APPENDIX D BDAR - Part 3

Appendices

Appendix A Haul route desktop study

File Note

ARUP

Level 4, 108 Wickham Street
Fortitude Valley
QLD 4006
GPO Box 685 Brisbane QLD 4001
Australia
www.arup.com

t +61 7 3023 6000
f +61 7 3023 6023

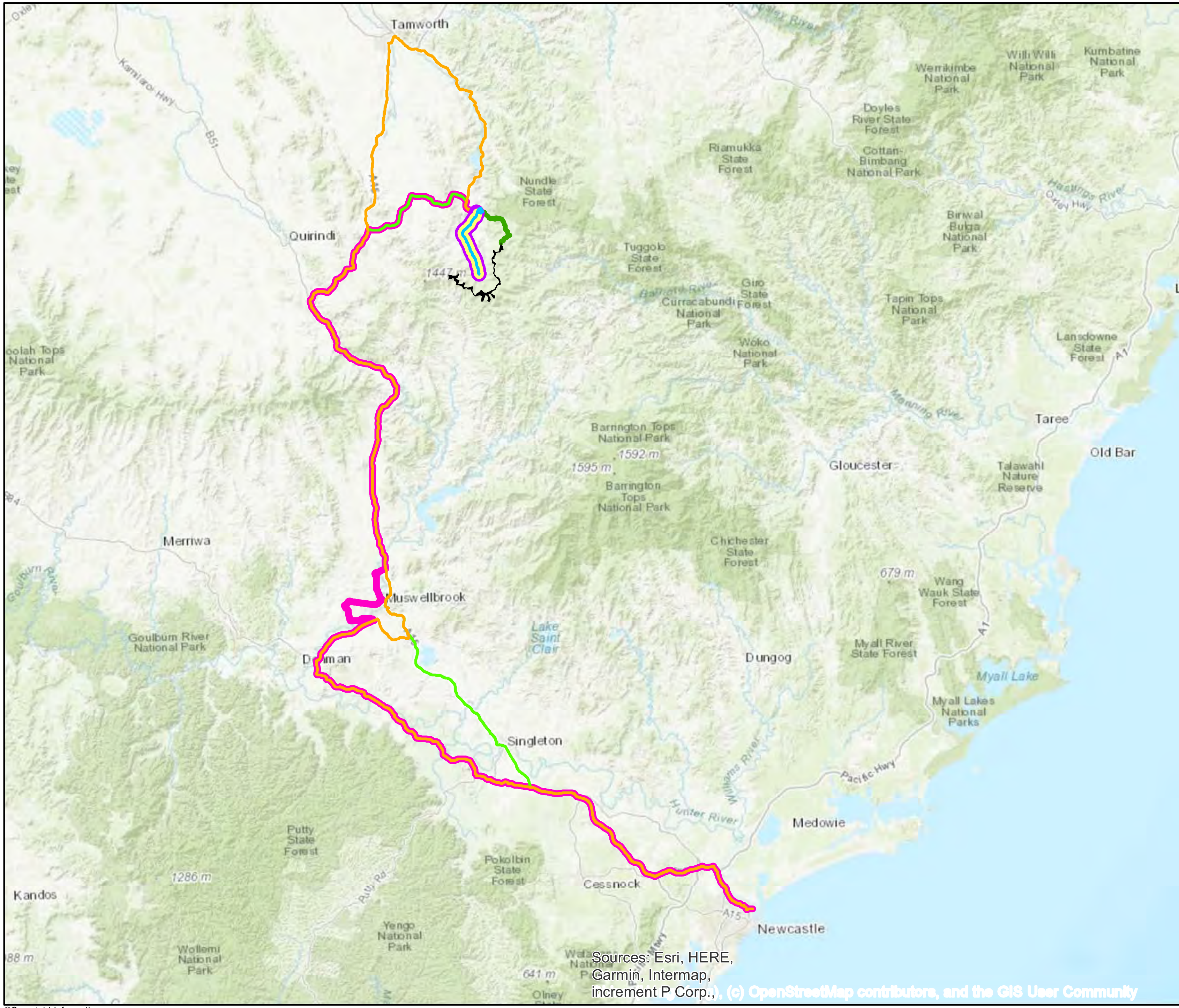
Project title	Hills of Gold Wind Farm	Job number	273023-00
cc	Wind Energy Partners Biosis	File reference	HoG_HaulRoute_TN_1.0
Prepared by	Chani Wheeler	Date	25 August 2020
Subject	Haul route assessment		

1 Introduction

A haul route from the Port of Newcastle to Nundle is proposed for the Hills of Gold Wind Farm development. Figure 1 shows haul route options currently being considered. Some selective clearing of vegetation and increased hardstand may be required in locations along the proposed routes to accommodate the transportation of construction materials to site. A number bridge/culvert upgrades may also be required at the following locations:

- Goonoo Goonoo Creek, Lindsay's Gap Road, Garoo
- Middlebrook Creek, Lindsay's Gap Road, Garoo
- Four separate tributaries of the Peel River, Head of Peel Road, Nundle
- Wardens Brook, Head of Peel Road, Nundle
- Peel River Nundle.

This Technical Note has been prepared to support the assessment of biodiversity impacts associated with the proposed haul routes. It documents the result of a desktop review of constraints at each proposed works area and is intended to inform requirements for additional survey works.



Wind Farm Development Corridor

Haul Route Options

- Newcastle to Nundle - Option 1 - Blades
- Newcastle to Nundle - Option 1 - Remaining Components
- Newcastle to Nundle - Option 2 - Towers
- Nundle to Site - Primary Options - All Components - Morrisons Gap Rd
- Nundle to Site - Secondary Option (a) - All Components - Head of the Peel Rd
- Nundle to Site - Secondary Option (b) - All Components - Head of the Peel Rd
- Nundle to Site - Secondary Option (c) - All Components - Head of the Peel Rd

Issue	Date	By	Chkd	Appd
D1	21/08/2020	CW	MJD	MJD

Kilometers
0 4.5 9 18 27 36 45 54

ARUP

Level 4, 108 Wickham Street
Fortitude Valley, QLD 4006
Tel +61 (7)3023 6000 Fax +61 (7)3023 6023
www.arup.com

Client
Wind Energy Partners

Job Title
Hills of Gold Wind Farm

Drawing Title
Haul route options

Scale at A4	Drawing Status
1:1,200,000	Draft

Coordinate System
GDA 1994 MGA Zone 56

Job No	Drawing No
270335-00	Figure 1

J:\270000\270335-00 Hills of Gold\Work\Internal\Design\GIS\Figures\Haul Route Assessment\Figure 1.mxd

2 Method

A review of the following existing datasets and data was carried out:

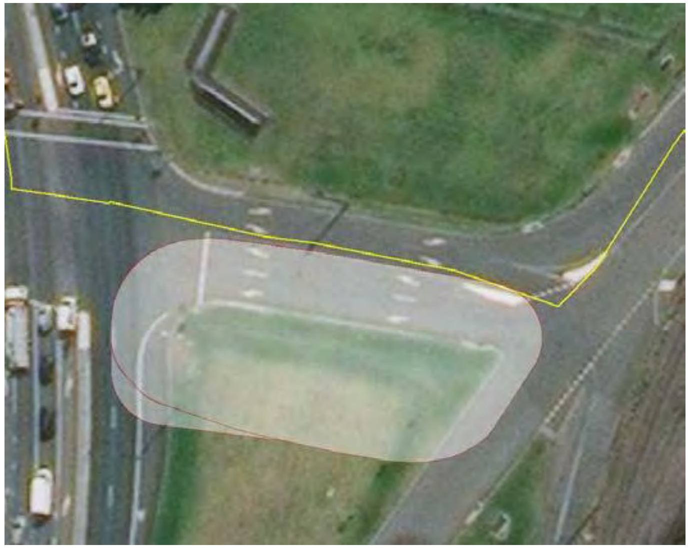
- Greater Hunter Native Vegetation Mapping v4.0. VIS_ID_3855 (DPIE, 2012)
- State Vegetation Type Map: Border Rivers Gwydir/ Namoi Region v2.0. VIS_ID_4467 (DPIE, 2015)
- Aerial imagery (Google, 2020a)
- Street View imagery (Google, 2020b)

Based on the above information sources, sites were ranked from low to high risk depending on the likely presence of native vegetation communities and potential habitat for threatened species.

3 Results

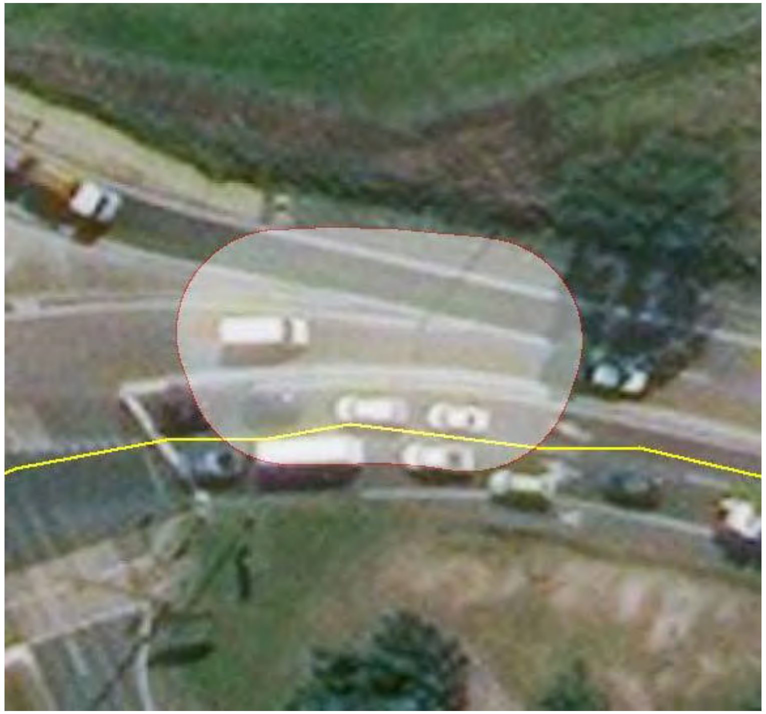
Table 1: Haul route assessment results and site risk rating

Location	Assessment Results	Risk Rating
Selwyn Street, Mayfield North 	Based on a review of DPIE (2012), River Red Gum/ River Oak grassy riparian woodland of the Hunter Valley is mapped within the northern portion of the works footprint. Review of latest aerial imagery and Street View indicates the site iss clear of vegetation. However, based on location of site, there is potential for marine plants where surface waters are saline. There is also potential for Green and Golden Bell Frog where bulrushes/ sedges are present. Survey of site recommended to confirm marine plants and potential habitat for Green and Golden Bell Frog.	Moderate

Location	Assessment Results	Risk Rating
George Street, Tighes Hill 	No native vegetation is mapped for the area (DPIE, 2012). Based on aerial imagery and street view, the site supports maintained lawns. Survey not required.	Low

File Note

273023-00 25 August 2020

Location	Assessment Results	Risk Rating
Industrial Drive, Mayfield West 	No native vegetation is mapped for the site (DPIE, 2012). Based on aerial imagery and street view, the site supports existing road hardstand and some grassed verges. Survey not required.	Low

Location	Assessment Results	Risk Rating
Hunter Expressway, adjacent to Buchanan Road, Buchanan 	No native vegetation is mapped for the area (DPIE, 2012). Based on aerial imagery and street view, the site supports road hardstand and landscaped median. Survey not required.	Low

Location	Assessment Results	Risk Rating
Cnr New England Highway and Golden Highway & Mitchell Line of Rd, Whittingham 	No native vegetation is mapped for the area (DPIE, 2012). Based on aerial imagery and street view, the site supports existing road hardstand and grassed verges. Survey not required.	Low

Location	Assessment Results	Risk Rating
Cnr of Golden Highway & Mitchell Line of Rd and Putty Road, Mount Thorley 	No native vegetation is mapped for the site (DPIE, 2012). Based on aerial imagery and street view, site is within and adjacent to rail corridor. The site appears to support grassland with some regenerating woodland. No disturbance of vegetation is likely as the site is situated on a rail bridge and the extent of likely blade overhang will be elevated above the ground. No survey required.	Low

Location	Assessment Results	Risk Rating
Mount Thorley Road exit lane, adjacent to Putty Highway, Mount Thorley 	No native vegetation is mapped for the site (DPIE, 2012). Based on review of aerial imagery and street view, site is dominated by road hardstand and exotic grassland. Survey not required.	Low

<table>
<tr><th>Location</th><th>Assessment Results</th><th>Risk Rating</th></tr>
<tr><td>Golden Highway, Pagan and Pringle Streets, Jerry Plains
</td><td>No native vegetation is mapped for the site (DPIE, 2012). Based on review of aerial imagery and street view, site is dominated by maintained road verges with scattered remnant native and exotic landscape trees.
Survey required to confirm native trees within proposed clearing footprints, presence of habitat features and any requirements under the BAM.</td><td>Moderate</td></tr>
</table>

Location	Assessment Results	Risk Rating
Cnr Golden Highway and Denman Road, Denman 	No native vegetation is mapped for the site (DPIE, 2012). Based on review of aerial imagery and street view, site is dominated by maintained road verges and pasture dominated by exotic grasses. Survey not required.	Low

Location	Assessment Results	Risk Rating
Cnr Denman Road and Bengalla Road, Muswellbrook 	No native vegetation is mapped for the site (DPIE, 2012). However, review of aerial imagery and street view indicates potential presence of regenerating Eucalypt woodland immediately east of Bengalla Road. Other areas appear to be dominated by exotic grassland. Survey to confirm presence and extent of native vegetation within the works footprint.	Moderate

Location	Assessment Results	Risk Rating
Cnr Bengalla Road and Wybong Road, Castle Rock 	No native vegetation is mapped for the site (DPIE, 2012). Review of latest aerial imagery and street view indicates the site lacks woody vegetation and is dominated by grassed road verges. Survey not required.	Low

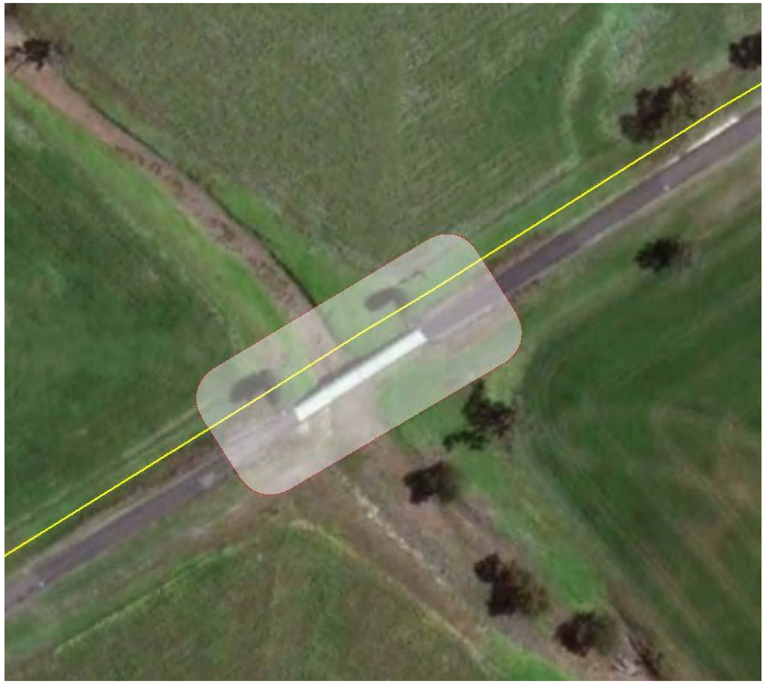
Location	Assessment Results	Risk Rating
Cnr Wybong Road and Kayuga Road, Muswellbrook 	No native vegetation is mapped for the site (DPIE, 2012). Review of latest aerial imagery and street view indicates the site is dominated by exotic pasture and road hardstand. Survey not required.	Low

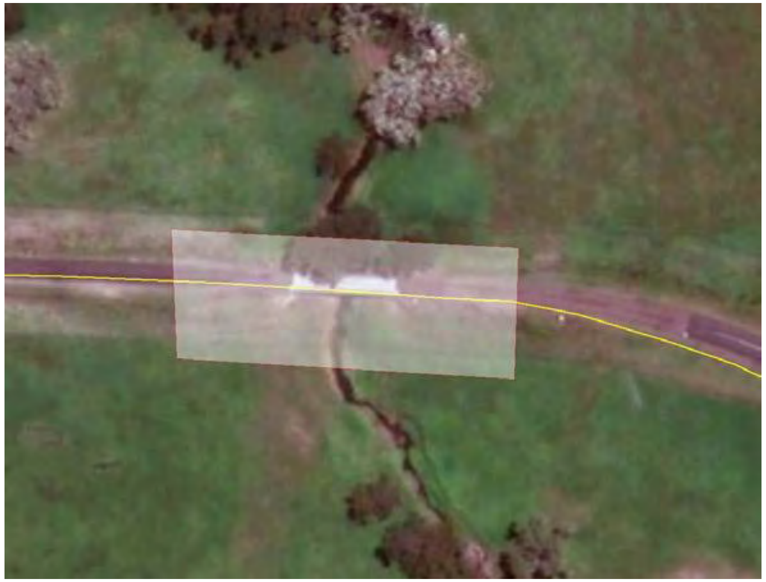
Location	Assessment Results	Risk Rating
Cnr Invermein Street and Stair Street, Kayuga 	No native vegetation is mapped for the site (DPIE, 2012). Review of latest aerial imagery and street view indicates the site is dominated by exotic pasture. Although some regenerating Eucalypts appear to be located on the northern periphery of proposed works. Survey not required.	Low

Location	Assessment Results	Risk Rating
Stair Street, Kayuga 	No native vegetation is mapped for the site (DPIE, 2012). Review of latest aerial imagery and street view indicates the site is dominated by exotic pasture. Although there are a couple of scattered regenerating Eucalypts on the north-western periphery of proposed works, adjacent to the carpark. Survey not required.	Low

Location	Assessment Results	Risk Rating
Cnr Stair Street and New England Highway, Aberdeen 	No native vegetation is mapped for the site (DPIE, 2012). Review of latest aerial imagery and street view indicates the site is dominated by exotic pasture. Survey not required.	Low

Location	Assessment Results	Risk Rating
Cnr New England Highway and Lindsays Gap Road, Wallabadah 	No native vegetation is mapped for the site (DPIE, 2015). Review of latest aerial imagery and street view indicates the site is dominated by exotic pasture. However some scattered Eucalypt trees are located on the periphery of proposed works. Survey not required.	Low

Location	Assessment Results	Risk Rating
Goonoo Goonoo Creek crossing, Lindsay's Gap Road, Garoo 	Review of DPIE (2015) indicates riparian vegetation is mapped as PCT 84- River Oak- Rough-barked Apple- Red Gum- Box riparian tall woodland (wetland of the Brigalow Belt South and Nandewar Bioregions. Review of the latest aerial imagery suggests the footprint largely lacks woody vegetation. Proposed works at the site are likely to include bridge upgrade or bypass. Survey of site required to confirm extent of native vegetation and potential habitat for threatened species within proposed footprint.	High

Location	Assessment Results	Risk Rating
Middlebrook Creek crossing, Lindsay's Gap Road, Garoo 	Review of DPIE (2015) indicates the presence of the following native vegetation communities within the proposed footprint: • PCT 84- River Oak- Rough-barked Apple- Red Gum- Box riparian tall woodland (wetland of the Brigalow Belt South and Nandewar Bioregions. • Candidate Native Grasslands Proposed works at the site are likely to include creek crossing upgrade. Survey of site required to confirm extent of native vegetation and potential habitat for threatened species within the works footprint.	High

Location	Assessment Results	Risk Rating
Cnr Lindsay's Gap Road and Nundle Road, Nundle 	Review of DPIE (2015) indicates site supports Candidate Native Grasslands. Review of latest aerial imagery and street view indicates recent road works and a lack of native vegetation. Survey of footprint required to confirm extent of any native grasslands.	Moderate

Location	Assessment Results	Risk Rating
Oakenville Street, Herron Street, Innes Street and Jenkins Street, Nundle 	No native vegetation is mapped for the site (DPIE, 2015). Based on the review of aerial imagery and street view, lands within the works footprint is dominated by maintained road verges with scattered remnant native and exotic landscape trees. Site survey is recommended to confirm native trees, presence of habitat features and any requirements under the BAM.	Moderate

Location	Assessment Results	Risk Rating
Gill Street and Point Street, Nundle 	No native vegetation is mapped for the site (DPIE, 2015). Review of latest aerial imagery and Streetview indicates the footprint is dominated by maintained road verges with some scattered landscape shrubs. Survey not required.	Low

Location	Assessment Results	Risk Rating
Cnr River Road and Happy Valley Road, Nundle 	No native vegetation is mapped for the site (DPIE, 2015). Review of latest aerial imagery and Streetview indicates site supports grasslands with scattered Eucalypt regen. Site survey recommended to confirm presence and extent of native vegetation in works footprint.	Moderate

Location	Assessment Results	Risk Rating
Cnr Oakenvill Street and Old Hanging Rock Road, Nundle 	Review of DPIE (2015) indicates riparian vegetation is mapped as PCT 84- River Oak- Rough-barked Apple- Red Gum- Box riparian tall woodland (wetland of the Brigalow Belt South and Nandewar Bioregions. Review of aerial imagery and Streetview indicates the site is dominated by exotic pasture with some scattered Eucalypt and Casuarina spp. trees. Survey recommended to confirm extent of vegetation.	Moderate

<table>
<tr><th>Location</th><th>Assessment Results</th><th>Risk Rating</th></tr>
<tr><td>Cnr of Happy Valley Road and Old Hanging Rock Road, Nundle
</td><td>Review of DPIE (2015) indicates presence of candidate native grasslands. Based on review of latest aerial imagery and Streetview lands immediately adjacent to the road appear to support exotic grasses and forbs. Although some regenerating Eucalypts are observed and native grasses may still be present in areas further from the road.
Survey recommended to confirm the extent of native vegetation.</td><td>Moderate</td></tr>
</table>

Location	Assessment Results	Risk Rating
Hanging Rock State Forest, Barry Road, Nundle 	Review of DPIE (2015) indicates the following native vegetation communities are present within the proposed works footprint: • PCT 492- Silvertop Stringybark – Yellow Box- Apple Box- Rough-barked Apple shrub grass open forest mainly on southern lopes of the Liverpool Range, Brigalow Belt South Bioregion • PCT526- Mountain Gum- Messmate- Broad-leaved Stringybark open forest on granitic soils of the New England Tablelands Bioregion • PCT 541- Silvertop Stringybark- Rough-barked Apple grassy open forest of southern Nandewar Bioregion, southern New England Tablelands and NSW North Coast Bioregion • PCT 563- White-box- Silvertop Stringybark ± White Cypress Pine grass shrub open forest of the southern Nandewar Bioregion and New England Tablelands Bioregion • PCT 486- River Oak moist riparian tall open forest of the upper Hunter Valley, including Liverpool Range • Candidate Native Grasslands Survey of works footprints required to confirm native vegetation communities and map extent including any important habitat features.	High

Location	Assessment Results	Risk Rating
Morrisons Gap Road, Nundle 	Review of DPIE (2015) indicates the following native vegetation communities are present within the proposed works footprint: • PCT 494- Snow Gum- Mountain Gum- Silver Wattle tall open forest of the Liverpool Range, Brigalow belt South Bioregion • PCT1194- Snow Gum- Mountain Gum- Mountain Ribbon Gum open forest on ranges of the NSW North Coast Bioregion and eastern New England Tablelands Bioregion • PCT526- Mountain Gum- Messmate- Broad-leaved Stringybark open forest on granitic soils of the New England Tablelands Bioregion • Candidate Native Grasslands Survey of works footprints required to confirm native vegetation communities and map extent including any important habitat features.	High

Location	Assessment Results	Risk Rating
Cnr Crawney Road and Head of Peel Road, Nundle 	Review of DPIE (2015) and latest aerial imagery indicates native vegetation is limited to scattered Eucalypt trees.	Low

Location	Assessment Results	Risk Rating
Tributary of the Peel River, Head of Peel Road, Nundle- heading south 	Review of DPIE (2015) indicates the site may support Candidate Native Grasslands with adjacent PCT 599- Blakely's Red Gum- Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion. Review of aerial imagery suggests works will not impact woody vegetation. Survey of site recommended to confirm extent of native vegetation communities relative to the works footprint.	Moderate

Location	Assessment Results	Risk Rating
Tributaries of the Peel River, Head of Peel Road, Nundle- heading south 	Review of DPIE (2015) indicates the site may support Candidate Native Grasslands. Survey of works footprint recommended to confirm extent of native grasslands and habitat for threatened species where relevant.	Moderate.

Location	Assessment Results	Risk Rating
Tributary of the Peel River, Head of Peel Road, Nundle- heading south 	Review of DPIE (2015) indicates the site may support Candidate Native Grasslands. Survey of works footprint recommended to confirm extent of native grasslands and habitat for threatened species where relevant.	Moderate

Location	Assessment Results	Risk Rating
Wardens Brook, Head of Peel Road, Nundle- heading south 	Review of DPIE (2015) indicates the site may support Candidate Native Grasslands. Survey of works footprint recommended to confirm extent of native grasslands and habitat for threatened species where relevant.	Moderate

Location	Assessment Results	Risk Rating
Peel River, Head of Peel River, Nundle- heading south 	Review of DPIE (2015) indicates the site supports PCT 486- River Oak moist riparian tall open forest of the upper Hunter Valley, including Liverpool Range and Candidate Native Grasslands. Survey of works footprint recommended to confirm extent of native vegetation communities.	High
Alternative route to Nundle via Tamworth		

Location	Assessment Results	Risk Rating
Cnr Goonoo Goonoo Rd/ New England Highway and Wilburtree Street, South Tamworth 	Review of DPIE (2015) indicates the site is dominated by non-native vegetation. Based on a review of aerial imagery the works footprint includes disturbed road hardstand and verges only. No survey required.	Low

Location	Assessment Results	Risk Rating
Cnr Goonoo Goonoo Rd/ New England Highway and Vera Street, South Tamworth 	Review of DPIE (2015) indicates the site is dominated by non-native vegetation. Based on a review of aerial imagery the works footprint includes disturbed road hardstand and verges only. No survey required.	Low

Location	Assessment Results	Risk Rating
Cnr Scott Rd/ New England Highway and Marius Street/ New England Highway, Tamworth 	Review of DPIE (2015) indicates the site is dominated by non-native vegetation. Based on a review of aerial imagery the works footprint includes disturbed road hardstand and verges only. No survey required.	Low

Location	Assessment Results	Risk Rating
Cnr Nundle Road and Ogunbil Road, Dungowan 	Review of DPIE (2015) indicates the site is dominated by non-native vegetation. Based on a review of aerial imagery the works footprint includes disturbed road hardstand and verges only. No survey required.	Low

4 Summary

Based on the assessment, 19 sites were identified as having a low risk of biodiversity impacts and do not require further field survey. A total of 12 sites were identified as moderate risk and five sites as high risk. Further survey of these sites is recommended to confirm the presence and extent of any native vegetation communities and habitat for threatened species.

File Note

273023-00 25 August 2020

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name	Chani Wheeler	Matt Davis	Matt Davis
Signature			

Appendix B Detailed PCT descriptions

PCT 433 - White Box grassy woodland to open woodland on basalt flats and rises in the Liverpool Plains sub-region, BBS Bioregion

Vegetation formation: Grassy Woodlands

Vegetation class: Western Slopes Grassy Woodlands

Conservation status:

- EPBC Act: White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland
- BC Act: White Box Yellow Box Blakely's Red Gum Woodland

Extent within development footprint: 0.01 hectares

No. BAM plots: 0

Characteristic species (NSW BioNet):

- Canopy: *Eucalyptus albens, Acacia pendula, Brachychiton populneus* subsp. *populneus,*
- Shrub: *Sclerolaena birchii, Sclerolaena muricata* var. *muricata, Acacia implexa,*
- Ground: *Austrostipa aristiglumis, Mentha satureioides, Boerhavia dominii, Austrostipa bigeniculata, Chloris ventricosa, Plantago debilis, Elymus scaber* var. *scaber, Rumex brownii, Chamaesyce drummondii, Oxalis perennans, Euchiton sphaericus, Bothriochloa decipiens, Bothriochloa macra, Desmodium varians, Aristida leptopoda, Wahlenbergia communis, Rhynchosia minima, Vittadinia pterochaeta, Vittadinia muelleri, Einadia nutans* subsp. *nutans.*

Justification of PCT: PCT commonly mapped in the locality (DPIE 2019, DPIE 2015) and noted as present with *Eucalyptus albens* scattered along the western end of the transmission line.

PCT 434 - White Box grass shrub hill woodland on clay to loam soils on volcanic and sedimentary hills in the southern Brigalow Belt South Bioregion

Vegetation formation: Grassy Woodlands

Vegetation class: Western Slopes Grassy Woodlands

Conservation status:

- EPBC Act: White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland
- BC Act: White Box Yellow Box Blakely's Red Gum Woodland

Extent within development footprint: 0.01 hectares

No. Bam plots: 0

Characteristic species (NSW BioNet):

- Canopy: *Eucalyptus albens, Brachychiton populneus subsp. populneus, Alectryon oleifolius subsp. elongatus, Callitris endlicheri*.
- Shrub: *Acacia implexa, Notelaea microcarpa var. microcarpa, Acacia decora, Acacia penninervis var. penninervis, Cassinia quinquefaria, Indigofera australis, Amyema miquelii, Pimelea curviflora var. curviflora, Indigofera adesmiifolia, Cassinia arcuata, Solanum parvifolium, Solanum cinereum,*
- Ground:, *Aristida jerichoensis var. jerichoensis, Goodenia glabra, Calotis cuneifolia, Gahnia aspera, Lepidosperma laterale, Dichelachne micrantha, Juncus remotiflorus, Austrostipa scabra* subsp. *scabra, Dianella revoluta var. revoluta, Einadia hastata, Vittadinia cuneata, Senecio quadridentatus, Wahlenbergia gracilis, Laxmannia compacta, Schoenus kennyi.*

Justification of PCT: PCT commonly mapped in the locality (DPIE 2019, DPIE 2015) and noted as present with *Eucalyptus albens* scattered along the western end of the transmission line.

PCT 486 - River Oak moist riparian tall open forest of the upper Hunter Valley, including Liverpool Range

Vegetation formation: Forested Wetlands

Vegetation class: Eastern Riverine Forests

Conservation status:

- EPBC Act: Not listed
- BC Act: Not listed

Extent within development footprint: 2.12 hectares

No. BAM plots: 0

Characteristic species (NSW BioNet):

- Canopy: *Casuarina cunninghamiana subsp. cunninghamiana, Eucalyptus viminalis, Angophora floribunda, Ficus coronata, Ficus rubiginosa, Daphnandra sp. A, Eucalyptus saligna*.
- Shrub: *Melicytus dentatus, Pittosporum undulatum, Breynia oblongifolia, Clerodendrum tomentosum, Notelaea microcarpa var. microcarpa, Hymenosporum flavum, Claoxylon australe*.
- Ground: *Bothriochloa macra, Microlaena stipoides var. stipoides, Urtica incisa, Elymus scaber var. scaber, Austrocynoglossum latifolium, Adiantum aethiopicum, Nyssanthes diffusa, Doodia aspera, Echinopogon ovatus, Hypolepis glandulifera, Asplenium flabellifolium, Plectranthus parviflorus, Acaena novae-zelandiae, Solanum aviculare, Adiantum formosum, Pellaea falcata, Sigesbeckia orientalis* subsp*. orientalis, Adiantum hispidulum*

Justification of PCT: PCT commonly mapped in the locality (DPIE 2019, DPIE 2015) and noted as present with *Casuarina cunninghamiana* subsp. *cunninghamiana, Eucalyptus viminalis,* and *Angophora floribunda* occurring within and surrounding creeks and drainage lines surrounding the development footprint.

PCT 490 - Silvertop Stringybark - Forest Ribbon Gum very tall moist open forest on basalt plateau on the Liverpool Range, Brigalow Belt South Bioregion

Vegetation formation: Grassy Woodlands

Vegetation class: New England Grassy Woodlands

Conservation status:

- EPBC Act: Not listed
- BC Act: Not listed

Extent within development footprint: 1.84 hectares

No. BAM plots: 0

Characteristic species (NSW BioNet):

- Canopy: *Eucalyptus laevopinea, Eucalyptus nobilis, Eucalyptus dalrympleana* subsp*. heptantha, Acacia melanoxylon, Eucalyptus pauciflora, Eucalyptus stellulata, Eucalyptus melliodora, Eucalyptus bridgesiana.*
- Shrub: *Acacia dealbata, Hibbertia obtusifolia, Eustrephus latifolius, Smilax australis, Leucopogon lanceolatus var. lanceolatus, Bursaria spinosa* subsp*. spinosa, Hibbertia acicularis, Indigofera australis, Pittosporum undulatum, Daviesia genistifolia, Pimelea curviflora var. curviflora, Acrothamnus hookeri, Xanthorrhoea glauca* subsp*. glauca.*
- Ground *Poa sieberiana, Pteridium esculentum, Rubus parvifolius, Poranthera microphylla, Themeda australis, Glycine clandestina, Hydrocotyle laxiflora, Desmodium varians, Geranium solanderi var. solanderi, Viola betonicifolia, Lomandra longifolia, Hardenbergia violacea, Imperata cylindrica var. major, Gonocarpus tetragynus, Brachyscome nova-anglica.*

Justification of PCT: PCT commonly mapped in the locality (DPIE 2019, DPIE 2015) on high ridgelines and noted as present with *Eucalyptus laevopinea, Eucalyptus dalrympleana subsp. heptantha* and *Acacia melanoxylon,* in the overstorey and *Poa sieberiana*, *Pteridium esculentum* and *Lomandra longifolia* occurring in the ground layer over a ridgeline in the central portion of the transmission line footprint.

PCT 492 – Silvertop Stringybark – Yellow Box – Apple Box – Rough-barked Apple shrub grass open forest mainly on southern slopes of the Liverpool Range, Brigalow Belt South Bioregion

Vegetation formation: Grassy Woodlands

Vegetation class: New England Grassy Woodlands

Conservation status:

- EPBC Act: White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland
- BC Act: White Box Yellow Box Blakely's Red Gum Woodland

Extent within development footprint: 4.62 hectares

No. Bam plots: 6

Species recorded:

- Canopy: *Angophora floribunda, Eucalyptus laevopinea, Eucalyptus melliodora, Eucalyptus nobilis* subsp. *nobilis.*
- Shrub: *Acacia melanoxylon, Bursaria spinosa* subsp*. spinosa.*
- Ground: *Anthosachne scabra, Arthropodium milleflorum, Brachyscome macrocarpa, Cheilanthes sieberi, Dianella longifolia, Echinopogon ovatus, Geranium solanderi, Glycine clandestine, Vittadinia cuneate, Wahlenbergia stricta.*

Justification of PCT: Species characteristic of the PCT recorded in all strata with understorey moderately shrubby where found to occur in higher condition states. The PCT determined to be present on shallower soils derived from basalt on hills across the development footprint.

PCT 507 - Black Sallee - Snow Gum grassy woodland of the New England Tableland Bioregion

Vegetation formation: Grassy Woodlands

Vegetation class: Tableland Clay Grassy Woodland

Conservation status:

- EPBC Act: Not listed
- BC Act: Not listed as vegetation not present within New England Tablelands IBRA Bioregion.

Extent within development footprint: 0.09 hectares

No. BAM plots: 1

Recorded species:

- Canopy: *Eucalyptus stellulata,*
- Shrubs: *Acacia melanoxylon,* Bursaria spinosa, Olearia microphylla,
- Ground: *Dichondra repens*, *Desmodium gunnii*, Poa sieberiana var. sieberiana, *Lobelia purpurascens, Einadia trigonos, Geranium potentilloides, Hardenbergia violace, Smilax australis.*

Justification of PCT: PCT was found to support a common occurrence of *Eucalyptus stellulata* within the canopy with and understorey of native shrubs and groundcovers. The PCT was found to represent an open forest with a mid-dense crown cover, at high elevation undulating plateaux, on basalt-derived heavy soils.

PCT 526 - Mountain Ribbon Gum - Messmate - Broad-leaved Stringybark open forest on granitic soils of the New England Tableland Bioregion

Vegetation formation: Dry Sclerophyll Forests (Shrub/grass sub-formation)

Vegetation class: New England Dry Sclerophyll Forests

Conservation status:

- EPBC Act: not listed
- BC Act: Not listed

Extent within development footprint: 1.12 hectares

No. BAM plots: 0

Characteristic species (NSW BioNet):

- Canopy: *Eucalyptus nobilis, Eucalyptus caliginosa, Eucalyptus obliqua, Eucalyptus campanulata, Eucalyptus radiata* subsp. *sejuncta.*
- Shrub: *Acacia filicifolia, Banksia integrifolia* subsp. *monticola, Leucopogon lanceolatus var. lanceolatus, Persoonia cornifolia, Monotoca scoparia, Acacia falciformis, Bursaria spinosa subsp. spinosa, Lomatia silaifolia.*
- Ground: *Poa sieberiana, Pteridium esculentum, Rubus parvifolius, Poranthera microphylla, Themeda australis, Glycine clandestina, Hydrocotyle laxiflora, Desmodium varians, Geranium solanderi var. solanderi, Viola betonicifolia, Lomandra longifolia, Hardenbergia violacea, Imperata cylindrica var. major, Gonocarpus tetragynus, Brachyscome nova-anglica.*

Justification of PCT: PCT commonly mapped in the locality (DPIE 2019, DPIE 2015) on mid to high hills and ridgelines, and noted as present with *Eucalyptus obliqua, Banksia integrifolia* subsp. *monticola, Poa sieberiana,* and *Pteridium esculentum* occurring commonly throughout, in the ground layer over a ridgeline in the central portion of the transmission line footprint.

PCT 540 - Silvertop Stringybark - Ribbon Gum - Rough-barked Apple open forest on basalt hills of southern Nandewar Bioregion, southern New England Tableland Bioregion and NSW North Coast Bioregion

Vegetation formation: Dry Sclerophyll Forests (Shrub/grass formation)

Vegetation class: New England Dry Sclerophyll Forests

Conservation status:

- EPBC Act: Not listed
- BC Act: Not listed

Extent within development footprint: 40.63 hectares

No. BAM plots: 9

Recorded species:

- Canopy: *Eucalyptus laevopinea, Eucalyptus viminallis, Angophora floribunda*
- Shrub: *Bursaria spinosa,* Cassinia laevis.
- Ground: *Ajuga australis, Aristida ramos, Arthropodium milleflorum, Carex inversa, Brachyscome spathulata, Cheilanthes sieberi* subsp*. sieberi, Cymbopogon refractus, Dianella longifolia, Dichondra repens, Echinopogon mckiei, Glycine microphylla, Lomandra confertifolia, Rytidosperma penicillatum, Poa sieberiana.*

Justification of PCT: PCT commonly recorded on mid to high hills below the ridgeline, generally with a north-facing aspect. *Eucalyptus laevopinea* is dominant in the canopy with *Eucalyptus viminallis,* and *Angophora floribunda* sub-dominant. Understorey vegetation was found to be generally open, with native species most common and diverse in the ground layer.

PCT 541 - Silvertop Stringybark - Rough-barked Apple grassy open forest of southern Nandewar Bioregion, southern New England Tableland Bioregion and NSW North Coast Bioregion

Vegetation formation: Dry Sclerophyll Forests (Shrub/grass formation)

Vegetation class: New England Dry Sclerophyll Forests

Conservation status:

- EPBC Act: Not listed
- BC Act: Not listed

Extent within development footprint: 11.37 hectares

No. BAM plots: 8

Recorded species:

- Canopy: *Angophora floribunda, Eucalyptus blakelyi, Eucalyptus laevopinea, Eucalyptus nortonii*
- Shrub: *Acacia implexa, Cassinia laevis, Melicytus dentatus, Solanum aviculare*
- Ground: *Crassula sieberiana, Dichondra repens, Echinopogon mckiei, Einadia nutans, Einadia trigonos, Eustrephus latifolius, Galium aparine Geranium solanderi var. solanderi, Glycine microphylla, Microlaena stipoides, Mentha diemenica, Rytidosperma leave.*

Justification of PCT: PCT commonly recorded as a mosaic with PCT 540 on mid to high hills below the ridgeline, generally with a north-facing aspect. *Eucalyptus laevopinea* is dominant in the canopy with *Eucalyptus nortonii,* and *Angophora floribunda* sub-dominant. Understory is grassy with shrub cover generally found to be quite low.

PCT 586 - Snow Grass - Swamp Foxtail tussock grassland sedgeland of cold air drainage valleys of the New England Tableland Bioregion

Vegetation formation: Grasslands

Vegetation class: Temperate Montane Grasslands

Conservation status:

- EPBC Act: Not listed
- BC Act: Not listed

Extent within development footprint: 2.56 hectares

No BAM plots: 3

Recorded species:

- Canopy: n/a
- Shrub: n/a
- Ground: *Pennisetum alopecuroides, Poa sieberiana, Carex inversa, Rumex brownii, Persicaria decipiens, Haloragis heterophylla, Juncus subsecundus*

Justification of PCT: PCT was found to occur as a grassland / sedgeland / swamp meadow dominated by *Pennisetum alopecuroides* and *Poa sieberiana*. PCT was found to occur along flats, bwteen slpopes, at mid elevation along the transverse track section of the development footprint.

PCT 599 - Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion

Vegetation formation: Grassy Woodlands

Vegetation class: Western Slopes Grassy Woodlands

Conservation status:

- EPBC Act: White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland
- BC Act: White Box Yellow Box Blakely's Red Gum Woodland

Extent within development footprint: 1.43 hectares

No BAM plot: 0

Characteristic species (NSW BioNet):

- Canopy: *Eucalyptus blakelyi, Eucalyptus melliodora, Angophora floribunda, Eucalyptus albens, Eucalyptus melanophloia, Brachychiton populneus* subsp*. populneus, Eucalyptus conica, Callitris glaucophylla,*
- Shrub: *Acacia implexa, Geijera parviflora, Acacia decora, Myoporum montanum, Olearia elliptica* subsp*. elliptica, Pimelea neo-anglica, Maireana microphylla, Hibbertia riparia, Pimelea curviflora var. curviflora, Notelaea microcarpa, Acacia deanei* subsp*. deanei,*
- Ground: *Aristida personata, Glycine tabacina, Carex inversa, Themeda triandra, Cyperus gracilis, Austrostipa verticillata, Bothriochloa macra, Microlaena stipoides var. stipoides, Aristida ramosa, Geranium solanderi var. solanderi, Hydrocotyle laxiflora, Ajuga australis, Dichelachne micrantha, Lomandra longifolia, Lomandra filiformis* subsp*. coriacea, Desmodium brachypodum.*

Justification of PCT: PCT commonly mapped in the locality (DPIE 2019, DPIE 2015) with *Eucalyptus albens, Eucalyptus blakelyi, Eucalyptus melliodora, Angophora floribunda* commonly noted as the dominant species in the canopy, *Acacia implexa* and *Notelaea macrocarpa* dominant in the generally sparse midstorey, with *Themeda triandra, Microlaena stipoides* var. *stipoides, Dichelachne micrantha* and *Lomandra filiformis* subsp. *coriacea* dominating parts of the ground layer.

PCT 931 - Messmate - Mountain Gum tall moist forest of the far southern New England Tableland Bioregion

Vegetation formation: Wet Sclerophyll Forests (Shrubby sub-formation)

Vegetation class: Northern Escarpment Wet Sclerophyll Forests

Conservation status:

- EPBC Act: Not listed
- BC Act: Not listed

Extent within development footprint: 3.21 hectares

No. BAM plots: 5

Recorded species:

- Canopy: *Eucalyptus obliqua*, *Eucalyptus dalrympleana* subsp. *heptantha, Eucalyptus viminalis*, *Acacia melanoxylon*
- Shrub: *Lomatia arborescens, Melicytus dentatus,*
- Ground: *Calochlaena dubia, Cotula australis, Dichondra repens, Geranium potentilloides, Lobelia concolo, Microlaena stipoides, Poa sieberiana var. sieberiana, Pteridium esculentum, Solanum prinophyllum*

Justification of PCT: PCT commonly recorded on high hills, on or just below the ridgeline moving down into deep gullies, generally with a south-facing aspect. *Eucalyptus obliqua* is dominant in the canopy with *Eucalyptus dalrympleana subsp. heptantha,* and *Acacia melanoxylon* sub-dominant. Understorey vegetation was found to be generally dense and closed (compared to the similar PCT934) where the PCT occurred in high condition, with native species common and diverse in the understorey.

PCT 934 - Messmate open forest of the tableland edge of the NSW North Coast Bioregion and New England Tableland Bioregion

Vegetation formation: Wet Sclerophyll Forests (Shrubby sub-formation)

Vegetation class: Northern Escarpment Wet Sclerophyll Forests

Conservation status:

- EPBC Act: Not listed
- BC Act: Not listed

Extent within development footprint: 22.82 hectares

No. BAM plots: 4

Recorded species:

- Canopy: *Eucalyptus obliqua, Eucalyptus nobilis, Eucalyptus pauciflora*.
- Shrub: *Dicksonia antarctica,* Coprosma quadrifida, Daviesia ulicifolia, Melicytus dentatus
- Ground: *Smilax australis, Asperula conferta, Desmodium varians, Dichondra repens, Ehrharta calycina, Einadia trigonos Galium gaudichaudii, Glycine microphylla, Glycine tabacina, Gonocarpus teucrioides, Hydrocotyle laxiflora, Microlaena stipoides, Oxalis perennans, Plantago debilis, Poa labillardierei, Poa sieberiana var. sieberiana, Pseuderanthemum variabile, Pteridium esculentum, Rytidosperma carphoides, Rytidosperma laeve, Urtica incisa, Veronica plebeian, Viola betonicifolia, Wahlenbergia gracilis.*

Justification of PCT: PCT commonly recorded on high hills, on or just below the ridgeline generally with a south-facing aspect. *Eucalyptus obliqua* is dominant in the canopy with *Eucalyptus nobilis* and *Eucalyptus pauciflora* sub-dominant. Understorey vegetation was found to be generally more open (compared to the similar PCT931) where the PCT occurred in high condition, with native species common and diverse in the understroey. A large area of this PCT occurs as a derived native grassland/shrubland in the central portion of the development footprint following historical clearing and ongoing low intensity farms landuse.

PCT 954 - Mountain Ribbon Gum - Messmate open forest of escarpment ranges of the NSW North Coast Bioregion and New England Tableland Bioregion

Vegetation formation: Wet Sclerophyll Forests (Grassy sub-formation)

Vegetation class: Northern Escarpment Wet Sclerophyll Forests

Conservation status:

- EPBC Act: Not listed
- BC Act: Not listed

Extent within development footprint: 1.23 hectares

No. BAM plots: 0

Characteristic species (NSW BioNet):

- Canopy: *Eucalyptus nobilis, Eucalyptus obliqua, Eucalyptus campanulata, Eucalyptus viminalis.*
- Shrub: *Acacia falciformis, Acacia melanoxylon, Banksia integrifolia* subsp*. monticola, Bursaria spinosa* subsp*. spinosa, Leucopogon lanceolatus, Podolobium ilicifolium, Rubus parvifolius.*
- Ground: *Acaena novae-zelandiae, Desmodium varians, Dichondra repens, Galium propinquum, Geranium potentilloides, Glycine clandestina, Gonocarpus teucrioides, Hibbertia scandens, Lomandra longifolia, Poa sieberiana var. sieberiana, Pteridium esculentum, Themeda australis, Wahlenbergia stricta, Viola betonicifolia, Viola hederacea.*

Justification of PCT: PCT present on upper slopes with a northern aspect in the western portion of the wind farm corridor. Species present include *Eucalyptus obliqua* and *Eucalyptus nobilis*.

PCT 1194 - Snow Gum - Mountain Gum - Mountain Ribbon Gum open forest on ranges of the NSW North Coast Bioregion and eastern New England Tableland Bioregion

Vegetation formation: Wet Sclerophyll Forests (Grassy sub-formation)

Vegetation class: Northern Tableland Wet Sclerophyll Forests

Conservation status:

- EPBC Act: Not listed
- BC Act: Ribbon Gum—Mountain Gum—Snow Gum Grassy Forest/Woodland of the New England Tableland Bioregion (when present within the New England Tablelands IBRA Bioregion)

Extent within development footprint: 39.29 hectares

No. BAM plots: 14

Recorded species:

- Canopy: *Eucalyptus viminalis, Eucalyptus pauciflora, Eucalyptus nobilis*
- Shrub: *Acacia melanoxylon, Melicytus dentatus, Lomatia arborescens, Bursaria spinosa*
- Ground: *Anthoxanthum odoratum, Asperula conferta, Dichondra repens, Geranium homeanum, Hybanthus monopetalus, Microlaena stipoides, Poa sieberiana, Pteridium esculentum, Veronica plebeia, Stellaria pungens, Urtica incisa, Lomandra longifolia*

Justification of PCT: The PCT was found to commonly occur on slopes and plateaux at high elevation with the canopy a co-dominant mix of *Eucalyptus viminalis, Eucalyptus pauciflora*, and *Eucalyptus nobilis*. The understorey was found to be generally open and grassy with the ground layer supporting the highest diversity in native species recorded.

PCT 1604 - Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter

Vegetation formation: Grassy Woodlands

Vegetation class: Coastal Valley Grassy Woodlands

Conservation status:

- EPBC Act: Not listed
- BC Act: Not listed

Extent within development footprint: 0.02 hectares

No BAM plots: 0

Characteristic species (NSW BioNet):

- Canopy: *Eucalyptus crebra, Eucalyptus moluccana, Corymbia maculata.*
- Shrub: *Bursaria spinosa, Olearia elliptica.*
- Ground: *Eremophila debilis, Cymbopogon refractus, Aristida ramosa, Aristida vagans, Microlaena stipoides, Austrodanthonia fulva, Cheilanthes sieberi, Lomandra multiflora, Brunoniella australis.*

Justification of PCT: PCT was found to occur on the road verge along the transport haul route as scattered occurrences of *Corymbia maculata Eucalyptus moluccana* and *Eucalyptus crebra*, over a generally disturbed understorey in low condition.

PCT 1691 - Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter

Vegetation formation: Grassy Woodlands

Vegetation class: Coastal Valley Grassy Woodlands

Conservation status:

- EPBC Act: Central Hunter Valley eucalypt forest and woodland
- BC Act: Central Hunter Grey Box—Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions

Extent within development footprint: 0.04 hectares

No. Bam plots: 0

Characteristic species (NSW BioNet:

- Canopy: *Eucalyptus crebra, Eucalyptus moluccana, Brachychiton populneus.*
- Shrub: *Notelaea macrocarpa.*
- Ground: *Eremophila debilis, Aristida ramosa, Cymbopogon refractus, Chloris ventricosa, Calotis lappulacea, Dichondra repens, Eragrostis leptostachya, Microlaena stipoides, Austrostipa verticillata.*

Justification of PCT: PCT was found to occur on the road verge along the transport haul route, with impacts only to occur to a highly degraded edge of the PCT, too disturbed to meet the listing requirements as a BC Act or EPB Act TEC. The PCT occurs as scattered occurrences of *Eucalyptus crebra* and *Eucalyptus tereticornis*, over a grassy understorey in low to moderate condition to the north and away from the road verge**.**

Appendix C Threatened species habitat suitability assessment

Table 83 Consideration of species requiring further assessment

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
Species name	Common name	Credit class	Species geographic constraints	Species associated with site PCT?	Native vegetation cover required	Required patch size	Requires further assessment	Habitat constraints	Suitable habitat	Habitat assessment	Likelihood of occurrence
Frogs											
Litoria booroolongensis	Booroolong Frog	Species		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes		Live along permanent streams with some fringing vegetation cover such as ferns, sedges, or grasses. ;1|Adults occur on or near cobble banks and other rock structures within stream margins.;2|Shelter under rocks or amongst vegetation near the ground on the stream edge.;3|Sometimes bask in the sun on exposed rocks near flowing water during summer.;4|Breeding occurs in spring and early summer and tadpoles metamorphose in late summer to early autumn.;5|Eggs are laid in	Marginal habitat supported by a number of minor waterbodies within the subject land. Low quality potential habitat present where transmission line corridor crosses Wombramurra Creek	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									submerged rock crevices and tadpoles grow in slow-flowing connected or isolated pools.;6|		
Litoria daviesae	Davies' Tree Frog	Species		Yes	Fragmented - 11-30 % habitat retained	< 5 ha	Yes	Other; Streams or swamps or within 250 m of waterbodies	Davies' Tree Frog occurs in permanent, slow-flowing small streams above 400 m elevation, mostly in the headwaters of eastern-flowing streams (although it does occur in the headwaters of the western-flowing Peel River).;1|On the tablelands, riparian habitat may be montane heath or dry open forest with fringing tea tree, tussocks and ferns. Escarpment habitat is typically rainforest and wet sclerophyll with a rainforest understorey.;2|Breeding occurs in spring and early summer. Daytime calling is common during the breeding season. At night, males can be found calling from perched positions on trees and shrubs 0.5 - 1.5	Marginal habitat supported by a number of minor waterbodies within the subject land. Habitats degraded on transmission line corridor	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									m above streams.;3|The species has rarely been observed away from the riparian zone, implying a reliance on that zone for breeding and foraging. However, nothing is known of habitat use outside the breeding season.;4|		
Litoria subglandulosa	Glandular Frog	Species		Yes	Fragmented - 11-30 % habitat retained	< 5 ha	Yes		Glandular Frogs may be found along streams in rainforest, moist and dry eucalypt forest or in subalpine swamps.;1|Breeding occurs in summer, and possibly in spring.;2|	Marginal habitat supported by a number of minor waterbodies within the subject land. Habitats degraded on transmission line corridor. Species records associated with large areas on intact vegetation to the east of the project site, with no records within 100kms of the project site.	Low
Mixophyes balbus	Stuttering Frog	Species		Yes	Variegated - 31-	5 - 24 ha	Yes		Found in rainforest and	Marginal habitat	Low

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
					70% habitat retained				wet, tall open forest in the foothills and escarpment on the eastern side of the Great Dividing Range.;1|Outside the breeding season adults live in deep leaf litter and thick understorey vegetation on the forest floor.;2|Feed on insects and smaller frogs.;3|Breed in streams during summer after heavy rain.;4|Eggs are laid on rock shelves or shallow riffles in small, flowing streams.;5|As the tadpoles grow they move to deep permanent pools and take approximately 12 months to metamorphose.;6|	supported by a number of minor waterbodies within the subject land. Habitats degraded on transmission line corridor. Species records associated with large areas on intact vegetation to the east of the project site, with no records within 100kms of the project site.	
Birds											
Anthochaera phrygia	Regent Honeyeater	Species/ Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes	Other; As per mapped areas	The Regent Honeyeater is a flagship threatened woodland bird whose conservation will benefit a large suite of other threatened and declining woodland fauna. The species inhabits dry open	Potential forage habitat supported across the development footprint. Project site does not occur within mapped	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									forest and woodland, particularly Box-Ironbark woodland, and riparian forests of River Sheoak. Regent Honeyeaters inhabit woodlands that support a significantly high abundance and species richness of bird species. These woodlands have significantly large numbers of mature trees, high canopy cover and abundance of mistletoes.;1|Every few years non-breeding flocks are seen foraging in flowering coastal Swamp Mahogany and Spotted Gum forests, particularly on the central coast and occasionally on the upper north coast. Birds are occasionally seen on the south coast.;2| In the last 10 years Regent Honeyeaters have been recorded in urban areas around Albury where woodlands tree species	Important Areas for the species	

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									such as Mugga Ironbark and Yellow Box were planted 20 years ago.;3|The Regent Honeyeater is a generalist forager, although it feeds mainly on the nectar from a relatively small number of eucalypts that produce high volumes of nectar. Key eucalypt species include Mugga Ironbark, Yellow Box, White Box and Swamp Mahogany. Other tree species may be regionally important. For example, the Lower Hunter Spotted Gum forests have recently been demonstrated to support regular breeding events. Flowering of associated species such as Thin-leaved Stringybark Eucalyptus eugenioides and other Stringybark species, and Broad-leaved Ironbark E. fibrosa can also contribute important nectar flows at times.		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									Nectar and fruit from the mistletoes Amyema miquelii, A. pendula and A. cambagei are also utilised. When nectar is scarce lerp and honeydew can comprise a large proportion of the diet. Insects make up about 15% of the total diet and are important components of the diet of nestlings. ;4|Colour-banding of Regent Honeyeater has shown that the species can undertake large-scale nomadic movements in the order of hundreds of kilometres. However, the exact nature of these movements is still poorly understood. It is likely that movements are dependent on spatial and temporal flowering and other resource patterns. To successfully manage the recovery of this species a full understanding of the		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									habitats used in the non-breeding season is critical.;5|There are three known key breeding areas, two of them in NSW - Capertee Valley and Bundarra-Barraba regions. The species breeds between July and January in Box-Ironbark and other temperate woodlands and riparian gallery forest dominated by River Sheoak. Regent Honeyeaters usually nest in horizontal branches or forks in tall mature eucalypts and Sheoaks. Also nest in mistletoe haustoria.;6|An open cup-shaped nest is constructed of bark, grass, twigs and wool by the female. Two or three eggs are laid and incubated by the female for 14 days. Nestlings are brooded and fed by both parents at an average rate of 23 times per hour and fledge after 16 days.		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									Fledglings fed by both parents 29 times per hour.;7|		
Artamus cyanopterus cyanopterus	Dusky Woodswallow	Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes		Primarily inhabit dry, open eucalypt forests and woodlands, including mallee associations, with an open or sparse understorey of eucalypt saplings, acacias and other shrubs, and ground-cover of grasses or sedges and fallen woody debris. It has also been recorded in shrublands, heathlands and very occasionally in moist forest or rainforest. Also found in farmland, usually at the edges of forest or woodland.;1|Primarily eats invertebrates, mainly insects, which are captured whilst hovering or sallying above the canopy or over water. Also, frequently hovers, sallies and pounces under the canopy, primarily over leaf litter and	Potential forage habitat supported across the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									dead timber. Also occasionally take nectar, fruit and seed. ;2|Depending on location and local climatic conditions (primarily temperature and rainfall), the dusky woodswallow can be resident year-round or migratory. In NSW, after breeding, birds migrate to the north of the state and to southeastern Queensland, while Tasmanian birds migrate to southeastern NSW after breeding. Migrants generally depart between March and May, heading south to breed again in spring. There is some evidence of site fidelity for breeding. Although dusky wood swallows generally breed as solitary pairs or occasionally in small flocks, large flocks may form around abundant food sources in winter. Large flocks may also form		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									before migration, which is often undertaken with other species. ;3|Nest is an open, cup-shape, made of twigs, grass, fibrous rootlets and occasionally casuarina needles, and may be lined with grass, rootlets or infrequently horsehair, occasionally unlined. Nest sites vary greatly, but generally occur in shrubs or low trees, living or dead, horizontal or upright forks in branches, spouts, hollow stumps or logs, behind loose bark or in a hollow in the top of a wooden fence post. Nest sites may be exposed or well concealed by foliage. ;4|		
Burhinus grallarius	Bush Stone-curlew	Species		Yes	Fragmented - 11-30 % habitat retained	< 5 ha	No	Fallen/standing dead timber including logs; Null	Inhabits open forests and woodlands with a sparse grassy ground layer and fallen timber.;1|Largely nocturnal, being especially active on moonlit nights.;2|Feed on insects	Species occurs at altitudes much lower than the development footprint with the highest elevation record of the	Negligible

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									and small vertebrates, such as frogs, lizards and snakes.;3|Nest on the ground in a scrape or small bare patch.;4|Two eggs are laid in spring and early summer.;5|	species within over 120kms of the project site at an altitude of 500 metres (approx.). The lowest point of the project site occurs along the transmission line at an altitude of 750 metres (approx.) and as such the development footprint does not support habitat for the species. Two records of the species occur at an elevation of approximately 1000 metres, one hears Armidale over 120kms from the project site, and the other in Washpool NP, over 270kms	

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
										from the project site. When these records are compared to the remainder of the 1350 species' records in BioNet, these occurrences are considered to be a vagrant.	
Callocephalon fimbriatum	Gang-gang Cockatoo	Species/ Ecosystem		Yes	Fragmented - 11-30 % habitat retained	< 5 ha	No	Hollow bearing trees; Eucalypt tree species with hollows greater than 9 cm diameter	In spring and summer, generally found in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. ;1|In autumn and winter, the species often moves to lower altitudes in drier more open eucalypt forests and woodlands, particularly box-gum and box-ironbark assemblages, or in dry forest in coastal areas and often found in urban areas.;2|May also occur in sub-alpine Snow Gum (Eucalyptus	Of the 16,000 records of the species in ebird (and >600 in BioNet), none occur north of Muswellbrook NSW, except occasional records along coast just south of Coffs Harbour. As such the development footprint does not support habitat for the species.	Negligible

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									pauciflora) woodland and occasionally in temperate rainforests.;3|Favours old growth forest and woodland attributes for nesting and roosting. Nests are located in hollows that are 10 cm in diameter or larger and at least 9 m above the ground in eucalypts.;4|		
Calyptorhynchus lathami	Glossy Black-Cockatoo	Species/ Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes	Forage: Presence of Allocasuarina and casuarina species Breeding: Hollow bearing trees; Living or dead tree with hollows greater than 15cm diameter and greater than 5m above	Inhabits open forest and woodlands of the coast and the Great Dividing Range where stands of sheoak occur. Black Sheoak (Allocasuarina littoralis) and Forest Sheoak (A. torulosa) are important foods.;1|Inland populations feed on a wide range of sheoaks, including Drooping Sheoak, Allocasuaraina diminuta, and A. gymnathera. Belah is also utilised and may be a critical food source for	Marginal potential forage habitat supported across the development footprint, very few Casuarina spp or Allocasuarina spp. have been recorded during floristic surveys of fauna habitat assessments. Breeding habitat potentially present in the	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
								ground.	some populations.;2|In the Riverina, birds are associated with hills and rocky rises supporting Drooping Sheoak, but also recorded in open woodlands dominated by Belah (Casuarina cristata).;3|Feeds almost exclusively on the seeds of several species of she-oak (Casuarina and Allocasuarina species), shredding the cones with the massive bill.;4|Dependent on large hollow-bearing eucalypts for nest sites. A single egg is laid between March and May.;5|	form of hollow trees.	
Chthonicola sagittata	Speckled Warbler	Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes		The Speckled Warbler lives in a wide range of Eucalyptus dominated communities that have a grassy understorey, often on rocky ridges or in gullies.;1|Typical habitat	Potential forage habitat supported across the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy.;2|Large, relatively undisturbed remnants are required for the species to persist in an area.;3|The diet consists of seeds and insects, with most foraging taking place on the ground around tussocks and under bushes and trees.;4|Pairs are sedentary and occupy a breeding territory of about ten hectares, with a slightly larger home-range when not breeding.;5|The rounded, domed, roughly built nest of dry grass and strips of bark is located in a slight hollow in the ground or the base of a low dense plant, often among fallen branches and other litter. A side entrance allows the bird to walk directly inside.;6|A clutch of 3-4 eggs is laid, between		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									August and January, and both parents feed the nestlings. The eggs are a glossy red-brown, giving rise to the unusual folk names 'Blood Tit' and 'Chocolatebird'.;7|Some cooperative breeding occurs. The species may act as host to the Black-eared Cuckoo.;8|Speckled Warblers often join mixed species feeding flocks in winter, with other species such as Yellow-rumped, Buff-rumped, Brown and Striated Thornbills.;9|		
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes		Found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or	Potential forage habitat supported across the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									more shrub species; also found in mallee and River Red Gum (Eucalyptus camaldulensis) Forest bordering wetlands with an open understorey of acacias, saltbush, lignum, cumbungi and grasses; usually not found in woodlands with a dense shrub layer; fallen timber is an important habitat component for foraging; also recorded, though less commonly, in similar woodland habitats on the coastal ranges and plains.;1|Sedentary, considered to be resident in many locations throughout its range; present in all seasons or year-round at many sites; territorial year-round, though some birds may disperse locally after breeding.;2|Gregarious and usually observed in pairs or small groups of 8 to 12 birds; terrestrial and		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									arboreal in about equal proportions; active, noisy and conspicuous while foraging on trunks and branches of trees and amongst fallen timber; spend much more time foraging on the ground and fallen logs than other treecreepers. ;3|When foraging in trees and on the ground, they peck and probe for insects, mostly ants, amongst the litter, tussocks and fallen timber, and along trunks and lateral branches; up to 80% of the diet is comprised of ants; other invertebrates (including spiders, insects larvae, moths, beetles, flies, hemipteran bugs, cockroaches, termites and lacewings) make up the remaining percentage; nectar from Mugga Ironbark (Eucalyptus sideroxylon) and paperbarks, and sap from		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									an unidentified eucalypt are also eaten, along with lizards and food scraps; young birds are fed ants, insect larvae, moths, craneflies, spiders and butterfly and moth larvae.;4|Hollows in standing dead or live trees and tree stumps are essential for nesting. ;5|The species breeds in pairs or co-operatively in territories which range in size from 1.1 to 10.7 ha (mean = 4.4 ha). Each group is composed of a breeding pair with retained male offspring and, rarely, retained female offspring. Often in pairs or cooperatively breeding groups of two to five birds. ;6|		
Daphoenositta chrysoptera	Varied Sittella	Ecosystem		Yes	Fragmented - 11-30 % habitat retained	< 5 ha	Yes		Inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with	Potential forage habitat supported across the development footprint	Moderate

<table>
<tr><th colspan="3">BAM candidate species identification</th><th colspan="5">Step 1: Identify threatened species for assessment</th><th>Step 2</th><th colspan="3">Step 3: Identify candidate species credit species for further assessment</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>dead branches, mallee and Acacia woodland.;1|Feeds on arthropods gleaned from crevices in rough or decorticating bark, dead branches, standing dead trees and small branches and twigs in the tree canopy.;2|Builds a cup-shaped nest of plant fibres and cobwebs in an upright tree fork high in the living tree canopy, and often re-uses the same fork or tree in successive years.;3|Generation length is estimated to be 5 years.;4|</td><td></td><td></td></tr>
<tr><td>Glossopsitta pusilla</td><td>Little Lorikeet</td><td>Ecosystem</td><td></td><td>Yes</td><td>Relictual - 10% or less habitat retained</td><td>< 5 ha</td><td>Yes</td><td></td><td>Forages primarily in the canopy of open Eucalyptus forest and woodland, yet also finds food in Angophora, Melaleuca and other tree species. Riparian habitats are particularly used, due to higher soil</td><td>Potential forage habitat supported across the development footprint</td><td>Moderate</td></tr>
</table>

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									fertility and hence greater productivity.;1|Isolated flowering trees in open country, e.g. paddocks, roadside remnants and urban trees also help sustain viable populations of the species.;2|Feeds mostly on nectar and pollen, occasionally on native fruits such as mistletoe, and only rarely in orchards;3|Gregarious, travelling and feeding in small flocks (<10), though often with other lorikeets. Flocks numbering hundreds are still occasionally observed and may have been the norm in past centuries.;4|Roosts in treetops, often distant from feeding areas.;5|Nests in proximity to feeding areas if possible, most typically selecting hollows in the limb or trunk of smooth-barked Eucalypts. Entrance is small (3 cm) and usually high above the ground (2–		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									15 m). These nest sites are often used repeatedly for decades, suggesting that preferred sites are limited. Riparian trees often chosen, including species like Allocasuarina.;6|Nesting season extends from May to September. In years when flowering is prolific, Little Lorikeet pairs can breed twice, producing 3-4 young per attempt. However, the survival rate of fledglings is unknown.;7|		
Grantiella picta	Painted Honeyeater	Ecosystem		Yes	Fragmented - 11-30 % habitat retained	< 5 ha	Yes		Inhabits Boree/ Weeping Myall (Acacia pendula), Brigalow (A. harpophylla) and Box-Gum Woodlands and Box-Ironbark Forests.;1|A specialist feeder on the fruits of mistletoes growing on woodland eucalypts and acacias. Prefers mistletoes of the genus Amyema.;2|Ins	Potential forage habitat supported across the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									ects and nectar from mistletoe or eucalypts are occasionally eaten.;3|Nest from spring to autumn in a small, delicate nest hanging within the outer canopy of drooping eucalypts, she-oak, paperbark or mistletoe branches.;4|		
Haliaeetus leucogaster	White-bellied Sea-Eagle	Species/ Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	No	Waterbodies; Within 1km of a rivers, lakes, large dams or creeks, wetlands and coastlines; Living or dead mature trees within suitable vegetation within 1km of a rivers, lakes, large dams or creeks, wetlands and coastlines	Habitats are characterised by the presence of large areas of open water including larger rivers, swamps, lakes, and the sea.;1|Occurs at sites near the sea or sea-shore, such as around bays and inlets, beaches, reefs, lagoons, estuaries and mangroves; and at, or in the vicinity of freshwater swamps, lakes, reservoirs, billabongs and saltmarsh. ;2|Terrestrial habitats include coastal dunes, tidal flats, grassland, heathland, woodland, and forest (including rainforest). ;3|Breeding habitat consists of mature tall	Project site does not occur within 1km of a rivers, lakes, large dams or creeks, wetlands and coastlines. Where Peel River occurs within 1km of the development footprint it is a minor watercourse.	Negligible

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									open forest, open forest, tall woodland, and swamp sclerophyll forest close to foraging habitat. Nest trees are typically large emergent eucalypts and often have emergent dead branches or large dead trees nearby which are used as 'guard roosts. Nests are large structures built from sticks and lined with leaves or grass. ;4|Feed mainly on fish and freshwater turtles, but also waterbirds, reptiles, mammals and carrion.;5|Hunts its prey from a perch or whilst in flight (by circling slowly, or by sailing along 10–20 m above the shore). Prey is usually carried to a feeding platform or (if small) consumed in flight, but some items are eaten on the ground.;6|May be solitary, or live in pairs or small family groups consisting of a pair of		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									adults and dependent young. ;7|Typically lays two eggs between June and September with young birds remaining in the nest for 65-70 days.;8|		
Hamirostra melanosternon	Black-breasted Buzzard	Species/ Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes	Waterbodies; Land within 40 m of riparian woodland on inland watercourses /waterholes containing dead or dying eucalypts	Lives in a range of inland habitats, especially along timbered watercourses which is the preferred breeding habitat.;1|Also hunts over grasslands and sparsely timbered woodlands.;2|Not a powerful hunter, despite its size, mostly taking reptiles, small mammals, birds, including nestlings, and carrion.;3|Also specialises in feeding on large eggs, including those of emus, which it cracks on a rock.;4|Breeds from August to October near water in a tall tree. The stick nest is large and flat and lined with green leaves. Normally two eggs	Riparian habitats are degraded within the development footprint.	Negligible

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									are laid.;5|		
Hieraaetus morphnoides	Little Eagle	Species/ Ecosystem		Yes	Fragmented - 11-30 % habitat retained	< 5 ha	Yes	Other; Nest trees - live (occasionally dead) large old trees within vegetation.	Occupies open eucalypt forest, woodland or open woodland. Sheoak or Acacia woodlands and riparian woodlands of interior NSW are also used.;1|Nests in tall living trees within a remnant patch, where pairs build a large stick nest in winter.;2|Lays two or three eggs during spring, and young fledge in early summer.;3|Preys on birds, reptiles and mammals, occasionally adding large insects and carrion.;4|	Potential forage and breeding habitat supported across the development footprint	Moderate
Lathamus discolor	Swift Parrot	Species/ Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes	Other; As per mapped areas	Migrates to the Australian south-east mainland between February and October.;1|On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations.;2|Favoured	Potential forage habitat supported across the development footprint. Project site does not occur within mapped Important Areas for the species	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									feed trees include winter flowering species such as Swamp Mahogany Eucalyptus robusta, Spotted Gum Corymbia maculata, Red Bloodwood C. gummifera, Forest Red Gum E. tereticornis, Mugga Ironbark E. sideroxylon, and White Box E. albens.;3|Commonly used lerp infested trees include Inland Grey Box E. microcarpa, Grey Box E. moluccana, Blackbutt E. pilularis, and Yellow Box E. melliodora.;4|Retur n to some foraging sites on a cyclic basis depending on food availability.;5|Following winter they return to Tasmania where they		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									breed from September to January, nesting in old trees with hollows and feeding in forests dominated by Tasmanian Blue Gum Eucalyptus globulus.;6|		
Lophoictinia isura	Square-tailed Kite	Species/ Ecosystem		Yes	Fragmented - 11-30 % habitat retained	< 5 ha	Yes	Other; Nest trees	Found in a variety of timbered habitats including dry woodlands and open forests. Shows a particular preference for timbered watercourses.;1|In arid north-western NSW, has been observed in stony country with a ground cover of chenopods and grasses, open acacia scrub and patches of low open eucalypt woodland.;2|Is a specialist hunter of passerines, especially honeyeaters, and most particularly nestlings, and insects in the tree canopy, picking most prey items from the outer foliage.;3| Appears to occupy large hunting ranges of more	Potential forage and breeding habitat supported across the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									than 100km2.;4|Breeding is from July to February, with nest sites generally located along or near watercourses, in a fork or on large horizontal limbs.;5|		
Melanodryas cucullata	Hooded Robin (south-eastern form)	Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes		Prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas.;1|Requires structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses.;2|Often perches on low dead stumps and fallen timber or on low-hanging branches, using a perch-and-pounce method of hunting insect prey.;3|Territories range from around 10 ha during the breeding season, to 30 ha in the non-breeding season.;4|May breed any	Potential forage habitat supported across the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									time between July and November, often rearing several broods.;5|The nest is a small, neat cup of bark and grasses bound with webs, in a tree fork or crevice, from less than 1 m to 5 m above the ground.;6|The nest is defended by both sexes with displays of injury-feigning, tumbling across the ground.;7|A clutch of two to three is laid and incubated for fourteen days by the female. Two females often cooperate in brooding.;8|		
Ninox connivens	Barking Owl	Species/ Ecosystem		Yes	Fragmented - 11-30 % habitat retained	25 - 100 ha	Yes	Hollow bearing trees; Living or dead trees with hollows greater than 20 cm diameter and greater than 4m above the ground.	Inhabits woodland and open forest, including fragmented remnants and partly cleared farmland. It is flexible in its habitat use, and hunting can extend in to closed forest and more open areas. Sometimes able to successfully breed along timbered watercourses in heavily	Potential forage and breeding habitat supported across the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									cleared habitats (e.g. western NSW) due to the higher density of prey found on these fertile riparian soils.;1|Roost in shaded portions of tree canopies, including tall midstorey trees with dense foliage such as Acacia and Casuarina species. During nesting season, the male perches in a nearby tree overlooking the hollow entrance.;2|Preferentially hunts small arboreal mammals such as Squirrel Gliders and Common Ringtail Possums, but when loss of tree hollows decreases these prey populations the owl becomes more reliant on birds, invertebrates and terrestrial mammals such as rodents and rabbits. Can catch bats and moths on the wing, but typically hunts by sallying from a tall		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									perch.;3|Requires very large permanent territories in most habitats due to sparse prey densities. Monogamous pairs hunt over as much as 6000 hectares, with 2000 hectares being more typical in NSW habitats.;4|Two or three eggs are laid in hollows of large, old trees. Living eucalypts are preferred though dead trees are also used. Nest sites are used repeatedly over years by a pair, but they may switch sites if disturbed by predators (e.g. goannas).;5|Nesting occurs during mid-winter and spring, being variable between pairs and among years. As a rule of thumb, laying occurs during August and fledging in November. The female incubates for 5 weeks, roosts outside the hollow when chicks are 4 weeks old, then fledging occurs 2-3 weeks later.		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									Young are dependent on their parents for several months.;6|Territorial pairs respond strongly to recordings of Barking Owl calls from up to 6 km away, though humans rarely hear this response farther than 1.5 km. Because disturbance reduces the pair's foraging time and can pull the female off her eggs even on cold nights, recordings should not be broadcast unnecessarily nor during the nesting season.;7|		
Ninox strenua	Powerful Owl	Species/ Ecosystem		Yes	Fragmented - 11-30 % habitat retained	< 5 ha	Yes	Hollow bearing trees; Living or dead trees with hollow greater than 20cm diameter	The Powerful Owl inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest.;1|The Powerful Owl requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well. The species breeds and hunts in open or	Potential forage and breeding habitat supported across the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation comprising species such as Turpentine Syncarpia glomulifera, Black She-oak Allocasuarina littoralis, Blackwood Acacia melanoxylon, Rough-barked Apple Angophora floribunda, Cherry Ballart Exocarpus cupressiformis and a number of eucalypt species. ;2|The main prey items are medium-sized arboreal marsupials, particularly the Greater Glider, Common Ringtail Possum and Sugar Glider. There may be marked regional differences in the prey taken by Powerful Owls. For example, in southern NSW, Ringtail		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									Possum make up the bulk of prey in the lowland or coastal habitat. At higher elevations, such as the tableland forests, the Greater Glider may constitute almost all of the prey for a pair of Powerful Owls. Flying foxes are important prey in some areas; birds comprise about 10-50% of the diet depending on the availability of preferred mammals. As most prey species require hollows and a shrub layer, these are important habitat components for the owl. ;3|Pairs of Powerful Owls demonstrate high fidelity to a large territory, the size of which varies with habitat quality and thus prey densities. In good habitats a mere 400 can support a pair; where hollow trees and prey have been depleted the owls need up to 4000 ha.;4|Powerful		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									Owls nest in large tree hollows (at least 0.5 m deep), in large eucalypts (diameter at breast height of 80-240 cm) that are at least 150 years old. While the female and young are in the nest hollow the male Powerful Owl roosts nearby (10-200 m) guarding them, often choosing a dense "grove" of trees that provide concealment from other birds that harass him.;5|Powerful Owls are monogamous and mate for life. Nesting occurs from late autumn to mid-winter but is slightly earlier in north-eastern NSW (late summer - mid autumn). Clutches consist of two dull white eggs and incubation lasts approximately 38 days.;6|		
Pachycephala olivacea	Olive Whistler	Ecosystem		Yes	Variegated - 31-70% habitat retained	25 - 100 ha	Yes		Mostly inhabit wet forests above about 500m. During the winter months they	Potential forage habitat supported across	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									may move to lower altitudes.;1|Forage in trees and shrubs and on the ground, feeding on berries and insects.;2|Make nests of twigs and grass in low forks of shrubs.;3|Lay two or three eggs between September and January;4|	the development footprint	
Petroica boodang	Scarlet Robin	Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes		The Scarlet Robin lives in dry eucalypt forests and woodlands. The understorey is usually open and grassy with few scattered shrubs.;1|This species lives in both mature and regrowth vegetation. It occasionally occurs in mallee or wet forest communities, or in wetlands and tea-tree swamps.;2|Scarlet Robin habitat usually contains abundant logs and fallen timber: these are important components of its habitat.;3|The Scarlet Robin breeds on ridges, hills and foothills of the	Potential forage habitat supported across the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									western slopes, the Great Dividing Range and eastern coastal regions; this species is occasionally found up to 1000 metres in altitude.;4|The Scarlet Robin is primarily a resident in forests and woodlands, but some adults and young birds disperse to more open habitats after breeding.;5|In autumn and winter many Scarlet Robins live in open grassy woodlands, and grasslands or grazed paddocks with scattered trees.;6|The Scarlet Robin is a quiet and unobtrusive species which is often quite tame and easily approached.;7|Birds forage from low perches, fence-posts or on the ground, from where they pounce on small insects and other invertebrates which are taken from the ground, or off tree trunks and logs; they sometimes		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									forage in the shrub or canopy layer.;8|Scarlet Robin pairs defend a breeding territory and mainly breed between the months of July and January; they may raise two or three broods in each season.;9|This species' nest is an open cup made of plant fibers and cobwebs and is built in the fork of tree usually more than 2 metres above the ground; nests are often found in a dead branch in a live tree, or in a dead tree or shrub.;10|Eggs are pale greenish-, bluish- or brownish-white, spotted with brown; clutch size ranges from one to four.;11|Birds usually occur singly or in pairs, occasionally in small family parties; pairs stay together year-round.;12|In autumn and winter, the Scarlet Robin joins mixed flocks of other small insectivorous		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									birds which forage through dry forests and woodlands.;13|		
Petroica phoenicea	Flame Robin	Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes		Breeds in upland tall moist eucalypt forests and woodlands, often on ridges and slopes.;1|Prefers clearings or areas with open understoreys.;2|The ground layer of the breeding habitat is dominated by native grasses and the shrub layer may be either sparse or dense.;3|Occasionally occurs in temperate rainforest, and also in herbfields, heathlands, shrublands and sedgelands at high altitudes.;4|In winter, birds migrate to drier more open habitats in the lowlands (i.e. valleys below the ranges, and to the western slopes and plains).;5|Often occurs in recently burnt areas; however, habitat becomes unsuitable as vegetation	Potential forage habitat supported across the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									closes up following regeneration.;6|In winter lives in dry forests, open woodlands and in pastures and native grasslands, with or without scattered trees.;7|In winter, occasionally seen in heathland or other shrublands in coastal areas.;8|Birds forage from low perches, from which they sally or pounce onto small invertebrates which they take from the ground or off tree trunks, logs and other coarse woody debris.;9|Flying insects are often taken in the air and sometimes gleans for invertebrates from foliage and bark.;10|In their autumn and winter habitats, birds often sally from fence-posts or thistles and other prominent perches in open habitats.;11|Occur singly, in pairs, or in flocks of up to 40 birds or more; in the		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									non-breeding season they will join up with other insectivorous birds in mixed feeding flocks.;12|Breeds in spring to late summer.;13|Nests are often near the ground and are built in sheltered sites, such as shallow cavities in trees, stumps or banks.;14|Builds an open cup nest made of plant materials and spider webs.;15|Eggs are oval in shape and are pale bluish- or greenish-white and marked with brownish blotches; clutch size is three or four eggs.;16|		
Stagonopleura guttata	Diamond Firetail	Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes		Found in grassy eucalypt woodlands, including Box-Gum Woodlands and Snow Gum Eucalyptus pauciflora Woodlands.;1|Also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland	Potential forage habitat supported across the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									derived from other communities.;2|Often found in riparian areas (rivers and creeks), and sometimes in lightly wooded farmland.;3|Feeds exclusively on the ground, on ripe and partly-ripe grass and herb seeds and green leaves, and on insects (especially in the breeding season).;4|Usually encountered in flocks of between 5 to 40 birds, occasionally more.;5|Groups separate into small colonies to breed, between August and January.;6|Nests are globular structures built either in the shrubby understorey, or higher up, especially under hawk's or raven's nests.;7|Birds roost in dense shrubs or in smaller nests built especially for roosting.;8|Appears to be sedentary, though some		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									populations move locally, especially those in the south.;9|Has been recorded in some towns and near farm houses.;10|		
Tyto novaehollandiae	Masked Owl	Species/ Ecosystem		Yes	Fragmented - 11-30 % habitat retained	< 5 ha	Yes	Hollow bearing trees; Living or dead trees with hollows greater than 20cm diameter.	Lives in dry eucalypt forests and woodlands from sea level to 1100 m.;1|A forest owl, but often hunts along the edges of forests, including roadsides.;2|The typical diet consists of tree-dwelling and ground mammals, especially rats.;3|Pairs have a large home-range of 500 to 1000 hectares.;4|Roosts and breeds in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting.;5|	Potential forage and breeding habitat supported across the development footprint	Moderate
Tyto tenebricosa	Sooty Owl	Species/ Ecosystem		Yes	Intact - over 70% natural habitat retained	> 100 ha	Yes	Caves; Caves or cliffines/ledges Hollow bearing trees; Living or dead trees with hollows	Occurs in rainforest, including dry rainforest, subtropical and warm temperate rainforest, as well as moist eucalypt forests.;1|Roosts by day in the hollow of a tall forest tree or in heavy vegetation;	Potential forage and breeding habitat supported across the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
								greater than 20cm diameter.	hunts by night for small ground mammals or tree-dwelling mammals such as the Common Ringtail Possum (Pseudocheirus peregrinus) or Sugar Glider (Petaurus breviceps).;2|Nests in very large tree-hollows.;3|		
Mammals											
Aepyprymnus rufescens	Rufous Bettong	Species		Yes	Variegated - 31-70% habitat retained	< 5 ha	Yes		Rufous Bettongs inhabit a variety of forests from tall, moist eucalypt forest to open woodland, with a tussock grass understorey. A dense cover of tall native grasses is the preferred shelter.;1|They sleep during the day in cone-shaped nests constructed of grass in a shallow depression at the base of a tussock or fallen log.;2|At night they feed on grasses, herbs, seeds, flowers, roots, tubers, fungi and occasionally insects.;3|	Marginal potential habitat occurs within the subject land and habitats within the transmission line corridor are degraded	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
Cercartetus nanus	Eastern Pygmy-possum	Species		Yes	Fragmented - 11-30 % habitat retained	< 5 ha	Yes		Found in a broad range of habitats from rainforest through sclerophyll (including Box-Ironbark) forest and woodland to heath, but in most areas woodlands and heath appear to be preferred, except in north-eastern NSW where they are most frequently encountered in rainforest.;1|Feeds largely on nectar and pollen collected from banksias, eucalypts and bottlebrushes; an important pollinator of heathland plants such as banksias; soft fruits are eaten when flowers are unavailable.;2|Also feeds on insects throughout the year; this feed source may be more important in habitats where flowers are less abundant such as wet forests.;3|Shelters in tree hollows, rotten stumps, holes in the ground, abandoned bird-nests,	Potential habitat is present within the development footprint.	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									Ringtail Possum (Pseudocheirus peregrinus) dreys or thickets of vegetation, (e.g. grass-tree skirts); nest-building appears to be restricted to breeding females; tree hollows are favoured but spherical nests have been found under the bark of eucalypts and in shredded bark in tree forks.;4|Appear to be mainly solitary, each individual using several nests, with males having non-exclusive home-ranges of about 0.68 hectares and females about 0.35 hectares.;5|Young can be born whenever food sources are available, however most births occur between late spring and early autumn.;6|Agile climbers, but can be caught on the ground in traps, pitfalls or postholes; generally nocturnal.;7|Frequently		

<table>
<tr><th colspan="3">BAM candidate species identification</th><th colspan="5">Step 1: Identify threatened species for assessment</th><th>Step 2</th><th colspan="3">Step 3: Identify candidate species credit species for further assessment</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>spends time in torpor especially in winter, with body curled, ears folded and internal temperature close to the surroundings.;8|</td><td></td><td></td></tr>
<tr><td>Chalinolobus dwyeri</td><td>Large-eared Pied Bat</td><td>Species</td><td></td><td>Yes</td><td>Fragmented - 11-30 % habitat retained</td><td>< 5 ha</td><td>Yes</td><td></td><td>Roosts in caves (near their entrances), crevices in cliffs, 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. Females have been recorded raising young in maternity roosts (c. 20-40 females) from November through to January in roof domes in sandstone caves and overhangs. They remain loyal to the same cave over many years.;1|Found in well-timbered areas containing gullies.;2|The relatively short, broad wing</td><td>Habitat occurs within and adjacent to the development footprint</td><td>Recorded by survey</td></tr>
</table>

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									combined with the low weight per unit area of wing indicates maneuverable flight. This species probably forages for small, flying insects below the forest canopy.;3|Likely to hibernate through the coolest months.;4|It is uncertain whether mating occurs early in winter or in spring.;5|		
Dasyurus maculatus	Spotted-tailed Quoll	Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes		Recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline.;1|Individual animals use hollow-bearing trees, fallen logs, small caves, rock outcrops and rocky-cliff faces as den sites.;2|Mostly nocturnal, although will hunt during the day; spends most of the time on the ground,	Habitat occurs within and adjacent to the development footprint	Recorded by survey

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									although also an excellent climber and will hunt possums and gliders in tree hollows and prey on roosting birds.;3|Use communal 'latrine sites', often on flat rocks among boulder fields, rocky cliff-faces or along rocky stream beds or banks. Such sites may be visited by multiple individuals and can be recognised by the accumulation of the sometimes characteristic 'twisty-shaped' faeces deposited by animals.;4|A generalist predator with a preference for medium-sized (500g-5kg) mammals. Consumes a variety of prey, including gliders, possums, small wallabies, rats, birds, bandicoots, rabbits, reptiles and insects. Also eats carrion and takes domestic fowl.;5|Females occupy home ranges of 200-500 hectares, while males		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									occupy very large home ranges from 500 to over 4000 hectares. Are known to traverse their home ranges along densely vegetated creeklines.;6|Average litter size is five; both sexes mature at about one year of age. Life expectancy in the wild is about 3-4 years.;7|		
Falsistrellus tasmaniensis	Eastern False Pipistrelle	Ecosystem		Yes	Variegated - 31-70% habitat retained	5 - 24 ha	Yes		Prefers moist habitats, with trees taller than 20 m.;1|Generally roosts in eucalypt hollows, but has also been found under loose bark on trees or in buildings.;2|Hunts beetles, moths, weevils and other flying insects above or just below the tree canopy.;3|Hibernates in winter.;4|Females are pregnant in late spring to early summer.;5|	Habitat occurs within and adjacent to the development footprint	Recorded by survey
Macropus parma	Parma Wallaby	Species		Yes	Variegated - 31-70% habitat retained	5 - 24 ha	Yes		Preferred habitat is moist eucalypt forest with thick, shrubby understorey, often	Potential habitat occurs in higher condition areas	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									with nearby grassy areas, rainforest margins and occasionally drier eucalypt forest.;1|Typically feed at night on grasses and herbs in more open eucalypt forest and the edges of nearby grassy areas.;2|During the day they shelter in dense cover.;3|	connected to Ben Halls Gap Nature Reserve. Potential habitats within the transmission line corridor are degraded	
Micronomus norfolkensis	Eastern Coastal Free-tailed Bat	Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes		Occur in dry sclerophyll forest, woodland, swamp forests and mangrove forests east of the Great Dividing Range.;1|Roost mainly in tree hollows but will also roost under bark or in man-made structures.;2|Usually solitary but also recorded roosting communally, probably insectivorous.;3|	Habitat occurs within and adjacent to the development footprint	Recorded by survey
Miniopterus australis	Little Bent-winged Bat	Species/ Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes	Caves; Cave, tunnel, mine, culvert or other structure known or	Moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, Melaleuca swamps, dense coastal forests and banksia scrub. Generally found in	Habitat occurs within and adjacent to the development footprint	Recorded by survey

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
								suspected to be used for breeding including species records in BioNet with microhabitat code 'IC – in cave'; observation type code 'E nest-roost'; with numbers of individuals >500; or from the scientific literature.	well-timbered areas.;1|Little Bentwing-bats roost in caves, tunnels, tree hollows, abandoned mines, stormwater drains, culverts, bridges and sometimes buildings during the day, and at night forage for small insects beneath the canopy of densely vegetated habitats.;2|They often share roosting sites with the Common Bentwing-bat and, in winter, the two species may form mixed clusters.;3|In NSW the largest maternity colony is in close association with a large maternity colony of Large Bentwing-bats (Miniopterus orianae) and appears to depend on the large colony to provide the high temperatures needed to rear its young.;4|Maternity colonies form in spring and birthing occurs in early summer. Males and		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									juveniles disperse in summer.;5|Only five nursery sites /maternity colonies are known in Australia.;6|		
Miniopterus orianae oceanensis	Large Bent-winged Bat	Species/ Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes	Caves; Cave, tunnel, mine, culvert or other structure known or suspected to be used for breeding including species records with microhabitat code "IC - in cave;" observation type code "E nest-roost;" with numbers of individuals >500	Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures.;1|Form discrete populations centered on a maternity cave that is used annually in spring and summer for the birth and rearing of young.;2|Maternity caves have very specific temperature and humidity regimes.;3|At other times of the year, populations disperse within about 300 km range of maternity caves.;4|Cold caves are used for hibernation in southern Australia.;5|Breeding or roosting colonies can number from 100 to	Habitat occurs within and adjacent to the development footprint	Recorded by survey

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									150,000 individuals.;6|Hunt in forested areas, catching moths and other flying insects above the tree tops.;7|		
Myotis macropus	Southern Myotis	Species		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes		Generally roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage.;1|Forage over streams and pools catching insects and small fish by raking their feet across the water surface.;2|In NSW females have one young each year usually in November or December.;3|	Habitat occurs within and adjacent to the development footprint	Recorded by survey
Nyctophilus corbeni	Corben's Long-eared Bat	Ecosystem		Yes	Fragmented - 11-30 % habitat retained	5 - 24 ha	Yes		Inhabits a variety of vegetation types, including mallee, bulloke Allocasuarina leuhmanni and box eucalypt dominated communities, but it is distinctly more common in	Potential habitat is present within the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland.;1|Roosts in tree hollows, crevices, and under loose bark.;2|Slow flying agile bat, utilising the understorey to hunt non-flying prey - especially caterpillars and beetles - and will even hunt on the ground.;3|Mating takes place in autumn with one or two young born in late spring to early summer.;4|		
Petauroides volans	Greater Glider	Ecosystem		Yes	Variegated - 31-70% habitat retained	5 - 24 ha	Yes			Habitat occurs within and adjacent to the development footprint	Recorded by survey
Petaurus australis	Yellow-bellied Glider	Ecosystem		Yes	Variegated - 31-70% habitat retained	25 - 100 ha	Yes		Occur in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils.;1|Forest type preferences vary with latitude and elevation; mixed coastal forests to dry	Habitat occurs within and adjacent to the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									escarpment forests in the north; moist coastal gullies and creek flats to tall montane forests in the south.;2|Feed primarily on plant and insect exudates, including nectar, sap, honeydew and manna with pollen and insects providing protein.;3|Extract sap by incising (or biting into) the trunks and branches of favoured food trees, often leaving a distinctive 'V'-shaped scar.;4|Live in small family groups of two - six individuals and are nocturnal.;5|Den, often in family groups, in hollows of large trees.;6|Very mobile and occupy large home ranges between 20 to 85 ha to encompass dispersed and seasonally variable food resources.;7|		
Petaurus norfolcensis	Squirrel Glider	Species		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes		Inhabits mature or old growth Box, Box-Ironbark woodlands and River Red	Potential habitat is present within the development	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									Gum forest west of the Great Dividing Range and Blackbutt-Bloodwood forest with heath understorey in coastal areas.;1|Prefers mixed species stands with a shrub or Acacia midstorey.;2|Live in family groups of a single adult male one or more adult females and offspring.;3|Require abundant tree hollows for refuge and nest sites.;4|Diet varies seasonally and consists of Acacia gum, eucalypt sap, nectar, honeydew and manna, with invertebrates and pollen providing protein.;5|	footprint	
Petrogale penicillata	Brush-tailed Rock-wallaby	Species		Yes	Fragmented - 11-30 % habitat retained	5 - 24 ha	Yes		Occupy rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges, often facing north.;1|Shelter or bask during the day in rock crevices, caves and	Potential habitat is present within the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									overhangs and are most active at night when foraging.;2|Browse on vegetation in and adjacent to rocky areas eating grasses and forbs as well as the foliage and fruits of shrubs and trees.;3|Highly territorial and have strong site fidelity with an average home range size of about 15 ha. Males tend to have larger home ranges than females.;4|The home range consists of a refuge area and a foraging range linked by habitually used commuting routes.;5|Females settle in or near their mother's range, while males mainly disperse between female groups within colonies, and less commonly between colonies.;6| Dominant males associate and breed with multiple females.;7|Breeding occurs throughout the year with a peak in births between		

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									February and May, especially in the southern parts of the range and at higher altitudes.;8|		
Phascogale tapoatafa	Brush-tailed Phascogale	Species		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes		Prefer dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter.;1|Also inhabit heath, swamps, rainforest and wet sclerophyll forest.;2|Agile climber foraging preferentially in rough barked trees of 25 cm DBH or greater..;3|Feeds mostly on arthropods but will also eat other invertebrates, nectar and sometimes small vertebrates.;4|Females have exclusive territories of approximately 20 - 40 ha, while males have overlapping territories often greater than 100 ha.;5|Nest and shelter in tree hollows with entrances 2.5 - 4 cm wide and use many different hollows	Potential habitat is present within the development footprint. However, BioNet notes the species occurrences in the following IBRA subregions relevant to the project site. Walcha Plateau IBRA - Known to occur, but a geographic restriction exists stating "East of the Tia River". This river's headwaters occur >50kms north-east of the assessment area. Nearest record of the species is	Negligible

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									over a short time span.;6|Mating occurs May - July; males die soon after the mating season whereas females can live for up to three years but generally only produce one litter.;7|	56kms east. Tomala IBRA - species known, with no geographic restrictions listed. However, only records of the species comprise an inaccurate record (10kms) noted as Mount Royal SF (or NP) from 1991, one more low accuracy (10kms) in similar location (but in Barrington Tops IBRA), one further single record in the IBRA from 1974, and >66kms from the assessment area. Peel IBRA - Species predicted to occur (i.e. not known), no	

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
										geographic restrictions listed. Species never recorded in IBRA.	
Phascolarctos cinereus	Koala	Species/ Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes	Other; Areas identified via survey as important habitat (see comments)	Inhabit eucalypt woodlands and forests.;1|Feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area will select preferred browse species.;2|Inactive for most of the day, feeding and moving mostly at night.;3|Spend most of their time in trees, but will descend and traverse open ground to move between trees.;4|Home range size varies with quality of habitat, ranging from less than two ha to several hundred hectares in size.;5|Generally solitary, but have complex social hierarchies based on a dominant male with a territory overlapping several females and sub-	Habitat occurs within and adjacent to the development footprint	Recorded by survey

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									ordinate males on the periphery.;6|Females breed at two years of age and produce one young per year.;7|		
Phoniscus papuensis	Golden-tipped Bat	Ecosystem		Yes	Variegated - 31-70% habitat retained	< 5 ha	Yes		Found in rainforest and adjacent wet and dry sclerophyll forest up to 1000m. Also recorded in tall open forest, Casuarina-dominated riparian forest and coastal Melaleuca forests.;1|Bats will fly up to two kilometres from roosts to forage in rainforest and sclerophyll forest on mid and upper-slopes.;2|Roost mainly in rainforest gullies on small first- and second-order streams in usually abandoned hanging Yellow-throated Scrubwren and Brown Gerygone nests modified with an access hole on the underside. Bats may also roost under thick moss on tree trunks, in tree	Potential habitat is present within the development footprint	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									hollows, dense foliage and epiphytes.;3|Bats will use multiple roost and change roosts regularly.;4|Bats roost individually or in small colonies which can contain up to approximately 20 bats of both males and females or just a single sex.;5|Maternity roots may occur away from water sources with one maternity roost found 450m upslope of the nearest water course in a broken bough.;6|Specialist feeder on small web-building spiders.;7|There is one breeding cycle per year.;8|		
Pteropus poliocephalus	Grey-headed Flying-fox	Species/ Ecosystem		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes	Other; Breeding camps	Occur in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops.;1|Roosting camps are generally located within 20 km of a regular food	Potential forage habitat supported across the development footprint	Recorded by survey

<table>
<tr><th colspan="3">BAM candidate species identification</th><th colspan="5">Step 1: Identify threatened species for assessment</th><th>Step 2</th><th colspan="3">Step 3: Identify candidate species credit species for further assessment</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>source and are commonly found in gullies, close to water, in vegetation with a dense canopy.;2|Individual camps may have tens of thousands of animals and are used for mating, and for giving birth and rearing young.;3|Annual mating commences in January and conception occurs in April or May; a single young is born in October or November.;4|Site fidelity to camps is high; some camps have been used for over a century.;5|Can travel up to 50 km from the camp to forage; commuting distances are more often <20 km.;6|Feed on the nectar and pollen of native trees, in particular Eucalyptus, Melaleuca and Banksia, and fruits of rainforest trees and vines.;7|Also forage in cultivated gardens and fruit crops.;8|</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="3">BAM candidate species identification</th><th colspan="5">Step 1: Identify threatened species for assessment</th><th>Step 2</th><th colspan="3">Step 3: Identify candidate species credit species for further assessment</th></tr>
<tr><td>Saccolaimus flaviventris</td><td>Yellow-bellied Sheathtail-bat</td><td>Ecosystem</td><td></td><td>Yes</td><td>Fragmented - 11-30 % habitat retained</td><td>< 5 ha</td><td>Yes</td><td></td><td>Roosts singly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows.;1|When foraging for insects, flies high and fast over the forest canopy, but lower in more open country.;2|Forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory.;3|Breeding has been recorded from December to mid-March, when a single young is born.;4|Seasonal movements are unknown; there is speculation about a migration to southern Australia in late summer and autumn.;5|</td><td>Habitat occurs within and adjacent to the development footprint</td><td>Recorded by survey</td></tr>
<tr><td>Scoteanax rueppellii</td><td>Greater Broad-nosed Bat</td><td>Ecosystem</td><td></td><td>Yes</td><td>Variegated - 31-70% habitat retained</td><td>5 - 24 ha</td><td>Yes</td><td></td><td>Utilises a variety of habitats from woodland through to moist and dry eucalypt forest and rainforest, though it is most</td><td>Habitat occurs within and adjacent to the development footprint</td><td>Recorded by survey</td></tr>
</table>

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									commonly found in tall wet forest.;1|Although this species usually roosts in tree hollows, it has also been found in buildings.;2|Forages after sunset, flying slowly and directly along creek and river corridors at an altitude of 3 - 6 m.;3|Open woodland habitat and dry open forest suits the direct flight of this species as it searches for beetles and other large, slow-flying insects; this species has been known to eat other bat species.;4|Little is known of its reproductive cycle, however a single young is born in January; prior to birth, females congregate at maternity sites located in suitable trees, where they appear to exclude males during the birth and raising of the single young.;5|		
Thylogale	Red-legged	Ecosystem		Yes	Fragmented - 11-30	5 - 24 ha	Yes		Inhabits forest with a dense	Potential forage	Moderate

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
stigmatica	Pademelon				% habitat retained				understorey and ground cover, including rainforest, moist eucalypt forest and vine scrub.;1| Wet gullies with dense, shrubby ground cover provide shelter from predators.;2|In NSW, rarely found outside forested habitat.;3|They disperse from dense shelter areas to feed from late afternoon to early morning, favouring native grasses and herbs on the edge of the forest.;4|Also known to feed on fruits, young seedling leaves and stems, fungi and ferns.;5|	habitat supported across the development footprint	
Vespadelus troughtoni	Eastern Cave Bat	Species		Yes	Fragmented - 11-30 % habitat retained	5 - 24 ha	Yes	Caves; Within two kilometres of rocky areas containing caves, overhangs, escarpments, outcrops, crevices or	Very little is known about the biology of this uncommon species.;1|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 in colonies of	Habitat occurs within and adjacent to the development footprint	Recorded by survey

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
								boulder piles, or within two kilometres of old mines, tunnels, old buildings or sheds."	up to 500 individuals.;2|Occasionally found along cliff-lines in wet eucalypt forest and rainforest.;3|Little is understood of its feeding or breeding requirements or behaviour.;4|		
Reptiles											
Hoplocephalus bitorquatus	Pale-headed Snake	Species		Yes	Fragmented - 11-30 % habitat retained	< 5 ha	No		The Pale-headed Snake is a highly cryptic species that can spend weeks at a time hidden in tree hollows.;1|Found mainly in dry eucalypt forests and woodlands, cypress forest and occasionally in rainforest or moist eucalypt forest.;2|In drier environments, it appears to favour habitats close to riparian areas.;3|Shelter during the day between loose bark and tree-trunks, or in hollow trunks and limbs of dead trees.;4|The main prey is tree frogs although lizards and small mammals are also	Species known only to occur at altitudes much lower than the development footprint, within highest elevation BioNet records including 550m elevation (approx.) north of Bindarri NP (>200kms from the project site), 390m elevation (approx.) west of Kwiambal NP (>150kms from the project site) and 375m	Negligible

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									taken.;5|The Pale-headed Snake is relatively unusual amongst elapid snakes in that it is well adapted to climbing trees.;6|	elevation (approx.) west of Gunnedah (>100kms from the project site). The lowest point of the project site occurs along the transmission line at an altitude of 750 metres (approx.) and as such the development footprint does not support habitat for the species.	
Uvidicolus sphyrurus	Border Thick-tailed Gecko	Species		Yes	Relictual - 10% or less habitat retained	< 5 ha	Yes		As implied by another of its common names (Granite Thick-tailed Gecko), this species often occurs on steep rocky or scree slopes, especially granite. Recent records from basalt and metasediment slopes and flats indicate its habitat selection is broader than formerly thought and may	Species distribution is north of the project site and has never been recorded (or predicted to occur in) Tomala or Walcha Plateau IBRA subregions. Peel	Low

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									have extended into areas that were cleared for agriculture.;1|Favours forest and woodland areas with boulders, rock slabs, fallen timber and deep leaf litter. Occupied sites often have a dense tree canopy that helps create a sparse understorey.;2|These Geckos are active at night and shelter by day under rock slabs, in or under logs, and under the bark of standing trees.	IBRA has records 20-25kms north of the site across cleared land, which are at the southern extent of the species' occurrence. Peel IBRA abuts parts of the subject land and includes the western 60% of the transmission line corridor.	
Plants											
Acacia atrox	Myall Creek Wattle	Species	N/A	N/A	N/A	N/A	Yes	N/A	Species grows in soils ranging from deep black clay over basalt to shallow red stony loams on the upper slope and crest of a low hill. Currently known from two populations near Delungra and Gurley. There individuals grow in a partly cleared paddock of box woodland with a native grassy understorey.	Known populations more than 200km north/ northwest of the assessment area. No records within proximity to the site. Potential habitat in PCT599 is marginal and unlikely to	Unlikely

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
										support the species.	
Eucalyptus nicholii	Narrow-leaved Black Peppermint	Species	N/A	N/A	N/A	N/A	Yes	N/A	Typically grows in dry grassy woodland, on shallow soils of slopes and ridges- prefers infertile soils derived from granite or metasedimentary rock. The species occurs from Nundle to north of Tenterfield being most common in the central portions of its range.	Potential habitat within grassy woodland and dry sclerophyll forests within the site	Possible
Chiloglottis platyptera	Barrington Tops Ant Orchid	Species	N/A	N/A	N/A	N/A	Yes	N/A	Grows in moist areas in tall open Eucalypt forest with a grassy understorey and also around rainforest edges; generally on rich brown loam soils. Known to occur within the area including at Ben Halls Gap Nature Reserve.	Potential habitat within grassy woodland and open forests within the site.	Likely
Dichanthium setosum	Bluegrass	Species	N/A	N/A	N/A	N/A	Yes	N/A	Found in heavy basaltic black soil and red-brown loams with clay subsoil. Often in moderately disturbed areas including cleared woodland, grassy	Potential habitat within dry sclerophyll forests, derived native grassland and forested	Possible

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									roadside remnants and high disturbed pasture; associated with species including Eucalyptus albens, E.melanophloia, E.melliodora, E.viminalis, Myoporum debile, Aristida ramose, Themeda triandra, Poa sieberiana, Bothriochloa ambigua, Medicago minima.	wetlands within the site.	
Digitaria porrecta	Finger Panic Grass	Species	N/A	N/A	N/A	N/A	Yes	N/A	Occurs in native grassland, woodland or open forest with a grassy understorey on richer soils. Typically associated with E.albens, Acacia pendula Austrostipa aristiglumis, Enteropogon acicularis, Cyperus bifax, Hibiscus trionum and Neptunia gracilis.	Habitat within box woodland marginal for the species. No other suitable habitat within the site.	Unlikely
Homoranthus prolixus	Granite Homoranthus	Species	N/A	N/A	N/A	N/A	Yes	On or near granite outcrops and slabs or within 100m	Grows in heath patches, in skeletal soil among crevices of granite outcrops within the Ironbark Nature Reserve (east of Barraba) and neighbouring properties. The species has not been recorded in a	No suitable habitat within the site	Unlikely

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									survey of other granitic outcrop areas in the region.		
Monotaxis macrophylla	Large-leafed Monotaxis	Species	N/A	N/A	N/A	N/A	Yes	N/A	Found in coastal heath, arid shrubland, forests and montane heath from sea level to 1300m altitude, subject to regular fire.	No suitable habitat within the site	Unlikely
Picris evae	Hawkweed	Species	N/A	N/A	N/A	N/A	Yes	N/A	Occurs within open Eucalypt forest including a canopy of E.melliodora, E.crebra, E.populnea, E.albens, Angophora subvelutina, Allocasuarina torulosa, Cunninghamiana with a Dichanthium grassy understorey. Recorded north of Inverell and at Oxley Park Tamworth.	Open Eucalypt woodland within site does not support Dichanthium spp. dominated ground layer and is marginal for the species.	Unlikely
Polygala linariifolia	Native Milkwort	Species	N/A	N/A	N/A	N/A	Yes	N/A	Sandy soils in dry eucalypt forest and woodland with a sparse understorey. The species has been recorded from the Inverell and Torrington districts growing in dark sandy loam on granite in shrubby forest of Eucalyptus caleyi, Eucalyptus dealbata and	Potential habitat within PCT 1194	Possible.

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									Callitris, and in yellow podsolic soil on granite in layered open forest		
Pterostylis elegans	Elegant Greenhood	Species	N/A	N/A	N/A	N/A	Yes	N/A	Known to occur on red-brown loams at elevations between 950m and 1200m. Found among grass and shrubs in tall open Eucalypt forest.	Suitable habitat in open forest within the site.	Possible
Commersonia procumbens	Commersonia procumbens	Species	N/A	N/A	N/A	N/A	Yes	Piliga sandstone	Grows in sandy sites, often along roadsides. The species is often found as a pioneer species of disturbed habitats. It has been recorded colonising disturbed areas such as roadsides, the edges of quarries and gravel stockpiles and a recently cleared easement under power lines.	No PCTs known to be associated with the species occur within the site	Unlikely
Tasmannia glaucifolia	Fragrant Pepperbush	Species	N/A	N/A	N/A	N/A	Yes	N/A	Usually grows in or near Antarctic Beech Nothofagus moorei rainforest along streams in mountain areas at altitudes of between 1200 and 1500 m altitude. Also occurs in	Eucalypt forest within PCT 934, 931 and 927 offers marginal habitat for the species.	Possible

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									tall scrub, on seepage lines in tall eucalypt forest and in grassy woodland.		
Tasmannia purpurascens	Broad-leaved Pepperbush	Species	N/A	N/A	N/A	N/A	Yes	N/A	Grows in tall, moist eucalypt forest, sub-alpine woodland and cool temperate rainforest. Has been observed growing on cleared land, logged forest and graded fire trails.	Suitable habitat within open woodland and forest within the site (PCT 934, 931, 927 and 1194)	Likely
Thesium australe	Austral Toadflax	Species	N/A	N/A	N/A	N/A	Yes	N/A	It occurs in shrubland, grassland or woodland, often on damp sites. Vegetation types include open grassy heath dominated by Leptospermum myrtifolium, Hakea microcarpa, Callistemon sieberi, Grevillea lanigera, Epacris microphylla and Poa spp., Kangaroo Grass grassland surrounded by Eucalyptus woodland; and grassland dominated by Cymbopogon refractus.	Suitable habitat within open woodland, Eucalypt forest and derived native grasslands.	Possible
Tylophora linearis	Tylophora linearis	Species	N/A	N/A	N/A	N/A	Yes	N/A	Grows in dry scrub and open forest. Records from	Associated PCTs within the	Unlikely

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									low altitude (300-400m) sedimentary flats and dry woodlands of E.fribosa, E.sideroxylon, E.albens, Callitris endlicheri, Callitris glaucophylla and Allocasuarina luehmannii.	subject land occur at higher altitudes than recorded for the species.	
***Asterolasia* sp. 'Dungowan Creek'**	Dungowan Starbush	Species	N/A	N/A	N/A	N/A	Yes	N/A	In the vicinity of Dungowan Dam the Dungowan Starbush grows in rocky alluvial soil along a creekbank dominated by Casuarina cunninghamiana with or without Eucalyptus viminalis. Recent populations have been found growing near (100-150m) major drainage lines on lower and mid slopes in open forest in moderately deep brown loamy soils. Overstorey trees at these locations were dominated by Eucalyptus obliqua and E. nobilis with or without E. radiata ssp. sejuncta.	Marginal habitat within PCT 934.	Possible.
Homopholis belsonii	Belson's Panic	Species	N/A	N/A	N/A	N/A	Yes	N/A	Grows in dry woodland (e.g. Belah) often on poor soils. Found mostly on	Site lacks suitable habitat.	Unlikely

BAM candidate species identification			Step 1: Identify threatened species for assessment					Step 2	Step 3: Identify candidate species credit species for further assessment		
									heavy texture cracking soils derived from basalt or alluvials between 00-520m altitude.		
Euphrasia arguta	Euphrasia arguta	Species	N/A	N/A	N/A	N/A	Yes	N/A	Plants from the Nundle area have been recorded in Eucalypt forest with a mixed grass and shrub understorey. Also know to occur in highly disturbance areas including road edges	Suitable habitat within the assessment area	Likely

* Conservation advice taken from BioNet and Commonwealth SPRAT databases

Appendix D Collision Risk Model Report

Hills of Gold Wind Farm
Bird Collision Risk Assessment

Prepared for Arup Group Pty Ltd

30 September 2020

Biosis offices

NEW SOUTH WALES

Albury
Phone: (02) 6069 9200
Email: albury@biosis.com.au

Newcastle
Phone: (02) 4911 4040
Email: newcastle@biosis.com.au

Sydney
Phone: (02) 9101 8700
Email: sydney@biosis.com.au

Western Sydney
Phone: (02) 9101 8700
Email: sydney@biosis.com.au

Wollongong
Phone: (02) 4201 1090
Email: wollongong@biosis.com.au

VICTORIA

Ballarat
Phone: (03) 5304 4250
Email: ballarat@biosis.com.au

Melbourne
Phone: (03) 8686 4800
Email: melbourne@biosis.com.au

Wangaratta
Phone: (03) 5718 6900
Email: wangaratta@biosis.com.au

Document information

Report to:	Arup Group Pty Ltd
Prepared by:	Ian Smales
Biosis project no.:	30695
File name:	30695.HoG.WF.CRM.DFT01.20200930.docx

Citation: Biosis 2020. Hills of Gold Wind Farm – Bird Collision Risk Assessment.

Document control

Version	Internal reviewer	Date issued
Draft version 01	Callan Wharfe	30/09/2020

Acknowledgements

Biosis acknowledges the contribution of the following people and organisations in undertaking this study:

- Arup Group – Matt Davis

Contents

1. Introduction 1

1.1 Background to quantitative risk modelling 1

1.2 Turbine collision risk model 2

1.2.1 Overview of the model 2

1.2.2 Avoidance rate 3

1.2.3 Result metrics – number of flights at risk vs number of collisions 4

2. Preliminary evaluation of turbine options 5

3. Model inputs and assumptions 6

3.1 Wind farm and turbine parameters 6

3.2 Bird species data 6

3.2.1 Estimating site-populations for raptors 7

4. Model results 9

4.1 Raptors 9

4.2 Other species 9

5. Conclusion 11

References 12

Appendix 1 13

1. Introduction

This document presents a collision risk assessment for birds at the proposed Hills of Gold Wind Farm, near Nundle New South Wales (NSW).

Biosis Pty Ltd has conducted a range of ecological assessments for the project. These surveys have included seasonal bird utilisation surveys at 21 sites across the wind farm study area. The data collected during those surveys forms the basis of the collision risk model presented in this report.

A background to risk modelling is provided in Section 1.1, and a description of the Biosis collision risk model can be found in Smales et al. (2013), provided in Appendix 1.

The risk modelling for Hills of Gold Wind Farm followed a three-stage approach, as detailed in this report. In the first stage, a brief evaluation was made of three different models of turbine that are under consideration for the project. The object of this stage was to ascertain which turbine might represent a 'worst-case' collision risk. This turbine was then used for subsequent stages of modelling with the intention that if either of the other two turbines are chosen for operational use by the project, the potential collision risk they pose will be lower than that presented herein.

In the second stage, the collision risk model was run to obtain results expressed as the probable annual number of flights at risk of collision (see Section 1.2.3) for all species that were recorded flying at rotor-swept height for the 'worst-case' turbine.

In the third stage, a likely size of the site-population was estimated for species of raptors and those values were incorporated into the model to obtain results expressed as the probable annual number of collisions (see Section 1.2.3) for those species.

1.1 Background to quantitative risk modelling

Collisions of birds and bats with wind turbines have been documented to occur at various frequencies around the world. Quantitative modelling to estimate the number of collision mortalities of threatened and non-threatened taxa is widely used as part of environmental impact assessments for proposed wind energy facilities (Masden & Cook 2016).

The impact of any collisions on the viability of threatened and non-threatened fauna populations is more important than determination of simple numbers of mortalities, and population models can be used in combination with results of collision risk models to evaluate such impacts, but population modelling would be a separate exercise to the collision risk modelling presented here.

Modelling of collision risk is reliant on empirical data for flights by species at the wind farm site. There is no practicable method to obtain species-specific flight data for bats that are likely to utilise the site and bat-call data does not provide information about the number of flights by bats. The modelling presented here is therefore confined to diurnal birds.

Mathematical modelling of risk is intended to provide an articulated, transparent and replicable evaluation of what may occur in the real world. The rationale behind projections is explicitly stated in the mathematics of a model, which means that the logical consistency of the predictions can be easily evaluated. The explicit nature of inputs and rigour entailed in modelling means that the process is replicable and consistent and it is open to analysis, criticism or modification when new information becomes available. Modelling is designed as a mechanism to evaluate uncertainties – if there was no uncertainty there would be no need to use a model. As a consequence of uncertainty in various parameters, some assumptions are required and while it is necessary to include some assumptions and arbitrary choices when deciding on the structure and parameters of a model, these choices are explicit. To the extent feasible, assumptions are informed by the best available information.

Models are also valuable for their heuristic capacities as they focus attention on important processes and parameters entailed in risk (Brook et al. 2002). Their very nature facilitates incorporation of information as it is learnt (Burgman 2005) and refinements should thus be expected of any model.

Most factors related to the layout, dimensions and geometry of turbines are known. The risk modelling detailed here entails the use of informed assumptions related particularly to the flights of birds. The bird utilisation data collected from the site provides an empirical basis for extrapolations required for use in the model. We consider the assumptions and values used are reasonable and they are informed by available information about the ecology of relevant species. As a consequence, we consider the results of modelling detailed here provide a basis for evaluation of probable effects of the proposed Hills of Gold Wind Farm on relevant species of birds.

The only alternative to a quantitative modelling approach is one of qualitative subjective judgement. All the benefits of using mathematical modelling outlined above are difficult, if not impossible to achieve with a purely qualitative assessment.

1.2 Turbine collision risk model

The risk of birds colliding with turbines at the proposed Hills of Gold Wind Farm has been assessed using the Biosis Pty. Ltd. Deterministic Collision Risk Model. The model was first developed in 2002 and has been refined over time to incorporate new data and knowledge, and has been applied at a wide range of proposed wind farm sites in Australia. A full description of the model (Smales *et al.* 2013) is provided in Appendix 1.

1.2.1 Overview of the model

The collision risk model takes account of bird flights that occur within the height zone that will be occupied by turbines. Data for the number of flights and their heights was documented by a regime of fixed-time point counts at locations representative of future turbine locations across the site. The model uses the empirical sample of flight data for each species and extrapolates that to determine a potential number of such flights that might occur over an entire 12-month period. This factor takes into account what is known about seasonal presence of particular species that may be migratory or may be present only for part of the year for other reasons.

In the model, the turbine is decomposed into its static and dynamic components. The entire turbine (including the tower, nacelle and the rotor *when stationary*) represents the static component. The dynamic component is the volume swept by the leading edge of the rotor blades in the time it takes the species of interest to pass across the depth of the swept disk.

Since the turbine tower below rotor swept height is always a static component and poses minimal collision risk, the model takes this into account by dividing flights into those below turbine rotor height, and those within the height zone swept by turbine rotors and allocating different risk rates to these height classes.

The risk assessment accounts for a combination of variables that are specific to the proposed wind farm and to data for birds from the vicinity of the farm. They include the following:

- The numbers flights of each species below rotor height, and for which just the lower portion of turbine towers present a collision risk.
- The numbers of flights at heights within the zone swept by turbine rotors, and for which the upper portion of towers, nacelles and rotors present a collision risk.
- The numbers of bird movements-at-risk, as recorded during timed point counts, extrapolated to determine an estimated number of movements-at-risk the species makes in an entire year. Account is taken of the portion of the year that birds are within proximity of the site and that they may thus be at risk.
- The mean area (m^2 per turbine), of tower, nacelle and stationary rotor blades of a wind generator that present a risk to birds. Thus, the mean area presented by a turbine is between the maximum (where the direction of the bird is perpendicular to the plane of the rotor sweep) and the minimum (where the direction of the bird is parallel to the plane of the rotor sweep). The mean presented area is determined from turbine specifications supplied to Biosis for specific make and model of a turbine. It represents the average area presented to an incoming flight from any direction.
- The additional area (m^2 per turbine) presented by the movement of rotors during the potential flight of a bird through a turbine. This information is determined via a calculation involving species-specific, independent parameters of flight speed and body length and supplied turbine specifications.
- The model assumes that all turbines in the site represent equal risk.
- A calculation of the average number of turbines a bird is likely to encounter in a given flight through the site. This is based on the scattered configuration of turbines in the landscape and the total number of turbines proposed for the project.

1.2.2 Avoidance rate

Results are provided for various avoidance rates. Avoidance rate is the capacity for a bird to avoid a collision, whether that occurs due to a cognitive response on the part of a bird or not. Thus at the extremes of the rates applied, a 0.90 avoidance rate equates to one flight in 10 in which a bird takes no action to avoid a turbine and a 0.99 avoidance rate equates to one flight in 100 in which it does not avoid a turbine. Based on experience with a wide range of bird species, it is certain that virtually all species have high capacity to avoid collision with the static components of turbines. Avoidance rate for these components is thus consistently considered to be 0.999 in the modelling. Various avoidance rates are modelled for the dynamic turbine components because it is not certain how adept various species may be at evading collision with the moving rotor. For this reason, results are provided for 0.90, 0.95, 0.98 and 0.99 avoidance rates for the dynamic components (moving rotor) of turbines.

It should be noted that internationally there is very little empirical evidence for the actual avoidance rate for any bird species and for this reason it is prudent to provide a range of estimates that are considered to be reasonable. The evidence that is available suggests that avoidance capacity is species-specific and that the great majority of birds have very high avoidance capability that is higher than 0.98. Nonetheless, the avoidance rate of some large raptors in Australia appears to be between 0.93 and 0.95 (Smales et al. 2013; Smales 2017).

1.2.3 Result metrics – number of flights at risk vs number of collisions

Generally, the model's results are expressed as the number of flights at risk of collision per annum for each species. This is a relative measure that permits us to compare risk rates associated with various turbines or turbine configurations. It does not necessarily equate to the number of collisions that might occur because we do not know how many individual birds of each species use the site and may thus be at risk. The difference between flights at risk of collision and number of actual collisions can be simply explained by way of an example. If there are just two individuals of a given species occupying the wind farm, they may make multiple flights that could result in collisions, however the maximum number of fatalities that could occur is two. As can be seen from this example, the number of actual collisions can be no greater than the number of flights at risk, and if the site-population is small but the birds fly actively within the site, the number of collisions will always be considerably lower than the number of flights at risk.

In cases where a good estimate of the site-population for particular species can be made, the model permits that to be incorporated to provide results expressed as an annual estimate of collisions.

Existing knowledge of the population dynamics for most of the species at the Hills of Gold site, is not sufficient to allow an estimate to be made for their site-populations. However, for two resident raptors, an estimate of their possible site-populations has been made and the model has been run to provide a projection of results for them as an annual estimate of collisions.

The model cannot forecast the frequency of collisions around the predicted annual average and it is important to recognize that the number of any actual collisions that might occur can be expected to vary from year to year in a distribution around the average.

All results are provided to two significant figures, however they represent annual 'average' results and, of course actual bird fatalities will always be measured in numbers of individuals and the average results of modelling must represent a distribution that can be expected to vary from year-to-year around the mean.

2. Preliminary evaluation of turbine options

An array of 70 wind turbines is proposed for the Hills of Gold Wind Farm. At present the project is considering options for three different models of turbine (Vestas 5.6, GE 5.5, SGRE 6). The three turbines differ in various aspects that may affect the collision risk they pose to birds in flight. The differences include rotor-swept area, rotor-sweep height above the ground and rotor speed. As a consequence, the risk to various species of birds will differ between them in response to the documented data for flight heights.

The Biosis turbine collision risk model was initially applied to a single species (Wedge-tailed Eagle) for each of the three turbines with a view to providing a preliminary consideration of how they might differ and to determine which turbine might represent a 'worst-case' collision risk. Wedge-tailed Eagle was chosen for this purpose because it had the greatest number of flights recorded at the site that were within rotor-swept height for all three turbines. An avoidance rate of 0.95 was used (see below and Appendix 1). The size of the population of Wedge-tailed Eagles at risk for the project was determined as set out under *Raptor populations at-risk*, below.

Results of the preliminary assessment of the three turbines are shown in Table 1.

Table 1 Comparison of three turbine models for a configuration of 70 of each turbine. Results show projected annual collision mortalities of Wedge-tailed Eagles at 0.95 avoidance rate.

Turbine model	Projected annual collision mortalities of Wedge-tailed Eagles at 0.95 avoidance rate
Vestas 5.6	3.71
GE 5.5	2.90
SGRE 6	3.23

On the basis of the preliminary evaluation it was determined that the Vestas 5.6 turbine represents the likely 'worst-case' collision risk for birds at the proposed Hills of Gold Wind Farm. While it has a slightly smaller rotor-swept area than the SGRE 6 turbine, it has a greater rotor speed and that can factor significantly in collision risk for birds.

3. Model inputs and assumptions

The Biosis collision risk model requires a range of numeric inputs, to quantify the number of turbines, key dimensions of turbines, and to estimate bird utilisation characteristics, including the number of flights within and outside of rotor swept height for species to be included in the model.

3.1 Wind farm and turbine parameters

The collision risk model requires input values for 36 turbine parameters that include number and layout of turbines and multiple aspects of turbine dimensions and geometry.

Following the results of the preliminary evaluation, the collision risk model was run for the Vestas 5.6 turbine.

Key parameters used in this modelling are:

- Number of turbines: 70
- Turbine type: based on Vestas 5.6
- Turbine tower height: 139 m
- Rotor diameter: 162 m
- Rotational speed: 12.1 rpm

The rotor-swept area is 17331.5 m^2. The 162 metres diameter blades have a length of 81 metres, resulting in rotor swept height between 58 and 220 metres above the ground.

The landscape configuration of the proposed Hills of Gold Wind Farm is essentially a linear row of turbines. This is different from most wind energy facilities in Australia in which turbines are scattered across a site. In the more usual scattered or 'clustered' array, a bird has a high probability of encountering multiple turbines in a given flight. The configuration of Hills of Gold turbines is such that a bird is likely to encounter multiple turbines only in the rare event that it flies directly along the row of turbines. The collision risk model has a built-in function to account for this difference whereby the turbine array can have any setting from 100% of turbines fully clustered to 0% in which turbines are entirely linearly configured. Given the slight sinuosity of the ridge-top array, this factor was set to 5%.

3.2 Bird species data

Following the results of the preliminary evaluation, the collision risk model was run for all species for which there were any flights recorded at rotor-swept height for the Vestas 5.6 turbine. That included all flights documented from between 58 and 220 metres above the ground.

A total of 51 species of birds were recorded during investigations of the Hills of Gold site. While all of them may have capacity to fly at rotor swept height, 18 species were recorded doing so, and thus have data available for use in the model. They are listed in Table 3, below.

White-breasted Woodswallow is the only one of the modelled species that is known to be present seasonally as its population migrates to inland and northern Australia during the winter. It was modelled as being present at the site for nine months per annum.

With the exception of two species of raptors (Section 3.2.1), it is not feasible to estimate the site-population sizes of the species modelled. As a consequence, model results for those 16 species are expressed as the number of flights at risk of collision per annum. The resident raptors, Nankeen Kestrel and Wedge-tailed Eagle, tend to occupy territories that remain stable over periods of several years and, because they are apex predators they occur at relatively low densities. In light of published studies for those species, Biosis undertook a process to estimate the sizes of their potential populations for the site. For those two species it was thus possible to run the model to provide results expressed as annual estimate of collisions.

3.2.1 Estimating site-populations for raptors

Information was collated from published sources to ascertain the likely number of Wedge-tailed Eagles and Nankeen Kestrels that might occupy the site and thus be at some risk of turbine collision. Brown Goshawk was recorded once only and is not considered further. There are a number of relevant studies of Wedge-tailed Eagle, but less for Nankeen Kestrel. Information for the latter was drawn from data collated in Marchant and Higgins (1993). The population dynamics of neither species has been studied at the Hills of Gold Wind Farm site.

The first item of information relates to average home-range size or documented spacing between home-ranges and to the number of birds that might occupy a given home-range. The second requires an understanding of the likely number of flying birds that might occupy a given territory. For the two species in question, published data indicates that they function as territorial pairs that usually attempt to raise one brood per annum. For the purposes of considering collision risk, the number of birds occupying a territory thus includes the adult pair and the average number of their offspring that fledge.

Wedge-tailed Eagle

Cherriman (2007) provided an overview of studies, including his own, that have investigated the size of Wedge-tailed Eagle territories in temperate regions. Territory sizes in studies near Perth (Cherriman 2007); at two other sites in the south-east of Western Australia (Ridpath and Brooker 1987); near Canberra in south-eastern Australia (Leopold and Wolfe 1970); and, in South Australia (Rowe et al. 2017) were all between 31 km^2 and 42 km^2. Foster and Wallis (2010) studied the species west of Melbourne and recorded nearest-neighbour distances averaged 4.7 kilometres. In a study in western NSW, Sharp et al. (2001) found the mean distance to nearest neighbour between Wedge-tailed Eagle nests was in the order of 1 pair per 3–9 km^2. They noted this was considerably higher than that noted in other semi-arid zone studies (~1 pair per 40–48 km^2).

Using a conservative mean Wedge-tailed Eagle territory size of 30 km^2, the average diameter of a territory would be slightly greater than 12 kilometres. As a consequence, we have based the modelling exercise for Wedge-tailed Eagles on the assumption that the 26 kilometre linear array of the proposed wind farm may intersect with three territories, occupied by six adult birds.

Cherriman (2013) reported that breeding productivity (number of chicks fledged) was 0.73 young per pair, across 15 occupied territory-years. Debus et al. (2007) recorded very similar results with 10 young produced in 12 pair-years, equating to 0.8 young fledged per pair per year. On the basis of those studies, we have conservatively assumed that, on average, three pairs will be accompanied by a total of three flying juveniles, bringing the average site-population of Wedge-tailed Eagles to a total of 9. Hence we have modelled for this number of birds as being at potential risk of collision.

During field investigations of the site, Biosis staff documented one instance each in which three, four and five Wedge-tailed Eagles were observed simultaneously.

Nankeen Kestrel

Near Armidale, NSW, one pair of Nankeen Kestrels occupied at least 200 hectares (2 km^2) (Genelly 1978) and active nests were recorded approximately 1 kilometre apart (Baker-Gabb 1985). Near Mildura, Victoria, 12 pairs were documented from an area with a 10 kilometre radius (i.e. approx. 314 km^2), and 25 nests averaged

1-3.6 kilometre apart equating to 1 pair per 5.4 km^2 (Baker-Gabb 1984). At Millewa, Victoria, Campbell (1986) reported an average of 1 active pair per 5.3 km^2 [all references in Marchant and Higgins (1993)].

Using a conservative mean Nankeen Kestrel territory size of 5.3 km^2, the average diameter of a territory would be approximately 2.6 kilometre . As a consequence, we have based the modelling exercise for Nankeen Kestrels on the assumption that the 26 kilometre linear array of the proposed wind farm may intersect with 10 territories, occupied by 20 adult birds.

Baker-Gabb (1984) reported a mean number of 1.3 fledglings per territorial pair. On the basis of that study, we have assumed that, on average, 10 pairs will be accompanied by a total of 13 flying juveniles, bringing the average site-population of Nankeen Kestrels to a total of 33 and we have modelled for this number of birds as being at potential risk of collision.

4. Model results

4.1 Raptors

Collision risk model results for Nankeen Kestrel and Wedge-tailed Eagle are shown in Table 2. As discussed earlier, informed assumptions have been made for the possible site-population sizes of these two species, and results for them are provided here expressed as projected numbers of annual average collisions. Results are provided for four potential avoidance rates.

Experience with these two species at wind energy facilities in south-eastern Australia demonstrates that both Nankeen Kestrels and Wedge-tailed Eagles collide with wind turbines (Moloney et al. 2019). For Wedge-tailed Eagles there is some published empirical data (Smales et al. 2013) and more recent unpublished data for actual mortalities available to validate the outputs of the Biosis collision risk model. That evidence suggests that the model's projections accurately equate to avoidance capacity of between 0.90 and 0.95. As with any forward-projection modelling, the accuracy of the results presented here for the proposed Hills of Gold Wind Farm, will depend upon the precision of all assumptions used for the modelling process.

Table 2 Collision risk model results for 70 x Vestas 5.6 turbines for two raptors at Hills of Gold Wind Farm site

Common name	Scientific name	Dynamic rotor avoidance rate			
		0.90	0.95	0.98	0.99
Nankeen Kestrel	*Falco cenchroides*	0.36	0.20	0.10	0.07
Wedge-tailed Eagle	*Aquila audax*	5.86	3.71	1.77	0.98

4.2 Other species

Collision risk model results for all 18 species of birds that were documented flying within rotor-swept height of the Vestas 5.6 turbines as proposed for Hills of Gold Wind Farm, are shown in Table 3. As discussed earlier in the report, information about the possible site-population sizes of 16 of these species is not available, and results for them are provided here expressed as projected numbers of annual flights that may be at risk of turbine collisions. Results are provided for four potential avoidance rates.

Fewer than 20 flights were recorded during the total of all point count field observations for the species shaded grey in Table 3. In cases such as these where the sample size of flights is low, it is possible that the model results may be less reliable than they are for species that were recorded more frequently. If the low number of observations for those species indicates that they occur relatively infrequently, or make few flights, that may still indicate that their risk is relatively low. We include them here for completeness, but under the caveat that the model's estimates for them may be less certain than the results for species with a greater number of records.

Table 3 Results for 70 x Vestas 5.6 turbines for 18 species of birds recorded within RSH at Hills of Gold Wind Farm site

Common name	Scientific name	Dynamic rotor avoidance rate			
		0.90	0.95	0.98	0.99
Brown Goshawk	*Accipiter fasciatus*	0.24	0.12	0.05	0.03
Galah	*Cacatua roseicapilla*	0.34	0.17	0.07	0.04
Nankeen Kestrel	*Falco cenchroides*	0.36	0.20	0.10	0.07
White-browed Treecreeper	*Climacteris affinis*	1.08	0.54	0.22	0.11
Australian Magpie	*Gymnorhina tibicen*	1.07	0.61	0.33	0.24
Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus*	3.27	1.64	0.67	0.34
Laughing Kookaburra	*Dacelo novaeguineae*	0.73	0.38	0.16	0.09
Red Wattlebird	*Anthochaera carunculata*	0.59	0.38	0.25	0.21
Spotted Pardalote	*Pardalotus punctatus*	1.03	0.52	0.21	0.11
Common Starling	*Sturnus vulgaris*	0.30	0.16	0.08	0.05
Rainbow Lorikeet	*Trichoglossus haematodus*	0.52	0.26	0.11	0.06
Crimson Rosella	*Platycercus elegans*	0.62	0.35	0.20	0.14
Little Wattlebird	*Anthochaera chrysoptera*	1.70	0.87	0.36	0.20
Pied Currawong	*Strepera graculina*	1.99	1.02	0.43	0.24
White-breasted Woodswallow	*Artamus leucorynchus*	1.67	0.84	0.35	0.18
Australian Raven	*Corvus coronoides*	4.02	2.04	0.86	0.46
Sulphur-crested Cockatoo	*Cacatua galerita*	3.95	2.01	0.84	0.45
Wedge-tailed Eagle	*Aquila audax*	9.46	4.78	1.97	1.03

5. Conclusion

A total of 51 species of birds were recorded during investigations of the Hills of Gold site. While all of them may have capacity to fly at rotor-swept height, 18 species were recorded doing so and the Biosis turbine collision risk model was run for them. The modelling was undertaken for 70 x Vestas 5.6 turbines after preliminary assessment suggested that this turbine is likely to represent a greater collision risk than two other types of turbines under consideration for operational use by the project.

None of the species involved are listed within any category of threat status under New South Wales or Commonwealth legislation.

Informed assumptions were able to be developed and employed for the potential site-population sizes of Nankeen Kestrels and Wedge-tailed Eagles and this permitted the model to provide projections expressed as average numbers of potential collisions per annum for those two species. Depending upon avoidance capacity and all other assumptions used for Nankeen Kestrels the model returned a likely range of between 0.36 and 0.07 collisions for that species per annum. Under the same caveats for Wedge-tailed Eagles, the likely range was between 5.86 and 0.98 collisions per annum. Empirical evidence from some wind farms in south-eastern Australia suggest that avoidance capacity for this species at those sites has been between 0.90 and 0.95.

For 16 other species, of birds collision risk modelling provided results expressed as average numbers of their flights that might be at risk of turbine collisions. For nine of those species the model indicates that they might make between one and four flights per annum that would be at some risk of collision assuming their collision avoidance capacity was no greater than 0.90. This is considered to be a very low avoidance rate and most birds appear to avoid turbine collisions at a significantly higher rate than that. On the basis of the bird utilization data collected for these birds at the site, and other assumptions entailed in the modelling, it is reasonable to conclude that the number of actual collisions that might occur per annum for all of these species would be lower than the number of their flights-at-risk.

References

Brook, B.W., Burgman, M.A., Akçakaya, H.R., O'Grady, J.J., Frankham, R., 2002. Critiques of PVA ask the wrong questions: throwing the heuristic baby out with the numerical bath water. Conservation Biology 16, 262-263.

Burgman, M. 2005. Risks & Decisions for Conservation & Environmental Management. Cambridge University Press. Cambridge.

Cherriman, S. C. 2007. Territory size and diet throughout the year of the Wedge-tailed Eagle *Aquila audax* in the Perth region, Western Australia. B.Sc. (Hons) Thesis, Curtin University, Western Australia.

Cherriman, S. C. 2013. Nest-site characteristics and breeding productivity of Wedge-tailed Eagles (*Aquila audax*) near Perth, Western Australia. Amytornis Western Australian Journal of Ornithology 5: 23–28.

Debus, S.J.S., Hatfield, T.S., Ley, A.J. and Rose, A.B. 2007. Breeding biology and diet of the Wedge-tailed Eagle *Aquila audax* in the New England region of New South Wales. Australian Ornithology 24: 93-120.

Foster, A. and Wallis, R. 2010. Nest-site characteristics of the Wedge-tailed Eagle *Aquila audax* in Southern Victoria Corella 34(2):36-44.

Leopold, A. S. and Wolfe, T. O. 1970. Food habits of nesting wedge-tailed eagles, *Aquila audax*, in south-eastern Australia. CSIRO Wildlife Research 15: 1-17.

Marchant, S. and Higgins, P.J. (editors) 1993. Handbook of Australian, New Zealand & Antarctic Birds. Volume 2, Raptors to lapwings. Melbourne, Oxford University Press.

Masden, E.A. & Cook, A.S.C.P. 2016. Avian collision risk models for wind energy impact assessments. Environmental Impact Assessment Review 56: 43–49.

Moloney, P.D., Lumsden, L.F. and Smales, I. 2019. Investigation of existing post-construction mortality monitoring at Victorian wind farms to assess its utility in estimating mortality rates. Arthur Rylah Institute for Environmental Research Technical Report Series No. 302. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Ridpath, M. G. and Brooker, M. G. 1987. Sites and spacing as determinants of wedge-tailed eagle breeding in Arid Western Australia. Emu 87: 143-149.

Rowe, E., Brinsley, R. and Dennis, T. 2017. A review of Wedge-tailed Eagle population stability in the Fleurieu Peninsula region of South Australia in 2017. South Australian Ornithologist 43 (1 - 2): 27-37.

Sharp, A., Norton, M. and Marks, A. 2001. Breeding activity, nest site selection and nest spacing of Wedge-tailed Eagles (*Aquila audax*) in western New South Wales. Emu 101: 323–328.

Smales, I., Muir, S., Meredith, C. & Baird, R. 2013. A description of the Biosis Model to assess risk of bird collisions with wind turbines. Wind Energy and Wildlife Conservation 37(1): 59-65.

Smales, I. 2017. Modelling of collision risk and populations. in M. Perrow (ed) Wildlife and Wind Farms: conflicts and solutions. Pelagic Publishing. UK.

Appendix 1

Wildlife Society Bulletin 37(1):59–65; 2013; DOI: 10.1002/wsb.257

Wind Energy and Wildlife Conservation

A Description of the Biosis Model to Assess Risk of Bird Collisions With Wind Turbines

IAN SMALES,[1] *Biosis Propriety Limited 38, Bertie Street, Port Melbourne, Vic. 3027, Australia*
STUART MUIR, *Symbolix Propriety Limited, 1A/14 Akuna Drive, Williamstown North, Vic. 3016, Australia*
CHARLES MEREDITH, *Biosis Propriety Limited 38, Bertie Street, Port Melbourne, Vic. 3027, Australia*
ROBERT BAIRD, *Biosis Propriety Limited 38, Bertie Street, Port Melbourne, Vic. 3027, Australia*

ABSTRACT We describe the model of Biosis Propriety Limited for quantifying potential risk to birds of collisions with wind turbines. The description follows the sequence of the model's processes from input parameters, through modules of the model itself. Aspects of the model that differentiate it from similar models are the primary focus of the description. These include its capacity to evaluate risk for multi-directional flights by its calculation of a mean presented area of a turbine; its use of bird flight data to determine annual flux of movements; a mathematical solution to a typical number of turbines that might be encountered in a given bird flight; capacity to assess wind-farm configurations ranging from turbines scattered in the landscape to linear rows of turbines; and the option of assigning different avoidance rates to structural elements of turbines that pose more or less risk. We also integrate estimates of the population of birds at risk with data for numbers of their flights to predict a number of individual birds that are at risk of collision. Our model has been widely applied in assessments of potential wind-energy developments in Australia. We provide a case history of the model's application to 2 eagle species and its performance relative to empirical experience of collisions by those species.

KEY WORDS bird, collision, model, risk, turbine, wind energy.

A number of mathematical models have been developed for the purposes of either describing the interaction of a bird with a wind turbine or to predict the risks of bird collisions with turbines (Tucker 1996*a*, *b*; Podolsky 2003, 2005; Bolker et al. 2006; Band et al. 2007). Tucker (1996*a*, *b*) and Band et al. (2007) detailed their models in the peer-reviewed literature. The collision risk model developed by Biosis Propriety Limited has been widely used to assess wind-energy developments in Australia since 2002, but it has not previously been described in detail. Given high levels of interest in effects of wind turbines on fauna, we believe it is important for the model to be accessible.

Our model provides a predicted number of collisions between turbines and a local or migrating population of birds. It has the potential to be modified to accommodate Monte-Carlo simulation, although at its core it uses a deterministic approach. It is modular by design, and allows various customizations, depending upon the unique configuration of the wind facility and characteristics of the taxa modeled.

The initial calculation involves species-specific parameters for speed and size of birds and specifications of the turbine, including its dimensions and rotational speed of its blades. Using these parameters, we derive the mean area of turbine presented to a bird in flight. This allows the model to accommodate flight approaches from any potential direction. Alternatively, unidirectional flights can be modeled by using the relevant turbine surface area presented to birds approaching from a given direction.

Data for bird flights are collected at the wind-farm site according to a specific and consistent field methodology. These data are used to determine the flux (density) of bird flights. When combined with turbine specifications, this yields the probability of collision during a single flight–turbine interaction. The density flux approach has not been used for this application previously.

The number of movements at risk of collision with one turbine is then scaled according to a typical number of turbines that a bird might encounter in a given flight. This is further refined by a metric for the capacity of the particular species to avoid collisions. Where a population census or estimate is available for the number of birds that may be at risk, a further deduction is used to attribute the number of flights-at-risk to individuals, and hence provide a final model output as the number of individuals at risk of collisions. The ability to transform from flights-at-risk to individuals-at-risk has been uniquely developed and applied as a routine component of our model.

DESCRIPTION OF THE MODEL

The model requires data for input parameters and, using these, functions in a sequence of modules (Fig. 1).

Published: 18 March 2013

[1]*E-mail: ismales@biosis.com.au*

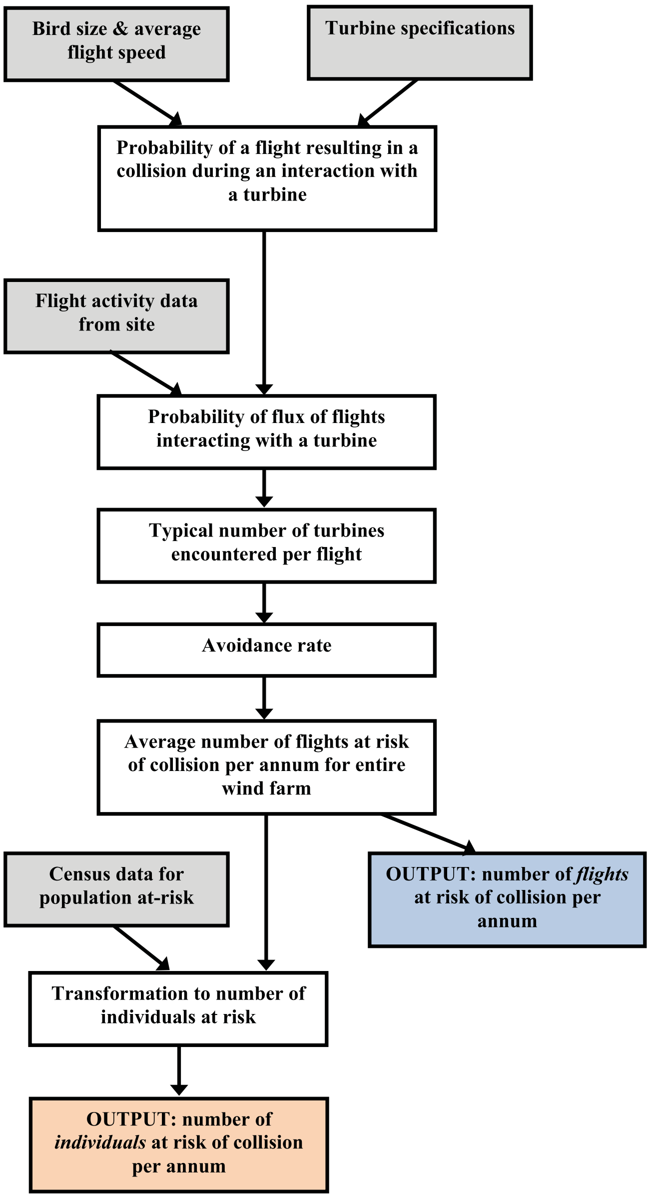


Figure 1. Overview of the collision risk model that quantifies risk to birds of colliding with wind turbines, showing input parameters (gray boxes), modules, and sequence.

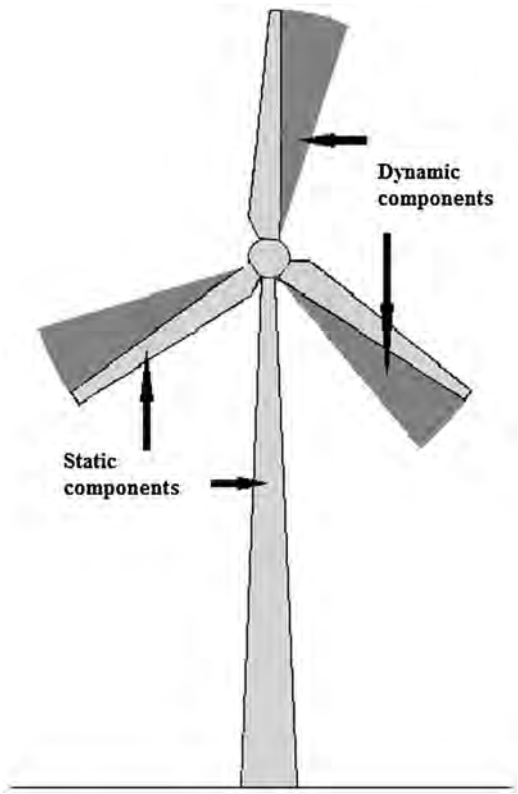


Figure 2. Schematic indication of the static and dynamic components of a wind turbine that may be encountered by a flying bird. The dynamic component is the area swept by rotor blades during the time that a bird of a particular species would take to pass through the rotor-swept zone.

Model Inputs

Turbine parameters.—The primary risk faced by a flying bird, whether it may strike or be struck by a turbine, is that the machine presents a potential obstacle in its path. Ultimately this equates to the surface area of the turbine presented to the bird from whatever its angle of approach. Other models, such as probably Band et al. (2007), use individualistic representations of birds. Our model uses a projection of the presented area onto all possible flight angles. For this reason, multiple dimensions of turbine components and rotor speed for the particular type of turbine are used as input values to the risk model. Turbine specifications are as provided by the machine's manufacturer.

The modeled wind turbine consists of 2 fundamental components representing potentially different risks. We refer to these as the static and dynamic components (Fig. 2). The static areas of a turbine include all surfaces of the entire machine comprising a tower, which in current turbines is a simple taper with known base and top diameters; a rectangular nacelle housing the generator; a hemi-spherical hub; and rotor blades that taper in 2 planes. The dynamic component is the area swept by the leading edges of rotor blades during the time that a bird would take to pass through the rotor-swept zone.

Size and flight speed of birds.—For each taxon, the model requires values for the total length of the bird in flight, from bill tip to tip of the tail or outstretched legs, and the average speed of the species' flights. We obtained bird lengths either from museum specimens or from standard ornithological texts.

Accurate determinations of bird flight speeds can be complex and difficult to obtain (Videler 2005, Pennycuick 2008) and published data are not available for most species. However, published radar studies (e.g., Bruderer 1995, Bruderer and Boldt 2001) provide ranges of flight speeds for a variety of species, including congenerics with similar morphologies and ecological traits to a number of species we have assessed. Use of radar to collect bird flight data at the wind-farm site may provide flight speeds for species of interest. We consider that average ground speed (as opposed to air speed) is appropriate for modeling of multidirectional movements of birds.

Bird flight data.—The model requires data from the wind-farm site for the number of flights made by species of interest within a measured time and volume of airspace. Movement data may be obtained from fixed-time point counts using a methodology adapted from Reynolds et al. (1980), incorporating an effective detection range (Buckland et al. 1993). It may be collected by human observers or by using horizontal and vertical radar combined with call recording or visual species identification (e.g., Gauthreaux and Belser 2003, Desholm et al. 2006). Data represent the number of flights that birds make within a cylinder of airspace that is centered horizontally on the observer and the height of which is the maximum reached by rotor blades of the turbines. The data collection regime is designed with the aim of providing a representative sample of flight activity across the local range of diel, seasonal, and other environmental variables.

Model Modules

Probability of a single flight interacting with a turbine.—In some situations, such as during highly directional migratory passage, the presented area of turbines is determined from the angle of the birds' flight relative to the compass orientation of turbines. However, for the great majority of species (including temporary or permanent residents at an on-shore wind farm) this does not apply, and flights can be expected to approach turbines from any direction. For this situation, all dimensions of the turbine contribute to the area with which a flying bird might collide and the model uses a simple integration to determine a mean presented area. This represents a substantial advance over other collision risk models that depend on the assumption of a specific angle of approach as a bird encounters a turbine (e.g., Tucker 1996*a*, *b*; Bolker et al. 2006; Band et al. 2007).

We calculate the area presented by the static components of a turbine using a conservative assumption that none of them overlap or obscure any others. The area of each component is calculated individually, and these are then summed to determine a total static area for the turbine. Static areas are calculated from the simple length × width dimensions of all components visible by line of sight. These are then projected onto an arbitrary approach direction (effectively scaling by the cosine of the approach angle). For example, viewed directly from one side, only the side panel of the nacelle is visible. However, approached from 45° to the turbine, both the front and side panels are visible, and are thus scaled by $\cos(45)\varrho 1/\sqrt{2}$ to match that particular angle of view.

We calculate the dynamic area, swept during the movement of blades, from the dimensions of the stationary blades and the distance they travel at their average speed during the time taken by a bird to fly through the rotor-swept area. We assume that all flights involve forward movement, so the swept-area is derived from the length and speed of the particular species of bird, in combination with the thickness of the sweeping blade.

Each rotor blade is tapered in 2 planes. Thus the thickness of the blades, used to determine the time taken for a bird to cross through the swept area, is actually a function of the point in the rotor radius at which an individual bird's flight intersects the swept area. This presents a complication that we overcome by defining an effective blade, which is a simple rectangular cross-section that sweeps out precisely the same volume of space as the physical blade. In doing so, we calculate a constant thickness of blade that accounts for the fact that the thinner tips actually sweep far more space than the thicker base of the blade. This ensures also that our flux calculation is not compromised by introduction of a spatial variation at odds with other aspects of the model.

A further input parameter is the percentage of time per annum when rotors are not turning due to inappropriate wind speeds and routine turbine maintenance. Prior to commissioning of a wind farm, wind speed data are usually gathered and the expected percentage of downtime due to inappropriate wind speeds is determined. During downtime periods the rotor simply stops turning; and so risks associated with dynamic components only are reduced by this percentage of time, while all static components of the turbine remain as potential obstacles to flying birds.

Combining all presented areas of the turbine.—Modeling for multidirectional bird movements requires no dependence on approach angles nor on complexities of interactions between flight direction and wind direction. We thus reduce the turbine to its mean presented area. This is solved by the equation

$$\frac{1}{\pi}\int_0^{\pi} A(\theta)\,\mathrm{d}\theta$$

where A is the presented area of the turbine as a function of approach angle θ. We solve this numerically using a trapezoidal integrator (Press et al. 1992).

Probability of multiple flights interacting with a turbine.—Because counts of bird flights have been made across the wind-farm site and there is no obligatory relationship between point-count locations and particular sites proposed for turbines, we combine the data collected from all point counts. This provides a measure of flight activity, which is assumed to be constant across the site. Thus the field data reduce to a single ratio value for the subject species, which is the sum of all flights documented during all counts divided by the total time of observations. This equates to a maximum likelihood estimation of the mean of an assumed Poisson distribution.

To calculate a number of flights at risk of collision, we first reduce documented bird movements (M) to a measure of flux (F) using the equation

$$F = \frac{M}{T_{\mathrm{obs}} A_{\mathrm{obs}}}$$

where T_{obs} is the combined total time of all point counts and A_{obs} is the area of the vertical plane dissecting the observation cylinder. This flux is a measure of bird movements per time per square meter of vertical airspace. The third dimension, volume of airspace, is redundant (or tacit) due to the assumption that, unless involved in a collision, flight paths do not end arbitrarily in space.

We next multiply activity measure by the number of minutes in which the species is active during the 24-hour diel period, T, and the total presented area of the turbine, A. For year-round resident species, the "active minutes" are calculated for the entire year, while for seasonal or migratory species, they are calculated for the portion of the year that the species is present at the site. This then gives a measure of risk to the bird movements, $M_{\text{risk}} = \text{FTA}$.

Because the flight data are a measure of movements by the species in question and do not discriminate the number of individuals making the movements, the measure (M_{risk}) quantifies the total movements-at-risk for the species and does not reflect risk to individual birds.

To determine a risk rate from total of recorded movements-at-risk, it is necessary to extrapolate to a total number of expected bird movements per annum, M_{yearly}. We calculate this from the flight data, extrapolating the movements to a yearly total through the equation

$$M_{\text{yearly}} = M\frac{T_{\text{yearly}}}{T_{\text{obs}}}$$

We then deduce a probability of flights at risk of collision as $M_{\text{risk}}/M_{\text{yearly}}$. Note that T_{year} is the total time in a year, and not the diel activity period of the species, which has already been factored into the calculation of movements at risk.

The resultant value is now a probability of flights being at risk of collision with a single turbine. To this point, no account is taken of the bird's own ability to avert a collision. This is modified later through use of an avoidance factor.

Estimating number of turbines encountered per flight.—Every turbine is presumed to represent some risk for birds, so the total number of turbines proposed for the wind farm is an input to the model. Turbine layout of modern wind farms is primarily determined by the wind resource and turbines are micro-sited accordingly. Consequently, the machines are usually scattered on the landscape. Older wind farms had turbines arrayed in rows, and occasional modern facilities may be linear where they follow a single topographic feature.

To account for the number of turbines with which a single flight might interact, it would be necessary either to know precisely the route of every flight or to make informed assumptions about flight paths. The manner in which turbines are arrayed in the landscape is important to ascertain a typical number of turbines that a bird might encounter in a given flight. This number differs according to whether turbines are in a scattered array or a single row, and these require different calculations.

For a row of turbines, the likely number of encounters can be visualized by considering a row of N turbines in plan view and a flight path at angle Φ to the row. A flight directly along the line of turbines (Φ') will interact with all N turbines. As the angle of flight relative to the row increases toward 90°, flight paths have potential to interact with fewer turbines until an angle (Φ'') is reached at which the path has potential to interact with a maximum of one turbine.

For a single row of turbines, we define the piecewise smooth function, which gives the number of turbines for a given angle of crossing with,

$$n_{\text{interaction}} = \begin{cases} N, & \text{if } \theta \le \phi\prime \\ \cot(\theta), & \text{if } \phi' < \theta \le \phi'' \\ 1, & \text{if } \phi'' < \theta \le \frac{\pi}{2} \end{cases}$$

This gives us an expected number of interactions as

$$\langle n_{\text{interaction}} \rangle = \frac{2}{\pi} \left[N\arctan\left(\frac{1}{N}\right) + \frac{\pi}{4} - \ln\left(\sqrt{2}\sin\left(\arctan\left(\frac{1}{N}\right)\right)\right)\right]$$

For scattered turbine arrays it is not realistic to assume that a bird will encounter all turbines in the wind farm in a given flight. We assume each flight has potential to cross between any 2 points on the outer edges of the farm. Given the size of most on-shore wind farms, this is a reasonable assumption for typical species of concern, such as raptors. When multiple flight paths are drawn randomly across the plan view of a wind farm, some paths may be circuitous and have potential to encounter many turbines, while others will pass through a small portion of the site and have potential to encounter relatively few turbines.

To deduce an average number of turbines likely to be encountered by any flight we use a topological, non-affine mapping technique. This spatial transformation can be illustrated as follows: if we were to throw a lasso around the perimeter of the site and shorten it to its minimum, we would find that all the turbines had collected in a circle. A straight flight path through this "lassoed" site is mathematically equivalent to a random walk across the unconstrained layout. The average of all flight paths crossing the center of this remapped farm will intersect with $\sqrt{N}$ turbines (where N is the total no. of turbines in the wind farm). This value is used in the model for the number of turbines that might be encountered per flight within a scattered turbine array.

For arrays that are neither entirely scattered nor linear, the model employs a simple weighted average of the values for fully scattered and entirely linear arrays.

Application of turbine avoidance capacity.—Birds have substantial ability to avoid obstacles; therefore, it is necessary to incorporate this capacity into the model. In common with other workers (Percival et al. 1999), we use "avoidance" in specific reference to behavior on the part of a bird that averts a potential collision with a turbine. The "avoidance rate" equates to the proportion of flights that might otherwise have involved interaction with a turbine but where the bird alters course and the flight does not result in a collision. For the purposes of the model it is of no consequence whether or not this is a result of a cognitive response by the bird to the presence of the turbine.

Turbine avoidance remains little-studied for any species, and empirical information about actual avoidance can be obtained for a given site only by studying the responses of birds in the presence of operational turbines (Chamberlain et al. 2006). One recent investigation has compared flight behaviors of 2 species of eagles in the presence of turbines at

2 operating wind farms with their behaviors at a site without turbines (Hull and Muir 2013).

Avoidance rate is incorporated into the model by scaling the movements at risk by $(1 - v)$, where v is a measure of the bird's ability to avoid objects. In this scenario, $v = 0$ corresponds to a blind, non-responsive projectile, and $v = 1$ represents a perfectly responsive bird able to avoid any object.

A novel feature of our model is its capacity to apply different avoidance values to the static and dynamic portions of a turbine. As noted by Martin (2011), birds are known to collide with both stationary and moving parts of turbines. This aspect of our model allows for differences in capacity of birds to detect and avoid the large, static components of modern turbines relative to their capacity to detect and avoid the small and fast-moving leading edges of rotor blades.

Size of population at risk.—When information about the size of the population at-risk is available, this can be factored directly into our model to provide results in the form of an expected number of individuals at risk of collision per annum. This is an important consideration because an input measured in terms of bird movements cannot provide an output in terms of individual birds. This aspect appears to have been largely overlooked by other workers, although Chamberlain et al. (2006) alluded to the use of a number of flights only, without incorporation of the number of individuals, as a potential issue in evaluation of collision estimates provided by the Band model (Band et al. 2007).

To deduce a predicted number of individual birds that are at risk of collision, a valid estimate is required of the number of individuals that may interact with turbines at the wind farm in the course of a year. If it is not feasible to obtain this for a species, then the output of the collision risk model will necessarily be the number of flights-at-risk per annum. Although this metric is not predictive of the number of individuals that might collide, it permits risk to be compared for various designs of a wind farm or between one facility and another. In rare cases, such as where there is a single migration passage through the site per annum, the number of movements may equate with the number of individual birds that are at risk. The great majority of risk modeling we have undertaken has been for raptors that are year-round residents. Due to their territoriality and relatively low densities, our studies at wind-farm sites have been able to ascertain the number of individuals using a site per annum, including both resident adults and juveniles, with a high level of confidence. For some other species, such as cranes (Gruidae), we have undertaken home-range studies to determine numbers present during the breeding season, and we have obtained local census data to estimate numbers of individuals that might encounter turbines during non-breeding seasons.

Given a population estimate, the number of flights at risk is attributed equally to the relevant number of individuals through the simple relation $M_{\text{individuals}} = \text{Yearly Movements}/\text{Population}$. We can then attribute individual mortality through

$$\text{mortality} = \text{Population}\left(1 - \frac{\text{Movements At Risk}}{\text{Yearly Movements}}\right)^{M_{\text{individuals}}}$$

MODEL VALIDATION

The model we describe here has been used to assess potential turbine collision risk for numerous species of birds for 23 commercial-scale wind farms proposed in Australia and one in Fiji. Eleven of these facilities have subsequently been built and are now operational. The model's projections have been used by regulatory authorities in determination of approval or modification to wind-farm designs for a range of species of concern. These include taxa as diverse as the orange-bellied parrot (*Neophema chrysogaster*), wedge-tailed eagle (*Aquila audax*), brolga (*Grus rubicunda*), and the large and readily observable Pacific fruit-bat (*Pteropus tonganus*) in Fiji.

The model's performance can be validated only when it can be compared with post-construction mortality data that are sufficient to permit calculation of an actual annual mortality rate and a 95% confidence interval for that rate. Conditions of regulatory approval for most wind farms that have been built to-date in Australia have varied considerably between state jurisdictions and over time. Generally they have not required rigorous investigation or public reporting of avian collisions that occur during operation. We have thus had limited opportunity to validate our model against empirical information for actual collisions. However, where these are available, we can compare the model's predicted average estimates with the measured confidence interval for actual mortalities to assess its predictive capacity. We present one such case study below.

Comparing the Model's Predictions With Empirical Data—A Case History

Substantial investigations have been undertaken at Bluff Point and Studland Bay wind farms in northwestern Tasmania entailing a number of studies of wedge-tailed eagle and white-bellied sea-eagle (*Haliaeetus leucogaster*). These have included utilization surveys designed to measure eagle activity before and after development of the wind farm; collision monitoring; eagle breeding success; eagle behaviors and movements relative to turbines and observers; and investigations and trials aimed at reduction of collisions (Hull et al. 2013). Commissioning of turbines began at Bluff Point Wind Farm in 2002 and at Studland Bay Wind Farm in 2007. Bluff Point Wind Farm consisted of 37 Vestas V66 turbines in a scattered array on an area of 1,524 ha. Studland Bay Wind Farm was situated 3 km south of Bluff Point and comprised 25 Vesta V90 turbines in a scattered array over an area of 1,410 ha. Both wind farms were close to the coast of northwestern Tasmania and resident white-bellied sea-eagles and Tasmanian subspecies of wedge-tailed eagle (*A. a. fleayi*) occurred at both sites.

Monitoring Eagle Flights

Movement data for both species were collected during point counts at Bluff Point Wind Farm site in 3 years prior to construction of turbines and in 4 years after they commenced operating. At Studland Bay, they were collected in 6 years prior to turbine construction and in 3 years after turbines commenced operation. As prescribed by regulatory authorities, point counts were undertaken in the austral autumn and spring. Ten replicate point counts were made in each season at 18 locations per wind farm. There were 545 point counts undertaken at Bluff Point between 1999 and 2007 and 854 point counts at Studland Bay between 1999 and 2009.

Collision Risk Model Results

We used the model to estimate risk based on movement data collected prior to construction for populations of 6 wedge-tailed eagles and 4 white-bellied sea-eagles at-risk per annum at each of the 2 wind farms.

State regulatory authorities have required that the collision risk model be re-run with the accumulated sum of eagle movement data obtained during the entire period of both pre-construction and operation of the 2 wind farms spanning the period from 1999 to 2009 (Table 1). We modeled static avoidance rate at 99% in all cases.

Documented Eagle Collisions

Carcass monitoring surveys were conducted at the Bluff Point and Studland Bay wind farms since they commenced operating. Fences to exclude mammalian scavengers were maintained at 27% of turbines across the 2 sites. All turbines, both fenced and unfenced, were searched routinely within a 100-m radius of the tower base. Search frequency was initially informed by trials to determine rates of loss to scavengers and of observers' capacity to detect carcasses. Since 2007, searches were carried out twice weekly during periods that may have represented higher risk to the species (i.e., eagle display period Jun–Aug, inclusive; and eagle fledging period mid-Dec–Feb, inclusive) and fortnightly outside these periods (Hull et al. 2013). Assessment of the extent of undetected eagle collisions (Hydro Tasmania 2012; Hull et al. 2013) concluded that it is unlikely that significant numbers of eagle carcasses were missed because they are conspicuous; the search zone around turbines was adequate to detect eagle carcasses where they will fall after colliding with turbines (Hull and Muir 2010); personnel on site had capacity to detect carcasses that may have been moved from the formal search zones; eagle carcasses in vegetation were found not to decompose readily and, even when scavenged, remains were identifiable; avian scavengers did not remove all evidence of carcasses and, although mammalian scavengers could remove carcasses, this was controlled at the subset of fenced turbines; survey intensity was informed by predetermined scavenger removal rates; and, although a small number of eagles survived collision with a turbine, in all documented cases such birds were unable to fly and are likely to have been detected because both scavenger exclusion and farm fences prevented them from leaving the site.

Table 1. Modeled mean annual turbine collision estimates for 2 eagle species based on movement data collected over the span of pre-construction and operation of 2 wind farms in northwestern Tasmania, Australia, from 1999 to 2009. Estimates are shown for 4 potential dynamic avoidance rates. Static avoidance rate was modeled at 99% in all cases

	White-bellied sea-eagle		Wedge-tailed eagle	
Dynamic avoidance rate (%)	Bluff Point	Studland Bay	Bluff Point	Studland Bay
90	0.9	0.8	2.7	1.9
95	0.5	0.4	1.5	1.1
98	0.2	0.2	0.7	0.5
99	0.1	0.1	0.4	0.3

Comparison of Collision Risk Model Estimates With Actual Mortality Rates

Given constraints of statistically low collision numbers, the model's estimates of annual collisions, based on the combined total of movement data from pre-construction and operation of the 2 wind farms from 1999 until 2009 (Table 1), compare well with actual mortality of the 2 eagle species at both wind farms (Table 2). The model's estimate of the number of wedge-tailed eagle collisions per annum at Bluff Point at a 95% avoidance rate was 1.5, which is the same as the mean number of documented mortalities per annum. Estimates provided for this case by model iterations for 90% and 95% avoidance rates fell within the 95% confidence interval of measured mortality rates. The model's estimates for number of collisions at a 95% avoidance rate for white-bellied sea-eagles at Bluff Point (0.5) and for wedge-tailed eagles at Studland Bay (1.1; Table 1) also closely approximated the mean numbers of documented mortalities per annum for the 2 species (0.4 and 1.0, respectively; Table 2). For those cases, the model's estimates for the range of avoidance rates between 90% and 99% fell within the 95% confidence interval of measured mortality rates. No white-bellied sea-eagle collisions have yet been reported from Studland Bay so, to date, the model's estimates are higher than actual experience for that species there.

MANAGEMENT IMPLICATIONS

We consider that there are 2 different, although not mutually exclusive, applications for modeling of bird collision risks at prospective wind farms. These are to provide projections of long-term effects of a particular wind-energy facility on key bird species; and to determine relative risks for key species that are associated with different wind-farm sites, different portions of large wind farms, and different types of turbines and/or turbine configurations.

In many respects, we consider the latter use of collision risk modeling is the most important contribution it offers. This application provides a tool for planning of wind farms to avoid, reduce, or mitigate potential risks to birds. The model we describe here has now been used in such an iterative manner for a number of prospective sites to evaluate relative risks to key species posed by different types, sizes, numbers, and layouts of turbines.

The integration in our model of data for numbers of bird flights with numbers of birds in the population at-risk is key to the accurate prediction of potential numbers of collisions. This aspect appears not to have been adequately considered previously but has real implications to the appropriate determination of actual risks posed by a wind farm. Our model's use of bird flight data to determine annual flux of movements; a mathematical solution to the typical number of turbines that might be encountered in a bird flight; capacity to assess wind-farm configurations ranging from turbines scattered in the landscape to linear rows of turbines; and the option of assigning different avoidance rates to components

Table 2. Average annual mortality rate and variance for 2 eagle species based on carcasses detected at 2 wind farms in northwestern Tasmania, Australia

	White-bellied sea-eagle		Wedge-tailed eagle	
Wind farm	**Mean annual mortality**	**Annual variance (95% CI)**	**Mean annual mortality**	**Annual variance (95% CI)**
Bluff Point 2002–2012	0.4	0.1–1.0	1.5	0.8–2.6
Studland Bay 2007–2012	0.0	0.0–0.7	1.0	0.3–2.2

of turbines that pose more or less risk, all represent refinements designed to improve the predictive capacity of turbine collision risk modeling.

In the cases outlined here, where long-term mortality data sets have permitted validation of the model's collision estimates at given avoidance rates, the two have closely approximated each other. We will seek further opportunities to compare the results of our model with empirical mortality information from operating wind farms, with a view to wider application of the model.

ACKNOWLEDGMENTS

C. Hull and E. Stark have been constant sources of ideas and valued discussions. C. Hull also facilitated our access to information about Bluff Point and Studland Bay wind farms and provided critical review of 2 drafts of the paper. M. McCarthy provided comment on early incarnations of the model. R. Brereton offered important inputs and S. Allie assisted to improve the model in relation to predicting risk to individual birds. Two early reviews of the model by T. Pople, H. Possingham, L. Joseph, and T. Regan of the Ecology Centre University of Queensland offered ideas for improvements to the model. Assessments of numerous wind-farm sites have been the foundation of development of the model and we are grateful to various wind-energy companies for involvement in their projects.

The model described here is the property of Biosis Propriety Limited, an environmental consultancy business incorporated in Australia. It is used commercially by Biosis Propriety Limited.

LITERATURE CITED

Band, W., M. Madders, and D. P. Whitfield. 2007. Developing field and analytical methods to assess avian collision risk at wind farms. Pages 259–275 *in* M. De Lucas, G. Janss, and M. Ferrer, editors. Birds and wind farms risk assessment and mitigation. Servicios Informativos Ambientales/Quercus, Madrid, Spain.

Bolker, E. D., J. J. Hatch, and C. Zara. 2006. Modeling bird passage through a windfarm. University of Massachusetts Boston, Boston, Massachusetts, USA. <http://www.cs.umb.edu/~eb/windfarm/paper072706.pdf>. Accessed 10 Nov 2012.

Bruderer, B. 1995. The study of bird migration by radar part 2: major achievements. Naturwissenschaften 84:45–54.

Bruderer, B., and A. Boldt. 2001. Flight characteristics of birds: 1. radar measurements of speed. Ibis 143:178–204.

Buckland, S. T., D. R. Anderson, K. P. Burnham, and J. L. Laake. 1993. Distance sampling: estimating abundance of biological populations. Chapman and Hall, London, England, United Kingdom.

Chamberlain, D. E., M. R. Rehfisch, A. D. Fox, M. Desholm, and S. J. Anthony. 2006. The effect of avoidance rates on bird mortality predictions made by wind farm turbine collision risk models. Ibis 148:198–202.

Desholm, M., A. D. Fox, D. L. Beasley, and J. Kahlert. 2006. Remote techniques for counting and estimating the number of bird–wind turbine collisions at sea: a review. Ibis 148:76–89.

Gauthreaux, S. A., and C. G. Belser. 2003. Radar ornithology and biological conservation. The Auk 120:266–277.

Hull, C. L., and S. Muir. 2010. Search areas for monitoring bird and bat carcasses at wind farms using a Monte-Carlo model. Australasian Journal of Environmental Management 17:77–87.

Hull, C. L., and S. C. Muir. 2013. Behavior and turbine avoidance rates of eagles at two wind farms in Tasmania, Australia. Wildlife Society Bulletin 37:49–58.

Hull, C. L., C. Sims, E. Stark, and S. Muir. 2013. Results and analysis of eagle studies from Bluff Point and Studland Bay Wind Farms 2002–2012. Wind and Wildlife. Proceedings of the Conference on Wind and Wildlife, 9 October 2012, Melbourne, Australia. Springer, Dordrecht, The Netherlands, in press.

Hydro Tasmania. 2012. Bluff Point Wind Farm and Studland Bay Wind Farm Annual Environmental Performance Report 2011. Hydro Tasmania. <http://www.hydro.com.au/system/files/documents/wind-environment/2011-AEPR-BPWF-SBWF.pdf>. Accessed 10 Nov 2012.

Martin, G. R. 2011. Understanding bird collisions with man-made objects: a sensory ecology approach. Ibis 153:239–254.

Pennycuick, C. J. 2008. Modeling the flying bird. Academic Press, Elsevier, Oxford, England, United Kingdom.

Percival, S. M., B. Band, and T. Leeming. 1999. Assessing the ornithological effects of wind farms: developing a standard methodology. Proceedings of the 21st British Wind Energy Association Conference, Cambridge, England, United Kingdom.

Podolsky, R. 2003. Avian risk of collision (ARC) model. NWCC Biological Significance Workshop, 17–18 November 2003, Washington, D.C. National Wind Coordinating Committee, Washington, D.C., USA.

Podolsky, R. 2005. Application of risk assessment tools: avian risk of collision model. Proceedings of the Onshore Wildlife Interactions with Wind Developments: Research Meeting V, 3–4 November 2004, Lansdowne, Virginia. Prepared for the Wildlife Subcommittee of the National Wind Coordinating Committee. RESOLVE, Washington, D.C., USA.

Press, W. H., S. A. Teukolsky, W. T. Vetterling, and B. P. Flannery. 1992. Numerical recipes in Fortran 77: the art of scientific computing. Second edition. Cambridge University Press, New York, New York, USA.

Reynolds, R. T., J. M. Scott, and R. A. Nussbaum. 1980. A variable circular-plot method for estimating bird numbers. Condor 82:309–313.

Tucker, V. A. 1996*a*. A mathematical model of bird collisions with wind turbine rotors. Journal of Solar Energy Engineering 118:253–262.

Tucker, V. A. 1996*b*. Using a collision model to design safer wind turbine rotors for birds. Journal of Solar Energy Engineering 118:263–269.

Videler, J. J. 2005. Avian flight. Oxford University Press, Oxford, England, United Kingdom.

Associate Editor: Smallwood.

Appendix E Serious and irreversible impact assessments

SAII assessment for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland

White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (Box Gum Woodland) is a CEEC listed under the BC Act and EPBC Act. The vegetation community has an open woodland or open forest structure and often contains a high diversity of groundcover species. Its distribution is strongly associated with more fertile soils on lower elevations across the known range in Queensland, New South Wales and Victoria. The geographic range of Box Gum Woodland is quite broad, ranging from the Queensland border in the north, to the Victorian border in the south. In NSW, occurs in the following bioregions NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina.

Over much of its range, the CEEC has been subject to extensive clearing and modification for agriculture and grazing, so it often occurs as derived native grasslands with no overstorey. It now mostly occurs as fragmented, isolated and modified fragments. Key historical and current threats to this CEEC include clearing for agriculture and urban development.

There are four PCTs within the development footprint that align with the floristic description of this TEC, including:

- PCT 433 - White Box grassy woodland to open woodland on basalt flats and rises in the Liverpool Plains sub-region, Brigalow Belt South Bioregion.
- PCT434 - White Box grass shrub hill woodland on clay to loam soils on volcanic and sedimentary hills in the southern Brigalow Belt South Bioregion
- PCT 492 - Silvertop Stringybark - Yellow Box - Apple Box - Rough-barked Apple shrub grass open forest mainly on southern slopes of the Liverpool Range, Brigalow Belt South Bioregion.
- PCT 599- Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion.

The CEEC is listed in the BioNet Threatened Biodiversity Data Collection (TBDC) as an entity at risk of SAII based on the following principles (DPIE 2019):

- Principle 1: an ecological community that is currently observed, estimated, inferred or reasonably suspected to be in a rapid rate of decline.
- Principle 2: an ecological community that is observed, inferred or reasonably suspected to be severely degraded or disturbed.

Given the absence of definitive impact thresholds stated for the community, the potential for a SAII will be determined by the consent authority, guided by the additional assessment provided below.

Impacts to Box Gum Woodland in the context of this SAII assessment are mapped on Figure 28.

1. Impacts to the CEEC and the action and measures taken to avoid the direct and indirect impact on the CEEC at risk of an SAII.

It has been conservatively assumed that all condition states of the above listed PCTs support the required floristic diversity to represent the CEEC. Within the development footprint, there is a total of 6.07 hectares of Box Gum Woodland, which has been considered to meet the listing requirements of both the EPBC Act TEC and the BC Act.

The CEEC was found to occur along the transmission line corridor, mainly to the west of the wind farm, with a small area in the central portion of the development site downslope (and north) of the wind farm itself. Furthermore the CEEC was found to occur at the far northern end of the access track servicing the central portion of the transmission line, and within two areas requiring upgrades for the transport route including just east of Nundle, and at Devils Elbow (Figure 9).

The patches of Box Gum Woodland within the development footprint are predominantly located in the Nandewar Bioregion (5.54 hectares), with a small area (0.53 hectares) located in the NSW North Coast Bioregion.

Actions and measures to avoid direct impacts

Throughout the development of the project layout, design decisions have been implemented to avoid impacts to Box Gum Woodland. This has included early biodiversity surveys, prior to development of the preferred corridor.

A preliminary biodiversity assessment (Arup 2019) was undertaken prior to the development of the wind farm layout and the selection of the preferred transmission line corridor. This preliminary assessment highlighted areas of key ecological concern and allowed for avoidance of these areas during the wind farm concept design. During the wind farm layout design, workshops were held between project ecologists, civil engineers and wind modellers to further optimise layout options and ensure impacts to the areas of mapped Box Gum Woodland.

During the design development phase, a wider landscape was reviewed for potential transmission line corridor and seven potential transmission line routes were identified to understand visual impact and willingness to reach land agreements. Desktop and field validated vegetation and habitat maps were reviewed and transmission line options assessed for likely impacts to significant biodiversity features, with a focus on minimising impacts to TECs. A desktop assessment was undertaken to identify the potential impacts to native vegetation communities for each of the seven options using the State Vegetation Type Mapping for the alignments.

Following the review of each of these seven options two preferred routes were selected and an optimisation consisting of a 200 metre corridor was undertaken to adjust the routes to minimise further impact around mapped PCTs and TECs. The transmission line corridor was then further refined to a single option a 60 metre wide impact areas was determined, resulting in impacts to 31.4 hectares of exotic grassland, and 53.5 hectares of native vegetation, of which 3.1 hectares comprises Box Gum Woodland CEEC. This level of impact includes those areas determined as impacted by AECOM (2021) where the vegetation occurs within valleys spanned by the overhead lines (refer section 7.3 for more detail).

Impacts to Box Gum Woodland also occur along the transport route where upgrades are required to allow delivery of turbine components to site. Impacts to the CEEC at Devils Elbow occur to vegetation that would not be considered the typical grassy woodland form of the CEEC, with PCT 492 in this area present on thinner rockier soils, with a relatively high shrubby understorey cover. However, floristically the vegetation matches BC Act requirements well (based on data collected from three BAM plots), and the PCT is noted as 'Equivalent' to the CEEC in the BioNet Vegetation Classification Database. As such, the vegetation in this area has been conservative assessed as representing Box Gum Woodland CEEC.

Design of roadworks required to bypass the hairpin turns at Devils Elbow have been refined significantly since the exhibited BDAR (refer Plate 1 above). Impacts assessed in that location have been reduced from the removal of approximately 17 hectares of native vegetation, including approximately 6 hectares of Box Gum Woodland CEEC (as presented in the exhibited BDAR), to 2.5 hectares of impact to Box Gum Woodland (PCT 492) in the current amended BDAR. Previously exhibited impacts considered a number of design options of which only one was intended to be constructed. The final route selected presented the lowest impact option and was further refined to avoid impacts. Furthermore, it should be noted that actual impacts are considered likely to be almost half of that current assessed at Devils Elbow following detailed design of project components. The current impact footprint assesses impact over a width of between 30 to 60 metres, with the expected final design only requiring a 14.5 metre average total width.

Overall design refinements undertaken since the exhibited BDAR have resulted in a reduction of assessed impact to Box Gum Woodland CEEC from 13.3 hectares to 6.07 hectares.

Furthermore the current transmission line development footprint considers a conservative 'worst case' clearing footprint for the transmission line easement, assessing complete clearing within the areas of the 60 metre easement not spanned by the overhead wires (AECOM 2021).

Planning for the construction of the transmission line corridor has also been completed as part of the impact assessment. This has included consideration for the placement of access tracks into the main transmission line corridor. Existing road infrastructure and farm tracks have been prioritised to provide the required access during construction and operation. By utilising pre-existing infrastructure, the Project has avoided and minimised impacts to sensitive ecological areas, including areas of Box Gum Woodland.

Actions and measures to avoid indirect impacts

As outlined above, the current transmission line development footprint considers a conservative 'worst case' clearing footprint for the transmission line easement, assessing complete clearing within the areas of the 60 metre easement not spanned by the overhead wires (AECOM 2021). Actual impacts, as determined to occur by the AECOM (2021) (Appendix I) will likely be smaller than, and contained entirely within, the 60 metre wide development footprint. This detailed investigation has shown that impacts to native vegetation can be avoided along the transmission line due to spanning and implementation of a construction methodology that allows vegetation in gullies to be completed avoided, and that these areas will not be subject to ongoing indirect impacts from the overhead wires. Impacts to over 1 kilometre of Box Gum Woodland CEEC (PCT 492) has been confirmed as avoided as a result.

Opportunities to complete revegetation works using species characteristic of Box Gum Woodland have been committed to in Section 8.9 of this BDAR, and the current concept design assumes that a large portion of the transmission line corridor can be subject to revegetation works using native species. Options to plant trees, shrubs and groundcovers will be explored where appropriate safety and operational constraints allow taller vegetation to be established. Where this is not possible, such as locations underneath the transmission line where suitable clearance is required, opportunities to plant groundcover species that occur in Box Gum Woodland will be included in revegetation species mixes. Revegetation of road batters associated with Devils Elbow upgrade works will ensure only Box Gum Woodland characteristic species are used. With all revegetation seed / plantings sourced to ensure appropriate local provenance.

Additional indirect impacts associated with construction will be managed through preparation and implementation of a Biodiversity Management Plan that will highlight ecologically sensitive areas, including areas Box Gum Woodland CEEC, and ensure these areas are maintained as no-go zones, ensure current condition of retained areas are maintained and improved, and no indirect impacts associated with water, materials storage, access etc occur and ongoing weed control will occur.

2a. Evidence of reduction in geographic distribution, as the current total geographic extent of the TEC in NSW and the estimated reduction in geographic extent of the TEC since 1970 (not including impacts of the proposal). (SAII Principle 1)

Species and ecological communities that have undergone large reductions or are likely to undergo large reductions in the future are considered to be at greater risk of extinction than those that have undergone or are likely to undergo smaller reductions (NSW TSSC 2018).

To be considered under this principle, the ecological community should have been observed, estimated, inferred, or reasonably suspected to have undergone, or be projected to undergo, a very large reduction in distribution (DPIE 2019).

The Final Determination for the listing of Box Gum Woodland as a CEEC under the BC Act states the community undergone "a very large reduction in geographic distribution" evidenced by the community having been extensively cleared throughout its range, and remnants typically are small, isolated, highly fragmented, that occur in predominantly cleared landscapes and exhibit a highly modified understorey (TSSC 2006). Based on a compilation of available maps depicting the current extent of the community at the national scale, TSSC (2006) estimated that less than 5% of the original distribution remained (NSW TSSC 2020a).

The NSW Threatened Species Scientific Committee (TSSC) Conservation Assessment of Box Gum Woodland (NSW TSSC 2020b) presents indicative estimates of the historical decline in geographic distribution compiled by the Commonwealth TSSC (2006) for state jurisdictions from sub-jurisdictional vegetation maps. The total reduction in NSW is stated as being approximately 93% of the pre-1750 distribution of the community (with 250,729 hectares remaining from a historical area of 3,717,366 hectares). It is noted that there are uncertainties around the pre-1750 distribution of the community, however the plausible ranges for variants of the community estimated to have been most extensively distributed in NSW suggest that these have almost certainly been reduced to less than 10% of their pre-1750 distribution (NSW TSSC 2020b).

Data is not available on the community's reduction in geographic extent since 1970 (i.e. over the last 50 years), however NSW TSC (2020b) states there is evidence that clearing of Box Gum Woodland CEEC is ongoing and has increased in recent years. During the period 2009 – 2016 it is noted that:

- An average of 395 ha of Grassy Woodland (sensu Keith 2004, of which Box Gm Woodland CEEC is a major component) was lost annually across NSW to agriculture-related activities (cropping, conversion to pasture and thinning)
- A further 155 ha per annum of Grassy Woodland is lost due to infrastructure developments (NSW DPIE 2019).
- Losses due to agriculture rose during the period 2016-2017 to 654 ha (166% of the average over the preceding seven years) and to 1,344 ha (340%) for the period 2017-2018.
- Losses attributable to infrastructure rose to 216 ha (138% of the 2009-2016 average) and 589 ha (378% of the 2009-2016 average), respectively (NSW DPIE 2019).

It should be noted that these figures include other forms of grassy woodland communities, and impacts to Box Gum Woodland CEEC only form a sub-component of these impacted figures, however the data illustrates ongoing pressures and an expected ongoing reduction in geographic extent of the TEC since 1970.

2b. Extent of reduction in ecological function for the TEC using evidence that describes the degree of environmental degradation or disruption to biotic processes, as indicated by i. change in community structure, ii. change in species composition, iii. disruption of ecological processes, iv. invasion and establishment of exotic species, v. degradation of habitat, and vi. fragmentation of habitat. (SAII Principle 2)

Reduction in ecological function relates to the IUCN principle of "very small population size" which for ecological communities means communities have very high levels of either environmental degradation or disruption of biotic processes, and interactions have an increased risk of failure to sustain their characteristic native species assemblages (Bland et al. 2016).

Ecological communities that are considered to have a very large degree of environmental degradation or disruption of biotic processes or interactions are those with:

- ≥90% extent and severity where the disruption or impacts are measured since 1970.
- ≥80% extent and severity where the disruption or impacts are over a 50-year period, either in the past, future, or any part of the past, present and future (as per (Bland et al. 2016). (DPIE 2019).

Box Gum Woodland CEEC is listed as being Data Deficient for an assessment of environmental degradation of ecological community by NSW TSSC (2020a), however it is listed in the same document as being subject to very large disruption of biotic processes or interactions.

NSW TSSC (2020a) states that Box Gum Woodland CEEC is subject to a number of threatening processes that have negatively impacted upon biotic processes and interactions throughout its range and are likely to cause continuing decline in the future. An almost complete conversion of the community to agricultural production has occurred which invariably includes the removal and/or thinned of the tree canopy resulting in op-down pressures on the ecosystem, with follow-on grazing of domestic stock being the most widespread activity. The impacts of grazing vary depending on the historical grazing regime (timing, intensity, continuity), methods employed to improve pasture (fertilizer application, augmentation with exotic or native species) and the extent of associated impacts on soil structure and biota (soil erosion, compaction).

Grazing has also been shown to lead to a reduction in understorey species diversity and richness due to the loss of native species that are both highly palatable and intolerant of grazing by domestic stock, with many previously widespread species now confined to the least disturbed remnants NSW TSSC (2020a). Shifts in the dominance of pasture species have also been observed as grazing intensity increases and is attributed to differential palatability and resilience to grazing among species, and the reduction of native plant cover by grazing presents opportunities for the invasion of the community by exotic plant species NSW TSSC (2020a).

NSW TSSC (2020b) also states that Box Gum Woodland CEEC is subject to a number of other threatening processes associated with fragmentation, increased soil salinity, inappropriate fire regimes, and reduced recruitment of tree species.

2c. Evidence of restricted geographic distribution, based on the TEC's geographic range in NSW based on i. extent of occurrence, ii. area of occurrence and iii. number of threat-define locations. (SAII Principle 3)

The geographic distribution of ecological communities is defined by the area of occupancy, sensu (Bland et al. 2016). Ecological communities with a very limited geographic distribution have an area of occupancy of less than or equal to two 10 x 10 km grid cells (200 km2) or an extent of occurrence of ≤1,000 km2, sensu (Bland et al. 2016), and one of the following:

- An observed or inferred continuing decline in:
  - A measure of spatial extent appropriate to the ecological community.
  - A measure of environmental quality appropriate to characteristic biota of the ecological community.
  - A measure of disruption to biotic interactions appropriate to the characteristic biota of the ecological community.
- Observed or inferred threatening processes that are likely to cause continuing declines in geographic distribution, environmental quality or biotic interactions within the next 20 years.
- An ecological community that exists at one location (DPIE 2019).

NSW TSSC (2020a) states that the geographic distribution of Box Gum Woodland CEEC is not restricted.

The best estimate of the extent of occurrence (EOO) is 702,800 km2, based on a minimum convex polygon enclosing likely occurrences of the community, the method of assessment recommended by (Bland et al. 2016). The best estimate of the area of occupancy (AOO) is 151,100 km2 based on 10 x 10 km grid cells (with a minimum of 1% occupied by the community), the scale recommended for assessing AOO by (Bland et al. 2016). The best estimates of EEO and AOO derive from a compilation of maps from multiple sources. Not all of the areas occupied by the community are covered by maps of appropriate scale and accuracy. Therefore, the values for EOO and AOO quoted above may underestimate the true values.

2d. Evidence that the TEC is unlikely to respond to management.(SAII Principle 4)

This principle encompasses two components, firstly whether there are any particular traits of the community which limits its' response to management, and secondly whether there are any key threatening processes affecting the community which cannot be effectively managed (DPIE 2019).

The Commonwealth TSSC (2006) states that Box Gum Woodland CEEC has suffered a severe decline in extent and condition, and remaining areas are generally small and highly fragmented, and that the key threats to the survival of the ecological community include clearing, grazing and weed invasion. Other threats include salinity, nutrient enrichment, altered fire regimes and the effects of fragmentation.

The priority recovery and threat abatement actions required for the listed ecological community include:

- protection of remnants of the listed ecological community through the development of conservation agreements and covenants;
- protection of remnants from weeds, particularly Coolatai Grass, by preventing soil disturbance in and around remnants, and the speedy eradication of any newinvasion;
- avoid the use of fertilisers in or nearremnants
- avoid soil disturbance in or near remnants, such as ripping planting lines and road grading;
- in very small derived grassland sites, avoid planting trees as they may reduce the floral diversity through competition for light, nutrients and water;
- planting and other rehabilitation-focused disturbance should focus on the edges of patches, expanding them, rather than within the patches;
- expansion and connection of existing remnants;
- exclusion of continuous grazing from remnants is important, coupled with weed management and control;
- use strategic grazing (incorporating rest at appropriate times) in areas still containing a diverse native understorey;
- burning or slashing if native tussock grasses have built up to a high level, to open inter- tussock spaces for tree seedlings, forbs and shrubs to establish; and,

Further information on recovery actions and conservation measures are detailed in the *National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland* (DECC 2009). Furthermore the TBDC lists 10 management actions to aid the threat abatement and recovery of the CEEC.

Based on the existence of a national recovery plan providing a guidance as to the management of the CEEC, the community is not considered to be unlikely to respond to management.

3. Where the TBDC indicates data is 'unknown' or 'data deficient' for a TEC, the assessor must record this in the BDAR or BCAR.

Not applicable.

4a. The impact on the geographic extent of the TEC, by estimating the total area of the TEC to be impacted by the proposal.

The majority of the impacted area of Box Gum Woodland TEC within the development footprint have been calculated based on a worst case clearing footprint requirement for the transmission line corridor. This corridor has been calculated for a maximum clearing footprint that is 60 metre wide. This width of corridor is unlikely be required, and is considered to be the maximum width is sufficient to capture any indirect impacts to adjacent retained areas of Box Gum Woodland CEEC.

A summary of the area of direct and indirect impact assessed as total loss, with PCTs and the measured vegetation integrity score is provided in the below table.

PCT and condition class	Area (ha)	Vegetation integrity score*
433 - Moderate	0.01	99.9
434 – Low	0.01	99.9
492 – High	2.60	93.0
492 – Moderate	0.55	93.0
492 – Low	0.58	60.3
492 – DNG	0.89	59.9
599 – High	0.36	99.9
599 – Moderate	0.09	99.9
599 – Low	0.97	99.9

* The vegetation integrity scores provided in the above table are artificially inflated due to the use of benchmark values to compensate for a reduced number of vegetation integrity plots in the following vegetation zones *433 – Moderate, 434 – Low, 492 – DNG, 599 – High, 599 – Moderate, 599 – Low* (refer Section 4.1 for more detail).

Approximately 41 % of the impacts to Box Gum Woodland (2.47 hectares) as a result of the project will occur on areas of DNG or that have been assessed as occurring in Low condition.

The construction and operation of the 330kV transmission line or section of open road built to the required Australian Standards is unlikely to result in changes to any abiotic factors that are critical to the long term survival of Box Gum Woodland in areas adjacent to the development footprint. The construction of the transmission line will not require substantial earthworks that could impact on surface water or groundwater flow patterns. The current design has also allowed for several access tracks into the transmission line corridor to limit the need for substantial earthworks along the length of the alignment to enable construction. Earthworks and design of the roadway constructed to bypass Devils Elbow will ensure that existing environmental processes are not substantially altered or negatively impacted by the construction.

The impacts to Box Gum Woodland associated with the project are confirmed to generally low condition vegetation within a fragmented landscape associated with the transmission line and its access racks, and to high condition vegetation within larger patches of intact vegetation associated with road upgrades. Neither will result in clearing of vegetation unique to the locality, or to species locally common when compared to elsewhere in the development footprint or broader locality. As such the project is not considered likely to cause a substantial change in the species composition of an occurrence of Box Gum Woodland such that it would continue to decline.

The project is unlikely to result in substantial additional impacts to characteristic and functionally important species beyond these areas that has been assessed as being lost during construction. Opportunities to include characteristic trees, shrubs and groundcover species from the Box Gum Woodland TEC will be included as part of revegetation works following construction.

The proposed development will not directly lead to altered fire regimes in areas of adjacent retained Box Gum Woodland. Recommendations to implement a suitable fire regime to manage biodiversity and fuel load may be required in areas of retained Box Gum Woodland adjacent to the transmission line corridor.

As outlined above impacts to Box Gum Woodland associated with the project are confirmed to be generally low condition vegetation within a fragmented landscape associated with the transmission line and its access racks, and to high condition vegetation within larger patches of intact vegetation associated with road upgrades.

Box Gum Woodland present along the transmission line and in the surrounding landscape largely occurs as fragmented and isolated patches in an over-cleared landscape. The construction and operation of the transmission line will not result in negative ongoing impacts to the CEEC in the landscape, nor will it increase existing pressures associated with fragmentation, isolation and edge effects.

Box Gum Woodland along Barry Road mainly occurs on the edges of the extent of the CEEC, and within larger patches of intact grassy and shrub/grass woodland. The construction and operation of the new roadways may result in an increase in edge effects where the new road will occur through an existing patch of intact vegetation, however it is not expected that sources of negative impacts such as weed encroachment will increase above the levels that already existing in the landscape. The vegetation currently exists in in high condition away from the immediate roadside edges and there is no reason to expect this would change into the future.

Based on the above additional indirect impacts to Box Gum Woodland are not expected to be substantial or significant as a result of the project and therefore only the direct impacts are considered in the calculation of the project's impacts on the geographic extent of the TEC.

As outlined above, the NSW (2020b) states the current geographic extent of Box Gum Woodland as being estimated as 250,729 hectares. The project will remove a total of 6.07 hectares of Box Gum Woodland, or approximately 0.002% of the extant area of the community.

4b. The extent that the proposed impacts are likely to contribute to further environmental degradation or the disruption of biotic processes of the TEC by i. estimating the size of any remaining, but now isolated, areas of the TEC; including areas of the TEC within 500m of the development footprint or equivalent area for other types of proposals.

Patches of potential Box Gum Woodland CEEC present in the wider landscape surrounding the project area occurs in an already highly fragmented state. GIS was used to determine the range and average size of mapped (Biosis 2021, DPIE 2019, DPIE 2015) occurrences of PCTs representative of Box Gum Woodland CEEC within a 500 metre buffer of the development footprint. The results of which are provided below both for those patches intersected by the development footprint (i.e. subject to vegetation removal) and those patches not intersected by the development footprint (i.e. not directly impact by the project). It should be noted that only the broad components of the development footprint proximal to impacted Box Gum Woodland have been included in these calculations, i.e. large areas of the transport route, where no Box Gum Woodland is impacted, have been excluded.

Mapped areas of known and potential Box Gum Woodland within 500m not directly impacted:

- Size range: <0.001ha to 305 ha
- Average size: 6.69 ha
- Median: 1.23 ha

- Total no. mapped patches (dissolved Box Gum Woodland PCT polygons): 197

Mapped areas of known and potential Box Gum Woodland within 500m directly impacted:

- Size range: 2.81 ha to 164 ha
- Average size: 29.99 ha
- Median: 6.52 ha
- Total no. mapped patches: 8

It can be seen that there are a large number of mapped known an potential Box Gum Woodland patches within 500 metres of the development footprint, ranging from <0.001 hectares to >300 hectares in area. Patches directly impacted by the project are generally lager with a larger minimum size, average size and median size, than those patches not impacted by the project. This mainly relates to larger patches of PCT 492 mapped within the intact vegetation to the north and east of the subject land. The project is not expected to result in impacts that will substantially increase fragmentation, and/or increase perimeter to area ratios of retained patches of known and potential Box Gum Woodland vegetation based on both the generally large patch sizes of impacted patches and high level of variation in patch sizes within 500 metres of the development footprint.

ii. describing the impacts on connectivity and fragmentation of the remaining areas of TEC measured by:

- ***distance between isolated areas of the TEC, presented as the average***
- ***distance if the remnant is retained AND the average distance if the remnant is removed as proposed, and***
- ***estimated maximum dispersal distance for native flora species characteristic of the TEC, and***
- ***other information relevant to describing the impact on connectivity and fragmentation, such as the area to perimeter ratio for remaining areas of the TEC as a result of the development***

GIS was used to undertake a nearest neighbour analysis of mapped (DPIE 2019, DPIE 2015) occurrences of potential Box Gum Woodland CEEC prior to and post vegetation removal to determine the distance between impacted areas of the CEEC before and after the proposed development. The average and median distance between mapped occurrences of potential Box Gum Woodland CEEC within a 500 m buffer of the impact area, include:

- An average before development separation distance of 75.6 m
- An average after development separation distance of 85.3 m
- A median before development separation distance of 20.11 m
- A median after development separation distance of 15.06 m.

As can be seen from the above calculations the proposed vegetation removal will result in an increase of the average separation distance between patches of known and potential Box Gum Woodland CEEC by approximately 10 meters, but will result in a decrease in the median separation distance by 5 metres. Furthermore it should be noted that the increase in mean separation distance stated above is being driven by the removal of one small patch (<0.1 hectares) of known Box Gum Woodland CEEC vegetation resulting in the increased isolation of another larger patch (approx. 3.29 hectares) of potential Box Gum Woodland CEEC vegetation, such that the patch of the CECC nearest the larger retained patch post development is over 2.9 kilometres away. If that outlier is excluded from the 'post-clearing' dataset, the development also results in a decrease of mean separation distance from 75.6 metres prior to development to 71.7 metres after development.

These decreases in mean and median separation distance are the result of the very large study area and 500 metre buffer considered in this analysis that supports larger and well separated patches of potential Box Gum Woodland CEEC vegetation the majority of which are not directly impacted by the project, the effect of the relatively narrow vegetation clearing within the development footprint creating new patches separated by between 5 and up to 60 metres, and the generally isolated nature of the majority of the impacted Box Gum Woodland CEEC polygons within the development footprint.

Native flora species characteristic of the CEEC include a range trees, shrubs, grasses, forbs and other groundcover species, the majority of which are dispersed via wind or animal vectors, with some species primary method of dispersal likely to be via non-flying insects such as ants. The expected changes to average separation distance between patches of retained known and potential Box gum Woodland CEEC within 500 m of the impact area are not expected to result in a significant or substantial impediment to the dispersal of native species between these patches, in an already highly fragmented landscape.

It is noted in EPBC Act conservation advice documents that allowances can be made for "breaks" of up to 30 metres between areas of MNES habitat, and that such breaks, which may be the result of watercourses, tracks, paths, roads, etc., do not significantly alter the overall functionality of the ecological community, or habitat (CoA 2020). As such, breaks in connectivity caused by the development footprint, of between 5 and 30 metres are not considered to be substantial in nature, which include all impacts, outside the proposed Devils Elbow upgrade, where assessed impacts include a worst case scenario of up to 60 metres of clearing.

Box Gum Woodland occurs within the development footprint in association with the transmission line corridor, transmission line access tracks and road upgraded along Barry Road outside Nundle and at Devils elbow.

Along the transmission line and its access tracks the CEEC occurs in an already highly fragmented landscape, with the impacted patches of the CEEC, and the patches mapped in the surrounding landscape largely occurring as isolated patches of vegetation in an over-cleared landscape. Some larger patches of potential CEEC also occur on steeper slopes in more intact vegetation where the CEEC is associated with PCT 488 Silvertop Stringybark - Yellow Box +/- Nortons Box grassy woodland on basalt hills, however these areas are mainly south of the development footprint and on the southern side of the ridgeline. Impacts associated with the construction and operation of the project's transmission line (and associated access tracks) will not result in fragmentation of any substantial patches of the CEEC, nor will it increase fragmentation in the landscape.

Near Nundle, a small isolated patch of Box Gum Woodland will be impacted by the required transport route upgrade works to allow for wind turbine components to be transported to the site. This impact will occur to a single Blakelys Red Gum tree present on the road side in low condition, and within a landscape of scattered paddock trees, and retained vegetation near creeks. This impact will not fragment or increase fragmentation of the CEEC in this location.

More significant road upgrades works are required further east along Barry Road, at Devils Elbow, where the double hairpin turns must be bypassed to allow for turbine components to reach the site. Box Gum Woodland in this location exists not in its more typical grassy woodland form but on thinner rockier soils with a shrubbier understorey, as PCT 492 Silvertop Stringybark - Yellow Box - Apple Box - Rough-barked Apple shrub grass open forest. It does however, align well with the floristic and condition requirements for listing as the CEEC.

Minor clearing of the CEEC is required at the eastern extent of the works area on road edges to widen the corners, and as such no fragmentation impacts will occur in this area. However to bypass the Devils Elbow corners, clearing will occur over approximately 700 metres, between 30 to 60 metres in width, up the ridgeline through a patch of intact vegetation. This will result in the fragmentation of an approximately 5.5 hectare patch of vegetation to the north, that will no longer be part of the large contiguous patch of vegetation, and will be surrounded on all side by roads (approximately 10 to 15 m wide). This vegetation was mapped as PCT 541 Silvertop Stringybark - Rough-barked Apple grassy open forest during ground assessment haul route impacts and is noted as having the upper stratum dominated by Silvertop Stringybark and Rough-barked Apple. It is considered likely that this vegetation supports occasional Yellow Box, moving downslope from the adjacent PCT 492 (Box Gum Woodland CEEC), but the vegetation to the north is considered unlikely to represent the CEEC. Indirect impacts to this fragmented patch of retained vegetation (PCT 541) will be managed through best practice road drainage designs, ensuring current hydrological patterns are maintained a close as possible to the system. Impacts to PCT 492 in this location occur along a ridgeline on the northern edge of a large mapped patch of the PCT, and as such fragmentation impacts are not expected to occur.

It is therefore considered that the project will not fragment or increase fragmentation of Box Gum Woodland CEEC.

iii. describing the condition of the TEC according to the vegetation integrity score for the relevant vegetation zone(s) (Section 4.3). The assessor must also include the relevant composition, structure and function condition scores for each vegetation zone.

Box Gum Woodland occurs as four separate PCTs across nine vegetation zones. The relevant composition, structure and function condition scores are provided below.

PCT and condition class	Comp. score	Struc. score	Func. score	VI score	Comments
433 - Moderate	99.7	100	100	99.9	Condition of PCT 433 has been assumed to be benchmark due to a shortfall in collection of BAM plot data. The actual condition of the vegetation is 'moderate' being subject to historical clearing and ongoing agricultural processes.
434 – Low	99.7	100	100	99.9	Condition of PCT 434 has been assumed to be benchmark due to a shortfall in collection of BAM plot data. The actual condition of the vegetation is 'low' being subject to a high level of historical clearing and ongoing agricultural processes.
492 – High	100	80.9	99.5	93.0	Condition of PCT 492 has been assumed where a shortfall in in collection of BAM plot data has occurred. This has increased the attribute and VI scores for each condition state, with the exception of PCT 492 Low. The actual condition of the vegetation ranges from 'high' to 'DNG' depending on the level of historical clearing, ongoing agricultural processes and edge affectedness.
492 – Moderate	98.4	99.7	81.9	93.0	
492 – Low	68.4	60	53.5	60.3	
492 – DNG	75	57.2	50	59.9	
599 – High	99.7	100	100	99.9	Condition of PCT 599 has been assumed to be benchmark due to a shortfall in collection of BAM plot data. The actual condition of the vegetation ranges from 'high' to 'low' depending on the level of historical clearing, ongoing agricultural processes and edge affectedness.
599 – Moderate	99.7	100	100	99.9	
599 – Low	99.7	100	100	99.9	

No specific measures are proposed to contribute to the recovery of Box Gum Woodland in the IBRA subregion, with the exception of the goal of seeking local offsets in the form of Biodiversity Stewardship Sites established in the local area.

It cannot be guaranteed that any Biodiversity Stewardship Sites that are established will directly benefit Box Gum Woodland however rehabilitation of native vegetation in the locality is likely to provide indirect benefits to Box Gum Woodland in the locality.

The project's proposed offset strategy of targeting local properties for the establishment of Biodiversity Stewardship Sites provides potential opportunities for strategic enhancement of local habitat connectivity. Such enhancements could occur along the southern side of the ridgeline between Ben Halls Gap Nature Reserve and Crawney Pass National Park, and over Crawney Mountain to Wallabadah Nature Reserve, linking the three conservation areas. This enhancement of local connectivity can be achieved through the in-perpetuity conservation agreements being pursued over a number of properties along the ridge line, which will improve the biodiversity values on the land and increase habitat connectivity. Connectivity enhancements realised in this strategic location will not only offset direct impacts resulting from the project, but also allow for potential indirect impacts associated with disruption of habitat connectivity to be mitigated against and offset through the establishment of a managed corridor linking local conservation reserves and high-quality habitats.

Areas of the transmission line alignment and road batters surrounding the future bypass of Devils Elbow will also be subject to revegetation works, with species characteristic of Box Gum Woodland to be included in plant species mixes where appropriate. This will have an indirect benefit to Box Gum Woodland, mainly along the transmission line, through increasing propagative material and decreasing area available for colonisation by existing species in some more degraded areas.

Large Bent-winged Bat SAII assessment in accordance with the BAM (2017) methodology

Large Bent-winged Bat is a member of the Miniopteridae family. The species occurs along the east coast of Australia from Cape York in northern Queensland to Castlemaine in Victoria, east of the Great Dividing Range (Churchill 2008). It is listed as Vulnerable under the BC Act.

Large Bent-winged Bat utilises a range of habitats including rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, *Melaleuca* spp. dominated forests, and open grasslands. The species typically forages for moths and flying insects above the forest canopy, in open grassy areas it will forage a few metres off the ground (Churchill 2008).

Large Bent-winged Bat is considered a species credit species under the BAM, specifically in relation to the species' breeding habitat. This breeding habitat is defined in the Atlas of NSW Wildlife (DPIE 2021) as any:

'Cave, tunnel, mine, culvert or other structure known or suspected to be used for breeding including species records with microhabitat code "IC - in cave;" observation type code "E nest-roost;" with numbers of individuals >500 or from the scientific literature'.

Impacts to these breeding habitat features, and the area within a 100 metre radius buffer around an accurate GPS point location centred on the cave / feature entrance, are what are considered to be potentially serious and irreversible for the species (DPIE 2021). Such areas were previously located within the development footprint, requiring the undertaking of an SAII assessment. However, amendments to the project design, as outlined in Table 1, have since resulted in these areas being successfully avoided. Whilst no longer required, this SAII has still been included and updated due to the importance of the species.

(a) The action and measures taken to avoid the direct and indirect impacts on the potential entity for an SAII.

Actions and measures to avoid direct impacts

A preliminary biodiversity assessment (Arup 2019) was undertaken prior to the development of the wind farm layout and the selection of the preferred transmission line corridor. This preliminary assessment highlighted areas of key ecological concern and allowed for avoidance of these areas during the wind farm concept design. During the wind farm layout design, workshops were held between project ecologists, civil engineers and wind modellers to further optimise layout options and ensure impacts to the areas of highest potential Large Bent-winged Bat breeding areas were avoided or minimised. These workshops resulted in the removal of turbines from areas of steep and rocky terrain located within 100 metres of areas of steep slopes considered to potentially support cave bat roosting/breeding opportunities. A total of 8 turbines were removed during these workshops, down to 70 turbines from a maximum of 78, which contributed to an approximately 30 % reduction in clearing extents.

Existing road infrastructure and farm tracks have been prioritised to provide the required access during construction and operation. By utilising pre-existing infrastructure the Project has avoided and minimised impacts to sensitive ecological areas, including potential microbat breeding habitat and the surrounding native vegetation that supports these habitats.

Two high potential cave bat roosting/breeding habitats were identified within the previous development footprint (as described in Section 5.4.2). Whilst there were no direct impacts to these potential cave bat breeding habitats, the turbine pad associated with turbine WP27 partially occurred within the 100 metre buffer zone surrounding one of the high potential cave bat roosting/breeding habitats. This would have resulted in the removal of approximately 2,000 square metres of native vegetation from this buffer zone (1.8 % of the overall buffer zone). The removal of the WP27 as part of project design (Table 1) means that this impact has been successfully avoided.

Actions and measures to avoid indirect impacts

Indirect impacts to Large Bent-winged Bat associated with the project operation phase primarily involve potential collision and possibly barotrauma risks associated with the wind turbine blades during the operational phase of the project. In designing the wind farm layout the spacing of the turbines was considered to limit interactions with fauna and an essentially linear row of turbines was designed. This is different from most wind energy facilities in Australia in which turbines are scattered across a site. In the more usual scattered or 'clustered' array, microbats and avian fauna have a high probability of encountering multiple turbines in a given flight. The configuration of Hills of Gold turbines is such that an individual is likely to encounter multiple turbines only in the rare event that it flies directly along the row of turbines. The minimum spacing between two adjacent turbines along the development footprint is 270 metres (110 metres at turbine height) and the maximum distance between two adjacent turbines is 1,600 metres (1,400 metres at turbine height). The average range is 300 – 500 metres or 138 – 338 metres between turbines. These gaps provide movement corridors, allowing for migrating and foraging bats to pass through the landscape, reducing the chance of collision and possibly barotrauma.

Prior to design amendments there would have been some incursion into the air space above the 100 metre radius buffers surrounding two identified breeding/roosting habitats in the vicinity of WP27 and WP50. This overlap extended over 8,100 square metres (7.5 %) of the 108,465 square metre buffer applied to the WP27 habitat, and over 470 square metres (0.3 %) of the 168,036 square metre buffer applied to the WP50 habitat, when considered on the horizontal plane. Distances between the tip of turbine blades and the top of canopy were considered as part of the wind farm design to ensure that ample vertical buffers were provided for foraging microbats and other avian fauna. A buffer distance above the canopy (estimated to be 23.5 metres high) surrounding WP27 and WP50 of approximately 36.67 metres and 43.35 metres was allowed.

As the two identified high potential roosting/breeding habitats consisted of rocky outcrop and cliffline habitats, buffer distances between tip of the WP27 and WP50 turbine blades and the nearby potential microbat habitats were calculated at ground level in accordance with TIN051 (Natural England 2009). A distance of approximately 91 metres occurs between the tips of the WP27 turbine blades and the nearby potential microbat roosting/breeding habitat, and a distance of approximately 139 metres occurred between the tips of the WP50 turbines blades and the potential microbat roosting/breeding habitat in that vicinity. WP50 therefore exceeded the BAM 100 metres radius buffer (DPIE 2021), whereas WP27 only intruded within the first 9 metres of this buffer. However, as outlined in Table 1, the removal of WP27 and relocation of WP50 means impacts to the identified breeding/roosting habitats and surrounding buffer areas has been successfully avoided.

Section 5.4.2 of this BDAR outlines the potential for collision mortality for the Large Bent-winged Bat, as well as other threatened and more common bats, which were recorded by acoustic detectors mounted on met masts at approximately 60 metres above the ground. In terms of the Large Bent-winged Bat, although there are no direct impacts to the potential roosting/breeding habitats within the development footprint, this species is migratory and are a fast-flying species that often forage above canopy height and may fly with RSH. Therefore, it is considered a moderate risk that repeated loss of individuals as a result of collision mortality may cause change to the local abundance of this species in the short term (up to 5 years).

Construction related indirect impacts include light, noise, and vibration. These impacts will be managed during construction to minimise impacts to nocturnal fauna. They also will not occur within the 100 metre buffer zone of the two high potential bat roosts. An Operational Bird and Bat Adaptive Management Plan will be prepared prior to construction to monitor any potential bat mortality and to continually assess the assumptions of this impact assessment. Furthermore, this will include detailed and stringent mitigation measures for high risk turbines and adaptive management strategies for moderate and low risk turbines.

Additional mitigation measures are recommended for inclusion in the CEMP that will further reduce the potential for impact to the species. These are provided in Section 8.9 of the BDAR.

(b) The size of the local population directly and indirectly impacted by the development, clearing or biodiversity certification.

Historical records for the species are located approximately 5 kilometres south-west of the wind farm development footprint. This includes one survey event in 2003 at Timor Caves, a known non-breeding roost location for the species (NPWS 2011), where approximately 2,000 individuals were recorded. A second survey event undertaken in 2008, slightly west of the first event, utilising anabat recording devices and seven separate detection events were recorded (DPIE 2021). Ultrasonic detectors were deployed at Timor Caves, as part of the current assessment, for three nights in March 2020, however the species was not recorded by this survey.

The species was recorded during the targeted surveys supporting the current assessment. These surveys were conducted from February 2020 to May 2020 and included deployment of units at ground-level as well as deployment on three meteorological masts at heights of 2 metres, c.30 metres and c.60 metres. Additional acoustic/ultrasonic survey was also undertaken in spring 2019 between 19 – 21 November 2019 (three nights) Across the 24 deployed ultrasonic detector units deployed in 2020 and the three nights of spring surveys in 2019, the total mean call for the species per night was 10.3 calls, indicating individuals of the species were utilising areas within the development footprint on most nights.

Due to the rural location of the assessment area, where historical survey coverage is lower, the overall size of the local population is unknown. This assessment considers the local population to include all individuals within 100 kilometres of the development footprint, which is based on a balance between the maximum overnight foraging distance of 65 kilometres (Churchill 2008), and the several hundred kilometre distances the species is known to travel between maternity and non-breeding roosts (Hoye & Hall 2008).

Within the development footprint, the impacts that were previously considered potentially serious and irreversible for the local population were restricted to two high potential roosting/breeding locations that were detected within the proximity of proposed turbines WP27 and WP50 (as described in Section 8.3). Due to the avoidance measures that have been employed (Table 1), there are now no direct impacts to these sites.

There are also indirect impacts associated with project construction and operation including collision mortality and possibly barotrauma, as well as noise, light and vibrations. In terms of the Large Bent-winged Bat, this species is migratory and are a fast-flying species that often forage above canopy height and may fly within RSH. Therefore, it is considered a moderate risk that repeated loss of individuals as a result of collision mortality may cause change to the local abundance of this species in the short term (up to 5 years). These will be minimised through the avoidance measure outlined in under question (a) above.

As direct impacts to the identified high potential roosting/breeding locations have been avoided, impacts to the local population as a result of the Project are primarily associated with loss of native vegetation that provides foraging habitat at the individual level, potential turbine strike and possibly barotrauma, and possible interruptions to habitat connectivity. Assessment of these indirect impacts has been provided in Section 8.3 of this BDAR.

(c) The extent to which the impact exceeds any threshold for the potential entity that is specified in the Guidance to assist a decision-maker to determine a serious and irreversible impact.

The SAII threshold specified for Large Bent-winged Bat within the Atlas of New South Wales is 'breeding habitat to be identified by survey'. This threshold does not provide a numerical value for the species that would assist a decision-maker in determining the level of impact above which a serious and irreversible impact may occur for this species. As such the extent to which the proposed impacts may exceed a threshold target for the species cannot be calculated. The general notes provided for the species state that any impact on breeding habitat could be considered potentially serious and irreversible (DPIE 2021).

Two high potential roosting/breeding habitat locations were previously identified within the vicinity of the development footprint (refer Figure 15). Whilst there were no direct impacts to these potential cave bat breeding habitats, the turbine pad associated with turbine WP27 partially occurred within the 100 metre buffer zone surrounding one of the high potential cave bat roosting/breeding habitats. This would have resulted in the removal of approximately 2,000 square metres of native vegetation from this buffer zone (1.8 % of the overall buffer zone). Road infrastructure supporting turbine pad WP50 was also located within 5 metres of a cave bat roosting/breeding habitat buffer. Due to avoidance measures adopted by the project (outlined in Table 1), these impacts have now been successfully avoided.

A geomorphological assessment of the assessment area was also commissioned which found that the landscape within and surrounding the development footprint was formed by a range of volcanic activity resulting in a basalt lithology (Environmental Geosurveys Pty Ltd 2021). The extent to which potential microbat habitat is present and suitable is a function initially of lithology and rock structure modified over time by geological and environmental processes. The assessment found that whilst the basalt lithology present at the development footprint may support opportunities for microbat roosts, no substantial caves were likely to be present, and that no data was found to suggest that the development footprint and immediate surrounds geomorphologically standout from the surrounding landscape in one way or another (Environmental Geosurveys Pty Ltd 2021).

Given the avoidance measures adopted by the project (Table 1) mean that there are now no direct impacts to identified cave bat breeding habitat, the project is considered unlikely to result in a serious and irreversible impacts for the species.

(d) The likely impact (including direct and indirect impacts) that the development, clearing or biodiversity certification will have on the habitat of the local population, including but not limited to:

(i) An estimate of the change in habitat available to the local population as a result of the proposed development.

(ii) The proposed loss, modification, destruction or isolation of the available habitat used by the local population.

(iii) Modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.

Approximately 2.54 million hectares of native vegetation occurs within a 100 kilometre buffer zone surrounding the development footprint. This represents the available foraging habitat available with the range of the local population, as defined in question (b). Only 132.43 hectares of native vegetation occurs within the development footprint, a tiny fraction of the vegetation within the locality. Of this vegetation approximately 37.92 hectares (28.6 %) is in high condition providing good habitat values for foraging native fauna, including Large Bent-winged Bat. This foraging habitat would be modified as a result of the Project.

Two high potential roosting/breeding sites for Large Bent-winged Bat have been identified adjacent to the development footprint. No direct impacts are proposed for these habitats. As such there will be no reduction in the availability of breeding habitat for Large Bent-winged Bat. Similarly, there will be no direct impact to important species 'life cycle' processes as no habitats that support these processes are being directly impacted.

The project will also result in indirect impacts during construction and afterward during operation of the wind farm. During construction these indirect impacts will consist of increased traffic, noise and light during the project construction. These impacts will be managed during construction to reduce impacts to nocturnal fauna and will cease once construction is completed. Restriction of works to outside of breeding season within the vicinity of the two high potential roosting/breeding habitats is recommended for inclusion within the CEMP's mitigation measures which will further reduce scale of construction related indirect impacts.

There are also indirect impacts associated with the operations phase where collision and possibly barotrauma risks associated with the wind turbine blades could occur, as well as potential impacts to habitat connectivity. These impacts are discussed further in Sections 8.3 and 8.5 of the BDAR, however these impacts will not significantly change the availability of habitat in the locality. In terms of the Large Bent-winged Bat, although there are no direct impacts to the potential roosting/breeding habitats within the development footprint, this species is migratory and are a fast-flying species that often forage above canopy height and may fly with RSH. Therefore, it is considered a moderate risk that repeated loss of individuals as a result of collision mortality may cause change to the local abundance of this species in the short term (up to 5 years). An Operational Bird and Bat Adaptive Management Plan will be prepared prior to construction to monitor any bat mortality and to continually assess the assumptions of this impact assessment and enable adaptive management measures to be implemented if required to reduce measured impacts.

(e) The likely impact on the ecology of the local population. At a minimum, address the following:

- For fauna:
  - Breeding

Maternity roosts for Large Bent-winged Bat are uncommon with 12 roosts known throughout the species' range (Hoye & Hall 2008). These colonies are reportedly large, ranging from 100 to 150,000 individuals (DPIE 2021), with one study estimating established colonies ranging from 15,000 to 200,000 Bent-winged Bats (prior to the split into subspecies) (Dwyer & Hamilton-Smith 1965).

Within NSW the Saving Our Species program has identified seven priority management sites across the state, none of which occur within the same IBRA subregion as the development footprint (DPIE 2015). The closest of these is a volcanic cave in the Mount Kaputar National Park, north of Tamworth, approximately 135 kilometres to the north-west of the development footprint. A second priority area is located at Willi Caves, approximately 140 kilometres to the north-east of the development footprint. Both of these areas are known maternity roosts for the species (DPIE 2015, Dwyer 1966). However, individuals recorded within the assessment area, and those likely to utilise Timor Caves as a non-breeding roost are expected to utilise the maternity roost at Kanangra-Boyd NP, due it's similarities to the assessment area in terms of topography and climatic conditions, rather than the northerly hotter/driers, and sub-tropical sites.

Within this area there are many potential roosting and breeding habitats for the species with over 80 caves identified in the Timor Caves karst system alone (Rutledge 2008). A geomorphological assessment of the assessment area found that there is diverse terrain and lithology and dynamic geomorphology within the locality that creates a high potential for microbat roosting sites across landscapes at all elevations, within the expected flight range of microbats that may be present within the assessment area (Environmental Geosurveys Pty Ltd 2021). The assessment notes that the assessment area lies in the southern margin of the New England Orogen, which comprises a complex geological history resulting in a wide range of rock types and structures in northeast NSW and southeast Queensland, with the diverse geology present in the landscape continuing to the north through the NSW North Coast, Nandewar and New England Tablelands bioregions (which together comprise much of the New England Orogen), thus habitats present in the locality of the project area are also likely to occur elsewhere within broader geological landscape, and therefore unlikely to form a substantial portion of the habitat available, or be significant at a bioregional scale (Environmental Geosurveys Pty Ltd 2021). Finally the nearby town of Nundle has a rich mining history, being settled in 1852 following the discovery of gold at "The Hanging Rock" and Swamp Creek, and consequently there are many (dozens) historic mines and unnamed pits in the region (AUSGIN 2021) which may also provide potential roosting habitat to the local population.

Adjacent to the development footprint there are two identified high potential roosting/breeding sites. This is comparatively few when placed in context of the similar habitat available within the locality and broader region. There are also no direct impacts proposed to either of these potential habitat locations or their surrounding buffer areas. The avoidance and minimisation for reducing indirect impacts during operation of the wind farm are discussed in question (a) above. Finally, the actual likelihood of the two potential breeding sites being a new and previously undiscovered breeding location for the species is considered to be very low. As such, the Project is unlikely to result in impacts to breeding habitat for Large Bent-winged Bat.

– Foraging

Large Bent-winged Bat uses a broad range of habitats including rainforests, wet and dry sclerophyll forests and vine thicket. The species hunts in timbered areas, catching beetles, moths and flies above the canopy trees (Churchill 2008, DPIE 2021). Approximately 2.54 million hectares of native vegetation occurs within a 100 kilometre buffer zone surrounding the development footprint. This represents the available foraging habitat available with the 100 kilometre range of the local population, as defined in question (b). Only 132.43 hectares of native vegetation occurs within the development footprint, a tiny fraction of the vegetation within the locality. Of this vegetation approximately 37.92 hectares (28.6 %) is in high condition providing good habitat values for foraging native fauna, including Large Bent-winged Bat. This foraging habitat would be modified as a result of the Project.

Vegetation within the development footprint is connected to surrounding vegetation in all directions, and across the 100 kilometre area surrounding the development footprint there is approximately 85 % coverage of native vegetation. This includes large tracts of intact native vegetation within the Ben Halls Gap National Park, Crawney Pass National Park, Wallabadah Nature Reserve and the Nundle and Hanging Rock State Forests. These areas represent prime foraging habitat for the species and are all within two kilometres of various locations along the development footprint. Given the species has been known to travel up to 65 kilometres in a single night to access foraging habitat (Churchill 2008), all of these foraging habitats would be easily accessible individuals within the local population. The removal of native vegetation as part of the proposed works is therefore not considered to have a significant impact on the foraging ecology of Large Bent-winged Bat.

– Roosting

Large Bent-winged Bat primarily roosts in caves however the species is also known to utilise derelict mines, storm-water tunnels, buildings and other man-made structures (DPIE 2021). Bionet records for Large Bent-winged Bat occur within the locality and the species was also detected as part of the targeted acoustic surveys undertaken as part of this assessment. A known non-breeding roost for the species also occurs in the locality at Timor Caves (NPWS 2011), located approximately 5 kilometres to the south-west of the development footprint.

Within the locality there are many potential roosting and breeding habitats for the species with over 80 caves identified in the Timor Caves karst system alone (Rutledge 2008). A geomorphological assessment of the assessment area found that there is diverse terrain and lithology and dynamic geomorphology within the locality that creates a high potential for microbat roosting sites across landscapes at all elevations, within the expected flight range of microbats that may be present within the assessment area (Environmental Geosurveys Pty Ltd 2021). The assessment notes that the assessment area lies in the southern margin of the New England Orogen, which comprises a complex geological history resulting in a wide range of rock types and structures in northeast NSW and southeast Queensland, with the diverse geology present in the landscape continuing to the north through the NSW North Coast, Nandewar and New England Tablelands bioregions (which together comprise much of the New England Orogen), thus habitats present in the locality of the project area are also likely to occur elsewhere within broader geological landscape, and therefore unlikely to form a substantial portion of the habitat available, or be significant at a bioregional scale (Environmental Geosurveys Pty Ltd 2021). Finally the nearby town of Nundle has a rich mining history, being settled in 1852 following the discovery of gold at "The Hanging Rock" and Swamp Creek, and consequently there are many (dozens) historic mines and unnamed pits in the region (AUSGIN 2021) which may also provide potential roosting habitat to the local population.

There are two high potential roosting habitats located adjacent to the development footprint. As a result of avoidance measures adopted by the project (Table 1), there are no direct impacts to either of these features or the surrounding buffer areas. Given the underlying geology outlined by the geomorphological report (Environmental Geosurveys Pty Ltd 2021), there are likely to be numerous cracks and crevices along ridgelines within the broader locality that may be used as overnight roosts by individuals or small groups of Large Bent-winged Bats. Given the high potential for similar habitat across the locality, the Project is not expected to significantly alter the availability of these crack/crevice overnight roosting habitats.

- Dispersal or movement pathways

Large Bent-winged Bat is a highly mobile species, with some individuals documented dispersing up to three hundred kilometres from known maternity caves (DPIE 2021). While it is assumed that connected vegetation is preferred by the species for movement, the existence of many records of the species within urbanised areas, and its utilisation of man-made structures as roosting sites, suggests that the species does not rely on specialised dispersal or movement habitat.

Furthermore, in designing the wind farm layout the spacing of the turbines was considered to limit interactions with fauna and an essentially linear row of turbines was designed. This is different from most wind energy facilities in Australia in which turbines are scattered across a site. In the more usual scattered or 'clustered' array, microbats and avian fauna have a high probability of encountering multiple turbines in a given flight. The configuration of Hills of Gold turbines is such that an individual is likely to encounter multiple turbines only in the rare event that it flies directly along the row of turbines. The minimum spacing between two adjacent turbines along the development footprint is 270 metres (110 metres at turbine height) and the maximum distance between two adjacent turbines is 1,600 metres (1,400 metres at turbine height). The average range is 300 – 500 metres or 138 – 338 metres between turbines. These gaps provide movement corridors, allowing for migrating and foraging bats to pass through the landscape, reducing the chance of collision and possibly barotrauma.

Given the local population is most likely to be utilising the known important non-breeding roosting habitats afforded by Timor Caves (NPWS 2011), and then travelling further south to the known maternity roost in the Kanangra-Boyd NP, it is unlikely that individuals would be making multiple north-south movements at turbine blade height over the linear wind farm footprint. Such north-south movement are more likely to be associated with foraging flights which would be conducted at canopy level, out of turbine blade range (see Section 7.2 for details regarding turbine blade buffers). The layout also retains areas of preferred foraging habitat in steeper areas of terrain, with more densely vegetated gullies preserved. Overall, although collision mortality is unlikely and may occur only during some circumstances, it is considered a moderate risk that repeated loss of individuals as a result of collision mortality may cause change to the local abundance of this species in the short term (up to 5 years). Impacts to habitat connectivity are further assessed in Section 8.5 of the BDAR.

(f) A description of the extent to which the local population will become fragmented or isolated as a result of the proposed development.

Large Bent-winged Bat is a highly mobile species, capable of traversing and surviving in highly urbanised environments with hundreds of observations recorded across metropolitan areas, including Sydney, one of the most urbanised regions in the country. The species also utilises man-made structures such as culverts, bridges, buildings and derelict mines as roosting sites. Given the transient nature of the species, the high level of native vegetation connection across the region, and the high level of potential roosting locations, the project is not expected to result in significant amount of landscape fragmentation that would result in the local population becoming isolated. Impacts to habitat connectivity are further assessed in Section 8.5 of the BDAR.

(g) The relationship of the local population to other population/populations of the species. This must include consideration of the interaction and importance of the local population to other population/populations for factors such as breeding, dispersal and genetic viability/diversity, and whether the local population is at the limit of the species' range.

Large Bent-winged Bat is distributed along the east coast of Australia from Cape York in northern Queensland to Castlemaine in Victoria, east of the Great Dividing Range (Churchill 2008). The occurrence of Large Bent-winged Bat is contiguous across its range within NSW, as evidenced by Bionet records for the species. Records are more isolated towards the southern and western edges of its distribution, however, the assessment area occurs well within the range of the species and is not considered to be at the limit of its range. Seven priority areas have been identified for the species as part of the Saving Our Species program (DPIE 2015).

The closest priority area to the Project is located north of Tamworth, in the Mount Kaputar National Park, approximately 135 kilometres to the north-west. Willi Caves, another priority area, occurs approximately 140 kilometres to the north-east (DPIE 2015, Dwyer 1966). In addition to these priority areas, a known non-breeding roost for the species occurs at Timor Caves, approximately 5 kilometres south-west of the development footprint (NPWS 2011). The species is known to travel up to several hundred kilometres between maternity and non-breeding roosts (Hoye & Hall 2008, DPIE 2021), with one study detailing 194 movement records from banded individuals in excess of 160 kilometres (Wilson 2003). Given the highly mobile nature of the species it is likely that individuals recorded within the development footprint would be dispersing through to other areas including the maternity roost at Kanangra-Boyd NP, due it's similarities to the assessment area in terms of topography and climatic conditions, rather than the northerly hotter/driers, and sub-tropical sites at Mount Kaputar and Willi Caves. The impacts associated with the Project will not impact on the ability for these interactions to occur.

(h) The extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population

The potential threats to Large Bent-winged Bat, as identified in the species profile included in the Bionet Atlas of NSW (DPIE 2021), are addressed below in Table 84.

Table 84 Potential threats to Large Bent-winged Bat

Threat	Relevance to proposed works
Disturbance by recreational cavers and general public accessing caves and adjacent areas particularly during winter or breeding	Only two high potential roosting/breeding habitats occur adjacent to the development footprint. No direct impacts are proposed to either of these locations and, due to avoidance measure adopted by the project, there are now no impacts within the buffer areas of these features As such there will be no significant impacts to breeding habitat for Large Bent-winged Bat as a result of the Project. Mitigation measures to control indirect impacts (noise, light and vibration) during construction will further ensure no impacts to the species, as will recommendations to avoid undertaking works in the proximity of these habitat features during breeding season.

Threat	Relevance to proposed works
Loss of high productivity foraging habitat	The proposed works include impacts to 132.43 hectares of native vegetation from the development footprint. However, only 37.92 hectares of this vegetation is considered high quality and potential foraging habitat for the species. Approximately 2.54 million hectares of native vegetation occurs within a 100 kilometre buffer zone surrounding the development footprint. This represents the available foraging habitat available with the range of the local population, as defined in question (b). There are also large tracts of intact native vegetation within the Ben Halls Gap National Park, Crawney Pass National Park, Wallabadah Nature Reserve and the Nundle and Hanging Rock State Forests which all occur within foraging distance of the development footprint. As such the Project is considered unlikely to significantly reduce the availability of high productivity foraging habitat for the local population of Large Bent-winged Bat.
Introduction of exotic pathogens, particularly White-nose fungus.	There have been no cases of White-nose fungus recorded in Australia (DAWE 2019). It is unlikely that the proposed development would result in the fungus being spread to microbats due to its non-detection within Australia.
Cave entrances being blocked for human health and safety reasons, or vegetation (particularly blackberries) encroaching on and blocking cave entrances	There are two high potential roosting sites located within the vicinity of the development footprint. No direct impacts are proposed to either of these locations. As such the Project is unlikely to result in these locations becoming inaccessible to Large Bent-winged Bat individuals.
Hazard reduction and wildfire fires during the breeding season.	The risk of fire as a result of sparks from machinery during proposed works is unlikely but could increase the risk of fire occurring nearby potential roost sites. This risk will be managed by implementing appropriate mitigation measures such as spark dampeners, water spraying or the close proximity of fire-fighting gear such as extinguishers as necessary within the Project's CEMP.
Predation by feral cats	The project does not substantially alter the environment in such a way that the numbers of feral cats within the locality are likely to increase. As such the project is unlikely to result in exacerbation of this threatening process upon Large Bent-winged Bat.

(i) An estimate of the area, or number of populations and size of populations that is in the reserve system in NSW, the IBRA region and the IBRA subregion.

The following information has been gathered from BioNet Atlas records as well as scientific literature and government reports.

New South Wales

A total of 6,234 BioNet Atlas records for Large Bent-winged Bat exist across NSW (DPIE 2021). These records continuously across its range along the coastal region of NSW from the border with Queensland in the north down to the southern border of NSW with Victoria. Records exist within the following IBRA regions within NSW:

- Australian Alps
- Brigalow Belt South

- Nandewar
- New England Tablelands
- NSW North Coast
- NSW South Western Slopes
- South East Corner
- South Eastern Highlands
- South Eastern Queensland
- Sydney Basin

Low numbers of records also occur within the Cobar Peneplain (3 records) and Riverina (1 record) IBRA regions.

The Saving Our Species strategy (DPIE 2015) for this species has identified seven priority management sites within NSW occurring in the following areas:

- Kwiamble in the Inverell LGA.
- Mount Kaputar in the Narrabri LGA.
- Willi Willi Cave in the Kempsey LGA.
- Yessabah in the Kempsey LGA.
- Church Cave in the Yass Valley LGA.
- Drum Cave in the Goulburn Mulwaree LGA.
- Dip Cave in the Yass Valley LGA.

A total of 1,229 (20 %) of the historical sightings occur within the NSW reserve system spread across 181 national parks, nature reserves and conservation areas.

Nandewar – Peel IBRA sub-region

A total of 372 records for Large Bent-winged Bat occur within the Nandewar IBRA region, 326 within the Peel IBRA sub-region. Of these only a single record from the Peel sub-region occurs within the NSW reserve system, located in the Serpentine Ridge CCA Zone 1 National Park.

New England Tablelands – Walcha Plateau IBRA sub-region

A total of 128 records for Large Bent-winged Bat occur within the New England Tablelands IBRA region, 10 within the Walcha Plateau sub-region. Of these, four records from the Walcha Plateau sub-region occur within the NSW reserve system, located in the Curracabundi National Park and Oxley Wild Rivers National Park.

NSW North Coast – Tomalla IBRA sub-region

A total of 1,103 records for Large Bent-winged Bat occur within the NSW North Coast IBRA region, 26 within the Tomalla sub-region. Of these only a single record from the Tomalla sub-region occurs within the NSW reserve system, located within the Curracabundi National Park.

(j) The measure/s proposed to contribute to the recovery of the species in the IBRA subregion.

The proposed works are not considered likely to have a substantial impact on Large Bent-winged Bat, and thus no measures have been proposed to contribute to the recovery of the species.

Little Bent-winged Bat SAII assessment in accordance with the BAM (2017) methodology

Little Bent-winged Bat is a member of the Miniopteridae family (Churchill 2008). The species occurs along the east coast of Australia from northern Queensland to Albion Park south of Wollongong, and is listed as Vulnerable under the BC Act.

Little Bent-winged Bat uses a broad range of habitats including moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, *Melaleuca* spp. swamps, dense coastal forests and banksia scrub (Churchill 2008, DPIE 2019). Little Bent-winged bats prefer well-timbered areas where they feed primarily in the shrub and canopy layers. Their diet consists primarily of beetles, moths, flies and spiders (Churchill 2008).

Little Bent-winged Bat is considered a species credit species under the BAM, specifically in relation to the species' breeding habitat. This breeding habitat is defined in the Atlas of NSW Wildlife (DPIE 2021) as any:

'Cave, tunnel, mine, culvert or other structure known or suspected to be used for breeding including species records in BioNet with microhabitat code 'IC – in cave'; observation type code 'E nest-roost'; with numbers of individuals >500; or from the scientific literature'.

Impacts to these breeding habitat features, and the area within a 100 metre radius buffer around an accurate GPS point location centred on the cave / feature entrance, are what are considered to be potentially serious and irreversible for the species (DPIE 2021). Such areas were previously located within the development footprint, requiring the undertaking of an SAII assessment. However, amendments to the project design, as outlined in Table 1, have since resulted in these areas being successfully avoided. Whilst no longer required, this SAII has still been included and updated due to the importance of the species.

(a) The action and measures taken to avoid the direct and indirect impact on the potential entity for an SAII.

Actions and measures to avoid direct impacts

A preliminary biodiversity assessment (Arup 2019) was undertaken prior to the development of the wind farm layout and the selection of the preferred transmission line corridor. This preliminary assessment highlighted areas of key ecological concern and allowed for avoidance of these areas during the wind farm concept design. During the wind farm layout design, workshops were held between project ecologists, civil engineers and wind modellers to further optimise layout options and ensure impacts to the areas of highest potential Little Bent-winged Bat breeding areas were avoided or minimised. These workshops resulted in the removal of turbines from areas of steep and rocky terrain located within 100 metres of areas of steep slopes considered to potentially support cave bat roosting/breeding opportunities. A total of 8 turbines were removed during these workshops, down to 70 turbines from a maximum of 78, which contributed to an approximately 30 % reduction in clearing extents.

Existing road infrastructure and farm tracks have been prioritised to provide the required access during construction and operation. By utilising pre-existing infrastructure the Project has avoided and minimised impacts to sensitive ecological areas, including potential microbat breeding habitat and the surrounding native vegetation that supports these habitats.

Two high potential cave bat roosting/breeding habitats were identified within the previous development footprint (as described in Section 5.4.2). Whilst there were no direct impacts to these potential cave bat breeding habitats, the turbine pad associated with turbine WP27 partially occurred within the 108,546 square metre (100 metre radius) buffer zone surrounding one of the high potential roosting/breeding habitats. This would have resulted in the removal of approximately 2,000 square metres of native vegetation from this buffer zone (1.8 % of the overall buffer zone). The removal of the WP27 as part of project design (Table 1) means that this impact has been successfully avoided.

Actions and measures to avoid indirect impacts

Indirect impacts to Little Bent-winged Bat associated with the project operation phase primarily involve potential collision and possibly barotrauma risks associated with the wind turbine blades during the operational phase of the project. In designing the wind farm layout the spacing of the turbines was considered to limit interactions with fauna and an essentially linear row of turbines was designed. This is different from most wind energy facilities in Australia in which turbines are scattered across a site. In the more usual scattered or 'clustered' array, microbats and avian fauna have a high probability of encountering multiple turbines in a given flight. The configuration of Hills of Gold turbines is such that an individual is likely to encounter multiple turbines only in the rare event that it flies directly along the row of turbines. The minimum spacing between two adjacent turbines along the development footprint is 270 metres (110 metres at turbine height) and the maximum distance between two adjacent turbines is 1,600 metres (1,400 metres at turbine height). The average range is 300 – 500 metres or 138 – 338 metres between turbines. These gaps provide movement corridors, allowing for migrating and foraging bats to pass through the landscape, reducing the chance of collision and possibly barotrauma.

Prior to design amendments there would have been some incursion into the air space above the 100 metre radius buffers surrounding two identified breeding/roosting habitats in the vicinity of WP27 and WP50. This overlap extended over 8,100 square metres (7.5 %) of the 108,465 square metre buffer applied to the WP27 habitat, and over 470 square metres (0.3 %) of the 168,036 square metre buffer applied to the WP50 habitat, when considered on the horizontal plane. Distances between the tip of turbine blades and the top of canopy were considered as part of the wind farm design to ensure that ample vertical buffers were provided for foraging microbats and other avian fauna. A buffer distance above the canopy (estimated to be 23.5 metres high) surrounding WP27 and WP50 of approximately 36.67 metres and 43.35 metres was allowed.

As the two identified high potential roosting/breeding habitats consisted of rocky outcrop and cliffline habitats, buffer distances between tip of the WP27 and WP50 turbine blades and the nearby potential microbat habitats were calculated at ground level in accordance with TIN051 (Natural England 2009). A distance of approximately 91 metres occurs between the tips of the WP27 turbine blades and the nearby potential microbat roosting/breeding habitat, and a distance of approximately 139 metres occurred between the tips of the WP50 turbines blades and the potential microbat roosting/breeding habitat in that vicinity. WP50 therefore exceeded the BAM 100 metres radius buffer (DPIE 2021), whereas WP27 only intruded within the first 9 metres of this buffer. However, as outlined in Table 1, the removal of WP27 and relocation of WP50 means impacts to the identified breeding/roosting habitats and surrounding buffer areas has been successfully avoided.

Section 5.4.2 of this BDAR, outlines the potential for collision mortality for the Little Bent-winged Bat, as well as other threatened and more common bats, which were recorded by acoustic detectors mounted on met masts at approximately 60 metres above the ground. In terms of the Little Bent-winged Bat, although there are no direct impacts to the potential roosting/breeding habitats within the development footprint, this species is migratory and are a fast-flying species that often forage beneath or above canopy height and may fly within RSH. Therefore, although collision mortality is unlikely and may occur only during some circumstances, it is considered a moderate risk that repeated loss of individuals as a result of collision mortality may cause change to the local abundance of this species in the short term (up to 5 years).

Construction related indirect impacts include light, noise, and vibration. These impacts will be managed during construction to minimise impacts to nocturnal fauna. They also will not occur within the 100 metre buffer zone of the two high potential bat roosts. An Operational Bird and Bat Adaptive Management Plan will be prepared prior to construction to monitor any potential bat mortality and to continually assess the assumptions of this impact assessment. Furthermore, this will include detailed and stringent mitigation measures for high risk turbines and adaptive management strategies for moderate and low risk turbines

Additional mitigation measures are recommended for inclusion in the CEMP that will further reduce the potential for impact to the species.

(b) The size of the local population directly and indirectly impacted by the development, clearing or biodiversity certification.

Two historical records for the species are located approximately 14 kilometres south-west of the wind farm development footprint. These records were based on ultrasonic recording that were made in December 2016 and December 2018 (DPIE 2021). The records occur within the Timor Caves locality, which is a known important non-breeding roost location for Large Bent-winged Bat, with which Little Bent-winged Bat is known to form mixed roosting colonies (NPWS 2011, Dwyer 1968).

The species was recorded during the targeted surveys supporting the current assessment. These surveys were conducted from February 2020 to May 2020 and included deployment of units at ground-level as well as deployment on three meteorological masts at heights of 2 metres, c.30 metres and c.60 metres. Additional acoustic/ultrasonic survey was also undertaken in spring 2019 between 19 – 21 November 2019 (three nights) Across the 24 deployed ultrasonic detector units deployed in 2020 and the three nights of spring surveys in 2019, the total mean call for the species per night was 2.6 calls, indicating a low activity within the development footprint on an infrequent basis.

Due to the rural location, where historical survey coverage is lower, the overall size of the local population is unknown. This assessment considers the local population to include all individuals within 100 kilometres of the development footprint, which is balance between the recorded maximum overnight distance of 28 kilometres (Dwyer 1968), and the over 200 kilometre distances the species is known to travel between maternity and non-breeding roost locations (Hoye & Hall 2008).

Within the development footprint the impacts that were previously considered potentially serious and irreversible for the local population were restricted to two high potential roosting/breeding locations that were detected within the proximity of proposed turbines WP27 and WP50 (as described in Section 8.3). Due to the avoidance measures that have been employed (Table 1), there are now no direct impacts to these sites.

There are also indirect impacts associated with project construction and operation including wind turbine strike and possibly barotrauma, as well as noise, light and vibrations. In terms of the Little Bent-winged Bat, this species is migratory and are a fast-flying species that often forage above canopy height and may fly within RSH. Therefore, it is considered a moderate risk that repeated loss of individuals as a result of collision mortality may cause change to the local abundance of this species in the short term (up to 5 years). These will be minimised through the avoidance measure outlined in under question (a) above.

As direct impacts to the identified high potential roosting/breeding locations have been avoided, impacts to the local population as a result of the Project are primarily associated with loss of native vegetation that provides foraging habitat at the individual level, potential turbine strike and possibly barotrauma, and possible interruptions to habitat connectivity. Assessment of these indirect impacts has been provided in Sections 8.3 and 8.5 of this BDAR.

(c) The extent to which the impact exceeds any threshold for the potential entity that is specified in the Guidance to assist a decision-maker to determine a serious and irreversible impact.

The SAII threshold specified for Little Bent-winged Bat within the Atlas of New South Wales is 'breeding habitat to be identified by survey'. This threshold does not provide a numerical value for the species that would assist a decision-maker in determining the level of impact above which a serious and irreversible impact may occur for this species. As such the extent to which the proposed impacts may exceed a threshold target for the species cannot be calculated. The general notes provided for the species state that any impact on breeding habitat could be considered potentially serious and irreversible (DPIE 2021).

Two high potential roosting/breeding habitat locations were previously identified within the vicinity of the development footprint (refer Figure 15). Whilst there were no direct impacts to these potential cave bat breeding habitats, the turbine pad associated with turbine WP27 partially occurred within the 100 metre buffer zone surrounding one of the high potential cave bat roosting/breeding habitats. This would have resulted in the removal of approximately 2,000 square metres of native vegetation from this buffer zone (1.8 % of the overall buffer zone). Road infrastructure supporting turbine pad WP50 was also located within 5 metres of a cave bat roosting/breeding habitat buffer. Due to avoidance measures adopted by the project (outlined in Table 1), these impacts have now been successfully avoided.

A geomorphological assessment of the assessment area was also commissioned which found that the landscape within and surrounding the development footprint was formed by a range of volcanic activity resulting in a basalt lithology (Environmental Geosurveys Pty Ltd 2021). The extent to which potential microbat habitat is present and suitable is a function initially of lithology and rock structure modified over time by geological and environmental processes. The assessment found that whilst the basalt lithology present at the development footprint may support opportunities for microbat roosts, no substantial caves were likely to be present, and that no data was found to suggest that the development footprint and immediate surrounds geomorphologically standout from the surrounding landscape in one way or another (Environmental Geosurveys Pty Ltd 2021).

Given the avoidance measures adopted by the project (Table 1) mean that there are now no direct impacts to identified cave bat breeding habitat, the project is considered unlikely to result in a serious and irreversible impacts for the species.

(d) The likely impact (including direct and indirect impacts) that the development, clearing or biodiversity certification will have on the habitat of the local population, including but not limited to:

> ***(i) An estimate of the change in habitat available to the local population as a result of the proposed development.***
>
> ***(ii) The proposed loss, modification, destruction or isolation of the available habitat used by the local population***
>
> ***(iii) Modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.***

Approximately 2.54 million hectares of native vegetation occurs within a 100 kilometre buffer zone surrounding the development footprint. This represents the available foraging habitat available with the range of the local population, as defined in question (b). Only 132.43 hectares of native vegetation occurs within the development footprint, a tiny fraction of the vegetation within the locality. Of this vegetation approximately 37.92 hectares (28.6 %) is in high condition providing good habitat values for foraging native fauna, including Little Bent-winged Bat. This foraging habitat would be modified as a result of the Project.

Two high potential roosting/breeding sites for Little Bent-winged Bat have been identified adjacent to the development footprint. No direct impacts are proposed for these habitats. As such there will be no direct impact to important species 'life cycle' processes as no habitats that support these processes are being directly impacted.

The project will also result in indirect impacts during construction and afterward during operation of the wind farm. During construction these indirect impacts will consist of increased traffic, noise and light during the project construction. These impacts will be managed during construction to reduce impacts to nocturnal fauna and will cease once construction is completed. Restriction of works to outside of breeding season within the vicinity of the two high potential roosting/breeding habitats is recommended for inclusion within the CEMP's mitigation measures which will further reduce scale of construction related indirect impacts.

There are also indirect impacts associated with the operations phase where collision and possibly barotrauma risks associated with the wind turbine blades could occur, as well as potential impacts to habitat connectivity. These impacts are discussed further in Section 8.5 of the BDAR, however these impacts will not significantly change the availability of habitat in the locality. In terms of the Little Bent-winged Bat, although there are no direct impacts to the potential roosting/breeding habitats within the development footprint, this species is migratory and are a fast-flying species that often forage above canopy height and may fly with RSH. Therefore, it is considered a moderate risk that repeated loss of individuals as a result of collision mortality may cause change to the local abundance of this species in the short term (up to 5 years). An Operational Bird and Bat Adaptive Management Plan will be prepared prior to construction to monitor any bat mortality and to continually assess the assumptions of this impact assessment and enable adaptive management measures to be implemented if required to reduce measured impacts.

(e) The likely impact on the ecology of the local population. At a minimum, address the following:

- For fauna:
  - Breeding

Maternity roosts for Little Bent-winged Bat are rare with only five documented nursery sites within Australia (DPIE 2021). The species maternity roosts are documented as being large, with groups of 3,000 to 4,000 individuals, with the largest known maternity colony at Mt Etna in central Queensland consisting of over 100,000 individuals (Churchill 2008, Hoye & Hall 2008). The largest maternity colony in NSW co-occurs with a large maternity colony of Large Bent-winged Bat. This pattern of co-occurrence is repeated across several roost sites and it is thought that the smaller species depends on the heat generated by the larger species to successfully rear its young (DPIE 2021, Dwyer 1968, Churchill 2008).

The Saving Our Species strategy for Little Bent-winged Bat has identified two priority management areas (one north of Newcastle and one in Byron Bay), as well one key management site, Willi Willi Cave in northern NSW, (DPIE 2015). Willi Willi Cave is the closets of these locations, at approximately 140 kilometres north-east of the development footprint (DPIE 2015). The Willi Willi Cave is an important maternity colony for the species and is a mixed colony of both Little Bent-winged Bat and Large Bent-winged Bat. The size of this colony was estimated over three years, from 1961-1963, with the average estimate being 4,069 Little Bent-winged Bat individuals. (Dwyer 1968).

Within this area there are many potential roosting and breeding habitats for the species with over 80 caves identified in the Timor Caves karst system alone (Rutledge 2008). A geomorphological assessment of the assessment area found that there is diverse terrain and lithology and dynamic geomorphology within the locality that creates a high potential for microbat roosting sites across landscapes at all elevations, within the expected flight range of microbats that may be present within the assessment area (Environmental Geosurveys Pty Ltd 2021). The assessment notes that the assessment area lies in the southern margin of the New England Orogen, which comprises a complex geological history resulting in a wide range of rock types and structures in northeast NSW and southeast Queensland, with the diverse geology present in the landscape continuing to the north through the NSW North Coast, Nandewar and New England Tablelands bioregions (which together comprise much of the New England Orogen), thus habitats present in the locality of the project area are also likely to occur elsewhere within broader geological landscape, and therefore unlikely to form a substantial portion of the habitat available, or be significant at a bioregional scale (Environmental Geosurveys Pty Ltd 2021). Finally the nearby town of Nundle has a rich mining history, being settled in 1852 following the discovery of gold at "The Hanging Rock" and Swamp Creek, and consequently there are many (dozens) historic mines and unnamed pits in the region (AUSGIN 2021) which may also provide potential roosting habitat to the local population.

Adjacent to the development footprint there are two identified high potential roosting/breeding sites. This is comparatively few when placed in context of the similar habitat available within the locality and broader region. There are also no direct impacts proposed to either of these potential habitat locations or their surrounding buffer areas. The avoidance and minimisation for reducing indirect impacts during operation of the wind farm are discussed in question (a) above. Finally, the actual likelihood of the two potential breeding sites being a new and previously undiscovered breeding location for the species is considered to be very low. As such, the Project is unlikely to result in impacts to breeding habitat for Little Bent-winged Bat.

- Foraging

Little Bent-winged Bat uses a broad range of habitats including rainforests, wet and dry sclerophyll forests and vine thicket. The species hunts in timbered areas, catching beetles, moths and flies within the shrub and canopy layer (Churchill 2008, DPIE 2021). Approximately 2.54 million hectares of native vegetation occurs within a 100 kilometre buffer zone surrounding the development footprint. This represents the available foraging habitat available with the 100 kilometre range of the local population, as defined in question (b). Only 132.43 hectares of native vegetation occurs within the development footprint, a tiny fraction of the vegetation within the locality. Of this vegetation approximately 37.92 hectares (28.6 %) is in high condition providing good habitat values for foraging native fauna, including Little Bent-winged Bat. This foraging habitat would be modified as a result of the Project.

Vegetation within the development footprint is connected to surrounding vegetation in all directions, and across the 100 kilometre area surrounding the development footprint there is approximately 85 % coverage of native vegetation. This includes large tracts of intact native vegetation within the Ben Halls Gap National Park, Crawney Pass National Park, Wallabadah Nature Reserve and the Nundle and Hanging Rock State Forests. These areas represent prime foraging habitat for the species and are all within two kilometres of various locations along the development footprint. Given the species has been known to travel up to 65 kilometres in a single night to access foraging habitat (Churchill 2008), all of these foraging habitats would be easily accessible individuals within the local population. The removal of native vegetation as part of the proposed works is therefore not considered to have a significant impact on the foraging ecology of Little Bent-winged Bat.

- Roosting

Little Bent-winged Bat is known to roost in caves, tunnels, tree hollows, abandoned mines, stormwater drains, culverts, bridges and occasionally buildings (DPIE 2021). Bionet records for Little Bent-winged Bat occur within the locality and the species was also detected as part of the acoustic surveys undertaken as part of this assessment, although at low levels. A known non-breeding roost for Large Bent-winged Bat also occurs in the locality at Timor Caves (NPWS 2011), located approximately 5 kilometres to the south-west of the development footprint. Given Little Bent-winged Bat is known to co-occur and share roost sites with Large Bent-winged Bat (Dwyer 1968, DPIE 2021), it is likely that the Timor Caves site is also utilised by Little Bent-winged Bat.

Within the locality there are many potential roosting and breeding habitats for the species with over 80 caves identified in the Timor Caves karst system alone (Rutledge 2008). A geomorphological assessment of the assessment area found that there is diverse terrain and lithology and dynamic geomorphology within the locality that creates a high potential for microbat roosting sites across landscapes at all elevations, within the expected flight range of microbats that may be present within the assessment area (Environmental Geosurveys Pty Ltd 2021). The assessment notes that the assessment area lies in the southern margin of the New England Orogen, which comprises a complex geological history resulting in a wide range of rock types and structures in northeast NSW and southeast Queensland, with the diverse geology present in the landscape continuing to the north through the NSW North Coast, Nandewar and New England Tablelands bioregions (which together comprise much of the New England Orogen), thus habitats present in the locality of the project area are also likely to occur elsewhere within broader geological landscape, and therefore unlikely to form a substantial portion of the habitat available, or be significant at a bioregional scale

(Environmental Geosurveys Pty Ltd 2021). Finally the nearby town of Nundle has a rich mining history, being settled in 1852 following the discovery of gold at "The Hanging Rock" and Swamp Creek, and consequently there are many (dozens) historic mines and unnamed pits in the region (AUSGIN 2021) which may also provide potential roosting habitat to the local population.

There are two high potential roosting habitats located adjacent to the development footprint. As a result of avoidance measures adopted by the project (Table 1), there are no direct impacts to either of these features or the surrounding buffer areas. Given the underlying geology outlined by the geomorphological report (Environmental Geosurveys Pty Ltd 2021), there are likely to be numerous cracks and crevices along ridgelines within the broader locality that may be used as overnight roosts by individuals or small groups of Little Bent-winged Bats. Given the high potential for similar habitat across the locality, the Project is not expected to significantly alter the availability of these crack/crevice overnight roosting habitats.

- Dispersal or movement pathways

Little Bent-winged Bat is a highly mobile species, with some individuals documented as dispersing up to two hundred kilometres from known maternity caves (Hoye & Hall 2008). While it is assumed that connected vegetation is preferred by the species for movement, the existence of many records of the species within urbanised areas, and its utilisation of man-made structures as roosting sites, suggests that the species does not rely on specialised dispersal or movement habitat.

Furthermore, in designing the wind farm layout the spacing of the turbines was considered to limit interactions with fauna and an essentially linear row of turbines was designed. This is different from most wind energy facilities in Australia in which turbines are scattered across a site. In the more usual scattered or 'clustered' array, microbats and avian fauna have a high probability of encountering multiple turbines in a given flight. The configuration of Hills of Gold turbines is such that an individual is likely to encounter multiple turbines only in the rare event that it flies directly along the row of turbines. The minimum spacing between two adjacent turbines along the development footprint is 270 metres (110 metres at turbine height) and the maximum distance between two adjacent turbines is 1,600 metres (1,400 metres at turbine height). The average range is 300 – 500 metres or 138 – 338 metres between turbines. These gaps provide movement corridors, allowing for migrating and foraging bats to pass through the landscape, reducing the chance of collision and possibly barotrauma.

Given the local population is most likely to be utilising the known important non-breeding roosting habitats afforded by Timor Caves (NPWS 2011), and then travelling further south to the known maternity roost in the Kanangra-Boyd NP, it is unlikely that individuals would be making multiple north-south movements at turbine blade height over the linear wind farm footprint. Such north-south movement are more likely to be associated with foraging flights which would be conducted at canopy level, out of turbine blade range (see Section 7.2 for details regarding turbine blade buffers). The layout also retains areas of preferred foraging habitat in steeper areas of terrain, with more densely vegetated gullies preserved. It is therefore unlikely that the Project will interfere in the dispersal of movement pathways of the species. Overall, although collision mortality is unlikely and may occur only during some circumstances, it is considered a moderate risk that repeated loss of individuals as a result of collision mortality may cause change to the local abundance of this species in the short term (up to 5 years). Impacts to habitat connectivity are further assessed in Section 8.5 of the BDAR.

(f) A description of the extent to which the local population will become fragmented or isolated as a result of the proposed development.

Little Bent-winged Bat is a highly mobile species, capable of traversing and surviving in highly urbanised environments with hundreds of observations recorded across metropolitan areas, including Sydney, one of the most urbanised regions in the country. The species also utilises man-made structures such as culverts, bridges, buildings and derelict mines as roosting sites. Given the transient nature of the species, the high level of native vegetation connection across the region, and the high level of potential roosting locations, the project is not expected to result in significant amount of landscape fragmentation that would result in the local population becoming isolated. Impacts to habitat connectivity are further assessed in Section 8.5 of the BDAR.

(g) The relationship of the local population to other population/populations of the species. This must include consideration of the interaction and importance of the local population to other population/populations for factors such as breeding, dispersal and genetic viability/diversity, and whether the local population is at the limit of the species' range.

Little Bent-winged Bat is distributed along the east-coast of Australia, ranging from north of Batemans Bay up to Cape York in Queensland (DPIE 2021). The occurrence of Little Bent-winged Bat is contiguous across its range within NSW, as evidenced by Bionet records for the species. Records are more isolated towards the southern and western edges of its distribution, however, the assessment area occurs well within the range of the species and is not considered to be at the limit of its range. Two priority areas have been identified for the species as part of the Saving Our Species program, one north of Newcastle and one in Byron Bay), as well one key management site, Willi Willi Cave in northern NSW (DPIE 2015).

The closest of these sites is Willi Willi Cave, located approximately 140 kilometres to the north-east of the development footprint, which is an important maternity colony for the species (DPIE 2015, Dwyer 1968). In addition, an important non-breeding roost for the Large Bent-winged Bat occurs at Timor Caves, approximately 5 kilometres south-west of the development footprint (NPWS 2011). Given the Little Bent-winged Bat is known to form mixed roosting colonies with Large Bent-winged Bat, it is likely Timor Caves are also utilised by Little Bent-winged Bat. With the species being high mobile, known to travel over two hundred kilometres between maternity and over-wintering roosts (Hoye & Hall 2008), it is likely that individuals recorded within the development footprint would be dispersing through to other areas including the Willi Willi Cave maternity roost, and the Timor Caves non-breeding roost. The impacts associated with the Project will not impact on the ability for these interactions to occur.

(h) The extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population.

The potential threats to Little Bent-winged Bat, as identified in the species profile included in the Bionet Atlas of NSW (DPIE 2021), are addressed below in Table 85.

Table 85 Potential threats to Little Bent-winged Bat

Threat	Relevance to proposed works
Disturbance of colonies, especially in nursery or hibernating caves.	Only two high potential roosting/breeding habitats occur adjacent to the development footprint. No direct impacts are proposed to either of these locations and, due to avoidance measure adopted by the project, there are now no impacts within the buffer areas of these features. As such there will be no significant impacts to breeding habitat for Little Bent-winged Bat as a result of the Project. Mitigation measures to control indirect impacts (noise, light and vibration) during construction will further ensure no impacts to the species, as will recommendations to avoid undertaking works in the proximity of these habitat features during breeding season.
Destruction of caves that provide seasonal or potential roosting sites.	No direct impacts are proposed to either of the two high potential roosting/breeding locations. As there are no direct impacts these habitat features, there will be no destruction of potential roosting sites as a result of the Project.

Threat	Relevance to proposed works
Changes to habitat, especially surrounding maternity/nursery caves and winter roosts.	The proposed works include impacts to 132.43 hectares of native vegetation from the development footprint. However, only 37.92 hectares of this vegetation is considered high quality and potential foraging habitat for the species. Approximately 2.54 million hectares of native vegetation occurs within a 100 kilometre buffer zone surrounding the development footprint. This represents the available foraging habitat available with the range of the local population, as defined in question (b). There are also large tracts of intact native vegetation within the Ben Halls Gap National Park, Crawney Pass National Park, Wallabadah Nature Reserve and the Nundle and Hanging Rock State Forests which all occur within foraging distance of the development footprint. As such the Project is considered unlikely to significant alter the habitat of Little Bent-winged Bat surrounding maternity/nursery caves and winter roosts.
Pesticides on insects and in water consumed by bats bio accumulates, resulting in poisoning of individuals.	The project is not likely to substantially increase the levels of pesticides within the environment.
Predation from foxes, particularly around maternity caves, winter roosting and roosts within culverts, tunnels and under bridges.	Foxes are already present within the development footprint. The project does not substantially alter the environment such that the numbers of foxes within the locality are likely to increase. As such the project is unlikely to result in exacerbation of this threatening process upon Little Bent-winged Bat.
Predation from feral cats, particularly around maternity caves, winter roosts and roosts within culverts, tunnels and under bridges.	The project does not substantially alter the environment such that the numbers of feral cats within the locality are likely to increase. As such the project is unlikely to result in exacerbation of this threatening process upon Little Bent-winged Bat.
Introduction of exotic pathogens such as White-nose fungus.	There have been no cases of White-nose fungus recorded in Australia (DAWE 2019). It is unlikely that the proposed development would result in the fungus being spread to microbats due to its non-detection within Australia.
Hazard reduction and wildfire fires during the breeding season.	The risk of fire as a result of sparks from machinery during proposed works is unlikely but could increase the risk of fire occurring nearby potential roost sites. This risk will be managed by implementing appropriate mitigation measures such as spark dampeners, water spraying or the close proximity of fire-fighting gear such as extinguishers as necessary within the Project's CEMP.
Large scale wildfire or hazard reduction can impact on foraging resources.	The proposed works are unlikely to result in large-scale wildfire and do not involve hazard reduction practices. As such the impact of this threatening process is unlikely to be exacerbated by the proposed works.
Poor knowledge of reproductive success and population dynamics.	This threatening process will not be exacerbated by the proposed works. It is also unlikely that the proposed works will have an impact on the reproductive success of the species and local population dynamics given the scope of the impact and the lack of evidence of a known maternity roost being present in the development footprint
Destruction of caves that	No direct impacts are proposed to the two potential breeding/roosting habitats

Threat	Relevance to proposed works
provide roosting sites.	within the development footprint. This threatening process will not be exacerbated by the Project.
Impacts from invasive flora and fauna.	Weeds occurring within the development footprint commonly occur across the locality. The current land use within the development footprint is agricultural with grazing cattle present that are likely already acting as vectors for the spreading of weeds. Measures to ensure adequate control of weeds and pathogens during construction will be detailed in the Project's CEMP. These measures will ensure weed material is properly managed such that there are no significant increases in weed densities that would lead to impacts to the potential Little Bent-winged Bat breeding habitat. The assessment area already supports several pest animal species including Red Fox Vulpes, Feral cats Felis catus and several species of deer. The CEMP will detail monitoring and management measures to ensure that the presence of such species does not increase due to proposed works. Such activities include improper disposal of rubbish that might attract pests. Overall, the impacts associated with the Project are unlikely to increase the presence of pest animal populations that might disturb potential Little Bent-winged Bat habitat.

(i) An estimate of the area, or number of populations and size of populations that is in the reserve system in NSW, the IBRA region and the IBRA subregion.

The following information has been gathered from BioNet Atlas records as well as scientific literature and government reports.

New South Wales

A total of 4,433 BioNet Atlas records for Little Bent-winged Bat exist across NSW (DPIE 2021). These records are generally contiguous along the east coast occurring from the Queensland border in the north, to Albion Park in the south, and up to 130 kilometres inland from the coast. Records occur within the following IBRA regions within NSW:

- New England Tablelands
- NSW North Coast
- South Eastern Queensland
- Sydney Basin

Low number of records also occur within the Nandewar (1 record), NSW South Western Slopes (1 record), South East Corner (2 records), and South Eastern Highlands (3 records).

The Saving our Species strategy for this species identifies two priority management areas and one priority management site (Willi Willi Cave) where management of important populations is underway. An estimated total of 23 % of the species' distribution occurs on reserves within the National Parks and Wildlife Service Estate (DPIE 2015). This is slightly higher than historical records suggest with 741 (16 %) sightings occurring within the NSW reserve system. These records occur within 138 national parks, nature reserves and conservation areas.

Nandewar – Peel IBRA sub-region

One historical record for Little Bent-winged Bat occurs within the Nandewar IBRA region, in the Kaputar IBRA sub-region. No records exist with the Peel IBRA sub-region.

New England Tablelands – Walcha Plateau IBRA sub-region

A total of 22 records for Little Bent-winged Bat occur within the New England Tablelands IBRA region, however, only one of these occurs within the Walcha Plateau sub-region. This record occurs within the Oxley Wild Rivers National Park.

NSW North Coast – Tomalla IBRA sub-region

A total of 1,487 records for Little Bent-winged Bat occur within the NSW North Coast IBRA region, four within the Tomalla IBRA sub-region. None of the records from the Tomalla sub-region are associated with NSW reserves.

(j) The measure/s proposed to contribute to the recovery of the species in the IBRA subregion.

The proposed works are not considered likely to have a substantial impact on Little Bent-winged Bat, and thus no measures have been proposed to contribute to the recovery of the species.

Large-eared Pied Bat SAII assessment in accordance with the BAM (2017) methodology

Large-eared Pied Bat is a member of the Vespertilionidae family (Churchill 2008). The species is considered data-deficient and its current distribution is poorly known, however records for the species exist from Shoalwater Bay, north of Rockhampton, Queensland, through to Ulladulla in southern NSW (DAWE 2020, DPIE 2021a). The species is listed as Vulnerable under both the EPBC Act and BC Act. The species is commonly recorded from dry sclerophyll forests and woodlands however they do also occur in sub-alpine woodland as well as the edges of rainforest, wet sclerophyll forest, and *Callitris* sp. dominated forests, and areas with sandstone outcropping. (Churchill 2008).

Large-eared Pied Bat is considered a full species credit species under the BAM as it cannot be reliably predicted to occur on a site based on vegetation and other landscape features. Identified habitat constraints for the species include areas within two kilometres of rocky areas containing caves, overhangs, escarpments, outcrops, or crevices, or within two kilometres of old mines or tunnels (DPIE 2021b). The SAII threshold for the species specifically relates to potential breeding habitat and the presence of breeding habitat. The Atlas of NSW Wildlife identified these areas as follows:

Potential breeding habitat is PCTs associated with the species within 100m of rocky areas containing caves, or overhangs or crevices, cliffs or escarpments, or old mines, tunnels, culverts, derelict concrete buildings.

Such areas were previously located within the development footprint, requiring the undertaking of an SAII assessment. However, amendments to the project design, as outlined in Table 1, have since resulted in these areas being successfully avoided. Whilst no longer required, this SAII has still been included and updated due to the importance of the species. ***(a) The action and measures taken to avoid the direct and indirect impact on the potential entity for an SAII.***

Actions and measures to avoid direct impacts

A preliminary biodiversity assessment (Arup 2019) was undertaken prior to the development of the wind farm layout and the selection of the preferred transmission line corridor. This preliminary assessment highlighted areas of key ecological concern and allowed for avoidance of these areas during the wind farm concept design. During the wind farm layout design, workshops were held between project ecologists, civil engineers and wind modellers to further optimise layout options and ensure impacts to the areas of highest potential Large-eared Pied Bat breeding areas were avoided or minimised. These workshops resulted in the removal of turbines from areas of steep and rocky terrain located within 100 metres of areas of steep slopes considered to potentially support cave bat roosting/breeding opportunities. A total of 8 turbines were removed during these workshops, down to 70 turbines from a maximum of 78, which contributed to an approximately 30% reduction in clearing extents.

Existing road infrastructure and farm tracks have been prioritised to provide the required access during construction and operation. By utilising pre-existing infrastructure, the Project has avoided and minimised impacts to sensitive ecological areas, including potential microbat breeding habitat and the surrounding native vegetation that supports these habitats.

Two high potential cave bat roosting/breeding habitats were identified within the previous development footprint (as described in Section 5.4.2). Whilst there were no direct impacts to these potential cave bat breeding habitats, the turbine pad associated with turbine WP27 partially occurred within the 100 metre buffer zone surrounding one of the high potential cave bat roosting/breeding habitats. This would have resulted in the removal of approximately 2,000 square metres of native vegetation from this buffer zone (1.8 % of the overall buffer zone). The removal of the WP27 as part of project design (Table 1) means that this impact has been successfully avoided.

Actions and measures to avoid indirect impacts

Indirect impacts to Large-eared Pied Bat associated with the project operation phase primarily involve potential collision mortality and possibly barotrauma risks associated with the wind turbine blades during the operational phase of the project. In designing the wind farm layout the spacing of the turbines was considered to limit interactions with fauna and an essentially linear row of turbines was designed. This is different from most wind energy facilities in Australia in which turbines are scattered across a site. In the more usual scattered or 'clustered' array, microbats and avian fauna have a high probability of encountering multiple turbines in a given flight. The configuration of Hills of Gold turbines is such that an individual is likely to encounter multiple turbines only in the rare event that it flies directly along the row of turbines. The minimum spacing between two adjacent turbines along the development footprint is 270 metres (110 metres at turbine height) and the maximum distance between two adjacent turbines is 1,600 metres (1,400 metres at turbine height). The average range is 300 – 500 metres or 138 – 338 metres between turbines. These gaps provide movement corridors, allowing for migrating and foraging bats to pass through the landscape, reducing the chance of collision and possibly barotrauma.

Prior to design amendments there would have been some incursion into the air space above the 100 metre radius buffers surrounding two identified breeding/roosting habitats in the vicinity of WP27 and WP50. This overlap extended over 8,100 square metres (7.5 %) of the 108,465 square metre buffer applied to the WP27 habitat, and over 470 square metres (0.3 %) of the 168,036 square metre buffer applied to the WP50 habitat, when considered on the horizontal plane. Distances between the tip of turbine blades and the top of canopy were considered as part of the wind farm design to ensure that ample vertical buffers were provided for foraging microbats and other avian fauna. A buffer distance above the canopy (estimated to be 23.5 metres high) surrounding WP27 and WP50 of approximately 36.67 metres and 43.35 metres respectively was allowed.

As the two identified high potential roosting/breeding habitats consisted of rocky outcrop and cliffline habitats, buffer distances between tip of the WP27 and WP50 turbine blades and the nearby potential microbat habitats were calculated at ground level in accordance with TIN051 (Natural England 2009). A distance of approximately 91 metres occurs between the tips of the WP27 turbine blades and the nearby potential microbat roosting/breeding habitat, and a distance of approximately 139 metres occurred between the tips of the WP50 turbines blades and the potential microbat roosting/breeding habitat in that vicinity. WP50 therefore exceeded the BAM 100 metres radius buffer (DPIE 2021b), whereas WP27 only intrudes within the first 9 metres of this buffer. However, as outlined in Table 1, the removal of WP27 and relocation of WP50 means impacts to the identified breeding/roosting habitats and surrounding buffer areas has been successfully avoided.

Section 5.4.2 of this BDAR, outlines the potential for collision mortality for the Large-eared Pied Bat, as well as other threatened and more common bats, which were recorded by acoustic detectors mounted on met masts at approximately 60 metres above the ground. In terms of the Large-eared Pied Bat, although there are no direct impacts to the potential roosting/breeding habitats within the development footprint, and although the likelihood of a collision is considered in highly unusual circumstances due to foraging and movement behaviour, it is considered a moderate risk that repeated loss of individuals as a result of collision mortality may cause change to the local abundance of this species in the short term (up to 5 years).

Construction related indirect impacts include light, noise, and vibration. These impacts will be managed during construction to minimise impacts to nocturnal fauna. They also will not occur within the 100 metre buffer zone of the two high potential bat roosts. An Operational Bird and Bat Adaptive Management Plan will be prepared prior to construction to monitor any potential bat mortality and to continually assess the assumptions of this impact assessment. Furthermore, this will include detailed and stringent mitigation measures for high risk turbines and adaptive management strategies for moderate and low risk turbines.

Additional mitigation measures are recommended for inclusion in the CEMP that will further reduce the potential for impact to the species.

(b) The size of the local population directly and indirectly impacted by the development, clearing or biodiversity certification.

The species appears to exist in a number of small populations throughout its known range with colonies seldom containing more than 50 individuals (DERM 2011). Historical records for the species occur approximately 14 kilometres south-west of the wind farm development footprint around the Timor Cave area (DPIE 2021b). These records were collected in December 2018 with acoustic recording devices.

The species was recorded during the targeted surveys supporting the current assessment. These surveys were conducted from February 2020 to May 2020 and included deployment of units at ground-level as well as deployment on three meteorological masts at heights of 2 metres, c.30 metres and c.60 metres. Additional acoustic/ultrasonic survey was also undertaken in spring 2019 between 19 – 21 November 2019 (three nights) across the 24 deployed ultrasonic detector units deployed in 2020 and the three nights of spring surveys in 2019, the total mean call for the species per night was 1.0 call, indicating a low level of activity within the development footprint on an infrequent basis.

Due to the rural location, where historical survey coverage is low, and a lack of existing scientific literature of the species' population biology, the overall size of the local population is unknown. As such, this assessment has utilised the available information regarding the roosting and foraging behaviour of the species to determine the likely local population relevant to, and potentially impacted by, the Project. Studies have shown that the species prefers roosting locations within 700 metres of foraging habitats, with the maximum distance travelled between a known roost and the edge of preferred foraging areas being 2.5 kilometres (Williams & Thomson 2018). This is supported by the 2 kilometre habitat constraint buffer required from rocky cliffline areas containing caves, overhangs, escarpments, outcrops, or crevices that represent potential habitat for the species in the Bionet Atlas of NSW (DPIE 2021b).

This assessment therefore assumes that the local population comprises, at a minimum, any individual bats foraging within the development footprint, as well as those present within a 2.5 kilometre buffer surrounding the development footprint. Furthermore, given the species proclivity to form small colonies (DERM 2011), the local population is considered likely to include individuals from multiple small over-lapping colonies, each occurring within a 2 – 2.5 kilometre distance of potential roosting habitat. Which, as the broader locality is rich in potential roosting habitat and foraging resources (Environmental Geosurveys Pty Ltd 2021), means there is potential for many small over-lapping colonies to exist over a large area, and all of these colonies together could be expected to form the local population.

Within the development footprint the impacts that were previously considered potentially serious and irreversible for the local population were restricted to two high potential roosting/breeding locations that have been detected within the proximity of proposed turbines WP27 and WP50 (as described in Section 8.3). Due to the avoidance measures that have been employed (Table 1), there are now no direct impacts to these sites.

There are also indirect impacts associated with project construction and operation including collision mortality and possibly barotrauma, as well as noise, light and vibrations. Although the likelihood of a collision is low due to foraging and movement behaviour, it is considered a moderate risk that repeated loss of individuals as a result of collision mortality may cause change to the local abundance of this species in the short term (up to 5 years). These will be minimised through the avoidance measure outlined in under question (a) above.

As direct impacts to the identified high potential roosting/breeding locations have been avoided, impacts to the local population as a result of the Project are primarily associated with loss of native vegetation that provides foraging habitat at the individual level, potential turbine strike and possibly barotrauma, and possible interruptions to habitat connectivity. Assessment of these indirect impacts has been provided in Sections 8.3 and 8.5 of this BDAR.

(c) The extent to which the impact exceeds any threshold for the potential entity that is specified in the Guidance to assist a decision-maker to determine a serious and irreversible impact.

The SAII threshold specified for Large-eared Pied Bat within the Atlas of New South Wales is 'breeding habitat to be identified by survey'. This threshold does not provide a numerical value for the species that would assist a decision-maker in determining the level of impact above which a serious and irreversible impact may occur for this species. As such the extent to which the proposed impacts may exceed a threshold target for the species cannot be calculated. The general notes for the species states that the SAII threshold is potential breeding habitat and presence of breeding individuals (DPIE 2021b).

Two high potential roosting/breeding habitat locations were previously identified within the vicinity of the development footprint (refer Figure 15). Whilst there were no direct impacts to these potential cave bat breeding habitats, the turbine pad associated with turbine WP27 partially occurred within the 100 metre buffer zone surrounding one of the high potential cave bat roosting/breeding habitats. This would have resulted in the removal of approximately 2,000 square metres of native vegetation from this buffer zone (1.8% of the overall buffer zone). Road infrastructure supporting turbine pad WP50 was also located within 5 metres of a cave bat roosting/breeding habitat buffer. Due to avoidance measures adopted by the project (outlined in Table 1), these impacts have now been successfully avoided.

A geomorphological assessment of the assessment area was also commissioned which found that the landscape within and surrounding the development footprint was formed by a range of volcanic activity resulting in a basalt lithology (Environmental Geosurveys Pty Ltd 2021). The extent to which potential microbat habitat is present and suitable is a function initially of lithology and rock structure modified over time by geological and environmental processes. The assessment found that whilst the basalt lithology present at the development footprint may support opportunities for microbat roosts, no substantial caves were likely to be present, and that no data was found to suggest that the development footprint and immediate surrounds geomorphologically standout from the surrounding landscape in one way or another (Environmental Geosurveys Pty Ltd 2021).

Given the avoidance measures adopted by the project (Table 1) mean that there are now no direct impacts to identified cave bat breeding habitat, the project is considered unlikely to result in a serious and irreversible impacts for the species.

(d) The likely impact (including direct and indirect impacts) that the development, clearing or biodiversity certification will have on the habitat of the local population, including but not limited to:

(i) An estimate of the change in habitat available to the local population as a result of the proposed development.

(ii) The proposed loss, modification, destruction or isolation of the available habitat used by the local population, and

(iii) Modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.

A total of 28,033 hectares of native vegetation occurs within the 2.5 kilometre area surrounding the development footprint, with only 132.43 hectares of native vegetation (0.47 %) occurring within the development footprint. Of this vegetation approximately 37.92 hectares is in high condition providing good habitat values for foraging native fauna, including Large-eared Pied Bat. This foraging habitat would be modified as a result of the Project.

Two high potential roosting/breeding sites for Large-eared Pied Bat have been identified adjacent to the development footprint. No direct impacts are proposed for these habitats. As such there will be no reduction in the availability of breeding habitat for Large-eared Pied Bat. Similarly, there will be no direct impact to important species 'life cycle' processes as no habitats that support these processes are being directly impacted.

The project will also result in indirect impacts during construction and afterward during operation of the wind farm. During construction these indirect impacts will consist of increased traffic, noise and light during the project construction. These impacts will be managed during construction to reduce impacts to nocturnal fauna and will cease once construction is completed. Restriction of works to outside of breeding season within the vicinity of the two high potential roosting/breeding habitats is recommended for inclusion within the CEMP's mitigation measures which will further reduce scale of construction related indirect impacts.

There are also indirect impacts associated with the operations phase where collision and possibly barotrauma risks associated with the wind turbine blades could occur, as well as potential impacts to habitat connectivity. These impacts are discussed further in Section 8.5 of the BDAR, however, these impacts will not significantly change the availability of habitat in the locality. Although the likelihood of a collision is low due to foraging and movement behaviour, it is considered a moderate risk that repeated loss of individuals as a result of collision mortality may cause change to the local abundance of this species in the short term (up to 5 years). An Operational Bird and Bat Adaptive Management Plan will be prepared prior to construction to assess any bat mortality and to continually assess the assumptions of this impact assessment and enable adaptive management measures to be implemented if required to reduce measured impacts.

(e) The likely impact on the ecology of the local population. At a minimum, address the following:

- For fauna:
  - Breeding

Large-eared Pied Bat utilises cave roosts almost exclusively for breeding. While individuals are known to utilise disused mine adits as roost sites, limited research suggests that the species requires a highly specific karst configuration (bell-shaped) with a dome roof that is deep enough to allow juvenile bats to learn to fly safely inside and with indentations in the roof to allow bats to cluster, as well as a specific microclimate (i.e. temperature of 15.5 – 18^{o}C and 51 – 76% relative humidity) for rearing young. The size of maternity roosts typically consist of between 15 and 40 adult females and their young, although one maternity cave north-west of Coonabarabran in central NSW has recorded approximately 40 adults accompanied by twin young for an estimate of around 110 individuals (Pennay 2008, DERM 2011, Churchill 2008, Dwyer 1966).

Known breeding locations are extremely limited within NSW. Five locations are known to have been used for breeding within NSW, including:

- A mine tunnel at Copeton that was used for breeding until flooded by dam waters in 1976 (Dwyer 1966).
- A sandstone cave near Coonabarabran, NSW (Pennay 2008).
- Capture of lactating females adjacent to sandstone cliffs in Ulan, NSW (Fly By Night 2005).
- Observations of small groups of females in a disused gold mine near Barraba, NSW (DERM 2011).
- Anecdotal observations of small groups of females and young bats in the sandstone Pilliga region, NSW (DERM 2011).

The closest of these known breeding sites is the disused gold mine near Barraba, with the town of Barraba located approximately 145 kilometres away from the development footprint. The Saving Our Species strategy for this species is currently listed as data-deficient, with no priority management areas currently identified for the species (DPIE 2021a).

Within the locality of the assessment area there are many potential roosting and breeding habitats for the species. A geomorphological assessment of the assessment area found that there is diverse terrain and lithology and dynamic geomorphology within the locality that creates a high potential for microbat roosting sites across landscapes at all elevations, within the expected flight range of microbats that may be present within the assessment area (Environmental Geosurveys Pty Ltd 2021). The assessment notes that the assessment area lies in the southern margin of the New England Orogen, which comprises a complex geological history resulting in a wide range of rock types and structures in northeast NSW and southeast Queensland, with the diverse geology present in the landscape continuing to the north through the NSW North Coast, Nandewar and New England Tablelands bioregions (which together comprise much of the New England Orogen), thus habitats present in the locality of the project area are also likely to occur elsewhere within broader geological landscape, and therefore unlikely to form a substantial portion of the habitat available, or be significant at a bioregional scale (Environmental Geosurveys Pty Ltd 2021). Finally, the nearby town of Nundle has a rich mining history, being settled in 1852 following the discovery of gold at "The Hanging Rock" and Swamp Creek, and consequently there are many (dozens) historic mines and unnamed pits in the region (AUSGIN 2021), which may also provide potential roosting habitat to the local population.

Adjacent to the development footprint there are two identified high potential roosting/breeding sites. This is comparatively few when placed in context of the similar habitat available within the locality and broader region. There are also no direct impacts proposed to either of these potential habitat locations or their surrounding buffer areas. The avoidance and minimisation for reducing indirect impacts during operation of the wind farm are discussed in question (a) above. As such, the Project is unlikely to result in impacts to breeding habitat for Large-eared Pied Bat.

- Foraging

Studies on the foraging behaviour of Large-eared Pied Bat in the western Blue Mountains found that the species preferred foraging areas consisted of sharp grassland-forest border in west-facing valleys with a creek or moist drainage gully and wet vegetation types within 700 metres of day roosts (Williams & Thomson 2018). A total of 28,033 hectares of native vegetation occurs within the 2.5 kilometre area surrounding the development footprint, with only 132.43 hectares of native vegetation (0.47 %) occurring within the development footprint. Of this vegetation approximately 37.92 hectares is in high condition providing good habitat values for foraging native fauna, including Large-eared Pied Bat. This foraging habitat would be modified as a result of the Project.

Vegetation within the development footprint is well connected to surrounding vegetation, with large patches of native vegetation occurring within the 2.5 kilometre area surrounding the development footprint. This includes large tracts of intact native vegetation within the Ben Halls Gap National Park, Crawney Pass National Park, Wallabadah Nature Reserve and the Nundle and Hanging Rock State Forests. These areas represent prime foraging habitat for the species and are all within two kilometres of various locations along the development footprint. Given the plentiful natural roosts that are likely to be available to individuals within 2.5 kilometres of the development footprint, due to the underlying geomorphology (Environmental Geosurveys Pty Ltd 2021), these foraging habitats would be easily accessible to individuals within the local population. The removal of native vegetation as part of the proposed works is therefore not considered to have a significant impact on the foraging ecology of Large-eared Pied Bat.

- Roosting

Large-eared Pied Bat typically roosts in entrances of caves, crevices in cliffs, old mine workings and occasionally in the disused, bottle-shaped mud nests of the Fairy Martin *Petrochelidon ariel* (DPIE 2021b). Studies on the roosting behaviour of Large-eared Pied Bat in the western Blue Mountains found that crevices in vertical, sheer cliff faces were used exclusively for day roosts by males and females without offspring, with no individuals utilising tree roosts favoured by other microbat species (Williams & Thomson 2018, DERM 2011).

Within the locality there are many potential roosting and breeding habitats for the local population. A geomorphological assessment of the assessment area found that there is diverse terrain and lithology and dynamic geomorphology within the locality that creates a high potential for microbat roosting sites across landscapes at all elevations, within the expected flight range of microbats that may be present within the assessment area (Environmental Geosurveys Pty Ltd 2021). The assessment notes that the assessment area lies in the southern margin of the New England Orogen, which comprises a complex geological history resulting in a wide range of rock types and structures in northeast NSW and southeast Queensland, with the diverse geology present in the landscape continuing to the north through the NSW North Coast, Nandewar and New England Tablelands bioregions (which together comprise much of the New England Orogen), thus habitats present in the locality of the project area are also likely to occur elsewhere within broader geological landscape, and therefore unlikely to form a substantial portion of the habitat available, or be significant at a bioregional scale (Environmental Geosurveys Pty Ltd 2021). Finally the nearby town of Nundle has a rich mining history, being settled in 1852 following the discovery of gold at "The Hanging Rock" and Swamp Creek, and consequently there are many (dozens) historic mines and unnamed pits in the region (AUSGIN 2021) which may also provide potential roosting habitat to the local population.

There are two high potential roosting habitats located adjacent to the development footprint. As a result of avoidance measures adopted by the project (Table 1), there are no direct impacts to either of these features or their surrounding buffer areas. Given the underlying geology outlined by the geomorphological report (Environmental Geosurveys Pty Ltd 2021), there are likely to be numerous cracks and crevices along ridgelines within the broader locality that may be used as overnight roosts by individuals or small groups of Large-eared Pied Bat. Given the high potential for similar habitat across the locality, the Project is not expected to significantly alter the availability of these crack/crevice overnight roosting habitats.

- Dispersal or movement pathways

Large-eared Pied Bat is a mobile species capable of dispersing across small breaks in habitats. In designing the wind farm layout, the spacing of the turbines was considered to limit interactions with fauna and an essentially linear row of turbines was designed. This is different from most wind energy facilities in Australia in which turbines are scattered across a site. In the more usual scattered or 'clustered' array, microbats and avian fauna have a high probability of encountering multiple turbines in a given flight. The configuration of Hills of Gold turbines is such that an individual is likely to encounter multiple turbines only in the rare event that it flies directly along the row of turbines. The minimum spacing between two adjacent turbines along the development footprint is 270 metres (110 metres at turbine height) and the maximum distance between two adjacent turbines is 1,600 metres (1,400 metres at turbine height). The average range is 300 – 500 metres or 138 – 338 metres between turbines. These gaps provide movement corridors, allowing for migrating and foraging bats to pass through the landscape, reducing the chance of collision and possibly barotrauma. Although the likelihood of a collision is low due to foraging and movement behaviour, it is considered a moderate risk that repeated loss of individuals as a result of collision mortality may cause change to the local abundance of this species in the short term (up to 5 years).

Known maternity roosts of Large-eared Pied Bat maternity roosts are extremely limited, and the distance bats move from maternity roosts to non-breeding roosts has not been established but it likely to be less than 100 kilometres (DAWE 2020). It is therefore unlikely that individuals would be making multiple north-south movements at turbine blade height over the linear wind farm footprint for migratory purposes. Such north-south movement are more likely to be associated with foraging flights which would be conducted at canopy level, out of turbine blade range (see Section 7.2 for details regarding turbine blade buffers). The layout also retains areas of preferred foraging habitat in steeper areas of terrain, with more densely vegetated gullies preserved. It is therefore unlikely that the Project will interfere in the dispersal of movement pathways of the species. Impacts to habitat connectivity are further assessed in Section 8.5 of the BDAR.

(f) A description of the extent to which the local population will become fragmented or isolated as a result of the proposed development.

Large-eared Pied Bat is a mobile species, capable of traversing small breaks in native vegetation, which also utilise man-made structures such as culverts, bridges, buildings and derelict mines as roosting sites. The geomorphology of the 2.5 kilometre area surrounding the development footprint has the potential to provide the species with numerous roosting habitats (Environmental Geosurveys Pty Ltd 2021). There are large tracts of intact native vegetation within and adjacent to these areas such as the Ben Halls Gap National Park, Crawney Pass National Park, Wallabadah Nature Reserve and the Nundle and Hanging Rock State Forests which are connected to the development footprint which would facilitate dispersal of the local population. The spacing between wind turbines within the development footprint is such that movement corridors have been conserved, allowing for migrating and foraging bats to pass through the landscape.

Given the transient nature of the species, the high level of native vegetation connection across the region, and the high level of potential roosting locations, the project is not expected to result in significant amount of landscape fragmentation that would result in the local population becoming isolated. Impacts to habitat connectivity are further assessed in Section 8.5 of the BDAR.

(g) The relationship of the local population to other population/populations of the species. This must include consideration of the interaction and importance of the local population to other population/populations for factors such as breeding, dispersal and genetic viability/diversity, and whether the local population is at the limit of the species' range.

Large-eared Pied Bat is distributed along the east-coast of Australia, ranging from Shoalwater Bay, north of Rockhampton, Queensland, through to Ulladulla in southern NSW (DAWE 2020, DPIE 2021a). Whilst the range of the species is large, it has been suggested that the species is restricted within its range, and does not occur continuously (DAWE 2020). This may be due to the lack of available roosts throughout its range and has likely resulted in the populations of the species in north-east NSW and south-east Queensland, Shoalwater Bay and Blackdown Tablelands to become isolated from each other, with little interaction (DAWE 2020).

The Saving Our Species strategy for this species is currently listed as data-deficient, with no priority management areas currently identified for the species (DPIE 2021a). Known breeding locations are extremely limited within NSW. Five locations are known to have been used for breeding within NSW, including:

- A mine tunnel at Copeton which was used for breeding until flooded by dam waters in 1976 (Dwyer 1966).
- A sandstone cave near Coonabarabran, NSW (Pennay 2008).
- Capture of lactating females adjacent to sandstone cliffs in Ulan, NSW (Fly By Night 2005).
- Observations of small groups of females in a disused gold mine near Barraba, NSW (DERM 2011).
- Anecdotal observations of small groups of females and young bats in the sandstone Pilliga region, NSW (DERM 2011).

The closest of these known breeding sites is the disused gold mine near Barraba, with the town of Barraba located approximately 145 kilometres away from the development footprint.

The dispersal capabilities of the species are poorly understood, as are the size of local populations within the locality. However, the surface geology of the 2.5 kilometre area surrounding the development footprint has the potential to provide small colonies that may be present within the area with numerous roosting habitats. There are also large tracts of intact native vegetation within and adjacent to these areas such as the Ben Halls Gap National Park, Crawney Pass National Park, Wallabadah Nature Reserve and the Nundle and Hanging Rock State Forests which are connected to the development footprint which would facilitate dispersal of individuals between these colonies

As consideration has been made with regards to the spacing of wind turbines, leading to preservation of movement corridors, it is unlikely that the movement of individuals between colonies would be significantly restricted by the proposed development. As such, the Project is unlikely to lead to a reduction in the pre-existing level of interactions that may be occurring between small, over-lapping colonies that may exist in the area that comprise the local population of the species.

(h) The extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population.

The potential threats to Large-eared Pied Bat, as identified in the species profile included in the Atlas of NSW Wildlife (DPIE 2021b), are addressed below in Table 86.

Table 86 Potential threats to Large-eared Pied Bat

Threat	Relevance to proposed works
Clearing and isolation of forest and woodland habitats near cliffs, caves and old mine workings for agriculture or development	Only two high potential roosting/breeding habitats occur adjacent to the development footprint. No direct impacts are proposed to either of these locations and, due to avoidance measure adopted by the project, there are now no impacts within the buffer areas of these features. As such there will be no significant impacts to breeding habitat for Large-eared Pied Bat as a result of the Project. Mitigation measures to control indirect impacts (noise, light and vibration) during construction will further ensure no impacts to the species, as will recommendations to avoid undertaking works in the proximity of these habitat features during breeding season.
Loss of foraging habitat close to cliffs, caves and old mine workings for forestry activities and too-frequent burning, usually associated with grazing	The proposed works include impacts to 132.43 hectares of native vegetation from the development footprint. However, only 37.92 hectares of this vegetation is considered high quality and potential foraging habitat for the species. A total of 28,033 hectares of native vegetation occurs within the 2.5 kilometre area surrounding the development footprint, which, given the highly mobile nature of the species, is readily available to individuals as foraging habitat. There are also large tracts of intact native vegetation within the Ben Halls Gap National Park, Crawney Pass National Park, Wallabadah Nature Reserve and the Nundle and Hanging Rock State Forests which all occur within foraging distance of the development footprint. As such the Project is considered unlikely to significantly reduce the availability of foraging habitat for the local population of Large-eared Pied Bat.
Damage to roosting and maternity sites from mining operations, and recreational caving activities	Only two high potential roosting/breeding habitats occur adjacent to the development footprint. No direct impacts are proposed to either of these locations and due to avoidance measure adopted by the project, there are now no impacts within the buffer areas of these features. As such there will be no significant impacts to breeding habitat for Large-eared Pied Bat as a result of the Project. Mitigation measures to control indirect impacts (noise, light and vibration) during construction

Threat	Relevance to proposed works
	will further ensure no impacts to the species, as will recommendations to avoid undertaking works in the proximity of these habitat features during breeding season.
Use of pesticides	The project is not likely to substantially increase the levels of pesticides within the environment.
Disturbance to roosting areas by goats	The assessment area and surrounds likely support several pest animal species and it is highly likely that feral goats are already present within the area. The small-scale nature of works is unlikely to result in an increase in feral goat activity in the area or alter the existing disturbances to roosting sites that may already be exhibited by goats within the locality.
Insufficient understanding of habitat requirements	Only two high potential roosting/breeding habitats occur adjacent to the development footprint. No direct impacts are proposed to either of these locations and due to avoidance measure adopted by the project, there are now no impacts within the buffer areas of these features. Whilst the species is considered data-deficient, the lack of impacts to key habitats that support critical species life processes (i.e. breeding) means it is unlikely that the proposed impacts would have a significant impact on the population. The geomorphology assessment of the assessment area also found that whilst the basalt lithology present at the development footprint may support opportunities for microbat roosts, no substantial caves were likely to be present, and that no data was found to suggest that the development footprint and immediate surrounds geomorphologically standout from the surrounding landscape in one way or another (Environmental Geosurveys Pty Ltd 2021).

(i) An estimate of the area, or number of populations and size of populations that is in the reserve system in NSW, the IBRA region and the IBRA subregion.

The following information has been gathered from BioNet Atlas records as well as scientific literature and government reports.

New South Wales

A total of 1,967 BioNet Atlas records for Large-eared Pied Bat exist across NSW (DPIE 2021b). The species is considered data-deficient and its current distribution is poorly known, however records for the species exist from Shoalwater Bay, north of Rockhampton, Queensland, through to Ulladulla in southern NSW (DAWE 2020, DPIE 2021a). Records exist within the following IBRA regions within NSW:

- Brigalow Belt South
- Nandewar
- NSW North Coast
- NSW South Western Slopes
- South Eastern Highlands
- South Eastern Queensland
- Sydney Basin

Low numbers of records also occur within the Cobar Peneplian (3 records), New England Tablelands (1 record), and the South East Corner (4 records) IBRA region.

The Saving Our Species strategy for this species identifies that the species is currently data-deficient and additional survey and collection of ecological information is required. As such no priority management areas are identified (DPIE 2021a). A total of 453 (23%) of the historical sightings occurring within the NSW reserve system. These records occur within 63 national parks, nature reserves and conservation areas.

Nandewar – Peel IBRA sub-region

A total of 627 records for Large-eared Pied Bat occur within the Nandewar IBRA region, 618 within the Peel IBRA sub-region. Of these, six records from the Peel sub-region occurs within the NSW reserve system, located in the Boonalla CCA Zone 2 Aboriginal Area (1 record), Horton Falls CCA Zone 1 National Park (1 record), Mount Kaputar National Park (2 records), and the Woodsreef CCA Zone 3 State Conservation Area (2 records).

New England Tablelands – Walcha Plateau IBRA sub-region

A single record for Large-eared Pied Bat occurs within the New England Tablelands IBRA region. This record occurs outside of the Walcha Plateau sub-region.

NSW North Coast – Tomalla IBRA sub-region

A total of 19 records for Large-eared Pied Bat occur within the NSW North Coast IBRA region, four of which are within the Tomalla sub-region. None of the records from the Tomalla sub-region as associated with areas of land that are protected under the NSW reserve system.

(j) The measure/s proposed to contribute to the recovery of the species in the IBRA subregion.

The proposed works are not considered likely to have a substantial impact on Large-eared Pied Bat, and thus no measures have been proposed to contribute to the recovery of the species.

Eastern Cave Bat SAII asessment in accordance with the BAM (2017) methodology

The Eastern Cave Bat is a member of the Vespertilionidae family (Churchill 2008), with a range that extends from Cape York in northern Queensland down to at least the Sydney Basin in NSW (Law, Chidel, & Mong 2005). The species is listed as Vulnerable under both the EPBC Act and BC Act. Very little is known about the biology of the species, however, all records are in close proximity to sandstone or volcanic escarpments. They have been found inhabiting tropical moist woodland, as well as wet and dry sclerophyll forests. (Churchill 2008).

Eastern Cave Bat is considered a full species credit species under the BAM as it cannot be reliably predicted to occur on a site based on vegetation and other landscape features. Identified habitat constraints for the species include areas within two kilometres of rocky areas containing caves, overhangs, escarpments, outcrops, crevices or boulder piles, or within two kilometres of old mines, tunnels, old buildings or sheds (DPIE 2021a). The SAII threshold for the species specifically relates to potential breeding habitat and the presence of breeding habitat. The Atlas of NSW Wildlife identified these areas as follows:

Potential breeding habitat is PCTs associated with the species within 100m of rocky areas, caves, overhangs crevices, cliffs and escarpments, or old mines or tunnels, old buildings and sheds within the potential habitat.

Such areas were previously located within the development footprint, requiring the undertaking of an SAII assessment. However, amendments to the project design, as outlined in Table 1, have since resulted in these areas being successfully avoided. Whilst no longer required, this SAII has still been included and updated due to the importance of the species.

(a) The action and measures taken to avoid the direct and indirect impact on the potential entity for an SAII.

Actions and measures to avoid direct impacts

A preliminary biodiversity assessment (Arup 2019) was undertaken prior to the development of the wind farm layout and the selection of the preferred transmission line corridor. This preliminary assessment highlighted areas of key ecological concern and allowed for avoidance of these areas during the wind farm concept design. During the wind farm layout design, workshops were held between project ecologists, civil engineers and wind modellers to further optimise layout options and ensure impacts to the areas of highest potential Eastern Cave Bat breeding areas were avoided or minimised. These workshops resulted in the removal of turbines from areas of steep and rocky terrain located within 100 metres of areas of steep slopes considered to potentially support cave bat roosting/breeding opportunities. A total of 8 turbines were removed during these workshops, down to 70 turbines from a maximum of 78, which contributed to an approximately 30% reduction in clearing extents.

Existing road infrastructure and farm tracks have been prioritised to provide the required access during construction and operation. By utilising pre-existing infrastructure, the Project has avoided and minimised impacts to sensitive ecological areas, including potential microbat breeding habitat and the surrounding native vegetation that supports these habitats.

Two high potential cave bat roosting/breeding habitats were identified within the previous development footprint (as described in Section 5.4.2). Whilst there were no direct impacts to these potential cave bat breeding habitats, the turbine pad associated with turbine WP27 partially occurred within the 100 metre buffer zone surrounding one of the high potential cave bat roosting/breeding habitats. This would have resulted in the removal of approximately 2,000 square metres of native vegetation from this buffer zone (1.8% of the overall buffer zone). The removal of the WP27 as part of project design (Table 1) means that this impact has been successfully avoided.

Actions and measures to avoid indirect impacts

Indirect impacts to Eastern Cave Bat associated with the project operation phase primarily involve potential collision and possibly barotrauma risks associated with the wind turbine blades during the operational phase of the project. In designing the wind farm layout the spacing of the turbines was considered to limit interactions with fauna and an essentially linear row of turbines was designed. This is different from most wind energy facilities in Australia in which turbines are scattered across a site. In the more usual scattered or 'clustered' array, microbats and avian fauna have a high probability of encountering multiple turbines in a given flight. The configuration of Hills of Gold turbines is such that an individual is likely to encounter multiple turbines only in the rare event that it flies directly along the row of turbines. The minimum spacing between two adjacent turbines along the development footprint is 270 metres (110 metres at turbine height) and the maximum distance between two adjacent turbines is 1,600 metres (1,400 metres at turbine height). The average range is 300 – 500 metres or 138 – 338 metres between turbines. These gaps provide movement corridors, allowing for migrating and foraging bats to pass through the landscape, reducing the chance of collision and possibly barotrauma.

Prior to design amendments there would have been some incursion into the air space above the 100 metre radius buffers surrounding two identified breeding/roosting habitats in the vicinity of WP27 and WP50. This overlap extended over 8,100 square metres (7.5%) of the 108,465 square metre buffer applied to the WP27 habitat, and over 470 square metres (0.3%) of the 168,036 square metre buffer applied to the WP50 habitat, when considered on the horizontal plane. Distances between the tip of turbine blades and the top of canopy were considered as part of the wind farm design to ensure that ample vertical buffers were provided for foraging microbats and other avian fauna. A buffer distance above the canopy (estimated to be 23.5 metres high) surrounding WP27 and WP50 of approximately 36.67 metres and 43.35 metres respectively was allowed.

As the two identified high potential roosting/breeding habitats consisted of rocky outcrop and cliffline habitats, buffer distances between tip of the WP27 and WP50 turbine blades and the nearby potential microbat habitats were calculated at ground level in accordance with TIN051 (Natural England 2009). A distance of approximately 91 metres occurs between the tips of the WP27 turbine blades and the nearby potential microbat roosting/breeding habitat, and a distance of approximately 139 metres occurred between the tips of the WP50 turbines blades and the potential microbat roosting/breeding habitat in that vicinity. WP50 therefore exceeded the BAM 100 metres radius buffer (DPIE 2021a), whereas WP27 only intrudes within the first 9 metres of this buffer. However, as outlined in Table 1, the removal of WP27 and relocation of WP50 means impacts to the identified breeding/roosting habitats and surrounding buffer areas has been successfully avoided.

Section 5.4.2 of this BDAR, outlines the potential for collision mortality for the Eastern Cave Bat, as well as other threatened and more common bats, which were recorded by acoustic detectors mounted on met masts at approximately 60 metres above the ground. In terms of the Eastern Cave Bat, it is not expected that impacts associated with potential blade strike would result in impacts significant enough to threaten the persistence of this species. It is considered that the likelihood of a collision event for the Eastern Cave Bat may occur only in unusual circumstances given the low level of relative activity at higher elevations due to foraging and movement behaviour (i.e. within the range of rotor blades), and the expected volume of commensurate habitat available in the landscape. Should collision mortality occur however, it is considered that the repeated loss of a small number of individuals would not be of concern to the viability of the local or broader population.

Construction related indirect impacts include light, noise, and vibration. These impacts will be managed during construction to minimise impacts to nocturnal fauna. They also will not occur within the 100 metre buffer zone of the two high potential bat roosts. An Operational Bird and Bat Adaptive Management Plan will be prepared prior to construction to monitor any potential bat mortality and to continually assess the assumptions of this impact assessment. Furthermore, this will include detailed and stringent mitigation measures for high risk turbines and adaptive management strategies for moderate and low risk turbines.

Additional mitigation measures are recommended for inclusion in the CEMP that will further reduce the potential for impact to the species.

(b) The size of the local population directly and indirectly impacted by the development, clearing or biodiversity certification.

Historical records for the species occur approximately 10 kilometres west, and 24 kilometres south-west of the wind farm development footprint, around the Timor Cave area (DPIE 2021a). These records were collected in 2002 and 2005 respectively via acoustic recording devices.

The species was recorded during the targeted surveys supporting the current assessment. These surveys were conducted from February 2020 to May 2020 and included deployment of units at ground-level as well as deployment on three meteorological masts at heights of 2 metres, c.30 metres and c.60 metres. Additional acoustic/ultrasonic survey was also undertaken in spring 2019 between 19 – 21 November 2019 (three nights) Across the 24 deployed ultrasonic detector units deployed in 2020 and the three nights of spring surveys in 2019, the total mean call for the species per night was 0.6 calls, indicating a low level of activity within the development footprint on an infrequent basis.

Due to the rural location, where historical survey coverage is low, and a lack of existing scientific literature of the species' population biology, the overall size of the local population is unknown. As such, this assessment has utilised the available information regarding the roosting and foraging behaviour of the species to determine the likely local population relevant to, and potentially impacted by, the Project. Radio-tracking studies have shown that most movements of individuals between roost sites were within 1.5 kilometres, with the maximum measured distance between a roost sites by a single individual being 3.75 kilometres. Foraging range is typically small, with one individual observed foraging over five consecutive nights in an area of only 33 hectares (Law, Chidel, & Mong 2005, Churchill 2008). This is supported by the 2 kilometre habitat constraint buffer required from rocky cliffline areas containing caves, overhangs, escarpments, outcrops, or crevices that represent potential habitat for the species in the Bionet Atlas of NSW (DPIE 2021a).

This assessment therefore assumes that the local population comprises, at a minimum, any individual bats foraging within the development footprint, as well as those present within a 2.5 kilometre buffer surrounding the development footprint. The local population is considered likely to include individuals from multiple small over-lapping colonies, each occurring within a 2 – 2.5 kilometre distance of potential roosting habitat. Which, as the broader locality is rich in potential roosting habitat and foraging resources (Environmental Geosurveys Pty Ltd 2021), means there is potential for many small over-lapping colonies to exist over a large area, and all of these colonies together could be expected to form the local population.

Within the development footprint the impacts that were previously considered potentially serious and irreversible for the local population were restricted to two high potential roosting/breeding locations that have been detected within the proximity of proposed turbines WP27 and WP50 (as described in Section 8.3). Due to the avoidance measures that have been employed (Table 1), there are now no direct impacts to these sites.

There are also indirect impacts associated with project construction and operation including collision mortality and possibly barotrauma, as well as noise, light and vibrations. It is considered that the likelihood of a collision event for the Eastern Cave Bat may occur only in unusual circumstances given the low level of relative activity recorded for this species at higher elevations due to foraging and movement behaviour (i.e. within the range of rotor blades), and the expected volume of commensurate habitat available in the landscape. Should collision mortality occur however, it is considered that the repeated loss of a small number of individuals would not be of concern to the viability of the local or broader population. These will be minimised through the avoidance measure outlined in under question (a) above.

As direct impacts to the identified high potential roosting/breeding locations have been avoided, impacts to the local population as a result of the Project are primarily associated with loss of native vegetation that provides foraging habitat at the individual level, potential turbine strike and possibly barotrauma, and possible interruptions to habitat connectivity. Assessment of these indirect impacts has been provided in Sections 8.3 and 8.5 of this BDAR.

(c) The extent to which the impact exceeds any threshold for the potential entity that is specified in the Guidance to assist a decision-maker to determine a serious and irreversible impact.

The SAII threshold specified for Eastern Cave Bat within the Atlas of New South Wales is 'only for breeding habitat to be identified'. This threshold does not provide a numerical value for the species that would assist a decision-maker in determining the level of impact above which a serious and irreversible impact may occur for this species. As such the extent to which the proposed impacts may exceed a threshold target for the species cannot be calculated. The general notes for the species states that the SAII threshold is potential breeding habitat and presence of breeding individuals (DPIE 2021a).

Two high potential roosting/breeding habitat locations were previously identified within the vicinity of the development footprint (refer Figure 15). Whilst there were no direct impacts to these potential cave bat breeding habitats, the turbine pad associated with turbine WP27 does partially occurred within the 100 metre buffer zone surrounding one of the high potential cave bat roosting/breeding habitats. This would have resulted in the removal of approximately 2,000 square metres of native vegetation from this buffer zone (1.8% of the overall buffer zone). Road infrastructure supporting turbine pad WP50 was also located within 5 metres of a cave bat roosting/breeding habitat buffer. Due to avoidance measures adopted by the project (outlined in Table 1), these impacts have now been successfully avoided.

A geomorphological assessment of the assessment area was also commissioned which found that the landscape within and surrounding the development footprint was formed by a range of volcanic activity resulting in a basalt lithology (Environmental Geosurveys Pty Ltd 2021). The extent to which potential microbat habitat is present and suitable is a function initially of lithology and rock structure modified over time by geological and environmental processes. The assessment found that whilst the basalt lithology present at the development footprint may support opportunities for microbat roosts, no substantial caves were likely to be present, and that no data was found to suggest that the development footprint and immediate surrounds geomorphologically standout from the surrounding landscape in one way or another (Environmental Geosurveys Pty Ltd 2021).

Given the avoidance measures adopted by the project (Table 1) mean that there are now no direct impacts to identified cave bat breeding habitat, the project is considered unlikely to result in a serious and irreversible impacts for the species.

(d) The likely impact (including direct and indirect impacts) that the development, clearing or biodiversity certification will have on the habitat of the local population, including but not limited to:

(i) An estimate of the change in habitat available to the local population as a result of the proposed development.

(ii) The proposed loss, modification, destruction or isolation of the available habitat used by the local population, and

(iii) Modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.

A total of 28,033 hectares of native vegetation occurs within the 2.5 kilometre area surrounding the development footprint, with only 132.43 hectares of native vegetation (0.47 %) occurring within the development footprint. Of this vegetation approximately 37.92 hectares is in high condition providing good habitat values for foraging native fauna, including Eastern Cave Bat. This foraging habitat would be modified as a result of the Project.

Two high potential roosting/breeding sites for Eastern Cave Bat have been identified adjacent to the development footprint. No direct impacts are proposed for these habitats. As such there will be no reduction in the availability of breeding habitat for Eastern Cave Bat. Similarly, there will be no direct impact to important species 'life cycle' processes as no habitats that support these processes are being directly impacted.

The project will also result in indirect impacts during construction and afterward during operation of the wind farm. During construction these indirect impacts will consist of increased traffic, noise and light during the project construction. These impacts will be managed during construction to reduce impacts to nocturnal fauna and will cease once construction is completed. Restriction of works to outside of breeding season within the vicinity of the two high potential roosting/breeding habitats is recommended for inclusion within the CEMP's mitigation measures which will further reduce scale of construction related indirect impacts.

There are also indirect impacts associated with the operations phase where collision mortality and possibly barotrauma risks associated with the wind turbine blades could occur, as well as potential impacts to habitat connectivity. These impacts are discussed further in Section 8.5 of the BDAR, however, these impacts will not significantly change the availability of habitat in the locality. It is considered that the likelihood of a collision event for the Eastern Cave Bat may occur only in unusual circumstances given the low level of relative activity recorded for this species at higher elevations due to foraging and movement behaviour (i.e. within the range of rotor blades), and the expected volume of commensurate habitat available in the landscape. Should collision mortality occur, however, it is considered that the repeated loss of a small number of individuals would not be of concern to the viability of the local or broader population. An Operational Bird and Bat Adaptive Management Plan will be prepared prior to construction to assess any bat mortality and to continually assess the assumptions of this impact assessment and enable adaptive management measures to be implemented if required to reduce measured impacts.

(e) The likely impact on the ecology of the local population. At a minimum, address the following:

- For fauna:
  - Breeding

The size and locations of maternity colonies for Eastern Cave Bat typically are poorly understood, however they appear to form small colonies of between 6-50 individuals. Larger colonies can form though with separate studies recording estimates of 240 and 500 individuals. A preference may be shown for sandstone caves with a rear dome, however, individuals have also formed a colony beneath corrugated iron roof where temperatures exceeded 40ºC, suggesting that buffering against extreme temperature may not be as important for this species. Roost fidelity is also low, and cave switching between successive years has been recorded (Law, Chidel, & Mong 2005, Churchill 2008, Parnaby et al. 2008, DPIE 2021a). The species has been assigned to the Landscape species management stream under the Saving Our Species strategy. No priority management areas are currently identified for the species. This may due to its roost switching behaviour leading to no single site being able to be accurately identified for direct management for the species (DPIE 2021b).

Within the locality of the assessment area there are many potential roosting and breeding habitats for the species. A geomorphological assessment of the assessment area found that there is diverse terrain and lithology and dynamic geomorphology within the locality that creates a high potential for microbat roosting sites across landscapes at all elevations, within the expected flight range of microbats that may be present within the assessment area (Environmental Geosurveys Pty Ltd 2021). The assessment notes that the assessment area lies in the southern margin of the New England Orogen, which comprises a complex geological history resulting in a wide range of rock types and structures in northeast NSW and southeast Queensland, with the diverse geology present in the landscape continuing to the north through the NSW North Coast, Nandewar and New England Tablelands bioregions (which together comprise much of the New England Orogen), thus habitats present in the locality of the project area are also likely to occur elsewhere within broader geological landscape, and therefore unlikely to form a substantial portion of the habitat available, or be significant at a bioregional scale (Environmental Geosurveys Pty Ltd 2021). Finally the nearby town of Nundle has a rich mining history, being settled in 1852 following the discovery of gold at "The Hanging Rock" and Swamp Creek, and consequently there are many (dozens) historic mines and unnamed pits in the region (AUSGIN 2021) which may also provide potential roosting habitat to the local population.

Adjacent to the development footprint there are two identified high potential roosting/breeding sites. This is comparatively few when placed in context of the similar habitat available within the locality and broader region. There are also no direct impacts proposed to either of these potential habitat locations or their surrounding buffer areas. The avoidance and minimisation for reducing indirect impacts during operation of the wind farm are discussed in question (a) above. As such, the Project is unlikely to result in impacts to breeding habitat for Eastern Cave Bat.

- Foraging

Studies on the movement and foraging behaviour of Eastern Cave Bat found that most distance were typically less than 1.5 kilometres, with a maximum distance of 3.75 kilometres observed by one individually travelling between roosts. The foraging area utilised by the species is also likely to be small and localised, with one individual foraging for five consecutive days of an area of only 33 hectares. Individuals are capable of dispersing over small breaks in the landscape, with individuals recorded covering a 500 metre gap over a cleared paddock (Law, Chidel, & Mong 2005).

A total of 28,033 hectares of native vegetation occurs within the 2.5 kilometre area surrounding the development footprint, with only 132.43 hectares of native vegetation (0.47 %) occurring within the development footprint. Of this vegetation approximately 37.92 hectares is in high condition providing good habitat values for foraging native fauna, including Eastern Cave Bat. This foraging habitat would be modified as a result of the Project.

Vegetation within the development footprint is well connected to surrounding vegetation, with large patches of native vegetation occurring within the 2.5 kilometre area surrounding the development footprint. This includes large tracts of intact native vegetation within the Ben Halls Gap National Park, Crawney Pass National Park, Wallabadah Nature Reserve and the Nundle and Hanging Rock State Forests. These areas represent prime foraging habitat for the species and are all within two kilometres of various locations along the development footprint. Given the plentiful natural roosts that are likely to be available to individuals within 2.5 kilometres of the development footprint, due to the underlying geomorphology (Environmental Geosurveys Pty Ltd 2021), these foraging habitats would be easily accessible to individuals within the local population. The removal of native vegetation as part of the proposed works is therefore not considered to have a significant impact on the foraging ecology of Eastern Cave Bat.

- Roosting

Eastern Cave Bat typically roosts in entrances of sandstone overhang caves, boulder piles, mines, road culverts occasionally in buildings, and in disused, bottle-shaped mud nests of the Fairy Martin *Petrochelidon ariel* beneath bridges and in culverts (Law, Chidel, & Mong 2005, Churchill 2008, Parnaby et al. 2008, Churchill 2008). Roost fidelity is low, even within a single season, with individuals regularly changing roosts, sometimes daily. These roosts are usually less than 1.5 kilometres part (Law, Chidel, & Mong 2005, Parnaby et al. 2008).

Within the locality there are many potential roosting and breeding habitats for the local population. A geomorphological assessment of the assessment area found that there is diverse terrain and lithology and dynamic geomorphology within the locality that creates a high potential for microbat roosting sites across landscapes at all elevations, within the expected flight range of microbats that may be present within the assessment area (Environmental Geosurveys Pty Ltd 2021). The assessment notes that the assessment area lies in the southern margin of the New England Orogen, which comprises a complex geological history resulting in a wide range of rock types and structures in northeast NSW and southeast Queensland, with the diverse geology present in the landscape continuing to the north through the NSW North Coast, Nandewar and New England Tablelands bioregions (which together comprise much of the New England Orogen), thus habitats present in the locality of the project area are also likely to occur elsewhere within broader geological landscape, and therefore unlikely to form a substantial portion of the habitat available, or be significant at a bioregional scale (Environmental Geosurveys Pty Ltd 2021). Finally the nearby town of Nundle has a rich mining history, being settled in 1852 following the discovery of gold at "The Hanging Rock" and Swamp Creek, and consequently there are many (dozens) historic mines and unnamed pits in the region (AUSGIN 2021) which may also provide potential roosting habitat to the local population.

There are two high potential roosting habitats located adjacent to the development footprint. As a result of avoidance measures adopted by the project (Table 1), there are no direct impacts to either of these features or their surrounding buffer areas. Given the underlying geology outlined by the geomorphological report (Environmental Geosurveys Pty Ltd 2021), there are likely to be numerous cracks and crevices along ridgelines within the broader locality that may be used as overnight roosts by individuals or small groups of Eastern Cave Bat. Given the high potential for similar habitat across the locality, the Project is not expected to significantly alter the availability of these crack/crevice overnight roosting habitats.

- Dispersal or movement pathways

Eastern Cave Bat is a mobile species capable of dispersing across small breaks in habitats with individuals capable of crossing cleared paddocks of at least 500 metres. The species is known to move between roosting sites, sometimes daily, typically travelling less than 1.5 kilometres between these sites, however distances of up to 3.75 kilometres in a single night have been recorded (Law, Chidel, & Mong 2005).

In designing the wind farm layout the spacing of the turbines was considered to limit interactions with fauna and an essentially linear row of turbines was designed. This is different from most wind energy facilities in Australia in which turbines are scattered across a site. In the more usual scattered or 'clustered' array, microbats and avian fauna have a high probability of encountering multiple turbines in a given flight. The configuration of Hills of Gold turbines is such that an individual is likely to encounter multiple turbines only in the rare event that it flies directly along the row of turbines. The minimum spacing between two adjacent turbines along the development footprint is 270 metres (110 metres at turbine height) and the maximum distance between two adjacent turbines is 1,600 metres (1,400 metres at turbine height). The average range is 300 – 500 metres or 138 – 338 metres between turbines. These gaps provide movement corridors, allowing for migrating and foraging bats to pass through the landscape, reducing the chance of collision and possibly barotrauma. It is considered that the likelihood of a collision event for the Eastern Cave Bat may occur only in unusual circumstances given the low level of relative activity recorded for this species at higher elevations due to foraging and movement behaviour (i.e. within the range of rotor blades), and the expected volume of commensurate habitat available in the landscape. Should collision mortality occur however, it is considered that the repeated loss of a small number of individuals would not be of concern to the viability of the local or broader population.

North-south movements over the wind arm alignment are more likely to be associated with foraging flights which would be conducted at canopy level, out of turbine blade range (see Section 7.2 for details regarding turbine blade buffers). The layout also retains areas of preferred foraging habitat in steeper areas of terrain, with more densely vegetated gullies preserved. It is therefore unlikely that the Project will interfere in the dispersal of movement pathways of the species. Impacts to habitat connectivity are further assessed in Section 8.5 of the BDAR.

(f) A description of the extent to which the local population will become fragmented or isolated as a result of the proposed development.

Eastern Cave Bat is a mobile species capable of dispersing across small breaks in habitats with individuals capable of crossing cleared paddocks of at least 500 metres. The species is known to move between roosting sites, sometimes daily, typically travelling less than 1.5 kilometres between these sites, however distances of up to 3.75 kilometres in a single night have been recorded (Law, Chidel, & Mong 2005). The species will also utilise man-made structures such as culverts, bridges, buildings and derelict mines as roosting sites. The surface geology of area 2.5 kilometre area surrounding the development footprint has the potential to provide the species with numerous roosting habitats (Environmental Geosurveys Pty Ltd 2021). There are large tracts of intact native vegetation within and adjacent to these areas such as the Ben Halls Gap National Park, Crawney Pass National Park, Wallabadah Nature Reserve and the Nundle and Hanging Rock State Forests which are connected to the development footprint which would facilitate dispersal of the local population. The spacing between wind turbines within the development footprint is such that movement corridors have been conserved, allowing for migrating and foraging bats to pass through the landscape.

Given the transient nature of the species, the high level of native vegetation connection across the region, and the high level of potential roosting locations, the project is not expected to result in significant amount of landscape fragmentation that would result in the local population becoming isolated. Impacts to habitat connectivity are further assessed in Section 8.5 of the BDAR.

(g) The relationship of the local population to other population/populations of the species. This must include consideration of the interaction and importance of the local population to other population/populations for factors such as breeding, dispersal and genetic viability/diversity, and whether the local population is at the limit of the species' range.

The ecology of Eastern Cave Bat is poorly understood, with the BioNet Atlas of NSW stating "very little is known about the biology of this uncommon species", whose threatening processes include insufficient understanding of species/community ecology (DPIE 2021a). The species is distributed along the east-coast of Australia, ranging from Cape York in northern Queensland down to at least the Sydney Basin in NSW, however it's extent south of Sydney is not fully understood (Law, Chidel, & Mong 2005, Parnaby et al. 2008).

The species has been assigned to the Landscape species management stream under the Saving Our Species strategy. No priority management areas are currently identified for the species. This may due to its roost switching behaviour leading to no single site being able to be accurately identified for direct management for the species (DPIE 2021b).

The full dispersal capabilities of the species are poorly understood, as are the size of local populations within the locality. However, the surface geology of the 2.5 kilometre area surrounding the development footprint has the potential to provide small colonies that may be present within the area with numerous roosting habitats. There are also large tracts of intact native vegetation within and adjacent to these areas such as the Ben Halls Gap National Park, Crawney Pass National Park, Wallabadah Nature Reserve and the Nundle and Hanging Rock State Forests which are connected to the development footprint which would facilitate dispersal of individuals between these colonies.

As consideration has been made with regards to the spacing of wind turbines, leading to preservation of movement corridors, it is unlikely that the movement of individuals between colonies would be significantly restricted by the proposed development. As such the Project is unlikely to lead to a reduction in the pre-existing level of interactions that may be occurring between small, over-lapping colonies that may exist in the area that comprise the local population of the species.

(h) The extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population.

The potential threats to Eastern Cave Bat, as identified in the species profile included in the Atlas of NSW Wildlife (DPIE 2021a), are addressed below in Table 87.

Table 87 Potential threats to Eastern Cave Bat

Threat	Relevance to proposed works
Clearing and isolation of dry eucalypt forest and woodland, particularly about cliffs and other areas containing suitable roosting and maternity sites, mainly as a result of agricultural and residential development.	Only two high potential roosting/breeding habitats occur adjacent to the development footprint. No direct impacts are proposed to either of these locations and, due to avoidance measure adopted by the project, there are now no impacts within the buffer areas of these features. As such there will be no significant impacts to breeding habitat for Eastern Cave Bat as a result of the Project. Mitigation measures to control indirect impacts (noise, light and vibration) during construction will further ensure no impacts to the species, as will recommendations to avoid undertaking works in the proximity of these habitat features during breeding season.
Loss of suitable feeding habitat near roosting and maternity sites as a result of modifications from timber harvesting and inappropriate fire regimes usually associated with grazing.	The proposed works include impacts to 132.43 hectares of native vegetation from the development footprint. However, only 37.92 hectares of this vegetation is considered high quality and potential foraging habitat for the species. A total of 28,033 hectares of native vegetation occurs within the 2.5 kilometre area surrounding the development footprint, which, given the highly mobile nature of the species, is readily available to individuals as foraging habitat. There are also large tracts of intact native vegetation within the Ben Halls Gap National Park, Crawney Pass National Park, Wallabadah Nature Reserve and the Nundle and Hanging Rock State Forests which all occur within foraging distance of the development footprint. As such the Project is considered unlikely to significantly reduce the availability of foraging habitat for the local population of Eastern Cave Bat. The Project is unlikely to result in changes to timber harvesting, fire regimes or grazing pressures such that a significant impact to Eastern Cave Bat would occur.
Pesticides and herbicides may reduce the availability of invertebrates, or result in the accumulation of toxic residues in individuals' fat stores.	The project is not likely to substantially increase the levels of pesticides within the environment.
Damage to roosting and maternity sites from mining operations, and recreational activities such as caving.	Only two high potential roosting/breeding habitats occur adjacent to the development footprint. No direct impacts are proposed to either of these locations and due to avoidance measure adopted by the project, there are now no impacts within the buffer areas of these features. As such there will be no significant impacts to breeding habitat for Eastern Cave Bat as a result of the Project. Mitigation measures to control indirect impacts (noise, light and vibration) during construction will further ensure no impacts to the species, as will recommendations to avoid undertaking works in the proximity of these habitat features during breeding season.
There is a strong likelihood that unrecorded populations	Targeted anabat survey and cave habitat inspections have been undertaken to support the current assessment. These surveys successfully detected the presence

Threat	Relevance to proposed works
could be unintentionally affected by land management actions.	of the species within the locality as well as two high potential roosting/breeding habitats occur adjacent to the development footprint. No direct impacts are proposed to either of these locations and only 2,000 square metres (1.8%) of native vegetation will be removed from the 108,546 square metre (100 metre radius) buffer zone applied to the high potential roosting/breeding habitat adjacent to turbine WP27. As such it is unlikely that an unrecorded population would be unintentionally affected by the Project.
Probable predation by cats and foxes.	The project does not substantially alter the environment in such a way that the numbers of feral cats and foxes within the locality are likely to increase. As such the project is unlikely to result in exacerbation of this threatening process upon Eastern Cave Bat.
Very little is known about the ecology, behaviour and habitat requirements.	Only two high potential roosting/breeding habitats occur adjacent to the development footprint. No direct impacts are proposed to either of these locations and due to avoidance measure adopted by the project, there are now no impacts within the buffer areas of these features. Whilst the species is considered data-deficient, the lack of impacts to key habitats that support critical species life processes (i.e. breeding) means is unlikely that the proposed impacts would have a significant impact on the population.

(i) An estimate of the area, or number of populations and size of populations that is in the reserve system in NSW, the IBRA region and the IBRA subregion.

The following information has been gathered from BioNet Atlas records as well as scientific literature and government reports.

New South Wales

A total of 616 BioNet Atlas records for Eastern Cave Bat exist across NSW (DPIE 2021a). The species range extends from Cape York in northern Queensland down to at least the Sydney Basin in NSW (Law, Chidel, & Mong 2005). Records exist within the following IBRA regions within NSW:

- Brigalow Belt South
- Nandewar
- New England Tablelands
- NSW North Coast
- South Eastern Highlands
- South Eastern Queensland
- Sydney Basin

Low numbers of records also occur within the Cobar Peneplian (2 records) IBRA region.

The Saving Our Species strategy for this species is at the landscape level as no single site can be accurately identified to direct management for the species. As such no priority management areas are identified (DPIE 2021b). A total of 107 (17%) of the historical sightings occurring within the NSW reserve system. These records occur within 34 national parks, nature reserves and conservation areas.

Nandewar – Peel IBRA sub-region

A total of 50 records for Eastern Cave Bat occur within the Nandewar IBRA region, 25 within the Peel IBRA sub-region. Of these a single record from the Peel sub-region occurs within the NSW reserve system, located in the Wallabadah CCA Zone 1 National Park.

New England Tablelands – Walcha Plateau IBRA sub-region

A total of 18 records for Eastern Cave Bat occur within the New England Tablelands IBRA region. None of these occur within the Walcha Plateau IBRA sub-region.

NSW North Coast – Tomalla IBRA sub-region

A total of 100 records for Eastern Cave Bat occur within the NSW North Coast IBRA region. None of these occur within the Tomalla IBRA sub-region.

(j) The measure/s proposed to contribute to the recovery of the species in the IBRA subregion.

The proposed works are not considered likely to have a substantial impact on Eastern Cave Bat, and thus no measures have been proposed to contribute to the recovery of the species.

Appendix F Geomorphology, ecology and potential microbat roosting habitat (Environmental Geosurveys Pty Ltd)

HILLS OF GOLD WIND FARM

GEOMORPHOLOGY AND GEOLOGY

&

POTENTIAL MICROBAT ROOSTING HABITAT

Prepared by: ENVIRONMENTAL GEOSURVEYS Pty Ltd (Neville Rosengren)

Prepared for: BIOSIS Pty Ltd.

VERSION 2: April 2021

Table of Contents

1 INTRODUCTION 1

1.1 Scope and Purpose 1

1.2 Study Area 2

1.3 Methodology 2

2 GEOLOGY AND GEOMORPHOLOGY 4

2.1 Context: New England Orogen 4

2.2 Cenozoic and Mesozoic Volcanics 5

2.3 Volcanic Terrain 6

2.3.1 Walcha, Mount Royal Range, Liverpool Range, Barrington Volcanic Provinces ..7

3 POTENTIAL FOR MICROBAT HABITAT 9

3.1 Potential Habitat Types 9

3.2 Known Habitat Occurrence 10

3.2.1 Timor Caves 10

3.2.2 Barry Caves 10

3.2.3 Glenrock 10

3.2.4 Travelling Stock Route 10

3.3 Potential Habitat Occurrence 11

3.3.1 Biosis Desktop Assessment 11

3.3.2 This Desktop Review 11

3.3.3 Potential Habitat in Extended Area 12

3.4 Landform Diversity 14

4 CONCLUSION 15

5 REFERENCES 16

Table Figures

Figure 1. Location of proposed wind farm and extended study area......................................1

Figure 2. Topography and location of components of proposed wind farm...........................2

Figure 3. Surface geology and volcanic provinces of the New England Orogen.......................4

Figure 4. Digital elevation model northeast NSW showing Cenozoic volcanic provinces and position of the Great Divide 5

Figure 5. Distribution of volcanic units approximately 100 km radius of proposed HOGWF ...8

Figure 6. Mount Royal Range and Great Divide volcanic rock distribution.. 8

Figure 7. Karsts of the New England Fold Belt (Orogen).. 12

Figure 8. Potential habitat (red outlines) determined from LiDAR 5 m DEM and aerial photography...13

1 INTRODUCTION

1.1 Scope and Purpose

This short report was prepared in response to a letter brief (e-mail March # 2021) from Callan Wharfe (Senior Ecologist, Biosis Pty Ltd) for a desktop assessment of the geology and geomorphology at and enclosing the proposed Hills of Gold Wind Farm (HGWF) in the Mount Royal and Liverpool Ranges 60 km south-east of Tamworth in northeast New South Wales (Figure 1).

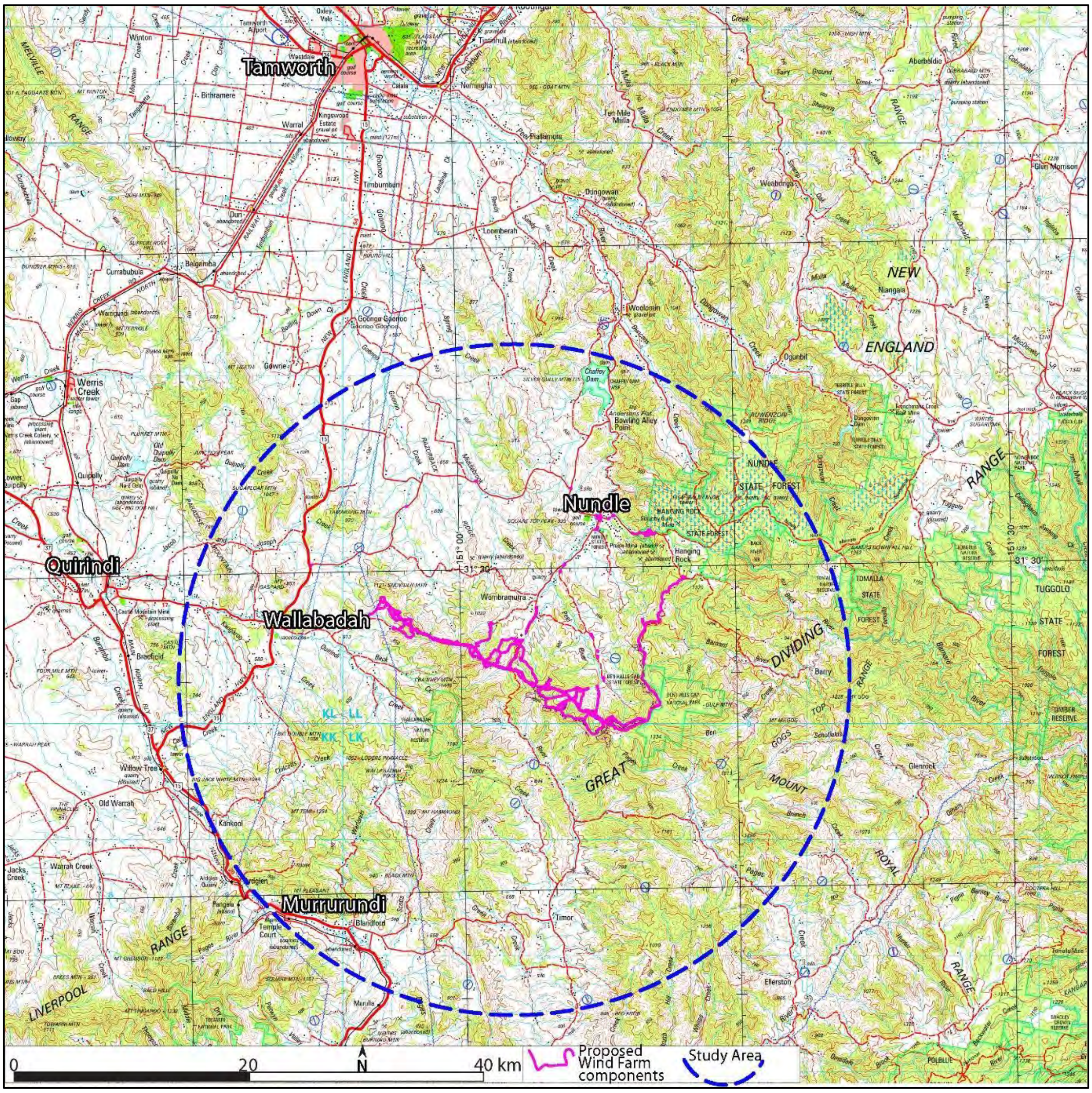


Figure 1. Location of proposed wind farm and extended study area. Base map part of Tamworth 1:250,000 Topographical Map. (Map Source: Geoscience Australia).

The purpose of the report—as requested in the letter brief—is to provide an opinion on the likelihood of the geology and landform of the area as potential microbat roosting habitat. Such habitat are cavities large enough to provide bat colony roosting space and with external access dimensions sufficient to allow flight entry and exit. The cavities may be inherent as *in situ* attributes of the geology or produced by subaerial and subsurface weathering and denudation (erosion), including rock piles accumulated from landslides or other mass movement processes. Habitat created by human activities such as mining and quarry sites may also provide habitat.

1.2 Study Area

The study area includes precinct of the proposed HOGWF (turbines, transmission lines, roads and tracks), and a region extending approximately 30 km beyond these (Figure 1). The HOGWF turbines will be located on ridges and spurs from east of Crawney Pass to the south of Hanging Rock (Figure 2). Associated components will extend north and west of the turbine field.

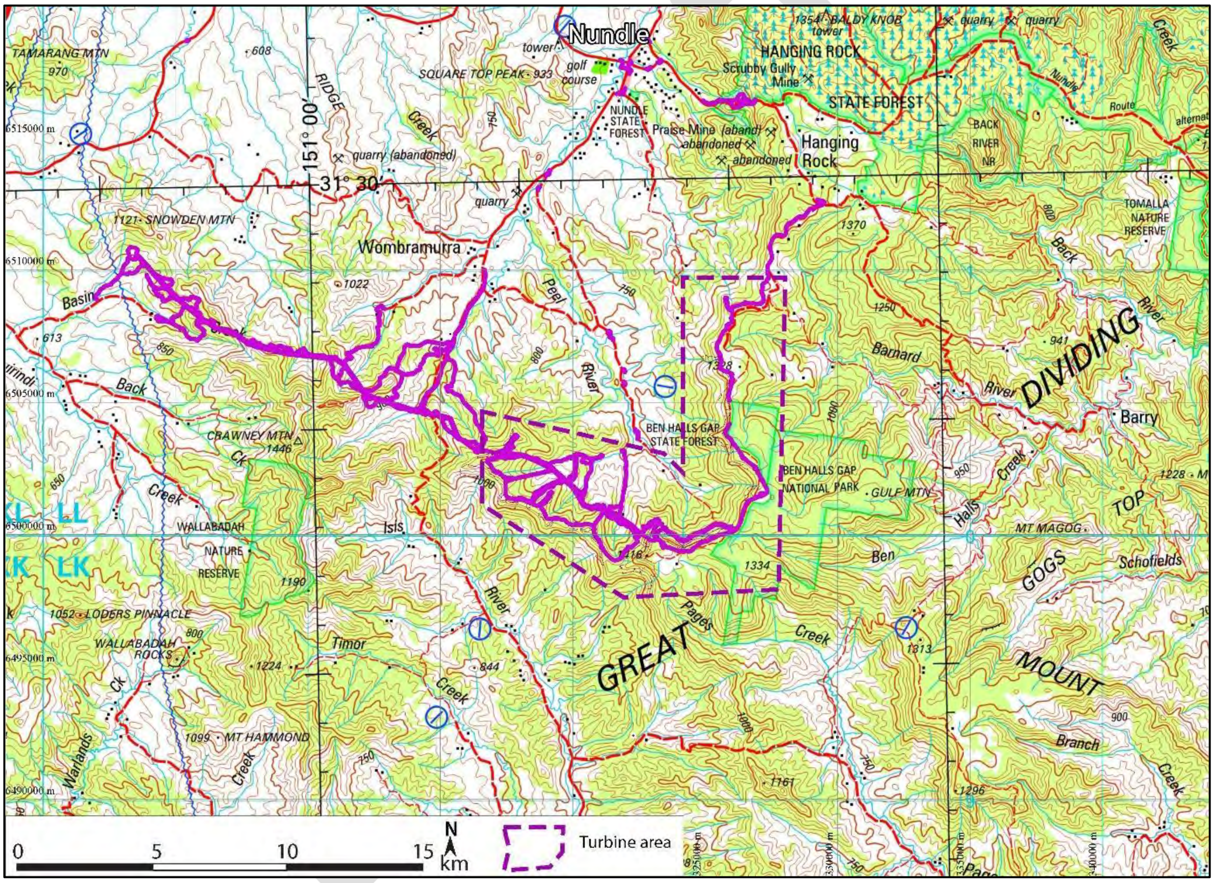


Figure 2. Topography and location of components of proposed wind farm. Base map part of Tamworth 1:250,000 Topographical Map. (Map Source: Geoscience Australia).

1.3 Methodology

This report was prepared from literature, spatial data (topography, geology) and aerial photography. Topographic data (Point Cloud LiDAR) and orthophoto imagery supplied by Someva and Biosis Pty Ltd, was supplemented by data downloaded from Geoscience Australia, Geological Survey of New South Wales, the SIX Maps mapping tool, and other products from Spatial Services New South Wales.

The GIS data was displayed on Global Mapper V22.1 LiDAR module. A DEM of the immediate study area (turbines and access tracks) was constructed from LiDAR Keypoints files with a drape of the orthophotograph and overlay of New South Wales digital Seamless Geology 2020. DEMs of turbine locations were created from LiDAR point cloud files. Combinations of slope shading and elevation shading at screen scales between 1:500 and 1:1,000 were used to identify potential habitat based on photo-interpretation of rock outcrop and scree slopes.

To provide context for potential habitat surrounding the proposed HOGWF site by identifying areas of outcrop, a DEM with 30 km buffer from the turbine sites was constructed from 5 metre LiDAR data obtained from Geoscience Australia ELVIS portal. An overlay of aerial photography of this envelope was accessed via Global Mapper allowing display of the DEM, photography, and geology. This image was viewed at screen scale approximately 1:4,000. Initially areas of slope $>20^{o}$ were identified on the DEM and then the photograph layer displayed to discern visible outcrop. These were outlined and the layer exported and displayed in Figure 8 in the report. Areas of steep slope where outcrop was possible—but ground could not be seen due to tree cover or shadow—were also selected as potential habitat.

2 GEOLOGY AND GEOMORPHOLOGY

2.1 Context: New England Orogen

The study area lies in the southern margin of the New England Orogen (NEO) the youngest and easternmost of the eastern Australian Tasmanides[1]. The geological history of the NEO is complex resulting in a wide range of rock types and structures in northeast New South Wales and southeast Queensland. The basement rocks of the NEO developed from the Cambrian—540 million years ago (Ma) to the Carboniferous—320 Ma, and over time have been altered by multiple episodes of deformation and igneous intrusions, and further sedimentation during the Permian (300 Ma) to (Triassic-Jurassic 250 to 16 Ma) prior to the break-up of Gondwana (Scheibner 1976) (Figure 3).

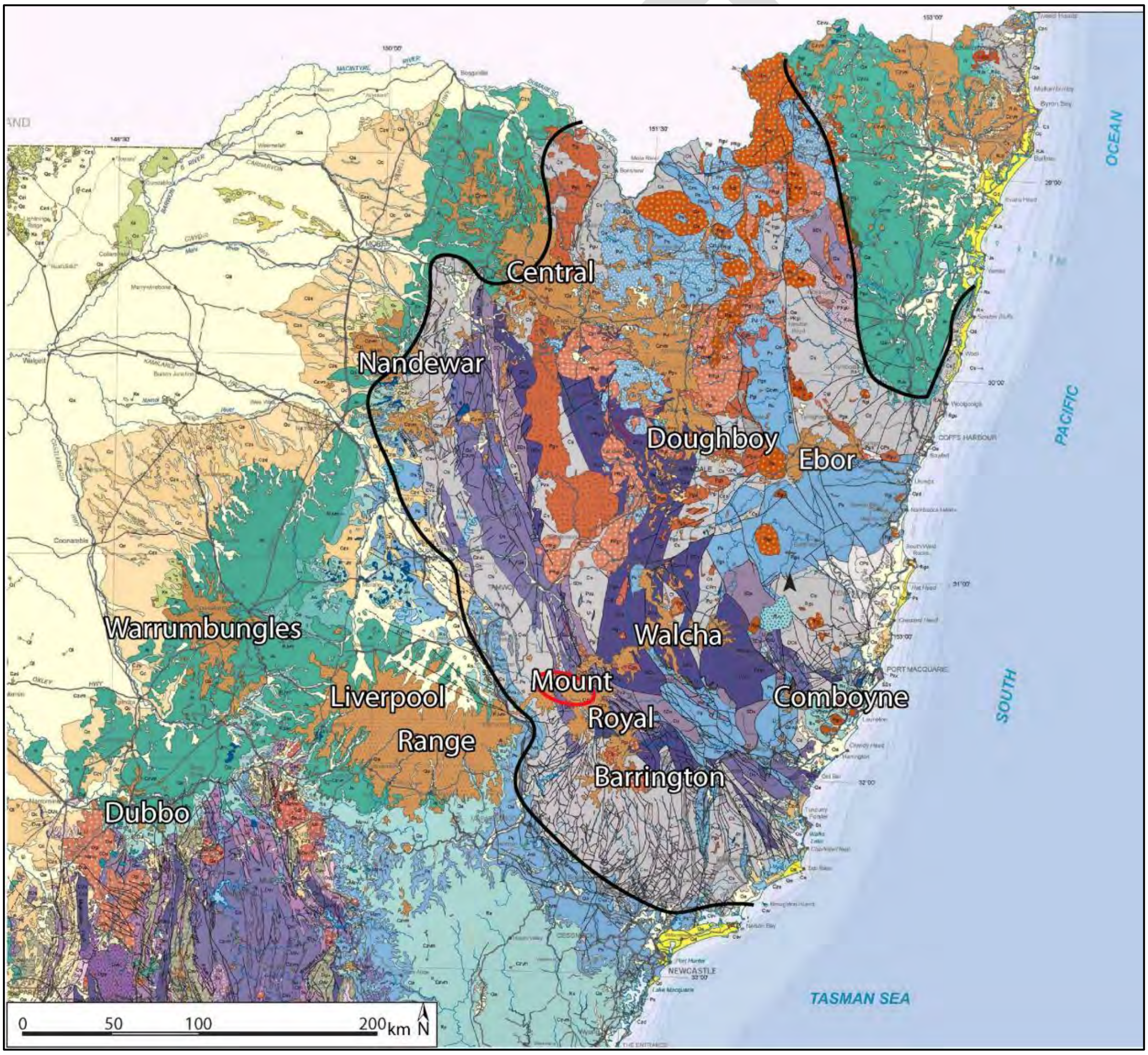


Figure 3. Surface geology and volcanic provinces of the New England Orogen (heavy black line) in northeast New South Wales. Proposed HOGWF shown as red ellipse at Mount Royal. (Province names after Kutson *et al. (1989)* From: Surface Geology of New South Wales 1:1 500 000, Planning Industry and Environment NSW 2009).

[1] The Tasmanides are geological units that form the basement rocks of eastern Australia. The New England Orogen is also referred to as the New England Fold Belt.

The exposed basement geology includes stratified silicic and calcareous sedimentary beds, granitoids and interbedded volcanics previously subjected to and altered by metamorphism, large-scale folding and faulting (Rosenbaum *et al.* 2005). Widespread volcanism in the Cenozoic covered much of the surface of the NEO, but the areal extent of volcanics has been reduced by denudation.

2.2 Cenozoic and Mesozoic Volcanics

Across much of the NEO the basement rocks are unconformably overlain by late Mesozoic and Cenozoic volcanic rocks (less than 80 Ma). Extensive remnants of eruption points (the volcano) and lava flows are conspicuous features of the modern landscape of northeast New South Wales (Figure 3, Figure 4).

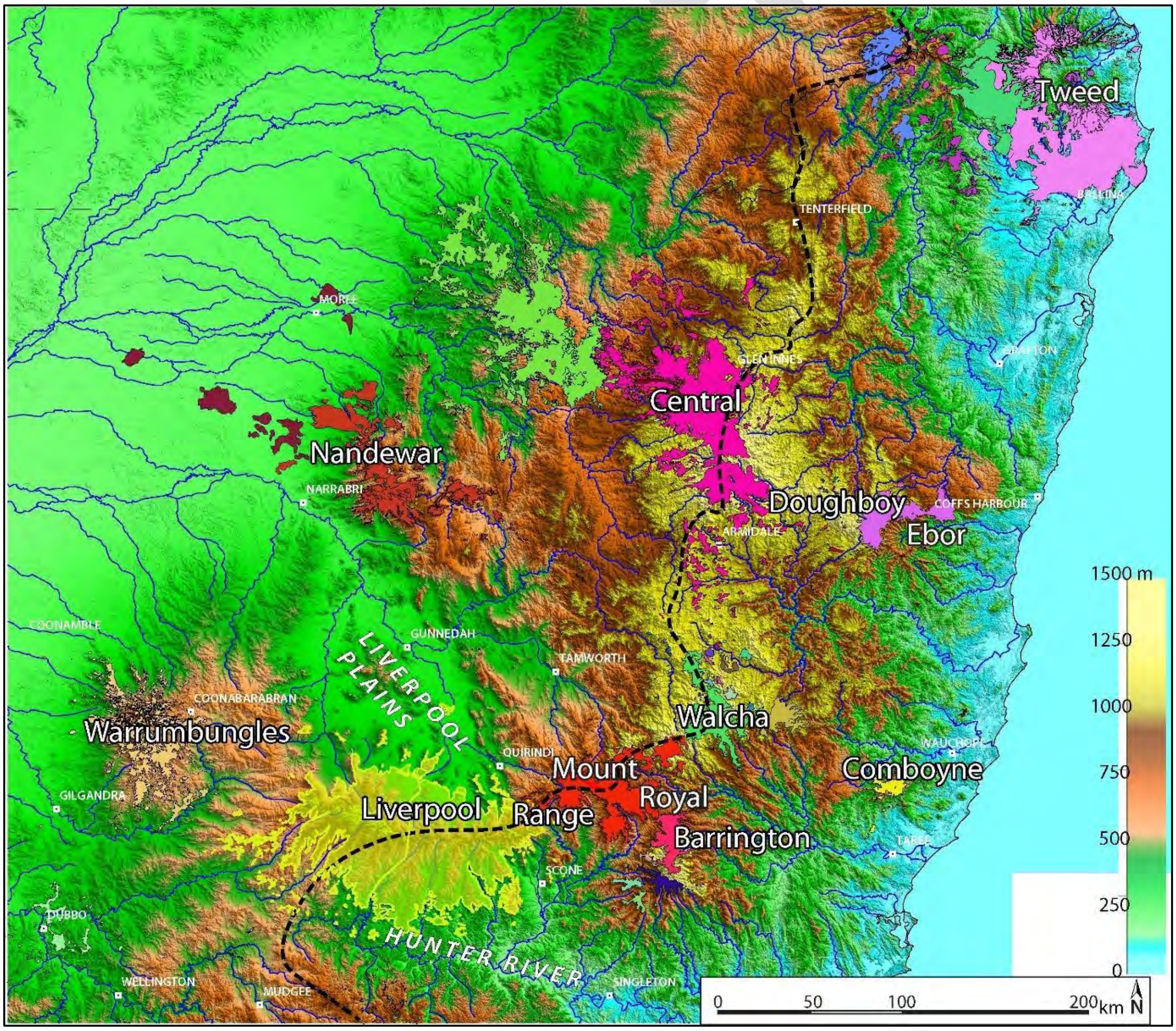


Figure 4. Digital elevation model northeast NSW showing Cenozoic volcanic provinces and position of the Great Divide (broken black line). (Volcanic province names from Knutson et al. (1989) and Seamless Geology NSW 2018. Base map 1 sec DEM: Geoscience Australia 2013).

Volcanoes are classified according to a range of overlapping characteristics including 1, *eruption source*—localised vents and fissures or numerous widespread eruption locations; 2, *eruption styles*—effusive with coherent lava flows or explosive with fragmentalpyroclastic deposits; 3, *geochemistry*—fraction of silica that determines mineralogy; 4*, spatial and temporal distribution*—the extent, duration and the continuity of eruptions; 5, *geomorphic representation*—position in present landscape and preservation of initial volcanic characteristics.

Wilkinson (1969) grouped the volcanic rocks of north-eastern NSW into eight geographical provinces and recognised the petrographic (compositional) associations that occurred in some of these. Later studies, supported by radiometric dating (Wellman and McDougall 1974a, 1974b) refined the distinction based on geochemical affinity and age, and defined eleven volcanic provinces ranging from 70 Ma to 12 Ma. Recent mapping (Colquhoun *et al.* 2020) extends this to 12 provinces (Figure 3, Figure 4).

Wellman and McDougall (1974) and Knutson (in Johnson 1989) further classified the volcanic provinces into central volcanoes and lava fields. *Central volcanoes* are large single vent or clusters of close-spaced vents with frequent basaltic and felsic (higher silica) lava flows building a thick pile referred to as a shield volcano up to 100 km across. The Tweed, Warrumbungle, Nandewar, Ebor, Comboyne, Liverpool and Barrington provinces were identified as central (shield) volcanoes. Paine (1983) showed the Barrington Tops shield volcano to be at least 400 m thick and consist of 20 lava flows. *Lava fields* are provinces with eruptions from a diffuse pipe and dyke swarm producing generally thin lava flows, but in places with lava piles hundreds of metres thick. Wellman and McDougall (1974a) identified the Central Province is as a lava field.

2.3 Volcanic Terrain

The original lava thickness was determined by the lava viscosity, rate of effusion and pre-volcanic relief, with greatest thickness adjacent to the eruption point and in now-buried valleys and depressions. The thickness and distribution to-day is a function of denudation and tectonic history. Three groups of terrain occur across the volcanic provinces: planar surfaces, basalt margins, sub-basaltic (exhumed) terrain.

Planar surfaces are the undulating plains formed on the denuded surfaces of lava flows. The surface is the product of weathering and erosion over millions of years and does not represent the original post-eruptive landform materials or morphology. Much of the volcanic terrain occurs along the Great Divide—a continuous topographically variable watershed in the Eastern Uplands of Australia—commonly referred to as the Great Dividing Range. The Great Divide trends north-south along the northern New England Fold Belt to 60 km south of Walcha where it turns southwest and west as the Liverpool Range headwater tributaries of the Hunter River and Peel River with ridge and plateau summits rising to over 1400 metres (Figure 4). As the volcanism preceded and accompanied the uplift of much of the Eastern Uplands of Australia, volcanic rocks occur at a range of elevations, in places as broad elevated plateau and elongated ridges on the crest and flanks of the Great Divide.

Basalt margins are now the eroded edges of the original lava flows and are either continuous enclosures of the largest lava bodies across or adjacent to the Great Divide or outlying detached remnants—typically as hill capping. The basalt is geologically unconformable with the underlying older rocks and the base is commonly marked by a defined slope change or escarpment with locally precipitous slopes.

Sub-basaltic terrain surfaces are defined by the range in elevations of the basalt base contact with pre-volcanic rock. For example, a granite outcrop along the Main Divide at Morrisons Gap at an elevation of 1,260 m ASL is surrounded by basalt that has a base elevation around 900 m ASL in Nundle Creek, illustrating around 300 m of local relief. Paine (1983) mapped a series of bedrock benches occurring as plateau surfaces or flattened ridge crests at the base of the basalt around Barrington volcano, demonstrating pre-volcanic relief of about 1,000 m.

Weathering profiles are locally preserved in the buried-exhumed basement rocks. The basement rocks are exposed as narrow zones striking north-north-east locally defining strike ridges and valley alignment and spacing. There is variable rock outcrop and locally thick accumulations of colluvial rock debris.

2.3.1 Walcha, Mount Royal Range, Liverpool Range, Barrington Volcanic Provinces

The Walcha, Mount Royal Range, Liverpool Range and Barrington volcanic provinces are a geographically continuous surface of volcanic rocks extending 150 km south and west of Walcha and bracketing the Main Divide (Figure 5). Wellman and McDougall (1974), and Schön (1989) showed the Liverpool Range Volcanics Province as all the Liverpool Ranges south and west of Whites Sugarloaf to west of Murrurundi to Coolah Tops (Figure 6). The most recent geological mapping (Colquhoun *et al.* 2020) separates the Liverpool Range volcanics to be only west of Murrurundi—Liverpool East Basalt and Liverpool West Basalt—and recognises a new volcanic sub-province—Mount Royal Volcanics—as all the volcanics south of Whites Sugarloaf along the Main Divide to Crawney Mountain and the high southwest Liverpool Range ridge of Lagoon Mountain, Mount Temi and Mount Helen.

The newly-defined Mount Royal Volcanic complex encloses the ridges and hills of the proposed HOGWF turbine field and associated infrastructure (Figure 5).

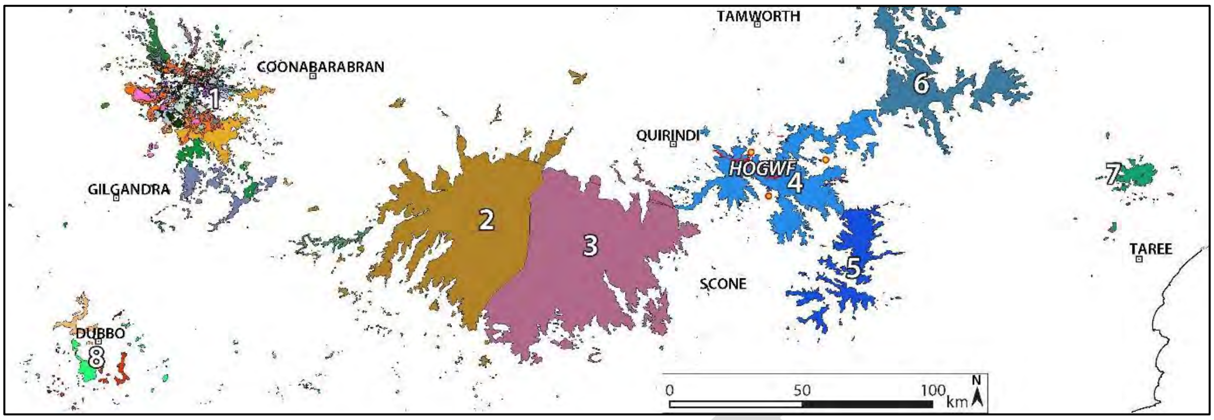


Figure 5. Distribution of volcanic units approximately 100 km radius of proposed HOGWF. **1**, Warrumbungle Volcanic Complex; **2**, Liverpool Range Volcanic Complex – Liverpool West Basalt; **3**, Liverpool Range Volcanic Complex – Liverpool East Basalt; **4**, Mount Royal Volcanic Complex; **5**, Barrington Volcanic Complex; **6**, Walcha Volcanic Complex; **7**, Comboyne Volcano; **8**, Dubbo Volcanic Complex.

The relationship between volcanic outcrop and topography in the region of the HOGWF is shown in Figure 6. The Mount Royal Volcanic province accumulated over Palaeozoic sediment at elevations between 600 m and 900 m ASL. The remnant planar basalt surface along the divide reaches elevations to nearly 1,500 m along the Great Divide indicating lava thickness in places of almost 1,000 metres, in accordance with the figure of 850 m determined by Wellman and McDougall (1974b).

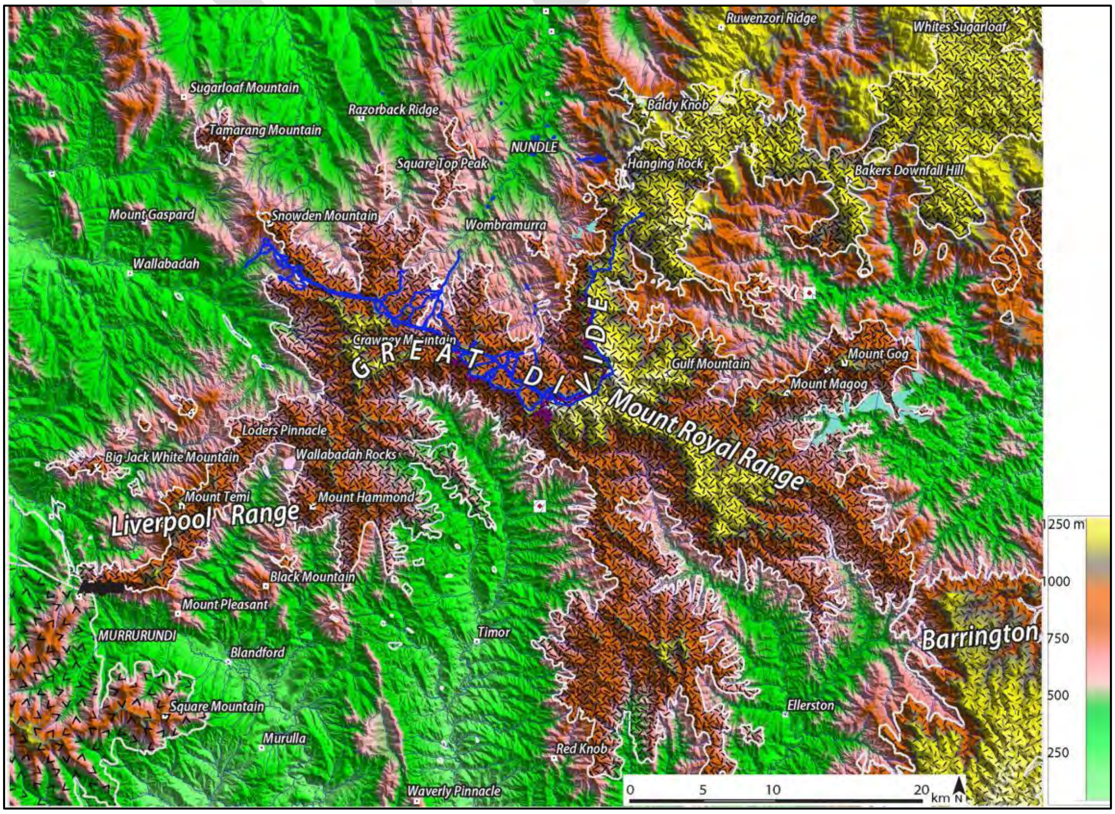


Figure 6. Mount Royal Range and Great Divide volcanic rock distribution. Mount Royal Volcanic Province extends from Whites Sugarloaf to Murrurundi. Base of basalt shown by white lines. (Base: 5 m DEM).

3 POTENTIAL FOR MICROBAT HABITAT

3.1 Potential Habitat Types

The occurrence of suitable microbat habitat is determined by the presence and persistence of spaces in a coherent rock mass or in accumulations of detached rock clasts. The extent to which either of these niches is present and suitable is a function initially of lithology and rock structure modified over time by geological and environmental processes that can increase or decrease the available space. As noted in Section 1.1 above, suitable space may be due to inherent attributes of the rock mass or produced by subsequent processes.

A broad initial classification of types and origins of habitat in rock groups that are likely to crop out within flight distance of the HOGWF is outlined in Table 1.

TABLE 1. Potential Microbat Habitat by Geology

TYPE	TYPE OF ROCK	SPACE	ORIGIN of SPACE	OPPORTUNITY	CONSTRAINT	MODIFICATION
Inherent structure	Fissile sedimentary. Slate, phyllite, shale, laminated mudstone	Narrow fissure	Partings along planar surfaces -bedding, cleavage, faults, shrinkage joints.	Multiple and close-spaced planes	Narrow, linear, discontinuous, unstable, soft, smooth surface.	Inherently soft rock. Change by failure along slip planes. Weathering.
Inherent structure & weathering	Interbedded, cross-bedded	Variable, overhang, small cavern	Selective failure and weathering of different lithologies.	Overhangs or small cavern	Potentially unstable roof overhangs.	Enlarged by weathering and collapse.
Secondary structure	Sandstone, coarse-grained igneous.	Broad fissure to cavernous .	Tension – stress during deformation, expansion by pressure release on unloading.	Small, cavernous. Rough-textured surface. Dry. Stable.	Wet.	Brittle failure.
Inherent structure and weathering	Conglomerate	Small caverns	Partial disaggregation of rock mass by dislodgement of large clasts	Small, cavernous. Rough-textured surface. Dry. Stable.	Wet.	Enlarged by weathering and collapse.
Inherent structure	Basalt lava flows	Wide range of fissures and caverns	Flow cooling and crusting. Volatile emission. Cooling/contraction fractures.	Wide range of shape and size of caverns and overhangs. Stable.	Wet. Locally unstable due to roof collapse.	Local collapse
Secondary processes	Basalt lava flows	Solution caverns (rare)	Solution of amygdaloidal lava.	Limited occurrence.	Large entrance opening, limited dark space.	Flooding
Secondary processes	Carbonate	Enlarged fissures and caverns.	Weathering – solution and precipitation.	Wide range of habitat.		Flooding, sediment and precipitation infill

TYPE	TYPE OF ROCK	SPACE	ORIGIN of SPACE	OPPORTUNITY	CONSTRAINT	MODIFICATION
Inherent properties and secondary processes	Intrusive igneous (granitic)	Enlarged fissure, overhang, small caverns.	Weathering enlarging joints developed by stress release and expansion	Typically vertical and fluted fissures to overhang and caverns.	Wide openings and limited dark space.	Accumulation of colluvium and surface wash debris. Vegetation growth.
Secondary processes	Basalt, sandstone, conglomerate.	Irregular caverns	Stacking and arrangement of fallen talus and landslide rock blocks.	Newly developed.	Irregular space. Limited entry size or limited dark space. Unstable.	Slope movement. Infill by fines, Vegetation growth.

3.2 Known Habitat Occurrence

Biosis supplied the location of three known cave roosting sites in proximity to the HOGWF areas—Timor Caves, Travelling Stock Route and Barry Cave (Figure 7). No details of the cave site were provided. The caves were located on the Seamless Geology map and the distribution of that geological formation displayed across the study area.

3.2.1 Timor Caves

Timor Caves are developed in the Timor Limestone Member of the Yarrimie Formation located in the valley of Isis River. Cave and geological details are provided by Connolly and Francis (1979). Limestone of the Yarrimie Formation crops out across nearly 900 ha along the Isis River but caves are known from only two small localities.

3.2.2 Barry Caves

Barry Cave is located on the crest of a spur 250 m north of a bend in the Barnard River in an area mapped as Myra beds of the Woolomin Group. The cave is not in limestone but in low-grade metamorphic geology described as slate, phyllite, chert, jasper and metabasalts. Rocks of the Myra Group crop out in NW-SE strike in -wide belts and are exposed here as the Mount Royal Range Volcanics have been eroded. The cave is described in Allen *et al.* (1986).

3.2.3 Glenrock

Glenrock karst area is 30 km southeast of the HOGWF. Over 100 caves are known in Silver Gully Formation limestone along a ridge and slopes between Orham Creek and Spring Creek (tributaries of Barnard River) (Allen et al. (1986).

3.2.4 Travelling Stock Route

Travelling Stock Route Cave is marked as adjacent to an outcrop and block scatter of rocks shown as Yarrimie Formation mudstone, chert, siliceous siltstone, limestone, and conglomerate. It is possible the cave is developed in the Crawney Limestone Member "coralline biohermal limestone" as that formation is mapped 140 metres from the cave location. The Crawney Limestone Member is mainly covered by Liverpool Range and Royal Range basalt and crops out along strike for a short distance south of the of the marked cave location. No detail of cave geomorphology is available for this site.

3.3 Potential Habitat Occurrence

Advice from an academic and expert speleologist—Dr Susan White (La Trobe University) is that the foraging range of bats is significantly larger than previously thought and may be at least 75 km (Appendix A). Potential roost sites in basalt and other lithologies across this wider area e.g., up to 75 km foraging range must be considered.

3.3.1 Biosis Desktop Assessment

A desktop study by Biosis identified several discontinuous areas of potential habitat along the upper slopes on both sides of the Main Divide and some higher ridges between Crawney Pass and Wardens Brook. All were areas of surficial basalt geology. It was assessed that the likelihood for unreported caves was low given the areas were not remote and there was generally good surface visibility. No assessment was made of areas of non-basalt geology beyond these limits.

3.3.2 This Desktop Review

As shown in Table 1, potential habitat can occur in a wide range of geological materials. Some habitat entrances will not be discernible on aerial photography or airborne LiDAR, and small outcrop with potential habitat sites can be masked by medium to tall or other closely-spaced vegetation. After examining Point Cloud LiDAR and orthophotography of the HOGWF precinct and immediately adjacent terrain the conclusion of this desktop review is that while these techniques can be applicable for exposed ground surfaces, they cannot be conclusive in identifying (or dismissing) the likelihood of potential geological habitat.

It is unlikely that large caverns—such as those formed by dissolution of limestone at Timor and amygdaloidal basalt as at Coolah Tops—have remained undetected in the immediate and adjacent study area. The area is not remote and has been mapped in some geological detail by expert groups (Government and academic). It is an area visited by trampers and speleologists and there are known caves (see 3.2 above and Appendix A). The limited area of limestone constrains the potential for large habitat caves. Habitat in other rock type is also constrained by limited outcrop of suitable structural and weathering forms.

The undulating plateau and ridge terrain of the proposed HOGWF has no extended rock escarpments and limited outcrop of fractured basalt as vertical or inclined columnar structures. Detailed ground survey would be needed to define the extent of such outcrop but the evidence from the available data point to discontinuous and limited habitat in the immediate vicinity. Talus deposits appear to be inactive and substantially vegetated at the altitude range of the HOGWF, reducing the likelihood of habitat cavity flight entry being preserved.

3.3.3 Potential Habitat in Extended Area

The New England Orogen has limited areas of karst and cave development (Figure 7).

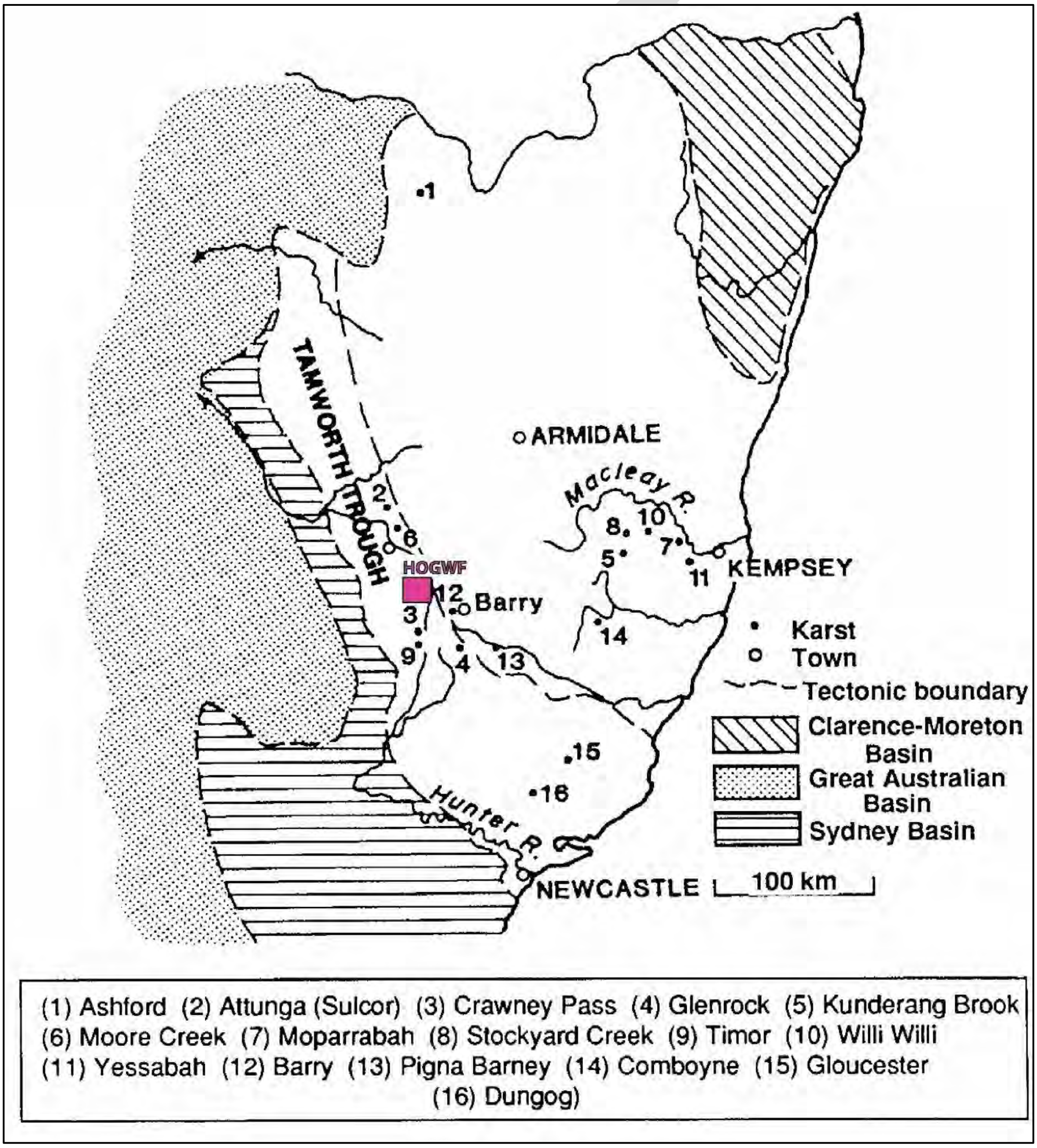


Figure 7. Karsts of the New England Fold Belt (Orogen). (From Osborne and Branagan 1988).

Dense crystalline Devonian limestone has developed multiple caverns and other karst terrain at Timor and Glenrock. The cave at Barry is unusual in being developed in non-carbonate rock.

As outlined in section 1.3 above, an envelope of approximately 30 km around the HOGWF was examined for potential habitat (Figure 7).

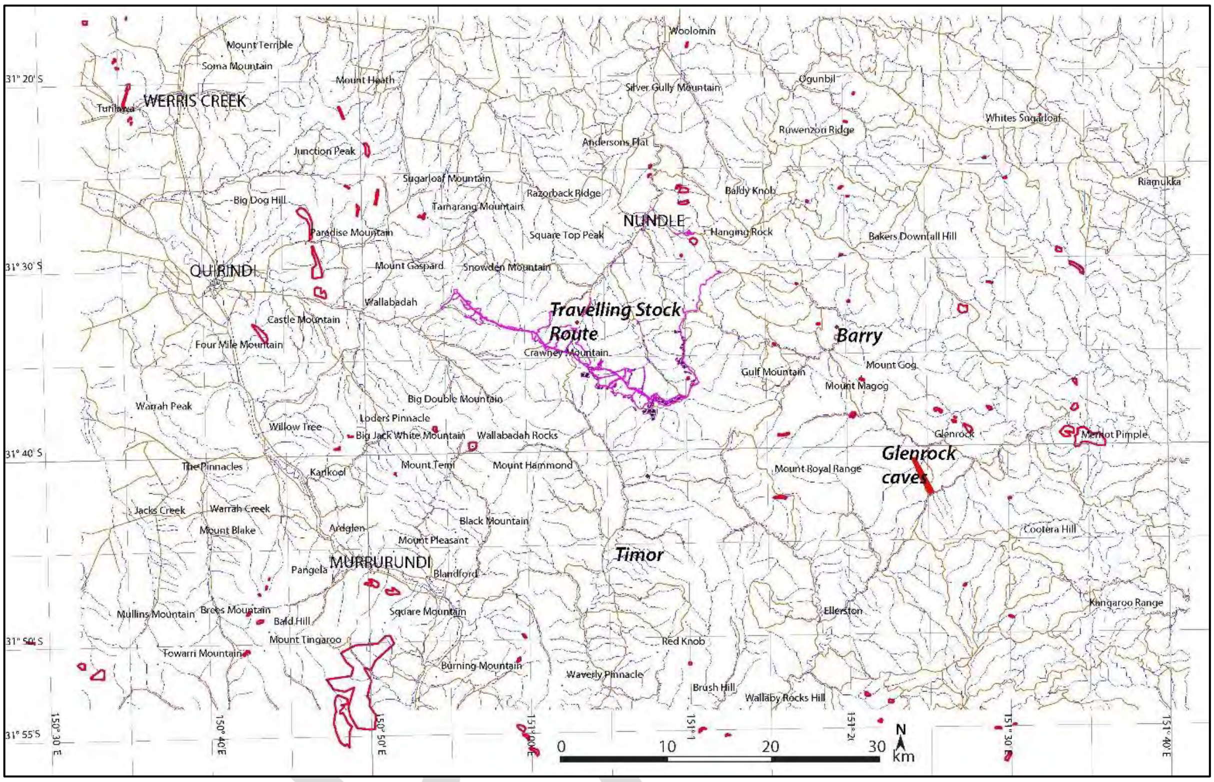


Figure 8. Potential habitat (red outlines) determined from LiDAR 5 m DEM and aerial photography. Four known cave areas shown are Glenrock, Barry, Timor and Travelling Stock Route.

The extent of basalt exposure in valleys and at the margins of the several lava fields within foraging range means smaller cavities formed in this rock may occur. Outcrop of fractured and weathered rock and downslope accumulations of blocky scree as potential habitat sites are also possibly widespread. As the basalts are hundreds of metres total thickness and are comprised of multiple flow units, there are numerous discontinuities in a vertical exposure. The discontinuities may be intra-flow e.g., separation and inflation planes of flow tongues and lobes, or more substantially defined by time-separation of upper flows with lithological differences and weathering developing stepped profiles with broad overhands and access to cavities.

Basalt relict blockstreams and limited areas of exposed scree with minimal vegetation cover at higher altitudes east and south of the HOGWF area are habitat potential, but assessment of extent and distribution of these is beyond the scope of the present study.

3.3.3.1 Habitat in Other Lithologies

The structure of the basement rocks exposed north and south of the main lava fields produce narrow ridges aligned along the NNW strike direction with a core of resistant beds forming the ridge crest and upper slopes. Isolated and groups of such ridges with crestal outcrop occur across parts of the Liverpool Plains and on the lower and mid-slopes of the Main Divide, Liverpool Range and Mount Royal Range. The wide range of lithology including carbonate and close-bedded sandstone-mudstone units have the inherent and secondary properties to develop potential habitat sites.

3.4 Landform Diversity

The geological evolution of northeast NSW has resulted in a diverse and dynamic landscape. Key elements in producing this diversity are the tectonic and volcanic history generating a range of slope forms developed by palaeo and on-going landforming processes on diverse geological materials. Cenozoic climate changes produced weathering regimes where episodes of intense rock decomposition alternated with mechanical breakdown in subsequent cold climate. Uplift of the Eastern Uplands and the rejuvenation of river systems has developed a complex drainage system.

4 CONCLUSION

Diverse terrain and lithology and dynamic geomorphology of the New England Orogen make high potential for microbat roosting sites across landscapes at all elevations in a range of rock types.

In the immediate area of the HOGWF, outcrops of fractured basalt may provide localised habitat, However, terrain and geology of this precinct provides limited opportunity for extensive habitat. While several large solution caverns in limestone and basalt occur in surrounding terrain, these are localised and there is a low probability that similar unreported large habitat sites occur. It is extremely unlikely there are basalt caverns of the dimension to accommodate a large colony. There is also a low possibility that unknown caves occur in the Devonian crystalline limestone, as these outcrops have been searched on several occasions (Allen *et al.* (1986).

5 REFERENCES

ALLEN, A., COOPER, I. & SCOTT, M. (1986). Exploratory Caving in New England. *Sydney University Speleological Society Bulletin* 26 (2), 1 – 8.

BROWN, M.C. (2000). Cenozoic tectonics and landform evolution of the coast and adjacent highlands of southeast New South Wales. *Australian Journal of Earth Sciences* 51, 273-290.

BULL, K.F., TROEDSON, A.L., BODORKOS, S., BLEVIN, P L., BRUCE, M.C., &. WALTENBERG, K. (2021) Warrumbungle Volcano: facies architecture and evolution of a complex shield volcano, *Australian Journal of Earth Sciences*, 68:2, 149-187.

COLQUHOUN G.P., HUGHES K.S., DEYSSING L., BALLARD J.C., FOLKES C.B, PHILLIPS G., TROEDSON A.L. & FITZHERBERT J.A. (2020). *New South Wales Seamless Geology dataset, version 2.0 [Digital Dataset*]. Geological Survey of New South Wales, Department of Regional NSW, Maitland.

CONNOLLY M., & FRANCIS G., (1979) Cave and Landscape Evolution At Isaacs Creek, New South Wales. Helictite, , Vol 17, Issue 1, p. 5-24

ERSKINE, W., & FITYUS, S. (1998). Geomorphology of the Hunter Valley, New South Wales and its relevance to natural resource management and development. In: Fityus S, Hitchcock P, Allman M, Delaney M (Eds) *Geotechnical Engineering and Engineering geology in the Hunter Valley.* Australian Geomechanics Society, 45-66.

FIELDING, C.R., SHAANAN, U. & ROSENBAUM, G. (1995). Sedimentological evidence for rotation of the Early Permian Nambucca block (eastern Australia). Lithosphere: 8 (6) Geological Society of America, 684–698.

GEOSCIENCE AUSTRALIA AND AUSTRALIAN STRATIGRAPHY COMMISSION (2017). *Australian Stratigraphic Units Database*.

GLEN R. A. (2005). The Tasmanides of eastern Australia. In: Alan P. M. Vaughan, Philip T. Leat and Robert J. Pankhurst (eds) Terrane processes at the margins of Gondwana. *Geological Society, London, Special Publications*, 246.

JOHNSON, R.W. (1989). Framework for volcanism: Volcano distribution and classification. In R. W. Johnson (Ed.), *Intraplate volcanism in Eastern Australia and New Zealand* (pp. 7– 11). Cambridge University Press, 408 pp.

KNUTSON, J. (1989). Eastern Australian volcanic geology: Northern New South Wales, Introduction. In R. W. Johnson (Ed.) *Intraplate volcanism in Eastern Australia and New Zealand* (pp. 116–117). Cambridge University Press, 408 pp.

MCDOUGALL, I., & WILKINSON, J. F. G. (1967). Potassium—argon dates on some Cainozoic volcanic rocks from northeastern New South Wales. *Journal of the Geological Society of Australia,* 14(2), 225–233.

OSBORNE, R.A (1979). Preliminary report: Caves in Tertiary basalt, Coolah,N.S.W. *Helictite* 17(1):25-29.

OSBORNE, R.A. (1986) Cave and landscape chronology at Timor Caves, New South Wales *Journal and Proceedings - Royal Society of New South Wales* 119 (1/2):55-76.

OSBORNE, R.A.L. & BRANAGAN, D.F., (1988). Karst landscapes of New South Wales, Australia. In: J. Firman (Editor), Landscapes of the Southern Hemisphere. *Earth Science. Reviews,* 25: 467-480.

PACKHAM, G.H., & DAY, A.A. (1969) The general features of the geological provinces of New South Wales, *Journal of the Geological Society of Australia*, 16:1, 1-17.

PAIN C. F. (1983). Geomorphology of the Barrington Tops area, New South Wales. *Journal of the Geological Society of Australia* 30, 187–194.

ROBERTS, J., AND ENGEL, B.A. (1987) Depositional and tectonic history of the southern New England Orogen: *Australian Journal of Earth Sciences*, 34, p. 1–20.

RYAN, P.J., & HOLMES G.I., (1986) Geology of Hanging Rock and Nundle State Forests. *Technical Paper No. 37.* Soils and Nutrition Group Forestry Commission of New South Wales.

SCHEIBNER, E. (1973). A plate tectonic model of the Palaeozoic tectonic history of New South Wales: *Geological Society of Australia Journal*, 20, p. 405–426,

SCHON, R.W. (1989). Liverpool Range. In '*Intraplate Volcanism in Eastern Australia and New Zealand*'. (Compl. R.W. Johnson) pp. 122-123. (Cambridge University Press: Cambridge).

SUTHERLAND F. L. (1991). Cainozoic volcanism, eastern Australia: a predictive model based on migration over multiple hotspot magma sources. In: Williams, M. A. J., De Deckker, P. & Kershaw, A. P. eds. *The Cainozoic in Australia: a Re-appraisal of the Evidence*, pp. 15–43. Geological Society of Australia Special Publication 18.

SUTHERLAND, F.L. (2011). Diversity within geodiversity, underpinning habitats in New South Wales volcanic areas. *Proceedings of the Linnean Society of New South Wales* 132, 37-54.

SUTHERLAND, F. L., & FANNING, C. M. (2001) Gem-bearing basaltic volcanism, Barrington, New South Wales: Cenozoic evolution, based on basalt K–Ar ages and zircon fission track and U–Pb isotope dating, *Australian Journal of Earth Sciences*, 48:2, 221-237.

VOISEY, A.H. (1969) The New England region, *Journal of the Geological Society of Australia*, 16:1, 227-310.

WELLMAN, P., & MCDOUGALL, I. (1974a). Potassium—argon ages on the Cainozoic volcanic rocks of New South Wales. *Journal of the Geological Society of Australia*, 21(3), 247–271.

WELLMAN, P., & MCDOUGALL, I. (1974b). Cainozoic igneous activity in eastern Australia. *Tectonophysics*, 23 (1–2), 49–65.

Appendix G Offset credit summary reports

BAM Credit Summary Report

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00020779/BAAS18138/20/00020780	Hills of Gold Wind Farm	24/11/2021

Assessor Name	Report Created	BAM Data version *
Callan Wharfe	06/01/2022	50

Assessor Number	BAM Case Status	Date Finalised
BAAS18138	Finalised	06/01/2022

Assessment Revision	Assessment Type
3	Major Projects

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone name	TEC name	Current Vegetation integrity score	Change in Vegetation integrity (loss / gain)	Area (ha)	Sensitivity to loss (Justification)	Species sensitivity to gain class	BC Act Listing status	EPBC Act listing status	Biodiversity risk weighting	Potential SAII	Ecosystem credits
Black Sallee - Snow Gum grassy woodland of the New England Tableland Bioregion												
12	507_Moderate	Not a TEC	60	60.0	0.09	PCT Cleared - 87%	High Sensitivity to Potential Gain			2.00		3
											Subtotal	**3**

Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion												
27	599_High	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highla	99.9	99.9	0.36	PCT Cleared - 80%	High Sensitivity to Potential Gain	Critically Endangered Ecological Community	Critically Endangered	2.50	TRUE	22

28	599_Moderate	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highla	99.9	99.9	0.09	PCT Cleared - 80%	High Sensitivity to Potential Gain	Critically Endangered Ecological Community	Critically Endangered	2.50	TRUE	6

29	599_Low	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highla	99.9	99.9	0.98	PCT Cleared - 80%	High Sensitivity to Potential Gain	Critically Endangered Ecological Community	Critically Endangered	2.50	TRUE	61
											Subtotal	**89**
Messmate - Mountain Gum tall moist forest of the far southern New England Tableland Bioregion												
30	931_High	Not a TEC	45.1	45.1	1.1	PCT Cleared - 85%	High Sensitivity to Potential Gain			2.00		25
31	931_Moderate	Not a TEC	53.3	53.3	1.9	PCT Cleared - 85%	High Sensitivity to Potential Gain			2.00		50
32	931_Low	Not a TEC	27	27.0	0.22	PCT Cleared - 85%	High Sensitivity to Potential Gain			2.00		3

											Subtotal	**78**
Messmate open forest of the tableland edge of the NSW North Coast Bioregionand New England Tableland Bioregion												
33	934_High	Not a TEC	97.6	97.6	5.6	PCT Cleared - 71%	High Sensitivity to Potential Gain			2.00		273
34	934_Moderate	Not a TEC	99.3	99.3	0.29	PCT Cleared - 71%	High Sensitivity to Potential Gain			2.00		14
35	934_Low	Not a TEC	99.3	99.3	0.4	PCT Cleared - 71%	High Sensitivity to Potential Gain			2.00		20
36	934_DNG	Not a TEC	21.2	21.2	16.5	PCT Cleared - 71%	High Sensitivity to Potential Gain			2.00		175
											Subtotal	**482**
Mountain Ribbon Gum - Messmate - Broad-leaved Stringybark open forest on granitic soils of the New England Tableland Bioregion												
13	526_High	Not a TEC	99	99.0	0.43	PCT Cleared - 56%	High Sensitivity to Potential Gain			1.75		19
14	526_Moderate	Not a TEC	99	99.0	0.69	PCT Cleared - 56%	High Sensitivity to Potential Gain			1.75		30
											Subtotal	**49**

Mountain Ribbon Gum - Messmate open forest of escarpment ranges of the NSW North Coast Bioregion and New England Tableland Bioregion												
37	954_High	Not a TEC	99.6	99.6	1.2	PCT Cleared - 50%	High Sensitivity to Potential Gain			1.75		54
											Subtotal	**54**
River Oak moist riparian tall open forest of the upper Hunter Valley, including Liverpool Range												
3	486_High	Not a TEC	99.1	99.1	0.52	PCT Cleared - 40%	High Sensitivity to Potential Gain			1.50		19
4	486_Moderate	Not a TEC	99.1	99.1	1.5	PCT Cleared - 40%	High Sensitivity to Potential Gain			1.50		55
5	486_Low	Not a TEC	99.1	99.1	0.06	PCT Cleared - 40%	High Sensitivity to Potential Gain			1.50		2
6	486_DNG	Not a TEC	69.2	69.2	0.07	PCT Cleared - 40%	High Sensitivity to Potential Gain			1.50		2
											Subtotal	**78**

Silvertop Stringybark - Forest Ribbon Gum very tall moist open forest on basalt plateau on the Liverpool Range, Brigalow Belt South Bioregion												
7	490_Low	Not a TEC	98.3	98.3	1.8	PCT Cleared - 28%	High Sensitivity to Potential Gain			1.50		68
											Subtotal	**68**
Silvertop Stringybark - Ribbon Gum - Rough-barked Apple open forest on basalt hills of southern Nandewar Bioregion, southern New England Tableland Bioregion and NSW North Coast Bioregion												
15	540_High_TEC	Not a TEC	80.3	80.3	0.49	PCT Cleared - 56%	High Sensitivity to Potential Gain			1.75		17
16	540_Moderate_TEC	Not a TEC	86.1	86.1	0.92	PCT Cleared - 56%	High Sensitivity to Potential Gain			1.75		35
17	540_Low_TEC	Not a TEC	95.9	95.9	0.03	PCT Cleared - 56%	High Sensitivity to Potential Gain			1.75		1
18	540_High	Not a TEC	80.3	80.3	9.5	PCT Cleared - 56%	High Sensitivity to Potential Gain			1.75		334
19	540_Moderate	Not a TEC	86.1	86.1	20.3	PCT Cleared - 56%	High Sensitivity to Potential Gain			1.75		763
20	540_Low	Not a TEC	95.9	95.9	5.3	PCT Cleared - 56%	High Sensitivity to Potential Gain			1.75		223

21	540_DNG	Not a TEC	45.9	45.9	4.1	PCT Cleared - 56%	High Sensitivity to Potential Gain			1.75		82
											Subtotal	**1455**
Silvertop Stringybark - Rough-barked Apple grassy open forest of southern Nandewar Bioregion, southern New England Tableland Bioregion and NSW North Coast Bioregion												
22	541_High	Not a TEC	88.7	88.7	3.4	PCT Cleared - 64%	High Sensitivity to Potential Gain			1.75		134
23	541_Moderate	Not a TEC	83.6	83.6	3.4	PCT Cleared - 64%	High Sensitivity to Potential Gain			1.75		123
24	541_Low	Not a TEC	69.4	69.4	2.5	PCT Cleared - 64%	High Sensitivity to Potential Gain			1.75		76
25	541_DNG	Not a TEC	54.7	54.7	2.1	PCT Cleared - 64%	High Sensitivity to Potential Gain			1.75		49
											Subtotal	**382**

Silvertop Stringybark - Yellow Box - Apple Box - Rough-barked Apple shrub grass open forest mainly on southern slopes of the Liverpool Range, Brigalow Belt South Bioregion												
8	492_High	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highla	93	93.0	2.6	PCT Cleared - 43%	High Sensitivity to Potential Gain	Critically Endangered Ecological Community	Critically Endangered	2.50	TRUE	151

9	492_Moderate	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highla	93	93.0	0.55	PCT Cleared - 43%	High Sensitivity to Potential Gain	Critically Endangered Ecological Community	Critically Endangered	2.50	TRUE	32

10	492_Low	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highla	60.3	60.3	0.58	PCT Cleared - 43%	High Sensitivity to Potential Gain	Critically Endangered Ecological Community	Critically Endangered	2.50	TRUE	22

11	492_DNG	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highla	59.9	59.9	0.89	PCT Cleared - 43%	High Sensitivity to Potential Gain	Critically Endangered Ecological Community	Critically Endangered	2.50	TRUE	33
											Subtotal	**238**
Snow Grass - Swamp Foxtail tussock grassland sedgeland of cold air drainage valleys of the New England Tableland Bioregion												
26	586_Low	Not a TEC	59.6	59.6	2.6	PCT Cleared - 75%	High Sensitivity to Potential Gain			2.00		76
											Subtotal	**76**
Snow Gum - Mountain Gum - Mountain Ribbon Gum open forest on ranges of the NSW North Coast Bioregion and eastern New England Tableland Bioregion												
38	1194_High_TEC	Not a TEC	73.6	73.6	9	PCT Cleared - 80%	High Sensitivity to Potential Gain			2.00		329

39	1194_Moderate_TEC	Not a TEC	76.4	76.4	8	PCT Cleared - 80%	High Sensitivity to Potential Gain			2.00		306
40	1194_Low_TEC	Not a TEC	41.9	41.9	3.1	PCT Cleared - 80%	High Sensitivity to Potential Gain			2.00		65
41	1194_DNG_TEC	Not a TEC	8.9	8.9	1.9	PCT Cleared - 80%	High Sensitivity to Potential Gain			2.00		0
42	1194_High	Not a TEC	73.6	73.6	3.7	PCT Cleared - 80%	High Sensitivity to Potential Gain			2.00		135
43	1194_Moderate	Not a TEC	76.4	76.4	8.5	PCT Cleared - 80%	High Sensitivity to Potential Gain			2.00		326
44	1194_Low	Not a TEC	41.9	41.9	1.6	PCT Cleared - 80%	High Sensitivity to Potential Gain			2.00		34
45	1194_DNG	Not a TEC	8.9	8.9	3.6	PCT Cleared - 80%	High Sensitivity to Potential Gain			2.00		0
											Subtotal	**1195**

White Box grass shrub hill woodland on clay to loam soils on volcanic and sedimentary hills in the southern Brigalow Belt South Bioregion												
2	434_Low	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highla	99.9	99.9	0.01	PCT Cleared - 65%	High Sensitivity to Potential Gain	Critically Endangered Ecological Community	Critically Endangered	2.50	TRUE	1
											Subtotal	**1**

White Box grassy woodland to open woodland on basalt flats and rises in the Liverpool Plains sub-region, BBS Bioregion												
1	433_Moderate	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highla	99.9	99.9	0.01	PCT Cleared - 85%	High Sensitivity to Potential Gain	Critically Endangered Ecological Community	Critically Endangered	2.50	TRUE	1
											Subtotal	**1**
											Total	**4249**

Species credits for threatened species

Vegetation zone name	Habitat condition (Vegetation Integrity)	Change in habitat condition	Area (ha)/Count (no. individuals)	Sensitivity to loss (Justification)	Sensitivity to gain (Justification)	BC Act Listing status	EPBC Act listing status	Potential SAII	Species credits
Cercartetus nanus / Eastern Pygmy-possum (Fauna)									
526_High	99.0	99.0	0.43			Vulnerable	Not Listed	False	21

599_High	99.9	99.9	0.36			Vulnerable	Not Listed	False	18
931_High	45.1	45.1	1.1			Vulnerable	Not Listed	False	25
934_High	97.6	97.6	4			Vulnerable	Not Listed	False	198
954_High	99.6	99.6	1.2			Vulnerable	Not Listed	False	61
1194_High	73.6	73.6	2			Vulnerable	Not Listed	False	74
1194_High_TEC	73.6	73.6	9			Vulnerable	Not Listed	False	329
								Subtotal	**726**
Chalinolobus dwyeri / Large-eared Pied Bat (Fauna)									
599_Low	99.9	99.9	0.22			Vulnerable	Vulnerable	True	16
599_High	99.9	99.9	0.06			Vulnerable	Vulnerable	True	4
599_Moderate	99.9	99.9	0.04			Vulnerable	Vulnerable	True	3
931_High	45.1	45.1	0.29			Vulnerable	Vulnerable	True	10
931_Moderate	53.3	53.3	1.4			Vulnerable	Vulnerable	True	57
934_Moderate	99.3	99.3	0.13			Vulnerable	Vulnerable	True	10
934_Low	99.3	99.3	0.4			Vulnerable	Vulnerable	True	30
934_DNG	21.2	21.2	7.5			Vulnerable	Vulnerable	True	119
1194_High_TEC	73.6	73.6	2.7			Vulnerable	Vulnerable	True	150
1194_Moderate_TEC	76.4	76.4	4			Vulnerable	Vulnerable	True	228
1194_Low_TEC	41.9	41.9	1.8			Vulnerable	Vulnerable	True	55
1194_DNG_TEC	8.9	8.9	1.2			Vulnerable	Vulnerable	True	8
								Subtotal	**690**
Litoria booroolongensis / Booroolong Frog (Fauna)									
486_Moderate	99.1	99.1	0.6			Endangered	Endangered	False	30

540_High	80.3	80.3	0.04			Endangered	Endangered	False	2
541_High	88.7	88.7	0.01			Endangered	Endangered	False	1
								Subtotal	**33**
Myotis macropus / Southern Myotis (Fauna)									
934_DNG	21.2	21.2	1.8			Vulnerable	Not Listed	False	19
1194_Moderate	76.4	76.4	1.4			Vulnerable	Not Listed	False	55
1194_High_TEC	73.6	73.6	0.06			Vulnerable	Not Listed	False	2
1194_Moderate_TEC	76.4	76.4	0.64			Vulnerable	Not Listed	False	24
								Subtotal	**100**
Ninox connivens / Barking Owl (Fauna)									
540_Moderate	86.1	86.1	1.8			Vulnerable	Not Listed	False	76
1194_Moderate	76.4	76.4	0.23			Vulnerable	Not Listed	False	9
								Subtotal	**85**
Ninox strenua / Powerful Owl (Fauna)									
540_Moderate	86.1	86.1	1.8			Vulnerable	Not Listed	False	76
1194_Moderate	76.4	76.4	0.23			Vulnerable	Not Listed	False	9
								Subtotal	**85**
Petaurus norfolcensis / Squirrel Glider (Fauna)									
433_Moderate	99.9	99.9	0.01			Vulnerable	Not Listed	False	1
526_High	99.0	99.0	0.43			Vulnerable	Not Listed	False	21
526_Moderate	99.0	99.0	0.68			Vulnerable	Not Listed	False	34
599_High	99.9	99.9	0.36			Vulnerable	Not Listed	False	18
599_Moderate	99.9	99.9	0.07			Vulnerable	Not Listed	False	3

1194_High	73.6	73.6	0.05			Vulnerable	Not Listed	False	2
1194_Moderate	76.4	76.4	0.86			Vulnerable	Not Listed	False	33
1194_High_TEC	73.6	73.6	6.7			Vulnerable	Not Listed	False	246
1194_Moderate_TEC	76.4	76.4	6.9			Vulnerable	Not Listed	False	264
								Subtotal	**622**
Phascolarctos cinereus / Koala (Fauna)									
433_Moderate	99.9	99.9	0.01			Vulnerable	Vulnerable	False	1
434_Low	99.9	99.9	0.01			Vulnerable	Vulnerable	False	1
507_Moderate	60.0	60.0	0.09			Vulnerable	Vulnerable	False	3
526_High	99.0	99.0	0.43			Vulnerable	Vulnerable	False	21
526_Moderate	99.0	99.0	0.68			Vulnerable	Vulnerable	False	34
599_Low	99.9	99.9	0.94			Vulnerable	Vulnerable	False	47
599_High	99.9	99.9	0.36			Vulnerable	Vulnerable	False	18
599_Moderate	99.9	99.9	0.09			Vulnerable	Vulnerable	False	4
931_Low	27.0	27.0	0.12			Vulnerable	Vulnerable	False	2
931_High	45.1	45.1	1.1			Vulnerable	Vulnerable	False	25
931_Moderate	53.3	53.3	1.7			Vulnerable	Vulnerable	False	45
934_Moderate	99.3	99.3	0.26			Vulnerable	Vulnerable	False	13
934_High	97.6	97.6	4.9			Vulnerable	Vulnerable	False	240
934_Low	99.3	99.3	0.4			Vulnerable	Vulnerable	False	20
954_High	99.6	99.6	1.1			Vulnerable	Vulnerable	False	56
1194_Low	41.9	41.9	1.6			Vulnerable	Vulnerable	False	34
1194_High	73.6	73.6	3.7			Vulnerable	Vulnerable	False	135

1194_Moderate	76.4	76.4	1.7			Vulnerable	Vulnerable	False	66
1194_High_TEC	73.6	73.6	8.5			Vulnerable	Vulnerable	False	314
1194_Moderate _TEC	76.4	76.4	5.7			Vulnerable	Vulnerable	False	217
1194_Low_TEC	41.9	41.9	2.9			Vulnerable	Vulnerable	False	62
								Subtotal	**1358**
Tyto novaehollandiae / Masked Owl (Fauna)									
540_Moderate	86.1	86.1	0.99			Vulnerable	Not Listed	False	43
								Subtotal	**43**
Tyto tenebricosa / Sooty Owl (Fauna)									
540_Moderate	86.1	86.1	1.8			Vulnerable	Not Listed	True	114
1194_Moderate	76.4	76.4	0.23			Vulnerable	Not Listed	True	13
								Subtotal	**127**
Uvidicolus sphyrurus / Border Thick-tailed Gecko (Fauna)									
599_High	99.9	99.9	0.13			Vulnerable	Vulnerable	False	6
599_Moderate	99.9	99.9	0.04			Vulnerable	Vulnerable	False	2
								Subtotal	**8**
Vespadelus troughtoni / Eastern Cave Bat (Fauna)									
599_Low	99.9	99.9	0.22			Vulnerable	Not Listed	True	16
599_High	99.9	99.9	0.06			Vulnerable	Not Listed	True	4
599_Moderate	99.9	99.9	0.04			Vulnerable	Not Listed	True	3
931_High	45.1	45.1	0.29			Vulnerable	Not Listed	True	10
931_Moderate	53.3	53.3	1.4			Vulnerable	Not Listed	True	57
934_Moderate	99.3	99.3	0.13			Vulnerable	Not Listed	True	10

934_Low	99.3	99.3	0.4			Vulnerable	Not Listed	True	30
934_DNG	21.2	21.2	7.5			Vulnerable	Not Listed	True	119
1194_High_TEC	73.6	73.6	2.7			Vulnerable	Not Listed	True	150
1194_Moderate_TEC	76.4	76.4	4			Vulnerable	Not Listed	True	228
1194_Low_TEC	41.9	41.9	1.8			Vulnerable	Not Listed	True	55
1194_DNG_TEC	8.9	8.9	1.2			Vulnerable	Not Listed	True	8
								Subtotal	**690**

BAM Credit Summary Report

Proposal Details

Assessment Id
00020779/BAAS18138/20/00021863

Proposal Name
Hills of Gold Wind Farm

BAM data last updated *
24/11/2021

Assessor Name
Callan Wharfe

Report Created
06/01/2022

BAM Data version *
50

Assessor Number
BAAS18138

BAM Case Status
Finalised

Date Finalised
06/01/2022

Assessment Revision
3

Assessment Type
Major Projects

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone name	TEC name	Current Vegetation integrity score	Change in Vegetation integrity (loss / gain)	Area (ha)	Sensitivity to loss (Justification)	Species sensitivity to gain class	BC Act Listing status	EPBC Act listing status	Biodiversity risk weighting	Potential SAII	Ecosystem credits
Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter												
1	1604_Low	Not a TEC	99.7	99.7	0.02	PCT Cleared - 71%	High Sensitivity to Potential Gain			2.00		1
											Subtotal	**1**

Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter												
2	1691_Low	Not a TEC	99.7	99.7	0.04	PCT Cleared - 77%	High Sensitivity to Potential Gain			2.00		2
											Subtotal	**2**
											Total	**3**

Species credits for threatened species

Vegetation zone name	Habitat condition (Vegetation Integrity)	Change in habitat condition	Area (ha)/Count (no. individuals)	Sensitivity to loss (Justification)	Sensitivity to gain (Justification)	BC Act Listing status	EPBC Act listing status	Potential SAII	Species credits
Myotis macropus / Southern Myotis (Fauna)									
1604_Low	99.7	99.7	0.02			Vulnerable	Not Listed	False	1
								Subtotal	**1**
Phascolarctos cinereus / Koala (Fauna)									
1604_Low	99.7	99.7	0.02			Vulnerable	Vulnerable	False	1
1691_Low	99.7	99.7	0.02			Vulnerable	Vulnerable	False	1
								Subtotal	**2**

Appendix H BAM plot survey data

BDAR plot	Field ID	PCT	Cond.	easting	northing	bearing	Comp Tree	Comp Shrub	Comp Grass	Comp Forbs	Comp Ferns	Comp Other	Struc Tree	Struc Shrub	Struc Grass
1	HoG-Mar-13	931	Low	327308.9662	6509746.216	352	1	0	2	4	1	0	55.0	0.0	6.0
2	HoG_Mar_14	1194	DNG	318788.1415	6501027.491	112	0	0	3	15	1	1	0.0	0.0	14.1
3	HoG_Mar_15	541	High	319104.1107	6501473.217	282	2	4	4	25	1	3	70.0	50.6	2.7
4	HoG_Mar_16	540	High	319185.5396	6501621.687	180	1	4	9	27	2	2	75.0	27.4	9.4
5	HoG_TLC_Mar_01	1194	Low	324070.4841	6499595.519	300	1	2	9	27	1	5	5.0	0.2	7.9
6	HoG_TLC_Mar_02	540	High	321676.0275	6500657.758	0	1	7	17	27	1	4	60.0	12.7	33.5
7	HoG_TLC_Mar_03	540	Moderate	320039.0753	6501800.129	320	3	6	15	18	4	6	15.2	65.2	74.1
8	HoG_TLC_Mar_04	540	DNG	320626.6472	6501288.621	30	1	6	9	25	0	1	0.1	1.7	112.1
9	HoG_TLC_Mar_05	492	Moderate	320460.6042	6501462.687	190	4	7	13	26	2	5	54.3	5.5	28.1
10	HoG-Mar-01	934	High	326223.9671	6500317.283	340	2	6	5	18	1	3	40.0	9.7	85.3
11	HoG-Mar-02	1194	Low	326447.0812	6500884.121	345	1	2	1	9	1	1	5.0	70.0	20.0
12	HoG-Mar-03	1194	High	325970.2763	6503456.045	136	2	5	3	13	1	1	20.0	5.3	82.5
13	HoG-Mar-04	1194	Moderate	325897.2991	6504202.339	10	3	3	2	14	1	5	25.0	10.3	3.0
14	HoG-Mar-05	1194	DNG	325809.2251	6498707.069	176	0	0	2	6	1	0	0.0	0.0	52.0
15	HoG-Mar-06	931	High	325416.449	6498917.793	294	1	2	2	9	1	2	45.0	6.0	6.0
16	HoG-Mar-07	934	DNG	323571.1749	6499222.691	168	0	0	4	11	1	1	0.0	0.0	21.1
17	HoG-Mar-08	1194	Moderate	323694.2016	6499507.521	116	2	1	2	11	1	1	25.0	8.0	31.0
18	HoG-Mar-09	931	Moderate	317618.9057	6502049.383	56	1	3	2	9	1	3	40.0	3.6	3.1
19	HoG-Mar-10	507	Moderate	317222.7521	6502995.643	304	2	2	3	17	1	3	33.0	2.5	11.1
20	HoG-Mar-11	1194	High	316955.454	6502914.754	58	2	4	6	20	1	1	15.5	15.1	77.8
21	HoG-Mar-12	931	Moderate	327223.7577	6509755.951	0	2	2	3	12	0	2	23.0	1.0	74.0
22	HoG_TLC_Mar_07	492	Low	309500.9931	6506810.496	282	1	2	6	12	0	1	5.0	8.0	37.0
23	HoG_TLC_Mar_06	541	High	307959.7084	6507113.884	126	2	4	5	13	0	2	35.0	35.2	14.0
24	HoG_TLC_Mar_08	492	Moderate	308602.1704	6507013.704	81	2	1	7	12	1	3	30.0	50.0	65.0
25	NWF_02	934	DNG	324407.3537	6498745.128	112	0	0	0	0	0	0	0.0	0.0	0.0
26	NWF_01	1194	High	324838.1716	6497967.382	100	0	0	0	0	0	0	0.0	0.0	0.0
27	34784_01	540	Moderate	323407.929	6500249.198	150	3	5	9	20	0	5	55.1	6.3	69.7
28	34784_02	540	Moderate	324879.2154	6500128.176	55	3	8	8	25	1	5	20.1	2.5	49.9
29	34784_04	541	Moderate	319336.5404	6502344.313	345	2	9	11	16	1	6	15.0	19.0	79.8
30	34784_05	1194	Moderate	329445.6977	6512527.375	225	3	2	6	16	0	1	22.0	0.6	76.5
31	34784_07	1194	High	325201.2616	6499090.96	270	2	0	3	11	1	1	35.1	0.0	30.2
32	34784_13	540	Low	319781.5162	6501896.426	155	2	5	6	18	0	3	85.0	3.2	21.2
33	34784_16	540	Moderate	323184.6919	6500162.409	330	4	2	7	21	2	2	30.2	0.3	23.7
34	34784_17	540	High	324824.4673	6500104.34	40	2	6	14	29	1	4	20.1	0.7	26.9
35	34784_20	492	High	326388.8792	6516251.367	100	6	6	13	22	3	5	22.5	4.4	72.9
36	34784_28	586	Low	324631.2	6500025.962	90	0	0	7	5	0	0	0.0	0.0	11.5
37	34784_34	934	High	325935.6234	6500220.052	60	4	7	5	17	2	5	32.0	80.6	85.7
38	34784_42	931	Moderate	324169.2682	6499236.13	200	3	0	2	11	1	0	0.3	0.0	60.1
39	34784_46	541	Low	314828.1934	6504683.359	130	0	1	12	13	0	1	0.0	0.1	78.7

BDAR plot	Field ID	PCT	Cond.	Struc Forbs	Struc Ferns	Struc Other	Fun Large Trees	Fun Hollow Trees	Fun Litter Cover	Fun Len Fallen Logs	Fun Tree Stem 5to9	Fun Tree Stem 10to19	Fun Tree Stem 20to29
1	HoG-Mar-13	931	Low	2.6	0.1	0.0	4	0	4.0	0.0	0	0	0
2	HoG_Mar_14	1194	DNG	91.4	4.0	0.1	0	0	2.0	0.0	0	0	0
3	HoG_Mar_15	541	High	13.0	0.1	0.8	1	0	22.0	0.0	1	0	1
4	HoG_Mar_16	540	High	9.1	0.2	0.6	1	1	62.0	35.0	0	1	1
5	HoG_TLC_Mar_01	1194	Low	4.6	70.0	0.6	0	1	7.0	60.0	0	0	1
6	HoG_TLC_Mar_02	540	High	15.5	0.2	3.9	2	0	45.0	5.0	0	0	1
7	HoG_TLC_Mar_03	540	Moderate	10.0	2.3	5.9	1	0	21.0	53.0	0	0	1
8	HoG_TLC_Mar_04	540	DNG	15.0	0.0	0.1	0	0	2.0	0.0	0	0	0
9	HoG_TLC_Mar_05	492	Moderate	7.6	1.1	2.3	5	0	56.0	356.0	0	1	1
10	HoG-Mar-01	934	High	12.6	5.0	2.5	0	2	62.0	64.0	0	1	1
11	HoG-Mar-02	1194	Low	27.4	1.0	5.0	0	0	29.0	19.0	0	1	1
12	HoG-Mar-03	1194	High	6.4	0.2	0.1	2	2	73.0	24.0	0	1	1
13	HoG-Mar-04	1194	Moderate	10.3	1.0	2.3	2	0	70.0	22.0	0	1	1
14	HoG-Mar-05	1194	DNG	11.9	95.0	0.0	0	0	8.0	0.0	0	0	0
15	HoG-Mar-06	931	High	74.9	0.5	4.0	0	0	72.0	56.0	0	1	1
16	HoG-Mar-07	934	DNG	14.0	75.0	0.1	0	0	11.0	0.0	0	0	0
17	HoG-Mar-08	1194	Moderate	14.0	3.0	0.5	16	6	94.0	203.0	0	0	1
18	HoG-Mar-09	931	Moderate	28.7	0.1	0.8	8	7	51.0	28.0	0	0	0
19	HoG-Mar-10	507	Moderate	20.6	5.0	0.3	2	4	52.0	72.0	0	1	1
20	HoG-Mar-11	1194	High	7.7	0.1	0.1	2	4	57.0	44.0	0	0	1
21	HoG-Mar-12	931	Moderate	16.1	0.0	0.6	2	2	18.0	86.0	0	1	1
22	HoG_TLC_Mar_07	492	Low	46.4	0.0	0.1	1	0	45.0	73.0	0	0	1
23	HoG_TLC_Mar_06	541	High	14.7	0.0	2.0	2	1	37.0	64.0	0	0	0
24	HoG_TLC_Mar_08	492	Moderate	47.7	1.0	1.6	2	2	33.0	36.0	0	0	1
25	NWF_02	934	DNG	0.0	0.0	0.0	0	0	9.0	0.0	0	0	0
26	NWF_01	1194	High	0.0	0.0	0.0	4	0	62.0	70.0	0	1	1
27	34784_01	540	Moderate	19.8	0.0	3.3	3	1	30.0	66.0	0	0	1
28	34784_02	540	Moderate	13.5	4.0	1.1	2	0	41.0	82.0	1	0	1
29	34784_04	541	Moderate	12.2	0.2	6.7	1	1	25.0	66.0	1	1	1
30	34784_05	1194	Moderate	13.5	0.0	0.1	8	2	21.0	55.0	1	1	1
31	34784_07	1194	High	16.3	0.1	0.1	4	0	50.0	19.0	0	0	0
32	34784_13	540	Low	16.5	0.0	1.6	2	1	54.0	34.0	1	1	1
33	34784_16	540	Moderate	34.9	0.2	6.0	3	2	12.0	77.0	1	1	1
34	34784_17	540	High	3.8	0.1	0.4	24	0	32.0	73.0	0	1	1
35	34784_20	492	High	8.4	0.3	0.6	20	1	29.0	45.0	0	1	1
36	34784_28	586	Low	0.7	0.0	0.0	0	0	11.0	0.0	0	0	0
37	34784_34	934	High	2.5	0.8	0.7	13	3	83.0	202.0	1	1	1
38	34784_42	931	Moderate	1.6	30.0	0.0	3	3	4.0	17.0	0	0	0
39	34784_46	541	Low	5.6	0.0	0.1	0	0	56.0	0.0	0	1	1

BDAR plot	Field ID	PCT	Cond.	Fun Tree Stem 30to49	Fun Tree Stem 50to79	Fun Tree Regen	Fun High Threat Exotic
1	HoG-Mar-13	931	Low	0	0	0	0.0
2	HoG_Mar_14	1194	DNG	0	0	0	0.0
3	HoG_Mar_15	541	High	1	1	0	0.1
4	HoG_Mar_16	540	High	1	0	0	0.0
5	HoG_TLC_Mar_01	1194	Low	1	1	1	0.0
6	HoG_TLC_Mar_02	540	High	1	0	0	0.0
7	HoG_TLC_Mar_03	540	Moderate	0	0	0	0.7
8	HoG_TLC_Mar_04	540	DNG	0	0	0	0.6
9	HoG_TLC_Mar_05	492	Moderate	1	0	0	0.2
10	HoG-Mar-01	934	High	1	1	0	4.0
11	HoG-Mar-02	1194	Low	0	0	0	1.0
12	HoG-Mar-03	1194	High	1	1	0	0.2
13	HoG-Mar-04	1194	Moderate	1	1	0	10.0
14	HoG-Mar-05	1194	DNG	0	0	0	0.0
15	HoG-Mar-06	931	High	1	0	0	0.0
16	HoG-Mar-07	934	DNG	0	0	0	0.0
17	HoG-Mar-08	1194	Moderate	1	1	0	1.0
18	HoG-Mar-09	931	Moderate	0	1	0	1.0
19	HoG-Mar-10	507	Moderate	1	0	0	1.0
20	HoG-Mar-11	1194	High	1	1	0	0.0
21	HoG-Mar-12	931	Moderate	1	1	0	0.0
22	HoG_TLC_Mar_07	492	Low	1	0	0	0.0
23	HoG_TLC_Mar_06	541	High	1	0	0	0.0
24	HoG_TLC_Mar_08	492	Moderate	1	0	0	0.0
25	NWF_02	934	DNG	0	0	0	0.0
26	NWF_01	1194	High	1	0	0	0.0
27	34784_01	540	Moderate	1	0	0	0.0
28	34784_02	540	Moderate	1	0	1	0.0
29	34784_04	541	Moderate	1	0	0	0.0
30	34784_05	1194	Moderate	1	1	1	0.0
31	34784_07	1194	High	0	1	0	0.0
32	34784_13	540	Low	1	0	0	0.0
33	34784_16	540	Moderate	1	0	0	0.0
34	34784_17	540	High	1	1	0	0.0
35	34784_20	492	High	1	1	1	0.0
36	34784_28	586	Low	0	0	0	0.7
37	34784_34	934	High	1	1	1	0.0
38	34784_42	931	Moderate	1	0	0	0.2
39	34784_46	541	Low	1	0	1	0.0

BDAR plot	Field ID	PCT	Cond.	easting	northing	bearing	Comp Tree	Comp Shrub	Comp Grass	Comp Forbs	Comp Ferns	Comp Other	Struc Tree	Struc Shrub	Struc Grass
40	34784_47	492	High	326274.4454	6516190.311	90	6	7	12	17	0	7	12.6	16.2	24.9
41	34784_08	1194	Low	323360.9042	6499626.655	295	1	2	1	16	1	1	40.0	0.3	1.0
42	34784_09	1194	High	326494.6185	6508705.079	45	1	3	8	16	1	5	1.0	3.0	8.0
43	34784_11	1194	High	317363.9959	6502097.867	310	3	4	5	26	2	4	51.2	5.6	65.1
44	34784_21	492	High	326599.2775	6516285.376	20	3	7	12	19	0	6	18.5	9.9	70.5
45	34784_23	541	High	314558.1255	6504520.94	105	4	6	11	18	2	6	16.2	6.8	97.7
46	34784_27	586	Low	325034.6554	6500182.867	50	0	0	6	10	0	0	0.0	0.0	33.1
47	34784_29	586	Low	325349.1568	6500365.69	232	0	0	9	9	0	0	0.0	0.0	85.2
48	34784_32	541	Moderate	314437.0618	6504741.527	110	2	8	10	20	2	8	40.2	8.6	34.6
49	34784_35	541	High	318203.0365	6501353.959	130	4	8	6	25	1	6	40.0	13.6	52.1
50	34784_45	541	Low	314275.2971	6504581.488	340	3	3	5	20	0	2	50.1	0.3	50.2

BDAR plot	Field ID	PCT	Cond.	Struc Forbs	Struc Ferns	Struc Other	Fun Large Trees	Fun Hollow Trees	Fun Litter Cover	Fun Len Fallen Logs	Fun Tree Stem 5to9	Fun Tree Stem 10to19	Fun Tree Stem 20to29
40	34784_47	492	High	2.8	0.0	1.2	8	1	69.0	15.0	0	1	1
41	34784_08	1194	Low	16.4	0.5	0.1	1	2	27.0	17.0	0	0	1
42	34784_09	1194	High	16.0	1.0	5.0	18	0	52.0	65.0	0	1	1
43	34784_11	1194	High	11.9	2.1	2.6	4	3	58.0	69.0	1	1	1
44	34784_21	492	High	7.3	0.0	2.5	11	0	9.0	47.0	1	1	1
45	34784_23	541	High	9.9	0.2	6.5	0	1	71.0	181.0	1	1	1
46	34784_27	586	Low	7.8	0.0	0.0	0	0	4.0	0.0	0	0	0
47	34784_29	586	Low	6.8	0.0	0.0	0	0	4.0	0.0	0	0	0
48	34784_32	541	Moderate	11.4	1.0	7.2	2	0	70.0	16.0	1	1	1
49	34784_35	541	High	20.7	3.0	8.7	5	0	43.0	139.0	1	1	1
50	34784_45	541	Low	18.0	0.0	1.5	4	0	32.0	58.0	1	1	1

BDAR plot	Field ID	PCT	Cond.	Fun Tree Stem 30to49	Fun Tree Stem 50to79	Fun Tree Regen	Fun High Threat Exotic
40	34784_47	492	High	1	1	1	0.1
41	34784_08	1194	Low	1	1	0	0.0
42	34784_09	1194	High	1	1	0	0.0
43	34784_11	1194	High	1	1	0	0.0
44	34784_21	492	High	1	1	1	0.0
45	34784_23	541	High	1	0	1	0.0
46	34784_27	586	Low	0	0	0	0.0
47	34784_29	586	Low	0	0	0	0.0
48	34784_32	541	Moderate	1	0	1	0.0
49	34784_35	541	High	1	1	0	0.0
50	34784_45	541	Low	1	0	1	0.0

Family	Scientific name	Common name	Plot 01 (HoG_Mar_13)		Plot 02 (HoG_Mar_14)		Plot 03 (HoG_Mar_15		Plot 04 (HoG_Mar_16		Plot 05 (HoG_TLC_Mar_01)		Plot 6 (HoG_TLC_Mar_02)		Plot 07 (HoG_TLC_Mar_03)		Plot 08 (HoG_TLC_Mar_04)		Plot 09 (HoG_TLC_Mar_05)		Plot 10 (HoG-Mar-01)		Plot 11 (HoG-Mar-02)		Plot 12 (HoG-Mar-03		Plot 13 (HoG-Mar-04)		Plot 14 (HoG-Mar-05)		Plot 15 (HoG-Mar-06)		Plot 16 (HoG-Mar-07)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Native species																																		
Acanthaceae	Pseuderanthemum variabile	Pastel Flower																			0.1	20												
Adiantaceae	Adiantum formosum	Giant Maidenhair																	0.1	1														
Adiantaceae	Cheilanthes distans	Bristly Cloak Fern													1	100																		
Adiantaceae	Pellaea falcata	Sickle Fern													1	60																		
Adiantaceae	Pellaea nana	Dwarf Sickle Fern																																
Anthericaceae	Arthropodium milleflorum										0.1	7	0.2	5	5	200			0.4	20														
Anthericaceae	Arthropodium sp.																																	
Anthericaceae	Laxmannia gracilis																																	
Anthericaceae	Thysanotus sp.																																	
Anthericaceae	Thysanotus tuberosus										0.1	4																						
Anthericaceae	Tricoryne elatior																																	
Apiaceae	Daucus glochidiatus								0.1	6	0.1	1	0.1	20	0.1	10																		
Apiaceae	Daucus sp.																																	
Apiaceae	Hydrocotyle laxiflora	Stinking Pennywort																			1	50	0.5	100	2	500	1	200			1	100	0.3	50
Apiaceae	Hydrocotyle sibthorpioides												2	100			0.5	70	0.5	40														
Apocynaceae	Tylophora barbata	Bearded Tylophora																																
Araliaceae	Astrotricha sp.																																	
Araliaceae	Polyscias sambucifolia																																	
Aspleniaceae	Asplenium flabellifolium	Necklace Fern							0.1	4					0.2	30																		
Asteraceae	Ammobium alatum				0.1	1																												
Asteraceae	Brachyscome aculeata	Hill Daisy																																
Asteraceae	Brachyscome microcarpa																																	
Asteraceae	Brachyscome multifida var. multifida																0.4	70																
Asteraceae	Brachyscome nova	anglica											0.1	1																				
Asteraceae	Brachyscome sieberi										0.1	2																						
Asteraceae	Brachyscome sp.																																	
Asteraceae	Brachyscome spathulata						0.1	4			0.1	1	0.1	2																				
Asteraceae	Calotis sp.	A Burr-daisy																																
Asteraceae	Cassinia laevis	Cough Bush					30	50	25	20			1	10	60	60																		
Asteraceae	Cassinia quinquefaria																																	
Asteraceae	Chrysocephalum apiculatum										0.1	8			0.1	10																		
Asteraceae	Cotula australis	Common Cotula																									0.1	50			0.1	10		
Asteraceae	Cymbonotus lawsonianus	Bear's Ear			1	30	0.1	1	0.1	1			0.2	10			0.2	8	0.1	3														
Asteraceae	Euchiton involucratus	Star Cudweed																																
Asteraceae	Euchiton japonicus										0.1	60																						
Asteraceae	Euchiton sphaericus	Star Cudweed			0.1	1											0.1	20																
Asteraceae	Euchiton spp.	A Cudweed																									1	50						
Asteraceae	Helichrysum spp.																																	
Asteraceae	Lagenophora gracilis	Slender Lagenophora																																
Asteraceae	Lagenophora spp.																																0.1	30

Family	Scientific name	Common name	Plot 17 (HoG-Mar-08)		Plot 18 (HoG-Mar-09)		Plot 19 (HoG-Mar-10)		Plot 20 (HoG-Mar-11)		Plot 21 (HoG-Mar-12)		Plot 22 (HoG_TLC_Mar_07)		Plot 23 (HoG_TLC_Mar_06)		Plot 24 (HoG_TLC_Mar_08)		Plot 27 (34784_01)		Plot 28 (34784_02)		Plot 29 (34784_04)		Plot 30 (34784_05)		Plot 31 (34784_07)		Plot 32 (34784_13)		Plot 33 (34784_16)		Plot 34 (34784_17)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Native species																																		
Acanthaceae	Pseuderanthemum variabile	Pastel Flower																																
Adiantaceae	Adiantum formosum	Giant Maidenhair																																
Adiantaceae	Cheilanthes distans	Bristly Cloak Fern																																
Adiantaceae	Pellaea falcata	Sickle Fern																																
Adiantaceae	Pellaea nana	Dwarf Sickle Fern																																
Anthericaceae	Arthropodium milleflorum																																0.1	2
Anthericaceae	Arthropodium sp.																		0.1		0.1								0.1		0.1			
Anthericaceae	Laxmannia gracilis																				0.1		0.1											
Anthericaceae	Thysanotus sp.																																	
Anthericaceae	Thysanotus tuberosus																																	
Anthericaceae	Tricoryne elatior																																	
Apiaceae	Daucus glochidiatus																																	
Apiaceae	Daucus sp.																												0.1					
Apiaceae	Hydrocotyle laxiflora	Stinking Pennywort	0.1	20			5	200			0.5	20									2		2		5						5			
Apiaceae	Hydrocotyle sibthorpioides																										10	5000					0.2	500
Apocynaceae	Tylophora barbata	Bearded Tylophora																																
Araliaceae	Astrotricha sp.																																	
Araliaceae	Polyscias sambucifolia																																	
Aspleniaceae	Asplenium flabellifolium	Necklace Fern																													0.1			
Asteraceae	Ammobium alatum																																	
Asteraceae	Brachyscome aculeata	Hill Daisy							1	30																								
Asteraceae	Brachyscome microcarpa																																	
Asteraceae	Brachyscome multifida var. multifida																																	
Asteraceae	Brachyscome nova	anglica																																
Asteraceae	Brachyscome sieberi																																	
Asteraceae	Brachyscome sp.																								0.2									
Asteraceae	Brachyscome spathulata																																	
Asteraceae	Calotis sp.	A Burr-daisy																	0.1		0.1										0.1			
Asteraceae	Cassinia laevis	Cough Bush											5	20	15	30																		
Asteraceae	Cassinia quinquefaria																						15						1				0.1	1
Asteraceae	Chrysocephalum apiculatum																																	
Asteraceae	Cotula australis	Common Cotula					0.1	10	0.1	5					0.1	10	0.1	20																
Asteraceae	Cymbonotus lawsonianus	Bear's Ear																																
Asteraceae	Euchiton involucratus	Star Cudweed																									0.1	1					0.1	10
Asteraceae	Euchiton japonicus						0.1	5																									0.1	1
Asteraceae	Euchiton sphaericus	Star Cudweed																	0.5		0.1		0.2						0.2		3			
Asteraceae	Euchiton spp.	A Cudweed																																
Asteraceae	Helichrysum spp.																																0.1	1
Asteraceae	Lagenophora gracilis	Slender Lagenophora																																
Asteraceae	Lagenophora spp.																																	

Family	Scientific name	Common name	Plot 35 (34784_20)		Plot 36 (34784_28)		Plot 37 (34784_34)		Plot 38 (34784_42)		Plot 39 (34784_46)		Plot 40 (34784_47)		Plot 41 (34784_08)		Plot 42 (34784_09)		Plot 43 (34784_11)		Plot 44 (34784_21)		Plot 45 (34784_23)		Plot 46 (34784_27)		Plot 47 (34784_29)		Plot 48 (34784_32)		Plot 49 (34784_35)		Plot 50 (34784_45)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Native species																																		
Acanthaceae	Pseuderanthemum variabile	Pastel Flower																																
Adiantaceae	Adiantum formosum	Giant Maidenhair																																
Adiantaceae	Cheilanthes distans	Bristly Cloak Fern																																
Adiantaceae	Pellaea falcata	Sickle Fern					0.5	30																										
Adiantaceae	Pellaea nana	Dwarf Sickle Fern	0.1	10																														
Anthericaceae	Arthropodium milleflorum		0.3	100									0.2	200																				
Anthericaceae	Arthropodium sp.														0.1														0.1					
Anthericaceae	Laxmannia gracilis																				0.1													
Anthericaceae	Thysanotus sp.																						0.1											
Anthericaceae	Thysanotus tuberosus																																	
Anthericaceae	Tricoryne elatior																						0.1											
Apiaceae	Daucus glochidiatus																																	
Apiaceae	Daucus sp.										0.1																0.1						0.1	
Apiaceae	Hydrocotyle laxiflora	Stinking Pennywort					0.2	100			2				3		10						5						1		5		5	
Apiaceae	Hydrocotyle sibthorpioides		0.1	1					0.2	100																								
Apocynaceae	Tylophora barbata	Bearded Tylophora											0.1	1																				
Araliaceae	Astrotricha sp.														0.2																			
Araliaceae	Polyscias sambucifolia																				0.1													
Aspleniaceae	Asplenium flabellifolium	Necklace Fern	0.1	10															0.1										0.5					
Asteraceae	Ammobium alatum																																	
Asteraceae	Brachyscome aculeata	Hill Daisy																																
Asteraceae	Brachyscome microcarpa		1	1000									0.1	30																				
Asteraceae	Brachyscome multifida var. multifida																																	
Asteraceae	Brachyscome nova	anglica																																
Asteraceae	Brachyscome sieberi																																	
Asteraceae	Brachyscome sp.																																	
Asteraceae	Brachyscome spathulata																																	
Asteraceae	Calotis sp.	A Burr-daisy																			0.5								0.1					
Asteraceae	Cassinia laevis	Cough Bush																																
Asteraceae	Cassinia quinquefaria		3	500									15	200							9								3		0.2		0.1	
Asteraceae	Chrysocephalum apiculatum																																	
Asteraceae	Cotula australis	Common Cotula																																
Asteraceae	Cymbonotus lawsonianus	Bear's Ear							0.1	1																								
Asteraceae	Euchiton involucratus	Star Cudweed	0.1	20	0.1	10			0.1	1																								
Asteraceae	Euchiton japonicus								0.1	10																								
Asteraceae	Euchiton sphaericus	Star Cudweed									0.1				0.1		0.1		0.1				0.1		0.1				0.5		0.1		0.5	
Asteraceae	Euchiton spp.	A Cudweed																																
Asteraceae	Helichrysum spp.																																	
Asteraceae	Lagenophora gracilis	Slender Lagenophora											0.1	10																				
Asteraceae	Lagenophora spp.																																	

Family	Scientific name	Common name	Plot 01 (HoG_Mar_13)		Plot 02 (HoG_Mar_14)		Plot 03 (HoG_Mar_15		Plot 04 (HoG_Mar_16		Plot 05 (HoG_TLC_Mar_01)		Plot 6 (HoG_TLC_Mar_02)		Plot 07 (HoG_TLC_Mar_03)		Plot 08 (HoG_TLC_Mar_04)		Plot 09 (HoG_TLC_Mar_05)		Plot 10 (HoG-Mar-01)		Plot 11 (HoG-Mar-02)		Plot 12 (HoG-Mar-03)		Plot 13 (HoG-Mar-04)		Plot 14 (HoG-Mar-05)		Plot 15 (HoG-Mar-06)		Plot 16 (HoG-Mar-07)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Asteraceae	Lagenophora stipitata	Common Lagenophora																																
Asteraceae	Leontodon spp.												0.1	1					0.1	5														
Asteraceae	Olearia alpicola	Alpine Daisy-bush											0.1	1																				
Asteraceae	Olearia elliptica	Sticky Daisy-bush																																
Asteraceae	Olearia elliptica subsp. Elliptica																																	
Asteraceae	Olearia sp.																																	
Asteraceae	Olearia spp.																																	
Asteraceae	Podolepis sp.																																	
Asteraceae	Senecio diaschides																																	
Asteraceae	Senecio gunnii																0.1	10																
Asteraceae	Senecio hispidulus	Hill Fireweed					0.2	4	0.1	1									1	40														
Asteraceae	Senecio linearifolius	Fireweed Groundsel																																
Asteraceae	Senecio minimus																																	
Asteraceae	Senecio prenanthoides						0.1	1	0.1	7	0.1	10							0.2	20	1	20	0.1	10	0.1	1	0.5	30						
Asteraceae	Senecio quadridentatus	Cotton Fireweed					0.6	10	0.2	5			0.4	10					0.1	1														
Asteraceae	Senecio sp.																																	
Asteraceae	Senecio spp.	Groundsel, Fireweed																																
Asteraceae	Senecio tenuiflorus										0.3	20																						
Asteraceae	Sigesbeckia orientalis subsp. Orientalis	Indian Weed			5	100	5	200	5	100	0.1	1			1	50	0.3	10	0.6	60														
Asteraceae	Solenogyne gunnii	Solengyne							0.1	1			0.2	20	0.1	2																		
Asteraceae	Vittadinia cervicularis												0.1	1																				
Asteraceae	Vittadinia cuneata	A Fuzzweed																																
Asteraceae	Vittadinia cuneata var. cuneata	A Fuzzweed											0.1	2			0.3	50																
Asteraceae	Vittadinia hispidula																0.1	10																
Asteraceae	Vittadinia sp.																																	
Bignoniaceae	Pandorea pandorana	Wonga Wonga Vine													0.1	1																		
Blechnaceae	Blechnum sp.																																	
Boraginaceae	Cynoglossum australe																																	
Boraginaceae	Hackelia latifoli						0.1	2																										
Boraginaceae	Hackelia latifolia				0.4	5													0.1	1														
Campanulaceae	Lobelia concolor	Poison Pratia					0.1	3	0.1	5	0.1	2	0.2	50			0.1	10	0.1	5			0.1	50	0.1	10	2	100			0.1	30		
Campanulaceae	Lobelia pedunculata										0.1	10																						
Campanulaceae	Lobelia purpurascens	whiteroot																			0.1	50												
Campanulaceae	Lobelia spp.																				0.5	30												
Campanulaceae	Wahlenbergia gracilis	Sprawling Bluebell			0.1	6	0.1	4									0.1	10			0.1	5												
Campanulaceae	Wahlenbergia stricta	Tall Bluebell																																
Campanulaceae	Wahlenbergia stricta subsp. Stricta	Tall Bluebell							0.2	6					0.4	30	0.1	10	0.1	3														
Caryophyllaceae	Scleranthus biflorus	Two-flowered Knawel															0.1	2																
Caryophyllaceae	Stellaria pungens				0.1	1	0.1	5	0.1	3	0.2	10			0.1	10					0.2	30			0.1	10	0.2	50						
Casuarinaceae	Allocasuarina torulosa	Forest Oak													0.1	1																		
Chenopodiaceae	Dysphania pumilio	Small Crumbweed	0.8	20	55	200	2	40	0.1	7	0.3	5			0.5	10	0.4	20	0.1	1			3	100					0.2	100			1	100
Chenopodiaceae	Einadia hastata	Berry Saltbush	0.3	7																														

Family	Scientific name	Common name	Plot 17 (HoG-Mar-08)		Plot 18 (HoG-Mar-09)		Plot 19 (HoG-Mar-10)		Plot 20 (HoG-Mar-11)		Plot 21 (HoG-Mar-12)		Plot 22 (HoG_TLC_Mar_07)		Plot 23 (HoG_TLC_Mar_06)		Plot 24 (HoG_TLC_Mar_08)		Plot 27 (34784_01)		Plot 28 (34784_02)		Plot 29 (34784_04)		Plot 30 (34784_05)		Plot 31 (34784_07)		Plot 32 (34784_13)		Plot 33 (34784_16)		Plot 34 (34784_17)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Asteraceae	Lagenophora stipitata	Common Lagenophora																																
Asteraceae	Leontodon spp.																																	
Asteraceae	Olearia alpicola	Alpine Daisy-bush																																
Asteraceae	Olearia elliptica	Sticky Daisy-bush																																
Asteraceae	Olearia elliptica subsp. Elliptica																																	
Asteraceae	Olearia sp.																																	
Asteraceae	Olearia spp.						2	20	5	5																								
Asteraceae	Podolepis sp.																				0.1										0.1			
Asteraceae	Senecio diaschides																		2		0.5								0.5		10			
Asteraceae	Senecio gunnii																																	
Asteraceae	Senecio hispidulus	Hill Fireweed																									0.1	2					0.1	1
Asteraceae	Senecio linearifolius	Fireweed Groundsel					1	20			0.5	10															0.1	20						
Asteraceae	Senecio minimus				0.5	20																												
Asteraceae	Senecio prenanthoides		0.1	5					0.1	10																								
Asteraceae	Senecio quadridentatus	Cotton Fireweed																																
Asteraceae	Senecio sp.																		0.2						0.2				0.1					
Asteraceae	Senecio spp.	Groundsel, Fireweed																															0.1	10
Asteraceae	Senecio tenuiflorus																																	
Asteraceae	Sigesbeckia orientalis subsp. Orientalis	Indian Weed			2	30	0.1	10	0.1	10											0.5								3				0.1	1
Asteraceae	Solenogyne gunnii	Solengyne																			1				0.2						0.1			
Asteraceae	Vittadinia cervicularis																																	
Asteraceae	Vittadinia cuneata	A Fuzzweed													1	10	1	10																
Asteraceae	Vittadinia cuneata var. cuneata	A Fuzzweed																																
Asteraceae	Vittadinia hispidula																																	
Asteraceae	Vittadinia sp.																						0.1		0.1									
Bignoniaceae	Pandorea pandorana	Wonga Wonga Vine																																
Blechnaceae	Blechnum sp.																																	
Boraginaceae	Cynoglossum australe																																	
Boraginaceae	Hackelia latifoli																																	
Boraginaceae	Hackelia latifolia				0.1	5																							1					
Campanulaceae	Lobelia concolor	Poison Pratia	0.1	20									0.5	20	1	20	3	50																
Campanulaceae	Lobelia pedunculata																																0.2	100
Campanulaceae	Lobelia purpurascens	whiteroot					1	50	0.5	30											0.1				2									
Campanulaceae	Lobelia spp.								0.1	5																								
Campanulaceae	Wahlenbergia gracilis	Sprawling Bluebell																	0.1		0.1													
Campanulaceae	Wahlenbergia stricta	Tall Bluebell							0.1	5			1	20	0.5	20	0.5	20															0.1	500
Campanulaceae	Wahlenbergia stricta subsp. Stricta	Tall Bluebell																	1		1		0.1		0.3				0.5		5			
Caryophyllaceae	Scleranthus biflorus	Two-flowered Knawel																																
Caryophyllaceae	Stellaria pungens		0.5	70	0.1	10			1	30	5	300															0.5	20						
Casuarinaceae	Allocasuarina torulosa	Forest Oak																											35					
Chenopodiaceae	Dysphania pumilio	Small Crumbweed			15	1000							40	200	1	50	1	30																
Chenopodiaceae	Einadia hastata	Berry Saltbush									0.5	20																						

Family	Scientific name	Common name	Plot 35 (34784_20)		Plot 36 (34784_28)		Plot 37 (34784_34)		Plot 38 (34784_42)		Plot 39 (34784_46)		Plot 40 (34784_47)		Plot 41 (34784_08)		Plot 42 (34784_09)		Plot 43 (34784_11)		Plot 44 (34784_21)		Plot 45 (34784_23)		Plot 46 (34784_27)		Plot 47 (34784_29)		Plot 48 (34784_32)		Plot 49 (34784_35)		Plot 50 (34784_45)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Asteraceae	Lagenophora stipitata	Common Lagenophora					0.1	30																										
Asteraceae	Leontodon spp.																																	
Asteraceae	Olearia alpicola	Alpine Daisy-bush																																
Asteraceae	Olearia elliptica	Sticky Daisy-bush	0.1	5									0.5	30																				
Asteraceae	Olearia elliptica subsp. Elliptica																												1					
Asteraceae	Olearia sp.																		1															
Asteraceae	Olearia spp.																																	
Asteraceae	Podolepis sp.										0.1				0.1		0.2		0.1										0.5					
Asteraceae	Senecio diaschides																		1		0.2								0.1		2		2	
Asteraceae	Senecio gunnii																																	
Asteraceae	Senecio hispidulus	Hill Fireweed	0.5	500			0.1	1	0.1	10			0.5	200																				
Asteraceae	Senecio linearifolius	Fireweed Groundsel					0.1	1																										
Asteraceae	Senecio minimus																																	
Asteraceae	Senecio prenanthoides																																	
Asteraceae	Senecio quadridentatus	Cotton Fireweed																																
Asteraceae	Senecio sp.														2		0.1				0.1								0.1		0.5		0.1	
Asteraceae	Senecio spp.	Groundsel, Fireweed	0.1	100									0.5	200																				
Asteraceae	Senecio tenuiflorus																																	
Asteraceae	Sigesbeckia orientalis subsp. Orientalis	Indian Weed	0.1	10															1		0.1		0.1								0.5		0.1	
Asteraceae	Solenogyne gunnii	Solengyne																	0.1		1								0.1		0.1			
Asteraceae	Vittadinia cervicularis																																	
Asteraceae	Vittadinia cuneata	A Fuzzweed	0.1	1									0.1	2																				
Asteraceae	Vittadinia cuneata var. cuneata	A Fuzzweed																																
Asteraceae	Vittadinia hispidula																																	
Asteraceae	Vittadinia sp.														0.1						2		0.2						0.1					
Bignoniaceae	Pandorea pandorana	Wonga Wonga Vine					0.2	50																										
Blechnaceae	Blechnum sp.																												0.5					
Boraginaceae	Cynoglossum australe		0.6	10			0.2	50																										
Boraginaceae	Hackelia latifoli																																	
Boraginaceae	Hackelia latifolia														3				1												0.5		0.1	
Campanulaceae	Lobelia concolor	Poison Pratia																																
Campanulaceae	Lobelia pedunculata				0.2	2000																												
Campanulaceae	Lobelia purpurascens	whiteroot					0.1	100			2								0.5				1		0.2		0.2						0.5	
Campanulaceae	Lobelia spp.																																	
Campanulaceae	Wahlenbergia gracilis	Sprawling Bluebell															1						0.2				0.1		0.1		0.1		0.1	
Campanulaceae	Wahlenbergia stricta	Tall Bluebell	0.1	100					0.2	1000			0.1	1000																				
Campanulaceae	Wahlenbergia stricta subsp. Stricta	Tall Bluebell									0.1				0.1		2		0.1		2		0.2						0.2		0.1		0.5	
Caryophyllaceae	Scleranthus biflorus	Two-flowered Knawel																																
Caryophyllaceae	Stellaria pungens		2	100																														
Casuarinaceae	Allocasuarina torulosa	Forest Oak																																
Chenopodiaceae	Dysphania pumilio	Small Crumbweed													2																			
Chenopodiaceae	Einadia hastata	Berry Saltbush																																

Family	Scientific name	Common name	Plot 01 (HoG_Mar_13)		Plot 02 (HoG_Mar_14)		Plot 03 (HoG_Mar_15		Plot 04 (HoG_Mar_16		Plot 05 (HoG_TLC_Mar_01)		Plot 6 (HoG_TLC_Mar_02)		Plot 07 (HoG_TLC_Mar_03)		Plot 08 (HoG_TLC_Mar_04)		Plot 09 (HoG_TLC_Mar_05)		Plot 10 (HoG-Mar-01)		Plot 11 (HoG-Mar-02)		Plot 12 (HoG-Mar-03		Plot 13 (HoG-Mar-04)		Plot 14 (HoG-Mar-05)		Plot 15 (HoG-Mar-06)		Plot 16 (HoG-Mar-07)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Chenopodiaceae	Einadia nutans						1	40	0.1	10	0.1	2																						
Chenopodiaceae	Einadia sp.																																	
Chenopodiaceae	Einadia trigonos	Fishweed			3	60	0.5	20	0.2	20	0.5	20									1	30							0.1	50			5	2000
Clusiaceae	Hypericum gramineum	Small St John's Wort											4	600			0.1	10	0.1	1	0.5	100			0.1	1								
Convolvulaceae	Dichondra repens						1	80	0.1	3	0.1	10	3	100					2	100	5	500	2	50	2	200	2	300			1	500		
Crassulaceae	Crassula sieberiana	Australian Stonecrop					0.1	1	0.1	10																								
Crassulaceae	Crassula sieberiana subsp. Sieberiana																																	
Cyperaceae	Carex appressa	Tall Sedge															3	60	1	20														
Cyperaceae	Carex incomitata				0.1	10			0.1	10	0.1	6																						
Cyperaceae	Carex inversa	Knob Sedge									0.2	60	0.3	30	0.2	20													2	1000			0.1	50
Cyperaceae	Carex sp.																																	
Cyperaceae	Carex spp.																																	
Cyperaceae	Cyperus sp.																																	
Cyperaceae	Cyperus spp.																																	
Cyperaceae	Gahnia aspera																																	
Cyperaceae	Lepidosperma laterale	Variable Sword-sedge							1	10																								
Cyperaceae	Lepidosperma limicola														0.5	4																		
Cyperaceae	Schoenoplectus sp.																																	
Dennstaedtiaceae	Pteridium esculentum		0.1	1	4	30	0.1	1			70	200							1	20	5	30	1	30	0.2	10	1	5	95	3000	0.5	10	75	1000
Dicksoniaceae	Calochlaena dubia	Rainbow Fern																													1	5		
Dicksoniaceae	Dicksonia antarctica	Soft Treefern																																
Dilleniaceae	Hibbertia acicularis												0.2	8	0.1	3	0.1	1	0.1	1														
Dilleniaceae	Hibbertia obtusifolia	Hoary Guinea Flower																																
Dilleniaceae	Hibbertia sp.																																	
Dilleniaceae	Hibbertia spp.																								0.1	2								
Ericaceae	Acrothamnus hookeri																				0.1	10												
Ericaceae	Epacris sp.																																	
Ericaceae	Leucopogon lanceolatus																																	
Ericaceae	Melichrus urceolatus	Urn Heath											0.5	10	0.7	9	0.1	2																
Ericaceae	Monotoca scoparia																0.6	9																
Escalloniaceae	Quintinia sieberi	Possumwood																	7	50														
Euphorbiaceae	Euphorbia spp.												0.1	20	0.1	4			0.1	4														
Fabaceae	Acacia implexa	Hickory Wattle					0.1	1	0.1	5																								
Fabaceae	Acacia melanoxylon	Blackwood													0.1	1			0.3	7			5	6			5	1			45	30		
Fabaceae	Acacia spp.	Wattle																			0.1	2			0.1	3								
Fabaceae	Daviesia genistifolia	Broom Bitter Pea																																
Fabaceae	Daviesia ulicifolia	Gorse Bitter Pea																			3	10												
Fabaceae	Desmodium brachypodum	Large Tick-trefoil																																
Fabaceae	Desmodium gunnii	Slender Tick-trefoil																																
Fabaceae	Desmodium rhytidophyllum																																	
Fabaceae	Desmodium spp.	Tick-trefoil																																

Family	Scientific name	Common name	Plot 17 (HoG-Mar-08)		Plot 18 (HoG-Mar-09)		Plot 19 (HoG-Mar-10)		Plot 20 (HoG-Mar-11)		Plot 21 (HoG-Mar-12)		Plot 22 (HoG_TLC_Mar_07)		Plot 23 (HoG_TLC_Mar_06)		Plot 24 (HoG_TLC_Mar_08)		Plot 27 (34784_01)		Plot 28 (34784_02)		Plot 29 (34784_04)		Plot 30 (34784_05)		Plot 31 (34784_07)		Plot 32 (34784_13)		Plot 33 (34784_16)		Plot 34 (34784_17)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Chenopodiaceae	Einadia nutans														2	50	0.5	30																
Chenopodiaceae	Einadia sp.																												0.1					
Chenopodiaceae	Einadia trigonos	Fishweed			5	200	2	50	0.1	10																								
Clusiaceae	Hypericum gramineum	Small St John's Wort																																
Convolvulaceae	Dichondra repens		2	300			5	500	1	100	1	50	1	50	5	1000	5	50	1		1		3		1		0.1	10	5				0.2	500
Crassulaceae	Crassula sieberiana	Australian Stonecrop																																
Crassulaceae	Crassula sieberiana subsp. Sieberiana																		1		0.1		0.1		0.2						3			
Cyperaceae	Carex appressa	Tall Sedge																															0.1	2
Cyperaceae	Carex incomitata										1	30																						
Cyperaceae	Carex inversa	Knob Sedge							0.1	10			5	200	3	100	10	1000									0.1	5					0.2	50
Cyperaceae	Carex sp.																								0.1									
Cyperaceae	Carex spp.																																	
Cyperaceae	Cyperus sp.																																	
Cyperaceae	Cyperus spp.																																0.1	2
Cyperaceae	Gahnia aspera																						1						3					
Cyperaceae	Lepidosperma laterale	Variable Sword-sedge																					1											
Cyperaceae	Lepidosperma limicola																																	
Cyperaceae	Schoenoplectus sp.																																	
Dennstaedtiaceae	Pteridium esculentum		3	20	0.1	10	5	70	0.1	5							1	10			4						0.1	5			0.1		0.1	5
Dicksoniaceae	Calochlaena dubia	Rainbow Fern																																
Dicksoniaceae	Dicksonia antarctica	Soft Treefern																																
Dilleniaceae	Hibbertia acicularis																																	
Dilleniaceae	Hibbertia obtusifolia	Hoary Guinea Flower																																
Dilleniaceae	Hibbertia sp.																						0.1											
Dilleniaceae	Hibbertia spp.																																	
Ericaceae	Acrothamnus hookeri																																	
Ericaceae	Epacris sp.																		2		0.1		0.1		0.1									
Ericaceae	Leucopogon lanceolatus																				0.5		1											
Ericaceae	Melichrus urceolatus	Urn Heath																																
Ericaceae	Monotoca scoparia																																	
Escalloniaceae	Quintinia sieberi	Possumwood																																
Euphorbiaceae	Euphorbia spp.																																	
Fabaceae	Acacia implexa	Hickory Wattle																			0.5		0.1											
Fabaceae	Acacia melanoxylon	Blackwood					3	10	0.5	1	3	1							0.1		0.1				5		0.1	10			0.2		0.1	5
Fabaceae	Acacia spp.	Wattle			0.1	2																												
Fabaceae	Daviesia genistifolia	Broom Bitter Pea							8	20																								
Fabaceae	Daviesia ulicifolia	Gorse Bitter Pea																																
Fabaceae	Desmodium brachypodum	Large Tick-trefoil																																
Fabaceae	Desmodium gunnii	Slender Tick-trefoil					0.2	30	0.1	10	0.5	50	0.5	20									0.5						0.5		1		0.1	50
Fabaceae	Desmodium rhytidophyllum																																0.1	1
Fabaceae	Desmodium spp.	Tick-trefoil			0.2	30																												

Family	Scientific name	Common name	Plot 35 (34784_20)		Plot 36 (34784_28)		Plot 37 (34784_34)		Plot 38 (34784_42)		Plot 39 (34784_46)		Plot 40 (34784_47)		Plot 41 (34784_08)		Plot 42 (34784_09)		Plot 43 (34784_11)		Plot 44 (34784_21)		Plot 45 (34784_23)		Plot 46 (34784_27)		Plot 47 (34784_29)		Plot 48 (34784_32)		Plot 49 (34784_35)		Plot 50 (34784_45)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Chenopodiaceae	Einadia nutans																																	
Chenopodiaceae	Einadia sp.																																	
Chenopodiaceae	Einadia trigonos	Fishweed											0.1	1																				
Clusiaceae	Hypericum gramineum	Small St John's Wort																					0.1											
Convolvulaceae	Dichondra repens						0.1	50			0.5						3												2		3			
Crassulaceae	Crassula sieberiana	Australian Stonecrop	0.1	20																														
Crassulaceae	Crassula sieberiana subsp. Sieberiana										0.2				0.1		0.1		0.1				0.1		0.1		0.5		0.5		0.1			
Cyperaceae	Carex appressa	Tall Sedge																																
Cyperaceae	Carex incomitata						0.1	1					0.5	10																				
Cyperaceae	Carex inversa	Knob Sedge	0.2	1000	0.2	1000			0.1	10			0.1	50																				
Cyperaceae	Carex sp.										0.5																							
Cyperaceae	Carex spp.				0.1	1																												
Cyperaceae	Cyperus sp.										0.5														2									
Cyperaceae	Cyperus spp.						0.1	1																										
Cyperaceae	Gahnia aspera										1										0.2						0.5							
Cyperaceae	Lepidosperma laterale	Variable Sword-sedge	0.5	100									1	20							5								1					
Cyperaceae	Lepidosperma limicola																																	
Cyperaceae	Schoenoplectus sp.																								0.1									
Dennstaedtiaceae	Pteridium esculentum						0.3	20	30	5000					0.5		0.5		2				0.1								3			
Dicksoniaceae	Calochlaena dubia	Rainbow Fern																																
Dicksoniaceae	Dicksonia antarctica	Soft Treefern					0.1	1											0.1															
Dilleniaceae	Hibbertia acicularis																																	
Dilleniaceae	Hibbertia obtusifolia	Hoary Guinea Flower											0.1	5																				
Dilleniaceae	Hibbertia sp.																				0.1		0.5											
Dilleniaceae	Hibbertia spp.																																	
Ericaceae	Acrothamnus hookeri																																	
Ericaceae	Epacris sp.																						0.5											
Ericaceae	Leucopogon lanceolatus												0.1	2							0.1		0.5											
Ericaceae	Melichrus urceolatus	Urn Heath	0.1	2									0.3	5																				
Ericaceae	Monotoca scoparia																																	
Escalloniaceae	Quintinia sieberi	Possumwood																																
Euphorbiaceae	Euphorbia spp.																																	
Fabaceae	Acacia implexa	Hickory Wattle													0.1														0.1		0.2			
Fabaceae	Acacia melanoxylon	Blackwood	0.1	5					0.1	1			0.1	10					0.2		0.5		0.2											
Fabaceae	Acacia spp.	Wattle																																
Fabaceae	Daviesia genistifolia	Broom Bitter Pea																																
Fabaceae	Daviesia ulicifolia	Gorse Bitter Pea																																
Fabaceae	Desmodium brachypodum	Large Tick-trefoil											0.1	1																				
Fabaceae	Desmodium gunnii	Slender Tick-trefoil	0.1	50			0.2	1000					0.1	500									0.1								4		1	
Fabaceae	Desmodium rhytidophyllum																																	
Fabaceae	Desmodium spp.	Tick-trefoil																																

Family	Scientific name	Common name	Plot 01 (HoG_Mar_13)		Plot 02 (HoG_Mar_14)		Plot 03 (HoG_Mar_15)		Plot 04 (HoG_Mar_16)		Plot 05 (HoG_TLC_Mar_01)		Plot 6 (HoG_TLC_Mar_02)		Plot 07 (HoG_TLC_Mar_03)		Plot 08 (HoG_TLC_Mar_04)		Plot 09 (HoG_TLC_Mar_05)		Plot 10 (HoG-Mar-01)		Plot 11 (HoG-Mar-02)		Plot 12 (HoG-Mar-03)		Plot 13 (HoG-Mar-04)		Plot 14 (HoG-Mar-05)		Plot 15 (HoG-Mar-06)		Plot 16 (HoG-Mar-07)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Fabaceae	Desmodium varians	Slender Tick-trefoil			0.1	1	0.4	30	0.3	30	0.1	20	3	100	0.5	30			0.3	20	0.5	100					0.5	100						
Fabaceae	Glycine clandestina	Twining glycine											0.1	1											0.1	30	1	100						
Fabaceae	Glycine microphylla	Small-leaf Glycine					0.1	1	0.3	40	0.1	5	0.5	100	0.1	10	0.1	10	0.1	10														
Fabaceae	Glycine tabacina										0.2	50			3	100					1	200												
Fabaceae	Hardenbergia violacea										0.1	1							0.8	10														
Fabaceae	Indigofera australis	Australian Indigo																	0.7	20														
Fabaceae	Swainsona galegifolia										0.5	30	0.3	10							0.1	5												
Geraniaceae	Geranium homeanum																																	
Geraniaceae	Geranium potentilloides																						0.2	30	0.1	20	0.2	50	0.5	100	0.5	100	0.1	50
Geraniaceae	Geranium solanderi	Native Geranium																																
Geraniaceae	Geranium solanderi var. solanderi				0.4	30	0.1	6	0.4	30	0.5	50	0.5	20	0.2	20	5	200	0.5	60														
Geraniaceae	Geranium sp.																																	
Geraniaceae	Geranium spp.																				0.2	30												
Haloragaceae	Gonocarpus micranthus										0.1	20																						
Haloragaceae	Gonocarpus sp.																																	
Haloragaceae	Gonocarpus tetragynus	Poverty Raspwort																																
Haloragaceae	Gonocarpus teucrioides	Germander Raspwort																			0.5	50											0.1	40
Haloragaceae	Haloragis heterophylla	Variable Raspwort																																
Juncaceae	Juncus flavidus										1	40																						
Juncaceae	Juncus subsecundus																																	
Juncaceae	Luzula flaccida	Woodrush																																
Lamiaceae	Ajuga australis	Austral Bugle							0.7	30			0.5	20	1	30	0.1	4																
Lamiaceae	Mentha diemenica	Slender Mint			0.2	10	0.1	1									0.2	10																
Lamiaceae	Mentha satureioides																																	
Lamiaceae	Plectranthus parviflorus																																	
Lamiaceae	Scutellaria humilis	Dwarf Skullcap					0.1	10	0.1	2			1	200	0.1	30			0.5	60														
Lamiaceae	Scutellaria mollis	Soft Skullcap																																
Lamiaceae	Scutellaria sp.																																	
Lomandraceae	Lomandra bracteata	Mat-rush																	0.1	1														
Lomandraceae	Lomandra confertifolia	Matrush											0.1	3																				
Lomandraceae	Lomandra filiformis	Wattle Matt-rush																			0.2	20												
Lomandraceae	Lomandra filiformis subsp. filiformis												0.1	1																				
Lomandraceae	Lomandra filiformis subsp. Flavior								0.5	30	0.1	4	0.1	10			0.1	1																
Lomandraceae	Lomandra glauca	Pale Mat-rush													1	70																		
Lomandraceae	Lomandra longifolia										4	80			40	100			0.2	2	50	300												
Lomandraceae	Lomandra multiflora subsp. Multiflora	Many-flowered Mat-rush																	0.2	2														
Lomandraceae	Lomandra sp.																																	
Loranthaceae	Amyema sp.																																	
Luzuriagaceae	Eustrephus latifolius	Wombat Berry					0.3	7			0.1	2	0.3	5	2	20			1	20														
Luzuriagaceae	Geitonoplesium cymosum	Scrambling Lily																									0.1	3						
Myrsinaceae	Myrsine variabilis																																	
Myrtaceae	Angophora floribunda	Rough-barked Apple																	40	5														
Myrtaceae	Callistemon spp.																																	
Myrtaceae	Eucalyptus blakelyi						5	2																										

			Plot 17 (HoG-Mar-08)		Plot 18 (HoG-Mar-09)		Plot 19 (HoG-Mar-10)		Plot 20 (HoG-Mar-11)		Plot 21 (HoG-Mar-12)		Plot 22 (HoG_TLC_Mar_07)		Plot 23 (HoG_TLC_Mar_06)		Plot 24 (HoG_TLC_Mar_08)		Plot 27 (34784_01)		Plot 28 (34784_02)		Plot 29 (34784_04)		Plot 30 (34784_05)		Plot 31 (34784_07)		Plot 32 (34784_13)		Plot 33 (34784_16)		Plot 34 (34784_17)	
Family	Scientific name	Common name	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Fabaceae	Desmodium varians	Slender Tick-trefoil													1	50							3		0.1									
Fabaceae	Glycine clandestina	Twining glycine					0.1	30	0.1	20			0.1	20			0.1	20	0.5		0.2												0.1	10
Fabaceae	Glycine microphylla	Small-leaf Glycine																	2		0.2		1								5		0.1	10
Fabaceae	Glycine tabacina				0.1	10					0.5	20			1	100	0.5	10																
Fabaceae	Hardenbergia violacea						0.1	1											0.5				2								1			
Fabaceae	Indigofera australis	Australian Indigo																	0.2															
Fabaceae	Swainsona galegifolia								0.1	1																							0.1	1
Geraniaceae	Geranium homeanum																										5	1000						
Geraniaceae	Geranium potentilloides		0.5	50	5	300	1	200	1	30			0.2	10	0.5	10	0.1	10							0.5									
Geraniaceae	Geranium solanderi	Native Geranium																	10		5		5						2		5		0.5	1000
Geraniaceae	Geranium solanderi var. solanderi																																	
Geraniaceae	Geranium sp.																		2				0.5											
Geraniaceae	Geranium spp.																																	
Haloragaceae	Gonocarpus micranthus																																	
Haloragaceae	Gonocarpus sp.																		0.1						2						0.1			
Haloragaceae	Gonocarpus tetragynus	Poverty Raspwort																																
Haloragaceae	Gonocarpus teucrioides	Germander Raspwort							0.5	20																							0.1	10
Haloragaceae	Haloragis heterophylla	Variable Raspwort																																
Juncaceae	Juncus flavidus																																	
Juncaceae	Juncus subsecundus																																	
Juncaceae	Luzula flaccida	Woodrush																															0.1	1
Lamiaceae	Ajuga australis	Austral Bugle																	0.1		0.2		0.1								0.5			
Lamiaceae	Mentha diemenica	Slender Mint																																
Lamiaceae	Mentha satureioides																		0.1				0.1											
Lamiaceae	Plectranthus parviflorus																						0.1											
Lamiaceae	Scutellaria humilis	Dwarf Skullcap																																
Lamiaceae	Scutellaria mollis	Soft Skullcap																															0.1	1
Lamiaceae	Scutellaria sp.																		0.1										0.1					
Lomandraceae	Lomandra bracteata	Mat-rush																																
Lomandraceae	Lomandra confertifolia	Matrush																																
Lomandraceae	Lomandra filiformis	Wattle Matt-rush																	0.1												0.1			
Lomandraceae	Lomandra filiformis subsp. filiformis																																0.1	2
Lomandraceae	Lomandra filiformis subsp. Flavior																																	
Lomandraceae	Lomandra glauca	Pale Mat-rush																																
Lomandraceae	Lomandra longifolia						0.1	5	0.5	1									3		3				0.1				0.1		0.5		0.1	1
Lomandraceae	Lomandra multiflora subsp. Multiflora	Many-flowered Mat-rush																	0.1		0.1		0.2						0.1		0.1			
Lomandraceae	Lomandra sp.																																	
Loranthaceae	Amyema sp.																				0.5													
Luzuriagaceae	Eustrephus latifolius	Wombat Berry																	0.2				0.1										0.1	20
Luzuriagaceae	Geitonoplesium cymosum	Scrambling Lily									0.1	2					1	5			0.1								0.5					
Myrsinaceae	Myrsine variabilis																				0.1													
Myrtaceae	Angophora floribunda	Rough-barked Apple													20	2							5						50					
Myrtaceae	Callistemon spp.																																0.1	3
Myrtaceae	Eucalyptus blakelyi																																	

Family	Scientific name	Common name	Plot 35 (34784_20)		Plot 36 (34784_28)		Plot 37 (34784_34)		Plot 38 (34784_42)		Plot 39 (34784_46)		Plot 40 (34784_47)		Plot 41 (34784_08)		Plot 42 (34784_09)		Plot 43 (34784_11)		Plot 44 (34784_21)		Plot 45 (34784_23)		Plot 46 (34784_27)		Plot 47 (34784_29)		Plot 48 (34784_32)		Plot 49 (34784_35)		Plot 50 (34784_45)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Fabaceae	Desmodium varians	Slender Tick-trefoil									0.1						3				1		5						0.5				1	
Fabaceae	Glycine clandestina	Twining glycine	0.2	200									0.1	100							0.1		0.2						0.5					
Fabaceae	Glycine microphylla	Small-leaf Glycine					0.1	10									1		1		1		0.5						1		2			
Fabaceae	Glycine tabacina																																	
Fabaceae	Hardenbergia violacea												0.5	100							0.2								3		1			
Fabaceae	Indigofera australis	Australian Indigo																			0.2								3		0.1			
Fabaceae	Swainsona galegifolia		0.3	20			0.1	1					0.2	200																				
Geraniaceae	Geranium homeanum						0.2	1000	0.3	1000			0.2	1000																				
Geraniaceae	Geranium potentilloides																																	
Geraniaceae	Geranium solanderi	Native Geranium	0.2	1000			0.1	500			0.1				2		3		2		0.1						5		5		3		5	
Geraniaceae	Geranium solanderi var. solanderi																																	
Geraniaceae	Geranium sp.																		0.1		0.1										0.1		1	
Geraniaceae	Geranium spp.																																	
Haloragaceae	Gonocarpus micranthus																																	
Haloragaceae	Gonocarpus sp.																		0.1								0.1				0.1			
Haloragaceae	Gonocarpus tetragynus	Poverty Raspwort							0.1	1																								
Haloragaceae	Gonocarpus teucrioides	Germander Raspwort																																
Haloragaceae	Haloragis heterophylla	Variable Raspwort			0.2	5000																												
Juncaceae	Juncus flavidus																																	
Juncaceae	Juncus subsecundus																						0.1		20		2							
Juncaceae	Luzula flaccida	Woodrush	0.1	1																														
Lamiaceae	Ajuga australis	Austral Bugle													0.1								0.1						0.1		0.1			
Lamiaceae	Mentha diemenica	Slender Mint									0.1								0.1															
Lamiaceae	Mentha satureioides																		0.5				0.2											
Lamiaceae	Plectranthus parviflorus																				0.1													
Lamiaceae	Scutellaria humilis	Dwarf Skullcap							0.1	3																								
Lamiaceae	Scutellaria mollis	Soft Skullcap																																
Lamiaceae	Scutellaria sp.																						0.1		0.1									
Lomandraceae	Lomandra bracteata	Mat-rush																																
Lomandraceae	Lomandra confertifolia	Matrush																																
Lomandraceae	Lomandra filiformis	Wattle Matt-rush																															0.1	
Lomandraceae	Lomandra filiformis subsp. filiformis																																	
Lomandraceae	Lomandra filiformis subsp. Flavior																																	
Lomandraceae	Lomandra glauca	Pale Mat-rush																																
Lomandraceae	Lomandra longifolia		0.5	20			85	2000													5								1					
Lomandraceae	Lomandra multiflora subsp. Multiflora	Many-flowered Mat-rush	2	100									1	200			0.1				3		0.1						0.5		0.1		0.1	
Lomandraceae	Lomandra sp.																		0.1															
Loranthaceae	Amyema sp.																												0.1					
Luzuriagaceae	Eustrephus latifolius	Wombat Berry	0.1	10			0.1	10					0.2	50			0.1		1		0.1		0.2						1		5		0.5	
Luzuriagaceae	Geitonoplesium cymosum	Scrambling Lily	0.1	10									0.1	20																				
Myrsinaceae	Myrsine variabilis																																	
Myrtaceae	Angophora floribunda	Rough-barked Apple	0.3	2									0.1	1									10						40					
Myrtaceae	Callistemon spp.						40	200																										
Myrtaceae	Eucalyptus blakelyi																																	

Family	Scientific name	Common name	Plot 01 (HoG_Mar_13)		Plot 02 (HoG_Mar_14)		Plot 03 (HoG_Mar_15		Plot 04 (HoG_Mar_16		Plot 05 (HoG_TLC_Mar_01)		Plot 6 (HoG_TLC_Mar_02)		Plot 07 (HoG_TLC_Mar_03)		Plot 08 (HoG_TLC_Mar_04)		Plot 09 (HoG_TLC_Mar_05)		Plot 10 (HoG-Mar-01)		Plot 11 (HoG-Mar-02)		Plot 12 (HoG-Mar-03		Plot 13 (HoG-Mar-04)		Plot 14 (HoG-Mar-05)		Plot 15 (HoG-Mar-06)		Plot 16 (HoG-Mar-07)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Myrtaceae	Eucalyptus dalrympleana subsp. Heptantha		55	4																														
Myrtaceae	Eucalyptus dives	Broad-leaved Peppermint																																
Myrtaceae	Eucalyptus fastigata																																	
Myrtaceae	Eucalyptus laevopinea	Silver-top Stringybark					65	10	75	20			60	8	15	1	0.1	1																
Myrtaceae	Eucalyptus melliodora	Yellow Box																																
Myrtaceae	Eucalyptus nobilis	Forest Ribbon Gum																			30	6												
Myrtaceae	Eucalyptus nobilis subsp. Nobilis																																	
Myrtaceae	Eucalyptus nortonii	Large-flowered Bundy																																
Myrtaceae	Eucalyptus obliqua	Messmate																																
Myrtaceae	Eucalyptus pauciflora										5	10									10	1			15	7	15	5						
Myrtaceae	Eucalyptus stellulata	Black Sally																																
Myrtaceae	Eucalyptus viminalis	Ribbon Gum																	7	1					5	2	5	1						
Myrtaceae	Leptospermum polygalifolium	Tantoon																																
Oleaceae	Notelaea longifolia																																	
Oleaceae	Notelaea microcarpa	Native Olive																																
Onagraceae	Epilobium billardierianum																																	
Onagraceae	Epilobium billardierianum subsp. Cinereum				0.7	10																												
Orchidaceae	Acianthus sp.																																	
Orchidaceae	Pterostylis sp.																																	
Orchidaceae	Pterostylis sp. 2																																	
Orchidaceae	Pterostylis spp.	Greenhood																																
Oxalidaceae	Oxalis chnoodes																																	
Oxalidaceae	Oxalis perrenans						0.1	1	0.1	6					0.1	3	0.1	20	0.1	6	1	100					1	100					5	200
Phormiaceae	Dianella caerulea	Blue Flax-lily																							0.1	10								
Phormiaceae	Dianella longifolia	Blueberry Lily											0.2	5																				
Phormiaceae	Dianella revoluta	Blueberry Lily											0.1	2	0.5	30																		
Phormiaceae	Dianella sp.																																	
Phyllanthaceae	Phyllanthus virgatus	Wiry Spurge															0.1	10																
Phyllanthaceae	Poranthera microphylla	Small Poranthera																																
Pittosporaceae	Billardiera mutabilis	Climbing Apple Berry																									0.5	50					0.1	20
Pittosporaceae	Bursaria spinosa	Native Blackthorn																																
Pittosporaceae	Bursaria spinosa subsp. Spinosa	Native Blackthorn							2	10			10	30	3	10	0.4	3	1	10														
Pittosporaceae	Pittosporum revolutum																																	
Pittosporaceae	Pittosporum undulatum	Sweet Pittosporum													0.6	3																		
Plantaginaceae	Plantago debilis	Shade Plantain					0.1	1	0.1	3																								
Plantaginaceae	Plantago spp.	Plantain																					0.5	40										
Plantaginaceae	Veronica calycina								0.2	10	0.1	4																						
Plantaginaceae	Veronica plebeia	Trailing Speedwell			0.2	5	0.3	10																							0.1	5		
Plantaginaceae	Veronica sp.																																	

Family	Scientific name	Common name	Plot 17 (HoG-Mar-08)		Plot 18 (HoG-Mar-09)		Plot 19 (HoG-Mar-10)		Plot 20 (HoG-Mar-11)		Plot 21 (HoG-Mar-12)		Plot 22 (HoG_TLC_Mar_07)		Plot 23 (HoG_TLC_Mar_06)		Plot 24 (HoG_TLC_Mar_08)		Plot 27 (34784_01)		Plot 28 (34784_02)		Plot 29 (34784_04)		Plot 30 (34784_05)		Plot 31 (34784_07)		Plot 32 (34784_13)		Plot 33 (34784_16)		Plot 34 (34784_17)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Myrtaceae	Eucalyptus dalrympleana subsp. Heptantha																																	
Myrtaceae	Eucalyptus dives	Broad-leaved Peppermint																																
Myrtaceae	Eucalyptus fastigata																														10			
Myrtaceae	Eucalyptus laevopinea	Silver-top Stringybark															20	1	50		10		10								10			
Myrtaceae	Eucalyptus melliodora	Yellow Box															10	4																
Myrtaceae	Eucalyptus nobilis	Forest Ribbon Gum	10	2																														
Myrtaceae	Eucalyptus nobilis subsp. Nobilis																																	
Myrtaceae	Eucalyptus nortonii	Large-flowered Bundy											5	1	15	3																		
Myrtaceae	Eucalyptus obliqua	Messmate			40	6																												
Myrtaceae	Eucalyptus pauciflora		15	5					15	0															2									
Myrtaceae	Eucalyptus stellulata	Black Sally					30	8																										
Myrtaceae	Eucalyptus viminalis	Ribbon Gum									20	4							5		10				15		35	4			10		20	9
Myrtaceae	Leptospermum polygalifolium	Tantoon																																
Oleaceae	Notelaea longifolia																																	
Oleaceae	Notelaea microcarpa	Native Olive																																
Onagraceae	Epilobium billardierianum																				0.1												0.1	5
Onagraceae	Epilobium billardierianum subsp. Cinereum																																	
Orchidaceae	Acianthus sp.																																	
Orchidaceae	Pterostylis sp.																																	
Orchidaceae	Pterostylis sp. 2																																	
Orchidaceae	Pterostylis spp.	Greenhood																																
Oxalidaceae	Oxalis chnoodes																																	
Oxalidaceae	Oxalis perrenans						1	100			0.5	30	0.1	20	1	50	5	200			0.1												0.1	1
Phormiaceae	Dianella caerulea	Blue Flax-lily	0.1	1																														
Phormiaceae	Dianella longifolia	Blueberry Lily																															0.1	1
Phormiaceae	Dianella revoluta	Blueberry Lily																																
Phormiaceae	Dianella sp.																																	
Phyllanthaceae	Phyllanthus virgatus	Wiry Spurge											1	30																				
Phyllanthaceae	Poranthera microphylla	Small Poranthera																													0.5		0.1	10
Pittosporaceae	Billardiera mutabilis	Climbing Apple Berry																																
Pittosporaceae	Bursaria spinosa	Native Blackthorn					0.5	2	0.1	1									2		0.3		2						0.1					
Pittosporaceae	Bursaria spinosa subsp. Spinosa	Native Blackthorn																															0.2	10
Pittosporaceae	Pittosporum revolutum																																	
Pittosporaceae	Pittosporum undulatum	Sweet Pittosporum																																
Plantaginaceae	Plantago debilis	Shade Plantain																			0.2		0.1		0.5						0.5		0.1	1
Plantaginaceae	Plantago spp.	Plantain							0.1	5																								
Plantaginaceae	Veronica calycina																				0.2								0.1				0.1	1
Plantaginaceae	Veronica plebeia	Trailing Speedwell									0.1	20															0.1	2						
Plantaginaceae	Veronica sp.																		0.1												0.1			

Family	Scientific name	Common name	Plot 35 (34784_20)		Plot 36 (34784_28)		Plot 37 (34784_34)		Plot 38 (34784_42)		Plot 39 (34784_46)		Plot 40 (34784_47)		Plot 41 (34784_08)		Plot 42 (34784_09)		Plot 43 (34784_11)		Plot 44 (34784_21)		Plot 45 (34784_23)		Plot 46 (34784_27)		Plot 47 (34784_29)		Plot 48 (34784_32)		Plot 49 (34784_35)		Plot 50 (34784_45)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Myrtaceae	Eucalyptus dalrympleana subsp. Heptantha																																	
Myrtaceae	Eucalyptus dives	Broad-leaved Peppermint							0.1	1																								
Myrtaceae	Eucalyptus fastigata																						1											
Myrtaceae	Eucalyptus laevopinea	Silver-top Stringybark	10	7									10	10							3		5								5		25	
Myrtaceae	Eucalyptus melliodora	Yellow Box	10	8									2	1																				
Myrtaceae	Eucalyptus nobilis	Forest Ribbon Gum											0.2	1							15										5		25	
Myrtaceae	Eucalyptus nobilis subsp. Nobilis		2	2			10	5																										
Myrtaceae	Eucalyptus nortonii	Large-flowered Bundy											0.2	1																				
Myrtaceae	Eucalyptus obliqua	Messmate					5	1																							20			
Myrtaceae	Eucalyptus pauciflora																		50															
Myrtaceae	Eucalyptus stellulata	Black Sally					2	1																										
Myrtaceae	Eucalyptus viminalis	Ribbon Gum					15	7	0.1	1					40		50		1												10			
Myrtaceae	Leptospermum polygalifolium	Tantoon					10	20																										
Oleaceae	Notelaea longifolia																												0.2					
Oleaceae	Notelaea microcarpa	Native Olive	0.1	1																														
Onagraceae	Epilobium billardierianum																																	
Onagraceae	Epilobium billardierianum subsp. Cinereum																																	
Orchidaceae	Acianthus sp.																		0.1															
Orchidaceae	Pterostylis sp.																		0.1		0.1								0.1					
Orchidaceae	Pterostylis sp. 2																				0.1								0.1					
Orchidaceae	Pterostylis spp.	Greenhood	0.1	10			0.1	30					0.1	2																				
Oxalidaceae	Oxalis chnoodes																										0.1				0.1			
Oxalidaceae	Oxalis perrenans										0.1								1														0.1	
Phormiaceae	Dianella caerulea	Blue Flax-lily																																
Phormiaceae	Dianella longifolia	Blueberry Lily	2	50									0.1	10																				
Phormiaceae	Dianella revoluta	Blueberry Lily																																
Phormiaceae	Dianella sp.																				0.1		0.1						0.1		0.1			
Phyllanthaceae	Phyllanthus virgatus	Wiry Spurge																																
Phyllanthaceae	Poranthera microphylla	Small Poranthera	0.1	10																	0.2										0.1		0.1	
Pittosporaceae	Billardiera mutabilis	Climbing Apple Berry																																
Pittosporaceae	Bursaria spinosa	Native Blackthorn									0.1						0.1				0.3		5						0.3		2			
Pittosporaceae	Bursaria spinosa subsp. Spinosa	Native Blackthorn	0.1	10			0.2	10					0.1	30																				
Pittosporaceae	Pittosporum revolutum																														5			
Pittosporaceae	Pittosporum undulatum	Sweet Pittosporum																																
Plantaginaceae	Plantago debilis	Shade Plantain															3				0.1		2								0.1			
Plantaginaceae	Plantago spp.	Plantain																																
Plantaginaceae	Veronica calycina		0.1	1													0.5																	
Plantaginaceae	Veronica plebeia	Trailing Speedwell																																
Plantaginaceae	Veronica sp.																		0.1										0.5					

Family	Scientific name	Common name	Plot 01 (HoG_Mar_13)		Plot 02 (HoG_Mar_14)		Plot 03 (HoG_Mar_15		Plot 04 (HoG_Mar_16		Plot 05 (HoG_TLC_Mar_01)		Plot 6 (HoG_TLC_Mar_02)		Plot 07 (HoG_TLC_Mar_03)		Plot 08 (HoG_TLC_Mar_04)		Plot 09 (HoG_TLC_Mar_05)		Plot 10 (HoG-Mar-01)		Plot 11 (HoG-Mar-02)		Plot 12 (HoG-Mar-03		Plot 13 (HoG-Mar-04)		Plot 14 (HoG-Mar-05)		Plot 15 (HoG-Mar-06)		Plot 16 (HoG-Mar-07)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Poaceae	Anthosachne scabra	Wheatgrass, Common Wheatgrass											0.1	1																				
Poaceae	Aristida lignosa														5	100																		
Poaceae	Aristida ramosa	Purple Wiregrass							0.1	2			0.1	10	4	200																		
Poaceae	Aristida sp.																																	
Poaceae	Aristida vagans	Threeawn Speargrass											0.1	1																				
Poaceae	Austrostipa scabra	Speargrass																																
Poaceae	Austrostipa verticillata	Slender Bamboo Grass																																
Poaceae	Bothriochloa decipiens var. decipiens	Pitted Bluegrass							0.1	3			20	500	15	300	75	700	1	50														
Poaceae	Bothriochloa macra	Red Grass																																
Poaceae	Chloris truncata	Windmill Grass																																
Poaceae	Cymbopogon refractus	Barbed Wire Grass											0.5	30	4	100																		
Poaceae	Dichelachne crinita	Longhair Plumegrass																	0.3	50														
Poaceae	Dichelachne micrantha	Shorthair Plumegrass											0.1	1																				
Poaceae	Echinopogon cheelii	Long-flowered Hedgehog Grass																																
Poaceae	Echinopogon mckiei						0.1	2	5	200	0.2	20	0.3	30	0.1	1			3	300														
Poaceae	Echinopogon ovatus	Forest Hedgehog Grass																							2	50	2	100						
Poaceae	Enneapogon nigricans	Niggerheads																	0.2	10														
Poaceae	Entolasia marginata										1	70																						
Poaceae	Eragrostis leptostachya	Paddock Lovegrass															0.5	50																
Poaceae	Eragrostis sp.																																	
Poaceae	Eriochloa pseudoacrotricha	Early Spring Grass																															10	200
Poaceae	Imperata cylindrica	Blady Grass																	6	200														
Poaceae	Lachnagrostis aemula																																	
Poaceae	Lachnagrostis filiformis																																	
Poaceae	Microlaena stipoides	Weeping Grass	5	100	10	200	2	80	0.3	20	1	50	5	300	2	100	25	1000	5	400	5	300	20	1000	0.5	30	1	100	50	2000	5	500	10	500
Poaceae	Microlaena stipoides var. stipoides																																	
Poaceae	Panicum effusum																																	
Poaceae	Panicum simile																																	
Poaceae	Paspalum distichum	Water Couch																																
Poaceae	Pennisetum alopecuroides																																	
Poaceae	Poa labillardierei var. labillardierei	Tussock	1	30	4	40	0.5	20	2	50	0.3	30	0.5	30	1	30	4	50	10	400														
Poaceae	Poa sieberiana	Snowgrass											5	100	0.5	20																		
Poaceae	Poa sieberiana var. sieberiana	Snowgrass																			30	100			80	500					1	20	1	20
Poaceae	Rytidosperma carphoides	Short Wallaby Grass																			0.1	50												
Poaceae	Rytidosperma laeve	Wallaby Grass					0.1	10					0.1	10			3	200																
Poaceae	Rytidosperma penicillatum	Slender Wallaby Grass							0.3	20			1	100	0.2	20	0.5	50	0.3	40														

Family	Scientific name	Common name	Plot 17 (HoG-Mar-08)		Plot 18 (HoG-Mar-09)		Plot 19 (HoG-Mar-10)		Plot 20 (HoG-Mar-11)		Plot 21 (HoG-Mar-12)		Plot 22 (HoG_TLC_Mar_07)		Plot 23 (HoG_TLC_Mar_06)		Plot 24 (HoG_TLC_Mar_08)		Plot 27 (34784_01)		Plot 28 (34784_02)		Plot 29 (34784_04)		Plot 30 (34784_05)		Plot 31 (34784_07)		Plot 32 (34784_13)		Plot 33 (34784_16)		Plot 34 (34784_17)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Poaceae	Anthosachne scabra	Wheatgrass, Common Wheatgrass																															0.2	20
Poaceae	Aristida lignosa																																	
Poaceae	Aristida ramosa	Purple Wiregrass																																
Poaceae	Aristida sp.																				0.2		2						2					
Poaceae	Aristida vagans	Threeawn Speargrass																																
Poaceae	Austrostipa scabra	Speargrass							0.2	10																								
Poaceae	Austrostipa verticillata	Slender Bamboo Grass											2	50			5	100																
Poaceae	Bothriochloa decipiens var. decipiens	Pitted Bluegrass																																
Poaceae	Bothriochloa macra	Red Grass											10	300	5	500	5	200					25											
Poaceae	Chloris truncata	Windmill Grass											3	50			2	50																
Poaceae	Cymbopogon refractus	Barbed Wire Grass																					5											
Poaceae	Dichelachne crinita	Longhair Plumegrass																															0.2	30
Poaceae	Dichelachne micrantha	Shorthair Plumegrass																			15													
Poaceae	Echinopogon cheelii	Long-flowered Hedgehog Grass																																
Poaceae	Echinopogon mckiei																																	
Poaceae	Echinopogon ovatus	Forest Hedgehog Grass							1	10									10				5		5.2						2		5	2000
Poaceae	Enneapogon nigricans	Niggerheads																																
Poaceae	Entolasia marginata																																	
Poaceae	Eragrostis leptostachya	Paddock Lovegrass																																
Poaceae	Eragrostis sp.																																	
Poaceae	Eriochloa pseudoacrotricha	Early Spring Grass																																
Poaceae	Imperata cylindrica	Blady Grass																					0.1											
Poaceae	Lachnagrostis aemula																																	
Poaceae	Lachnagrostis filiformis																																0.1	10
Poaceae	Microlaena stipoides	Weeping Grass	1	50	0.1	10	1	100	1	30	70	2000	2	100	3	500	40	1000									0.1	10					0.5	200
Poaceae	Microlaena stipoides var. stipoides																		5		0.5				1				15					
Poaceae	Panicum effusum																		1												1			
Poaceae	Panicum simile																																	
Poaceae	Paspalum distichum	Water Couch																															0.1	100
Poaceae	Pennisetum alopecuroides																																	
Poaceae	Poa labillardierei var. labillardierei	Tussock																	30		30		20		70				1		10			
Poaceae	Poa sieberiana	Snowgrass																	20		1						30	2000			10		20	500
Poaceae	Poa sieberiana var. sieberiana	Snowgrass	30	100	3	50	10	100	75	700	3	20	15	100	1	10	2	30																
Poaceae	Rytidosperma carphoides	Short Wallaby Grass																																
Poaceae	Rytidosperma laeve	Wallaby Grass													2	100																		
Poaceae	Rytidosperma penicillatum	Slender Wallaby Grass																																

Family	Scientific name	Common name	Plot 35 (34784_20)		Plot 36 (34784_28)		Plot 37 (34784_34)		Plot 38 (34784_42)		Plot 39 (34784_46)		Plot 40 (34784_47)		Plot 41 (34784_08)		Plot 42 (34784_09)		Plot 43 (34784_11)		Plot 44 (34784_21)		Plot 45 (34784_23)		Plot 46 (34784_27)		Plot 47 (34784_29)		Plot 48 (34784_32)		Plot 49 (34784_35)		Plot 50 (34784_45)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Poaceae	Anthosachne scabra	Wheatgrass, Common Wheatgrass	3	300									0.2	20																				
Poaceae	Aristida lignosa																																	
Poaceae	Aristida ramosa	Purple Wiregrass																																
Poaceae	Aristida sp.																						5											
Poaceae	Aristida vagans	Threeawn Speargrass																																
Poaceae	Austrostipa scabra	Speargrass																																
Poaceae	Austrostipa verticillata	Slender Bamboo Grass																																
Poaceae	Bothriochloa decipiens var. decipiens	Pitted Bluegrass																																
Poaceae	Bothriochloa macra	Red Grass									25										2		20				50		3				5	
Poaceae	Chloris truncata	Windmill Grass																																
Poaceae	Cymbopogon refractus	Barbed Wire Grass											0.5	30									0.5						0.1					
Poaceae	Dichelachne crinita	Longhair Plumegrass	0.1	10									0.1	2																				
Poaceae	Dichelachne micrantha	Shorthair Plumegrass									5										5		1											
Poaceae	Echinopogon cheelii	Long-flowered Hedgehog Grass	0.1	10	0.1	10																												
Poaceae	Echinopogon mckiei																																	
Poaceae	Echinopogon ovatus	Forest Hedgehog Grass	1	1000	0.5	1000							0.5	100			1		10		5		10						5		20		5	
Poaceae	Enneapogon nigricans	Niggerheads																																
Poaceae	Entolasia marginata																																	
Poaceae	Eragrostis leptostachya	Paddock Lovegrass																									5							
Poaceae	Eragrostis sp.										0.5																							
Poaceae	Eriochloa pseudoacrotricha	Early Spring Grass																																
Poaceae	Imperata cylindrica	Blady Grass																																
Poaceae	Lachnagrostis aemula																										1							
Poaceae	Lachnagrostis filiformis				0.5	1000											0.2								1									
Poaceae	Microlaena stipoides	Weeping Grass	0.2	100	10	1000	0.3	30	60	1000			0.5	50																				
Poaceae	Microlaena stipoides var. stipoides																5		10		0.2		10						10		5			
Poaceae	Panicum effusum										5												1											
Poaceae	Panicum simile										10						0.5										0.2							
Poaceae	Paspalum distichum	Water Couch																																
Poaceae	Pennisetum alopecuroides																								5		0.5							
Poaceae	Poa labillardierei var. labillardierei	Tussock									20						20		20		25		15		5		25		3		20		40	
Poaceae	Poa sieberiana	Snowgrass	60	2000			0.2	30					15	1000	1		10		25								1				5			
Poaceae	Poa sieberiana var. sieberiana	Snowgrass																																
Poaceae	Rytidosperma carphoides	Short Wallaby Grass																																
Poaceae	Rytidosperma laeve	Wallaby Grass																																
Poaceae	Rytidosperma penicillatum	Slender Wallaby Grass																																

Family	Scientific name	Common name	Plot 01 (HoG_Mar_13)		Plot 02 (HoG_Mar_14)		Plot 03 (HoG_Mar_15		Plot 04 (HoG_Mar_16		Plot 05 (HoG_TLC_Mar_01)		Plot 6 (HoG_TLC_Mar_02)		Plot 07 (HoG_TLC_Mar_03)		Plot 08 (HoG_TLC_Mar_04)		Plot 09 (HoG_TLC_Mar_05)		Plot 10 (HoG-Mar-01)		Plot 11 (HoG-Mar-02)		Plot 12 (HoG-Mar-03		Plot 13 (HoG-Mar-04)		Plot 14 (HoG-Mar-05)		Plot 15 (HoG-Mar-06)		Plot 16 (HoG-Mar-07)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Poaceae	Rytidosperma pilosum	Smooth-flowered Wallaby Grass																																
Poaceae	Rytidosperma racemosum	Wallaby Grass																																
Poaceae	Rytidosperma racemosum var. racemosum	Wallaby Grass													0.1	5	1	70	0.8	100														
Poaceae	Rytidosperma sp.																																	
Poaceae	Rytidosperma spp.																																	
Poaceae	Sorghum leiocladum	Wild Sorghum											0.1	2	0.5	50																		
Poaceae	Sporobolus creber																																	
Poaceae	Themeda triandra																																	
Polygalaceae	Polygala japonica	Dwarf Milkwort											0.1	10																				
Polygonaceae	Persicaria decipiens	Slender Knotweed																																
Polygonaceae	Persicaria hydropiper	Water Pepper																																
Polygonaceae	Rumex brownii	Swamp Dock	1	10	0.1	1	0.2	3	0.2	5	0.1	1					0.3	5	0.1	1									1	50				
Portulacaceae	Portulaca oleracea	Pigweed															0.1	1	0.1	1														
Proteaceae	Lomatia arborescens	Tree Lomatia																					10	10							5	2		
Pteridaceae	Cheilanthes sieberi																																	
Pteridaceae	Cheilanthes sieberi subsp. Sieberi	Rock Fern							0.1	1			0.2	6	0.1	10																		
Ranunculaceae	Clematis aristata	Old Man's Beard																	0.1	2														
Ranunculaceae	Clematis glycinoides	Headache Vine													0.2	7																		
Ranunculaceae	Ranunculus lappaceus																																	
Ranunculaceae	Ranunculus sessiliflorus	Small-flowered Buttercup											0.1	1																				
Rosaceae	Acaena novae-zelandiae	Bidgee-widgee			25	200			0.1	1							0.1	10									0.2	40					0.1	30
Rosaceae	Acaena ovina	Acaena															0.2	10	0.1	6														
Rosaceae	Rubus parvifolius	Native Raspberry							0.3	20	0.1	2	0.2	10	0.8	10	0.3	4	0.8	20	0.5	10			0.1	5	0.1	30						
Rubiaceae	Asperula conferta	Common Woodruff					0.1	20	0.2	30			1	200	0.2	30	5	1000	0.1	1	0.1	100			0.1	50	0.5	200						
Rubiaceae	Asperula scoparia								0.1	1																								
Rubiaceae	Coprosma quadrifida	Prickly Currant Bush																			5	10			2	10	0.2	1						
Rubiaceae	Galium binifolium																																	
Rubiaceae	Galium binifolium subsp. Binifolium																																	
Rubiaceae	Galium ciliare										0.2	60							0.1	10														
Rubiaceae	Galium gaudichaudii	Rough Bedstraw																			0.1	50			0.1	50	0.1	20					0.3	50
Rubiaceae	Galium gaudichaudii subsp. gaudichaudii																																	
Rubiaceae	Galium leiocarpum												0.1	10	0.2	10															0.1	50		
Rubiaceae	Galium leptogonium						0.3	80	0.1	10	0.1	3			0.2	20			0.2	10														
Rubiaceae	Galium sp. 2																																	
Rubiaceae	Morinda jasminoides																																	
Santalaceae	Exocarpos cupressiformis	Cherry Ballart																	2	1														
Sapindaceae	Dodonaea viscosa subsp. Spatulata	Broad-leaf Hopbush																																
Smilacaceae	Smilax australis	Lawyer Vine																			1	20	5	30			0.2	30			3	10		
Solanaceae	Solanum aviculare	Kangaroo Apple					0.5	6											0.2	2														

Family	Scientific name	Common name	Plot 17 (HoG-Mar-08)		Plot 18 (HoG-Mar-09)		Plot 19 (HoG-Mar-10)		Plot 20 (HoG-Mar-11)		Plot 21 (HoG-Mar-12)		Plot 22 (HoG_TLC_Mar_07)		Plot 23 (HoG_TLC_Mar_06)		Plot 24 (HoG_TLC_Mar_08)		Plot 27 (34784_01)		Plot 28 (34784_02)		Plot 29 (34784_04)		Plot 30 (34784_05)		Plot 31 (34784_07)		Plot 32 (34784_13)		Plot 33 (34784_16)		Plot 34 (34784_17)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Poaceae	Rytidosperma pilosum	Smooth-flowered Wallaby Grass															1	50																
Poaceae	Rytidosperma racemosum	Wallaby Grass																															0.1	10
Poaceae	Rytidosperma racemosum var. racemosum	Wallaby Grass																			0.1				0.1									
Poaceae	Rytidosperma sp.																		0.5				0.5											
Poaceae	Rytidosperma spp.																																	
Poaceae	Sorghum leiocladum	Wild Sorghum																																
Poaceae	Sporobolus creber																																	
Poaceae	Themeda triandra																						20											
Polygalaceae	Polygala japonica	Dwarf Milkwort																																
Polygonaceae	Persicaria decipiens	Slender Knotweed																																
Polygonaceae	Persicaria hydropiper	Water Pepper																															0.2	30
Polygonaceae	Rumex brownii	Swamp Dock											0.5	5	1	20	1	20																
Portulacaceae	Portulaca oleracea	Pigweed																																
Proteaceae	Lomatia arborescens	Tree Lomatia							2	10																								
Pteridaceae	Cheilanthes sieberi																						0.2											
Pteridaceae	Cheilanthes sieberi subsp. Sieberi	Rock Fern																																
Ranunculaceae	Clematis aristata	Old Man's Beard																			0.1		0.5						1					
Ranunculaceae	Clematis glycinoides	Headache Vine																																
Ranunculaceae	Ranunculus lappaceus																																	
Ranunculaceae	Ranunculus sessiliflorus	Small-flowered Buttercup																																
Rosaceae	Acaena novae-zelandiae	Bidgee-widgee	0.1	10			0.5	20	0.5	10	0.5	20	0.5	10	0.1	5					0.5				1						0.2		0.2	50
Rosaceae	Acaena ovina	Acaena																																
Rosaceae	Rubus parvifolius	Native Raspberry									0.5	5			0.2	5			2		0.2		0.5		0.5				1				0.1	5
Rubiaceae	Asperula conferta	Common Woodruff					0.5	100	0.5	40			0.1	10					0.1		0.1		0.1		0.1		0.1	10	1		0.1			
Rubiaceae	Asperula scoparia																																	
Rubiaceae	Coprosma quadrifida	Prickly Currant Bush																			0.5												0.1	1
Rubiaceae	Galium binifolium																										0.1	2						
Rubiaceae	Galium binifolium subsp. Binifolium																																0.1	2
Rubiaceae	Galium ciliare																																	
Rubiaceae	Galium gaudichaudii	Rough Bedstraw									1	30																						
Rubiaceae	Galium gaudichaudii subsp. gaudichaudii																																0.1	20
Rubiaceae	Galium leiocarpum						2	100																										
Rubiaceae	Galium leptogonium																																0.1	10
Rubiaceae	Galium sp. 2																												0.1		0.1			
Rubiaceae	Morinda jasminoides																						0.1						0.1					
Santalaceae	Exocarpos cupressiformis	Cherry Ballart																	0.1				0.1											
Sapindaceae	Dodonaea viscosa subsp. Spatulata	Broad-leaf Hopbush													10	20																		
Smilacaceae	Smilax australis	Lawyer Vine	0.5	10	0.5	4	0.1	5											0.1								0.1	1					0.1	5
Solanaceae	Solanum aviculare	Kangaroo Apple			0.5	5																							0.1		0.2			

Family	Scientific name	Common name	Plot 35 (34784_20)		Plot 36 (34784_28)		Plot 37 (34784_34)		Plot 38 (34784_42)		Plot 39 (34784_46)		Plot 40 (34784_47)		Plot 41 (34784_08)		Plot 42 (34784_09)		Plot 43 (34784_11)		Plot 44 (34784_21)		Plot 45 (34784_23)		Plot 46 (34784_27)		Plot 47 (34784_29)		Plot 48 (34784_32)		Plot 49 (34784_35)		Plot 50 (34784_45)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Poaceae	Rytidosperma pilosum	Smooth-flowered Wallaby Grass																																
Poaceae	Rytidosperma racemosum	Wallaby Grass	5	500									5	500																				
Poaceae	Rytidosperma racemosum var. racemosum	Wallaby Grass									0.2										0.1													
Poaceae	Rytidosperma sp.										10						0.5				5								1		2			
Poaceae	Rytidosperma spp.				0.1	20																												
Poaceae	Sorghum leiocladum	Wild Sorghum																																
Poaceae	Sporobolus creber										1																							
Poaceae	Themeda triandra		0.2	100									0.5	30							15		35						10					
Polygalaceae	Polygala japonica	Dwarf Milkwort																																
Polygonaceae	Persicaria decipiens	Slender Knotweed			0.1	30																			3									
Polygonaceae	Persicaria hydropiper	Water Pepper																							2		0.2							
Polygonaceae	Rumex brownii	Swamp Dock			0.1	10	0.1	1							3				0.1						2		0.5							
Portulacaceae	Portulaca oleracea	Pigweed																																
Proteaceae	Lomatia arborescens	Tree Lomatia																																
Pteridaceae	Cheilanthes sieberi		0.1	10																			0.1											
Pteridaceae	Cheilanthes sieberi subsp. Sieberi	Rock Fern																																
Ranunculaceae	Clematis aristata	Old Man's Beard											0.1	2			0.1				0.1		0.5						1		0.5			
Ranunculaceae	Clematis glycinoides	Headache Vine	0.1	20									0.1	30																				
Ranunculaceae	Ranunculus lappaceus																								0.1									
Ranunculaceae	Ranunculus sessiliflorus	Small-flowered Buttercup																																
Rosaceae	Acaena novae-zelandiae	Bidgee-widgee													0.5		0.5		1		0.1										0.5		0.5	
Rosaceae	Acaena ovina	Acaena																																
Rosaceae	Rubus parvifolius	Native Raspberry					0.1	10									0.2		0.5				0.2						0.5		0.1			
Rubiaceae	Asperula conferta	Common Woodruff							0.2	500	0.1						0.1				0.2		0.1								0.1		1	
Rubiaceae	Asperula scoparia																																	
Rubiaceae	Coprosma quadrifida	Prickly Currant Bush					20	500																										
Rubiaceae	Galium binifolium		0.2	200																														
Rubiaceae	Galium binifolium subsp. Binifolium						0.1	30					0.1	50																				
Rubiaceae	Galium ciliare		0.1	2																														
Rubiaceae	Galium gaudichaudii	Rough Bedstraw							0.1	10																								
Rubiaceae	Galium gaudichaudii subsp. gaudichaudii																																	
Rubiaceae	Galium leiocarpum																																	
Rubiaceae	Galium leptogonium						0.1	20																										
Rubiaceae	Galium sp. 2																														0.1			
Rubiaceae	Morinda jasminoides																												0.1		0.1			
Santalaceae	Exocarpos cupressiformis	Cherry Ballart	1	1									0.1	1							0.1		0.1						0.5				0.1	
Sapindaceae	Dodonaea viscosa subsp. Spatulata	Broad-leaf Hopbush																																
Smilacaceae	Smilax australis	Lawyer Vine					0.2	20							0.1		0.5		0.5				0.1								0.1			
Solanaceae	Solanum aviculare	Kangaroo Apple																	0.1												1			

Family	Scientific name	Common name	Plot 01 (HoG_Mar_13)		Plot 02 (HoG_Mar_14)		Plot 03 (HoG_Mar_15		Plot 04 (HoG_Mar_16		Plot 05 (HoG_TLC_Mar_01)		Plot 6 (HoG_TLC_Mar_02)		Plot 07 (HoG_TLC_Mar_03)		Plot 08 (HoG_TLC_Mar_04)		Plot 09 (HoG_TLC_Mar_05)		Plot 10 (HoG-Mar-01)		Plot 11 (HoG-Mar-02)		Plot 12 (HoG-Mar-03		Plot 13 (HoG-Mar-04)		Plot 14 (HoG-Mar-05)		Plot 15 (HoG-Mar-06)		Plot 16 (HoG-Mar-07)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Solanaceae	Solanum linearifolium	Mountain Kangaroo Apple																																
Solanaceae	Solanum papaverifolium																																	
Solanaceae	Solanum prinophyllum	Forest Nightshade																					1	10	0.1	5			0.1	20	2	30		
Solanaceae	Solanum pungetium	Eastern Nightshade																																
Solanaceae	Solanum sp.	A Nightshade																																
Sterculiaceae	Brachychiton populneus subsp. Populneus																																	
Thymelaeaceae	Pimelea curviflora var. divergens												0.2	20			0.9	70	0.1	1														
Thymelaeaceae	Pimelea curviflora var. gracilis												0.7	60			0.2	40																
Thymelaeaceae	Pimelea linifolia																																	
Urticaceae	Urtica incisa	Stinging Nettle	0.5	10			0.5	40			0.2	10									0.1	3	20	300	0.5	10	1	20	10	200	70	500	2	50
Violaceae	Hybanthus monopetalus	Slender Violet-bush																																
Violaceae	Melicytus dentatus	Tree Violet					20	40			0.1	1							0.7	1	1	5	60	50	3	7	10	10			1	3		
Violaceae	Viola betonicifolia								0.1	3	0.1	4	0.5	50	0.1	10			0.1	3	1	50			1	100	0.5	30						
Violaceae	Viola hederacea	Ivy-leaved Violet																																
Violaceae	Viola sp.																																	
Zamiaceae	Macrozamia concinna																																	
	Rainforest species																																	
	Rainforest sp.																																	
Introduced Species																																		
Amaranthaceae	Amaranthus viridis	Green Amaranth	0.1	1																														
Amygdalaceae	Prunus avium																		0.1	1														
Apiaceae	Cyclospermum leptophyllum	Slender Celery					0.1	5									0.1	10	0.2	20														
Apocynaceae	Gomphocarpus fruticosus	Narrow-leaved Cotton Bush																																
Asteraceae	Ambrosia artemisifolia	Annual Ragweed																																
Asteraceae	Bidens pilosa	Cobbler's Pegs							1	50			0.1	10	20	200			0.1	10														
Asteraceae	Bidens sp.																																	
Asteraceae	Bidens subalternans	Greater Beggar's Ticks					1	50	0.1	1																								
Asteraceae	Bidens tripartita						3	100																										
Asteraceae	Carthamus lanatus	Saffron Thistle					0.1	2									0.1	3																
Asteraceae	Centaurea spp.	Thistle																					0.1	5										
Asteraceae	Cirsium spp.																								0.1	20								
Asteraceae	Cirsium vulgare	Spear Thistle	2	40	2	40	0.3	10	0.2	30	5	50			0.1	10	2	50	0.2	30							0.1	5	1	100	0.1	10	1	20
Asteraceae	Conyza bonariensis	Flaxleaf Fleabane			2	30											1	100	0.1	10														
Asteraceae	Conyza parva	Fleabane															0.1	10																
Asteraceae	Conyza sp.																																	
Asteraceae	Gamochaeta purpurea	Purple Cudweed															0.1	6																
Asteraceae	Hypochaeris radicata	Catsear	0.2	10	2	40			0.1	1	0.1	1	0.1	4	0.1	2	1	80	0.2	20	0.5	20	0.1	10	0.2	10	0.1	10					1	20
Asteraceae	Senecio madagascariensis	Fireweed			0.1	1																												
Asteraceae	Sonchus asper										0.1	10																						
Asteraceae	Sonchus oleraceus	Common Sowthistle					0.1	2					0.1	1					0.3	40														
Asteraceae	Sonchus sp.																																	

Family	Scientific name	Common name	Plot 17 (HoG-Mar-08)		Plot 18 (HoG-Mar-09)		Plot 19 (HoG-Mar-10)		Plot 20 (HoG-Mar-11)		Plot 21 (HoG-Mar-12)		Plot 22 (HoG_TLC_Mar_07)		Plot 23 (HoG_TLC_Mar_06)		Plot 24 (HoG_TLC_Mar_08)		Plot 27 (34784_01)		Plot 28 (34784_02)		Plot 29 (34784_04)		Plot 30 (34784_05)		Plot 31 (34784_07)		Plot 32 (34784_13)		Plot 33 (34784_16)		Plot 34 (34784_17)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Solanaceae	Solanum linearifolium	Mountain Kangaroo Apple																																
Solanaceae	Solanum papaverifolium														0.5	10	0.5	5																
Solanaceae	Solanum prinophyllum	Forest Nightshade			0.5	10	0.5	10																										
Solanaceae	Solanum pungetium	Eastern Nightshade																																
Solanaceae	Solanum sp.	A Nightshade																	0.5		0.1				0.1				2		0.2			
Sterculiaceae	Brachychiton populneus subsp. Populneus																																	
Thymelaeaceae	Pimelea curviflora var. divergens																																	
Thymelaeaceae	Pimelea curviflora var. gracilis																																	
Thymelaeaceae	Pimelea linifolia																						0.1								0.1			
Urticaceae	Urtica incisa	Stinging Nettle	10	50	0.5	10					5	20	1	6	1	10	30	100			0.1				0.1				0.1		0.2			
Violaceae	Hybanthus monopetalus	Slender Violet-bush																									0.1	1						
Violaceae	Melicytus dentatus	Tree Violet	8	7	3	20					0.5	10	3	2	10	50	50	40			0.3								1				0.1	5
Violaceae	Viola betonicifolia						0.5	20	0.5	30	1	30							0.5		0.1		0.1										0.1	2
Violaceae	Viola hederacea	Ivy-leaved Violet	0.5	20			0.1	20	0.1	20																								
Violaceae	Viola sp.																																	
Zamiaceae	Macrozamia concinna																																	
	Rainforest species																																	
	Rainforest sp.																																	
Introduced Species																																		
Amaranthaceae	Amaranthus viridis	Green Amaranth																																
Amygdalaceae	Prunus avium																																	
Apiaceae	Cyclospermum leptophyllum	Slender Celery																															0.1	2
Apocynaceae	Gomphocarpus fruticosus	Narrow-leaved Cotton Bush																																
Asteraceae	Ambrosia artemisiifolia	Annual Ragweed																																
Asteraceae	Bidens pilosa	Cobbler's Pegs			0.2	20	0.1	20	0.1	5							0.1	5																
Asteraceae	Bidens sp.																						0.2						5		0.5			
Asteraceae	Bidens subalternans	Greater Beggar's Ticks																																
Asteraceae	Bidens tripartita																																	
Asteraceae	Carthamus lanatus	Saffron Thistle																																
Asteraceae	Centaurea spp.	Thistle																																
Asteraceae	Cirsium spp.																																	
Asteraceae	Cirsium vulgare	Spear Thistle	1	10	1	30	1	50	0.1	10	1	30			1	10	1	10	0.5		0.1		0.1				0.1	5	0.5		0.5		0.1	10
Asteraceae	Conyza bonariensis	Flaxleaf Fleabane					0.5	10																			0.1	1					0.1	1
Asteraceae	Conyza parva	Fleabane																																
Asteraceae	Conyza sp.																		1		0.2				0.2				1		1			
Asteraceae	Gamochaeta purpurea	Purple Cudweed																																
Asteraceae	Hypochaeris radicata	Catsear							1	10					1	30			0.5		0.2		0.1		0.2		0.1	1	0.5		0.1		0.1	10
Asteraceae	Senecio madagascariensis	Fireweed																																
Asteraceae	Sonchus asper																																	
Asteraceae	Sonchus oleraceus	Common Sowthistle																																
Asteraceae	Sonchus sp.																																	

Family	Scientific name	Common name	Plot 35 (34784_20)		Plot 36 (34784_28)		Plot 37 (34784_34)		Plot 38 (34784_42)		Plot 39 (34784_46)		Plot 40 (34784_47)		Plot 41 (34784_08)		Plot 42 (34784_09)		Plot 43 (34784_11)		Plot 44 (34784_21)		Plot 45 (34784_23)		Plot 46 (34784_27)		Plot 47 (34784_29)		Plot 48 (34784_32)		Plot 49 (34784_35)		Plot 50 (34784_45)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Solanaceae	Solanum linearifolium	Mountain Kangaroo Apple	0.1	1																														
Solanaceae	Solanum papaverifolium																																	
Solanaceae	Solanum prinophyllum	Forest Nightshade					0.1	1									0.1																	
Solanaceae	Solanum pungetium	Eastern Nightshade	0.1	10									0.1	2																				
Solanaceae	Solanum sp.	A Nightshade									0.1						0.1		0.2		0.1				0.1				0.1		0.1		0.1	
Sterculiaceae	Brachychiton populneus subsp. Populneus																																0.1	
Thymelaeaceae	Pimelea curviflora var. divergens																																	
Thymelaeaceae	Pimelea curviflora var. gracilis																																	
Thymelaeaceae	Pimelea linifolia																																	
Urticaceae	Urtica incisa	Stinging Nettle					0.5	200					0.1	2	0.1				0.1						0.1								0.1	
Violaceae	Hybanthus monopetalus	Slender Violet-bush																	0.1															
Violaceae	Melicytus dentatus	Tree Violet					10	30									0.2		4										0.2		5		0.1	
Violaceae	Viola betonicifolia														0.1		1		0.2												0.2		0.1	
Violaceae	Viola hederacea	Ivy-leaved Violet																	2															
Violaceae	Viola sp.																		0.1															
Zamiaceae	Macrozamia concinna		0.1	2																														
	Rainforest species						0.3	1																										
	Rainforest sp.						0.1	1																										
Introduced Species																																		
Amaranthaceae	Amaranthus viridis	Green Amaranth																																
Amygdalaceae	Prunus avium																																	
Apiaceae	Cyclospermum leptophyllum	Slender Celery																																
Apocynaceae	Gomphocarpus fruticosus	Narrow-leaved Cotton Bush											0.1	1																				
Asteraceae	Ambrosia artemisifolia	Annual Ragweed																					0.1											
Asteraceae	Bidens pilosa	Cobbler's Pegs	0.1	2									0.1	5																				
Asteraceae	Bidens sp.										0.1										0.1		0.2						0.2					
Asteraceae	Bidens subalternans	Greater Beggar's Ticks	0.1	2									0.1	1																				
Asteraceae	Bidens tripartita																																	
Asteraceae	Carthamus lanatus	Saffron Thistle															0.1				0.1													
Asteraceae	Centaurea spp.	Thistle																																
Asteraceae	Cirsium spp.																																	
Asteraceae	Cirsium vulgare	Spear Thistle			0.1	1	0.1	20	0.1	10			0.1	10	0.5		0.3		0.1		0.1				0.2						0.1			
Asteraceae	Conyza bonariensis	Flaxleaf Fleabane	0.1	20	0.1	2	0.1	1					0.1	10																				
Asteraceae	Conyza parva	Fleabane																																
Asteraceae	Conyza sp.										0.1										0.1		0.1		0.2		0.1		0.2		0.1		0.5	
Asteraceae	Gamochaeta purpurea	Purple Cudweed																																
Asteraceae	Hypochaeris radicata	Catsear			0.1	10			0.1	10							0.5		0.5				0.3		0.5		0.5		0.2				0.1	
Asteraceae	Senecio madagascariensis	Fireweed																																
Asteraceae	Sonchus asper																																	
Asteraceae	Sonchus oleraceus	Common Sowthistle																																
Asteraceae	Sonchus sp.														0.2																			

Family	Scientific name	Common name	Plot 01 (HoG_Mar_13)		Plot 02 (HoG_Mar_14)		Plot 03 (HoG_Mar_15		Plot 04 (HoG_Mar_16		Plot 05 (HoG_TLC_Mar_01)		Plot 6 (HoG_TLC_Mar_02)		Plot 07 (HoG_TLC_Mar_03)		Plot 08 (HoG_TLC_Mar_04)		Plot 09 (HoG_TLC_Mar_05)		Plot 10 (HoG-Mar-01)		Plot 11 (HoG-Mar-02)		Plot 12 (HoG-Mar-03		Plot 13 (HoG-Mar-04)		Plot 14 (HoG-Mar-05)		Plot 15 (HoG-Mar-06)		Plot 16 (HoG-Mar-07)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Asteraceae	Tagetes minuta	Stinking Roger			40	200	4	100	0.3	7																								
Asteraceae	Taraxacum officinale	Dandelion	0.1	7													0.5	40																
Asteraceae	Xanthium spinosum	Bathurst Burr																																
Boraginaceae	Echium plantagineum	Patterson's Curse																																
Brassicaceae	Brassica juncea	Indian Mustard																																
Brassicaceae	Brassica napus	Canola	0.1	2																														
Brassicaceae	Brassica spp.	Brassica																															0.1	20
Brassicaceae	Brassicaceae indeterminate	Mustards																							0.1	2								
Brassicaceae	Capsella bursa	pastoris*																																
Brassicaceae	Raphanus raphanistrum						0.1	2																										
Brassicaceae	Rapistrum rugosum	Turnip Weed	1	50																														
Caprifoliaceae	Lonicera japonica																																	
Caryophyllaceae	Cerastium glomeratum	Mouse-ear Chickweed	0.3	10							0.1	1																						
Caryophyllaceae	Cerastium spp.																						0.5	100							0.2	300		
Caryophyllaceae	Cerastium vulgare	Mouse-ear Chickweed					1	50	0.2	50																								
Caryophyllaceae	Petrorhagia prolifera	Proliferous Pink																																
Caryophyllaceae	Silene latifolia subsp. Alba						0.1	4	0.1	1																								
Caryophyllaceae	Stellaria media																																	
Clusiaceae	Hypericum perforatum																																	
Cyperaceae	Cyperus brevifolius																																	
Fabaceae (Faboideae)	Medicago lupulina	Black Medic											0.1	3																				
Fabaceae (Faboideae)	Trifolium campestre	Hop Clover															0.3	50																
Fabaceae (Faboideae)	Trifolium pratense																																	
Fabaceae (Faboideae)	Trifolium repens	White Clover	0.1	2	0.5	10	0.2	20			0.1	2	0.1	20	0.1	5	0.2	20	0.1	7			0.1	20			0.1	20					0.1	50
Fabaceae (Faboideae)	Trifolium spp.	A Clover																							0.1	10								
Fabaceae (Faboideae)	Trifolium subterraneum	Subterranean Clover																																
Fabaceae (Faboideae)	Vicia hirsuta	Hairy Vetch																																
Gentianaceae	Centaurium tenuiflorum	Branched Centaury, Slender centaury																																
Iridaceae	Romulea sp.																																	
Lamiaceae	Lamium amplexicaule	Dead Nettle	0.1	1																														
Lamiaceae	Marrubium vulgare	White Horehound			0.2	2	0.1	10	0.1	2					0.1	1																		
Linaceae	Linum trigynum																																	
Malvaceae	Modiola caroliniana	Red-flowered Mallow	0.2	8	3	100	0.1	2	0.1	1																								
Oleaceae	Ligustrum lucidum	Large-leaved Privet																																
Oleaceae	Ligustrum sinense	Small-leaved Privet													0.1	1																		
Phyllanthaceae	Phyllanthus sp.																																	
Phytolaccaceae	Phytolacca octandra	Inkweed	0.9	20	5	100	0.1	1	0.3	40	0.1	3	0.1	1	0.1	10			0.1	10					1	50								
Pinaceae	Pinus sp.																																	

Family	Scientific name	Common name	Plot 17 (HoG-Mar-08)		Plot 18 (HoG-Mar-09)		Plot 19 (HoG-Mar-10)		Plot 20 (HoG-Mar-11)		Plot 21 (HoG-Mar-12)		Plot 22 (HoG_TLC_Mar_07)		Plot 23 (HoG_TLC_Mar_06)		Plot 24 (HoG_TLC_Mar_08)		Plot 27 (34784_01)		Plot 28 (34784_02)		Plot 29 (34784_04)		Plot 30 (34784_05)		Plot 31 (34784_07)		Plot 32 (34784_13)		Plot 33 (34784_16)		Plot 34 (34784_17)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Asteraceae	Tagetes minuta	Stinking Roger			1	30																							0.1					
Asteraceae	Taraxacum officinale	Dandelion																																
Asteraceae	Xanthium spinosum	Bathurst Burr																																
Boraginaceae	Echium plantagineum	Patterson's Curse					0.5	5																										
Brassicaceae	Brassica juncea	Indian Mustard			0.5	10											0.1	2																
Brassicaceae	Brassica napus	Canola																																
Brassicaceae	Brassica spp.	Brassica																																
Brassicaceae	Brassicaceae indeterminate	Mustards																																
Brassicaceae	Capsella bursa	pastoris*																																
Brassicaceae	Raphanus raphanistrum																																	
Brassicaceae	Rapistrum rugosum	Turnip Weed																																
Caprifoliaceae	Lonicera japonica																								2									
Caryophyllaceae	Cerastium glomeratum	Mouse-ear Chickweed																																
Caryophyllaceae	Cerastium spp.		0.1	100	5	100					0.1	50			0.5	50	1	50																
Caryophyllaceae	Cerastium vulgare	Mouse-ear Chickweed																																
Caryophyllaceae	Petrorhagia prolifera	Proliferous Pink																																
Caryophyllaceae	Silene latifolia subsp. Alba																																	
Caryophyllaceae	Stellaria media																												0.1					
Clusiaceae	Hypericum perforatum																																	
Cyperaceae	Cyperus brevifolius																								0.1									
Fabaceae (Faboideae)	Medicago lupulina	Black Medic																																
Fabaceae (Faboideae)	Trifolium campestre	Hop Clover																																
Fabaceae (Faboideae)	Trifolium pratense																						1						0.2					
Fabaceae (Faboideae)	Trifolium repens	White Clover			0.1	30	1	50					1	100	0.5	20			0.5		1		0.5		0.1		0.1	5	2				0.2	100
Fabaceae (Faboideae)	Trifolium spp.	A Clover																																
Fabaceae (Faboideae)	Trifolium subterraneum	Subterranean Clover																															0.3	1000
Fabaceae (Faboideae)	Vicia hirsuta	Hairy Vetch																																
Gentianaceae	Centaurium tenuiflorum	Branched Centaury, Slender centaury																																
Iridaceae	Romulea sp.																																	
Lamiaceae	Lamium amplexicaule	Dead Nettle									0.5	20																						
Lamiaceae	Marrubium vulgare	White Horehound																																
Linaceae	Linum trigynum																																	
Malvaceae	Modiola caroliniana	Red-flowered Mallow																															0.1	10
Oleaceae	Ligustrum lucidum	Large-leaved Privet																																
Oleaceae	Ligustrum sinense	Small-leaved Privet																																
Phyllanthaceae	Phyllanthus sp.																		0.1															
Phytolaccaceae	Phytolacca octandra	Inkweed	0.1	10	1	10	0.1	5			0.1	10			0.5	10	2	30											1		0.2			
Pinaceae	Pinus sp.																																	

Family	Scientific name	Common name	Plot 35 (34784_20)		Plot 36 (34784_28)		Plot 37 (34784_34)		Plot 38 (34784_42)		Plot 39 (34784_46)		Plot 40 (34784_47)		Plot 41 (34784_08)		Plot 42 (34784_09)		Plot 43 (34784_11)		Plot 44 (34784_21)		Plot 45 (34784_23)		Plot 46 (34784_27)		Plot 47 (34784_29)		Plot 48 (34784_32)		Plot 49 (34784_35)		Plot 50 (34784_45)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Asteraceae	Tagetes minuta	Stinking Roger			0.1	2																									0.1			
Asteraceae	Taraxacum officinale	Dandelion									0.1						0.1		0.1						0.1									
Asteraceae	Xanthium spinosum	Bathurst Burr			0.1	2																			0.1		0.1							
Boraginaceae	Echium plantagineum	Patterson's Curse																																
Brassicaceae	Brassica juncea	Indian Mustard																																
Brassicaceae	Brassica napus	Canola																																
Brassicaceae	Brassica spp.	Brassica																																
Brassicaceae	Brassicaceae indeterminate	Mustards																																
Brassicaceae	Capsella bursa	pastoris*																																
Brassicaceae	Raphanus raphanistrum																																	
Brassicaceae	Rapistrum rugosum	Turnip Weed																																
Caprifoliaceae	Lonicera japonica																																	
Caryophyllaceae	Cerastium glomeratum	Mouse-ear Chickweed					0.1	1																										
Caryophyllaceae	Cerastium spp.																																	
Caryophyllaceae	Cerastium vulgare	Mouse-ear Chickweed	0.1	1																														
Caryophyllaceae	Petrorhagia prolifera	Proliferous Pink	0.1	1																														
Caryophyllaceae	Silene latifolia subsp. Alba																																	
Caryophyllaceae	Stellaria media																																0.1	
Clusiaceae	Hypericum perforatum										10												5						0.5					
Cyperaceae	Cyperus brevifolius																0.2				0.5						1				0.1		2	
Fabaceae (Faboideae)	Medicago lupulina	Black Medic																																
Fabaceae (Faboideae)	Trifolium campestre	Hop Clover																																
Fabaceae (Faboideae)	Trifolium pratense																										0.3							
Fabaceae (Faboideae)	Trifolium repens	White Clover			5	1000	0.2	100	0.1	100					1		1						0.1		10		10		0.1		1			
Fabaceae (Faboideae)	Trifolium spp.	A Clover																																
Fabaceae (Faboideae)	Trifolium subterraneum	Subterranean Clover																																
Fabaceae (Faboideae)	Vicia hirsuta	Hairy Vetch	0.1	1									0.1	1																				
Gentianaceae	Centaurium tenuiflorum	Branched Centaury, Slender centaury	0.1	10																														
Iridaceae	Romulea sp.														0.1																			
Lamiaceae	Lamium amplexicaule	Dead Nettle																																
Lamiaceae	Marrubium vulgare	White Horehound																																
Linaceae	Linum trigynum																																0.5	
Malvaceae	Modiola caroliniana	Red-flowered Mallow	0.1	1					0.1	3																								
Oleaceae	Ligustrum lucidum	Large-leaved Privet											0.1	1																				
Oleaceae	Ligustrum sinense	Small-leaved Privet																																
Phyllanthaceae	Phyllanthus sp.																																	
Phytolaccaceae	Phytolacca octandra	Inkweed	0.1	20			0.1	1					0.1	10	0.5						0.1										1		0.1	
Pinaceae	Pinus sp.																				2													

Family	Scientific name	Common name	Plot 01 (HoG_Mar_13)		Plot 02 (HoG_Mar_14)		Plot 03 (HoG_Mar_15)		Plot 04 (HoG_Mar_16)		Plot 05 (HoG_TLC_Mar_01)		Plot 6 (HoG_TLC_Mar_02)		Plot 07 (HoG_TLC_Mar_03)		Plot 08 (HoG_TLC_Mar_04)		Plot 09 (HoG_TLC_Mar_05)		Plot 10 (HoG-Mar-01)		Plot 11 (HoG-Mar-02)		Plot 12 (HoG-Mar-03		Plot 13 (HoG-Mar-04)		Plot 14 (HoG-Mar-05)		Plot 15 (HoG-Mar-06)		Plot 16 (HoG-Mar-07)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Plantaginaceae	Plantago lanceolata	Lamb's Tongues															0.2	2	0.1	1														
Poaceae	Anthoxanthum odoratum	Sweet Vernal Grass																																
Poaceae	Avena sp.																																	
Poaceae	Axonopus compressus	Broad-leaved Carpet Grass			5	100											5	200																
Poaceae	Bromus catharticus	Praire Grass	70	500			0.5	20	2	60									0.2	10														
Poaceae	Bromus sp.																																	
Poaceae	Cenchrus clandestinus	Kikuyu Grass																			1	40	1	30	0.2	30	10	300						
Poaceae	Dactylis glomerata	Cocksfoot															0.2	10	1	80														
Poaceae	Echinochloa crusgalli	Barnyard Grass																																
Poaceae	Ehrharta calycina	Perennial Veldtgrass																			3	50												
Poaceae	Ehrharta erecta																																	
Poaceae	Eleusine tristachya																																	
Poaceae	Holcus lanatus	Yorkshire Fog	2	50																							0.1	10						
Poaceae	Lolium multiflorum	Italian Ryegrass	15	200			3	100	1	30																								
Poaceae	Lolium perenne	Perennial Ryegrass																																
Poaceae	Lolium sp.																																	
Poaceae	Lolium spp.	A Ryegrass																																
Poaceae	Panicum gilvum																																	
Poaceae	Paspalum dilatatum	Paspalum													0.5	10	0.5	30	0.2	7														
Poaceae	Paspalum urvillei	Vasey Grass																	0.2	10														
Poaceae	Poa annua																																	
Poaceae	Poaceae indeterminate	Grasses, reeds and bamboos																																
Poaceae	Setaria parviflora																0.2	8																
Poaceae	Sporobolus africanus																																	
Poaceae	Vulpia bromoides	Squirrel Tail Fesque																							0.1	20								
Polygonaceae	Acetosella vulgaris	Sheep Sorrel																																
Polygonaceae	Polygonum aviculare	Wireweed	0.1	1	0.1	1																												
Polygonaceae	Rumex obtusifolius	Broadleaf Dock	0.2	3			0.4	8	0.1	3			0.1	1					0.1	4														
Primulaceae	Lysimachia arvensis	Scarlet Pimpernel			0.2	20	0.1	1					0.1	1	0.1	20	0.2	60	0.1	1														
Rosaceae	Rosa rubiginosa	Sweet Briar													0.1	1																		
Rosaceae	Rubus fruticosus sp. agg.	Blackberry complex			0.1	1	0.1	1			0.1	2	0.1	5	2	20			1	20													0.1	1
Rubiaceae	Galium aparine	Goosegrass					2	100																										
Rubiaceae	Galium divaricatum	Slender Bedstraw	0.2	10			0.1	7					0.1	3																				
Rubiaceae	Galium spurium																		0.7	40														
Rutaceae	Rutaceae indeterminate																										0.5	100						
Salicaceae	Populus sp.																																	
Scrophulariaceae	Parentucellia latifolia	Red Bartsia																																
Scrophulariaceae	Verbascum blattaria										0.1	2																						
Scrophulariaceae	Verbascum thapsus subsp. Thapsus	Great Mullein																																
Scrophulariaceae	Verbascum virgatum	Twiggy Mullein															0.1	1	0.1	1														
Solanaceae	Solanum chenopodioides						4	100	5	70	30	100	0.1	3	0.3	10	0.3	30	1	50														

Family	Scientific name	Common name	Plot 17 (HoG-Mar-08)		Plot 18 (HoG-Mar-09)		Plot 19 (HoG-Mar-10)		Plot 20 (HoG-Mar-11)		Plot 21 (HoG-Mar-12)		Plot 22 (HoG_TLC_Mar_07)		Plot 23 (HoG_TLC_Mar_06)		Plot 24 (HoG_TLC_Mar_08)		Plot 27 (34784_01)		Plot 28 (34784_02)		Plot 29 (34784_04)		Plot 30 (34784_05)		Plot 31 (34784_07)		Plot 32 (34784_13)		Plot 33 (34784_16)		Plot 34 (34784_17)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Plantaginaceae	Plantago lanceolata	Lamb's Tongues											1	20	0.5	10													0.1				0.1	10
Poaceae	Anthoxanthum odoratum	Sweet Vernal Grass																							0.2		0.2	100	30					
Poaceae	Avena sp.																				0.5													
Poaceae	Axonopus compressus	Broad-leaved Carpet Grass																																
Poaceae	Bromus catharticus	Praire Grass															1	50																
Poaceae	Bromus sp.																																	
Poaceae	Cenchrus clandestinus	Kikuyu Grass	1	20	1	50	1	20			3	50																						
Poaceae	Dactylis glomerata	Cocksfoot									1	30	1	50																			0.2	200
Poaceae	Echinochloa crusgalli	Barnyard Grass																															0.1	10
Poaceae	Ehrharta calycina	Perennial Veldtgrass																																
Poaceae	Ehrharta erecta																																	
Poaceae	Eleusine tristachya																												2					
Poaceae	Holcus lanatus	Yorkshire Fog																																
Poaceae	Lolium multiflorum	Italian Ryegrass																																
Poaceae	Lolium perenne	Perennial Ryegrass																									0.1	2					0.1	2
Poaceae	Lolium sp.																				0.2				0.5									
Poaceae	Lolium spp.	A Ryegrass			15	1000	7	1000																										
Poaceae	Panicum gilvum																																	
Poaceae	Paspalum dilatatum	Paspalum																					0.5		2				1					
Poaceae	Paspalum urvillei	Vasey Grass																																
Poaceae	Poa annua																																	
Poaceae	Poaceae indeterminate	Grasses, reeds and bamboos					1	100																										
Poaceae	Setaria parviflora																																	
Poaceae	Sporobolus africanus																						0.1											
Poaceae	Vulpia bromoides	Squirrel Tail Fesque													0.5	20																		
Polygonaceae	Acetosella vulgaris	Sheep Sorrel																																
Polygonaceae	Polygonum aviculare	Wireweed																																
Polygonaceae	Rumex obtusifolius	Broadleaf Dock																																
Primulaceae	Lysimachia arvensis	Scarlet Pimpernel															0.5	30							0.1									
Rosaceae	Rosa rubiginosa	Sweet Briar																																
Rosaceae	Rubus fruticosus sp. agg.	Blackberry complex	0.1	5															0.5		0.2		5		0.1				5				0.1	10
Rubiaceae	Galium aparine	Goosegrass									0.2	20																						
Rubiaceae	Galium divaricatum	Slender Bedstraw																																
Rubiaceae	Galium spurium																																	
Rutaceae	Rutaceae indeterminate																																	
Salicaceae	Populus sp.																																	
Scrophulariaceae	Parentucellia latifolia	Red Bartsia																															0.1	2
Scrophulariaceae	Verbascum blattaria																																	
Scrophulariaceae	Verbascum thapsus subsp. Thapsus	Great Mullein							0.5	10															0.1									
Scrophulariaceae	Verbascum virgatum	Twiggy Mullein																																
Solanaceae	Solanum chenopodioides																																	

Family	Scientific name	Common name	Plot 35 (34784_20)		Plot 36 (34784_28)		Plot 37 (34784_34)		Plot 38 (34784_42)		Plot 39 (34784_46)		Plot 40 (34784_47)		Plot 41 (34784_08)		Plot 42 (34784_09)		Plot 43 (34784_11)		Plot 44 (34784_21)		Plot 45 (34784_23)		Plot 46 (34784_27)		Plot 47 (34784_29)		Plot 48 (34784_32)		Plot 49 (34784_35)		Plot 50 (34784_45)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Plantaginaceae	Plantago lanceolata	Lamb's Tongues									0.5																								1	
Poaceae	Anthoxanthum odoratum	Sweet Vernal Grass							20	6000									5						1		0.2		1		5		1	
Poaceae	Avena sp.																				0.5						0.1							
Poaceae	Axonopus compressus	Broad-leaved Carpet Grass																																
Poaceae	Bromus catharticus	Praire Grass																																
Poaceae	Bromus sp.																												2		2			
Poaceae	Cenchrus clandestinus	Kikuyu Grass			0.5	100									1																			
Poaceae	Dactylis glomerata	Cocksfoot			30	1000	0.2	100																										
Poaceae	Echinochloa crusgalli	Barnyard Grass			0.1	10																												
Poaceae	Ehrharta calycina	Perennial Veldtgrass																																
Poaceae	Ehrharta erecta																																1	
Poaceae	Eleusine tristachya																								1									
Poaceae	Holcus lanatus	Yorkshire Fog																																
Poaceae	Lolium multiflorum	Italian Ryegrass																																
Poaceae	Lolium perenne	Perennial Ryegrass			0.1	10																												
Poaceae	Lolium sp.																								20		0.1				1			
Poaceae	Lolium spp.	A Ryegrass																																
Poaceae	Panicum gilvum				0.1	30																												
Poaceae	Paspalum dilatatum	Paspalum			0.1	10					6														25		5		0.5				1	
Poaceae	Paspalum urvillei	Vasey Grass																																
Poaceae	Poa annua																								2									
Poaceae	Poaceae indeterminate	Grasses, reeds and bamboos																																
Poaceae	Setaria parviflora																																	
Poaceae	Sporobolus africanus																																	
Poaceae	Vulpia bromoides	Squirrel Tail Fesque																																
Polygonaceae	Acetosella vulgaris	Sheep Sorrel							0.2	1000																								
Polygonaceae	Polygonum aviculare	Wireweed			0.2	1000																												
Polygonaceae	Rumex obtusifolius	Broadleaf Dock																																
Primulaceae	Lysimachia arvensis	Scarlet Pimpernel									0.1				2								0.1		0.2						0.1			
Rosaceae	Rosa rubiginosa	Sweet Briar																															0.1	
Rosaceae	Rubus fruticosus sp. agg.	Blackberry complex			0.1	1	0.1	2			10		0.1	1									1						60		0.1		0.5	
Rubiaceae	Galium aparine	Goosegrass																																
Rubiaceae	Galium divaricatum	Slender Bedstraw																																
Rubiaceae	Galium spurium																																	
Rutaceae	Rutaceae indeterminate																																	
Salicaceae	Populus sp.																																0.2	
Scrophulariaceae	Parentucellia latifolia	Red Bartsia																																
Scrophulariaceae	Verbascum blattaria																																	
Scrophulariaceae	Verbascum thapsus subsp. Thapsus	Great Mullein	0.1	2							0.1		0.1	2	0.1								0.1						0.1		0.1			
Scrophulariaceae	Verbascum virgatum	Twiggy Mullein									0.1																							
Solanaceae	Solanum chenopodioides																																	

Family	Scientific name	Common name	Plot 01 (HoG_Mar_13)		Plot 02 (HoG_Mar_14)		Plot 03 (HoG_Mar_15		Plot 04 (HoG_Mar_16		Plot 05 (HoG_TLC_Mar_01)		Plot 6 (HoG_TLC_Mar_02)		Plot 07 (HoG_TLC_Mar_03)		Plot 08 (HoG_TLC_Mar_04)		Plot 09 (HoG_TLC_Mar_05)		Plot 10 (HoG-Mar-01)		Plot 11 (HoG-Mar-02)		Plot 12 (HoG-Mar-03		Plot 13 (HoG-Mar-04)		Plot 14 (HoG-Mar-05)		Plot 15 (HoG-Mar-06)		Plot 16 (HoG-Mar-07)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Solanaceae	Solanum nigrum	Black-berry Nightshade	0.2	4	10	50															1	100	15	500	0.1	10	0.1	10	1	50	1	100	10	1000
Verbenaceae	Verbena bonariensis	Purpletop													0.1	3	0.1	3	0.1	10														
Verbenaceae	Verbena rigida var. rigida																																	
	Pasture Grass																																	

Family	Scientific name	Common name	Plot 17 (HoG-Mar-08)		Plot 18 (HoG-Mar-09)		Plot 19 (HoG-Mar-10)		Plot 20 (HoG-Mar-11)		Plot 21 (HoG-Mar-12)		Plot 22 (HoG_TLC_Mar_07)		Plot 23 (HoG_TLC_Mar_06)		Plot 24 (HoG_TLC_Mar_08)		Plot 27 (34784_01)		Plot 28 (34784_02)		Plot 29 (34784_04)		Plot 30 (34784_05)		Plot 31 (34784_07)		Plot 32 (34784_13)		Plot 33 (34784_16)		Plot 34 (34784_17)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Solanaceae	Solanum nigrum	Black-berry Nightshade	1	50	30	500	0.1	10	1	20	1	10			1	20	1	30															0.1	20
Verbenaceae	Verbena bonariensis	Purpletop																	0.1				0.1		0.1				0.5				0.1	2
Verbenaceae	Verbena rigida var. rigida																																	
	Pasture Grass																																	

Family	Scientific name	Common name	Plot 35 (34784_20)		Plot 36 (34784_28)		Plot 37 (34784_34)		Plot 38 (34784_42)		Plot 39 (34784_46)		Plot 40 (34784_47)		Plot 41 (34784_08)		Plot 42 (34784_09)		Plot 43 (34784_11)		Plot 44 (34784_21)		Plot 45 (34784_23)		Plot 46 (34784_27)		Plot 47 (34784_29)		Plot 48 (34784_32)		Plot 49 (34784_35)		Plot 50 (34784_45)	
			Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.	Cvr %	Abnd.
Solanaceae	Solanum nigrum	Black-berry Nightshade	0.1	2			0.1	2	0.1	1			0.1	20	0.2																			
Verbenaceae	Verbena bonariensis	Purpletop	0.1	2							0.5		0.1	5							0.1		0.2						0.1					
Verbenaceae	Verbena rigida var. rigida																								0.2		0.1							
	Pasture Grass				20	2000																												

Appendix I AECOM 330 kV Overhead Line vegetation Clearance Report

Prepared for
Hills of Gold Wind Farm Pty Limited
ABN: 28 145 173 324

Hills of Gold Wind Farm

330 kV Overhead Line Vegetation Clearance Report

13-Aug-2021
Hills of Gold Wind Farm Grid Connection

Hills of Gold Wind Farm

330 kV Overhead Line Vegetation Clearance Report

Client: Hills of Gold Wind Farm Pty Limited

ABN: 28 145 173 324

Prepared by

AECOM Australia Pty Ltd
Level 10, Tower Two, 727 Collins Street, Melbourne VIC 3008, Australia
T +61 3 9653 1234 F +61 3 9654 7117 www.aecom.com
ABN 20 093 846 925

13-Aug-2021

Job No.: 60633842

AECOM in Australia and New Zealand is certified to ISO9001, ISO14001 AS/NZS4801 and OHSAS18001.

Quality Information

Document Hills of Gold Wind Farm

Ref 60633842
p:\606x\60633842\400_technical\431_s1 shared network assets\vegetation clearance\hogwf 330kv vegetation clearing report 20210813_cm.docx

Date 13-Aug-2021

Prepared by Hew McLachlan

Reviewed by Rita Bu, Caitie McClelland, Rajesh Arora

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
0	13-Aug-2021	For Issue	Rajesh Arora Technical Director - Power and Industrial	

Table of Contents

1.0	Overview	1
2.0	Scope of Works – 330 kV Concept Vegetation Clearing	1
3.0	Key Deliverables	1
3.1	Concept Design	1
3.2	Vegetation Clearing Criteria	1
3.3	Vegetation Clearing Results	2
Appendix A		
	Plan and Profile Drawing	A

1.0 Overview

Hills of Gold Wind Farm Pty Limited is considering the development of Hills of Gold Wind Farm located 60 km south-east of Tamworth New South Wales, Australia. The wind farm has a proposed capacity of 400 MW and is proposed to connect to the TransGrid network.

The project is currently in the early stages of development for the 330 kV connection interface between a new TransGrid 330 kV switching station and a new 330 kV transmission line (20 km in length) to the Hills of Gold new collector 330/33 kV substation located within the boundaries of the proposed wind farm development.

This report discusses the vegetation clearing that may be required based on an indicative transmission line concept design and route.

2.0 Scope of Works – 330 kV Concept Vegetation Clearing

The agreed scope is as follows:

- Update the transmission line alignment
- Review the Lidar Survey to incorporate the vegetation data for upload into PLS-CADD.
- Prepare the PLS-CADD Maximum design temperature bottom conductor profile with a vegetation clearance line – 3.0 metres plus 1.0 metre regrowth (minimum 4.0 metre required)
- Prepare the structure clearance envelope of 60.0 metres around structure locations.
- Prepare the 50 degree C and 500 pa vegetation clearance envelopes for all spans on the Hills of Gold 330 kV transmission line.

3.0 Key Deliverables

The agreed deliverables are as follows:

- Basis of Design summary on vegetation Standards as per AS7000, inclusive of a table of vegetation clearance locations with chainages. (TransGrid reference standard to be included)
- Shapefiles (and kmz) of the 60 meter transmission line corridor with vegetation clearance locations identified
- Updated plan and profile cross sections with vegetation canopy height and calculated clearance envelopes overlayed. Locations where these overlays intersect requiring vegetation clearance will be clearly shown with chainages

3.1 Concept Design

The PLS-CADD transmission line model has been updated based on the concept design prepared last year (2020). The updated model includes the recently received ground and vegetation lidar, as well as the received alignment centreline which includes both minor and major changes for almost the entirety of the route compared to the previous design. As this is a concept design and the terrain is highly challenging, a single indicative strain pole arrangement has been used for the design to determine the vegetation clearing that may be required. The pole height has been adjusted for the terrain and is a maximum of 32 m.

3.2 Vegetation Clearing Criteria

Vegetation clearing has been assessed with the transmission line at 85°C no wind, and 500 Pa at 50°C. Vegetation within 4 m of the conductors under these conditions have been identified as requiring clearing. This 4 m value is comprised of a 3 m clearance zone plus a 1 m regrowth zone. Although there is no vegetation clearance requirement in AS/NZS 7000, SA/SNZ HB 331 notes 3 m clearance is required up to 33 kV. We are aware that TransGrid has previously used 7.5 m clearance required for 330 kV lines.

3.3 Vegetation Clearing Results

The vegetation clearing identified from this analysis is shown in the plan and profile drawings, the shapefile, the Google Earth KMZ file, and is summarised in the table below. The approximate total area of vegetation clearance is 193,000 m^2.

Table 1 Vegetation Clearing Results

Site #	Site X (m)	Site Y (m)	Chainage (m)	Approx. Area (m^2)
1	303643	6510443	181	574
2	303709	6510386	269	137
3	303826	6510267	435	2086
4	303906	6510165	565	99
5	304075	6509984	812	1750
6	304297	6509750	1135	178
7	304399	6509643	1283	126
8	304550	6509456	1522	202
9	305242	6508765	2501	31
10	305905	6508233	3351	135
11	305730	6508359	3136	1075
12	305960	6508192	3419	100
13	306007	6508151	3482	148
14	306149	6508048	3658	486
15	306697	6507756	4282	2574
16	307859	6507182	5590	172
17	307958	6507138	5698	262
18	306939	6507680	4536	590
19	307009	6507644	4613	2
20	306830	6507718	4420	7
21	311408	6506370	9286	2686
22	309377	6506829	7151	56
23	309466	6506820	7241	317
24	309275	6506847	7048	249
25	308986	6506886	6756	2766
26	308847	6506911	6614	1109
27	310450	6506707	8232	580
28	310089	6506750	7868	13
29	310179	6506726	7960	537
30	310360	6506705	8142	69
31	311065	6506619	8852	4644
32	310880	6506661	8664	8
33	310801	6506674	8583	24
34	310744	6506680	8526	5

Site #	Site X (m)	Site Y (m)	Chainage (m)	Approx. Area (m^2)
35	310692	6506668	8476	17
36	311833	6505783	10010	618
37	311974	6505566	10269	1459
38	312067	6505446	10421	4358
39	311930	6505654	10171	56
40	312319	6505262	10739	22
41	312473	6505170	10919	2924
42	312997	6505008	11468	2406
43	313372	6504903	11858	49
44	313483	6504861	11976	2665
45	313186	6504938	11669	5971
46	318569	6502287	18095	4563
47	318983	6502368	18517	3087
48	319176	6502420	18716	186
49	319381	6502349	18955	1218
50	319449	6502273	19057	0
51	315456	6504169	14136	3689
52	313898	6504723	12413	4285
53	314119	6504657	12644	3340
54	314746	6504524	13285	26021
55	314272	6504621	12801	1108
56	315589	6503850	14481	3303
57	316011	6503389	15119	23765
58	316553	6503014	15778	2762
59	316745	6502882	16012	2729
60	316969	6502690	16307	796
61	317184	6502493	16599	454
62	317264	6502422	16707	1944
63	318369	6502242	17890	4794
64	317933	6502145	17443	2075
65	317689	6502207	17184	2
66	320967	6500986	21164	3081
67	321173	6500939	21375	598
68	319767	6502003	19473	277
69	319829	6501945	19558	587
70	319984	6501817	19759	2632
71	319506	6502242	19120	0
72	319662	6502106	19327	0
73	320241	6501384	20265	3092
74	320611	6501059	20801	6348
75	320830	6500419	25321	874

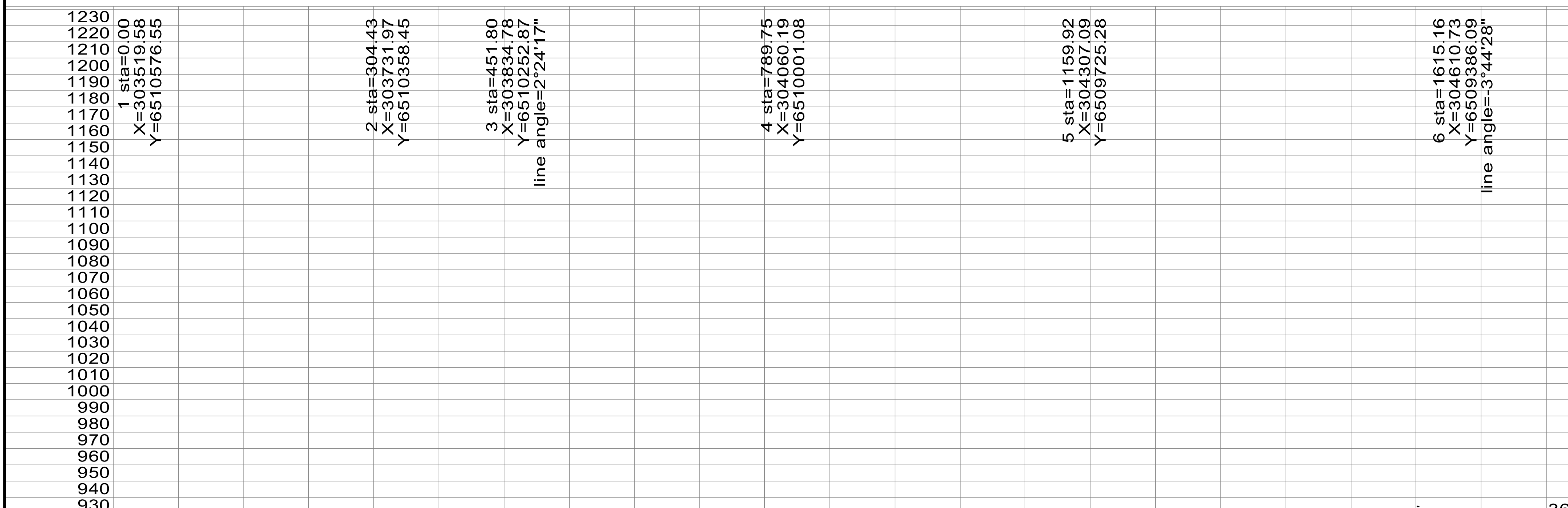
Site #	Site X (m)	Site Y (m)	Chainage (m)	Approx. Area (m^2)
76	322145	6500385	22502	23
77	321359	6500873	21574	219
78	321504	6500803	21737	3338
79	321139	6500815	24819	958
80	321075	6500711	24942	2
81	322063	6500443	22402	1092
82	322420	6500145	22870	7574
83	322966	6499819	23537	23167
84	323336	6499611	24027	4401

Appendix A

Plan and Profile Drawing

Appendix A Plan and Profile Drawing


1
2
3
4
5
6
PI 451.80
2°24'17"
0°00'00"
PI 1615.16
-3°44'28"


1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
1 sta=0.00
X=303519.58
Y=6510576.55
2 sta=304.43
X=303731.97
Y=6510358.45
3 sta=451.80
X=303834.78
Y=6510252.87
line angle=2°24'17"
4 sta=789.75
X=304060.19
Y=6510001.08
5 sta=1159.92
X=304307.09
Y=6509725.28
6 sta=1615.16
X=304610.73
Y=6509386.09
line angle=-3°44'28"

1320
1310
1300
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020

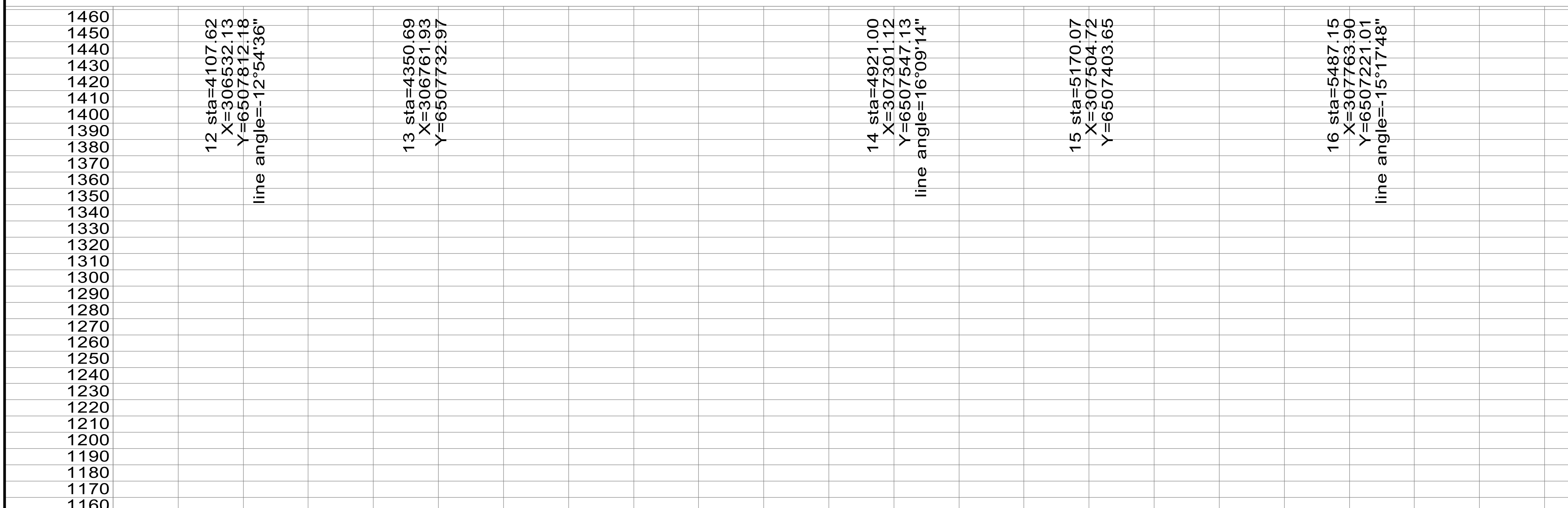
8 sta=2122.62
X=304973.15
Y=6509030.88
line angle=1°03'46"

9 sta=2407.10
X=305172.59
Y=6508828.02
line angle=-5°34'37"

10 sta=3067.68
X=305679.29
Y=6508404.21
line angle=-1°16'03"

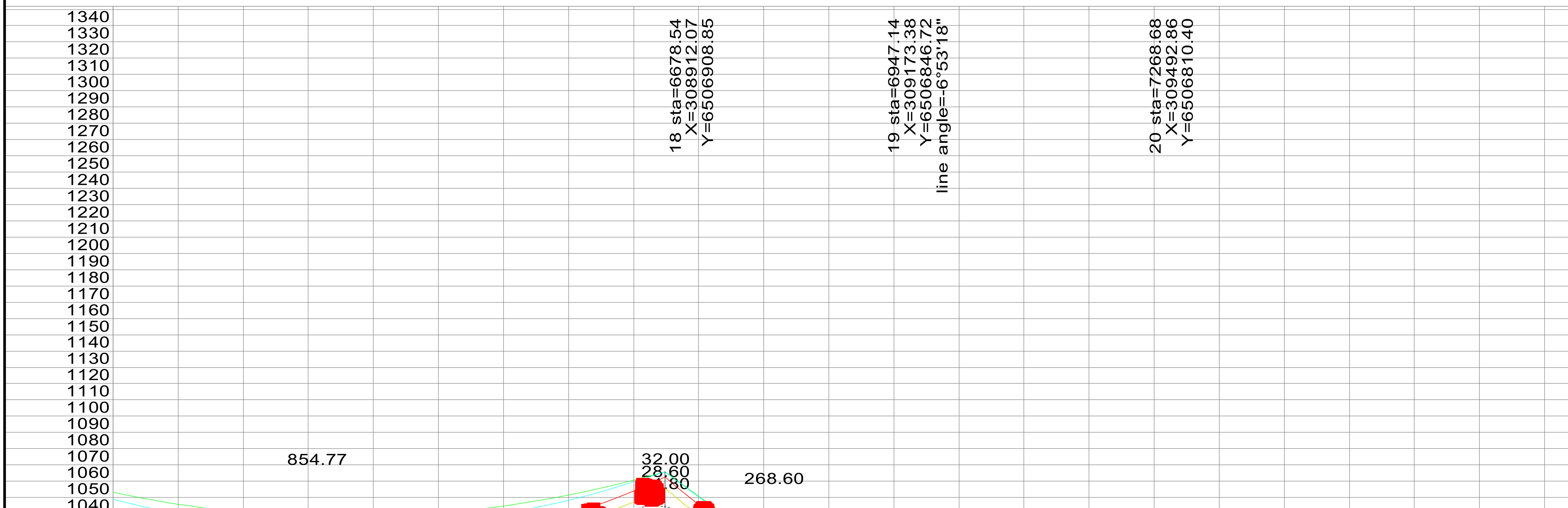
11 sta=3507.61
X=306022.90
Y=6508129.49
line angle=-6°42'52"

12
PI 4107.62
-12°54'36"
13
PI 4921.00
16°09'14"
14
15
16
PI 5487.16
-15°17'48"

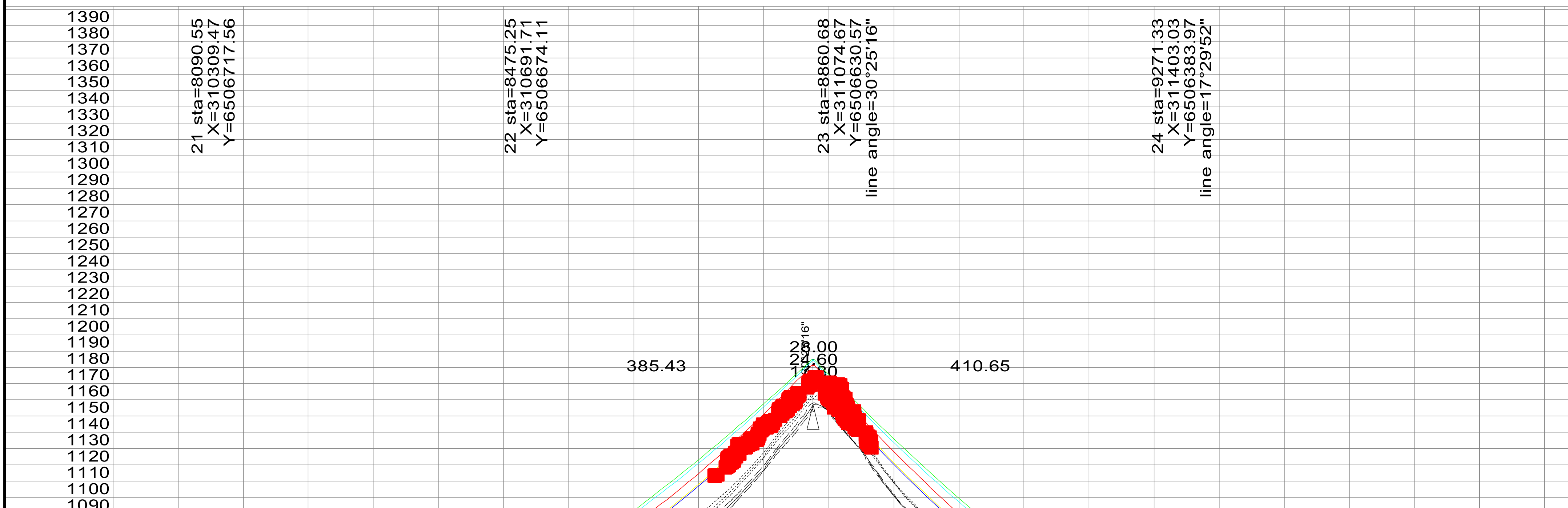


1460
1450
1440
1430
1420
1410
1400
1390
1380
1370
1360
1350
1340
1330
1320
1310
1300
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
1160
12 sta=4107.62
X=306532.13
Y=6507812.18
line angle=-12°54'36"
13 sta=4350.69
X=306761.93
Y=6507732.97
14 sta=4921.00
X=307301.12
Y=6507547.13
line angle=16°09'14"
15 sta=5170.07
X=307504.72
Y=6507403.65
16 sta=5487.15
X=307763.90
Y=6507221.01
line angle=-15°17'48"

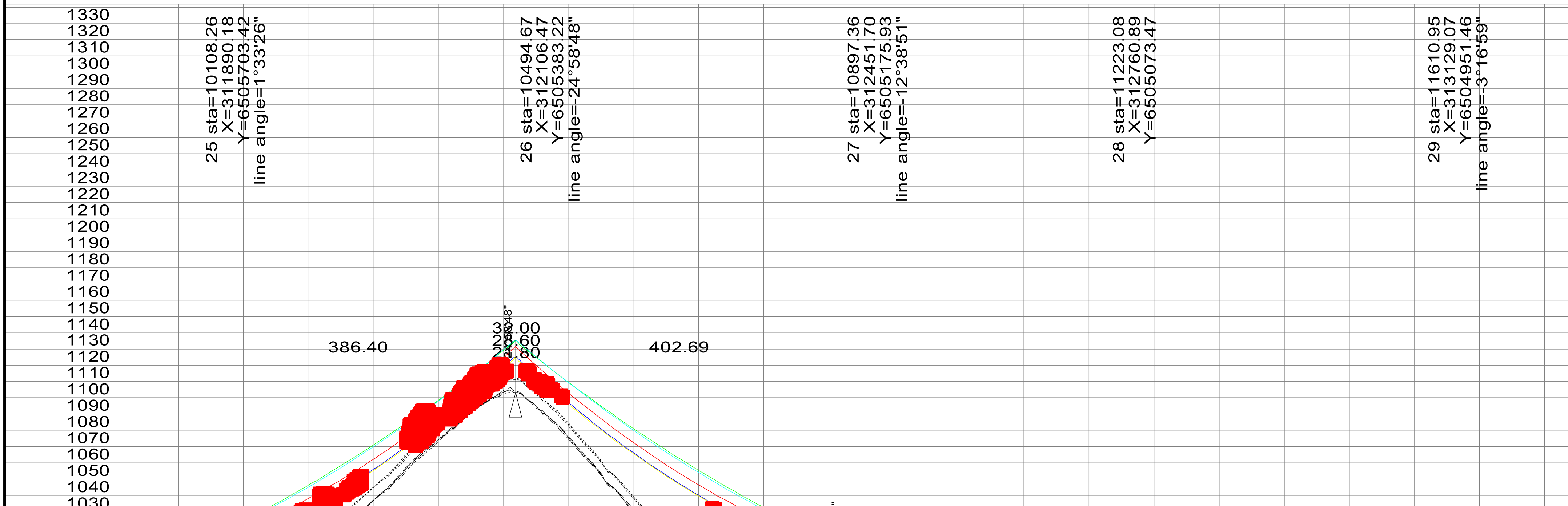

18
19
20
PI 6947.14
-6°53'18"


1340
1330
1320
1310
1300
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
1090
1080
1070
1060
1050
1040
18 sta=6678.54
X=308912.07
Y=6506908.85
19 sta=6947.14
X=309173.38
Y=6506846.72
line angle=-6°53'18"
20 sta=7268.68
X=309492.86
Y=6506810.40
854.77
32.00
28.60
268.60


22


1390
1380
1370
1360
1350
1340
1330
1320
1310
1300
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
1090
21 sta=8090.55
X=310309.47
Y=6506717.56
22 sta=8475.25
X=310691.71
Y=6506674.11
23 sta=8860.68
X=311074.67
Y=6506630.57
line angle=30°25'16"
24 sta=9271.33
X=311403.03
Y=6506383.97
line angle=17°29'52"
385.43
410.65


PI 10108.26
1°33'26"
25
PI 10494.67
-24°58'48"
27
28


1330
1320
1310
1300
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
1090
1080
1070
1060
1050
1040
1030
25 sta=10108.26
X=311890.18
Y=6505703.42
line angle=1°33'26"
26 sta=10494.67
X=312106.47
Y=6505383.22
line angle=-24°58'48"
27 sta=10897.36
X=312451.70
Y=6505175.93
line angle=-12°38'51"
28 sta=11223.08
X=312760.89
Y=6505073.47
29 sta=11610.95
X=313129.07
Y=6504951.46
line angle=-3°16'59"
386.40
402.69

1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980

30 sta=12011.64
X=313516.01
Y=6504847.41
line angle=2°48'44"

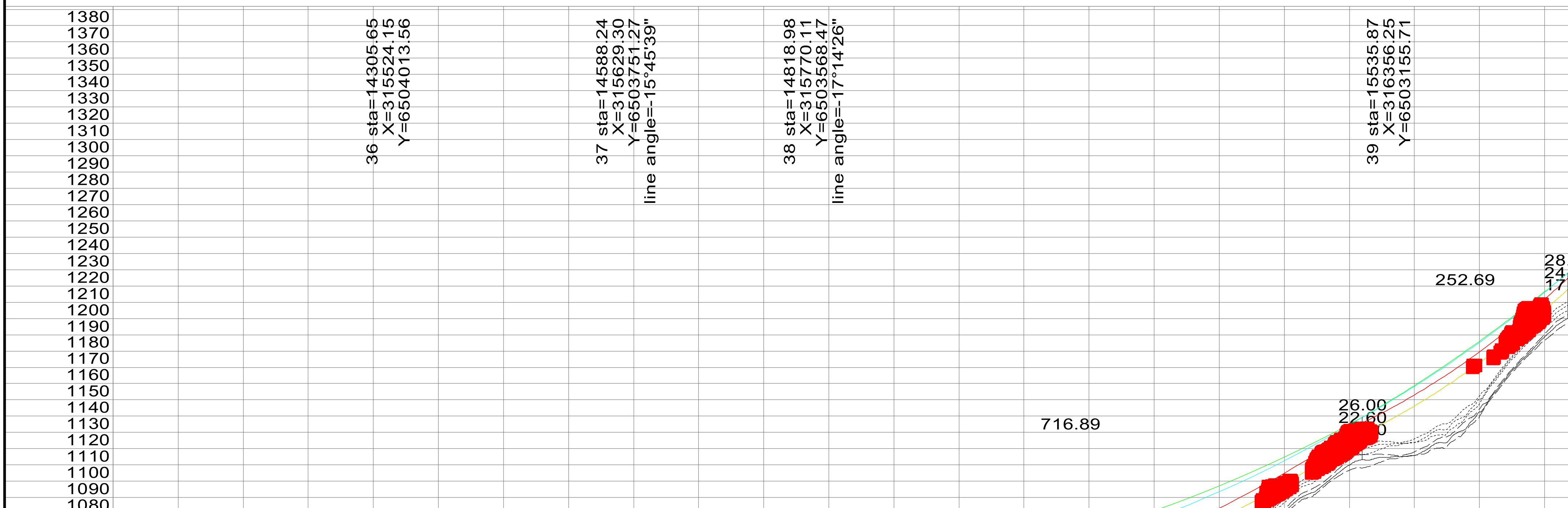
31 sta=12578.05
X=314055.12
Y=6504673.66
line angle=-5°45'48"

32 sta=12985.32
X=314453.34
Y=6504588.29

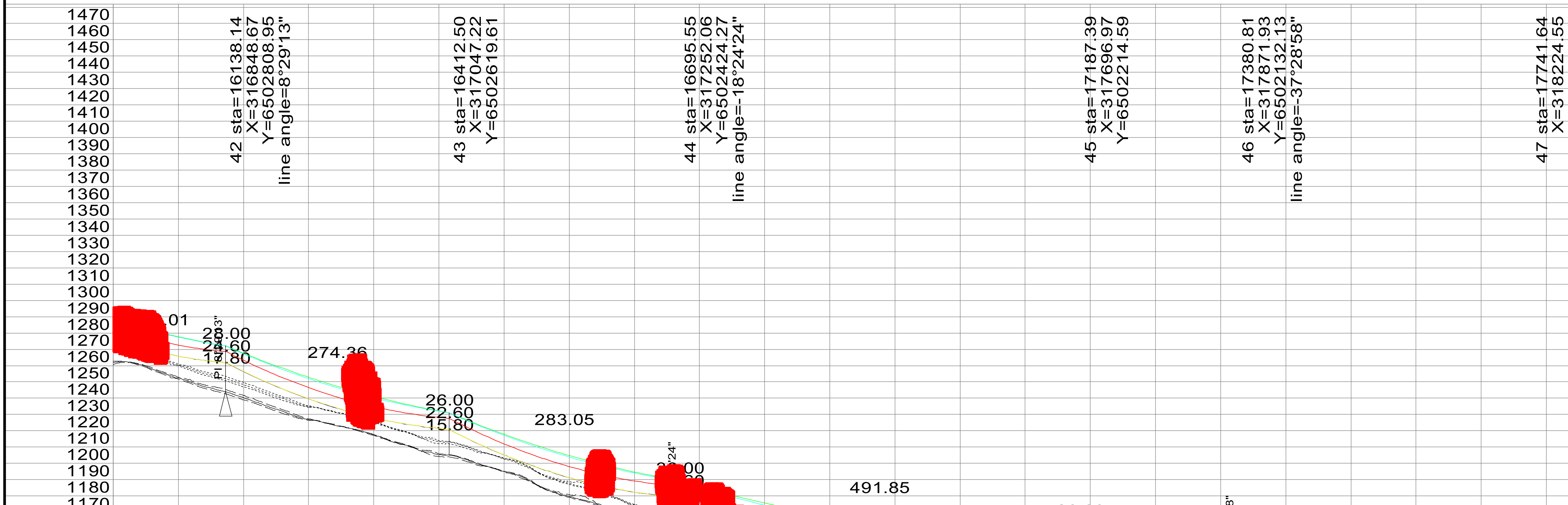
33 sta=13458.38
X=314915.89
Y=6504489.13

34 sta=13741.04
X=315192.27


9982.73
9°19'02"
36
37
PI 14588.24
-15°45'39"
PI 14818.98
-17°14'26"
40


1380
1370
1360
1350
1340
1330
1320
1310
1300
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
1090
1080
36 sta=14305.65
X=315524.15
Y=6504013.56
37 sta=14588.24
X=315629.30
Y=6503751.27
line angle=-15°45'39"
38 sta=14818.98
X=315770.11
Y=6503568.47
line angle=-17°14'26"
39 sta=15535.87
X=316356.25
Y=6503155.71
716.89
252.69
26.00
22.60

42
44
45
46
47
71
72
73



1470
1460
1450
1440
1430
1420
1410
1400
1390
1380
1370
1360
1350
1340
1330
1320
1310
1300
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
42 sta=16138.14
X=316848.67
Y=6502808.95
line angle=8°29'13"
43 sta=16412.50
X=317047.22
Y=6502619.61
44 sta=16695.55
X=317252.06
Y=6502424.27
line angle=-18°24'24"
45 sta=17187.39
X=317696.97
Y=6502214.59
46 sta=17380.81
X=317871.93
Y=6502132.13
line angle=-37°28'58"
47 sta=17741.64
X=318224.55
28.00
24.60
18.80
274.36
26.00
22.60
15.80
283.05
491.85

1370
1360
1350
1340
1330
1320
1310
1300
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
1090
1080
1070

48 sta=18028.40
X=318504.78
Y=6502269.53

49 sta=18685.16
X=319146.59
Y=6502408.87

50 sta=18819.01
X=319277.39
Y=6502437.27
line angle=53°21'29"

51 sta=19087.55
X=319479.73
Y=6502260.71

52 sta=19281.07
X=319625.54
Y=6502133.47

53 sta=19462.87
X=319762.51
Y=6502013.94

1370
1360
1350
1340
1330
1320
1310
1300
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
1090
1080
1070

55 sta=20162.45
X=320194.42
Y=6501476.04

56 sta=20592.42
X=320407.51
Y=6501102.59
line angle=-48°34'28"

57 sta=20951.63
X=320759.24
Y=6501029.65

58 sta=21142.65
X=320946.27
Y=6500990.86

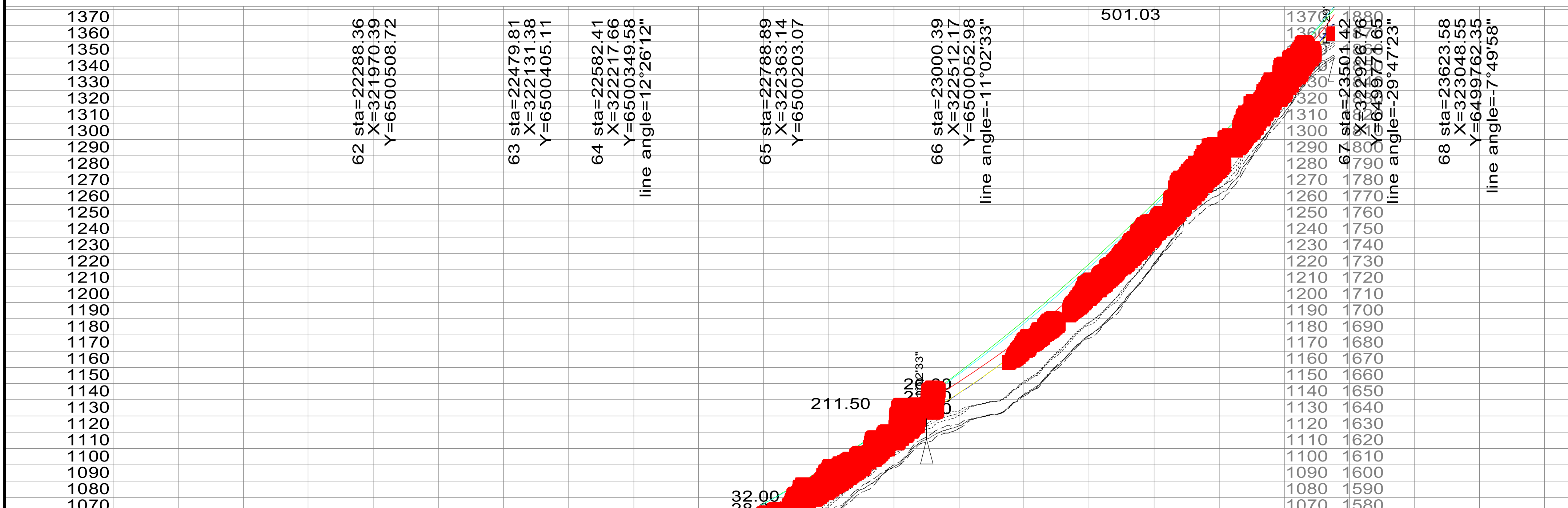
59 sta=21269.85
X=321070.83
Y=6500965.03

60 sta=21427.62
X=321225.31
Y=6500932.99
line angle=9°45'56"

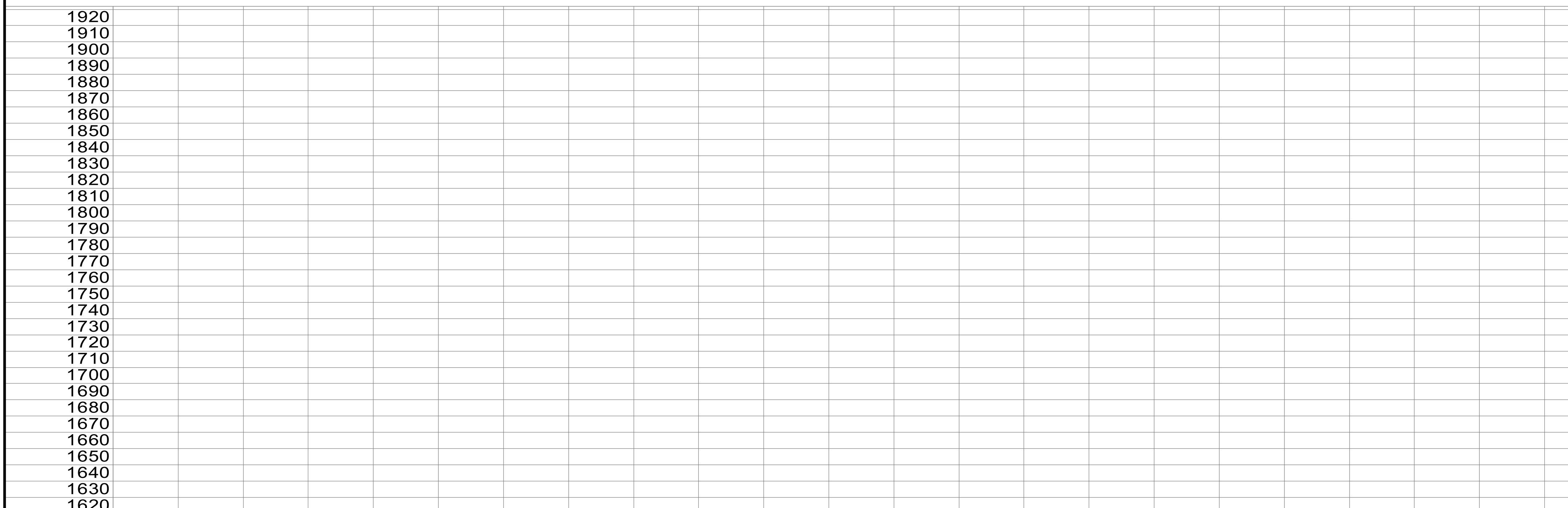
61 sta=21665.17
X=321446.35
Y=6500846.00
line angle=11°17'03"

32.00


62
63
PI 22582.41
12°26'12"
64


1370
1360
1350
1340
1330
1320
1310
1300
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
1090
1080
1070
62 sta=22288.36
X=321970.39
Y=6500508.72
63 sta=22479.81
X=322131.38
Y=6500405.11
64 sta=22582.41
X=322217.66
Y=6500349.58
line angle=12°26'12"
65 sta=22788.89
X=322363.14
Y=6500203.07
66 sta=23000.39
X=322512.17
Y=6500052.98
line angle=-11°02'33"
501.03
211.50
32.00
67 sta=23501.42
Y=6499771.65
line angle=-29°47'23"
68 sta=23623.58
X=323048.55
Y=6499762.35
line angle=-7°49'58"
1880
1790
1780
1770
1760
1750
1740
1730
1720
1710
1700
1690
1680
1670
1660
1650
1640
1630
1620
1610
1600
1590
1580


70
PI 24186.84
0°00'00"


1920
1910
1900
1890
1880
1870
1860
1850
1840
1830
1820
1810
1800
1790
1780
1770
1760
1750
1740
1730
1720
1710
1700
1690
1680
1670
1660
1650
1640
1630
1620