Photograph 3-2 Blakely's Red Gum - Yellow Box grassy woodland on floodplain and lower slopes of the Southern Travelling Stock Reserve

The dominant native understorey species observed included *Carex appressa*, *Lomandra filiformis, Elymus scaber*, and *Austrodanthonia* spp.

Some patches were highly disturbed by past and current land uses, including the existing Hume Highway, grazing and other agricultural practices. These disturbances have fragmented the vegetation community and modified the floristic composition and structure.

While the majority of patches of this community were in moderate condition (refer Figure 3-6) with a mix of native and exotic groundcover species, most contained large areas dominated by exotic species. Many of the exotic species observed were 'pasture improvement' species used to improve soil conditions and/or provide feed for grazing stock in the adjoining pastures. The most abundant exotic species within the community were *Bromus spp., Plantago lanceolata, Medicago polymorpha, Phalaris aquatica, Silybum marianum, Lolium spp., Echium plantagineum, Avena fatua, Trifolium spp.* and *Romulea rosea.*

Within the Southern Travelling Stock Reserve, south of the Tarcutta village, this vegetation community was generally in medium condition with a groundcover dominated by a relatively diverse floristic assemblage of native species and some exotic pasture species. This is likely to be a result of less frequent grazing than the adjoining pastures, no cropping and no introduction of pasture improvement species. The roadsides adjoining the Southern Travelling Stock Reserve and the existing Hume Highway were dominated by exotic and native pasture species.

This community is consistent with the White Box, Yellow Box, Blakely's Red Gum Woodland community listed as an Endangered Ecological Community under the *Threatened Species Conservation Act 1995* and White Box, Yellow Box, Blakely's Red Gum Grassy Woodland and Derived Native Grassland listed as Critically Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (refer Chapter 4).

3.2.5 Inland Grey Box tall grassy woodland

Inland Grey Box tall grassy woodland of the NSW South Western Slopes Bioregion is a woodland community up to 25 metres high dominated by *E. microcarpa*.

Within the study area this community consisted predominantly of narrow remnants of semi-continuous canopy and isolated trees within the existing Hume Highway road corridor as well as adjoining paddocks, typically associated with mid and lower slopes (refer Photograph 3-3 and Figure 3-5). There was also a highly disturbed paddock variation within the northern section of the study area that consisted of isolated canopy species over a predominantly exotic pasture understorey.

Photograph 3-3 Inland Grey Box tall grassy woodland within the northern section of the study area

This community shares similar conditions with the adjoining Blakely's Red Gum - Yellow Box grassy woodland. The dominant eucalypts ranged in age from older hollow-bearing (habitat) trees to young regrowth within the road reserves. The shrub stratum was sparse with the exception of several patches of *Acacia genistifolia*, *Acacia paradoxa, Pultenaea* spp and regrowth eucalypt understoreys. The groundcover was the most diverse stratum within this community, comprising a variety of native and exotic grasses sedges and herbs. Within the road reserves, the average number of native species sampled per 400 metre square quadrat was moderate at 11 species; while exotics typically made up less than 40 per cent of the diversity with an average of six species per quadrat.

Within the disturbed paddock community the native species diversity was very low with an average of three native species recorded per 400 metre square quadrat sampled. Exotics typically made up more than 60 per cent of the diversity with an average of four species per quadrat.

The dominant native species observed included *Einadia hastata, Lomandra filiformis, Austrostipa scabra* and *Austrodanthonia* spp.

Some of the isolated paddock patches were highly disturbed by past land uses, including, grazing and other agricultural practices. These disturbances have fragmented the vegetation community and modified the floristic composition and structure.

While the majority of patches of this community within the Hume Highway road reserve were in moderate condition (refer Figure 3-6), with a mix of native and exotic groundcover species, most contained large areas dominated by exotic species. Many of the exotic species observed were 'pasture improvement' species used to improve soil conditions and/or provide feed for grazing stock in the adjoining pastures. The most abundant exotic species within the community were *Bromus* spp., *Hordeum leporinum, Lolium spp., Echium plantagineum, Avena fatua, Hypochaeris radicata* and *Romulea rosea.*

Within the northern Hume Highway road reserves, this vegetation community was generally in medium condition with groundcover dominated by a relatively diverse floristic assemblage of native grass species. This is likely to be a result of less frequent grazing than the adjoining pastures, no cropping and no introduction of pasture improvement species. However, the isolated paddock remnants were dominated by exotic pasture species.

This community is consistent with Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions community listed as an Endangered Ecological Community under the *Threatened Species Conservation Act 1995* (refer Chapter 4). The community is also consistent with the preliminary listing of Inland grey box woodland ecological community under the *Environment Protection and Biodiversity Conservation Act 1999.*

3.2.6 Red Stringybark - Red Box - Scribbly Gum open forest

Red Stringybark - Red Box - Scribbly Gum open forest is an open forest community up to 20 metres high dominated by *E. macrorhyncha* and *E. polyanthemos* subsp*. polyanthemos* with subdominant canopy species including *E. rossii* and *E. blakelyi*. Within the study area this community occurred within the southern section on rocky mid slopes of the Southern Travelling Stock Reserve (refer Figure 3-5).

The community consisted of a narrow band of semi-continuous canopy and isolated trees within the Southern Travelling Stock Reserve and adjoining paddocks, typically associated with rocky outcrops and shallow soils on upper slopes (refer Photograph 3-4 and 3-5).

The dominant eucalypts ranged in age from older hollow-bearing (habitat) trees to young regrowth. The shrub stratum was sparse with several patches of low, scattered species, including *Dillwynia phylicoides* and *Acacia genistifolia*. The groundcover was the most diverse stratum within this community, which comprised a variety of native and exotic grasses, sedges and herbs. The average number of native species sampled per 400 metre square quadrat was moderate to high at 18 species. Exotic species typically made up less than 40 per cent of the diversity with an average of 16 species per quadrat.

The dominant native species observed included *Lomandra filiformis, Tricoryne elatior, Elymus scaber, Austrodanthonia* sp., *Wahlenbergia gracilis*, *Hydrocotyle laxiflora* and *Austrostipa* spp.

Photograph 3-4 Red Stringybark - herbaceous valley open forest in the south of the study area

On the upper slopes of the Southern Travelling Stock Reserve adjoining the Mugga Ironbark community, the community was dominated by *E. polyanthemos* subsp. *polyanthemos* (refer Photograph 3-5).

Photograph 3-5 Red Box dominant canopy over exposed rocky slope in the south of the study area

The majority of this community was in moderate condition with a relatively diverse floristic assemblage of native species. This is likely to be a result of less frequent grazing than the adjoining pastures and no cropping. Many of the exotic species observed were 'pasture improvement' species used to improve soil conditions and/or provide feed for grazing stock in the adjoining pastures. The most abundant exotic species within the community were *Avena fatua, Lolium spp., Bromus* spp., *Echium plantagineum, Hypochoeris radicata, Trifolium spp.* and *Hypericum perforatum.*

3.2.7 Mugga Ironbark - Scribbly Gum - Red Gum open forest on hillcrests in the NSW South Western Slopes Bioregion

Mugga Ironbark - Scribbly Gum - Red Gum open forest on hillcrests is a community up to 20 metres high dominated by *E. sideroxylon* with a subdominant canopy of *E. polyanthemos* subsp*. polyanthemos*. Within the study area, this community occurred within the south-western section of the Southern Travelling Stock Reserve (refer Figure 3-5).

The community consisted of a semi-continuous canopy and isolated trees within the Southern Travelling Stock Reserve and adjoining paddocks, typically associated with rocky, shallow soils on upper slopes (refer Photograph 3-6).

Photograph 3-6 Mugga Ironbark - Scribbly Gum - Red Gum open forest in the south of the study area

The dominant eucalypts were typically semi-mature in age with few older hollow-bearing (habitat) trees. The shrub stratum was generally sparse *Acacia genistifolia, Acacia paradoxa* and *Melichrus urceolatus*. The groundcover was the most diverse stratum within this community and comprised a variety of native and exotic grasses sedges and herbs. The average number of native species sampled per 400 metre square quadrat was high in this community at 17 species. Exotic species typically made up less than 25 per cent of the diversity with an average of seven species per quadrat.

The dominant native species observed included *Xerochrysum viscosum, Wahlenbergia gracilis, Lomandra filiformis, Tricoryne elatior, Austrodanthonia* spp., and *Austrostipa scabra* subsp*. falcata*.

Disturbances in this community were restricted to past selective logging and some grazing. These disturbances have fragmented the vegetation community within the study area as well as modifying the floristic composition and structure.

The majority of patches of this community were in moderate condition (refer Figure 3-6) with a mix of native and exotic groundcover species. Many of the exotic species recorded were 'pasture improvement' species introduced from neighbouring paddocks. The most abundant exotic species within the community were *Avena fatua, Lolium spp., Bromus* spp., *Echium plantagineum, Hypochoeris radicata, Trifolium spp.* and *Hypericum perforatum.*

3.2.8 Apple Box moist grass-forb open forest

The Apple Box moist grass-forb open forest is an open forest-woodland community up to 20 metres high dominated by *E. bridgesiana* and occasionally *E. blakelyi* and *E. melliodora*. This community occurred on the fertile alluvial plains of the southern section of the study area (refer Figure 3-5).

Within the road reserves this community consisted of long, narrow remnants and patches of semi-continuous canopy and isolated trees within the road corridor and adjoining paddocks.

This community shares similar conditions with the adjoining Blakely's Red Gum - Yellow Box grassy woodland. Eucalypts in this community ranged in age from older hollow-bearing (habitat) trees to young regrowth. A moderately dense shrub stratum was generally present dominated by *Cassinia aculeata, Acacia dealbata,* and *Acacia pycnantha*. The groundcover was the most diverse stratum within this community, which comprised a variety of native and exotic grasses, sedges and herbs. The average number of native species sampled per 400 metre square quadrat was low-moderate in this community at nine species. Exotic species typically made up less than 60 per cent of the diversity with an average of 13 species per quadrat.

The dominant native species observed included *Elymus scaber, Austrodanthonia* spp. and *Austrostipa scabra*.

The roadside patches were generally highly disturbed by past land uses, including edge effects, construction of the Hume Highway, and grazing and other agricultural practices. These disturbances have fragmented the vegetation community and modified the floral composition and structure. Many of the exotic species observed were 'pasture improvement' species used to improve soil conditions and/or provide feed for grazing stock in the adjoining pastures. The most abundant exotic species within the community were *Bromus diandrus, Phalaris aquatica, Echium plantagineum*, *Hypericum japonicum, Plantago lanceolata* and *Romulea rosea.*

Photograph 3-7 Apple Box moist grass-forb open forest

This community was consistent with White Box, Yellow Box, Blakely's Red Gum Woodland community listed as an Endangered Ecological Community under the *Threatened Species Conservation Act 1995* and White Box, Yellow Box, Blakely's Red Gum Grassy Woodland and Derived Native Grassland, which is listed as Critically Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (refer Chapter 4).

3.2.9 Derived native grassland

Derived native grassland was a disturbed grassland community with isolated mature paddock trees up to 25 metres high dominated by *E. microcarpa*.

The community was restricted to a single fenced paddock in the northern portion of the study area (refer Photograph 3-8 and Figure 3-5).

The groundcover comprised a variety of native and exotic grasses, sedges and herbs. The average number of native species sampled per 400 metre square quadrat was considered moderate in this community, at 14 species. Exotic species typically made up less than 40 per cent of the diversity with an average of 10 species per quadrat.

The dominant native species observed included *Chloris truncata, Eragrostis* sp *Lomandra filiformis, Bothriochloa macra*, *Austrostipa scabra* and *Austrodanthonia* spp.

Many of the exotic species observed were 'pasture improvement' species used to improve soil conditions and/or provide feed for grazing stock in the adjoining pastures. The most abundant exotic species within the community were *Bromus* spp., *Hordeum leporinum, Lolium spp., Echium plantagineum, Avena fatua, Hypochoeris radicata* and *Romulea rosea.*

Photograph 3-8 Derived native grassland within the northern portion of the study area

This community was consistent with Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions community listed as an Endangered Ecological Community under the *Threatened Species Conservation Act 1995* (refer Chapter 4). The community is also consistent with the preliminary listing of Inland grey box woodland ecological community under the *Environment Protection and Biodiversity Conservation Act 1999.*

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, as described in Table 3-4. 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 Box-Gum Woodland, Riparian Woodland and Grazed Pasture Land. The habitats and species associations are discussed in Sections 3.3.1 and 3.3.2. Specific habitat attributes of each community type are described in further detail in Table 3-5. The location of broad habitat types and their condition are shown in Figure 3-7.

Table 3-4 Fauna habitat with corresponding vegetation description

Fauna habitat description	Corresponding vegetation community
Box-Gum Woodland	Blakely's Red Gum - Yellow Box grassy woodland, Inland Grey Box tall grassy woodland
	Red Stringybark - Red Box - Long-leaved Box - Scribbly Gum shrub
	Mugga Ironbark - Scribbly Gum - red gum graminoid open forest
	Apple Box moist gully grass-forb open forest
Riparian Woodland	River Red Gum very open forest of the NSW South Western Slopes
Grazed Pasture Land	Derived Grassland

3.3.1 Box-Gum Woodland

Box-Gum Woodland within the study area occurred as remnant stands of moderate to highly disturbed vegetation. Given the presence of numerous tree hollows and the role of remnant vegetation in providing connectivity within the surrounding cleared landscape, Box-Gum Woodland in the study area was considered as having a moderate value to fauna species. Furthermore, the paucity of such vegetation at a landscape scale suggests that these remnants are likely to provide important resources for native fauna.

Box-Gum Woodland habitat in the study area provided a variety of tree hollows and dead trees suitable as nesting opportunities for open country and generalist species of bird, nesting dens for arboreal mammals, including the Threatened Squirrel Glider, and roosting habitat.

Species recorded in such habitats within the study area included Western Gerygone, White-throated Treecreeper, Galah and Common Brushtail Possum. During current field surveys, only low numbers of honeyeaters and other species of bird were recorded due to the low density of flowering eucalypt species.

Many of the Box-Gum Woodland habitats within the study area have experienced varying levels of disturbance, due to past and current land use practices, primarily grazing. The effects of grazing are present throughout the study area, with only the upper canopy remaining. Shrub layers and leaf litter were largely absent in such habitats with only low percentage foliage cover of native ground covers (refer Photograph 3-9).

Conversely, survey site S3 (refer Figure 2-2), particularly the Southern Travelling Stock Reserve occurring in the south of the study area, was considered good condition fauna habitat. Survey site S3 contained numerous mature and hollow-bearing trees, a native shrub layer, high levels of native grass and herbs as well as a good covering of leaf litter, fallen logs and bush rocks. Survey site S3 occurs as part of a larger section of remnant Box-Gum Woodland, effectively providing relatively undisturbed habitat and habitat linkages in the local area. The diversity of upper canopy trees observed in Box-Gum Woodland located at survey site S3 indicated year-round food resources (particularly with respect to flowering tree species), providing valuable foraging resources for both woodland bird and mammal species, including the Threatened Squirrel Glider.

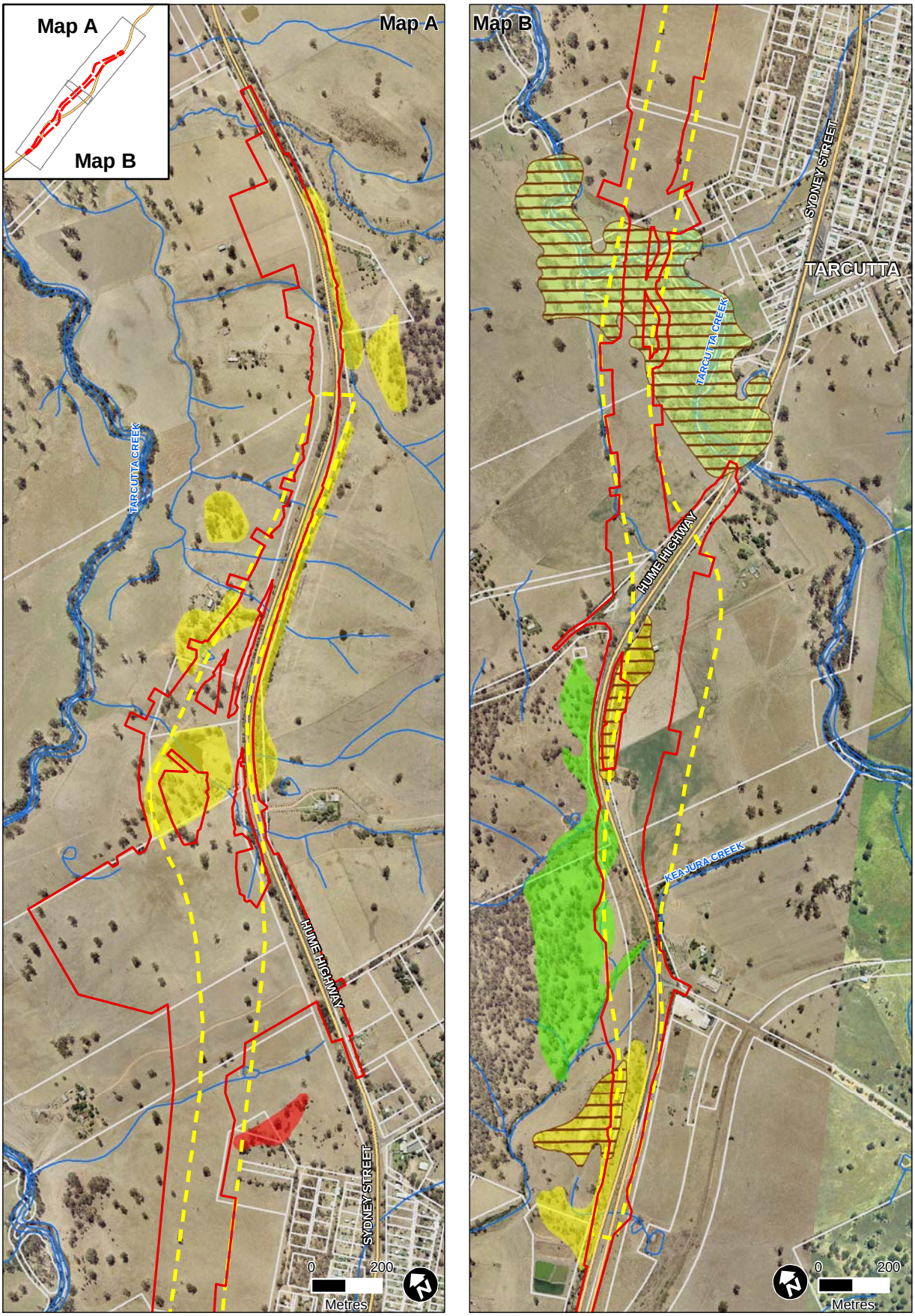


Figure 3-7 Fauna habitat and condition

Photograph 3-9 Box-Gum Woodland at survey site S1

Many of the roadside remnants of Box-Gum Woodland (such as those occurring at survey site S7 and S8) were relatively diverse due to the lack of grazing, containing a higher percentage of native grasses. This diversity provides greater foraging resources for local fauna, such as woodland bird species.

Specific habitat attributes for Box-Gum Woodland surveyed along the proposed alignment are summarised in Table 3-5.

3.3.2 Riparian woodland

The proposed alignment traverses Tarcutta Creek (survey site S2) on the south-western side of the Township of Tarcutta (refer Photograph 3-10). The majority of creek lines running under or adjacent to the current highway contained standing pools of water or, in the case of Tarcutta Creek, contained flowing water and was considered a semi-permanent water body.

Vegetation along Tarcutta Creek (survey site S2) contained a range of age classes of *E. camaldulensis* with patches of *E. camaldulensis* regrowth within the creek channel. A dense sub canopy of juvenile *E. camaldulensis* and patches of the exotic *Salix babylonica* were also present.

This habitat type provided habitat resources for common species of amphibian and birds, including species such as Peron's Tree Frog, Red-browed Finch, Clamorous Reed Warbler, Azure Kingfisher and Rainbow Bee-eater.

Farm dams within the study area did not contain riparian vegetation; however, they did provide water resources for birds and mammals. A farm dam located near survey site 1C in the northern section of the study area provided good aquatic habitat for amphibians and

water birds. The dam perimeter contained emergent plants with species such as Australasian Grebe, Black-fronted Dotterel, Peron's Tree Frog and Eastern Long-necked Tortoise observed using dam resources.

Specific habitat attributes for Riparian Woodland surveyed along the proposed alignment are summarised in Table 3-5.

Photograph 3-10 Riparian Woodland on floodplain of Tarcutta creek, west of Tarcutta

3.3.3 Grazed pasture land

Grazed pasture comprised the majority of the habitats surrounding the study area. These areas provided limited habitat and were highly disturbed from grazing and other agricultural practices that have removed native understorey and groundcover vegetation. However, within such environments, isolated paddock trees can be important for the conservation of fauna, providing habitat for a range of fauna and maintaining connectivity between larger patches of vegetation (Carruthers & Paton 2005; Gibbons & Boak 2002; Lumsden & Bennet 2003; Robertson & Radford 2009).

Table 3-5 Description of microhabitat features along the proposed alignment

Microhabitat attributes	Vegetation community	
	Box-Gum Woodland	**Riparian Woodland**
Upper canopy	Upper canopy trees were greater than 15 metres tall in most areas with an average diameter at breast height (DBH) greater than 0.7 metres. The crown cover in survey site S1 was generally dominated by White Box, River Red Gum, Apple Box and Blakely's Red Gum. A canopy cover of 90 per cent was estimated and DBH greater than 0.9 metres. The crown cover in survey site S2 was generally dominated by River Red Gum with a canopy cover estimated at approximately 90 per cent and an average DBH greater than 0.9 metres. The crown cover in survey site S3 was generally dominated by *E. macrorhyncha, E. polyanthemos, E. rossi* and *E. blakelyi*. A canopy cover of 90 per cent was estimated and an average DBH greater than 0.9 metres. The crown cover in roadside reserves was moderate to high with a crown cover estimated to be greater than 80 per cent. A light scattering of mistletoe plants was recorded within the upper canopy across the study area.	Upper Canopy trees, including *E. camaldulensis* (with a range of age classes) were greater than 15 metres tall in most areas with an average DBH greater than 0.9 metres. The crown cover at survey site S2 was almost complete and estimated to be greater than 90 per cent.
Shrub layer	Generally absent. Survey site S3 contained species including *Acacia genistifolia*, *A. paradoxa* and *Dillwynia phylicoides*.	Generally absent.
Grasses, herbs, forbs, sedges and rushes	The groundcover was generally dominated by pasture improvement species and weeds. However, survey site S3 was generally dominated by native species including *Dillwynia phylicoides* and *Acacia genistifolia.*	The groundcover was dominated by pasture improvement species and weeds.
Leaf litter	Generally absent. However, leaf litter was present at survey site S3.	Generally absent.
Fallen timber	A small to moderate amount of fallen dead branches were present in this habitat.	A small amount of fallen dead branches were present in this habitat.
Tree hollows and stags	Numerous small (10-20 centimetre diameter) and medium sized (20-30 centimetre diameter) tree hollows were recorded within Box and Red Gum trees. A moderate number of hollow-bearing stags were recorded within this habitat.	Numerous small (10-20 centimetre diameter) and medium sized (20-30 centimetre diameter) tree hollows were recorded within Red Gum trees. A moderate number of hollow-bearing stags were recorded within this habitat.

Microhabitat attributes	Vegetation community	
	Box-Gum Woodland	**Riparian Woodland**
Rocks and rock shelves	Rocky hillsides were observed in the Southern Travelling Stock Reserve and roadside reserves in the southern and northern sections of the Proposal study area respectively. This habitat provided important resources for reptiles including the Olive Legless Lizard and potentially for the Pink-tailed Worm-lizard and Striped Legless Lizard.	Absent.
Drainage lines and water bodies	Farm dams varying in size. Only one (survey site S3) contained emergent vegetation and provided moderate-good habitat value for native fauna. However, all provided a source of water for native fauna. The creek line running parallel to the rocky hillside (survey site S3), contained moderate habitat for amphibian and avifauna species.	Tarcutta Creek (survey site S2) contained flowing water and standing pools of water and was considered moderate habitat for amphibian and avifauna species.
Overall condition	Moderate.	Moderate.

3.4 Aquatic habitat

Tarcutta Creek is part of a 170,000 hectare catchment on the south-west slopes of New South Wales, and is a tributary and major source of sediments and nutrients in the Murrumbidgee and Murray River systems (Landcare Australia 2009). Tarcutta Creek begins near Tumbarumba and flows in a northerly direction to Borambola where it joins the Murrumbidgee River, approximately 25 kilometres east of Wagga Wagga (Department Infrastructure, Planning and Natural Resources 2004). Tarcutta creek is the only Class 1 water way as defined by the RTA (Witheridge 2002) within the study area.

The section of Tarcutta Creek, which occurs to the west of the town of Tarcutta has been modified as a result of anthropogenic disturbance, which includes agricultural activities, clearing and grazing of cattle. The existing Hume highway crosses Tarcutta creek to the south of the town of Tarcutta, where the creek passes under a bridge.

The Riparian bank vegetation was dominated by exotic weeds including significant incursions of *Salix babylonica* (refer to Photograph 3-11, 3-12 and 3-13). Pools and sediment deposits within the active creek channel were dominated by a mixture of native and exotic sedges, rushes and aquatic species, including *Persicaria decipiens, Typha australis, Phragmites australis, Carex appressa, Juncus usitatus* and *Triglochin procera.* Habitats within the creek included undercut banks, sand/gravel shallow beds, and a wide range of natural structures, including large dead trees.

In addition to Tarcutta creek a minor Class 3 water way, Keajura Creek, as defined by the RTA (Witheridge 2002) is located in the southern section of the study area. Keajura Creek is crossed in the south of the study area by the existing Hume Highway where it passes through a concrete box culvert.

The section of Keajura Creek, which occurs to the south of the town of Tarcutta has been significantly modified as a result of anthropogenic disturbance, which includes altered drainage systems, artificially created channels, agricultural activities, clearing and grazing of cattle. The Riparian bank vegetation was dominated by exotic weeds including significant incursions of *Salix babylonica*. This creek was predominately characterised by a dry bed with isolated pools for semi-permanent water and dense exotic pasture improvement species and weeds, including *Carex appressa, Microlaena stipoides* var*. stipoides, Echium plantagineum, Hordeum leporinum, Vulpia myuros, Lythrum hyssopifolia, Lolium perenne, Amphibromus nervosus, Phalaris aquatica* and *Bromus* spp*.* Given the Class 3 water way classification, high levels of disturbance and predominately dry bed no aquatic sampling was completed within this creek.

Photograph 3-11 Aquatic survey location at the point of crossing

Photograph 3-12 Aquatic survey location upstream

Photograph 3-13 Aquatic survey location downstream

3.4.1 Water quality

Physical water parameters were sampled at three locations (Tarcutta Downstream, Tarcutta Bypass and Tarcutta Upstream) within Tarcutta Creek. All physical parameters were within ANZECC (2000) guidelines, except for turbidity, which was recorded above the ANZECC (2000) guideline at all sites (refer Table 3-6).

Table 3-6 Mean (± SE) measurements of water quality variables recorded at each site within each location

Variable	TD1[1]	TD2[1]	TB1[1]	TB2[1]	TU1[1]	TU2[1]
Temperature (°C)	23.2 (0.02)	23.2 (0.02)	23.2 (0.003)	23.2 (0.009)	22.6 (0.003)	22.6 (0.003)
pH (6.5-8.0[2])	7.8 (0.07)	7.8 (0.03)	7.7 (0.08)	7.9 (0.07)	7.9 (0.08)	7.7 (0.1)
Conductivity (µS/cm) (125-2200[2])	172 (0)	166 (9.4)	172 (0)	172 (0)	170 (0)	170 (0)
Dissolved oxygen (mg/L) (85 %-110 %[2])	7.1 (0.1)	6.6 (0.1)	6.5 (0)	6.4 (0.03)	6.7 (0.03)	6.6 (0.03)
Turbidity (NTU) (6-50[2])	67.0 (2.0)	92.3 (24.7)	88.4 (7.0)	273.7 (81.4)	176.5 (68.4)	80.6 (3.1)

Note: 1: TD – Tarcutta Downstream, TB – Tarcutta Bypass, TU – Tarcutta Upstream

2: Default trigger values for lowland rivers in south east Australia, Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines (ANZECC (2000).

3.4.2 Macroinvertebrates

A total of 1,728 individuals from 23 macroinvertebrate taxon were collected from the three locations in Tarcutta. The most abundant macroinvertebrate taxa were aquatic bugs (Corixidae – 1,414 individuals) followed by mayflies (Caenidae - 115 individuals).

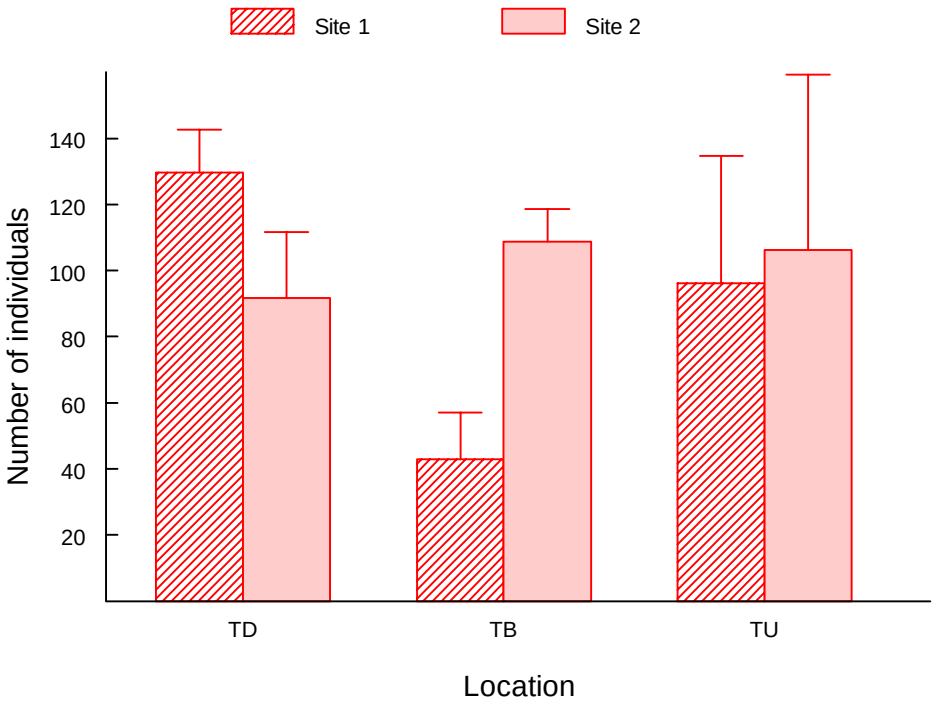
There were no significant differences detected in the total abundance (number of individuals) and total richness (number of taxa) of macroinvertebrates at any scale (refer Table 3-7).

The non-metric multidimensional scaling (nMDS) ordination indicated that there were differences in the structure of the macroinvertebrate assemblages between locations (refer Figure 3-10). The stress value (0.03) associated with the ordination indicated that it was an excellent representation with no prospect of misinterpretation (Clarke & Warwick 1994). The ANOSIM test (Global R: 0.030) indicated that there were no significant differences ($P > 0.05$) in the structure of the assemblages among locations (Clarke & Warwick 1994).

Table 3-7 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 Tarcutta

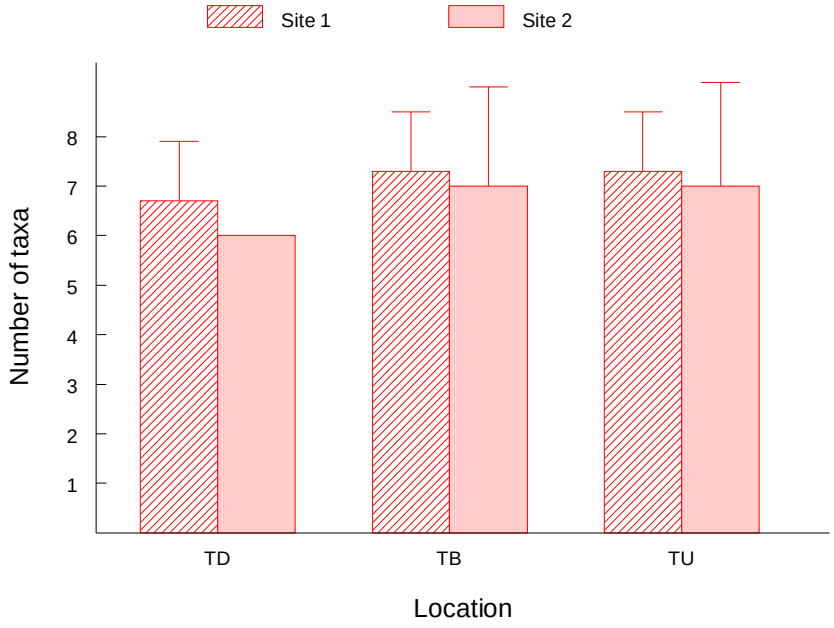
		Abundance		*Richness*	
Source of Variation	**df**	**MS**	**F**	**MS**	**F**
Location	2	1956.2	0.7ns	1.4	4.2ns
Site (location)	3	2924.8	1.1ns	0.3	0.4ns
Residual	12	2594.3		8.2	
Total	17				
Cochran's test			0.544ns		0.293ns
Transformation			none		none

Note: ns = not significant ($P > 0.05$); * = significant ($P < 0.05$); ** = significant ($P < 0.01$)



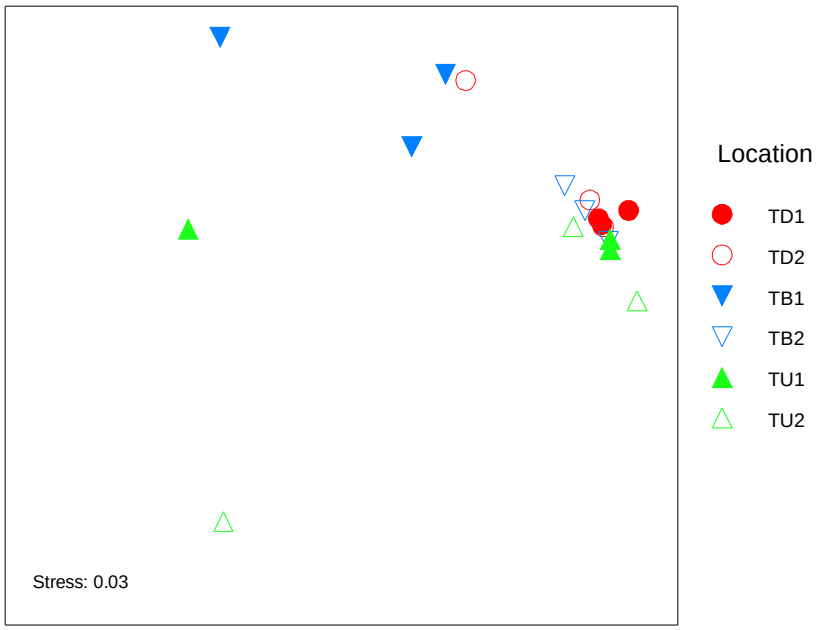
(TD – Tarcutta Downstream, TB – Tarcutta Bypass, TU – Tarcutta Upstream)

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



(TD – Tarcutta Downstream, TB – Tarcutta Bypass, TU – Tarcutta Upstream)

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



(TD – Tarcutta Downstream, TB – Tarcutta Bypass, TU – Tarcutta Upstream)

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

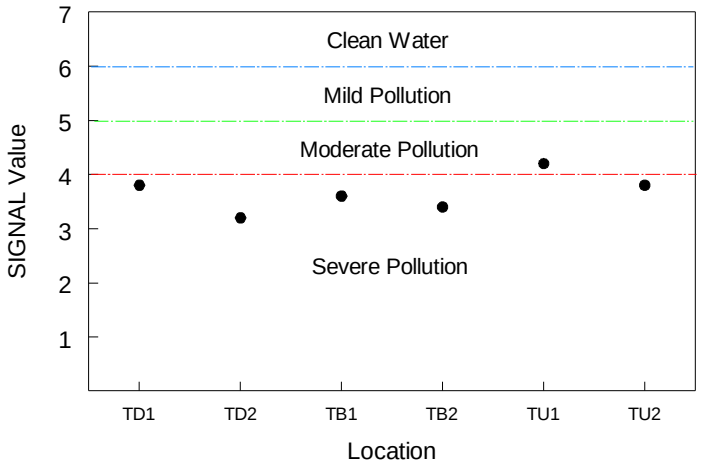
The SIMPER procedure ranked Corixidae (True Bugs) and Caenidae (Mayflies) as the most important taxa that contributed to the structure of the macroinvertebrate assemblage at all locations (refer Table 3-8). The families Notonectidae (True Bugs) and Atyidae (Freshwater Shrimps) were also ranked highly at location TD2 and location TB1 respectively (refer Table 3-8).

The SIGNAL values calculated that all sites were severely polluted except for TU1, which was classed as moderately polluted (refer Figure 3-11). The relatively large number of pollution tolerant macroinvertebrate taxa suggested that the water quality was generally quite poor (Chessman 2003).

Table 3-8 Macroinvertebrate taxa ranked in order of importance according to the SIMPER procedure for each site within a location

Name	Taxa	TD1	TD2	TB1	TB2	TU1	TU2
Shrimps	Atyidae			2			
Mayflies	Caenidae	2	3	3	2	2	2
True Flies	Chironomidae	4	6	4		6	
True Bugs	Corixidae	1	1	1	1	1	1
Beetles	Dytiscidae	7					
Leeches	Hirudinae	5					
Beetles	Hydraenidae		7				
Beetles	Hydrophilidae		5			5	4
Caddis Flies	Hydropsychidae		8				3
Caddis Flies	Leptoceridae	3	4		4	3	
Mayflies	Leptophlebiidae	6			5	4	5
Worm	Lumbriculidae			5			
True Bugs	Notonectidae		2	6	3	7	
Gastropods	Physidae			7			6

(TD – Tarcutta Downstream, TB – Tarcutta Bypass, TU – Tarcutta Upstream).



(TD – Tarcutta Downstream, TB – Tarcutta Bypass, TU – Tarcutta Upstream).

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

3.5 Recorded flora and fauna

3.5.1 Terrestrial flora

A total of 222 species of plant was recorded in the study area of which 129 species (60 per cent) were native (Appendix A). The most diverse family recorded was the Poaceae (grasses), with 63 species, followed by the Asteraceae and Fabaceae, with 22 and 23 species respectively (Appendix A). In addition to these species, a small number of unidentified planted native and exotic cultivated species were observed within the subject site's residential and planted areas.

Seven species of plant listed under the *Noxious Weeds Act 1993* for the Wagga Wagga local government area were recorded in the study area (refer Table 3-9). Blackberry and Willows are also listed as Weeds of National Significance (Thorp & Lynch 2000).

Table 3-9 Noxious weeds recorded in the study area

Name	*Noxious Weeds Act 1993* control category[1]
Xanthium sp.	Class 4
Echium plantagineum	Class 4
Hypericum perforatum (St Johns Wort)	Class 4
Rosa rubiginosa (Sweet Briar)	Class 4
Romulea rosea	Class 5
Rubus fruticosus (Blackberry)*	Class 4
Salix babylonica (Weeping willow)*	Class 5

Notes: 1. *Noxious Weeds Act 1993*: Class 4: The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority. Class 5: The requirements in the *Noxious Weeds Act 1993* for a notifiable weed must be complied with. * listed as a Weed of National Significance (Thorp & Lynch 2000).

3.5.2 Terrestrial fauna

One hundred and thirteen species of animal were recorded in the study area during field surveys (refer Table 3-10), including five threatened species: Brown Treecreeper, Speckled Warbler, Barking Owl, Squirrel Glider and Eastern False Pipistrelle and (refer Appendix B). Box-Gum Woodland across the study area contained the greatest diversity of animals with 106 species recorded, while 39 species of animal were recorded within the Riparian Woodland. Four introduced species were recorded in the study area.

Table 3-10 Faunal species diversity recorded in study area

Faunal group	Species diversity (introduced species) (Threatened species)
Birds	80 (1) (3)
Mammals	19 (3) (2)
Reptiles	11 (0) (0)

Amphibians	3 (0) (0)
Total	**113 (4) (5)**

Birds

Native birds were the most diverse group of animals recorded in the study area (79 species). The majority of the species were common, open country generalists, or species common to grassy woodland environments, including the Sulphur-crested Cockatoo, Red-rumped Parrot and White-plumed Honeyeater. The Threatened Brown Treecreeper was observed in Box Gum Woodland and Riparian Woodland across the study area, while the Threatened Speckled Warbler (observed in drainage line) and Barking Owl were observed in Box-Gum Woodland at survey site S3. Remnant habitat throughout the study area was suitable for woodland species of bird, including Threatened and declining species.

Mammals

Sixteen species of native animal were recorded in the study area. The Common Brushtail Possum, Eastern Grey Kangaroo and microchiropteran bats were associated with Box-Gum and Riparian Woodland habitats in the study area.

Microchiropteran bat activity was moderate throughout the night and included 10 species, including freetail bats, forest bats and species typical of open woodland areas like the White-striped Freetail Bat (refer Appendix B).

Two Threatened species of mammal — Eastern False Pipistrelle and Squirrel Glider — were recorded in the study area.

Three species of introduced mammal — Rabbit, Brown Hare and House Mouse — were recorded across the study area, but primarily on Grazed Pasture Land (refer Appendix B).

Amphibians

Three species of amphibian were recorded during field surveys. The Plains Froglet, Peron's Tree Frog and the Spotted Grass Frog (refer Appendix B) were heard calling at various locations throughout the study area, including Box Gum Woodland, Riparian Woodland and drainage lines. Tarcutta Creek (survey site S2) together with the creek line associated with the Southern Travelling Stock Reserve at the southern end of the study area (survey site S3), contained moist habitat for amphibians, other than farm dams along the Proposal alignment. Habitat for frogs was generally in moderate condition.

Reptiles

Eleven species of reptile were recorded during field surveys (refer Appendix B). The Olive Legless Lizard was located in the vicinity of rocky outcrops in Box-Gum Woodland. This species was recorded in the northern and southern ends of the Proposal alignment at an existing Hume Highway cutting (survey site S7 and S8) and rocky hillside (survey site S3). The Marbled Gecko was recorded at Tarcutta Cemetery in a remnant stand of Box-Gum Woodland (survey site S4).

Habitat across the study area was generally considered poor for reptiles due to the paucity of microhabitat elements (and habitat structure) necessary for these species. Three locations, survey site S3, S7 and S8 did, however, provide moderate habitat for reptile species. These locations provided rocky hillside/outcrop (survey site S3 only) and various sized rocks and boulders, which provide refuge and foraging habitat.

3.5.3 Aquatic species

A total of 166 individuals representing five species of fish and two species of crustacean were collected from the three locations at Tarcutta using the electrofisher and nets. The most abundant fish caught was the introduced Mosquito Fish (*Gambusia holbrooki* – 13 individuals), followed by the Common Carp (*Cyprinus carpio* – 9 individuals) and Redfin Perch (*Perca fluviatilis* - 5 individuals). The only native fish caught were Southern Pygmy Perch (*Nannoperca australis* – 1 individual) and Australian Smelt (*Retropinna semoni* – 1 individual) at location TB2. The Southern Pygmy perch is listed as Endangered under the *Fisheries Management Act 1994*. The crustaceans included Freshwater Shrimps (*Paratya australiensis* – 135 individuals) and Yabbies (*Cherax* sp. - 2 individuals).

There was a significant difference detected in Sites (location) for the total abundance (number of individuals) of fish and crustaceans (refer Table 3-11), due to the greater numbers of individuals collected in Site 2 at the TB location (refer Table 3-11, Figure 3-12). No significant difference was detected at any scale for total richness of fish and crustaceans (refer Table 3-11, Figure 3-13).

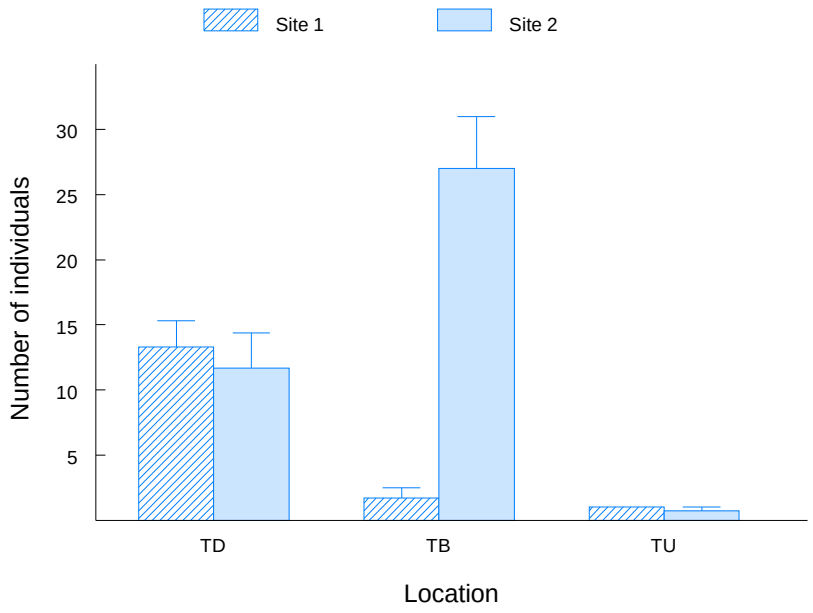
Table 3-11 Summary of analyses of variance comparing the total abundance (number of individuals) and richness (number of taxa) of fish and crustaceans recorded in the three locations in Tarcutta

		Abundance		***Richness***	
Source of Variation	**df**	**MS**	**F**	**MS**	**F**
Location	2	321.7	1.0ns	1.7	1.2ns
Site (Location)	3	322.3	21.9**	1.4	2.1ns
Residual	12	14.7		0.7	
Total	17				
Cochran's Test			0.589ns		0.583ns
Transformation			none		none

Note: ns = not significant (P > 0.05); * = significant (P < 0.05); ** = significant (P < 0.01).

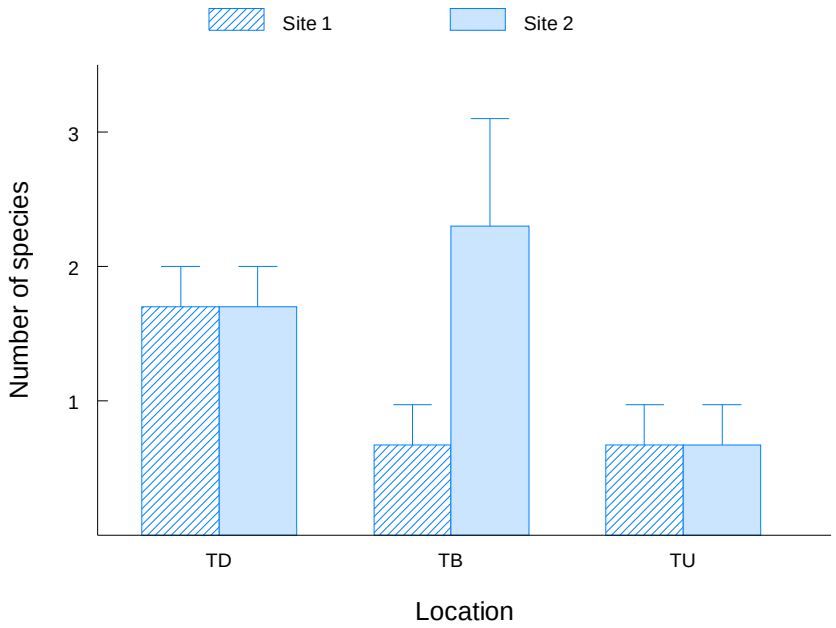
The non-metric multidimensional scaling (nMDS) ordination indicated that there were differences in the structure of the fish and crustacean assemblages between the three locations (refer Figure 3-14). The stress value (0.01) associated with the ordination indicated an excellent representation with no prospect of misinterpretation (Clarke and Warwick, 1994).

The ANOSIM test (Global R: 0.399) confirmed that there were significant differences (P < 0.01) in the structure of the assemblages among the three locations (Clarke and Warwick, 1994). The pairwise comparisons found that TB and TU were not significantly different (R: 0.157; P > 0.05), however, HD was significantly different from HB (R: 0.419; P < 0.01) and HU (R: 0.503; P < 0.01).



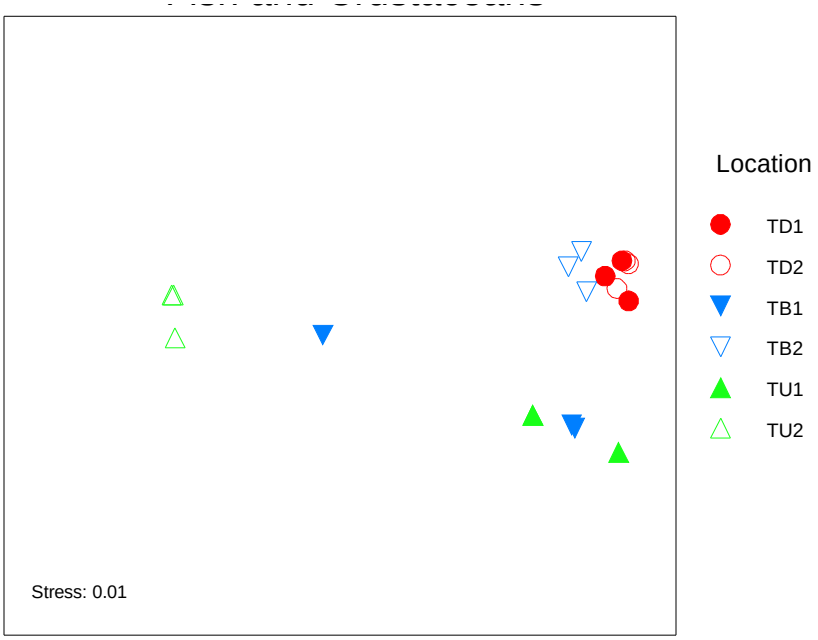
(TD – Tarcutta Downstream, TB – Tarcutta Bypass, TU – Tarcutta Upstream)

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



(TD – Tarcutta Downstream, TB – Tarcutta Bypass, TU – Tarcutta Upstream).

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



(TD – Tarcutta Downstream, TB – Tarcutta Bypass, TU – Tarcutta Upstream)

Figure 3-14 nMDS ordination for fish and crustaceans for each site within the three locations

The SIMPER procedure ranked shrimp as the most important species that contributed to the structure of the fish and crustacean assemblage at TD and TB2, whilst Carp were ranked highest at TB1 and TU1. Yabbies were ranked highest at TU2 (refer Table 3-12).

Table 3-12 Fish and crustaceans ranked in order of importance according to the SIMPER procedure for each site within a location

Name	TD1	TD2	TB1	TB2	TU1	TU2
Carp			1	2	1	
Mosquito Fish	3		2			
Redfin Perch	2	2				
Shrimp	1	1		1		
Yabbie						1

(TD – Tarcutta Downstream, TB – Tarcutta Bypass, TU – Tarcutta Upstream).