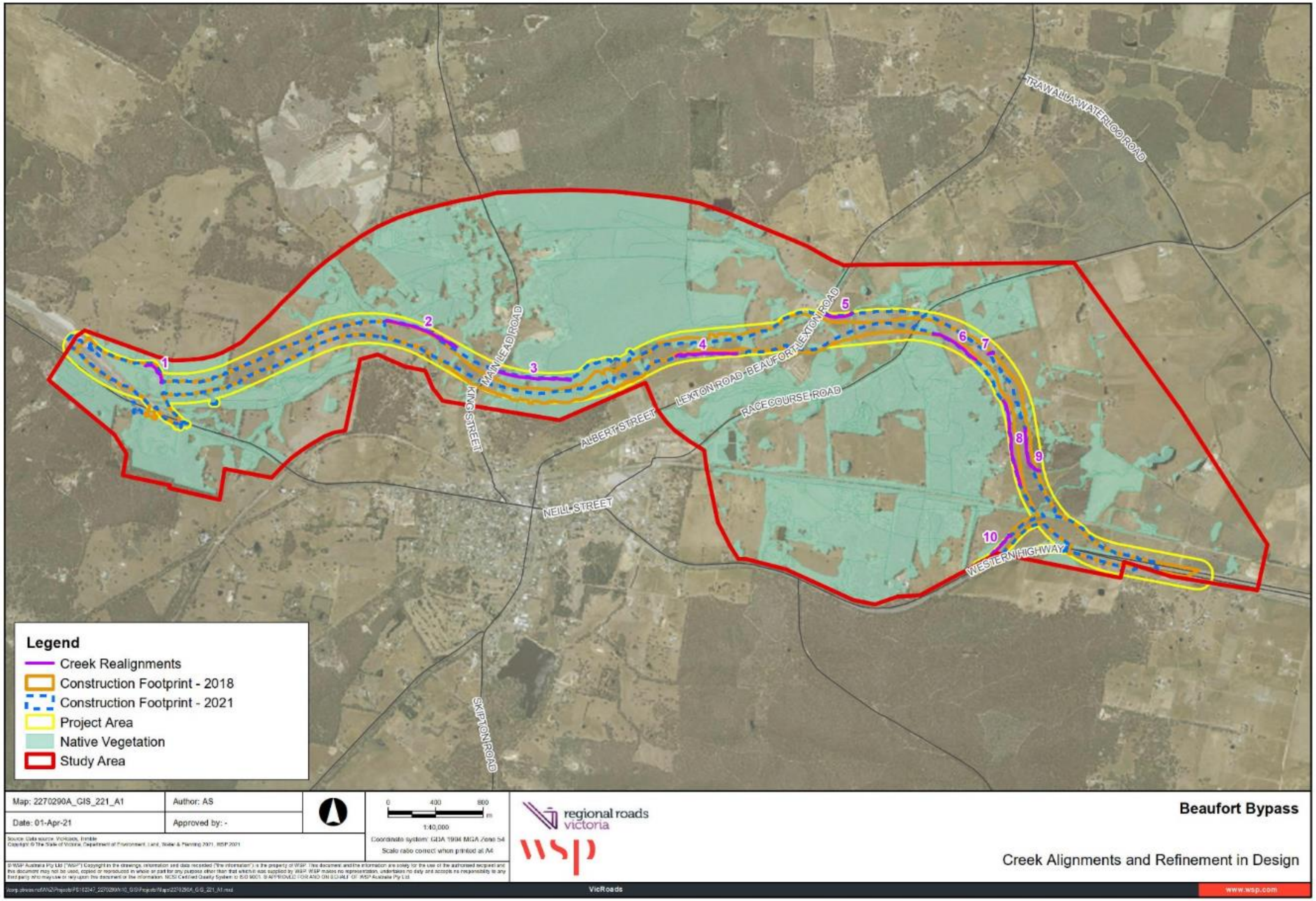


Figure 9.1 Creek alignments and refinement in design

9.1 LOSS OF VEGETATION AND HABITAT

Loss of vegetation and habitat is considered to have an impact severity rating of high (without mitigation) based on the large extent of EVC patches and the number of large trees in the construction footprint, and the impact on ecological communities and flora and fauna habitat.

9.1.1 ECOLOGICAL VEGETATION CLASSES AND TREES

The total area of each EVC recorded within the construction footprint is provided in Table 9.1 below. EVCs with cleared canopies (derived grassland) are split out as these patches can support very different habitat resources to patches with canopies.

Table 9.1 Impacts to native vegetation from the C2 construction footprint

EVC	DESCRIPTION (TREED EVCS)	AREA (HA)
Alluvial Terraces Herb-rich Woodland	With canopy	1.081
Alluvial Terraces Herb-rich Woodland	Treeless/derived	0.244
Aquatic Herbland		0.944
Aquatic Sedgeland		0.350
Grassy Dry Forest	With canopy	19.585
Grassy Dry Forest	Treeless/derived	0.947
Grassy Woodland	With canopy	0.473
Grassy Woodland	Treeless/derived	0.291
Heathy Dry Forest	With canopy	3.324
Heathy Dry Forest	Treeless/derived	11.108
Plains Grassy Wetland		0.510
Plains Sedgy Wetland		0.030
Valley Grassy Forest	With canopy	5.546
Valley Grassy Forest	Treeless/derived	1.639
Grand total mapped patches		**46.072**
DELWP modelled wetland		1.878
Grand total including DELWP modelled wetland		**47.950**

Tree losses are presented in the table below, they include small and large scattered trees and large trees in patches as per the assessment methodology in the Guidelines (DELWP 2017e). The numbers below account for trees which may be impacted due to TPZ impacts (i.e. >10% impact to TPZ). Small trees in patches are currently accounted for through the mapping and assessment of EVC patches (refer above). However scattered trees are not, which is why the value of native vegetation removal presented in the above table is different to the extent of proposed removal presented in the NVR report (refer to section 12.1).

The total number of trees lost will be assessed during the detailed design phase through an arborist assessment.

The tree losses within the C2 alignment also includes one Scarred Tree (VAHR7523-0372) as identified in the Cultural Heritage Impact Assessment Report (Tardis, 2020), which is located south of Beaufort – Lexton Rd.

Table 9.2 Tree impacts

TREE IMPACTS	LARGE	SMALL
Scattered Tree	21	7
Trees in Patches	327	Not counted (assessed through EVC patches)

9.1.2 THREATENED ECOLOGICAL COMMUNITIES

The proposed construction footprint will impact two threatened ecological communities as detailed in Table 9.3.

Table 9.3 Impacts on threatened ecological communities

COMMUNITY NAME	STATUS	IMPACT (HA)	TOTAL EXTENT IN STUDY AREA (HA)
Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	Critically Endangered under EPBC Act	0.312	18.981
White box – Yellow Box – Blakely's Red Gum Grassy Woodland	Critically Endangered under EPBC Act	0	31.884
Victorian Temperate Woodland Bird Community	Threatened under FFG Act	32.800	688.145 ha

9.1.3 THREATENED FLORA

Four threatened flora species were recorded within the study area for the C2 alignment, they are listed in Table 9.4 below. Two species are listed under the EPBC Act. Of the species recorded one Yarra Gum, one Matted Flax-lily and one patch of River Swamp Wallaby-Grass are likely to require removal based on the current construction footprint.

The alignment will pass through potential habitat for Ben Major Grevillea and there are two records within the alignment close to where a fire track is to be constructed in Camp Hill. However, the current construction footprint avoids all known records of this plant.

The significance of all impacts (not just direct clearing) on all threatened flora species recorded or with a moderate or higher potential to occur is assessed in Section 9.10.2.

The values of DELWP's Habitat Importance Model and specific offset triggers for the estimated impacts of the constructed footprint of the C2 alignment are provided in the table below. Further offset triggers are provided in Section 12.1.

Table 9.4 Threatened flora impacted by current construction footprint

COMMON NAME	SCIENTIFIC NAME	EPBC ACT	FFG ACT	ADVISORY LIST	RECORDS WITHIN ALIGNMENT	DIRECT CLEARING IMPACTS	HABITAT IMPORTANCE MODEL IN STUDY AREA AND OFFSET TRIGGERS
Matted Flax-lily	*Dianella amoena*	Endangered	L	Endangered	2	The current construction footprint is likely to impact 1 of the two records within alignment.	699 ha habitat modelled Offset requirements not triggered for this species
River Swamp Wallaby-grass	*Amphibromus fluitans*	Vulnerable			2	Species was recorded in a dam off Topp Lane, current construction footprint intersects the dam it was recorded in. The current construction footprint avoids another record of this species by approx. 70 m east of Main Lead Road.	No Habitat Importance Model available Offset requirements not triggered for this species
Yarra Gum	*Eucalyptus yarraensis*	–	X	Rare	2	One large Yarra Gum was recorded along the rail corridor where the alignment crosses the corridor to the east. It is likely to impacted. A second Yarra Gum was recorded north of the Trotting Track outside the construction footprint.	1973 ha habitat modelled Offset requirements not triggered for this species

COMMON NAME	SCIENTIFIC NAME	EPBC ACT	FFG ACT	ADVISORY LIST	RECORDS WITHIN ALIGNMENT	DIRECT CLEARING IMPACTS	HABITAT IMPORTANCE MODEL IN STUDY AREA AND OFFSET TRIGGERS
Ben Major Grevillea	*Grevillea floripendula*	Vulnerable	Listed	Vulnerable	2	Two records within alignment, both likely to be avoided based on current construction footprint	534 ha habitat modelled Offset requirements equate to 27.002 species units
Emerald-lip Greenhood	*Pterostylis smaragdyna*			Rare	0	No impacts on individuals Numerous plants recorded in other parts of the study area	1227 ha habitat modelled Offset requirements equate to 32.250 species units
Wimmera Scentbark	*Eucalyptus sabulosa*			Rare	0	No impacts on individuals Not recorded in study area. Closest records are found near Ararat Hills Regional Park	1120 ha habitat modelled Offset requirements omitted for this species (refer to Section 12.1.2 and Appendix R)
Rough Wattle	*Acacia aspera subsp. parviceps*			Rare	0	No impacts on individuals Historical record in Snow Gums Bushland reserve but not recently recorded in study area	777 ha habitat modelled Offset requirements equate to 28.002 species units

9.1.4 POTENTIAL IMPACTS RESULTING FROM MITIGATION MEASURES

Structures such as open span bridges, culverts, land bridges and rope ladders have been proposed as mitigation measures in Section 10. A detailed appraisal of the design features will occur at the detailed design phase, however any mitigation measures are expected to be contained within the construction footprint.

9.1.5 *FAUNA HABITAT*

The extent of different fauna habits in the construction footprint are provided below.

The impacts on significant fauna when all potential impacts are considered are provided in Section 9.10.

9.1.5.1 WETLAND BIRDS

The C2 footprint will impact 1.520 ha of medium quality wetland bird habitat, no direct impacts on high quality wetland habitat is proposed. This area could provide habitat for the following significant bird species, as well as the Eastern Long-necked Turtle:

- Australian Shoveler
- Baillon’s Crake
- Blue-billed Duck
- Brolga *Grus*
- Eastern Great Egret
- Hardhead
- Latham's Snipe
- Musk Duck
- Pied Cormorant.

9.1.5.2 WOODLAND BIRDS

The C2 footprint has impacts to 32.800 ha of woodland habitat which could potentially impact the following species:

- Brown Treecreeper
- Diamond Firetail
- Painted Honeyeater
- Powerful Owl
- Speckled Warbler.

The Emu is considered moderately likely to occur across the study area however given its large distribution and range of environments it inhabits, it is difficult to quantify the impacts to this species.

9.1.5.3 AMPHIBIANS

- Growling Grass Frog- Based on the current construction footprint there are likely to be impacts to 0.281 ha of high quality aquatic potential habitat and 17.285 ha of associated terrestrial habitat, as well as 1.132 ha of moderate quality aquatic potential habitat with 68.179 ha of associated terrestrial habitat (excluding overlap with potential terrestrial habitat associated with high quality aquatic). Potential impacts to Growling Grass Frog terrestrial habitat were conservatively estimated using a 200 m buffer from waterbodies as per the Significant Impact Guidelines for the species (DEWHA 2009c). This is likely to lead to an overestimation of the extent of terrestrial habitat, as discussed in Section 9.10.3.
- Brown Toadlet – 1.680 ha of potential habitat for Brown Toadlet will be impacted based on the current construction footprint.

9.1.5.4 FISH

Little Galaxias does not have a known permanent population within the C2 alignment, however, has a high likelihood of occurrence within the alignment in Yam Holes Creek and its tributaries, particularly during flood events. The current construction footprint intersects 2.011 km of waterways that could be potential habitat for this species and would require seven creek crossings.

9.1.5.5 ARBOREAL MAMMALS

The construction footprint is likely to impact 6.985 ha of moderate quality habitat for Brush-tailed Phascogale and and 15.598 ha of high quality habitat (Total: 22.583 ha).

9.1.5.6 INVERTEBRATES

Based on the current construction footprint, 1.672 ha of confirmed Golden Sun Moth habitat is likely to be impacted along with 9.431 ha of higher quality potential habitat and 2.822 ha of lower quality potential habitat, equating to a total of 13.925 ha.

9.2 LOSS OF CONNECTIVITY

Alignment C2 was found to have the lowest impact on structural connectivity. Despite having the highest impact on stepping stones, alignment C2 has considerably less impact on core areas and similar impacts on terrestrial and wetland and riparian corridors when compared to the other alignments.

The connectivity modelling assessment found that all four alignment options reduced the connectivity in the landscape. Overall, alignment option C2 was modelled to have the least impact on connectivity for three of the conservation targets as it has less impact on Camp Hill State Forest. The differences between the four alignments on connectivity for the remaining two conservation targets was likely to be negligible, with the majority of impacts on these targets likely due to loss of habitat and road mortality rather than reductions in connectivity. See Section 7.2 for more detail on impacts resulting from C2.

Given the results of the assessments, alignment C2 was considered to have the least negative impacts on connectivity out of the four proposed alignments. However, substantial impacts are still likely without mitigation. An impact severity of High is attributed to loss of connectivity.

The current construction footprint would impact connectivity in the following ways:

- The alignment passes through the southern extent of the Camp Hill Recreation Reserve and will result in the fragmentation of part of this reserve. The road will be a substantial connectivity barrier between the two fragmented sections of the reserve, likely to stop movement of all but the most mobile of fauna (i.e. birds and bats).
- Within highly modified landscapes, narrow roadside remnants provide important connectivity between larger patches of remnant vegetation, including for species such as Brush-tailed Phascogale and small woodland birds. The alignment will result in the loss of vegetation along linear reserves such as Beaufort-Lexton Road. It will also bisect some narrow remnants which are likely to function as movement corridors for some species.
- Without mitigation, the road will also lead to a substantial reduction in connectivity across the landscape for fauna which utilise open grassy areas and paddocks such as Eastern Grey Kangaroo, and potentially Emu.
- The current construction footprint is likely to reduce connectivity for wetland fauna (and wetland plant seed dispersal) which move between ponds, particularly frogs and turtles, and may also affect fish movement at Yam Holes Creek (without mitigation).
- As many pollinators are highly mobile (birds and flying invertebrates), the project is unlikely to substantially affect plant pollination or connectivity of threatened or rare plants.

9.3 FAUNA INJURY AND MORTALITY

9.3.1 CONSTRUCTION PHASE

Mortality of wildlife during construction may occur during clearing, or during instances when wildlife strays into the construction zone (van der Ree, Smith & Grilo 2015).

The potential for injury and mortality of wildlife from the project is summarised in Table 9.5 below.

The impact severity rating of mortality during construction is considered to be high without mitigation.

Table 9.5 Summary of potential for increased injury and mortality from construction phase

ACTIVITY WITH POTENTIAL TO CAUSE MORTALITY	NATIVE ANIMALS WITH POTENTIAL TO BE AFFECTED	NATURE AND MAGNITUDE OF THE IMPACT OF THE PROJECT
Vegetation/habitat removal during construction: Removal of mature trees with hollows and dead standing trees	— Hollow-dependent bats — Hollow-nesting and canopy-nesting birds — Arboreal mammals — Arboreal reptiles — Arboreal frogs — Invertebrates	A large number of potentially hollow bearing large old trees are likely to be removed for the proposed road, which support a range of fauna species. Appropriate controls during construction will need to be implemented.
Removal of understorey, groundcover, topsoil and debris (wood, rocks, rubbish etc.)	— Small woodland birds — Ground-dwelling reptiles — Frogs — Invertebrates	Mortality of species of native reptiles and frogs is likely to occur from vegetation (groundcover) clearance.
Machinery/plant and vehicle collisions with fauna during construction	— Terrestrial, semi-aquatic and arboreal reptiles, frogs and mammals — Birds, especially waterbirds	Occasional mortality of native animals may occur during vehicle movements within the study area. This is unlikely to be a substantial risk as construction speed limits would be low.
Other causes of mortality (trenches etc)	— Terrestrial, semi-aquatic and arboreal reptiles, frogs and mammals	Without sufficient controls, mortality may result from fauna falling into trenches or sheltering in materials. This risk can be substantially reduced through stringent fauna management measures.

9.3.2 OPERATIONAL PHASE

9.3.2.1 WILDLIFE-VEHICLE COLLISIONS

Wildlife-vehicle collisions ('roadkill') is likely to be a direct effect of the project. Although it may be highest immediately following opening of the road, this impact would continue for the life of the road. It is given a rating of 'high' without mitigation.

Roadkill is likely to be highest where the alignment:

- bisects areas of substantial animal habitat, including wildlife corridors – within the C2 alignment this includes the areas around the southern extent of the Camp Hill Reserve, as well as open cleared areas which support high numbers of Eastern Grey Kangaroos
- is located in close proximity to natural or artificial water bodies – within the C2 alignment this includes where the alignment crosses Yam Holes Creek
- supports food sources (e.g. mown grass verges, nectar-producing shrubs) which attract animals to the road edge – this may apply along much of the C2 alignment
- have high speed limits – this will apply along the entire C2 alignment
- provide poor visibility of wildlife (e.g. due to bends, crests and poor lighting), which is largely considered unlikely to apply to C2 based on the current design.

Fauna likely to be most at risk of roadkill without mitigation are terrestrial mammals, arboreal mammals, reptiles and frogs. Birds may also be at some risk, although are generally capable of flying between or above vehicles. Larger and heavier birds such as some wetland birds and birds of prey may be at higher risk as they are less able to avoid vehicles and are slower to ascend to a safe height. Birds of prey are also at risk of collision when scavenging other dead animals on the road.

9.3.2.2 PREDATION PRESSURE

Increased predation pressure from species such as Red Fox, is unlikely to be a significant indirect impact of the project on native fauna. Introduced predators are mostly advantaged where roads dissect otherwise intact and dense habitat. The study area is located within a largely agricultural and fragmented landscape, where foxes are already widespread and prevalent and already have access into the vegetation being impacted or bisected. Therefore, a demonstrable and significant increase in fox numbers or predation pressure is unlikely to occur.

9.4 NOISE AND VIBRATION

Given the short-term nature of any high noise-generating activities, the impacts of construction noise on wildlife are expected to be generally minor. However, noisy and high vibration work near sensitive habitats (wetlands and woodland) from July-October inclusive may impact breeding of significant fauna species, including woodland and wetland birds.

With regard to operation of the project, the C2 alignment was considered to result in the fewest areas of substantially impacted habitat from increased noise, however an impact rating of moderate is still appropriate, particularly due to impacts on woodland habitat. Of the sensitive receptors studied, those likely to be impacted by noise from the C2 alignment include:

- the Camp Hill State Forest
- Martin's Lane roadside woodland
- woodland between Back Raglan Road and Main Lead Road
- wetlands between Beaufort-Lexton Road and Racecourse Road
- forest north of railway line west of Packhams Lane.

Impacts on the other sensitive areas (woodlands and wetlands) are likely to be negligible. See Section 7.4.2.2 for more detail on each of the areas 10 areas of ecological sensitivity assessed for the C2 alignment.

9.5 ECOLOGICAL LIGHT POLLUTION

Upon the projects' completion, the area surrounding the C2 alignment is likely to be affected by a low level of light pollution. The ecological values most at risk of impact from construction lighting, artificial lighting and headlights are:

- fauna occurring at the waterway crossings through the Yam Holes Creek valley between Racecourse Road and Beaufort-Lexton Road, including wetland birds
- fauna occurring at the waterway crossing through the Yam Holes Creek valley near Main Lead Road
- fauna occurring in proximity to the crossing through Camp Hill State Forest, although some light may be reduced in cuttings, and vegetation will provide shielding
- fauna occurring in the vicinity of Back Raglan Road and areas near Martins Lane
- fauna occurring in the vicinity of the remnant habitats near the railway and Packhams Lane.

The sensitive fauna receptors are likely to be largely consistent with those identified in the noise impact assessment (refer to previous section and to Section 10.4.4.2). However, for light impacts, spread of light across wetlands is expected to be a greater impact than light spread into woodland habitats

An impact rating of moderate has been attributed to light impacts, without mitigation.

9.6 VISUAL IMPACT

The impacts of the presence of artificial structures and car movement (as separate from noise, light and mortality impacts) are poorly known, however, it is understood that certain species, including wetland birds such as Brolga, may be affected. This may lead to decreased use of habitat nearby to the structure. Increased access to habitat by people and dogs is also likely to affect fauna, particularly wetland birds, should there be parking or stopping points with visual or physical access to habitat.

Further assessment of potential impacts on fauna from visual impact of the project, in collaboration with the landscape and visual impact assessment team, will be required during detailed design. However, as for light impacts, mitigation options are available and have been recommended.

An impact rating of low-moderate has been attributed to visual impacts.

9.7 PHYSICAL HABITAT DISTURBANCE AND MODIFICATION

9.7.1 WEED INVASION AND DISEASE

Fragmentation of patches of vegetation will create additional edges from which weed and disease incursion may occur. Where the alignment intersects Camp Hill State Forest, the vegetation currently supports a low cover of weeds. This relatively intact patch of vegetation will be at increased risk from weed and disease from road construction and operation.

The type of disturbance associated with the construction of road pavement can result in a window of opportunity for weeds and soil pathogens such as Phytophthora *Phytophthora cinnamomi* to establish.

An impact rating of moderate has been attributed to weed invasion and disease, largely due to ongoing risk from road operation and maintenance.

9.7.2 RUBBISH

Both the construction and operational phase of the project are expected to result in an increase in rubbish in terrestrial and aquatic habitats. Without the implantation of suitable mitigation measures, rubbish will reduce visual amenity and may have a negative impact upon habitat quality in close proximity to the road alignment.

A rating of low-moderate has been applied to this impact.

9.7.3 EROSION, SEDIMENTATION, AND WATER POLLUTANTS

Bare ground after clearing, stockpiling, earthworks, or driving vehicles and plant off-road is susceptible to erosion. Similarly, there is the potential for an increase in water pollutants in wetlands at or near the study area as a result of road construction or ongoing use of the road, through spills or run-off.

The risk of erosion, sedimentation, and water pollution is highest in the Yam Holes Creek valley. Lack of appropriate erosion, sediment and pollution control may lead to the deterioration of aquatic flora and fauna, and resulting impacts to foraging wetland birds, amphibians and degradation of the relevant EVCs. This is discussed in more detail in the following section.

A severity rating of moderate has been applied to this impact.

9.7.4 CHANGES IN GROUNDWATER AND SURFACE HYDROLOGY

9.7.4.1 GROUNDWATER

A severity rating of low has been applied to this impact.

Both aquatic and terrestrial groundwater dependant ecosystems (GDEs) are present within the C2 alignment including Yam Holes Creek and its tributaries and unnamed wetlands, and the following EVCs: Alluvial Terraces Herb-rich Woodland, Heathy Dry Forest, Valley Grassy Forest and Plains Grassy Wetland.

The Groundwater report (WSP 2020a) also identified several potential risks to groundwater levels and quality including:

- reduction in groundwater levels affecting existing users/sensitive receptors – such as registered and unregistered groundwater bores (water users), GDEs and surface waters systems
- spill events during construction resulting in contaminants entering groundwater
- disturbance of existing soils with elevated levels of contamination during construction resulting in mobilisation of contaminants into groundwater
- excavation of cuttings resulting in groundwater inflows during construction (and operation), leading to groundwater drawdown and changes to groundwater flow paths
- inflow of contaminated groundwater presenting OH&S and ongoing environmental compliance issues
- construction works impacting water quality in watercourses, GDE environments, and wetlands (as applicable)
- water quality impacts during operation of road.

9.7.4.2 SURFACE WATER

A severity rating of moderate has been applied to this impact.

Potential surface water impacts relevant to ecology include:

- changes to flooding conditions and water levels in sensitive wetlands caused by clearing of vegetation along the route alignment and cut and fill works to achieve proposed alignment design levels
- vegetation clearing, soils compaction and floodplain storage removal resulting in increased runoff rates and subsequent impacts to significant habitat both nearby the study area and further downstream
- alterations to catchment hydrology from temporary construction works such as watercourse diversion, modifications to drainage networks and pumping of surface water. Permanent features (roads, bridges and culverts) can also change the dynamic response of the catchment to excess rainfall. This may lead to changes in the natural seasonal filling and drying cycles of wetlands in the study area

- reduced water quality caused by sediment runoff during the construction phase. This has the potential to increase turbidity which, depending on the severity, may impact flora, fauna, and ecological communities that are dependent on the aquatic ecosystem
- reduced water quality caused by road runoff, accidental oil/fuel spillages and pollutant runoff generated from maintenance activities. Untreated and undiluted, these pollutants (typically consisting of sediments, hydrocarbons, nutrients and metals) may result in a deterioration of water quality in the receiving water environment and in aquatic systems further downstream.

IMPACT ON FAUNA

Any significant changes outlined above may have flow-on effects upon waterbirds including Australasian Shoveler, Blue-billed Duck, Brolga, Eastern Great Egret, Hardhead; amphibians such as Growling Grass Frog and Brown Toadlet; and fish species including Little Galaxias. If surface water changes are not managed appropriately the project may also affect the EPBC Act listed community Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains mapped in multiple locations throughout the study area, as well as wetland flora species Floodplain Fireweed and River Swamp Wallaby-grass.

FLOOD IMPACTS

The Surface Water Impact Assessment also included a flood impact assessment to consider how the alignment performs against the surface water objectives and to identify potential issues associated with waterway crossings. This was based on the results of initial flood modelling against project objectives and does not consider ecological impact. A summary of the findings is detailed in the Surface Water Impact Assessment (WSP 2021).

Option C2 was identified as the alignment which would have the greatest impact to surface water objectives, with the highest values for maximum flood width, length of alignment within the 100 year ARI extent and extent of ground disturbing works within 50m of significant waterway crossings. However, Option C2 is the preferred option for ecology as it has the least impacts on a number of ecological parameters compared with the other options.

The most useful flood event to determine the potential effects on seasonal wetlands and dependent fauna species is likely to be the 1 EY as the seasonal flooding and drying cycles are most affected by proposed roads and catchments. The impacts following detailed modelling show changes from existing conditions to the flood regime in the 1 AEP are only present at discrete locations and are unlikely to have significant impacts on significant flora and fauna species. Refer to Table 9.7 below for more detail

CHANNEL REALIGNMENTS

The road corridor intercepts a number of waterways and overland flow paths, requiring realignment of these channels and reconnection to a suitable point downstream and clear of the road corridor. These realignments may also fragment and disconnect habitats associated with the waterways and flow paths. As stated in the EES Appendix L: Surface Water Impact Assessment (WSP 2021), the design currently includes 10 channel realignments to connect waterways across the alignment. See Table 9.6 for summary of potential impacts resulting from the channel realignments.

Table 9.6 Creek realignment and proposed discharge points in relation to ecological impacts

SECTION	CREEK REALIGNMENT AND PROPOSED DISCHARGE POINTS
Western Highway – western end to Back Raglan Road	A creek realignment is proposed at the interchange of the western end of the Western Highway. This occurs on an upper slope of the drainage line for ~200 m. Minor drainage lines to be impacted and realigned contain little to no habitat for aquatic and semi-aquatic species, therefore direct impacts are unlikely to significantly affect aquatic and semi-aquatic species. Three discharge points in this Section with catchment area in brackets: A (8.74 ha), B (3.70 ha) and C (4.19 ha) (WSP 2021).
Back Raglan Road to Main Lead Road	A creek realignment is proposed north of the CF from Back Raglan Road to open area to the east for ~600 m long. This will realign multiple minor drainage lines into one channel. Minor drainage lines to be impacted and realigned contain little to no habitat for aquatic and semi-aquatic species, therefore direct impacts are unlikely to significantly affect aquatic and semi-aquatic species. Three proposed discharge points in this Section with catchment area in brackets: D (8.66 ha), E (upstream area) and F (11.3 ha) (WSP 2021). Two locations with multiple culverts are proposed.
Main Lead Road to Beaufort-Lexton Road	Two creek realignments (3 and 4). One is ~650 m long in a minor gully from Main Lead Road up the slope to the east. The other is located along the slope running roughly parallel with Beaufort-Lexton Road. Both are minor drainage lines to be impacted and realigned contain little to no habitat for aquatic and semi-aquatic species, therefore direct impacts are unlikely to significantly affect aquatic and semi-aquatic species. Three proposed discharge points in this Section with catchment area in brackets: G (7.82 ha), E (upstream area) and H (7.09 ha) (WSP 2021).
Beaufort-Lexton Road to Racecourse Road	One creek realignment (5). It is ~230 m long connecting the drain running along Beaufort-Lexton Road to Yam Holes Creek. This is a minor drainage line to be impacted and realigned which contains little to no habitat for aquatic and semi-aquatic species, therefore direct impacts are unlikely to significantly affect aquatic and semi-aquatic species. Three proposed discharge points in this Section with catchment area in brackets: I (15.98 ha), J (4.63 ha) and K (3.61 ha) (WSP 2021).

WETLANDS

Wetlands were categorised into high, moderate and low quality in Section 6.4.4 and shown on Figure 6.8 and in more detail in Appendix K. These were assessed for their potential surface water and hydrological effects in relation to ecological impacts. The areas are broken up into sections of the proposed bypass, road to road. In addition, nine high value wetlands were identified within the alignment that could be impacted by changes to surface water regimes resulting from the project (refer to Section 4.4 of the Surface Water Report (WSP 2021). High quality wetlands are those that meet the criteria for the EPBC listed community Seasonal Herbaceous Wetland of the Temperate Lowland Plains. These are included in Table 9.7. See Figure 9.2 for Wetland Current number and wetland values from Section 6.4.4 overlaid with Peak Flood Afflux – Proposed Design Scenario Event: 1 EY or 1 in 1 year flood event.

For impacts on flooding regimes, only Wetlands 35649 and 35402 will experience changes in their flooding regimes but these changes are expected to be minimal and mainly occur at the high order events, with most significant impacts occurring within the project boundary. The impacts on the wetlands are therefore considered to be minor (WSP 2021).

Table 9.7 Potential surface water and hydrological effects in relation to ecological impacts

WETLAND NO.	FLOODING REGIME IMPACT	ECOLOGICAL IMPACT
Western Highway – western end to Back Raglan Road		Overview of area: — Minor areas of mapped low quality (Current Wetland without native vegetation) in CF. — No wetland actual wetland present in CF. — CF intersects three minor drainage lines and tributaries. — Group of connected wetlands, farm dams and stream south of CF, some areas within 50 m including high and moderate quality wetlands identified as Wetlands 7 and 8.
35596 (includes High value wetland 8)	No surface water impacts – outside project area of influence. Upstream from proposed freeway.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.
35597 (includes High value wetland 7)	No changes to regime to flood levels (afflux) for the 1 in 1, 1 in 10 and 1 in 100 year events. No changes in key flood duration impacts for the 1 EY, 10% AEP and 1% AEP events Upstream from proposed freeway. At high value Wetland 7, there is direct connectivity with cross drainage on unnamed tributary located 1.4 km upstream of wetland. Approx. 9% change to land use type and drainage characteristics of upstream catchment.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.
35595	No changes to regime to flood levels (afflux) for the 1 in 1, 1 in 10 and 1 in 100 year events. No changes in key flood duration impacts for the 1 EY, 10% AEP and 1% AEP events Upstream from proposed freeway. There is no change on catchment upstream.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities. Small population of River Swamp Wallaby-grass ~100 m north of CF in Moderate value wetland – unlikely to be impacted.

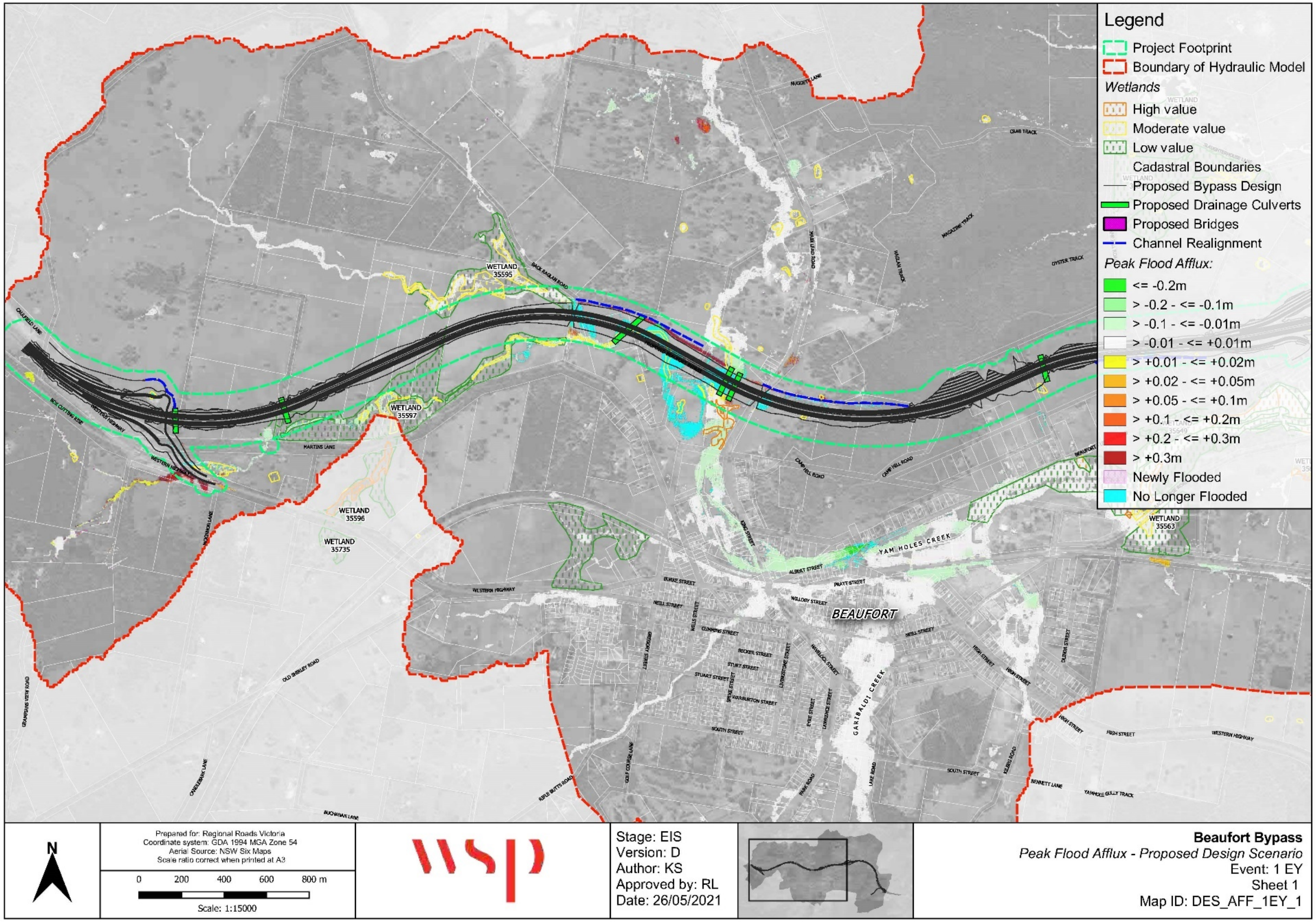
WETLAND NO.	FLOODING REGIME IMPACT	ECOLOGICAL IMPACT
35735	No changes to regime to flood levels (afflux) for the 1 in 1, 1 in 10 and 1 in 100 year events. No changes in key flood duration impacts for the 1 EY, 10% AEP and 1% AEP events. Upstream from proposed freeway. There is no change on catchment upstream.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.
Back Raglan Road to Main Lead Road		Overview of area: — Narrow areas of mapped as moderate quality wetland along stream, including Yam Holes Creek and tributaries, in CF. — CF intersects four sections of the streams above. — High quality wetland within 50 m of CF including wetland identified as Wetland 6.
No Wetland No. (includes High value wetland 6)	No changes to regime to flood levels (afflux) for the 1 in 1, 1 in 10 and 1 in 100 year events. No changes in key flood duration impacts for the 1 EY, 10% AEP and 1% AEP events. Downstream from proposed freeway. At high value Wetland 6, there is approximately 4% change to land use type and drainage characteristics of upstream catchment.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities. Some areas close to the construction footprint may have a minor decrease in flood duration which is not expected to significantly affect Moderate of High value wetlands which include Seasonal Herbaceous Wetlands and threatened flora including Floodplain Fireweed and River Swamp Wallaby-grass.
Main Lead Road to Beaufort-Lexton Road		Overview of area: — Six small dams mapped as moderate quality wetlands within or very close proximity to CF. — CF intersects four drainage lines and tributaries which ultimately feed into Yam Holes Creek. — No natural wetlands in this section – five small farm dams identified as moderate quality to be removed.

WETLAND NO.	FLOODING REGIME IMPACT	ECOLOGICAL IMPACT
35566	No surface water impacts – outside project area of influence. Upstream from proposed freeway.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.
35719	No surface water impacts – outside project area of influence. Upstream from proposed freeway.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.
Beaufort-Lexton Road to Racecourse Road		Overview of area: — Narrow areas of mapped as moderate quality wetland along stream, including Yam Holes Creek, in CF. — Large disused gold mine and mullock heap north of CF by ~100 m. — CF intersects Yam Holes Creek and two minor tributaries. — High value wetland within 80 m north of CF including wetland identified as Wetlands 1. Also high quality Wetland 2, 3 and 4 within 700–800 m of CF to the south.

WETLAND NO.	FLOODING REGIME IMPACT	ECOLOGICAL IMPACT
35649 (includes High value wetland 4)	Increases flood levels (afflux) for the 1 in 1 of up to 300 mm mainly within project boundary, with lesser increases extending up to 200 m upstream of Yam Hole Creek bridges. Localised duration changes for higher order events 100 to 200 m beyond project boundary. Localised velocity change within project boundary upstream of Yam Hole Creek bridges. There is approximately 3% change to land use type and drainage characteristics of upstream catchment.	The most useful flood event to determine the potential effects on seasonal wetlands and dependent fauna species is likely to be the 1 EY as the seasonal flooding and drying cycles are most affected by proposed roads and catchments. High value wetland area is approximately 550 m along the creekline from the bridges. This includes wetland bird habitat including Brolga. The effects of the predicted 1 EY flood levels (> -0.01 - <= +0.01 m) at this distance are unlikely to be different from current levels, therefore the impact on wetland bird habitat is not considered to be significant. It is possible that a minor increase in flooded land close to the proposed freeway may provide more temporal habitat/food resources for wetland birds. Areas of High potential habitat for Growling Grass Frog along Yam Holes Creek may be affected by approximately 50–100 mm. Larger areas of Moderate and High potential habitat for Growling Grass Frog within this wetland are mostly located 200–300 m away which at this distance, is unlikely to be different from current levels, therefore the potential impact on Growling Grass Frog habitat is not considered to be significant. Increases on flood levels are unlikely to significantly impact on other ecological values including Brown Toadlet, Little Galaxias and Seasonal Herbaceous Wetlands.
35650 (includes High value wetland 2)	No surface water impacts – outside project area of influence. Upstream from proposed freeway. Figure 9.2 shows flood levels changes of > +0.02 - <= +0.05 m however these are the result of model instabilities and are not true impacts (see Section 9.2.7 for details in *Surface Water Impact Assessment Report* (WSP 2021).	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.

WETLAND NO.	FLOODING REGIME IMPACT	ECOLOGICAL IMPACT
35562 (includes High value wetland 3)	No surface water impacts – outside project area of influence. Upstream from proposed freeway.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.
35563	No surface water impacts – outside project area of influence. Upstream from proposed freeway.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.
35402 (includes High value wetland 1)	Minor increases in flood level in the 1 EY of less than 20 mm over distances of up to 100 m downstream of Yam Hole Creek bridges. Localised duration changes for higher order events 100 m beyond project boundary. No significant velocity changes to this wetland. There is approximately 3% change to land use type and drainage characteristics of upstream catchment.	High value wetland area is approximately 60 m north of the proposed freeway. This includes wetland bird habitat including Brolga. The effects of the predicted 1 EY flood levels (> -0.01 - <= +0.01 m) at this distance are unlikely to be different from current levels. The minor increases occur closer to the culvert and bridge exits, therefore the impact from 1 in 1 floods on wetland bird habitat is not considered to be significant. Areas of High potential habitat for Growling Grass Frog in this wetland are unlikely to be affected as the aquatic habitat is expected to be largely unchanged. There may be some areas of slightly increased flooding (less than 20 mm) close to the culvert and bridges which are within the terrestrial buffer area for Growling Grass Frog. As changes in the High value wetland area are unlikely to be different from current levels, the impact of the freeway on other ecological values including Brown Toadlet, Little Galaxias and Seasonal Herbaceous Wetlands is unlikely to be significant.
35403	No surface water impacts – outside project area of influence. Downstream from proposed freeway.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.
35404	No surface water impacts – outside project area of influence. Downstream from proposed freeway.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.
35405	No surface water impacts – outside project area of influence. Downstream from proposed freeway.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.

WETLAND NO.	FLOODING REGIME IMPACT	ECOLOGICAL IMPACT
Racecourse Road to Western Highway – eastern end		Overview of area: — One small dam mapped as moderate value wetland within or very close proximity to CF. Six small dam mapped not mapped as wetlands within or very close proximity to CF. — CF intersects eight drainage lines or tributaries which ultimately feed into Yam Holes Creek and Mount Emu Creek. — Two wetland areas along stream mapped as moderate value wetlands within CF. — Two high value wetlands mapped downstream of CF to the north, near the rail line, of which one is identified as Wetland 9 (290 m from CF) and Wetland 5 (900 m from CF).
35540 (includes High value wetland 9)	No changes to regime to flood levels (afflux) for the 1 in 1, 1 in 10 and 1 in 100 year events. No changes in key flood duration impacts for the 1 EY, 10% AEP and 1% AEP events Downstream from proposed freeway.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.
No Wetland No. (includes High value wetland 5)	No changes to regime to flood levels (afflux) for the 1 in 1, 1 in 10 and 1 in 100 year events. No changes in key flood duration impacts for the 1 EY, 10% AEP and 1% AEP events Downstream from proposed freeway.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.
35564	No surface water impacts – outside project area of influence. Upstream from proposed freeway.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.
35539	No surface water impacts – outside project area of influence. Downstream from proposed freeway.	Unlikely to have impacts on any threatened flora and fauna and threatened ecological communities.


Legend
Project Footprint
Boundary of Hydraulic Model
Wetlands
High value
Moderate value
Low value
Cadastral Boundaries
Proposed Bypass Design
Proposed Drainage Culverts
Proposed Bridges
Channel Realignment
Peak Flood Afflux:
<= -0.2m
> -0.2 - <= -0.1m
> -0.1 - <= -0.01m
> -0.01 - <= +0.01m
> +0.01 - <= +0.02m
> +0.02 - <= +0.05m
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> +0.1 - <= +0.2m
> +0.2 - <= +0.3m
> +0.3m
Newly Flooded
No Longer Flooded
WETLAND 35595
WETLAND 35597
WETLAND 35596
WETLAND 35735
WETLAND 35563
BEAUFORT
YAM HOLES CREEK
GARIBALDI CREEK
N
Prepared for: Regional Roads Victoria
Coordinate system: GDA 1994 MGA Zone 54
Aerial Source: NSW Six Maps
Scale ratio correct when printed at A3
0 200 400 600 800 m
Scale: 1:15000
wsp
Stage: EIS
Version: D
Author: KS
Approved by: RL
Date: 26/05/2021
Beaufort Bypass
Peak Flood Afflux - Proposed Design Scenario
Event: 1 EY
Sheet 1
Map ID: DES_AFF_1EY_1

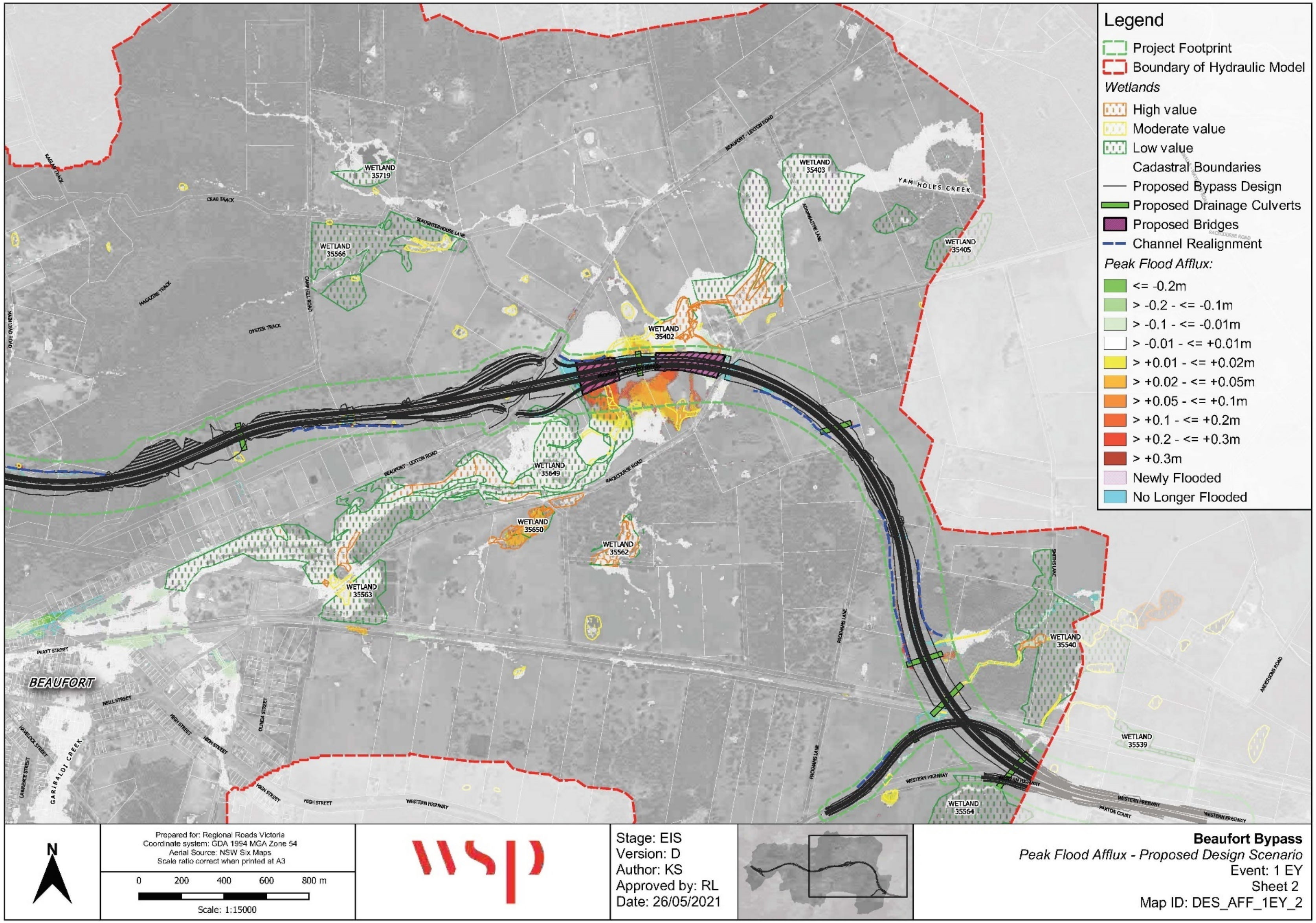


Figure 9.2 Peak Flood Afflux – Proposed Design Scenario Event: 1 EY

9.8 AIR QUALITY AND DUST

Without mitigation, dust and particulates during construction may have a temporary effect on flora and fauna and result in increased nutrients and turbidity in waterways.

With regard to operation of the road, although some impacts upon vegetation adjacent to the roadway from elevated nitrogen dioxide and other airborne pollutants are possible, it is unlikely that air pollutants are a substantial factor in comparison to many of the other likely effects of the road.

Based on the above, air quality and dust impacts are attributed an impact rating of moderate, largely due to the potential for dust during construction.

9.9 SUMMARY OF IMPACTS

The impacts of the project on biodiversity are summarised in Table 9.8 below.

Table 9.8 Summary of biodiversity impacts of the Project (C2) without mitigation

IMPACT	BIODIVERSITY WITH POTENTIAL TO BE AFFECTED	NATURE OF THE IMPACT	LIKELY DEGREE OF IMPACT FROM THE PROJECT WITHOUT MITIGATION	DURATION OF IMPACTS
Loss of vegetation and habitat	A total of 47.950 ha of native vegetation, 28 scattered trees and 327 large trees in patches are proposed for removal. One threatened ecological community (EPBC Act), one threatened fauna community (FFG Act) and habitat for a number of threatened flora and fauna species also occur within the construction footprint and would need to be cleared.	Direct loss of vegetation and habitat from construction of the bypass.	High.	Permanent.
Loss of connectivity	Particularly arboreal mammals (e.g. Brush-tailed Phascogale), small or less mobile fauna such as reptiles, frogs and Golden Sun Moth. Small woodland birds that use roadside remnant vegetation are also at risk in areas where the proposed project intersects smaller existing roads. Larger terrestrial fauna are also likely to be affected (e.g. Eastern Grey Kangaroo and potentially Emu).	Fragmentation of habitat through construction of the road resulting in increased ‘edge effects’, barriers to species dispersal and reduction of connectivity in the landscape.	High.	Permanent.

IMPACT	BIODIVERSITY WITH POTENTIAL TO BE AFFECTED	NATURE OF THE IMPACT	LIKELY DEGREE OF IMPACT FROM THE PROJECT WITHOUT MITIGATION	DURATION OF IMPACTS
Fauna Injury and Mortality	Birds, particularly low flying species. Arboreal mammals and bats (tree clearing). Amphibians and reptiles, particularly turtles and common frogs due to their lack of mobility. Also kangaroos and wallabies crossing pasture and wooded/partially wooded areas.	Impact from clearing during construction, and ongoing risk of wildlife vehicle collisions for the life of the road.	High.	Permanent, during both construction and operation phases of the project.
Noise and vibration	Many animal species, including threatened birds.	Works may lead to increased noise in certain locations and some species may be affected.	Moderate.	Temporary – construction noise and vibration Permanent – vehicle noise.
Ecological Light pollution	Many animal species, including threatened birds, particularly in wetland habitats.	Ecological light pollution may impact fauna behaviour and use of the nearby habitat.	Moderate.	Temporary – construction site lighting Permanent - street lighting and vehicle headlights.
Visual impact	Birds, particularly threatened waterbirds.	Visual impact of the road itself and movement of vehicles may affect use of the nearby habitat by fauna.	Low-moderate.	Permanent (may lessen slightly over time as revegetation matures).
Weed invasion and disease	Threatened flora. Threatened ecological communities. Native vegetation elsewhere in the study area.	Construction projects increase risk of weed invasion through soil disturbance and introduction of weed seed/propagule carrying material. The greatest risk will be from the road fragmenting native vegetation and providing space for weed colonisation along the alignment, as this is an ongoing risk and more difficult to mitigate.	Moderate.	Temporary risk (construction) Permanent (operation)

IMPACT	BIODIVERSITY WITH POTENTIAL TO BE AFFECTED	NATURE OF THE IMPACT	LIKELY DEGREE OF IMPACT FROM THE PROJECT WITHOUT MITIGATION	DURATION OF IMPACTS
Rubbish	Habitat for terrestrial and aquatic flora and fauna.	The construction and operational phase of the project are expected to result in an increase in rubbish in terrestrial and aquatic habitats.	Low-moderate	Temporary (construction) and ongoing (operation).
Erosion, sedimentation and water pollutants	Aquatic flora and fauna, wetland birds.	Wetlands connected to/adjacent to the study area may be impacted should adequate controls not be in place. Some residual risk of water pollution from spills on the road is likely to be unavoidable.	Moderate.	Temporary (construction) and ongoing risk.
Changes in groundwater and surface hydrology	Waterbirds, aquatic flora and fauna, vegetation communities, threatened flora.	Changes to groundwater hydrology and/or surface water flows.	Moderate.	Permanent.
Air quality and dust	Fauna and flora habitat, particularly wetland habitat.	Dust during construction, increased pollutants during operation.	Moderate (construction) Low (operation)	Temporary (construction) Ongoing (operation)

9.10 SEVERITY OF IMPACTS ON LISTED SPECIES AND ECOLOGICAL COMMUNITIES

9.10.1 ECOLOGICAL COMMUNITIES

Table 9.9 provides an assessment of the impacts (without mitigation) of the preferred alignment on threatened ecological communities, considering all potential types of impact. An impact severity rating is provided which gives an indication of the likely importance of mitigation for the community, with mitigation efforts for species focused on those with a moderate or higher impact severity rating. Impact ratings are based subjective evaluations with rationale discussed in each section.

This assessment, and the associated significant impact criteria assessments for MNES (Appendix Q) has been used to identify the mitigation measures required which have been incorporated into Section 10: Mitigation. Residual impacts of the project are discussed in Section 11.

Table 9.9 Impacts on threatened ecological communities

COMMUNITY NAME	STATUS	LIKELY IMPACT WITHOUT MITIGATION MEASURES	SEVERITY RATING OF IMPACT (WITHOUT MITIGATION)
Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	CE	One patch of Seasonal Herbaceous Wetlands was recorded within the construction footprint, comprised of 0.312 ha. The only direct loss of the community will occur near Yam Holes Creek, where the project will impact part of the wetland complex which is associated with the creek. Other impacts may occur during construction, such as from dust and introduction of weeds. Furthermore, any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this community. Groundwater in the study area has been shown to be deep and not connected to the wetlands. As such, no groundwater impacts are anticipated (WSP 2020a). A significant impact criteria assessment for the preferred alignment, as required for EPBC Act listed communities, is provided in Appendix Q.	Moderate, with a moderate likelihood of a significant impact without any mitigation (refer to significant impact criteria assessment Appendix Q).
White box – Yellow Box – Blakely's Red Gum Grassy Woodland	CE	One patch (~0.1 ha) of this community occurs within the C2 alignment but none occurs within the construction footprint. Given the distance of the construction footprint from the nearest patch of the community (approximately 80 m), indirect impacts are considered unlikely, although there is some potential for the community to be impacted by unapproved clearing, dust and weeds without mitigation. A significant impact criteria assessment for the preferred alignment, as required for EPBC Act listed communities, is provided in Appendix Q.	Low, with a low likelihood of a significant impact without any mitigation (refer to significant impact criteria assessment Appendix Q). However, precautionary mitigation has been included for this community.

COMMUNITY NAME	STATUS	LIKELY IMPACT WITHOUT MITIGATION MEASURES	SEVERITY RATING OF IMPACT (WITHOUT MITIGATION)
Victorian Temperate Woodland Bird Community	L	A number of patches totalling 32.800 ha will be impacted within the construction footprint. Impacts on the community may also occur outside of the construction footprint without mitigation, particularly from unapproved clearing, dust and weeds.	High

9.10.2 FLORA

Table 9.10 provides an assessment of the impacts (without mitigation) of the preferred alignment on significant flora species, considering all potential types of impact on the species. An impact severity rating is provided which gives an indication of the likely importance of mitigation for the species, with mitigation efforts for species focused on those with a moderate or higher impact severity rating.

This assessment, and the associated Significant Impact Criteria Assessments for MNES (Appendix Q) has been used to identify the mitigation measures required for the species which have been incorporated into Section 10: Mitigation. Residual impacts of the project are discussed in Section 11.

Table 9.10 Impacts on significant flora

COMMON NAME	STATUS	LIKELY IMPACT WITHOUT MITIGATION MEASURES	SEVERITY RATING OF IMPACT (WITHOUT MITIGATION)
Ben Major Grevillea	VU L vu	The alignment passes through the southern part of Camp Hill reserve, at the southern limit of the known range of the species. Several Ben Major Grevillea plants were recorded just north of the construction footprint within the state forest with three of these occurring within the project area. The construction footprint passes within approximately 10 m of the closest one. In this area, a fire track is proposed to be constructed, the bypass itself is located further away and in a cutting. Impacts on the species from construction may occur without mitigation, particularly from dust, weeds, or unapproved clearing. Material impacts from surface water changes are highly unlikely as only a fire track is proposed nearby the recorded plants and the bypass itself will occur downslope of these records. A significant impact criteria assessment for the preferred alignment, as required for EPBC Act listed communities, is provided in Appendix Q.	Moderate, with the likelihood of a significant impact low-moderate without mitigation (refer to significant impact criteria assessment Appendix Q).

COMMON NAME	STATUS	LIKELY IMPACT WITHOUT MITIGATION MEASURES	SEVERITY RATING OF IMPACT (WITHOUT MITIGATION)
Emerald-lip Greenhood	- - r	The alignment passes through the southern part of Camp Hill reserve. One Emerald-lip Greenhood plant was recorded within 30 m of the construction footprint boundary. In this area, a fire track is proposed to be constructed, the bypass itself is located further away and in a cutting. Impacts on the species from construction may occur without mitigation, particularly from dust, weeds, or inadvertent clearing. Material impacts from surface water changes are highly unlikely as only a fire track is proposed nearby the recorded plants and the bypass itself will occur downslope of these records.	Moderate
Floodplain Fireweed	- - r	One location of Floodplain Fireweed occurs within the alignment along Yam Holes Creek near the racecourse. These are located ~50 m south of the construction footprint. Impacts on the species from construction may occur without mitigation, particularly from dust, weeds, or inadvertent clearing. Furthermore, any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species.	Moderate
Matted flax-lily	EN L en	Two records of Matted flax-lily were recorded within the C2 alignment. One is located within the construction footprint and will be impacted, the other is located outside the construction footprint by ~65 m. Impacts on the species from construction may occur without mitigation, particularly from dust, weeds, or inadvertent clearing. Material impacts from surface water changes are unlikely as a tributary nearby is to be realigned and is downslope of the retained location of Matted flax-lily. A significant impact criteria assessment for the preferred alignment, as required for EPBC Act listed communities, is provided in Appendix Q.	Moderate with the likelihood of a significant impact low-moderate without mitigation (refer to significant impact criteria assessment Appendix Q).
Ornate Pink Fingers	Vu L vu	Alignment avoids all records of this species. Nearest records are located >600 m away. A significant impact criteria assessment for the preferred alignment, as required for EPBC Act listed communities, is provided in Appendix Q.	Low, with the likelihood of a significant impact low without mitigation (refer to significant impact criteria assessment Appendix Q.
Pale-flower Cranesbill	- - r	Alignment avoids all records of this species. Nearest records are located >600 m away.	Low

COMMON NAME	STATUS	LIKELY IMPACT WITHOUT MITIGATION MEASURES	SEVERITY RATING OF IMPACT (WITHOUT MITIGATION)
River Swamp Wallaby-grass	VU - -	Two records of River Swamp Wallaby-grass were recorded within the C2 alignment. One is located within the construction footprint in a dam off Topp Lane and will be impacted, the other is located outside the construction footprint by ~70 m east of Main Lead Road. Impacts on the species from construction may occur without mitigation, particularly from dust, weeds, or inadvertent clearing. Furthermore, any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species. A significant impact criteria assessment for the preferred alignment, as required for EPBC Act listed communities, is provided in Appendix Q.	Moderate, with the likelihood of a significant impact low-moderate without mitigation (refer to significant impact criteria assessment Appendix Q).
Rosemary Grevillea	- - r	Alignment avoids all records of this species. Nearest records are located >100 m away. Impacts on the species from construction may occur without mitigation, particularly from dust, weeds, or inadvertent clearing.	Low
Rough wattle	- - r	Alignment avoids all records of this species. Nearest records are located >400 m away.	Low
Yarra Gum	- - r	Two records of Yarra Gum were recorded within the C2 alignment. One is located within the construction footprint and will be impacted, the other is located outside the construction footprint by ~40 m. Impacts on the species from construction may occur without mitigation, particularly from dust, weeds, or inadvertent clearing. Any significant changes in surface water hydrology or changes to creek realignment to the west of the individual Yarra Gum north of the racecourse, may have flow on effects for this species.	Moderate

9.10.3 FAUNA

Table 9.11 provides an assessment of the impacts (without mitigation) of the preferred alignment on significant fauna species, considering all potential types of impact on the species. An impact severity rating is provided which gives an indication of the likely importance of mitigation for the species, with mitigation efforts for species focused on those with a moderate or higher impact severity rating.

This assessment, and the associated significant impact criteria assessments for MNES (Appendix Q) has been used to identify the mitigation measures required for the species which have been incorporated into Section 10: Mitigation. Residual impacts of the project are discussed in Section 11.

Table 9.11 Fauna impact assessment for preferred alignment (C2)

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITHOUT MITIGATION MEASURES	SEVERITY RATING OF IMPACT (WITHOUT MITIGATION)
Amphibians				
Growling Grass Frog	*Litoria raniformis*	VU L en	Although recent surveys have not recorded Growling Grass Frog within the study area, the species may re-colonise under suitable conditions or may be present in low numbers. Most of the impacts on potential habitat for this species are expected to occur at Yam Holes Creek floodplain between Racecourse Road and Beaufort-Lexton Road. The project will result in the removal and fragmentation of some potential terrestrial habitat and lead to a decrease in available potential aquatic habitat for this species. Other likely impacts include barriers to movement, injury and mortality from the construction and operation phase of the project spread of chytrid fungus, hydrological changes, and decreased water quality of Yam Holes Creek as a result of erosion, sedimentation and pollution. Based on the current construction footprint there are likely to be impacts to 0.281 ha of high quality aquatic potential habitat and 1.132 ha of moderate quality aquatic potential habitat. Potential impact to Growling Grass Frog terrestrial habitat were also conservatively estimated using a 200 m buffer from waterbodies as per the Significant Impact Guidelines for the species (DEWHA 2009c). Using this method, the anticipated loss of potential terrestrial habitat associated with high quality potential aquatic habitat is 17.285 ha and the anticipated loss of potential terrestrial habitat associated with moderate quality potential aquatic habitat is 68.179 ha (excluding any overlap with high quality). A large proportion of this terrestrial habitat is unlikely to be used by the species, if present at the associated wetlands, as the habitat does not occur between waterbodies or does not support features preferred by the species for overwintering or foraging (rocks, tussock grasses etc.). A moderate impact severity rating (without mitigation) has been applied, largely due to the potential for reduction of connectivity for this species in the landscape, rather than the direct clearance of potential habitat, which is low. A significant impact criteria assessment for the preferred alignment, as required for EPBC Act listed species, is provided in Appendix Q.	Moderate, with a moderate likelihood of a significant impact without mitigation (refer to significant impact criteria assessment Appendix Q).

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITHOUT MITIGATION MEASURES	SEVERITY RATING OF IMPACT (WITHOUT MITIGATION)
Brown Toadlet	*Pseudophryne bibroni*	L en	The project will result in some removal and fragmentation of potential habitat along Yam Holes Creek with 1.680 ha of direct loss of potential Brown Toadlet habitat. Other potential impacts include physical barriers to movement and increased risk of injury and mortality from the construction and operation phase of the project. Any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species.	Moderate
Birds				
Australasian Shoveler	*Anas rhynchotis*	vu	No direct impacts on high quality habitat are anticipated however loss of 1.520 ha medium-quality waterbird habitat is proposed. Other impacts include potential increased mortality from road collisions (mainly during breeding) where the road occurs near habitat. Retained habitat may be reduced in quality by an increase in noise disturbance and light pollution. Furthermore, any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species.	Moderate
Baillon's Crake	*Porzana pusilla*	L vu	No direct impacts on high quality habitat are anticipated however loss of 1.520 ha medium-quality waterbird habitat is proposed. Disturbance related impacts associated with noise and light pollution are likely. Any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species.	Moderate
Blue-billed Duck	*Oxyura australis*	L en	Some loss of potential habitat in the form of deep, permanent and open aquatic environments is likely. No direct impacts on high quality habitat are anticipated however loss of 1.520 ha medium-quality waterbird habitat is proposed. There is a risk of increased mortality from road collisions (mainly during breeding) and the quality of remaining habitat may be reduced by an increase in noise disturbance and light pollution. Furthermore, any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species.	Moderate

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITHOUT MITIGATION MEASURES	SEVERITY RATING OF IMPACT (WITHOUT MITIGATION)
Brolga	*Grus rubicunda*	L vu	Wetlands and waterbodies within and adjacent to the project are likely to be used on a seasonal basis by Brolga for foraging and possibly breeding. However, no primary breeding habitat is known to occur within or adjacent to the C2 alignment. No direct impacts on high quality habitat are anticipated however loss of 1.520 ha medium-quality waterbird habitat is proposed. Aside from habitat loss, other impacts include a heightened risk of wildlife vehicle collisions during the operational phase of the project, especially in areas located close to natural or artificial water bodies. Additionally, roads may lead to a decreased use of nearby habitat and can affect pre-fledged chicks if located between suitable habitat. Any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species.	Moderate
Brown Treecreeper	*Climacteris picumnus victoriae*	N nt	The Brown Treecreeper was recorded in the study area by WSP in 2015. The largest impact to this species will result from the removal of Victorian Temperate Woodland Bird Community habitat at Camp Hill State Forest. Some impact is also expected to occur in roadside reserves and private property within and adjacent to the alignments, but to a lesser extent due to these areas being less impacted. A total of 32.800 ha of direct woodland habitat impact is anticipated. Other potential impacts include fragmentation of habitat, loss of connectivity, increased noise disturbance and ecological light pollution.	Moderate
Diamond Firetail	*Stagonopleura guttata*	L nt	The largest impact to this species will result from the removal of Victorian Temperate Woodland Bird Community habitat at areas like Camp Hill State Forest. Some impact is also expected to occur in roadside reserves and private property within and adjacent to the alignments, but to a lesser extent due to these areas being less impacted. A total of 32.800 ha of direct woodland habitat impact is anticipated. Other potential impacts include fragmentation of habitat, loss of connectivity, increased noise disturbance and ecological light pollution. Given the species' ground foraging behaviour, there is an increased risk from fragmentation and loss of connectivity.	Moderate

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITHOUT MITIGATION MEASURES	SEVERITY RATING OF IMPACT (WITHOUT MITIGATION)
Eastern Great Egret	*Ardea modesta*	L vu	No direct impacts on high quality habitat are anticipated however loss of 1.520 ha medium-quality waterbird habitat is proposed. Disturbance related impacts associated with noise and light pollution are also likely. Any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species. As this species is less particular about habitat it is less likely to be affected by these factors than some of the other waterbirds.	Low
Emu	*Dromaius novaehollandiae*	nt	It is likely that the project will results in some loss of potential habitat for the Emu. Habitat for this species is not mapped due to the range of open habitat types the species may use. As the species is not regularly recorded this habitat is unlikely to be of high significance but may be important for movement. Other potential impacts include fragmentation, loss of connectivity and increased risk of mortality from wildlife vehicle collisions during the operational phase of the project. These risks may affect the species more than the direct loss of habitat.	Moderate
Hardhead	*Aythya australis*	vu	Some loss of potential habitat in the form of deep, permanent and open aquatic environments is likely. No direct impacts on high quality habitat are anticipated however loss of 1.520 ha medium-quality waterbird habitat is proposed. Other potential impacts include increased mortality from road collisions (mainly during breeding) and reduced habitat quality from noise disturbance and light pollution. Furthermore, any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species.	Moderate

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITHOUT MITIGATION MEASURES	SEVERITY RATING OF IMPACT (WITHOUT MITIGATION)
Latham's Snipe	*Gallinago hardwickii*	M N nt	Latham's Snipe may occur as an occasional visitor to wetlands at the study area. Habitat would be for foraging or roosting only, as the species is migratory and does not breed in Australia. No direct impacts on high quality waterbird habitat are anticipated however loss of 1.520 ha medium-quality waterbird habitat is proposed. There may be a slightly increased risk of increased mortality from road collisions, although the species is not commonly hit on roads in Australia as it tends not to fly low when disturbed. However, the quality of remaining habitat may be reduced by an increase in noise disturbance and light pollution. The species is readily disturbed by people and dogs and may be impacted should there be increased access to habitat. Visual impacts (moving vehicles etc) may also cause some disturbance. In addition, any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species. A significant impact criteria assessment for the preferred alignment, as required for EPBC Act listed species, is provided in Appendix Q.	Moderate, with a low likelihood of a significant impact without mitigation (refer to significant impact criteria assessment Appendix Q).
Musk Duck	*Biziura lobata*	vu	Some loss of potential habitat, consisting of large expanses of water with dense marginal vegetation and reed beds, is likely to occur. No direct impacts on high quality waterbird habitat are anticipated however loss of 1.520 ha medium-quality waterbird habitat is proposed. There is a risk of increased mortality from road collisions (mainly during breeding) and the quality of remaining habitat may be reduced by an increase in noise disturbance and light pollution. Any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species.	Moderate
Painted Honeyeater	*Grantiella picta*	VU L vu	Although 32.800 ha of woodland bird habitat is proposed to be impacted, given the species' preference for larger patches of vegetation, most of the impact will occur where the project intersects Camp Hill State Forest. Given the low number of records around Beaufort, it is unlikely that this habitat is of particularly high significance. Other potential impacts include increased fragmentation and loss of connectivity. A significant impact criteria assessment for the preferred alignment, as required for EPBC Act listed species, is provided in Appendix Q.	Low, with a low likelihood of a significant impact without mitigation (refer to significant impact criteria assessment Appendix Q).

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITHOUT MITIGATION MEASURES	SEVERITY RATING OF IMPACT (WITHOUT MITIGATION)
Pied Cormorant	*Phalacrocorax varius*	nt	Some loss of potential habitat, consisting of large expanses of water with dense marginal vegetation, is proposed. No direct impacts on high quality waterbird habitat are anticipated however loss of 1.520 ha medium-quality waterbird habitat is proposed. There is a small risk of increased mortality from road collisions and the quality of remaining habitat may be reduced by an increase in noise disturbance and light pollution. Any significant changes in surface water hydrology, including water levels and water quality, may have flow on effects for this species. However, the species is not as particular as some of the other waterbirds and is unlikely to be as affected by these less direct impacts.	Low
Powerful Owl	*Ninox strenua*	L vu	32.800 ha of woodland bird habitat is proposed to be impacted which may support Powerful Owl. Impacts will be heightened in woodland habitats that support large hollow bearing trees, a nesting requirement for the species. Hollow-bearing trees, with hollows of various sizes, are also required to support Powerful Owl food sources including possums and gliders. Woodland habitat supporting hollow-bearing trees includes Camp Hill State Forest as well as some areas of roadside reserves and private properties within and adjacent to the alignment. Other potential impacts include increased mortality from road collisions and reduced habitat quality from noise disturbance and light pollution.	High
Speckled Warbler	*Chthonicola sagittata (syn. Pyrrholaemus sagittatus)*	L vu	32.800 ha of woodland bird habitat is proposed to be impacted which may support Speckled Warbler. The greatest impact to this species will result from the removal of potential habitat in areas like Camp Hill State Forest, roadside reserves and private property within and adjacent to the project. The species is also likely to be affected by fragmentation and loss of connectivity.	Moderate

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITHOUT MITIGATION MEASURES	SEVERITY RATING OF IMPACT (WITHOUT MITIGATION)
Fish				
Little Galaxias	*Galaxiella toourtkoourt*	VU L en	The Little Galaxias is not currently known to have a self-sustaining population within the study area. However, it is considered to have a high likelihood of occurrence as there is a reasonable likelihood that they could recolonise the catchment under suitable conditions, such as flood events. The construction footprint intersects Yam Holes Creek and smaller tributaries and will result in some loss of potential Little Galaxias habitat. The current construction footprint intersects 2.011 km of waterways that could be potential habitat for this species. It would also require seven creek crossings which may result in fragmentation and habitat shading. Any significant changes in surface water hydrology may have flow on effects for this species including decreased water quality from erosion, sedimentation and water pollution. A significant impact criteria assessment for the preferred alignment, as required for EPBC Act listed species, is provided in Appendix Q.	Moderate, with a moderate likelihood of a significant impact without mitigation (refer to significant impact criteria assessment Appendix Q).
Invertebrates				
Golden Sun Moth	*Synemon plana*	CR L cr	Based on the current construction footprint, 1.672 ha of confirmed Golden Sun Moth habitat is likely to be impacted along with 9.431 ha of higher quality potential habitat and 2.822 ha of lower quality potential habitat. Impacts are anticipated to be highest just north of Martins Lane, near the proposed interchange with the Western Highway, where high quality Golden Sun Moth habitat was mapped and the species was recorded during 2018 surveys. The project is also likely to lead to an increase in habitat fragmentation and present a barrier to dispersal for the species. A significant impact criteria assessment for the preferred alignment, as required for EPBC Act listed species, is provided in Appendix Q.	High, with a high likelihood of a significant impact without mitigation (refer to significant impact criteria assessment Appendix Q).

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITHOUT MITIGATION MEASURES	SEVERITY RATING OF IMPACT (WITHOUT MITIGATION)
Mammals				
Brush-tailed Phascogale	*Phascogale tapoatafa*	L vu	The construction footprint is likely to impact 6.99 ha of moderate quality habitat and 15.598 ha of high quality habitat, including areas of mature native vegetation such as Camp Hill State Forest, and habitat along road reserves and on private property. Brush-tailed Phascogales are at risk of impacts associated with habitat fragmentation and changes to wildlife movement. They are also at risk of injury and mortality from the construction phase of the project, especially during the removal of hollow bearing trees, as well as the operational phase. Mortality from the road is anticipated to be highest where the project intersects Camp Hill State Forest.	High
Reptiles				
Eastern Long-necked Turtle	*Chelodina longicollis*	dd	The Eastern Long-necked Turtle is likely to occur in low numbers within the study area. Given that the species utilises aquatic habitats and terrestrial habitats for movement between wetlands, it is likely that the project will directly impact some habitat as well as result in loss of connectivity, mortality from groundcover clearance and wildlife vehicle collisions. The species is also at risk from decreased water quality of wetlands and disorientation from artificial light pollution. The current construction footprint impacts 1.520 ha of medium quality wetland habitat, with no impacts on high quality wetland habitat.	Moderate

Key for Conservation Status

Listing under the federal *Environment Protection and Biodiversity Conservation Act 1999*
CR = Critically Endangered, EN = Endangered, VU = Vulnerable, M = Migratory

Listing under the Flora and Fauna Guarantee Act 1988
L = listed as threatened, N = Nominated for listing as threatened,

Listed on the Victorian Advisory List of threatened species
cr = Critically Endangered, en = Endangered, vu = Vulnerable, nt = near threatened, dd = Data Deficient

9.11 CUMULATIVE IMPACTS

As part of this EES, a CIA was undertaken for all threatened species and ecological communities determined to have a likelihood of occurrence within the Beauport Bypass study area and also the CIAA (refer to Section 7.10 for background information and methodology). All threatened species and ecological communities with a moderate or higher likelihood were assessed for inclusion, however not all could be included due a number of reasons including the lack of available modelled data or other projects not containing species or communities found in the study area. Appendix N provides detail on how species and communities that were considered for inclusion or exclusion in this CIA.

Of the six flora species that were assessed, only one, Yarra Gum, was determined likely to be affected by minor cumulative impacts from the five projects within the CIAA. For the other five flora species, it is unlikely that a cumulative impact will occur. This is either because the Beaufort Bypass is not expected to remove any known populations or individuals of these species or, in instances where plant populations may be removed, no other populations were affected as a result of the other projects within the CIAA.

Impacts to Brown Toadlet and Golden Sun Moth modelled and known habitat within the Beaufort study area and the additional impacts associated with the Stage 2A upgrade and Growling Grass Frog at Stockyard Hill are likely to result in a minor cumulative impact to the species. However, they are not anticipated to be significant given that the anticipated impact to each species comprises less than 1% of their distribution modelled to occur within the CIAA. A minor cumulative impact is also anticipated to a local Brolga population in the Yam Holes Creek Valley.

Impacts on modelled Seasonal Herbaceous Wetland habitat are proposed with all four Beaufort alignments, however no substantial impacts in the CIAA have occurred as a result of other projects so a cumulative impact is considered unlikely. In contrast, native vegetation and mapped VTWBC habitat has/will be affected by all projects within the CIAA. As a result, a cumulative impact resulting from the combined effect of these projects is anticipated.

The results of the analysis indicated that the combined impact of the proposed bypass (C2 alignment) together with the four projects within the CIAA were unlikely to result in a significant cumulative impact on any of the species or communities included in the assessment.

However, unmitigated, the impacts of the four projects combined with impacts associated with the Beauport Bypass (any alignment, including the preferred C2 alignment) could potentially result in a minor cumulative impact on native vegetation and on some species, particularly those which may be impacted by the Beaufort Bypass: Yarra Gum, Brolga, Brown Toadlet, Growling Grass Frog and Golden Sun Moth. Refer to Appendix N for the full assessment.

10 AVOIDANCE, MINIMISATION, AND MITIGATION MEASURES

There is significant native vegetation and fauna habitat within and adjacent to the bypass footprint that is known to support Commonwealth and state listed species. In addition, the area supports large numbers of non-listed species, many of which are subject to high rates of wildlife-vehicle collision with subsequent implications for motorist safety, animal welfare and biodiversity conservation. This section provides strategies to avoid, minimise, and mitigate ecological impacts upon significant ecological values at the planning and design stage and during construction and operation. Biodiversity impact mitigation measures require significant planning and design and, must be considered in context with other landscape and design objectives.

There are several key documents which describe detailed measures to mitigate the impacts of roads and traffic on fauna, which can be drawn upon for further information regarding mitigation works if required:

- VicRoads Fauna Sensitive Road Design Guidelines (VicRoads 2012a).
- Fauna Sensitive Road Design Manual – Volume 1: Past and Existing Practices (Queensland Department of Transport and Main Roads 2010a).
- Fauna Sensitive Road Design Manual – Volume 2 (Queensland Department of Transport and Main Roads 2010b).
- NSW Roads and Maritime Services Draft Wildlife Connectivity Guidelines, November 2011 (RMS 2011)
- Review of mitigation measures used to deal with the issues of habitat fragmentation (van der Ree et al. 2008).
- Road Ecology (Foreman et al. 2003).
- Handbook of Road Ecology (van der Ree, Smith & Grilo 2015).

10.1 MEASURES TO AVOID AND MINIMISE IMPACTS

A key tenet of the Guidelines 2017 is the requirement to *avoid and minimise* impacts to native vegetation and fauna; this principal is also common to legislation such as the EPBC Act and the FFG Act. The principal is that preference should be first given to avoidance, followed by minimisation, mitigation and finally offsetting, and that this should be considered early in the design of the project.

10.1.1 STRATEGIC LEVEL PLANNING

Examples of impact avoidance and minimisation that were incorporated into the design options include:

- road corridor analysis to consider a range of feasible alternatives by incorporating engineering design principles with constraints and environmentally sensitive areas. This utilised the Trimble Quantm planning software tool (http://www.trimble.com/Alignment/Index.aspx) along with multiple workshops to optimise assumptions made
- consideration of new alignments to minimise impacts through areas such as Camp Hill State Forest
- modification of alignments to avoid known occurrences of Ben Major Grevillea
- modification of alignments to avoid a number of wetlands, threatened ecological communities and threatened species habitat
- micro-alignment of the design options in several areas to avoid and minimise impacts to isolated paddock trees (or scattered trees).

The preferred alignment selected (C2) has the lowest impacts to native vegetation of the four proposed.

10.1.2 SITE LEVEL PLANNING

Once the preferred alignment was chosen, a detailed exploration of measures to avoid and minimise impacts on native vegetation was undertaken, including the following summarised points:

- design modifications to reduce impacts on specific trees or areas of habitat such as locally steepened batters, use of retaining walls and kerb and channelling, installation of safety barriers and realigning drainage and culverts to avoid impacts
- design modifications to reduce impacts on specific trees or areas of habitat such as locally steepened batters, use of retaining walls and kerb and channelling, installation of safety barriers and realigning drainage and culverts to avoid impacts
- citing of laydowns, site offices, temporary access tracks, relocation of utility services etc within the construction footprint or outside of native vegetation and habitat. Given the amount of cleared pasture in the study area, this is highly feasible. While specific locations for site offices, laydowns and haul roads has not been defined, the figure Indicative Site Office and Laydown Areas in Appendix K-8 displays indicative locations where these ancillary facilities can be placed without impacting the Yam Holes Creek floodplain, areas of recorded vegetation, trees and their TPZs and fauna habitat. Approximately 28 hectares of land is available for these facilities within the project area and deemed adequate for project construction. The process to identify potential laydowns, site offices, temporary access tracks was used in the North East Link EES
- development project-wide No-go Zones which mapped all native vegetation (including avoiding impacts to tree TPZs) and fauna habitat outside the construction footprint within the C2 Project Area (SCO) to ensure it is not impacted during construction. All areas inside the C2 Project Area (SCO) were assessed for native vegetation and fauna habitat values
- use of bridges instead of culverts to avoid and minimise in-stream impacts.

10.1.3 FURTHER AVOIDANCE AND MINIMISATION OF IMPACTS

Once the project is awarded to build, further refinement during detailed design will likely present scope for further avoidance and minimisation of impacts to native vegetation. This might be through options such as further micrositing to avoid local impacts, reducing the width of the median dividing the road and reducing the width of the construction footprint outside the permanent earthworks.

10.2 STANDARD CONTROLS AND PROCEDURES

RRV has a well-established environmental management system for managing the potential environmental impacts of major road projects. RRV will prepare an Environmental Management Framework (EMF) as a part of the EES which will identify the systems, procedures and responsibilities for environmental management during the project design, construction and operation.

The delivery of the project would be managed by Major Roads Project Victoria (MRPV) under agreement with RRV. The EMF, developed by RRV would be implemented by MRPV and the procured designers and contractors. The EMF developed by RRV will be informed by RRV's established systems for environmental management.

During and after construction, the mitigation process is typically managed through a Construction Environmental Management Plan (CEMP). A CEMP typically outlines all practicable measures to minimise and mitigate impacts on biodiversity from the construction and operational phase to the management and maintenance phases.

Contractors are required to undertake monitoring and audits for construction activities, including works undertaken by subcontractors employed on their behalf to verify compliance with the Contract Specification and their Environmental Management Plan. In addition to the contractor auditing and monitoring of the works, RRV also conducts its own surveillance and auditing to assess the contractor's compliance with the CEMP and the requirements of the Contract Specifications.

RRV has standard environmental protection measures as well as more specific measures relating to fauna sensitive road design. The CEMP will include the standard flora and fauna mitigation measures in Section 177 Environmental Management document (VicRoads 2016a). Section 177 (document available online on the VicRoads website). This will include additional site-specific information, such as the location and monitoring frequency of No-go Zones. Other standard measures which will be followed during the relevant stages of the project are detailed in Section 720 Landscape Works, and Section 750 Routine Maintenance from VicRoads 2016a.

In addition to the above, protection measures outlined in the *Fauna Sensitive Road Design Guidelines* (VicRoads 2012a) should be included, where appropriate, in the CEMP.

The Australian Standard for *Protection of trees on development sites* (AS4970-2009) (Standards Australia 2009) and the Australian Standard for *Pruning of amenity trees* (AS4373-2007) (Standards Australia 2007) will need to be followed during construction.

10.3 MITIGATION FOR EPBC ACT AND FFG ACT SPECIES AND COMMUNITIES

This section provides an overview of mitigation measures for some of the key significant species and communities listed under the EPBC Act. Additional mitigation measures for other species and communities and these are provided in Section 10.4.2.2 including an assessment of their likely effectiveness based on evaluations on other projects.

The majority of threatened plants have been avoided through the design phase of the project, both through the option assessment and through further revision of the construction footprint within the chosen alignment. It is possible, despite extensive targeted surveys, that more plants may be encountered during construction and the mitigation measures outlined here should be applied if these plants are not able to be avoided.

Mitigation measures for these key species will need to be included within the CEMP and separately in a Threatened Species Management Plan. Mitigation measures recommended in the sections below such as seed collection, salvage and translocation may also require an FFG Act permit.

10.3.1 MATTED FLAX-LILY

The current construction footprint of the preferred alignment impacts one of the two known records of this species within the alignment. For this plant, and should any others be recorded during pre-clearing, mitigation is required. Measures are also required to ensure that the remaining plant is not indirectly impacted by the project.

Several mitigation approaches have been used for this species on other projects, including minimising the number of plants impacted, propagating from seed and planting at new sites and salvage and translocation of plants to new sites. Translocation of Matted Flax-lily has been undertaken in a number of areas including the F2 Freeway site of the Craigieburn bypass, Sugarloaf Pipeline (Carr & Rodda 2011), Kilmore-Gisborne Road, South Morang rail upgrade (GHD 2019) and numerous other sites (Department of the Environment 2016). The process of salvage (digging up, dividing rhizomes and establishing in tubestock) can be achieved with relative ease, however, successful establishment in recipient sites depends on a number of factors including appropriate levels of management, particularly in the early phases of establishment. Translocation of plants is usually deemed successful when there is evidence of reproduction and establishment of young plants other than those which have been transplanted. However, as seed development is thought to be rare for Matted Flax-lily, the production of ramets at a rate similar to that of naturally occurring populations has been considered sufficient (GHD 2019).

For any plants which cannot be avoided (currently only one plant/clump likely to be impacted), a fully-costed translocation plan is recommended. Plants should be translocated to a suitable recipient site within secure conservation reserves (either on or off site). Any translocation should be undertaken in accordance with the *Procedures Statement for the Translocation of Threatened Native Flora in Victoria* (DEPI 2013b) and the *Guidelines for the Translocation of Threatened Plants in Australia* (Commander et al. 2018). A monitoring program is often required as a part of a conservation management plan or Threatened Species Management Plan as a mechanism to report on the success and failure of the translocation as well as recommending management interventions as needed.

Suitable recipient sites would need to have similar environmental variables (e.g. soil types, position in the landscape, relatively intact understorey) and are secured for conservation purposes. This may include conservation estate such as the Snow Gums Bushland Reserve and potentially areas such as Crown Land, private bushland under conservation agreement or along the rail corridor and higher quality road reserves (although road and rail corridor sites are not typically preferred). All sites would need agreement from landowner or relevant management authority.

For remaining plants which are not being directly impacted (one known record), measures required to ensure they are protected during and post-construction include:

- No-go Zone identification/mapping, fencing and signage to protect retained native vegetation, habitat and threatened species (Section 10.4.1.1)
- pre-clearing survey for threatened flora (Section 10.4.1.1)
- weed and disease controls (Section 10.4.7.1)
- dust controls (Section 10.4.8)
- measures to prevent rubbish from entering habitat (Section 10.4.7.2).

10.3.2 BEN MAJOR GREVILLEA

The alignment passes through the southern part of Camp Hill reserve, at the southern limit of the known range for the species. Two Ben Major Grevillea plants were recorded within the C2 alignment. Whilst both are located outside of the construction footprint the current construction footprint passes within 10 m of the closest one. In this area, a fire track is proposed to be constructed, the bypass itself is located further away and in a cutting.

Mitigation measures required in this area to prevent impacts on these retained plants include:

- No-go Zone identification/mapping, fencing and signage (Section 10.4.1.1)
- pre-clearing survey for threatened flora (Section 10.4.1.1)
- dust controls (Section 10.4.8) – dust screens or other controls should be utilised in this location to ensure there are no impacts on the nearby plants from dust from the construction of the fire track
- weed and disease controls (Section 10.4.7.1).

If any new plants are found within the construction footprint during pre-clearing surveys, or design changes occur and approval to remove plants is granted, a fully-costed propagation and ex situ conservation management plan may be required. This should occur in a suitable recipient site within secure conservation reserves (either on or off site), which would likely include Camp Hill State Forest and Musical Gully State Forest.

Ben Major Grevillea can be grown easily from cuttings (Bill Blackburn pers. comm.) but are considered difficult to grow from seed (Nick Jaschenko pers. comm.). Further research is likely needed to understand mechanisms which might break the dormancy in the seeds (e.g. smoke water treatment) to enable a greater number of individuals to be grown. It is not known if translocation has been trialled but it is unlikely to be suitable for a shrub with deep, sprawling roots through hard, rocky soils. Part of a conservation management plan may need to involve relevant agencies (e.g. universities) and experts in Grevillea propagation to assist with appropriate propagation techniques.

Suitable recipient sites would need to have similar environmental variables (e.g. soil and geology types, north-facing position in the landscape, relatively intact understorey) and be secured for conservation purposes. Any future recipient sites would need to minimise inappropriate fire regimes such as repeated fires without adequate time for plants to meet maturity and spread seed. All sites would need agreement from landowner or relevant management authority.

10.3.3 RIVER SWAMP WALLABY-GRASS

There are two records of River Swamp Wallaby-grass within the C2 project area, one of which will be impacted by the current construction footprint.

For any plants which cannot be avoided a fully-costed translocation and/or restoration plan including seed collection is recommended. Plants should be translocated to a suitable recipient site within secure conservation reserves (either on or off site). Any translocation should be undertaken in accordance with the Procedures Statement for the Translocation of Threatened Native Flora in Victoria (DEPI 2013b) and the Guidelines for the Translocation of Threatened Plants in Australia (Commander et al. 2018). A monitoring program is often required as a part of a conservation management plan or Threatened Species Management Plan as a mechanism to report on the success and failure of the translocation as well as recommending management interventions as needed.

Suitable recipient sites would need to have similar environmental variables (e.g. soil types, water regime, position in the landscape) and are secured for conservation purposes.

The mitigation approaches used to mitigate impacts from the Peninsula Link freeway in the south-east region of Melbourne *(Southern Way 2013)* was to:

- retain substantial areas of the habitat found
- collect seed from the species to propagate to introduce to other areas
- fence off areas to be retained during construction as a No-go Zone
- increase water flows into the wetland area to improve the long-term habitat viability for the species.

Similar mitigation measures should be applied to the River Swamp Wallaby-grass populations in the study area. Collecting of seed from the population to be impacted and propagating to introduce to WSRD ponds should be considered. In addition, to protect the retained River-Swamp Wallaby-grass, the following measures are likely to be important:

- No-go Zone identification/mapping, fencing and signage to protect retained populations (Section 10.4.1.1)
- pre-clearing survey for threatened flora (Section 10.4.1.1)
- erosion and sedimentation controls to protect wetland habitat (Section 10.4.7.3)
- dust controls, which may include dust screens where works are occurring near known habitat (Section 10.4.8)
- WSRD elements to ensure that changes to drainage which may affect this species do not occur (Section 10.4.7.4)
- overland seasonal flows to be maintained or not significantly altered
- measures to prevent rubbish from entering habitat (Section 10.4.7.2).

10.3.4 BROLGA

The preferred alignment will impact 1.52 ha of medium quality wetland bird habitat (i.e. Brolga habitat). There may also be additional impacts from noise, light and the presence of artificial structures and car movement. Given the species status under the FFG Act and their low breeding success, species-specific mitigation measures should be implemented to protect brolgas from impacts associated with the project.

New research suggest that creating and restoring wetland complexes is more likely to improve breeding success for Brolgas than managing single wetlands (Veltheim, I. et al. 2019). In addition, the *Action Statement for Brolga Grus rubicunda* (DuGuesclin 2003) outlines management actions to ensure the species' protection including, but not limited to, the following;

- brolga survey and monitoring
- habitat protection, including from modified drainage schemes, flood regimes and increased salinity in freshwater systems
- predator control to reduce the risk of red foxes preying on eggs and chicks

Measures proposed for this project to mitigate impacts as far as practicable on Brolga include:

- No-go Zone identification/mapping, fencing and signage to protect retained habitat (Section 10.4.1.1)
- minimise the use of lighting where possible, especially near wetland habitat. Where lighting is required, consider fauna sensitive lighting designs (Section 10.4.5)
- use barriers and vegetation screening to shield sensitive habitat from noise, light and visual impacts, particularly through wetland habitat. For example, the area in the Yam Holes Creek valley will need noise attenuation to reduce the effects of noise on the large wetland, such as a height extension to the road barrier (Sections 10.4.4, 10.4.5 and 10.4.6)
- time construction works to avoid the breeding season of potentially impacted species
- revegetation and habitat creation for this species to be included in the landscape plan (Section 10.4.1.2)
- dust controls, which may include dust screens or other measures as required where works are occurring near known habitat (Section 10.4.8)
- implement appropriate sedimentation and erosion controls near waterways (Section 10.4.7.3)
- WSRD elements to minimise surface water changes (Section 10.4.7.4)
- weed management and control measures (Section 10.4.7.1)
- measures to prevent rubbish from entering habitat (Section 10.4.7.2).

10.3.5 BROWN TOADLET

1.680 ha of potential habitat for Brown Toadlet will be impacted based on the current construction footprint. Potential habitat for Brown Toadlet occurs in Yam Holes Creek, draining lines and small dams. Mitigation measures are required to reduce the risks associated with physical barriers to movement, increased risk of injury and mortality and significant changes in surface water hydrology.

Threatened Species Management Plans for the Western Highway Project utilised specific No-go Zones for Brown Toadlet to reduce the risk of impact to the species. In addition, Brown Toadlet salvage and translocation was undertaken before and during construction of the project (MRPV 2020c; VicRoads 2014).

Species-specific mitigation measures proposed for this project to mitigate impacts as far as practicable on Brown Toadlet include:

- No-go Zone identification/mapping, fencing and signage to protect retained habitat (Section 10.4.1.1)
- install underpasses, such as drainage structures, to help maintain landscape connectivity (Section 10.4.2) in combination with barriers that prevent wildlife from accessing the road (Section 10.4.3.2).
- minimise the use of lighting where possible, especially near waterways. Where lighting is required, consider fauna sensitive lighting designs (Section 10.4.5).
- revegetation and habitat creation for this species to be included in the landscape plan (Section 10.4.1.2)
- implement appropriate sedimentation and erosion controls near waterways (Section 10.4.7.3)
- WSRD elements to minimise surface water changes (Section 10.4.7.4)
- weed management and control measures (Section 10.4.7.1)
- dust controls, which may include dust screens or other measures as required where works are occurring near known habitat (Section 10.4.8)
- measures to prevent rubbish from entering habitat (Section 10.4.7.2).

10.3.6 BRUSH-TAILED PHASCOGALE

The construction footprint of the preferred alignment is likely to impact on a total of 22.58 ha of moderate and high quality habitat for Brush-tailed Phascogale, including areas of mature native vegetation such as Camp Hill State Forest and habitat along road reserves and on private property. Impacts on this species include direct loss of habitat, fragmentation, changes to wildlife movement and mortality from the construction and operational phase of the project. As such, mitigation will be required.

Canopy bridges, which would be beneficial to Brush-tailed Phascogale, have successfully been used in several road projects including Pacific Highway in northern NSW, Hume Freeway in Victoria and southern NSW and across Moreton Bay Regional Council. In addition, the Echuca Moama Bridge Project in north Victoria implemented several mitigation measures to reduce the impact on Squirrel Glider (WSP 2019). Such mitigation measures can also be adopted for Brush-tailed phascogale and include the following:

- avoid artificial lighting wherever possible and, where lighting is required, keep it to a minimum and design to be wildlife-friendly, particularly through woodland habitat
- use barriers and vegetation screening to minimise noise and headlight impacts, particularly through woodland habitat
- landscaping design to re-create natural vegetation composition, structure and improve connectivity.
- incorporate connectivity structures/measures into the detailed design

Mitigation measures proposed for this project to mitigate impacts as far as practicable on Brush-tailed Phascogale include:

- No-go Zone identification/mapping, fencing and signage to protect retained habitat (Section 10.4.1.1)
- install appropriate crossing structures such as a canopy rope bridge (Section 10.4.2.2)
- minimise the use of lighting where possible, especially near areas of known habitat such as Camp Hill State Forest. Where lighting is required, consider fauna sensitive lighting designs (Section 10.4.5)
- revegetation and habitat creation for this species to be included in the landscape plan (Section 10.4.1.2)
- weed management and control measures (Section 10.4.7.1)
- measures to prevent rubbish from entering habitat (Section 10.4.7.2).

10.3.7 GROWLING GRASS FROG

The current construction footprint impacts aquatic and terrestrial potential habitat for this species and bisects areas of potential habitat. As such, mitigation will be required. The findings in (Heard, GW & Scroggie 2009) showing the strong relationship between connectedness of habitat and recolonization provide direction for mitigating the impacts of urbanisation including maintaining or enhancing wetland hydroperiods, aquatic vegetation cover and connectivity of habitat (Heard, Geoffrey, Scroggie & Clemann 2010).

Various mitigation approaches for this species have been incorporated into other road and related linear infrastructure projects including salvage, creation of new suitable wetland habitats, installation of ‘frog friendly’ wildlife crossings, and installation of fences to prevent frogs from accessing the road to reduce mortality.

Some of these specific mitigation strategies were deployed for the Pakenham Bypass. Ten culverts were installed and 32 wetlands (ponds) were created during construction. The underpasses were located within 500 m of ponds known to support Growling Grass Frog. Created ponds were located at the entrance of underpasses, right of ways and on natural drainage lines along the length of the bypass. Drift fences were installed parallel to the bypass to prevent frogs moving onto the road and to direct them to the underpasses (Gleeson & Gleeson 2012).

Mitigation proposed for Growling Grass Frog includes:

- maintaining connectivity for the species through crossings and strategic habitat creation (refer Section 10.4.2 and below)
- reinstatement of temporary impacts to habitat which may support overwintering or movement of Growling Grass Frog
- No-go Zone identification/mapping, fencing and signage to protect retained habitat (Section 10.4.1.1)
- salvage from impacted ponds if required. This may not be required for Growling Grass Frog as the species has not recently been recorded from within the study area, however salvage and relocation of all wetland fauna from impacted wetlands should be considered
- appropriate disease controls to minimise spread of the waterborne fungal pathogen *Batrachochytrium dendrobatidis* which causes the disease chytridiomycosis (chytrid fungus) (Section 10.4.7.1)
- erosion and sedimentation controls to protect wetland habitat (Section 10.4.7.3). Where possible, earthworks and storage of material near Yam Holes Creek and other waterbodies should be avoided, particularly in the spring/summer breeding season
- dust controls, which may include dust screens where works are occurring near potential habitat (Section 10.4.8)
- WSRD elements to ensure that changes to drainage which may affect this species do not occur (Section 10.4.7.4). Overland seasonal flows to be maintained or not significantly altered
- measures to prevent rubbish from entering habitat which may include gross pollutant traps if WSRD and fencing utilised at crossing points is not sufficient (Section 10.4.7.2)
- construction should occur using techniques which minimise impacts on wetlands which are partially within the construction footprint to avoid impacts on the retained potential habitat. Direct impacts on wetlands and ponds should outside of the spring/summer breeding season if possible.

The standards of effective crossing structures for Growling Grass Frogs have been published by DELWP (2017) and will be followed along C2, and include the following:

- structures across both waterways and dry ‘terrestrial’ environments are required
- structures across waterways should be wide enough to allow frogs to travel along the banks of the waterway during high flow events and to maintain natural relatively natural climatic and lighting conditions along the waterway
- for these reasons, bridge structures with open spans are preferred over culvert structures
- the structure should be as open as possible, with a wide and tall entrance and short length
- the crossing structure should be readily encountered by the frogs and be positioned approximately 50 m apart
- if culverts are to be used as aquatic crossings, these should be permanently inundated
- regular box-cell culverts that remain dry are not recommended because they have not been shown to be used by Growling Grass Frogs.

The currently proposed crossings, including crossings for this species are described in Section 10.4.2. Four crossing points for Growling Grass Frog are currently proposed.

In addition to the standards in DELWP 2017, the Fauna Sensitive Road Design Guidelines (VicRoads 2012a) also recommends maintaining connectivity, as well as creating habitat for frogs including frog ponds and wetlands and the use of fencing to funnel frogs towards the crossings.

Any habitat creation for this species, including at culvert entrances, must consider the Growling Grass Frog habitat requirements as described by (Heard, Geoffrey, Scroggie & Clemann 2010), including: water surface area, hydro period, aquatic vegetation cover, water depth, water chemical composition and landscape requirements. They should also consider the habitat design standards (DELWP 2017d). Habitat preferences of this species should also be considered in the design of WSRD ponds, where possible.

Mitigation measures will need to be included within a Threatened Species Management Plan.

10.3.8 GOLDEN SUN MOTH

Options for mitigation strategies for Golden Sun Moth impacts are somewhat limited due to the low mobility and specific habitat requirements of the species. Recreation/planting of Golden Sun Moth habitat is a suitable option and should be considered as close as possible to impacts on known habitat to maximise likelihood of colonisation of the habitat. Translocation of the species has been trialled with some success in the ACT for the Majura Parkway Upgrade Project (ACT Government 2017), however translocation should not be relied-upon as a mitigation strategy.

With regard to connectivity for the species, Golden Sun Moths are likely to be difficult to funnel towards a small crossing structure such as a culvert, and the low light, unsuitable substrate (lack of grasses) and cooler temperatures are likely to be prohibitive to them using most crossing structures anyway. Therefore, larger crossing structures, such as land bridges and open span bridges are likely to be most effective for this species. These should be considered in detailed design, but may not be practicable for the project and are not currently part of the proposed connectivity structures (Section 10.4.2). The Fauna Sensitive Road Design Guidelines (VicRoads 2012a) recommends the following mitigation strategies specifically for Golden Sun Moth:

- when designing underpasses for larger species, consider designs that cater for species such as the Golden Sun Moth
- landscape using habitat plants which cater for species such as the Golden Sun Moth. Consider planting species such as the preferred Wallaby Grasses which occur in the study area to increase the area of habitat and to attract them to suitable crossing structures
- in general landscape plantings should use indigenous species and should consider catering for invertebrates. (note: planting of trees in retained Golden Sun Moth habitat should be avoided.)

Measures proposed for this project to mitigate impacts as far as practicable on this species are:

- No-go Zone identification/mapping, fencing and signage to protect retained habitat (Section 10.4.1.1)
- revegetation and habitat creation for this species to be included in landscape plan (Section 10.4.1.2 – Note: extent of habitat creation is not yet known)
- dust controls, which may include dust screens or other measures as required where works are occurring near known habitat (Section 10.4.8)
- WSRD elements to minimise surface water changes (Section 10.4.7.4)
- weed management and control measures (Section 10.4.7.1)
- measures to prevent rubbish from entering habitat (Section 10.4.7.2).

Mitigation measures will need to be included within a Threatened Species Management Plan. Provision of Commonwealth offsets for Golden Sun Moth are included within Section 12.

10.3.9 LITTLE GALAXIAS

Impacts on this species include direct loss of potential (although not current) habitat, fragmentation, shading and potential changes in surface water hydrology and quality. As such, mitigation will be required.

Several mitigation approaches for Galaxias have been used in other road and related linear infrastructure projects (mostly for the related Dwarf Galaxias) including construction of fish passages, improving water quality and run-off from roads and creating new habitats. The approaches used to mitigate impacts on Dwarf Galaxias from the Peninsula Link freeway in the south-east of Melbourne (Southern Way 2013) was to:

- create new ponds and enhance habitats
- apply water sensitive road design to ameliorate water flows from road surfaces and improve overall water quality
- revegetate surrounding wetland and riparian areas
- design waterways to allow for unimpeded fish crossings.

The Fauna Sensitive Road Design Guidelines (VicRoads 2012a) recommends the following mitigation strategies for Dwarf Galaxias, which would also apply to Little Galaxias:

- installation of baffles in new and existing culverts
- creation of habitat to allow for unimpeded fish movement along the waterway
- avoid creating waterways with sharp bends and strong currents.

Where works are to occur in-stream or in the vicinity of a waterway, there is a range of industry standard and best practice mitigation measures that should be implemented to protect aquatic habitat and water quality during construction, such as those applied in the Beaufort to Ararat Western Highway duplication (McGuckin 2014). These mitigation measures will also act to protect Little Galaxias and their habitat.

Based on the above, mitigation proposed for Little Galaxias for this project include:

- during construction works, flow connectivity should be maintained and unimpeded along Yam Holes Creek at all times that water is present and/or during flooding events
- No-go Zone identification/mapping, fencing and signage to protect retained habitat (Section 10.4.1.1) to include habitat and a 30 m buffer area off potential habitat. No access should occur in No-go Zones except for access for conservation works, supervised by an ecologist
- connectivity structures for Little Galaxias should be included in the final design, refer to proposed structures and design guidelines in Section 10.4.2. Bridges are proposed across Yam Holes Creek to maximise connectivity in this area for this species
- WSRD elements should be installed to minimise surface water changes (Section 10.4.7.4) and should take into consideration potential habitat for this species
- sediment and erosion controls as per Section 10.4.7.3 including the following.
  - control measures should be installed to prevent construction area sediments from entering waterways (e.g. silt fences, sausage/inlet filters, straw bale sediment traps, etc.)
  - stormwater management: temporary and/or permanent stormwater management devices should be installed and maintained to ensure stormwater quality and quantity is at pre-construction levels and/or meets relevant state guidelines/triggers (e.g. State Environment Protection Policy)
- store fuel and chemicals outside of flood zones and have designated refill areas to minimise the risk of pollution. Develop a contingency plan for containment, treatment and disposal of any spills
- measures to prevent rubbish from entering habitat (Section 10.4.7.2) which could include gross pollutant traps where WSRD measures are not sufficient.

It is highly recommended that consideration be given to bridging over habitat instead of use of culverts on Yam Holes Creek. This will minimise impacts and provide maximum connectivity for the species. Mitigation measures will need to be included within a Threatened Species Management Plan.

10.3.10 SEASONAL HERBACEOUS WETLANDS (FRESHWATER) OF THE TEMPERATE LOWLAND PLAINS

Key measures required for this community are:

- No-go Zone identification/mapping, fencing and signage to protect retained wetland areas (Section 10.4.1.1)
- sediment and erosion controls to prevent construction area sediments from entering waterways (Section 10.4.7.3)
- WSRD elements to be installed where required to minimise changes in surface water hydrology which may impact this community (Section 10.4.7.4). Hydrological regime to mimic pre-existing conditions to reduce adverse impacts on seasonal wetland hydrology. (Although note: flood modelling, catchment calculations and water quality modelling was undertaken in the Surface Water Report (WSP 2020d). For impacts on flooding regimes, only Wetlands 35649 and 35402 will experience changes in their flooding regimes but these changes are expected to be minimal and mainly occur at the high order events, with most significant impacts occurring within the project boundary. The impacts on the wetlands are therefore considered to be minor.)

- to manage impacts on water quality, sedimentation and increases in flows from road surface, areas for enhanced treatment (e.g. treatment swales, bioretention ponds) are to be built
- store fuel and chemicals outside of flood zones and have designated refill areas to minimise the risk of pollution. Develop a contingency plan for containment, treatment and disposal of any spills
- measures to prevent rubbish from entering habitat where required (Section 10.4.7.2), which may include gross pollutant traps where WSRD elements are not sufficient
- dust controls as appropriate should be utilised to ensure there are no impacts on the community from dust during construction (Section 10.4.8)
- habitat restoration or creation of habitat around culverts where new crossings are proposed to include wetland vegetation
- weed and disease controls during construction and road maintenance including monitoring and targeted control (Section 10.4.7.1).

Mitigation measures will need to be included within a Threatened Species Management Plan.

10.3.11 VICTORIAN TEMPERATE WOODLAND BIRD COMMUNITY

The current construction footprint of the preferred alignment impacts on 32.80 ha of this FFG Act listed community. Without the implementation of appropriate mitigation measures, impacts to this community may also occur outside of the construction footprint, particularly from unapproved clearing, dust and weeds. Several mitigation approaches for VTWBC have been used in other road and related linear infrastructure projects. For example, approaches used to mitigate impacts on VTWBC from the Echuca Moama Bridge Project in north Victoria (WSP 2019) include the following:

- pre-clearing targeted surveys
- staged habitat removal
- habitat improvement works including weed control and revegetation/infill planting
- re-use woody debris (i.e. dead or living tree trunks, root balls, branches and leaves)
- undertake monitoring before, during and after construction.

Based on the above, and with consideration to secondary impacts, mitigation measures proposed for VTWBC for this project include:

- pre-clearing surveys to detect community presence in and surrounding the construction zone. If practicable, clearing should be postponed in the vicinity of breeding fauna until young have fledged
- staged habitat removal to allow time for fauna to disperse from the construction zone prior to felling of habitat trees
- habitat improvement works including weed control and revegetation. Revegetation works within the project area should aim to re-create the original vegetation structure and floristics of the community
- where appropriate, woody debris removed to facilitate construction of the proposed alignment should be re-used to create new habitat or enhance habitat adjacent to the project
- No-go Zone identification/mapping, fencing and signage to protect areas of retained VTWBC (Section 10.4.1.1)
- measures to prevent rubbish from entering habitat, which may include roadside fencing where appropriate (Section 10.4.7.2)
- weed and disease controls during construction and road maintenance including monitoring and targeted control (Section 10.4.7.1).

10.3.12 WHITE BOX – YELLOW BOX – BLAKELY'S RED GUM GRASSY WOODLAND

Although this community is unlikely to be impacted by the project, precautionary mitigation includes:

- No-go Zone identification/mapping, fencing and signage to protect retained threatened community (note that nearest patch is approx. 80 m from construction footprint) (Section 10.4.1.1)
- measures to prevent rubbish from entering habitat, which may include roadside fencing where appropriate (Section 10.4.7.2)
- dust controls as appropriate should be utilised to ensure there are no impacts on the community from dust during construction (Section 10.4.8)
- weed and disease controls during construction and road maintenance including monitoring and targeted control (Section 10.4.7.1).

10.4 GENERAL MITIGATION MEASURES

The measures provided in this Section are in response to the types of impacts described in Section 9. They have been developed to mitigate risks upon biodiversity, not limited to Matters of National Environmental Significance, State significant species and communities and wildlife protected under the *Wildlife Act* and *FFG Act*. They include some of the standard controls provided in Section 177 (VicRoads 2016a) with additional detail or additional measures targeted to the specific significant values at the study area. This section also outlines the likely or known effectiveness of each mitigation approach.

Monitoring the effectiveness of these mitigation measures upon listed ecological values is required to determine whether additional measures are required after construction to further mitigate impacts (additional planting, weed control, fences etc). This evaluation will also provide valuable information regarding the effectiveness of mitigation measures, which will contribute to future projects. Should the results of the evaluation program indicate that the mitigation measures in place are insufficient, additional actions should be taken.

10.4.1 LOSS OF VEGETATION AND HABITAT

The measures required to minimise and control vegetation and habitat loss on site during construction are provided in Section 10.4.1.1.

10.4.1.1 MINIMISING IMPACTS TO VEGETATION AND HABITAT DURING CONSTRUCTION

The following mitigation measures should be implemented:

- Citing of laydowns, site offices, temporary access tracks, relocation of utility services etc within the construction footprint or outside of native vegetation and habitat, as identified on Appendix K, No-go Zone map. Given the amount of cleared pasture in the study area, this is highly feasible.
- Development project-wide No-go Zones which maps all native vegetation and fauna habitat outside the construction footprint to ensure it is not impacted during construction (see Appendix K, No-go Zone map).
- Install temporary fencing around vegetation and habitat that is to be retained (No-go Zones). No-go Zones should be fenced conservatively (i.e. with a vegetative buffer of at least two metres) where possible. No-go Zones should be well defined visually in the field and identified to all work crews as part of an induction undertaken on site. Some revision of the No-go Zones will be required once the design has been finalised to ensure that they are workable.
- The temporary fencing should be inspected on a regular basis to ensure it remains intact and vegetation is being protected.
- No access should occur in No-go Zones except for access for conservation works, supervised by an ecologist.

- When fencing the No-go Zones, ensure that fencing includes the Tree Protection Zones (TPZs) of trees to be retained. Unless specific advice to the contrary has been obtained from an arborist, the TPZ is defined for standing trees and stags (dead but upright trees) as follows:
  - Live trees: an area around the trunk of the tree which has a radius of 12 x the diameter at breast height (to a maximum of 15 metres but no less than 2 metres in diameter) and/or an area sufficient to protect the Structural Root Zone (SRZ) as identified in consultation with an arborist. The Australian standard AS 4970-2009 Protection of trees on development sites sets the standard for Tree Protection Zones (TPZ) and Structural Root Zones (SRZ) that should be protected. This is referred to in the *Assessor's handbook – Application to remove, destroy or lop native vegetation* (DELWP 2017b). The Australian standard AS 4970-2009 outlines a number of activities are restricted within the TPZ including but not limited to:
    - machine excavation including trenching
    - excavation for slit fencing
    - cultivation
    - storage
    - preparation of chemicals, including preparation of cement products
    - parking of vehicles and plant
    - refuelling
    - dumping of waste
    - wash down and cleaning of equipment
    - placement of fill
    - lighting of fires
    - soil level changes
    - temporary or permanent installation of utilities and signs
    - physical damage to trees.
  - Restricted activities listed above outside the construction footprint (including the 10 m buffer area) and within TPZs of No-go Zones cannot take place within SCO.
  - Dead (stag) trees: an area around the trunk of the tree which has a radius of 15 metres from the base as defined in the *Assessor's handbook – Application to remove, destroy or lop native vegetation* (DELWP 2017b).
- If the works involve an impact to an area of greater than 10% of a TPZ and/or within the SRZ of a tree, an arborist is required to conduct a root investigation to determine if the tree will remain viable. Unless determined otherwise by a suitably qualified and experienced arborist, the tree will be considered 'removed' for purposes of the *Guidelines for the Removal, Destruction or Lopping of Native Vegetation* (DELWP 2017e) and will need to be offset. Lopping of canopy trees in excess of what is provided for in the 'lopping and pruning for maintenance exemption in Clause 52.17' is also treated as assumed lost, unless an arborist report concludes that the tree will survive (DELWP 2017b).
- Locate any access/fire tracks, storage areas, compounds, creek realignments or service relocations within the defined current construction footprint wherever possible, preferably in areas devoid of native vegetation. All areas utilised for access, storage, or otherwise impacted by the works must be accounted for in the final project construction footprint and any impacts to native vegetation must be offset.
- Prior to the commencement of any works, brief contractors regarding the protection of vegetation and the purpose for avoiding impacts in No-go Zones and minimising impacts outside of the construction footprint.
- Utilise temporary signage to clearly identify areas as environmentally sensitive zones or No-go Zones.
- Prior to works commencing, a pre-clearing survey for threatened flora will need to be conducted. Any flora listed under the EPBC Act or FFG Act recorded within the study area (outside of existing No-go Zones) should be fenced off (to establish a new no go zone) or relocated to nearby habitat that is not proposed to be impacted.

- Prior to works commencing, a pre-clearing survey for threatened fauna will be required. Monitoring and fauna salvage by an ecologist will also be required during clearing, which should be conducted in two stages. Further information on measures to minimise fauna mortality is provided in Section 10.4.3.1.
- Monitoring and reporting of all of the above.

10.4.1.2 REHABILITATION, HABITAT CREATION, AND LANDSCAPE PLAN

Rehabilitation of any areas temporarily disturbed by the works (equipment storage areas, access tracks, etc.) should be completed following works, with revegetation using only site-indigenous species from the study area's EVCs with plants or seed of local provenance. Additional revegetation in the study area is recommended where this may help shield habitat from light and visual impacts (refer Sections 10.4.5 and 10.4.6), buffer habitat, or improve connectivity.

Planting should be undertaken with reference to planting densities in Appendix 1 of Native vegetation gain scoring manual Version 2 (DELWP 2017f) and be incorporated into the landscape plan for the project. The landscape plan, should also include any buffer zones around important habitat areas, the location and reason for No-go Zones, and the location and type of barriers (including vegetation, walls or fences as required) in order to reduce impacts upon fauna habitat (particularly threatened species) occurring adjacent to the study area.

Creation of habitat for Golden Sun Moth should occur near known habitat. Planting of trees which may shade known habitat for this species should be avoided. If crossing points for this species are deemed feasible during detailed design, creation/planting of habitat should occur on either side. Creation of habitat (including wetland ponds) for Growling Grass Frog should also occur at minimum at the entrances of culverts designed for connectivity for this species (refer to the following section). Habitat creation should be included in the landscape plan.

A considerable number of large trees are proposed for removal which will result in the loss of numerous hollows which provide valuable habitat for fauna. A tree re-use program should be developed for the project which specifies how the cleared trees will be re-used and the number and type of replacement logs and hollows to be installed. This program should specify the locations of installation, the methods of installation (e.g. carved hollow, nest box or log hollow) and any maintenance and monitoring requirements. Preference should be given to tree re-use and replacement hollows that are more natural and represent highest value ecological uses. For example, re-use of trees should preference habitat enhancement uses rather than firewood, and more natural hollows (e.g. carved hollows and log hollows) should be a preference over nest boxes.

A 'Better Best Practice Note - Repurposing Felled Trees' by Loci Environment and Place (Loci Environment 2017) outlines a hierarchy of re-use for timber that is felled for development projects. Once it has been determined that a tree must be removed, the re-use hierarchy is:

1. habitat logs [hollows and terrestrial logs – refer below]
2. milling
3. commercial woodchip [refer below]
4. arborist woodchip [refer below]
5. sawdust.

Woodchips should generally not be spread outside of the construction footprint or within No-go Zones as they may smother the native vegetation and significant flora present.

With regard to habitat logs, both arboreal and terrestrial use should be considered. For trees being removed that contain hollows, the section of the tree containing the hollow can be removed and reinstalled in trees outside the proposal footprint to increase the habitat value of another patch of vegetation. Due to past clearing of large trees in the area, hollows are extremely valuable, particularly medium to large-sized hollows, and a hollow replacement strategy is recommended to re-use hollows felled on site. A ratio of hollow replacement should be considered (e.g. 1:1 replacement of installed hollows to hollows being removed, or two hollows replaced per hollow-bearing tree removed) targeted in areas that are lower in natural hollows.

Due to past removal of fallen timber for firewood etc, large logs are generally rare in the landscape. Careful distribution of habitat logs should occur away from tracks and parking areas or behind bollards and fencing (to minimise theft risk), and in a way that minimises disturbance of understorey vegetation. Specific locations for log placement/enhancement should be determined during detailed design. Tree and tree hollows should be placed into areas that are secured and managed for conservation to ensure they provide habitat into the future and not removed.

Opportunities for any ecological restoration of acquired land which is not intended for use for road or associated infrastructure should be explored, as undertaken on other parts of the Western Highway.

10.4.1.3 POTENTIAL IMPACTS RESULTING FROM MITIGATION MEASURES

A number of fauna crossing structures such as open span bridges, culverts, land bridges and rope ladders have been proposed as mitigation measures in Section 10.4.2.2. A detailed appraisal of the design features will occur at the detailed design phase, however any mitigation measures are expected to be contained within the construction footprint. See extract from maps in Appendix K Wildlife crossings showing locations of crossings in respect to construction footprint.

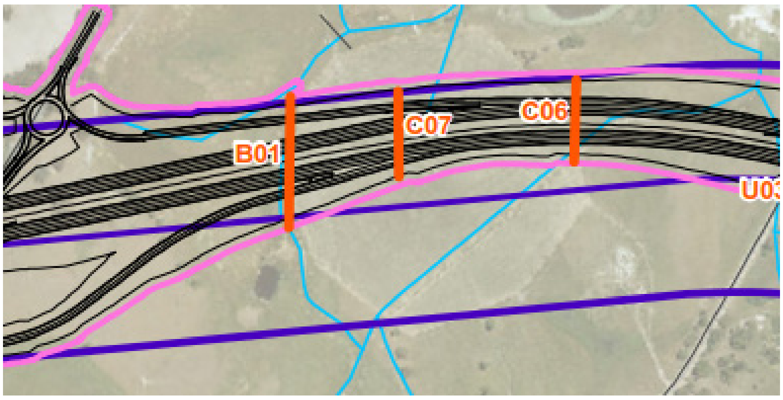
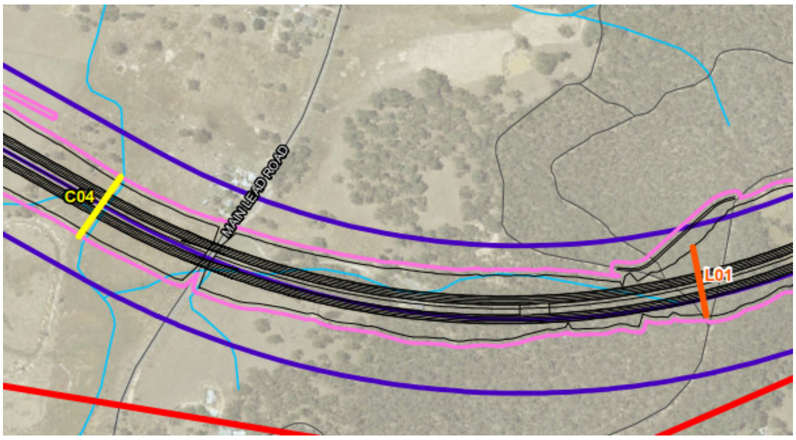
	Example area between Racecourse Road and Beaufort-Lexton Road where fauna crossing locations are proposed.
	Example of wildlife crossings near Main Lead Road

Figure 10.1 Extract of wildlife crossing maps in respect to construction footprint

10.4.2 LOSS OF CONNECTIVITY

There are many opportunities along the roadway to effectively enhance connectivity for wildlife across the road between patches of habitat. The locations where loss of connectivity is considered most likely to affect species such as Brush-tailed Phascogale and woodland birds is the cutting through Camp Hill State Forest and other locations where wooded habitat is dissected by the road (see Section 7.2). The movement of Kangaroos across the road, primarily through cleared farmland and between treed areas and waterbodies will also be affected.

General design features suggested to promote connectivity across the road include:

- the use of structures designed to improve connectivity should be used to facilitate safe passage across the road and discourage fauna from crossing the road at grade. Fauna crossings such as a vegetated land bridge should be considered in Camp Hill State Forest. Rope bridges connecting tree canopies should also be considered in Camp Hill State Forest, and in other locations where the road fragments woodland habitat. Underpasses, including drainage structures, bridges and dedicated wildlife crossings should be incorporated in areas where the roadway is elevated, including for Little Galaxias and Growling Grass Frog. Specific recommendations on the location of fauna crossings are detailed in the following section
- undertake a detailed feasibility study to explore options for a land bridge for where the road passes through Camp Hill State Forest
- plantings appropriate to the site's pre-clearance EVCs, using local provenance, indigenous flora. Wetland plantings in modified drainage swales may create additional stopover points for wetland birds to improve connectivity. This would need to be undertaken with consideration of fauna mortality risk. It could occur in conjunction with barriers, plantings or similar which minimise this risk. Locations where potential strategic revegetation could facilitate connectivity with suggested crossing structures are mapped in Appendix K
- consideration of terrestrial habitat requirements for the Growling Grass Frog in revegetation and habitat creation and inclusion in landscape plans, to improve terrestrial habitat quality for the species, particularly between potential habitat ponds in or near the preferred alignment. This may include planting of tussock species, avoiding regular short slashing of groundcover within terrestrial habitat and the addition of rocks and logs for shelter
- landscape plans to incorporate large scattered trees that are retained within the study area, and with the aim to establish connectivity between these trees and any remnant patches of habitat in adjacent properties, where possible
- where possible, relocation of logs cut from trees to be removed to sites within, or at the perimeter of, remnant patches and areas of retained habitat within the study area. These structures can contribute to habitat values for the region's fauna and flora, including threatened species. Consideration of log placement sites will be required to ensure the timber is protected and is not readily accessible by passers-by wishing to harvest firewood. Logs placed within fauna underpasses and on the land bridge will facilitate movement by wildlife.

The detailed design of features to mitigate loss of connectivity should be developed in consultation with ecologists, with consideration of the ecology of the relevant species most requiring mitigation. Further outlinging of details on each of these mitigation measures is provided in Section 10.4.2.2.

10.4.2.1 MITIGATION MEASURE MODELLING

The Wildlife Connectivity Impact and Mitigation Assessment (Lechner et al. 2019) in Appendix M highlighted ideal locations for investigating the effect of incorporating a land bridge and nine rope bridges into the design of preferred alignment C2. Analysis of the resultant increases in connectivity after the crossing structures were included demonstrated significant improvement in landscape permeability for Brush-tailed Phascogales and Echidnas (Figure 10.3 and Figure 10.4), and modest improvements in connectivity for woodland birds (Figure 10.2). However, the greatest benefit for woodland birds is likely to be the reduction in mortality as a result of preferential use of the land bridge, which was not able to be modelled using the GAP CLoSR framework. Improvements in connectivity for the Growling Grass Frog was not assessed because it was assumed that the identification of crossing structures would inevitably choose the waterways and that all waterways would include structures that allowed movements of the frogs. However, the absence of using this for modelling does not equate to effective mitigation; the efficacy of connecting Growling Grass Frog populations depends on the specific design of the crossing structures and habitat created either side to maximise the crossing probability, which is covered in Section 10.4.2.4 of this report. Golden Sun Moth was not assessed for effectiveness of connectivity as the design of effective crossing structures for Golden Sun Moth are not known and cannot be modelled at the time.

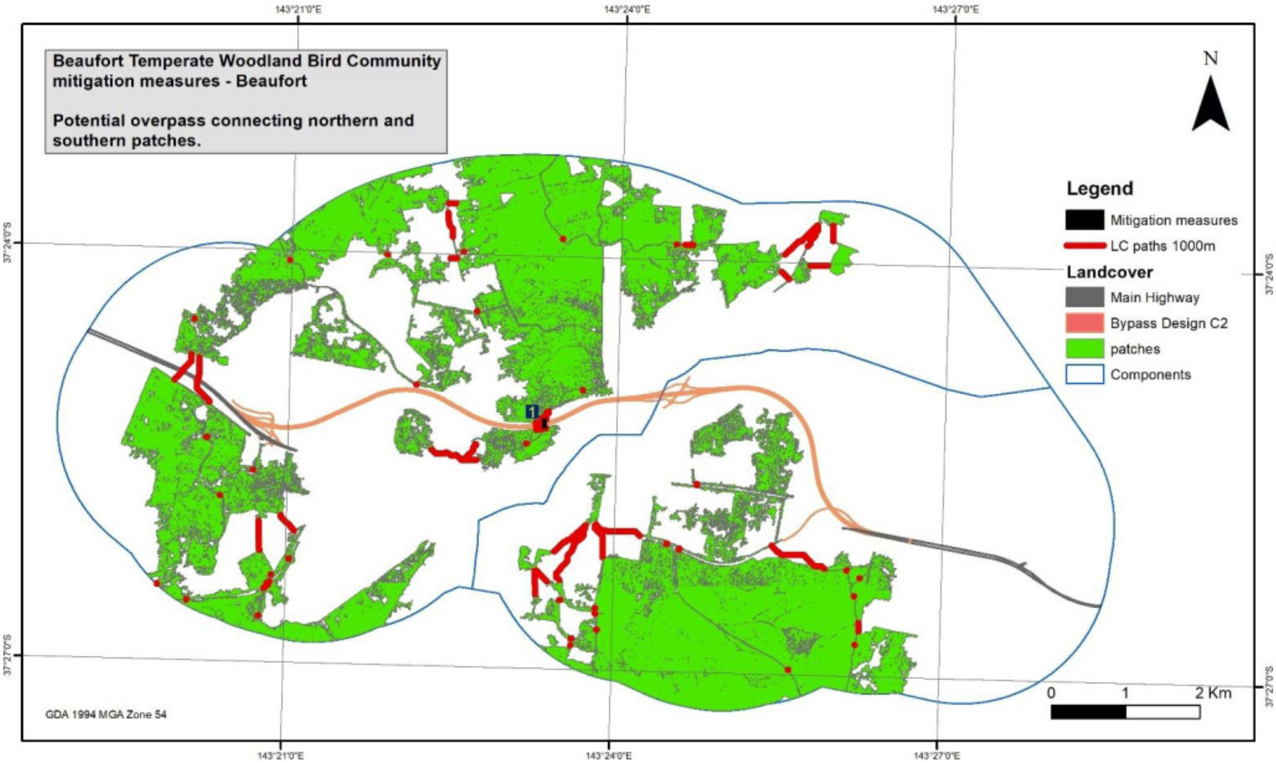


Figure 10.2 New least cost paths for Woodland Birds along Bypass design option C2 after the addition of the vegetated landbridge/overpass, denoted by the Number 1 from Appendix M

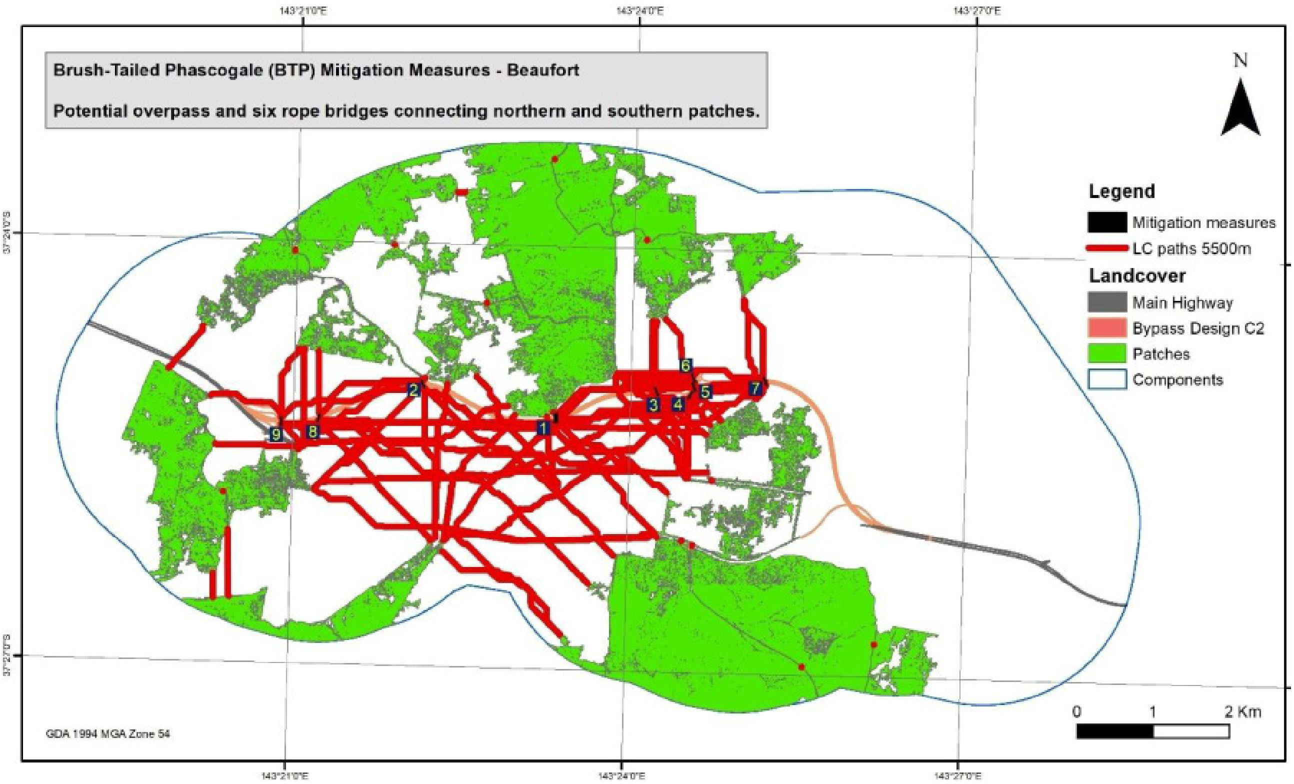


Figure 10.3 New least cost paths for Brush-tailed Phascogales along Bypass design option C2 after adding one landbridge and eight canopy rope bridges from Appendix M

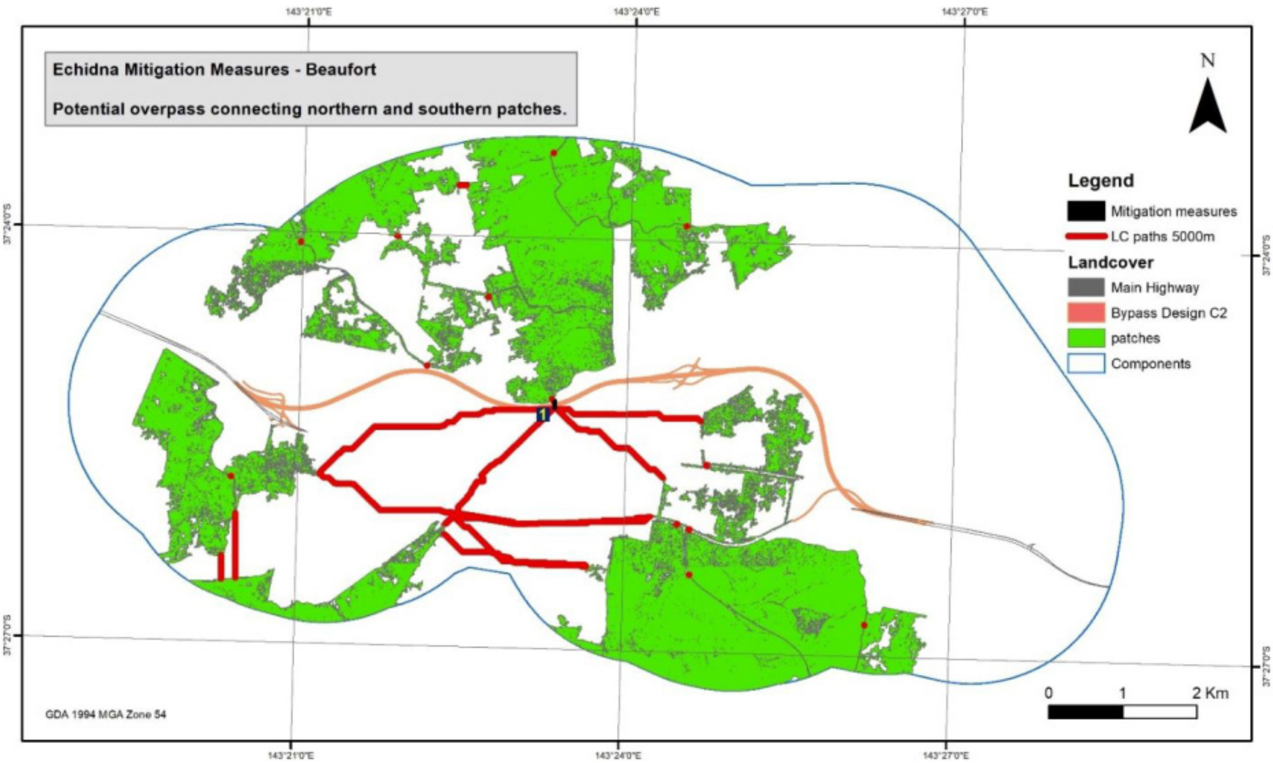


Figure 10.4 New least cost paths the Echidna along Bypass design option C2 ater the addition of the vegetated landbridge/overpass Appendix M

10.4.2.2 PROPOSED TYPES AND LOCATIONS OF CROSSING STRUCTURES FOR WILDLIFE

There are numerous locations along the C2 alignment where the road will act as a barrier or filter to the movement of wildlife and therefore structures that facilitate animal movement are recommended for further consideration during detailed design. There are also locations where wildlife will attempt to cross the roadway to access habitat on the opposite side and be at increased risk of injury and mortality due to collision with vehicles. The recommendations to restore wildlife movement and reduce rates of wildlife-vehicle collision along the roadway are detailed in Photo 10.1 and mapped in Appendix K. These are currently limited to the broad type of structure for the target species of wildlife that occurs in the location, can feasibly be built based on the current functional designs and those that have been demonstrated to improve the probability of movement. The specifics of each mitigation measure such as structure type (culvert vs open span bridge), culvert type (box vs pipe), structure size, specific location, and number of structures in each locality are specified in Section 10.4.2.3. The six broad types of mitigation are:

- land bridge
- modified drainage structure to include wildlife movement and drainage
- canopy rope bridge
- extended bridge underpass
- dedicated wildlife culvert
- strategic revegetation
- fencing to prevent wildlife from accessing the roadway and to funnel them towards the crossing structures.

LAND BRIDGE

Vegetated land bridges are the most effective approach to restoring connectivity for all wildlife because the bridge has a soil substrate in which native vegetation can grow, thus providing a continuous strip of habitat across the road (Photo 10.1 A-B). Three land bridges have been installed on the Pacific Highway in northern NSW and two have been installed in the suburbs of Brisbane, with a further two being installed in both Brisbane and near Sydney, plus one near Perth. Monitoring of these bridges in Australia has shown extensive use by a wide range of species, including birds, bats, terrestrial mammals, arboreal mammals and reptiles. Internationally, land bridges have been widely used to restore connectivity for whole communities of wildlife and hundreds have been built across roads in western Europe and North America (e.g. (Clevenger & Huijser 2011; Iuell et al. 2003). There is an increasing and overwhelming body of evidence from Australia and internationally that vegetated land bridges are the most effective approach to restore connectivity for a wide range of species (Jones & Pickvance 2013; Simpson et al. 2016; van der Ree, Gagnon & Smith 2015). Land bridges are particularly cost-effective to build when the road is in a cutting because less fill is required to build up the approaches to the land bridge, thereby reducing construction costs. A land bridge is recommended for where the road passes through Camp Hill State Forest.

MODIFIED DRAINAGE STRUCTURES

All locations where the roadway passes over waterways and flood prone areas have been identified as potentially suitable locations where the drainage structures could be modified to also facilitate animal movement. However, it should be noted that this list is neither exhaustive nor definitive, because some drainage structures may already be large enough for wildlife, some may be too small to be feasibly modified for use by wildlife, while others may not be required if a sufficiently large structure is close by (distance will vary by species). Therefore, the suitability of each drainage structure as currently proposed for use by wildlife (primarily Kangaroos, but also Black Wallaby, Echidna, frogs, some species of birds and bats) should be reviewed during detailed design and a final determination made. If designed appropriately (see Section 10.4.2.4) modified drainage structures are effective at allowing a wide range of species to pass, including terrestrial mammals, frogs, reptiles, wading birds and other species.

CANOPY ROPE BRIDGE

Rope bridges that connect tree canopies across the road are proposed for all locations where native woodland is dissected by the roadway, including large tracts of woodland and corridors of woodland along roadsides, waterways and unused road reserves. All the rope bridges as recommended on the C2 alignment are required because it is not possible to easily prevent possums, gliders, phascogales and antechinus from accessing the road or to funnel them to crossing structures because they can easily climb or jump fences. Therefore, canopy rope bridges are required wherever suitable wooded habitat occurs near the road. The final micro-position of rope bridges at each location should be determined when the extent of clearing is confirmed, including which large and hollow-bearing trees are being retained. Numerous studies from Victoria, NSW, Queensland and Western Australia have demonstrated high rates of use by a range of arboreal marsupials, including Squirrel Gliders, Sugar Gliders, Feathertail Gliders, Brush-tailed Phascogales, Common Ringtail Possums and Common Brushtail Possums, and Antechinus (Goldingay, Rohweder & Taylor 2013; Soanes et al. 2018; Yokochi & Bencini 2015); van der Ree, R. unpub. data).

EXTENDED BRIDGE UNDERPASS

Extended bridge underpasses are proposed for where the roadway is already proposed to be elevated and passes over smaller roads and the railway line, thus representing excellent opportunities to facilitate the movement of wildlife along an existing corridor of trees or other habitat. Extended bridge underpasses have an extra ~20 m of naturally-vegetated land under the roadway (e.g. Photo 10.1 C-F), adjacent to the existing low-volume road or railway, and effectively facilitate movement of birds, bats, terrestrial mammals, reptiles and amphibians. Where possible, any existing trees within the wildlife zone of the underpass should be retained as tall stumps to provide habitat and natural structures for wildlife, and potentially allow use by arboreal mammals (e.g. Photo 10.1 D). As for modified drainage structures, these extended bridge underpasses may be redundant if another crossing structure (e.g. land bridge, modified drainage structure or dedicated wildlife culvert) are installed nearby.

Monitoring results for the underpass adjacent to Taradale Rd under the Calder Freeway showed use by a wide range of species, including Kangaroos, Wallabies, birds, echidnas, and bats (Harrison and van der Ree 2013; Bhardwaj et al., 2017).

DEDICATED WILDLIFE CULVERT

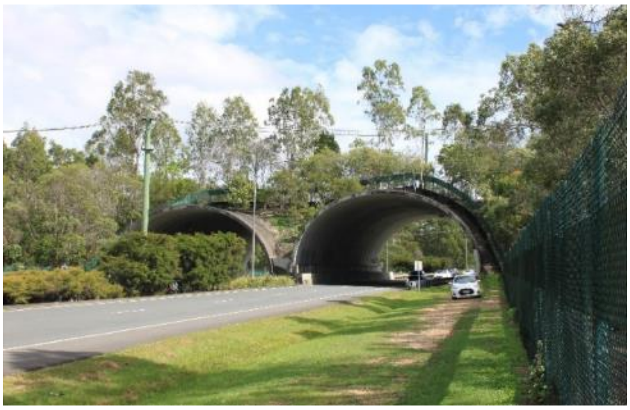
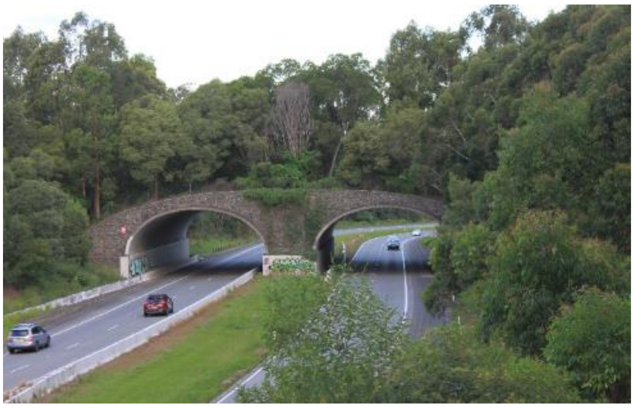
Dedicated wildlife-only culverts are recommended in areas where there is likely to be movement of kangaroos and wallabies and adjacent suitable crossing structures are located too far away to be easily accessed. These areas are characterised by forest or woodland on one side of the road, and grassland and waterbodies on the other. These culverts would be at least 2.4 m x 2.4 m box culverts. Monitoring data collected from similar culverts under the Calder Freeway show regular and frequent use by Eastern Grey Kangaroos (Harrison & van der Ree 2012), and culverts are used extensively in NSW and Queensland for terrestrial mammals (Photo 10.1 G-H).

STRATEGIC REVEGETATION

Areas where strategic revegetation would improve the function of the proposed crossing structures, particularly rope bridges and extended bridge underpasses have been identified. Strategic revegetation is particularly important to funnel arboreal species to rope bridges, as well as encourage other species to access the crossing structures. Strategic revegetation would contribute to the long-term success of the crossing structures by improving and facilitating access in the medium-term.

FENCING

The most effective solution to prevent wildlife-vehicle collision is to install continuous fencing along the road (Rytwinski et al. 2016; van der Ree, Gagnon & Smith 2015). Short lengths of fencing have limited effect at reducing rates of collision for wide-ranging species (i.e. kangaroos, wallabies) because they can easily traverse past the fence (Huijser et al. 2016). It has been assumed for wildlife crossings that the entire length of the Beaufort Bypass will be fenced for Kangaroos, with additional fencing for Growling Grass Frogs provided at crossings for frogs. All fencing should be well-connected to the crossing structures to prevent wildlife from squeezing in-between them and as well as integrated with noise walls. Further information about fencing is provided in Section 10.4.3.2.

	
A) Land Bridge over Compton Rd, Brisbane Qld.	B) Land bridge over Pacific Hwy, Yelgun NSW.
	
C) Extended bridge underpass adjacent to Metcalfe-Taradale Rd, Calder Freeway, Vic.	D) Extended bridge underpass adjacent to the Richmond River, showing tall stumps retained during construction for arboreal species, Pacific Hwy, NSW.
	
E) Extended bridge underpass across floodplain and river along Pacific Highway, Northern NSW.	F) Combined drainage and fauna underpass at Forest Creek, Calder Freeway, Vic.

	
G) 3m X 3m dedicated fauna culvert under Pacific Hwy, NSW, showing timber rail for arboreal species.	H) 3 x 3 m fauna culvert under Calder Freeway, Vic.
	
I) Multi-cell culvert along Pacific Highway, NSW, showing raised outer cells to maintain dry passage during low-flow periods.	J) Rope bridge over Hume Freeway, Longwood, Vic.

Photo 10.1 Examples of wildlife crossing structures (Photo Credit Rodney van der Ree)

10.4.2.3 DETAILED DESCRIPTION OF PROPOSED CROSSING STRUCTURE TYPE AND LOCATION ON THE C2 ALIGNMENT

Crossing structures are proposed for 23 locations along C2, including one land bridge, one combined drainage and wildlife bridge underpass, 11 combined drainage and wildlife culverts, one dedicated fauna culvert, six rope bridges and three underpasses where fauna movement is combined with an adjacent low-traffic volume road or the trainline. Full details of each proposed crossing location and type is shown in Appendix K and Table 10.1. The guidelines for detailed design referred to in Table 10.1 are provided in Section 10.4.2.4. The feasibility rating refers to the engineering constructability feasibility of each crossing type (e.g. underpasses in fill locations and overpasses in cut locations).

Table 10.1 Details of the type and location of mitigation measures to reduce rate of wildlife-vehicle collision and maintain wildlife movement across the C2 alignment. The ID of each structure corresponds with those mapped in Appendix K

ID	CHAINAGE	TYPE	PURPOSE	TARGET FAUNA	JUSTIFICATION	GUIDELINE TO ADOPT (SECTION 10.4.2.4)	FEASIBILITY	QUALITY
B01	6850	Bridge (underpass)	Drainage and fauna crossing	Frogs (incl Growling Grass Frog - GGF) fish (incl little galaxias) water birds, ground-dwelling mammals	Important link along Yam Holes Creek to herbaceous wetlands and low-lying areas north. Open span bridge much better than culverts	Growling Grass Frog, Little Galaxias, and General	High	High
C01	800	Culvert	Drainage plus fauna	Frogs, ground-dwelling mammals	Limited connection as there is limited structural habitat, could be used by frogs, echidna etc	General	High	Low
C02	1300	Culvert	Drainage plus fauna	Frogs, ground-dwelling mammals	Limited connection as there is limited structural habitat, could be used by frogs, echidna etc	General	High	Low
C03	3000	Culvert	Drainage plus fauna	Frogs, ground-dwelling mammals	Limited connection as there is limited structural habitat, could be used by frogs, echidna etc	General	High	Low
C04	3500	Culvert	Drainage plus fauna	Frogs including GGF, fish, little galaxias, ground-dwelling mammals	Link herbaceous wetlands south to creek and low-lying areas north; no records of Growling Grass Frog here yet	Growling Grass Frog and Little Galaxias, and General	High	Mod
C05	5200	Culvert	Drainage plus fauna	Frogs, ground-dwelling mammals	Limited connection as there is limited structural habitat, could be used by frogs, echidna etc	General	High	Low
C06	7200	Culvert	Drainage plus fauna	Frogs including GGF, ground-dwelling mammals	Connects herbaceous wetlands and low-lying areas either side	Growling Grass Frog, general	High	High

ID	CHAINAGE	TYPE	PURPOSE	TARGET FAUNA	JUSTIFICATION	GUIDELINE TO ADOPT (SECTION 10.4.2.4)	FEASIBILITY	QUALITY
C07	7000	Culvert	Drainage plus fauna	Frogs including GGF, ground-dwelling mammals	Connects herbaceous wetlands and low-lying areas either side	Growling Grass Frog, general	High	High
C08	8000	Culvert	Drainage plus fauna	Frogs, ground-dwelling mammals	Limited connection as there is limited structural habitat, could be used by frogs, echidna etc	General	High	Low
C09	9200	Culvert	Drainage plus fauna	Frogs, ground-dwelling mammals	Limited connection as there is limited structural habitat, could be used by frogs, echidna etc	General	High	Low
C10	9400	Culvert	Drainage plus fauna	Frogs, ground-dwelling mammals	Connection limited as main habitat area are seasonal herbaceous wetlands to north, could be used by frogs, echidna etc	General	High	Mod
C11	9800	Culvert	Drainage plus fauna	Frogs, ground-dwelling mammals	Limited connection as there is limited structural habitat, could be used by frogs, echidna etc; long culvert – would need light wells	General	High	Low
C12	2100	Culvert	Fauna crossing	Frogs, ground-dwelling mammals	Could be a link for habitat aquatic habitat further away either side. Evaluate surface water at location. Would need to create habitat to join	General	Mod	Mod

ID	CHAINAGE	TYPE	PURPOSE	TARGET FAUNA	JUSTIFICATION	GUIDELINE TO ADOPT (SECTION 10.4.2.4)	FEASIBILITY	QUALITY
L01	4600	Land bridge	Fauna crossing	Arboreal mammals, ground-dwelling mammals, woodland birds	Important link, ecosystem bridge, ~50 m wide. Help mitigate fragmentation of large patch of habitat. Would allow crossing for multiple species	Land bridge	High	High
R01	800	Rope ladder	Fauna crossing	Arboreal mammals	Connects trees on martins lane to row of trees through paddock	Arboreal	High	High
R02	1300	Rope ladder	Fauna crossing	Arboreal mammals	Connects trees on martins lane to row of trees through paddock	Arboreal	High	High
R03	2750	Rope ladder	Fauna crossing	Arboreal mammals	Rope ladder and revegetation to connect woodland on opposite sides of the road - or under bridge road verge	Arboreal	High	High
R04	6000	Rope ladder	Fauna crossing	Arboreal mammals	Rope ladder to connect woodland either side	Arboreal	High	High
R05	7400	Rope ladder	Fauna crossing	Arboreal mammals	Connects treed habitat along racecourse road. Lower priority if underpass constructed	Arboreal	High	High
R06	8800	Rope ladder	Fauna crossing	Arboreal mammals	Rope ladder to connect woodland on west to scattered large trees on east or ~160 m north if not feasible at this location	Arboreal	High	Mod

ID	CHAINAGE	TYPE	PURPOSE	TARGET FAUNA	JUSTIFICATION	GUIDELINE TO ADOPT (SECTION 10.4.2.4)	FEASIBILITY	QUALITY
U01	2750	Underpass / road verge	Fauna crossing	Ground-dwelling mammals, macropods, frogs, arboreal mammals, woodland birds	Could be a link for multiple species by allowing space for a 4–5 m wide road verge/underpass with habitat features such as logs, rope ladder, planted vegetation	General and Arboreal	High	High
U02	6500	Underpass / road verge	Fauna crossing	Arboreal mammals, ground-dwelling mammals, woodland birds	Important habitat link, wide interchange with freeway over road. Unsure what could be done here to connect roadside habitat as there are two roundabouts. Would need to look at specific design	General and Arboreal	Low	High
U03	7400	Underpass / road verge	Fauna crossing	Arboreal mammals, ground-dwelling mammals, woodland birds	Could be a link for multiple species by allowing space for a 4–5 m wide road verge/underpass with habitat features such as logs, rope ladder, planted vegetation	General and Arboreal	High	High

10.4.2.4 CROSSING STRUCTURE DESIGN GUIDELINES

For all crossing points, revegetation of appropriate habitat (using site-indigenous species) to link up to existing habitat is required to maximise use. Also for all crossing points, particularly those in key locations (higher priority crossings), fencing should be utilised to encourage use and prevent road mortality. More information on fencing for mortality minimisation is provided in Section 10.4.3.2.

The following sections provide design guidelines and considerations for the crossing structures recommended for this project.

GENERAL: DESIGN GUIDELINES FOR UNDERPASSES, INCLUDING CULVERTS, SPANS AND BRIDGES

To facilitate the movement of wildlife underneath roads it is always preferable to use open span bridges rather than pipe or box culverts. Larger underpasses, such as bridges, are almost always used at higher rates by a greater diversity of species than smaller underpasses because they are more open and can include a wider diversity of habitats within them (van der Ree et al. 2015). The 'openness' of underpasses is an important consideration and there is evidence that longer structures need to be higher and wider than shorter underpasses to function effectively. In addition, bridges and spans allow for the uninterrupted flow of waterways, thus enabling the unimpeded movement of waterway dependent species of wildlife including fish, frogs, and aquatic invertebrates.

Standard bridge designs can be easily modified to accommodate the movement of wildlife. The key considerations are: (1) ensuring sufficient height clearance under the bridge for the target species; (2) providing a sufficiently wide and dry bank on both sides of the waterway/wetland to enable dry passage at all (or most) times of the year; (3) allowing natural substrate and vegetation growth to continue under the bridge as much as possible, thereby providing a minimal break in natural conditions; and (4) allowing sufficient height for the safe movement of birds in flight. Where two bridges are planned to be constructed side by side, consider separating them to allow sufficient sunlight and rainfall to penetrate underneath the bridge, which will encourage natural vegetation growth and promote use by wildlife.

Smaller bridges (i.e. 'spans' across drainage lines) or underpasses are also preferable to culverts for fauna passage (Photo 10.1 F). Where possible, drainage lines within key habitat areas should be spanned by a small bridge, versus the removal of the drainage line and installation of culverts because the floor is more natural and waterways can continue uninterrupted, facilitating movement of fish, amphibians and other aquatic species.

With regard to combined-use culverts, the optimal approach is to keep wildlife passage and drainage requirements separate. When this is not feasible, combined drainage and wildlife culverts are possible. However, extra planning is required in these circumstances, as wildlife movement may be compromised when the focus of the design is primarily drainage. For example, culverts which have a concrete floor, required to prevent scour, are generally less preferred by wildlife than underpasses with a natural-substrate floor. Keeping some cells dry in multi cell culverts can be easily achieved by raising the floor height of the first and last culvert by 10 or 20 cm (or whatever is required relative to typical water heights) (Photo 10.1 I). This will ensure dry passage for wildlife during all times of the year apart from during flood events. If the drainage structure is a single culvert, a shelf or concrete platform can be installed to provide dry passage for wildlife (Photo 10.1 G).

The provision of 'fauna furniture' within crossing structures is an important consideration to maximise the rate of use by wildlife and minimise the risk of predation during use. For example, many species of wildlife, particularly smaller-bodied species, attempt to avoid being in open areas because of the increased risk of being preyed upon. Therefore, the provision of logs, some rocks, or piles of branches (Photo 10.1 D and G) that wildlife can hide under or within may increase the acceptance of crossing structures and rate of use, and also minimise predation rates.

It is generally well-recognised that rock beaching made of large, sharp and 'wobbly' rocks within a wildlife crossing structure can be a deterrent to the passage of wildlife. For example, turtles may fall in the gaps and be trapped. Therefore, where possible, the use of such rock beaching to prevent scour under bridges and at the entrances and exits of culverts should be avoided. If scour protection is required, use alternatives such as smaller-sized rocks, poured concrete, or replacement of a 2 m-wide strip of rock-beaching with natural substrate (or poured concrete if scour is an issue). This should be implemented at all underpasses designed to accommodate the movement of wildlife, and the specific alternative treatment (i.e. use of natural substrate or poured concrete) to be adopted will vary depending on the risk of erosion at each location.

ARBOREAL: GUIDELINES FOR CANOPY ROPE BRIDGES

The species targeted by rope bridges are arboreal mammals, including Common Ringtail Possums, Common Brushtail Possums, Brush-tailed Phascogales, Squirrel Gliders, Sugar Gliders and Antechinus. The height of the rope ladder above the road surface will need to be at least 7.5 m, to allow several metres or more of clearance between the tallest trucks and the rope ladder itself.

The design of the rope bridge, being two steel cables between two timber support poles, with a rope-ladder style rope bridge attached (Photo 10.1 J), is an appropriate and proven method to restore connectivity for the target species (Soanes & van der Ree 2015). A key consideration for longevity of the bridge is to use marine-grade UV-stabilised rope. An additional important consideration for the effectiveness of rope bridges is to tie-off the ends of each rope bridge to two to three adjacent trees, ideally large trees with hollows. This style bridge has been used extensively in Victoria, NSW and Queensland, with previous monitoring demonstrating its widespread use by the target species (Soanes & van der Ree 2015).

LAND BRIDGE

The land bridge should be a single structure of at least 50 m wide and include planting which connects the EVCs on either side of the bridge. Planting should include all strata of the EVCs being connected, and include logs and other habitat features to provide shelter and habitat. The land bridge should include fencing above the road to shield wildlife using the bridge from vehicle noise, light and disturbance, as well as prevent wildlife from accessing the roadway underneath the bridge. If a track is desired for pedestrian access, it should be a dirt walking track located to one side of the bridge, not toward the centre. No vehicle tracks should be located on the land bridge. At least one arboreal crossing should be placed at the bridge as an interim measure while trees on the bridge grow to a sufficient height to be of use to arboreal fauna.

GROWLING GRASS FROG CROSSING GUIDELINES

Structures intended specifically for Growling Grass Frogs should be designed in accordance with the standards and specifications detailed in (DELWP 2017c). These are broadly summarised in Section 10.3.7. Any habitat created for Growling Grass Frog (including at the entrances of culverts/underpasses) should be designed with consideration of the habitat preferences described by Heard et al. (2010) and with the habitat design standards (DELWP 2017d).

LITTLE GALAXIAS CROSSING GUIDELINES

Structures intended specifically for Little Galaxias should be designed with consideration of the 'Guidelines for fish passage at small structures' (O'Connor, Stuart & Campbell-Beschorner 2017).

10.4.2.5 PREDATION RISK

There is a widely-held misconception that wildlife crossing structures, such as underpasses and overpasses, including canopy rope bridges, are prey-traps for wildlife because predators learn that they can get an 'easy feed' at those locations. Despite this assertion, there is little to no evidence that predators systematically use crossing structures in this way (Little, Harcourt & Clevenger 2002; Mata et al. 2015). Furthermore, studies on rope bridge use and effectiveness along the Hume Freeway in southern NSW and northern Victoria (Soanes and van der Ree, unpub. data) have shown that the same individual possums and gliders used rope bridges over multiple years, demonstrating that individuals were able to use the bridges successfully over multiple years without being taken by owls. Nevertheless, predation and attempted predation does occur and simple strategies such as the inclusion of refuge pipes (short lengths of 100–150 mm diameter

PVC pipes) along a rope bridge may provide shelter if an owl attempts to predate on an animal using the crossing. The risk of predation in underpasses and land-bridges can be lowered by making them as wide as possible and including vegetation, logs, piles of branches and some rocks.

10.4.3 FAUNA INJURY AND MORTALITY

10.4.3.1 FAUNA MANAGEMENT DURING CONSTRUCTION

Although listed threatened and migratory species are unlikely to be inadvertently killed or injured during construction, management of wildlife protected under the *Wildlife Act* is required.

All construction personnel should attend a project-specific induction prior to commencing site work. The inductions should include relevant information about the ecological sensitivities of the site and appropriate management measures.

It will be necessary to engage suitably qualified and experienced fauna rescue and welfare contractors to salvage and release fauna dislodged during construction, including: bats, birds and possums from hollows, lizards, snakes, turtles, and echidnas, and any fish, frogs or aquatic fauna within wetland areas. This also includes Striped Legless Lizard should there be an unexpected sighting.

It will also be necessary to engage a suitably qualified, experienced and licensed ecologist to identify tree hollows that are likely to support native fauna, to inspect these prior to tree removal, and to supervise removal. A protocol for staged tree clearing and management and relocation of fauna during tree clearing should be developed in consultation with the arborist and a suitably qualified and licenced wildlife handler. A suggested protocol is provided below.

1. At least two weeks prior to clearing, a qualified ecologist should survey and clearly mark all habitat trees.
2. At least one week prior to clearing, contact veterinarians and wildlife carers to ensure they are willing to assist in treating injured animals if necessary. Their contact details are to be given to the site manager and clearly displayed in the site office.
3. No-go Zones to be clearly fenced by the contractor one week prior to clearing.
4. A qualified ecologist should be on site during all vegetation removal. The wildlife ecologist must hold a current Management Authorisation under the *Wildlife Act 1975*.
5. On the day of Stage 1 clearing, ecologist to inspect vegetation for nests and ecologist and/or level 5 arborist to inspect habitat trees for presence of fauna using binoculars and a pole mounted camera.
6. Stage 1. Remove non-habitat vegetation (i.e. shrubs, regrowth, ground cover and non-habitat trees). Ecologist to supervise in case of hollows that were not visible from the ground. Hollow-bearing trees that have been inspected and are considered by ecologist highly unlikely to contain fauna (i.e. hollow is not suitable or all hollows and loose bark is able to be inspected and no fauna seen) can also be removed during Stage 1.
7. Place tree collar on habitat trees with hollows (Stage 2 trees).
8. Leave Stage 2 vegetation (trees or shrubs with nests and/or hollows) for 24–48 hours to allow fauna to vacate remaining habitat. Nests to be relocated if possible.
9. Stage 2. Ecologist to inspect any trees with a camera before felling. If a tree is occupied, capture and relocate if possible or (preferably) allow tree to stand an additional day (repeat if animal still present). Relocate fauna to habitat pre-determined for release, either to an empty natural or replacement hollow (log hollow or carved hollow), or to a temporary nest box installed for fauna relocation and removed once empty.
10. Fell habitat trees carefully using equipment that allows habitat trees to be lowered to the ground with minimal impact (e.g. claw extension). Reinspect habitat trees again immediately after felling for any fauna not originally detected. Capture and relocate non-injured fauna that are found in any felled trees to pre-determined habitat identified for fauna release. Do not fell trees towards No-go Zones or other habitat trees. Relocate or reuse timber from felled habitat trees, with habitat improvement uses prioritised.

The construction project manager and/or environment manager must ensure that the outcomes of the clearing process are recorded. Reporting is usually the responsibility of an ecologist or environment officer. Reports are to be submitted to relevant personnel (e.g. environment manager). Information collected should include tree number and re-use classification.

The following guidelines should also be followed to minimise harm to fauna during construction:

- Pits and trenches should be filled in each day (or covered as appropriate) to prevent reptiles, mammals and frogs being trapped. If this is not practicable, they should be checked in the morning prior to the start of works. Where possible, trapped animals will be removed through the placement of a ramp to allow animals to escape themselves. Sides of the trenches should be graded to allow for animal escape where practicable.
- Avoid clearing to the extent practicable between July and October inclusive, which incorporates the key breeding period for most fauna species in the study area.
- Consider the risk of trapping wildlife on the road when selecting and placing construction fencing/barriers. Incorporate egress points.
- Where relevant, ensure traffic control are aware of the risk of kangaroos (and other fauna) on the road, and are able to respond quickly by stopping or slowing traffic.
- Pre-clearing survey of all potential fauna habitat and relocation of fauna to adjacent habitat. This includes wetlands and dams as well as species such as Striped Legless Lizard, should there be an unexpected sighting.

10.4.3.2 REDUCING THE RATE OF WILDLIFE-VEHICLE COLLISIONS AFTER ROAD COMPLETION

The rate of wildlife movement across the proposed road is difficult to quantify, however, based on the known or likely occurrence of species adjacent to the road and an understanding of their movement ecology, many species will attempt to cross the road. Based on data on rates of mortality from elsewhere on the Western Highway and other nearby roads, high rates of mortality of Eastern Grey Kangaroos, Black Wallabies and other smaller mammals, amphibians, birds and reptiles can be expected.

The most effective approach to reduce the rate of wildlife-vehicle collisions along roads is through the installation of barriers that prevents wildlife from accessing the road. Ideally, the entire length of the Bypass should be fenced to a height of 1.8 to 2.1 m to prevent Kangaroos from attempting to cross the road and to funnel them towards the crossing structures. This type of fencing is used as a standard approach to prevent wildlife-vehicle collisions on the Pacific Highway in NSW, the Bruce Highway in South East Queensland and on sections of the Calder Freeway in central Victoria near Black Forest and Taradale (Harrison and van der Ree 2012). Shorter lengths of fencing may assist in funnelling species with smaller home ranges than Kangaroos, however, continuous fencing is likely required for species with large-range movements. The specific details of the fencing should be determined on a site by site basis depending on the fauna occurring in the area. Mesh fencing for Kangaroos can be adapted for arboreal species (but not gliders) by attaching a 600 mm wide strip of sheet metal at the top. Floppy top fencing may also be suitable, however maintenance requirements are higher.

Barrier fencing must be considered in conjunction with measures to maintain connectivity, such as land bridges, rope bridges, fauna underpasses, and noise walls as described in Section 10.4.2.2.

10.4.4 NOISE AND VIBRATION

Specific mitigation measures required for noise and vibration are detailed below.

10.4.4.1 DURING CONSTRUCTION

Noise and vibration sources from construction activities are typically associated with the use of plant and equipment at the worksite.

The following mitigation techniques are recommended:

- fit all pneumatic tools, vehicles and plant with silencers where specifications allow
- maintain noise suppression devices to the manufacturer's specifications
- regularly maintain equipment and machinery to minimise operational noise
- where practicable enclose noisy equipment and establish suitable noise attenuation and insulation devices
- where appropriate use a less noise generating activity (e.g. such as saw –cutting instead of jack hammering)
- limit activities outside of daytime hours
- time construction works to avoid the breeding season of potentially impacted species.

10.4.4.2 ONGOING IMPACTS

The use of noise-reducing structures, surfaces and other measures, such as planted mounds/embankments and other noise attenuating structures has been considered for sensitive human receptors in the Noise and Vibration Impact Assessment (WSP 2020c), with surface treatment and noise walls for these receptors proposed for the project. However, in some cases this is unlikely to be adequate to shield sensitive ecological values from noise impacts. The results of a noise impacts assessment is provided in Table 7.13. For this assessment, 10 areas of ecological sensitivity and value were examined against the noise modelling for each alignment. The modelling that was examined was the 'mitigated' scenario, incorporating the mitigation proposed for residents (human sensitive receptors).

With the current noise mitigation, a residual area of impact (over 60 $dBL_{A10,18hr}$) is where the C2 alignment pass through Camp Hill State Forest. The road cutting will result in a lower impact than there would be with a theoretical road at grade, but substantial increases in noise are still likely. For C2, noise walls for residents will minimise impact to the western portion of Camp Hill State Forest, however, these walls are not currently proposed to be long enough to shield the remaining habitat. As such, extension of these walls by approximately 150 m to the east is recommended and should be investigated. In addition, the area in the Yam Holes Creek valley between Beaufort-Lexton Road and Racecourse Road will need noise attenuation to reduce the effects of noise (under 60 $dBL_{A10,18hr}$) on the large wetland (ecological sensitivity site 5), such as a height extension to the road barrier (eg Jersey barrier) for an adequate length (eg. 200 m long). These walls can also function as fauna barriers to minimise mortality on the road and to encourage use of crossing structures (culverts, rope bridges etc.), and as such, can be considered 'multi-function fauna barriers', as used in the Mordialloc Bypass (WSP 2018).

Table 10.2 Recommended mitigation measures for C2 to attenuate potential noise impacts

ID NUMBER	1	2	3	4	5	6	7	8	9	10
Description	Martin's Ln roadside woodland/forest	Woodland west of Back Raglan Rd	Woodland/ forest between Back Raglan Rd and Main Lead Rd	Camp Hill State Forest	Wetlands between Beaufort-Lexton Rd and Racecourse Rd	Wetlands south of Racecourse Rd	Snowgums woodland reserve	Forest north of rail line and west of Packhams Ln	Forest south of railway line, west of Packhams Ln	Wetlands east of Smiths Ln
Recommended mitigation	This vegetation is VTWBC habitat but is already impacted by noise from the Western Highway No mitigation recommended	Mitigation unlikely to be practicable, some residual impact likely. Mitigation not required for the preferred alignment.	Unlikely affected by C2	Noise walls proposed in this area. Consider extending the proposed noise walls approx. 150 m east to include more of Camp Hill State Forest.	Screening of wetland habitat and installing multi-function fauna barriers (for approx. 200 m) to attenuate noise and the effects of close to wetland to the north	Unlikely affected by C2	Unlikely significantly affected by C2	Noise walls proposed in this area. No additional mitigation recommended	Unlikely affected by C2	Unlikely affected by C2

10.4.5 ECOLOGICAL LIGHT POLLUTION

Artificial lights have the capacity to contribute to 'ecological light pollution' during construction, in particular due to the use of high powered lighting used for night-time construction, and post-construction associated with roadside lighting and vehicle headlights. Confining light spread by using directional lighting, lowered lighting and screening can reduce impacts to wildlife (Gleeson & Gleeson 2012). Specific recommendations are detailed below.

10.4.5.1 DURING CONSTRUCTION

It is preferable that light impacts during construction are avoided (or substantially minimised) by conducting work during daylight hours only. It is expected that the vast majority of the works will be conducted during daylight hours. Where lighting is required for construction purposes the following is recommended:

- ensure lighting, including those used on site compounds, is located away from sites of ecological value or areas of retained habitat wherever practicable
- ensure lighting is directed to works areas only and away from sites of ecological value wherever practicable
- near sites of ecological value, install shields or fittings to minimise light spill and direct light to where it is needed
- ensure temporary lighting is removed promptly from site once not required.

10.4.5.2 ONGOING MITIGATION OPTIONS

Recommended design principles for lighting are detailed in Table 10.3. It is recommended that these are followed for the project, particularly near important habitat areas. The final detailed lighting design for the project should be developed by a professional lighting designer with experience in minimising impacts on ecological values. This table also includes guidance for shielding habitat from headlights.

Table 10.3 Fauna-sensitive lighting design guidelines

<table>
<tr><th></th><th>LIGHTING DESIGN PRINCIPLES</th><th>KEY REFERENCES</th></tr>
<tr><td>Siting of lights</td><td>— Utilise lighting only where necessary – consider white lining and 'cats' eyes' in other location. Use the minimum amount of light (lumens) required.
— Site lighting columns away from sites of ecological value to all extent possible.
— Consider the height of lighting. Generally, a lower mounting height is preferred (although not always, this should be determined by a lighting designer with experience minimising impact on sensitive flora and fauna receptors).
— Ensure lighting does not shine onto any crossing structures, especially rope bridges.</td><td rowspan="2">— Interim Guidance: Artificial lighting and wildlife - Recommendations to help minimise the impact of artificial lighting (Bat Conservation Trust Undated).
— Fauna sensitive road design guidelines (VicRoads 2012a).
— Florida Fish and Wildlife Conservation Commission – Wildlife Lighting Criteria (Florida Fish and Wildlife Conservation Undated).
— International Dark-sky Association website</td></tr>
<tr><td>Fixtures</td><td>— Install full cut-off or fully shielded lights or fixtures to direct light down to where it is needed only, and to minimise light spill onto sites of ecological value.
— Fixture must fully shield the bulb/lens from important wildlife habitat.
— Avoid using reflective surfaces under lights.</td></tr>
</table>

	LIGHTING DESIGN PRINCIPLES	KEY REFERENCES
Wavelengths	— Use narrow-spectrum light sources to lower the range of species affected by lighting. — Avoid white or blue wavelengths – where white light sources are required they should be of a warm colour temperature (definitely <4,200 kelvin, preferably <3,000 kelvin). — Minimise emission of ultra-violet light. — Utilise long wavelength bulbs.	(International Dark-Sky Association Undated). — National Light Pollution Guidelines for Wildlife (DoEE 2020)
Barriers and/or plantings	— Low walls and/or plantings should be used where required to prevent headlight and streetlight spill across habitat/sites of ecological value. Densely planted vegetation on the roadsides can prevent light spill into the adjacent environment and may prevent light attracted species such as bats from being drawn to the lights to feed off insects. Walls and/or plantings are recommended on the edge of the land bridges and anywhere that headlights may spill across higher value wetlands, such as those identified in the noise mitigation section (Section 10.4.4.2). These should be incorporated into the landscape plan for the project.	
Temporary fencing	— Should vegetation be utilised as an ongoing screening measure, install temporary fencing with screening until vegetation is sufficiently mature. This is particularly important where there the effectiveness of screens may have impacts on breeding habitat for wetlands birds.	

10.4.6 VISUAL IMPACTS

Mitigation measures for the most significant visual impacts from the artificial raised structure and moving vehicles should be considered to reduce the visual impact of the road upon fauna, particularly near sensitive locations such as wetlands. Mitigation of visual impacts for fauna can include vegetation plantings, earth berms, or barriers.

10.4.7 PHYSICAL HABITAT DISTURBANCE AND MODIFICATION

10.4.7.1 WEED AND DISEASE MANAGEMENT

As stated in Section 10.2, RRV has standard environmental protection measures which will be covered in the CEMP for the project including standard flora and fauna mitigation measures in Section 177 Environmental Management document (VicRoads 2016a). This includes the following conditions:

The Contractor shall prevent the spread of declared noxious weeds, pests and diseases within the site and off-site through the implementation of controls that shall include the:

- treatment of declared noxious weeds prior to the commencement of any ground disturbing activities and in response to their identification through monitoring of the site
- management of noxious weeds and soil pathogens potential within imported materials
- provisions for cleaning plant and equipment at the following times:
  - prior to arrival on site
  - prior to departure from site, and
  - prior to movement within the site from infested to non-infested areas
- location of cleaning areas
- use of a vehicle and machinery hygiene log book.

Additional requirements include:

- prior to commencement of works, a detailed weed assessment will be completed in the study area in areas of ecological sensitivity, and preliminary weed control will be undertaken
- immediately following works, a program of weed monitoring and control will be commenced, targeting high-risk species and areas of ecological sensitivity in the study area. High risk species will be regularly controlled along road edges for the life of the road
- utilise appropriate chytrid fungus hygiene practices and controls during construction using the threat abatement plan (Commonwealth of Australia 2016)
- utilise appropriate hygiene protocols for *Phytophthora cinnamomi* during construction using the *Arrive Clean, Leave Clean - Guidelines to help prevent the spread of invasive plant diseases and weeds threatening our native plants, animals and ecosystems* (DoE 2015) mowing regime and trimming of road edges will be determined with consideration of ecological impacts and timing of seed set. Slashers will be cleaned prior to mowing near areas of ecological sensitivity to avoid spreading weeds
- weed monitoring before, during, and after construction will need to take into account the seasonality of different weed species. Multiple monitoring events per year will be required to ensure that weeds are not missed.

Currently, it is understood that Major Road Projects Authority (MRPV) will be responsible for weed control along the new stretch of road for two years post construction then it will be handed over to RRV for management. The standards applie above should apply to both road managers.

10.4.7.2 RUBBISH

Standard regular roadside maintenance and clean-up is expected to be largely sufficient at mitigating this impact upon significant values along most of the alignment, particularly where the road passes through cleared paddocks. However, additional measures are required to protect woodland and wetland habitat. The following additional measures are recommended for the preferred alignment:

- The design and location of any parking or rest stops should take into consideration the potential for increased rubbish in nearby habitat. Rest stops should be avoided near wetlands and waterways, and fencing should be utilised to stop rubbish and human/dog ingress into habitat.
- Fencing should be used where the road passes close to wetland and waterways, particularly near Yam Holes Creek. This will help to trap rubbish in the road reserve and minimise the amount which enters waterways. It is likely that fencing/barriers used to funnel fauna into underpasses (and toward other crossing structures) can be utilised to also trap rubbish in the road reserve. Roadside rubbish removal will need to include all areas inside the fencing and should be extended into nearby habitat if required.
- Gross pollutant traps should be installed along the bypass where water from WSRD enters waterways or water from the road enters WSRD. These will need to be regularly cleared and maintained.

10.4.7.3 SEDIMENT AND EROSION

CONSTRUCTION

Erosion mitigation measures will be required to prevent the movement of sediment and soil to sites outside of approved construction sites. While vegetation provides the most effective form of erosion control, interim measures involving a variety of soil erosion techniques and materials may be required on an as needs basis to ensure that there are no off-target impacts or ecological losses.

Clause 56 of the SEPP (Waters of Victoria) requires construction works be managed to minimise land disturbance, soil erosion and the discharge of sediment and other pollutants to surface waters. Throughout the study area, a number of principles should be applied in order to limit erosion and sedimentation. These should be in line with the Victoria EPA Principals of Best Practice Guidelines, including Environmental Guidelines for Major Construction Sites (Environmental Protection Agency 1996), Construction Techniques for Sediment Pollution Control (Environmental Protection Agency 1991), and EPA Publication 960 'Doing it right on subdivisions' (Environmental Protection Agency 2004).

DESIGN AND OPERATION OF ROAD

Clause 46 of the SEPP (Waters of Victoria) requires urban stormwater, which includes road runoff, provides for the protection of beneficial users and the demonstration of best practice. The best practice approach requires proposed road projects meet the best practice performance objectives and process outlined in Urban Stormwater: Best Practice Environmental Management Guidelines (Victorian Stormwater Committee 1999). To achieve this, increases to pollutant loads will be assessed and mitigated using Water Sensitive Road Design (WSRD) elements as part of the design phase.

Specific mitigation, corrective action and contingency measures to protect waterway habitat from pollutants must be determined, to ensure negligible or low impacts upon significant ecological values.

10.4.7.4 GROUNDWATER AND SURFACE HYDROLOGY

GROUNDWATER

Details on mitigation measures for the potential groundwater impacts associated with the project are covered in the Groundwater Impact Assessment (WSP 2020a) and the Environmental Management Framework. Based on the existing groundwater conditions and assessment of groundwater risks associated with the project, non-standard water management or mitigation measures are not considered necessary. Standard RRV environmental and engineering management procedures should be applied to the project design, construction and operational phases of the project. Refer to the Groundwater Impact Assessment (WSP 2020a) for details on mitigation measures.

SURFACE WATER

The Surface Water Impact Assessment (WSP 2021) recommends several management and mitigation measures to reduce impacts on hydrology and water quality including:

- preparing a Construction Environment Management Plan (CEMP) which outlines how the contractor will comply with any environmental conditions for the project and provide a framework to ensure that environmental risks are properly managed
- implementing engineering controls and staging rehabilitation of areas during the construction phase to reduce erosion and sediment run-off entering waterways
- incorporating WSRD elements into the project such as swales, bioretention systems, basins and wetlands to reduce the impacts of flooding and pollutants. These could be particularly useful in sensitive areas such as outfalls adjacent to threatened species habitat
- undertaking a spill risk assessment to determine the likelihood of spills occurring
- maintenance of culverts and bridges, particularly after heavy rainfall events, to reduce the likelihood of blockages occurring resulting in localised flooding.

With regard to ecological values, should avoidance of significant wetland areas not be possible, particular consideration of WSRD which maintains the current hydrology of wetland systems is highly recommended. Bridge and culvert design which facilitates fauna passage in key areas will be required.

Best practice for WSRD is defined in the *SEPP (Waters)* as “the best combination of techniques, methods, processes or technology used in an industry sector or activity that demonstrably minimises the environmental impact of that industry sector or activity.” This approach requires proposed road projects to meet the best practice performance objectives and process outlined in:

- Urban Stormwater: Best Practice Environmental Management Guidelines, Victorian Stormwater Committee (1999) (BPEMG) (Victorian Stormwater Committee 1999)
- Ausroads Guidelines for Road Drainage (AGRD)

The impacted areas in this project are along the proposed bypass corridors located in the sub-catchments of Yam Holes Creek. According to the BPEMG and AGRD Guidelines, WSRD is required to:

- protect the existing natural features and ecological processes
- maintain the natural hydrologic behaviour of the catchments
- protect water quality of surface and groundwater
- integrate water into the landscape to enhance visual, social, cultural and ecological values.

The performance criteria for stormwater quality and environmental flow regime impacts, as per BPEMG and AGRD, are summarised in Table 10.4.

CHANNEL REALIGNMENTS

As stated in the Surface Water Impact Assessment (WSP 2021), the design currently includes 10 channel realignments to connect waterways across the alignment.

To mitigate the effects of channel realignments, the following design features will be implemented to facilitate fauna passage and habitat creation/enhancement:

- robust engineering design to minimise channel velocities and scour/erosion risks within the channels and overbank areas
- transitions at the downstream ends of the channel realignments into the receiving stream lines that deliver flow at velocities similar to the existing conditions in the receiving streams
- incorporation of suitable aquatic and terrestrial planting within and along the channel realignments, maximising the use of native species and species resilient to the expected hydraulic and climatic conditions
- inclusion of pool and riffle features (see Figure 10.5), stilling areas and other similar features to provide habitat and refuge for aquatic species
- inclusion of other ecological and landscape design features in accordance with best practice guidelines such as the relevant parts of Melbourne Water’s Constructed Waterway Design Manual (Melbourne Water 2019) and DELWP’s Growling Grass Frog Crossing Design Standards (DELWP 2017c)
- creation of new channels must be undertaken in a way which minimises sediment from the construction of the new channel entering wetlands and fauna habitat up and downstream of realignment area. Pollution control measures may need to include temporary silt traps before work commences along with regular monitoring of water quality.

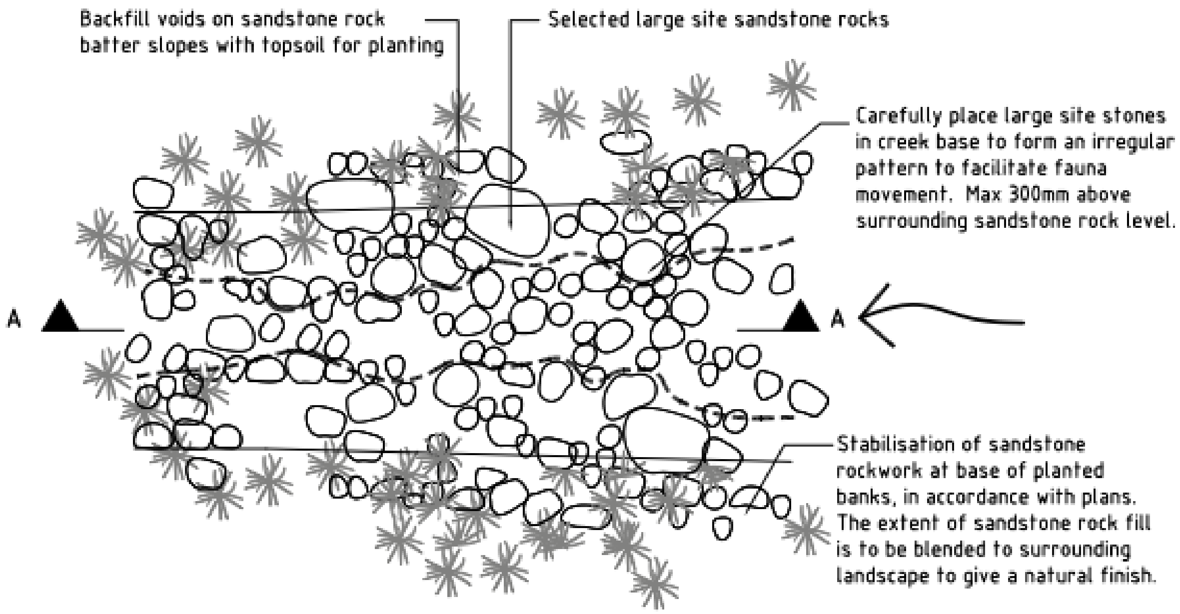


Figure 10.5 Example of meandering channel design to facilitate fauna movement (source: Sydney Water, 2020)

Table 10.4 Performance criteria for water quality and flow regime impacts

INDICATORS	TARGETED REDUCTION OF TYPICAL URBAN (ROAD) ANNUAL LOAD
Total suspended solids (TSS)	80% retention of the typical urban annual load
Total phosphorus (TP)	45% retention of the typical urban annual load
Total nitrogen (TN)	45% retention of the typical urban annual load
Litter	70% retention of the typical urban annual load
Flow	Maintain discharges for the 1.5 year Average Recurrence Interval (ARI) at pre-development rates

Detailed design will need to comply with these requirements to ensure impacts to surface water and subsequent secondary impacts to flora and fauna are avoided, minimised or mitigated.

SPECIFIC MITIGATION MEASURES

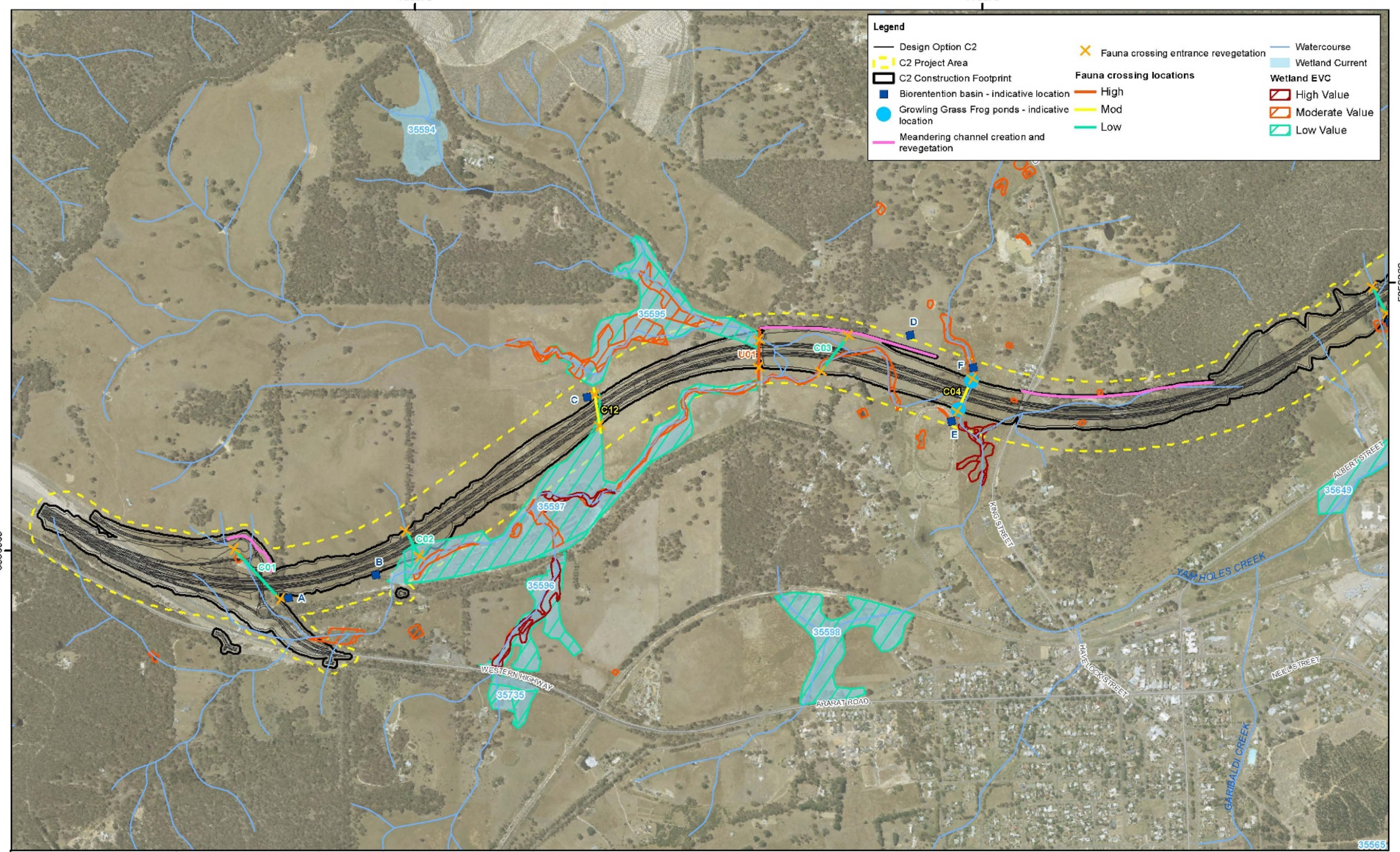
Wetlands were assessed for their potential surface water and hydrological effects in relation to ecological impacts in Section 9.7.4.2. These were categorised into high, moderate and low quality and broken up into sections of the proposed bypass, road to road. The table shows that the wetlands will be protected from water quality impacts by the proposed stormwater treatment measures. These are shown on Figure 10.6 below.

Table 10.5 Specific mitigation at each section of the proposed bypass

SECTION	PROPOSED CULVERTS	MITIGATION
Western Highway – western end to Back Raglan Road	Two locations with culverts are proposed.	To manage impacts on water quality, sedimentation and increases in flows from road surface, areas for enhanced treatment (e.g. treatment swales, bioretention ponds) should be built. These are particularly important for water flowing into moderate and high quality wetlands identified in this section. Pollutant loads from road drainage to be managed by treatment measures in accordance with BPEMG – no impact predicted in *Surface Water Impact Assessment Report* (WSP 2021). Changed hydrology should mimic pre-existing conditions to reduce adverse impacts on seasonal wetland hydrology. Culverts should be constructed to facilitate wildlife movement. Habitat restoration or creation of habitat around culverts or where new crossings are proposed.
Back Raglan Road to Main Lead Road	Two locations with multiple culverts are proposed.	To manage impacts on water quality, sedimentation and increases in flows from road surface, areas for enhanced treatment (e.g. treatment swales, bioretention ponds) should be built. These are particularly important for water flowing into moderate and high quality wetlands identified in this section downstream from the stream from the realignment and the culvert location. Pollutant loads from road drainage to be managed by treatment measures in accordance with BPEMG – no impact predicted in (WSP 2021). To reduce the effects of the creek realignment, the creek should be designed to have natural instream and riparian habitat features and designed in accordance with Integrated Water Management Guidelines (VicRoads 2013a). Indigenous semi-aquatic and riparian plants should be used to revegetate creekline. Changed hydrology should mimic pre-existing conditions to reduce adverse impacts on seasonal wetland hydrology. Culverts should be constructed to facilitate wildlife movement. Habitat restoration or creation of habitat around culverts or where new crossings are proposed.

SECTION	PROPOSED CULVERTS	MITIGATION
Main Lead Road to Beaufort-Lexton Road	One location with multiple culverts is proposed.	To manage impacts on water quality, sedimentation and increases in flows from road surface, areas for enhanced treatment (e.g. treatment swales, bioretention ponds) should be built. These are particularly important for water flowing into moderate and high quality wetlands identified in this section downstream from the stream from the realignment and the culvert location. Pollutant loads from road drainage to be managed by treatment measures in accordance with BPEMG – no impact predicted in (WSP 2021). To reduce the effects of the creek realignment, the creek should be designed to have natural instream and riparian habitat features and designed in accordance with Integrated Water Management Guidelines (VicRoads 2013a). Indigenous semi-aquatic and riparian plants should be used to revegetate creekline. Changed hydrology should mimic pre-existing conditions to reduce adverse impacts on seasonal wetland hydrology. Culverts should be constructed to facilitate wildlife movement. Habitat restoration or creation of habitat around culverts or where new crossings are proposed.
Beaufort-Lexton Road to Racecourse Road	One location with multiple culverts is proposed. Two open bridges proposed.	To manage impacts on water quality, sedimentation and increases in flows from road surface, areas for enhanced treatment (e.g. treatment swales, bioretention ponds) should be built. These are particularly important for water flowing into moderate and high quality wetlands identified in this section downstream from Yam Holes Creek. Pollutant loads from road drainage to be managed by treatment measures in accordance with BPEMG – no impact predicted in (WSP 2021). To reduce the effects of the creek realignment, the creek should be designed to have natural instream and riparian habitat features and designed in accordance with Integrated Water Management Guidelines (VicRoads 2013a). Indigenous semi-aquatic and riparian plants should be used to revegetate creekline. Changed hydrology should mimic pre-existing conditions to reduce adverse impacts on seasonal wetland hydrology. Culverts should be constructed to facilitate wildlife movement. Habitat restoration or creation of habitat around culverts or where new crossings are proposed.

SECTION	PROPOSED CULVERTS	MITIGATION
Racecourse Road to Western Highway – eastern end	Four locations with multiple culverts are proposed.	To manage impacts on water quality, sedimentation and increases in flows from road surface, areas for enhanced treatment (e.g. treatment swales, bioretention ponds) should be built. These are particularly important for water flowing into moderate and high quality wetlands identified in this section downstream from the stream from the realignment and the culvert location. Pollutant loads from road drainage to be managed by treatment measures in accordance with BPEMG – no impact predicted in (WSP 2021). To reduce the effects of the creek realignment, the creek should be designed to have natural instream and riparian habitat features and designed in accordance with Integrated Water Management Guidelines (VicRoads 2013a). Indigenous semi-aquatic and riparian plants should be used to revegetate creekline. Changed hydrology should mimic pre-existing conditions to reduce adverse impacts on seasonal wetland hydrology. Culverts should be constructed to facilitate wildlife movement. Habitat restoration or creation of habitat around culverts or where new crossings are proposed.



Map: 2270290A_GIS_226_A	Author: VD
Date: 6/3/2021	Approved by: NM

Data source: VicRoads, Timble
Copyright: © The State of Victoria, Department of Environment, Land, Water & Planning 2014

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Coordinate system: GDA 1994 MGA Zone 54
Scale ratio correct when printed at A3

vicroads
wsp

Beaufort Bypass

Waterway and wetland mitigation
Map 1 of 2

VicRoads

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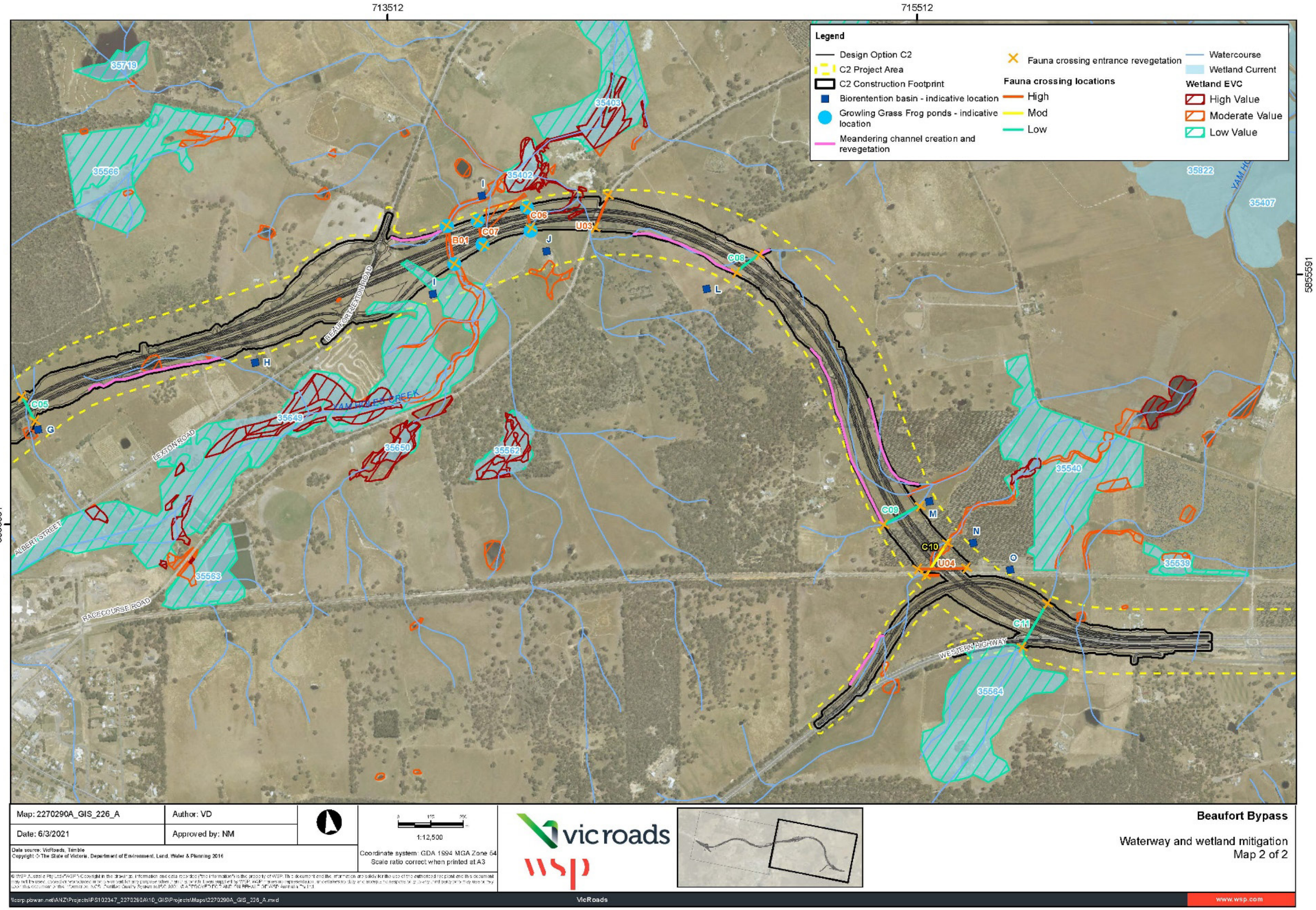


Figure 10.6 Waterway and wetland mitigation measures

10.4.8 AIR QUALITY AND DUST

Dust impacts are expected to be able to be mitigated using standard measures included in the project CEMP. Measures should include covering bare soil, using a water truck to spray construction access roads and exposed soil, locating spoil away from habitat, rehabilitation of exposed/cleared areas, and minimising earthworks during windy conditions. Use of dust screens or windbreaks should also be considered where required. Dust screens should be considered and utilised if required where there is a higher risk of impacts on retained threatened flora, such as where the fire track is being established near Ben Major Grevillea, or where works are occurring close to waterways, such as at Yam Holes Creek. The specific mitigation should be determined by the contractor to ensure that no impacts from dust occur on retained native vegetation, threatened flora, wetlands, or waterways. Monitoring and reporting on dust impacts will be required.

11 RESIDUAL IMPACTS

An assessment of residual impacts is provided in the following sections, assuming all recommended mitigation is incorporated. If the mitigation recommended is not practicable or otherwise incorporated into the project, this should be reassessed.

11.1 LOSS OF VEGETATION AND HABITAT

With mitigation, loss of terrestrial and aquatic vegetation and habitat is still given a high impact rating as clearing of the assessed amount of native vegetation and flora and fauna habitat is unavoidable. However, mitigation is critical to ensure no impacts occur outside of the construction footprint. It is anticipated that there will continue to be opportunities to further avoid and minimise impacts during subsequent detailed design and pre-construction phases of the project.

11.2 LOSS OF CONNECTIVITY

With the recommended mitigation, loss of connectivity is given a moderate impact rating.

11.3 FAUNA INJURY AND MORTALITY

11.3.1 CONSTRUCTION PHASE

With mitigation, fauna injury and mortality during construction is given a low-moderate severity rating. Some residual injury or mortality during construction is likely although the recommended measures are expected to substantially reduce these impacts.

11.3.2 OPERATIONAL PHASE

The recommended mitigation is likely to substantially reduce injury and mortality of terrestrial and aquatic fauna during operation of the road. However, in some locations, wildlife-vehicle collisions are likely to still occur. It is given a rating of moderate with mitigation.

11.4 NOISE AND VIBRATION

With the recommended mitigation proposed in this report, impacts of noise and vibration on ecological values are considered likely to be low.

11.5 ECOLOGICAL LIGHT POLLUTION

With the recommended mitigation, impacts of ecological light pollution from dusk til dawn, during the operational phase of the project on ecological values are considered to be low. Shielding and revegetation is expected to protect the habitats most sensitive to light, particularly wetlands.

11.6 VISUAL IMPACTS

With the proposed measures, the residual risk of visual impacts, particularly on fauna, is likely to be low-moderate. Design of measures to shield sensitive habitat should occur during detailed design.

11.7 PHYSICAL HABITAT DISTURBANCE AND MODIFICATION

11.7.1 WEED INVASION AND DISEASE

With the proposed mitigation, an impact rating of low-moderate has been attributed to weed invasion and disease, largely due to ongoing risk from road operation and maintenance that is difficult to fully mitigate.

11.7.2 RUBBISH

With the proposed mitigation, the impacts of rubbish on ecological values are expected to be low. Using fencing/barriers to stop rubbish entering sensitive habitat and considering the siting of rest stops etc, should mean that standard roadside maintenance and clean up will be largely sufficient to avoid habitat degradation.

11.7.3 EROSION, SEDIMENTATION, AND WATER POLLUTANTS

With best practice erosion controls during construction and use of WSRD in the detailed design of the road, the residual impact of sedimentation and polluted run-off entering waterways and/or impacting habitat is considered to be low. However, this will depend on the type of WSRD used and the ability of the design to stop any spills entering wetlands or waterways. Some residual risk associated with spills is likely to remain. Refer to the surface water assessment for assessment of this risk.

11.7.4 SURFACE WATER HYDROLOGY

With the measures recommended in the Surface Water Impact Assessment (WSP 2021) and in this report, the residual impact of changes in surface water hydrology on aquatic vegetation and habitat is likely to be low. The specific WSRD elements are yet to be designed – this should be undertaken during detailed design, based on the recommendations in Section 10.4.7.4.

11.8 FAUNA SPECIES

Table 11.1 Residual impacts on fauna

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITH MITIGATION MEASURES	SEVERITY RATING OF RESIDUAL IMPACT
Amphibians				
Growling Grass Frog	*Litoria raniformis*	VU L en	With the proposed measures, particularly connectivity retention measures, mortality reduction, and mitigation of changes in surface water hydrology and water quality, residual impacts are limited to the direct loss of aquatic and terrestrial potential habitat, which is minor and unlikely to significantly impact the species, particularly as the species has not been recently confirmed to occur in the study area (although may re-colonise under suitable conditions). A Significant Impact Criteria Assessment for the preferred alignment, as required for EPBC Act listed species, is provided in Appendix Q. Based on this assessment, the preferred alignment is unlikely to significantly impact the species with the mitigation measures proposed.	Low
Brown Toadlet	*Pseudophryne bibroni*	L en	With the proposed measures, particularly connectivity retention measures, mortality reduction, and mitigation of changes in surface water hydrology and water quality, residual impacts are limited to the direct loss of aquatic and terrestrial habitat, which is minor and unlikely to significantly impact the species.	Low
Birds				
Australasian Shoveler	*Anas rhynchotis*	vu	With the recommended measures to minimise mortality, shield sensitive habitat from noise, light and visual impacts, and mitigate changes in surface water hydrology and water quality, residual impact is the direct loss of a small amount of medium-quality waterbird habitat. This is considered unlikely to affect breeding or otherwise significantly impact this species.	Low

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITH MITIGATION MEASURES	SEVERITY RATING OF RESIDUAL IMPACT
Baillon's Crake	*Porzana pusilla*	L vu	With the recommended measures to minimise mortality, shield sensitive habitat from noise, light and visual impacts, and mitigate changes in surface water hydrology and water quality, residual impact is the direct loss of a small amount of medium-quality waterbird habitat. This is considered unlikely to affect breeding or otherwise significantly impact this species.	Low
Blue-billed Duck	*Oxyura australis*	L en	With the recommended measures to minimise mortality, shield sensitive habitat from noise, light and visual impacts, and mitigate changes in surface water hydrology and water quality, residual impact is the direct loss of a small amount of medium-quality waterbird habitat. This is considered unlikely to affect breeding or otherwise significantly impact this species.	Low
Brolga	*Grus rubicunda*	L vu	With the recommended measures to minimise mortality, shield sensitive habitat from noise, light and visual impacts, and mitigate changes in surface water hydrology and water quality, residual impact is the direct loss of a small amount of medium-quality waterbird habitat. This is considered unlikely to affect breeding or otherwise significantly impact this species.	Low
Brown Treecreeper	*Climacteris picumnus victoriae*	N nt	With connectivity mitigation (including land bridge in Camp Hill State Forest), hollow replacement, revegetation/landscaping with native vegetation, and noise and light mitigation measures, the residual impact relate largely to the direct loss of habitat. Whilst the majority of habitat for Brown Treecreeper is unlikely to be of high significance to the species, based on the low number of records and lower number of large trees for nesting, residual impact on this species may still remain after mitigation measures.	Moderate
Diamond Firetail	*Stagonopleura guttata*	L nt	With connectivity mitigation (including land bridge in Camp Hill State Forest), hollow replacement, revegetation/landscaping with native vegetation, and noise and light mitigation measures, the residual impact on this species is likely to be low. Residual impacts relate largely to the direct loss of habitat, the majority of which is unlikely to be of high significance to the species, based on the low number of records. The species is unlikely to be significantly impacted by the project.	Low

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITH MITIGATION MEASURES	SEVERITY RATING OF RESIDUAL IMPACT
Eastern Great Egret	*Ardea modesta*	L vu	With the recommended measures to minimise mortality, shield sensitive habitat from noise, light and visual impacts, and mitigate changes in surface water hydrology and water quality, residual impact is the direct loss of a small amount of medium-quality waterbird habitat. This is considered unlikely to affect breeding or otherwise significantly impact this species.	Low
Emu	*Dromaius novaehollandiae*	nt	With measures to minimise mortality risk and maintain connectivity for the species, the project is considered unlikely to significantly impact this species.	Low
Hardhead	*Aythya australis*	vu	With the recommended measures to minimise mortality, shield sensitive habitat from noise, light and visual impacts, and mitigate changes in surface water hydrology and water quality, residual impact is the direct loss of a small amount of medium-quality waterbird habitat. This is considered unlikely to affect breeding or otherwise significantly impact this species.	Low
Latham's Snipe	*Gallinago hardwickii*	M N nt	With the recommended measures to minimise mortality, shield sensitive habitat from noise, light and visual impacts, and mitigate changes in surface water hydrology and water quality, residual impact is the direct loss of a small amount of medium-quality waterbird habitat. This is considered unlikely to significantly impact this species.	Low
Musk Duck	*Biziura lobata*	vu	With the recommended measures to minimise mortality, shield sensitive habitat from noise, light and visual impacts, and mitigate changes in surface water hydrology and water quality, residual impact is the direct loss of a small amount of medium-quality waterbird habitat. This is considered unlikely to affect breeding or otherwise significantly impact this species.	Low

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITH MITIGATION MEASURES	SEVERITY RATING OF RESIDUAL IMPACT
Painted Honeyeater	*Grantiella picta*	VU L vu	With connectivity mitigation (including land bridge in Camp Hill State Forest), hollow replacement, revegetation/landscaping with native vegetation, and noise and light mitigation measures, the residual impact on this species is likely to be low, and relate largely to the direct loss of woodland habitat, which is unlikely to be habitat of high significance to the species based on the low number of records. The species is therefore unlikely to be significantly impacted by the project. A Significant Impact Criteria Assessment is not considered to be warranted for this species, due to the low degree of likely impacts.	Low
Pied Cormorant	*Phalacrocorax varius*	nt	With the recommended measures to minimise mortality, shield sensitive habitat from noise, light and visual impacts, and mitigate changes in surface water hydrology and water quality, residual impact is the direct loss of a small amount of medium-quality waterbird habitat. This is considered unlikely to affect breeding or otherwise significantly impact this species.	Low
Powerful Owl	*Ninox strenua*	L vu	With measures to minimise noise and light pollution, landscape/revegetate with local native species, replace hollows and minimise mortality, residual impacts relate largely to the loss of potential habitat, which may be used for foraging by the occasional dispersing owl, with a lower potential for breeding. The residual impact on this species may still remain after mitigation measures.	Moderate
Speckled Warbler	*Chthonicola sagittata (syn. Pyrrholaemus sagittatus)*	L vu	With connectivity mitigation (including land bridge in Camp Hill State Forest), hollow replacement, revegetation/landscaping with native vegetation, and noise and light mitigation measures, the residual impact on this species is likely to be low, and relate largely to the direct loss of woodland habitat. The species is unlikely to be significantly impacted by the project.	Low

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITH MITIGATION MEASURES	SEVERITY RATING OF RESIDUAL IMPACT
Fish				
Little Galaxias	*Galaxiella toourtkoourt*	VU L en	With measures to maintain waterway connectivity and minimise impacts on surface water hydrology or water quality, the residual impact on this species is expected to be low. A preliminary Significant Impact Criteria Assessment, as required for EPBC Act listed species, is provided in Appendix J. For the preferred alignment, a significant impact is not anticipated with mitigation.	Low
Invertebrates				
Golden Sun Moth	*Synemon plana*	CR L cr	Residual impacts on known occupied habitat and high and low-quality potential habitat are unavoidable, despite measures to revegetate with feed species. Connectivity impacts are also likely, as the species is unlikely to use culvert or underpass structures and large open-span bridges are unlikely to be feasible where the project impacts habitat. Further minimisation and mitigation is unlikely to be possible. A preliminary Significant Impact Criteria Assessment, as required for EPBC Act listed species, is provided in Appendix J. Based on this assessment, the preferred alignment is likely to significantly impact the species. On-site or local offsets should be considered.	High
Mammals				
Brush-tailed Phascogale	*Phascogale tapoatafa*	L vu	With measures to maintain connectivity, minimise mortality, revegetate, and replace hollows, the residual impact on this species is likely to be reduced from high to moderate. Residual impacts associated with the direct clearing of 6.99 ha of moderate quality habitat and 15.598 ha of high-quality habitat will still occur however and residual impacts on this species may still remain after mitigation measures.	Moderate

COMMON NAME	SCIENTIFIC NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITH MITIGATION MEASURES	SEVERITY RATING OF RESIDUAL IMPACT
Reptiles				
Eastern Long-necked Turtle	*Chelodina longicollis*	dd	With measures to maintain connectivity between wetland habitats, minimise mortality risk, and shield wetland habitat from light pollution, residual impacts on this species are considered likely to be low and not significant.	Low

Key for Conservation Status

Listing under the federal *Environment Protection and Biodiversity Conservation Act 1999*

CR = Critically Endangered, EN = Endangered, VU = Vulnerable, M = Migratory

Listing under the Flora and Fauna Guarantee Act 1988
L = listed as threatened, N = Nominated for listing as threatened,

Listed on the Victorian Advisory List of threatened species
cr = Critically Endangered, en = Endangered, vu = Vulnerable, nt = near threatened, dd = Data Deficient

11.9 FLORA SPECIES

With the mitigation proposed, including translocation, minimisation of hydrological changes, erosion and pollutants, weed and disease hygiene measures and rubbish mitigation, impacts on significant flora species are expected to be low and not significant.

For the EPBC Act listed flora species, Matted Flax-lily, Ben Major Grevillea and River-Swamp Wallaby-grass, a preliminary Significant Impact Criteria Assessment is provided in Appendix J.

11.10 ECOLOGICAL COMMUNITIES

Table 11.2 Residual impact on ecological communities

COMMUNITY NAME	STATUS	LIKELY IMPACT (C2 ONLY) WITH MITIGATION MEASURES	SEVERITY RATING OF RESIDUAL IMPACT
Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	CE	With the recommended measures to mitigate changes in surface water hydrology and water quality as well as install No-go Zones to avoid inadvertent clearing, residual impact is the direct loss of a small amount of Seasonal Herbaceous Wetlands. This is considered unlikely to significantly impact this community. A preliminary Significant Impact Criteria Assessment, as required for EPBC Act listed species, is provided in Appendix J. Based on this assessment, the preferred alignment is unlikely to significantly impact the species.	Low
White box – Yellow Box – Blakely's Red Gum Grassy Woodland	CE	With the recommended measures to install No-go Zones to avoid inadvertent clearing, no residual impacts are considered likely for this community. A preliminary Significant Impact Criteria Assessment, as required for EPBC Act listed species, is provided in Appendix J. Based on this assessment, the preferred alignment is unlikely to significantly impact the species.	Low
Victorian Temperate Woodland Bird Community	L	With mitigation, loss of woodland bird habitat is still given a high impact rating as clearing of the assessed amount of native vegetation and flora and fauna habitat is unavoidable. However, mitigation is critical to ensure no impacts occur outside of the construction footprint. Connectivity mitigation (including land bridge in Camp Hill State Forest), hollow replacement, revegetation/landscaping with native vegetation, and noise and light mitigation measures are proposed. However residual impacts on this community are likely to remain after mitigation measures.	High

12 OFFSET STRATEGY

12.1 NATIVE VEGETATION (GUIDELINES 2017)

The offset requirements for the preferred alignment (November 2020 construction footprint) have been estimated using DELWP's EnSym tool (https://ensym.dse.vic.gov.au/cms/). A summary of the native vegetation removal and offset requirements is provided in Table 12.1, with the full assessment output provided in Appendix F. This table summarises the EnSym report, outlines the extent of native vegetation clearance associated with this project, and identifies the commensurate offset target likely to be required to secure a 'no net loss' of biodiversity values.

As per the Guidelines 2017, the extent of proposed removal includes the impacted patches (and parts thereof) including canopies of canopy trees, and the buffers of small and large Scattered Trees.

Calculations of 'past removal' as per DELWP's Assessors Handbook (DELWP 2018a) have not been accounted for in these calculations. Western Highway Burrumbeet to Beaufort was completed in 2015 and Western Highway, Stage 2A Beaufort to Buangor was completed mostly by 2016. Accounting for past removal of native vegetation can apply if the same proponent/applicant undertakes works on the same or contiguous land in the five-year period since the permit for native vegetation is issued. As such, the inclusion of past removal will depend on the timing of the project, but accounting of past removal is not currently anticipated to be required as it will likely be more than five years after completion of other sections that clearing for this project begins.

Following further efforts to avoid and minimise impacts and development of a detailed design, submission of native vegetation losses to DELWP in Geographic Information Systems (GIS) format will need to be completed for submission of a formal Native Vegetation Removal (NVR) report. This is anticipated to occur following funding of the project.

Table 12.1 Native vegetation removal and offset requirements for the preferred alignment construction footprint (November 2020 refined construction footprint)

VEGETATION CLEARANCE AND OFFSET REQUIREMENTS FOR ALIGNMENT C2	
Assessment pathway	Detailed Assessment Pathway
Extent including past and proposed	50.714 ha
Extent of past removal	0.000 ha
Extent of proposed removal	50.714 ha
No. Large trees proposed to be removed	348
Location category	Location 2
General offset amount	2.041 general habitat units
Vicinity	Glenelg Hopkins Catchment Management Authority (CMA) or Pyrenees Shire Council
Minimum strategic biodiversity value score	0.489

VEGETATION CLEARANCE AND OFFSET REQUIREMENTS FOR ALIGNMENT C2	
Species offset amount	27.002 specific units of habitat for Ben Major Grevillea, *Grevillea floripendula* 32.250 specific units of habitat for Emerald-lip Greenhood, *Pterostylis smaragdyna* 28.002 specific units of habitat for Rough Wattle, *Acacia aspera subsp. parviceps*
The total number of large trees that the offset must protect	348 large trees to be protected in either the general, species or combination across all habitat units protected

12.1.1 SOURCING AND AVAILABILITY OF OFFSETS

The state offset targets will be purchased from a third-party offset credit supplier registered on the DELWP Native Vegetation Credit Register and transferred to the project with an Allocated Credit Extract secured to the Planning Scheme Amendment. The Allocated Credit Extract is to be secured *prior* to the clearance of any native vegetation on site. Offset credits will be sourced from sites local to the project wherever practicable.

RRV has been exploring the availability of sites to meet its potential native vegetation and fauna offset requirements for this project for both potential state and Commonwealth offsets. An initial Request for Information was sent to DELWP accredited offset brokers and site assessors in June 2019.

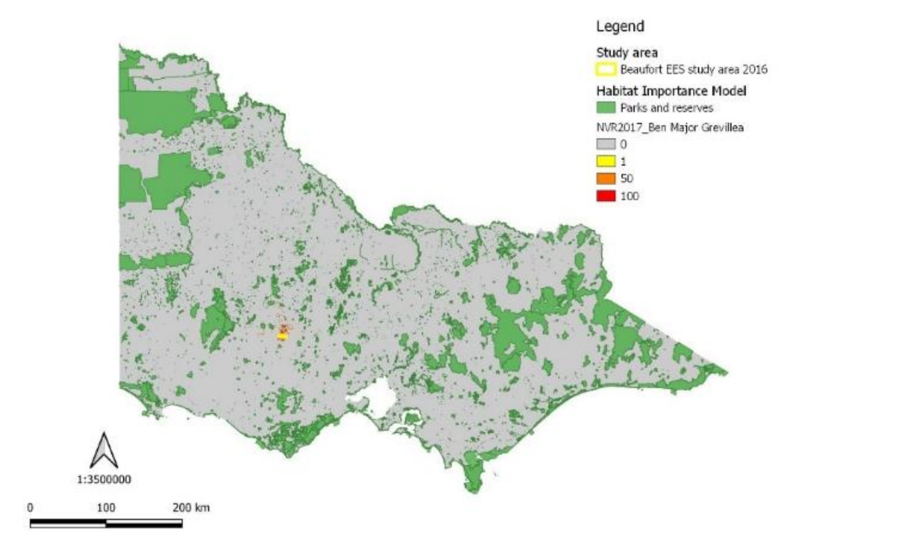
A search of DELWP's Native Vegetation Credit Register on 9 April 2021 identified some but not all Species Units are available:

Table 12.2 Availability and feasibility to source state offsets (as of 9 April 2021)

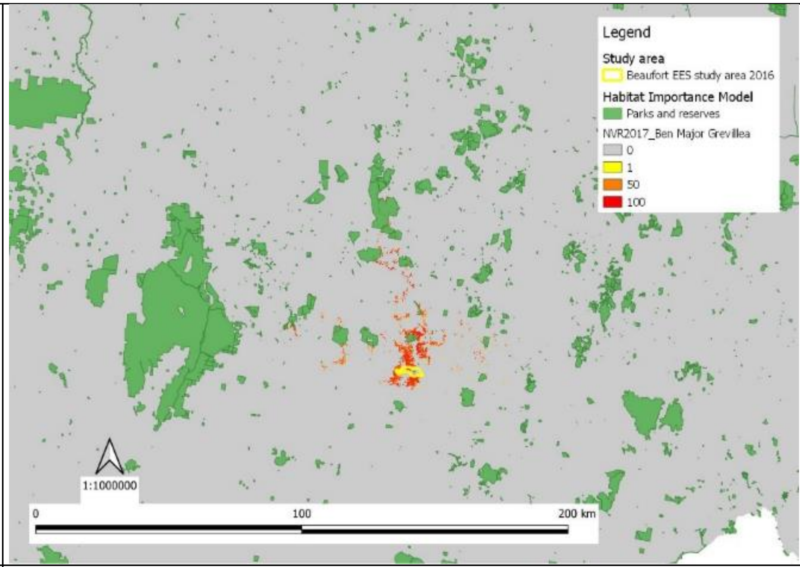
COMMON NAME	NATIVE VEGETATION CREDIT REGISTER	TOTAL AREA (HA) AVAILABILITY IN VIC (MINUS PARKS AND RESERVES)^	FEASIBILITY
Ben Major Grevillea	Three confirmed sites with a total of 8.211 SHU available. There is also one potential site (Credit Site ID VC_TFN-C2085_01) has 33.898 SHU.	17,389	More limited coverage than other Species Units below but likely feasible given the current and potential SHU availability and extent of coverage outside reserved areas
Emerald-lip Greenhood	Eleven confirmed sites with a total of 87.407 SHU available. There is also one potential site (Credit Site ID VC_TFN-C2085_01) has 33.913 SHU.	368,096	Likely feasible given the current and potential SHU availability and extent of coverage outside reserved areas
Rough Wattle	Three confirmed sites with a total of 22.465 SHU available. There is also one potential site (Credit Site ID VC_TFN-C2085_01) has 33.917 SHU.	56,448	Likely feasible given the current and potential SHU availability and extent of coverage outside reserved areas

^ data taken from Habitat Importance Models

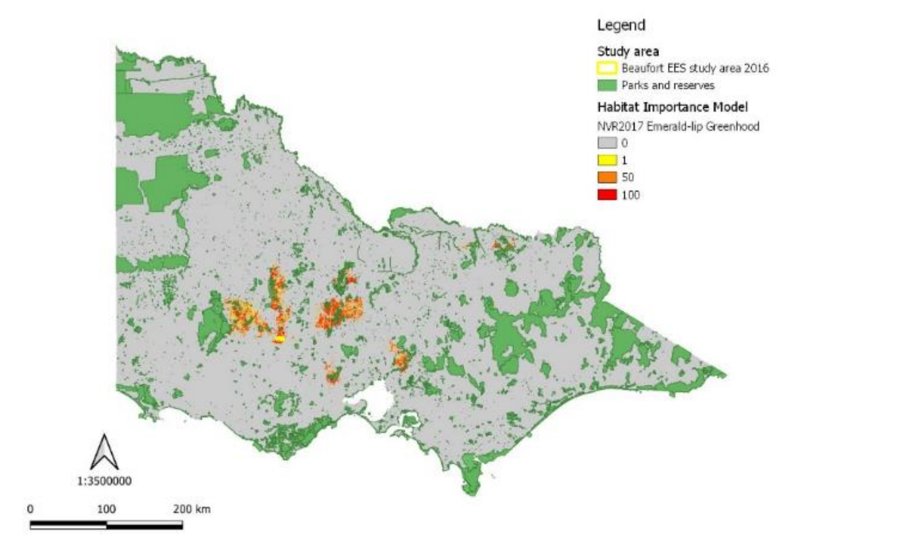
Table 12.3 Coverage of Species Units Habitat Importance Models and reserved areas



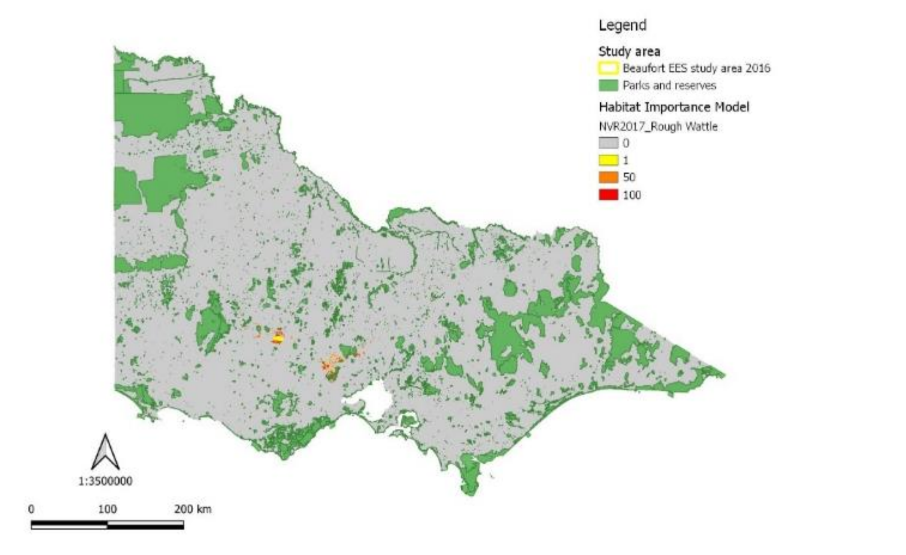
Ben Major Grevillea



Ben Major Grevillea – zoomed in



Emerald-lip Greenhood



Rough Wattle

12.1.2 ALTERNATIVE ARRANGEMENT - WIMMERA SCENTBARK

An Alternative Arrangement Request was submitted to DELWP on 18 June 2021 seeking permission to exclude Wimmera Scentbark from requiring offset obligations as was outlined in a previous EnSym report dated 25 November 2020. This was done based on the justification that the species' habitat requirements are clearly inconsistent with habitat characteristics of the native vegetation present at the site. This process was assessed in accordance with the *Guidelines for the removal, destruction or lopping of native vegetation* (DELWP 2017e) and *Assessors Handbook - Applications to remove, destroy or lop native vegetation* (DELWP 2018a).

As per the *Assessors Handbook* (DELWP 2018a) requirements, a proposal to remove a rare or threatened species from the assessment process must include the following points:

1 The NVR report for the proposed removal of native vegetation, identifying which species offset is proposed to be removed from the assessment process.

2 Photographs of the native vegetation to be removed, specifically the habitat zones under consideration.

3 Justification, confirmed by a competent ecologist, that the habitat characteristics of the native vegetation to be removed are clearly inconsistent with the habitat requirements of the species. The native vegetation should not meet any of the habitat requirements for the species. Habitat requirements may include (but are not limited to) areas suitable for propagation, breeding, foraging, movement, landscape permeability or habitat connectivity. Include:

   a a brief description of the habitat requirements of the species, with references from credible sources
   b a brief description of the habitat characteristics of the native vegetation proposed to be removed, specifically for the habitat zone under consideration.

4 The credentials of the competent ecologist.

DELWP completed as assessment of the proposed Alternative Arrangement Request. On 27 July 2021 DELWP provided written agreement that modelled habitat for Wimmera Scentbark could be removed from within the Beaufort Study area. This determination was made based on the characteristics of the subject areas of native vegetation being clearly inconsistent with the habitat requirements of the species. A copy of the letter is provided in Appendix R.

Following this adjustment, an updated NVR report was requested from DELWP and provided on 28 July 2021. It disregards modelled habitat for Wimmera Scentbark from areas of native vegetation proposed to be removed, therefore omitting any offset requirements for the species. The current NVR report for the preferred alignment is provided in Appendix F.

12.2 EPBC ACT ENVIRONMENTAL OFFSETS

Based on the information available in the referral (Section 5.1.2 of this report), it was considered that the proposed action is likely to have a significant impact on but not limited to Golden Sun Moth. As significant impacts on protected matters are considered likely and the proposed action is determined as a ‘controlled action’, the EPBC Act Environmental Offsets Policy (DSEWPaC 2012a) will apply as residual impacts remain significant, even after mitigation.

When a Commonwealth offset is required, an Offset Strategy and calculations in accordance with the EPBC Act environmental offsets policy (DSEWPaC 2012a) are needed.

12.2.1 PRELIMINARY EPBC ACT OFFSET REQUIREMENTS

The following section outlines the results of a preliminary estimation of EPBC offset requirements and targets. Initial offset targets have been determined in accordance with the *EPBC Act Environmental Offsets Policy* (DSEWPaC 2012a) and *Offsets Assessment Guide* (DSEWPAC 2012b) including the impact and offset calculator spreadsheet. Final calculated EPBC offset requirements for these impacts will be determined when a suitable site/s is identified. This will require the details of the area and quality of the habitat where gains are to be made. As required, a third-party offset site would need to be approved to the satisfaction of DAWE and secured with an appropriate offset covenant in accordance with the *EPBC Environmental Offsets Policy* (DSEWPaC 2012a) prior to commencement of works. This could be covered by on-title security agreements for third party offset sites are either:

- a Trust for Nature offset covenant under the *Conservation Trust Act 1972*, or
- a section 69 agreement under the *Conservation, Forests and Lands Act 1970* (DELWP).

In the interim, and subject to review and consultation with DAWE, these offset calculations are considered an estimate of the potential offset targets. The final decision for offsetting impacts and targets will be determined by DAWE.

12.2.1.1 HABITAT AREA LOSSES AND QUALITY ASSESSMENT

The quality score for an area of habitat or area of community is a measure of how well a particular site supports a particular threatened species or ecological community and contributes to its ongoing viability. There are three components that contribute to the calculation of habitat quality: site condition, site context and species stocking rates. Each of these quality components have been considered to provide a Habitat Quality Score for each of the habitat categories (breeding and dispersal habitat types) in accordance with the EPBC Offsets Policy.

The habitat loss for Golden Sun Moth are based on the current construction footprint in Section 9.1 which include: 1.672 ha of confirmed Golden Sun Moth habitat is likely to be impacted along with 9.431 ha of higher quality potential habitat and 2.822 ha of lower quality potential habitat, equating to a total of 13.925 ha.

Habitat Quality components in Table 12.4 are based on those from informal guidance on the calculation of Golden Sun Moth from DAWE (in email from Assistant Director, Southern NSW and ACT Assessments, the then DoEE on 14 August 2019). Each of the three Habitat Quality components are considered in general terms, with a final score out of 10 provided for each of the habitat categories for each species (refer to Table 12.6). These scores reflect these three attributes, however, we note that this value is subjective and is subject to review and approval by DAWE.

Table 12.4 Habitat Quality Components – Guidance for calculation of Golden Sun Moth offsets (from the then DoEE; 14/092019)

HABITAT QUALITY COMPONENT	NONE	LOW	MODERATE	HIGH	VERY HIGH	NOTES
Site context and condition						
Score	0/3	1/3	2/3	3/3		
Site context	Habitat patch* size <0.25 ha.	Habitat patch size more than 0.25 ha and up to 10 ha	Habitat patch size more than 10 ha, shaped appropriately** to reduce edge effects	Habitat patch size more than 10 ha, shaped appropriately to reduce edge effects, slightly sloped (3° or less) and north-facing, minimal shading	*n/a*	**A patch is considered to be an area of suitable habitat separated from other areas of suitable habitat by >200m of unsuitable habitat, or barriers to flight* ***Assessed on a case by case basis.* ***Note:** Add 1 point (up to a maximum of 3) if the proposed offset results in an occupied linkage between 2 populations.*
Site condition	dominated by introduced vegetation that isn't a known food source	dominated by poor quality native vegetation (VQA score greater than or equal to 30/75) including <20% cover known food source	dominated by moderate quality native vegetation (VQA score 31-45/75) including between 20% and 40% cover known food source and limited inter-tussock space (<5%), **or** dominated by introduced vegetation that is a known food source (i.e. Chilean needle grass) where species stocking rate is greater than 20 moths per hectare*	dominated by high quality native vegetation (VQA equal to or greater than 46/75) including >40% cover known food source, appropriate inter-tussock space.	*n/a*	**Density calculated as an average across the area of suitable habitat. Density to be rounded up if rounding is required.*

HABITAT QUALITY COMPONENT	NONE	LOW	MODERATE	HIGH	VERY HIGH	NOTES
Species stocking rate						
Score	0/4	1/4	2/4	3/4	4/4	
Species stocking rate	species not present	0-5 males per hectare*	>5-20 males per hectare	>20-50 males per hectare	>50 males per hectare	**Density calculated as an average across the area of suitable habitat. Density to be rounded up if rounding is required. It is expected that impact and offset sites to be surveyed on four occasions during the flying season and the survey results to be summed (consistent with survey guidelines). Justification will need to be provided to the Department to support proceeding in the absence of suitable survey effort. For clarity, if lower survey effort is accepted, the Department will consider:* *- for impact sites, the highest recorded density is assumed to be the remaining score (eg three surveys detect 5, 10, 15/ha, therefore the assumed score is 45/ha). If only one survey record of 5/ha, then assumed total 20/ha.* *- for offset sites, the lowest record is assumed to be the remaining score (eg three surveys detect 5, 10, 15/ha, therefore the assumed score is 35/ha). If only one survey record of 5/ha, then assumed total 20/ha.*

Table 12.5 Habitat Quality scores

HABITAT CATEGORY	AREA (HA)	SITE CONTEXT	SITE CONDITION	SPECIES STOCKING RATE	HABITAT QUALITY SCORE (1 – 10)
Confirmed habitat	1.672	**1/3** Habitat patches are between 1-3 ha	**2/3** Moderate VQA score (30-40/75%) and between 20-40% cover of wallaby grasses	**2/4** Confirmed during surveys - 5-20 males per hectare in Section 6.6.2.12.	**5/10**
Higher quality	9.431	**2/3** Habitat patches are between 10-12 ha with edge effects	**2/3** Moderate VQA score (30-40/75%) and between 20-40% cover of wallaby grasses	**2/4** Directly adjacent to confirmed during surveys 5-20 males per hectare in Section 6.6.2.12.	**6/10**
Lower quality	2.822	**1/3** Most habitat patches are between 1-3 ha	**1/3** Lower VQA score (>30/750%) and/or <20% cover of known food source (eg. wallaby grasses)	**0/4** Golden Sun Moth not recorded.	**2/10**
				Total	**4.3**
				Rounding	**4**

12.2.1.2 CALCULATOR ASSUMPTIONS

The final offset site/s are yet to be identified and confirmed. Once these sites and their respective management plans are determined, subject to confirmation by DAWE, then a Site Offset Management Plan will need to be prepared and sent to DAWE for endorsement.

Table 12.6 below outlines the values ascribed to one potential offset site which directly abuts the study area that were used in the EPBC Offset Calculator and to provide an estimate of an offset range for the project. The results from the EPBC Offset Calculator are provided below in Table 12.7. These are estimates only at the moment and may change depending on a range of variables used in the EPBC Offset Calculator.

Table 12.6 EPBC offset site value assumptions

EPBC CALCULATOR ATTRIBUTE	ATTRIBUTE DESCRIPTION	VALUE USED	VALUE RATIONALE
Total area of impact	The habitat loss for Golden Sun Moth are based on the current construction footprint	13.925 ha	
Time over which loss is averted (max. 20 years)	The foreseeable timeframe (in years) over which changes in the level of risk to a proposed offset site can be considered and quantified.	20 years	A 20 year covenant will be placed on Title guaranteeing the duration of risk mitigation for the offset sites.
Time until ecological benefit	Estimated time (in years) that it will take for the habitat quality improvement of the proposed offset to be realised.	10 years	Improvement works aimed at increasing and maintaining the appropriate level of cover, diversity and biomass of preferred indigenous grasses within the proposed offset site. It is assumed work will commence immediately; works will include woody weed removal, ecological burning and other biomass maintenance methods.

EPBC CALCULATOR ATTRIBUTE	ATTRIBUTE DESCRIPTION	VALUE USED	VALUE RATIONALE
Risk of loss (%) without offset	Describes the chance that the habitat on the proposed offset site will be completely lost (i.e. no longer hold any value for the protected matter) over the foreseeable future (in this case 20 years) in the absence of active conservation management.	4.07%	Loss or reduction of indigenous grass cover due to environmental weed invasion and reversion to woodland canopy structures is likely to occur at the offset sites in the absence of active management (woody weed removal, ecological burning and controlled grazing (sheep); current zoning permits unsustainable agricultural landuse and stocking rates. There is no evidence to suggest that the Risk of loss (ROL) at the site will be any greater than other sites in the landscape, the background rates of loss for the relevant LGA can be used to calculate ROL, as per *Guidance for deriving 'Risk of Loss' estimates when evaluating biodiversity offset proposals under the EPBC Act* (Maseyk, Evans & Maron 2017). In this case, the potential offset is located within the Pyrenees LGA which as a ROL value of 4.07%.
Risk of loss (%) with offset	Describes the chance that the habitat on the proposed offset site will be completely lost (i.e. no longer hold any value for the protected matter) over the foreseeable future (in this case 20 years) in the presence of active conservation management.	10%	A 20 year management plan, in conjunction with the offset covenant, will be placed on Title guaranteeing the delivery of Golden Sun Moth habitat improvements and associated population sustainability. A small risk of loss associated with unplanned burning, climate change and unforeseen impacts remains.
Start quality (scale of 0-10)	Current quality of offset site including vegetation condition and structure, the diversity of habitat species present, and relevance of habitat features.	4	As the potential offset site adjoins the study area and may contain similar habitat values, average values used in Table 12.5 were applied.
Future quality without offset (scale of 0-10)	Quality of the offset site predicted to occur without active improvement.	4	The potential offset is not expected to decline considerably over the 20 year period (even in the absence of active conservation management).

EPBC CALCULATOR ATTRIBUTE	ATTRIBUTE DESCRIPTION	VALUE USED	VALUE RATIONALE
Future quality with offset (scale of 0-10)	Quality of the offset site predicted to occur with active improvement.	8	Improvement works aimed at increasing and maintaining the appropriate level of cover, diversity and biomass of preferred indigenous grasses within the proposed offset site. It is assumed work will commence immediately; works will include woody weed removal, ecological burning and other biomass maintenance methods (eg pulse grazing).
Confidence in result	Level of certainty that the offset site will not decline.	70%	Landowners with experience with the management of EPBC offset sites and/or relationships with experienced ecological contractor will be prioritised.
Confidence in result	Level of certainty about the success of the proposed offset.	70%	Landowners with experience with the management of EPBC offset sites and/or relationships with experienced ecological contractor will be prioritised.
% of impact offset	Proportion of impact offset	100.52%	Meets all direct (90%) and indirect (10%) offset requirement.
Offset area required (= start area)		43 ha	

As stated above, the final EPBC offset target is yet to be determined, and the preferred offset site options are likewise yet to be identified for this project. Details of any EPBC offset requirements and offset site options will be provided in a Site Offset Management Plan.

Table 12.7 EPBC Offset Calculator - input values and preliminary estimated offset requirements

Offsets Assessment Guide

For use in determining offsets under the *Environment Protection and Biodiversity Conservation Act 1999*

2 October 2012

This guide relies on Macros being enabled in your browser.

Matter of National Environmental Significance	
Name	Golden Sun Moth
EPBC Act status	Critically Endangered
Annual probability of extinction Based on IUCN category definitions	6.8%

Key to Cell Colours
User input required
Drop-down list
Calculated output
Not applicable to attribute

Impact calculator

Protected matter attributes	Attribute relevant to case?	Description	Quantum of impact		Units	Information source
Ecological communities						
Area of community	No		Area			
			Quality			
			Total quantum of impact	0.00		
Threatened species habitat						
Area of habitat	Yes	Treeless grassland habitat	Area	13.93	Hectares	Consultancy report, EPBC referral and GIS mapping
			Quality	4	Scale 0-10	
			Total quantum of impact	5.57	Adjusted hectares	
Protected matter attributes	**Attribute relevant to case?**	**Description**	**Quantum of impact**		**Units**	**Information source**
Number of features e.g. Nest hollows, habitat trees	No					
Condition of habitat Change in habitat condition, but no change in extent	No					
Threatened species						
Birth rate e.g. Change in nest success	No					
Mortality rate e.g Change in number of road kills per year	No					
Number of individuals e.g. Individual plants/animals	No					

Offset calculator

Protected matter attributes	Attribute relevant to case?	Total quantum of impact	Units	Proposed offset	Time horizon (years)		Start area and quality		Future area and quality without offset		Future area and quality with offset		Raw gain	Confidence in result (%)	Adjusted gain	Net present value (adjusted hectares)		% of impact offset	Minimum (90%) direct offset requirement met?	Cost ($ total)	Information source
Ecological Communities																					
Area of community	No				Risk-related time horizon (max. 20 years)		Start area (hectares)		Risk of loss (%) without offset		Risk of loss (%) with offset										
									Future area without offset (adjusted hectares)	0.0	Future area with offset (adjusted hectares)	0.0									
					Time until ecological benefit		Start quality (scale of 0-10)		Future quality without offset (scale of 0-10)		Future quality with offset (scale of 0-10)										
Threatened species habitat																					
Area of habitat	Yes	5.57	Adjusted hectares	Back Raglan Road Offset Site with records of GSM	Time over which loss is averted (max. 20 years)	20	Start area (hectares)	43	Risk of loss (%) without offset	4%	Risk of loss (%) with offset	10%	-2.55	70%	-1.78	-0.48	5.60	100.52%	Yes		
									Future area without offset (adjusted hectares)	41.2	Future area with offset (adjusted hectares)	38.7									
					Time until ecological benefit	10	Start quality (scale of 0-10)	4	Future quality without offset (scale of 0-10)	4	Future quality with offset (scale of 0-10)	8	4.00	70%	2.10	1.45					
Protected matter attributes	**Attribute relevant to case?**	**Total quantum of impact**	**Units**	**Proposed offset**	**Time horizon (years)**		**Start value**		**Future value without offset**		**Future value with offset**		**Raw gain**	**Confidence in result (%)**	**Adjusted gain**	**Net present value**		**% of impact offset**	**Minimum (90%) direct offset requirement met?**	**Cost ($ total)**	**Information source**
Number of features e.g. Nest hollows, habitat trees	No																				
Condition of habitat Change in habitat condition, but no change in extent	No																				
Threatened species																					
Birth rate e.g. Change in nest success	No																				
Mortality rate e.g Change in number of road kills per year	No																				
Number of individuals e.g. Individual plants/animals	No																				

12.2.2 SOURCING AND AVAILABILITY OF OFFSETS

RRV has been exploring the availability of sites to meet its potential Commonwealth offset requirements. An initial Request for Information was sent to DELWP accredited offset brokers and site assessors in June 2019. As of June 2019, it is likely that Golden Sun Moth offsets are available.

There is no offset credit register of EPBC Act offsets which DAWE publishes, therefore a search of DELWP's Native Vegetation Credit Register on 9 April 2021 was used to identify potential offset site availability and coverage of potential habitat using DELWP's Habitat Importance Model. Whilst the method to determine a suitable offset site for Golden Sun Moth according to the *EPBC Act Environmental Offsets Policy* (DSEWPaC 2012a), the estimates in Table 12.8 and Figure 12.1 below provide an indication of the potential availability of offset sites.

Table 12.8 Availability and feasibility to source state offsets for Golden Sun Moth (as of 9 April 2021)

COMMON NAME	NATIVE VEGETATION CREDIT REGISTER	TOTAL AREA (HA) AVAILABILITY IN VIC (MINUS PARKS AND RESERVES)^	FEASIBILITY
Golden Sun Moth	Four confirmed sites with a total of 32.073 SHU available. Also one site adjacent to the study area which does not appear on the Native Vegetation Credit Register.	978,090	Likely feasible given the current and potential SHU availability and extent of coverage outside reserved areas

^ data taken from Habitat Importance Models

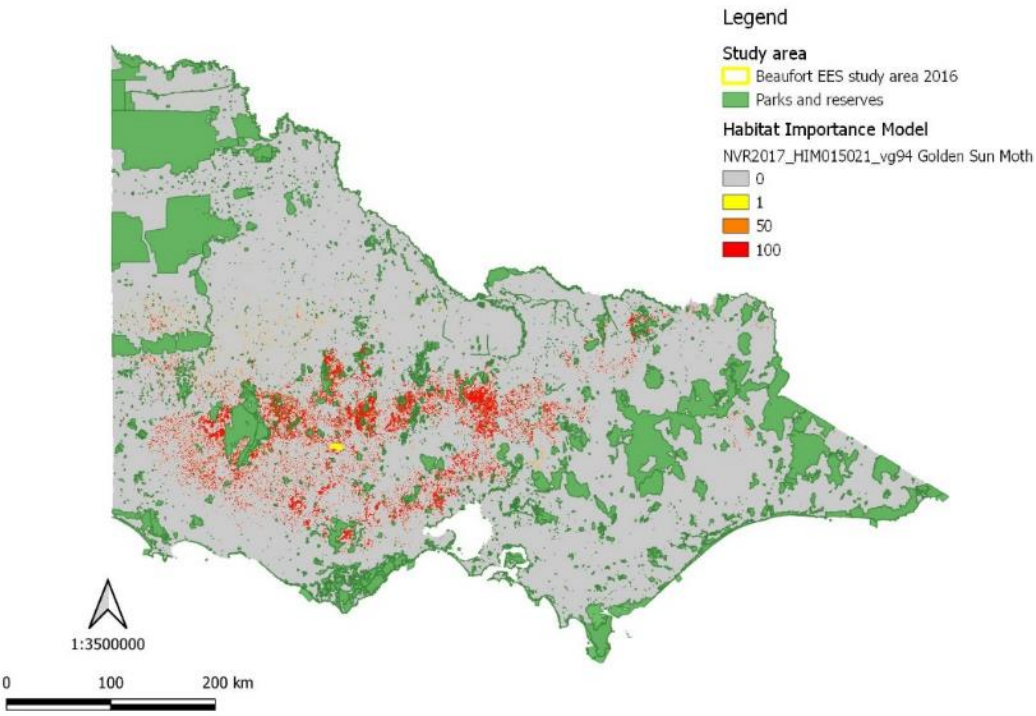


Figure 12.1 Coverage of Golden Sun Moth Species Units Habitat Importance Models and reserved areas

13 CONCLUSION

The purpose of this report is to characterise the existing environment and describe potential impacts of the proposed alignments in line with the Scoping Requirements. This report builds on previous investigations completed within and adjoining the study area, provided results of targeted surveys of threatened flora and fauna species, assessed all fieldwork data, information from relevant literature and databases and assessed alignment impacts against relevant policy and legislation.

The results of surveys in this report during 2016–2017 are provided below and broken up for native vegetation, flora and fauna.

13.1 ECOLOGICAL VEGETATION CLASSES AND THREATENED ECOLOGICAL COMMUNITIES

Seventeen Ecological Vegetation Classes (EVCs) were mapped within the study area.

Two EPBC Act listed communities, Seasonal Herbaceous Wetlands and White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Grasslands were mapped in the study area.

One FFG Act community, the Victorian Temperate Woodland Bird community, was mapped in the study area.

13.2 SIGNIFICANT FLORA SPECIES

A number of significant flora species have been recorded in the study area during surveys in 2015-2017, many of which had not been previously recorded in the area. These species are:

- Matted Flax-lily *Dianella amoena* (EPBC Act and FFG Act listed; endangered in Victoria) **new record for region**
- Floodplain Fireweed *Senecio campylocarpus* (rare in Victoria) **new record for region**
- Ben Major Grevillea *Grevillea floripendula* (EPBC Act and FFG Act listed; vulnerable in Victoria)
- Yarra Gum *Eucalyptus yarraensis* (rare in Victoria)
- River Swamp Wallaby-grass *Amphibromus fluitans* (EPBC Act) **new record for region**
- Pale-flower Cranesbill *Geranium sp. 3* (rare in Victoria) **new record for region**
- Rosemary Grevillea *Grevillea rosmarinifolia* (rare in Victoria)
- Ornate Pink Fingers *Caladenia ornata* (EPBC Act and FFG Act listed; vulnerable in Victoria) **new record for region**
- Emerald-lip Greenhood *Pterostylis smaragdyna* (rare in Victoria) – recorded in September 2017.

One species Rough Wattle *Acacia aspera subsp. parviceps* (rare in Victoria) was not found during surveys, despite repeated searches, but was previously recorded in the Victorian Biodiversity Atlas (VBA) in the Snow Gums Bushland Reserve in 1993.

13.3 SIGNIFICANT FAUNA SPECIES

A number of significant fauna species have been recorded in the study area during surveys in 2015-2018. This includes:

- Golden Sun Moth (EPBC Act and FFG Act listed; critically endangered in Victoria)
- Brown Toadlet (FFG Act listed; endangered in Victoria)
- Brush-tailed Phascogale (FFG Act listed; vulnerable in Victoria)
- Squirrel Glider (FFG Act listed; endangered in Victoria)
- Brown Treecreeper (near threatened in Victoria)
- Brolga (FFG Act listed; vulnerable in Victoria)
- Eastern Long-necked Turtle (data deficient in Victoria).

Despite not being recorded during current surveys for this assessment, there are records from previous studies and the VBA within the study area for a further 15 significant fauna species. Of these species, six have been assessed as highly likely to occur based on the availability of suitable habitat in parts of the study area. This includes the following:

- Growling Grass Frog (EPBC Act and FFG Act listed; endangered in Victoria)
- Powerful Owl (FFG Act listed; vulnerable in Victoria)
- Little Galaxias – closely related Dwarf Galaxias (EPBC Act and FFG Act listed)
- Painted Honeyeater (EPBC Act and FFG Act listed; vulnerable in Victoria)
- Hardhead (vulnerable in Victoria)
- Diamond Firetail (FFG Act listed; near threatened in Victoria).

13.3.1 POTENTIAL IMPACTS

A nominal potential construction impact footprint for alignment option comparison was determined and used to assess and compare alignments. Based on this assessment, alignment option C2 was determined to be the preferred alignment with regard to impact on significant ecological values, having the least impact on native vegetation, habitat and threatened species. Alignment option C2 has since been determined to be the preferred alignment for the project.

A refined construction footprint for C2 has since been developed which includes area required for creek realignments. This footprint was used to assess impacts on significant ecological values.

Likely impacts of the preferred alignment include:

- loss of 47.95 ha of native vegetation patches, including 327 large trees in patches. An additional 21 large and 7 small scattered trees will also be impacted
- impact on 0.312 ha of EPBC Act listed ecological community Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains
- impact on 32.800 ha of impact on FFG Act listed Victorian Temperate Woodland Bird Community
- impact on significant flora: one Yarra Gum, one Matted Flax-lily and one patch of River-swamp Wallaby-grass
- direct loss of habitat for significant fauna including the loss of habitat for significant wetland and woodland birds, potential habitat for Growling Grass Frog and Brown Toadlet, potential habitat for Little Galaxias, habitat for Brush-tailed Phascogale and Squirrel Glider, and habitat for Golden Sun Moth
- a range of other impacts are also likely without mitigation including loss of connectivity, mortality and injury of wildlife, noise impacts, light impacts, visual disturbance, habitat degradation from weeds and disease, rubbish, erosion, sedimentation, and water pollutants, hydrological changes (surface water, groundwater unlikely to be affected) and air quality and dust.

A range of mitigation measures have been tailored in response to the identified impacts. The measures have been developed to mitigate specific impacts to species and communities listed under the EPBC Act and FFG Act native vegetation (Guidelines 2017), flora, vertebrate fauna and invertebrate fauna listed under the relevant DELWP Advisory lists, and wildlife protected under the *Wildlife Act 1975*. Following the implementation of the identified mitigation measures, residual impacts for the significant ecological values identified in the assessment range from low to high subject to nature, extent and duration of impact.

Residual impact will be offset in accordance with Victorian native vegetation offset requirements and, if required, under the EPBC Act.

14 LIMITATIONS

This Report is provided by WSP Australia Pty Limited (*WSP*) for Regional Roads Victoria (*Client*) in response to specific instructions from the Client and in accordance with WSP's proposal dated 2 September 2020 and agreement with the Client dated 10 September 2020 (*Agreement*).

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