Hume Highway Upgrade

Holbrook bypass
Technical Paper 1
Flora and fauna

November, 2009

NSW Roads and Traffic Authority

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Glossary

Biodiversity	The biological diversity of life is commonly regarded as being made up of the following three components: ▪ Genetic diversity — the variety of genes (or units of heredity) in any population. ▪ Species diversity — the variety of species. ▪ Ecosystem diversity — the variety of communities or ecosystems.
Bioregion (region)	A bioregion defined in a national system of bioregionalisation. For this study this is the NSW South-western Slopes bioregion as defined in the Interim Biogeographic Regionalisation for Australia (Thackway and Cresswell 1995).
Black-chinned Honeyeater	Refers to the eastern subspecies of Black-chinned Honeyeater (*Melithreptus gularis gularis*).
Brown Treecreeper	Refers to the eastern subspecies of Brown Treecreeper (*Climacteris picumnus victoriae*).
Critical Habitat	The whole or any part or parts of an area or areas of land comprising the habitat of an Endangered species, an Endangered population or an Endangered ecological community that is critical to the survival of the species, population or ecological community (Department of Environment and Conservation 2004). Critical Habitat is listed under both the *Threatened Species Conservation Act 1995* and the *Environment Protection and Biodiversity Conservation Act 1999* and both the State (Department of Environment, Climate Change and Water) and Federal (Department of the Environment and Water Resources) Directors-General maintain a register of this habitat. Capitalisation of the term 'Critical Habitat' in this report refers to the habitat listed specifically under the relevant State and Commonwealth legislation.
Department of Environment, Climate Change and Water	Broadly, the Department of Environment, Climate Change and Water works towards a healthy environment cared for and enjoyed by the whole NSW community; manages the state's natural resources, including biodiversity, soils and natural vegetation; manages natural and cultural heritage across the state's land and waters; acts to minimise the impacts of climate change; promotes sustainable consumption, resource use and waste management; regulates activities to protect the environment; and conducts biodiversity, plant, environmental and cultural heritage research to improve decision making. The Department of Environment, Climate Change and Water formed on 1 July 2009, incorporating the former NSW Department of Environment, Climate Change and Water in addition to water management responsibilities of the former Department of Water and Energy.
Department of the Environment and Heritage	The former name for the Commonwealth Department of the Environment, Water, Heritage and the Arts.
Department of the Environment and Water Resources	The former name for the Commonwealth Department of the Environment, Water, Heritage and the Arts.
Department of the Environment, Water, Heritage and the Arts	The department develops and implements national policy, programs and legislation to protect and conserve Australia's natural environment and cultural heritage and administers the *Environment Protection and Biodiversity Conservation Act 1999*.The Commonwealth Department of the Environment, Water, Heritage and the Arts changed their name from the Department of the Environment and Water Resources in 2007, which was previously the Department of the Environment and Heritage.
Ecological community	An assemblage of species occupying a particular area.
Environmental weed	Any plant that is not native to a local area that has invaded native vegetation.
Grey-crowned Babbler	Refers to the eastern subspecies of Grey-crowned Babbler (*Pomatostomus temporalis temporalis*).
Habitat	An area or areas occupied, or periodically or occasionally occupied by a species, population or ecological community, including any biotic or abiotic components.
Hooded Robin	Refers to the south-eastern form of Hooded Robin (*Melanodryas cucullata cucullata*).

Key Threatening Processes	A process that threatens, or could threaten, the survival, abundance or evolutionary development of native species, populations or ecological communities (Department of Environment and Conservation 2004)(Department of Environment and Climate Change 2007). Key threatening processes are listed under the *Threatened Species Conservation Act 1995,* the *Fisheries Management Act 1994* and the *Environment Protection and Biodiversity Conservation Act 1999.* Capitalisation of the term 'Key Threatening Processes' in this report refers to those processes listed specifically under the relevant State and Commonwealth legislation.
Likely	Taken to be a real chance or possibility (Department of Environment and Conservation 2004).
Local population	The population that occurs within the study area, unless the existence of contiguous or proximal occupied habitat and the movement of individuals or exchange of genetic material across the boundary can be demonstrated (as defined by (Department of Environment and Climate Change 2007).
Locality	The area within a 10 kilometre radius of the study area.
Migratory species	Species listed as Migratory under the *Environment Protection and Biodiversity Conservation Act 1999.* Capitalisation of the term 'Migratory' in this report refers to those species listed as Migratory under the *Environment Protection and Biodiversity Conservation Act 1999*.
Protected species	Those species defined as protected under the *National Parks and Wildlife Act 1974*. Includes all native animals, and all native plants listed on Schedule 13 of the *National Parks and Wildlife Act 1974*.
Recovery plan	A plan prepared under the *Threatened Species Conservation Act 1995* or the *Environment Protection and Biodiversity Conservation Act 1999* to assist the recovery of a Threatened species, population or ecological community.
Region	A bioregion defined in a national system of bioregionalisation. (For this study this is the South-western Slopes Bioregion as defined in the Interim Biogeographic Regionalisation for Australia (Thackway & Cresswell 1995).
Significant	Important, weighty or more than ordinary (as defined by NSW National Parks and Wildlife Service 1996).
Subject site	The area to be directly affected by the construction and/ or operation of the project, such as ancillary construction areas, including a 10 m construction buffer to account for construction access (i.e. the extent of direct impacts) (Department of Environment and Climate Change 2007).
Study area	The subject site and any additional areas that could potentially be affected by the project either directly or indirectly. This is taken to include a 200 metre buffer around the project centreline (Department of Environment and Climate Change 2007).
Threatened biodiversity	Threatened species, populations or ecological communities, or their habitats as listed under either the *Threatened Species Conservation Act 1995* or the *Environment Protection and Biodiversity Conservation Act 1999*.
Threatened species, populations and ecological communities	Species, populations and ecological communities listed as Vulnerable, Endangered or Critically Endangered (collectively referred to as Threatened) under the *Threatened Species Conservation Act 1995*, *Fisheries Management Act 1994* or the *Environment Protection and Biodiversity Conservation Act 1999*. Capitalisation of the terms 'Threatened', 'Vulnerable', 'Endangered' or 'Critically Endangered' in this report refers to listing under the relevant State and/or Commonwealth legislation.
Viable local population	A population that has the capacity to live, develop and reproduce under normal conditions, unless the contrary can be conclusively demonstrated through analysis of records and references (as defined by NSW National Parks and Wildlife Service 1996).

1. Introduction

This Technical Paper addresses the biological impacts associated with the proposed bypass of the township of Holbrook, part of the Hume Highway Upgrade Project (the project).

The Technical Paper examines the terrestrial and aquatic flora and fauna assemblages and their habitats along the proposed bypass route and determines the biological impacts of the construction and operation of the project. It summarises the proposed mitigation measures as well as the assessments of significance required under the *Environmental Planning and Assessment Act 1979* and the (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999*.

1.1 Overview

The NSW Roads and Traffic Authority (RTA) are currently upgrading sections of the Hume Highway. The current upgrade, known as the Hume Highway Duplication, includes the creation of a dual carriageway along sections of the Hume Highway that were once single carriageway.

As part of the overall works a bypass of Holbrook is proposed. The Holbrook bypass would deviate to the west of Holbrook township, commencing from the existing Hume Highway approximately five kilometres (km) north of Holbrook (refer Figure 1-1). Heading south, the preferred route would first traverse cleared agricultural land before crossing the Holbrook - Wagga Wagga Road, requiring a grade-separated crossing. The route would then traverse a crown reserve passing to the west of a cemetery, sewage treatment works and industrial land, and to the east of the Holbrook waste management centre. The route would cross the non-operational Holbrook - Culcairn rail line and cut through the eastern edge of a travelling stock reserve before crossing the Holbrook - Culcairn Road, where a grade separated crossing is also required. From the Holbrook - Culcairn Road, the route would pass through the Greater Hume Shire Council depot and cross Ten Mile Creek before rejoining the existing Hume Highway approximately three kilometres south of Holbrook (refer Figure 1-1).

The road corridor would comprise dual two-lane carriageways, with traffic lane width of 3.5 metres (m) and shoulder width of two to three metres, separated by a landscaped median of approximately 12 m width. The overall road corridor width would nominally be 90 m, depending on environmental and interchange requirements. Grade-separated interchanges would provide access to Holbrook and the adjoining road network. The details of private property and local road access to the carriageway would be determined during detailed design development. In general terms, such access would be minimised and only provided where essential and where an appropriate level of safety can be ensured.

Pre-construction works would generally commence with site establishment activities, including set up of construction compounds, provision of alternative accesses to properties, installation of temporary fencing and other activities. The location of these facilities and work sites would be identified depending on access, residents and environmentally sensitive areas.

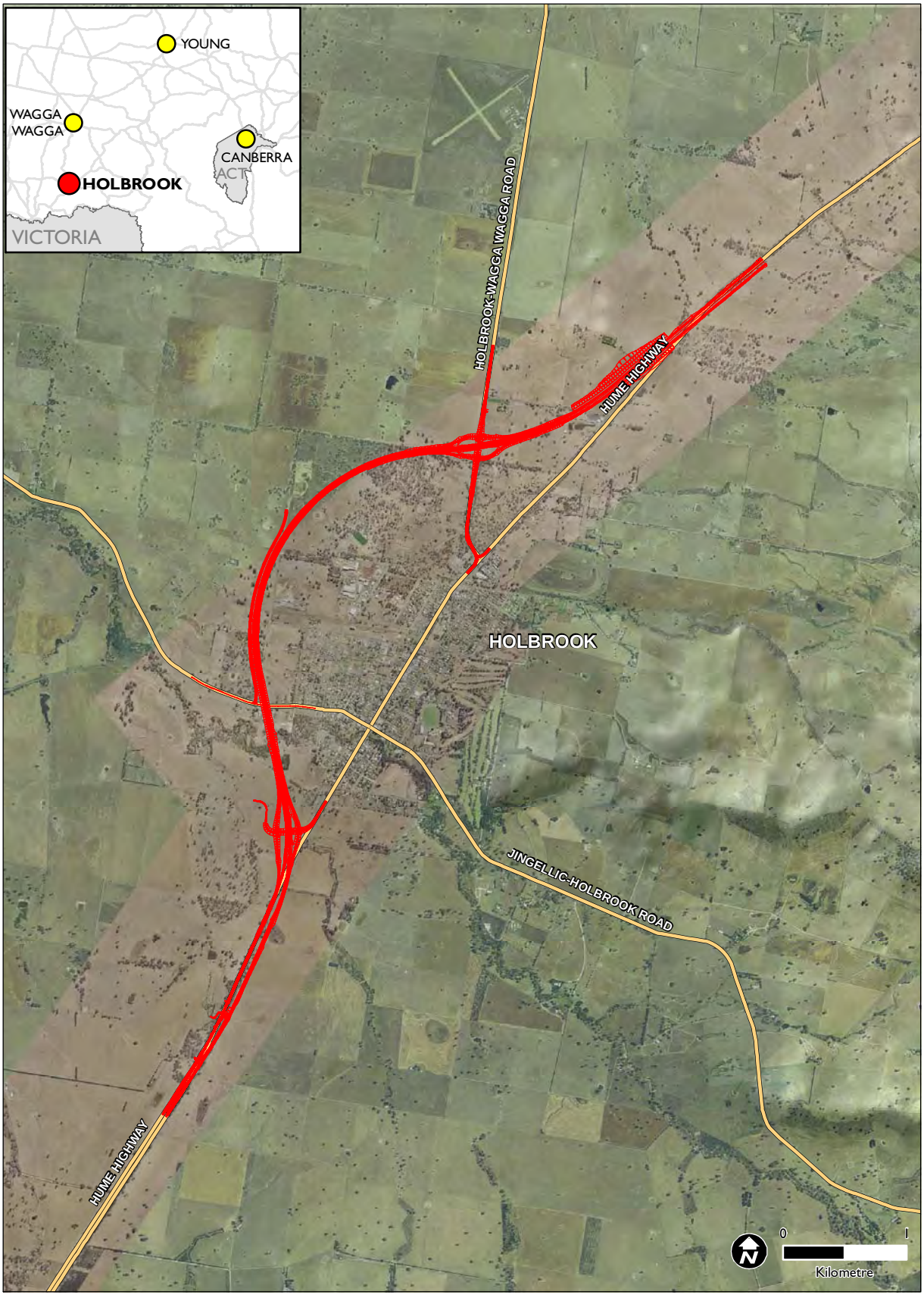


Figure 1.1 Site Location

Construction would typically commence with the clearing of vegetation and establishment of erosion and sedimentation control measures followed by earthworks and construction of structural elements (bridges, culverts, retaining structures etc.). Once design levels are reached, construction of the pavement would commence. Finishing works would include shaping of the median and shoulders, and landscaping.

Ongoing maintenance activities would be carried out in accordance with standard RTA maintenance procedures and safety requirements.

1.2 Legislative context

The project will be assessed under Part 3A of the *Environmental Planning and Assessment Act 197*9. Part 3A consolidates the assessment and approval regime for major projects under the *Environmental Planning and Assessment Act 1979*.

Further NSW legislation and planning policies relevant to the protection of biodiversity include:

- *Threatened Species Conservation Act 1995.*
- *Fisheries Management Act 1994.*
- *National Parks and Wildlife Act 1974.*
- *Native Vegetation Act 2003.*
- *Water Management Act 2000* and *Rivers and Foreshores Improvement Act 1948*.

Although licences and approvals may not be required under these or other state acts and policies, in addition to approval under Part 3A of the *Environmental Planning and Assessment Act 1979*, consideration has been given to their intent.

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* applies to the project.

1.3 Scope of the Technical Paper

The Director-General's Environmental Assessment Requirements for the environmental assessment of the Holbrook bypass indicate that the assessment should consider flora and fauna, including but not limited to:

- assessment of threatened terrestrial and aquatic species, populations, ecological communities and/or critical habitat, consistent with the Threatened Species Assessment Guidelines (Department of Environment and Climate Change 2007)[1], including details on the existing site conditions and quantity and likelihood of disturbance
- targeted surveys of threatened flora and fauna species, including White Box, Yellow Box, Blakely's Red Gum Woodland, Barking Owl, Diamond Firetail and Grey-crowned Babbler
- native vegetation loss; weed infestation; habitat fragmentation; impacts to wildlife corridors including riparian corridors; and impacts to groundwater dependent communities, riparian and aquatic habitat.

[1] Note that these guidelines do not apply to projects assessed under Part 3A of the *Environmental Planning and Assessment Act 1979*. Subsequent correspondence with the Department of Planning has confirmed this. The correct guidelines are the draft *Threatened Species Assessment Guidelines under Part 3A*.

The draft *Guidelines for Threatened Species Assessment under Part 3A* (2005a) state that the objective of the assessment process under Part 3A is to provide information to enable decision-makers to ensure that developments deliver the following environmental outcomes:

1. maintain or improve biodiversity values (ie there is no net impact on threatened species or native vegetation)
2. conserve biological diversity and promote ecologically sustainable development
3. protect areas of high conservation value (including areas of critical habitat)
4. prevent the extinction of threatened species
5. protect the long-term viability of local populations of a species, population or ecological community
6. protect aspects of the environment that are Matters of National Environmental Significance.

With these objectives in mind, the aims of this Technical Paper are to:

- determine and describe the characteristics and condition of the vegetation communities and flora and fauna habitats within the study area
- determine the occurrence, or likelihood of occurrence, of Threatened species, populations and communities (biodiversity) listed under the *Threatened Species Conservation Act 1995, Fisheries Management Act 1994* and *Environment Protection and Biodiversity Conservation Act 1999* within the study area
- undertake assessments of significance for Threatened biodiversity that occur or have potential habitat within the study area
- propose further investigations and/or amelioration measures to mitigate impacts on the ecological values of the study area.

1.4 Structure of the Technical Paper

The structure and content of this Technical Paper is as follows:

- Chapter 2 details the desk-based and field methods used in surveying the current environment as well as the assessment methods.
- Chapter 3 describes the study area and locality in terms of their 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.
- Chapter 4 describes the Threatened biodiversity occurring in the study area as well as other significant ecological features requiring consideration, such as those covered under the *Environment Protection and Biodiversity Conservation Act 1999*.
- Chapter 5 describes the potential impacts of the project on the biological environment, including loss of vegetation and habitats and impacts on Threatened species.
- Chapter 6 describes recommended mitigation measures to be incorporated into the final design and construction program.
- Chapter 7 summarises the assessment of significance of the potential impacts following the requirements of the *Environmental Planning and Assessment Act 1979* (draft *Guidelines for Threatened Species Assessment under Part 3A of the Environmental Planning and Assessment Act 1979*) and the *Environment Protection and Biodiversity Conservation Act 1999*.
- Chapter 8 presents conclusions and recommendations.

2. Methods

This chapter details the desk-based and field methods used in surveying the current environment as well as the assessment methods.

2.1 Location

Location information for the study area is outlined in Table 2-1.

Table 2-1 Study area location

Location information	Study area
Bioregion	South-west slopes,
Local government area	Greater Hume Shire
Catchment Management Authority, subregion	Murray CMA, Upper Slopes subregion
Mitchell landscape	Brokong Plains Landscape

2.2 Nomenclature

Names of plants used in this document follow Harden (Harden 1992, 1993, 2000, 2002) with updates from PlantNet (Royal Botanic Gardens 2009). Scientific names are used in this report for species of plant. Scientific and common names are provided in plant lists in Appendix A and C.

Names of vegetation communities used in this report are based on those described by (Benson 2008) for the South-west Slopes region and Biometric assessment methodology (Gibbons *et al.* 2008). They provide dominant species and structure of the community generally consistent with the methodology of Walker and Hopkins (1990). Corresponding vegetation community types are also provided for the existing broad scale regional vegetation mapping (Thomas *et al.* 2000), or Threatened community listings under the *Threatened Species Conservation Act 1995* and/or the *Environment Protection Biodiversity Conservation Act 1999*.

Names of vertebrates used in this document follow the Census of Australian Vertebrates (CAVS) database maintained by the Department of the Environment, Water, Heritage and the Arts (2008a) and as used in the Atlas of NSW Wildlife (Department of Environment and Climate Change 2008a). Common names are used in the report for species of animal. Scientific names are included in species lists found in Appendix B and D.

2.3 Contributors and qualifications

The contributors to the preparation of this Technical Paper, their qualifications and roles are listed in Table 2-2.

All work was carried out under the appropriate licences, including scientific licences as required under Clause 22 of the *National Parks and Wildlife Regulations 2002*, Section 132C of the *National Parks and Wildlife Act 1974* and Section 37 of the *Fisheries Management Act 1994,* as well as animal research authorities issued by the Department of Industry and Investment (Agriculture).

Table 2-2 Contributors and their roles

Name	Qualification	Role
Dr. Martin Predavec	BSc (Hons), PhD	Ecologist – biodiversity lead
Alex Cockerill	BSc (Hons)	Botanist – field surveys and report preparation
John Whyte	BBioSc	Botanist – field surveys and report preparation
Rob Gration	MWildMgt	Zoologist– field surveys
Nathan Cooper	BEnvSc	Zoologist– field surveys and report preparation
Dr. Dan Roberts	BSc (Hons), PhD	Aquatic Ecologist – field surveys and report preparation
Shane Murray	BSc	Aquatic Ecologist – field survey
Dr. Sharon Cummins	BSc (Hons), PhD	Aquatic Ecologist – invertebrate identification
Chris O'Dell	BAppSc	GIS Operator — mapping
Veronica Black	BA, MEngSci	GIS Operator — mapping
Erin Ibbertson	BSc (GIS)	GIS Operator — mapping

2.4 Literature and database review

Records of Threatened flora and fauna previously recorded, or predicted to occur, in the project locality or region were obtained from various databases as detailed in Table 2-3.

The results of these database searches are presented in Appendix D. Further records of Threatened biodiversity were obtained from various literature sources that are cited throughout this document.

Table 2-3 Databases searched for records of Threatened species

Database	Search date	Area searched	Reference
Atlas of NSW Wildlife	19 November 2008 (flora and fauna)	10 kilometre buffer around the project footprint (fauna)	Department of Environment, Climate Change and Water (2008a)
PlantNet Database	19 November 2008	10 kilometre buffer around the project footprint	Royal Botanic Gardens (2008)
Threatened species, populations and communities database	19 November 2008 (flora and fauna)	Murrumbidgee Catchment Management Authority, Lower Slopes Sub-Catchment	Department of Environment, Climate Change and Water (2008d)
Bionet	19 November 2008 (flora and fauna)	10 kilometre buffer around the project footprint (flora and fauna)	Department of Environment, Climate Change and Water (2008b)
Protected Matters Search Tool	19 November 2008 (flora and fauna)	10 kilometre buffer around the project footprint	Department of the Environment, Water, Heritage and the Arts (2008b)
Bird Data	15 December 2008	20 kilometre buffer around the project footprint	(Birds Australia 2008)

Note: Database searches were completed as a radius (generally 10 kilometres) around the following co-ordinates, Easting: 528744, Northing: 6047211.

2.5 Field survey

Terrestrial surveys of the study area were carried out between 9 and 13 November 2008. Aquatic surveys were completed between 30 November and 2 December 2008. The surveys sought primarily to assess the extent and condition of vegetation communities and potential flora and fauna habitat, with particular consideration given to species of conservation concern, such as Threatened and Migratory species or locally significant species. Sites surveyed included the project construction footprint and surrounding areas potentially affected by the construction and operation of the project (study area).

Survey effort and design built on previous ecological surveys within the study area and locality by nghenvironmental (2008) and considered the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (*Working Draft*) (Department of Environment and Conservation 2004).

2.5.1 Weather conditions

Weather conditions during the field survey were generally warm and dry (refer Table 2-4).

Table 2-4 Daily weather conditions before and during the survey (Wagga Wagga)

Date	Day	Temperature		Rain (mm)	Wind	
		Min (°C)	Max (°C)		Direction	Speed (kph)
1	Sat	9.0	28.2	0	ENE	46
2	Sun	14.9	27.3	0	E	41
3	Mon	16.8	24.8	17.2	WSW	67
4	Tue	8.5	24.4	0.2	S	39
5	Wed	10.5	24.7	0	WNW	28
6	Thur	9.7	26.8	0	W	46
7	Fri	10.5	21.7	0	SE	54
8	Sat	12.9	19.9	22.0	W	43
9	Sun	8.0	23.5	0	WSW	33
10	Mon	8.0	28.3	0	W	22
11	Tue	12.2	30.9	0	NNE	30
12	Wed	15.1	32.5	0	N	26
13	Thur	18.9	33.4	0	NNE	48

Notes: Data from Wagga Wagga (Bureau of Meteorology 2008). Shaded rows are the period of survey.

2.5.2 Terrestrial flora

Existing vegetation mapping

The NSW National Parks and Wildlife Service's *Forest Ecosystem Classification and Mapping of the Southern Comprehensive Regional Assessment Region* (Thomas *et al.* 2000) describes and maps vegetation communities across the project locality at a broad scale (1:250,000 and patches larger than 10 hectares in size). These vegetation communities were derived from pre-existing and supplementary floristic field survey data, aerial photograph interpretation, and statistical software (PATN and Fidel v 2.1).

Much of the vegetation in the study area occurs in remnants smaller than 10 hectares and was not mapped by the broad-scale vegetation mapping of Thomas et al. (2000). Aerial photograph interpretation was used to map the extent of these small remnants within the study area.

Ground-truthing of the broad-scale vegetation mapping of Thomas et al. (2000) and aerial photograph interpretation was completed within the study area to describe the character and condition of native vegetation remnants. Descriptions of those remnants not identified by the broad-scale vegetation mapping were based on their structure and dominant canopy species (Specht 1981) to allow comparison with the vegetation communities described in the broad-scale mapping. These surveys were completed along the length of the study area.

The vegetation within the South-western Slopes Bioregion has recently been identified and described at a relatively fine scale by Benson (2008) as part of the New South Wales Vegetation Classification and Assessment Database Project (NSWVCA). The aim of this project was to classify and assess the threat and conservation status of the plant communities that comprise the vegetation of NSW and incorporate this information into a database. Approximately 97 distinct communities have been classified for the NSW South-western Slopes Bioregion (Benson 2008).

This vegetation classification has been incorporated into the latest revision of the vegetation type by Catchment Management Authority (CMA) database adopted by the vegetation assessment tool (BioMetric version 2.0) for implementation of property management plans and determining offsets within the South-western Slopes bioregion under the *Native Vegetation Act 2003* (NSW Department of Environment and Climate Change 2008).

Given the likely requirement for the project to require offsets for impacts to vegetation and the relatively broad vegetation descriptions and poor resolution of the existing *Forest Ecosystem Classification and Mapping of the Southern Comprehensive Regional Assessment Region* (Thomas *et al.* 2000), the detailed field identification of the study area's vegetation was completed in accordance with the vegetation types described by Benson (2008).

Condition of vegetation communities

The quality of vegetation condition was assessed using parameters such as intactness, diversity, history of disturbance, regeneration potential, weed invasion and health. Four condition scores, adapted from the Biometric Assessment Manual (Gibbons *et al.* 2008) and Davidson et al. (2005), were used to summarise each remnant patch of vegetation within the study area.

The four categories used to describe the condition of vegetation communities are summarised in Table 2-5.

Table 2-5 Vegetation condition categories

Condition class	General description	Exotic understorey % cover	Regeneration potential
Good	Vegetation that still retains the species complement and structural characteristics of the pre-European equivalent. Such vegetation has usually changed very little over time and displays resilience to weed invasion due to intact groundcover, shrub and canopy layers.	<30% exotic species cover	Multi-age recruitment of all observed canopy species present
Moderate	Vegetation that generally still retains its structural integrity, but has been disturbed and has lost some components of its original species complement. Weed invasion can be significant in such remnants.	<50% exotic species cover	Recruitment of canopy species present
Poor	Vegetation that has lost most of its species and is significantly modified structurally. Often such areas now have a discontinuous canopy of the original tree cover and very few shrubs. Exotic species, such as introduced pasture grasses or weeds, have replaced much of the indigenous ground cover. Environmental weeds are often co-dominant with the original indigenous species.	>90% exotic species cover	No recruitment of canopy
Very poor	This vegetation exhibits the same high levels of disturbance and exotic understorey composition as the 'poor' condition vegetation; however, the canopy cover has undergone significant further reductions. This condition class corresponds directly with 'low condition' vegetation, as defined by the BioMetric (version 2.0) (NSW Department of Environment and Climate Change 2008) for woody vegetation: *The over-storey per cent foliage cover is <25% of the lower value of the over-storey per cent foliage cover benchmark for that vegetation type* *AND* *<50% of vegetation in the ground layer is indigenous species or >90% is ploughed or fallow.*	<50% of vegetation in the ground layer is indigenous species or >90% is ploughed or fallow.	No recruitment of canopy.

In addition to the general condition classification above, areas of vegetation identified as corresponding with the Endangered Ecological Community, White Box, Yellow Box, Blakely's Red Gum Woodland as defined under the *Threatened Species Conservation Act 1995* were classified in accordance with the five specific condition categories within the *Box-Gum Identification Guidelines* (NSW National Parks and Wildlife Service 2002a) (refer Table 2-6).

Table 2-6 Vegetation condition categories for the Endangered Ecological Community, White Box, Yellow Box, Blakely's Red Gum Woodland

Condition categories	General description
Multi-aged overstorey with a grassy, herb-rich understorey.	Remnants in this condition are very scarce and are generally confined to travelling stock reserves, roadside vegetation, cemeteries, some national parks and the occasional private property.
Partially cleared/thinned stands with a mixture of native and exotic understorey species.	This condition is far more common than the above; however, its long-term future is often insecure due to inadequate regeneration of overstorey species. Often current management (e.g. set-stocking) is inconsistent with tree regeneration.
Stands where White Box, Yellow Box or Blakely's Red Gum have been killed and other species dominate the canopy.	This condition occurs in woodlands where the characteristic trees occur in conjunction with White Cypress Pine. The understorey is often in reasonable to very good condition.
Grasslands (secondary or derived grasslands), where the tree overstorey has been removed and only the Box-Gum Woodland understorey is present.	This condition is likely to be reasonably common in some areas and is likely to be relatively easy to rehabilitate if appropriate management strategies are implemented.
Degraded remnants that have few, if any, native species in the understorey.	This condition is typical of Box-Gum Woodland where agricultural practices have been more intensive (e.g. pasture improvement over long periods).

Vegetation surveys

The floristic diversity and possible presence of Threatened species was assessed using a combination of random meander and plot-based (20 by 20 metre quadrat) surveys in accordance with the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities (Working Draft)* (Department of Environment and Conservation 2004).

Due to the linear nature of the project, random meander surveys were completed along the entire length of the study area. Random meander surveys are a variation of the transect type survey and were completed in accordance with the technique described by Cropper (1993), whereby the recorder walks in a random manner throughout the site recording all species observed, boundaries between various vegetation communities and condition of vegetation. The time spent in each vegetation community was generally proportional to the size of the community and its species richness.

The number of vegetation quadrats surveyed in the study area was initially determined in accordance with the suggested minimum survey effort specified by the *Threatened Biodiversity Survey and Assessment Guidelines* (Department of Environment and Conservation 2004) (refer Table 2-7).

Table 2-7 Suggested survey technique and effort for plant quadrats

Survey technique	Suggested minimum effort per stratification unit	Information recorded
Quadrat	1 quadrat for areas <2 hectares 2 quadrats for area 2-50 hectares 3 quadrats for areas 51-250 hectares 5 quadrats for areas 251-500 hectares 10 quadrats for areas 501-1,000 hectares, plus 1 additional quadrat for each extra 100 hectares thereof	Floristics, structure, Threatened species

Source: *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (Working Draft) (Department of Environment and Conservation 2004).

To assist with potential future offsetting calculations and to provide detailed condition information, additional vegetation quadrats were sampled in each remnant patch of vegetation indentified within the study area. This vegetation sampling was completed in accordance with the field methodology for site value assessment within Biometric Assessment Manual (Gibbons *et al.* 2008). A summary of the quadrats sampled per stratification unit is provided in Table 2-8. The locations of quadrats are shown in Figure 2-1.

Table 2-8 Stratification units and number of quadrats surveyed

Stratification unit	Area within study area (hectares)	Suggested minimum effort per stratification unit[1]	Number of quadrats surveyed
Blakely's Red Gum - Yellow Box grassy woodland	8.5	2	4
Grassy Yellow Box tall woodland on alluvial flats	44	2	9
Grassy White Box - Blakely's Red Gum - Yellow Box woodland	1.4	1	4
River Red Gum very tall open forest of the NSW South-western Slopes Bioregion	2.6	2	4

1. Suggested minimum effort per stratification unit as per the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (Working Draft) (Department of Environment and Conservation 2004).

The following information was recorded for each quadrat:

- location (easting–northing grid type WGS 84, Zone 55)
- stratification
- canopy regeneration
- dominant canopy species
- condition
- hollow-bearing trees (number and hollow size)
- length of fallen timber
- all species observed
- cover abundance of each species.

The cover abundance estimate was based on a modified Braun-Blanquet 1-6 scale assigned to each vascular plant species recorded. The cover abundance values for each 1-6 class are provided in Table 2-9.

Table 2-9 Cover abundance scale 1-6

Class	Cover abundance
1	<5% — Sparse 1 individual
2	<5% — More than 1 individual
3	5 – 25%
4	26 – 50%
5	51 – 75%
6	76 – 100%

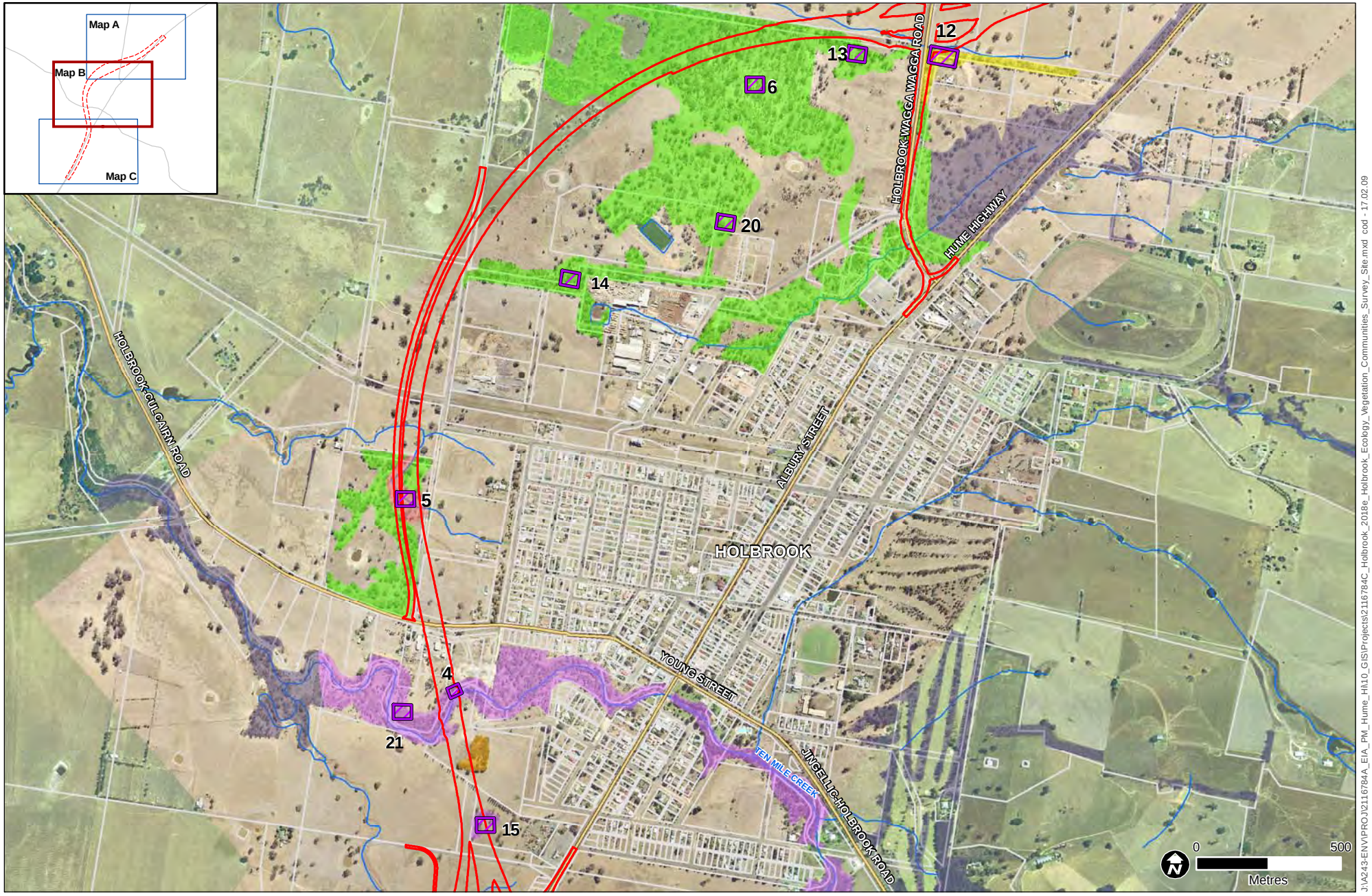
This sampling also involved collation of detailed structural information on per cent foliage cover within each for the following layers:

- canopy
- mid-storey
- groundcover-grasses
- groundcover-shrubs
- groundcover-other
- exotic cover.

Targeted threatened floral survey

Targeted searches were completed for the Threatened plant *Amphibromus fluitans* considered to have a moderate or higher likelihood of occurrence within the study area based on findings of the previous preliminary assessments, database reviews and desktop assessments. Targeted surveys consisted of random meanders within the preferred habitat types throughout the study area. Species specifically targeted by the surveys are listed in Table 2-10.

Figure 2-1 Flora survey locations - Holbrook (A)



Holbrook bypass design
Classified road
Drainage

Vegetation communities

Blakely's Red Gum - Yellow Box Grassy Woodland
Disturbed Exotic vegetation
Grassy White Box - Blakely's Red Gum - Yellow Box Woodland
Grassy Yellow Box Woodland on Alluvial Flats
Unclassified remnant vegetation
River Red Gum Open Forest
Flora survey site

Figure 2-1 Flora survey locations - Holbrook (B)

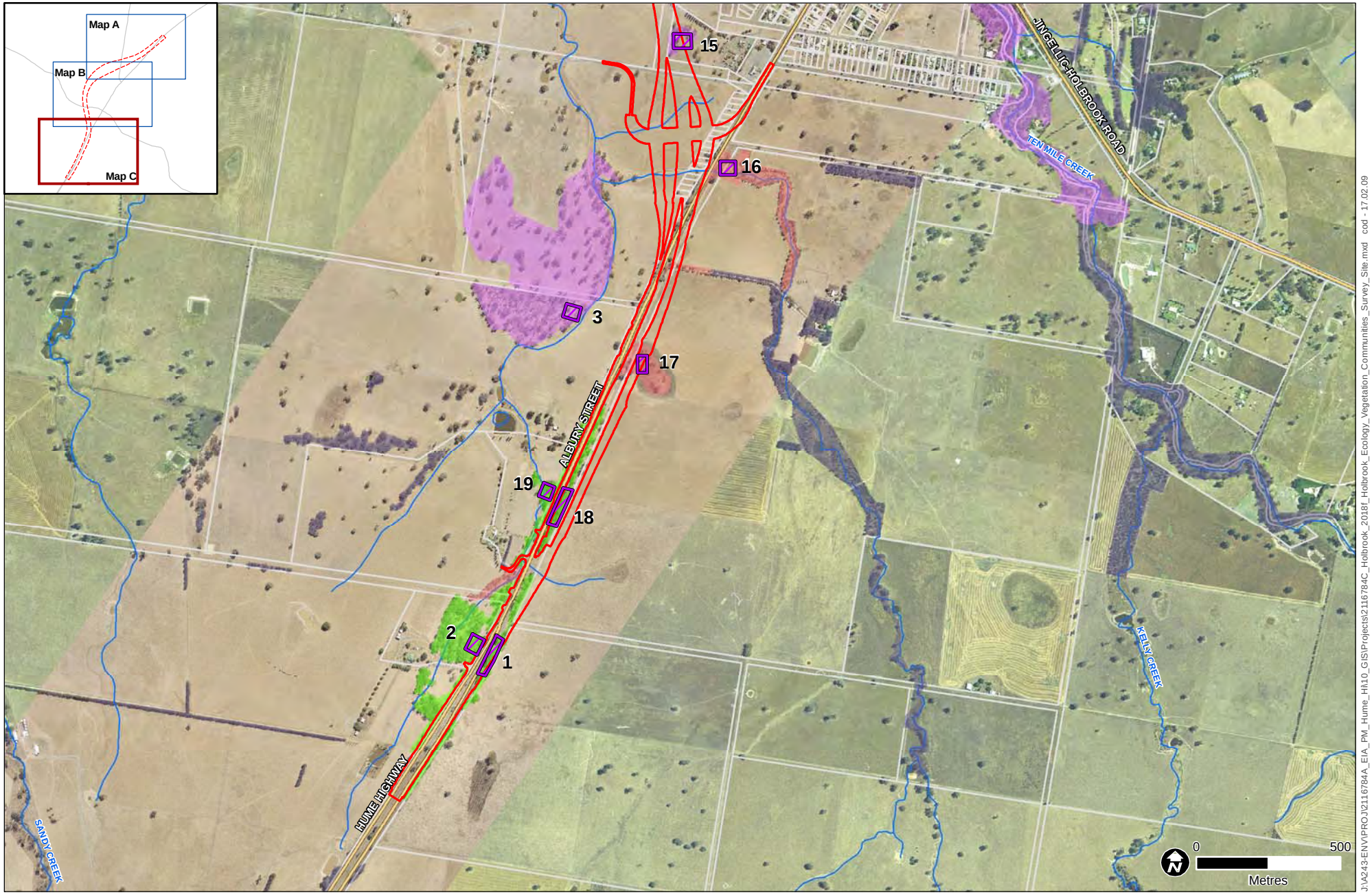


Figure 2-1 Flora survey locations - Holbrook (C)

Table 2-10 Threatened flora species targeted for survey

Species	Habitat	Survey
Amphibromus fluitans	Native to the South-western Plains and Slopes where it grows mostly in permanent swamps. Also recorded in the Southern Tablelands (Harden 1993). The species needs wetlands that are at least moderately fertile and that have some bare ground, conditions that are produced by seasonally-fluctuating water levels. Habitats in south-western NSW include swamp margins in mud, dam and tank beds in hard clay and in semi-dry mud of lagoons with *Potamogeton* and *Chamaeraphis* species (Department of Environment and Climate Change 2008d).	Random meander and plot-based (quadrat) surveys were completed for this species throughout the following vegetation communities: • Blakely's Red Gum - Yellow Box grassy woodland • Apple Box grass-forb open forest • River Red Gum very tall open forest of the NSW South Western Slopes Bioregion. In addition to these vegetation types, the periphery of all farm dams and artificial drainage lines within the cleared exotic and derived grasslands were targeted for this species.

2.5.3 Terrestrial fauna

Habitat mapping

Fauna habitat assessment was based on vegetation mapping undertaken through aerial photograph interpretation and ground-truthing. Habitats were delineated by grouping vegetation communities according to their structure and/or moisture regimes (ie characteristics that determine the type of fauna likely to use them).

Condition of terrestrial fauna habitats

Fauna habitats were assessed by examining characteristics, such as the structure and floristics of the canopy, understorey and ground vegetation; the structure and composition of the litter layer; and other habitat attributes important for feeding, roosting and breeding. Indirect evidence of faunal activity (such as scats, diggings, scratch marks, etc.) was also recorded. The criteria used to evaluate the condition of habitat values are summarised in Table 2-11.

Table 2-11 Categories used to describe fauna habitats

Category	Description
Good	A full range of fauna habitat components are usually present (for example, old-growth trees, fallen timber, feeding and roosting resources) and habitat linkages to other remnant ecosystems in the landscape are intact.
Moderate	Some fauna habitat components are often missing (for example, old-growth trees, fallen timber), although linkages with other remnant habitats in the landscape are usually intact, but sometimes degraded.
Poor	Many fauna habitat elements in low quality remnants have been lost, including old-growth trees (for example, due to past timber harvesting or land clearing) and fallen timber, and tree canopies are often highly fragmented. Habitat linkages with other remnant ecosystems in the landscape have usually been severely compromised by extensive past clearing.

Habitat assessment

Fauna habitat assessments were undertaken in 12 locations along the study area. Habitat assessments aimed to collect relevant data pertinent to faunal species. Features assessed at each location are described in Table 2-12.

Table 2-12 Fauna habitat features assessed

General features	Overstorey features	Other features	Fauna tracks/signs	If water body present
▪ Site number ▪ Easting ▪ Northing ▪ Evidence of disturbance ▪ Evidence of clearing ▪ Erosion ▪ Evidence of fire ▪ Epicormic growth ▪ Other disturbance	▪ Dominant vegetation ▪ Dominant overstorey species ▪ Senescence in canopy (%) ▪ Hollow high trunk ▪ Hollows mid trunk ▪ Hollows low trunk ▪ Fire scar hollows ▪ Limb hollows ▪ Stags	▪ Artificial habitat features ▪ Significant flowering events ▪ Midstorey (>2 m) cover ▪ Significant species for fauna (e.g. food) ▪ Understorey (<2 m) cover ▪ Groundcover vegetation (per cent) ▪ Groundcover leaf litter (per cent) ▪ Fallen logs ▪ Size of hollows infallen logs (if any) ▪ Rocks	▪ Fauna scats ▪ Squirrel/ Sugar Glider chews ▪ Scratches and worn areas on trees ▪ Potential Large Forest Owl roost trees ▪ Miscellaneous fauna traces	▪ Waterbody type ▪ Level of permanence ▪ Fringing composition ▪ Riparian vegetation ▪ Condition of water body

Vertebrate survey

A terrestrial fauna survey of the study area was carried out as described below and where applicable, followed the methodology detailed in *NSW Threatened Species Survey and Assessment Draft Guidelines (Working Draft)* (Department of Environment and Conservation 2004). The locations of the surveys are shown in Figure 2-2 (a-c), with sites chosen to represent the range of different habitat types within the study area (eg box woodland and riparian vegetation). The results of the targeted surveys and observations are presented in Appendix B.

The presence of faunal species in the study area was also determined through consideration of suitable habitats, with species of animal present on the site recorded opportunistically during the habitat assessments. Although recording Threatened species during field survey can confirm their presence in an area, a lack of Threatened species does not necessarily indicate the absence of the species from the site when suitable habitat is present. By the very nature of their rarity, Threatened species are often difficult to detect. Suitable habitat is, therefore, the most important factor to consider when determining the potential presence of Threatened species.

Small mammal trapping

Small to medium sized mammals were surveyed using a number of live trapping methods. Live capture/release methods included Elliott type A traps for small ground-dwelling mammals, Elliott type B traps for small arboreal mammals and wire cage traps for larger ground-dwelling mammals.

Elliott type A traps were placed at 10 metre intervals along five transect lines in survey sites TT1 and TT2 (five Elliott traps per transect). Traps were baited with standard bait mixture (rolled oats, peanut butter and honey) and were operated over a four night period at each site (refer Figure 2-2). A total of 100 trap nights were recorded at each of the two sites.

Elliott type B traps were secured on tree-mounted brackets and set approximately three metres above ground level in suitable habitat/hollow-bearing trees. Ten tree-mounted traps were set in each survey site, being TT1 (Former Town Common) and TT2 (Southern Travelling Stock Reserve) (refer Figure 2-2). Each trap was baited with a standard bait mixture, while a mixture of honey and water was sprayed onto the trunk of the tree above the tree-mounted Elliott trap as a lure. Elliott traps were operated over a four night period at each site, with total of 40 trap nights recorded at each of the two survey sites.

Wire cage traps located at survey sites TT1 and TT2 were baited with standard bait mixture and were located in the vicinity of Elliott trap lines. Three traps were located at each of two survey sites with a total of 12 trap-nights recorded at each survey site over a four night trapping period.

All traps were checked each morning at sunrise with captured animals identified to species and released at the site of capture.

Spotlighting

The objective of this survey technique was to target arboreal, flying and large ground-dwelling mammals. Spotlighting was done after dusk at four sites across the study area (refer Figure 2-2). Three person hours of survey effort was undertaken at each site on foot using two 100 watt vari-beam spotlights (see Table 2-13). The speed of the spotlight surveys was approximately one kilometre per hour. Surveys concentrated on areas that contained suitable habitat for nocturnal species, such as woodland that formed parts of larger areas, or fragmented habitats located nearby. Sighted animals were identified to species level.

Call playback

Call playback was used to survey for the Barking Owl, Powerful Owl and Squirrel Glider, using the methods of Kavanagh (1993) and Debus (1995). Call playback was done after dusk at three sites within the study area (refer Figure 2-2). For each survey, an initial listening period of 10 to 15 minutes was undertaken, followed by a spotlight search for 10 minutes to detect any animals in the immediate vicinity. The calls of the target species were then played intermittently for five minutes followed by a 10 minute listening period. After the calls were played, another 10 minutes of spotlighting was done in the vicinity to check for animals attracted by the calls, but not vocalising. Calls from Stewart (1998) were broadcast using an MP3 player and amplified through a megaphone. Surveys were conducted at various times, from one to three hours after dusk and repeated once at each site (see Table 2-13).

Microchiropteran bat surveys

Ultrasonic Anabat Bat detection (Anabat SD1 CF Bat Detector – Titley Electronics, Ballina) was used to record and identify the echolocation calls of microchiropteran bats foraging across four sites in the study area (refer Figure 2-2). Each site was surveyed on two consecutive nights with detectors set to record throughout the night. A further four bat surveys were completed during spotlight events at nominated sites across the study area, whereby an Anabat detector was used to track the animals and record their calls while actively spotlighting. Bat call analysis was undertaken by Rob Gration of Parsons Brinckerhoff, with the presentation of data (refer Appendix F) following the guidelines of the Australasian Bat Society. Bat calls of NSW southern region (Pennay *et al.* 2004) was used as a reference collection for bat call identification.

Harp traps were used to trap foraging microchiropteran bat species. Harp traps were located at sites within the study area (or on the periphery) that had the potential to be used as fly-ways by foraging microchiropteran bats. Four sites within the study area were targeted, with harp traps set in each location for two consecutive nights (refer Figure 2-2). Harp traps were checked each evening following spotlighting events and again the following day during morning hours. Microchiropteran bat species caught by harp traps, were identified to species level, sexed, weighed and measured. Microchiropteran bats caught before evening harp trap checks were released the same night, while those caught after the evening check were contained until the following evening for release.

Bird surveys

Targeted surveys were completed for threatened fauna, including for Threatened woodland birds. Surveys were completed following the methodology detailed in the DECC's NSW Threatened Species Survey and Assessment Draft Guidelines (Working Draft) (DECC 2004. [CP1] Woodland areas potentially supporting habitat for threatened woodland birds, including the Brown Treecreeper, Speckled Warbler, Barking Owl, Diamond Firetail and Grey-Crowned Babbler, were targeted as survey sites. Surveys were undertaken during different hours of the day, but generally during the morning and late afternoon. For cryptic species and where survey was completed outside the optimal time for detecting species, a precautionary approach was taken and it was assumed that the species was present if suitable habitat was observed.

Bird surveys, including survey for Threatened woodland birds (e.g. Brown Treecreeper, Speckled Warbler, Grey-crowned Babbler and Diamond Firetail), were undertaken at five sites within the study area (refer Figure 2-2) during different hours of the day, but generally during the morning and late afternoon. Bird surveys were completed by actively walking through nominated sites (transect) with all birds observed within an initial five minute period recorded. Only new species of bird were recorded in subsequent five minute periods, with the process continued until two consecutive five minute periods had recorded no new species. The birds were identified to species level, either through direct observation or identification of calls.

Reptile surveys

Reptile surveys were completed at two sites within the study area that showed potential habitat for reptile species (refer Figure 2-2 and Table 2-13) and were conducted between 11 am and 3 pm. The survey included turning over suitable ground debris, such as fallen timber, sheets of iron and rocks. All ground debris was immediately returned to their original positions. Reptile surveys were undertaken over a 30 minute period at each location.

Amphibian surveys

Amphibian surveys were undertaken during spotlight events and opportunistically across the study area. Amphibians were identified by call recognition or identified from captured specimens.

Terrestrial fauna survey effort

A summary of the terrestrial fauna survey effort within the study area is shown in Table 2-13. The locations of the survey methods are shown in Figure 2-2.

Table 2-13 Total survey effort and location of survey

Date	Survey method	Effort	Survey site	Location description	Location (MGA94 Zone 55)	
					Easting	Northing
09/11/08-13/11/08	Arboreal trapping	40 trap nights	TT1	Former Town Common	528550	6048509
09/11/08-13/11/08	Arboreal trapping	40 trap nights	TT2	Southern Travelling Stock Reserve	527447	6046992
09/11/08-13/11/08	Terrestrial trapping	100 trap nights	TT1	Former Town Common	528581	6048739
09/11/08-13/11/08	Terrestrial trapping	100 trap nights	TT2	Southern Travelling Stock Reserve	527329	6047036
09/11/08-13/11/08	Cage trapping	12 trap nights	TT1	Former Town Common	528550	6048509
09/11/08-13/11/08	Cage trapping	12 trap nights	TT2	Southern Travelling Stock Reserve	527447	6046992
09/11/08	Anabat[1]	1 night	TT1	Former Town Common	528673	6048638
09/11/08	Anabat[1]	1 night	TT2	Southern Travelling Stock Reserve	527447	6046992
09/11/08	Anabat	1.25 hrs	TT1	Former Town Common	528550	6048509
10/11/08	Anabat[1]	1 night	TT1	Former Town Common	528673	6048638
10/11/08	Anabat[1]	1 night	TT2	Southern Travelling Stock Reserve	527447	6046992
10/11/08	Anabat	30 minutes	TT2	Southern Travelling Stock Reserve	527447	6046992
10/11/08	Anabat	1 hour	S7	Bath Street, Holbrook	527919	6047847
11/11/08	Anabat[1]	1 night	S3W	Existing Hume Highway, north of Holbrook	530814	6049706
11/11/08	Anabat[1]	1 night	S3E	Northern Travelling Stock Reserve	531224	6049447

Date	Survey method	Effort	Survey site	Location description	Location (MGA94 Zone 55)	
					Easting	Northing
11/11/08	Anabat	45 minutes	S3E & S3W	Existing Hume Highway, north of Holbrook	531224	6049447
12/11/08	Anabat[1]	1 night	S3W	Existing Hume Highway, north of Holbrook	530910	6049804
12/11/08	Anabat[1]	1 night	S3E	Northern Travelling Stock Reserve	531224	6049447
09/11/08	Harp trap	1 night	TT1	Former Town Common	527693	6048888
09/11/08	Harp trap	1 night	S3W	Existing Hume Highway, north of Holbrook	530814	6049706
10/11/08	Harp trap	1 night	TT1	Former Town Common	527693	6048888
10/11/08	Harp trap	1 night	S3W	Existing Hume Highway, north of Holbrook	530814	6049706
11/11/08	Harp trap	1 night	S3E	Northern Travelling Stock Reserve	531224	6049447
11/11/08	Harp trap	1 night	S3W	Existing Hume Highway, north of Holbrook	530910	6049804
12/11/08	Harp trap	1 night	S3E	Northern Travelling Stock Reserve	531224	6049447
12/11/08	Harp trap	1 night	S3W	Existing Hume Highway, north of Holbrook	530910	6049804
09/11/08	Call playback	30 minutes	TT1	Former Town Common	528550	6048509
10/11/08	Call playback	30 minutes	TT2	Southern Travelling Stock Reserve	527447	6046992
11/11/08	Call playback	30 minutes	S3E	Northern Travelling Stock Reserve	531224	6049447
09/11/08	Spotlighting	3 hours	TT1	Former Town Common	528550	6048509
10/11/08	Spotlighting	2 hours	TT2	Southern Travelling Stock Reserve	527447	6046992
10/11/08	Spotlighting	4 hours	S7	Bath Street, Holbrook	527919	6047847
11/11/08	Spotlighting	1.5 hours	S3E & S3W	Northern Travelling Stock Reserve	531224	6049447

Date	Survey method	Effort	Survey site	Location description	Location (MGA94 Zone 55)	
					Easting	Northing
10/11/08	Bird Survey	55 minutes 10:10–11:05	TT2	Southern Travelling Stock Reserve	527447	6046992
10/11/08	Bird Survey	35 minutes 13:30-14:05	S7	Bath Street, Holbrook	527919	6047847
11/11/08	Bird Survey	50 minutes 09:50-10:40	TT1	Former Town Common	528550	6048509
11/11/08	Bird Survey	40 minutes 17:15-16:05	S4	Ten Mile Creek, Holbrook	527513	6046497
12/11/08	Bird Survey	30 minutes 09:45-10:15	S3E	Northern Travelling Stock Reserve	531224	6049447
12/11/08	Reptile survey	4 hours 10:55-11:55	TT1-Dump	Former Town Common	527745	6048649
12/11/08	Reptile survey	2 hours 12:50-13:20	S7	Bath Street, Holbrook	527919	6047847
09/11/08–12/11/08	Opportunistic recordings	4 days	Across study area			
09/11/08–12/11/08	General habitat assessment	12 person hours	Across study area			

Note: 1: Anabat Bat Detector set to record throughout the night

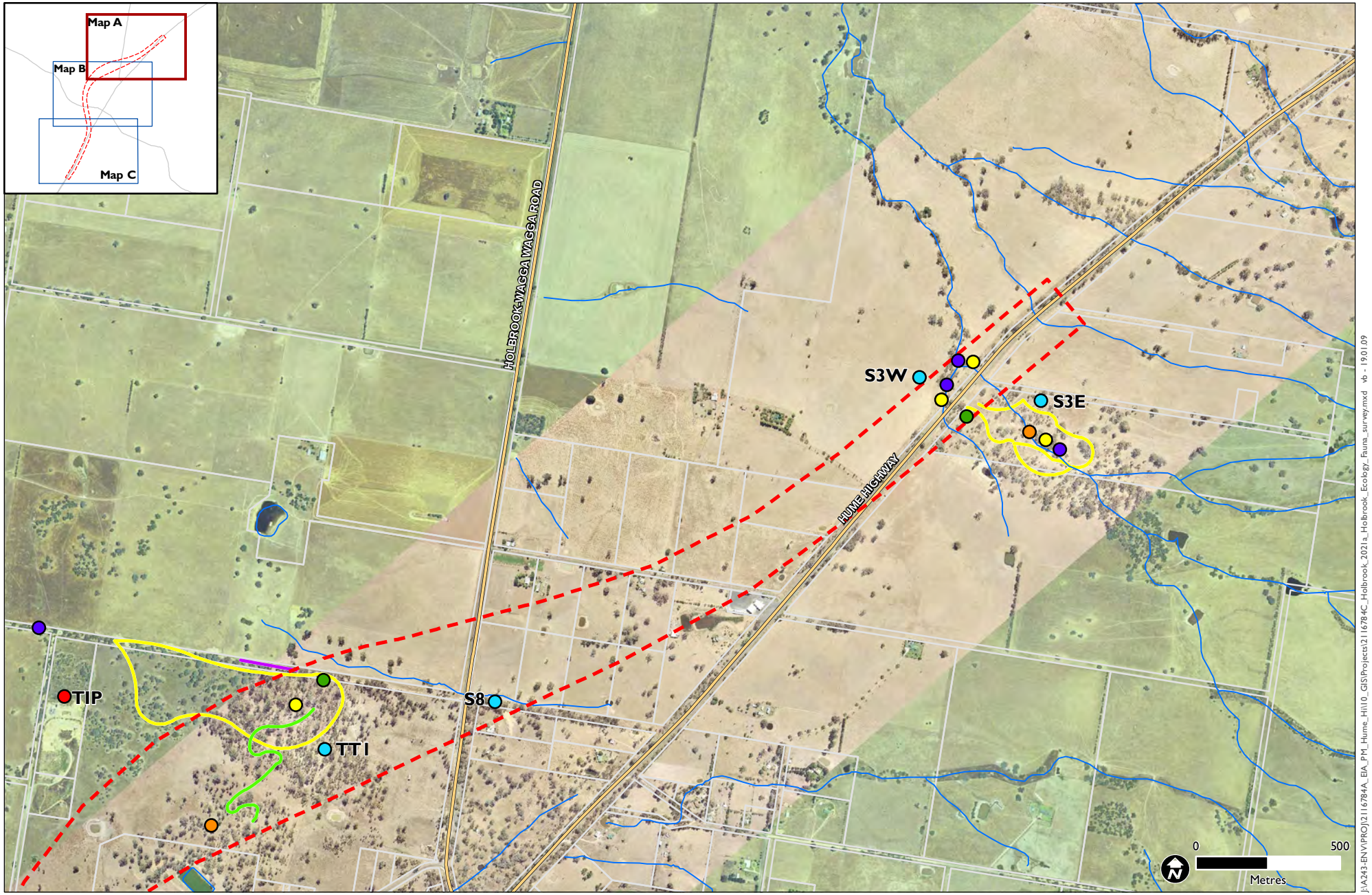


Figure 2-2 Location of fauna surveys (A)

Figure 2-2 Location of fauna surveys (B)

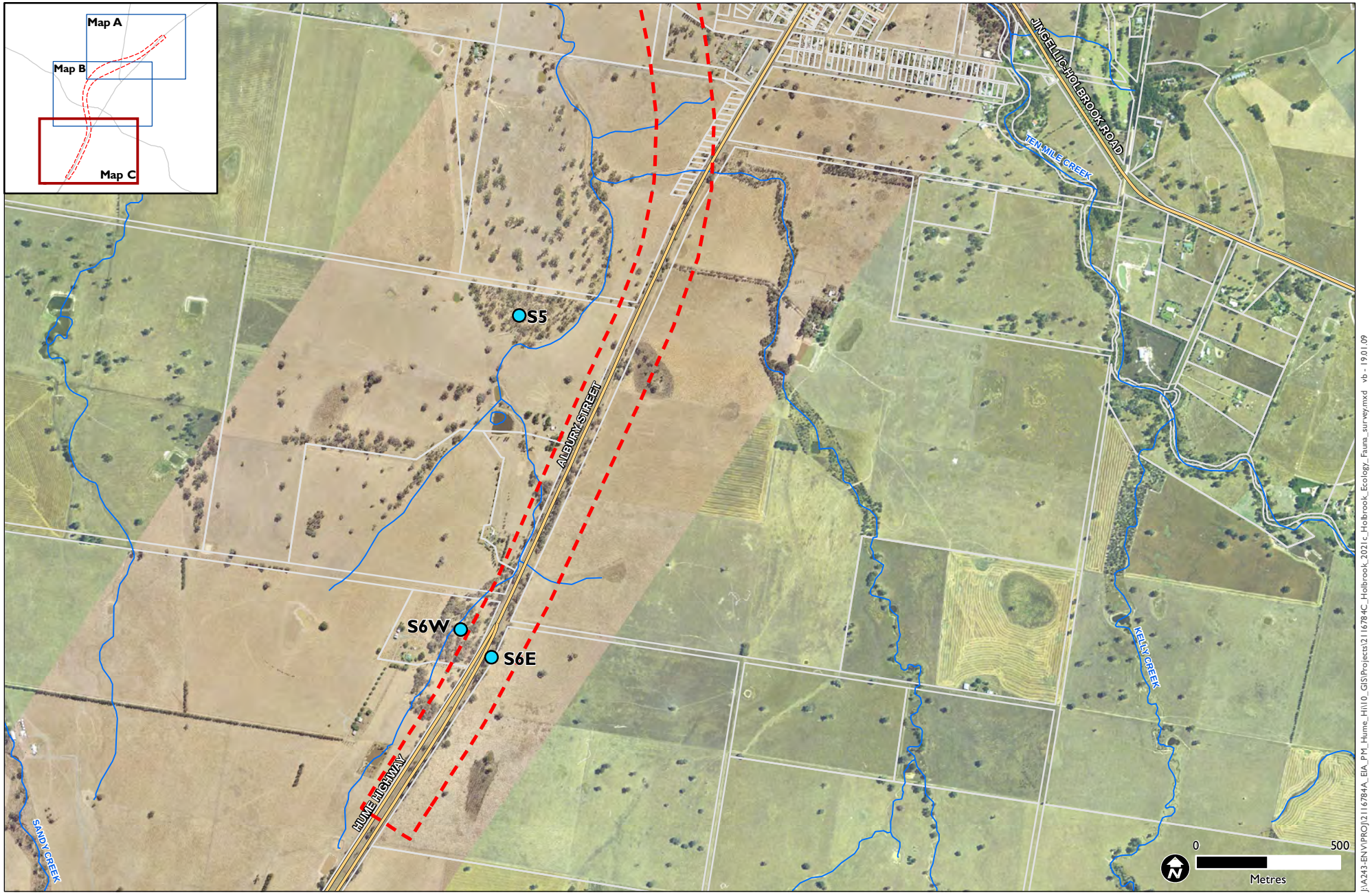


Figure 2-2 Location of fauna surveys (C)

2.5.4 Aquatic ecology

Field survey

Field surveys were used to quantify the aquatic ecology at three locations along Ten Mile Creek, which passes to the south of Holbrook. Location HB was situated where the project would cross Ten Mile Creek, whilst locations HU and HD were situated upstream and downstream of the project location respectively (refer Figure 2-2). The experimental design for the aquatic survey was based on quantifying the aquatic assemblages at appropriate spatial scales within each of the three locations. Within each location, two randomly nested sites were sampled. Each site was separated by approximately 200 m.

Within each site, three replicate measurements of physico-chemical water quality variables were recorded using a YEOKAL 611 submersible data logger. The variables included conductivity, dissolved oxygen, pH, temperature and turbidity.

At each site, three replicate macroinvertebrate samples were collected using timed 1-minute sweeps of all habitats (edge, riffle, pools, etc.), using a 250 x 250 centimetre (250 µm) dip net. The contents of the net were placed into plastic trays filled with fresh water and the macroinvertebrates sorted and placed into pre-labelled plastic sample containers filled with 70 per cent alcohol. The samples were identified to family level and counted in the laboratory using an ISSCO M400 stereomicroscope.

Within each site, three replicate samples of the assemblages of fish were collected using a Smith-Root 15C Electrofisher backpack unit. The electrofisher was used to stun the fish in open water and in submerged and emergent aquatic vegetation. Three minutes of electrofishing effort per replicate was used. All stunned fish were collected using a dip net and placed into plastic trays filled with water. In sites where deeper water occurred, additional sampling was done using nets and traps to sample the assemblages of fish. At least three replicates of each technique were used to quantify the fish assemblages at each site.

Fish were identified and counted in the trays and native species released back into the water once sampling at a site was completed. Exotic species such as carp and gold fish were euthanized using Animal Research Authority Care and Ethics Protocol 03/2445. All collections of fish were done in accordance with Section 37, of the NSW *Fisheries Management Act 1994*, using Scientific Collection Permit Number P03/0032(B)-5.0.

Analysis

Both univariate (ANOVA – GMAV) and multivariate (PRIMER) statistical routines were used to analyse the data. Analysis of variance (ANOVA) was used to test differences among locations and between sites for the total number of taxa (total richness) and the number of individuals (total abundance). Student Newman Kuels (SNK) tests were used to determine where differences were found in the ANOVA (Underwood 1981). Prior to analysis of variance, the data sets were examined for homogeneity of variances using Cochran's test (Winer 1971) and if necessary were transformed to stabilise the variances (Underwood 1981).

Multivariate statistical techniques were used to examine patterns in assemblages using the PRIMER software package (Plymouth Marine Laboratories, UK). Multivariate methods such as PRIMER allow comparisons of two (or more) samples based on the degree to which these samples share particular species, at comparable levels of abundance. A non-metric multidimensional scaling (nMDS) ordination was used to graphically illustrate relationships between samples for each assemblage. The significance of any apparent differences among sites was determined using ANOSIM (analysis of similarities). A SIMPER (similarity of

percentages) procedure was used to examine the contribution of taxa to the similarities (or dissimilarities) among locations and sites (Clarke & Warwick 1994).

The SIGNAL biotic index (Chessman 2001, 2003) was used to assign average pollution sensitivity grades to each of the sites. An average SIGNAL value was calculated for each site by summing the sensitivity grades assigned to each macroinvertebrate family and dividing by the number of families at each site. SIGNAL values range from 1 (most tolerant to pollution) to 10 (most sensitive to pollution). Average SIGNAL values greater than 6 indicate clean water, whilst between 5 and 6 the water quality is doubtful or mildly polluted. SIGNAL values between 4 and 5 indicate moderate pollution, whilst a value less than 4 indicates severe pollution.

2.6 Landscape context

Landscape context is the condition and nature of vegetation and habitats within and surrounding the study area. Many processes in a patch of vegetation are linked to processes in the surrounding landscape (Lindenmayer & Burgman 2005). The quality (including the long-term survival) of vegetation is dependent on a suite of factors that influence the patch or stand, including its position in the vegetated landscape (Todd 2003).

The assessment of landscape context was both qualitative and quantitative. The qualitative assessment included inspection of the following information within both the study area and the surrounding landscape, defined as 20 kilometres from the project centre-line:

- aerial photographs
- digital elevation model
- Mitchell Landscapes (NSW National Parks and Wildlife Service 2002b)
- forest ecosystem mapping for the Southern Comprehensive Regional Assessment (Thomas *et al.* 2000).

Using the Thomas et al. (2000) forest ecosystem mapping, the following quantitative assessment was undertaken using a geographic information system (GIS) (ArcView), following the methods proposed by Parkes et al. (2003). For the purpose of this assessment, a patch was defined as an area (remnant) of native vegetation with a defined physical boundary occurring in fragmented landscapes. A patch may occur across one or more land tenures and consist of one or more vegetation types. The following were assessed:

- **Patch size**: The size of remnant vegetation patches within the study area and within the wider landscape was measured, defined in this case as a distance of 20 kilometres from the study area. For this assessment, any patch intersecting the area of interest was counted. The sizes of vegetation remnants mapped in the study area as part of the current survey were also measured, although this mapping did not extend across the full landscape.
- **Neighbourhood**: The degree to which remnant vegetation is connected to other areas of native vegetation is likely to influence the regenerative capacity of the site, and therefore, its long-term viability (Cunningham 2000). The amount of cover within a locality can also strongly influence the species that occur in the landscape (Reid 2000). The proportion of native vegetation within a set distance of the footprint was measured: Distances were 100 metres, one kilometre, two kilometres and five kilometres from the footprint (refer Figure 2-3). The proportion of native vegetation was additionally calculated at a distance of 100 metres using the more detailed vegetation mapping of this study.

- **Distance to core area**: For the purposes of this assessment, a 'core area' was defined as a patch of native vegetation greater than 50 hectares. For this assessment, the Thomas et al (2000) mapping was combined with the vegetation mapping completed as part of this assessment. The distance was measured from the centroid of each remnant mapped within the study area to the nearest edge of a 'core area' (refer Figure 2-3).

2.7 Conservation significance

The conservation significance of native terrestrial flora, fauna and their habitats is generally categorised according to the hierarchy:

- national
- state
- regional
- local.

Meaningful comparisons of significance or value at a variety of scales rely on widely accepted criteria (for example, International Union for the Conservation of Nature 2001). The following criteria were used to assign the biodiversity within the study area to an appropriate conservation significance category:

- **National:** Where part of the study area contained features listed as Matters of National Environmental Significance, it was considered to be of national significance. Matters dealt with under the *Environment Protection and Biodiversity Conservation Act 1999* include:
  - important areas of habitat for migratory species covered under international agreements to which Australia is a signatory, such as the *China Australian Migratory Bird Agree*ment (CAMBA), *Japan Australian Migratory Bird Agreement* (JAMBA), *Republic of Korea Australian Migratory Bird Agree*ment (RoKAMBA) and the Bonn Convention
  - Ramsar wetlands
  - World Heritage properties that contain natural heritage considered to be of outstanding value to humanity, as listed under the Convention Concerning the Protection of the World Cultural and Natural Heritage
  - species populations or communities listed as Vulnerable, Endangered or Critically Endangered under the *Environment Protection and Biodiversity Conservation Act 1999*.

  This category also includes:
  - species listed as threatened and rare in *Rare or Threatened Australian Plants* (Briggs & Leigh 1996)
  - species listed as endangered, vulnerable or rare in *Australia in an Action Plan* published by the Department of the Environment, Water, Heritage and the Arts.

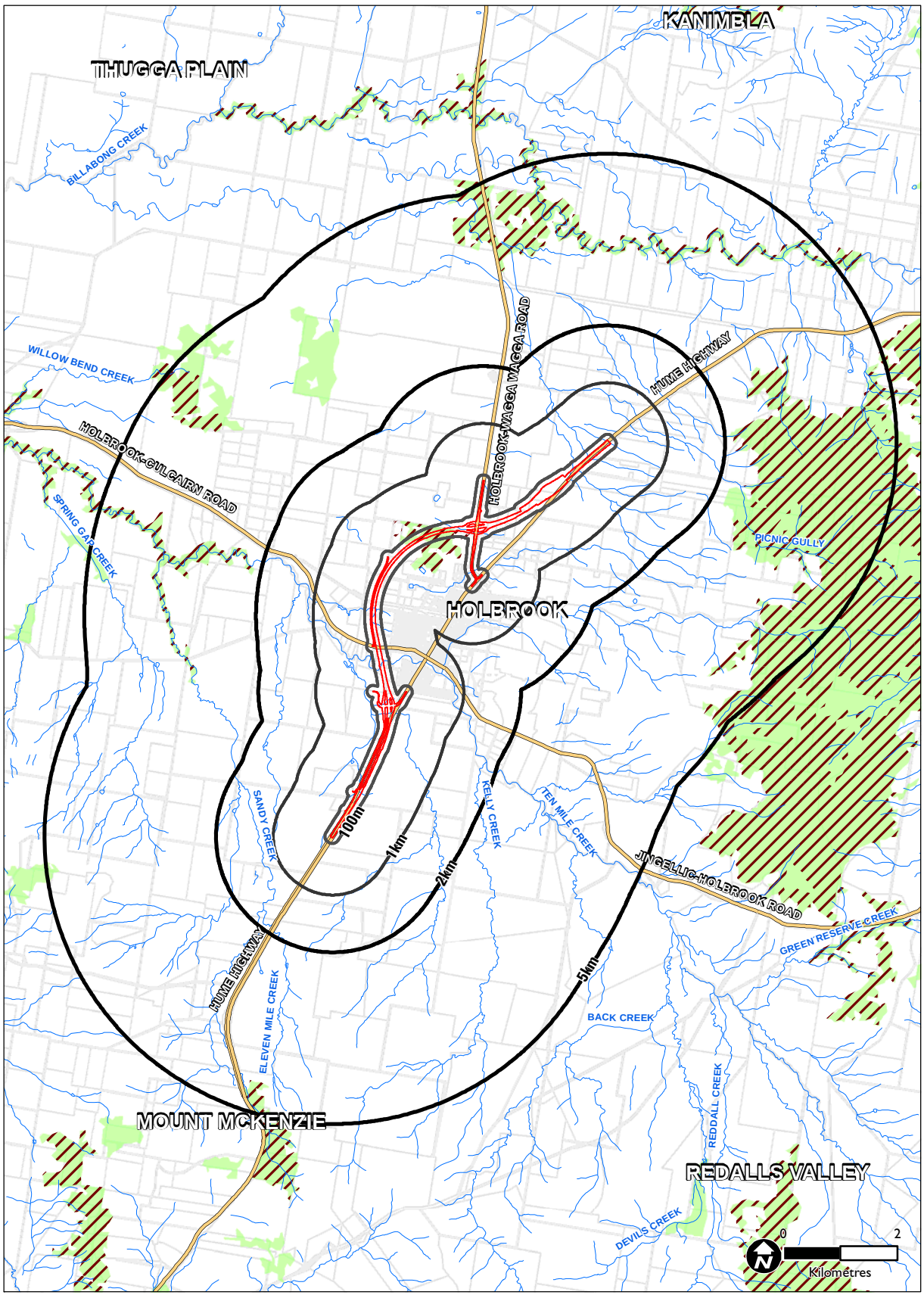


Figure 2-3 Landscape Context Method

- **State:** State significance refers to habitat containing populations of plant or animal species, or vegetation or animal communities considered Threatened in NSW, including species and communities listed pursuant to the *Threatened Species Conservation Act 1995* and the *Fisheries Management Act 1994.* This category also includes species of plant listed as 'poorly known' in Australia in *Rare or Threatened Australian Plants* (Briggs & Leigh 1996).
- **Regional:** There are no widely accepted criteria for regional significance in NSW. The State is divided into bioregions (Thackway & Cresswell 1995) and many of the listings of Endangered Ecological Communities under the *Threatened Species Conservation Act 1995* and the *Environment Protection and Biodiversity Conservation Act 1999* are based around these regions. Also, numerous published studies and vegetation mapping projects (e.g. Thomas *et al.* 2000) have indicated the importance of vegetation and species at various spatial scales. Within the region of the project, the Southern Comprehensive Regional Assessment (National Parks and Wildlife Service 2000) has assigned regional significance for species of both plant and animal.
- **Local:** All remnant native vegetation and fauna habitat that does not fall into the categories above is considered to be of at least local significance as most of these areas have been reduced in extent since European settlement. The overall significance of a site on a local scale can consider factors such as the size of remnants, degree of intactness and connectivity.
- **Potentially significant:** Often the limitations of field methods, seasonal factors or time constraints make it impossible to confirm the presence of a significant species or population. However, the habitat of an area being investigated may closely match that used by a significant species in areas nearby where it is known to occur (Department of Environment and Conservation 2004). In these circumstances, the level of significance that would otherwise apply is qualified by the term 'potential'.

2.8 Likelihood of occurrence and assessment of impact significance

Significance assessments were completed for those species recorded or predicted to occur with a moderate or greater likelihood. For this study, likelihood of occurrence is defined in Table 2-14.

Table 2-14 Likelihood of occurrence of threatened species

Likelihood	Description
Low	Species considered to have a **low likelihood of occurrence** include species not recorded during the field surveys that fit one or more of the following criteria: ▸ Have not been recorded previously in the study area and surrounds and for which the study area is beyond the current distribution range. ▸ Use specific habitat types or resources that are not present in the study area. ▸ Are considered locally extinct. ▸ Are a non-cryptic perennial flora species that were specifically targeted by surveys.
Moderate	Species considered to have a **moderate likelihood of occurrence** include species not recorded during the field surveys that fit one or more of the following criteria: ▸ Have infrequently been recorded previously in the study area and surrounds. ▸ Use habitat types or resources that are present in the study area, although

Likelihood	Description
	generally in a poor or modified condition. ▸ Are unlikely to maintain sedentary populations, however, may seasonally use resources within the study area opportunistically during variable seasons or migration. ▸ Are cryptic flowering flora species that were not seasonally targeted by surveys.
High	Species considered to have a **high likelihood of occurrence** include species recorded during the field surveys or species not recorded that fit one or more of the following criteria: ▸ Have frequently been recorded previously in the study area and surrounds. ▸ Use habitat types or resources that are present in the study area that are abundant and/or in good condition within the study area. ▸ Are known or likely to maintain resident populations surrounding the study area. ▸ Are known or likely to visit the site during regular seasonal movements or migration.

For species, populations and communities listed under the *Threatened Species Conservation Act 1995* and the *Fisheries Management Act 1994* that have a moderate or greater potential to occur in the study area, the significance of impacts was assessed based on the Department of Environment, Climate Change and Water's and Department of Industry and investments' *Draft Guidelines for Threatened Species Assessment under Part 3A* (Department of Environment and Conservation 2005a). Under these guidelines, impacts are considered more significant if:

- areas of high conservation value are affected
- individual animals and/or plants and/or sub-populations that are likely to be affected by a proposal play an important role in maintaining the long-term viability of the species, population or ecological community
- habitat features that are likely to be affected by a proposal play an important role in maintaining the long-term viability of the species, population or ecological community
- the duration of the impacts would be long-term
- the impacts would be permanent and irreversible (Department of Environment and Conservation 2005a).

For species listed under the *Environment Protection and Biodiversity Conservation Act 1999*, significance assessments were completed in accordance with the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of the Environment and Heritage 2006a).

Species listed under both the *Threatened Species Conservation Act 1995* and the *Environment Protection and Biodiversity Conservation Act 1999* were assessed using both assessment guidelines separately, although there is considerable overlap between the two assessment processes.

2.9 Limitations

A common limitation of ecological surveys is the short time period in which they are undertaken and the lack of seasonal sampling, which can lead to low capture rates or lack of detection of some species. For this reason, no sampling technique can totally eliminate the possibility that a species is present on a site. The conclusions in this report are based on data acquired for the site and the environmental field surveys and are, therefore, merely indicative of the environmental condition of the site at the time of preparing the report, including the presence or otherwise of species. Also, it should be recognised that site conditions, including the presence of Threatened species, can change with time.

Where survey was completed outside the optimal time for detecting species (e.g. *Diuris tricolor*), a precautionary approach was taken and it was assumed that the species was present if suitable habitat was observed.

In addition to field surveys completed by PB, information provided by the RTA on the dominate canopy characteristics for three sites originally located outside the study area and containing areas of unidentified remnant vegetation was used to classify the vegetation in these locations.