Bolivia Hill Upgrade - Assessment of Route Options

APPENDIX D
TERRESTRIAL ECOLOGY REPORT

Cardno
Shaping the Future

Biodiversity Impact Assessment

Bolivia Hill Upgrade - Assessment of Route Options

NA89913018

Prepared for
Roads and Maritime Services

30 July 2013

Cardno
Shaping the Future

Contact Information

Cardno (QLD) Pty Ltd
ABN 57 051 074 992

Level 11 Green Square North Tower
515 St Paul's Terrace
Fortitude Valley QLD 4006
Locked Bag 4006 Fortitude Valley

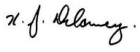
Telephone: 07 3369 9822
Facsimile: 07 3369 9722
International: +61 7 3369 9822

cardno@cardno.com.au.
www.cardno.com.au.

Document Information

Prepared for	Roads and Maritime Services
Project Name	Bolivia Hill Upgrade
File Reference	I:\NA89913018 Bolivia Hill\wp\Biodiveristy Impact Assessment_V1.docx
Job Reference	NA8991 3018
Date	30 July 2013

Document Control

Version	Date	Description of Revision	Prepared By	Prepared (Signature)	Reviewed By	Reviewed (Signature)
A	17 April 2013	Draft	DW MW GT		JD	
B	14 June 2013	Draft	JD		TM	
C	20 June 2013	Draft	JD		TM	
1	30 July 2013	Final	JD		TM	

Version	Reason for Issue	Approved for Release By	Approved (Signature)	Approved Release Date
A	Project Management Team Review	JD		17 April 2013
B	Inclusion of Option 7b	JD		14 June 2013
C	Issue for Client Review	JD		20 June 2013
1	For client use	JD		30 July 2013

Executive Summary

Roads and Maritime Services (RMS) are investigating options to upgrade a 3km long section of the New England Highway at Bolivia Hill. The design process encompasses identification of potential road corridors and route options, selection of the preferred route and development of a strategic concept design. This Biodiversity Impact Assessment will inform the relevant sections of a Preferred Route Option Report for the Bolivia Hill Upgrade.

This Biodiversity Impact Assessment is based on a combination of desktop and field based assessments the flora, fauna and ecosystems of the Bolivia Hill locality, with a particular focus on areas that would potentially be affected by the proposed upgrading of the New England Highway. The key findings of this assessment are that:

1. the Bolivia Hill locality has substantial biodiversity values; and
2. the proposed highway upgrade works are likely to impact on:
   - four threatened ecological communities;
   - four threatened flora species; and
   - sixteen threatened fauna species.

All of the four final short listed Route Options for the proposed upgrading of the highway would result in adverse impacts to the above features of biodiversity significance. In terms of minimising adverse biodiversity impacts, a route alignment which follows as closely as possible the current alignment of the New England Highway would be preferable, as it would result in less fragmentation of habitat. On this basis, the final four (4) short-listed Route Options may be ranked, from least impacting to most impacting, as:

> Route Option 7b;

> Route Option 7;

> Route Option 6; and

> Route Option 10.

It is also noted that the selected Route Option is likely to may have a significant impact upon one or more Matters of National Environmental Significance listed under the *Environment Protection and Biodiversity Conservation Act 1999*.

Acknowledgements:

The authors and field personnel would like to thank the following people for providing valuable assistance towards the preparation of this report and the completion of the field surveys.

> *Dr John Hunter for preparing the Flora Report and offering advice in relation to expected conditions on site.*

> *Trish and John Stadmiller for accompanying our field staff during some of the surveys and helping to provide some local context from their experiences.*

> *Michael Liebermann for help in relation to information regarding the fire that passed through Bolivia Hill Nature Reserve.*

Table of Contents

Tables

Figures

Appendices

1 Introduction

1.1 Project Background

Roads and Maritime Services (RMS) are investigating options to upgrade a section of the New England Highway at Bolivia Hill. The design process encompasses identification of potential road corridors and route options, selection of the preferred route and development of a strategic concept design.

The Bolivia Hill Upgrade project involves the investigation of options to realign approximately 3km of the New England Highway at Bolivia Hill from 56.4km to 59.4km north of Glen Innes (the Study Area). The location of the Study Area has been indicated in Figure 1 contained herein.

This Biodiversity Impact Assessment (BIA) will inform the relevant sections of a Preferred Route Option Report (PROR) which will ultimately assist with the selection of a preferred route for the Bolivia Hill Upgrade. The PROR will also provide input into the environmental assessment process.

1.2 Project Need

The Bolivia Hill section of the New England Highway is characterised by sections of steep and winding road. The road verge at certain points is substantially reduced and bound by hard rock cliffs and steep embankments. There have been a number of serious and fatal road incidents along the stretch of road. Improving the sub-optimal road conditions are an important consideration with respect to reducing the occurrence of serious and fatal incidents along this portion of the New England Highway.

1.3 Purpose of Ecological Surveys

Ecological surveys completed in the past, most notably within the Bolivia Hill Nature Refuge (Bolivia Hill NR), have identified a number of flora and fauna species and ecological communities which are specifically protected under the Threatened Species Conservation Act (TSC Act) and/or the Environment Protection and Biodiversity Conservation Act (EPBC Act). In response to such findings, RMS has identified the need to undertake detailed ecological surveys of the broader Study Area to help inform the final route selection by giving appropriate consideration to the biodiversity features that are known or may potentially occur within the Study Area.

This BIA will be used to inform the preparation of the PROR and a constraints plan which will identify those areas and aspects of the Study Area which have been identified as having features of significant biodiversity value for example:

> large, intact areas of remnant vegetation;

> areas which are found to support a diverse range of flora and fauna species;

> areas which are found to support threatened species; or

> areas which support an abundance of habitat resources required for threatened species.

1.4 Report Structure

This BIA aims to present the results and recommendations of the flora and fauna surveys and assessments in a manner that minimises the use of technical language and in a structure which aids in comprehension such that it may be viewed and understood by a range of audiences. As such this report presents:

> information relating to the Study Area in Section 2;

> the methodology employed for the flora and fauna surveys in Section 3;

> the results of the flora and fauna surveys in Section 4;

> an overview of the potential biodiversity impacts associated with the project and applicable impact avoidance and management recommendations in Section 5;

> an overview of the characteristics and relative magnitude of biodiversity impacts of the short-listed Route Options in Section 6;

> a summary of the key findings of this BIA in Section 7; and

> a list of information sources used in the preparation of this BIA in Section 8.

The BIA contains a number of Figures and Appendices which provide relevant additional information which is referred to in the body of the BIA.

2 Study Area

2.1 Location

The Study Area surrounds a 3km section of the New England Highway which passes through the Bolivia Range about 55km north of Glen Innes in NSW. The Bolivia Range tends to run from the east to west and connects with the Great Dividing Range to the east with Deepwater River passing through a gap in the range to the west of the Study Area. Bolivia Hill (1,225m) and Little Bolivia (1,100m) are hills within the Bolivia Range. Both the New England Highway (1,025m) and the Great Northern Railway line (disused) pass through gaps in the range just to the west of Bolivia Hill.

The section of the New England Highway that passes through the Bolivia Range is approximately 9km long. The section of road locally known as "Bolivia Hill", which is encompassed by the Study Area, descends 100m (980m to 880m AHD) over a distance of 2kms and is located on the northern granite escarpment of the range. The Bolivia Hill section of the highway has steep cross falls and narrow road corridors with hard rock cutting to the east of the alignment and steep rockfill embankments to the west.

2.2 Landscape and Landform

The Study Area sits, generally, along the western front of the Great Dividing Range and is characterised by granite dominated geology (NSW Government 2011a).

The Study Area is rugged in areas most notably in those areas associated with the Bolivia Range and Bolivia Hill to the south of the Study Area. Elevations within the Study Area range from 950 metres above sea level to 1,225 metres above sea level.

The broad geological feature which underlies the Study Area is the New England Fold Belt, which has a complex geology. The dominant rock type is an early Triassic granitoid called the Bolivia Range Leucomonzogranite (Hunter, 2002).

The dominant granitoid rock type is clearly evident within the Study Area both as steep exposed escarpments and smaller granitic outcrops consisting of very large boulder clusters (refer Plate 1 and Plate 2). This dominant landform characterised the Study Area which would be generally described as rocky with shallow to very shallow soils.

Plate 1: Granite boulder complex

Plate 2: Looking across deep valley towards the Bolivia Hill NR

2.3 Climate

Climate and weather statistics were obtained from the Bureau of Meteorology (BoM) for Tenterfield – Federation Park Station (Site number 056032). This station is located approximately 30km north-north east of the Study Area. Table 2-1 presents summarised data from the BoM report for the station.

The data presented in Table 2-1 indicate a climate which is characterised by a moderately pronounced summer rain regime with approximately one third of the annual average rainfall falling between the months of December and February. Severe weather events are generally associated with cyclonic depressions during summer months and cold fronts bringing snow and rain during winter months (Hunter 2002). It also indicates a region which is characterised by reasonably consistent wind speeds across the year but variable with respect to direction being a northerly to easterly flow for much of the year but clearly dominated by the cooler south westerly winds during the winter months.

Table 2-1 Summary of climate and weather data for Tenterfield (BoM Station Number 056032)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Maximum Temp °C	27.1	26.1	24.6	21.8	18.0	15.0	14.4	16.0	19.5	22.3	24.8	26.6	21.4
Mean Minimum Temp °C	14.4	14.3	12.4	8.5	4.9	2.4	1.0	1.8	4.7	8.0	10.8	13.0	8.0
Mean Rainfall (mm)	115.7	94.9	79.7	46.9	48.7	50.3	54.3	43.7	50.9	76.9	85.1	105.2	852.1
9am average wind speed and (predominant direction)	9 (NE)	8.9 (NE)	9.4 (NE)	8.5 (NE)	7.6 (NE SE)	7.3 (SW)	6.7 (SW)	8.5 (SW)	10.5 (SW NE)	10.4 (NE)	10.0 (NE)	9.0 (NE)	8.8 (NE)
3pm average wind speed and (predominant direction)	12.1 (NE)	12.0 (NE)	12.6 (NE)	12.4 (NE)	12.6 (NE)	13.3 (SW)	13.7 (SW)	14.4 (SW)	14.1 (SW)	13.6 (NE)	13.6 (NE)	12.9 (NE)	13.1 (NE)

The weather data for the BoM Tenterfield station was not available during the period of the fauna surveys or during the preparation of this report (BoM 2013a). As such, Table 2-2 below summarises the data obtained from the Glen Innes station (BoM Station Numbers 056013 and 056243) which is located 50km south west of the Study Area. A point of note is the likely difference between the conditions recorded at Glen Innes and those which occurred within the Study Area.

Table 2-2 Summary of weather data obtained from BoM Stations 056013 and 056243 for the period of the fauna surveys

Date	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)	9am cloud (8ths)	9am wind direction	9am wind speed (km/h)	3pm wind direction	3pm wind speed (km/h)
16/12/2012	-	29.5	0.0	-	E	9	W	26
17/12/2012	10.0	31.5	0.0	0	NW	15	WSW	13
18/12/2012	16.0	31.0	0.0	0	NW	7	W	19
19/12/2012	13.5	29.0	0.0	0	ESE	13	E	20
20/12/2012	16.0	24.0	39.0	8	SSW	13	W	9
21/12/2012	15.0	26.0	2.4	4	E	24	ENE	20
22/12/2012	16.5	24.0	0.6	5	E	20	ENE	24

Date	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)	9am cloud (8ths)	9am wind direction	9am wind speed (km/h)	3pm wind direction	3pm wind speed (km/h)
23/12/2012	14.0	26.0	0.8	2	ESE	15	N	15
24/12/2012	14.0	26.0	3.6	4	E	7	WSW	9

The flora surveys were conducted over a number of days between October 2012 and November 2012. The climatic conditions have less bearing on these surveys and as such a less detailed summary of the conditions over these two months have been provided below in Table 2-3.

Table 2-3 Summary of weather data for October 2012 (BoM Station Number 056032) and November 2012 (BoM Station Numbers 056013 and 056243)

Month	Min Temp (°C)	Max Temp (°C)	Average of max and min Temp (°C)	Total Rainfall (mm)	Average 9am wind speed (km/h)	Average 3pm wind speed (km/h)
October	0.5	30.6	14.0	83.6	9.5	11.9
November	5	30.5	17.4	109.9	16.4	18.2

Source: from the Tenterfield BoM Station (BoM Station Number 056032) for October and from the Glen Innes Station (BoM Station Numbers 056013 and 056243) for November as the Tenterfield Station data was not available for November 2012.

3 Methodology

3.1 Desktop Assessment

Information for the desktop component of the BIA has been drawn from relevant Commonwealth, State and Local government databases containing information concerning flora, fauna, vegetation communities and other environmentally relevant features.

In addition, a number of scientific reports and management plans which are of relevance to the Study Area and the surrounding landscape have been reviewed and considered in the preparation of this BIA.

Specifically, the following resources were reviewed in relation to the Study Area:

> the Atlas of NSW Wildlife (using a 10km by 10km polygon around the Study Area);

> PlantNET;

> EPBC Act Protected Matters Search Tool (using a 10km by 10km polygon around the Study Area);

> Vegetation and Floristics of the Tenterfield Nature Reserves (Hunter JT, 2002); and

> Plan of Management: Bluff River Nature Reserve and Bolivia Hill Nature Reserve.

It is important to note, with respect to online databases, that the NSW Wildlife Atlas results are based on actual sightings and consequently for the purpose of this BIA more confidence is assigned to the presence of those species and communities over the results obtained from the EPBC Protected Matters report, which returns results based on the presence of potential habitat for a particular species (as well as known presence of species or habitat).

3.2 Field Surveys

3.2.1 Flora

A requirement of the BIA for the Bolivia Hill Upgrade investigations was to engage and utilise the services of Dr John Hunter to conduct the flora surveys. Dr Hunter has significant local floristic expertise having been involved in a number of flora surveys associated with the Bolivia Hill Nature Reserve as well as many other locations within the New England Tableland. Dr Hunter's investigations and reporting have been used to inform a range of documents and plans, of relevance to this BIA is the Bluff River Nature Reserve and Bolivia Hill Nature Reserve – Plan of Management (NSW Government 2011a).

A detailed methodology for the flora surveys is provided within Dr Hunter's report "Survey of Vegetation and Flora Constraints: Bolivia Hill Road Re-alignment" dated December 2012 and a copy of the report is provided as Appendix A to this BIA.

In summary the flora surveys, which were completed between October and November 2012, involved the following.

1. Establishing 80 full and 22 rapid survey sites with the following data collected:
   - slope, aspect, elevation;
   - information on soils, fires and other disturbances; and
   - vegetation structure including growth form, height and crown cover of the dominant taxa within each strata (i.e. layer of vegetation).
2. Undertaking targeted threatened species searches.
3. Collection of critical habitat data (i.e. tree and hollow density).
4. Assessment of vegetation condition.
5. Preparation of a detailed flora community map for the Study Area.

With respect to vegetation condition the rating assigned by Dr Hunter was based on the following key requirements or features.

Good - Sites that were considered to be pristine to near pristine or with clear evidence of human disturbance but still retaining many important habitat features such as numerous hollows, logs on ground, old growth trees and/or minimal weed invasion.

Moderate - Sites which often lacked important fauna habitat elements and commonly contained stands of younger aged trees representative of the original overstorey with some isolated mature trees and a predominantly native understorey species.

Low - Sites often had little of the original overstorey cover, supported few if any features important for fauna habitat and had high weed infestations.

These condition ratings were used in the mapping of the vegetation communities within the Study Area. It should be noted that the habitat value methodology used for the flora surveys varied slightly to that which was used for the fauna surveys (refer Section 3.2.3 and Section 4.2.1).

3.2.2 Fauna

The fauna surveys were completed between the 16th and 24th of December 2012. The surveys were conducted under relevant NSW animal ethics and animal research authorities (TRIM 12/5710). The survey duration was, in total, nine days and eight nights within the Study Area. It should be noted that fauna trapping using Elliott and Cage traps was reduced from eight nights to six nights due to safety considerations and humane fauna handling requirements, which are discussed further in Section 3.3.

A total of eight formal fauna survey sites were established within the Study Area with each site being 100m by 200m in area. The location of each site was initially determined based on the flora mapping provided by Dr Hunter with a focus on locating sites within areas that:

> constitute the most dominant communities within the Study Area;

> may be fragmented by the proposed alignments;

> may be substantially disturbed or reduced by the proposed alignments; and/or

> are expected to contain threatened species and/or their habitat.

An initial site inspection was carried out and the location of the survey sites were adjusted as required to account for considerations such as safety, access, presence or absence of certain habitat features and other 'on-the-ground' considerations. The final location of the eight fauna survey sites has been illustrated in Figure 2 and the coordinates for the centre point of each of the survey sites has been provided in Table 3-1.

Table 3-1 The centre points for the eight fauna survey sites within the Study Area (GDA 94)

Survey Site Reference #	Centre Point	
	Easting	Northing
A1	394701.6815	6755765.2194
A2	395273.6574	6756640.1022
A3	395888.4822	6756925.6616
A4	396809.7499	6757348.9419
B1	395434.9963	6755785.2863
B2	395561.1295	6856622.7332
B3	396582.3804	6757308.0360
B4	396626.7168	6756631.4005

It was not practicable to place dedicated survey sites within all of the vegetation communities recorded during the flora surveys. By undertaking the assessment of suitable locations described above the final detailed fauna survey site locations were located in the four most dominant flora communities within the Study Area. These being:

> Community C2 Fuzzy Box-Ribbon Gun-Blakeley's Red Gum;

> Community C7 Broad-leaved Stringybark-Rough-barked Apple-Blakeley's Red Gum;

> Community C8 Blackley's Red Gum-Rough-barked Apple-Fuzzy Box; and

> Community C9 Broad-leaved Stringybark-Mountain banksia-Apple Box.

Combined these four communities occupy approximately 315.5 ha or 40 per cent of the total Study Area. All other communities were traversed during the surveys with incidental fauna observation and habitat data collected during these traverses.

The fauna surveys employed a range of techniques that were selected based on their applicability and usefulness with respect to capturing the range of fauna expected within the Study Area, with a specific focus on their applicability in detecting the threatened species that are known, or likely, to occur within the Study Area based on the findings of the desktop assessment. Consideration was also given to applicable fauna survey guidelines, primarily the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (DEC 2004) but also but also the *Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland* (Eyre *et al.* 2012) and applicable Commonwealth fauna survey guidelines (Commonwealth of Australia 2010a, 2010b, 2010c, 2011a, 2011b).

The following specific survey methods were employed:

> arboreal and terrestrial Elliott 'Type A' Traps (100mm x 100mm x 320mm);

> terrestrial cage traps (200mm x 230mm x 580mm);

> motion trigger infrared camera traps (Ltl Acorn Model: Ltl-6210HD);

> passive digital audio/ultrasonic recorders (Song Meter SM2Bat+);

> funnel traps (opening diameter 5cm);

> diurnal transect searches;

> nocturnal spotlight transect searches (50W globe);

> targeted aural detection; and

> scat, track, scratch and other signs searches.

Passive digital audio/ultrasonic recordings were submitted to Balance Environmental for analysis and identification of Microchiropteran Bat calls.

Plates 3, 4 and 5 show typical installations of some of the survey techniques while Table 3-2 below summarises the techniques used with respect to the specific target fauna group.

Table 3-2 Survey methods employed for target fauna groups within the Study Area

Target	Method (P = Primary; S = Secondary; - = Not used)							
	Elliott and Cage Trapping	Funnel	Ultrasonic Recording	Camera Trap	Spotlight Transect	Aural Detection	Diurnal Transect	Tracks and Signs
Terrestrial and Arboreal Mammals	P	S	-	P	P	S	-	S
Microchiropteran Bats	-	-	P	-	S	S	-	S
Reptiles	-	P	-	S	S	-	-	S
Amphibians	-	S	-	-	S	P	-	-
Avifauna	-	-	-	S	S	P	P	S

Plate 3: Elliott “Type A” Trap

Plate 4: Ultrasonic recording device

Plate 5: motion trigger infrared camera trap

At each of the eight sites the following different survey techniques were employed:

> 20 Elliot 'Type A' traps spaced at approximately 10m;

> 2 cage traps;

> 1 funnel array with 4 funnels;

> 1 passive acoustic/ultrasonic recorder;

> 1 motion trigger infrared camera trap;

> 1 spotlight transect;

> 1 diurnal transect; and

> random meander tracks and signs search.

A generalised configuration of survey effort within each survey site has been provided as Figure 2. Note that the exact locations of the various survey techniques was slightly modified as needed and on a site by site basis to account for site specific constraints.

The above techniques were supplemented by targeted aural detection surveys for amphibians. Due to the predominately dry weather conditions during the survey period, only a single area was specifically targeted by this survey technique (refer Figure 2) and further discussion in Section 3.3.

While the trapping component of the fauna surveys were conducted over six nights it should be noted that the overall effort has been calculated on a staggered trap line approach. As such, all "Trap Line A's" were set on night one with all "Trap Line B" closed on night one, this was alternated over the six nights meaning each of the eight survey sites were sampled three times. Table 3-3 below reflects this staggered survey effort.

Table 3-3 Survey effort across the eight fauna survey sites within the Study Area

	Effort Total (TN = trap nights, H = Hours)							
	Elliott and Cage Trapping (TN)	Funnel (TN)	Ultrasonic Recording (H)	Camera Trap (H)	Spotlight (H*)	Aural Detection (H*)	Diurnal Transect (H*)	Tracks and Signs (H*)
Effort/site/day	22	4	12	24	1.5	1.5	1.5	3
Total effort/site	66	32	48	96	6	6	6	12
Total Survey Effort for the Study Area	**528**	**256**	**384**	**768**	**48**	**48**	**48**	**96**

* NOTE: This time is based on 3 person surveys (i.e. 1.5 hours comprises of 3 people completing a 0.5 hour transect)

In addition to the formalised survey effort outlined in Table 3-3, approximately three person hours per day were spent conducting random meanders through the Study Area, generally while moving between formal survey sites or while conducting habitat assessments (see Section 3.2.3 below). Initial attempts to undertake specific surveys along the existing road alignment, to gain an appreciation of the road-kill count for fauna, were abandoned due to the restricted nature of road verge in many locations and associated health and safety risks.

3.2.3 Habitat Assessment

A further objective of the survey was to collect information pertaining to the habitat values of the Study Area in order to ascertain the relative value of the habitat to native fauna. The results of the habitat assessments may also be used to support a precautionary approach with respect to assessing the potential occurrence of specific fauna species, most notably threatened species. In effect this means that habitat within the Study Area may be considered high value habitat for threatened species (based on the presence of specific habitat features that are known to be of importance to a species) and as such may warrant specific protection even in the absence of direct sightings or indirect signs of occupation.

Habitat assessments were undertaken within each of the eight survey sites as indicated above with further generalised habitat assessments completed during traverses across the Study Area.

A basic Site pro-forma developed by Queensland Government was used for the collection of the habitat assessment data, a copy of which has been included as Appendix B. In summary the following features were noted and recorded where they were observed:

> slope;

> aspect;

> elevation;

> abundance of micro-habitat features including,

- hollows,
- fallen log,
- decorticating bark,

- leaf litter,
- bare ground,
- grass,
- soil cracks,
- rocks, small and large boulders,
- caves, rock crevices,
- exfoliating bark;

> Presence of possible breeding places (i.e. nests, permanent and ephemeral pools, termitaria);

> vegetation structure;

> fire or other disturbance; and

> weed infestations.

The following categories were used to classify fauna habitat value.

> **High:** ground flora containing a high number of indigenous species; vegetation community structure, ground log and litter layer intact and undisturbed; a high level of breeding, nesting, feeding, roosting and denning resources available; a high richness and diversity of native fauna species and good continuous connections of site habitat.

> **Moderate:** ground flora containing a moderate number of indigenous species; vegetation community structure, ground log and litter layer moderately intact and undisturbed; a moderate level of breeding, nesting, feeding and roosting resources available; a moderate richness and diversity of native fauna species and moderate contiguous connectivity to offsite habitats.

> **Low:** ground flora containing a low number of indigenous species, vegetation community structure, ground log and litter layer disturbed and modified; a low level of breeding, nesting, feeding and roosting resources available; low native species richness and diversity and little or no connectivity to offsite habitats.

3.3 Survey Limitations

The fauna surveys were conducted over a nine day period in early summer. As such the surveys were limited to detecting those species that are both present and active during this seasonal period. In the case of the flora surveys which were conducted in October and November 2012 detection of species may be limited by the presence of identifiable characteristics (i.e. reproductive material) during this time period. The fauna surveys were also limited by specific weather patterns and conditions (i.e. rainfall or cold snaps). For example, the fauna surveys coincided with a period of warm to hot days with only a single rain event (i.e. greater than 25mm in 24hrs) (see Section 2.3 and Table 2.1) and as such, detection of amphibian fauna was restricted to a single night of favourable conditions.

It was initially intended, where practicable, to install 40 per cent of the Elliott Traps on trees and to use two pitfall traps per survey site. However site and safety considerations meant that these desired techniques were not feasible. With respect to arboreal installations it was not possible to provide a consistent installation rate across the eight sites in locations that would be both suitable for fauna capture and safe for trap installation, baiting and checking. The shallow topsoil layer meant that the digging of pitfall traps within areas of the site that would also be most suited to reptiles was not practicable and as such only funnel traps were used, as indicated in Table 3-2.

The potential to locate fauna survey sites within the Bolivia Hill NR was initially limited by landscape, with many of the desired locations being too steep to safely access on a regular basis. The remaining, more accessible areas of the reserve that fall within the Study Area, had been impacted by a recent fire (see Figure 3). The fire occurred in October 2012 with the point of ignition presumed to be near the truck rest stop at the top of Bolivia Hill (M. Lieberman, NPWS *pers. comm*.). The fires appear to have been of sufficient intensity to have:

> removed all of the ground layer vegetation, with only small patchy regrowth evident during the surveys;

> compromised the structure of understorey with much of this layer dead but remaining in place (i.e. still present as standing woody debris);

> contributed to a singed but apparently viable canopy; and

> reduced the availability of large fallen timber.

It is likely that these impacts would have reduced the abundance and availability of habitat resources for many of the target fauna groups (i.e. reduction in food and shelter resources) and may also have resulted in a direct reduction in detectability through fauna mortality or fauna relocating from the affected area. The fires also limited the placement of flora survey plots within the reserve and as such these were placed within the unburnt margins of the fire's extent.

Finally it is recognised that not all survey techniques available were utilised for certain fauna groups. This is most particularly true for the Microchiropteran Bat (Micro Bat) species. It is recognised that certain species of Micro Bat cannot be reliably identified via a single technique (i.e. echolocation or trapping) and as such both trapping and recording of echolocation calls should be used where practicable. In this instance harp traps, a common trapping technique for Micro Bats, were not used due to concerns over animal welfare. It was determined that the survey schedule would result in an unacceptable risk that trapped animals may not be released in adequate timeframes to minimise undue stress or mortality to captured bats. Consequently the detection and identification of Micro Bat species is limited to those which can be reliably detected and identified using echolocation recording devices.

The above limitations notwithstanding, the survey methods and intensities are considered to be adequate for the purposes of informing the PROR. Additionally, where appropriate the surveys, inferences and recommendations have been guided and complimented by the results of past surveys within the region and the results of other available resources such as online database searches.

4 Results

4.1 Flora

Flora and vegetation surveys were undertaken by Dr John Hunter between October and November 2012 and a complete copy of Dr Hunter's report has been included herein as Appendix A.

The flora surveys recorded a total of 374 vascular plant taxa, from 87 families and 239 genera with the proportion of exotic species being 17 per cent.

A number of threatened species were recorded including Bolivia Hill Wattle (*Acacia pycnostachya*) and Bolivia Hill Pimelea (*Pimelea venosa*), which are listed as *Endangered* and *Vulnerable* respectively under both the TSC Act and the EPBC Act.

Impacts associated with weed abundance were noted as a key threatening process with the most prolific weed species being African Lovegrass, (*Eragrostis curvula*), Whiskey Grass (*Andropogon virginicus)* and Coolatai Grass (*Hyparrhenia hirta*).

The following sections provide further summaries of the results obtained during the flora and vegetation surveys including:

> an overview of the ten (10) plant communities identified in the Study Area, including information concerning their condition and status under the TSC Act and the EPBC Act; and

> detail on the threatened flora species that were recorded from within the Study Area and those which were not recorded but which are considered to be likely to occur.

4.1.1 Summary of Observed Communities

A total of 10 vegetation communities were recorded from within the Study Area and their distributions are illustrated in Figure 3. Four of these communities are considered to support the requisite species and be of a suitable quality and structure to be classified Threatened Ecological Communities (TEC) under the TSC Act and/or the EPBC Act. Figure 4 shows the location of those communities considered to be TEC as well as their indicative ecological condition as assigned by Dr Hunter.

Details concerning the name, extent, condition and conservation status of each vegetation community are provided in Table 4-1, along with some general comments regarding each community.

Table 4-1 Vegetation communities and their area, condition and status under relevant legislation recorded from within the Study Area

Community Name	Total Mapped Extent Ha	Condition – Ha (% of mapped extent)			TEC Extent - Ha (% of total mapped extent)	Conservation Status^		General Comments
		Good	Moderate	Poor		*TSC Act*	*EPBC Act*	
C1. Fuzzy Box – Yellow Box – Blakely's Red Gum Grassy Woodland	2.6	0.0 (-)	2.6 (100)	0.0 (-)	0.0 (-)			Though areas dominated by *Eucalyptus conica* (Fuzzy Box) are not listed as an endangered community within the New England Tablelands Bioregion, such areas should be considered at least as near threatened. This is because areas dominated by Yellow Box and Blakely's Red Gum would be considered to be part of the TEC of box gum woodlands, both of which species occur in this community.
C2. Fuzzy Box – Ribbon Gum – Blakely's Red Gum Grassy Woodland	24.6	4.3 (17.5)	20.1 (82)	0.1 (0.4)	12.8 (52.0) Ribbon Gum - Mountain Gum - Snow Gum grassy open forest/woodland of the New England Tableland Bioregion	*E*		Though the overstorey is intact, most of the understorey in the mapped units is dominated by *Eragrostis curvula* (African Lovegrass) which is listed as a Key Threatening Process (Invasion by Perennial Exotic Grasses) on the TSC Act. This is an unusual and undescribed assemblage type that is probably unique to the region between Deepwater and Tenterfield.
C3. New England Tea-tree – Pungent Bottlebrush – Swamp Tea-tree Wet Heath	1.5	0.0 (-)	1.5 (100)	0.0 (-)	1.5 (100) Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps Bioregions	*E*		This community has been affected by past grazing and clearing activities and regular fire. These disturbance activities are known to negatively affect the formation of peat. Some erosion has occurred through the centre of these wet heaths within the Nature Reserve.

Community Name	Total Mapped Extent Ha	Condition – Ha (% of mapped extent)			TEC Extent - Ha (% of total mapped extent)	Conservation Status^		General Comments
		Good	Moderate	Poor		*TSC Act*	*EPBC Act*	
C4. Derived Grassland (Red Grass – Wiregrass)	127.5	0.0 (-)	0.2 (0.2)	127.3 (99.8)	36.2 (28.5) Aspects of this community resemble two TECs: 1. Ribbon Gum - Mountain Gum - Snow Gum grassy open forest/woodland of the New England Tableland Bioregion 2. White Box Yellow Box Blakely's Red Gum grassy woodlands	*E* *E*	*CE*	Much of this assemblage is dominated by species listed as a Key Threatening Process (Invasion of Exotic Perennial Grasses) on the TSC Act and includes dense swards of *Eragrostis curvula* (African Lovegrass), *Andropogon virginicus* (Whiskey Grass) and *Hyparrhenia hirta* (Coolatai Grass). It is highly important that the spread of these introduced grasses is not exacerbated.
C5. Derived Grassland (Wire Grass – Bamboo Grass)	1.6	0.0 (-)	0.0 (-)	1.6 (100)	0 (-)			Highly disturbed areas commonly dominated by the introduced *Hyparrhenia hirta* (Coolatai Grass) which is listed as a Key Threatening Process (Invasion of Exotic Perennial Grasses) on the TSC Act. Found on highly disturbed and exposed areas associated with the railway cutting.

Community Name	Total Mapped Extent Ha	Condition – Ha (% of mapped extent)			TEC Extent - Ha (% of total mapped extent)	Conservation Status^		General Comments
		Good	Moderate	Poor		*TSC Act*	*EPBC Act*	
C6. Carex Fen	6.9	0.0 (-)	5.3 (76.8)	1.6 (23.2)	6.9ha (100) Aspects of this community resemble two TECs: 1. Carex Sedgelands of the New England Tableland, Nandewar, Brigalow Belt South and NSW North Coast Bioregions 2. Montane peatlands and swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps Bioregions	*E* *E*		There may be difficulty in determining which threatened ecological community this assemblage falls within without on-ground work. Fens are sensitive to small changes in groundwater flow.
C7. Broad-leaved Stringybark – Rough-barked Apple – Blakely's Red Gum Woodland	200.1	82.4 (41.2)	81.6 (40.8)	36.7 (18.3)	11.9 (5.9) Aspects of this community resemble: White Box Yellow Box Blakely's Red Gum grassy woodlands	*E*	*CE*	

Community Name	Total Mapped Extent Ha	Condition – Ha (% of mapped extent)			TEC Extent - Ha (% of total mapped extent)	Conservation Status^		General Comments
		Good	Moderate	Poor		*TSC Act*	*EPBC Act*	
C8. Blakely's Red Gum – Rough-barked Apple – Fuzzy Box Grassy Woodland	42.2	24.6 (58.3)	17.3 (41.0)	0.3 (0.7)	39.3 (93.1) Aspects of this community resemble two TECs: 1. White Box Yellow Box Blakely's Red Gum grassy woodlands 2. Ribbon Gum - Mountain Gum - Snow Gum grassy open forest/woodland of the New England Tableland Bioregion	*E* *E*	*CE*	Small open patches within the intact mosaic are dominated by *Eragrostis curvula* (African Lovegrass). Care should be taken not to spread this invasive species that is listed as a Key Threatening Process (Invasion by Perennial Exotic Grasses). Most of this community would be included within the Box – Gum Grassy Woodlands TECs. Furthermore most of the area mapped as this entity is of very high quality.
C9. Broad-leaved Stringybark – Mountain Banksia – Apple Box Shrubby Woodland and Forest	48.6	24.7 (50.8)	10.8 (22.2)	13.1 (27.0)	4.2 (8.5) Aspects of this community resemble: Ribbon Gum - Mountain Gum - Snow Gum grassy open forest/woodland of the New England Tableland Bioregion	*E*		Much of this assemblage has been cleared within the Study Area though a reasonable area remains in very good condition. It is within this community that the population of the Endangered *Pimelea venosa* is found.
C10. Black Pine – Caley's Ironbark – Kurrajong Shrubland, Shrubby Woodland & Dry Rainforest	18.9	7.5 (39.7)	7.4 (39.2)	4.0 (21.2)	0 (-)			The threatened *Acacia pycnostachya* (Bolivia Hill Wattle) is more commonly found in this community than any other and at times forms a dominant overstorey on some rocky slopes.

^Note: EPBC Act Status: CE=Critically Endangered. TSC Act Status: E=Endangered Ecological Community.

4.1.2 Taxa of Conservation Significance within the Study Area

A total of four threatened flora species were found within the Study Area during the flora surveys conducted by Dr Hunter, these being:

> Black Cypress Pine (*Callitris endlicheri*);

> Bolivia Wattle (*Acacia pycnostachya*);

> Bolivia Hill Pimelea (*Pimelea venosa*); and

> Pungent Bottlebrush (*Callistemon pungens*).

Details concerning the locations and vegetation communities within which these threatened flora species were recorded are provided in Table 4-1 and Figure 3.

Table 4-2 provides details concerning threatened flora species which have been previously recorded from the immediately surrounding landscape, primarily within the Bolivia Hill NR by Dr Hunter and others, including their legislative status and the vegetation communities they were recorded from. An assessment of the likely presence of each species within the Study Area is also provided, with likelihood ratings for the occurrence of a species based on the following set of criteria.

Confirmed – Species recorded during current surveys of the Study Area.

Likely – Study Area supports known critical habitat resources for the species and a NSW Atlas record exists for the species within 10km of the Study Area.

Possible – Study Area supports known critical habitat resources for the species, the EPBC Protected Matters Search Tool indicates the species is likely to occur within 10km of the Study Area, but there is no NSW Atlas record of the species within 10km of the Study Area.

Unlikely – Study Area contains very limited, degraded or no known habitat for the species.

The locations where threatened flora species have been previously recorded within the general locality of the Study Area are illustrated in Figure 5.

Table 4-2 Threatened flora species that were recorded within the Study Area or are considered likely to occur, their conservation status under relevant legislation and the communities within the Study Area from which they were recorded

Scientific Name	Common Name	Conservation Status^		Critical Habitat	Likelihood of Occurrence
		EPBC	TSC		
Callitris endlicheri	Black Cypress Pine	-	3	Usually found on stony hills or ridges.	**Confirmed** This species was commonly recorded within the New England Tea-tree – Pungent Bottlebrush – Swamp Tea-tree Wet Heath community, as well as the Black Pine – Caley's Ironbark – Kurrajong Shrubland, Shrubby Woodland and Dry Rainforest community, and was also recorded within the Broad-leaved Stringybark – Rough-barked Apple – Blakely's Red Gum Woodland community.
Almaleea cambagei	Torrington Pea	V	E1	Wet heath and acid swamp, and along watercourses on granite, above 900m altitude.	**Possible** Watercourses within the Study Area provide potentially suitable habitat for this species. The broad distribution of this species is known to include the vicinity of the Study Area.
Acacia pycnostachya	Bolivia Wattle	V	V	Dry sclerophyll forest, open woodland and dry heath. Occurs amongst granite outcrops, on hillsides at altitudes of 700 to 900m. Soil types range from sandy and skeletal on exposed outcrops, to shallow sandy loams in less exposed sites.	**Confirmed** A large population of this species was recorded within an area of Rock Outcrop Shrubland. Occasional individuals of this species were also found scattered through the Blakely's Red Gum – Rough-barked Apple – Fuzzy Box Grassy Woodland community. Potential habitat within the site occurs elsewhere within dry sclerophyll communities with granite outcrops.
Eucalyptus boliviana	Bolivia Stringybark	-	V	Low dry sclerophyll woodland on gritty sandy soils over granite and among outcropping boulders.	**Possible** The Study Area provides potentially suitable habitat for this species, specifically, dry sclerophyll forest with granite outcrops. This species is known only from the Bolivia Hill Nature Reserve and nearby locations.

Scientific Name	Common Name	Conservation Status^		Critical Habitat	Likelihood of Occurrence
		EPBC	TSC		
Homoranthus croftianus	Bolivia Homoranthus	-	E1	Open exposed situations in shrubland and low woodland on granitic outcrops.	**Possible** The Study Area provides potentially suitable habitat for this species, specifically, dry sclerophyll woodland on granite outcrops. This species is known only from the Bolivia Hill region.
Arthraxon hispidus	Hairy Jointgrass	V	V	Moisture and shade-loving grass, found in or on the edges of rainforest and in wet eucalypt forest, often near creeks or swamps.	**Possible** The Study Area provides potentially suitable habitat for this species, particularly along waterways in sclerophyll communities. The broad distribution of this species is known to include the Study Area.
Boronia boliviensis	Bolivia Hill Boronia	-	E1, 3	Dry sclerophyll forest and low shrublands amongst granite boulders, and heaths on granite outcrops.	**Possible** The Study Area provides potentially suitable habitat for this species, specifically, dry sclerophyll forest with granite outcrops and rock outcrop shrubland. This species is known only from the Bolivia Range.
Pimelea venosa	Bolivia Hill Pimelea/Bolivia Riceflower	E	E1, 3	Granite outcrops among granite boulders in skeletal or black sandy soil. Vegetation ranges from relatively more open woodland to shrubland to open grassland, on the western side of Bolivia Hill.	**Confirmed** One population of this species was found within the Broad-leaved Stringybark – Mountain Banksia – Apple Box Shrubby Woodland and Forest community. This is the only known population of this species. Potential habitat within the site occurs elsewhere within the woodland communities featuring granite outcrops.
Acacia pubifolia	Velvet Wattle	V	E1	Rocky granite hillsides, in sandy, stony or loamy soil in eucalypt-scrub woodland or forest.	**Unlikely** Although potentially suitable woodland habitat for this species is present within the site, this species is not known to occur in the vicinity of the Study Area.
Boronia granitica	Granite Boronia	E	V	Grows on granitic soils or screes amongst rock outcrops, often in rock crevices. It has been found in dry sclerophyll forests, woodlands and heathlands on mostly shallow soils.	**Possible** The Study Area provides potentially suitable habitat for this species, specifically, dry sclerophyll forest with granite outcrops. The broad distribution of this species is known to include the Study Area.

Scientific Name	Common Name	Conservation Status^		Critical Habitat	Likelihood of Occurrence
		EPBC	TSC		
Callistemon pungens	Pungent Bottlebrush	V		Grows in or near rocky watercourses, usually in sandy creek beds on granite or sometimes on basalt.	**Confirmed** Found as a shrub within community C3. Habitat restricted to heath swamp and wetlands.
Cryptostylis hunteriana	Leafless Tongue Orchid	V	V	Known from a range of habitats, including swamp-heath and woodland.	**Unlikely** Although potentially suitable woodland habitats are present within the Study Area, the distribution of this species is not known to encompass the Study Area.
Diuris pedunculata	Small Snake Orchid	E	E1	Grows on grassy slopes or flats. Often on peaty soils in moist areas. Also on shale and trap soils, on fine granite, and among boulders.	**Possible** The Study Area provides potentially suitable habitat for this species, specifically, peat soils supporting wet heath. The predicted distribution of this species encompasses the Study Area.
Eucalyptus nicholii	Narrow-leaved Black Peppermint	V	V	Dry grassy woodland, on shallow soils of slopes and ridges.	**Possible** The Study Area provides potentially suitable habitat for this species, specifically, dry sclerophyll forest. The predicted distribution of this species encompasses the Study Area.
Haloragis exalata subsp. *velutina*	Tall Velvet Sea-berry	V	V	Damp places near watercourses, and in steep rocky slopes of gorges.	**Unlikely** Although watercourses within the Study Area may provide potentially suitable habitat for this species, the broad distribution of this species is not known to include the Study Area.
Lepidium peregrinum	Wandering Pepper-cress	E	E1	Open riparian forest.	**Unlikely** Although watercourses within the Study Area may provide potentially suitable habitat for this species, the broad distribution of this species is not known to include the Study Area.
Streblus pendulinus	Siah's Backbone	E	-	Warmer well-developed rainforests, gallery forest and seasonal rainforest, chiefly along watercourses.	**Unlikely** The Study Area does not provide suitable rainforest habitat.

Scientific Name	Common Name	Conservation Status^		Critical Habitat	Likelihood of Occurrence
		EPBC	TSC		
Thesium australe	Austral Toadflax	V	V	Grassland or woodland, often in damp sites.	**Possible** The Study Area provides potentially suitable habitat for this species, specifically, grasslands and woodlands. This species has previously been recorded from the Bolivia Hill region.
Tylophora linearis	-	E	V	Dry scrub and open forest.	**Unlikely** Although the Study Area provides potentially suitable dry sclerophyll habitat, the known distribution of this species does not encompass the Study Area.
Tylophora woollsii	Cryptic Forest Twiner	E	E1	Moist eucalypt forest, moist sites in dry eucalypt forest and rainforest margins.	**Unlikely** Although the Study Area provides potentially suitable moist habitat, the known distribution of this species does not encompass the Study Area.

^Note: EPBC Act Status: E=Endangered; V=Vulnerable; M=Migratory. TSC Act Status: E4A=Critically Endangered Species; E1=Endangered Species; V = Vulnerable Species; 3 = Category 3 Sensitive Species

4.2 Fauna

A total of 115 fauna species were recorded during the surveys, a complete list of which has been provided as Appendix C. This comprised 105 native species and 10 introduced species. Diversity was greatest within the bird group with a total of 58 native and one introduced species. A total of nine reptile species were captured with no introduced species observed and nine amphibian species were recorded from the Study Area with one introduced species. A single native Crustacean was also recorded during the surveys.

The summary provided in Table 4-3 indicates that, by vegetation community type, community C9 showed the greatest diversity of those communities surveyed. C3 had the lowest faunal diversity, however this is due to the community only being surveyed during the targeted aural detection surveys for native frog species. Table 4-3 also illustrates the high proportion of introduced species within the mammal group.

Table 4-3 Summary of faunal diversity within surveyed vegetation communities

Faunal Group	Diversity by Vegetation Community					Proportion of exotic species (%)
	C2 (sites A4 & B3)	C3*	C7 (sites A2 & B1)	C8 (sites A3 & B4)	C9 (sites A1 & B2)	
Mammals	25	-	24	27	31	22
Birds	30	-	33	44	47	2
Reptiles	4	-	2	7	9	0
Amphibians	1	7	9	0	1	11
Crustaceans	0	-	1	0	1	0
Total	60	7	69	78	89	9

*: survey effort within C3 was limited to a single night of targeted surveys for native frog species.

4.2.1 Fauna Habitat

A qualitative assessment of the condition of fauna habitat within each survey site was undertaken during the surveys. The broad goals of the habitat assessments were to gain an appreciation of the habitat within the Study Area with respect to:

> quality (refer Section 3.2.3 for the methodology);

> type;

> availability of micro-habitat (e.g. hollows, boulders or fallen timber);

> threatening processes (e.g. weed infestation, fragmentation or clearing); and

> suitability for a range of threatened fauna species.

Table 4-4 provides a summary of the findings made during the habitat assessment and also includes those aspects of the flora investigations which are of relevance to habitat characteristics and condition.

Table 4-4 Summary of the Qualitative Habitat Assessments undertaken at Fauna Survey Sites within the Study Area

Site	Vegetation Community^	Condition	Slope (°)	Aspect	Elevation (mAHD)	Landscape Position	Primary Disturbance (Severity*)	Secondary Disturbance (Severity*)	Dominant Habitat Characteristics	Abundance**
A1	C9: Broad-leaved Stringybark - Mountain Banksia - Apple Box	High	6	SSE	953	Riparian to Footslope	Clearing (1)	Weeds (1)	- Hollows - Fallen Logs - Large Boulders (>2m)	- 6 - 5 - 5
A2	C7: Broad-leaved Stringybark - Rough-barked Apple - Blakely's Red Gum	High	11	E	960	Midslope to Hillcrest	Clearing (1)	Weeds (1)	- Hollows - Boulders (61cm - 2m) - Fallen Logs	- 6 - 6 - 5
A3	C8: Blakely's Red Gum - Rough-barked Apple - Fuzzy Box	High	6	SE	850	Footslope	Clearing (1)	Weeds (1)	- Hollows - Boulders (61cm - 2m) - Fallen Logs	- 6 - 6 - 5
A4	C2: Fuzzy Box - Ribbon Gum - Blakely's Red Gum	Low	1	NE	818	Plain	Isolation/Fragmentation (2)	Weeds (2)	- Grass - Fallen Logs - Hollows	- 7 - 3 - 3
B1	C7: Broad-leaved Stringybark - Rough-barked Apple - Blakely's Red Gum	Low	6	NW	975	Midslope	Fire (2)	Erosion (1)	- Large Boulders (>2m) - Boulders (61cm - 2m) - Hollows	- 7 - 6 - 3
B2	C9: Broad-leaved Stringybark - Mountain Banksia - Apple Box	High	22	SSE	865	Midslope	Clearing (1)	Weeds (1)	- Boulders (61cm - 2m) - Large Boulders (>2m) - Hollows	- 6 - 5 - 4
B3	C2: Fuzzy Box - Ribbon Gum - Blakely's Red Gum	Low	2	NW	815	Plain	Isolation/Fragmentation (2)	Weeds (2)	- Grass - Fallen Logs - Hollows	- 7 - 3 - 3
B4	C8: Blakely's Red Gum - Rough-barked Apple - Fuzzy Box	Moderate	11	NE	860	Midslope to Hillcrest	Clearing (1)	Erosion (1)	- Large Boulders (>2m) - Boulders (61cm - 2m) - Hollows	- 7 - 6 - 3

Note: *Severity rating (0 = nil to 3 = severe); **Abundance rating (0 = nil to 7 = Abundant) - see Appendix B for full classification. ^taken from Dr John Hunter's flora report

The habitat assessments indicate that the quality and condition of fauna habitats is variable across the Study Area. The majority of the survey sites were found to have a well-developed vegetation community that was in most instances well connected to the surrounding landscape. While there was evidence of weed invasion within the sites the levels were generally considered to be low and did not detract from the overall value of the area as habitat for native fauna. Possibly due to the rocky, shallow soils of the Study Area none of the sites were considered to have a well-developed or dense shrub or ground-layer however an abundance of rocks, fallen logs and leaf litter would compensate somewhat for the protection and cover usually afforded by the vegetation strata.

A general decline in habitat quality was recorded below Bolivia Hill, towards the north eastern section of the Study Area. This was found to be associated with lower elevations and a more 'plain-like' position within the landscape. These areas were represented by two survey sites (A4 and B3) that were also located close to the existing alignment of the New England Highway. The relatively poor habitat condition recorded at these sites is primarily driven by the isolation and fragmentation effects of the existing highway and the surrounding agricultural pastures which have been substantially cleared. However weed infestation and clearing have also contributed to a reduced overall condition at sites A4 and B3. Site B1 was also recorded as being of low quality at the time of the survey and this is primarily attributable to the fact that this site was located within a portion of the Bolivia Hill NR that had been recently subjected to an uncontrolled fire (refer Figure 3). Despite this impact, microhabitat features such as boulders and rock crevices remained as did many of the hollows in unburnt canopy trees. Consequently once there is regrowth within the ground layer and shrub layer the quality of the burnt area with respect to fauna habitat will increase.

The lower habitat value for sites A4 and B3 appears to have been reflected in the fauna abundance and diversity results. A total of 38 native fauna species were recorded within community C2 (represented by sites A4 and B3) which had the lowest habitat quality scores. This is compared against a total of 68 native fauna species recorded from within community C9 which is represented by the two sites with the highest habitat quality scores, A1 and B2.

The nature and availability of micro-habitat features was found to be reasonably consistent across the Study Area. The dominant fauna habitat features within the Study Area is driven by the underlying geology with an abundance of boulders, rocks, crevices, outcrops and similar geological formations that provide fauna refugia (see Plate 7). Interspersing these 'rock-based' habitat features are well-developed and structured vegetation communities which provide numerous hollows, fallen logs and substantial leaf-litter abundance all of which are important micro-habitat features for native fauna (see Plate 8 and Plate 9). Again, it is recognised that there was a decline in the abundance of boulders and rock crevices towards the lower elevation plains to the north and east of the Study Area. This was clearly evident within sites A4 and B3 (see Plate 10). However, despite the reduction in boulders and rock crevices, these sites were found to support a number of important micro-habitat features, the most prevalent of these being a well-developed ground layer vegetation and hollow bearing trees. It is expected that the absence of rocks and boulders would in part be compensated for by the dense ground-layer which would support small terrestrial mammals despite the prevalence of invasive flora species in parts. The hollow bearing trees recorded from within sites A4 and B3 would serve as suitable nesting and roosting sites for hollow dependant fauna, though the relatively isolated and fragmented nature of these patches means that they are more likely to support the more gregarious and disturbance tolerant bird groups (i.e. parrots) and common arboreal mammals (i.e. Common Brush-tailed possum).

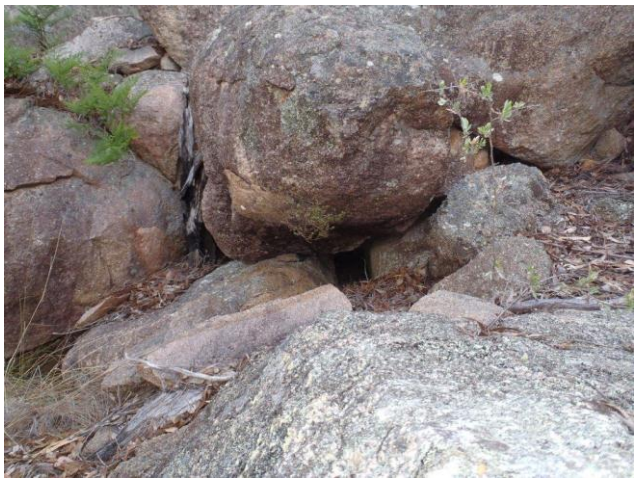


Plate 6: Boulder feature with clear crevice entry

Plate 7: Developed woodland with complex of microhabitat features

Plate 8: Fallen timber and rock complex

Plate 9: Dense ground cover at lower elevations

4.2.2 Fauna Corridors

Due to the location and size of the Study Area it is likely that it forms part of fauna movement corridors on both a local and regional scale. Figure 6 shows the general direction of these expected movements though it should be noted that this is based on a broad assessment of the surrounding landscape and specific corridors, such as any patterns of movement across the road corridor, could only be further delineated by detailed and specific investigations targeting specific fauna (e.g. spot-tailed quoll or macropods).

Despite the likely barrier effects of the New England Highway, the primary local movement corridor for fauna is expected to be northwest to southeast, linking the Study Area with the broader Bolivia Hill NR and areas of intact vegetation to the northwest. Local fauna movements are likely to occur in a north to northeast direction through the Study Area to areas of intact vegetation to the north. An unnamed tributary of Splitters Swamp Creek flows south to north in the northern section of the Study Area and is traversed by the existing highway alignment. This tributary ultimately joins Deepwater River and as such this tributary and associated riparian zone is expected to play an important role in fauna movements through the Study Area and ultimately the surrounding landscape.

There appears to be no dedicated safe fauna passage infrastructure (e.g. dedicated culverts, directional fencing etc) incorporated into the design of the existing section of highway through Bolivia Hill.

4.2.3 Birds

Birds were the most diverse fauna group recorded within the Study Area during the surveys. A total of 59 bird species were recorded either within the survey sites or during traverses through the broader Study Area.

The majority of species were recorded from within multiple vegetation community types and those that were only recorded from a single community are also likely to be recorded throughout other habitat types within the Study Area. The absence of a record of a species from a given community is most probably related to factors other than an inherent fidelity to a specific vegetation community particularly when, on a broad scale, much of the Study Area would be considered *Eucalypt* forest.

The Study Area was well represented by the more well-known and cosmopolitan species such as the Australian Magpie (*Cracticus tibicen*), Laughing Kookaburra (*Dacelo novaeguineae*), Superb Fairy-wren (*Malurus cyaneus*), Australian Raven (*Corvus coronoides*) and Noisy Miner (*Manorina melanocephala*). Other species that were less regularly encountered include the Double-barred Finch (*Taeniopygia bichenovii*), Eastern Spinebill (*Acanthorhynchus tenuirostris*) and Brush Cuckoo (*Cacomantis variolosus*). Only a single nocturnal species was recorded during these surveys being the Southern Boobook (*Ninox novaeseelandia*). This is likely due to factors such as seasonality as well as reduced survey effort and increased detection difficulties when compared with diurnal surveys.

The Study Area is also likely to support a wider range of bird species than was detected during these surveys. It was evident that the majority of the Study Area, including those locations which are comparably disturbed supported a range of habitat features which are of importance when considering bird abundance and diversity, as has been discussed in greater detail in Section 4.2.1.

4.2.4 Mammals

Mammals were well represented within the Study Area with a total of 37 species recorded. However the eight (8) species of introduced mammals constituted 22 per cent of the total number of mammal species recorded.

The most frequently encountered of all mammal species were the Microchiropteran Bats (Micro Bats). A total of 14 species were positively confirmed through analysis of their unique echolocation calls while a further three species may occur but could not be positively distinguished by echolocation call alone. A copy of the Balance Environmental Microbat Call Identification Report is provided as Appendix D.

The most frequently encountered terrestrial mammals were Macropods with the Eastern Grey Kangaroo (*Macropus giganteus*) being the most frequently recorded species and also being recorded within all habitat types surveyed within the Study Area.

The most frequently encountered invasive species was the European Rabbit (*Oryctolagus cuniculus*) which was recorded on multiple occasions at each site. Evidence of European Rabbit activity (i.e. scats and burrows) was clearly evident throughout most sections of the Study Area that were traversed.

While native mammals were recorded from within all vegetation communities, the results of these surveys show that community C9 had the highest diversity of native mammals with 26 species recorded. C8 had a comparable diversity of mammals with a total of 23 native species recorded. Communities C2 and C7 were similar with 19 and 20 native species respectively. Community C2 was found to have the highest diversity of introduced mammals at six species while community C7 and C8 were the lowest on four species each.

Despite a reasonable diversity of all mammals groups being recorded, the abundance of small terrestrial mammals was found to be quite low. Elliott and cage trapping returned only five individuals over the duration of the surveys with only the Yellow-footed Antechinus (*Antechinus flavipes*) captured on more than one occasion. It is possible that an apparent abundance of predatory introduced mammals (i.e. fox and cat) as well as native predators (i.e. Spot-tailed Quoll) is regulating the abundance of these prey species.

4.2.5 Reptiles

The surveys recorded a total of nine reptile species from within the Study Area. Most frequently encountered species were the Water Dragon (*Physignathus lesueurii*), Nobby Dragon (*Amphibolurus nobbi*) and Garden Sunskink (*Lampropholis delicata*). The only snake observed was the Red-bellied Black Snake (*Pseudechis porphyriacus*).

Given the abundance of suitable habitat, the diversity of reptiles recorded is below what was initially expected. The inability to practicably install pitfall traps may have contributed to the low detection levels with the funnel traps requiring individuals to actively choose to enter the traps (as opposed to passively 'falling'

into pitfall traps). The abundance of suitable micro-habitat may in itself be a contributing factor as it may lead to less movement between and within areas of suitable habitat by reptiles.

The low diversity and abundance would be expected to increase with increased survey effort targeted specifically at reptile fauna.

4.2.6 Amphibians

The majority of the survey period coincided with warm to hot conditions which, despite electrical storm activity, resulted in very little rainfall within the Study Area during the survey period. Consequently only a single night was considered to have provided favourable conditions for targeted aural detection surveys of amphibian species. A total of nine amphibian species were recorded from the surveys with the introduced Cane Toad (*Bufo marinus*) heard calling from within and external to the survey site and a single juvenile specimen being directly observed. The most commonly recorded native species were entirely of the genus *Litoria,* specifically, the Dwarf Green Treefrog (*Litoria fallax*), Keferstein's Tree Frog (*Litoria dentata*) and Peron's Tree Frog (*Litoria peronii*).

Amphibian species were observed and aurally detected from within constructed waterbodies (i.e. farm dams), natural waterways and the vegetation within and adjoining these features.

Due to the restricted survey time the targeted aural detection was only undertaken within two vegetation communities. As such it is not possible to comment on the relative importance of one vegetation community over another in this instance. However, those native frog species which were detected are considered to be reasonably common and would likely tolerate a range of conditions and habitats. Consequently it is expected that all aquatic habitats and areas of fringing terrestrial vegetation within the Study Area are expected to support both permanent and transient populations of the amphibian species recorded during the targeted surveys.

4.2.7 Crustaceans

Two individuals from a single crustacean species, the New England Crayfish (*Euastacus suttoni*) were recorded from within the Study Area. On both occasions the sighting was made as the New England Crayfish moved along a natural drainage line. The observations were made over two consecutive nights following the single rain event which occurred during the survey period.

4.2.8 Taxa of Conservation Significance

An assessment of the likelihood of occurrence within the Study Area of threatened fauna species that have been reported as occurring, or potentially occurring, within 10km of the Study Area is provided in Table 4-5. The likelihood of occurrence ratings for a species are based on the following set of criteria.

Confirmed – Species recorded during current surveys of the Study Area.

Likely – Study Area supports known critical habitat resources for the species and a NSW Atlas record exists for the species within 10km of the Study Area.

Possible – Study Area supports known critical habitat resources for the species, the EPBC Protected Matters Search Tool indicates the species is likely to occur within 10km of the Study Area, but there is no NSW Atlas record of the species within 10km of the Study Area.

Unlikely – Study Area contains very limited, degraded or no known habitat for the species.

Table 4-5 presents the findings of the assessment along with specific comments where appropriate regarding habitat requirements for specific species. Brief discussions of the results presented in Table 4-5 for each of the major fauna groups are provided in Sections 4.2.8.1 to 4.2.8.4 below.

Table 4-5 Taxa of Conservation Significance Potentially Occurring Within the Study Area

Scientific Name	Common Name	Conservation Status^		Critical Habitat	Likelihood of Occurrence	Regions of Study Area
		EPBC	TSC			
Frogs						
Philoria sphagnicolus	Sphagnum Frog	-	V	High moisture levels. Found in Sphagnum Moss beds or seepages on steep slopes. Habitat occurs in rainforest and wet sclerophyll forest. Burrow in loose, moist soil or moss, under leaf litter in soaks/seepages, or may use cracks/cavities next to small waterfalls.	**Likely**	There are a number of rocky well vegetated watercourses within the Study Area most notably south east of Sites A1, B2 and A3 and associated with communities C7 and C9.
Mixophyes balbus	Stuttering Frog	V	E1	Typically found in association with permanent streams through temperate and sub-tropical rainforest and wet sclerophyll forest. Outside the breeding season adults live in deep leaf litter and thick understorey vegetation on the forest floor.	**Possible**	Permanent sections of the watercourses below sites A1, B2 and A3 support appropriate habitat associated with communities C7 and C9.
Reptiles						
Underwoodisaurus sphyrurus	Border Thick-tailed Gecko	V	V	Dry sclerophyll open forest and woodland. Preference for canopy cover between 45-60, medium rock cover and high litter cover. Shelter sites include rocks, decaying logs, bark, and litter in rocky rubble. Usually shelters on litter substrate, shaded by nearby vegetation.	**Likely**	All sites surveyed, with the exception of B3 and A4 support appropriate habitat. However within the suitable sites there may only be small pockets which could be considered most suitable. The eastern facing bases of rock mounds, cliffs or crevices at sites A2 and B2 (Communities C7 and C9) would be considered most suitable. A single record from previous surveys has been made at the southern extent of the Study Area.
Delma torquata	Collared Delma	V	-	Normally inhabits eucalypt-dominated woodlands and open-forests. Suitable habitats are commonly associated with exposed rocky outcrops on ridges or slopes in vegetation communities dominated by Narrow-leafed Ironbark.	**Possible**	Study Area supports appropriate habitat features notably Site A1, A2 and B2 but the range of this species does not extend this far south and no vegetation communities supported Narrow-leafed Ironbark. Most closely aligned communities include C7 and C9.
Elseya belli	Bell's Turtle	V	V	Shallow to deep pools in upper reaches or small tributaries of major rivers in granite country. Occupied pools are most commonly less than 3m deep with rocky or sandy bottoms and patches of vegetation. Most typically uses narrow stretches of rivers or streams 30 - 40m wide. Nests are dug out in riverbanks of sand or loam.	**Unlikely**	Very limited areas of possibly suitable habitat and this species has not been found in this area previously. Generally restricted to the head waters of river systems to the north and south of the Study Area.

Scientific Name	Common Name	Conservation Status^		Critical Habitat	Likelihood of Occurrence	Regions of Study Area
		EPBC	TSC			
Birds						
Hieraaetus morphnoides	Little Eagle	-	V	Occupies open eucalypt forest, woodland or open woodland. Sheoak or Acacia woodlands and riparian woodlands of interior NSW are also used. Nests in tall living trees within a remnant patch.	**Confirmed**	A single individual was recorded overflying site B4. The entire Study Area would be considered suitable habitat for various life stages of this species.
Glossopsitta pusilla	Little Lorikeet	-	V	Forages primarily in the canopy of open Eucalyptus forest and woodland, yet also finds food in Angophora, Melaleuca and other species. Riparian habitats are used. Isolated flowering trees in open country are used e.g. paddocks, roadside remnants and urban trees. Nests in hollows in the limb or trunk of smooth-barked Eucalypts.	**Likely**	Much of the Study Area supports the required habitat for this species particularly those areas with a higher abundance of hollow bearing trees, (i.e. A1, A2, B2, B4 and A3) which fall within Communities C7, C8 and C9.
Tyto novaehollandiae	Masked Owl	-	V, 3	Lives in dry eucalypt forests and woodlands. Often hunts along the edges of forests, including roadsides. Roosts and breeds in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting.	**Likely**	The Study Area supports the range of habitat resources required to support this species. Those communities within the Study Area that contain suitable hollows are communities C7, C8 and C9.
Stagonopleura guttata	Diamond Firetail	-	V	Open grassy woodland, heath and farmland or grassland with scattered trees.	**Confirmed**	A single individual was recorded from within the Study Area within Site A2 which is within Community C7.
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	-	V	Found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest. Mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey. Fallen timber is an important habitat component for foraging. Hollows in standing dead or live trees and tree stumps are essential for nesting.	**Confirmed**	A number of individuals were recorded from sites A1, A2 and B2 which are within Communities C7 and C9. However, all communities within the Study Area are likely to provide habitat resources for this species from time to time.
Anthochaera phrygia	Regent Honeyeater	E, M	E4A	Dry open forest and woodland, particularly Box-Ironbark woodland and riparian forests of river Sheoak and Mistletoe. Regularly occur in remnant trees or patches of woodland in farmland, partly cleared agricultural land and riverine forest. Usually nest in the canopy of forests or woodlands, and in the crowns of tall trees, mostly eucalypts.	**Likely**	The Study Area supports the range of habitat resources required to support this species. Most particularly the well-developed canopies within communities C7, C8 and C9.
Dasyornis brachypterus	Eastern Bristlebird	E	E1	Tall, dense, grassy ground-cover in open Eucalyptus forests or woodlands. The ground-layer vegetation is usually about 1.0–1.5m tall and fairly dense, providing about 65–90 coverage.	**Unlikely**	Only site B3 and A4 support the required dense ground layer however these areas are otherwise likely to be too disturbed and small in area to support this species on a regular basis.
Erythrotriorchis radiatus	Red Goshawk	V	E4A	Inhabit open woodland and forest, preferring a mosaic of vegetation types and are often found in	**Unlikely**	The Study Area supports some of the habitat features required but lacks a well-developed broad

Scientific Name	Common Name	Conservation Status^		Critical Habitat	Likelihood of Occurrence	Regions of Study Area
		EPBC	TSC			
				riparian habitats along or near watercourses or wetlands. Preferred habitats include mixed subtropical rainforest, Melaleuca swamp forest and riparian Eucalyptus forest of coastal rivers.		scale mosaic of habitats (i.e. clearly defined riparian habitat amongst Eucalypt woodland).
Geophaps scripta scripta	Squatter Pigeon	V	E1	Occurs mainly in grassy woodlands and open forests and plains that are dominated by eucalypts. Has also been recorded in sown grasslands with scattered remnant trees, disturbed habitats (i.e. around stockyards, along roads and railways, and around settlements), in scrub and in acacia growth.	**Possible**	This species has been recorded from within 40km of the Study Area. Site A2 (community C7) is located within a vegetation community listed as known habitat. A possible but unconfirmed sighting was made during the surveys.
Lathamus discolor	Swift Parrot	E	E1	Inhabits dry sclerophyll eucalypt forests and woodlands. Occasionally occurs in wet sclerophyll forests. In northern New South Wales, Narrow-leaved Red Ironbark, Forest Red Gum forests and Yellow Box forest are commonly utilised. Occur in areas where eucalypts are flowering profusely or where there are abundant lerp infestations.	**Possible**	The entire Study Area supports the requisite habitat however surveys during profuse flowering would be required to increase detectability.
Leipoa ocellata	Malleefowl	V, M	E1	Predominantly inhabit mallee communities, preferring the tall, dense and floristically-rich mallee found in higher rainfall areas. Prefers habitats with a dense but discontinuous canopy and dense and diverse shrub and herb layers. Breeding habitat characterised by light soil and an abundant leaf litter.	**Unlikely**	The Study Area does not support areas of floristically rich mallee.
Rostratula australis	Australian Painted Snipe	V	E1	Generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. Typical sites include those with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire. Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds.	**Unlikely**	While there are areas of open water within the Study Area they generally lack the intact and dense fringing vegetation preferred by this species.
Mammals						
Dasyurus maculatus	Spotted-tailed Quoll	E	V	Prefers mature wet forest habitat. Suitable den sites include hollow logs, tree hollows, rock outcrops and caves. Require large areas of relatively intact vegetation to forage.	**Confirmed**	This species was only recorded from within Site A1 on two separate occasions. However the critical habitat resources (rock crevices, ground hollows for denning and available prey species) present within A1 (community C9) are comparable to that which occurs through the entire Study Area excluding the lower plain slopes. Past

Scientific Name	Common Name	Conservation Status^		Critical Habitat	Likelihood of Occurrence	Regions of Study Area
		EPBC	TSC			
						observations of this species along with the findings of this assessment indicate that the Study Area and the immediately surrounding landscape supports a functional, possibly important, population of this species.
Falsistrellus tasmaniensis	Eastern False Pipistrelle	-	V	Prefers moist habitats, with trees taller than 20m. Generally roosts in eucalypt hollows, but has also been found under loose bark on trees or in buildings.	**Likely**	The mountainous regions with steep cliff faces (i.e. below Site A2 in community C7) and those areas associated with Bolivia Hill (i.e. Site B1 also in C7) within the Study Area support the required habitat for this species. Further, echolocation calls which may be attributed, but not definitively, to this species were recorded from detectors located within all of the communities within the Study Area.
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	-	V	Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures.	**Confirmed**	Definitive echolocation calls were recorded at detectors located within all of the major vegetation communities surveyed.
Vespadelus troughtoni	Eastern Cave Bat	-	V	A cave-roosting species that is usually found in dry open forest and woodland, near cliffs or rocky overhangs; has been recorded roosting in disused mine workings. Occasionally found along cliff-lines in wet eucalypt forest and rainforest.	**Possible**	While no significant cave sites were recorded from this survey it is likely that they occur, particularly within the vertical outcrop below Site A2 (community C7 and C9) with both of these communities supporting the requisite vegetation for foraging.
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Roosts in cave entrances, cliff crevices, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin (*Petrochelidon ariel*), frequenting low to mid-elevation dry open forest and woodland close to these features. Requires a combination of sandstone cliff/escarpment to provide roosting habitat that is adjacent to higher fertility sites, particularly box gum woodlands or river/rainforest corridors.	**Unlikely**	Elevation of the Study Area and the surrounding landscape likely precludes the presence of this species.
Nyctophilus corbeni	South-eastern Long-eared Bat	V	V	Occurs in a range of inland woodland vegetation types, including box, ironbark and cypress pine woodlands. Moister woodland of various eucalypt species with a distinct shrub layer frequently adjacent to watercourses. Roosts in tree hollows, crevices, and under loose bark.	**Unlikely**	Study Area supports the habitat features required to support this species. However current known and predicted range ceases approximately 50km west of the Study Area.
Petrogale penicillata	Brush-tailed Rock-wallaby	V	E1	Occupy rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges. A range of vegetation types are associated with habitat, including dense rainforest,	**Possible**	The Study Area, particularly within Bolivia Hill NR and the higher slopes of sites B2 and B4 (communities C8 and C9) supports the specific habitat requirements for this species.

Scientific Name	Common Name	Conservation Status^		Critical Habitat	Likelihood of Occurrence	Regions of Study Area
		EPBC	TSC			
				wet sclerophyll forest, vine thicket, dry sclerophyll forest, and open forest.		
Phascolarctos cinereus	Koala	V	V	Inhabit a range of temperate, sub-tropical and tropical forest, woodland and semi-arid communities dominated by species from the genus Eucalyptus. Spend most of their time in trees, but will descend and traverse open ground to move between trees.	**Possible**	Despite an abundance of *Eucalypt* species the only recognised 'food' tree recorded within the Study Area by Dr Hunter was *Eucalyptus viminalis* (Manna Gum) which was recorded from within community C2. However the trees within the Study Area could be considered as potentially suitable for both foraging and resting. In addition to this there has been a past recorded sighting of this species within 10km of the Study Area.
Potorous tridactylus tridactylus	Long-nosed Potoroo	V	V	Can be found in dry and wet sclerophyll forests to coastal heaths and scrubs. Dense understorey with occasional open areas is essential, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas. A sandy loam soil is also a common feature. Dig small holes in the ground.	**Unlikely**	Generally recorded from more coastal environments east of the Great Dividing Range.
Pseudomys novaehollandiae	New Holland Mouse	V	-	Found from coastal areas and up to 100km inland on sandstone country. Deeper top soils and softer substrates are preferred for digging burrows. Inhabits open heathland, open woodlands with heathland understoreys and vegetated sand dunes.	**Unlikely**	May be within or on very edge of range for this species however key habitat requirement of deep topsoil is absent from the majority of the Study Area.
Pseudomys oralis	Hastings River Mouse	E	E1	Variety of dry open forest types with dense, low ground cover and a diverse mixture of ferns, grass, sedges and herbs. Access to seepage zones, creeks and gullies is important, as is permanent shelter such as rocky outcrops. Nests may be in either gully areas or ridges and slopes.	**Possible**	The Study Area supports the required habitat resources for this species including specific micro-habitat characteristics such as fallen timber and rock crevices (notably C7, C8 and C9). Individuals have been recorded from within protected reserves 20km from the Study Area.
Pteropus poliocephalus	Grey-headed Flying Fox	V	V	Occur in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops.	**Likely**	Though not recorded from these surveys the Study Area supports the required habitat resources particularly for foraging (i.e. densely treed areas of all woodland sites i.e. A1, A2 and B2 which are associated with communities C7 and C9). Surveys conducted over a number of seasons would likely detect their presence. It is recognised that there is only one known roost site within the vicinity of the Study Area and this is located 60km to the south east.

^Note: EPBC Act Status: E=Endangered; V=Vulnerable. TSC Act Status: E4A=Critically Endangered Species; E1=Endangered Species; V = Vulnerable Species; 3 = Category 3 Sensitive Species

4.2.8.1 Birds

Three species of bird which are listed as *Vulnerable* under the TSC Act were recorded from within the Study Area during the surveys these are:

> Brown Treecreeper (*Climacteris picumnus victoriae*);

> Diamond Firetail (*Stagonopleua guttata*); and

> Little Eagle (*Hieraaetus morphnoides*).

In addition to the species directly observed an assessment of the habitat within the Study Area determined that a further three threatened species are likely to occur within the Study Area based on their specific habitat requirements, these being:

> Masked Owl (*Tyto novaehollandiae)*, *Vulnerable* under the TSC Act;

> Little Lorikeet (*Glossopsitta pusilla*), *Vulnerable* under the TSC Act; and

> Regent Honey-eater (*Anthochaera phrygia*), *Critically Endangered* under the TSC Act and *Endangered* under the EPBC Act.

All three of the above species are expected to occur within the Study Area from time to time. The more developed Eucalypt forest communities occurring to the north and north west of the current highway alignment are considered to provide the most suitable foraging and nesting resources for the Little Lorikeet and the Regent Honey Eater. The Masked Owl is also expected to forage over the cleared grasslands which occur throughout the Study Area and would likely roost and perch in the mature Eucalypt forests that surround the grasslands.

4.2.8.2 Mammals

Three species of conservation significance were recorded from within the Study Area, these species were:

> Spot-tailed Quoll (*Dasyurus maculatus maculatus*), *Vulnerable* under the TSC Act and *Endangered* under the EPBC Act;

> Yellow-bellied Pouched Bat (*Saccolaimus flaviventris*), *Vulnerable* under the TSC Act; and

> Eastern Bent-wing Bat (*Miniopterus orianae oceanensis*), *Vulnerable* under the TSC Act.

The Spot-tailed Quoll was recorded on two consecutive nights by the camera trap installed at site A1 (refer Plate 11). On both occasions the Spot-tailed Quoll was captured two to three hours following dusk and then again two to three hours before dawn, suggesting it was making long-range movements throughout the surrounding habitat. In addition to the observations made during this survey, the Spot-tailed Quoll has been recorded from both the Study Area and the immediately surrounding area on a number of occasions, as road-kill observations (NSW Wildlife Atlas 2012). This would suggest that the Study Area and the surrounding landscape is very suitable habitat for this species.

Plate 10: Spot-tailed Quoll recorded from Site A1

The Eastern Bent-wing Bat and the Yellow-bellied Pouched Bat were both recorded from detectors located in all four of the major vegetation communities.

A further two Micro Bat species are considered likely to occur in the Study Area based on their range of occurrence and the recording of echolocation calls that may possibly be attributed to those species. These species, which are both listed as *Vulnerable* under the TSC Act, are:

> Beccari's Free-tail Bat (*Mormopterus beccarii*); and

> Eastern False Pipistrelle (*Falsistrellus tasmaniensis*).

In addition to the recorded (and likely recorded) species, the Grey-headed Flying Fox (*Pteropus poliocephalus*) which is listed as *Vulnerable* under the TSC Act and EPBC Act is also considered likely to occur based on the species known range and the habitat features of the Study Area. While there are no known roost sites for the Grey-headed Flying Fox within 10km of the Study Area this species is known to be highly dispersive with movements linked to foraging resources and periodic movement of camps. In this regard the utilisation of the Study Area by this species is likely to be of a transient nature and repeated surveys over a range of temporal and spatial scales would likely detect its presence.

Despite the conduct of targeted searches within areas of potentially suitable habitat there were no direct observations made of the Koala (*Phascolarctos cinereus*) which is listed as *Vulnerable* under both the TSC and EPBC Acts. A number of suitable food and shelter trees (i.e. *Eucalypt* species) were observed with scratch marks caused by arboreal mammals, potentially the Koala. However no Koala scats, which would have added further evidence towards Koala utilisation of the Study Area and those trees particularly, were recorded. Furthermore, an assessment of the flora communities within the Study Area and specific species within these has determined that the Study Area is not likely to constitute *State Environmental Planning Policy 44 – Koala Habitat Protection* (SEPP 44) habitat (refer Section 4.3).

4.2.8.3 Reptiles

Targeted searches failed to record the Border Thick-tailed Gecko (*Underwoodisaurus sphyrurus*), which is listed as *Vulnerable* under both the TSC Act and the EPBC Act, within the Study Area. However the Study Area, most notably eastern facing rock slopes below Sites A2 and B2, is considered to contain key habitat resource for this species.

While no reptiles of specific conservation significance were recorded from within the Study Area it is noted that it supports an abundance of suitable habitat features for reptiles (i.e. coarse leaf litter, fallen timber, exfoliating rock, crevice and decorticating bark). It is expected that with additional survey effort focussed towards detecting reptile species a number of additional species including threatened species would be identified.

4.2.8.4 Amphibians

No threatened amphibian species were recorded from the surveys. Of the two species that may occur, the habitat assessments determined that one species, being the Sphagnum Frog (*Philoria sphagnicolus*) which is listed as Vulnerable under the TSC Act is likely to occur within the Study Area. Based on the requirements of high moisture levels in rocky, preferable moss covered environments it is expected that this species would be restricted to the rocky creek line to the north-west of the current highway alignment and below sites A1 and B2.

It is also noted that the Endangered Tusked Frog population of the Nandewar and New England Tableland Bioregions is known to occur (or have occurred) in that part of the Border Rivers-Gwydir Catchment Management Region which encompasses the Study Area. However there are no records of the Tusked Frog (*Adelotus brevis*) within Atlas of NSW Wildlife search results for the Study Area and no Tusked Frogs were recorded during field surveys. Further in this respect the formal NSW Scientific Committee listing of this population also notes that "*The New England Tablelands and Nandewar population of Tusked Frog represents a distinct and disjunct high-elevation population that is at the western limit of the species' range in NSW. Given the apparent lack of records from this population in the last 25 years, its numbers are likely to be reduced to a critical level, if it is not already extinct.*" Given the above facts and circumstances, the Tusked Frog is considered to be unlikely to occur within the Study Area.

4.3 SEPP 44 Koala Habitat

The surveys undertaken did not record any core koala habitat[1] within the Study Area. In addition, the results of Dr Hunter's flora surveys indicate that the majority of the Study Area is unlikely to support potential koala habitat[2]. Only one species of *Eucalypt* listed in Schedule 2 of SEPP 44, was recorded from within the Study Area. This species is *Eucalyptus viminalis* (Manna Gum), and was recorded from within community C2. The results of the survey indicate that this species may be co-dominant or a secondarily dominant species within the community.

The lack of SEPP 44 core or potential Koala habitat notwithstanding it should be taken into consideration that the Study Area does support a large number of *Eucalypt* species and recorded sightings have been made of the Koala within 10km of the Study Area. Consequently the area may serve as a link between areas of more suitable habitat and may at times support resting or sheltering Koalas as they move between areas of habitat external to the Study Area.

4.4 Overall Biodiversity Significance

Based on the above survey and assessment results, the Study Area either supports or is likely to support:

> four endangered ecological communities (refer Table 4-1 and Figure 4);

> four threatened flora species (refer Table 4-2, Figure 3 and Figure 5); and

> twelve threatened fauna species (refer Table 4-5, Figure 3 and Figure 5).

An assessment of the overall biodiversity significance of the habitat contained within different sectors of the Study Area was undertaken based on consideration of the presence of threatened ecological communities, the presence of threatened species and the overall condition of the vegetation communities. Table 4-6 provides the criteria used to assign areas to a particular Biodiversity Significance category whilst Figure 6 illustrates the distribution of Biodiversity Significance categories within the Study Area.

Table 4-6 Overall Biodiversity Significance Matrix

Threatened Ecological Community Consideration	Threatened Species Considerations	Vegetation Quality Consideration	Biodiversity Significance Rating
Area mapped as supporting a Threatened Ecological Community	Confirmed or likely presence of one or more threatened flora or fauna species within Vegetation Community	Vegetation of any quality	High
Area not mapped as supporting a Threatened Ecological Community	Confirmed presence of one or more threatened flora or fauna species within Vegetation Community	Vegetation of any quality	High
	No threatened species recorded in Vegetation Community	Good quality vegetation	Moderate
		Moderate quality vegetation	Moderate
		Low quality vegetation	Low

The Study Area supports large areas of habitat that are classified as being of High biodiversity significance. These areas of High biodiversity significance value are also well connected through the Study Area (i.e. internally connected) and to the surrounding landscape (i.e. externally connected). The high degree of internal and external connectivity of areas of High biodiversity significance increases the overall value of the Study Area to native flora and fauna and more specifically to threatened species.

[1] Section 4 of SEPP 44 defines ***core koala habitat*** as an area of land with a resident population of koalas, evidenced by attributes such as breeding females (that is, females with young) and recent sightings of and historical records of a population.
[2] Section 4 of SEPP 44 defines ***potential koala habitat*** as areas of native vegetation where the trees of the types listed in Schedule 2 constitute at least 15% of the total number of trees in the upper or lower strata of the tree component.

5 Overview of Potential Biodiversity Impacts

5.1 Potential Impacts

The potential biodiversity impacts associated with road construction and operation are well documented (Goosem 2012, Trombulak & Frissell 2000, Andrews 1990). In response, numerous State road transport authorities operate under internally developed guidelines which seek to minimise the impacts to native wildlife and ecosystems at all stages of road construction and operation (NSW Government 2011b, QLD Government 2010a, 2010b).

Potential impacts to biodiversity may occur during all phases of road infrastructure development. Consequently there are management and mitigation measures which may be considered and implemented at each stage to minimise potential impacts.

Broadly, the impacts on native flora and fauna associated with road infrastructure installation can be broken into two groups listed below.

> Direct impacts, including:
  - mortality through vehicle strike; and
  - mortality during clearing or construction.
> Indirect impacts, including:
  - edge effects (e.g. reduced habitat value along a road edge); and
  - barrier effects (e.g. isolating habitat or restricting movement).

Specific impacts to flora and fauna that are of relevance to the Study Area and this proposed road upgrade project have been listed below, it should be noted that this list is not exhaustive and further work during detailed design should take place to identify all relevant impacts.

> Reduction and loss of habitat value and biodiversity.
> Increased barrier to movement across the highway.
> Edge effects and clearing increasing the potential for weed invasion, feral animal incursion and overall degradation of habitats.
> Direct mortality and injuries by road strike and from construction machinery during the construction.
> Loss of actual and potential nesting, roosting and denning resources for fauna.
> Reduction in quality and size of available wildlife corridors.
> Clearing which leads to a reduction in plant numbers and diversity.
> Damage to riparian areas as a result of inadequate erosion and sediment control, poorly designed or constructed riparian works and/or temporary and permanent changes in hydrology and drainage regimes.
> Inadvertent, unnecessary or unplanned disturbance of TECs, threatened flora species and other areas of habitat outside of the construction area.
> Failure to undertake adequate rehabilitation/re-vegetation of disturbed areas.
> An overall cumulative loss of habitat.
> Inappropriate waste disposal encouraging feral animals and pests to frequent the construction site.
> Accidental spills of hazardous chemicals and/or hydrocarbons.

5.2 Impacts Minimisation Options

With respect to impact minimisation it is recognised RMS has adopted and recommends the following considerations when undertaking road development, in order of preference (NSW Government 2011b).

1. Avoid and minimise impacts.
2. Mitigate impacts where avoidance is not possible.
3. Offset where residual impacts cannot be avoided.

The avoidance of all impacts to flora and fauna will not be practicable in this instance. The minimisation of impacts through appropriate planning, design and construction will be possible. The primary mechanism by which minimisation of impacts may occur will be by ensuring the selected alignment is, as far as practicable, located close to the current alignment of the highway (i.e. utilise existing areas of disturbance). Planning activities, such as the preparation of a PROR, will help to minimise impacts by ensuring that all possible alignment options are considered and evaluated in a systematic and criteria based manner. Careful consideration during final design stages may also help to identify ways to minimise impacts, primarily through reducing the overall disturbance footprint required for the construction of the new alignment.

A range of potentially suitable mitigation measures may be employed during the proposed upgrades. The exact nature and scale of the mitigation measure will need to be determined following consideration of the final alignment, final designs and the construction methodology.

Some broad mitigation strategies have been presented below for further consideration during the planning process.

5.2.1 Timing of Clearing and Construction

Conducting clearing and construction activities at the most appropriate time for fauna can be a suitable mitigation measure. This is particularly true for fauna which have seasonal behavioural patterns, often associated with activities such as mating and dispersal following mating. During these times fauna are more susceptible to disturbance both directly, such as by collision with machinery or indirectly, through the disturbance to mating behaviour or loss of denning resources.

It would not be practicable to account for the activity cycles of all fauna within the Study Area. However, seeking to undertake most clearing and disturbance following winter to spring breeding and juvenile weening period could be appropriate as a 'generic' exclusion period. Certainly, this timing would be appropriate for the Spot-tailed Quoll (recorded during these surveys) as this species gives birth during winter with juveniles weening at approximately 18 to 20 weeks (Oakwood *et al* 2007).

It is also important to install all temporary fauna exclusion and movement measures (i.e. fencing and temporary fauna passage) as soon as practicable following the clearing, preferably occurring sequentially with the clearing. This will help to ensure fauna have time to adjust to new boundaries and dispersal locations prior to construction commencing.

5.2.2 Fauna Exclusion Fencing

The consideration and use of fauna exclusion fencing will be important both during construction and operational phases of the proposed road upgrades.

Fauna exclusion fencing can be a readily constructible fauna impact mitigation measure; it can also be generally one of the more cost effective solutions. One key advantage being that fauna exclusion fencing can also be readily retrofitted to adjoining, non-upgraded, sections of the highway. This enables fencing coverage to be extend to areas of connected habitat limiting the potential for fauna to 'short-circuit' the fencing installed along the upgraded section of road.

The design and construction of the fencing should be in accordance with applicable design guidelines (see RMS Design Reference Documents – Fencing R201) and modified in agreement to suit specific fauna or any site specific constraints. There are a number of basic and general principals which should be considered during the planning and design stages including at a minimum the below points.

> Fences should extend well beyond the edge of forested habitats into cleared country, wherever possible, so that fauna following the roadside fence cannot easily turn onto the road when they reach the end of the fence.

> Where fauna fences must end at the edge of habitat or can only be constructed along an upgraded section (ie no retrofitting) and cannot extend into cleared country they should have return ends that run along the edge of the habitat away from the road.

> Side access roads should have return edges to turn fauna back into the forest and away from the highway.

> Where practicable, consideration could be given to side roads having gates with signage indicating the importance of their purpose.

> Where fences are used in conjunction with other movement structures across the highway these structures should be located to give fauna easier and earlier options to get through the fence before reaching its ends.

Temporary fencing to exclude fauna during construction should seek to follow the broad considerations listed above; however the fencing need not be as durable or permanent. Consideration should also be given to allowing some form of fauna movement through the temporary fencing and the locations where movement is facilitated should be located as close as practicable to the locations of any final 'operational phase' fauna movement structures.

5.2.3 Fauna Passage Provision

The fauna surveys observed a range of mobile and dispersive fauna species (ie Spot-tailed Quoll and Macropods) which are also known to be road-kill casualties within the Study Area. Consequently it is recommended that consideration be given to providing fauna passage during both construction and operational phases.

Movement structures provided for fauna in the Study Area could consist of three main types:

> Overpasses, which are vegetated bridges over the roadway designed to look like natural habitat or smaller rope or ladder bridges for arboreal fauna.

> Underpasses, which are typically purpose-constructed box-culverts passing underneath the roadway.

> Underpasses where roadway bridges span natural landscape features such as gullies and waterways.

The specific nature and location of movement structures will require careful consideration and planning as there is no 'one-size-fits-all' structure for fauna movement.

Broadly it is recommended that all movement structures be located as close as practicable to any existing features that are used as fauna passage (ie culverts) and are located where fauna are known or most likely to cross.

Consequently it is recommended that further detailed dispersal and movement surveys for certain target fauna (notably the Spot-tailed Quoll) are undertaken. Given the known occurrence of this species and their status with respect to the TSC and EPBC Act as well as the understood propensity for long-range and regular movement it may be beneficial to the proposed action to understand the location and frequency of crossings made by this species and others of particular interest such that movement structures may be appropriately sited during planning and design stages.

It will also be necessary to decide upon which fauna species are most likely to attempt passage across the upgraded road and to target the construction of particular structure types around these species.

Based on observations made during the fauna surveys the following species or groups would benefit from a combined fauna passage/exclusion fencing approach:

> macropods and other dispersive terrestrial fauna (i.e. Spot-tailed Quoll); and

> arboreal mammals (i.e. possums and gliders).

5.2.4 Training and Management Protocols for Construction Personnel

It will be necessary to develop and implement a Construction Environment Management Plan (CEMP). This will be the overarching document used to manage the expected environmental impacts associated with the construction. The CEMP should detail, at a minimum, the following for each area of potential impact (ie flora and fauna):

> Rationale: identification of the element to be managed and the environmental impact of activities associated with each element.

> Objective/Target: identification of the environmental objectives to be achieved in compliance with applicable legislation.

> Tasks/Actions: management measures to be implemented in order to achieve the stated objectives and to ensure impact mitigation.

> Performance Indicators: measurable indicators and standards set to assess the efficiency of management measures and determine compliance with the CEMP. This shall include reporting and review as required.

> Monitoring: monitoring requirements to measure compliance with the performance indicators and frequency of monitoring.

> Record Keeping: the requirements for record keeping.

> Corrective Action: measures to be undertaken should monitoring indicate non-compliance with performance indicators.

A further training and management strategy is to educate all site personnel on the importance of minimising fauna and flora impacts and the sensitivity and value of the environment surrounding the proposed upgrades.

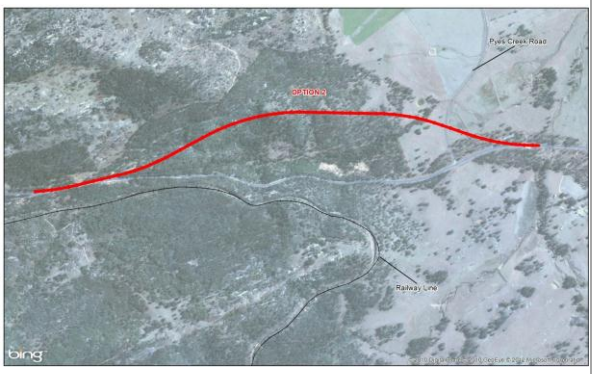
All site personnel should be made aware of the fauna that may be encountered and should be encouraged to report all sightings of fauna during construction. Generally when personnel are educated, engaged and involved in tasks such as reporting fauna sightings and are made aware of unique or iconic species in an area (i.e. the Spot-tailed Quoll) positive outcomes with respect to minimising impacts are observed.

It is also important to ensure that the project retains the services of wildlife spotter/catcher with experience and accreditation with respect to managing injured wildlife and relocation of captured wildlife. This person should be known to all site personnel along with their contact details and the contact details of wildlife carers in the area.

6 Overview of Route Options

A total of ten (10) route options for the upgrading of the Bolivia Hill section of the New England Highway were subjected to an initial assessment and an initial short list of four (4) route options was derived for further detailed assessment. The four short listed route options that were initially considered are briefly described in Table 6-1.

Table 6-1 Short-listed Route Options

Route Option	Indicative Alignment	Key Characteristics
2		3,200 metres long Deep cuts and high fills are required to achieve a maximum conforming vertical grade of 6 per cent. First 1,050 metres (from the southern project boundary) consists of minor cut and fill plus a bridge 150 metres long over the watercourse in the gully to the west of the existing highway. The alignment moves into a major cut through the ridge at the western extent of the study area. The cut is 600 metres long and up to 25 metres deep. The majority of the cut is on the western side of the alignment into the ridgeline. The alignment then moves into extensive fill up to 20 metres high as it grades down to the Brickyard Creek floodplain. Extensive retaining walls and or bridges may be required. A bridge up to 200 metres long will be required across the watercourse to the west of the existing highway just south of Pyes Creek Road. The high fill continues over Pyes Creek Road and grades down with the last 200 metres being an upgrade of the existing highway.
6		2,850 metres long Option has a maximum conforming vertical grade of 6 per cent. First 300 metres (from the southern project boundary) consists of minor cut and fill. Next 600 metres goes into cut up to 25 metres deep. The alignment then follows the line of the gully to the west of the highway on the eastern side of the waterway. A major bridge/viaduct up to 1,000 metres long is required to keep the roadway out of the creek line. From the end of the viaduct, fill up to 15 metres high tapers back to the existing highway over approximately 250 metres. The last 400 metres to just past Pyes Creek Road intersection is an upgrade of the existing highway.

Route Option	Indicative Alignment	Key Characteristics
7		2,350 metres long Option was developed to demonstrate a minimalist treatment of straightening out the bends in the steepest part of the highway. It has non-conforming grades up to 9.0 per cent in order to shorten the length and starts approximately 900 metres north of the other options. First 200 metres will require extensive retaining walls to keep the fill out of the creek line. A major bridge up to 550 metres long will then be required to keep the road out of the creek line. From the northern abutment at about 8 metres high, fill tapers back 400 metres to the existing highway.
10		2,950 metres in length Option has a maximum conforming vertical grade of 6 per cent. First 300 metres (from the southern project boundary) is in minor cut and fill. The alignment then moves into extensive cut 650 metres long and up to 25 metres deep. A major bridge/viaduct up to 900 metres long is then required to keep the road out of the creek line. The alignment then moves into extensive fill up to 15 metres high for 1,000 metres possibly requiring extensive retaining walls. A bridge up to 150 metres long will be required across the watercourse to the west of the existing highway. The last 300 metres is an upgrade of the existing highway.

It is possible to rank the short listed Route Options based on the relative magnitude of biodiversity impacts that would be associated with each option, based primarily on:

> the likely extent of impacts to areas classified as being of High biodiversity significance; and

> the additional degree of habitat fragmentation that would be associated with each option.

Based on such considerations the biodiversity impact rankings of the short listed options, in order of increasing impact, are provided in Table 6-2.

Table 6-2 Biodiversity Impact Ranking of Initial Short-listed Route Options

Ranking	Route Option	Rationale for Ranking
1	7	This route option is the shortest of the shortlisted options and is most closely aligned to the existing alignment of the New England Highway. As such the extent of additional habitat disturbance and fragmentation associated with this Option is likely to be substantially less than that associated with any of the alternative route options, particularly Route Option 2.
2	6	This route option would involve some additional habitat loss and fragmentation to that which would be required for Route Option 7, slightly less than that which is likely to be associated with Option 10 and substantially less than that associated with Route Option 2.
3	10	This route option would involve some additional habitat loss and fragmentation to that which would be required for either Route Option 7 or Route Option 6 and substantially less than that associated with Option 2.
4	2	This route option involves a substantial deviation from the existing alignment of the New England Highway. As such the extent of additional habitat disturbance and fragmentation associated with this Option is likely to be substantially greater than that associated with any of the alternative route options.

Based on the findings of the initial assessment of the four short-listed options the RMS Major Projects Review Committee (MPRC) requested that a "maximising the cost:benefit road safety option" be investigated due to the shortlisted options not demonstrating value for money. In response to the requirements of the MPRC, Option 2 was removed from the short list of preferred options and Option 7b was developed for further consideration.

In summary Option 7b is a sub-option of Option 7 and has a cross section consisting of one northbound lane, one southbound lane with 2.0m wide shoulders on either side. From an ecological perspective the key differences between Option 7 and Option 7b are that Option 7b is 1,635 metres long and starts approximately 475m further north and finishes approximately 240m further south than Option 7.

Based on such considerations the biodiversity impact rankings of the final short listed options, in order of increasing impact, are provided in Table 6-3.

Table 6-3 Biodiversity Impact Ranking of Final Short-listed Route Options

Ranking	Route Option	Rationale for Ranking
1	7b	This route option is the shortest of all the short listed options (1,635 metres) and along with Option 7 is the most closely aligned to the existing alignment of the New England Highway. As such the extent of additional habitat disturbance and fragmentation associated with this Option is likely to be substantially less than that associated with any of the alternative route options, particularly Route Option 6 and 10.
2	7	This route option is very similar to Option 7b in respect of its alignment, however it is approximately 40% longer than Option 7b and as such the biodiversity impacts will be greater.
3	6	This route option would involve some additional habitat loss and fragmentation to that which would be required for either Route Option 7 or 7b, and slightly less than that which is likely to be associated with Option 10.
4	10	This route option would involve some additional habitat loss and fragmentation to that which would be required for either Route Option 7, 7b or 6.

7 Summary

The flora and fauna surveys undertaken within the Study Area found the following matters of biodiversity significance, all of which are protected under the TSC Act and/or the EPBC Act.

> Four Threatened Ecological Communities including:
  - Ribbon Gum - Mountain Gum - Snow Gum grassy open forest/woodland of the New England Tableland Bioregion;
  - White Box Yellow Box Blakely's Red Gum grassy woodlands;
  - Carex Sedgelands of the New England Tableland, Nandewar, Brigalow Belt South and NSW North Coast Bioregions; and
  - Montane peatlands and swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps Bioregions.

> Four flora species of conservation significance including:
  - Black Cypress Pine;
  - Bolivia Wattle;
  - Bolivia Hill Pimelea; and
  - Pungent Bottlebrush.

> Six fauna species of conservation significance including:
  - Spot-tailed Quoll;
  - Yellow-bellied Pouched Bat;
  - Eastern Bent-wing Bat;
  - Brown Treecreeper;
  - Diamond Firetail; and
  - Little Eagle.

In addition to the above, a further 10 species of fauna are considered likely to occur based on the presence of key habitat resources within the Study Area and previous records of the species occurring within the general locality of the Study Area. The majority of the Study Area is considered to be of High biodiversity significance with respect to:

> the known and likely presence of threatened species and ecological communities; and

> the high degree of internal and external habitat connectedness.

Based on the findings of the flora and fauna surveys and in considering the potential impacts associated with the upgrading of the Bolivia Hill section of the New England Highway it is recognised that adverse biodiversity impacts will occur. Consequently, the minimisation, mitigation and offsetting of the potential impacts will be an important consideration for the project in order to reduce the degree of the impact to the native biodiversity.

With reference to Figure 6, it is noted that there is no alignment option through the Study Area that would result in no or negligible biodiversity impacts. However, in seeking to maintain existing levels of connectivity while minimising impacts to moderate and high value habitat it is noted that any alignment which follows as closely as possible the current alignment of the New England Highway is likely to be preferable, from a biodiversity conservation perspective, to options that will result in further fragmentation and isolation of the landscape as a result of clearing and construction occurring entirely in previously undisturbed areas.

Based on the above considerations, the final four (4) short-listed Route Options for upgrading the Bolivia Hill section of the highway may be ranked based on the relative magnitude of biodiversity impacts, from least impacting to most impacting, as:

> Route Option 7b;

> Route Option 7;

> Route Option 6; and

> Route Option 10.

It is also recognised that the selected route will require further consideration, assessment and approval under applicable State regulatory instruments. It is further noted that the selected proposal may have a significant impact upon Matters of National Environmental Significance (MNES) under the EPBC Act recorded from within the Study Area. In this regard it is recommended that at a referral be made to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) to confirm whether the proposed highway upgrade works at Bolivia Hill require formal assessment under the EPBC Act.

8 References

Andrews A (1990) Fragmentation of habitat by roads and utility corridors: A review. Australian Zoologist Volume 26:3 & 4.

Bureau of Meteorology (2013a) Tenterfield, New South Wales December 2012 Daily Weather Observations, http://www.bom.gov.au/climate/dwo/201212/html/IDCJDW2131.201212.shtml. Accessed 10/01/13.

Commonwealth of Australia (2012) EPBC Protected Matters Search Tool – Search Area -29.3298 151.90974 (10km buffer). Accessed 29/10/2012.

Commonwealth of Australia (2010a) Survey guidelines for Australia's threatened bats: Guidelines for detecting bats listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999.*

Commonwealth of Australia (2010b) Survey guidelines for Australia's threatened birds: Guidelines for detecting birds listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999.*

Commonwealth of Australia (2010c) Survey guidelines for Australia's threatened frogs: Guidelines for detecting frogs listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999.*

Commonwealth of Australia (2011a) Survey guidelines for Australia's threatened mammals: Guidelines for detecting mammals listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999.*

Commonwealth of Australia (2011b) Survey guidelines for Australia's threatened reptiles: Guidelines for detecting reptiles listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999.*

DEC (2004) Threatened Species Survey and Assessment: Guidelines for developments and activities (working draft), New South Wales Department of Environment and Conservation, Hurstville, NSW.

Eyre TJ, Ferguson DJ, Hourigan CL, Smith GC, Mathieson MT, Kelly, AL, Venz MF & Hogan, LD (2012) Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland. Department of Science, Information Technology, Innovation and the Arts, Queensland Government, Brisbane.

Goosem M (2012) Mitigating the impacts of rainforest roads in Queensland's Wet Tropics: Effective or a further evaluations and new mitigation strategies required? Ecological Management and Restoration, Volume 12 Number 3.

Hunter JT (2002) Vegetation and Floristics of the Tenterfield Nature Reserves (Bluff River, Bolivia Hill, Curry's Gap, Gibraltar & Mt McKenzie).

NSW Government (2012) NSW Wildlife Atlas – Search area: North: -29.27, West: 151.85, East: 151.95, South: -29.37. Accessed on 29/10/2012.

NSW Government (2011a) Plan of Management: Bluff River Nature Reserve and Bolivia Hill Nature Reserve.

NSW Government (2011b) Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects.

NSW Government (2008) Recovery Plan for the koala (*Phascolarctos cinerus*).

NSW Government (2006) Northern Tablelands Region Bolivia Hill NR Fire Management Strategy (type 2).

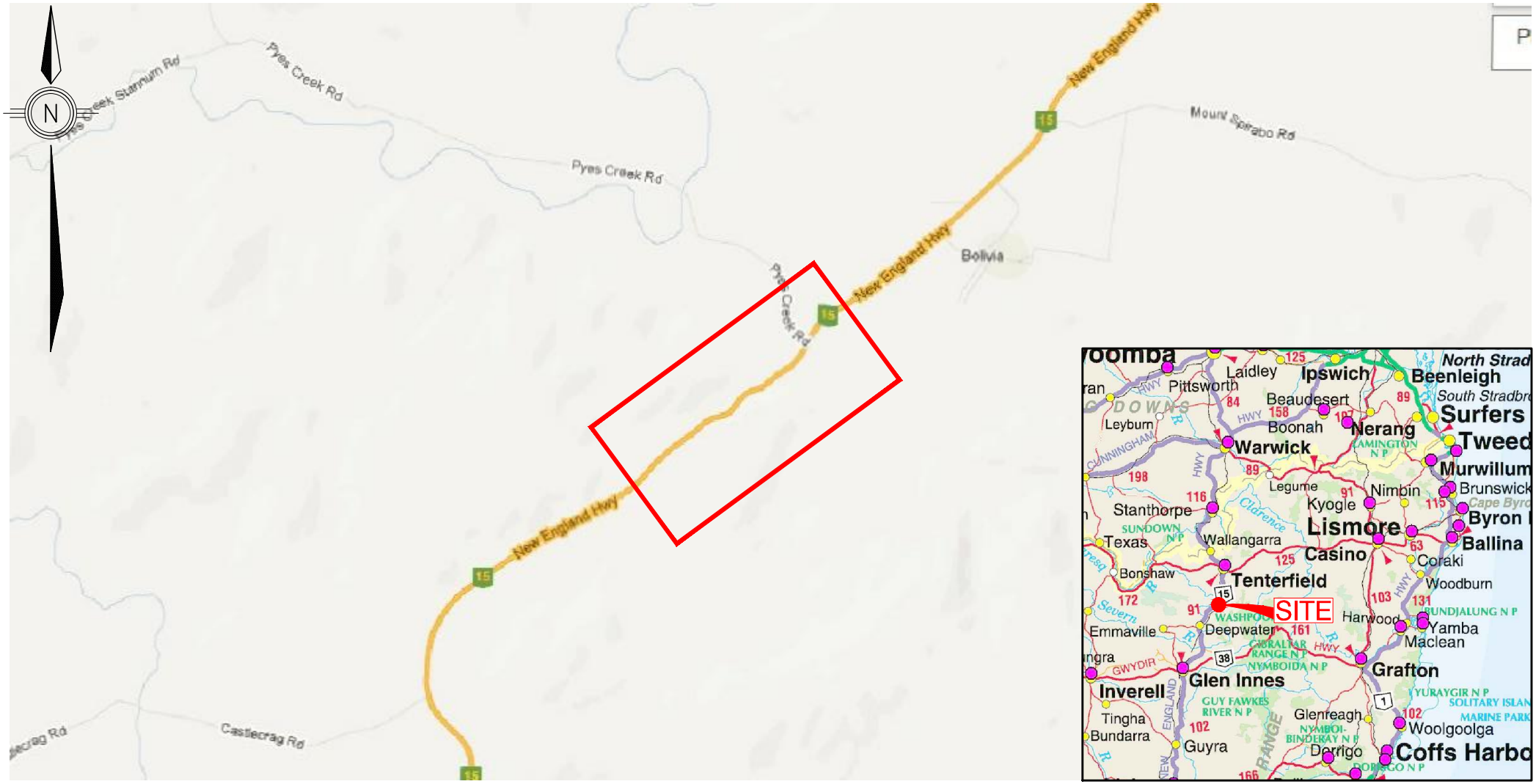
Queensland Government (2000a) Fauna Sensitive Road Design Volume 1 – Past and Existing Practices. Queensland Department of Main Roads, Planning, Design and Environment Division. Brisbane.

Queensland Government (2000b) Fauna Sensitive Road Design Manual Volume 2: Preferred Practices. Queensland Department of Main Roads, Planning, Design and Environment Division. Brisbane.

Trombulak SC & Frissell CA (2000) Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology Volume 14:1.

FIGURES

Cardno
Shaping the Future



Scale 1:60,000(A4)

FIGURE 1
LOCALITY PLAN

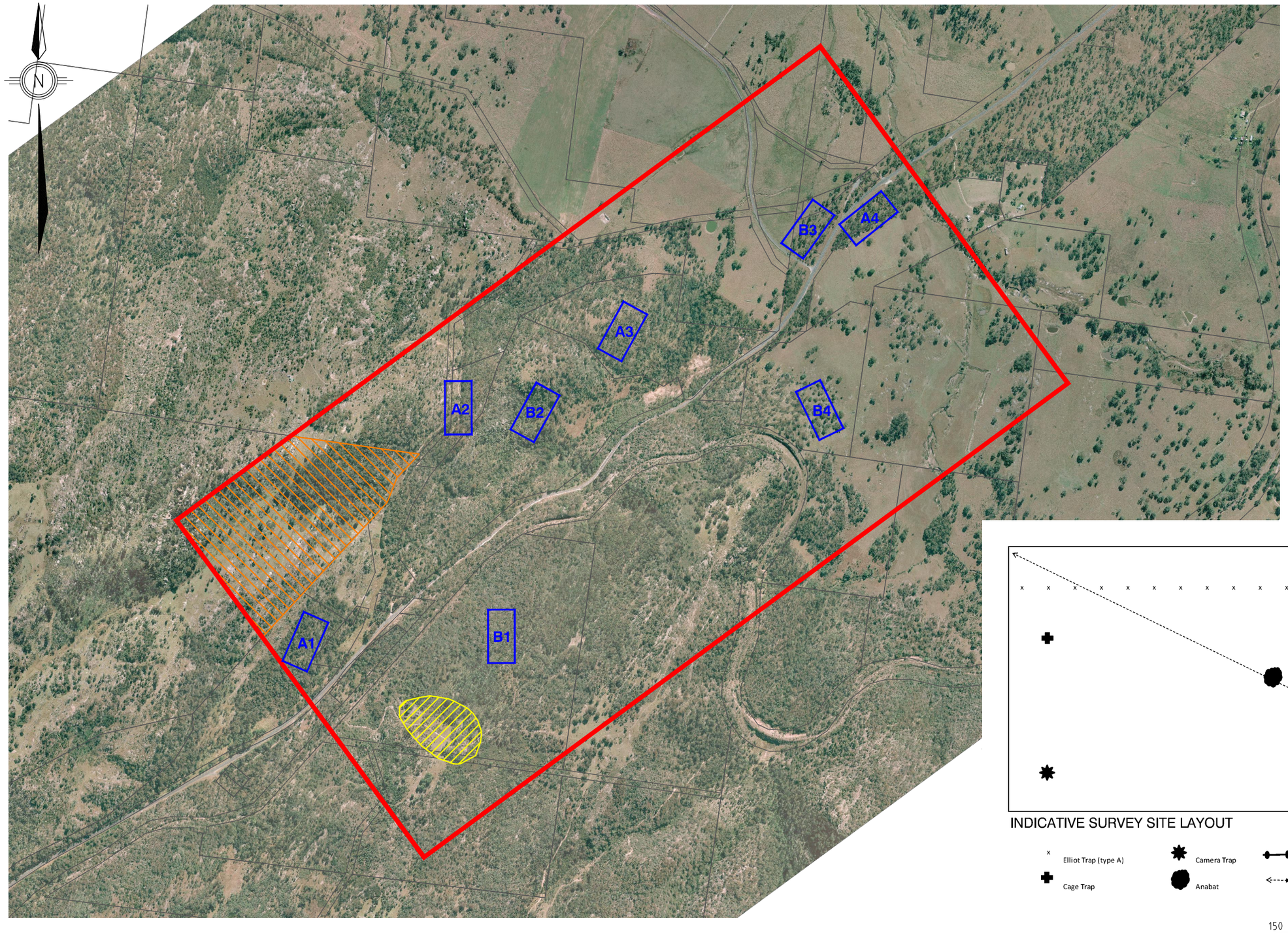
Rev: 0 | Drawn: J.M. | Checked: D.W. | Date: 15/01/2013

Project No.:NA8991/3018

NSW Roads and Maritime Services

CAD FILE: I:\NA89913018 Bolivia Hill\Acad\Biodiversity Impact assessment\Figure 1 - Locality Plan.dwg
XREF's: DCDB

PRINT DATE: 15 January, 2013 - 3:54pm



LEGEND

- Study Area
- A1 Survey Site Location
- Access Not Permitted
- Targeted Aural Survey Area

INDICATIVE SURVEY SITE LAYOUT

- Elliot Trap (type A)
- Camera Trap
- Funnel Array
- Cage Trap
- Anabat
- Spotlight and Bird Transect (approximate)

150 0 150 300 450 600 750m
1:15,000

Scale 1:15,000 (A3)

FIGURE 2
STUDY AREA AND FAUNA SURVEY SITE LAYOUT AND LOCATIONS

Rev: 0 | Drawn: J.M. | Checked: D.W. | Date: 16/01/2013

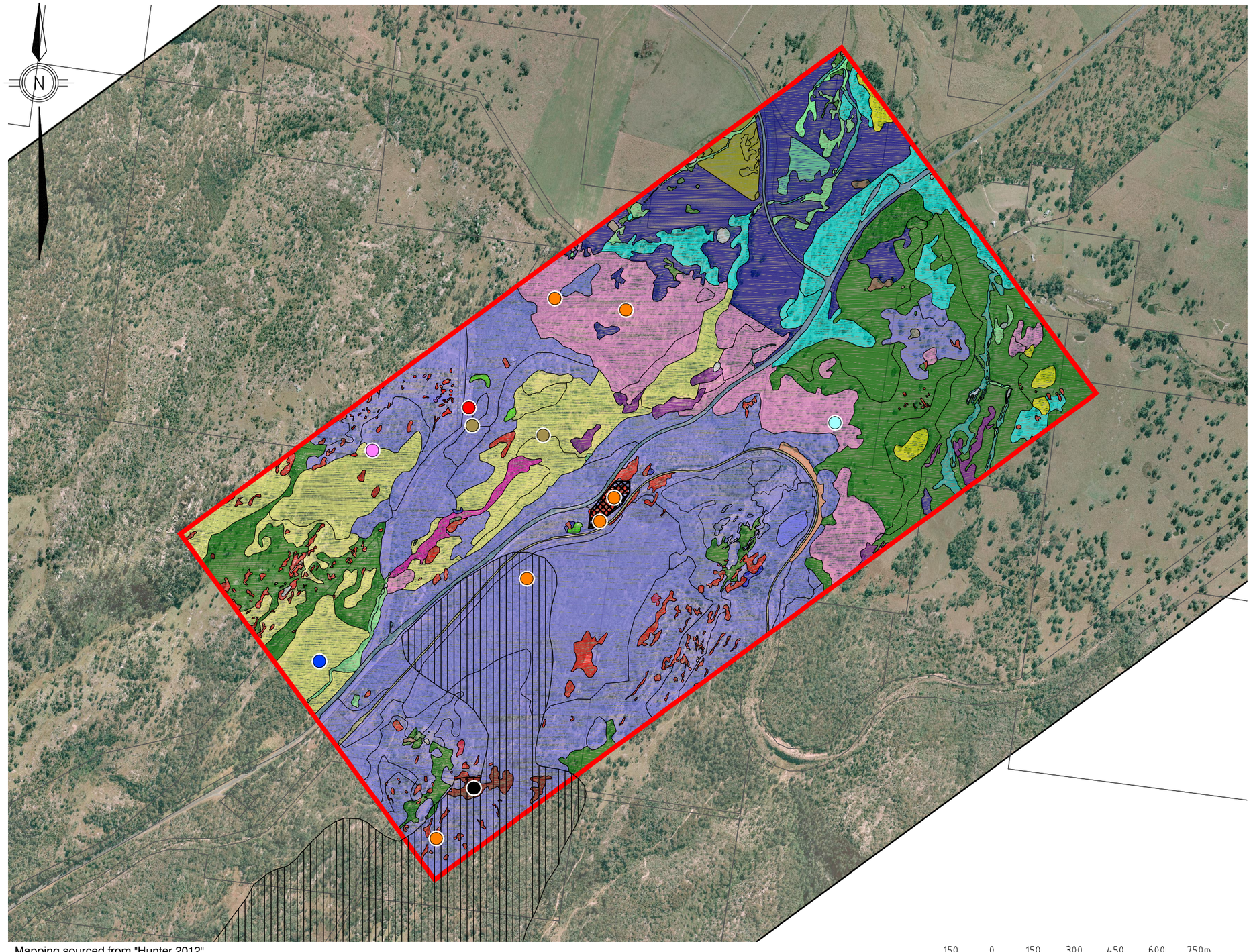
Project No.: NA8991/3018

NSW Roads and Maritime Services

CAD FILE: I:\NA8991\3018 Bolivia Hill\Acad\Biodiversity Impact assessment\Figure 2 - Study area and fauna survey site locations.dwg
XREF's: DCDB

PRINT DATE: 25 January, 2013 - 11:32am

Cardno



LEGEND

- Study Area
- Location of Fire

Vegetation Mapping

- C1 Fuzzy Box - Yellow Box - Blakley's Red Gum
- C2 Fuzzy Box - Ribbon Gum - Blakley's Red Gum
- C3 New England Tea-tree - Pungent Bottlebrush - Swamp Tea-tree
- C4 Derived Grassland - African Lovegrass
- C4a Derived Grassland (Red Grass - Wiregrass)
- C4c Derived Grassland - Whiskey Grass
- C4d Derived Grassland - Exotic Pasture
- C4e Derived Grassland - Disturbed Creeklines
- C5 Derived Grassland - Wire Grass - Bamboo Grass
- C6 Carnex Fen
- C7 Broad-leaved Stringybark - Rough-barked Apple - Blakley's Red Gum
- C8 Blakley's Red Gum - Rough-barked Apple - Fuzzy Box
- C9 Broad-leaved Stingybark - Mountain banksia - Apple Box
- Rock outcrop shrubland
- C10a Black Pine - Caley's Ironbark
- C10b Dry Rainforest
- C10c Rocky Creekline
- C10d Dam
- Exotic Plantings
- Farm Infrastructure
- Major Road Infrastructure
- Railway Infrastructure
- Acacia pycnostachya
- Main Acacia pycnostachya population
- Pimelea venosa
- Brown Treecreeper
- Callistemon pungens
- Spot-tailed Quoll
- Little Eagle
- Diamond Firetail

150 0 150 300 450 600 750m
1:15,000

Mapping sourced from "Hunter 2012"

Rev: 0 | Drawn: J.M. | Checked: D.W. | Date: 16/01/2013

NSW Roads and Maritime Services

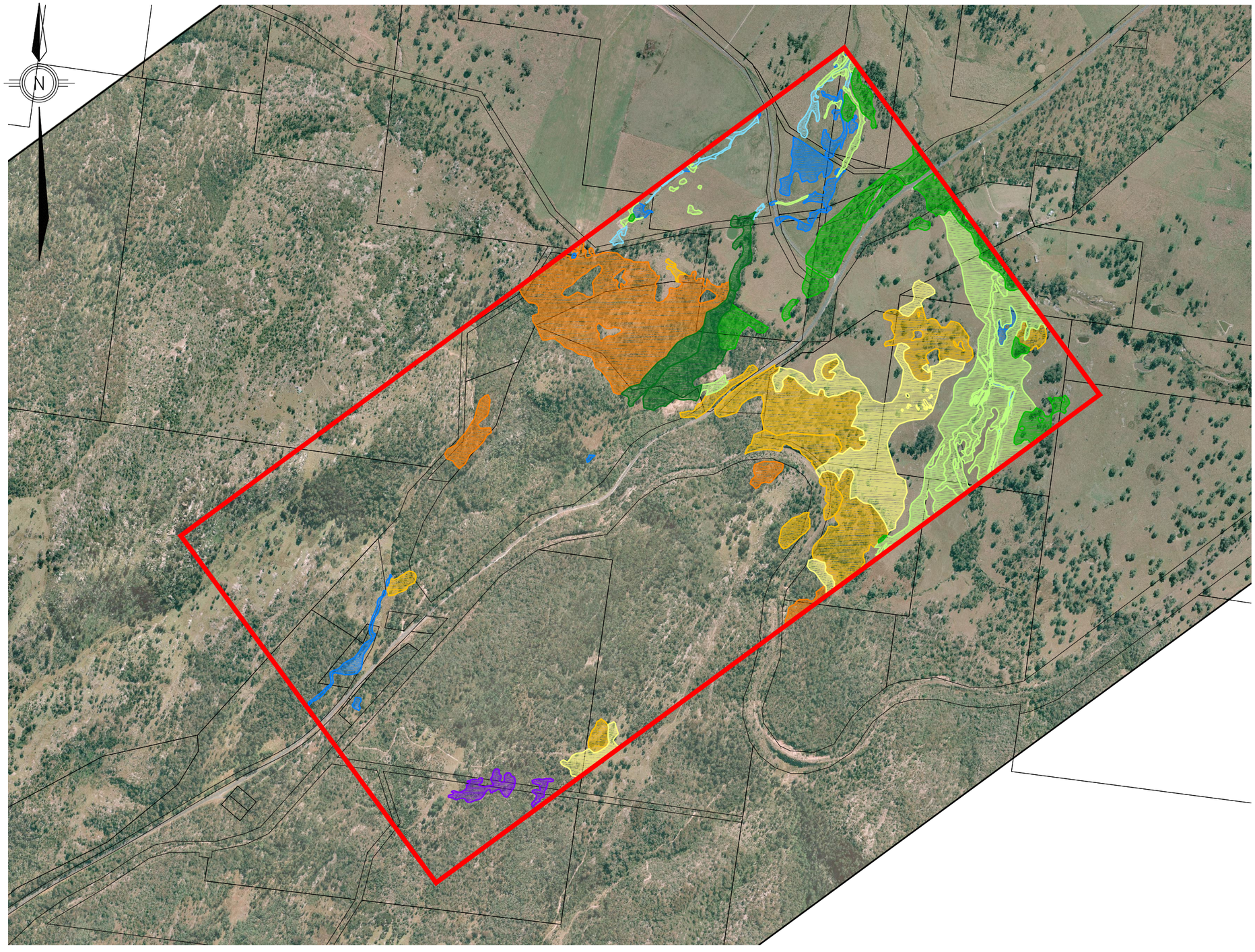
CAD FILE: I:\NA8991\3018 Bolivia Hill\Acad\Biodiversity Impact assessment\Figure 3 - Vegetation communities and bushfire extent.dwg
XREF's: DCDB; BoliviaVegetation

Scale 1:15,000 (A3)

FIGURE 3
VEGETATION COMMUNITIES, THREATENED SPECIES AND BUSHFIRE EXTENT

Project No.: NA8991/3018

PRINT DATE: 21 March, 2013 - 11:23am



LEGEND

Study Area

TEC Type Vegetation Condition

- Box Gum Woodland - Good
- Box Gum Woodland - Moderate
- Box Gum Woodland - Poor
- Carex sedgelands &/or Montane Peatlands of the NET- Moderate
- Carex sedgelands &/or Montane Peatlands of the NET - Poor
- Montane Peatlands of the NET - Moderate
- Ribbon Gum - Mountain Gum - Snow Gum of the NET - Good
- Ribbon Gum - Mountain Gum - Snow Gum of the NET - Moderate
- Ribbon Gum - Mountain Gum - Snow Gum of the NET - Poor

150 0 150 300 450 600 750m
1:15,000

Scale 1:15,000 (A3)

FIGURE 4

MAPPED THREATENED ECOLOGICAL COMMUNITIES AND THEIR CONDITION WITHIN THE STUDY AREA

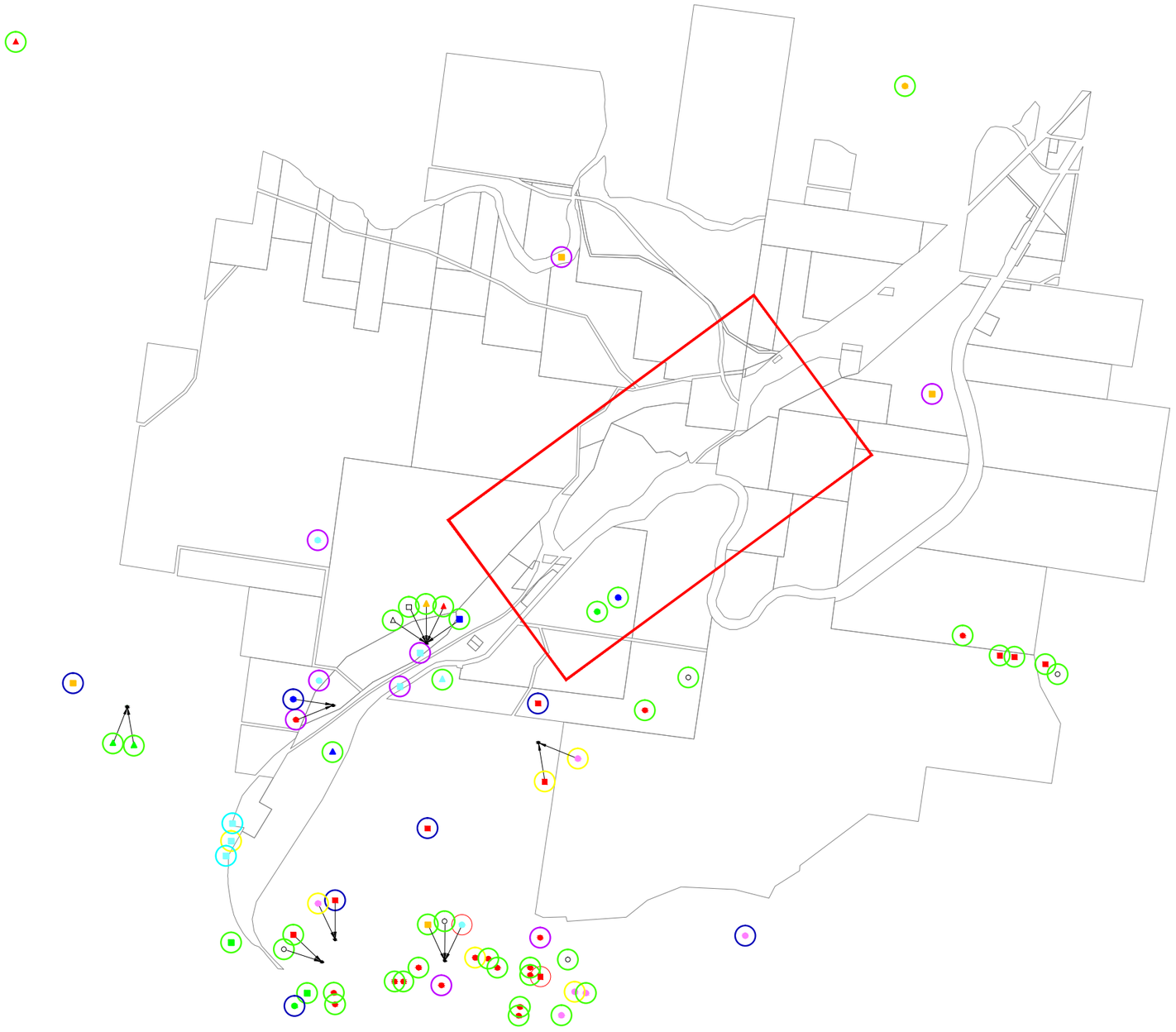
Rev: 0 | Drawn: J.M. | Checked: D.W. | Date: 16/01/2013

Project No.: NA8991/3018

NSW Roads and Maritime Services

CAD FILE: I:\NA8991\3018 Bolivia Hill\Acad\Biodiversity Impact assessment\Figure 4 - Mapped threatened ecological communities and their condition within the study area.dwg
XREF's: DCDB

PRINT DATE: 19 March, 2013 - 3:05pm



LEGEND

Study Area

Species

- Bolivia Wattle
- Torrington Pea
- Hairy Jointgrass
- Bolivia Hill Boronia
- Callistemon pungens
- Black Cypress Pine
- Bolivia Homoranthus
- Bolivia Stringybark
- Bolivia Hill Pimelea
- Brown Treecreeper
- Spot-tailed Quoll
- Eastern False Pipistrelle
- Little Lorikeet
- Little Eagle
- Eastern Bentwing-bat
- Sphagnum Frog
- Masked Owl
- Border Thick-tailed Gecko
- Eastern Cave Bat

Accuracy

- 10m
- 50m
- 100m
- 200m
- 1000m
- 10000m

Mapping souced from " NSW OEH - BioNet Atlas of NSW Wildlife 2012)

0.4 0 0.4 0.8 1.2 1.6 2km
1:40,000

Scale 1:40,000 (A3)

FIGURE 5
LOCATION OF PREVIOUSLY RECORDED THREATENED SPECIES

Rev: 0 | Drawn: J.M. | Checked: D.W. | Date: 16/01/2013

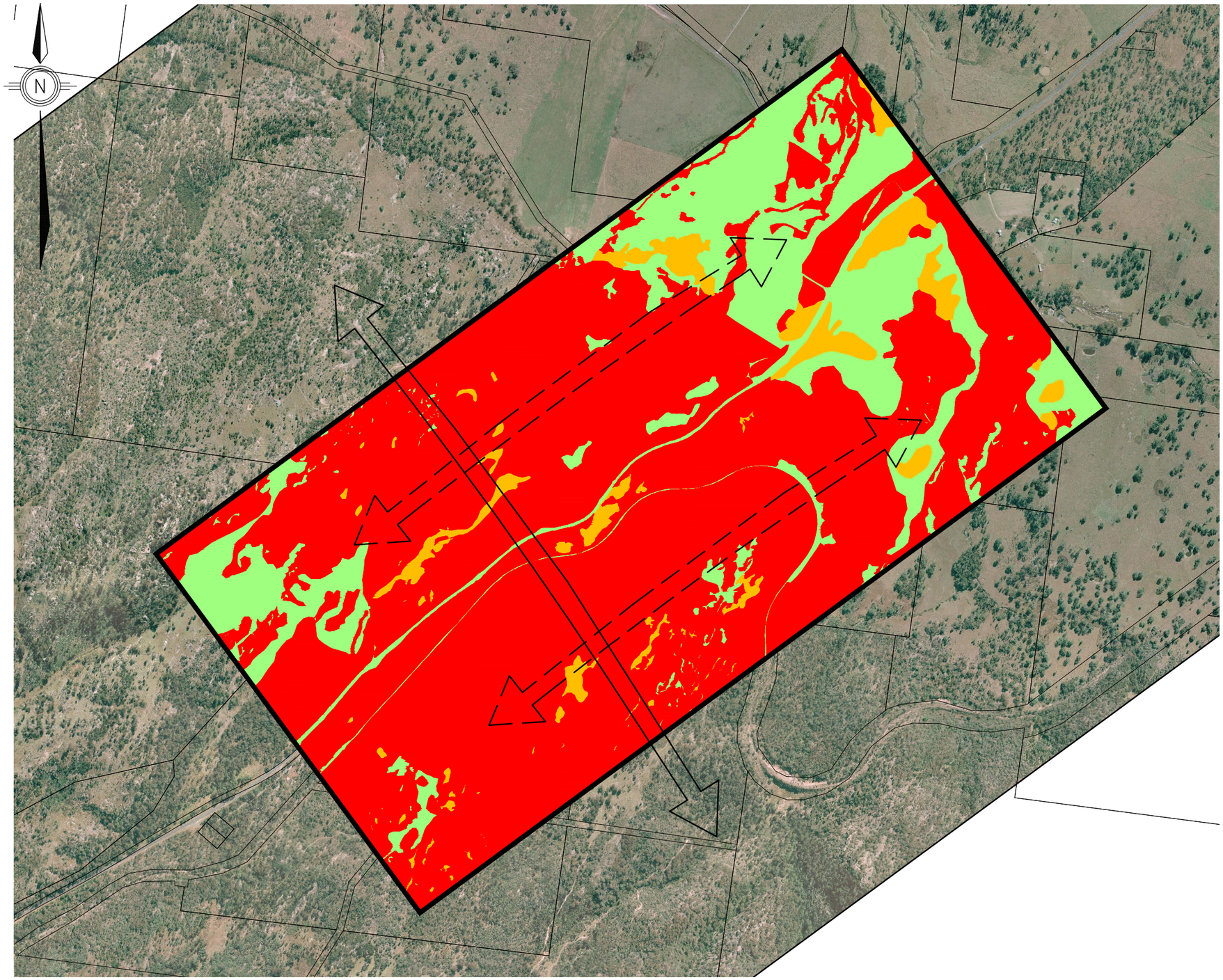
Project No.: NA8991/3018

NSW Roads and Maritime Services

PRINT DATE: 19 March, 2013 - 1:48pm

CAD FILE: I:\NA8991\3018 Bolivia Hill\Acad\Biodiversity Impact assessment\Figure 5 - Location of previously recorded threatened species.dwg
XREF's: DCDB

Cardno



LEGEND

Study Area

BIODIVERSITY SIGNIFICANCE RATING

High

Moderate

Low

Threatened Ecological Community Consideration	Threatened Species Considerations	Vegetation Quality Consideration	Biodiversity Significance Rating
Area mapped as supporting a Threatened Ecological Community	Confirmed or likely presence of one or more threatened flora or fauna species within Vegetation Community	Vegetation of any quality	High
Area not mapped as supporting a Threatened Ecological Community	Confirmed presence of one or more threatened flora or fauna species within Vegetation Community	Vegetation of any quality	High
	No threatened species recorded in Vegetation Community	Good quality vegetation	Moderate
		Moderate quality vegetation	Moderate
		Low quality vegetation	Low

FAUNA MOVEMENT CORRIDORS

Local Corridor

Regional Corridor

150 0 150 300 450 600 750m
1:15,000

Scale 1:15,000 (A3)

FIGURE 6
AREAS OF BIODIVERSITY SIGNIFICANCE

Rev: 0 | Drawn: J.M. | Checked: D.W. | Date: 15/04/2013

Project No.: NA8991/3018

NSW Roads and Maritime Services

CAD FILE: I:\NA89913018 Bolivia Hill\Acad\Biodiversity Impact assessment\Figure 6 - Movement corridors and habitat for threatened species.dwg
XREF's: DCDB

PRINT DATE: 26 July, 2013 - 4:12pm