

Woodburn to Ballina

Upgrading the Pacific Highway

Technical Review of the Ecological Investigations for the Route Selection Process

March 2008



The Pacific Highway Office of the Roads and Traffic Authority (RTA) engaged the professional services contractor Hyder Consulting to manage and coordinate a number of specialist studies as part of the route selection and concept design process for upgrading of the Pacific Highway between Woodburn and Ballina.

In October 2004, the RTA commenced investigations into a future preferred route. Route options were displayed in May – July 2005, and the preferred route was displayed in November 2005 – January 2006. This working paper has been prepared by Hyder Consulting and provides specialist input into the concept design.

During the preferred route display for the proposed upgrade of the Pacific Highway between Woodburn and Ballina, submissions were received from a number of stakeholders, including Ballina Shire Council and the Department of Environment and Climate Change, regarding the robustness of the ecological assessment of route options and therefore selection of the preferred route.

This technical review has been prepared to examine whether the ecology input to the route options assessment was such that selection of the preferred route was based on scientifically robust ecological advice.



Technical Review of the Ecological Investigations for the Route Selection Process

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Independent Ecological Review of the Route Options (Ecosense, 2008)

Executive Summary

As part of the route options investigations and concept development for the upgrading of the Pacific Highway between Woodburn and Ballina on the north coast of NSW, several ecological assessments have been undertaken. These assessments commenced in 2004 and have been the subject of several reviews by interested stakeholders who have been provided with copies of draft ecological reports.

During these reviews a number of concerns were raised by Ballina Shire Council, the Department of Environment and Conservation (now the Department of Environment and Climate Change), and other members of the community about the ecological investigations.

Following the concerns raised the RTA arranged for an independent peer review of the *Phase 1 and 2 Investigations Flora and Fauna Assessment of Options* (Geolyse 2005). The independent peer review was undertaken by Ecosense Consulting Pty Ltd (Ecosense) directly for the RTA. The overall aim of the independent peer review was to determine if there were any gaps in the data and to investigate whether the ecology input to the route options assessment was scientifically robust. The independent peer review found, that in its opinion, there were a number of gaps in the Geolyse report and it was recommended that these be addressed in order to make the report more scientifically robust.

Subsequent to the independent peer review and as a precaution, the RTA commissioned Ecosense to carry out an independent ecological review of the route options (shown in **Figure 1**). This review involved analysis and assessment of all available data, and additional field investigations, to address the gaps identified in the Geolyse report.

Overall, Ecosense found that the route options with the least ecological impacts comprised option 1A in section 1 and option 2F in section 2, although they found that route option 3B had slightly greater impacts than option 3A in section 3.

In section 2, Ecosense also found that route options 2A to 2E had significantly higher ecological impacts than route option 2F. Although the route options 2A to 2E were ecologically similar, trends were discernable. Options 2B and 2D performed similarly but had less overall ecological impacts than options 2A and 2E, which also performed similarly. Option 2C had higher ecological impacts than the other options in section 2.

The independent ecological review, plus additional flora and fauna investigations and mapping provided an opportunity for the project team to review the environmental rankings used in the value management workshop and subsequent preferred route selection process. The conclusion of this review was that the ecology input to the route options assessment and preferred route selection was scientifically robust.

As required by NSW environmental planning legislation the environmental assessment for the proposed upgrade will provide further assessment of the ecological impacts.

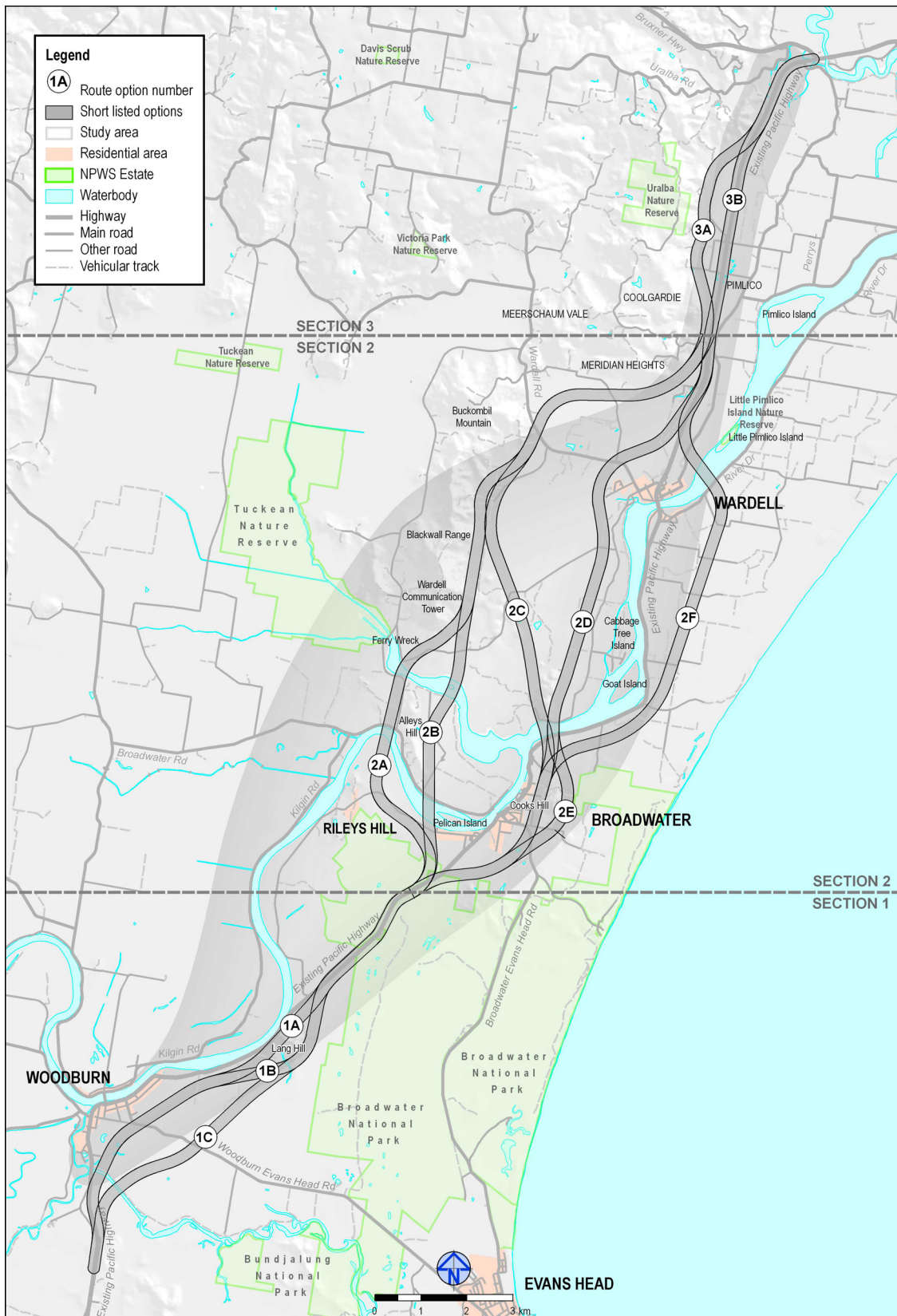


Figure 1 The short list of route options

1 Introduction

As part of the route options investigations and concept development for the upgrading of the Pacific Highway between Woodburn and Ballina on the north coast of NSW, several ecological assessments have been undertaken. These assessments commenced in 2004 and have been the subject of several reviews by interested stakeholders who have been provided with copies of draft ecological reports.

During these reviews a number of concerns were raised by Ballina Shire Council (BSC), the Department of Environment and Conservation (DEC) (now the Department of Environment and Climate Change (DECC)), and other members of the community about the ecological investigations. Following the concerns raised the RTA arranged for an independent peer review of the *Phase 1 and 2 Investigations Flora and Fauna Assessment of Options* (Geolyse 2005). The peer review was undertaken by Ecosense Consulting Pty Ltd (Ecosense) directly for the RTA and is summarised in **Section 2**.

Subsequent to the independent peer review and as a precaution, the RTA commissioned Ecosense to carry out an independent ecological review of the route options. This review involved analysis and assessment of all available data and additional field investigations, to address the gaps identified in the Geolyse report and is summarised in **Section 3**.

The independent ecological review, plus additional flora and fauna investigations and mapping provided an opportunity for the project team to review the environmental rankings used in the value management workshop (VMW) and subsequent preferred route selection process, and is summarised in **Section 4**.

An overview of the ecology review process is provided in **Figure 2** overleaf.

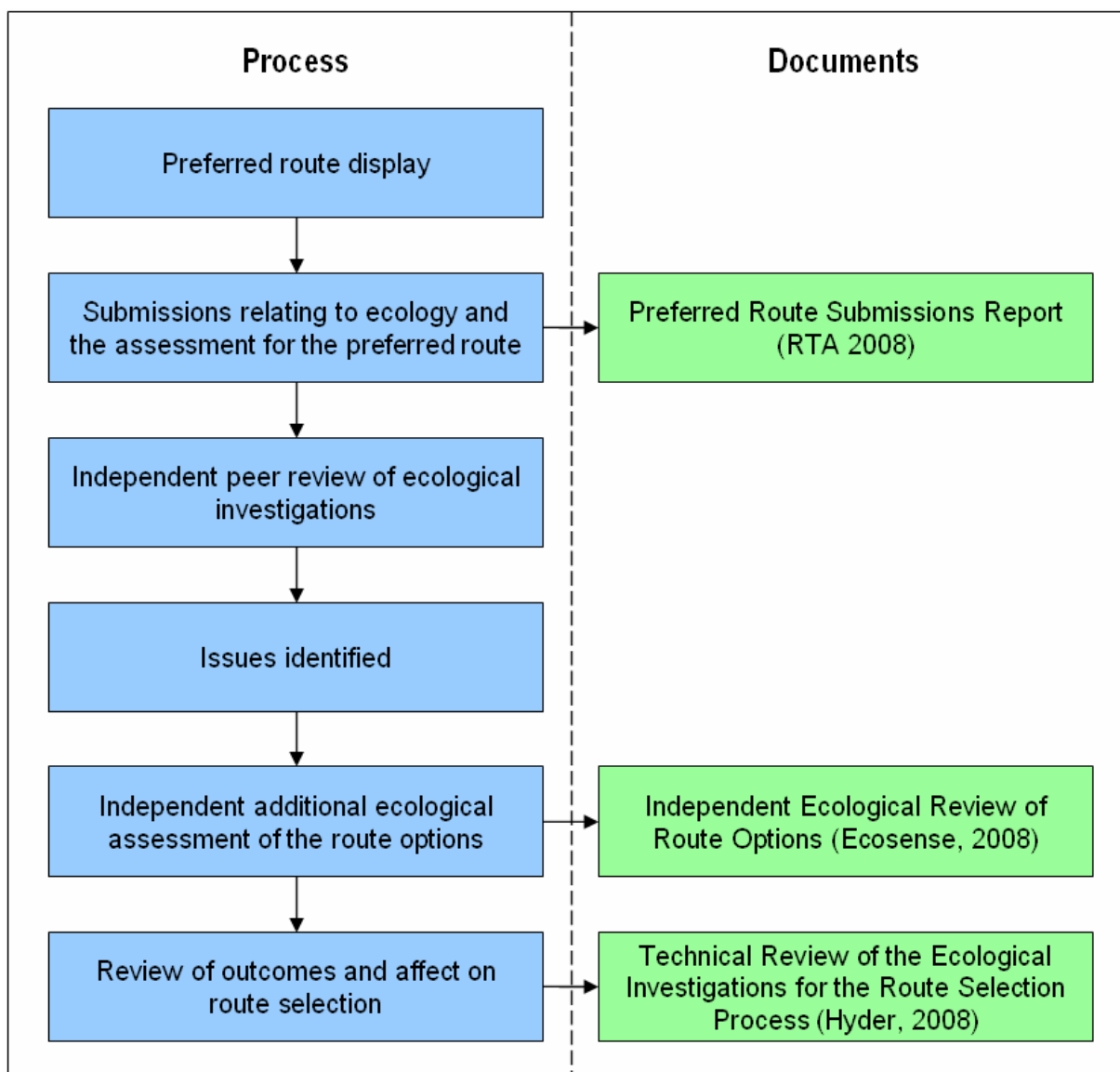


Figure 2 Ecological investigations review process

2 Independent peer review

The overall aim of the independent peer review was to determine if there were any gaps in the data and to investigate whether the ecology input to the route options assessment was scientifically robust.

The independent peer review examined:

- Flora and fauna survey, data analysis and assessment.
- Vegetation community mapping.
- Terrestrial flora assessment.
- Terrestrial fauna assessment, with particular reference to Table 3.7 of the Geolyse report.
- Route option rankings.

Ecosense was provided with the following reports and documents for consideration during the review:

- *Phase 1 and Phase 2 Investigations Flora and Fauna Assessment of Options* (Geolyse, September 2005) Volumes 1 and 2.
- *Flora and Fauna Assessment of Options Addendum Report: Supplementary Information for Vegetation Community Identification* (Geolyse, October 2005).
- Review of the flora component of the report “*Flora and Fauna Assessment of Route Options, Phase 1 and 2 Investigations, Proposed Woodburn to Ballina Pacific Highway Upgrade*” (Benwell, August 2005).
- Comments: *Woodburn to Ballina – Vegetation Survey Spreadsheet and Dendrogram* (Benwell, October 2005).
- *Woodburn to Ballina Highway Upgrade Assessment of Vegetation/Habitat Types on the Route Option 2A-2B-2C* (Benwell, January 2006).
- DEC and Ballina Shire Council submissions.
- Department of Primary Industries submissions.
- Various ecological focus group (EFG) and community liaison group (CLG) meeting notes.

In order to provide some context for the review, the following documents were also considered:

- Interim Report and transcripts from the Parliamentary Inquiry into Pacific Highway Upgrades;
- Nature Conservation Council submission on the Preferred Route Report; and
- *Woodburn to Ballina Preferred Route Report* (RTA, 2005).

Dr Renata Bali (Ecosense) was responsible for the overall structuring of the review report and review of documentation, including the terrestrial fauna

assessment section of the *Phase 1 and 2 Investigations Flora and Fauna Assessment of Options* (Geolyse 2005). Dr Bali's team included Khaalyd Brown who reviewed the terrestrial flora assessment of the Geolyse report, and Bill Rooney who reviewed the aquatic survey and assessment of the Geolyse report.

A site visit was conducted by Renata Bali and Khaalyd Brown on 18 April 2006 while Bill Rooney visited the site on 10 May 2006. The preferred route was examined wherever accessible from existing roads between Broadwater National Park in the south to Wardell in the north. The aim of the site visit was to examine broad vegetation communities, their connectivity and salient aquatic and terrestrial fauna features.

Renata Bali met with Toby Heys and Scott Lawrence from the NSW RTA and Rod Willis and Ian Gaskell of BSC on 2 May 2006, where BSC summarised its concerns with regards to the quality of information presented in the ecological reporting.

2.1 Independent peer review conclusions and recommendations

The independent peer review identified a number of gaps in the ecology reporting, including:

- Lack of transparency in the ecological assessment due to poor report structure and organisation.
- In some cases, the data was available but not examined robustly.
- Data necessary to compare routes objectively was not collected or analysed.
- Perceived errors in judgement.
- Data not assessed adequately within a regional or local context.

The independent peer review recommended the gaps in the ecology reporting be addressed in order to make the report more scientifically robust, and recommended that the following major tasks be undertaken:

- Terrestrial vegetation mapping for the entire study area using aerial photo interpretation (API), ground-truthing and existing mapping.
- Identification and accurate mapping of EECs and regionally significant vegetation communities.
- Terrestrial fauna habitat mapping and identification of important habitat features (including old growth) for the entire study area.
- Reassessment of potential habitat for the oxleyan pygmy perch in section 2.
- Consideration of all available data including regionally significant species, ROTAPs, invertebrates and nomadic and migratory fauna species.

- Reanalysis of the impacts of route options on vegetation communities, fauna habitat, threatened terrestrial species and oxleyan pygmy perch habitat.
- Reassessment of the potential ecological impacts associated with route options based on accurate vegetation mapping and reanalysis of all available.
- Ranking of route options based on reanalysis and reassessment of all available data.

Despite the perceived problems with the ecology reporting, the independent peer review noted that re-analysis of data may not affect the eventual outcome. Ecological criteria forms only one aspect of the route selection process and other non-ecological factors are also taken into consideration, and may at times be given higher priority than ecology. It is therefore impossible to rule out that the preferred route would again be selected even if ecological data were to be re-examined.

3 Independent ecological review of route options

Subsequent to the independent peer review and as a precaution, the RTA commissioned Ecosense to carry out an independent ecological review of the route options. This review involved analysis and assessment of all available data, and additional field investigations. The *Independent Ecological Review of the Route Options* (Ecosense, 2007) is contained in **Appendix 2**.

The following major tasks were undertaken:

- Terrestrial vegetation mapping for the entire study area using aerial photo interpretation (API), ground-truthing and existing mapping.
- Identification and mapping of endangered ecological communities (EEC's) and regionally significant vegetation communities.
- Terrestrial fauna habitat mapping and identification of important habitat features for the entire study area.
- Reassessment of potential habitat for the oxleyan pygmy perch in section 2.
- Consideration of all available data including regionally significant species, Rare or Threatened Australian Plants (ROTAPs), invertebrates and nomadic and migratory fauna species.
- Reanalysis of the ecological impacts of route options on vegetation communities, fauna habitat, threatened terrestrial species and oxleyan pygmy perch habitat.
- Reassessment of the ecological impacts associated with route options based on accurate vegetation mapping and reanalysis of all available data.
- Ranking of route options based on reanalysis and reassessment of all available data.

3.1 Independent ecological review conclusions

The independent ecological review referred to the route options in the same sections that original route option assessment utilised. The conclusions of this assessment broadly agreed with the previous project team assessment in sections 1 and 3 of the route options. In section 2 it agreed that route options 2A to 2E had significantly higher ecological impacts than route option 2F. The review attempted to obtain further resolution in section 2 by subjecting the data to a simple sensitivity analysis (refer to **Section 6.3.6 of Appendix 2**). The sensitivity analysis discerned trends that showed some differences in the ecological impact. Options 2B and 2D performed similarly but had less overall ecological impacts than options 2A and 2E, which also performed similarly. In the sensitivity analysis, option 2C had the highest weighted score for ecological impact 80% of the time.

Overall, the independent ecological review agreed with the findings of Geolyse that the route options with the least ecological impacts comprised

1A and 2F but found that option 3B had slightly greater impacts than option 3A.

The independent ecological review also assessed the final preferred route and found the alignment has less impact on the ecology than the original chosen route corridor options in sections 2 and 3.

However in section 1 the preferred route alignment does have greater ecological impacts than the original route corridor options in terms of removal of areas of high and medium-high conservation value and high ecological impacts on oxleyan pygmy perch (a threatened species) through the removal of known habitat and disturbance to downstream habitats at the McDonalds Creek crossing.

Oxleyan pygmy perch were recorded in a number of water bodies within the McDonalds Creek catchment. The permanent, semi permanent and intermittent tributaries of McDonalds Creek form important connection habitat during floods and important local breeding habitat during non-drought periods. The lower sections of McDonalds Creek appear to contain small numbers of oxleyan pygmy perch in degraded habitats. Although the best habitat for this species was predominantly located along the western border of Broadwater National Park, oxleyan pygmy perch were found scattered along most sections of McDonalds Creek.

The preferred route alignment has since been moved west to reduce impacts on oxleyan pygmy perch in the McDonalds Creek area.

3.2 Discussion on the independent review process

During the independent ecological review of the route options, Hyder raised some issues with regard to the assessment criteria utilised by Ecosense. Generally the assessment criteria were considered robust except for the following:

- *Areas of regional and sub-regional corridors removed*

If a wildlife corridor is not functional it should not be included as an impact. Also, as vegetation clearing is used in 4 other assessment criteria the number of functional corridors severed by the route options should have been used rather than the area impacted. Using the area of fauna corridor impacted as an assessment tool can give an unrealistic result, particularly where the corridor is not functional or where the route option runs along the edge of a corridor but does not sever it.

- *Distance of route through regional corridors*

As discussed in the previous point where the corridor is not functional or where the route option runs along the edge of a corridor but does not sever it the criteria can give an unrealistic result of the barrier impact of an option.

- *Number of known and potential threatened flora, fauna and aquatic species potentially impacted*

Hyder raised the point that the use of known records of threatened species to distinguish between options can be misleading as known records would

be highly correlated to survey effort and this method of classification could potentially exclude high conservation value areas because they haven't been sampled.

The other point raised by Hyder was the rating of non-vegetated areas within wildlife corridors as a "Medium-Low" classification. The issue was that the use of this classification overstates the importance of those areas as 'habitat' which in turn would reduce the importance of vegetated areas of high habitat value in the ranking system.

Although these issues were raised with Ecosense, the review team confirmed that they had applied the criteria they thought provided the best comparison of the options with regards to ecological impact. It was discussed that these criteria are open to different interpretation by others but maintained that they were the best criteria to use for the purposes of the independent ecological review of route options.

Hyder believes that if the above comments had been incorporated it is likely that the ecological impacts from route option 2C would have been less than those stated in the Ecosense independent review.

4 Discussion on the preferred route selection

The process for the selection of the preferred route is documented in the *Woodburn to Ballina: Preferred Route Report* (RTA 2005). It involved consideration of issues from:

- The assessment of route options.
- Issues raised in response to the preferred route display.
- Recommendations and issues arising from a value management workshop (VMW).

With the key issues identified, the final round of assessment was based on a framework based on guiding principles devised by the study team.

4.1 Value management workshop

A VMW was held during the route selection process bringing together a wide range of stakeholder interests and expertise. VMW attendees were required to review the investigations undertaken to date and on the balance of issues and assessment of the options against agreed assessment criteria, determine a preferred direction for further investigation to progress the project development.

During the VMW assessment criteria were developed under the five key perspectives of Environment, Heritage, Functional, Social and Noise, and Business and Economics. The 'Environmental perspective' was very much based on results of the ecological investigations and considered impacts on key habitats and corridors, threatened species and EECs. Extracts from the value management workshop that relate to assessment of environmental impacts are contained in **Appendix 1**. A full copy of this report is contained in Appendix B of the *Woodburn to Ballina: Preferred Route Report* (RTA, 2005).

The VMW attendees then assessed the corridor options in each section using the assessment criteria developed and ranked the performance of each option (see **Table 1**).

Table 1 - VMW route option rankings on the agreed assessment criteria

Option	Environ- mental	Heritage	Functional	Social & Noise	Business & Economic	Cost (units)
1A	1	3	3	2	3	100
1B	2	2	2	2	2	88
1C	3	1	1	1	1	86
2A	4	1	5	3	5	100
2B	4	3	4	3	4	109
2C	3	4	3	1	3	93

Option	Environ- mental	Heritage	Functional	Social & Noise	Business & Economic	Cost (units)
2D	2	5	2	2	2	88
2E	2	6	1	2	1	84
2F	1	2	6	1	6	160
3A	2	2	2	2	2	100
3B	1	1	1	1	1	98

The independent ecological review, plus additional flora and fauna investigations and mapping have provided an opportunity to update the environmental rankings of the section 2 options (see **Table 2**). For the purposes of the assessment, various ecological values were calculated, tabulated and then compared amongst route options. All available data was collated and reanalysed and assessed through the tabulation of all significant areas of vegetation to be removed or otherwise impacted as a result of each route option. The revised ranking is based solely on the ranking provided by the ecological review and is not a revisit of the criteria used at the VMW.

Table 2 - Updated route option rankings

Option	Environ- mental*	Heritage	Functional	Social & Noise	Business & Economic	Cost (units)
1A	1	3	3	2	3	100
1B	2	2	2	2	2	88
1C	3	1	1	1	1	86
2A	4	1	5	3	5	100
2B	3	3	4	3	4	109
2C	5	4	3	1	3	93
2D	2	5	2	2	2	88
2E	4	6	1	2	1	84
2F	1	2	6	1	6	160
3A	1	2	2	2	2	100
3B	2	1	1	1	1	98

*Note: All section 2 options except for 2F had high ecological impacts and were hard to differentiate between.

The outcomes of both the Ecosense independent ecological review and the original VMW environmental ranking assessment was that, with exception of option 2F, all options in section 2 would have moderate to high environmental impacts. The updated section 2 environmental ranking indicates some changes in the environmental rankings for some options in section 2 (options 2B, 2C and 2E).

The environmental impact of option 2C as a result of the ecological review was then considered to be the highest of all the section 2 options. However it should be noted that the Ecosense independent ecological review found that it was very difficult to differentiate between the route options in section 2, except for option 2F. Also, the original VMW assessment had considered that option 2C had potentially high environmental impacts and that the option was feasible subject to the implementation of environmental and heritage mitigation measures.

4.2 Guiding principles

Selection of option 2C as part of the preferred route was based on consideration of various selection criteria not only environmental. The final assessment of the preferred route applied 'guiding principles' adopted by the project team (*Woodburn to Ballina Preferred Route Report* RTA, 2005). These guiding principles were:

- Risk reduction: including the application of the 'precautionary principle.
- Cost: capital and road user cost.
- Ability to mitigate: possibility of redressing adverse impacts.
- Intergenerational equity: including consideration of high ecological impacts relating to impacts or imposts on future generations.

The preferred route that was selected represents a balance of the impacts presented by each option.

In refining the preferred route and continuing to apply all the 'guiding principles' additional work has been undertaken on the entire alignment to achieve an improved environmental outcome amongst other matters. Consequently, assessment of the preferred route by Ecosense as part of the independent ecological review determined that the preferred route in section 2 would have less ecological impacts than options 2A, 2C and 2E, but not 2B, 2D and 2F.

Further surveys have now been undertaken on the preferred corridor in order to seasonally target specific species. This has ensured that the concept design has been developed with a greater knowledge of the preferred corridor ecology.

5 Concluding comments

The degree of detail of ecological assessment undertaken to date has been commensurate with the ecological sensitivity of the NSW North Coast Bioregion and has exceeded the level of assessment required in past RTA route selection processes. It is not feasible to undertake a detailed ecological assessment of the entire study area at the project planning stage. The ecology investigations reported in the *Phase 1 and 2 Investigations Flora and Fauna Assessment of Options* (Geolyse 2005) were consistent with the RTA's *Scope of Work and Technical Criteria* regarding Biological Impacts (Section 6.24) for the development of the route options for Woodburn to Ballina.

Concerns raised as to the veracity of the ecological investigations for route option selection were responded to by the project team with the engagement of Ecosense to provide an independent peer review and independent ecological review of the route options.

It is felt that the reviews and consequent additional investigations, together with further targeted seasonal investigations, has provided more ecological information which will provide a basis for refining the concept design and the future environmental assessment process in accordance with the requirements of the *Environmental Planning and Assessment Act 1979*.

In particular, refinements of the preferred route as a result of the independent peer review, independent ecological review, additional ecological investigations, discussions with property owners and the continual application of the 'guiding principles' in the development of the concept design have reduced the potential ecological impacts of the proposed upgrade.

Following the review of ecological impacts of the proposed upgrade Hyder and the RTA held a project team meeting. At this meeting the team considered the results of the independent ecological review, the new ecological data, the original route options and the current preferred route. The team then determined the way forward in conjunction with the 'guiding principles'. The conclusion of this meeting was that the ecology input to the route options assessment was scientifically robust and a decision was made to proceed with the preparation of a concept design for the current preferred route. As required by NSW environmental planning legislation the environmental assessment for the proposed upgrade will provide further assessment of the ecological impacts.

Appendix 1

Extracts from the Woodburn to Ballina: Value
Management Workshop Report (RTA, 2005)

Assessment of Corridor Options

Having reviewed the shortlisted corridor options and discussed their advantages and disadvantages as well as issues to be addressed as planning proceeds in relation to the various specialist studies outlined in the presentations above (including information outlined in the Route Options Development Report), and supplemented with the knowledge and perspectives of the various workshop participants, the group was now in a position to assess the corridor options against the consideration and prompts under the five key perspectives developed earlier in the workshop.

The group (in five focus groups) assessed the corridor options in each Section using the considerations and prompts for each of the key perspectives being Environment, Heritage, Functional, Social and Noise, and Business and Economics. For instance, one focus group assessed the corridor options against the environmental considerations, whilst a second focus group assessed the corridor options against the heritage considerations, and so on.

The options were judged on a qualitative basis of how well each option met each consideration in each perspective on a scale of Excellent (**E**), Very Good (**VG**), Good (**G**), Fair (**F**) or Poor (**P**).

Once the qualitative assessment was completed, the focus group reflected on the assessment and established “on balance” of the considerations made, a ranking for each corridor option in each Section within their allocated perspective or cluster.

During the process, each focus group recorded their observations and conclusions as a result of their deliberations and findings.

The findings of each focus group was presented to the whole group for discussion, amendment (if required) and finally endorsement as to an agreed assessment and ranking of corridor options within each perspective and Section to assist the group move forward.

Their findings as presented (together with amendments) and as agreed by the whole group are listed below. Their key observations in reaching their findings is also recorded.

Assessment of Corridor Options within the Environmental Perspective

Section 1		Environmental Perspective									
		Considerations Prompts	Impact on key habitats & corridors	Threatened species & EECs	Hydrological impacts on ecosystems	Potential water quality impacts					
OPTIONS											
1A			E	E	E	E	E	E	E	E	RANK 1
			VG	VG	VG	VG	VG	VG	VG	VG	
			G	G	G	G	G	G	G	G	
			F	F	F	F	F	F	F	F	
			P	P	P	P	P	P	P	P	
1B			E	E	E	E	E	E	E	E	RANK 2
			VG	VG	VG	VG	VG	VG	VG	VG	
			G	G	G	G	G	G	G	G	
			F	F	F	F	F	F	F	F	
			P	P	P	P	P	P	P	P	
1C			E	E	E	E	E	E	E	E	RANK 3
			VG	VG	VG	VG	VG	VG	VG	VG	
			G	G	G	G	G	G	G	G	
			F	F	F	F	F	F	F	F	
			P	P	P	P	P	P	P	P	

Section 2		Environmental Perspective										RANK
		Considerations Prompts	Impact on key habitats & corridors	Threatened species & EECs	Hydrological impacts on ecosystems	Potential water quality impacts						
OPTIONS												
2A			E	E	E	E	E	E	E	E	E	4
			VG	VG	VG	VG	VG	VG	VG	VG	VG	
			G	G	G	G	G	G	G	G	G	
			F	F	F	F	F	F	F	F	F	
			P	P	P	P	P	P	P	P	P	
2B			E	E	E	E	E	E	E	E	E	4
			VG	VG	VG	VG	VG	VG	VG	VG	VG	
			G	G	G	G	G	G	G	G	G	
			F	F	F	F	F	F	F	F	F	
			P	P	P	P	P	P	P	P	P	
2C			E	E	E	E	E	E	E	E	E	2
			VG	VG	VG	VG	VG	VG	VG	VG	VG	
			G	G	G	G	G	G	G	G	G	
			F	F	F	F	F	F	F	F	F	
			P	P	P	P	P	P	P	P	P	
2D			E	E	E	E	E	E	E	E	E	3
			VG	VG	VG	VG	VG	VG	VG	VG	VG	
			G	G	G	G	G	G	G	G	G	
			F	F	F	F	F	F	F	F	F	
			P	P	P	P	P	P	P	P	P	
2E			E	E	E	E	E	E	E	E	E	3
			VG	VG	VG	VG	VG	VG	VG	VG	VG	
			G	G	G	G	G	G	G	G	G	
			F	F	F	F	F	F	F	F	F	
			P	P	P	P	P	P	P	P	P	
2F			E	E	E	E	E	E	E	E	E	1
			VG	VG	VG	VG	VG	VG	VG	VG	VG	
			G	G	G	G	G	G	G	G	G	
			F	F	F	F	F	F	F	F	F	
			P	P	P	P	P	P	P	P	P	

Section 3		Environmental Perspective									
		Considerations Prompts	Impact on key habitats & corridors	Threatened species & EECs	Hydrological impacts on ecosystems	Potential water quality impacts					
OPTIONS											
3A		E	E	E	E	E	E	E	E	E	RANK 2
		VG	VG	VG	VG	VG	VG	VG	VG	VG	
		G	G	G	G	G	G	G	G	G	
		F	F	F	F	F	F	F	F	F	
		P	P	P	P	P	P	P	P	P	
3B		E	E	E	E	E	E	E	E	E	RANK 1
		VG	VG	VG	VG	VG	VG	VG	VG	VG	
		G	G	G	G	G	G	G	G	G	
		F	F	F	F	F	F	F	F	F	
		P	P	P	P	P	P	P	P	P	

Key Observations

The group noted that as some updated ecological data had only been presented at the workshop, and that the Ecology report was still being finalised, it had to accept the updated information at face value when undertaking the assessments. The group raised concern that this may have resulted in some incorrect ranking of options (specifically in relation to section 2), although the collective knowledge of the group also assisted in the ranking of the options.

Section 1

- For the consideration of “Impact of key habitats and corridors”:
 - The focus group made the assumption that all likely/known threatened flora species and vegetation communities have been identified within the Study Area
 - The focus group made the assumption that the threatened species have been appropriately linked to the habitat type
 - The corridors identified do not necessarily include the smaller corridors
 - The EEC table in the Report is an overestimate except for freshwater wetland EECs
 - The amount of hectares of vegetation identified and impacted is questioned. Relative total vegetation of each corridor has been used as a reference point
- For the consideration of “Threatened Species and EECs”, the real differentiating factor is measured by the section between Woodburn and the start of the National Park
- For the consideration of “Hydrology impacts on ecosystems”:

- The focus group made the assumption that the inundation times are short enough that it does not impact upon the environment (Will there be changes to current trends?)
- De-oxygenation of water is a major factor
- For “Potential water quality impacts”, findings indicate that Option 1A and 1B are equal and that Option 1C is less preferred

Section 2

- For the consideration of “Impact of key habitats and corridors”, The focus group made the assumption that fauna usage is the same across all corridors that are crossed. The group could not differentiate between Options 2A, 2B, 2C, 2D or 2E initially as to which was relatively worse, although Option 2F was unanimously assumed the best option.
- For the consideration of “Threatened Species and EECs”:
 - Need to check the amount of vegetation removed in Options 2E & 2D in the area where the two corridors differentiate
 - Option 2E is assumed to link to Option 2D only (not to Option 2C or other options), thereby Option 2E was not possible to separate from Option 2D
 - Options 2A, 2B & 2C were acknowledged as being worse than the other options. The decision of these relative to each other was more difficult to make. They were decided as being equally as bad as each other because of the impact on a very important salt marsh (which is a very rare EEC in Option 2B) – even though the total area of EECs was less than in Option 2A & 2C
 - The assessment could be done at a finer level if the assessment of threatened species and EECs were separated
 - The two other species (with difficulty in mitigation) are the Wallum Sedge Frog and the Wallum Froglet – which are identified for being potentially being resident in Option 2D
 - Freshwater wetland EECs are also not mapped in Option 2D (this needs to be investigated, as this information is only an opinion)
 - The occurrence of Blossom Bats; Squirrel Gliders and known Koala habitats in the Lumleys Lane area of Option 2C, has to be considered in terms of possible mitigation measures
- For the consideration of “Hydrology impacts on ecosystems”:
 - Inundation was not considered as big a problem as the interruption of Coffee Rock, aquifers and water table interruptions is not large although the exact impacts needs to be quantified
 - There were difficulties in differentiating between Options 2A, 2B & 2C
 - Defining hydrological impact is very difficult to ascertain at this stage due to lack of data for Option 2A, 2B & 2C
- For “Potential water quality impacts”, all corridor options have a major effect at the tail route stage of water flow impacts

Section 3

- For the consideration of “Impact of key habitats and corridors”, the fragmentation issue already exists in Option 3B (existing road) therefore it is the better option

- For the consideration of “Threatened Species and EECs”, existing impacts are already there in Option 3B therefore it is the better option
- For “Potential water quality impacts”, there are many creek and drain line crossings in Option 3A. For Option 3B, flood mitigation is already in place therefore Option 3B is rated good

Appendix 2

Independent Ecological Review of the Route Options (Ecosense, 2008)



WOODBURN TO BALLINA

Independent Ecological Review of the Route Options

Prepared for NSW RTA

by Renata Bali, Khaalyd Brown &
Bill Rooney

March 2008

REPORT

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1.0 INTRODUCTION

Ecosense Consulting Pty Ltd was commissioned by the NSW Roads & Traffic Authority (RTA) to undertake an independent ecological review of the Woodburn to Ballina route options. Prior to the current report, an independent peer review of the *Phase 1 and 2 Investigations Flora and Fauna Assessment of Options* (Geolyse 2005) was conducted by Bali, Brown and Rooney (2006). A number of gaps were identified in the Geolyse reports and it was recommended that these be addressed in order to make the report more scientifically robust. It was recommended that the following major tasks be undertaken:

- ❑ Terrestrial vegetation mapping for the entire study area using Aerial Photographic Interpretation (API), ground-truthing and existing mapping;
- ❑ Identification and accurate mapping of Endangered Ecological Communities (EECs) and regionally significant vegetation communities;
- ❑ Terrestrial fauna habitat mapping and identification of important habitat features for the entire study area;
- ❑ Reassessment of potential habitat for the Oxleyan Pygmy Perch in Section 2;
- ❑ Consideration of all available data including regionally significant species, Rare or Threatened Australian Plants (ROTAPs), invertebrates and nomadic and migratory fauna species;
- ❑ Reanalysis of the ecological impacts of route options on vegetation communities, fauna habitat, threatened terrestrial species and Oxleyan Pygmy Perch habitat;
- ❑ Reassessment of the ecological impacts associated with route options based on accurate vegetation mapping and reanalysis of all available data; and
- ❑ Ranking of route options based on reanalysis and reassessment of all available data.

This report was compiled by Dr Renata Bali (Ecosense Consulting Pty Ltd) in association with Khaalyd Brown (Ecopro Pty Ltd) and Bill Rooney (W.S. Rooney & Associates). Dr Bali was responsible for coordinating the study team, liaising with the Client and preparing the report.

Khaalyd Brown was responsible for mapping vegetation, describing vegetation communities, identifying and calculating areas of ecologically significant communities along each route option, assessing vegetation impacts along each route option, liaising with the Client and preparing all figures. Bill Rooney assessed the impacts of route options on known and potential habitat for the Oxleyan Pygmy Perch, potential fish nurseries and aquatic crossing points.

Ben Lewis (Lewis Ecological Surveys) assisted with the description of fauna habitats, identified potential habitat for regionally significant, migratory and nomadic fauna and determined the likelihood of their occurrence along the route options.

2.0 APPROACH

It is our understanding that the main aim of a route selection study is not to provide all possible information, but to present adequate and appropriate data to robustly analyse and assess route option impacts. It is important to note that our approach to the current ecological review is based on the authors' 40 years of collective experience in undertaking route selection studies and flora and fauna assessments for Pacific Highway upgrades along the central and northern coastal areas of New South Wales. Any assumptions underlying the methodology used are based on this experience, familiarity with the relevant literature and sound scientific principles. Moreover, we have attempted to describe the methods used as clearly and transparently as possible.

Our approach is based primarily upon reassessing ecological impacts using the most accurate vegetation mapping available over the entire study area. It should be noted that, for the purposes of this study, the study area boundaries have been extended to include all route options (Section 3.1). Vegetation mapping was undertaken through API, use of mapping provided by the Department of Environment and Conservation (DEC) and Ballina Shire Council and ground-truthing (Section 4.1). However, there are still a number of limitations associated with the vegetation mapping methodology (Section 4.1.3).

The aim of the terrestrial and aquatic fauna and fauna habitat assessments was to target gaps in the existing data (Sections 4.2.1, 4.3.1). These involved minimal field survey (Sections 4.2.2, 4.3.2) and were also subject to limitations (Sections 4.2.3, 4.3.3).

As a first step in the reanalysis of ecological impacts, all data from previous studies and results of our own assessment were compiled and tabulated (Section 5) for the entire study area. For each section of the Woodburn to Ballina route, all ecological values removed or otherwise impacted as a result of each route option were summarised in comparative tables (Sections 6.2.4, 6.3.4, 6.4.4).

In order to reduce the complexity of the comparative tables and to highlight any apparent trends, it was first necessary to eliminate any possible bias amongst flora, fauna and aquatic values by combining these into conservation zones of similar value (Section 6.1.1). Route options were then scored and ranked on the basis of the amount of Very High, High, Medium-High, Medium and Low-Medium conservation value areas that they removed (Sections 6.2.5, 6.3.5, 6.4.5).

The same assessment process was used to undertake a preliminary assessment of ecological impacts associated with the Preferred Route (Section 7).

3.0 DESKTOP RESEARCH

The following reports were considered as part of the current review:

- ❑ Ecological Constraints Report Phase 1 Proposed Woodburn to Ballina Pacific Highway Upgrade (Geolyse 2005a);
- ❑ Phase 1 and Phase 2 Investigations Flora and Fauna Assessment of Options (Geolyse 2005b);
- ❑ Flora and Fauna Assessment of Options Addendum Report: Supplementary Information for Vegetation Community Identification (Geolyse 2005c);
- ❑ The national conservation significance of the Wardell wetlands, Tuckean Swamp and the Blackwall Range (Graham 2005);
- ❑ Woodburn to Ballina Pacific Highway Upgrade Project Hydrogeological Desk Study of Wardell Heathland (Coffey 2005);
- ❑ Preliminary hydrogeological assessment of impact of routes 2A, 2B, 2C, 2D/2E and 2F on Wardell Heathland (Coffey 2006); and
- ❑ Survey for the land snail *Thersites mitchellae* (Mitchell's Rainforest Snail) Woodburn-Ballina Pacific Highway Upgrade (Stanisic 2006).

It should be noted that no other studies undertaken within the study area have been considered in this report.

3.1 Study Area Boundaries

The study area boundaries have been modified to incorporate the entire preferred route and Option 2F (Figure 3.1). The field investigations for our aquatic reassessment were restricted to Section 2 of the Woodburn to Ballina route selection study area. This is because there was generally no particular disagreement or concern with the preferred route within Sections 1 and 3, with the possible exception of the McDonald's Creek crossing in Section 1.

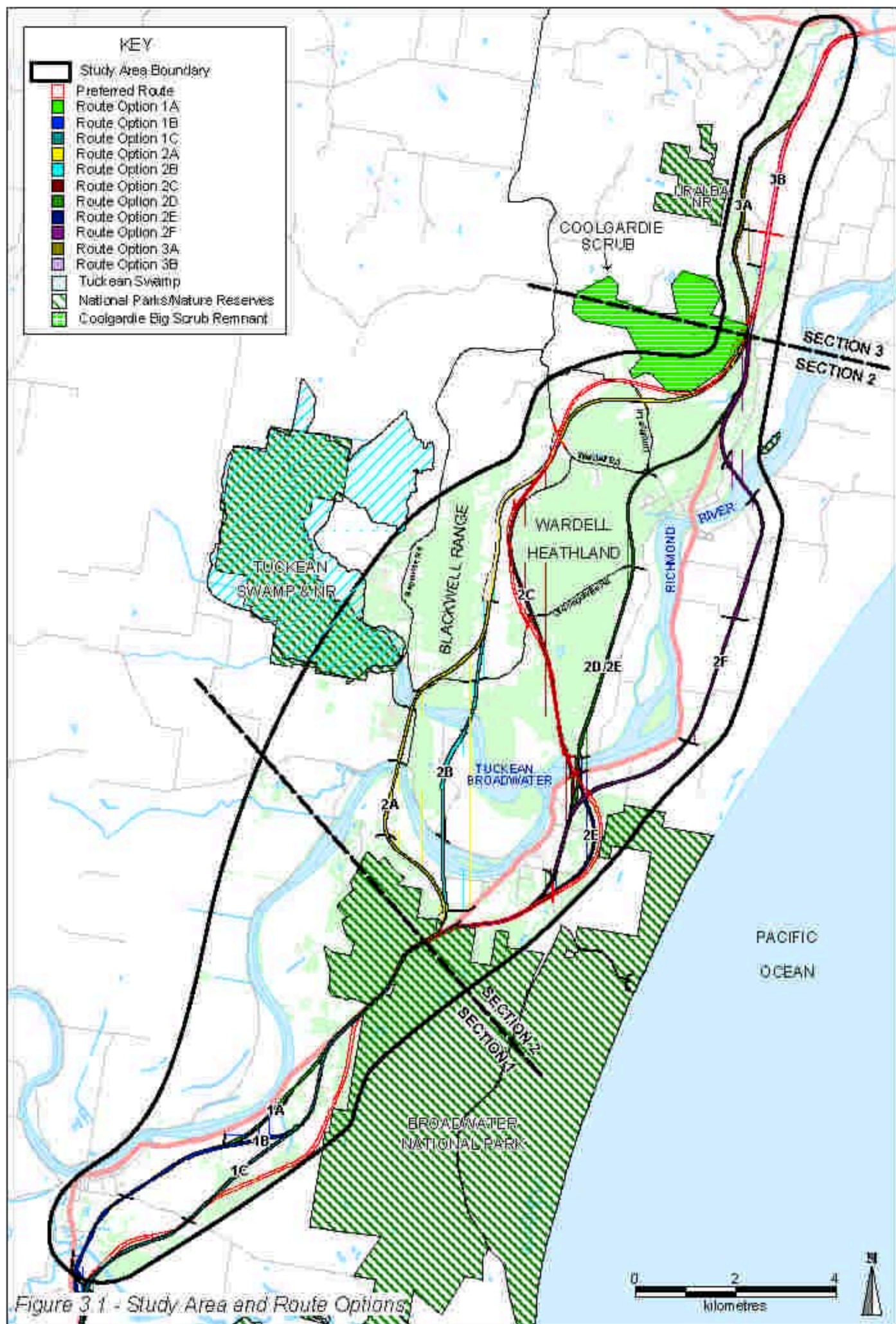
3.2 Conservation Values of the Study Area

The documented conservation values within and around the study area include the following:

- ❑ The Tuckean Swamp is listed on the Directory of Important Wetlands Database and is SEPP 14 wetland No. 114;
- ❑ Wardell Heathland has biological/ecological attributes that exceed the threshold values considered acceptable for entry on the Register of the National Estate (NPWS 1999a, in Geolyse 2005)¹;
- ❑ The Coolgardie Scrub remnant is an 'identified place' on the Register of the National Estate²;

¹ This could not be substantiated by Bali, Brown & Rooney (2006).

² It is not listed on the Register of the National Estate. It was an 'identified place' when the Australian Heritage Commission was disbanded in 2001.



- ❑ A number of SEPP 14 wetlands including Wetland Nos. 110, 113, 113a, 115, 117, 118a, 118b, 119, 119a and part of Wetland Nos. 108, 114, 121;
- ❑ Wardell Heathland, Tuckean NR, Broadwater NP, the Blackwall Range, parts of the Tuckean Broadwater and vegetation to the north and south of Lumleys Lane have been identified by Scotts (2000) as key habitats in the region;
- ❑ Five regional corridors (i.e. Tuckean, Wardell-Tuckean, Broadwater, Wardell-Blackwall and Wardell-Uralba) and four subregional corridors (i.e. Blackwall Range south, Blackwall Range north, Rous Hill, Dungarubba) for fauna (Ballina Shire Council submission);
- ❑ At least eight³ EECs listed on Part 3, Schedule 1 of the *Threatened Species Conservation (TSC) Act 1995* (Geolyse 2005);
- ❑ Habitat for at least 100 threatened terrestrial flora and fauna species listed on Schedules 1 and 2 of the TSC Act 1995 and the *Environmental Protection and Biodiversity Conservation (EPBC) Act 1999* (Geolyse 2005);
- ❑ Habitat for at least 13 Rare or Threatened Australian Plant (ROTAP) species (Graham 2005);
- ❑ Habitat for at least 21⁴ regionally significant flora and fauna species (Graham 2005); and
- ❑ DEC Estate including Broadwater National Park and part of the Tuckean Nature Reserve.

3.2.1 Invertebrate fauna

No threatened invertebrate fauna surveys were undertaken during the Phase 1 and 2 Investigations Report. While surveys are not an essential component of a route selection study, we would expect some discussion of the probability of particular species occurring in the study area and the need for future surveys.

Graham (2005) predicted that the following threatened or regionally significant invertebrate species would be likely to occur in the study area:

- ❑ Mitchell's Rainforest Snail (*Thersites mitchellae*);
- ❑ Atlas Rainforest Ground Beetle (*Nurus atlas*);
- ❑ Australian Fritillary (*Argyreus hyperbius*); and
- ❑ Richmond Birdwing Butterfly (*Ornithoptera richmondii*).

Since then, Stanistic (2006) conducted a survey for the Mitchell's Rainforest Snail. He found no evidence of live snails, shells or shell fragments or indicative slime trails or faeces in the rainforest patches along or adjacent to the preferred route of the Woodburn to Ballina Pacific Highway Upgrade. Although inability to find this cryptic species does not necessarily mean that it is not present, the absence of key floristic

³ This has been increased to nine as part of the current review.

⁴ This has been increased to 27 as part of the current review.

elements indicated an evolutionary history that was incompatible with the occurrence of this species.

The occurrence of the Atlas Rainforest Ground Beetle within the study area is unknown. Dr Chris Burwell (Curator Entomology, Queensland Museum) was contacted regarding significant invertebrate species. After speaking to G. Montieth, an expert on this species, Dr Burwell confirmed that little is known about this species of ground beetle. However, it is known from the Lismore-Alstonville area, is found in low-elevation rainforest and wet eucalypt forest with a well-developed rainforest understorey and may prefer rainforest on red soils.

Dr Don Sands (Honorary Scientist, CSIRO Entomology) was contacted regarding the probability of occurrence in the study area of the two butterfly species of conservation significance. The Ballina area is one of the strongholds for the Australian Fritillary, a very rare coastal species dependent on the presence and density of the native violet *Viola betonicifolia*. It is considered to be Endangered in NSW. This species has been found breeding on the edges of Melaleuca wetlands and a sugar cane farm. For these reasons, we would have expected that a preliminary search for this species and/or its habitat would have been undertaken as part of the route selection study. Although additional survey work was beyond the scope of the present study, we have broadly assessed this species' habitat in Table 5.5. Butterfly surveys should be undertaken by a suitably qualified expert as part of ongoing environmental assessments for the preferred route.

The Richmond Birdwing Butterfly is a regionally significant species dependant on the Richmond Birdwing Butterfly Vine (*Pararistolochia praevenosa*) that may occur in rainforest patches, particularly in the Coolgardie Scrub. Although the study area comprises the southernmost extent of this species' distribution, it appears that no targeted surveys were undertaken as part of the route selection study. Graham (2005) reported that large patches of the vine occur in the Buckombil and Coolgardie areas. Although additional survey work was beyond the scope of the present study, we have broadly assessed this species' habitat in Table 5.6. Surveys should be undertaken for this species' host plant by a suitably qualified botanist as part of ongoing environmental assessments for the preferred route.

3.3 Description of Route Options

Concept design footprints for all route corridor options were provided to us by Hyder Consulting and included approximate batters and a 10-m buffer. In general the footprints varied in width from 40 to 90 m (see Figure 3.1).

We were also asked to evaluate route option 2EC that came about as a result of the Value Management Workshop held in July 2005. It consists of route corridor option 2E south of the Richmond River and option 2C north of the river. This route is hereafter referred to as route option 2EC.

Finally we undertook a preliminary assessment of the preferred route that is a modified version of route options 1C, 2EC and 3B. It should be noted that we divided the preferred route into three sections (i.e. P1, P2 and P3) so that direct comparisons could be made with the original route options.

4.0 FIELD ASSESSMENT

Field assessments were necessarily brief and were aimed specifically at filling in gaps in the existing data.

4.1 Flora Survey

One of the major concerns and limitations identified in the initial route selection study (Bali, Brown & Rooney 2006) was the lack of detailed, accurate vegetation mapping. Previous vegetation mapping used quadrat surveys and PATN analysis to differentiate nine vegetation communities that were then mapped using API. However, it was considered that API was more suitable to separate vegetation communities given the complexity of the area. The lack of detailed vegetation mapping also limited the assessment and interpretation able to be undertaken for each of the route options.

4.1.1 Aims

In order to further differentiate the route corridor options on the basis of flora impacts, the current field assessment aimed to:

- ❑ Undertake detailed vegetation mapping over the entire study area for consideration in the route options assessment;
- ❑ Provide brief descriptions of the vegetation communities occurring in the study area;
- ❑ Identify national, state and regionally significant vegetation communities in the study area;
- ❑ Identify the likelihood of flora species listed under Schedules of the TSC Act 1995 and the EPBC Act 1999 occurring along each of the route options based upon more accurate vegetation mapping;
- ❑ Identify the likelihood of ROTAP species occurring along each of the route options; and
- ❑ Further analyse existing data (e.g. threatened plant records) with the aim of differentiating route corridor options in Section 2.

The vegetation survey, mapping and assessment were undertaken by Khaalyd Brown (EcoPro Pty Ltd).

4.1.2 Survey and Assessment Techniques

Given the time constraints of the study, we used available vegetation mapping undertaken by DEC for Wardell Heathland and Broadwater NP. Prior to field work being initiated, all other vegetated areas of the study area were stratified according to similar vegetation communities through API. Although the majority of stereo-paired colour photographs used were taken in April 2004 at a scale of 1:6,000, a few areas relied upon 1:16,000 air photos taken in October 2004. Preliminary stratification of the vegetation into photo types was undertaken with reference to diagnostic features such as colour, texture, height, crown architecture, aspect and topographic position.

Ground-truthing was subsequently undertaken over 40-person hours from 15-18 August 2006 to verify community boundaries. During this process

observations were made of the structure and floristic composition of photo types and vegetation community boundaries were assessed. The boundaries of the photo types, which correspond to plant communities, were subsequently digitised from the aerial photographs using MapInfo software.

4.1.3 Limitations

It was assumed the vegetation mapping provided by DEC for Wardell Heathland and Broadwater NP was accurate and no attempt was made to ground-truth and re-map these areas.

Due to time constraints and the inaccessibility of some areas, not all vegetated patches were surveyed. Areas primarily surveyed were those that were easily accessible (close to the road) and those enabled by landholder permission. It should be noted that twenty-six (26) landholders denied access or were not able to be contacted prior to the survey. Hence, some vegetation classifications and boundaries are based solely upon API and the presence of similar stratified units in the area. Due to this factor, the variability of the natural environment and the extreme complexity of the study area, it is likely that some units have been misidentified. However, where possible every effort was made to accurately identify those vegetation communities occurring along the various route options, with less emphasis being placed on vegetated areas not directly affected by any option (such as the Blackwall Range).

The complexity of the vegetation in the study area resulted in a very large number of communities being identified. Very similar communities were amalgamated to simplify the assessment. In these cases, the community name often ends in a +/-, with the final species being present in only some of the mapped areas of this community type. The scale of mapping undertaken (mostly 1:6,000) and the complexity of the vegetation also resulted in some vegetation communities being too small to be delineated accurately and instead these have been amalgamated into larger community types. For instance, although communities could have been divided into many more types in the Wardell Heathland (i.e. open Shrubland, closed Shrubland, low Heathland, etc.), this level of mapping accuracy was beyond the scope of the present study.

While every attempt was made to delineate the community boundaries as carefully as possible, some errors are likely to occur due to the difficulty in registering the aerial photographs on the GIS system and time constraints associated with the digitising process.

Despite these limitations, 82 vegetation communities were identified in the study area and the level of mapping undertaken is considered adequate for route selection purposes.

4.2 Fauna Survey

Generally the fauna survey techniques and effort used as part of the Investigations Report were considered by Bali, Brown & Rooney (2006) to be adequate for a route selection study. The large number of previous records for the study area compensated to some degree for the lack of seasonality in sampling and other limitations encountered. However, the route assessment was based entirely on fauna records rather than on a

combination of records and habitat assessment, and the scoring and weighting process used was unable to adequately differentiate route options in Section 2. Furthermore, the assessment did not consider regionally significant, migratory or nomadic species or threatened invertebrate species.

4.2.1 Aims

In order to further differentiate the route corridor options on the basis of fauna impacts, the current field assessment aimed to:

- ❑ Undertake habitat mapping over the entire study area for consideration in the route options assessment;
- ❑ Identify important fauna habitat resources in the study area;
- ❑ Identify the likelihood of species listed under Schedules of the TSC Act 1995 and the EPBC Act 1999 occurring along each of the route options;
- ❑ Identify regionally significant, migratory and nomadic fauna species and their likelihood of occurring along each of the route options; and
- ❑ Further analyse existing data (e.g. regional corridors) with the aim of differentiating route corridor options in Section 2.

Ben Lewis (Lewis Ecological Surveys) undertook the following tasks: a brief fauna habitat assessment; identification of migratory, nomadic and regionally significant fauna species likely to occur in the study area; and assessment of the likelihood that threatened and other significant fauna species occur within each vegetation community/habitat in the study area.

4.2.2 Survey and Assessment Techniques

Prior to the field assessment, a review was undertaken in order to determine which regionally significant species were likely to occur in the study area. Species considered to be regionally significant are those that are:

- ❑ At the edge of their distribution in the study area (e.g. *Ctenotus arcanus*);
- ❑ Seldom recorded during extensive surveys (>100 surveys) undertaken by the author (BL) on the far north coast of NSW (e.g. *Egernia frerei*); or
- ❑ Of uncertain taxonomic status (e.g. undescribed Whirring Tree Frog).

A field survey was undertaken from 15-18 August 2006. Whilst the primary objective of this visit was to identify and map vegetation communities within the study area, it also provided an opportunity to assess habitat quality and condition and to identify important fauna resources. As habitat assessment is reliant on vegetation mapping, these two tasks are highly compatible. Furthermore, the likelihood of occurrence of important habitat resources, including rookeries, flying-fox camps, migratory wader roosts and habitat and raptor nests, was assessed. Approximately 40-person hours were spent assessing fauna habitat in the field.

Each threatened or regionally significant species was assigned to one of four rating categories according to its likelihood of occurring in each of the identified vegetation communities/fauna habitats. The ratings ranged from 'not present or very low likelihood', to 'low', 'moderate' or 'high' likelihood of occurrence to 'known'. Previous surveys undertaken by *Lewis Ecological Surveys* in the locality facilitated these determinations. In addition, the distribution of individual species' records within the study area was taken into account and was used to guide the decision-making process. For example, there appear to be few records of Spotted-tailed Quoll and Square-tailed Kite on the DEC Wildlife Atlas. As such, these species received lower likelihood ratings despite some of the vegetation communities being regarded as suitable.

4.2.3 Limitations

Generally, weather conditions were fine and sunny during the fauna habitat assessment. Only those areas that were required to ground-truth vegetation mapping were visited. These were usually accessible (close to the road) or required prior permission from landowners to access. Twenty-six landowners declined access to their land or were not able to be contacted prior to the survey.

A number of limitations were associated with the process of determining the likelihood of fauna species occurring in particular vegetation communities. For example, the process did not:

- ❑ take into account the spatial arrangement and subsequent landscape attributes in the study area such as the area of habitat/vegetation, its isolation factor or its connectivity; or
- ❑ address key microhabitat variables which may be present in some vegetation communities but absent in others. For example, Bush-stone Curlew inhabits a variety of vegetation types all of which tend to have a relatively open understorey. Similarly, the presence of Swamp Mahogany and Paperbark may represent suitable habitat for Black Bittern where there are drainage lines (artificial or natural). Such examples occur between Wardell Road and Lumleys Lane in the Wardell Heathland. The approach taken during the current review does not adjust for these differences.

4.3 Aquatic Survey

Bali, Brown & Rooney (2006) found the aquatic assessment in the Investigations Report to be inadequate because it did not assess the impacts of various route options on aquatic communities and species. In particular, the sampling sites selected and the techniques applied were not appropriate to detect the only threatened freshwater species likely to be found in the study area, the Oxleyan Pygmy Perch. Sampling locations did not include potential habitat in the Wardell Heathland adjacent to Option 2C. During an earlier site visit (10-11 May 2006) we noted good potential habitat (paperbark and wallum heath swamp) for the Oxleyan Pygmy Perch in the latter area.

A significant difference between the Geolyse (2005b) field studies and the current field investigation associated with the current ecological review is

the amount of rainfall received in the area prior to and during the respective surveys. The former was apparently conducted during a prolonged period of dry weather (p. 113-114), when ponded surface water was considerably reduced in the paperbark swamps, creek levels were very low and the Richmond River was probably very brackish up to the barrage on the Tuckean Broadwater. By contrast, the current survey was conducted during a wet period, when the region had received over 150 mm of rain and experienced minor flooding the week prior to our site visit and received consistent rain up until and during the field work.

In 2006, known and potential Oxleyan Pygmy Perch habitat was identified by Biosis Research as part of their investigations along the preferred route. We have considered these data as part of the current assessment as they address some of the gaps identified in the Investigations Report.

4.3.1 Aims

In order to further differentiate the route corridor options on the basis of aquatic impacts, the current ecological review aimed to:

- ❑ Inspect areas of known and potential Oxleyan Pygmy Perch habitat within Section 2 based on a previous field assessment (Bali, Brown & Rooney 2006) and unsubstantiated records;
- ❑ Undertake additional sampling for freshwater fish (including the Oxleyan Pygmy Perch) using bait traps to survey potentially suitable habitat within Section 2;
- ❑ Assess and accurately describe the ecological habitats and values of the proposed bridged crossing points on the Richmond River and Tuckean Broadwater, particularly with respect to fish nursery habitat; and
- ❑ Liaise with the local Department of Primary Industry (DPI) Fisheries Inspector and local experts regarding the aquatic values in the study area.

The aquatic field survey and targeted aquatic assessment were conducted by Bill Rooney (W.S. Rooney and Associates).

4.3.2 Survey Techniques

Aquatic survey work was undertaken during 12-14 September 2006. Weather conditions during this time were partly cloudy with temperatures in the low 20s, with occasional showers and some heavy rainfalls at night. There had been over 150 mm of rain during the previous week (local residents *pers. comm.*) and there was evidence of minor flooding in low-lying areas.

Bridge crossings of the Richmond River and Tuckean Broadwater were inspected from the water using a kayak, allowing slow and deliberate visual assessment of the riparian and aquatic vegetation and the extent of shallow mud banks. This technique is preferred because aquatic fauna, particularly birds, are not disturbed and can be viewed at close range. Furthermore, access is provided to the shoreline under the mangrove canopy from any location. The inspections were intended to examine all aquatic and riparian characteristics and form an opinion as to the ecological value of the habitats observed. The bridge crossing locations

on the Richmond River and on the Tuckean Broadwater for route options 2A and 2B were examined for about two hours each.

Although water quality parameters were not systematically sampled, the salinity of water near the barrage in the Tuckean Broadwater was measured where water lilies were growing in close proximity to mangroves.

During the current survey, bait traps were set for two nights at several locations in the Wardell Heathland within route options 2C and 2D. Survey work was conducted under permit from DPI Fisheries. Each bait trap was 450 mm x 250 mm x 250 mm with a mesh aperture of 2 mm. Each trap was baited and set in shallow water with a tethered float marking its location and left overnight. Typical deployment periods were between 14-16 hours on each occasion.

Bait trap locations are shown in Figure 4.1. Sites 1 and 2 were located on Wardell Road. Site 1 was located in flowing water in an unnamed tributary of Bingal Creek while 2 was located in a paperbark swamp just next to the road. Sites 3 and 4 were located on Old Bagotville Road. Site 3 was located in flowing water in a tributary of Bingal Creek whereas 4 was located in a paperbark swamp just next to the road. Site 5 was located in a paperbark swamp on the property belonging to Mr. Melino.

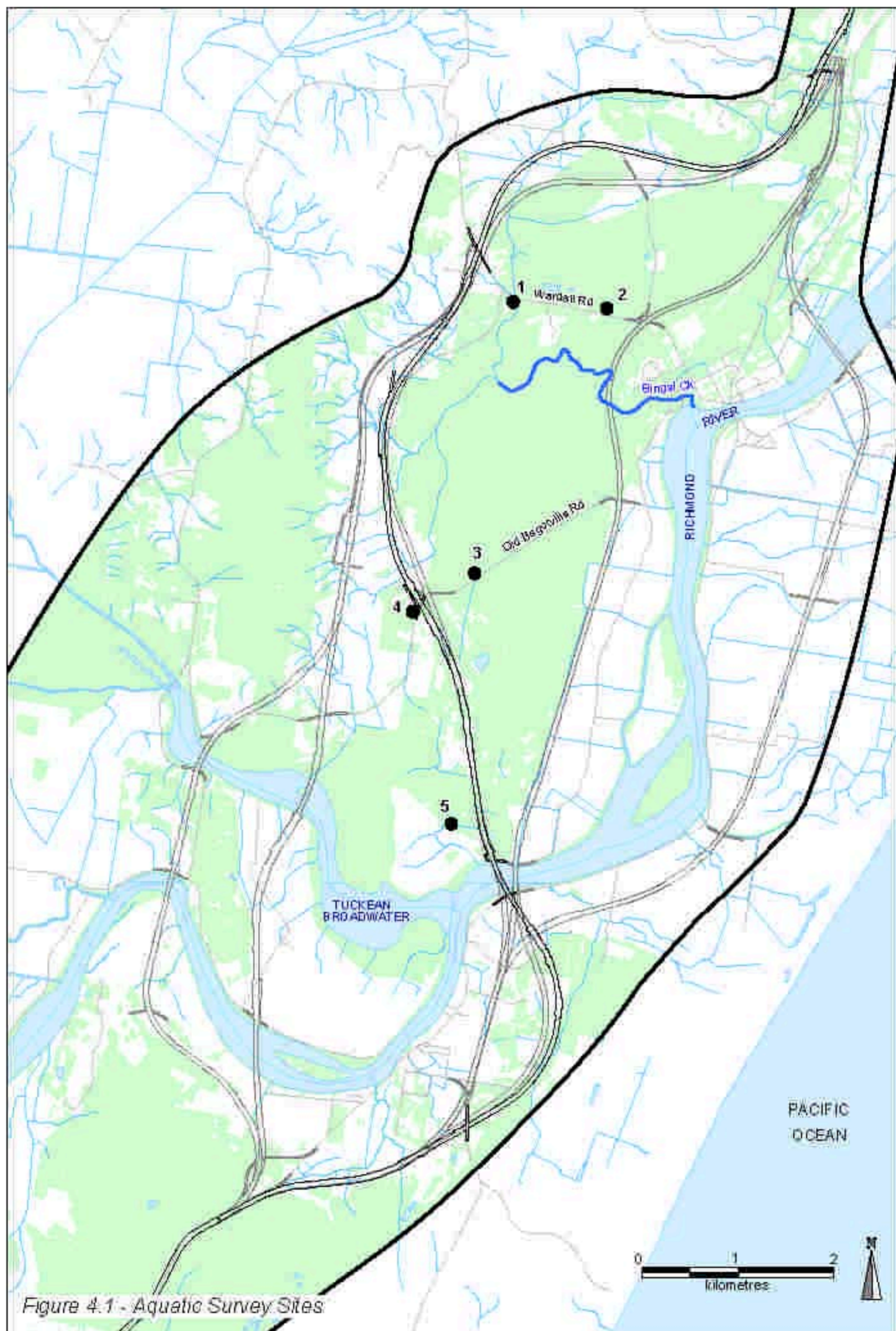
Fish were identified *in situ* by placing them in a glass jar of water and viewing their physical characteristics. Comparisons were made with the descriptions of fish species in McDowall (1996). In the case of juveniles that are difficult to identify in the field, specimens were preserved and returned to the laboratory where they were examined under a stereo microscope. Confirmation of the species was determined by depositing specimens with the freshwater fish curator at the Australian Museum.

As part of the site visit, we arranged to meet with the DPI Fisheries Inspector assigned to this RTA project, Mr. Max Enklaar. During that meeting he expressed concern at the risk to known Oxleyan Pygmy Perch habitat within the McDonald's Creek catchment.

4.3.3 Limitations

The field investigations were limited to a total of three days effort. It is considered that more fish trapping in a number of additional locations would provide more confidence in the completeness and robustness of our results. Furthermore, more research into the aquatic habitats and water quality variability (both spatial and temporal) within the Tuckean Broadwater would help to better explain the apparent conundrum of freshwater and estuarine plants co-existing at the same location (see Section 5.3.1). However, we consider that the field inspections and sampling undertaken were adequate to test the general conclusions of previous field work conducted in Section 2 as part of the Investigations Report.

The river crossings for route options 2C, 2D and 2E were examined from the southern shore only as time and access problems prevented inspection from the water.



The areas of suitable habitat for the Oxleyan Pygmy Perch within the Wardell Heathland have not been thoroughly mapped during this brief investigation. In particular, areas of heath crossed by the upper Bingal Creek between Old Bagotville Road and Thurgates Lane need to be traversed on foot. This area is very rich in native fish, and swampy areas adjacent to the creek line may be good Oxleyan Pygmy Perch habitat.

5.0 ECOLOGICAL CHARACTERISTICS OF THE STUDY AREA

This section summarises results from previous studies as well as those arising from the current study.

For the purposes of assessment, any vegetation community, fauna habitat, wetland and/or flora and fauna species is considered to be of conservation significance if it is:

- ❑ Listed or named under Commonwealth environmental legislation or on any nationally recognised register or directory (e.g. Register of the National Estate, Directory of Important Wetlands database);
- ❑ Listed as an Endangered Ecological Community under Part 3 Schedule 1 of the TSC Act;
- ❑ A regionally significant vegetation community as per criteria developed as part of the Regional Forest Agreement (RFA) process (NPWS 2000);
- ❑ A key habitat of regional significance as defined in Scotts (2000);
- ❑ Part of a regional and sub-regional corridor as defined in Scotts (2000);
- ❑ Any plant or animal species listed as Endangered or Vulnerable in Schedules 1 or 2 of the TSC Act 1995;
- ❑ Any plant or animal species listed as Endangered or Vulnerable on Schedules 1 or 2 of the EPBC Act 1999;
- ❑ Any migratory species as listed under the EPBC Act 1999;
- ❑ Any plant species considered to be a Rare or Threatened Australian Plant (ROTAP) as listed in Briggs and Leigh (1995);
- ❑ Identified as a coastal wetland under State Environment Planning Policy (SEPP) 14;
- ❑ Known or potential Oxleyan Pygmy Perch habitat as defined by Knight (2004), Biosis Research unpublished data or our own field assessment; and/or
- ❑ A fauna species that is regionally significant as per the criteria outlined in Section 4.2.2.

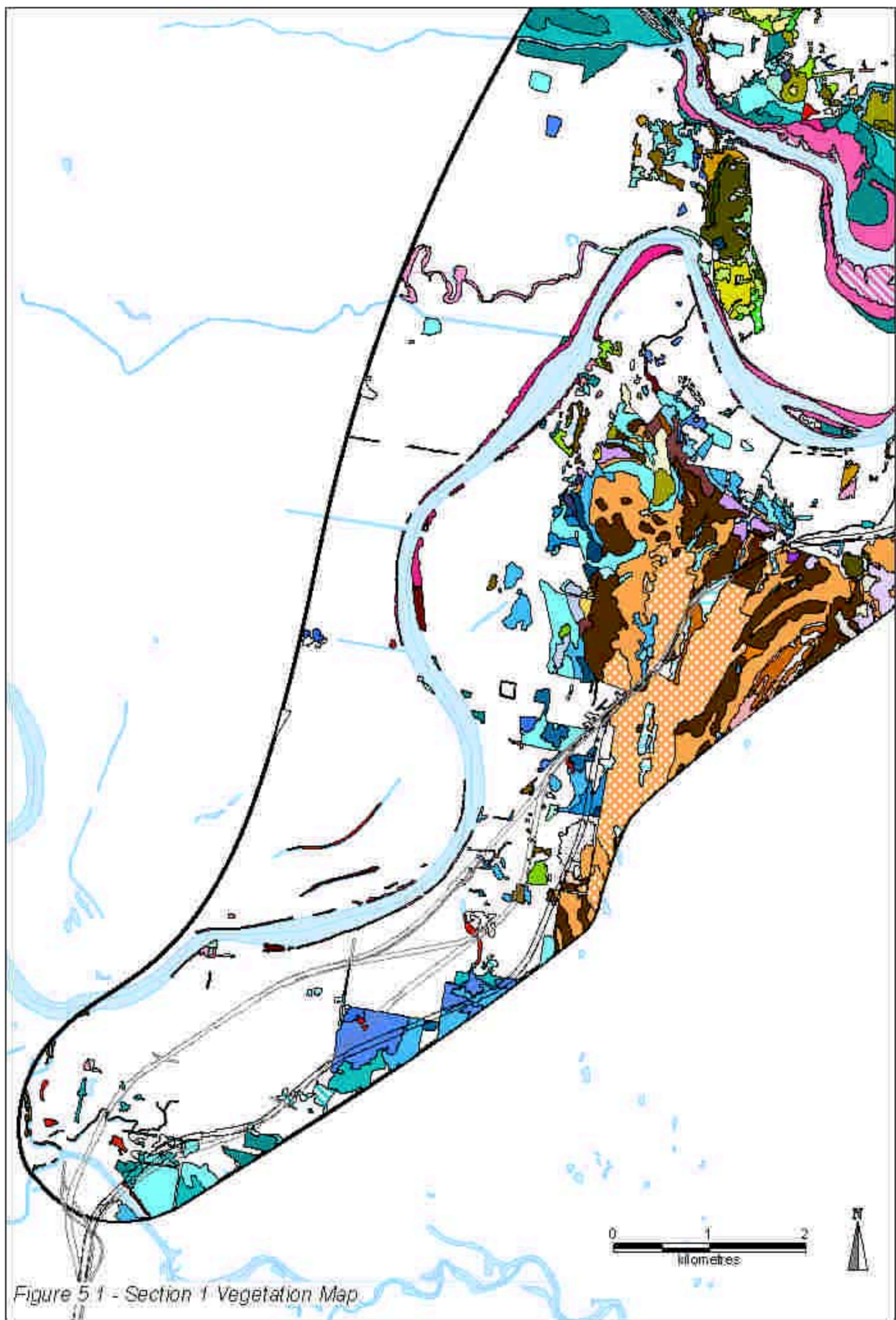
5.1 Terrestrial Flora

Overall, the study area contains 82 vegetation communities and supports at least 10 plants of national significance and 13 species of state significance. It should be noted that totals are not additive as some species are listed at both the national and state levels of conservation significance.

5.1.1 Vegetation communities

The identification of vegetation communities was determined as part of the current review.

Overall, 82 vegetation communities were identified in the study area as shown in Figures 5.1-5.4. These communities are outlined in Table 5.1



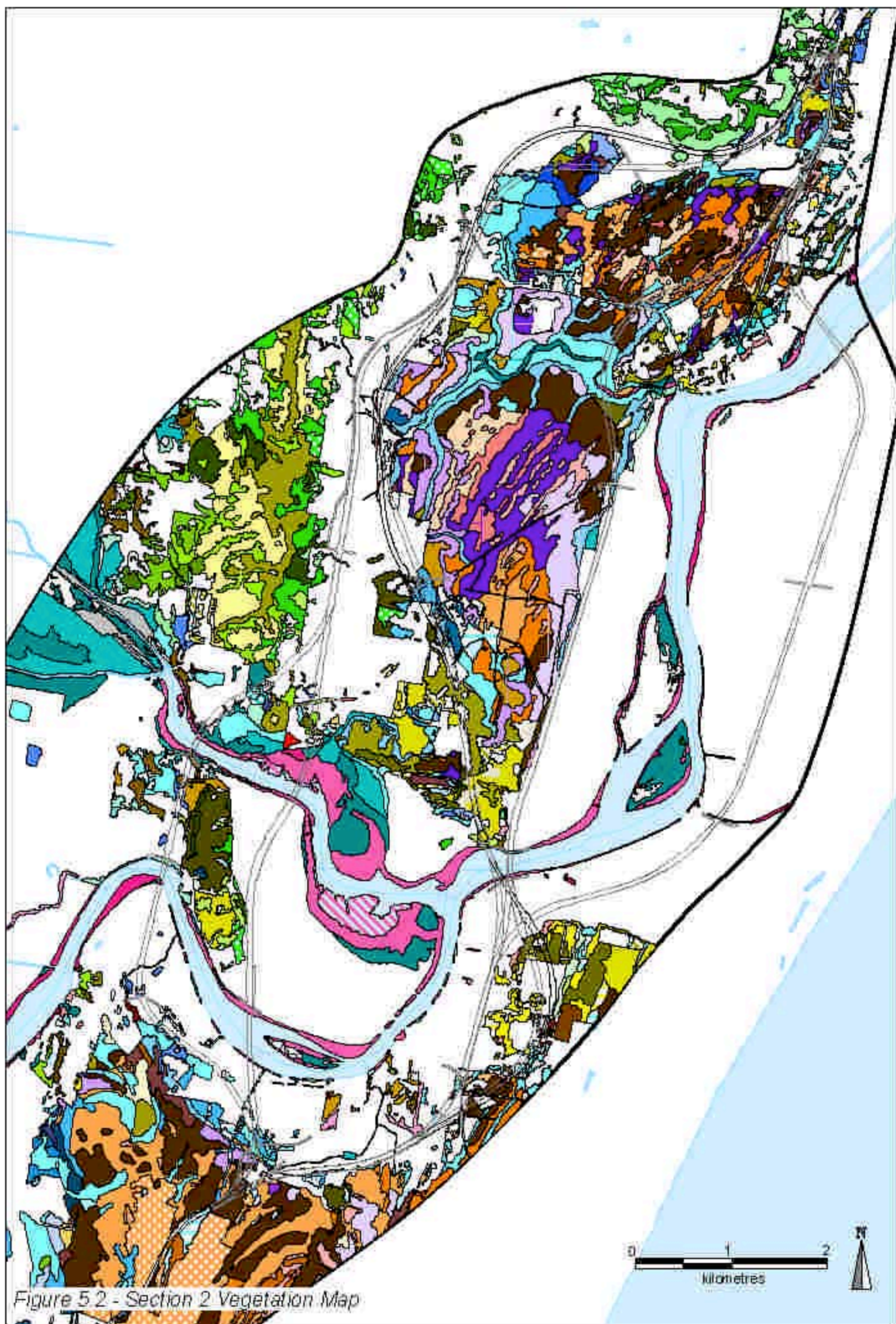
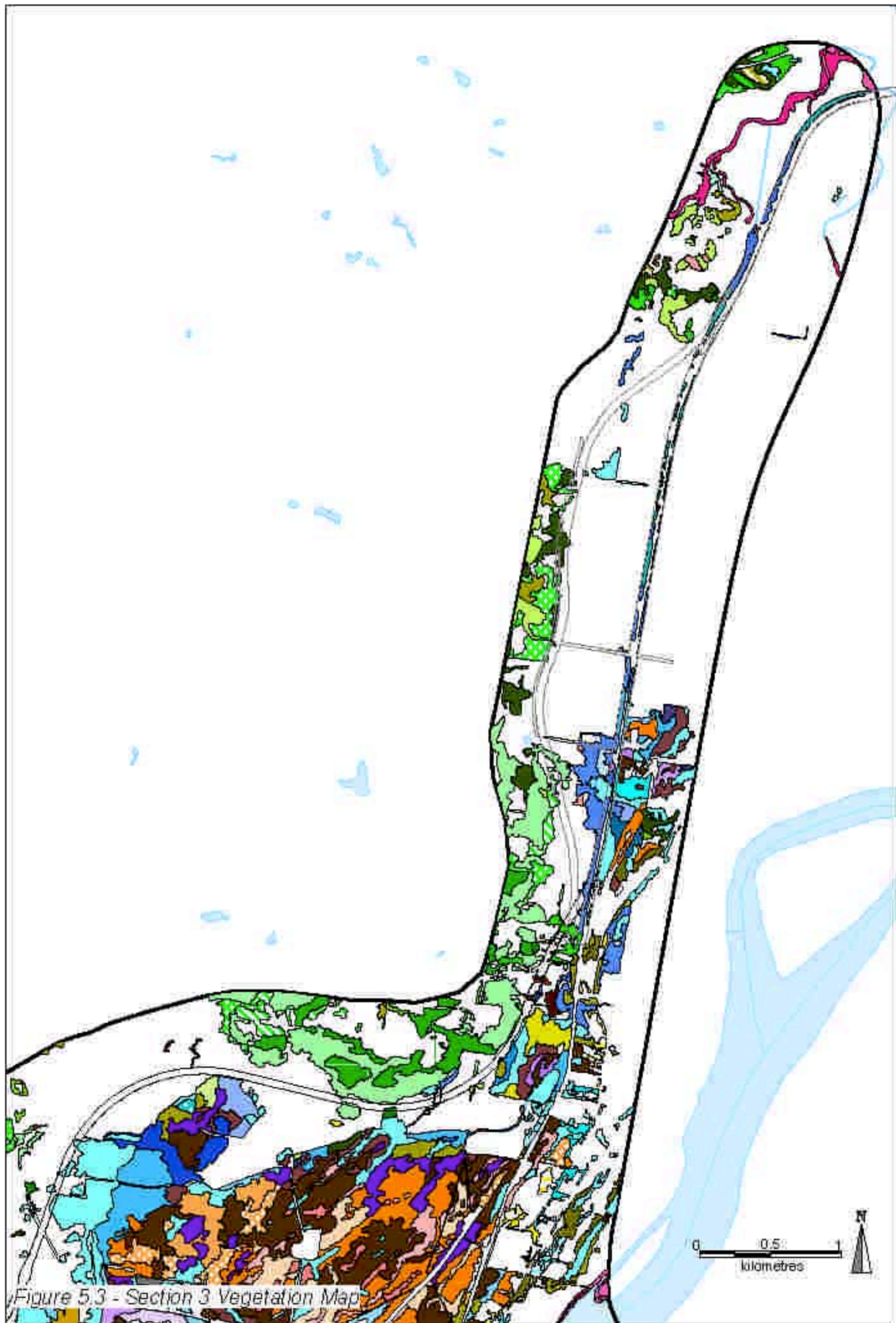


Figure 5.2 - Section 2 Vegetation Map



KEY

Dry Sclerophyll Forests and Woodlands

-  Blackbutt DSF
-  Blackbutt Woodland
-  Blackbutt/Cypress +/- Bloodwood
-  Blackbutt/Cypress Woodland
-  Blackbutt/Mahogany DSF
-  Blackbutt/Pink Bloodwood +/- Tallowwood DSF
-  Blackbutt/Red Bloodwood DSF
-  Blackbutt/Mahogany/Ironbark/Bloodwood/Tallowwood DSF
-  Cypress Pine DSF
-  Cypress Pine/Mahogany +/- Camphor DSF
-  Cypress Woodland
-  Forest Red Gum DSF
-  Forest Red Gum Woodland
-  Forest Red Gum/Bloodwood DSF
-  Ironbark/Bloodwood +/- Cypress DSF
-  Mahognay/Pink Bloodwood DSF
-  Pink Bloodwood DSF
-  Pink Bloodwood Woodland
-  Scribbly Gum DSF
-  Scribbly Gum Woodland
-  Tallowwood +/- Bloodwood DSF

Wet Sclerophyll Forests

-  Blue Gum/Brushbox WSF
-  Brushbox WSF
-  Brushbox/Tallowwood WSF
-  Flooded Gum WSF
-  Flooded Gum/Brushbox/Palm WSF
-  Flooded Gum/Forest Red Gum WSF
-  Blackbutt WSF

Rainforests and Rainforest/WSF

-  Bangalow Palm Subtropical Rainforest
-  Brushbox/Rainforest
-  Cabbage Tree Palm Subtropical Rainforest
-  Rainforest/Camphor/Privet
-  Dry Rainforest
-  Hoop Pine Rainforest
-  Moist Forest Regeneration
-  Rainforest Woodland

Eucalypt Swamp Forests

-  Forest Red Gum/Swamp Oak SSF
-  Swamp Honey Myrtle Sphagnum Woodland
-  Narrow Red Gum/Paperbark SSF
-  Paperbark/Forest Red Gum SSF
-  Paperbark/Mahogany SSF
-  Paperbark/Swamp Box SSF
-  Red Mahogany SSF
-  Swamp Box SSF
-  Swamp Mahogany SFF
-  Swamp Mahogany Sphagnum Woodland
-  Swamp Mahogany Woodland
-  Swamp Mahogany/Paperbark SSF
-  Swamp Mahogany/Paperbark Woodland

Routes

-  Preferred Route
-  Route Options

Paperbark Swamp Forests

-  Ball Honey Myrtle SSF
-  Broad-leaved Paperbark SSF
-  Paperbark Woodland
-  Paperbark/Cypress SSF
-  Paperbark/Swamp Oak SSF
-  Paperbark/Swamp Oak Woodland
-  Swamp Forest Regeneration
-  Swamp Oak SSF
-  Swamp Oak Woodland

Swamp Forest/Rainforest

-  Palm/Swamp Box SSF
-  Paperbark/Brushbox SSF
-  Paperbark/Rainforest SSF
-  Paperbark/Swamp Oak/Rainforest SSF
-  Swamp Mahogany/Swamp Box/Brushbox SSF

Mallee Forests

-  Blackbutt Dry Mallee Forest
-  Scribbly Gum Dry Mallee Forest
-  Scribbly Gum/Ball Honey Myrtle Swamp Mallee Forest
-  Swamp Mahogany Swamp Mallee
-  Wallum Banksia/Scribbly Gum Dry Mallee

Riparian Forests

-  Forest Red Gum/Tuckeroo Riparian Forest
-  Mangrove Forest
-  Mangrove Woodland
-  Mangrove/Swamp Oak +/- Forest Red Gum Forest
-  Mangrove/Tuckeroo Riparian Shrubland
-  Tuckeroo Riparian Shrubland

Heathlands and Shrublands

-  Banksia Moist Shrubland
-  Banksia/Paperbark Swamp Shrubland
-  Banksia/Paperbark Swamp Woodland
-  Banksia/Teatree Wet Heathland
-  Disturbed Heathland
-  Heath-leaved Banksia Swamp Shrubland
-  Paperbark Swamp Shrubland
-  Teatree Wet Shrubland
-  Wallum Banksia Dry Shrubland
-  Wallum Banksia/Black She-oak Dry Shrubland

Fernlands, Sedgeland and Others

-  Bats Wing Fernland
-  Camphor Plantings
-  Regrowth Wattle
-  Eucalyptus Plantation
-  Grassy Wet Meadow
-  Harsh Ground Fernland
-  Juncus/Carex Sedgeland
-  Knotweed Wet Meadow
-  Restio/Baumea Sedgeland
-  Restio/Baumea/Paperbark Sedgeland
-  Saltmarsh/Mudflat
-  Salvinia/Knotweed Wetland
-  Slash Pine Plantings

Figure 5.4 - Legend of Vegetation Map

below. The community descriptions have been categorised into twenty broad units based on structure:

- ❑ *Dry Sclerophyll Forest (DSF)* – usually contains a closed overstorey 20-30 metres in height, a sparse midstorey, but dense understorey;
- ❑ *Wet Sclerophyll Forest (WSF)* – usually contains a closed overstorey 20-35 metres in height and often both a dense mid and understorey;
- ❑ *Rainforest (Rf)* – consists of a closed overstorey 12-20 metres in height, sometimes with an emergent layer up to 30 metres, a sparse to dense midstorey and sparse understorey;
- ❑ *Wet Sclerophyll Forest/Rainforest (WSF/Rf)* – a mixed community containing a low closed canopy of about 10-15 metres with an emergent tree layer above this, the mid and understorey are usually both dense;
- ❑ *Swamp Sclerophyll Forest (SSF)* – usually contains a closed overstorey reaching 12-20 metres in height, a non-existent or very sparse mid-storey, while the understorey is sparse to dense depending upon light penetration;
- ❑ *Swamp Forest/Rainforest (SF/Rf)* – a mixed community with a swamp forest overstorey, but containing a moderately dense rainforest midstorey, while the understorey is variable;
- ❑ *Swamp/Wet Sclerophyll Forest (S/WSF)* – another mixed community with similar structural components to WSF, but with a lower canopy height;
- ❑ *Dry Mallee Forest (DMF)* – usually contains a low open to partially closed overstorey 4-8 metres in height, with an often dense 1-2 metre high midstorey and a variable understorey;
- ❑ *Swamp Mallee Forest (SMF)* – a community with a similar structure to the previous unit, except the understorey is usually a dense layer of sedges;
- ❑ *Mangrove Forest* – an intertidal community with a mostly closed canopy, 2-7 metres in height, with a very sparse understorey and mudflats being common;
- ❑ *Riparian Shrubland/Forest* – consists of a dense mid-stratum layer of shrubs 2-8 metres in height, the understorey is usually a dense layer of ferns, while a sparse emergent eucalypt layer is sometimes present;
- ❑ *Shrubland* – consists of a closed shrub layer varying in height from 2-6 metres, with usually a very sparse understorey;
- ❑ *Wet Heathland* – consists of a moderately dense layer of sedges in the understorey and a moderately dense shrub layer up to 2 metres in height;
- ❑ *Fernland* – a community lacking a mid and overstorey, with a dense understorey layer of ferns up to 1 metre in height.
- ❑ *Sedgeland* – this community has a dense layer of sedges up to 1 metre in height, in some areas emergent paperbarks are common and reach about 3-4 metres in height;

- ❑ *Wet Meadow* – this community has a dense covering of sedges and grass species of varying heights depending upon grazing history;
- ❑ *Saltmarsh/Mudflat* – usually consists of a sparse layer of salt-tolerant species less than 0.5 metres in height with bare mudflats being common;
- ❑ *Introduced Plantings/Plantation* – an artificial community of varying structure depending upon the age and disturbance levels of the stand;
- ❑ *Disturbed* – in areas subject to previously disturbance such as sandmining, with community structure being highly variable depending upon age and the type of disturbance, but usually without a closed overstorey.

The descriptions in Table 5.1 are mostly based upon the closed forest communities (where applicable), which have minimal disturbance or have been disturbed in the distant past. It should be noted that, throughout the study area, some of these communities occur in a regrowth form or a woodland form due to present and past disturbance events. In these cases, the plant species are similar, although the vegetation structure varies. These communities, while not described in the table, are shown on the attached map(s).

The table outlines the dominant species in the upper, middle and lower strata. The first column provides a description of the community using common names and structural components. The third column identifies the equivalent RFA ecosystem (see Appendix A) and its highest conservation status and the area occupied by each community within the study area. The EECs identified below are numbered as follows: Coastal Saltmarsh (1); Freshwater Wetlands on Coastal Floodplains (2); Lowland Rainforest (3); Littoral Rainforest (4); Swamp Sclerophyll Forest on Coastal Floodplains (5); Subtropical Coastal Floodplain Forest (6); Swamp Oak Floodplain Forest (7); Lowland Rainforest on Floodplains (8); and River-flat Eucalypt Forest on Coastal Floodplains (9).

Table 5.1: Vegetation Communities in Study Area

ID No	Community Name	Dominant Species	Equivalent RFA Ecosystem	Conservation Status	Total in Study Area (ha)
1	Blackbutt DSF	<i>Eucalyptus pilularis</i> , <i>Allocasuarina littoralis</i>	101	-	182.3 (27.2 woodland)
2	Blackbutt/Cypress +/- Bloodwood DSF	<i>E. pilularis</i> , <i>Callitris columellaris</i> +/- <i>Corymbia intermedia</i> , <i>C. gummifera</i>	37/22	Regionally Rare	55.5 (2.9 Woodland)
3	Blackbutt/Mahogany DSF	<i>E. pilularis</i> , <i>E. acmenoides</i> , <i>E. carnea</i> +/- <i>E. resinifera</i> , <i>E. seeana</i>	37/46	Regionally Vulnerable	53.9
4	Blackbutt/Pink Bloodwood +/- Tallowwood DSF	<i>E. pilularis</i> , <i>Corymbia intermedia</i> +/- <i>E. microcorys</i>	37	-	80.0
5	Blackbutt/Red Bloodwood DSF	<i>E. pilularis</i> , <i>Corymbia gummifera</i>	37	-	10.7
6	Blackbutt/Mahogany/ Ironbark/Bloodwood/ Tallowwood DSF	<i>E. pilularis</i> , <i>E. acmenoides</i> , <i>E. carnea</i> , <i>E. siderophloia</i> , <i>E. microcorys</i> , <i>Corymbia intermedia</i> , <i>C. gummifera</i>	34	<15% reserved	116.6

ID No	Community Name	Dominant Species	Equivalent RFA Ecosystem	Conservation Status	Total in Study Area (ha)
7	Cypress Pine DSF	<i>Callitris columellaris</i>	22	Regionally Rare (priority for cons. on private lands)	19.5 (11.5 Woodland)
8	Cypress Pine/Mahogany +/- Camphor DSF	<i>Callitris columellaris</i> , <i>E. carnea</i> +/- <i>Cinnamomum camphora</i>	22/23	Regionally Rare (priority for cons. on private lands)	16.7
9	Forest Red Gum DSF	<i>Eucalyptus tereticornis</i>	46	EEC (9)	37.0 (22.6 Woodland)
10	Forest Red Gum/Bloodwood DSF	<i>E. tereticornis</i> , <i>Corymbia intermedia</i> , <i>C. gummifera</i>	42	EEC (9)	16.2
11	Ironbark/Bloodwood +/- Cypress DSF	<i>E. siderophloia</i> , <i>C. intermedia</i> +/- <i>Callitris columellaris</i>	71/115	Regionally Rare (priority for cons. on private lands)	4.4
12	Mahogany/Pink Bloodwood DSF	<i>E. acmenoides</i> , <i>E. resinifera</i> <i>Corymbia intermedia</i>	23	<15% reserved	27.8
13	Pink Bloodwood DSF	<i>Corymbia intermedia</i>	N/A	-	2.8 (0.5 Woodland)
14	Scribbly Gum DSF	<i>Eucalyptus signata</i>	74	Reg. Vulnerable (priority for cons. on private lands)	47.5 (3.0 Woodland)
15	Tallowwood +/- Bloodwood DSF	<i>E. microcorys</i> +/- <i>Corymbia intermedia</i> , <i>C. gummifera</i> , <i>Cinnamomum camphora</i>	146	-	5.3
16	Blue Gum/Brushbox WSF	<i>E. saligna</i> , <i>Lophostemon confertus</i>	84	EEC (9)	2.2
17	Brushbox WSF	<i>Lophostemon confertus</i>	103	-	33.8
18	Brushbox/Tallowwood WSF	<i>L. confertus</i> , <i>E. microcorys</i>	153	<15% reserved	61.3
19	Flooded Gum WSF	<i>Eucalyptus grandis</i>	26	EEC (9)	35.6
20	Flooded Gum/Brushbox/Palm WSF	<i>E. grandis</i> , <i>L. confertus</i> , <i>Livistona australis</i> , <i>Archontophoenix cunninghamiana</i>	26/50	EEC (9)	8.5
21	Flooded Gum/Forest Red Gum WSF	<i>E. grandis</i> , <i>E. tereticornis</i> +/- <i>Livistona australis</i> , <i>Archontophoenix cunninghamiana</i>	26/46	EEC (9)	9.9
22	Blackbutt WSF	<i>E. pilularis</i> +/- <i>L. confertus</i> , <i>E. microcorys</i> , <i>E. carnea</i> , <i>E. acmenoides</i>	95	-	65.6
23	Bangalow Palm Subtropical Rf	<i>Archontophoenix cunninghamiana</i>	168	EEC (8)	8.9
24	Cabbage Tree Palm Subtropical Rf	<i>Livistona australis</i> +/- <i>Melaleuca quinquenervia</i> , <i>Casuarina glauca</i> , <i>Acacia spp.</i>	168	EEC (8)	0.7
25	Rainforest/Camphor/Privet	<i>Cinnamomum camphora</i> , <i>Ligustrum lucidum</i> , <i>L. sinense</i> , <i>Flindersia spp.</i> , <i>Glochidion sumatranum</i> .	168	EEC (3)	76.4
26	Dry Rainforest	<i>Flindersia spp.</i> , <i>Ficus spp.</i> , <i>Cryptocarya triplinervis</i> , <i>Ligustrum spp.</i>	168	EEC (3)	27.7 (18.8 Woodland)

ID No	Community Name	Dominant Species	Equivalent RFA Ecosystem	Conservation Status	Total in Study Area (ha)
27	Hoop Rf	<i>Araucaria cunninghamii</i> , <i>Ligustrum</i> spp., <i>Cryptocarya triplinervis</i> , <i>Alchornea ilicifolia</i>	168	EEC (8)	2.2
28	Brushbox/Rainforest	<i>Lophostemon confertus</i> , <i>Melicope elleryana</i> , <i>Archontophoenix cunninghamiana</i> , <i>Cupaniopsis anacardioides</i>	50	EEC (8)	67.7 (50.8 Regen.)
29	Forest Red Gum/Swamp Oak SSF	<i>Eucalyptus tereticornis</i> , <i>Casuarina glauca</i>	46/143	EEC (9)	31.2
30	Narrow Red Gum/Paperbark SSF	<i>Eucalyptus seeana</i> , <i>Melaleuca quinquenervia</i> +/- <i>Lophostemon confertus</i>	46/112	EEC (6)	6.7
31	Paperbark/Forest Red Gum SSF	<i>Melaleuca quinquenervia</i> , <i>E. tereticornis</i> +/- <i>Lophostemon suaveolans</i> , <i>Casuarina glauca</i> , <i>E. resinifera</i>	46/112	EEC (9)	64.2
32	Paperbark/Mahogany SSF	<i>M. quinquenervia</i> , <i>E. resinifera</i> +/- <i>Corymbia intermedia</i>	112	EEC (5)	15.6
33	Paperbark/Swamp Box SSF	<i>M. quinquenervia</i> , <i>Lophostemon suaveolans</i> +/- <i>Casuarina glauca</i> , <i>Livistonia australis</i> , <i>E. resinifera</i> ,	112	EEC (5)	23.6
34	Swamp Box SSF	<i>Lophostemon suaveolans</i>	N/A	EEC (6)	7.5
35	Swamp Mahogany SSF	<i>Eucalyptus robusta</i> +/- <i>Livistonia australis</i> , <i>Casuarina glauca</i>	142	EEC (5)	93.5 (7.9 Woodland)
36	Swamp Mahogany/Paperbark SSF	<i>Eucalyptus robusta</i> , <i>Melaleuca quinquenervia</i>	112/142	EEC (5)	53.9 (3.1 Woodland)
37	Red Mahogany SSF	<i>Eucalyptus resinifera</i>	117	EEC (6)	13.5
38	Ball Honeymyrtle SSF	<i>Melaleuca nodosa</i>	112	EEC (5)	2.2
39	Broad-leaved Paperbark SSF	<i>Melaleuca quinquenervia</i>	112	EEC (5)	368.8 (44 Woodland, 1.9 Regen.)
40	Paperbark/Cypress SSF	<i>Melaleuca quinquenervia</i> , <i>Callitris columellaris</i>	112/22	EEC (5)	11.9
41	Paperbark/Swamp Oak SSF	<i>Melaleuca quinquenervia</i> , <i>Casuarina glauca</i>	112/143	EEC (5)	157.7 (12.7 Woodland)
42	Swamp Honeymyrtle Sphagnum Woodland	<i>Melaleuca squamea</i> , <i>Sphagnum</i> sp.	112	EEC (5)	1.6
43	Swamp Mahogany Sphagnum Woodland	<i>Eucalyptus robusta</i> , <i>Sphagnum</i> sp.	142	EEC (5)	1.2
44	Swamp Oak SSF	<i>Casuarina glauca</i>	143	EEC (7)	184.6 (32.1 Woodland)
45	Palm/Swamp Box SSF	<i>Livistonia australis</i> , <i>Archontophoenix cunninghamiana</i> <i>Lophostemon suaveolans</i>	N/A	EEC (5)	8.4
46	Paperbark/Rainforest SSF	<i>Melaleuca quinquenervia</i> , <i>Livistonia australis</i> , <i>Cupaniopsis anacardioides</i> +/- <i>Lophostemon suaveolans</i> , <i>Ficus</i> spp., <i>Glochidion sumatranum</i>	112/168	EEC (5)	85.8

ID No	Community Name	Dominant Species	Equivalent RFA Ecosystem	Conservation Status	Total in Study Area (ha)
47	Paperbark/Swamp Oak/Rainforest SSF	<i>Melaleuca quinquenervia</i> , <i>Casuarina glauca</i> , <i>Cupaniopsis anacardioides</i> , <i>Ficus</i> spp., <i>Glochidion sumatranum</i>	112/168	EEC (5)	11.1
48	Paperbark/Brushbox/Swamp Box SSF	<i>Melaleuca quinquenervia</i> , <i>Lophostemon suaveolans</i> , <i>L. confertus</i> +/- <i>Corymbia intermedia</i>	112/50	EEC (5)	9.1
49	Swamp Mahogany/Swamp Box/Brushbox SSF	<i>Eucalyptus robusta</i> , <i>Lophostemon suaveolans</i> , <i>L. confertus</i>	142/50	EEC (5)	11.8
50	Wallum Banksia/Scribbly Gum Dry Mallee Forest	<i>Banksia aemula</i> , <i>E. signata</i>	64	Regionally Vulnerable	132.9
51	Blackbutt Dry Mallee Forest	<i>E. pilularis</i> , <i>Banksia</i> spp., <i>Boronia</i> spp., <i>Dillwynia retorta</i> , <i>Hibbertia</i> spp., <i>Leptospermum</i> spp.	72	Regionally Rare (priority for cons. on private lands)	127.5
52	Scribbly Gum Dry Mallee Forest	<i>E. signata</i> , <i>Banksia</i> spp., <i>Dillwynia retorta</i> , <i>Hibbertia</i> spp., <i>Leptospermum</i> spp.	74	Regionally Vulnerable (priority for cons. on private lands)	75.9
53	Scribbly Gum/Ball Honey Myrtle Swamp Mallee Forest	<i>Eucalyptus signata</i> , <i>Melaleuca nodosa</i> , <i>Banksia</i> spp.	74	Reg. Vulnerable (priority for cons. on private lands)	2.6
54	Swamp Mahogany Swamp Mallee Forest	<i>Eucalyptus robusta</i> , <i>Blechnum</i> spp.	142	EEC (5)	1.1
55	Mangrove Forest	<i>Avicennia marina</i> , <i>Aegiceras corniculatum</i> , <i>Sporobolus indicus</i> , <i>Einadia hastata</i>	77	Regionally Rare	173 (31.0 Woodland)
56	Mangrove/Swamp Oak +/- Forest Red Gum Forest	<i>Avicennia marina</i> , <i>Aegiceras corniculatum</i> , <i>Casuarina glauca</i> +/- <i>E. tereticornis</i>	77/143	EEC (9)	57.3
57	Forest Red Gum/Tuckeroo Riparian Forest	<i>E. tereticornis</i> , <i>Cupaniopsis anacardioides</i>	46/199	EEC (9)	26.2
58	Mangrove/Tuckeroo Riparian Shrubland	<i>Aegiceras corniculatum</i> , <i>Cupaniopsis anacardioides</i> , <i>Crinum pedunculatum</i> , <i>Ficus</i> spp.	199	EEC (4)	4.2
59	Tuckeroo Riparian Shrubland	<i>Cupaniopsis anacardioides</i> , <i>Ficus</i> spp.	199	EEC (4)	2.0
60	Wallum Banksia/Black Sheoak Dry Shrubland	<i>Banksia aemula</i> , <i>Allocasuarina littoralis</i>	64	Regionally Vulnerable	6.8
61	Wallum Banksia Dry Shrubland	<i>Banksia aemula</i> , <i>Baeckea</i> spp., <i>Leptospermum</i> spp., <i>Leucopogon</i> spp.	64	Regionally Vulnerable	391.1
62	Teatree Dry Shrubland	<i>Leptospermum speciosum</i> +/- <i>Banksia</i> spp., <i>Baeckea</i> spp.	64	Regionally Vulnerable	1.4
63	Banksia Moist Shrubland	<i>Banksia ericifolia</i> , <i>B. aemula</i> +/- <i>Leptospermum</i> spp., <i>Epacris</i> spp., <i>Leucopogon</i> spp.	64	Regionally Vulnerable	67.8
64	Heath-leaved Banksia Swamp Shrubland	<i>Banksia ericifolia</i> +/- <i>Callistemon pachyphyllus</i> , <i>Epacris</i> spp., <i>Leptospermum</i> spp., <i>Gahnia sieberiana</i>	64	Regionally Vulnerable	134.9

ID No	Community Name	Dominant Species	Equivalent RFA Ecosystem	Conservation Status	Total in Study Area (ha)
65	Banksia/Paperbark Swamp Shrubland	<i>Banksia aemula</i> , <i>Melaleuca nodosa</i> , <i>Homoranthus virgatus</i> , <i>Leptospermum spp.</i> , <i>Leucopogon spp.</i>	64	EEC (5)	2.1 (0.6 Woodland)
66	Broad-leaved Paperbark Swamp Shrubland	<i>Melaleuca quinquenervia</i>	112	EEC (5)	18.7
67	Banksia/Teatree Wet Heathland	<i>Banksia oblongifolia</i> , <i>Leptospermum liversidgei</i> +/- <i>Callistemon pachyphyllus</i> , <i>Cyperus spp.</i>	64	Regionally Vulnerable	245.5
68	Bats Wing Fernland	<i>Histiopteris incisa</i>	N/A	-	0.9
69	Harsh Ground Fernland	<i>Hypolepis muelleri</i>	N/A	-	0.8
70	Juncus/Carex Sedgeland	<i>Juncus spp.</i> , <i>Carex appressa</i> , <i>Cyperus spp.</i>	141	EEC (2)	7.9
71	Restio/Baumea Sedgeland	<i>Restio pallens</i> , <i>Baumea rubiginosa</i>	141	EEC (2)	37.4
72	Restio/Baumea/Paperbark Sedgeland	<i>Restio pallens</i> , <i>Baumea rubiginosa</i> , <i>Melaleuca quinquenervia</i>	141	EEC (2)	74.2
73	Knotweed Wet Meadow	<i>Persicaria spp.</i> , <i>Paspalum paniculatum</i> , <i>Carex lophocarpa</i>	141	EEC (2)	11.4
74	Grassy Wet Meadow	<i>Persicaria spp.</i> , <i>Paspalum spp.</i> , <i>Cynodon dactylon</i> , <i>Juncus spp.</i> , <i>Agrostis avenacea</i> , <i>Centella asiatica</i>	N/A	*EEC (2)	14.6
75	Saltmarsh/Mudflat	+/- <i>Sporobolus indicus</i> , <i>Einadia hastata</i>	N/A	EEC (1)	20.7
76	Camphor Plantings	<i>Cinnamomum camphora</i>	N/A	-	12.1
77	Eucalyptus Plantation	<i>Eucalyptus spp.</i>	N/A	-	1.5
78	Slash Pine Plantings	<i>Pinus elliotti</i>	N/A	-	16.4
79	Disturbed ¹ Heathland	<i>Banksia spp.</i> , <i>Leptospermum spp.</i> , <i>Leucopogon spp.</i> , <i>Acacia spp.</i>	N/A	Regionally Vulnerable	220.7
80	Regrowth Wattle	<i>Acacia spp.</i> +/- <i>Melaleuca spp.</i> , <i>Banksia spp.</i>	N/A	-	5.0
81	Salvinia/Knotweed Wetland	<i>Salvinia molesta</i> , <i>Persicaria spp.</i>	141	*EEC (2)	2.1
82	Cleared Land	<i>Introduced grasses, sugar cane and weeds.</i>	N/A	-	

* May be classified as an EEC depending upon individual site/species characteristics; it should be noted that a precautionary approach has been taken in mapping all these communities as EECs.

¹ Previously mined.

The table above highlights that a number of vegetation communities within the study area are considered to be EECs. The relevant EECs and their distribution are shown in Figures 5.5-5.7.

5.1.2 Threatened plant species

Threatened plant species records are from Geolyse (2005b) or were provided to Hyder Consulting in digital form by DEC, Ballina Shire Council and Mark Graham. No surveys for threatened plant species were undertaken as part of the current review.

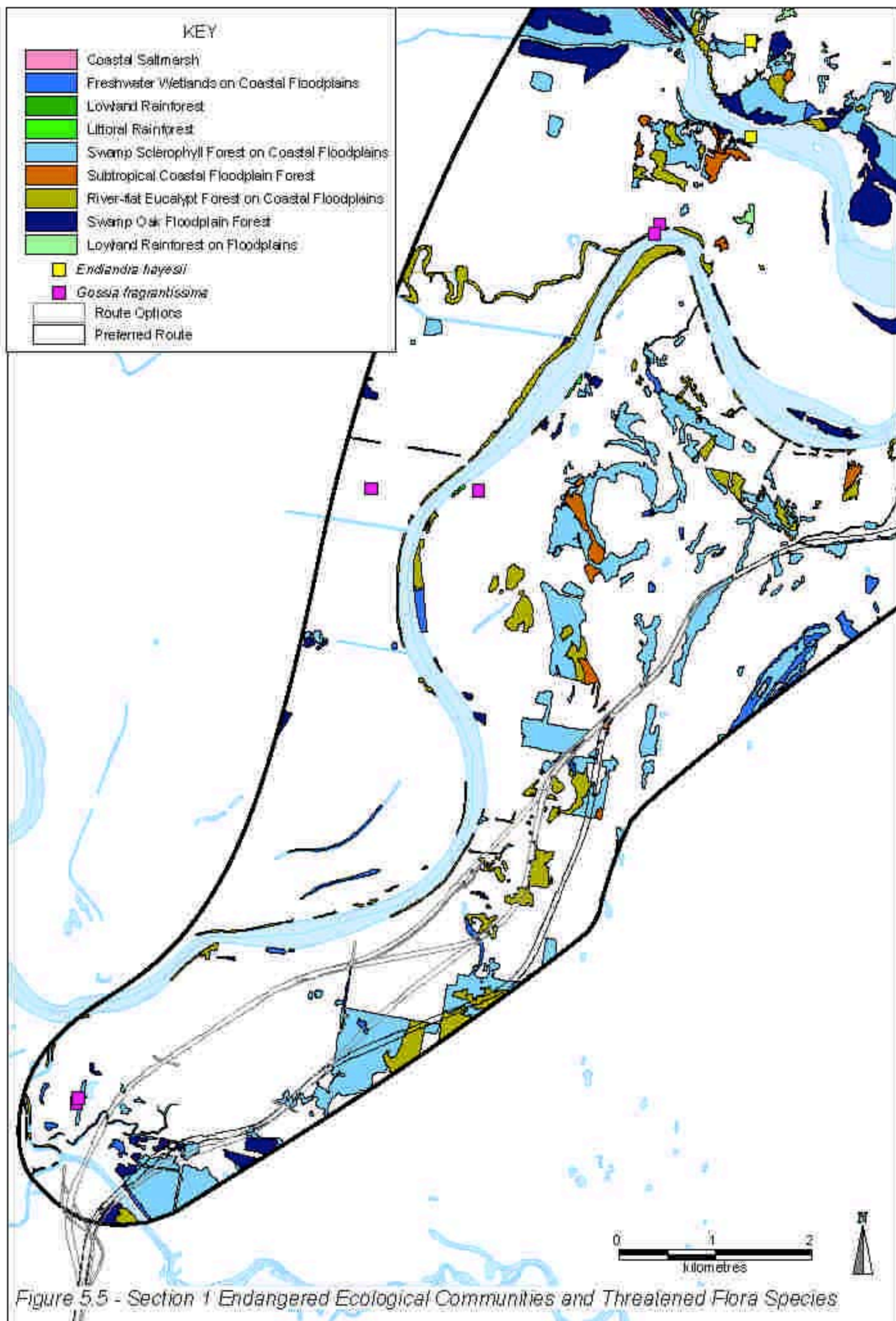
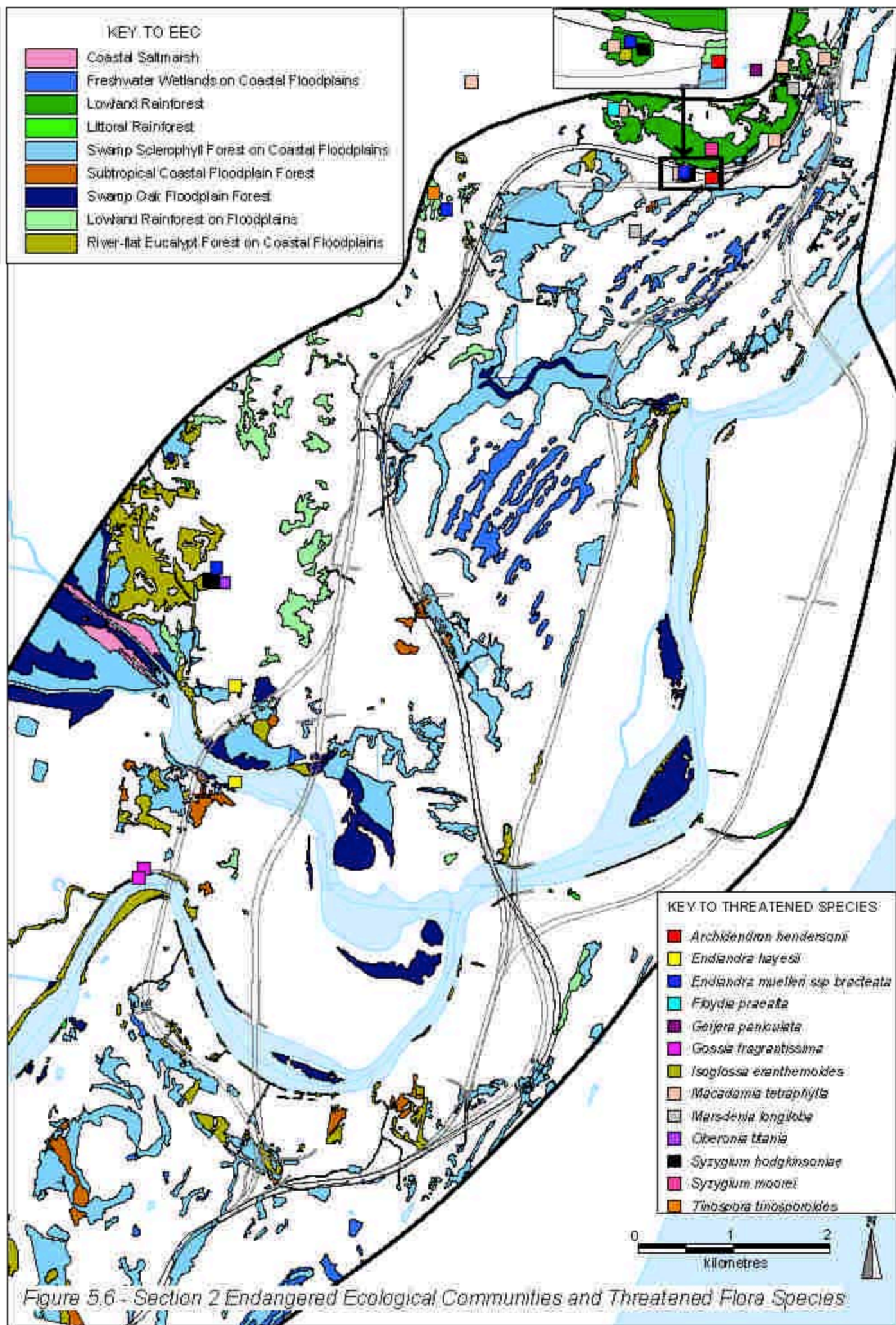
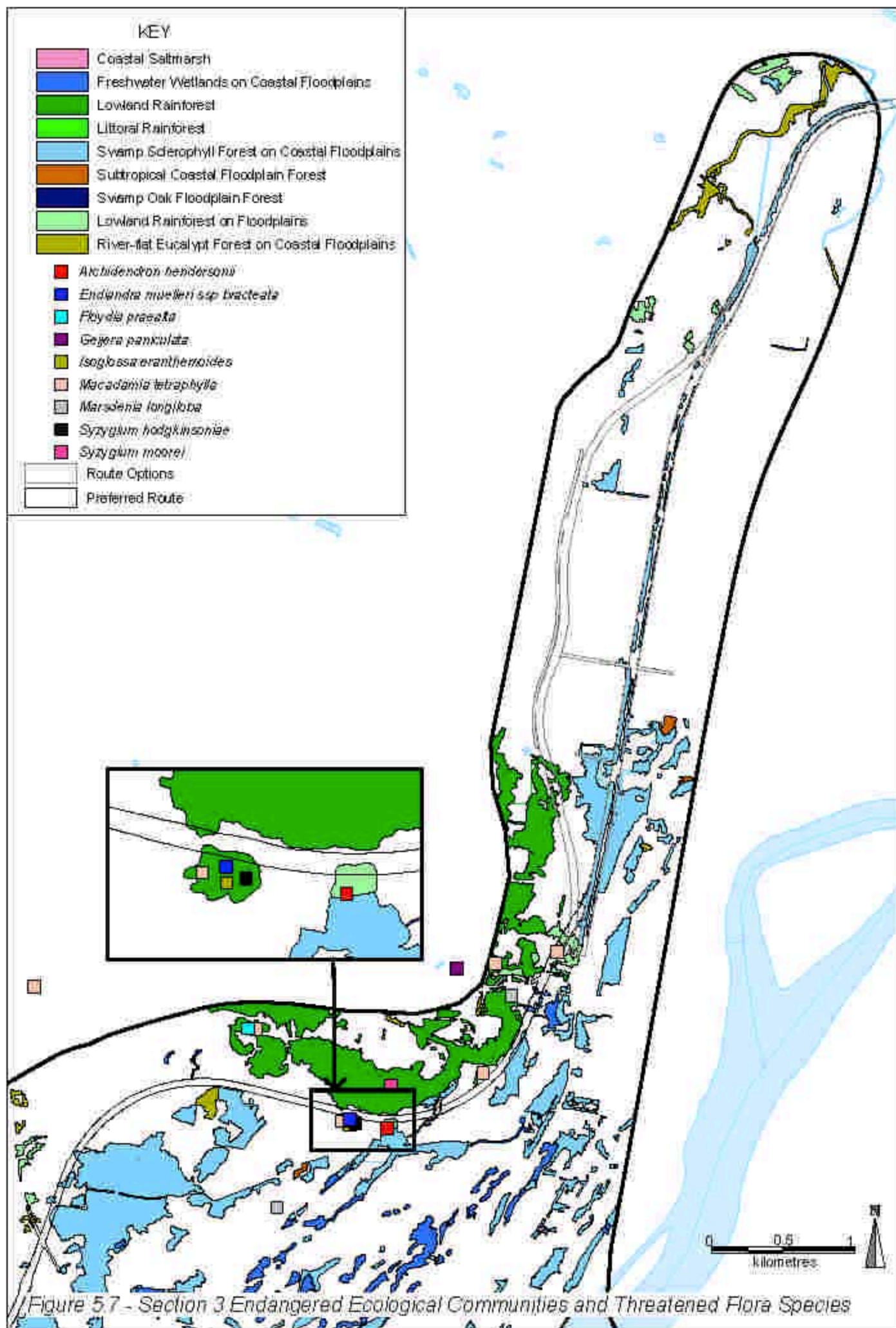


Figure 5.5 - Section 1 Endangered Ecological Communities and Threatened Flora Species





Threatened plant species known from or potentially found in the study area are listed below in Table 5.2 and records are shown in Figures 5.5-5.7. It should be noted that a number of species previously tabulated by Geolyse (2005b) are not listed in the table below as they are considered to be unlikely or only have a low likelihood of occurring in the study area.

Table 5.2: Threatened Plants Known or Considered Likely to Occur in Study Area

Threatened Species	Conservation Significance	Likelihood of Occurring in Study Area	Likely Vegetation Communities
Arrow Head Vine <i>Tinospora tinoporoides</i>	EPBC (V), TSC (V), ROTAP	Recorded	25, 26, 27, 28
Axe Breaker <i>Geijera paniculate</i>	TSC (E)	Recorded	25, 26, 27, 28
Ball Nut <i>Floydia praealta</i>	EPBC (V), TSC (V), ROTAP	Recorded	25, 26, 27, 28, 57, 58, 59
Blotched Sarcochilus <i>Sarcochilus weinthalii</i>	EPBC (V), TSC (V), ROTAP	Moderate	25, 26, 27, 28
Brown Fairy Chain Orchid <i>Peristeranthus hillii</i>	TSC(V), ROTAP	Moderate	23, 24, 25, 26, 27, 28, 46, 47
Cameron's Tarenna <i>Tarenna cameronii</i>	TSC (E)	Moderate	26, 27
Dark Greenhood Orchid <i>Pterostylis nigricans</i>	TSC(V), ROTAP	Moderate	60, 61, 62, 63, 64, 65, 67
Green Leaved Rose Walnut <i>Endiandra muelleri ssp. bracteata</i>	TSC (E), ROTAP	Recorded	23, 24, 25, 26, 27, 28, 46, 47
Heath Wrinklewort <i>Rutidosia heterogama</i>	TSC (V)	Moderate	60, 61, 62, 63, 64, 65, 67
- <i>Hicksbeachia pinnatifolia</i>	EPBC (V), TSC (V), ROTAP	Moderate	25, 26, 27, 28
Jointed Baloghia <i>Baloghia marmorata</i>	EPBC (V), TSC (V), ROTAP	Moderate-High	25, 26, 27, 28
- <i>Isoglossa eranthemoides</i>	EPBC (E), TSC (E), ROTAP	Recorded	25, 26, 27, 28
Magenta Lilly Pilly <i>Syzygium paniculatum</i>	TSC (V)	Moderate	23, 24, 25, 26, 27, 28, 46, 47
- <i>Marsdenia longiloba</i>	EPBC (E), TSC (E), ROTAP	Recorded	25, 26, 27, 28
Needle-leaf Fern <i>Belvisia mucronata</i>	TSC (E)	Moderate	25, 26, 27, 28
Northern Clematis <i>Clematis fawcettii</i>	EPBC (V), TSC (V), ROTAP	Moderate	25, 26, 27, 28
- <i>Oldenlandia galioides</i>	TSC (E)	Moderate	31, 39
Palm Orchid <i>Oberonia titania (syn.palmicola)</i>	TSC(V)	Recorded	23, 24, 25, 26, 27, 28, 30, 31, 32, 33, 36, 38, 39, 40, 41, 42, 46, 47, 55, 56
- <i>Phyllanthus microcladus</i>	TSC (E)	Moderate	57, 58, 59

Threatened Species	Conservation Significance	Likelihood of Occurring in Study Area	Likely Vegetation Communities
- <i>Randia moorei</i>	EPBC (E), TSC (E), ROTAP	Moderate	25, 26, 27, 28
Red Lilly Pilly <i>Syzygium hodgkinsoniae</i>	EPBC (V), TSC (V), ROTAP	Recorded	25, 26, 27, 28, 57, 58, 59
Rough Shelled Bush Nut <i>Macadamia tetraphylla</i>	EPBC (V), TSC (V), ROTAP	Recorded	25, 26, 27, 28
Rusty Plum <i>Niemeyera whitei</i>	TSC (V)	Moderate	23, 24, 25, 26, 27, 28, 46, 47
Rusty Rose Walnut <i>Endiandra hayesii</i>	EPBC (V), TSC (V), ROTAP	Recorded	25, 26, 27, 28
Scented Acronychia <i>Acronychia littoralis</i>	EPBC (E), TSC (E)	Moderate	23, 24, 46, 47
Small-leaved Hazelwood <i>Symplocos baeuerlenii</i>	EPBC (V), TSC (V), ROTAP	Moderate	25, 26, 27, 28
Small-leaved Tamarind <i>Diploglottis campbellii</i>	EPBC (E), TSC (V)	Moderate	57, 58, 59
Smooth Davidson's Plum <i>Davidsonia johnsonii</i>	TSC (E)	Moderate	25, 26, 27, 28
Southern Ochrosia <i>Ochrosia moorei</i>	EPBC (E), TSC (E)	Moderate	25, 26, 27, 28
Stinking Cryptocarya <i>Cryptocarya foetida</i>	EPBC (V), TSC (V), ROTAP	Moderate-High	23, 24, 46, 47
Swamp Orchid <i>Phaius australis</i>	EPBC (E), TSC (E), ROTAP	Recorded	39, 46
Sweet Myrtle <i>Gossia fragrantissima</i>	EPBC (E), TSC (E)	Recorded	25, 26, 27, 28
- <i>Syzygium moorei</i>	EPBC (V), TSC (V), ROTAP	Recorded	25, 26, 27, 28
Three-leaved Bosistoa <i>Bosistoa transversa</i>	EPBC (V), TSC (V), ROTAP	Moderate	23, 24, 25, 26, 27, 28, 46, 47
Tinospora Vine <i>Tinospora smilacina</i>	TSC (E)	Moderate	25, 26, 27, 28
Waterwheel Plant <i>Aldrovanda vesiculosa</i>	TSC (E)	Moderate	70, 71, 72, 73, 74, 81
Weeping Paperbark <i>Melaleuca irbyana</i>	TSC (E)	Moderate	30, 31, 32, 33
White Laceflower <i>Archidendron hendersonii</i>	TSC (V)	Recorded	25, 26, 27, 28

5.1.3 Regionally significant plant species

Regionally significant plant species listed below in Table 5.3 are from Graham (2005). No surveys for regionally significant plant species were undertaken as part of the current review.

Table 5.3: Regionally Significant Plants Known or Likely to Occur in Study Area

Threatened Species	Conservation Significance	Likelihood of Occurring in Study Area	Likely Vegetation Communities
Byron Bay Acronychia <i>Acronychia baeuerlenii</i>	ROTAP	Moderate	25, 26, 27, 28
Veiny Laceflower <i>Archidendron muellerianum</i>	ROTAP	High	23, 24, 25, 26, 27, 28, 46, 47
Glenugie Karaka <i>Corynocarpus rupestris</i> ssp. <i>arborescens</i>	ROTAP	High	26, 27
Swamp Palm Lily <i>Cordyline congesta</i>	ROTAP	High	25, 26, 27, 28
Midge Orchids <i>Acianthus amplexicaulis</i> and <i>A. exiguus</i>	ROTAP	Moderate	16, 17, 18, 19, 20, 21, 22, 46, 47

5.1.4 Overall Flora Conservation Values

The overall flora conservation values in the study area are depicted in Figures 5.8-5.10. These maps show vegetation communities of national conservation significance (i.e. the Coolgardie Scrub), state conservation significance (i.e. EECs) and regionally significant species (as per Table 5.1). These maps also show the distribution of known threatened species without identifying individual species.

5.2 Terrestrial Fauna

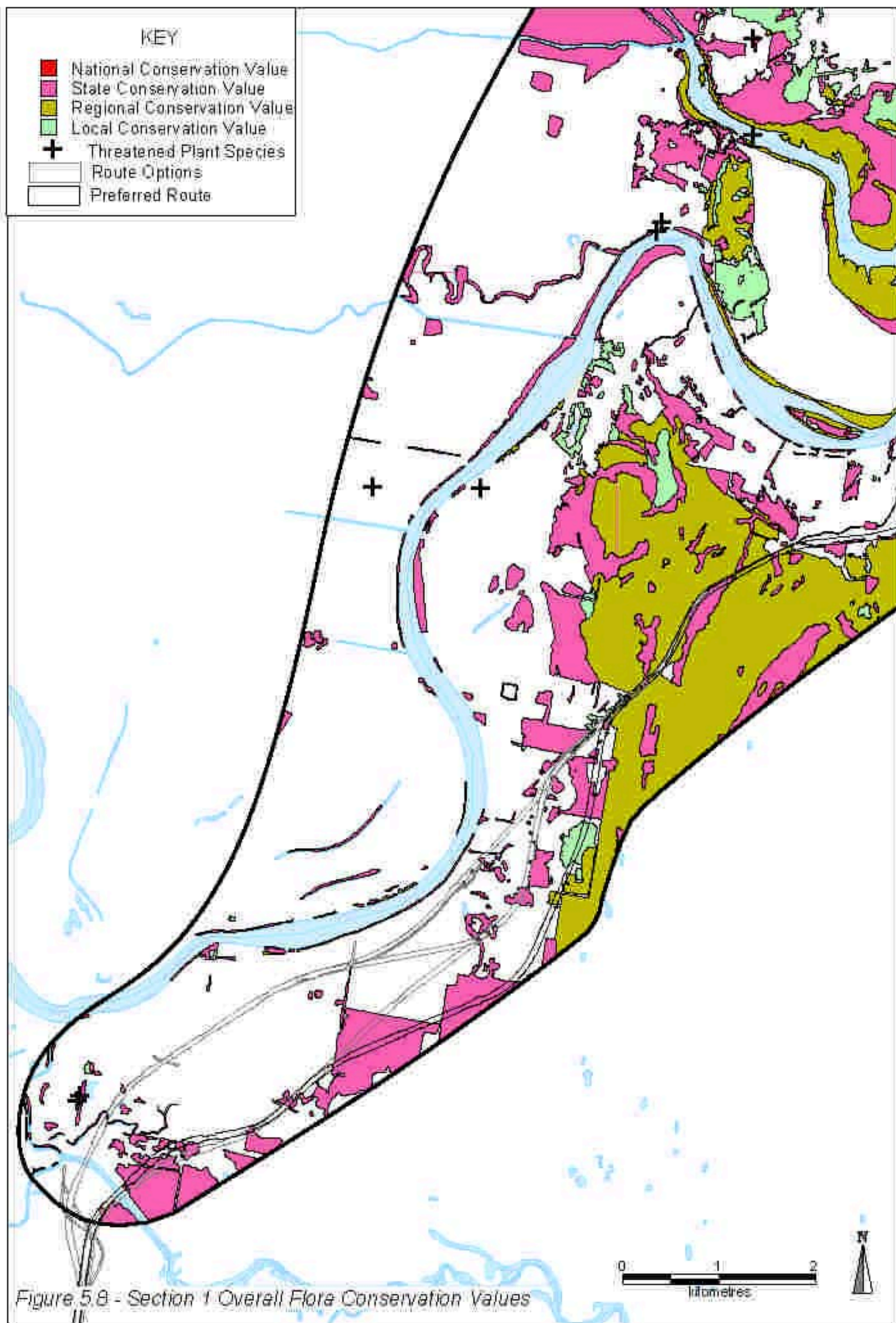
Overall, the study area comprises at least 31 fauna habitats and supports at least 39 (and possibly up to 101) fauna species of conservation significance. Of those species that are known to occur, five are of national significance (2 mammals, 2 birds, 1 frog) and 39 are of state significance (12 mammals, 25 birds, 2 frog). No regionally significant fauna species or migratory birds were recorded in the study area although some had a high likelihood of occurring. It should be noted that totals are not additive as some species are listed at both the national and state levels of conservation significance.

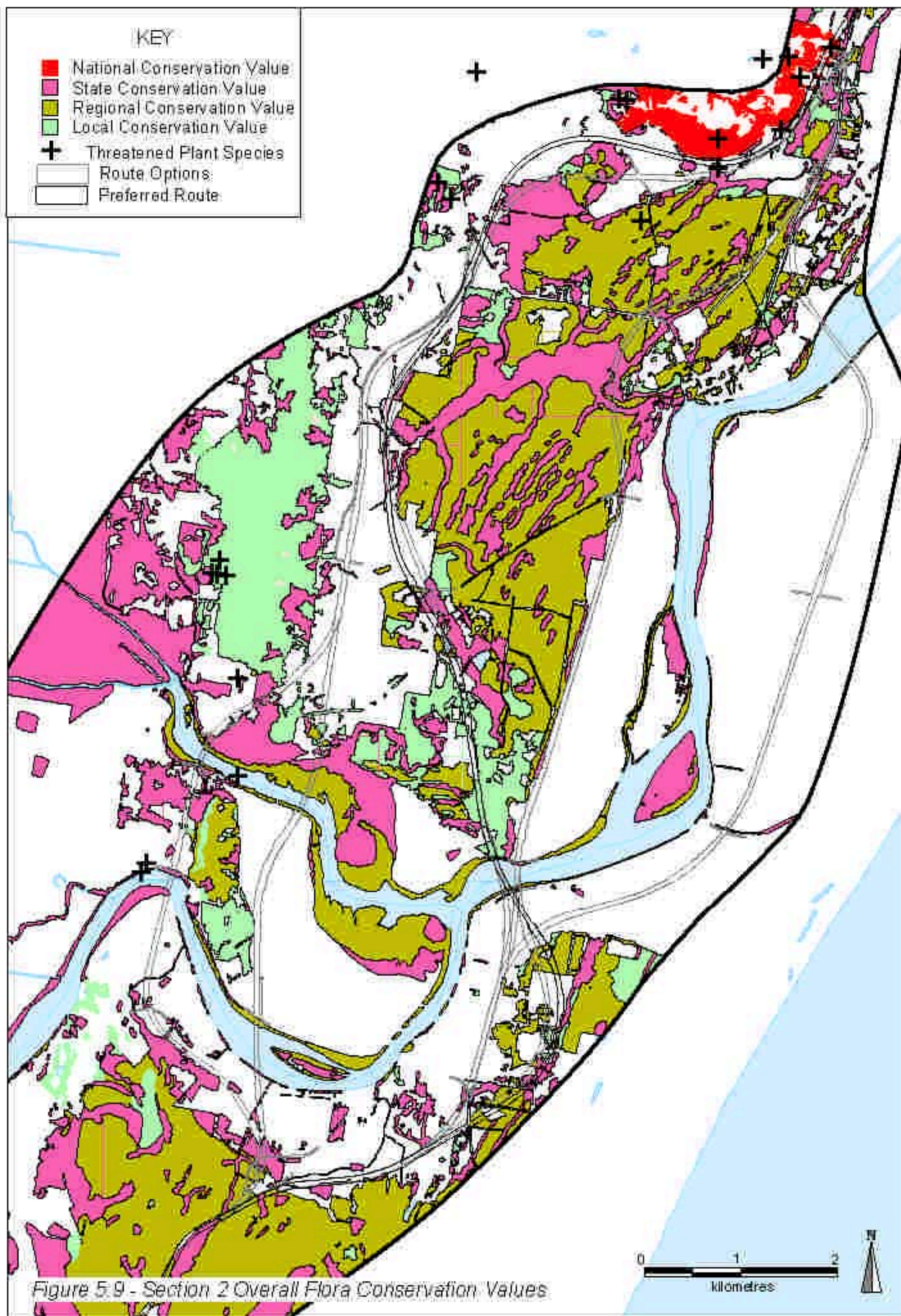
5.2.1 Fauna habitats

The identification of fauna habitats was determined as part of the current review. Fauna habitats recorded in the study area are briefly described in Table 5.4 below and are shown in Figures 5.11-5.13.

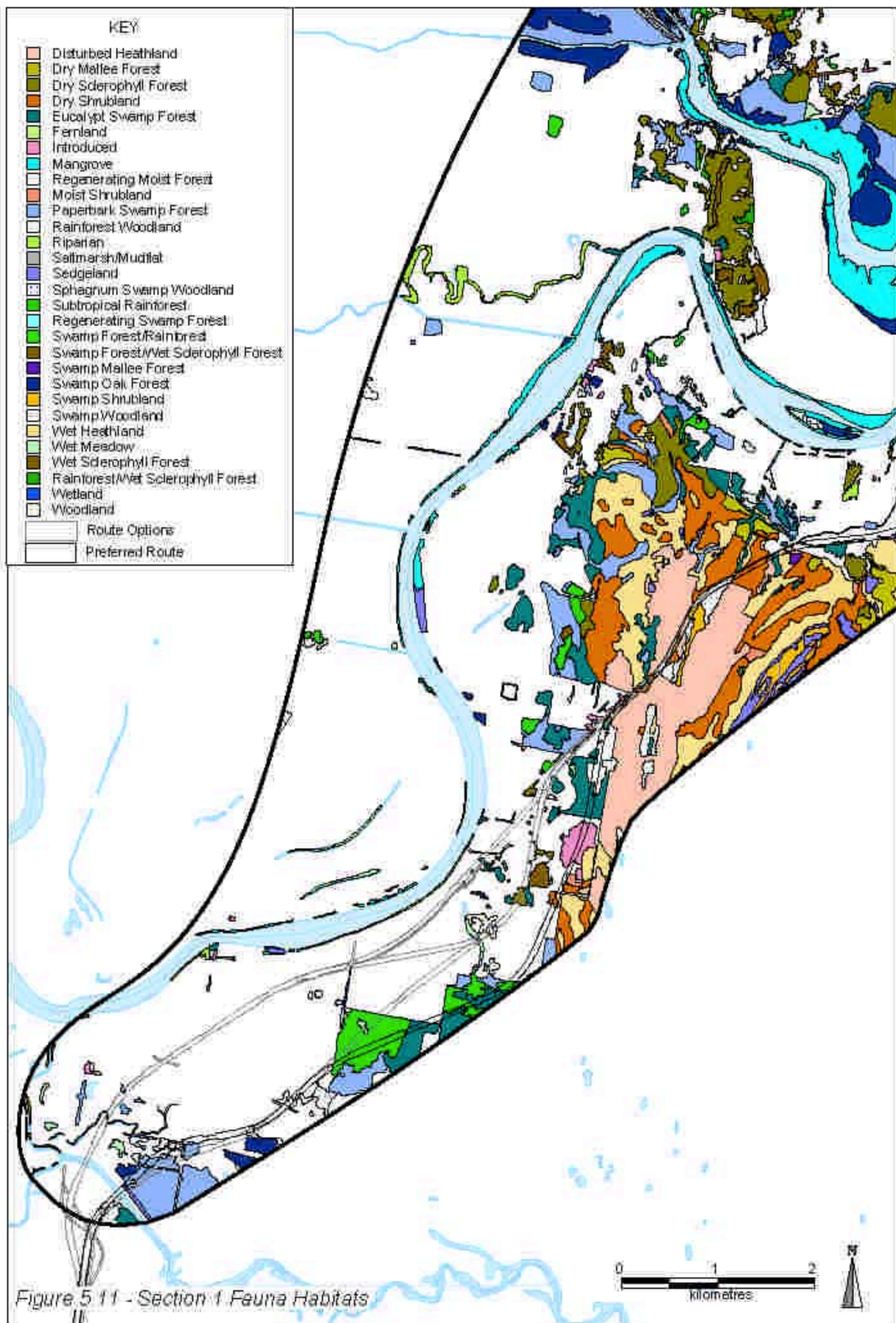
Table 5.4: Fauna Habitats in the Study Area

ID No.	Habitat Type	Structure	Habitat Elements	Likely Threatened Species/Groups
1	Fernland	No canopy, no mid-stratum, dense ground layer.	Open habitat	Ground-nesting birds
2	Wet Meadow	No canopy, no mid-stratum, dense ground layer.	Open habitat	Granivorous birds, ground-nesting birds, frogs, waterbirds









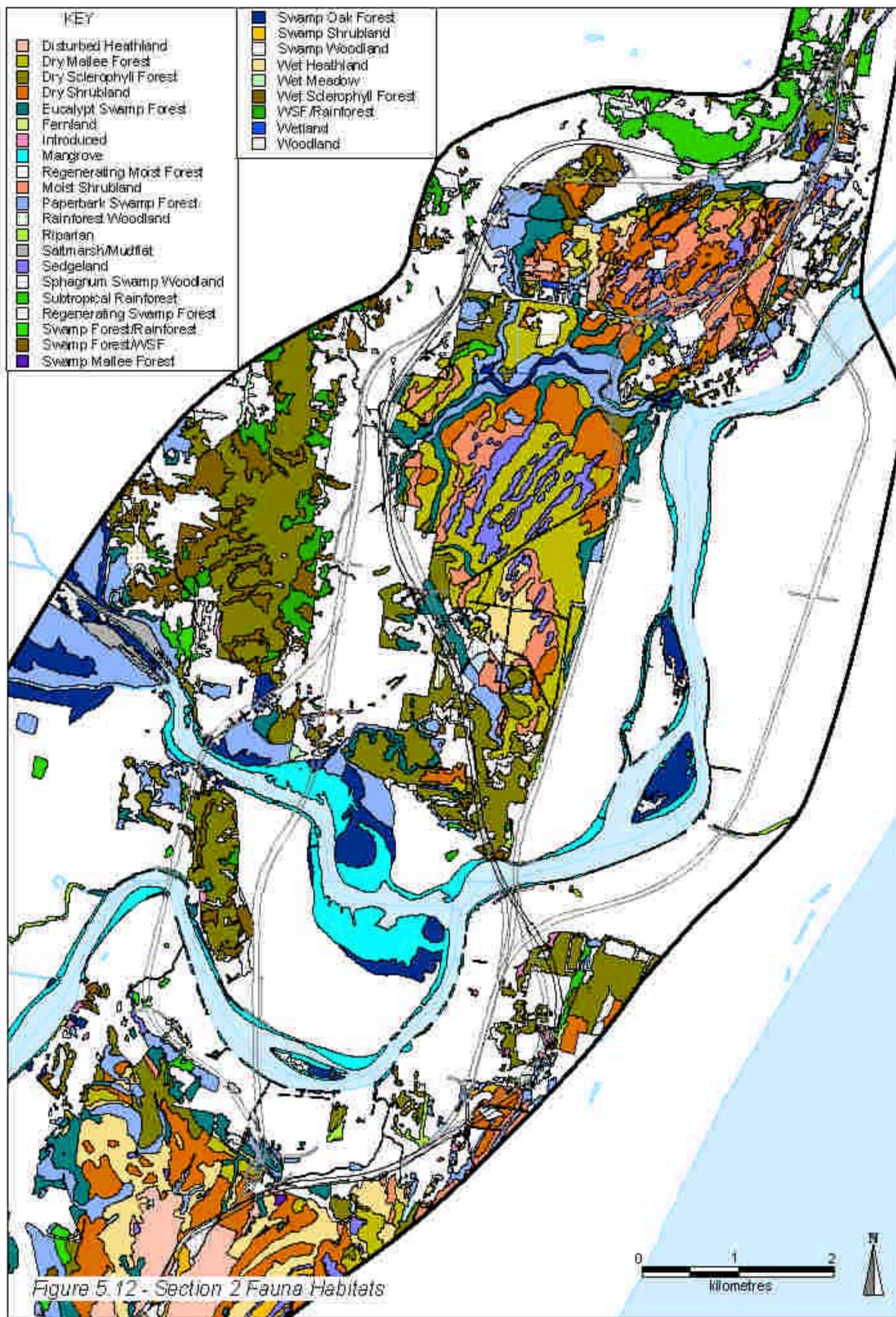
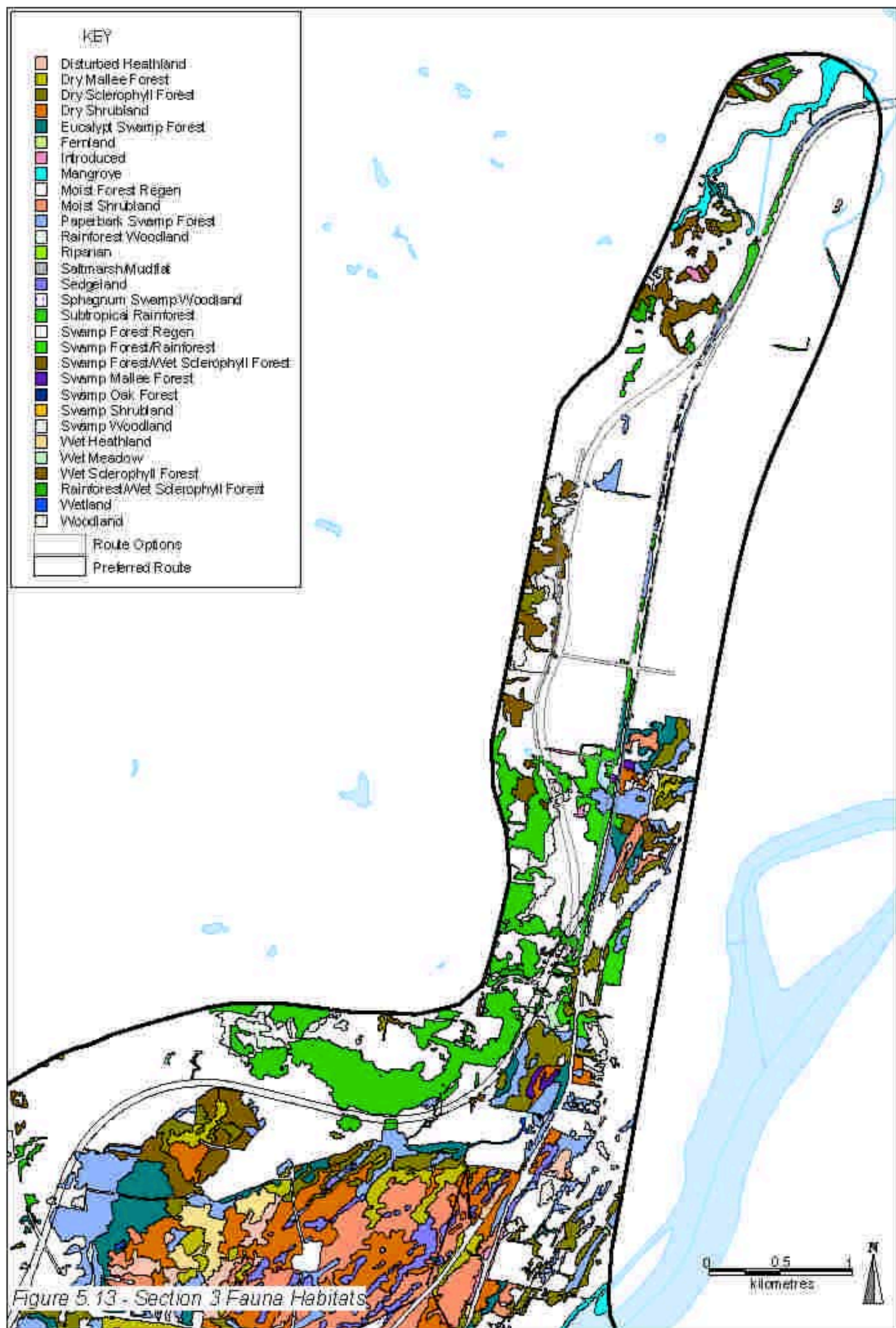


Figure 5.12 - Section 2 Fauna Habitats



ID No.	Habitat Type	Structure	Habitat Elements	Likely Threatened Species/Groups
3	Sedgeland	No canopy, no mid-stratum, dense ground layer.	Open habitat	Granivorous birds, ground-nesting birds, frogs, waterbirds.
4	Mangroves	Closed low canopy, no mid-stratum, sparse ground layer.	Intertidal mudflats	Waders, Mangrove birds
5	Swamp Shrubland	No canopy, dense mid-stratum, variable understorey	Flowering shrubs	Shrub-nesting birds, nectivorous birds
6	Paperbark Swamp Forest	Medium closed canopy, sparse mid-stratum, sparse to moderately dense understorey.	Swamp substrate, loose bark for sheltering, flowering trees	Common Blossom-bat, Flying-foxes, frogs, insectivorous bats
7	Swamp Oak Forest	Medium closed canopy, sparse mid-stratum, sparse understorey.	Nesting resources for raptors and other birds	Insectivorous bats, Black Bittern
8	Eucalypt Swamp Forest	Medium closed canopy, sparse mid-stratum, sparse to moderately dense understorey.	Sedges, swamp substrate, winter flowering trees, Koala food trees	Flying foxes, insectivorous bats, nectivorous birds, koalas.
9	Swamp Forest/Rainforest	Medium closed canopy, dense mid-stratum, moderately dense understorey.	Rainforest elements, swamp substrate, Koala food trees	Rainforest birds, frogs, insectivorous bats, Common Planigale
10	Dry Sclerophyll Shrubland	No canopy, dense mid-stratum, variable understorey.	Dense shrubland	Shrub-nesting birds, Common Blossom-bat
11	Moist Shrubland	No canopy, dense mid-stratum, variable understorey.	Diverse shrubland	Frogs, shrub-nesting birds, Common Blossom-bat
12	Wet Heath	No canopy, dense mid-stratum, variable understorey.	Low diversity shrubland	Shrub-nesting birds, nectivorous and granivorous birds, frogs.
13	Disturbed Heath	No canopy, moderately dense mid-stratum, dense understorey.	Low diversity shrubland	Shrub-nesting birds, nectivorous and granivorous birds.
14	Dry Mallee Forest	Very low open to closed canopy, dense mid-stratum, variable understorey.	Hollow-bearing trees, low diversity shrubland	Squirrel Gliders, insectivorous bats, flying foxes.
15	Swamp Mallee Forest	Very low open to closed canopy, dense mid-stratum, dense understorey	Koala food trees, low diversity shrubland, swamp substrate	Shrub-nesting birds, flying-foxes, frogs, insectivorous bats, Koalas.
16	Dry Sclerophyll Forest	Moderately tall, closed canopy. Sparse to dense mid-stratum, sparse to dense understorey.	<i>Allocasuarina</i> stands, hollow-bearing trees, logs, grasses, Koala food trees	Cockatoos, arboreal mammals, honeyeaters, hollow-nesting birds, microbats, owls, Squirrel Glider.

ID No.	Habitat Type	Structure	Habitat Elements	Likely Threatened Species/Groups
17	Wet Sclerophyll Forest	Tall, closed canopy, dense mid-stratum, sparse to dense understorey.	Rainforest elements, leaf litter, moist substrate, Koala food trees	Frogs, arboreal mammals, nectivorous birds, frugivorous birds, fruit bats, owls, Koala
18	Subtropical Rainforest	Low to medium closed canopy, sparse to dense mid-stratum, sparse understorey.	Rainforest elements, moist substrate	Frugivorous birds, rainforest snakes, Alberts Lyrebird
19	Subtropical Rainforest/Wet Sclerophyll Forest	Low closed canopy, emergent tree layer, dense mid-stratum and understorey.	Rainforest elements, moist substrate, leaf litter, Koala food trees	Frugivorous birds, rainforest snakes, Alberts Lyrebird, arboreal mammals, owls, microbats
20	Swamp Forest/Wet Sclerophyll Forest	Medium closed canopy, dense mid- stratum, moderately dense understorey.	Koala food trees, hollow-bearing trees, swamp substrate	Frogs, arboreal mammals, nectivorous birds, flying foxes, koala
21	Swamp Woodland	Open medium canopy, sparse mid-stratum, dense ground layer.	Koala food trees, swamp substrate	Flying foxes, microbats, frogs
22	Sphagnum Swamp Woodland	Open medium canopy, sparse mid-stratum, dense understorey.	Koala food trees, sphagnum swamp substrate	Frogs, flying foxes, microbats
23	Rainforest Woodland	Open canopy, sparse to dense mid-stratum, dense ground layer.	Rainforest fruiting trees	Frugivorous birds, Alberts Lyrebird, microbats
24	Woodland	Open variable canopy, sparse mid-stratum, variable understorey.	Grassy substrate, hollow-bearing trees, koala food trees	Grey-crowned Babbler, Masked owl, microbats, Koala
25	Wetland	No canopy, no mid-stratum, dense understorey.	Swamp substrate, ponding water	Frogs, waders, microbats
26	Riparian	Closed low canopy, sparse mid-stratum, variable understorey.	Rainforest fruiting trees, moist substrate	Rainforest birds, frogs
27	Freshwater	Open water	Open habitat	Ducks, bitterns, Osprey
28	Saltwater	Open water	Open habitat	Waders
29	Introduced (pines and exotics)	Variable.	Variable	Some rainforest birds
30	Cleared (pastures and canefields)	No canopy, no mid-stratum, dense grassy ground cover.	Open habitat	Grassland birds, Black-necked Stork
31	Saltmarsh/mudflat	No canopy or mid-stratum, sparse to mid-dense understorey.	Intertidal mudflats	Waders

It should be noted that fauna habitats are considered to have conservation significance when they correspond to vegetation communities that are of significance at the state or regional level.

Furthermore, any habitats falling within areas delineated as key habitat or regional corridors as defined by NPWS (2000) are considered to have regional conservation significance.

Within the study area, 13 habitat types were found to support a particularly high diversity (20-30 species) of threatened fauna species (see Section 6.1). These include: Sedgeland; Riparian; Paperbark Swamp Forest; Eucalypt Swamp Forest; Swamp Forest/Rainforest; Dry Mallee Forest; Dry Sclerophyll Forest; Wet Sclerophyll Forest; Subtropical Rainforest; Subtropical Rainforest/Wet Sclerophyll Forest; Swamp Forest/Wet Sclerophyll Forest; Sphagnum Swamp Woodland; and Rainforest Woodland.

Other communities such as shrubland may provide important habitat for specific fauna groups but are not considered to be of particular conservation significance. For example, wallum habitats are particularly important to habitat specialists such as wallum frog fauna.

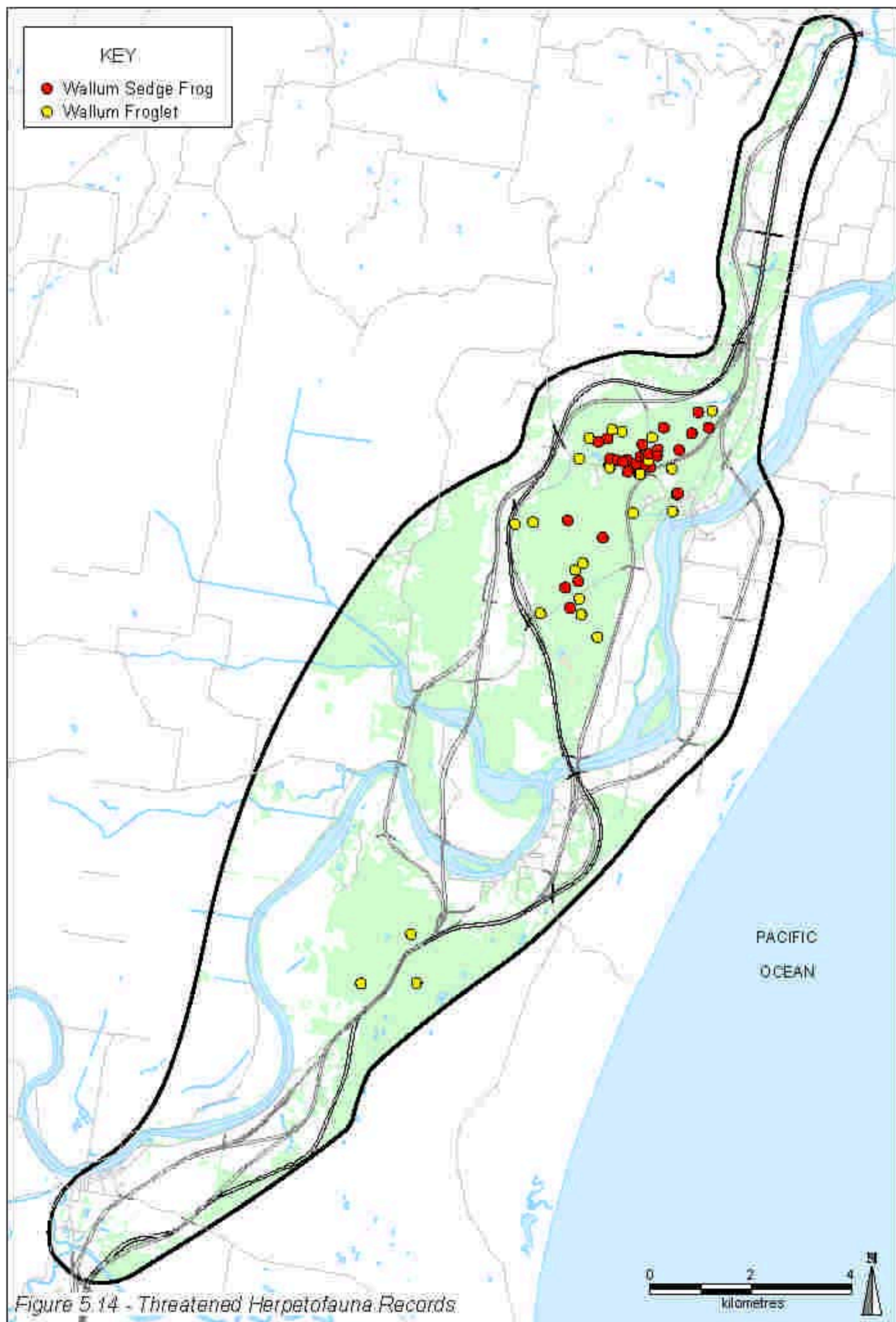
5.2.2 Threatened fauna species

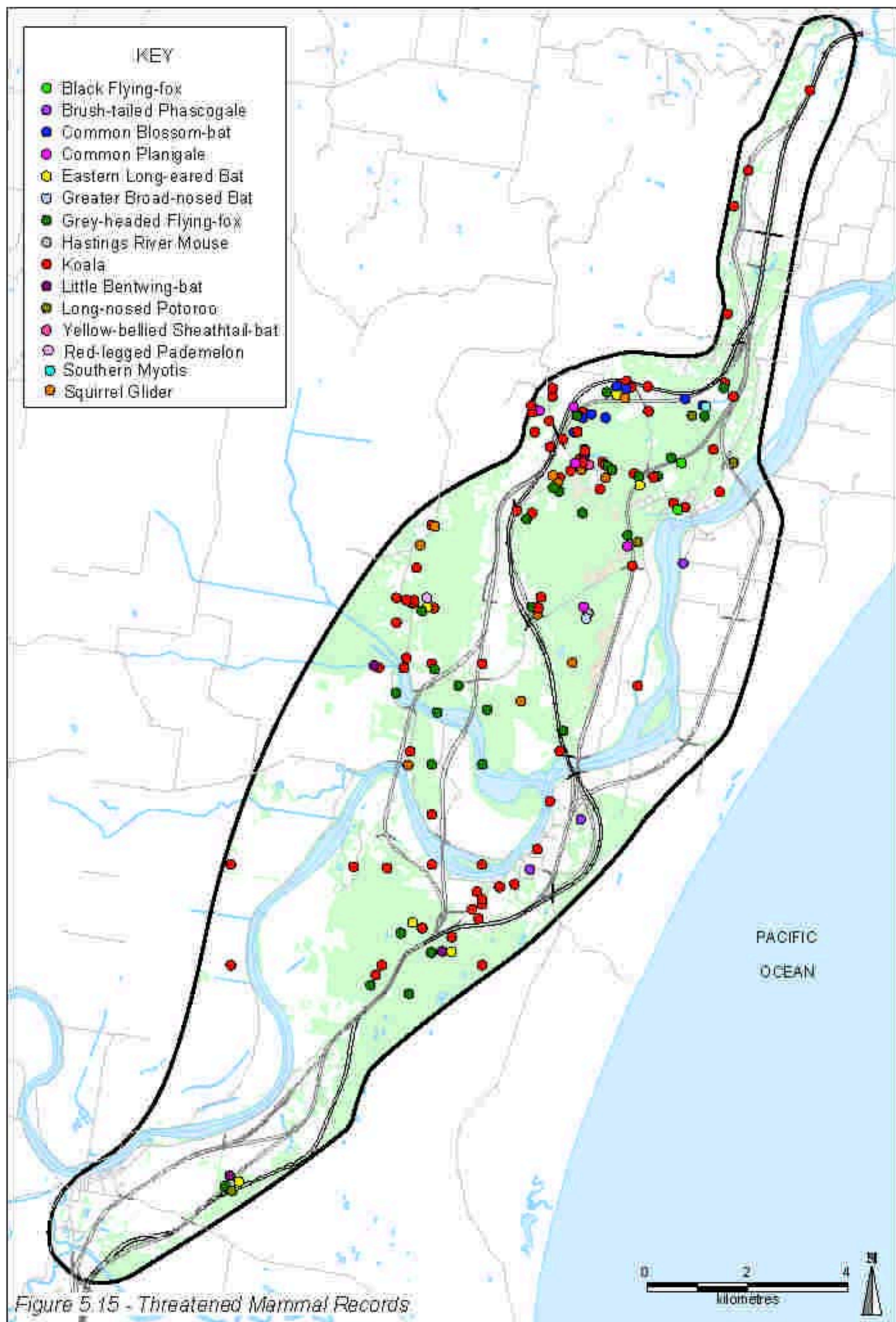
Threatened fauna species records are from Geolyse (2005b) or were provided to Hyder Consulting in digital form by DEC, Ballina Shire Council and Mark Graham. Migratory bird species were determined as part of the current review. Recorded threatened species are shown on Figures 5.14-5.17.

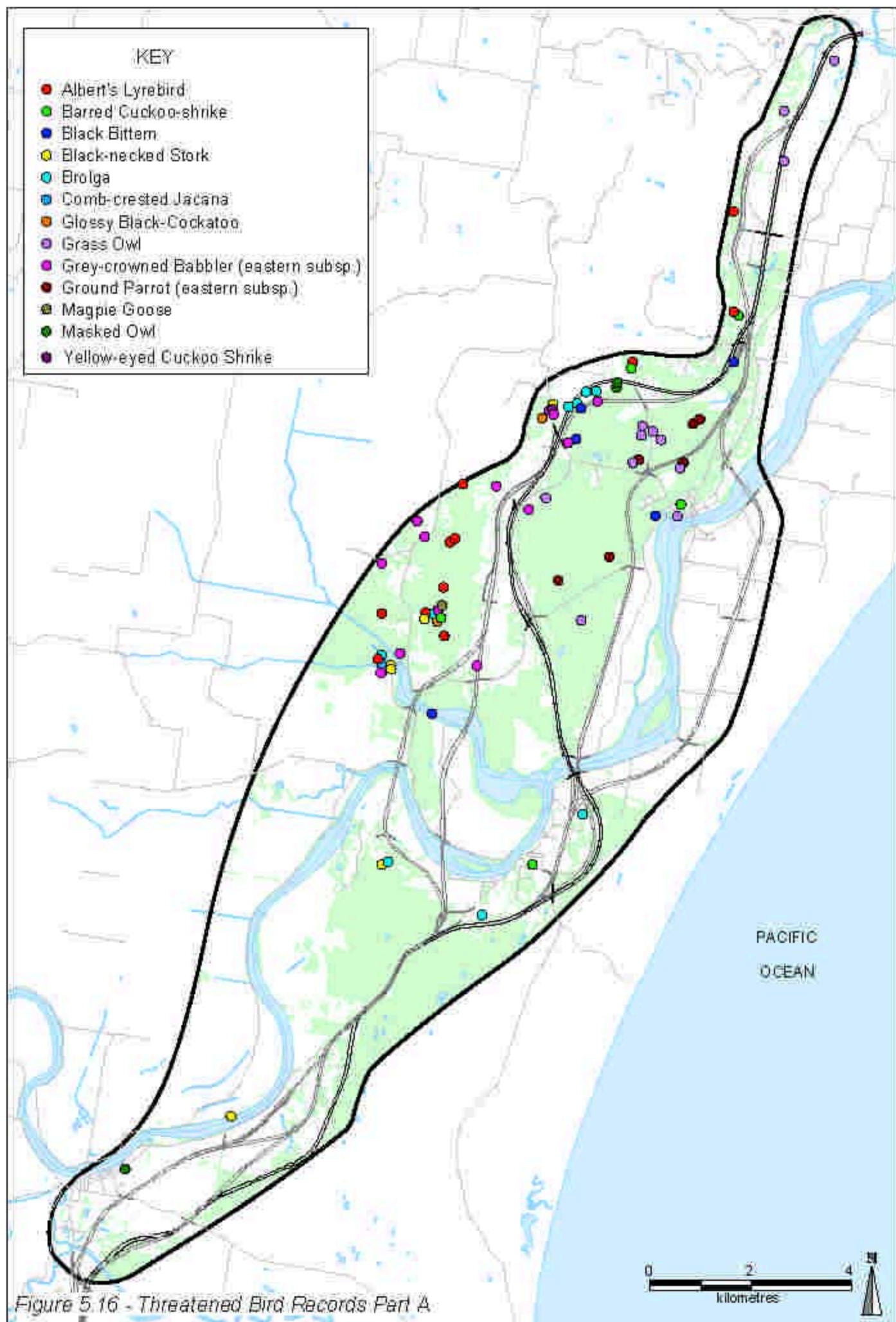
No surveys for threatened fauna species were undertaken as part of the current review. Only those fauna species considered to be moderately to highly likely to occur within habitats identified in the study area are listed in Table 5.5 below. Those species with a very low or low likelihood of occurring within the study area are not considered further. It should be noted that although the Red-tailed Black Cockatoo was recorded in the study area in 1990 (Wildlife Atlas Data), it is considered to have only a low likelihood of occurring and as such is not listed below.

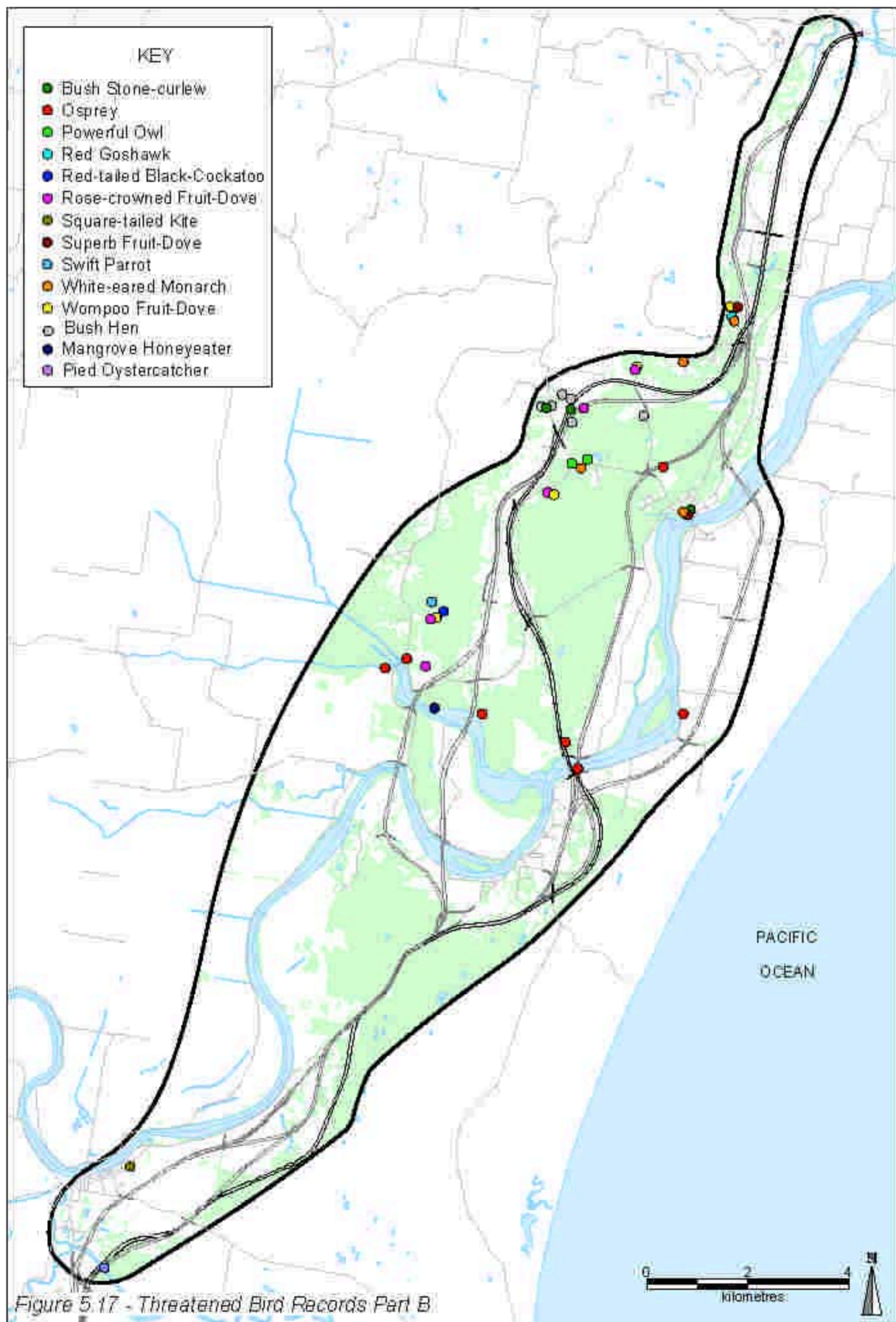
Table 5.5: Threatened or Migratory Fauna Known or Likely to Occur in Study Area

Threatened Species	Conservation Significance	Likelihood of Occurring in Study Area	Likely Habitats (see Table 5.3)
INVERTEBRATES			
Australian Fritillary <i>Argyreus hyperbius</i>	TSC(E)	High	6, 8, 9, 21
AMPHIBIANS			
Green-thighed Frog <i>Litoria brevipalmata</i>	TSC(V)	Moderate	5, 6, 7, 8, 9, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24
Wallum Sedge Frog <i>Litoria olongburensis</i>	TSC(V), EPBC(V)	Recorded	2, 3, 5, 11, 22
Wallum Froglet <i>Crinia tinnula</i>	TSC(V)	Recorded	3, 5, 6, 8, 10, 11, 12, 13, 14, 21, 22
REPTILES			
Three-Toed Snake-Toothed Skink <i>Coeranoscincus reticulatus</i>	TSC(V), EPBC(V)	High	9, 17, 18, 19, 23, 26









Threatened Species	Conservation Significance	Likelihood of Occurring in Study Area	Likely Habitats (see Table 5.3)
Stephens Banded Snake <i>Hoplocephalus stephensi</i>	TSC(V)	Moderate	16, 17, 18
White-crowned Snake <i>Cacophis harriettae</i>	TSC(V)	High	8, 9, 16, 17, 18, 19, 23, 26
BIRDS			
Albert's Lyrebird <i>Menura alberti</i>	TSC(V)	Recorded	9, 16, 17, 18, 19, 29
Australasian Bittern <i>Botaurus poiciloptilus</i>	TSC(V)	High	3, 27
Barred Cuckoo Shrike <i>Coracina lineata</i>	TSC(V)	Recorded	6, 8, 9, 16, 17, 18, 19, 20, 22, 26, 29
Bar-tailed Godwit <i>Limosa lapponica</i>	EPBC(M)	High	27, 28, 31
Black Bittern <i>Ixobrychus flavicollis</i>	TSC(V)	Recorded	2, 3, 4, 5, 6, 7, 8, 9, 25, 26, 27, 28
Black-necked Stork <i>Epphipiorhynchus asiaticus</i>	TSC(E)	Recorded	1, 2, 3, 4, 25, 27, 28, 30
Blue-billed Duck <i>Oxyura australis</i>	TSC(V)	High	27
Brolga <i>Grus ribicunda</i>	TSC(V)	Recorded	2, 3, 5, 12, 25, 27, 28
Bush Hen <i>Amaurornis olivaceus</i>	TSC(V)	Recorded	1, 2, 3, 4, 5, 6, 8, 11, 12, 18, 20, 22, 27
Bush Stone Curlew <i>Burhinus grallarius</i>	TSC(E)	Recorded	10, 14, 16
Collared Kingfisher <i>Todiramphus chloris</i>	TSC(V)	High	4, 15, 28
Comb Crested Jacana <i>Irediparra gallinacea</i>	TSC(V)	Recorded	27
Common Greenshank <i>Tringa nebularia</i>	EPBC(M)	High	2, 27, 28, 31
Cotton Pygmy Goose <i>Nettapus coromandelianus</i>	TSC(V)	High	27
Curlew Sandpiper <i>Calidris ferruginea</i>	EPBC(M)	High	27, 28, 31
Eastern Curlew <i>Numenius madagascariensis</i>	EPBC(M)	High	27, 28, 31
Freckled Duck <i>Stictonetta naevosa</i>	TSC(E)	High	27
Glossy Black Cockatoo <i>Calyptorhynchus lathami</i>	TSC(V)	Recorded	10, 14, 16, 17, 24
Grass Owl <i>Tyto capensis</i>	TSC(V)	Recorded	1, 2, 3, 5, 10, 11, 12, 13, 22, 25, 30
Grey Crowned Babbler <i>Pomatostomus temporalis</i>	TSC(V)	Recorded	8, 10, 11, 14, 16, 19, 21, 22, 24, 29

Threatened Species	Conservation Significance	Likelihood of Occurring in Study Area	Likely Habitats (see Table 5.3)
Grey-tailed Tattler <i>Heteroscelus brevipes</i>	EPBC(M)	High	4, 27, 28, 31
Ground Parrot <i>Pezoporus wallicus</i>	TSC(V)	Recorded	3, 5, 11, 12, 13
Latham's Snipe <i>Gallinago hardwickii</i>	EPBC(M)	High	2, 3, 25, 27, 30
Magpie Goose <i>Anseranas semipalmata</i>	TSC(V)	Recorded	2, 25, 27
Mangrove Honeyeater <i>Lichenostomus fasciolaris</i>	TSC(V)	Recorded	4, 26, 28
Marbled Frogmouth <i>Podargus ocellatus</i>	TSC(V)	High	18, 19, 29
Masked Owl <i>Tyto novaehollandiae</i>	TSC(V)	Recorded	4, 6, 8, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 30
Musk Duck <i>Biziura lobata</i>	TSC(V)	High	25, 27, 28
Osprey <i>Pandion haliaetus</i>	TSC(V)	Recorded	4, 26, 28
Pacific Golden Plover <i>Pluvialis fulva</i>	EPBC(M)	High	27, 28, 31
Painted Snipe <i>Rostratula benghalensis</i>	TSC(V), EPBC(V)	High	3, 27, 30
Pied Oystercatcher <i>Haematopus longirostris</i>	TSC(V)	Recorded	28, 31
Powerful Owl <i>Ninox strenua</i>	TSC(V)	Recorded	16, 17
Red-backed Button Quail <i>Turnix maculosa</i>	TSC(V)	High	16, 19, 20, 27, 30
Red Goshawk <i>Erythrotriorchis radiatus</i>	TSC(E), EPBC(V)	Recorded	8, 9, 16
Rose Crowned Fruit Dove <i>Ptilinopus regina</i>	TSC(V)	Recorded	8, 9, 17, 18, 19, 20, 23, 26, 29
Sooty Owl <i>Tyto tenebricosa</i>	TSC(V)	High	9, 16, 17, 18, 19, 23, 29
Square Tailed Kite <i>Lophoictinia isura</i>	TSC(V)	Recorded	6, 8, 9, 14, 16
Superb Fruit Dove <i>Ptilinopus superbus</i>	TSC(V)	Recorded	9, 17, 18, 19, 23, 26, 29
Swift Parrot <i>Lathamus discolor</i>	EPBC(E), TSC(E)	Recorded	8, 16, 21, 24
Whimbrel <i>Numenius phaeopus</i>	EPBC(M)	High	4, 27, 28, 31
White-eared Monarch <i>Monarcha leucotis</i>	TSC(V)	Recorded	4, 6, 8, 9, 15, 16, 17, 18, 19, 21, 22, 23, 26, 29
Wompoo Fruit Dove <i>Ptilinopus magnificus</i>	TSC(V)	Recorded	8, 9, 17, 18, 20, 23, 26

Threatened Species	Conservation Significance	Likelihood of Occurring in Study Area	Likely Habitats (see Table 5.3)
MAMMALS			
Beccari's Freetail Bat <i>Mormopterus beccarii</i>	TSC(V)	High	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 29, 30
Black Flying-fox <i>Pteropus alecto</i>	TSC(V)	Recorded	3, 4, 5, 6, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 26, 29
Brush-tailed Phascogale <i>Phascogale tapoatafa</i>	TSC(V)	Moderate	8, 14, 16, 17
Common Planigale <i>Planigale maculata</i>	TSC(V)	Recorded	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 24, 26
Eastern Blossom Bat <i>Syconycteris australis</i>	TSC(V)	Recorded	3, 5, 6, 8, 9, 10, 11, 12, 13, 14, 18, 20, 21, 24, 26, 29
Eastern Cave Bat <i>Vespadelus troughteni</i>	TSC(V)	Moderate	16
Eastern Chestnut Mouse <i>Pseudomys gracilicaudatus</i>	TSC(V)	Moderate	1, 3, 5, 6, 8, 12, 13
East Coast Freetail Bat <i>Mormopterus norfolkensis</i>	TSC(V)	High	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 29, 30
Eastern Long-eared Bat <i>Nyctophilus bifax</i>	TSC(V)	Recorded	3, 4, 6, 7, 8, 9, 10, 11, 13, 14, 16, 17, 18, 19, 20, 21, 23, 26, 27, 28, 29
Eastern Tube-nosed Bat <i>Nyctimene robinsoni</i>	TSC(V)	Moderate	18, 20, 23
Golden Tipped Bat <i>Kerivoula papuensis</i>	TSC(V)	High	9, 17, 18, 19, 20, 23, 29
Greater Broad-nosed Bat <i>Scoteanax ruepellii</i>	TSC(V)	Recorded	2, 4, 5, 6, 8, 9, 10, 11, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 29, 30
Grey-headed Flying-fox <i>Pteropus poliocephalus</i>	TSC(V), EPBC(V)	Recorded	3, 4, 5, 6, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 26, 29
Hoary Wattled Bat <i>Chalinolobus nigrogriseus</i>	TSC(V)	Moderate	3, 6, 8, 10, 11, 12, 13, 14, 16, 22, 27
Koala <i>Phascolarctos cinereus</i>	TSC(V)	Recorded	4, 6, 8, 15, 16, 17, 20, 21, 22, 24, 26
Large Bentwing Bat <i>Miniopterus schreibersii</i>	TSC(V)	High	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 24, 25, 27, 28
Large-eared Pied Bat <i>Chalinobolus dwyeri</i>	EPBC(V), TSC(V)	Moderate	27
Large-footed Myotis <i>Myotis adversus</i>	TSC(V)	High	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 16, 17, 19, 21, 22, 24, 25, 26, 27, 28

Threatened Species	Conservation Significance	Likelihood of Occurring in Study Area	Likely Habitats (see Table 5.3)
Little Bentwing Bat <i>Miniopterus australis</i>	TSC(V)	Recorded	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30
Long-nosed Potoroo <i>Potorous tridactylus</i>	TSC(V), EPBC(V)	Recorded	3, 5, 8, 10, 11, 12, 14, 18, 19, 20, 21, 24
Red Legged Pademelon <i>Thylogale stigmatica</i>	TSC(V)	Recorded	17, 18
Spotted Tailed Quoll <i>Dasyurus maculatus</i>	TSC(V), EPBC(V)	Moderate	17
Squirrel Glider <i>Petaurus breviceps</i>	TSC(V)	Recorded	6, 8, 9, 10, 14, 15, 16, 17, 20, 21, 22, 24
Yellow-bellied Sheath-tail-bat <i>Saccolaimus flaviventris</i>	TSC(V)	Recorded	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 22, 26, 27, 29

5.2.3 Regionally significant fauna species

Regionally significant fauna species and their likelihood of occurring in the study area was determined as part of the current review (see Section 4.2.2) and are shown in Table 5.6. Only those species considered to have a moderate or high likelihood of occurring are shown in the table. No surveys for regionally significant species were undertaken as part of the current review.

Table 5.6: Regionally Significant Fauna Known or Likely to Occur in Study Area

Species	Likelihood of Occurring in Study Area	Likely Habitats (see Table 5.3)
Richmond Birdwing Butterfly <i>Ornithoptera richmondii</i>	High	18, 19
Brown Toadlet <i>Pseudophryne bibronii</i>	High	2, 3, 5, 6, 13, 10, 11, 12, 14, 16, 22, 24
Coastal Taipan <i>Oxyuranus scutellatus</i>	Moderate	30
- <i>Ctenotus arcanus</i>	High	5, 10, 11, 13, 14, 16, 22, 24
Eastern Horseshoe Bat <i>Rhinolophus megaphyllus</i>	Moderate	7, 16, 17, 18, 20
- <i>Egernia frerei</i>	High	16, 17, 18, 19, 20, 23, 29, 30
Fawn-footed Melomys <i>Melomys cervinipes</i>	High	9, 14, 16, 17, 18, 20, 21, 23, 29
Forest Kingfisher <i>Todiramphus macleayi</i>	Moderate	3, 6, 7, 8, 9, 10, 14, 16, 21, 22, 25, 26
Glossy Ibis <i>Plegadis falcinellus</i>	High	2, 3, 25, 27, 30
Keelback <i>Tropidonophis mairii</i>	Moderate	1, 2, 3, 5, 6, 8, 9, 12, 21, 22, 25

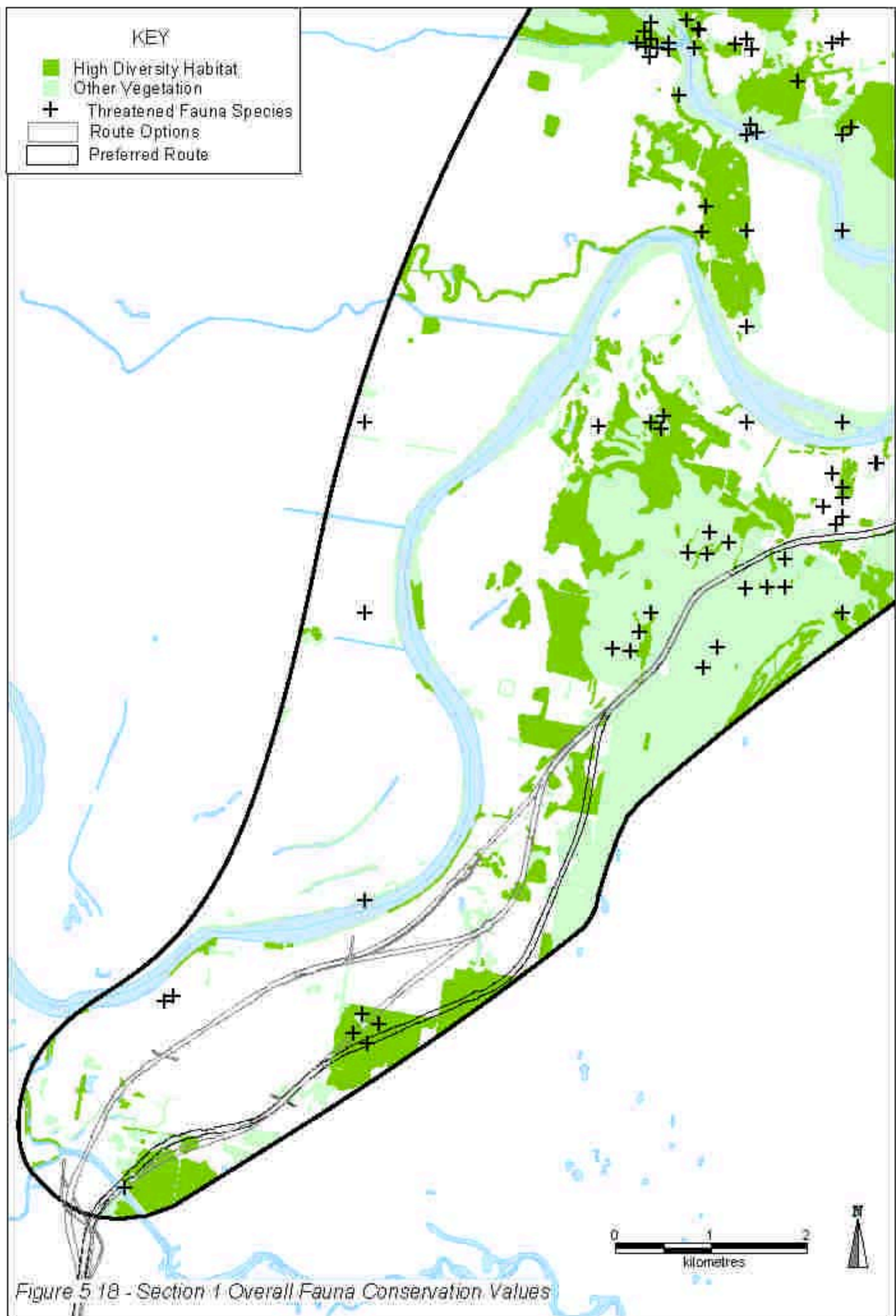
Species	Likelihood of Occurring in Study Area	Likely Habitats (see Table 5.3)
Lewins Rail <i>Rallus pectoralis</i>	High	1, 2, 3, 4, 5, 6, 8, 9, 11, 12, 20, 21, 22, 25, 26, 27
Little Bittern <i>Ixobrychus minutus</i>	High	3, 4, 5, 26, 27
Little Bronze Cuckoo <i>Chrysococcyx malayanus</i>	High	4, 6, 7, 8, 9, 14, 15, 16, 17, 18, 19, 21, 22, 23, 26, 29
Little Shrike Thrush <i>Colluricincla megarhyncha</i>	High	6, 8, 9, 15, 17, 18, 19, 20, 21, 22, 23, 26, 29
New Holland Mouse <i>Pseudomys novaehollandiae</i>	High	8, 9, 10, 11, 13, 14, 15, 16, 17, 22, 24
Pale Field Rat <i>Rattus tunneyi</i>	Moderate	3, 5, 10, 11, 14, 21
Platypus <i>Ornithorhynchus anatinus</i>	High	27
Satin Flycatcher <i>Myiagra cyanoleuca</i>	High	4, 6, 8, 9, 16, 17, 18, 19
Tawny-crowned Honeyeater <i>Phylidonyrus melanops</i>	High	5, 10, 11, 12, 13, 14
Tommy Roundhead <i>Diporiphora australis</i>	High	5, 10, 13, 14, 16, 22, 24
- <i>Ramphotyphlops wiedii</i>	Moderate	14, 16
- <i>Saproscincus oriarus</i>	High	1, 3, 5, 6, 8, 9, 10, 11, 12, 14, 16, 18, 21, 22
Southern Angle-headed Dragon <i>Hypsilurus spinipes</i>	High	9, 17, 18, 19, 23, 26
Southern Forest Bat <i>Vespadelus regulus</i>	Moderate	8, 10, 14, 15, 16, 17, 20, 21, 22, 23, 24
Undescribed Whirring Tree Frog <i>Litoria revelata</i>	High	3, 6, 7, 8, 9, 21, 22
Wallum Rocket Frog <i>Litoria freycineti</i>	High	3, 5, 6, 10, 11, 12, 13, 14, 21, 22, 24
Wandering Whistling Duck <i>Dendrocygna arcuata</i>	High	2, 25, 27

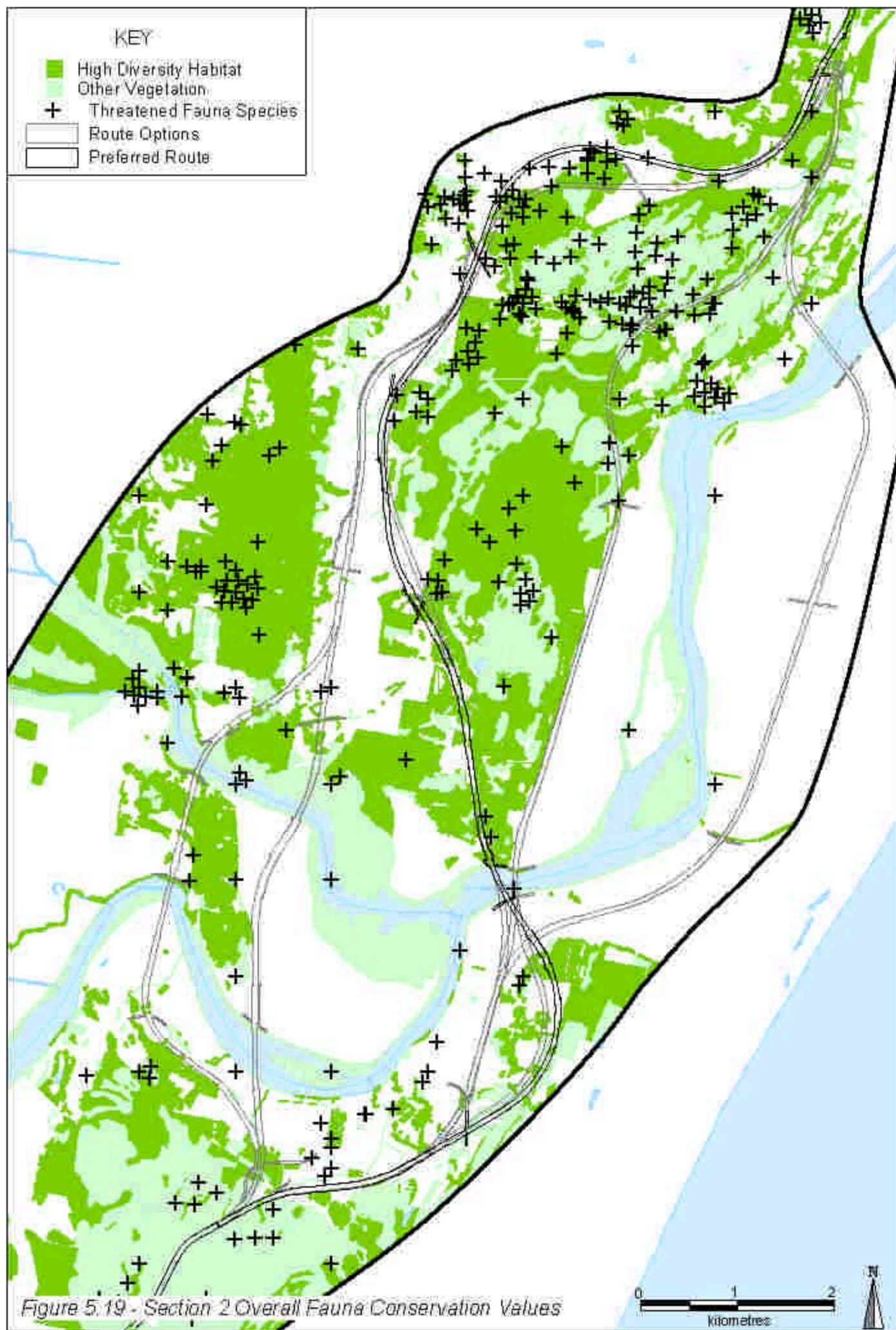
5.2.4 Overall fauna conservation values

The overall fauna conservation values in the study area are depicted in Figures 5.18-5.20. These maps show the distribution of high diversity fauna habitats (see Section 5.2.1) and the distribution of known threatened species records. The mapped key habitats and corridors (Scotts 2000) that occur in the study area and have conservation significance for regional fauna are shown in Figure 5.21.

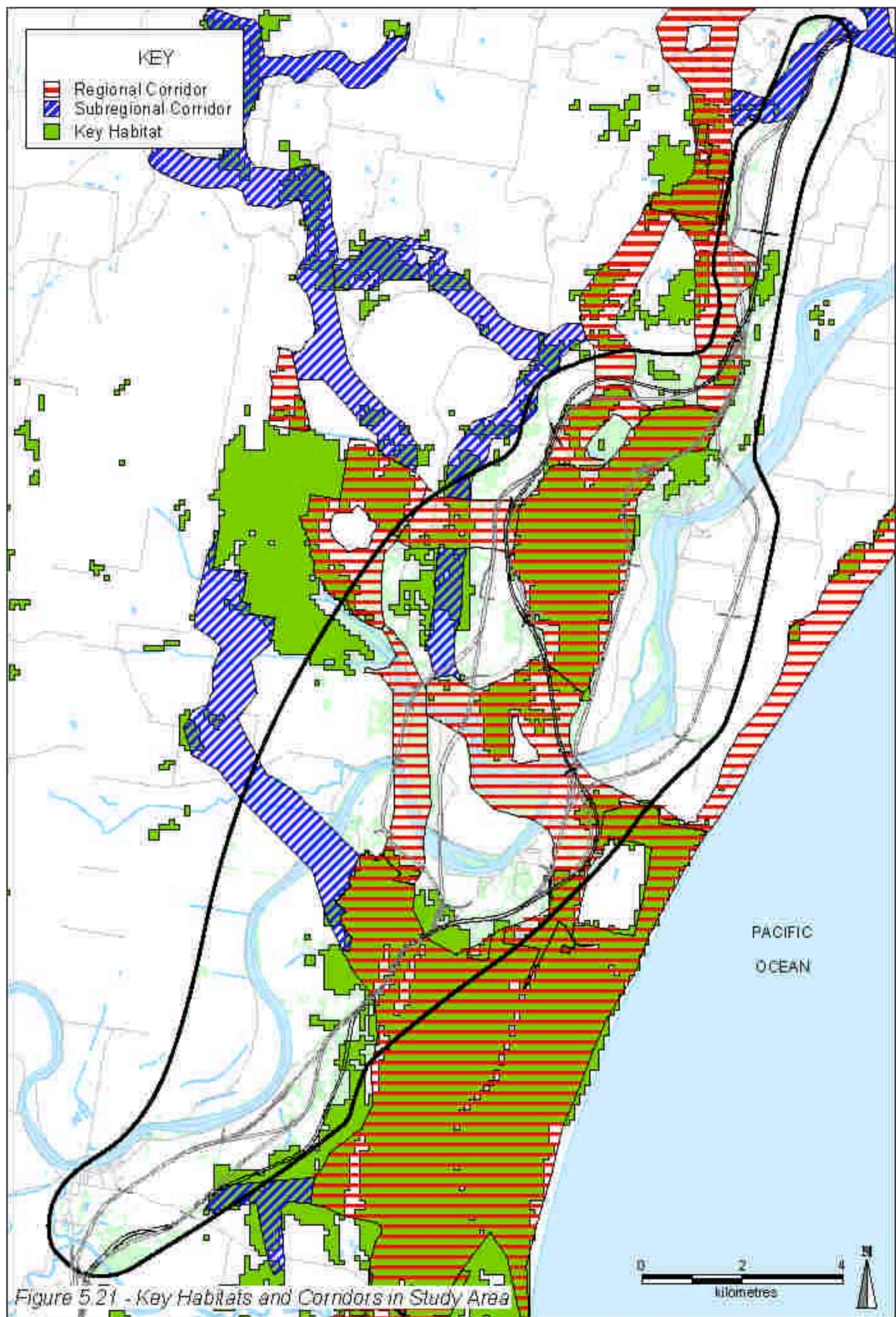
5.3 Aquatic Biota

Geolyse (2005b) classified waterways in the study area with respect to fish habitat and fish passage as per Fairfull and Witheridge (2003). Major









fish habitat was identified within route options 1A, 1B and 1C and was crossed by route option 2A. Our assessment targeted gaps in existing data for Section 2 of the Woodburn to Ballina Upgrade, including assessments of the following: fish nursery habitat in the Tuckean Broadwater, aquatic habitat where route options crossed over the Richmond River and potential habitat for Oxleyan Pygmy Perch.

5.3.1 Aquatic Habitat

The two major bridge crossings within Section 2 are the Richmond River for all route options and the Tuckean Broadwater for route options 2A and 2B. The current survey focused principally on the 2A and 2B options during this field inspection to gain a better appreciation of the ecological sensitivity of these crossings.

Fish habitat was assessed by means of bait trapping in Section 2 (see Section 4.3.2) and through liaison with the DPI Fisheries Inspector in the case of Section 1.

Richmond River

The Richmond River crossings for options 2A and 2B were examined from the water and the following was noted:

- ❑ Option 2A crosses the Richmond River on a sharp bend in the River, with a dense stand of *Avicennia marina* (Grey Mangrove) on the south bank and scattered stunted *Avicennia marina* on the north bank. The mangroves on the south bank of the bend comprise SEPP 14 Wetland No. 119b. The presence of mangroves indicates that the salinity (conductivity) is brackish to marine in this locality during dry weather flow, and therefore exhibits some tidal range in water heights. The mangroves do not provide good fish nursery habitat in this locality because they occur on an elevated mud bank that is exposed at most stages of the tide except high water.
- ❑ Option 2B crosses the Richmond River about one kilometre further downstream than 2A and just upstream of Pelican Island. The south bank in this locality consists of a thin band of *Avicennia marina* at the high water level. The north bank is vegetated by a dense and fairly broad (20-30 m) monotypic band of *Aegiceras corniculatum* (River Mangrove). This is one of the largest and best monotypic stands of this species that the author (BR) has seen in NSW. Despite comprising high value riparian vegetation on the north bank, the mangrove habitat on both sides of the river at this location does not provide particularly good fish nursery habitat because the mud banks are exposed for most of the tidal cycle.
- ❑ Three other mangrove species that are variously restricted to parts of the north coast of NSW (*Excoecaria agallocha*, *Rhizophora stylosa*, and *Bruguiera gymnorhiza*) were not observed at the crossing sites.

The riparian vegetation near route options 2C, 2D and 2E appears to consist primarily of *Avicennia marina* mangroves on the southern bank and Brushbox/Forest Red Gum on the northern bank. The river crossing for option 2F does not appear to affect any SEPP 14 wetlands and there is only a very thin band of riparian vegetation that was not inspected on the ground.

Tuckean Broadwater

The 2A and 2B crossings of the Tuckean Broadwater were examined from the water and found to be sensitive aquatic and riparian habitat that is considered to be ecologically significant. At both locations, the banks are SEPP 14 wetlands, colonised by extensive stands of mangroves (predominantly *Avicennia marina*, except for the south bank of option 2B which consists of a monotypic stand of *Aegiceras corniculatum*). These mangrove forests, in contrast to the Richmond River crossing sites, provide good fish nursery areas because the riparian vegetation in this case has colonised broad mudflats for the most part, which remain inundated at most stages of the tidal cycle. They are also relatively wide (>25 m of mangroves perpendicular to the shore), particularly on the north bank of the Broadwater, and provide extensive structural shelter and foraging areas for juvenile fish.

A curious feature of the Broadwater downstream of the barrage was that these extensive mangrove forests occur immediately adjacent to extensive shallow mud banks colonised by water lilies (*Nymphaea* sp.), which are not known to tolerate saline conditions. The water lilies were in poor condition as a result of scouring and abrasion from the recent high water flows, and were not in flower at the time of our visit. Time did not permit examination of the root/rhizome/stolon arrangement so that the species could be verified, but it is an interesting association of a freshwater plant cohabiting with a saline or brackish species in the same habitat.

At the time of our visit during the wet period, the conductivity of the water was between 220 and 240 $\mu\text{S}/\text{cm}$ (virtually drinking water salinity) throughout the water column, to a maximum depth of 5 m and about 0.5 km downstream of the barrage. Possibly during dry weather the water is usually stratified in this reach of the Broadwater, with denser saline water in the deeper channel and lighter freshwater on the surface and covering the shallow mud banks. An understanding of the spatial and temporal water quality dynamics would probably explain this apparent paradox.

Wardell Heathland (Section 2)

The results of the current bait trapping survey show that native freshwater fish are very abundant in the tributaries of Bingal Creek. It should be noted (see Table 5.8) that a large number of gudgeons (121) belonging to three species (none being threatened) were caught in two bait traps over two nights from the southern tributary crossing Old Bagotville Road (sample site 3). At least one specimen of Striped Gudgeon was exceptionally large and possibly a record size, suggesting ideal conditions for those species in that locality. This, together with a paucity of Mosquitofish records, indicates that Bingal Creek in the area of our survey sites represents good quality native fish habitat. However, we

are unaware of habitat conditions further upstream because they were sampled during the present study.

McDonald's Creek (Section 1)

Compiling all available data on the Oxleyan Pygmy Perch from this region shows that DPI have found it in numerous swamps and ponds that occur in a linear belt within Broadwater National Park. These linear swamps could be located within a Pleistocene relict dune system, with the ponds occurring in the old swales that have been subjected to sand mining. During floods and wet periods the floodwater escapes over or through shallow relict ridges taking the Oxleyan Pygmy Perch with it. Biosis Research (unpublished data) has recently confirmed the presence of the threatened fish in and around McDonald's Creek, which drains the westernmost line of ponds.

5.3.2 Fish species

At least 14 fish species were previously positively identified in the study area by Geolyse (2005b). Of these, at least 13 species are native and one, Eastern Gambusia (*Gambusia holbrooki*), is an introduced pest fish species.

Table 5.7: Fish Species Recorded in the Study Area

Species	Significance	Habitat
Olive Perchlet <i>Ambassis agassizii</i>	-	Freshwater
Empire Gudgeon <i>Hypseleotris compressa</i>	-	Freshwater
Firetail Gudgeon <i>Hypseleotris galii</i>	-	Freshwater
Softspined Rainbowfish <i>Rhadinocentrus ornatus</i>	-	Freshwater
Striped Gudgeon <i>Gobiomorphus australis</i>	-	Freshwater
Eastern Gambusia <i>Gambusia holbrooki</i>	Introduced	Freshwater
Oxleyan Pygmy Perch <i>Nannoperca oxleyana</i>	EPBC (E), TSC (E)	Freshwater
Small-mouthed Hardy Head <i>Atherinosoma microstoma</i>	-	Freshwater/estuarine
Bullrout <i>Notesthes robusta</i>	-	Freshwater/estuarine
Freshwater Herring <i>Potamalosa richmondia</i>	-	Freshwater/estuarine
Estuary Perchlet <i>Ambassis marianus</i>	-	Estuarine/saltwater
Sea Mullet <i>Mugil cephalus</i>	Recreational catch in Richmond River	Estuarine/saltwater
Yellowtail Bream <i>Acanthopagrus australis</i>	Commercial & recreational catch in Richmond River	Estuarine/saltwater
Unidentified Gobies	-	Estuarine/saltwater

Only the Oxleyan Pygmy Perch is of conservation significance, being listed as Endangered at the state and national levels. Three other fish species listed as threatened under the *Fisheries Management Act 1994* potentially occur in the Richmond River: Eastern Freshwater Cod (*Maccullochella ikei*), Black Cod (*Epinephelus daemilii*) and Estuary Cod (*E. coioides*). None of these has been recorded in the study area.

A further 19 fish species are caught commercially and 12 fish species are caught recreationally in the Richmond River (Appendix G, Geolyse 2005b). These may also occur in the study area.

The results of the field survey undertaken during 12-14 September 2006 are summarised in Table 5.8 below. Trap locations have previously been depicted in Figure 4.1.

Table 5.8: Results of Bait Trapping in Wardell Heathland in September 2006

Location	Number of traps	Trapping nights	Number of each fish species collected
1*	2	2	3 Firetail Gudgeon 8 Striped Gudgeon
2	1	1	Nil
3	2	2	106 Striped Gudgeon** 13 Firetail Gudgeon 2 Empire Gudgeon
4	1	1	Nil
5	3	2	4 Eastern Gambusia

*Note: also caught one cane toad tadpole (*Bufo marinus*) and one yabbie (*Cherax destructor*).

**Note: one of the Striped gudgeons was about 190mm long, which is larger than the maximum size reported in McDowall (1996) and could be a record for this species.

The fishing effort at each location can be calculated by multiplying the number of traps by the number of trapping nights (e.g. 3 traps x 2 nights = 6 trapping-nights of bait trap effort).

Our study has not added any new fish species to those recorded in the Investigations Report.

No Oxleyan Pygmy Perch were caught in the Wardell Heathland. However, there does appear to be good potential habitat within the heathland for this shy species, as described by McDowall (1996): coastal wallum heath; dark tea-coloured, still to slow-flowing acidic water; dense vegetation; the sedge *Eleocharis ochrostachys*; and substrates of siliceous sands and plant debris. However, it should be noted that the Oxleyan Pygmy Perch has not been recorded north of the Richmond River to date.

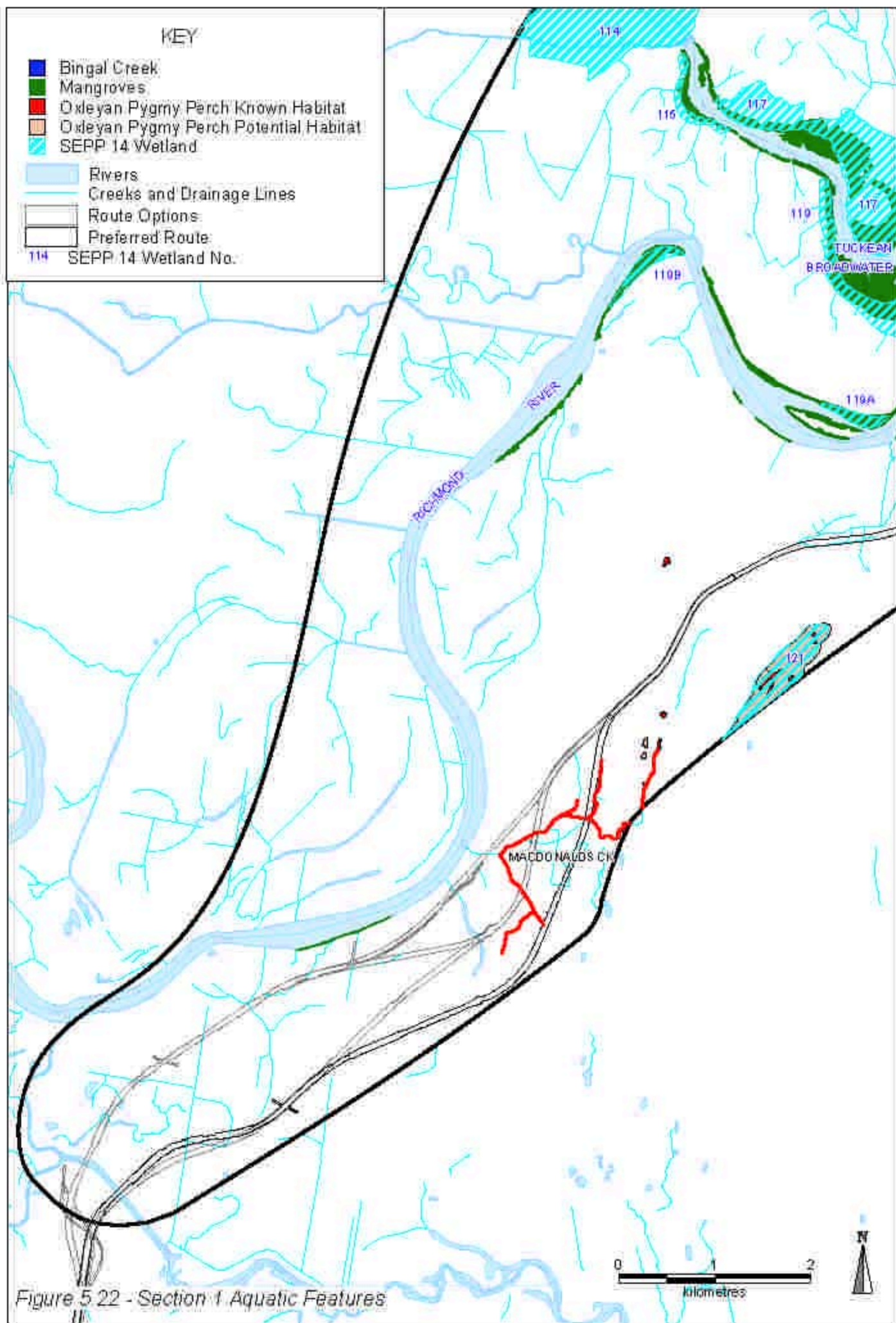
It should be noted that failure to detect a species in an area does not indicate that it does not occur there, that it has not occurred there in the past nor that it could not occur in the future. This species appears to disperse principally during floods, when it can easily migrate from one swampy area to another. Therefore, areas of potentially suitable habitat should be protected in case it should arrive there during a flood.

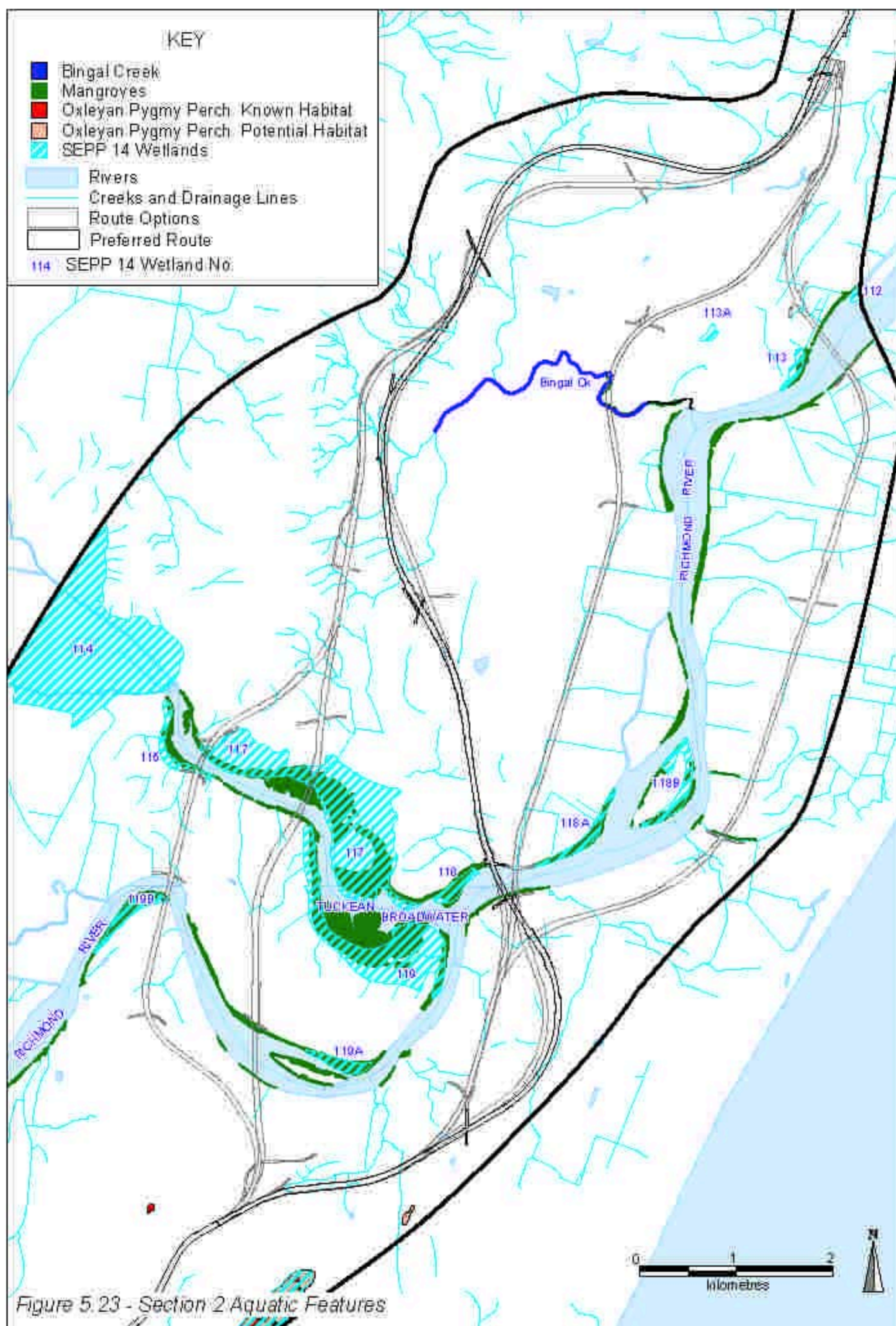
Graham (2005) reported that the Oxleyan Pygmy Perch had been recorded in the Wardell Heathland between Lumleys Lane and Thurgates

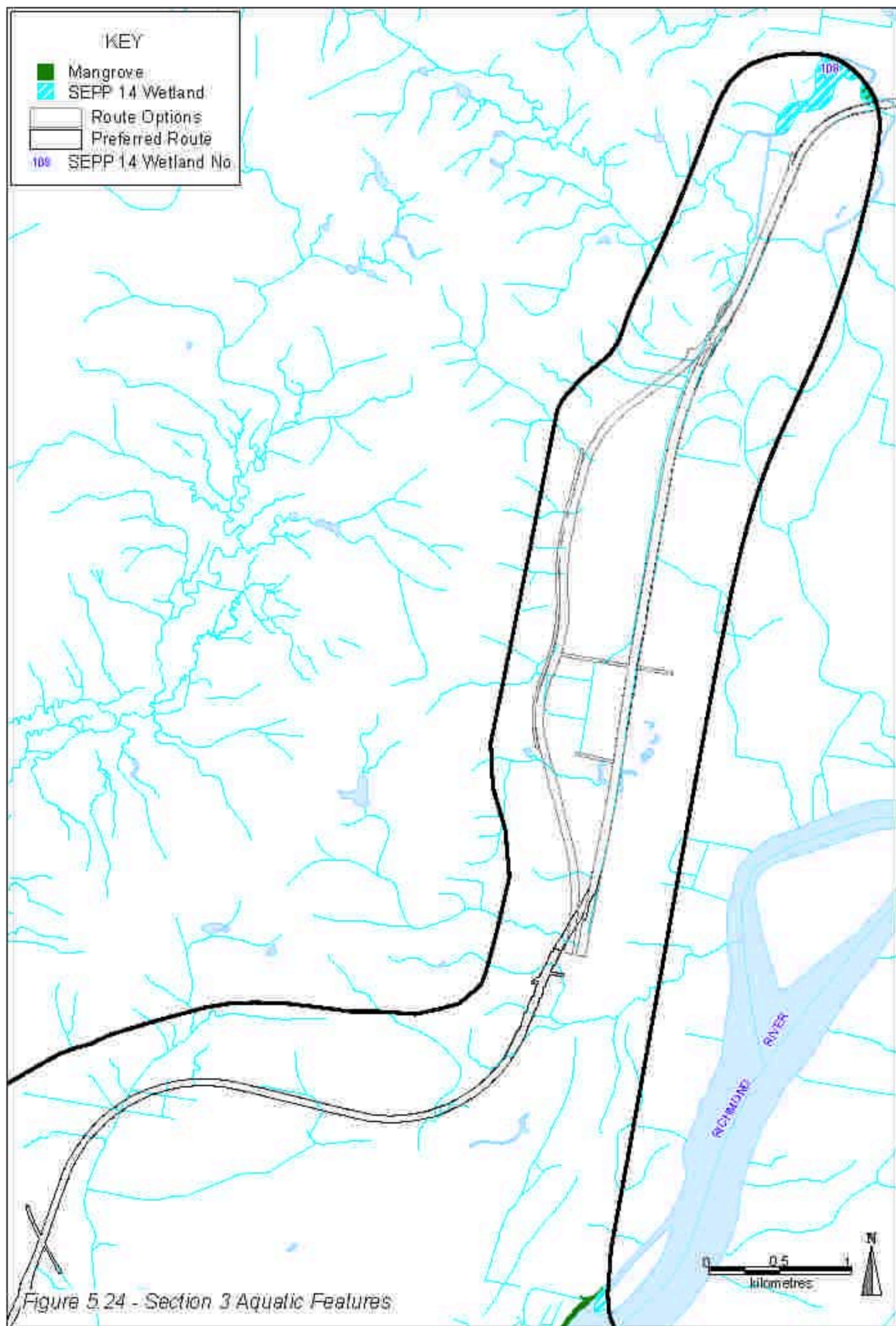
Lane. We investigated this claim and referred it to DPI Fisheries for confirmation as part of the current review. However, the staff of DPI Fisheries who have been investigating the potential habitat for the Oxleyan Pygmy Perch for a number of years, have no record of any other persons collecting fish or investigating this species in this area. It therefore appears that no such record exists.

5.3.3 Overall aquatic conservation values

The overall aquatic conservation values in the study area are depicted in Figures 5.22-5.24. These maps show relevant aquatic features including rivers (regionally significant), creeks and drainage lines (locally significant), the distribution of SEPP 14 wetlands (state significant) and mangroves (regionally significant) and also identifies known and potential Oxleyan Pygmy Perch habitat (state significant).







6.0 ROUTE OPTIONS ASSESSMENT

This section collates all available data and tabulates all significant areas to be removed or otherwise impacted as a result of each route option. The methodology used is described in Section 6.1. In order to facilitate comparisons and simplify mapping, route sections 1, 2 and 3 are compared separately below in Sections 6.2 to 6.4.

6.1 Comparing Ecological Values

For the purposes of this assessment, the following ecological values were calculated, tabulated and then compared amongst route options. Reasons for considering these values to assist in the differentiation of ecological impacts associated with route options are briefly summarised below.

- *Areas of vegetation of national, state and regional conservation significance to be removed;*

The area of high conservation significance vegetation removed represents the further incremental loss of vegetation associations already depleted at the national, state and/or regional levels. Those route options resulting in the removal of most national and state significant vegetation are considered to have relatively greater ecological impacts than those affecting mainly regionally significant communities.

- *Total vegetation removed;*

Total vegetation removed gives a general indication of the amount of vegetation transected by each route option, without any regard for its conservation significance or condition.

- *Area of key (regionally significant) habitats removed;*

Area of key habitat removed represents the loss and/or fragmentation of fauna habitat recognised by DEC of having regional conservation significance.

- *Areas of high diversity habitats removed;*

High diversity fauna habitats were identified as part of the current review. Firstly, the likelihood of 74 threatened fauna species moderately or highly likely to occur in the study area was assessed, with moderately likely species scoring 2 and highly likely (and recorded) species scoring 3. Scores were then tallied for each habitat type to generate a cumulative weighted total value. Those habitats having cumulative totals greater than 50 (i.e. those supporting 20-30 threatened species) were considered to be high diversity habitats. Like key habitat removed, loss of high diversity habitat provides an additional index of the impact of each route option on important fauna habitat.

- *Areas of regional and sub-regional corridors removed;*

Area of regional corridor removed represents the loss of habitat recognised by DEC as being a regional fauna movement corridor and provides an index of the potential barrier impacts associated with route options. Although, it is acknowledged that some identified corridors may contain cleared land, for simplicity it is

assumed that a greater area removed represents greater severance of the movement corridor, especially for less mobile species.

□ *Distance of route through regional corridors;*

The distance transected by route options through identified regional corridors provides an alternative way of assessing barrier impacts. The greater the distance, the more severe the barrier impacts created, especially for less mobile species.

□ *Area of sub-regional corridors removed;*

Although sub-regional corridors tend to be more fragmented than regional corridors, they may still be used by more mobile fauna species. A greater area of corridor removed signifies greater barrier impacts for these species.

□ *Area of Oxleyan Pygmy Perch habitat removed;*

Known and potential Oxleyan Pygmy Perch habitat was identified as a major ecological constraint in the study area. Any route options that affect known habitat would have greater ecological impacts than those that avoid it.

□ *Number of known and potential threatened flora, fauna and aquatic species potentially impacted;*

□ *Number of regionally significant species potentially impacted;*

□ *Number migratory species potentially impacted;*

The following discussion encompasses the three dot points listed above.

Using only known species records is not a reliable index of ecological impacts because these rely on the number of records available that is in turn dependent on the amount and intensity of field survey undertaken in the area. Furthermore, just because a species is not recorded during field surveys, it cannot be assumed that it does not occur there. For these reasons, less emphasis should be placed on species numbers when assessing the ecological impacts associated with route options.

Instead the number of threatened and regionally significant flora and fauna species and migratory birds potentially impacted by route options was calculated through habitat assessment. Species numbers were estimated by firstly noting the habitats transected by each option (see Tables 6.3, 6.11, 6.20, 7.3) and then tallying the numbers of species potentially occurring within each habitat (see Table 5.2, 5.5, 5.6).

This is a more reliable and conservative indicator of ecological impacts because it assumes that threatened species can occur wherever suitable habitat is present. However, where routes are in close proximity and transect similar habitat types (i.e. 2A-2E), this index is less likely to clearly separate options on the basis of species' impacts alone.

□ *Area of SEPP 14 wetlands to be removed;*

The removal of coastal wetlands identified under SEPP 14 provides an indication of the loss/fragmentation of protected wetland habitat by route options.

□ *Level of potential barrier effects;*

Barrier impacts are those associated with the severance of recognized fauna corridors as defined by NPWS (2001) and are ranked from very high to low in comparative tables. Very high terrestrial barrier impacts are associated with those route options that sever a high number of regional and sub-regional corridors, remove large areas of recognised regional and sub-regional corridors and/or completely isolate areas of key habitat. The lowest terrestrial barrier impacts are associated with those route options that follow the existing highway and sever few if any regional or sub-regional corridors. The intermediate rankings form a sliding scale between these two extremes. The highest aquatic barrier impacts are associated with the severance of known and potential Oxleyan Pygmy Perch habitat.

□ *Level of fragmentation impacts.*

Although barrier impacts and fragmentation effects are closely associated, the latter are used to describe the fragmentation of extensive habitat and the isolation of smaller and less viable habitat patches. Very high fragmentation is associated with route options that sever large contiguous stands of vegetation into one or more small less viable patches. Low fragmentation effects are associated with route options that follow the edge of existing vegetation or remove small amounts of habitat. The intermediate rankings form a sliding scale between these two extremes.

These are summarised for each route section in Tables 6.6, 6.14 and 6.23.

6.1.1 Mapping conservation zones

While comparative tables provide useful information, they are very cumbersome and do not adequately differentiate the importance of ecological values (e.g. terrestrial flora versus aquatic biota) associated with particular route options. In order to reduce the complexity of comparative tables and to highlight any apparent trends, it was necessary firstly to eliminate any possible bias in comparing flora, fauna and aquatic values by combining these into overall conservation zonings.

Conservation zones were ranked as Very High, High, Medium-High, Medium, Low-Medium and Low. The conservation zones were then mapped for each section of the route and those areas removed by each route option footprint were calculated and tabulated.

It should be noted that vegetated areas were only included in the conservation maps if they were greater than one hectare in size or less than 10 metres from a larger vegetated area (except if they had Very High conservation status) as these are more likely to remain viable. Conservation status was determined on the basis of a classification procedure as follows:

Areas of **Very High conservation** value are those that comprise:

- ❑ nationally significant vegetation (i.e. the Coolgardie Scrub, an 'identified place' on the Register of the National Estate); and
- ❑ nationally significant fauna habitat (i.e. a Grey-headed Flying-fox camp (and associated 200 metre buffer) that is considered to be an important and restricted resource for a species that is listed at both national and state levels AND known Oxleyan Pygmy Perch habitat).

Areas of **High** conservation significance are those that contain:

- ❑ vegetation communities that are significant at the state level (i.e. EECs);
- ❑ important fish habitat (i.e. major fish nurseries);
- ❑ SEPP 14 wetlands; and
- ❑ areas of otherwise medium-high conservation significance with high numbers and/or diversity of threatened species' records (especially sedentary species).

Areas of **Medium-High** conservation significance are those containing:

- ❑ regionally significant vegetation within key habitat (as defined in Section 5.2.4);
- ❑ regionally significant vegetation within identified fauna corridors;
- ❑ regionally significant vegetation within high diversity habitats; and
- ❑ areas of otherwise medium conservation significance with high numbers and/or diversity of threatened species records.

Areas of **Medium** conservation significance include:

- ❑ all remaining regionally significant vegetation;
- ❑ any other vegetation within key habitat;
- ❑ any other vegetation within recognised fauna corridors;
- ❑ any other vegetation within high diversity habitats; and
- ❑ the major rivers, as they provide important habitat for a number of threatened fauna species recorded in the area (e.g. Osprey, Black-necked Stork, Large-footed Myotis).

Areas with **Low-Medium** Conservation significance include:

- ❑ any remaining vegetated areas; and
- ❑ cleared areas within identified fauna corridors, as these have the potential to be used by mobile fauna species that are subject to road strike.

Areas with **Low** conservation significance are:

- remaining cleared or agriculturally cultivated lots that have limited habitat values.

Figures 6.1-6.3 depict the overall ecological conservation values within the study area as defined above. It should be noted that areas of Low conservation significance were not included in further analysis.

6.1.2 Scoring and ranking route options

The amounts of Very High, High, Medium-High, Medium and Low-Medium conservation value areas to be removed by each route option were then tabulated and scored. However, as conservation zones are not directly comparable, it was first necessary to develop a simple weighting system whereby the Very High category was considered to be 1 and all other categories were assigned values relative to it as follows:

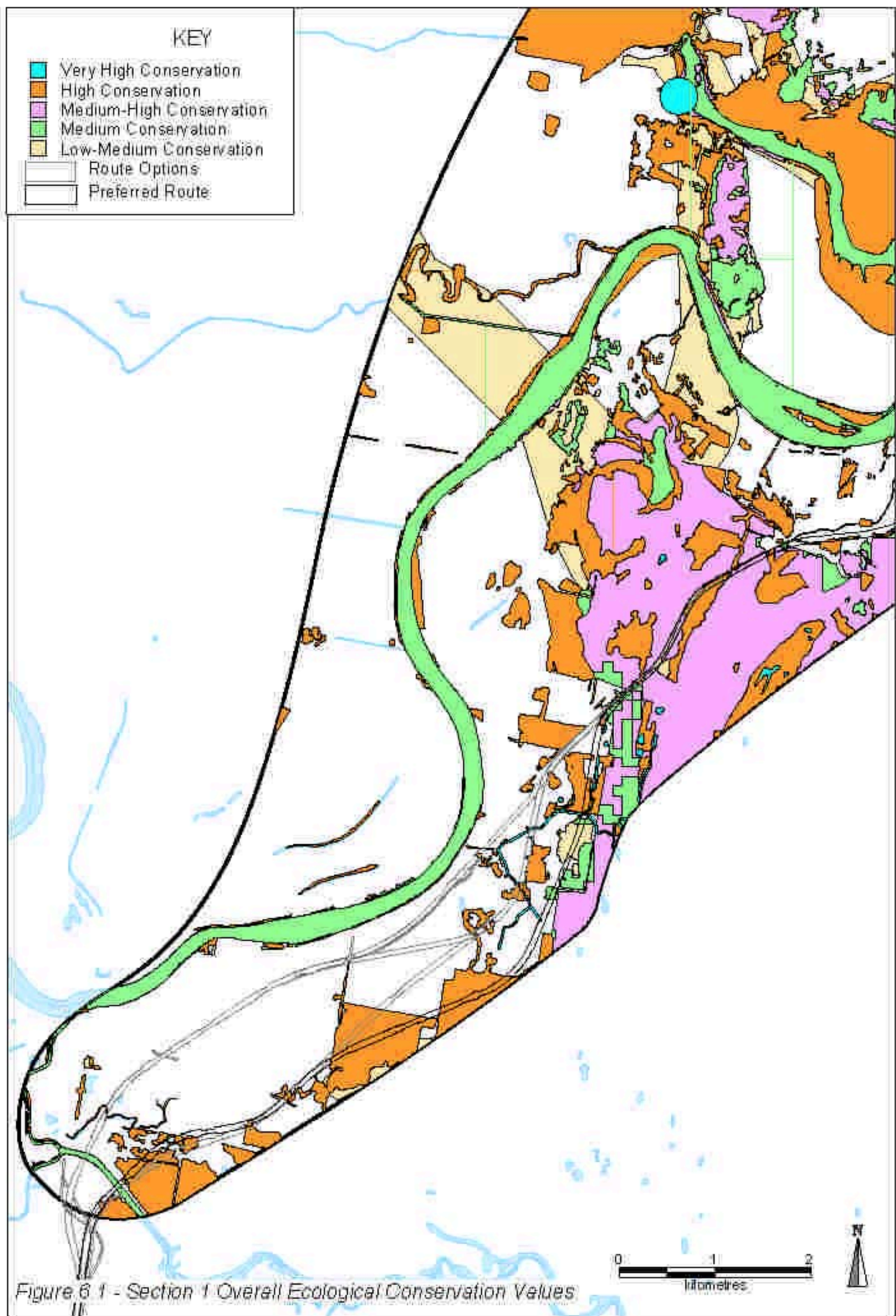
- High is considered to be 0.8:1 (i.e. areas of High conservation value are considered to be equivalent to 80% of Very High conservation value);
- Medium-High is considered to be 0.6:1 or equivalent to 60% of Very High;
- Medium is 0.4:1 or equivalent to 40% of Very High; and
- Low-Medium is 0.2:1 or equivalent to 20% of Very High.

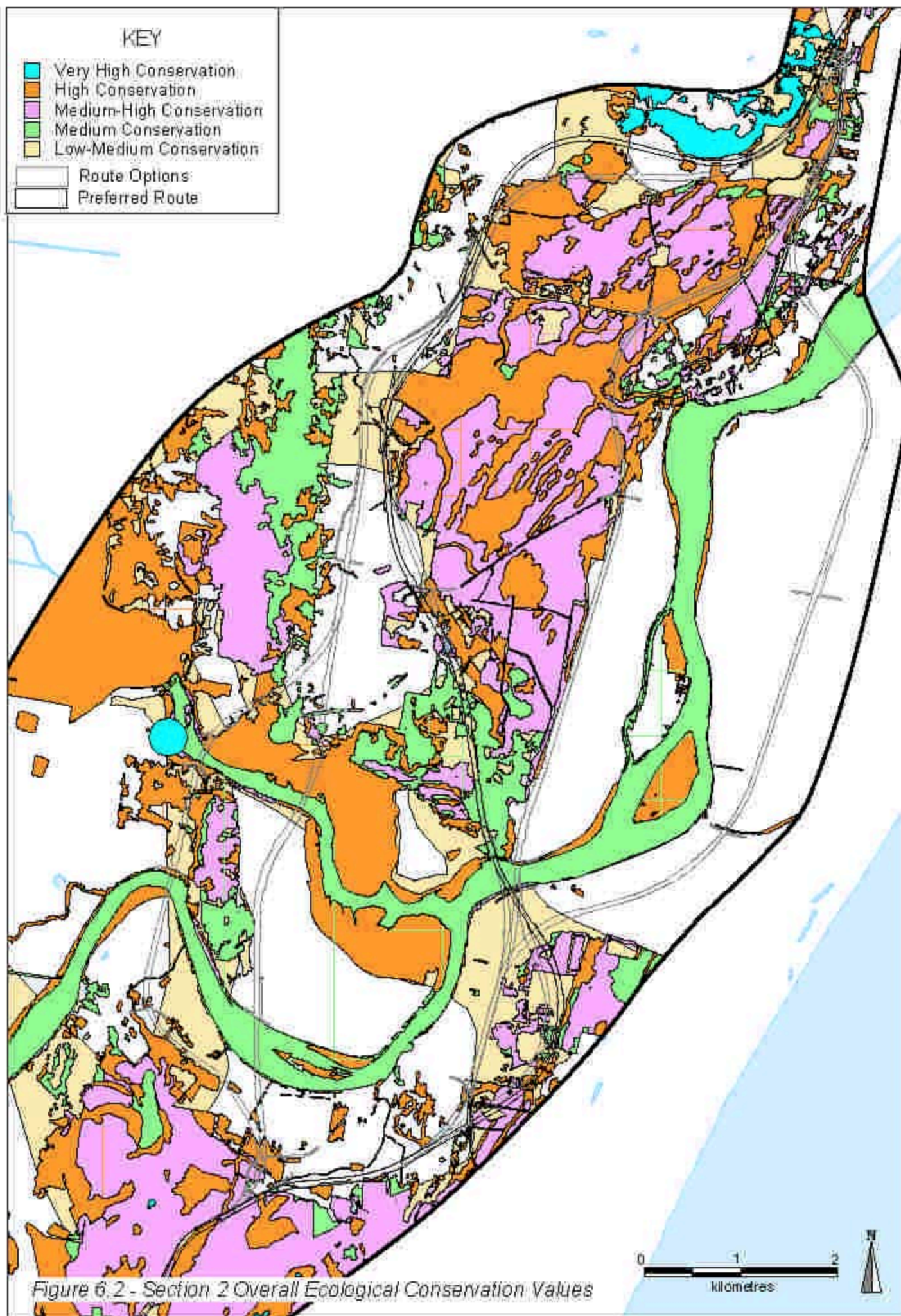
As an example, route option 1A comprises 0 ha of Very High, 3.1 ha of High, 2.5 ha of Medium-High, 1.6 ha of Medium and 0.2 ha of Low-Medium conservation values. When multiplied by the above conversion factors (i.e. $(0 \times 1) + (3.1 \times 0.8) + (2.5 \times 0.6) + (1.6 \times 0.4) + (0.2 \times 0.2)$), the relative score equals 4.7 (see Table 6.7).

Conservation zones are considered to be the most appropriate criteria for ranking route options because they take into consideration all known flora, fauna and aquatic conservation values. The inclusion of Low-Medium areas ensures that recognised corridors (both cleared and vegetated) are also given some importance when ranking.

However, conservation zones alone do not take into account the number of threatened species known to occur along or directly adjacent to route options (i.e. likely to be directly impacted). The number of species recorded along each option was ranked; the ranked value was then added to the conservation scores to provide a final value for ranking the route options. In the case of route options 1A-1C, records of threatened species were scored from 1-3 with 1A having the least number of records ($n=2$) and 1C having the most ($n=7$). In the case of option 1A, the final score is $4.7+1=5.7$ (see Table 6.7). The species ranking procedure (as opposed to merely adding the number of species records) ensured that species records would not be overly emphasised in the scoring process.

In the case of the Section 2 route options, records of threatened species were scored from 1-6 with the route option affecting the least number of threatened species being ranked 1 and the option affecting the most species being ranked 6. However, it should be noted that options 2A and 2B affected the same number of species and were subsequently assigned a ranking of 5 each.







6.1.3 Mitigation and compensation

This section is not intended to describe in detail those mitigation measures required along each route option. Rather it provides notional measures based on the following underlying assumptions:

Major fauna structures (i.e. fauna overpasses) would be required in areas of major fauna movement as determined by concentrations of fauna records and habitat availability and/or where routes transect significant conservation areas such as Broadwater National Park.

We consider that minor fauna structures (e.g. underpasses, culverts) would be required where route options fragment existing habitat supporting threatened fauna species. The number and spacing of structures is based primarily on the identity and mobility of the species involved.

The length of fauna exclusion fencing is loosely based on the number and locations of major and minor fauna structures, the concentrations of fauna records and/or where route options transect significant conservation areas (i.e. Broadwater National Park). It should be noted that these distances are approximate only.

The NSW RTA considers that where compensatory habitat is already established, it should replace key habitat lost at a ratio of 1:1 (RTA Draft Policy 7, 5/03/01). For these purposes, key habitat is defined as habitat that has statutory conservation protection, provides habitat for threatened species, populations and/or ecological communities and/or is of particular significance to relevant government agencies. Due to the prevalence of EECs and threatened species in the Woodburn to Ballina study area, all habitat removed was considered to be key habitat. Therefore, the amount of compensatory habitat is roughly equivalent to the amount of native vegetation removed by each route option. Although edge effects are not referred to in the RTA policy, Bali (2005) was commissioned by the NSW RTA to prepare a discussion paper regarding the compensation of edge effects associated with road development. Following the recommendations of that report, we included an additional 30-m strip to compensate for edge effects along newly created corridors.

Major bridges would be required where routes cross over the Richmond River and the Tuckean Broadwater. All route options comprise at least one major water crossing, although route options 2A and 2B comprise two each. It should be noted that bridge construction over the Tuckean Broadwater is discussed with respect to feasibility only and is not based on any assessment of aquatic habitats and/or vegetation communities potentially directly impacted nor does it take into account any cost implications for the RTA. It is recognised that the spans of major bridges can incorporate terrestrial fauna underpasses along the river banks.

Other bridges are assumed to be required to cross over waterways that are named in mapping provided by Hyder Consulting or were determined during the present study to provide important fish habitat. The need to construct three bridges over the upper tributaries of Bingal Creek along Option 2C is unknown as a detailed assessment of the aquatic communities at these sites has not been conducted. However, based on the sampling undertaken during the current study, we have adopted a precautionary approach in the case of option 2C which is closest to our

aquatic sampling sites 3 and 4. It is also recognised that the spans of bridges can incorporate terrestrial fauna underpasses along the river banks.

Finally, it was assumed that pipes and culverts would be required where creeks or drainage lines were unnamed on mapping provided by Hyder Consulting.

It is recognised that these notional measures may be altered depending on final alignment and concept design.

6.2 Section 1

6.2.1 Flora

The areas of each vegetation community that would be removed as a result of the Section 1 options are listed below in Table 6.1.

Table 6.1: *Vegetation Removed by Section 1 Route Options*

Vegetation community	Conservation status	Vegetation Removed Route Option (ha)		
		1A	1B	1C
Banksia/Teatree Wet Heathland	Regional	-	-	0.05
Broad-leaved Paperbark Swamp Shrubland	State	0.59	0.59	0.49
Broad-leaved Paperbark SSF	State	-	-	2.79
Disturbed Heathland	Regional	2.38	2.38	1.95
Forest Red Gum DSF	State		1.08	1.02
Forest Red Gum DSF Woodland	State	0.05	0.47	0.53
Introduced Pines	-	0.40	0.40	0.46
Juncus/Carex Sedgeland	State	-	-	0.09
Paperbark SSF Woodland	State	1.67	1.67	1.41
Paperbark/Forest Red Gum SSF	State	0.46	0.24	0.20
Paperbark/Rainforest SSF	State	-	-	3.21
Paperbark/Swamp Oak SSF	State	0.11	0.11	0.82
Paperbark/Swamp Oak SSF Woodland	State	-	-	1.29
Swamp Box SSF	State	0.32	0.32	0.24
Swamp Mahogany/Paperbark SSF	State	0.24	0.24	0.25
Swamp Oak SSF	State	-	0.04	0.03
Swamp Oak SSF Woodland	State	0.10	0.08	0.96
Wallum Banksia Dry Shrubland	Regional	1.44	1.44	1.19
Grassy Wet Meadow	State	0.10	0.34	0.41
Total		7.9	9.4	17.4

The removal of each vegetation community was subsequently calculated as a percentage of the total occurrence of the community in the entire study area. These calculations show that all communities removed would be less than 10% of their total occurrence within the study area.

The number of known and potential plant species of conservation significance at the national, state and regional levels likely to be affected as a result of the Section 1 options is listed below in Table 6.2.

Table 6.2: Plant Species Likely to be Affected by Section 1 Route Options

Plant Species' Conservation Status	No. Species Impact by Route Option		
	1A	1B	1C
National	1	1	1
State	5	6	6
Regional	0	0	1
Total	6	7	8

6.2.2 Fauna

The areas of fauna habitats that would be removed as a result of the Section 1 options are listed below in Table 6.3.

Table 6.3: Fauna Habitats Removed by Section 1 Route Options

Fauna Habitat (ID No.)	High Diversity Habitat	Habitat Removed Route Option (ha)		
		1A	1B	1C
Wet Meadow (2)		0.10	0.34	0.41
Sedgeland (3)	✓	-	-	0.09
Swamp Shrubland (5)		0.59	0.59	0.49
Paperbark Swamp Forest (6)	✓	0.11	0.11	3.61
Swamp Oak Forest (7)		-	0.04	0.03
Eucalypt Swamp Forest (8)	✓	1.02	0.80	0.69
Swamp Forest/Rainforest (9)	✓	-	-	3.21
Dry Sclerophyll Shrubland (10)		1.44	1.44	1.19
Wet Heath (12)		-	-	0.05
Disturbed Heathland (13)		2.38	2.38	1.95
Dry Sclerophyll Forest (16)	✓	-	1.08	1.02
Swamp Woodland (21)		1.77	1.75	3.66
Woodland (24)		0.05	0.47	0.53
Introduced (29)		0.40	0.40	0.46
Total		7.9	9.4	17.4

The number of known and potential fauna species of conservation significance at the national, state and regional levels likely to be affected as a result of the Section 1 options is listed below in Table 6.4.

Table 6.4: Fauna Species Likely to be Affected by Section 1 Route Options

Fauna species' Conservation Status	No. Species Impact by Route Option		
	1A	1B	1C
National	4	4	4
State	34	35	36
Regional	19	20	23
Migratory	2	2	2
Total	58	60	64

6.2.3 Aquatic

Potential aquatic impacts occurring along Section 1 of the route are summarised below in Table 6.5.

Table 6.5: *Aquatic Impacts of Section 1 Route Options*

Aquatic Impact	Route Option		
	1A	1B	1C
Remove or affect known Oxleyan Pygmy Perch habitat	No	Remove 0.3 ha McDonald's Ck (& downstream effects)	Remove 0.3 ha McDonald's Ck (& downstream effects)
Remove potential Oxleyan Pygmy Perch Habitat	No	Yes	Yes
Remove or indirectly affect important fish habitat ¹	No	No	No
Create barrier to fish passage	No	Possibly	Possibly
Remove or indirectly impact SEPP 14 wetland	No	No	No

¹Includes fish nurseries and high density fish habitat

Within Section 1, route options 1B and 1C would result in a significant ecological impact on Oxleyan Pygmy Perch habitat through the removal of known habitat and disturbance to downstream habitats at the McDonald's Creek crossing. The impact of route option 1A is relatively low as it does not directly affect any known or potential Oxleyan Pygmy Perch habitat or any other significant wetland.

6.2.4 Comparative impact assessment

The ecological impacts associated with route options 1A-1C are compared in Table 6.6 below:

Table 6.6: *Comparative Ecological Impacts of Section 1 Route Options*

Ecological criteria	Route Options		
	1A	1B	1C
Area of nationally significant vegetation removed	0	0	0
Area of EECs to be removed	3.6 ha	5.2 ha	13.7 ha
Area of regionally significant vegetation removed	3.8 ha	3.8 ha	3.2 ha
Total vegetation removed	7.9 ha	9.4 ha	17.4 ha
Area of key (regionally signif.) habitat to be removed	3.4 ha	3.4 ha	6.1 ha
Area of high diversity habitat removed	1.1 ha	2.0 ha	8.5 ha
Area of regional corridors removed	8.1 ha	8.1 ha	7.7 ha
Distance of route through regional corridors	1.5 km	1.5 km	1.5 km
Area of sub-regional corridors removed	0	0	0
Area of known/likely habitat for OPP to be removed	0	At least 0.3 ha (McDonald's Ck)	At least 0.3 ha (McDonald's Ck)
No. known threatened plant species impacted	0	0	0
No. potential threatened plant species impacted	6	7	7
	(1 EPBC, 5 TSC)	(1 EPBC, 6 TSC)	(1 EPBC, 6 TSC)

Ecological criteria	Route Options		
	1A	1B	1C
No. known threatened fauna species impacted	2 (1 EPBC, 1 TSC)	3 (2 EPBC, 1 TSC)	7 (3 EPBC, 4 TSC)
No. potential threatened fauna species impacted	36 (3 EPBC, 33 TSC)	36 (2 EPBC, 34 TSC)	33 (1 EPBC, 32 TSC)
No. regionally significant species potentially impacted	19 (all fauna)	20 (all fauna)	24 (23 fauna, 1 plant)
No. migratory species potentially affected	2	2	2
Area SEPP 14 wetlands to be removed	0 ha	0 ha	0 ha
Barrier effects	Low-Med	High	High
Fragmentation impacts	Low-Med	High	High

6.2.5 Ranking

The areas of conservation significance traversed by route options 1A-1C are shown in Figure 6.1 and areas lost are calculated below in Table 6.7:

Table 6.7: Conservation Significance Traversed & Final Rankings of Section 1 Route Options

Ecological criteria	Route Options		
	1A	1B	1C
Area of Very High conservation value removed	0 ha	0.3 ha	0.3 ha
Area of High conservation value removed	3.1 ha	4.6 ha	13.4 ha
Area of Medium-High conservation value removed	2.5 ha	2.5 ha	2.1 ha
Area of Medium conservation value removed	1.6 ha	1.6 ha	1.3 ha
Area of Low-Medium conservation value removed	0.2 ha	0.2 ha	0.2 ha
Relative Scores	4.7	6.2	12.8
Threatened Species Records Ranking	1	2	3
Final Score	5.7	8.2	15.8
Rank	1	2	3

Scores and consequent ecological rankings for Section 1 route options show consistent trends for most of the criteria measured with option 1A having the least ecological impact and option 1C having the greatest ecological impact. Impacts associated with option 1B are intermediate. Both 1B and 1C have the potential to remove and fragment known Oxleyan Pygmy Perch habitat.

6.2.6 Mitigation and compensation

A summary of notional mitigation measures associated with each of the Section 1 route options is listed in Table 6.8 and depicted in Figure 6.4.

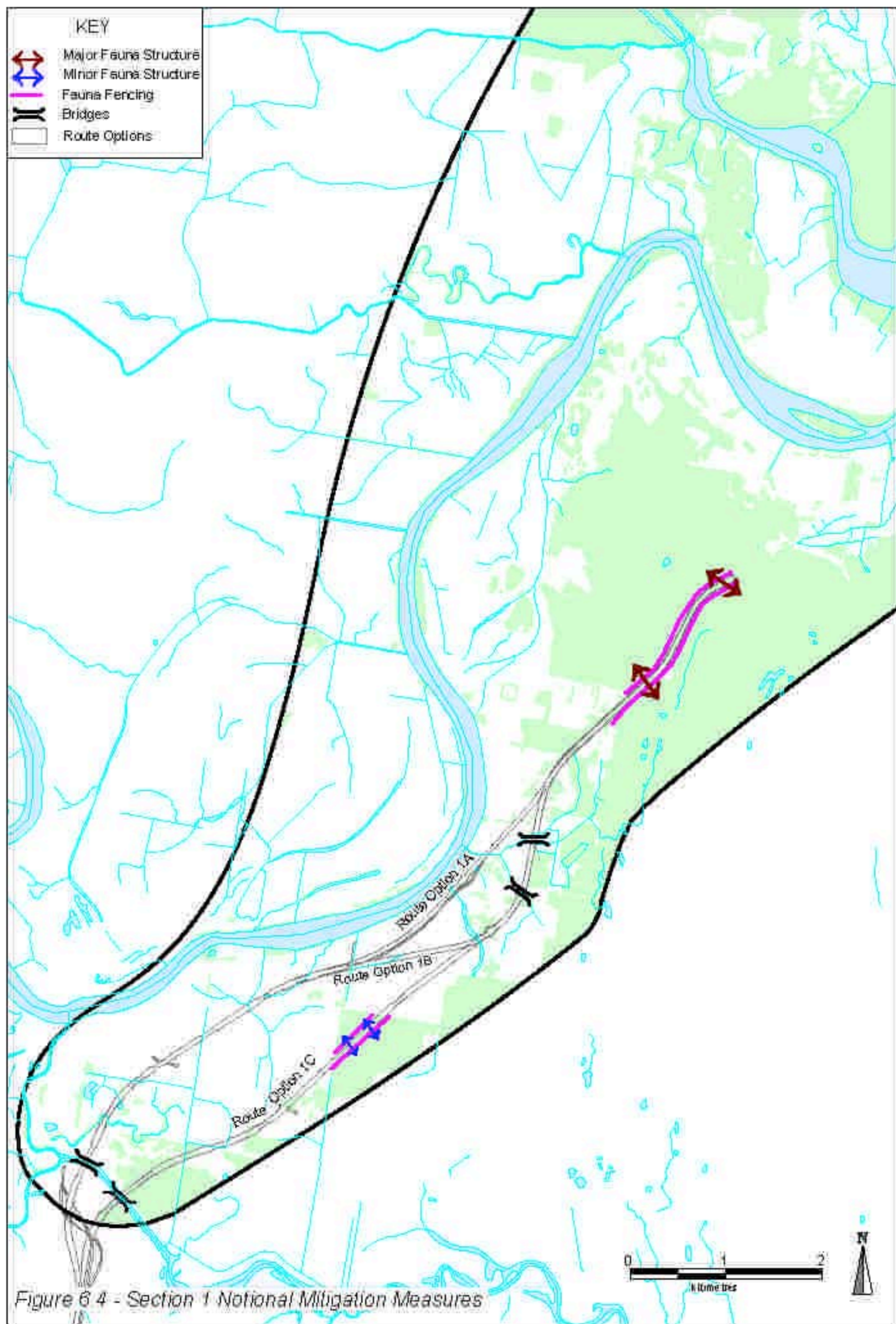


Table 6.8: Notional Mitigation Measures Required for Section 1 Route Options

Mitigation Measures	Route Options		
	1A	1B	1C
No. major fauna structures	2	2	2
No. minor fauna structures (e.g. underpasses, box culverts)	0	0	3
Fauna exclusion fencing (kms)	3.64	3.64	5
Compensation of key habitat and edge effects (ha)	8.9	13.2	33.2
No. of major bridges (incorporating fauna underpass)	0	0	0
No. of bridges* (incorporating fauna underpass)	2	3 (incl. McDonald's Ck)	3 (incl. McDonald's Ck)
No. of culverts/pipes*	9	12	6

* This is assuming that major (named) creeks require bridging and minor (unnamed) creeks will require culverts/pipes. However, we understand that this trend may not hold true in all cases.

The mitigation table supports the conclusion that route option 1C has the greatest ecological impacts therefore requiring more minor fauna structures, exclusion fencing and compensatory habitat. Route options 1B and 1C would each require three bridges as they transect known Oxleyan Pygmy Perch habitat.

6.3 Section 2

6.3.1 Flora

The areas of each vegetation community that would be removed as a result of the Section 2 options are listed below in Table 6.9.

Table 6.9: Vegetation Removed by Section 2 Route Options

Vegetation community	Cons. status	Vegetation Removed Route Option (Ha)					
		2A	2B	2C	2D	2E	2F
Banksia Moist Shrubland	Regional	-	-	-	1.53	1.74	-
Wallum Banksia/Scribbly Gum Mallee	Regional	1.41	1.41	1.44	-	-	-
Heath-leaved Banksia Swamp Shrubland	Regional	0.02	0.02	0.03	2.33	2.33	0.51
Banksia/Paperbark Swamp Shrubland	State	-	-	0.13	0.13	0.13	0.13
Banksia/Paperbark Swamp Woodland	State	-	-	0.06	0.06	0.06	0.06
Banksia/Teatree Wet Heath	Regional	0.35	0.33	0.32	0.32	0.32	0.30
Blackbutt DSF	-	0.53	0.48	2.17	0.8	0.85	0.73
Blackbutt Dry Mallee Forest	Regional	-	-	-	0.52	0.52	-
Blackbutt WSF	-	0.03	0.08	-	-	-	-
Blackbutt DSF Woodland	-	-	-	0.72	0.06	0.06	0.05
Blackbutt/Cypress +/- Bloodwood DSF	Regional	0.02	0.46	0.2	0.95	1.93	0.74
Blackbutt/Mahogany DSF	-	0.01	-	0.46	-	-	-
Blackbutt/Pink Bloodwood +/- Tallowood DSF	-	1.03	1.03	3.95	0.41	0.41	0.4
Broad-leaved Paperbark SSF	State	7.05	5.92	5.67	4.6	4.17	1.73

Vegetation community	Cons. status	Vegetation Removed Route Option (Ha)					
		2A	2B	2C	2D	2E	2F
Brushbox WSF	-	0.17	0.87	0.68	0.02	0.02	-
Brushbox/Rainforest	National	0.5	0.5	0.46	0.13	0.13	0.2
Camphor/Privet/Rainforest	State	0.16	0.16	0.13	-	-	0.05
Cypress Pine DSF	Regional	0.09	0.09	0.21	0.12	0.39	0.05
Cypress Pine DSF Woodland	Regional	-	-	-	-	0.33	0.19
Cypress/Mahogany +/- Camphor DSF	Regional	-	-	-	-	0.61	-
Disturbed Heathland	Regional	-	-	0.73	2.11	2.48	0.76
Regrowth Wattle	-	-	-	-	-	0.03	-
Forest Red Gum DSF	State	0.08	-	-	-	-	-
Forest Red Gum/Bloodwood DSF	State	0.35	-	-	-	-	-
Forest Red Gum/Swamp Oak SSF	State	0.76	0.04	0.04	0.32	0.32	-
Forest Red Gum/Tuckeroo Riparian	State	-	-	-	0.12	0.12	-
Hoop Rainforest	State	0.04	0.04	0.04	-	-	-
Camphor Plantings	-	-	-	0.06	0.06	0.01	0.06
Eucalyptus Plantation	-	-	-	-	-	0.3	-
Slash Pine Plantings	-	-	-	-	-	-	0.35
Mangrove Forest	State	0.35	1.86	0.11	0.71	0.71	0.1
Mangrove Woodland	State	-	0.12	-	-	-	-
Mangrove/Swamp Oak +/- Red Gum	State	0.21	0.09	-	-	-	0.11
Mangrove/Tuckeroo Riparian Forest	State	-	-	-	-	-	0.05
Ball Honeymyrtle SSF	State	-	-	-	0.69	0.69	0.33
Narrow Red Gum/Paperbark Forest SSF	State	-	-	0.82	-	-	-
Paperbark SSF Woodland	State	0.6	0.24	0.15	0.14	0.4	0.14
Paperbark/Brushbox/Swamp Box SSF	State	0.53	0.53	0.56	-	-	-
Paperbark/Forest Red Gum SSF	State	0.82	0.92	-	-	-	-
Paperbark/Mahogany SSF	State	0.45	0.45	0.45	-	-	-
Paperbark/Rainforest SSF	State	0.69	0.11	0.19	0.53	0.53	0.55
Paperbark/Swamp Box SSF	State	-	-	0.1	-	-	-
Paperbark/Swamp Oak SSF	State	0.16	1.4	-	-	-	-
Knotweed Wet Meadow	State	0.89	0.81	1.34	0.05	0.05	0.03
Restio/Baumea/Paperbark Sedgeland	State	-	-	-	0.74	0.74	0.44
Scribbly Gum DSF	Regional	0.54	0.54	0.53	-	-	-
Scribbly Gum Dry Mallee Forest	Regional	0.49	0.43	-	0.62	0.62	-
Scribbly Gum DSF Woodland	Regional	-	-	0.58	-	-	-
Swamp Mahogany/Swamp Box/Brushbox SSF	State	1.55	1.55	1.57	-	-	-
Regenerating Swamp Forest	State	-	-	0.01	-	-	-
Swamp Mahogany Swamp Mallee Forest	State	-	-	0.03	0.03	0.03	0.01

Vegetation community	Cons. status	Vegetation Removed Route Option (Ha)					
		2A	2B	2C	2D	2E	2F
Swamp Mahogany SSF	State	-	-	0.59	1.25	1.25	0.12
Swamp Mahogany SSF Woodland	State	0.22	0.26	0.28	0.28	0.28	0.29
Swamp Mahogany/Paperbark SSF	State	-	-	1.95	1.57	1.57	0.86
Swamp Mahogany/Paperbark Woodland	State	-	-	0.49	-	-	-
Swamp Oak SSF	State	0.6	0.85	-	-	-	-
Swamp Oak SSF Woodland	State	0.13	0.34	-	-	-	0.05
Tallowwood/Brushbox WSF	Regional	-	0.71	-	-	-	-
Wallum Banksia Dry Shrubland	Regional	2.35	2.4	1.5	6.13	7.8	2.5
Grassy Wet Meadow	State	-	-	0.79	0.79	0.67	0.66
Total		23.2	25.0	29.5	28.1	32.6	12.6

The removal of each vegetation community was subsequently calculated as a percentage of the total occurrence of the community in the entire study area. The majority of vegetation loss represents less than 10% of the total amount of each vegetation community found, with the exception of:

- ❑ 2A, 2B and 2C would remove 13 % of Swamp Mahogany/Brushbox/Swamp Box SSF (an EEC) occurring in the study area;
- ❑ 2C also would remove 12 % of the Narrow Red Gum/Paperbark SSF (an EEC);
- ❑ 2D and 2E would remove 31% of the Ball Honeymyrtle SSF (an EEC) in the study area; and
- ❑ 2F would remove 15% of the Ball Honeymyrtle SSF.

The number of known and potential plant species of conservation significance at the national, state and regional levels likely to be affected as a result of the Section 2 options is listed below in Table 6.10.

Table 6.10: *Plant Species Likely to be Affected by Section 2 Route Options*

Plant Species' Conservation Status	No. Species Impact by Route Option					
	2A	2B	2C	2D	2E	2F
National	25	25	25	6	6	5
State	16	16	16	9	9	6
Regional	5	5	5	3	3	0
Total	46	46	46	18	18	11

6.3.2 Fauna

The areas of fauna habitats that would be removed as a result of the Section 2 options is listed below in Table 6.11.

Table 6.11: Fauna Habitats Removed by Section 2 Route Options

Fauna Habitat (ID No.)	High Diversity Habitat	Habitat Removed Per Route Option (ha)					
		2A	2B	2C	2D	2E	2F
Disturbed Heathland (13)		-	-	0.73	2.11	2.51	0.76
Dry Mallee Forest (14)	✓	1.90	1.84	1.44	1.14	1.14	-
Dry Sclerophyll Forest (16)	✓	2.65	2.60	7.52	2.28	4.19	1.92
Dry Sclerophyll Shrubland (10)		2.35	2.40	1.50	6.13	7.80	2.50
Eucalypt Swamp Forest (8)	✓	2.03	1.41	3.96	3.14	3.14	0.98
Introduced (29)		-	-	0.06	0.06	0.31	0.41
Mangrove Forest (4)		0.56	2.07	0.11	0.71	0.71	0.21
Moist Shrubland (11)		0.02	0.02	0.03	3.86	4.07	0.51
Paperbark Swamp Forest (6)	✓	7.21	7.32	5.67	5.29	4.86	2.06
Riparian (26)	✓	-	-	-	0.12	0.12	0.05
Sedgeland (3)	✓	-	-	-	0.74	0.74	0.44
Subtropical Rainforest/WSF (19)	✓	0.70	0.70	0.63	0.13	0.13	0.25
Swamp Forest/Rainforest (9)	✓	0.69	0.11	0.19	0.53	0.53	0.55
Swamp Forest/WSF (20)	✓	2.08	2.08	2.13	-	-	-
Swamp Mallee Forest (15)		-	-	0.03	0.03	0.03	0.01
Swamp Oak Forest (7)		0.60	0.85	-	-	-	-
Swamp Shrubland (5)		-	-	0.13	0.13	0.13	0.13
Swamp Woodland (21)		0.95	0.84	0.98	0.48	0.74	0.54
Wet Heath (12)		0.35	0.33	0.32	0.32	0.32	0.30
Wet Meadow (2)		0.89	0.81	2.13	0.84	0.72	0.69
Wet Sclerophyll Forest (17)	✓	0.20	1.66	0.68	0.02	0.02	-
Woodland (24)		-	-	1.30	0.06	0.39	0.24
Total		23.2	25.0	29.5	28.1	32.6	12.6

The number of known and potential fauna species of conservation significance at the national, state and regional levels likely to be affected as a result of the Section 2 options is listed below in Table 6.12.

Table 6.12: Fauna Species Likely to be Affected by Section 2 Route Options

Fauna Species' Conservation Status	No. Species Impact by Route Option					
	2A	2B	2C	2D	2E	2F
National	4	4	4	4	4	4
State	50	50	51	48	47	44
Regional	24	24	24	24	24	25
Migratory	3	3	4	4	4	4
Total	79	79	81	78	67	75

6.3.3 Aquatic

Potential impacts potentially occurring along Section 2 of the route are summarised below in Table 6.13.

Table 6.13: *Aquatic Impacts of Section 2 Route Options*

Aquatic Impact	Route Option					
	2A	2B	2C	2D	2E	2F
Remove or affect known Oxleyan Pygmy Perch habitat	No	No	No	No	No	No
Remove or affect potential Oxleyan Pygmy Perch Habitat	Possibly N between Thurgates & Lumleys Lane	Possibly N between Thurgates & Lumleys Lane	Possibly between Old Bagotville Rd & Lumleys Lane	Unlikely	Unlikely	No
Remove or indirectly affect important fish habitat	Fish nursery, Tuckean Broadwater	Fish nursery, Tuckean Broadwater	Potentially in Bingal Ck tributaries	Potentially at Bingal Ck	Potentially at Bingal Ck	No
Remove riparian vegetation	Yes, SEPP 14 wetlands & mangroves	Yes, SEPP 14 wetlands & mangroves	Yes, mangroves	Yes, mangroves	Yes, mangroves	Thin band
Create barrier to fish passage	No	No	Potentially in Bingal Ck tributaries	Potentially at Bingal Ck	Potentially at Bingal Ck	No
Remove or indirectly impact SEPP 14 wetland	Remove 1.3 ha of SEPP 14 Nos. 119b, 115, 117	Remove 1.2 ha of SEPP 14 No. 117	No	No	No	No

Within Section 2, the most significant ecological impacts on aquatic habitat are associated with the crossings of the Tuckean Broadwater. The impacts associated with route options 2A and 2B crossing the Tuckean Broadwater include the risk of damage or loss to the SEPP 14 protected riparian vegetation and mudflats, both of which combine to provide good fish nursery habitat. Furthermore, these options transect possible Oxleyan Pygmy Perch habitat between Thurgates Lane and Lumleys Lane.

There may also be aquatic impacts on Bingal Creek and its tributaries. Limited field work in September indicates that a tributary of this creek north of Old Bagotville Road (site 3) is very rich in terms of native fish abundances. Route option 2C crosses within 500 metres of site 3 and also crosses a number of other tributaries of Bingal Creek between this site and Thurgates Lane. These tributaries are likely to provide high quality fish habitat and may also provide Oxleyan Pygmy Perch habitat. The location of route option 2C on the edge of the Wardell Heathland could create fish passage barriers or alter water quality or flow characteristics downstream, thereby affecting these habitats. In addition, route option 2C transects possible Oxleyan Pygmy Perch habitat between Thurgates Lane and Lumleys Lane.

Route options 2D and 2E cross Bingal Creek near its confluence with the Richmond River and could possibly affect fish habitat. Based on survey

work undertaken by Geolyse (2005) these areas do not appear to contain suitable Oxleyan Pygmy Perch habitat. Route option 2F would not result in any significant aquatic impacts.

6.3.4 Comparative impact assessment

The ecological impacts associated with route options 2A-2F are compared in Table 6.14 below:

Table 6.14: Comparative Ecological Impacts of Section 2 Route Options

Ecological criteria	Route Option					
	2A	2B	2C	2D	2E	2F
Area of nationally significant vegetation removed	0.3 ha	0.3 ha	0 ha	0 ha	0 ha	0 ha
Area of EECs to be removed	15.8 ha	15.9 ha	16.0 ha	12.1 ha	11.9 ha	5.9 ha
Area of regionally significant vegetation removed	5.3 ha	6.4 ha	5.5 ha	14.6 ha	19.1 ha	5.1 ha
Total vegetation removed	23.2 ha	25 ha	29.5 ha	28.1 ha	32.6 ha	12.6 ha
Area of key (regionally signif) habitat removed	13.5 ha	13.2 ha	18.0 ha	23.1 ha	27.1 ha	5.7 ha
Area of high diversity habitat removed	16.0 ha	15.0 ha	21.2 ha	12.2 ha	13.7 ha	5.9 ha
Area of regional corridors removed	45.1 ha	34.2 ha	57.3 ha	39.5 ha	42.2 ha	18.1 ha
Distance of route through regional corridors	6.2 km	4.4 km	7.8 km	4.9 km	4.6 km	2.2 km
Area of subregional corridors removed	2.7 ha	0 ha	0 ha	0 ha	0 ha	0 ha
Distance of route through possible OPP habitat	2.7 km	2.7 km	7.6 km	0	0	0
No. known threatened plant species impacted	2 (1 EPBC, 1 TSC)	2 (1 EPBC, 1 TSC)	2 (1 EPBC, 1 TSC)	0	0	0
No. potential threatened plant species impacted	39 (24 EPBC, 15 TSC)	39 (24 EPBC, 15 TSC)	39 (24 EPBC, 15 TSC)	15 (6 EPBC, 9 TSC)	15 (6 EPBC, 9 TSC)	11 (5 EPBC, 6 TSC)
No. known threatened fauna species impacted	18 (1 EPBC, 17 TSC)	18 (1 EPBC, 17 TSC)	12 (1 EPBC, 11 TSC)	10 (3 EPBC, 7 TSC)	11 (3 EPBC, 8 TSC)	2 (1 EPBC, 1 TSC)
No. potential threatened fauna species impacted	36 (3 EPBC, 33 TSC)	36 (3 EPBC, 33 TSC)	43 (3 EPBC, 40 TSC)	42 (1 EPBC, 41 TSC)	40 (1 EPBC, 39 TSC)	45 (3 EPBC, 42 TSC)
No. regionally significant species potentially impacted	29 (24 Fauna, 5 Flora)	29 (24 Fauna, 5 Flora)	29 (24 Fauna, 5 Flora)	27 (24 Fauna, 3 Flora)	27 (24 Fauna, 3 Flora)	24 (All Fauna)
No migratory species potentially affected	3	3	4	4	4	4
Area SEPP 14 wetlands impacted	1.3 ha	1.2 ha	0 ha	0 ha	0 ha	0 ha
Barrier effects	High	Medium	Very High	Low-Med	Low-Med	Low-Med
Fragmentation impacts	Medium	Medium	Medium	High	High	Low

6.3.5 Ranking

The areas of conservation significance traversed by route options 2A-2F are shown in Figure 6.2 and areas lost are calculated below in Table 6.15.

Table 6.15: Conservation Significance Traversed & Final Rankings of Section 2 Route Options

Ecological criteria	Route Option					
	2A	2B	2C	2D	2E	2F
Area of Very High conservation value removed	0.3 ha	0.3 ha	0 ha	0 ha	0 ha	0 ha
Area of High conservation value removed	16.1 ha	14.3 ha	15.3 ha	17.1 ha	17.5 ha	4.9 ha
Area of Medium-High conservation value removed	4.5 ha	4.8 ha	4.5 ha	8.0 ha	12.3 ha	3.7 ha
Area of Medium conservation value removed	3.1 ha	6.4 ha	10.1 ha	3.2 ha	3.3 ha	4.7 ha
Area of Low-Medium conservation value removed	30.9 ha	19.6 ha	34.5 ha	14.9 ha	12.8 ha	13.6 ha
Relative Scores	23.3	21.1	25.9	22.7	25.3	10.7
Threatened Species Affected (ranked)	5	5	4	2	3	1
Final Score	28.3	26.1	29.8	24.7	28.3	11.7
Rank	4	3	5	2	4	1

With the exception of option 2F, there is a relatively small difference amongst the scores of route options in Section 2. This indicates that they are ecologically similar. Scoring and ranking values should be used to indicate trends rather than be treated as absolute values.

Route option 2F consistently scored the lowest (Rank=1) on the basis of ecological impacts and this result is expected as the route traverses mainly cleared and agricultural land.

Route option 2B scored second lowest (Rank=2) while 2D scored third lowest (Rank=3) for ecological impacts. The difference between scores for 2B and 2D is due to a higher number of threatened species records being associated with 2B.

Options 2A and 2E scored equally (Rank=4). Although option 2E resulted in the removal of more areas of High and Medium-High conservation value, more threatened species may be affected by option 2A.

Using this ranking process, option 2C had the highest score (Rank=5). It resulted in the highest relative score for removal of conservation value land, had the greatest barrier impacts and would potentially affect an intermediate number of threatened species.

Alterations to hydrogeological flows also have the potential to significantly affect heathland vegetation by permanently changing its flora and fauna assemblages. A preliminary assessment prepared by Coffey (2006) examined the hydrogeological impacts of route options 2A-2F on the Wardell Heathland. The report concluded that options 2D/E had the potential to have a greater impact on groundwater levels and flows in the heathland than option 2C, while options 2A, 2B and 2F were unlikely to have significant impacts on groundwater.

Barrier effects associated with options 2D/E could occur where earthworks were above the average water levels; this would act to raise groundwater levels on the western side of the road and reduce them to the east, especially in the vicinity of Bingal Creek and near a 'freshwater swamp' (comprising Sphagnum Swamp Woodland, Sedgeland and Wet Heath). However, as Bingal Creek would be bridged, the impacts in this area are

likely to be minimised. Moreover, the hydrological effects of options 2D/E would be localised and could be substantially reduced through construction methods (e.g. piles) near the freshwater swamp.

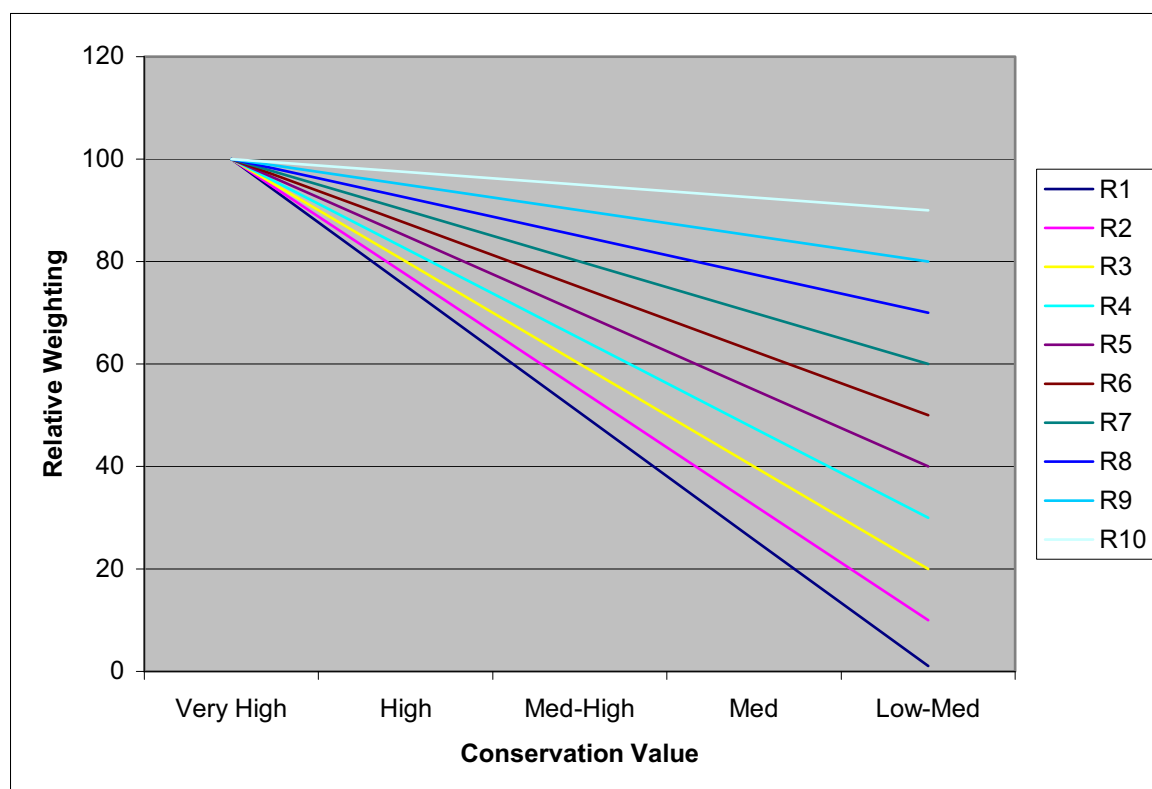
Coffey (1996) also found that barrier effects associated with option 2C could occur in the tributaries of Bingal Creek. The extent of impacts would be dependent on the type of construction used but could be minimised by bridging (or using large culverts on) the tributaries. Potential hydrogeological impacts therefore do not change our initial ranking.

6.3.6 Sensitivity analysis

Because scores within Section 2 routes were similar, we attempted to obtain further resolution by subjecting the data to a simple sensitivity analysis.

We assumed that the relationship between all levels of conservation value (Very High, High, Medium-High, Medium, Low-Medium) is a linear one, although the slope of the line is unknown. For simplicity, we arbitrarily assigned a value of 100 to Very High conservation value and then adjusted the value for Low-Medium conservation value from 1 (R1) through increments of 10 to a maximum value of 90 (R10) as per Figure 6.5 below:

Figure 6.5: Potential Linear Relationships (R1-R10) amongst levels of conservation value.



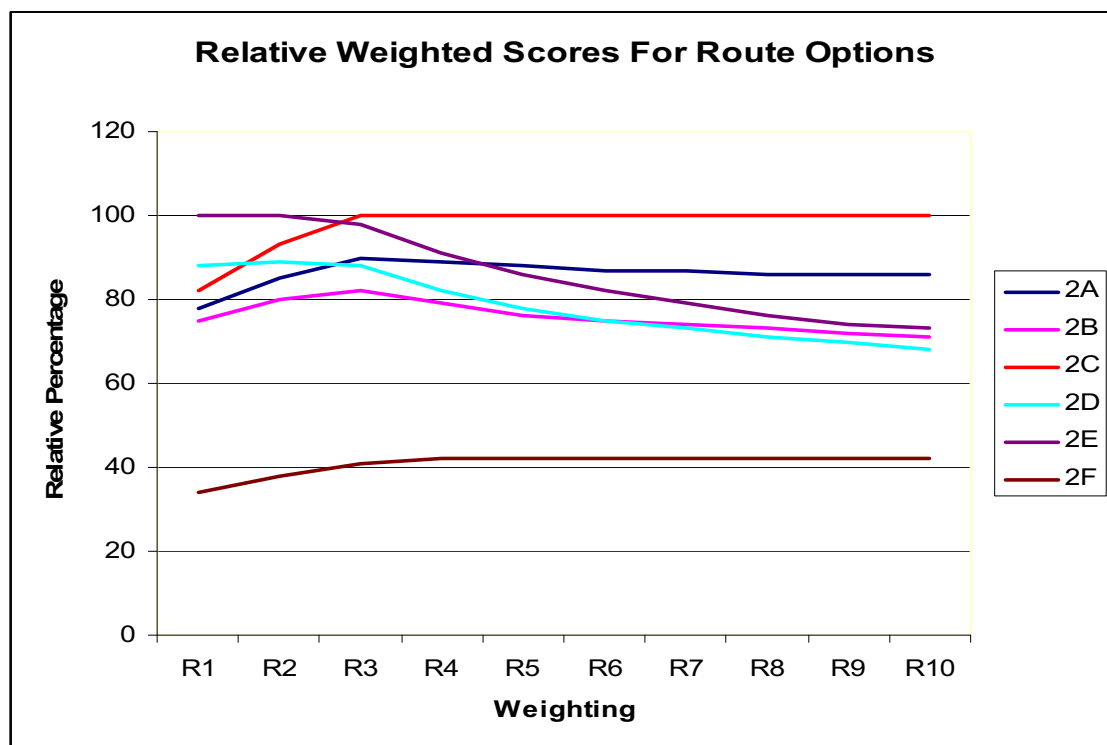
It should be noted that R3 (yellow line) represents the relative weighting used to obtain relative scores shown in the Table 6.15, although the rating was out of 1 rather than 100.

We then applied the 10 different weightings (R1-R10) to the figures shown in Table 6.14 to obtain weighted scores (expressed as percentage scores relative to the highest value). These are shown in Table 6.16 below:

Table 6.16: Relative Weighted Scores for Section 2 Route Options

Weighting	Route Option					
	2A	2B	2C	2D	2E	2F
R1	78	75	82	88	100	34
R2	85	80	93	89	100	38
R3	90	82	100	88	98	41
R4	89	79	100	82	91	42
R5	88	76	100	78	86	42
R6	87	75	100	75	82	42
R7	87	74	100	73	79	42
R8	86	73	100	71	76	42
R9	86	72	100	70	74	42
R10	86	71	100	68	73	42

The relative weighted scores for each route option are shown graphically below:



The results show that option 2F consistently has the least ecological impacts while all the other options have greater (and more similar) ecological impacts. It appears from this analysis that option 2C consistently (i.e. 80% of the time) had greater ecological impacts than other options, regardless of the slope of the linear relationship amongst conservation values. However, option 2B is similar to option 2D and option 2A is equivalent to option 2E. Using this ranking process, the route options are ranked as follows from least to highest ecological impacts: 2F, 2B and 2D, 2A and 2E and 2C.

6.3.7 Mitigation and compensation

A summary of notional mitigation measures associated with each of the Section 2 route options is shown in Table 6.17 and depicted in Figure 6.6.

Table 6.17: Notional Mitigation Measures Required for Section 2 Route Options

Mitigation Measures	Route Options					
	2A	2B	2C	2D	2E	2F
No. major fauna structures	2	2	3	1	1	0
No. minor fauna structures	4	2	4	6	8	0
Fauna exclusion fencing (kms)	5.9	4.5	8.2	9.9	10.9	1.9
Compensation of key habitat plus edge effects (ha)	58.4	55.8	68.4	70.8	81.4	31.5
No. of major bridges (incorporating fauna underpass)	2	2	1	1	1	1
No. of bridges* (incorporating fauna underpass)	1 ¹	1 ¹	5	3 (incl. Bingal Ck)	2 (incl. Bingal Ck)	4
No. of culverts/pipes*	25 (incl. upper reaches of Bingal Ck) ²	28 (incl. upper reaches of Bingal Ck) ²	21 (incl. upper reaches of Bingal Ck) ²	11	11	23

*This is assuming that major (named) creeks require bridging and minor (unnamed) creeks will require culverts. However, we understand that this trend may not hold true in all cases.

¹Over streams flowing to survey sites with high fish density/diversity.

²Some of these may require bridging.

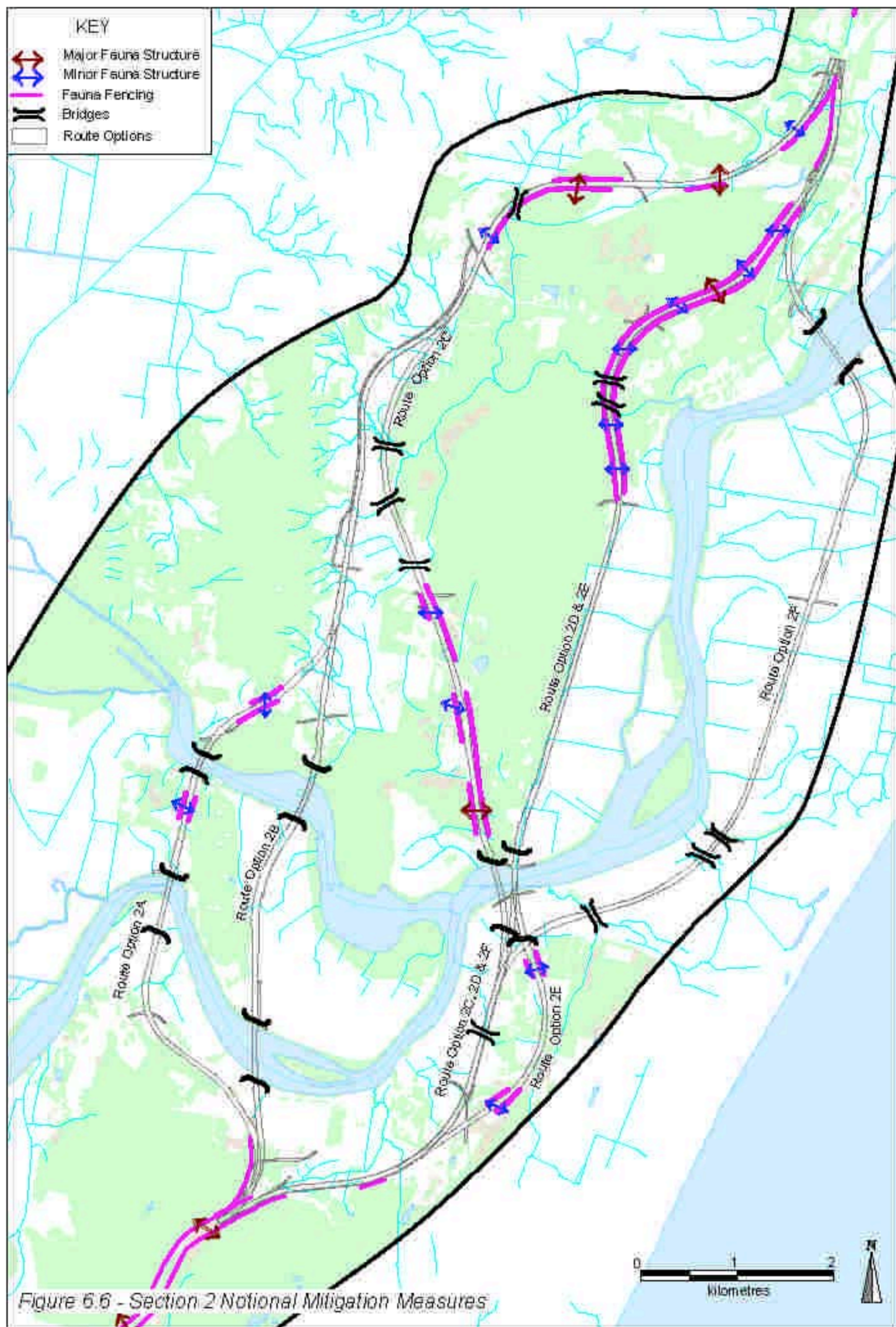
This mitigation table demonstrates the difficulties encountered in separating ecological impacts amongst route options 2A-2E. The relative importance of terrestrial versus aquatic impacts further complicates the issue. For this reason, we discuss terrestrial and aquatic mitigation separately below.

Terrestrial

The mitigation table demonstrates that route options 2A-2C require more major fauna structures than options 2D-2E. The higher number of minor fauna structures and fauna fencing for options 2D and 2E reflects greater fragmentation of heathland habitat and consequently the need to facilitate movement of smaller more sedentary species (e.g. frogs). Route options 2C, 2D and 2E require more fauna exclusion fencing and compensatory habitat than options 2A-2B. Option 2C requires more major fauna structures whereas options 2D and 2E require more minor fauna structures, exclusion fencing and compensatory habitat.

Aquatic

Within Section 2, route options 2A and 2B have the greatest potential to result in aquatic impacts by affecting SEPP 14 wetlands in the Tuckean Broadwater and significant riparian vegetation on the Richmond River. However, it would be possible to minimise impacts on SEPP 14 wetlands and mangroves by constructing a bridge at least 350 m long. It would also be necessary to place any bridge supports carefully within these sensitive vegetation communities.



The potential aquatic impacts of Option 2B on the important fish nurseries in the Tuckean Broadwater could be minimised through bridge design and the implementation of mitigation measures, including: careful placement of support structures (i.e. to avoid sensitive plant communities), the use of long (e.g. 60 m) spans where necessary and the construction of a separated dual carriageway to prevent overshadowing of the mangroves. In order to minimise impacts on sensitive vegetation, the bridge would have to extend at least 590 m.

Route option 2C crosses in close proximity to the headwaters of the Bingal Creek tributary that was shown to support a very high fish species density/diversity. It should be noted that Route options 2A and 2B also cross Bingal Creek tributaries that were not surveyed as part of the current ecological review. However, these options occur further to the west in disturbed agricultural land and are not expected to support as high quality fish habitat. If any crossing sites are found to have high fish species diversity and density, then water quality and stream flow characteristics should be maintained by implementing best practice construction techniques near and within the catchment of this tributary to maintain fish passage and water quality and flow characteristics.

Route options 2D and 2E cross Bingal Creek near its confluence with the Richmond River and therefore would require a substantial bridge structure and mitigation efforts aimed at avoiding impacts on water quality and flow.

An appropriate high level bridge structure associated with the crossing of the Richmond River by route option 2F would be required to avoid bank impacts.

6.4 Section 3

6.4.1 Flora

The areas of vegetation communities of conservation significance that would be removed as a result of the Section 3 options are listed below in Table 6.18.

Table 6.18: *Vegetation Removed by Section 3 Route Options*

Vegetation Community	Conservation Status	Vegetation Removed Route Option (ha)	
		3A	3B
Blackbutt DSF		-	0.01
Broad-leaved Paperbark SSF	State	0.02	1.47
Brushbox WSF	Regional	0.04	-
Brushbox/Rainforest	National	0.50	0.19
Rainforest/Camphor/Privet	State	0.40	-
Blackbutt WSF		1.99	-
Regenerating WSF		0.98	-
Regrowth Wattle		0.02	-
Paperbark/Cypress SSF	State	-	0.33
Paperbark/Rainforest SSF	State	-	6.00
Paperbark/Swamp Box SSF	State	-	0.04

Vegetation Community	Conservation Status	Vegetation Removed Route Option (ha)	
		3A	3B
Paperbark/Swamp Oak SSF	State	1.76	4.60
Paperbark/Swamp Oak/Rainforest	State	2.74	3.01
Rainforest Woodland	State	0.50	-
Scribbly Gum/Ball Honeymyrtle Swamp Mallee Forest	Regional	-	0.27
Swamp Mahogany SSF	State	-	0.57
Swamp Mahogany/Paperbark SSF	State	-	0.89
Wallum Banksia Dry Shrubland	Regional	-	0.06
Total		8.95	17.4

The removal of each vegetation community was subsequently calculated as a percentage of the total occurrence of the community in the entire study area. These calculations show that both route options 3A and 3B would remove 25% and 27% respectively of the Paperbark/Swamp Oak/Rainforest vegetation community (an EEC). Option 3B would also remove 10% of the Scribbly Gum/Ball Honeymyrtle Swamp Mallee Forest in the study area. Less than 10% would be removed of all remaining vegetation communities by either of the route options in Section 3.

The number of known and potential plant species of conservation significance at the national, state and regional levels to be affected as a result of the Section 3 options is listed below in Table 6.19.

Table 6.19: *Plant Species Likely to be Affected by Section 3 Route Options*

Plant species' Conservation Status	No. Species Impact by Route Option	
	3A	3B
National	6	3
State	9	3
Regional	3	1
Total	18	7

6.4.2 Fauna

The areas of fauna habitats that would be removed as a result of the Section 3 options are listed below in Table 6.20.

Table 6.20: Fauna Habitats Removed by Section 3 Route Options

Fauna Habitat (ID No.)	High density Habitat	Habitat Removed Per Route Option (ha)	
		3A	3B
Disturbed Heathland (13)		0.02	0
Dry Sclerophyll Forest (16)	✓	0	0.01
Dry Sclerophyll Shrubland (10)		0	0.06
Eucalypt Swamp Forest (8)	✓	0	1.5
Paperbark Swamp Forest (6)	✓	1.78	6.4
Rainforest Woodland (23)	✓	0.5	0
Subtropical Rainforest/WSF (19)	✓	0.9	0.19
Swamp Forest/Rainforest (9)	✓	2.74	9.01
Swamp Mallee Forest (15)		0	0.27
Wet Sclerophyll Forest (17)	✓	3.01	0
Total		8.95	17.4

The number of known and potential fauna species of conservation significance at the national, state and regional levels to be affected as a result of the Section 3 options is listed below in Table 6.21.

Table 6.21: Fauna Species Likely to be Affected by Section 3 Route Options

Fauna Species' Conservation Status	No. Species Impact by Route Option	
	3A	3B
National	1	3
State	37	37
Regional	16	20
Migratory	0	0
Total	54	60

6.4.3 Aquatic

A summary of mitigation measures associated with each of the Section 3 route options is shown in Table 6.22.

Table 6.22: Aquatic Impacts of Section 3 Route Options

Aquatic Impact	Route Option	
	3A	3B
Remove or affect known Oxleyan Pygmy Perch habitat	No	No
Remove potential Oxleyan Pygmy Perch Habitat	No	No
Remove or indirectly affect important fish habitat ¹	No	No
Create barrier to fish passage	No	No
Remove or indirectly impact SEPP 14 wetland	Yes, removes 0.9 ha of SEPP 14 wetland No. 108	Yes, removes 0.9 ha of SEPP 14 wetland No. 108

¹Includes fish nurseries and high density fish habitat.

6.4.4 Comparative impact assessment

The ecological impacts associated with route options 3A and 3B are compared in Table 6.23 below:

Table 6.23: Comparative Ecological Impacts of Section 3 Route Options

Ecological criteria	Route Option	
	3A	3B
Area of nationally significant vegetation removed	0.3 ha	0 ha
Area of EECs to be removed	5.6 ha	17.1 ha
Area of regionally significant vegetation removed	0 ha	0.3 ha
Total vegetation removed	9.0 ha	17.4 ha
Area of key (regionally signif.) habitat to be removed	0.01 ha	4.0 ha
Area of high diversity habitat removed	7.4 ha	17.4 ha
Area of regional corridors removed	6.8 ha	2.5 ha
Distance of route through regional corridors	1.1 km	0.2 km
Area of sub-regional corridors removed	13.9 ha	13.3 ha
Area of known/likely habitat for OPP to be removed	0	0
No. known threatened plant species impacted	0	0
No. potential threatened plant species impacted	15 (6 EPBC, 9 TSC)	6 (3 EPBC, 3 TSC)
No. known threatened fauna species impacted	7 (7 TSC)	2 (2 TSC)
No. potential threatened fauna species impacted	32 (1 EPBC, 31 TSC)	39 (3 EPBC, 36 TSC)
No. potential migratory fauna species impacted	0	0
No. regionally significant species potentially impacted	20 (17 Fauna, 3 Flora)	22 (21 Fauna, 1 Flora)
No. migratory species potentially impacted	0	0
Area SEPP 14 wetlands to be removed	0.9 ha	0.9 ha
Barrier effects	Low-Medium	Low
Fragmentation Impacts	Low-Medium	Low

6.4.5 Ranking

The areas of conservation significance traversed by route options 3A and 3B are shown in Figure 6.3 and areas lost are calculated below in Table 6.24:

Table 6.24: Conservation Significance Traversed & Final Rankings of Section 3 Route Options

Ecological criteria	Route Option	
	3A	3B
Area of Very High conservation value removed	0.3 ha	0 ha
Area of High conservation value removed	5.8 ha	14.6 ha
Area of Medium-High conservation value removed	0 ha	0 ha
Area of Medium conservation value removed	3.0 ha	0.1 ha
Area of Low-Medium conservation value removed	14.4 ha	9.1 ha
Relative Scores	9	13.5
Threatened Species Records Ranking	2	1
Final Score	11.0	14.5
Rank	1	2

Option 3A has lower ecological impacts than option 3B and is ranked 1. Although it has greater barrier impacts than 3B and potentially affects more threatened species, it removes less high conservation value areas than 3B. Option 3B is therefore ranked 2 as it has overall greater ecological impacts.

6.4.6 Mitigation and compensation

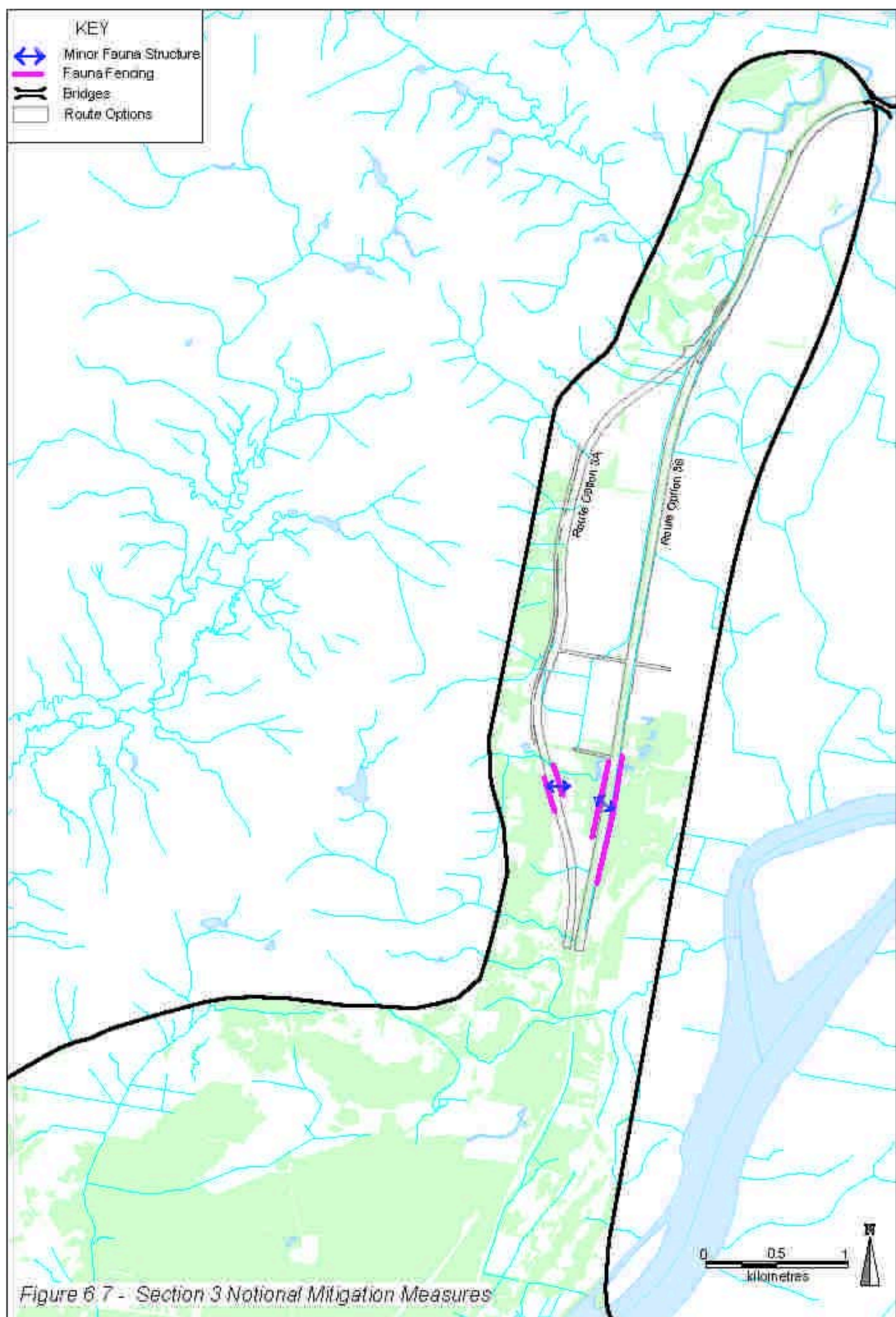
A summary of notional mitigation measures associated with each of the Section 3 route options is shown in Table 6.25 and depicted in Figure 6.7.

Table 6.25: Notional Mitigation Measures Required for Section 3 Route Options

Mitigation Measures	Route Option	
	3A	3B
No. major fauna structures	0	0
No. minor fauna structures	1	1
Fauna exclusion fencing (kms)	0.5	1.5
Compensation of key habitat plus edge effects	16.0	17.5
No. of major bridges (incorporating fauna underpass)	0	0
No. of bridges* (incorporating fauna underpass)	0	0
No. of culverts/pipes*	13	8

* This is assuming that major (named) creeks require bridging and minor (unnamed) creeks will require culverts. However, we understand that this trend may not hold true in all cases.

The mitigation table shows that impacts associated with route options 3A and 3B are similar although 3B would require more exclusion fencing and compensatory habitat.



7.0 PRELIMINARY ASSESSMENT OF PREFERRED ROUTE

One of the aims of this report is to compare the ecological impacts of the original route corridor options with route 2EC and the preferred route. It should be noted that the preferred route footprint was not originally divided into equivalent sections to the route options. This was adjusted to enable direct comparisons with relevant route options. Equivalent sections of the preferred route are named P1, P2 and P3. For comparative purposes, P2 is equivalent to 2EC.

Ecological criteria for all route options within each section are compared in Appendix B.

7.1 Flora

The areas of each vegetation community that would be removed as a result of the preferred route is listed below in Table 7.1.

Table 7.1: Vegetation Removed by Preferred Route Options.

Vegetation community	Cons. status	Vegetation Removed Route Option (ha)			
		P1	P2	P3	2EC
Bangalow Palm Subtropical Rainforest	State		0.21		
Banksia/Paperbark Swamp Shrubland	State		0.03		0.13
Banksia/Paperbark Swamp Woodland	State				0.06
Heath-leaved Banksia Swamp Shrubland	Regional		0.29		
Banksia Moist Shrubland	Regional		0.03		0.22
Banksia/Teatree Wet Heath	Regional	0.36	0.32		0.32
Blackbutt DSF	-		1.86		2.22
Blackbutt DSF Woodland	-		0.75		0.72
Blackbutt/Cypress +/- Bloodwood DSF	Regional		1.41		1.18
Blackbutt/Mahogany DSF	Regional		0.98		0.46
Blackbutt/Pink Bloodwood +/- Tallowwood DSF	-		2.81		3.95
Broad-leaved Paperbark Swamp Shrubland	State	0.5			
Broad-leaved Paperbark SSF	State	1.34	1.84	1.01	5.23
Brushbox WSF	-		0.68	0.05	0.68
Brushbox/Rainforest	State		0.13	0.28	0.43
Camphor/Privet/Rainforest	State		0.57		0.11
Cypress Pine DSF	Regional				0.48
Cypress Pine/Mahogany +/- Camphor DSF	Regional		0.3		0.61
Cypress Pine DSF Woodland	Regional				0.33
Disturbed Heathland	Regional	2.15	0.93		1.09
Eucalyptus Plantation	-		0.26		0.3
Forest Red Gum/Swamp Oak SSF	State		0.03		
Hoop Rainforest	State		0.23		
Harsh Ground Fernland	-		0.18		
Slash Pine Plantations	-	2.33			
Juncus/Carex Sedgeland	State	0.12			

Vegetation community	Cons. status	Vegetation Removed Route Option (ha)			
		P1	P2	P3	2EC
Mangrove Forest	Regional		0.11		0.11
Narrow Red Gum/Paperbark SSF	State		1.27		0.82
Paperbark SSF Woodland	State	1.37	0.83		0.41
Regrowth Wattle	-		0.09		0.03
Paperbark/Brushbox/Swamp Box SSF	State				0.56
Paperbark/Cypress SSF	State			0.33	
Paperbark/Forest Red Gum SSF	State	3.69			
Paperbark/Mahogany SSF	State	1.82	0.07		0.45
Paperbark/Rainforest SSF	State	6.36	0.08	5.15	0.19
Paperbark/Swamp Box SSF	State	0.41		0.05	0.1
Paperbark/Swamp Oak SSF	State	1.68		4.26	
Paperbark/Swamp Oak SSF Woodland	State	1.23			
Paperbark/Swamp Oak/Rainforest SSF	State			2.97	
Knotweed Wet Meadow	State		0.73		1.34
Scribbly Gum DSF	Regional				0.53
Scribbly Gum DSF Woodland	Regional				0.58
Scribbly Gum Dry Mallee Forest	Regional				1.44
Scribbly Gum/Ball Honeymyrtle Swamp Mallee	State			0.27	
Swamp Box SSF	State	0.56			
Swamp Mahogany SSF	State		0.07	0.55	0.59
Swamp Mahogany Swamp Mallee Forest	State				0.03
Swamp Mahogany SSF Woodland	State		0.28		1.57
Swamp Mahogany/Paperbark SSF	State	0.25	0.51	0.89	1.95
Swamp Mahogany/Paperbark SSF Woodland	State		0.26		0.49
Swamp Mahogany/Swamp Box/Brushbox SSF	State				0.28
Swamp Oak SSF	State	0.02			
Swamp Oak SSF Woodland	State	0.98			
Wallum Banksia Dry Shrubland	Regional	1.65	3.43	0.66	3.16
Grassy Wet Meadow	State		0.98		0.67
Total		26.82	22.55	16.47	33.82

The removal of each vegetation community was subsequently calculated as a percentage of the total occurrence of the community in the entire study area. The preferred route primarily removed less than 10% of each vegetation community, with following exceptions:

- ❑ 2EC would remove 12 % of the Narrow Red Gum/Paperbark SSF (an EEC);
- ❑ P1 would remove 12% of the Paperbark/Mahogany SSF (an EEC) in the study area;
- ❑ P2 would remove 19 % of the Narrow Red Gum/Paperbark SSF (an EEC) and 10% of the Hoop Rainforest (an EEC) in the study area; and

- P3 would remove 27% of the Paperbark/Swamp Oak/Rainforest vegetation community (an EEC) and 10% of the Scribbly Gum/Ball Honeymyrtle Swamp Mallee Forest.

The numbers of known and potential plant species of conservation significance at the national, state and regional levels to be affected as a result of the preferred route and route 2EC are listed below in Table 7.2.

Table 7.2: Plant Species Likely to be Affected by Preferred Route Options

Plant Species' Conservation Status	No. Species Impact by Route Option			
	P1	P2	P3	2EC
National	1	25	3	25
State	6	16	3	16
Regional	1	5	1	5
Total	8	46	7	46

7.2 Fauna

The areas of fauna habitats that would be removed as a result of the preferred route and route 2EC are listed below in Table 7.3.

Table 7.3: Fauna Habitats Removed by Preferred Route Options

Fauna Habitat (ID No.)	High Density Habitat	Habitat Removed Route Option (ha)			
		P1	P2	P3	2EC
Disturbed Heathland (13)		2.15	1.02		1.12
Dry Mallee Forest (14)	✓				1.44
Dry Sclerophyll Forest (16)	✓		7.36		9.43
Dry Sclerophyll Shrubland (10)		1.65	3.43	0.66	3.16
Eucalypt Swamp Forest (8)	✓	6.73	1.95	1.49	3.91
Fernland (1)			0.18		
Introduced (29)		2.33	0.26		0.3
Mangrove Forest (4)			0.11		0.11
Moist Shrubland (11)			0.32		0.22
Paperbark Swamp Forest (6)	✓	3.02	1.84	5.6	5.23
Sedgeland (3)	✓	0.12			
Subtropical Rainforest/WSF (19)	✓		1.14	0.28	
Swamp Forest/Rainforest (9)	✓	6.36	0.08	8.12	0.19
Swamp Forest/WSF (20)	✓				0.84
Swamp Mallee Forest (15)				0.27	0.03
Swamp Oak Forest (7)		0.02			
Swamp Shrubland (5)		0.5	0.03		0.13
Swamp Woodland (21)		3.58	1.37		2.53
Wet Heath (12)		0.36	0.32		0.32
Wet Meadow (2)			1.71		2.01
Wet Sclerophyll Forest (17)	✓		0.68	0.05	0.68
Woodland (24)			0.75		1.63
Total		26.82	22.55	16.47	33.82

The number of known and potential fauna species of conservation significance at the national, state and regional levels to be affected as a result of the preferred route and route 2EC are listed below in Table 7.4.

Table 7.4: Fauna Species Likely to be Affected by Preferred Route Options

Fauna species' Conservation Status	No. Species Impact by Route Option			
	P1	P2	P3	2EC
National	4	4	4	4
State	34	47	49	49
Regional	21	23	18	23
Migratory	2	2	0	2
Total	61	76	71	76

7.3 Aquatic

Potential aquatic impacts occurring along the preferred route and Option 2EC are summarised below in Table 7.5.

Table 7.5: Aquatic Impacts of Preferred Route Options

Aquatic Impact	Route Option			
	P1	P2	P3	2EC
Remove or affect known Oxleyan Pygmy Perch habitat	Remove 0.4 ha McDonald's Ck (& downstream effects)	No	No	No
Remove potential Oxleyan Pygmy Perch Habitat	Possibly	Possibly	No	Possibly
Remove or indirectly affect important fish habitat ¹	-	Potentially in Bingal Creek tributaries	-	Potentially in Bingal Creek tributaries
Remove riparian vegetation	-	Yes, mangroves	-	Yes, mangroves
Create barrier to fish passage	No	Possibly	No	Possibly
Remove or indirectly impact SEPP 14 wetland	No	No	0.9 ha of SEPP 14 wetland No. 108	No

¹ Includes fish nurseries, high density fish habitat.

Section P1 closely parallels McDonald's Creek that is known habitat for the Oxleyan Pygmy Perch. Potential aquatic impacts would be minimised by moving the route further west. Section P1 should be bridged where it crosses over the drainage line as pipes and/or box culverts would be unacceptable for maintaining fish passage for this species. Furthermore, sedimentation and contamination should be strictly controlled in this area.

Aquatic impacts for Section P2 and 2EC are similar to those described for route option 2C (see Section 6.3.3).

7.4 Comparative Impact Assessment

The ecological impacts associated with preferred route sections P1, P2 and P3 (and the 2EC option) are compared in Table 7.6 below:

Table 7.6: Conservation Significance Traversed & Final Rankings of Preferred Route Options

Ecological criterion	Route Option			
	P1	P2	P3	2EC
Area of nationally significant vegetation removed	0 ha	0.5 ha	0.3 ha	0.05 ha
Area of EECs to be removed	20.3 ha	7.6 ha	15.5 ha	15.4 ha
Area of regionally significant vegetation removed	4.2 ha	7.8 ha	0.7 ha	10.5 ha
Total vegetation removed	26.8 ha	22.6 ha	16.4 ha	33.8 ha
Area of key (regionally signif.) habitat to be removed	17.5 ha	15.5 ha	4.1 ha	22.1 ha
Area of high diversity habitat removed	16.1 ha	13.3 ha	15.8 ha	22.0 ha
Area of regional corridors removed	7.6 ha	54.7 ha	2.4 ha	59.7 ha
Distance of route through regional corridors	1.5 km	9.3 km	0.5 km	9.0 km
Area of sub-regional corridors removed	0.8 ha	0 ha	12.4 ha	0 ha
Area of known/likely habitat for OPP to be removed	0.4 ha	0 ha	0 ha	0
Distance of route through possible OPP habitat	4.3 km	7.6 km	0 km	7.6 km
No. known threatened plant species impacted	0	2 (1 EPBC, 1 TSC)	0	2 (1 EPBC, 1 TSC)
No. potential threatened plant species impacted	7 (1 EPBC, 6 TSC)	39 (24 EPBC, 15 TSC)	6 (3 EPBC, 3 TSC)	39 (24 EPBC, 15 TSC)
No. known threatened fauna species impacted	7 (3 EPBC, 4 TSC)	18 (1 EPBC, 17 TSC)	7 (7 TSC)	18 (1 EPBC, 17 TSC)
No. potential threatened fauna species impacted	32 (1 EPBC, 31 TSC)	34 (3 EPBC, 31 TSC)	35 (3 EPBC, 32 TSC)	36 (3 EPBC, 33 TSC)
No. migratory species potentially affected	2	4	0	4
No. regionally significant species potentially impacted	22 (21 Fauna, 1 Flora)	29 (24 Fauna, 5 Flora)	20 (19 Fauna, 1 Flora)	28 (23 Fauna, 5 Flora)
Area SEPP 14 wetlands to be removed	0 ha	0 ha	0.9 ha	0 ha
Barrier effects	High	Very High	Low	Very High
Fragmentation impacts	High	Medium	Low	Medium

7.5 Ranking

The areas of conservation significance traversed by route options P1, P2 and P3 (and the 2EC option) are shown in Figure 7.1 and areas lost are calculated below in Table 7.7:

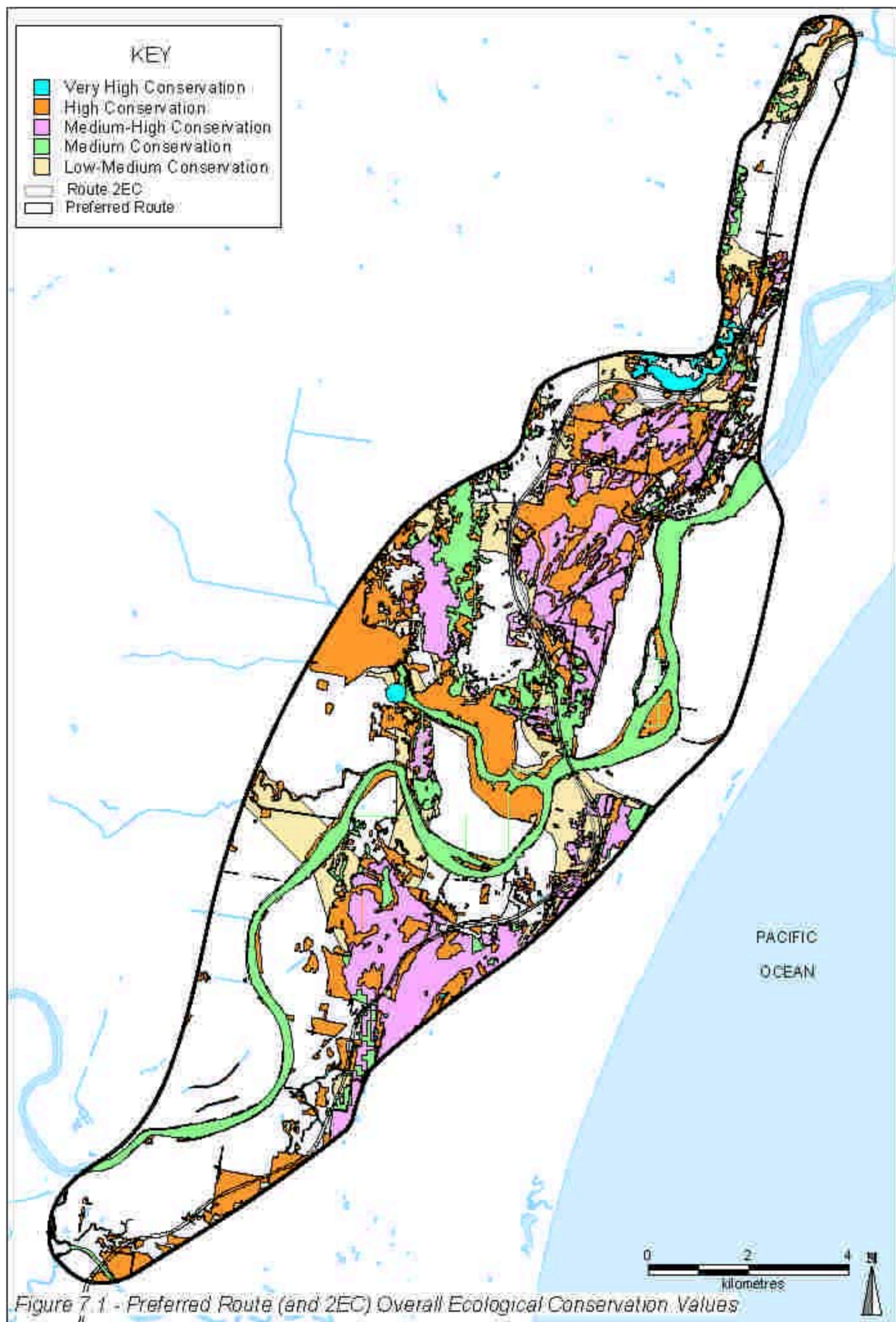


Figure 7.1 - Preferred Route (and 2EC) Overall Ecological Conservation Values

Table 7.7: Conservation Significance Traversed & Final Rankings of Preferred Route Options

Ecological criteria	Route Option			
	P1	P2	P3	2EC
Area of Very High conservation value removed	0.4	0.5	0.3	0.05
Area of High conservation value removed	19.9	7.2	12.9	15.7
Area of Medium-High conservation value removed	2.1	6.2	0	8.8
Area of Medium conservation value removed	2.2	9.2	0.1	10.3
Area of Low-Medium conservation value removed	2.3	38.3	8.7	32.2
Relative Scores	18.9	21.3	12.4	28.3
Threatened Species Records Ranking	3	5	1	5
Final Score	21.9	26.3	13.4	33.5

The preferred route score for each section compared to the route option scores for equivalent sections is summarised below:

- ❑ The score for P1 is higher than the highest score for Section 1 (1C=15.8) indicating that it would have greater ecological impacts than 1C.
- ❑ The score for option 2EC is greater than the highest score for Section 2 (2C=29.8) indicating that it would have greater ecological impacts than 2C.
- ❑ The score for P2 is less than that for 2C and 2EC indicating that it would have less ecological impacts than either of these options.
- ❑ The score for P3 is less than the highest score for Section 3 (3B=14.5), indicating that it would have fewer ecological impacts than 3B.

In summary, the preferred route has greater ecological impacts than the original route corridor options in Section 1 and fewer ecological impacts than the original route corridor options in Sections 2 and 3.

7.6 Mitigation and Compensation

A summary of notional mitigation measures associated with each section of the preferred route and option 2EC is shown in Table 7.8 and depicted in Figure 7.2.

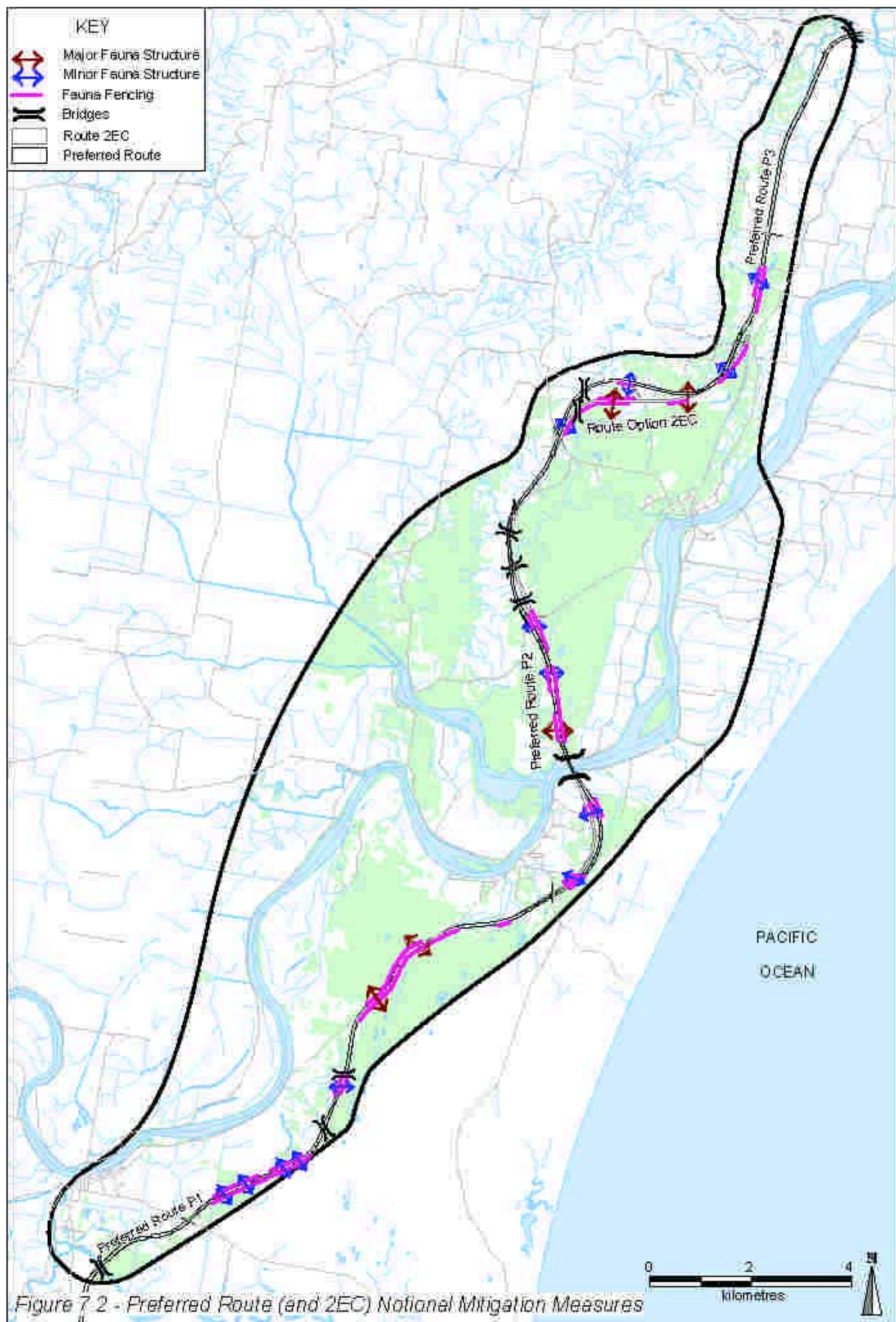


Table 7.8: *Notional Mitigation Measures Required for Preferred Route Options*

Mitigation Measures	Route Option			
	P1	P2	P3	2EC
No. major fauna structures	2	2	0	3
No. minor fauna structures	5	7	1	6
Fauna exclusion fencing (kms)	9.5	8.8	0.5	9.8
Compensation of key habitat plus edge effects	51.9	57.0	17.0	77.6
No. of major bridges (incorporating underpasses)	0	1	0	1
No. of bridges* (incorporating underpasses)	3 (incl. McDonald's Ck)	4 (incl. upper tributaries of Bingal Ck)	0	4 (incl. upper tributaries of Bingal Ck)
No. of culverts/pipes*	5	29	8	22

* This is assuming that major (named) creeks require bridging and minor (unnamed) creeks will require culverts. However, we understand that this trend may not hold true in all cases.

The mitigation table supports the conclusion that option 2EC has the greatest ecological impacts and therefore requires most mitigation and compensation effort. The reduction in mitigation measures required for P2 reflects the adjustments made to option 2EC to avoid native vegetation. On the other hand, the greater number of major fauna structures, exclusion fencing and compensatory habitat required for P1 reflects the increased environmental impacts associated with this option compared to 1C. Mitigation measures for P3 are similar to those for 3B.

8.0 CONCLUSION

This report addresses the gaps identified in the Phase 1 and 2 Investigations Report. We have endeavoured to prepare a review that is both scientifically robust and transparent to address the concerns of the DEC, Ballina Shire Council and community members/groups.

The final scores for all route options considered in this report are summarised in Table 8.1 below.

Table 8.1: Summary of Route Option Final Scores

Option	1A	1B	1C	P1
Score	5.7	8.2	15.8	21.9

Option	2A	2B	2C	2D	2E	2F	2EC	P2
Score	28.3	26.1	29.8	24.7	28.3	11.7	33.5	26.3

Option	3A	3B	P3
Score	11	14.5	13.4

Overall, we agree with the findings of Geolyse (2005b) that the route sections with the least ecological impacts comprised 1A and 2F, although we found that option 3B had slightly greater impacts than 3A.

We found that although the route options 2A-2E were ecologically similar, we were able to discern trends. When a sensitivity test was applied to the data, options 2B and 2D performed similarly but had less overall ecological impacts than options 2A and 2E, which also performed similarly. Option 2C had the highest weighted score 80% of the time.

Route option 2EC (a combination of route options 2E and 2C) has greater ecological impacts than all other options in Section 2. The preferred route (a modified version of 1C, 2EC and 3B) has the following ecological impacts:

- ❑ In Section 1, The preferred route option P1 has greater ecological impacts than the route option 1C;
- ❑ In Section 2, the preferred route option P2 has fewer ecological impacts than the route option 2EC; and
- ❑ In Section 3, the preferred route option P3 has fewer ecological impacts than the route option 3B.

9.0 REFERENCES

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Appendix A: Percentage reservation status of Forest and Non-Forest Ecosystems in the CAR Reserve System in the Upper North East region based on vegetation modelling to establish the pre-1750 extent of Forest Ecosystems in the region (Source: NPWS 2000).

Forest Ecosystems	AREA		Percent Remaining	Status	Percent of Forest Ecosystem (pre-1750) extent in the CAR Reserve System			
	Pre 1750 (ha)	Current (ha)			Dedicated Reserves	Informal Reserve	Prescription	Total
2 Alpine Gum*	4165	1329	31.9	V	5.9	1.5	0.8	8.2
3 Baileys Stringybark	46720	34931	74.8	-	28.6	5.1	0.2	33.9
10 Black Sallee	6	6	100.0	R	100.0	0.0	0.0	100.0
12 Blue Mountain Ash	121	121	100.0	R	43.3	0.0	52.4	95.7
14 Brown Barrell	398	166	41.7	R	6.0	0.0	0.1	6.2
15 Brown Barrell-Gum*	2587	1004	38.8	R	6.1	0.0	0.1	6.2
16 Bull Oak	2	2	100.0	R	0.0	100.0	0.0	100.0
17 Candlebark*	10200	1961	19.2	R	0.8	0.1	0.0	0.9
19 Central Mid Elevation Sydney Blue Gum*	12586	6786	53.9	-	6.9	0.9	3.0	10.8
20 Clarence Lowland Needlebark Stringybark	12496	10817	86.6	-	26.6	21.9	6.9	55.4
21 Lowlands Grey Box*	61789	23913	38.7	V	0.3	0.1	0.2	0.6
22 Coast Cypress Pine*	158	82	51.9	R	41.2	0.0	0.0	41.2
23 Coast Range Bloodwood-Mahogany	18055	5919	32.8	-	9.0	4.5	0.3	13.8
24 Clarence Lowlands Spotted Gum*	343968	174787	50.8	-	2.5	1.6	1.4	5.5
25 Coast Range Spotted Gum-Blackbutt*	885	743	84.0	R	10.0	0.9	3.1	14.0
26 Coastal Flooded Gum	14910	9426	63.2	-	22.2	0.4	1.4	24.0
27 Coastal Sands Blackbutt	4518	3101	68.6	-	63.0	0.0	0.1	63.1
29 Corkwood-Crabapple and Mixed Stringybarks	7149	6093	85.2	-	30.4	5.3	12.4	48.1
30 Diehard Stringybark-New England Blackbutt*	2769	1062	38.4	R	4.0	0.3	0.1	4.3
31 Dorrig White Gum*	3851	3385	87.9	R	9.3	0.1	0.1	9.5
32 Dry Foothills Blackbutt-Turpentine	9370	7364	78.6	-	8.1	1.8	3.1	12.9
33 Dry Foothills Spotted Gum	97714	90829	93.0	-	13.4	4.1	10.6	28.1
34 Dry Grassy Blackbutt-Tallowwood	9880	6052	61.3	-	9.8	0.4	3.4	13.6
35 Dry Grassy Stringybark	87820	69987	79.7	-	23.1	2.3	4.6	30.1
36 Dry Grassy Tallowwood-Grey Gum*	9726	5564	57.2	-	3.9	0.4	1.4	5.7
37 Dry Heathy Blackbutt-Bloodwood	75580	46630	61.7	-	8.4	6.6	2.6	17.6
38 Dry Heathy New England Blackbutt	4580	4276	93.4	-	38.9	5.9	16.5	61.4
39 Dry Heathy New England Stringybarks	1178	1178	100.0	-	99.5	0.0	0.0	99.5
40 Dry Heathy Sandstone Blackbutt	20939	19036	90.9	-	25.2	5.9	3.0	34.1
41 Dry Open New England Blackbutt	219262	121339	55.3	-	13.6	1.5	3.0	18.0
42 Dry Redgum-Bloodwood-Apple	245	243	99.2	R	89.5	0.0	0.2	89.7
43 Dry Silvertop Stringybark-Apple	15059	13041	86.6	-	31.7	0.1	0.2	32.0
44 Dry open Redgum-Broad Leaved Apple	11330	10484	92.5	-	46.9	0.5	1.0	48.4
45 Dunns White Gum*	1453	975	67.1	R	34.9	1.3	4.2	40.3
46 Eastern Red Gums	2967	3002	100.0	V	38.2	19.4	7.0	64.5
47 Escarpment Redgum*	55897	28206	50.5	-	8.1	0.8	4.1	12.9
48 Escarpment Scribbly Gum-Apple	5871	5488	93.5	-	14.7	13.6	16.8	45.1
50 Wet Bangalow-Brushbox*	16154	10098	62.5	V	19.2	0.5	0.7	20.4

Forest Ecosystems	AREA		Percent Remaining	Status	Percent of Forest Ecosystem (pre-1750) extent in the CAR Reserve System			
	Pre 1750 (ha)	Current (ha)			Dedicated Reserves	Informal Reserve	Prescription	Total
52 Foothill Grey Gum-Ironbark-Spotted Gum	59393	46753	78.7	-	11.4	4.1	3.0	18.5
53 Gorge Grey Box	12259	11147	90.9	-	47.5	0.3	1.9	49.7
54 Grey Box-Red Gum-Grey Ironbark	38416	20438	53.2	-	5.4	0.2	0.6	6.2
55 Foothills Grey Gum-Spotted Gum	10634	8685	81.7	-	5.9	3.7	4.5	14.1
56 Granite Mallee	1951	1887	96.7	-	74.8	4.1	0.0	78.8
57 Highland Granite Stringybarks	2708	2483	91.7	-	83.8	0.0	0.0	83.8
58 Gorge Grey Gum	6218	5532	89.0	-	46.2	2.0	0.8	49.0
59 Gorge Ironbark-Grey Gum	74798	63226	84.5	-	16.7	1.6	10.5	28.8
60 Grassy New England Blackbutt-Tallowwood-Blue Gum	46952	40245	85.7	-	19.1	3.7	11.1	33.8
61 Grey Box-Ironbark*	146	131	89.7	R	20.3	1.4	0.1	21.7
62 Grey Box-Northern Grey Gum*	1625	509	31.3	R	0.4	1.7	1.1	3.2
63 Grey Gum-Stringybark	14033	12810	91.3	-	30.4	1.4	3.5	35.3
65 Heathy Scribbly Gum	10544	7758	73.6	-	31.3	5.8	2.8	39.9
67 High Elevation Ferny Blackbutt	12235	10462	85.5	-	14.6	2.5	5.6	22.6
68 High Elevation Messmate-Brown Barrel*	1932	329	17.0	R	4.7	0.0	0.1	4.8
69 High Elevation Moist Open Tallowwood-Blue Gum	4003	3533	88.3	-	15.3	6.9	12.3	34.5
70 High Elevation Open Spotted Gum	61596	50005	81.2	-	8.8	2.1	7.3	18.2
71 Ironbark*	24667	7713	31.3	-	4.1	0.1	0.5	4.7
72 Low Relief Coastal Blackbutt*	1574	859	54.6	R	9.1	0.6	0.6	10.4
73 Lowland Red Gum*	141011	57016	40.4	-	3.5	2.6	1.2	7.3
74 Lowlands Scribbly Gum*	6783	3496	51.5	V	26.4	1.0	2.3	29.7
75 Lowlands Spotted Gum-Box	37104	19737	53.2	-	7.7	0.8	0.3	8.8
76 Coastal Mallee	2493	1412	56.6	V	48.3	0.0	0.0	48.3
78 Mann River Wet New England Blackbutt	5139	5132	99.9	-	88.4	0.2	0.9	89.5
79 Manna Gum-Stringybark*	95	90	94.7	R	55.8	0.0	0.0	55.8
80 Manna Gum*	5476	1287	23.5	R	3.4	0.0	1.8	5.2
81 Messmate*	17001	6309	37.1	V	5.6	1.2	0.5	7.3
83 Mid Elevation Wet Blackbutt	1333	1180	88.5	-	45.2	8.5	5.9	59.5
84 Mid North Coast Wet Brushbox-Tallowwood-Blue Gum	12743	10378	81.4	-	21.0	6.7	6.5	34.1
85 Mixed Moist Hardwood*	818	346	42.3	R	14.9	0.9	1.2	16.9
86 Mixed New England Stringybarks	3320	3002	90.4	-	17.9	2.9	14.9	35.6
87 Mixed Tableland Stringybark-Gum Open Forest*	13471	4694	34.9	-	2.6	1.1	0.4	4.1
88 Moist Escarpment New England Blackbutt	10354	10275	99.2	-	70.4	4.6	3.3	78.3
89 Moist Foothills Spotted Gum	37545	35657	95.0	-	17.2	4.4	13.5	35.0
90 Moist Messmate-Gum	30214	25159	83.3	-	30.7	4.2	6.4	41.3
91 Moist Open Escarpment White Mahogany	1966	1814	92.3	-	13.1	9.2	10.0	32.3
92 Moist Shrubby Stringybark-Gum	5868	4139	70.5	-	18.9	2.5	7.2	28.6

Forest Ecosystems	AREA		Percent Remaining	Status	Percent of Forest Ecosystem (pre-1750) extent in the CAR Reserve System			
	Pre 1750 (ha)	Current (ha)			Dedicated Reserves	Informal Reserve	Prescription	Total
93 Montane Stringybark-Gum*	61335	28687	46.8	-	4.3	0.5	1.2	6.0
95 Northern Moist Blackbutt	10897	9101	83.5	-	37.3	0.9	0.9	39.1
97 Needlebark Stringybark-Large Fruited Blackbutt	10595	9966	94.1	-	25.8	18.2	3.5	47.6
98 New England Peppermint	4372	3590	82.1	-	21.3	8.3	37.6	67.1
99 New England Stringybark-Blakelys Red Gum	14496	10786	74.4	-	20.5	0.0	0.4	20.8
100 Northern Grassy Sydney Blue Gum*	11251	9245	82.2	V	27.9	5.2	9.7	42.8
101 Northern Open Grassy Blackbutt	30488	21590	70.8	-	14.0	2.6	1.3	17.9
102 Northern Ranges Dry Tallowwood	100595	57107	56.8	-	6.7	0.4	2.8	9.9
103 Northern Wet Brushbox	25433	16379	64.4	-	18.0	1.8	3.6	23.3
104 Northern Wet Tallowwood-Blue Gum	29607	25764	87.0	-	33.8	3.4	4.0	41.2
105 Nymboida Tallowwood-Turpentine	3005	2645	88.0	-	54.1	1.6	8.1	63.8
106 Open Coastal Brushbox	9549	6533	68.4	-	11.1	2.2	8.5	21.7
109 Open Shrubby Brushbox-Tallowwood	23572	17472	74.1	-	13.7	2.7	8.0	24.4
110 Open Silvertop Stringybark-Blue Gum	3681	3130	85.0	-	44.3	3.7	3.2	51.2
111 Open Silvertop Stringybark-Tallowwood	4876	4525	92.8	-	16.7	7.4	16.0	40.1
112 Paperbark*	NA	28577	NA	V	NA	NA	NA	NA
113 Peppermint	11200	6478	57.8	-	22.1	0.8	2.4	25.3
114 Peppermint-Mountain/Manna Gum*	42796	12829	30.0	V	3.5	0.0	0.0	3.5
115 Red Bloodwood	239	217	90.8	R	13.2	37.3	31.5	82.0
116 Red Gum-Stringybark*	58064	27128	46.7	-	0.5	0.4	0.2	1.1
117 Red Mahogany	1363	1273	93.4	-	85.1	0.1	0.1	85.4
118 Richmond Range Spotted Gum	48691	22511	46.2	-	4.8	0.3	0.5	5.6
119 Richmond Range Spotted Gum-Box*	41836	24814	59.3	-	5.0	0.8	0.6	6.3
120 River Oak*	4771	3221	67.5	V	4.0	0.3	1.7	6.0
122 Rough-barked Apples	3764	1683	44.7	V	20.5	9.2	6.4	36.2
123 Roundleaved Gum*	40718	17975	44.2	-	11.1	1.0	1.3	13.4
124 Roundleaved Gum-Turpentine	30	30	100.0	R	0.0	0.0	69.5	69.5
126 Sandstone Spotted Gum-Blackbutt*	8872	4808	54.2	-	5.4	3.2	3.1	11.7
127 Sherwood Needlebark Stringybark	11497	9098	79.1	-	6.9	4.2	0.5	11.6
128 Silverleaved Ironbark	2328	1988	85.4	-	0.1	0.0	2.9	3.0
129 Smoothbarked Apple	273	270	98.9	R	93.0	3.3	0.0	96.3
131 Snow Gum	304	288	94.7	R	77.0	0.0	2.7	79.7
132 Snow Gum - Mountain/Manna Gum*	97976	21305	21.8	V	0.9	0.3	0.4	1.6
133 Snow Gum-Black Sallee	2	2	100.0	R	100.0	0.0	0.0	100.0
135 South Coast Tallowwood-Blue Gum	6754	5338	79.0	-	14.3	2.7	6.3	23.4
138 Steel Box/Craven Grey Box*	634	427	67.4	R	23.6	0.9	1.5	26.0
139 Stringybark-Apple	57502	34813	60.5	-	6.5	0.1	2.1	8.7
140 Stringybark-Mallee	2196	2194	99.9	-	98.6	0.1	0.0	98.6
142 Swamp Mahogany*	695	578	83.2	R	25.7	12.3	1.4	39.5
143 Swamp Oak*	11165	2883	25.8	R	7.6	0.2	0.5	8.3
145 Sydney Peppermint-Stringybark*	267	255	95.5	R	9.4	0.3	0.0	9.7
146 Tallowwood	9191	8430	91.7	-	52.3	0.9	2.5	55.6

Forest Ecosystems	AREA		Percent Remaining	Status	Percent of Forest Ecosystem (pre-1750) extent in the CAR Reserve System			
	Pre 1750 (ha)	Current (ha)			Dedicated Reserves	Informal Reserve	Prescription	Total
147 Turpentine	6784	2943	43.4	-	15.2	0.6	0.6	16.4
148 Very Wet New England Blackbutt-Tallowwood	1499	1498	99.9	-	89.0	1.1	0.1	90.2
149 Mallee-Peppermint mosaic*	2721	1618	59.5	-	11.4	0.4	1.3	13.0
150 Washpool Brushbox-Tallowwood	5683	5683	100.0	-	83.5	4.3	3.5	91.3
152 Wet Bloodwood-Tallowwood	53783	33357	62.0	-	9.6	0.5	2.2	12.3
153 Wet Coastal Tallowwood-Brushbox	12436	6581	52.9	-	0.7	0.6	1.6	2.9
154 Wet Flooded Gum-Tallowwood*	24207	9317	38.5	-	2.2	0.7	1.1	3.9
155 Wet Foothills Blackbutt-Turpentine	8219	7437	90.5	-	16.0	4.6	4.9	25.6
157 Wet Shrubby Brushbox-Tallowwood	6265	4891	78.1	-	22.2	5.9	13.5	41.6
158 Wet Spotted Gum-Tallowwood	2539	2538	100.0	-	24.7	3.5	5.4	33.6
162 Whitetopped Box	4	4	100.0	R	0.0	23.0	77.0	100.0
163 Yellow Box-Blakely's Red Gum*	39525	7245	18.3	V	0.5	0.4	0.1	1.0
168 Rainforest*	NA	159211	NA	E	NA	NA	NA	NA
174 Orange Gum-Tumbledown Gum-Apple	27288	15435	56.6	-	0.0	0.0	0.6	0.7
175 Orange Gum-New England Blackbutt-Tumbledown Gum*	39537	19304	48.8	-	2.3	0.3	0.1	2.7
176 Orange Gum-Ironbark*	82312	34295	41.7	-	0.5	0.6	0.1	1.1
177 Outcrop Orange Gum-New England Blackbutt*	26428	7945	30.1	-	1.1	2.4	0.3	3.8
178 Outcrop Black Cypress-Tumbledown Gum	1642	1034	63.0	-	0.0	0.1	0.2	0.3
179 Yellow Box-Broad-leaved Stringybark*	11549	3859	33.4	V	0.0	0.7	6.1	6.8
180 Western New England Blackbutt	14754	12415	84.2	-	0.0	21.9	0.3	22.2
181 Stringybark-Gum	34306	30258	88.2	-	0.0	53.3	0.1	53.4
182 Apple-Black Cypress	2350	1994	84.9	-	0.0	9.3	0.0	9.3
183 Red Gum-Apple*	1569	592	37.7	R	0.0	0.1	0.0	0.1
184 Tumbledown Gum-Ironbark	13841	11070	80.0	-	0.0	27.2	0.4	27.6
185 Orange Gum-Black Cypress	5585	3510	62.9	-	0.0	15.9	9.3	25.2
186 Open Tumbledown Gum-Black Cypress-Orange Gum*	25417	10593	41.7	-	1.7	0.4	0.3	2.4
189 Silverleaved Ironbark-Cypress	40819	23285	57.0	-	0.2	0.2	0.0	0.5
190 Yellow Box-Grey Box-Red Gum*	60630	21273	35.1	V	0.5	0.5	0.1	1.0
194 Round-leaved Gum wet heath	8627	5997	69.5	-	0.0	26.0	2.3	28.3
195 Apple-Manna Gum woodland*	35674	16214	45.5	-	2.9	0.1	0.0	3.0
196 Broad-leaved Stringybark-Apple Box*	53457	19948	37.3	V	2.3	1.4	3.1	6.8
197 Broad-leaved Stringybark*	4409	1643	37.3	V	1.6	0.3	0.1	2.0
198 Silvertop Stringybark*	4527	1200	26.5	V	0.1	0.1	0.2	0.3
200 Broad-leaved Stringybark-Ribbon Gum*	2022	650	32.2	R	0.0	0.0	0.0	0.0

* Priority for reservation on Private Lands

Non-Forest Ecosystems	AREA		Percent Remaining	Status	Percent of Forest Ecosystem (pre-1750) extent in the CAR Reserve System			
	Pre 1750 (ha)	Current (ha)			Dedicated Reserves	Informal Reserve	Prescription	Total
5 Banksia	7561.0	2046	27.1	R	6.5	0.3	0.0	6.8
18 Casuarina Woodland	NA	43	NA	R	NA	NA	NA	NA
64 Heath	NA	9805	NA	V	NA	NA	NA	NA
66 Herbfield and Fjaeldmark	NA	68	NA	R	NA	NA	NA	NA
77 Mangrove	NA	734	NA	R	NA	NA	NA	NA
96 Natural Grassland	NA	370	NA	R	NA	NA	NA	NA
121 Rock	NA	18162	NA	-	NA	NA	NA	NA
125 Saltbush	17.0	16	94.1	R	55.8	0.0	0.0	55.8
141 Swamp	NA	24118	NA	E	NA	NA	NA	NA
169 Scrub	NA	5447	NA	V	NA	NA	NA	NA
199 Riparian Shrubland	5508.0	1252	22.7	V	0.0	0.0	0.0	0.0

Appendix B: Comparison of ecological criteria for all route options within each section.

Ecological criteria	Route Options			
	1A	1B	1C	P1
Area of nationally significant vegetation removed	0 ha	0 ha	0 ha	0 ha
Area of EECs to be removed	3.6 ha	5.2 ha	13.7 ha	20.3 ha
Area of regionally significant vegetation removed	3.8 ha	3.8 ha	3.2 ha	4.2 ha
Total vegetation removed	7.9 ha	9.4 ha	17.4 ha	26.8 ha
Area of key (regionally signif.) habitat to be removed	3.4 ha	3.4 ha	6.1 ha	17.5 ha
Area of high diversity habitat removed	1.1 ha	2.0 ha	8.5 ha	16.1 ha
Area of regional corridors removed	8.1 ha	8.1 ha	7.7 ha	7.6 ha
Distance of route through regional corridors	1.5 km	1.5 km	1.5 km	1.5 km
Area of sub-regional corridors removed	0	0	0	0.8 ha
Area of known/likely habitat for OPP to be removed	0	At least 0.3 ha (McDonald's Ck)	At least 0.3 ha (McDonald's Ck)	0.4 ha
No. known threatened plant species impacted	0	0	0	0
No. potential threatened plant species impacted	6 (1 EPBC, 5 TSC)	7 (1 EPBC, 6 TSC)	7 (1 EPBC, 6 TSC)	7 (1 EPBC, 6 TSC)
No. known threatened fauna species impacted	2 (1 EPBC, 1 TSC)	3 (2 EPBC, 1 TSC)	7 (3 EPBC, 4 TSC)	7 (3 EPBC, 4 TSC)
No. potential threatened fauna species impacted	36 (3 EPBC, 33 TSC)	36 (2 EPBC, 34 TSC)	33 (1 EPBC, 32 TSC)	32 (1 EPBC, 31 TSC)
No. regionally significant fauna species potentially impacted	19 (all fauna)	20 (all fauna)	24 (23 fauna, 1 flora)	22 (21 fauna, 1 flora)
No. migratory species potentially impacted	2	2	2	2
Area SEPP 14 wetlands to be removed	0 ha	0 ha	0 ha	0 ha
Barrier effects	Low-Med	High	High	High
Fragmentation impacts	Low-Med	High	High	High

Ecological criteria	Route Options							
	2A	2B	2C	2D	2E	2F	2EC	P2
Area of nationally significant vegetation removed	0.3 ha	0.3 ha	0 ha	0 ha	0 ha	0 ha	0.05 ha	0.5 ha
Area of EECs to be removed	15.8 ha	15.9 ha	16.0 ha	12.1 ha	11.9 ha	5.9 ha	15.4 ha	7.6 ha
Area of regionally significant vegetation removed	5.3 ha	6.4 ha	5.5 ha	14.6 ha	19.1 ha	5.1 ha	10.5 ha	7.8 ha
Total vegetation removed	23.2 ha	25 ha	29.5 ha	28.1 ha	32.6 ha	12.6 ha	33.8 ha	22.6 ha
Area of key (regionally signif) habitat removed	13.5 ha	13.2 ha	18.0 ha	23.1 ha	27.1 ha	5.7 ha	22.1 ha	15.5 ha
Area of high diversity habitat removed	16.0 ha	15.0 ha	21.2 ha	12.2 ha	13.7 ha	5.9 ha	22.0 ha	13.3 ha
Area of regional corridors removed	45.1 ha	34.2 ha	57.3 ha	39.5 ha	42.2 ha	18.1 ha	59.7 ha	54.7 ha
Distance of route through regional corridors	6.2 km	4.4 km	7.8 km	4.9 km	4.6 km	2.2 km	9 km	9.3 km
Area of subregional corridors removed	2.7 ha	0 ha	0 ha	0 ha	0 ha	0 ha	0 ha	0 ha
Distance of route through possible OPP habitat	2.7 km	2.7 km	7.6 km	0 km	0 km	0 km	7.6 km	7.6 km
No. known threatened plant species impacted	2 (1 EPBC, 1 TSC)	2 (1 EPBC, 1 TSC)	2 (1 EPBC, 1 TSC)	0	0	0	2 (1 EPBC, 1 TSC)	2 (1 EPBC, 1 TSC)
No. potential threatened plant species impacted	39 (24 EPBC, 15 TSC)	39 (24 EPBC, 15 TSC)	39 (24 EPBC, 15 TSC)	15 (6 EPBC, 9 TSC)	15 (6 EPBC, 9 TSC)	11 (5 EPBC, 6 TSC)	39 (24 EPBC, 15 TSC)	39 (24 EPBC, 15 TSC)
No. known threatened fauna species impacted	18 (1 EPBC, 17 TSC)	18 (1 EPBC, 17 TSC)	12 (1 EPBC, 11 TSC)	10 (3 EPBC, 7 TSC)	11 (3 EPBC, 8 TSC)	2 (1 EPBC, 1 TSC)	18 (1 EPBC, 17 TSC)	18 (1 EPBC, 17 TSC)
No. threatened fauna species potentially impacted	36 (3 EPBC, 33 TSC)	36 (3 EPBC, 33 TSC)	43 (3 EPBC, 40 TSC)	43 (1 EPBC, 41 TSC)	40 (1 EPBC, 39 TSC)	45 (3 EPBC, 42 TSC)	36 (3 EPBC, 33 TSC)	33 (3 EPBC, 30 TSC)
No. regionally significant species potentially impacted	29 (24 fauna, 5 flora)	29 (24 fauna, 5 flora)	29 (24 fauna, 5 flora)	27 (24 fauna, 3 flora)	27 (24 fauna, 3 flora)	24 (all fauna)	28 (23 fauna, 5 flora)	29 (24 fauna, 5 flora)
No. migratory species potentially impacted	3	3	4	4	4	4	4	4
Area SEPP 14 wetlands impacted	1.3 ha	1.2 ha	0 ha	0 ha	0 ha	0 ha	0 ha	0 ha
Barrier effects	High	Medium	Very High	Low-Med	Low-Med	Low-Med	Very High	Very High
Fragmentation impacts	Medium	Medium	Medium	High	High	Low	Medium	Medium

Ecological criteria	Route Options		
	3A	3B	P3
Area of nationally significant vegetation removed	0.3 ha	0 ha	0.3 ha
Area of EECs to be removed	5.6 ha	17.1 ha	15.5 ha
Area of regionally significant vegetation removed	0 ha	0.3 ha	0.7 ha
Total vegetation removed	9.0 ha	17.4 ha	16.4 ha
Area of key (regionally signif.) habitat to be removed	0.01 ha	4.0 ha	4.1 ha
Area of high diversity habitat removed	7.4 ha	17.4 ha	15.8 ha
Area of regional corridors removed	6.8 ha	2.5 ha	2.4 ha
Distance of route through regional corridors	1.1 km	0.2 km	0.5 km
Area of sub-regional corridors removed	13.9 ha	13.3 ha	12.4 ha
Area of known/likely habitat for OPP to be removed	0	0	0 ha
No. known threatened plant species impacted	0	0	0
No. potential threatened plant species impacted	15 (6 EPBC, 9 TSC)	6 (3 EPBC, 3 TSC)	6 (3 EPBC, 3 TSC)
No. known threatened fauna species impacted	7 (7 TSC)	2 (2 TSC)	7 (7 TSC)
No. potential threatened fauna species impacted	32 (1 EPBC, 31 TSC)	39 (3 EPBC, 36 TSC)	34 (3 EPBC, 31 TSC)
No. regionally significant species potentially impacted	20 (17 fauna, 3 flora)	22 (21 fauna, 1 flora)	20 (19 fauna, 1 flora)
Area SEPP 14 wetlands to be removed	0.9 ha	0.9 ha	0.9 ha
Barrier effects	Low-Medium	Low	Low
Fragmentation Impacts	Low-Medium	Low	Low