

3. Description of the study area

This Chapter describes the study area and locality in terms of the existing environment, including vegetation communities, terrestrial flora and fauna and aquatic habitats and fauna, based on the results of the desk-based and field assessments.

3.1 Landscape context

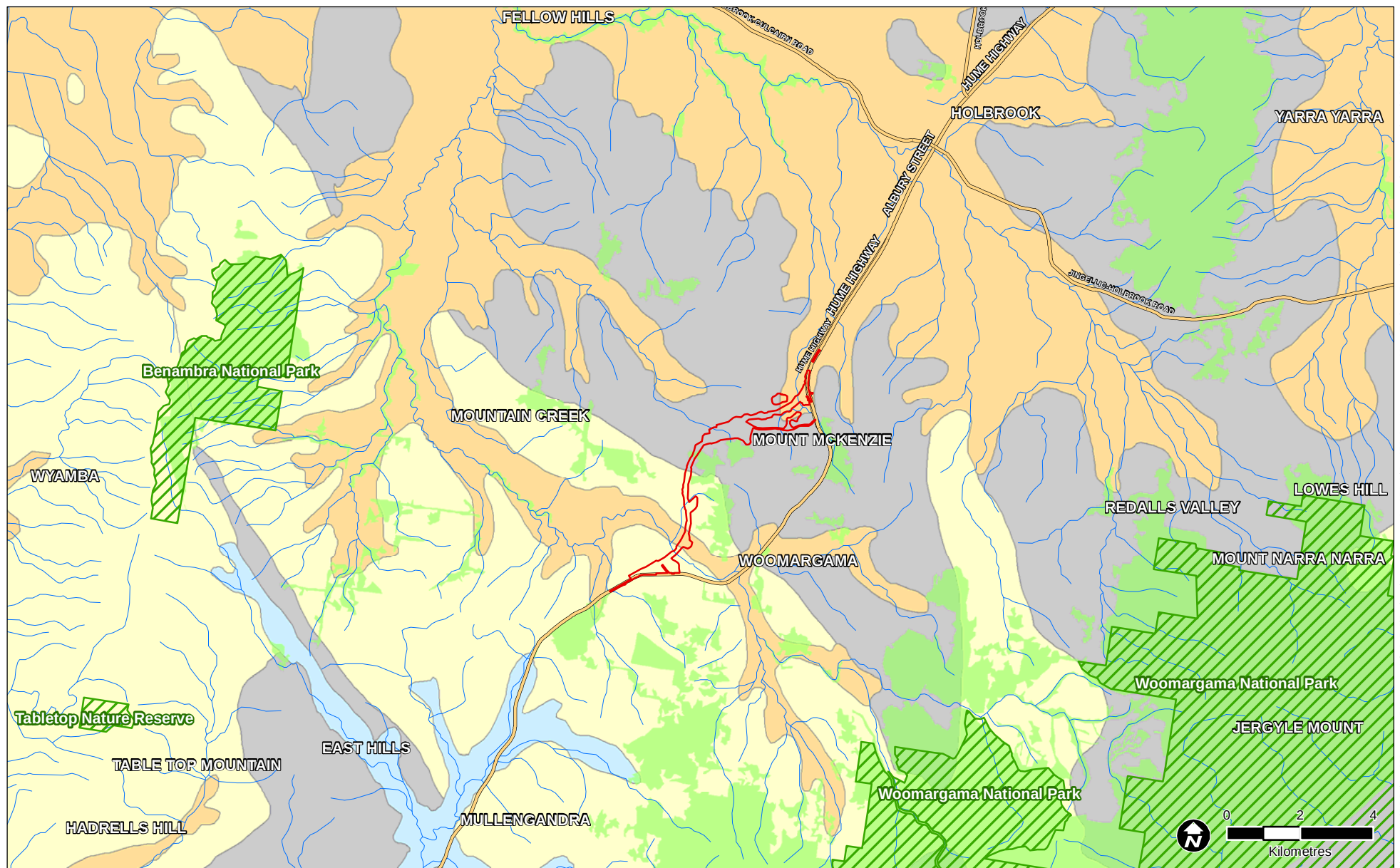
The Proposal lies within the NSW South Western Slopes bioregion (Thackway & Cresswell 1995). This bioregion consists of 8,070,608 hectares of foothills and ranges, comprising the western fall of the Great Dividing Range to the edge of the Riverina Bioregion. It has hot summers, with summer and winter rainfall. Remaining native vegetation is dominated by eucalypt woodlands, *Callitris* forests and woodlands, and eucalypt tall open forests. Patches of low closed forests and closed shrublands, eucalypt open woodlands, grasslands and *Acacia* forests and woodlands occur (NSW National Parks and Wildlife Service 2003).

Major land uses are grazing of native and modified pastures, native forests and nature conservation (NSW National Parks and Wildlife Service 2003).

The region has been largely cleared of eucalypt woodlands for grazing and dryland agriculture, with the larger remaining areas of vegetation now occurring on the rockier, hilly areas, or as roadside vegetation.

Four conservation reserves occur within the local area. Woomargama National Park occurs approximately six kilometres to the south-east of the current highway (see Figure 3-1). This park is the largest protected area west of the Great Dividing Range in south-eastern NSW and contains the largest remnant of box woodlands on the South-West Slopes. It is an important haven for a large number of Threatened or rare species, such as the Regent Honeyeater, Swift Parrot, Powerful Owl, Brown Toadlet and Carpet Python (NSW National Parks and Wildlife Service 2006). Benambra National Park occurs approximately 13 kilometres to the west of the current highway and covers an area of 1,399 hectares, while Tabletop Nature Reserve occurs to the south-west of the current highway and covers 102 hectares (see Figure 3-1). Both reserves contain the Threatened White Box, Yellow Box, Blakely's Red Gum woodlands, and play an important role in the landscape as fragmented vegetated links between the forested country to the south (including Woomargama National Park) and the open woodland country to the north (including Livingstone National Park, Nest Hill Nature Reserve and The Rock Nature Reserve) (NSW National Parks and Wildlife Service 2004). Mullengandra Nature Reserve occurs approximately 12 kilometres to the south of the current highway and covers an area of 80 hectares. A number of Threatened species have been recorded in these reserves (see Table 3-1).

The Proposal would cross Mountain Creek. Mountain creek begins approximately 10 kilometres to the east in Woomargama National Park (Figure 3-1), and flows in a north-west direction, past Woomargama, until it joins Billabong Creek. Billabong Creek flows to the west and drains to the Murray River 350 kilometres west of Holbrook.



- Clearing boundary
- Classified road
- Drainage
- Forest Ecosystem Southern CRA Vegetation Mapping
- National parks
- Mitchell landscapes**
 - Brokong Plains
 - Wonga Hills and Ranges
 - Tipperary Hills Granites
 - Murray Channels and Floodplains

Figure 3-1 Landscape context for the Proposal

Table 3-1 Threatened species recorded in surrounding conservation reserves

Scientific name	Common name	TSC ¹	EPBC ²	Woomargama National Park	Benambra National Park	Tabletop Nature Reserve	Mullengandra National Park
<i>Litoria booroolongensis</i>	Booroolong Frog	E1		●			
<i>Litoria raniformis</i>	Southern Bell Frog	E1	V	●			
<i>Stictonetta naevosa</i>	Freckled Duck	V		●			
<i>Climacteris picumnus</i>	Brown Treecreeper	V		●	●	●	●
<i>Grantiella picta</i>	Painted Honeyeater	V		●			
<i>Melanodryas cucullata</i>	Hooded Robin	V			●	●	
<i>Melithreptus gularis gularis</i>	Black-chinned Honeyeater	V			●	●	
<i>Neophema pulchella</i>	Turquoise Parrot	V		●	●	●	
<i>Ninox strenua</i>	Powerful Owl	V		●			
<i>Pyrrholaemus sagittatus</i>	Speckled Warbler	V			●	●	●
<i>Stagonopleura guttata</i>	Diamond Firetail	V			●		●
<i>Cercartetus nanus</i>	Eastern Pygmy-possum	V			●		
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheath-tail Bat	V		●			
<i>Falsistrellus tasmaniensis</i>	Great Pipistrelle	V		●			
<i>Nyctophilus timoriensis</i>	Greater long-eared Bat	V		●	●		
<i>Petaurus norfolcensis</i>	Squirrel Glider	V		●	●		
<i>Phascolarctos cinereus</i>	Koala	V		●			
<i>Senecio garlandii</i>	Woolly Ragwort	V	V	●		●	
<i>Acacia phasmoides</i>	Phantom Wattle	V	V	●			

Notes: Data from BioNet (Department of Environment and Climate Change 2009b)

1. V = Vulnerable, E1 = Endangered - *Threatened Species Conservation Act 1995*
2. V = Vulnerable - *Environment Protection and Biodiversity Conservation Act 1999*.

3.1.1 Mitchell Landscapes

Mitchell Landscapes are a system of ecosystem classification mapped at the 1:250,000 scale, based on a combination of soils, topography and vegetation (NSW National Parks and Wildlife Service 2002b).

The Proposal lies within the Tipperary Hills Granites, Wonga Hills and Ranges, and additional Brokong Plains (Figure 3-1). These landscapes are described below based on the descriptions by the NSW National Parks and Wildlife Service (NSW National Parks and Wildlife Service 2002b), including an estimation of clearing across the landscape. Clearing estimates are derived from the Mitchell landscapes percentage cleared estimates for CMA database (Department of Environment Climate Change 2007). Under the vegetation assessment tool (BioMetric version 2.0) (NSW Department of Environment and Climate Change 2008), a landscape that is greater than 70% cleared is considered to be over-cleared.

Wonga Hills and Ranges – 88% cleared

This landscape consists of rolling hills, low rises and ridges on Ordovician siltstone, slate, quartzite and phyllite, generally at elevations between 250 and 370 metres, with a local relief of 50 metres. It contains stony, thin, red and brown texture-contrast soils, merging to yellow harsh texture-contrast soils on valley floors. It has high salinity in the subsoil and some brackish flows in small creeks. The vegetation consists of woodlands of Tumbledown Red Gum, Red Stringybark and Grey Box on slopes; and Yellow Box, White Box and occasional Blakely's Red Gum on flats, with Kangaroo Grass and Plains Grass.

Tipperary Hills Granites – 70% cleared

This landscape includes rounded hills and peaks on Silurian massive and gneissic granite, with some gneiss and schist, generally at elevations between 400 and 930 metres and a local relief of 350 metres. Soils consist of gritty gradational red earths and red texture-contrast. Vegetation consists of forests of Yellow Box, Grey Box, Blakely's Red Gum, Red Stringybark, Red Box, Apple Box, Broad-leaved Peppermint and Black Cypress Pine. River Red Gums occur along streams.

Brokong Plains – 87% cleared

This landscape consists of quaternary alluvial plains, generally at elevations of 170 metres, with a local relief less than 10 metres. It contains red-brown texture contrast soils. Vegetation has been extensively cleared and cropped, and formerly would have consisted of Grey Box, Yellow Box, Blakely's Red Gum and White Cypress Pine woodland to open forest.

3.1.2 Patch sizes

The size of a remnant patch of vegetation can play an important role in its long-term viability (Gillfedder & Kirkpatrick 1998; Lonsdale 1999; Parkes *et al.* 2003), with larger patches generally having a better prognosis for long-term survival than smaller remnants more susceptible to disturbances (Drayton & Primack 1996; Renjifo 1999). A number of factors are thought to contribute to this, including:

- 'Edge effects', both biotic and abiotic (i.e. the ratio of patch perimeter to patch interior area is higher in fragmented landscapes (Saunders *et al.* 1991)).
- Species-area relationships (i.e. large areas tend to support more species than smaller ones (Burbidge *et al.* 1997)).
- Size of resident populations, which decreases with decreasing patch size (Zanette *et al.* 2000).

- Larger areas are more likely to retain refuges for susceptible species in or after disturbances, such as fires, floods or droughts (Lindenmayer & Burgman 2005).

The majority of patches within 20 kilometres of the Proposal are sized 20 hectares or greater (see Figure 3-2b). This figure does not, however, include the numerous patches of vegetation smaller than 10 hectares, which are common within the study area (see Figure 3-2a). In the general Holbrook area (including Woomargama), 54% of the remnant White Box, Yellow Box, Blakely's Red Gum Grassy Woodlands tree-cover occurs as patches of less than 1 hectare (Gibbons & Boak 2002).

Generally, patch sizes within the study area are small, indicating that in isolation each patch is likely to be significantly edge-affected and with a reduced capacity to maintain viable populations. However, in combination they may provide significant habitat and connectivity within the landscape (see below).

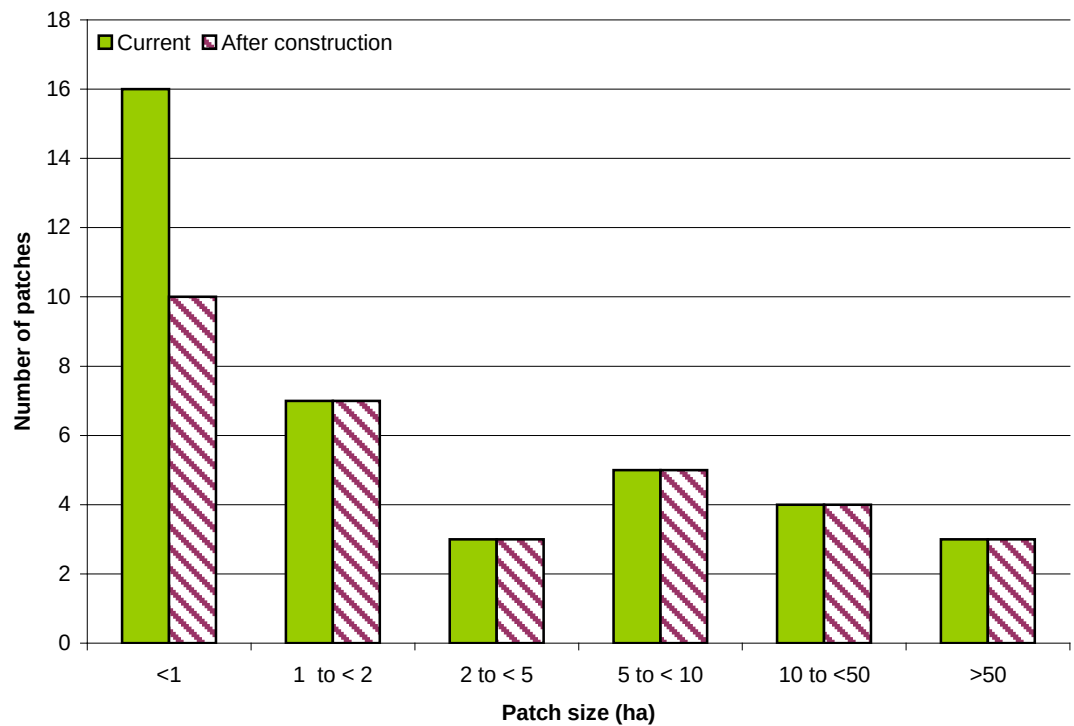
The size of patches can, by themselves, be misleading, since the shape can also play an important role in determining species composition. Linear strips, such as roadside and creek side vegetation, can become 'edge' habitats that may be unsuitable for species dependent on forests (Bennett 1993). Many of the species recorded in the study area are species that forage in open farmlands (e.g. Eastern Rosella and Red-rumped Parrot), and the majority of true woodland species were found within the larger patches.

3.1.3 Neighbourhood

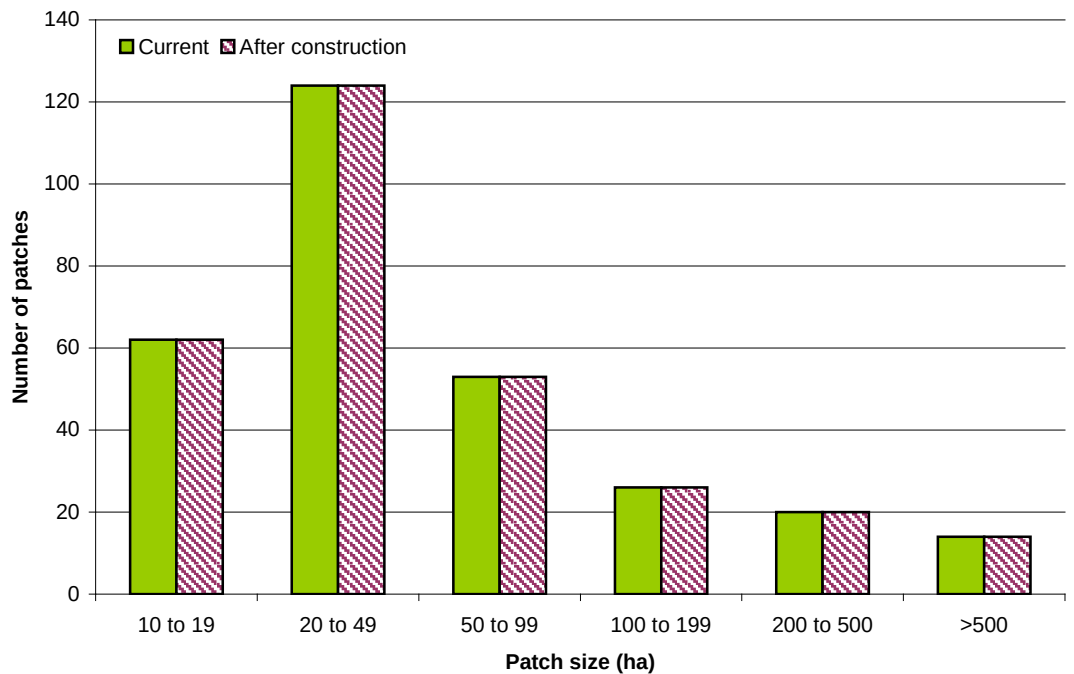
The degree to which remnant vegetation is connected to other areas of native vegetation often influences the regenerative capacity of a site, and therefore, its long-term viability. In the longer term, populations may 'move' across the landscape, taking advantage of short-term changes that provide suitable habitat, at the same time as other local changes decrease their ability to survive at sites of current occupation (Morgan 1998). Their ability to occupy newly-suitable sites depends on the ability of individuals, or their propagules, to arrive at the newly-suitable site, and hence, depends on the connectivity between sites (Parkes *et al.* 2003).

Connections through the landscape may be physical linkages, such as with adjacent blocks of vegetation, or more narrow links, such as corridors. Alternatively, connections may not be through physical linkages, but may be due to dispersal of both plants and animals between blocks of native vegetation that are separated from one another (Parkes *et al.* 2003).

A number of studies have shown that woodland species of animal require a certain level of vegetation cover within the landscape. For example, Reid (2000) suggests that declining woodland birds drop out when native cover in the landscape falls below 30 per cent. Similarly, McIntyre *et al.* (2000) suggest a minimum 30 per cent woodland cover is required to maintain ecological sustainability on grazed properties. Bennett and Radford (2004) suggest that there is a sharp decline in the species richness of woodland birds in landscapes with a habitat cover less than 10 per cent.



(a) Patches within 200 m of the construction footprint including detailed vegetation maps (minimum patch size 0.1 ha)



(b) Patches within 20 km of the construction footprint using broad-scale vegetation mapping (minimum patch size 10 ha)

Figure 3-2 Distribution of vegetation patch size within the Woomargama study area

Within the locality of the Proposal, approximately 11 per cent of the landscape is vegetated (at a minimum patch resolution of 10 hectares) (see Table 3-2). It is likely, however, that the broad-scale mapping of patches greater than 10 hectares would underestimate the level of cover within the landscape (refer small patches at the 100 metre distance in Table 3-2). However, in this case there still remains less than 10 per cent cover in the area of the project (8%).

Table 3-2 Percent vegetation surrounding the Woomargama Proposal

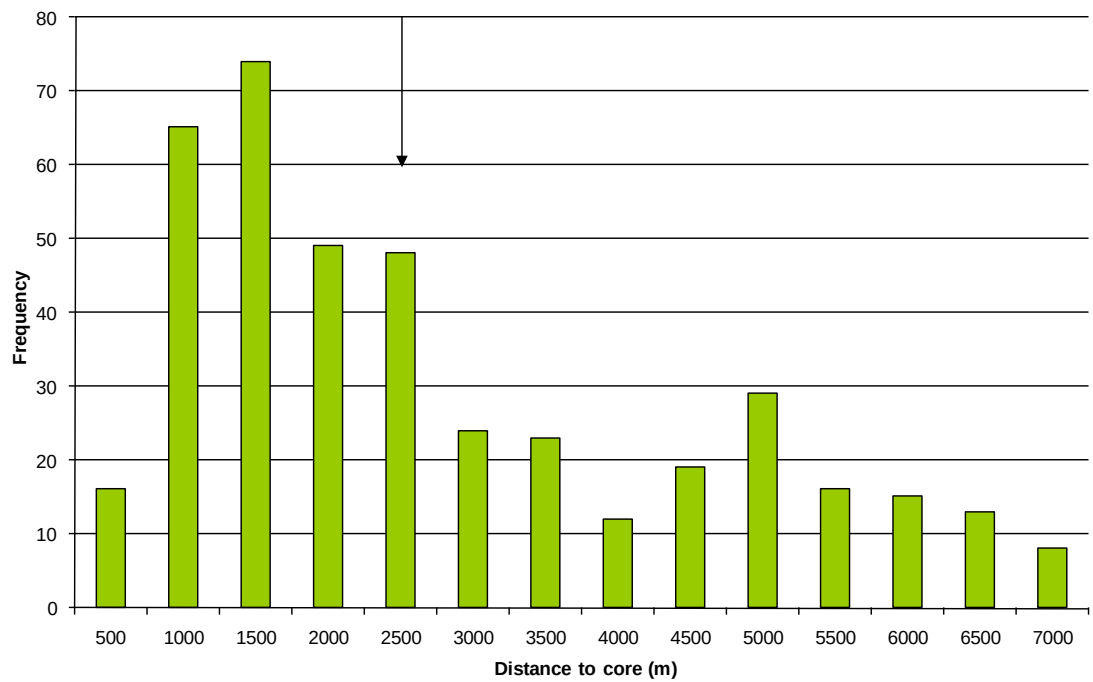
Buffer distance	Total area (hectares)	Vegetation (hectares)	% vegetation
100 metres (including small patches)	280	21	8
100 metres (patches larger than 10 hectares)	280	8	3
1 kilometre (patches larger than 10 hectares)	2286	389	17
2 kilometres (patches larger than 10 hectares)	5059	616	12
5 kilometres (patches larger than 10 hectares)	16922	1812	11

This pattern of vegetation clearing places an upper limit on the size that populations can achieve, regardless of the distribution of the vegetation. The fragmented nature of the remaining vegetation can only reduce the population sizes in the region for woodland-dependent species. Conversely, the loss of vegetation in the landscape has meant that species able to use farmland and grassland environments have increased amounts of habitat available. Based on the threshold limit for woodland birds suggested by Bennett and Radford (2004), the study area is unlikely to be currently capable of maintaining viable populations of woodland birds.

3.1.4 Distance to core

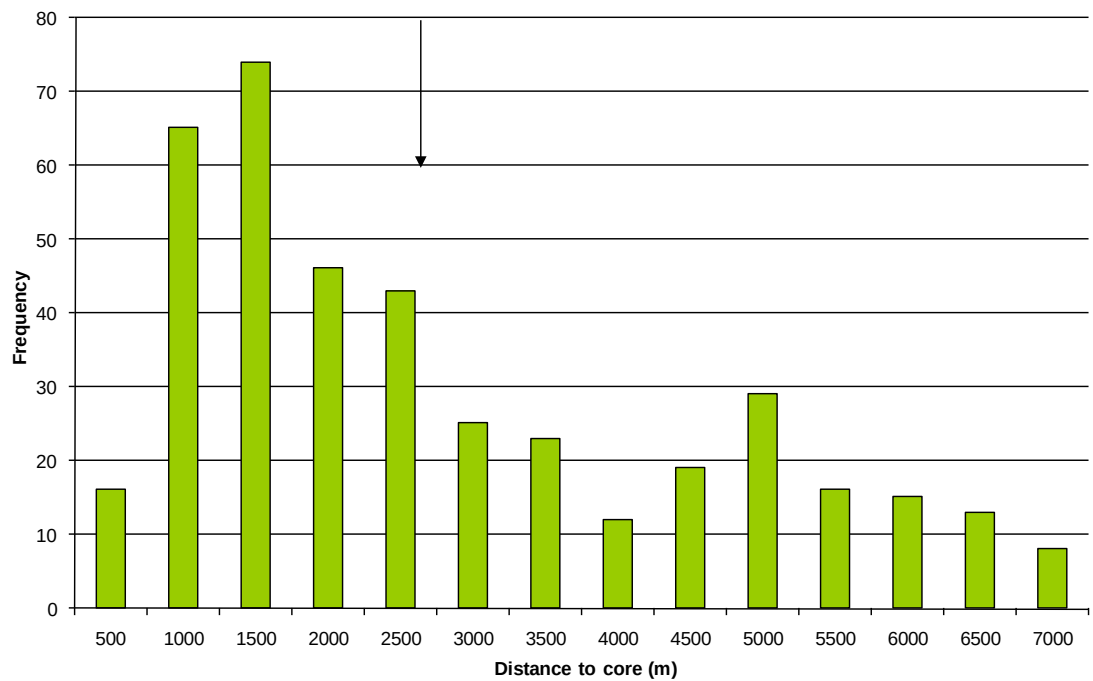
The survival of a population within a small remnant patch of vegetation may be supported by the nearby location of a larger patch of habitat, through what is known as metapopulation dynamics. A metapopulation is defined as a set of local populations that interact via individuals moving between local populations (Hanski 1999). Within a landscape, larger patches in which larger populations are secure and only rarely become extinct, can act as a source of individuals for smaller patches in which extinctions are regular, thereby maintaining the presence of a species in the smaller patches (Arnold *et al.* 1993; Hanski 1999; Lindenmayer & Burgman 2005).

Currently within the study area, the majority of remnant vegetation patches (85 per cent) are distant from a core area (greater than 500 metres) (see Figure 3-3). However, 17 (15 per cent) of the remnants within the Woomargama study area are less than 500 metres from the nearest core area, indicative that remnant areas are rather fragmented within the area.



Arrow indicates mean value.

Figure 3-3 Frequency of distance to core for vegetation patches in the Woomargama Proposal before the bypass



Arrow indicates mean value

Figure 3-4 Frequency of distance to core for vegetation patches in the Woomargama Proposal after the bypass

Taking into consideration the Proposal clearing boundary, the project will remove seven patches of vegetation within the study area. This is less than two per cent of all patches within the area and shifts the average distance to core by 9 metres from 2,542 metres to 2,551 metres (see Figure 3-4). This indicates that the Proposal will have only a minor impact on the distance to core areas.

3.1.5 Corridors and connectivity

Wildlife corridors can be defined as 'retained and/or restored systems of (linear) habitat which, at a minimum enhance connectivity of wildlife populations and may help them overcome the main consequences of habitat fragmentation' (Wilson & Lindenmayer 1995). Corridors can assist ecological functioning at a variety of spatial and temporal scales, from daily foraging movements of individuals, to broad-scale genetic gradients across biogeographical regions.

Corridors serve a number of different functions in terms of biodiversity conservation including:

- Providing increased foraging area for wide-ranging species.
- Providing cover for movement between habitat patches, particularly for cover-dependent species and species with poor dispersal ability and enhancing the movement of animals through sub-optimal habitats.
- Reducing genetic isolation.
- Facilitating access to a mix of habitats and successional stages to those species that require them for different activities (for example, foraging or breeding).
- Providing refuge from disturbances such as fire.
- Providing habitat in itself.
- Linking wildlife populations and maintaining immigration and re-colonisation between otherwise isolated patches. This in turn may help reduce the risk of population extinction (Wilson & Lindenmayer 1995).

How species use a corridor network depends largely on the home and activity ranges of the species, their habitat requirements and the ecological characteristics of the corridor. For example, some large or mobile species may make direct movements through a corridor network, moving from one patch of habitat to another. These direct movements may be on the scale of a foraging expedition or a migration (Bennett 1990). Other species may have movements by single individuals punctuated by pauses in the corridor, which can last anything from a small foraging or resting bout to weeks and even months. If the corridor contains sufficient resources to maintain a population, then continuity through the corridor may be through gene flow through the resident population (Bennett 1990; Wilson & Lindenmayer 1995).

Vegetation within the locality of the Proposal is highly fragmented, surrounded by large expanses of cleared land. Although some vegetation in patches is of sufficient size to maintain viable populations, in many cases there may be only limited connectivity among the patches, given the extent of clearing and the distance to core areas. Even small patches may, however, provide stepping stones within the wider landscapes (Bennett 1993).

In such a modified landscape, vegetation within roadside reserves can play an important role in the connectivity of remnant patches of vegetation and is often used by species that will not move across the more open surrounding matrix (refer Figure 3-5). For example, it has been shown that at Barmah Forest in Victoria, the Superb Parrot nests in large River Red Gums in the forest and feeds in remnant Box Woodlands in nearby farmland. These birds regularly use forested roadside corridors as a pathway for flight between habitats, instead of flying across open paddocks (Webster 1988 cited in Bennett 1990, 1993).

The roadside reserve corridors will be affected by the Proposal to the north and south of Woomargama, where the existing Hume Highway is upgraded and bypass diversions are created.

Given the width and condition of the vegetation within the road reserve and the presence of a number of nodes, or larger patches of vegetation adjacent to the road reserve, it is likely that these areas are used by a range of species, predominately birds and mammals, as part of a wider corridor network.

The former Holbrook Shire Council (now incorporated into the Greater Hume Shire) commissioned a roadside vegetation survey throughout the shire that classed roadside vegetation conservation value as high, medium or low (Costello 2001). Vegetation on both sides of the current highway surrounding Woomargama was classified as medium conservation value. Medium conservation value roadsides are those environments that can benefit most from active management, such as weed control and supplemental planting.

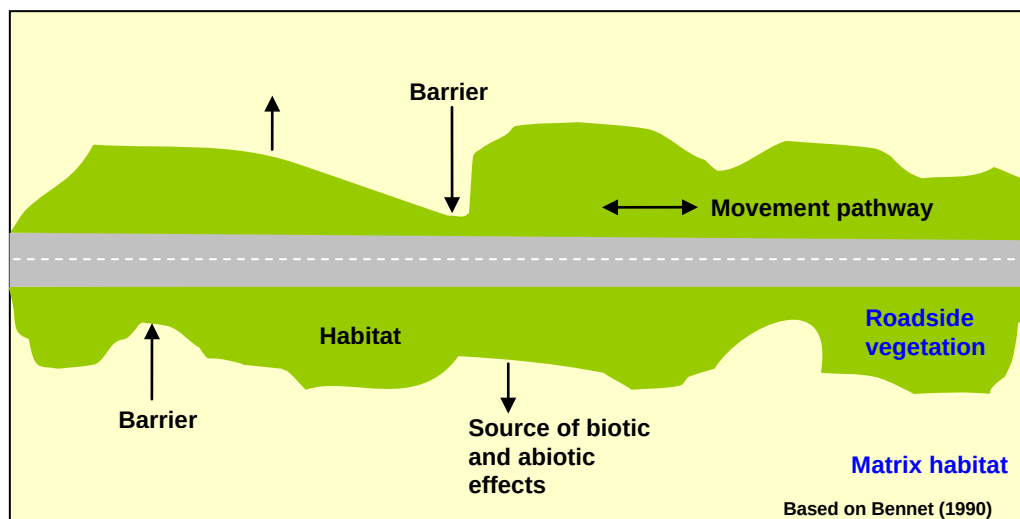


Figure 3-5 Diagrammatic representation of roadside vegetation and the main functions of the corridor

The Murray Catchment Management Authority has prepared biolink mapping of the Murray Catchment. Biolinks are not corridors in the traditional sense (Brereton et al. 1995), but rather landscapes across which there is increased tree and native vegetation cover. Corridors would form local scale contributions to the broader biolink landscape. The biolink mapping of the Murray Catchment was based on the following criteria for inclusion as part of the biolinks:

- Any vegetation or proposed vegetation within 2 kilometres of a 'special bit' was considered part of a critical corridor or biolink. The implementation officers determined the 'special bits' for their relevant areas.
- Sites >10 hectares within 1 kilometres of a riparian zone that showed value as a corridor (through the presence of mapped vegetation cover).
- Any sites outside these zones that was within 1 kilometre of a 100 hectare block of vegetation.

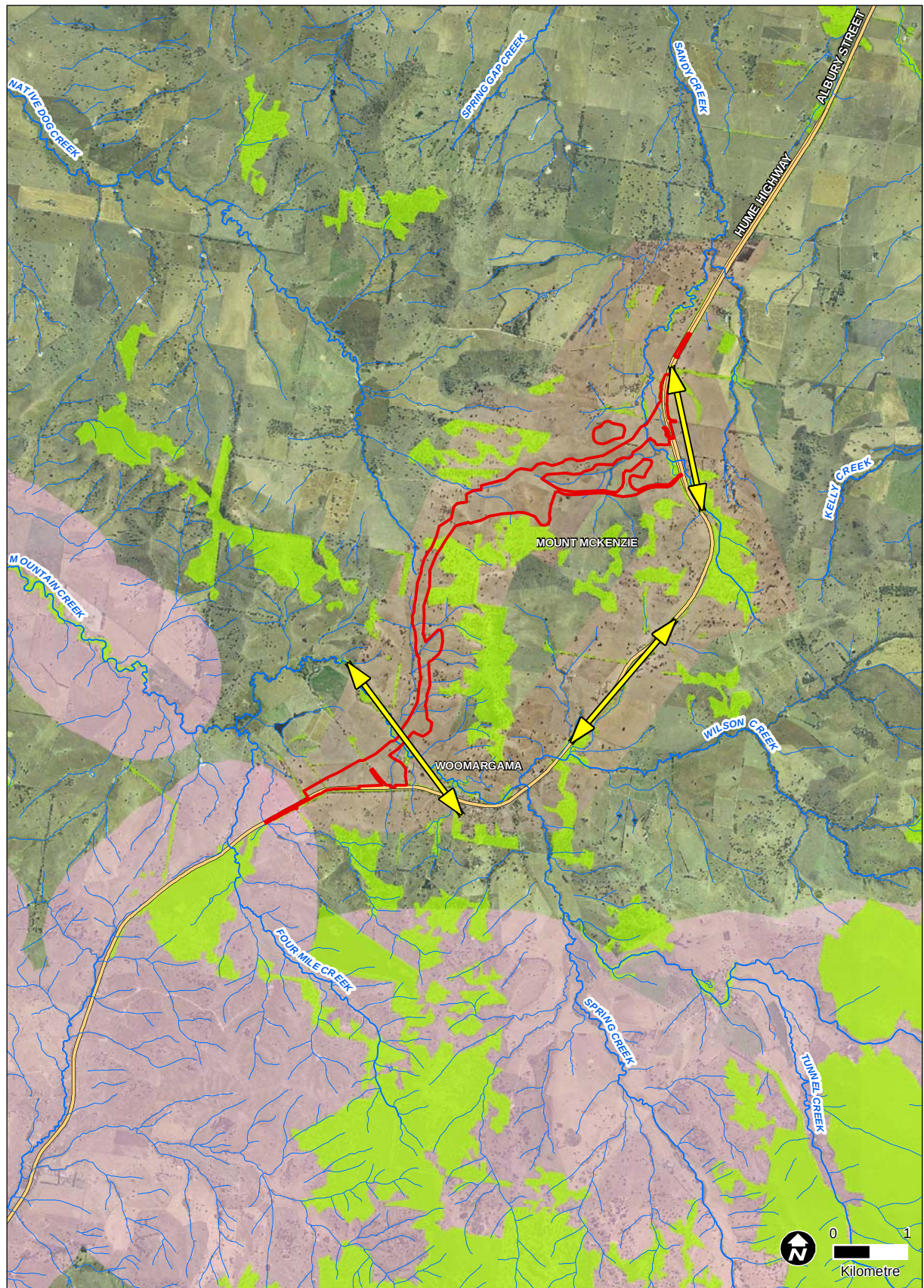
The southern extent of the study areas falls within sites identified as part of the broad Murray biolinks (see Figure 3-6).

Aside from these broad linkages and the existing roadside vegetation, corridors within the study area would also be associated with the riparian vegetation of Mountain Creek.

3.1.6 Summary of landscape context

The analysis of the landscape context presented above indicates that the study area lies within a landscape that has been significantly modified through anthropogenic disturbance, including cropping, grazing and other developments. The remaining vegetation is highly fragmented, occurring mainly as small remnant patches spread across the landscape. Larger patches of vegetation do remain in the locality/ landscape, including Woomargama National Park, which occurs approximately six kilometres to the south-east of the current highway alignment (see Figure 3-1). This park is the largest protected area west of the Great Dividing Range in south-eastern NSW and contains the largest remnant of Box-gum Woodland within south-west slopes bioregion.

The pattern of vegetation clearing has reduced the condition of vegetation remaining within the study area, but at the same time has increased its significance both in terms of its conservation value (the majority of the vegetation within the study area is listed as a Critically Endangered Ecological Community) and its role in the broad-scale corridor network. In such a modified landscape, vegetation within the study area can play an important role in the connectivity of remnant patches of vegetation in the broader landscape.



- Clearing boundary
- Biolink
- Local corridor
- Drainage
- Vegetation
- Classified road

Figure 3-6 Biolinks and local corridors

3.2 Vegetation communities

Four broad vegetation communities were identified during the ecological investigation (ngnhenvironmental 2007). These are described below based on ngnhenvironmental (2007) and are shown in Figure 3-7.

3.2.1 Box-gum woodland

Box-gum Woodland is characterised by the presence or prior occurrence of White Box (*Eucalyptus albens*), Yellow Box (*Eucalyptus melliodora*) or Blakey's Red Gum (*Eucalyptus blakelyi*). Given that the estimated proportion of Box-gum Woodland remaining across the south-west slopes bioregion is less than five percent, Priday and Mulvaney (2005) suggest that all remnants of this community should be considered to be of conservation significance. Thus, identified remnants of Box-gum Woodland within the study area were classified by their condition (Low, Moderate or High) and their legal status was determined (Table 3-3).

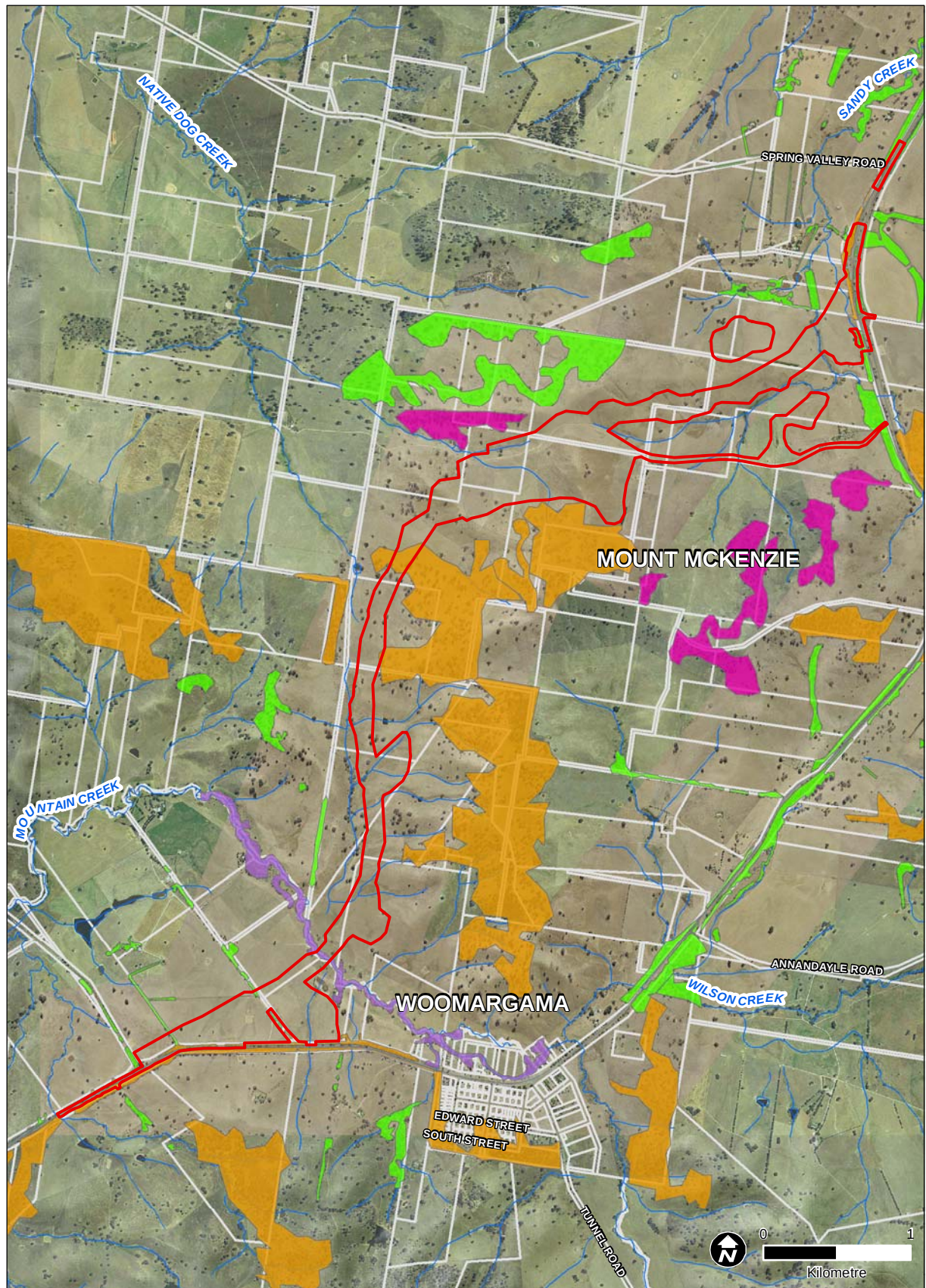
While agricultural clearing has resulted in most of the remnants of this community being confined to the Hume Highway roadside corridor, patches still remain spread throughout the local area. The remnants that exist away from the roadside corridor have been subject to higher levels of disturbance such as heavy grazing due to (lack of grasses and herbs), firewood removal due to (lower levels of fallen timber) and invasion by introduced flora species (e.g. *Phalaris*, *St Johns Wort*).

Table 3-3 Box-gum Woodland surveyed in the study area

Survey site*	Consistent with TSC Act	Consistent with EPBC Act	EPBC comment
WB1	Yes	Yes	Larger than 2 ha and has more than 20 mature trees per ha
WM1	Yes	Yes	Larger than 2 ha and has more than 20 mature trees per ha
WM2	Yes	Yes	Larger than 2 ha, natural regeneration present
S2	Yes	No	Although larger than 2 ha, not more than 20 trees per hectare and no natural regeneration evident

Source: ngnhenvironmental (2007)

* Site codes refer to those presented in Figure 2-1



- ▬ Clearing boundary
- ▬ Drainage

Vegetation communities

- Box Gum Woodland
- Riparian vegetation
- Rocky Outcrop Woodland
- Potential Box Gum Woodland*

* vegetation classified as 'other tree cover' in previous studies which 'may contain Box Gum Woodland'

Figure 3-7 Vegetation communities within the study area

Within the study area, remnants of this community were dominated or co-dominated by White Box, Yellow Box or Blakely's Red Gum. Other canopy species present included Apple Box (*Eucalyptus Bridgesiana*) and Long-leaved Box (*Eucalyptus goniocalyx*). The shrub layer was absent in all remnants, a common feature of remnants in the south-west slopes. Shrub species present as single or several plants included Golden Wattle (*Acacia pycnantha*) and Silver Wattle (*Acacia dealbata*). Grasses and forbs were a mix of exotic and native species, however, some remnants had a high diversity of native grasses. Native grasses and forbs present include Wiregrasses (*Aristida jerichoensis* and *A. behriana*), Kangaroo grass (*Themeda triandra*), Bluebell (*Wahlenbergia* sp.) and Golden Everlasting (*Xerochrysum bracteatum*).

All remnant areas suffered from weed invasion and had a high abundance of exotic floral species comprising of up to 50 per cent of the vegetation cover. Species included wild fruit trees (*Prunus* sp.), rose bushes such as Sweet Briar (*Rosa rubiginosa*), forbs such as St Johns Wort (*Hypericum perforatum*) and grasses such as Phalaris (*Phalaris* sp.).

This community is consistent with White Box Yellow Box Blakely's Red Gum Woodland as listed under the *Threatened Species Conservation Act 1995* and White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland as listed under the *Environment Protection and Biodiversity Conservation Act 1999* (see Section 4.1.1 and Section 4.2.1).

3.2.2 Rocky Outcrop Woodland

Rocky Outcrop Woodland was characterised by a number of species found also in Box-gum Woodland. However, sites dominated by other tree species that do not have White Box, Yellow Box or Blakely's Red Gum as co-dominants, or would have been unlikely to be present in the past, are not considered as part of the Box-gum Woodland community and do not form part of the Endangered Ecological Community.

Rocky Outcrop Woodland communities occurred to both the east and west of the study area, where the soils were poorer quality and rock outcrops occur. Characteristic species included Tumbledown Red Gum (*Eucalyptus dealbata*), Rock Fern (*Cheilanthes austrotenuifolia*), Currawong (*Acacia doratoxylon*) and Kurrajong (*Brachychiton populneus*).

The presence of Rocky Outcrop Woodland on steeper slopes with unproductive soils has limited the extent of grazing and cropping and therefore disturbance to this community. Although native flora abundance was lower than expected during the survey period (i.e. during a drought), in average rainfall periods it is expected to be dominated by native grasses and forbs.

Within the study area, remnants of this community were dominated by Tumbledown Red Gum (*Eucalyptus dealbata*), with other species including Red Stringybark (*Eucalyptus macrorhyncha*) and Apple Box (*Eucalyptus bridgesiana*). Numerous species of forbs, lilies and native grasses were present, with all remnants showing high levels of diversity, with abundance likely to be reduced due to the current drought.

The Rocky outcrop woodland remnants have a moderate level of weed invasion; however, weed abundance was far less than in the Box-gum Woodland of the lower slopes of the study area. St Johns Wort was the main species of concern, although is quite common across this community.

3.2.3 Cleared land with scattered eucalypts

The landscape has been subject to large scale clearing since European settlement. Much of the study area today is dominated by agricultural activities such as cropping and grazing. Within these cleared areas, isolated paddock trees of species such as Yellow Box and White Box exist. Such features in a highly modified landscape are likely to constitute valuable fauna habitats.

The intensive grazing practices of this community have resulted in high levels of disturbance, more evident in the drought present during the survey. The removal of fallen timber around paddocks for firewood and the destruction of leaf litter and soil compaction from livestock trampling is likely to result in the loss of microhabitat structure for fauna, loss of seedbank for flora and the inability of the community to store nutrients, slow runoff and reduce erosion potential. Despite this, isolated paddock trees have been recognised as providing important habitat features for fauna within agricultural landscapes (Gibbons & Boak 2002), where much of the remaining native vegetation has been removed.

At present these communities are dominated by exotic species including Saffron Thistle (*Carthamus lanatus*), Phalaris (*Phalaris* sp.), Perennial Ryegrass (*Lolium perenne*), Barley Grass (*Hordeum leporinum*) and Scotch Thistle (*Onopordum acanthium*).

3.2.4 Riparian vegetation

Riparian areas were identified by the presence of a permanent water body that is usually flowing, or semi-permanent water body that although presently dry, provides evidence of recent flow. This definition was deemed appropriate given the drought conditions during survey and its impact on this community. Riparian areas were usually characterised by the presence or likely prior occurrence of River Red Gum (*Eucalyptus camaldulensis*), as well as the occurrence of Willows (*Salix* sp.).

The main occurrence of this vegetation community was along Mountain Creek, located at the southern section of the study area (see Figure 3-7). Exotic floral species dominated most of the remnants of this community with Willows (*Salix* sp.) being present along the Mountain Creek system. Conversely, one area along Mountain Creek was identified as being dominated by native species such as Spiny-headed Mat Rush (*Lomandra longifolia*), numerous sedges (*Carex* sp. and *Cyperus* sp.), rush (*Juncus* sp.) and reed (*Phragmites* sp.) and does not appear to be extensively grazed.

Structural integrity of the shrub layer was generally absent in all remnants, a common feature of most riparian areas within the south-west slopes and a likely result of heavy and continued grazing. Exotic species include Chicory (*Cichorium intybus*), Arum Lily (*Zantedeschia aethiopica*) and Wild Turnip (*Brassica tournefortii*). As well as willows, numerous exotic tree species were also present including Oaks (*Quercus* sp.), Small Leaved Privet (*Ligustrum sinense*) and Golden Ash (*Fraxinus excelsior*).

3.3 Terrestrial fauna habitats

The suitability, size and configuration of the fauna habitats correlated broadly with the structure, floristic, connectivity and quality of the local and regional vegetation types. The majority of the fauna habitat was restricted to remnant stands of vegetation in an otherwise modified landscape. These areas of vegetation provide habitat for a range of woodland birds and mammals and limited reptiles and were in low to good condition.

Habitat features recorded along the proposed alignment generally include those associated with Woodland, Rock outcrops, Cleared land with scattered eucalypts and Riparian areas. The habitats and species associations are discussed below.

3.3.1 Woodland

Woodland habitat corresponds to the Box-gum woodland vegetation identified in section 3.2.1.

To determine a specific quality index of the woodland habitat within the study area is difficult due to overlapping effects of vegetation composition and structure, along with external effects such as drought and land management. Roadside woodland remnants are diverse in terms of native flora due to a lack of grazing. However, fallen timber and logs are absent, most likely due to collection from locals for firewood. Alternatively, all roads surveyed in the study area had bushfire hazard reduction, with adjacent properties ploughing firebreaks into the roadside reserve, which may also add to the removal of fallen wood. Conversely, many of the woodland areas on the private property have experienced varying levels of disturbance, dominated by grazing. With the drought conditions during the survey all areas surveyed indicated heavy effects of grazing. Many of the graziers within the study area recognise the value of large woody debris as an important resource for fauna. Although the removal of wood is a practise that has occurred for hundreds of years, many remnants still have sufficient quantities to provide habitat for a wide variety of fauna, including the regionally significant Yellow-footed Antechinus and Carpet Python. Weed management and the replacement of woody material or placement of artificial refuge are likely to enhance these areas of habitat for fauna benefits.

All woodland remnants should be regarded as having conservation significance throughout their remaining range as, although they may be highly disturbed remnants, they are likely to provide some habitat resources to Threatened and non-Threatened species. Moreover, all areas of Woodland habitat surveyed provided a variety of tree-hollows suitable for microbats and gliders (see Table 3-4).

Table 3-4 Fauna habitat values of woodland areas within the study area

Site ID	Vegetation community	No. of logs intersected > 100 mm	Mean rate of decay	Mistletoe	Hollow logs on ground	Hollows in trees	Mean % cover of native ground plant	General comments
WM4	Rock outcrop woodland	15	4	Yes	3	1	30	Although heavily grazed, this patch offers potential habitat to Diamond Firetails and Brown Treecreepers. However, its isolation is likely to lessen this value greatly. About 5% rocks with black ants. Native ground cover diversity moderate. Most rocks not eroded, so partially embedded rocks virtually non-existent. It has a southerly aspect as low potential for threatened reptiles.
WB1	Box-gum Woodland	25	3-4	Yes	4	3	10	Heavily grazed remnant, but lots of woody material with good levels of decay. Potential for quality habitat in better seasons. Yellow-footed Antechinus have been trapped here in previous studies.
WM1	Box-gum Woodland	12	2	Yes	0	2	20	Some regeneration occurring, lots of exotic plant cover, woody material absent, likely from firewood collection.
WM2	Box-gum Woodland	29	4	Yes	4	5	50	Some regeneration of understorey species, but structural layer still could not be considered present. Good habitat, with lots of hollows. Squirrel Glider potential is high.
S2	Cleared land with scattered eucalypts	8	3	Yes	3	0	8	Very heavily grazed, with extreme disturbance from stock. Lots of bare ground. Most timber has been removed. Potential for Squirrel Gliders is quite low, but possible.

Notes: 1 – See Figure 2-1 for site codes

3.3.2 Rock outcrops

Rocky outcrops are present to both the east and west of the Proposal. The main fauna habitat feature concerned the presence of partially imbedded rocks with moderate to good native ground cover diversity. The most likely Threatened fauna to inhabit such areas is the Pink-tailed Worm Lizard and the Striped Legless Lizard.

Disturbance to Rocky outcrops is likely to be far less than Woodland areas, due to their occurrence on steeper less accessible slopes. Although the general flora abundance was much lower than expected, with a moderate level of weed invasion, in times of average rainfall, the area is expected to be dominated by native grasses and forbs.

Potential areas of habitat for the Pink-tailed Worm Lizard and Stripped Legless Lizard were identified within the study area. However, due to the drought conditions during previous field surveys, sampling of these species became problematic as they burrow deeper in the soil cracks, voids and ant burrows to avoid the harsher, surface conditions. The closest site in proximity to the Proposal was site WM4, but this was considered poor quality habitat for Threatened reptiles (see Table 3-4).

3.3.3 Cleared land with scattered eucalypts

Fauna resources have previously been reduced in cleared land with scattered eucalypt habitat. However, the presence of some tree hollows, mistletoe and other foraging resources did provide limited habitat for Threatened and non-Threatened species of fauna. Such habitats are more commonly used by generalist species such as open country species of bird.

Extensive trampling and destruction of leaf litter by stock is evident around these areas. Removal of fallen timber for use as firewood is likely to have resulted in the loss of suitable microhabitat structure for fauna, heavy grazing is likely to reduce the seedbank of flora, and the inability of the community to store nutrients, slow run-off and reduce erosion potential.

This habitat type is unlikely to support any resident threatened species. However scattered paddock trees have been known to support Squirrel Gliders in agricultural dominated landscapes (van der Ree 2006). Further, isolated paddock trees have been recognised as providing important habitat features for fauna within agricultural landscapes (Gibbons & Boak 2002), where much of the remaining native vegetation has been removed. Higher quality habitat for threatened and non-threatened fauna is found in other habitats across the study area.

3.3.4 Riparian areas

Riparian areas were identified by the presence of a permanent water body that is usually flowing, or semi-permanent water body that although presently dry, provides evidence of recent flow. This definition was deemed appropriate given the current drought conditions and its impact on this community. Riparian areas were usually characterised by the presence or likely prior occurrence of River Red Gum (*Eucalyptus camaldulensis*), as well as, the occurrence of Willows (*Salix* sp.).

The proposed Hume Highway bypass would cross Mountain Creek. The majority of Mountain Creek neighbouring the existing Hume Highway is heavily infested with exotic species. In particular, the presence of willow species appeared to be altering the flow regime and adding excessive exotic leaf litter to the channel. However, this section of Mountain Creek still hosted numerous species of typical riparian areas and water bodies such as waterbirds and migratory birds such as Dollarbirds and Rainbow Bee-eaters.

A unique example of river red gum forest within the study area in excellent condition lies to the west of the proposed Mountain Creek crossing. Willow infestation is very low, although there appears to be some downstream dispersal, so without appropriate management this area will also become infested. Despite this, the presence of river red gum and a predominately native understory provides good value habitat. The flowering eucalypts have been observed providing thousands of honeyeaters with a reliable food source, which suggests that these trees are in good condition and that this resource is especially important during the present drought conditions (ngnvironmental 2007).

3.4 Aquatic habitat

The proposed bypass works fall within the Mountain Creek catchment and would cross Mountain Creek approximately two kilometres downstream of the existing Hume Highway crossing and a small drainage line called Sandy Creek which flows in a general northerly direction and is a tributary of Ten Mile Creek. The existing Hume Highway crosses Mountain Creek at Woomargama to the east of the village.

Mountain Creek is a tributary of Billabong Creek, which itself is a tributary of the Murray River. Mountain Creek joins Billabong Creek approximately 17 kilometres north-west of Woomargama. In the vicinity of Woomargama, Mountain Creek is also known as Woomargama Creek.

Mountain Creek has been modified as a result of anthropogenic disturbance, which includes agricultural activities, clearing and grazing of cattle (Photograph 3-1). Riparian bank vegetation was dominated by weeds (Photograph 3-1). Water quality within the study area, as measured using physico-chemical variables, was generally considered poor and some variables were not within the ANZECC (2000) guidelines (see Section 3.4.1). The macroinvertebrate data and the SIGNAL index also supported this finding. (see Section 3.4.2).

Sandy Creek is currently degraded with little riparian vegetation. The site has not been fully surveyed to date, but preliminary ecological studies of the site did not map any native vegetation along the creek (ngnvironmental 2007). Fish and aquatic surveys have not been completed in Sandy Creek due to a lack of water and the waterway is considered to be Class 3 minimal fish habitat (Fairfull & Witheridge 2003). As such, any crossing would need to meet as a minimum low flow design requirements (Fairfull & Witheridge 2003). Currently there is little terrestrial connectivity along the creek due to the lack of riparian vegetation.

1) WU site 1



2) WU site 2



3) WB Site 1



4) WB Site 2



5) WD Site 1



6) WD Site 2



(See Figure 2-1 for survey points)

Photograph 3-1 Mountain Creek and the surrounding vegetation

3.4.1 Water quality

The mean water temperature within the three surveyed locations ranged from 10.8 – 13.2° C (Table 3-5). The mean pH ranged from 7.4 - 7.6, which was within the range recommended by the ANZECC (ANZECC) guidelines (6.5 - 8.0) for upland rivers, i.e. systems at > 150 m altitude (Table 3-5). Mean conductivity values (range = 478 – 1338 µS/cm) were above the ANZECC (2000) guidelines (30 – 350 µS/cm) at all sites (Table 3-5). The mean dissolved oxygen concentrations (mg/L) ranged from 6.2 – 9.2 mg/L and (converted to % saturation: 90– 110%) were within the ANZECC (2000) guidelines (Table 3-5). Mean turbidity ranged from 31.7 – 106.2 NTU and were above the ANZECC (2000) guideline (2 – 25 NTU) for all sites (Table 3-5).

Table 3-5 Mean ($\pm$ SE) measurements of water quality variables recorded at each site within each location

Variable	WD1	WD2	WB1	WB2	WU1	WU2
Temperature (°C)	11.8 (0)	11.8 (0)	13.2 (0.007)	12.9 (0.003)	10.8 (0.01)	11.0 (0.01)
pH	7.6 (0)	7.6 (0)	7.5 (0)	7.5 (0.003)	7.4 (0)	7.5 (0.01)
Conductivity (µS/cm)	1,328 (0)	1,338 (0)	653 (0)	647 (0)	478 (1.9)	478 (0.3)
DO (mg/L)	6.2 (0.2)	6.6 (0.1)	7.5 (0.3)	6.7 (0.2)	7.1 (0.06)	9.2 (0.2)
Turbidity (NTU)	106.2 (0.3)	34.03 (0.1)	31.7 (2.3)	74.0 (0.7)	38.7 (0.8)	37.9 (0.8)

Notes: WD – Woomargama Downstream, WB – Woomargama Bypass, WU – Woomargama Upstream

3.4.2 Macroinvertebrates

A total of 428 individuals from 31 macroinvertebrate taxon were collected from the three locations in Woomargama. The most abundant macroinvertebrate taxa were Beetles (Dytiscidae - 105 individuals) followed by Flies (Chironomidae - 100 individuals).

There were no significant differences detected in the total abundance (number of individuals) and total richness (number of taxa) of macroinvertebrates at any scale (Table 3-6, Figures 3-8 and 3-9).

The non-metric multidimensional scaling (nMDS) ordination indicated that there were differences in the structure of the macroinvertebrate assemblages between some locations (Figure 3-10). The stress value (0.12) associated with the ordination indicated that it was a useful 2-D picture (Clarke & Warwick 1994). The ANOSIM test (Global R: 0.222) however could not detect a significant difference ($P > 0.05$) in the structure of the assemblages among the three locations (Clarke & Warwick 1994).

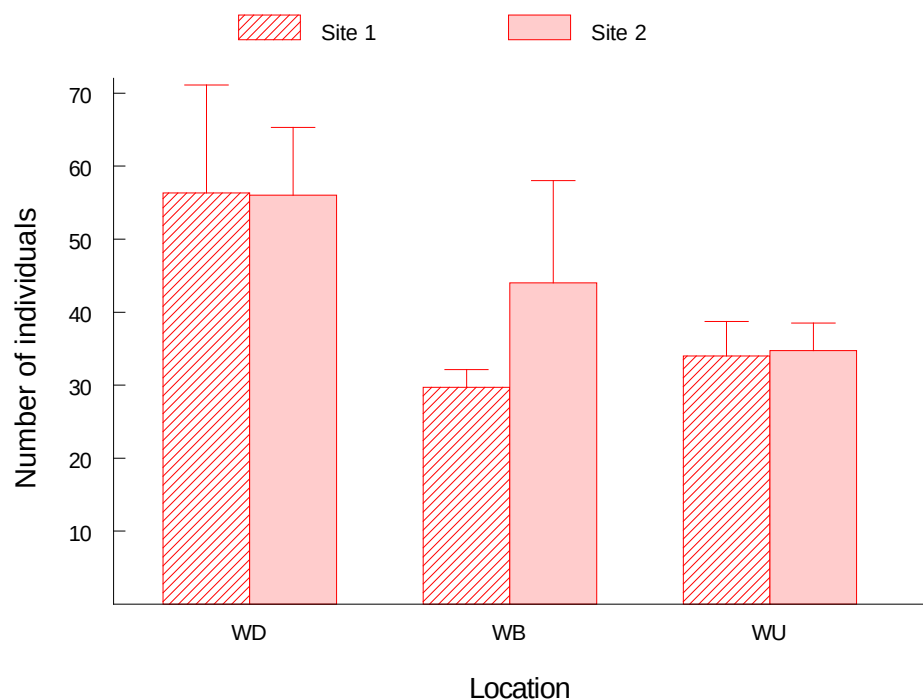
The SIMPER procedure ranked Dytiscidae (Beetles) and Chironomidae (True flies) as the most important taxa that contributed to the structure of the macroinvertebrate assemblage at all locations (Table 3-7). The families Corixidae and Notonectidae (True Bugs) were also ranked highly at some locations (Table 3-7).

Table 3-6 Summary of analyses of variance comparing the total abundance (number of individuals) and richness (number of taxa) of macroinvertebrates recorded in the three locations in Woomargama

Source of Variation	df	Abundance		Richness	
		MS	F	MS	F
Location	2	851.2	7.9ns	27.6	2.2ns
Site (Location)	3	107.8	0.4ns	12.6	0.5ns
Residual	12	273.9		14.3	
Total	17				
Cochran's Test			0.402ns	0.494ns	
Transformation			none	none	

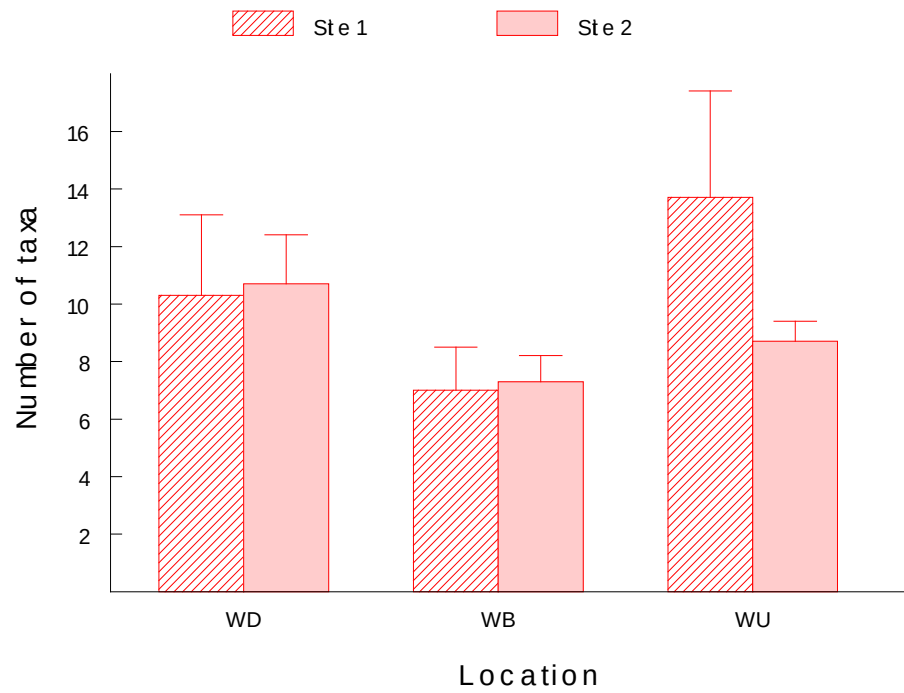
Notes: ns = not significant ($P > 0.05$); * = significant ($P < 0.05$); ** = significant ($P < 0.01$); df = Degrees of freedom; MS = Mean squared; F = F ratio

The SIGNAL values calculated that all sites were severely (Figure 3-11). The relative large number of pollution tolerant macroinvertebrate taxa suggested that the water quality was generally quite poor (Chessman 2003).



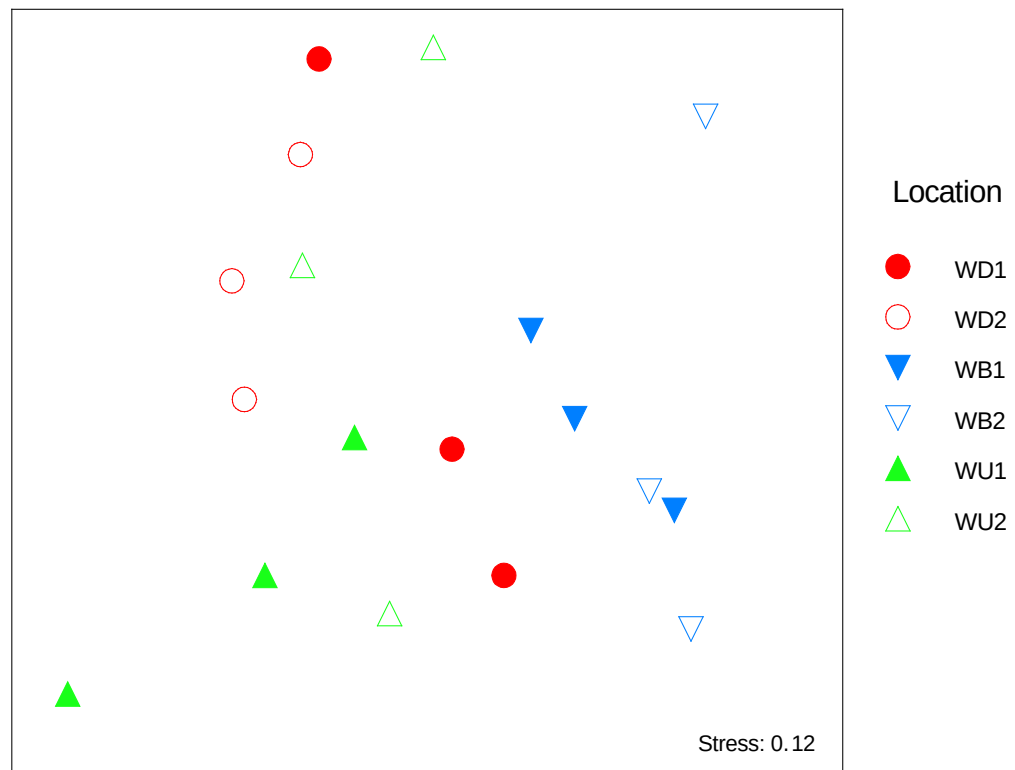
(WD = Downstream, WU = Upstream, WB = Bypass)

Figure 3-8 Mean (+SE) total abundance (number of individuals) of macroinvertebrates at each site



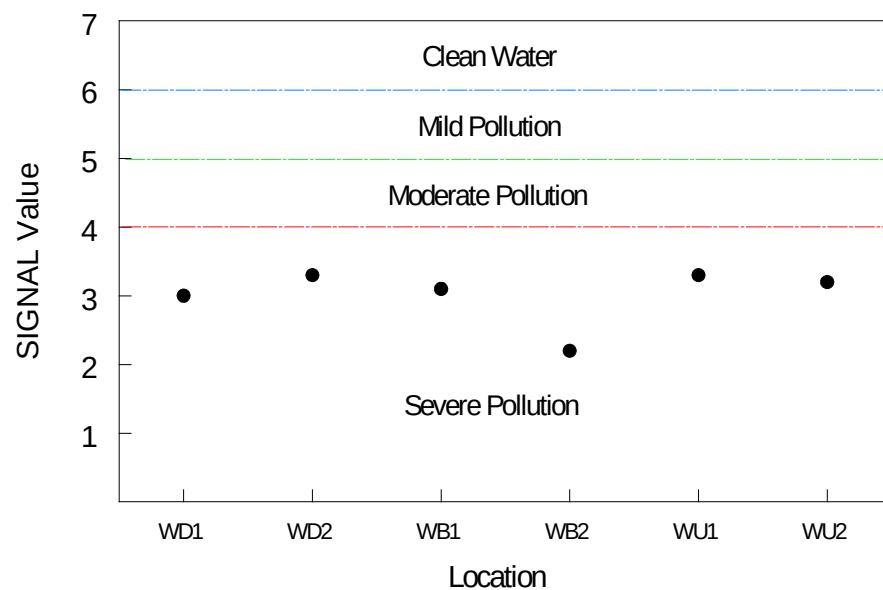
(WD = Downstream, WU = Upstream, WB = Bypass)

Figure 3-9 Mean (+SE) total richness (number of taxa) of macroinvertebrates at each site



(WD = Downstream, WU = Upstream, WB = Bypass)

Figure 3-10 nMDS ordination for macroinvertebrates for each site within the three locations



(WD = Downstream, WU = Upstream, WB = Bypass)

Figure 3-11 Average macroinvertebrate SIGNAL values for each site within the three locations

Table 3-7 Macroinvertebrate taxa ranked in order of importance according to the SIMPER procedure for each site within a location

Name	Taxa	WD1	WD2	WB1	WB2	WU1	WU2
Crustacean	Amphipod sp.		3			10	
Shrimps	Atyidae	5				5	
Dragonflies	Aeshnidae					11	
True Flies	Chironomidae	2	6	1	1	7	2
Water Fleas	Cladocera sp.			6	4		5
True Bugs	Corixidae	4	4			1	3
Copepods	Cyclopoida	6	7	3	5		
Beetles	Dytiscidae	1	1	2	2	2	1
Dragonflies	Hemicorduliidae					12	
Beetles	Hydrophilidae					6	
Caddis Flies	Leptoceridae	7	9			8	
Dragonflies	Megapodagrionidae						6
True Bugs	Notonectidae	3	2			3	7
Worms	Oligochaeta sp.		8	5	6		
Crustaceans	Ostracoda sp.		5				
Decapods	Parastacidae						4
Gastropods	Physidae	6		4	3		
Gastropods	Planorbidae					9	8
Beetles	Scirtidae					4	

Notes: WD – Woomargama Downstream, WB – Woomargama Bypass, WU – Woomargama Upstream

3.5 Recorded flora and fauna

3.5.1 Terrestrial flora

Flora surveys in the 31 survey sites, across four broad vegetation types, identified 103 species of plant (Appendix A). Thirty-six of these were exotic, none were listed as Threatened under the *Threatened Species Conservation Act 1995* or *Environment Protection and Biodiversity Conservation Act 1999*. The highest diversity of species was identified in the woodland survey sites (71 species), then riparian and rocky areas (47 and 40 species respectively), with the least number of species present in cleared areas (27).

3.5.2 Terrestrial fauna

Fauna surveys by ngenvironmental across the four broad vegetation types identified 108 species of fauna (Appendix B). Three are listed as threatened under the *Threatened Species Conservation Act 1995* (Hooded Robin, Brown Tree-creeper, Squirrel Glider); none were listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Eight of the birds recorded (Chestnut-rumped Thornbill, Jacky Winter, White-browed Babbler, Varied Sittella, Crested Shrike-tit, Rufous Whistler, White-browed Woodswallow and Dusky Woodswallow) have been classified as declining in the wheat-sheep belt of NSW (Reid 1999) and may therefore be at risk of becoming threatened in the future. Seven species were exotic. The highest diversity of species was identified in the riparian and woodland survey sites (65 and 64 species respectively), then rocky areas (36 species), with the least number of species present in cleared areas (31).

Survey timing was poor for detecting many species, particularly wetland species and reptiles; the dry conditions force many species to migrate or become dormant. It is likely that under better conditions, a larger number of species would have been identifiable.

3.5.3 Aquatic species

The Southern Pygmy Perch (*Nannoperca australis* - 42 individuals), which is listed as Endangered under the *Fisheries Management Act 1994*, Freshwater Blackfish (*Gadopsis bispinosus* - 3 individuals) and Freshwater Shrimps (*Paratya australiensis* - 2 individuals) were the only species collected from the three locations at Woomargama using the electrofisher and nets.

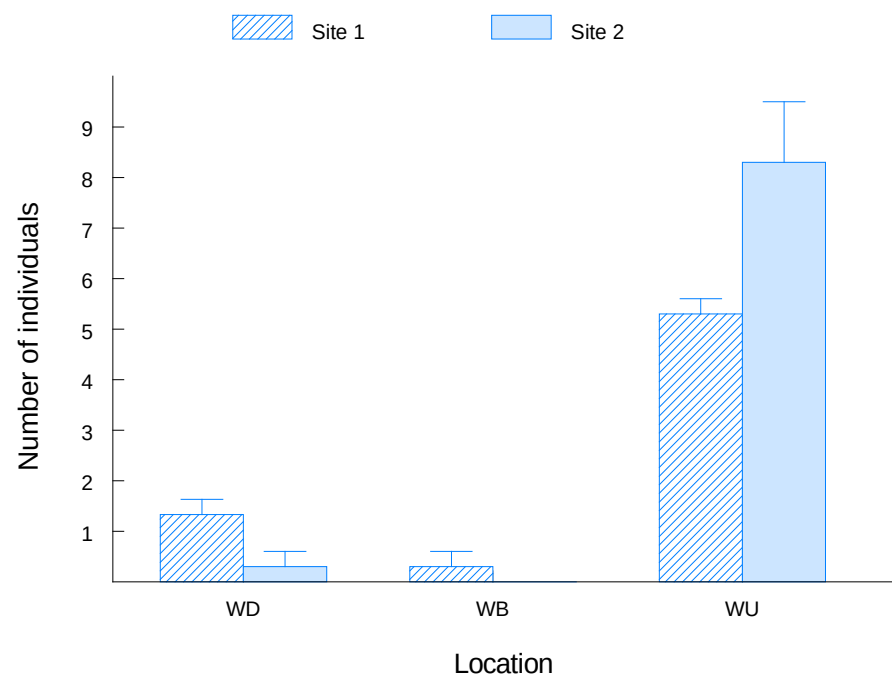
There was a significant difference detected in locations for the total abundance (number of individuals) of fish and crustaceans (Table 3-8), due to the greater numbers of individuals collected at location WU (Table 3-8; Figure 3-12). No significant difference was detected at any scale for total richness of fish and crustaceans (Table 3-8; Figure 3-13).

Due to the low number of species (i.e. three) no multivariate analyses were required to establish spatial patterns in the structure of the assemblage. The Southern Pygmy Perch was the only fish recorded at the upstream location; two were recorded at the downstream location and one individual at the bypass location. The Freshwater Blackfish was only recorded at the downstream location.

Table 3-8 Summary of analyses of variance comparing the total abundance (number of individuals) and richness (number of taxa) of fish and crustaceans recorded in the three locations in Woomargama

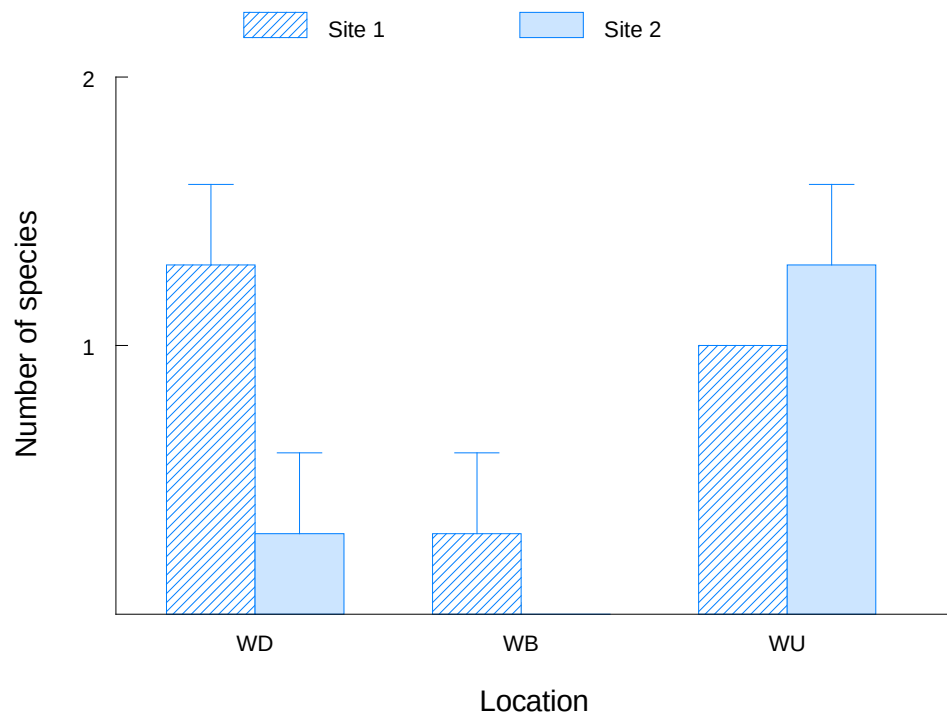
Source of Variation	df	Abundance		Richness	
		MS	F	MS	F
Location	2	6.1	22.2**	1.6	2.6ns
Site (Location)	3	0.3	3.7*	0.6	2.8ns
Residual	12	0.07		0.2	
Total	17				
Cochran's Test			0.364ns	0.250ns	
Transformation			Ln(x+1)	none	

Notes: ns = not significant ($P > 0.05$); * = significant ($P < 0.05$); ** = significant ($P < 0.01$); df = Degrees of freedom; MS = Mean squared; F = F ratio



(WD = Downstream, WU = Upstream, WB = Bypass)

Figure 3-12 Mean (+SE) total abundance (number of individuals) of fish and crustaceans at each site



(WD = Downstream, WU = Upstream, WB = Bypass)

Figure 3-13 Mean (+SE) total richness (number of species) of fish and crustaceans at each site

4. Species, populations and communities of conservation concern

This Chapter describes the Threatened biodiversity and other species of conservation concern likely to occur within the study area based on those found within the Proposal locality and the nature of the habitats within the existing environment.

4.1 Matters of National Environmental Significance

Matters of National Environmental Significance are listed and protected under the *Environment Protection and Biodiversity Conservation Act 1999*. The Act identifies three Matters of National Environmental Significance relevant to the Proposal:

- Wetlands of international importance (Ramsar wetlands).
- Threatened species and ecological communities.
- Migratory species.

Matters of National Environmental Significance relating to biodiversity are discussed below in relation to the Proposal based on the results of the *Environment Protection and Biodiversity Conservation Act 1999* Protected Matters Search Tool (Department of the Environment Water Heritage and the Arts 2008b), desktop review of databases and literature, and the results of previous field surveys.

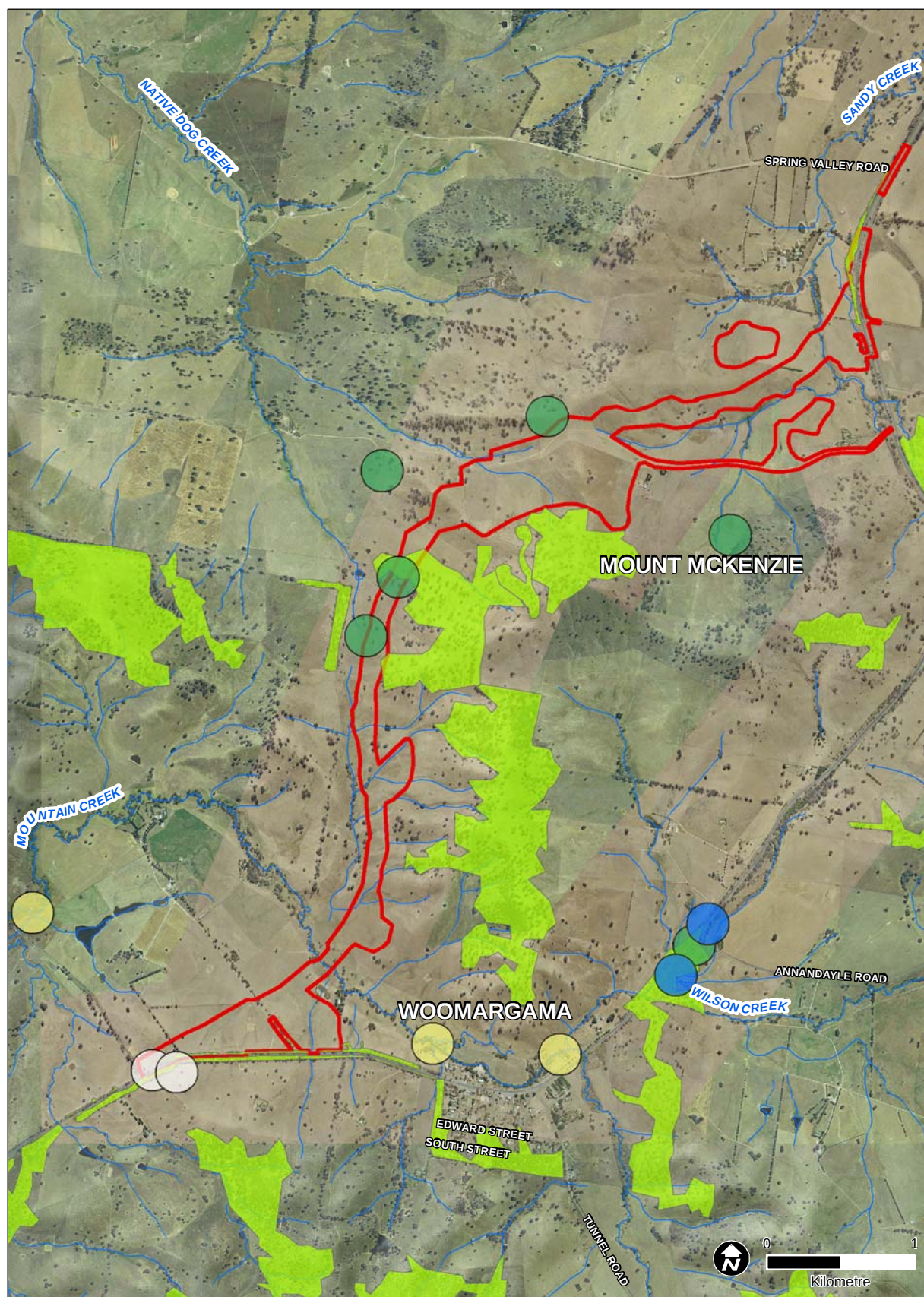
A summary of Matters of National Environmental Significance is provided below and complete significance tests showing likely impacts of the proposed Woomargama Bypass on them are presented in Appendix E of this Technical Report.

4.1.1 Threatened ecological communities

One Threatened ecological community listed as Critically Endangered was recorded within the study area and is discussed below.

White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and derived Native Grassland

White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (Box-gum Woodland) was the only Threatened ecological community recorded in the study area listed under the *Environment Protection and Biodiversity Conservation Act 1999* and is shown in (Figure 4-1).



-  Clearing boundary
  Box-gum Woodland
 Threatened species
 Brown Tree-creeper
- Drainage
  Hooded Robin
- Classified road
  Squirrel Glider
-  Southern Pygmy Perch

4.1.2 Threatened species

Threatened species of plant

Five Threatened floral species have been recorded, are predicted to occur or have habitat in the locality (10 kilometre radius) of the study area as listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, Water, Heritage and the Arts, accessed 1 June 2009 (see Appendix C). Two of these species are considered to have a moderate or greater likelihood of occurrence based on potential habitat and a precautionary approach to their cryptic flowering survey requirements: *Diuris tricolor* and *Amphibromus fluitans*.

Threatened species of animal

Fourteen Threatened terrestrial faunal species have been recorded, are predicted to occur, or have potential habitat in the locality (10 kilometre radius) of the study area as listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, Water, Heritage and the Arts, accessed 1 June 2009) (see Appendix D). This comprised two species of amphibian, two species of reptile, four species of bird, two species of mammal, and four species of fish (refer Table 4-1). Details of these species are provided in Appendix D. No Threatened species listed under the *Environment Protection and Biodiversity Conservation Act 1999* were recorded during previous surveys.

Table 4-1 Threatened species of animal listed under the *Environment Protection and Biodiversity Conservation Act 1999* recorded or predicted to occur within the Proposal locality based on database search results

Group	Number of species (those likely to occur)
Amphibians	2 (0)
Birds	4 (3)
Mammals	2 (1)
Reptiles	2 (0)
Fish	4 (0)
TOTAL	14 (4)

Notes: A comprehensive list of these Threatened fauna species and their likelihood of occurrence within the study area is presented within Appendix D

It is unlikely, however, that all these species would be affected by the Proposal (refer Appendix D). Despite the existence of records in the locality, ten Threatened species are considered to have a low likelihood of occurring in the study area due to a lack of suitable habitat. Full details of species requirements and reasons for not considering impacts of the Proposal further are provided in Appendix D.

Significance assessments required under the *Environment Protection and Biodiversity Conservation Act 1999* have been completed for the remaining four species (refer Section 7 and Appendix E), which includes Swift Parrot, Superb Parrot, Regent Honeyeater and Greater Long-eared Bat.

4.1.3 Migratory species

Migratory species are protected under the international agreements to which Australia is a signatory, including the *Japan-Australia Migratory Bird Agreement* (JAMBA) the *China-Australia Migratory Bird Agreement* (CAMBA), the *Republic of Korea-Australia Migratory Bird Agreement* (RoKAMBA) and the *Bonn Convention on the Conservation of Migratory Species of Wild Animals*. Migratory species are considered Matters of National Environmental Significance and are protected under the *Environment Protection and Biodiversity Conservation Act 1999*.

One species of bird, Rainbow Bee-eater, recorded during previous field surveys is currently recognised under the migratory provisions of the *Environment Protection and Biodiversity Conservation Act 1999*. A further nine species have the potential to occur in the Proposal locality based on the Department of the Environment, Water, Heritage and the Art's *Protected Matters Search Tool*. This includes Satin Flycatcher, Rufous Fantail, Fork-tailed Swift, Great Egret, Cattle Egret, Latham's Snipe, White-bellied Sea-Eagle, White-throated Needletail, Painted Snipe and Regent Honeyeater.

Under the *Environment Protection and Biodiversity Conservation Act 1999*, an action is likely to have a significant impact on a migratory species if it substantially modifies, destroys or isolates an area of important habitat for the species (Department of the Environment and Heritage 2006a).

For five species of migratory bird recorded or considered likely to occur, the study area is not considered to comprise important habitat as it does not contain:

- Habitat used by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species.
- Habitat that is of critical importance to the species at particular life-cycle stages.
- Habitat used by a migratory species that is at the limit of the species' range.
- Habitat within an area where the species is declining (Department of the Environment and Heritage 2006a).

As such, impacts of the Proposal on migratory species are not considered further for these species.

One species — Regent Honeyeater — is, however, listed as Endangered and as such, the study area could be considered to contain habitat where the species is declining. For species listed as migratory and threatened under the *Environment Protection and Biodiversity Conservation Act 1999*, assessments of significance were carried out using the threatened species criteria (refer Section 7 and Appendix E).

4.1.4 World heritage properties

No world heritage properties are within the locality of the Proposal.

4.1.5 Ramsar wetlands

No Internationally important wetlands (Ramsar sites) are mapped within the locality of the study area. Fivebough and Tuckerbil Swamps (Ramsar Wetlands) are located in the Murrumbidgee Catchment, but are located approximately 160 kilometres north-west of

Woomargama. As such, the Proposal is not likely to have an adverse effect on any Ramsar Wetland either directly or indirectly.

4.2 State-listed species and communities

4.2.1 Threatened ecological communities

One Threatened ecological community listed under the *Threatened Species Conservation Act 1995* and one under the *Fisheries Management Act 1994* have been identified during previous ecological assessment as occurring within the study area (Figure 4-1). These are discussed below.

White Box Yellow Box Blakely's Red Gum Woodland

White Box Yellow Box Blakely's Red Gum Woodland is listed as an Endangered Ecological Community under the *Threatened Species Conservation Act 1995*.

The final determination for this community under the *Threatened Species Conservation Act 1995* is broad, with five main features defining whether a patch is consistent with the community determination:

- Whether the site is within the area defined in the determination.
- Whether the characteristic trees of the site are (or are likely to have been) White Box, Yellow Box or Blakely's Red Gum.
- Whether the site is mainly grassy.
- Whether any of the listed characteristic species occur (including as part of the seedbank in the soil).
- If the site is degraded, whether there is potential for assisted natural regeneration of the overstorey or understorey (NSW National Parks and Wildlife Service 2002a).

One of the vegetation communities, Box-gum Woodland, in the study area (including cleared land with scattered eucalypts) is consistent with the abovementioned criteria.

Degraded remnants and scattered trees may be included in the definition of the community if sufficient natural soil and seedbank remain, so that under appropriate management, assisted natural regeneration of the overstorey or understorey could occur (NSW National Parks and Wildlife Service 2002c).

Aquatic Ecological Community in the Natural Drainage System of the Lower Murray River Catchment

The Aquatic Ecological Community in the Natural Drainage System of the Lower Murray River Catchment is listed as an Endangered Ecological Community under the *Fisheries Management Act 1994* (NSW Fisheries 2002).

The Lower Murray ecological community includes all native fish and aquatic invertebrates within all natural creeks, rivers, and associated lagoons, billabongs and lakes of the regulated portions of the Murray River below the Hume Weir, the Murrumbidgee River below the Burrinjuck Dam, and the Tumut River below the Blowering Dam, as well as all of their tributaries and branches (NSW Fisheries 2002).

Mountain Creek is a tributary of Billabong Creek, which is a tributary listed under the definition, and therefore, forms part of this community. Sandy Creek is also part of this community (Figure 4-1).

4.2.2 Endangered populations

No endangered population as listed under the *Threatened Species Conservation Act 1995* occurs within the Greater Hume Shire local government area.

In the Wagga Wagga local government area, which borders the Greater Hume Shire local government area to the north, the Squirrel Glider is listed as an Endangered Population (NSW Scientific Committee 2000). A recent review of this listing and the populations of Squirrel Gliders within the South-west Slopes Bioregion of NSW, suggests that the populations are spread wider than originally thought and that other disjunct populations within the bioregion are likely to be as equally endangered as the population(s) within the Wagga Wagga local government area (Claridge & van der Ree 2004).

When considering the populations of Squirrel Glider at the landscape scale, there may be some connectivity between individuals and habitats within the study areas and the population(s) in the Wagga Wagga local government area. Hence, there could be indirect impacts on the Endangered Population. The significance of impacts on this species should, however, be considered for the species based on its Vulnerable species listing under the *Threatened Species Conservation Act 1995*.

4.2.3 Threatened species

Threatened plants

Seven Threatened species of plant listed under the *Threatened Species Conservation Act 1995* were recorded previously, or are predicted to occur, within the locality (refer Appendix C). No threatened species of plant was identified in the study areas during previous field survey.

Three species are considered to have a Moderate Likelihood of occurrence based on suitable habitat within the study area and cryptic seasonal survey requirements: *Diuris tricolor*, *Swainsona sericea* and *Amphibromus fluitans* (refer Appendix C).

An assessment of the likely significance of impacts on these species has been considered in Chapter 7 and Appendix E.

Threatened animals

Forty-six Threatened faunal species, as listed under the *Threatened Species Conservation Act 1995* or the *Fisheries Management Act 1994* (Department of Environment and Conservation 2006), accessed 2 December 2008), have been recorded, are predicted to occur or have habitat in the locality (10 kilometre radius) of the study area or have been predicted to occur (Appendix D). This comprised three species of amphibian, three species of reptile, 25 species of bird, nine species of mammal, five species of fish and one aquatic invertebrate (refer Table 4-2). Details of these species are provided in Appendix D.

Table 4-2 **Threatened species of animal listed under the *Threatened Species Conservation Act 1995* recorded or predicted to occur within the Proposal locality based on database search results**

Group	Number of species (likely to occur)
Amphibians	3 (0)
Birds	25 (14)
Mammals	9 (5)
Reptiles	3 (0)
Fish and aquatic invertebrates	6 (1)
TOTAL	46 (20)

Notes: A comprehensive list of these Threatened fauna species and their likelihood of occurrence within the study area is presented within Appendix D

Four Threatened species were recorded as part of previous field surveys (Figure 4-1). This included the Brown Treecreeper (eastern subspecies), Hooded Robin, Squirrel Glider and Southern Pygmy Perch.

It is not likely, however, that all 46 species would be affected by the Proposal (refer Appendix D). Twenty-six Threatened species are considered to have a low likelihood of occurrence based on the availability of habitats (refer Appendix D). Full details of species requirements and reasons for not considering impacts of the Proposal further are provided in Appendix D.

Significance assessments required under the *Environmental Planning and Assessment Act 1979* were completed for the remaining 20 species (refer Chapter 7 and Appendix E).

4.3 Regionally listed species and communities

4.3.1 Regionally rare communities

River Red Gum very tall open forest of the NSW South-western Slopes Bioregion is estimated as having an 85% reduction in its pre European distribution due to clearing (Benson 2008) and is classified as an over-cleared vegetation type by Biometric (version 2.0) (NSW Department of Environment and Conservation 2005), within the Murray catchment. The Riparian Community within the study area (e.g. along Mountain Creek) would fit within this community.

4.3.2 Regionally rare species

No regionally rare species were recorded within the current surveys.

5. Potential impacts

This chapter describes the potential impacts of the Proposal on the biological environment, including loss of vegetation and habitats and impacts on Threatened species.

5.1 Loss of vegetation/habitats

The most significant impact of the Proposal would be loss of native vegetation and associated habitats. The Proposal would result in the loss of native vegetation within the subject site (as summarised in Table 5-1 and presented in Figure 5-1) including eight hectares of native vegetation. This includes six hectares of Endangered Ecological Communities (Box-gum Woodland) as listed under the *Threatened Species Conservation Act 1995* and under the *Environment Protection and Biodiversity Conservation Act 1999*. A further one hectare of vegetation has not been fully classified and may fit the definition of the Endangered Ecological Community, at least under the *Threatened Species Conservation Act 1995*.

Table 5-1 Potential loss of vegetation and habitat within study area

Vegetation communities	Woomargama study area		
	Area occupied within 1 km of Clearing Boundary (ha)	Clearing Boundary (ha)	% removal
Box-gum Woodland	239	6	3
Rocky outcrop woodland	24	0	0
Other tree cover ¹	109	1	1
Riparian vegetation	17	1	6
Total	389	8	3

Notes: 1 – Area may contain Box-gum Woodland

Clearing of native vegetation is listed as a Key Threatening Process under the *Threatened Species Conservation Act 1995* and the *Environment Protection and Biodiversity Conservation Act 1999*.

While the Proposal corridor generally traverses a modified agricultural landscape, significant areas of roadside vegetation, areas of the Riparian Woodland and remnant Box Woodland would be affected. The Proposal would require the removal of approximately eight hectares of remnant native vegetation/ fauna habitat along the alignment, which effectively removes three per cent of vegetation within one kilometre of the clearing boundary. While the amount of clearing is small in relation to the extent of these communities in south-eastern NSW, locally it is still important, particularly as it is estimated that less than 50 per cent of the Murray catchment's native woodland vegetation remains (Miles & Trust 2001).

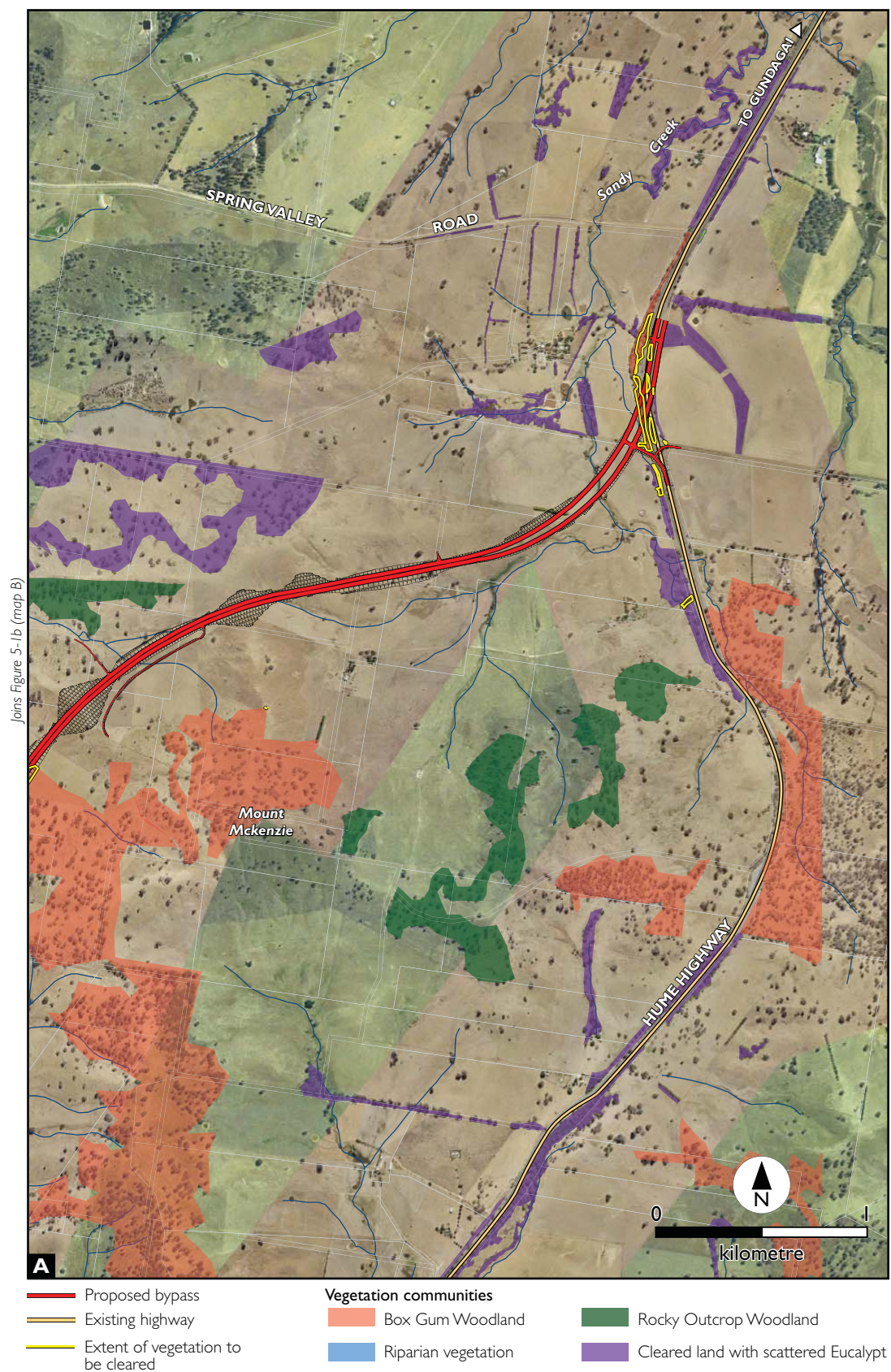
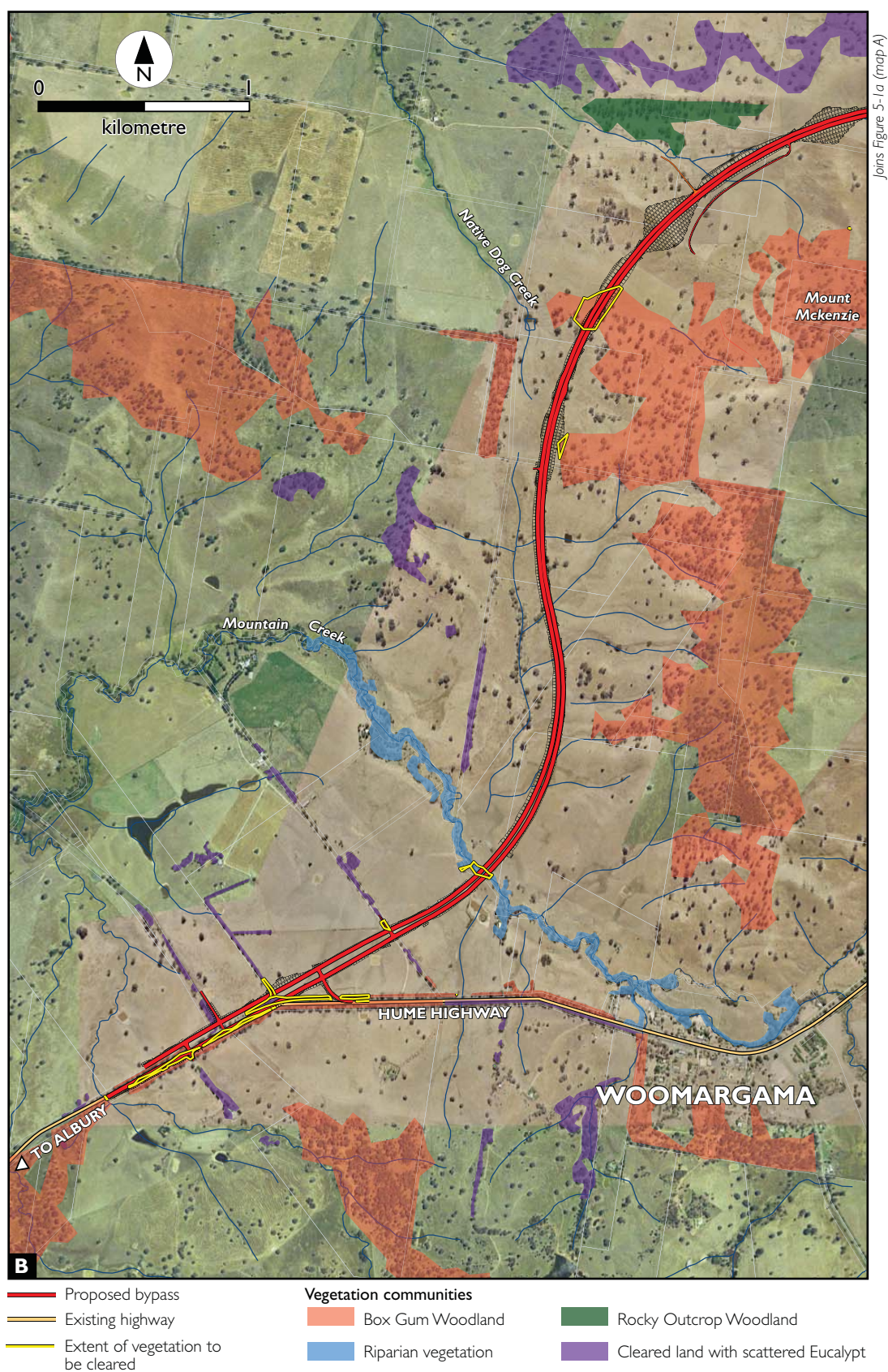


Figure 5-1a Potential loss of vegetation and habitat within study area (northern section)



Joins Figure 5-1a (map A)

Figure 5-1b Potential loss of vegetation and habitat within study area (southern section)

Within the study area, the Proposal would reduce the extent of vegetation cover from six per cent to three per cent within a 100 metre buffer of the Proposal and reduce the vegetation cover from 18 per cent to 17 per cent within a one kilometre buffer of the Proposal. While the value for the one kilometre buffer of the Proposal is still above the 10 per cent threshold suggested by Reid (2000) for woodland birds, it would mean that the vegetation cover would remain below the 30 per cent level above which Bennett and Radford (2004) suggested that most organisms and ecological processes characteristic of that ecosystem persist.

Vegetation would be removed along much of the northern and southern portions of the Proposal, particularly within those areas associated with diversions from the existing Hume Highway, and remnant patches associated with Riparian areas around Mountain Creek. The total (cumulative) length of clearing is approximately six kilometres. This vegetation clearing would be spread over all identified remnant patches of vegetation within the study area.

5.2 Habitat fragmentation and barrier effects

Habitat fragmentation is the division of a single area of habitat into two or more smaller areas, with the occurrence of a new habitat type in the area between the fragments. This new dividing habitat type is often artificial and inhospitable to the species remaining within the fragments (Bennett 1990, 1993; Johnson *et al.* 2007). Although the newly created habitat is generally used by some species, those species are usually generalists and are often considered aggressive (e.g. Noisy Miners, Grey *et al.* 1998), further decreasing population levels of the species remaining in the fragments. Habitat fragmentation can result in a number of impacts including:

- **Barrier effects:** Barrier effects occur where particular species are either unable, or are unwilling, to move between suitable areas of fragmented habitat. This could result in either a complete halt to movement or a reduced level of movement between fragments. Species most vulnerable to barrier effects include rare species 2626, smaller ground-dwelling species and species with low mobility. Species least vulnerable to barrier effects tend to be those that are highly mobile (e.g. birds and bats), although even these species can vary in their response to barriers.
- **Genetic isolation:** Genetic isolation occurs where individuals from a population within one fragment are unable to interbreed with individuals from populations in adjoining fragments. Genetic isolation can lead to inbreeding and genetic drift problems for populations isolated within a fragment.
- **Edge effects:** Edge effects are where a zone of changed environmental conditions occurs along the edges of habitat fragments (refer Section 5.3).

The construction and operation of the Proposal would further fragment habitat and increase the isolation of remnant vegetation. With the Proposal alignment traversing roadside vegetation and modified agricultural landscapes, the Proposal (nominal 50 to 100 metre corridor) would present a barrier within the landscape (in an east-west direction), particularly within the Mountain Creek riparian corridor and remnant patches of Box-gum Woodland within the central Proposal area.

These areas have been significantly disturbed by a history of agricultural land uses and the existing Hume Highway. Given these disturbances the majority of species likely to be using these disrupted corridors are the highly mobile species, such as birds and bats primarily as marginal foraging habitats within a greater foraging range.

Barrier effects would increase for some species and in some areas may effectively isolate remaining vegetation on either side of the road. This would particularly be the case for small and sedentary fauna, such as ground-dwelling/arboreal mammals, reptiles and amphibians. However, more mobile species, such as birds and bats, may not be as affected by the barrier.

With the Murray catchment being an important and diverse area of primary production in Australia, it is of no surprise that less than 50 per cent of the catchment's native woodland vegetation remains (Miles & Trust 2001). Therefore, vegetation currently occurring along the Proposal alignment, although moderately to highly disturbed, is likely to play a key role in the wider corridor network. The Proposal would increase the level fragmentation and isolation of some patches of vegetation in an east-west direction.

A study of the effects of clearing and habitat fragmentation on Threatened Squirrel Gliders in the Wyong local government area (Smith 2002) classified remnant isolation as follows (refer Figure 5-2):

- Class 1 — remnants connected to other remnants by a narrow corridor (up to 250 metres wide).
- Class 2 — remnants separated from other remnants by a cleared gap (e.g. road or clearing) up to 100 metres wide, but with a broad area of contact, including native vegetation on both sides of the gaps for a width of at least 250 metres.
- Class 3 — as in Class 2, but with a narrow width of contact (less than 250 metres wide).
- Class 4 — remnants separated from other remnants by cleared areas of 100–400 metres in rural environments or 100–200 metres in urban environments.
- Class 5 — remnants separated by more than 200 metres of urban habitat or 400 metres of cleared habitat.

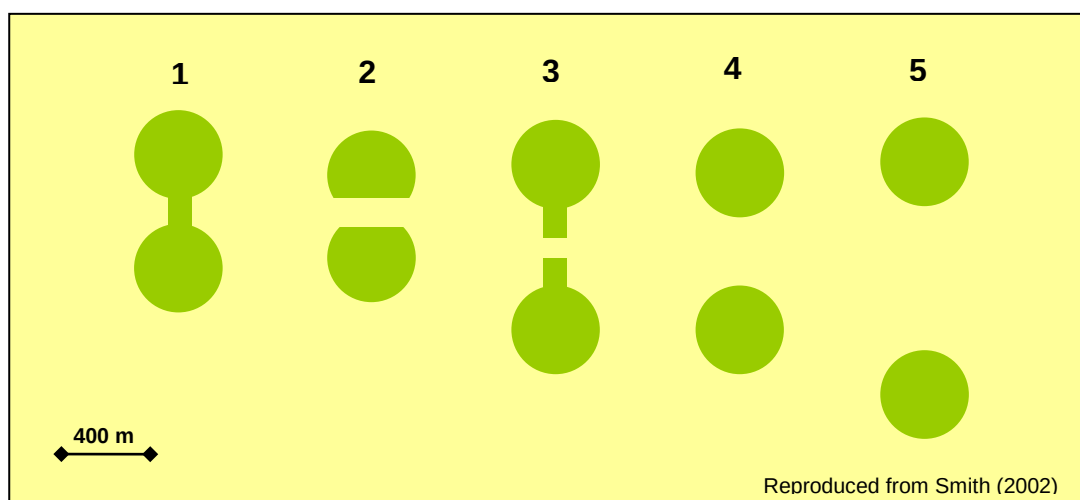


Figure 5-2 Remnant isolation classes

Vegetation in the study area is already fragmented by infrastructure, including roads (e.g. the existing Hume Highway), urban development and land clearing for agricultural purposes. Following the definitions outlined by (Smith 2002) isolation of vegetation communities as a result of the Proposal would largely fall into Class 2 (refer Figure 5-2).

The Threatened Squirrel Glider was recorded during recent field surveys carried out by nphenvironmental. Box-Gum Woodland habitat throughout the Proposal essentially provided year-round foraging resources with *E. albens* flowering during winter, *E. melliodora* flowering during summer, *E. blakelyi* flowering during autumn and spring. Box-Gum Woodland habitat provides good condition fauna habitat with a relatively full suite of resources available to species such as the Squirrel Glider. While good condition habitat was only recorded in one other area (riparian area) along the Proposal alignment, it is likely that Squirrel Glider would potentially use some of the habitat trees and food resources in the Box-gum Woodland recorded along the alignment, as Squirrel Gliders are often found in remnant and roadside patches of eucalypt woodland (van der Ree 2008).

Recent studies comparing movements of Squirrel Gliders across a single carriageway highway in Victoria with a section of dual carriage highway nearby, suggest that individuals are far less likely to cross the wider road (van der Ree 2006). This work suggests that the difference is likely due to a combination of the width of the road, the volume of traffic and the speeds of the traffic. Squirrel Gliders can glide for more than 50 metres (NSW National Parks and Wildlife Service 1999); however, average glides are generally 20 metres (Jackson 1999). As such, the construction and operation of the proposed dual carriageway bypass is likely to create a barrier to their movement.

5.3 Edge effects

Edge effects are zones of changed environmental conditions (i.e. altered light levels, wind speed and/or temperature) occurring along the edges of habitat fragments. These new environmental conditions along the edges can promote the growth of different vegetation types (including weeds) and allow invasion by pest animals specialising in edge habitats and/or change the behaviour of resident animals. Edge zones can be subject to higher levels of predation by introduced mammalian predators and native avian predators. Edge effects have mainly been recorded adjacent to roads and at distances greater than 1,000 metres from the road surface (Forman *et al.* 2000). However, Bali (2000), in a comparison of edge effects in a variety of different habitat types, estimated that average edge effects generally occur up to 50 metres away from the road edge.

The majority of vegetation within the study area occurs within relatively small, fragmented patches, many of which are subject to past and present disturbance regimes (e.g. grazing) and hence, already consist of edge-affected habitats. Using the estimate of 50 metres proposed by Bali (2005), it is likely that new edge effects would only be introduced in the one large remnant of vegetation in the centre of the Proposal.

A change in the microhabitat conditions in remnant vegetation patches as a result of vegetation clearing and earthworks increases the likelihood of the germination and establishment of exotic plants (weeds). The germination and establishment of weeds is most likely to occur in areas affected by vegetation clearing, in areas of exposed soil/fill (such as topsoil stockpiles, soil cuttings, fill batters and scree slopes) and along edge-affected areas of remnant vegetation. However, field surveys within these remnant patches identified significant disturbances associated with edge effects from grazing and adjoining agricultural

land practices. It is considered that any marginal increase in these effects caused by the Proposal is unlikely to be significant.

5.4 Vehicle strike and direct mortality

Fauna injury or death could occur as a result of the Proposal's construction phase, when vegetation and habitats are being cleared. Injury and death to fauna also have the potential to occur during the operation of the bypass as a result of collision with vehicles.

While some mobile species, such as birds, have the potential to move away from the path of clearing, other species that are less mobile, or those that are nocturnal and restricted to tree hollows, may have difficulty moving over relatively large distances. Threatened species that may be affected by vegetation clearing include microchiropteran bats and Squirrel Gliders. The RTA has policies and guidelines in place that outline procedures to prevent fauna mortality during construction. These procedures will be captured in the Construction Environmental Management Plan (CEMP) before work commences.

While the Proposal would result in a road corridor traversing a relatively modified landscape, this would result in a wide area of road for animals to cross and negotiate, which would increase the extent of vehicle strike. Threatened fauna that may be affected by vehicle strikes include the Squirrel Glider (Claridge & van der Ree 2004), the Swift Parrot (Swift Parrot Recovery Team 2001) and woodland species of bird such as the Grey-crowned Babbler (Davidson & Robinson 1992; Robinson *et al.* 2001).

It is likely that the Proposal would have the greatest impacts on these species in the central and southern parts of the study area, where the alignment traverses between existing remnant roadside vegetation.

5.5 Weeds

Thirty-six species of weed were observed within the study area. Amongst these were five species of noxious weed listed under the *Noxious Weed Act 1993* (refer Appendix A).

The distribution of these exotic weed infestations across the study area can generally be split into the following broad distributional areas:

- Riparian areas associated with the River Red Gum Open Forest vegetation community contained dense thickets of *Salix babylonica* along the creek banks, while the groundcover on the creek banks and floodplains was dominated by exotic rushes and sedges and pasture improvement species and weeds, including *Echium plantagineum*, *Hordeum leporinum*, *Vulpia myuros*, *Lythrum hyssopifolia*, *Lolium perenne*, *Phalaris aquatica* and *Bromus* spp.
- The remaining paddock remnants of natural vegetation communities and the road side remnants north and south of the town of Woomargama, were heavily infested by a variety of exotic 'pasture improvement' species used to improve soil conditions and/or provide feed for grazing. The most abundant exotic species within these areas were *Bromus* spp., *Plantago lanceolata*, *Medicago polymorpha*, *Phalaris aquatica*, *Silybum marianum*, *Lolium* spp., *Echium plantagineum*, *Avena fatua*, *Trifolium* spp. and *Romulea rosea*.

The construction of the Proposal has the potential to disperse weeds into areas of remnant vegetation where weed species do not currently occur. The most likely causes of weed dispersal associated with the Proposal would include earthworks, movement of soil and attachment of seed (and other propagules) to vehicles and machinery. This may, in turn, reduce the habitat quality of the sites for Threatened species, such as woodland species of bird (Robinson *et al.* 2001). The majority of the vegetation within the study area, however, already has considerable weed growth; therefore, the overall extent of habitat modification is not likely to increase significantly. Spread of weeds during the operation of the Proposal would relate generally to maintenance activities.

5.6 Changed hydrology

Two waterways, Mountain Creek and Sandy Creek, would be crossed by the Proposal.

Waterway crossings could modify the natural hydrology of creeks within the study area, which could ultimately affect the aquatic assemblages that use these areas (Fairfull & Witheridge 2003). Impacts from waterway crossings may include:

- Excessive flow velocities, which could erode creek banks and lead to changes in water quality, as well as acting as a barrier to any fish movements in the creek.
- Modified water depths of the creek, which could act as a barrier to fish movement and cause loss of interconnectivity between pools.
- Increased water turbulence, which could lead to the avoidance of the area by various aquatic organisms.

5.7 Aquatic disturbance and impacts on fish passage

The construction of the Proposal would require the crossing of Mountain Creek and Sandy Creek, with potential indirect impacts associated with these crossings. Twin bridges proposed to span across Mountain Creek have the potential to alter creek bed characteristics; however, as bridge piers are not likely to be located in the channel, this is not considered to be a significant issue. Also, the design of bridges would be in accordance with NSW Department of Industry and Investments (Fisheries) guidelines (Fairfull & Witheridge 2003).

Barriers to fish passage from the installation of waterway crossings (including bridges and culverts) can occur temporarily (i.e. during construction) and/or over the long term if inappropriate structures are used. Several species of fish occur in the study area that need to move between habitats for a variety of reasons, including the search for food and shelter, dispersal into available habitat and reproduction. In addition to potential impacts from alteration of natural hydrology at waterway crossings (refer Section 5.6), other impacts, such as decreased light levels and debris blockage, have the potential to affect fish passage (Fairfull & Witheridge 2003).

Mountain Creek currently has disturbed fish passages due to waterway crossings. These crossings include an existing bridge associated with the Hume Highway crossing. Sandy Creek is considered to be a Class three minimal fish habitat (Fairfull & Witheridge 2003), as it essentially occurs as a small drainage line, and as such, the proposed bridge crossing would meet low flow design requirements (Fairfull & Witheridge 2003) and have minimal impact on connectivity.

During construction, run-off from disturbed surfaces would potentially affect water quality in local creeks due to sedimentation. In addition, there is the potential for accidental spillage/leakage of road construction materials, fuels, lubricants and hydraulic oils from construction equipment.

During operation, the paved surface of the Proposal would result in an increase in stormwater run-off volumes and flows. This could potentially increase flood levels and velocities in drainage lines downstream of the highway, although this is unlikely to be significant.

While the Threatened Southern Pygmy Perch was recorded in Mountain Creek, within the study area, fish and mobile invertebrate assemblages of the water bodies sampled during this study were fairly typical of freshwater habitats within the region and the fish assemblage consisted mostly of introduced species. Therefore, it is unlikely that any unique fish assemblages would be significantly affected by the proposed waterway crossings themselves, as it is unlikely that bridge piers would be located in the channel of the creek. Given that suitable habitat exists upstream and downstream of the Proposal and providing that best practice erosion and sediment controls are implemented in accordance with Volume 2D of Managing Urban Stormwater: soils and construction (Department of Environment and Climate Change 2008b), no long-term impacts from the proposed waterway crossings would be expected for fish and mobile invertebrate assemblages within the area.

5.8 Potential impacts on groundwater dependent ecosystems

Groundwater dependent ecosystems are communities of plants, animals and other organisms whose extent and life processes are dependent on groundwater (Department of Land and Water Conservation 2002). When considering groundwater dependent ecosystems, groundwater is generally defined as the saturated zone of the regolith (the layer of loose rock resting on bedrock, constituting the surface of most land) and its associated capillary fringe; however, it excludes soil water held under tension in soil pore spaces (the unsaturated zone or vadose zone) (Eamus et al. 2006).

The term 'groundwater dependent ecosystem' refers to ecosystems ranging from those entirely dependent on groundwater to those that may use groundwater while not having a dependency on it for survival (i.e. ecosystems or organisms that use groundwater opportunistic or as a supplementary source of water) (Hatton & Evans 1998).

Groundwater dependent ecosystems possess a range of values, including being important and sometimes rare ecosystems in themselves, as well as providing important ecosystem services such as water purification (Department of Land and Water Conservation 2002). Groundwater is also an increasingly important resource for human uses in Australia (there was a 90 per cent increase in groundwater extraction between 1985 and 1997 (National Land and Water Resources Audit 2001)). Nationally groundwater is extracted for uses including irrigation (48 per cent), urban and industrial use (33 per cent) and stock watering and rural use (19 per cent) (Department of the Environment and Heritage 2001).

The potential for groundwater extraction to exceed recharge has resulted in awareness of the effects of groundwater availability or regimes that may result in adverse impacts to groundwater dependent ecosystems (Department of Land and Water Conservation 2002; Eamus et al. 2006; Murray et al. 2003; PPK Environment & Infrastructure 1999; Sinclair Knight Mertz 2001), and thereby threaten the values they provide.

Within the study area there are two main flow systems present — fractured rock and alluvial aquifers. The unconsolidated alluvial aquifer is relatively close to the surface at 1 to 20 metres below the surface, with the fractured rock much deeper (greater than 40 metres deep). Much of the vegetation within the study area is likely to access groundwater resources. However, given the broad regional distribution of these communities and the varied topography over which they occur, it is unlikely that they will be dependent on the groundwater resources. The exception is the River Red Gums and other riparian vegetation that may show a proportional dependence on the groundwater.

The Proposal would require the excavation and shaping of the upper soil profile and minor alterations to the existing surface water drainage. There is agreement from Riverina Water (the authority responsible for supplying water to Woomargama) for the project to access water from the town water supply for concrete production. Currently town water is sourced from a single groundwater bore within the town's boundaries. The bore infrastructure is relatively old and is nearing the end of its working life. As part of any agreement to supply water, the bore infrastructure may be upgraded and left as a positive legacy to the township when construction is completed. PE or HDPE pipelines would be placed on the ground surface in the road reserve of the existing highway both north and south to allow the transfer of water from the bore to the batch plants. This would be the preferred option for water supply as it would involve less pumping than other options, and therefore, would be more economic and generate less greenhouse gases. This is unlikely to have significant impacts on the existing subsurface aquifers and their associated groundwater dependent ecosystems.

Table 5-2 Vegetation community dependency on groundwater

Ecosystem type ¹	Vegetation communities ²	Possible groundwater dependency ²
Terrestrial ecosystem	Box-gum Woodland	No apparent dependency on groundwater
	Rocky outcrops	No apparent dependency on groundwater
	Cleared lands with scattered eucalypts	No apparent dependency on groundwater
River base flow	River Red Gum very tall open forest of the NSW South Western Slopes Bioregion	Proportional dependence on groundwater
	Riparian Vegetation (ephemeral)	Groundwater accessed opportunistically or to a very limited extent

Notes: 1- Ecosystem Types as per Murray et al (2003); 2 - Groundwater dependency as per Hatton & Evans (1998)

5.9 Cumulative impacts

The potential biodiversity impacts of the Proposal have been considered as a consequence of the construction and operation of the Proposal within the existing environment. The incremental effect of multiple sources of impact (past, present and future) are referred to as cumulative impacts (Contant & Wiggins 1991; Council on Environmental Quality 1978) and provide an opportunity to consider the Proposal within a strategic context. This is necessary so that impacts associated with the Proposal and other activities within the region are examined collectively.

Due to its location in general agricultural lands, the Hume Highway Woomargama bypass and previously assessed Hume highway duplications to the north and south of the Proposal are the primary developments within the local area. The construction and development of the Hume Highway duplication to the north and south of the Proposal have previously been considered separately (Parsons Brinckerhoff 2007; SKM 2007). This report has considered the impacts from the Hume Highway Woomargama bypass.

As described for the Southern CRA region, six broad vegetation communities and habitats have been recorded within five kilometres of the subject site:

- Northern Slopes Dry Grass Woodland - *E. blakelyi* / *E. melliodora* / *Danthonia racemosa* / *Austrostipa scabra* ssp *falcate*.
- Western Slopes Dry Grass Woodland - *E. albens* / *Microlaena stipoides* / *Bothriochloa macra*.
- Western Slopes Moist Herb/Sedge/Grass Woodland - *E. blakelyi* / *Carex appressa*.
- Western Slopes Riparian Moist Sedge Woodland - *E. camaldulensis*.
- Western Slopes Shrub/Herb/Grass Dry Forest - *E. macrorhyncha* / *E. albens* / *Hydrocotyle laxiflora* / *Microlaena stipoides*.
- Western Tablelands Dry Shrub/Grass Forest - *E. macrorhyncha* / *E. polyanthemus* / *Hibbertia obtusifolia* / *Gonocarpus tetragynus*.

Although the project would remove approximately one per cent of such vegetation/ fauna habitat, approximately 868 hectares of similar or better quality vegetation will remain within five kilometres of the subject site.

The biodiversity impacts of the Proposal considered in this report are likely to be more significant as a result of biodiversity impacts from the previous surrounding Hume Highway duplication and bypass projects (refer Table 5-3). These cumulative impacts would include a greater extent of clearing of native vegetation and fauna habitats, including Endangered Ecological Communities, as well as further fragmentation of habitats. Furthermore, a number of Threatened species are known or are likely to be associated with such habitats throughout the region. It is estimated that a total of approximately 128 hectares of native vegetation has been or will be cleared for the current eight projects of the upgrade of the Hume Highway. While similar or better quality vegetation/ habitat remain within the region (approximately 69,002 hectares [combined total of above listed vegetation communities]), the extent of clearing for the eight projects would reduce the extent of viable habitat in the region. However, this would only account for approximately 0.2 per cent of vegetation/fauna habitat within the region.

While the projects listed in Table 5-3 would essentially result in minimal reduction to habitats within the region, the loss of 98 hectares of Threatened Ecological Communities, of which the current project contributes six hectares, is considered significant.

Table 5-3 Extent of vegetation clearing for the current Hume Highway duplication and bypass projects

Section of upgrade	Extent of vegetation clearing (ha)	Extent of EEC ¹
Woomargama duplication	13.55	7.48
N1 Tarcutta duplication	9.17	4.22
N2 – Kyeamba duplication	27.23	21.8
N3 – Little Billabong duplication	18.9	13.0
N4 – Yarra Yarra duplication	15.12	14.53
Holbrook Bypass ²	20	19
Tarcutta Bypass	16	12
Woomargama Bypass(this Project)	8	6
TOTAL	127.97	98.03

Note: 1 – includes all Endangered Ecological Communities. 2 – Estimates based on preliminary concept designs.