

22 June 2021

Matthew Sprott

Director Resource Assessments
NSW Department of Planning, Industry and Environment
GPO Box 39
Sydney NSW 2001

via email matthew.sprott@planning.nsw.gov.au

MALABAR RESOURCES

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Website:
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Dear Matthew,

RE: MAXWELL UNDERGROUND COAL MINE PROJECT (SSD 9526) – BIODIVERSITY CREDIT REQUIREMENTS UNDER CONDITION B49

The Maxwell Underground Mine is an approved, but yet to be developed, mine in the Upper Hunter Valley of New South Wales (NSW), east-southeast of Denman and south-southwest of Muswellbrook. Development Consent SSD 9526 for the Maxwell Underground Mine (the Project) was granted by the NSW Independent Planning Commission in December 2020.

Conditions B47 and B48 of the Development Consent SSD 9526 outlines the biodiversity credit requirements for the Project. Condition B49 states:

*The biodiversity credit requirements outlined in conditions B47 and B48 for *Diuris tricolor*; *Prasophyllum petilum*; *Pterostylis chaetophora*; *Ozothamnus tessellatus* and *Thesium australe*, may be reduced if the Applicant demonstrates to the satisfaction of the Planning Secretary, that the credit requirements in Table 6 and/or Table 7 do not accurately reflect the extent of impacts on these species as a result of the development. Any request from the Applicant to reduce these credit requirements must:*

- (a) be in writing and addressed to the Planning Secretary; and*
- (b) be supported by an expert report or survey report outlining the findings of additional surveys, which has been prepared:*
 - (i) by a suitably qualified and experienced person/s;^{a,b}*
 - (ii) in accordance with the BAM;*
 - (iii) in consultation with Council; and*
 - (iv) in consultation with BCD,*

to the satisfaction of the Planning Secretary.

^a In the case of an expert report, a 'suitably qualified and experienced person' means a person who meets the relevant requirements outlined in section 6.5.2 of the BAM

^b In this case of a survey report, a 'suitably qualified and experienced person' means an accredited person as defined in section 1.6 of the BC Act.

Malabar commissioned additional flora surveys and expert report to satisfy the requirements of Condition B49. These reports were provided to the Biodiversity, Conservation and Science Directorate (BCD) within the Department of Planning, Industry and Environment (DPIE) and the Muswellbrook Shire Council on 23 February 2021 for consultation in accordance with Condition B49(b). Following the provision of the additional flora surveys and expert report, BCD and Muswellbrook Shire Council provided comments on 22 April 2021 and 25 February 2021, respectively (Attachments 1 and 2).

Malabar subsequently prepared and provided a response to the comments received from BCD on 17 May 2021 (Attachment 1). No further comments have been received from BCD to date.

A response to the comments provided by Muswellbrook Shire Council, as well as a summary of the response to BCD, is provided in Attachment 3. A summary of the biodiversity offset requirements and findings of the reports is provided below and copies of the reports are provided in Attachments 4 to 6.

Additional Surveys and Expert Report

In accordance with Condition B49, Malabar commissioned Hunter Eco (Dr Colin Driscoll, BAM assessor accreditation BAAS17004) to undertake additional flora surveys in September 2020, targeting *Ozothamnus tessellatus* and *Thesium australe* in potential habitat identified in the BDAR and as advised by BCD. These surveys were undertaken in accordance with the *Surveying Threatened Plants and their Habitats – NSW Survey Guide for the Biodiversity Assessment Method* (DPIE, 2020a) and the findings are outlined in the attached survey report (Attachment 4).

Malabar also commissioned Eastcoast Flora Survey (Dr Stephen Bell, Approved Expert) to prepare an expert report for *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora* in relation to the Project. The expert report was prepared in accordance with the *Biodiversity Assessment Method* (DPIE, 2020b) and is provided in Attachment 5.

Malabar commissioned Hunter Eco (Dr Colin Driscoll) to also undertake additional flora surveys in September 2020, targeting *Diuris tricolor* and *Prasophyllum petilum* in potential habitat identified by Dr Stephen Bell (note, no potential habitat was identified for *Pterostylis chaetophora*). These surveys were also undertaken in accordance with *Surveying Threatened Plants and their Habitats – NSW Survey Guide for the Biodiversity Assessment Method* (DPIE, 2020a) and the findings are outlined in the attached survey report (Attachment 6).

Outcomes

The supplementary surveys undertaken by Hunter Eco did not identify any of the target species within the Project areas, supporting the survey outcomes described in the BDAR (Hunter Eco, 2019) that none of the target species are likely to be present (Attachments 4 and 6).

The expert report prepared by Eastcoast Flora Survey (Attachment 5) concludes that *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora* are unlikely to be present within the Project areas, also supporting the assessment outcomes of the BDAR (Hunter Eco, 2019).

As such, in accordance with Condition B49 of Development Consent SSD 9526, Malabar requests that the biodiversity credit requirements for *Diuris tricolor*, *Ozothamnus tessellatus*, *Prasophyllum petilum*, *Pterostylis chaetophora* and *Thesium australe* be reduced to zero as these species are not likely to be present in the Project areas.

If you have any queries or would like to arrange a meeting to discuss the findings, please do not hesitate to contact me (dmclaughlin@malabarresources.com.au or [02] 6542 0298).

Yours sincerely,



Donna McLaughlin
Health, Safety, Environment and Community Manager
Malabar Resources

- Attachment 1 Correspondence with Biodiversity, Conservation and Science Directorate
- Attachment 2 Correspondence with Muswellbrook Shire Council
- Attachment 3 Responses to Comments from Biodiversity, Conservation and Science Directorate and Muswellbrook Shire Council
- Attachment 4 Maxwell Project (SSD 9526) – Targeted Searches for *Ozothamnus tessellatus* and *Thesium australe*
- Attachment 5 Expert Report – Expected Presence of Threatened Terrestrial Orchids (*Diuris tricolor*, *Prasophyllum petilum*, *Pterostylis chaetophora*): Maxwell Project
- Attachment 6 Maxwell Project Targeted Orchid Surveys

Attachment 1

Correspondence with Biodiversity, Conservation and Science Directorate

22 February 2021

Steven Cox

Senior Team Leader Planning
Biodiversity, Conservation and Science Directorate
Department of Planning, Industry and Environment
PO Box 1226
Newcastle NSW 2300

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By email: info@environment.nsw.gov.au

Dear Steven,

RE: MAXWELL UNDERGROUND COAL MINE PROJECT (SSD 9526) – SPECIFIC ENVIRONMENTAL CONDITION B49

In December 2020, the Maxwell Underground Coal Mine Project (SSD 9526) (the Project) was approved by the Independent Planning Commission of New South Wales, subject to Development Consent conditions. Conditions B47 and B48 of the Specific Environmental Conditions for Biodiversity outline the credit requirements for the Project under the *Biodiversity Conservation Act, 2016*. Condition B49 states:

The biodiversity credit requirements outlined in conditions B47 and B48 for Diuris tricolor; Prasophyllum petilum; Pterostylis chaetophora; Ozothamnus tessellatus and Thesium australe, may be reduced if the Applicant demonstrates to the satisfaction of the Planning Secretary, that the credit requirements in Table 6 and/or Table 7 do not accurately reflect the extent of impacts on these species as a result of the development. Any request from the Applicant to reduce these credit requirements must:

- (a) *be in writing and addressed to the Planning Secretary; and*
- (b) *be supported by an expert report or survey report outlining the findings of additional surveys, which has been prepared:*
 - (i) *by a suitably qualified and experienced person/s;^{a,b}*
 - (ii) *in accordance with the BAM;*
 - (iii) *in consultation with Council; and*
 - (iv) *in consultation with BCD,**to the satisfaction of the Planning Secretary.*

^a In the case of an expert report, a 'suitably qualified and experienced person' means a person who meets the relevant requirements outlined in section 6.5.2 of the BAM

^b In this case of a survey report, a 'suitably qualified and experienced person' means an accredited person as defined in section 1.6 of the BC Act.

Malabar has commissioned additional flora surveys and an expert report to satisfy the requirements of Condition B49. These reports are being provided to Biodiversity, Conservation and Science Directorate within the Department of Planning, Industry and Environment (BCS) for consultation in accordance with Condition B49(b)(iii). A summary of the offset requirements and findings of the reports is provided below. Copies of the reports are provided in Attachments 1 to 3.

Malabar requests that any comments BCS wish to make on the attached reports be provided by 19 March 2021.

Background

In response to concerns raised by Muswellbrook Shire Council, the Department of Planning, Industry and Environment (DPIE) requested that the then Biodiversity and Conservation Division (BCD) review the flora survey methodology employed during preparation of the Biodiversity Development Assessment Report (BDAR) for the Project.

In a letter dated 22 May 2020, BCD requested further information for 10 threatened flora species considered to potentially occur in the Project Area. Following additional surveys and the provision of additional information by Malabar in July and August 2020, BCD was satisfied that further survey efforts were not required for five of the species (*Commersonia rosea*, *Cymbidium canaliculatum*, *Eucalyptus glaucina*, *Lasiopetalum longistamineum* and *Monotaxis macrophylla*), however recommended further surveys for the remaining five threatened flora species (*Diuris tricolor*, *Ozothamnus tessellatus*, *Prasophyllum petilum*, *Pterostylis chaetophora* and *Thesium australe*).

Therefore, for the purposes of its assessment of the Project, DPIE conservatively assumed the presence of these five species and included a species credit requirement for each in the Development Consent (Conditions B47 and B48). The conditions require Malabar to undertake additional surveys or commission an expert report to seek a reduction of its offsetting obligations where flora species credits are found to have been overestimated (Condition B49).

Additional Surveys and Expert Report

In accordance with Condition B49, Malabar commissioned Hunter Eco (Dr Colin Driscoll, BAM assessor accreditation BAAS17004) to undertake additional flora surveys in September 2020, targeting *Ozothamnus tessellatus* and *Thesium australe* in potential habitat identified in the BDAR and as advised by BCD. These surveys were undertaken in accordance with the 2020 *Surveying Threatened Plants and their Habitats – NSW Survey Guide for the Biodiversity Assessment Method* and the findings are outlined in the attached survey report (Attachment 1).

Malabar also commissioned Eastcoast Flora Survey (Dr Stephen Bell, approved Expert) to prepare an expert report for *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora* in relation to the Project. The expert report was prepared in accordance with the 2020 *Biodiversity Assessment Method* and is provided in Attachment 2.

Malabar commissioned Hunter Eco (Dr Colin Driscoll) to also undertake additional flora surveys in September 2020, targeting *Diuris tricolor* and *Prasophyllum petilum* in potential habitat identified by Dr Stephen Bell (note, no potential habitat was identified for *Pterostylis chaetophora*). These surveys were also undertaken in accordance with the 2020 *Surveying Threatened Plants and their Habitats – NSW Survey Guide for the Biodiversity Assessment Method* and the findings are outlined in the attached survey report (Attachment 3).

Outcomes

Supplementary surveys undertaken by Hunter Eco did not record any of the target species in the Project disturbance areas, confirming the original survey outcomes that none are likely to be present (Attachments 1 and 3).

The expert report prepared by Eastcoast Flora Survey (Attachment 2) concludes that *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora* are unlikely to be present within the Project disturbance areas, also confirming original assessment outcomes.

In accordance with Condition B49, the expert report and survey reports are required to be prepared in consultation with BCS, and other stakeholders. Malabar requests that any comments BCS wishes to make on the attached reports be provided by 19 March 2021.

If you have any queries or would like to arrange a meeting to discuss the findings, please do not hesitate to contact me (dmclaughlin@malabarresources.com.au or [02] 6542 0298).

Yours sincerely,



Donna McLaughlin
Health, Safety, Environment and Community Manager
Malabar Resources

Our ref: DOC21/132140-5

Your ref: SSD 9526

Ms Donna McLaughlin

Health, Safety, Environment and Community Manager
Malabar Resources
Level 26, 259 George Street
SYDNEY NSW 2000
dmclaughlin@malabarresources.com.au

Dear Ms McLaughlin

Maxwell Underground Coal Mine Project (SSD 9526) – Consent Condition B49

I refer to your letter dated 22 February 2021 to Biodiversity and Conservation Division (BCD) in which Malabar Resources commissioned additional flora surveys and an expert report for the Maxwell Underground Coal Mine Project (SSD 9626). The letter is a request under SSD 9526 Consent Condition B49 to reduce the offset credits required for five threatened flora species. The letter included three attachments:

- Attachment 1: 'Maxwell Project (SSD 9526) – Targeted Searches for *Ozothamnus tessellatus* and *Thesium australe*' by Hunter Eco (dated 29 January 2021)
- Attachment 2: 'Expert Report: Expected Presence of Threatened Terrestrial Orchids (*Diuris tricolor*, *Prasophyllum petilum*, *Pterostylis chaetophora*): Maxwell Project' by Eastcoast Flora Survey (dated February 2021)
- Attachment 3: 'Maxwell Project: Targeted Orchid Surveys' by Hunter Eco (dated 29 January 2021)

BCD has reviewed the letter and attachments and is satisfied that field surveys failed to find any *Ozothamnus tessellatus* and *Thesium australe* plants. BCD is also satisfied that the expert report concludes that there is no suitable habitat present for *Pterostylis chaetophora*.

BCD does not agree that the all field surveys for *Diuris tricolor* and *Prasophyllum petilum* were undertaken in accordance the 2020 *Surveying threatened plants and their habitats: NSW survey guide for the Biodiversity Assessment Method* (the 2020 Survey Guidelines). Figure 4 of Attachment 3 of your letter shows that random meanders were undertaken in some of the areas of potential habitat identified in the expert report. The 2020 Survey Guidelines do not support the use of random meanders. Parallel field transects should have been undertaken at a spacing of 10 metres apart in open vegetation, and 5 metres apart in dense vegetation.

BCD notes that appropriately spaced parallel field transects were undertaken in the potential habitat area shown on Figure 3 of Attachment 3 of your letter, and no *Diuris tricolor* or *Prasophyllum petilum* plants were found.

BCD recommends that parallel field transects (in accordance with the 2020 Survey Guidelines) are undertaken across the potential habitat area shown in Attachment 3 of Figure 4 of your letter. BCD considers that in the absence of appropriate field surveys, there is potential for *Diuris tricolor* and *Prasophyllum petilum* to occur in the potential habitat areas identified in the expert report.

If you require any further information regarding this matter, please contact Steven Cox, Senior Team Leader Planning, on 4927 3140 or via email at huntercentralcoast@environment.nsw.gov.au

Yours sincerely

A handwritten signature in black ink that reads "Joe Thompson". The signature is written in a cursive, flowing style.

JOE THOMPSON
Director Hunter Central Coast Branch
Biodiversity and Conservation Division

Date: 22/04/2021

From: Jamie Gleeson
Sent: Monday, 17 May 2021 9:54 AM
To: huntercentralcoast@environment.nsw.gov.au
Cc: Andrew Bunch; dmclaughlin@malabarresources.com.au; Steven Cox
Subject: RE: Maxwell Underground Coal Mine Project Expert Reports for condition B49 - Response from Biodiversity and Conservation Division
Attachments: BCD Letter - Condition B49 - SSD 9526 - Mar 2021.pdf;
Ltr_MaxwellTargetedOrchidSurveys_Supplementary Final (13 May 2021).pdf

ATTENTION: STEVEN COX

Hi Steven,

As discussed, we have obtained additional clarification from Dr Colin Driscoll (Hunter Eco) in relation to where the parallel field transects were undertaken relative to the potential habitat identified in the Expert Report. Please find a letter attached.

It would be much appreciated if you could please consider this new information and provide an updated advice in relation to SSD 9526 Consent Condition B49.

Regards

Jamie Gleeson

Environmental Manager - Senior Ecologist

e jgleeson@resourcestrategies.com.au

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Donna McLaughlin
Malabar Resources
c/- Resource Strategies
PO Box R864 Royal Exchange
NSW 1225

13 May 2021

Dear Donna

**Maxwell Project
Targeted Orchid Surveys – Supplementary Information**

Further to my letter dated 29 January 2021, I would like to clarify the scope of the targeted orchid surveys undertaken in September 2020.

The attached figure shows:

- the Maxwell Project disturbance areas;
- areas of potential habitat of *Diuris tricolor* (Pine Donkey Orchid) and *Prasophyllum petilum* (Tarengo Leek Orchid) identified in the *Expert Report - Expected Presence of Threatened Terrestrial Orchids (Diuris tricolor, Prasophyllum petilum, Pterostylis chaetophora): Maxwell Project* (the Expert Report) (Bell 2021)¹; and
- traces showing the transects undertaken in the areas of potential habitat.

Approximately 0.3 ha of derived native grassland was identified during a field inspection as potential habitat by Dr Stephen Bell in an area of potential ponding. In the field I conducted some 10 metre transects and random meanders in this area and found an eroded drainage line that was holding ponded water. There was also very dense and deep grass cover which made it unsafe to continue due to the risk of dropping into hidden eroded holes. The density of the grass cover made it likely that it would have choked any orchids that might have sprouted there.

While I am confident in my field observations, if the Biodiversity and Conservation Division disagree with my field observations, the 0.3 ha of derived native grassland in the area of potential ponding would equate to approximately 5 credits for *Diuris tricolor* and 6 credits for *Prasophyllum petilum*.

In response to the Biodiversity and Conservation Division's letter (22/04/2021), my letter dated 29 January 2021 describes additional survey work (random meanders) undertaken outside of areas of potential habitat identified in the Expert Report (Bell 2021), so therefore there is no requirement to undertake additional parallel field transects.

Yours Faithfully
HUNTER ECO

Dr Colin Driscoll
Environmental Biologist

¹ Bell, S.A.J. (2021) *Expert Report - Expected Presence of Threatened Terrestrial Orchids (Diuris tricolor, Prasophyllum petilum, Pterostylis chaetophora): Maxwell Project*. Report to Malabar Resources. January 2021. Eastcoast Flora Survey.

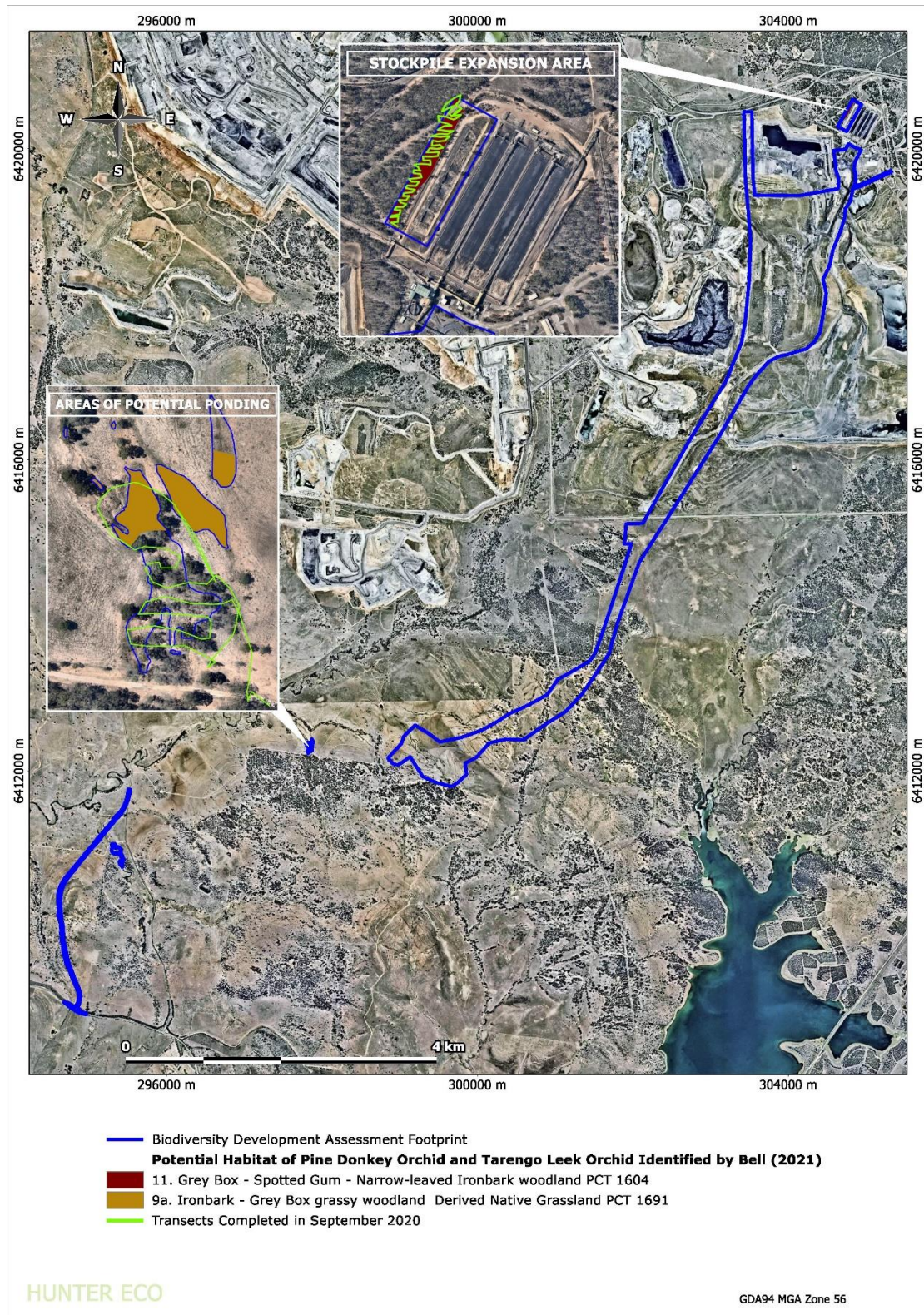


Figure 1: Potential Habitat Transect Surveys

Attachment 2

Correspondence with Muswellbrook Shire Council

22 February 2021

Sharon Pope

Executive Manager Planning, Environment and Regulatory Services
Muswellbrook Shire Council
PO Box 122
Muswellbrook NSW 2333

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Website:
www.malabarresources.com.au

By email: Sharon.Pope@muswellbrook.nsw.gov.au

Dear Sharon,

RE: MAXWELL UNDERGROUND COAL MINE PROJECT (SSD 9526) – SPECIFIC ENVIRONMENTAL CONDITION B49

In December 2020, the Maxwell Underground Coal Mine Project (SSD 9526) (the Project) was approved by the Independent Planning Commission of New South Wales, subject to Development Consent conditions. Conditions B47 and B48 of the Specific Environmental Conditions for Biodiversity outline the credit requirements for the Project under the *Biodiversity Conservation Act, 2016*. Condition B49 states:

The biodiversity credit requirements outlined in conditions B47 and B48 for Diuris tricolor; Prasophyllum petilum; Pterostylis chaetophora; Ozothamnus tessellatus and Thesium australe, may be reduced if the Applicant demonstrates to the satisfaction of the Planning Secretary, that the credit requirements in Table 6 and/or Table 7 do not accurately reflect the extent of impacts on these species as a result of the development. Any request from the Applicant to reduce these credit requirements must:

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 - (i) *by a suitably qualified and experienced person/s;^{a,b}*
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 - (iv) *in consultation with BCD,**to the satisfaction of the Planning Secretary.*

^a *In the case of an expert report, a 'suitably qualified and experienced person' means a person who meets the relevant requirements outlined in section 6.5.2 of the BAM*

^b *In this case of a survey report, a 'suitably qualified and experienced person' means an accredited person as defined in section 1.6 of the BC Act.*

Malabar has commissioned additional flora surveys and an expert report to satisfy the requirements of Condition B49. These reports are being provided to Muswellbrook Shire Council for consultation in accordance with Condition B49(b)(iii). A summary of the offset requirements and findings of the reports is provided below. Copies of the reports are provided in Attachments 1 to 3.

Malabar requests that any comments Muswellbrook Shire Council wish to make on the attached reports be provided by 19 March 2021.

Background

In response to concerns raised by Muswellbrook Shire Council, the Department of Planning, Industry and Environment (DPIE) requested that the then Biodiversity and Conservation Division (BCD) review the flora survey methodology employed during preparation of the Biodiversity Development Assessment Report (BDAR) for the Project.

In a letter dated 22 May 2020, BCD requested further information for 10 threatened flora species considered to potentially occur in the Project Area. Following additional surveys and the provision of additional information by Malabar in July and August 2020, BCD was satisfied that further survey efforts were not required for five of the species (*Commersonia rosea*, *Cymbidium canaliculatum*, *Eucalyptus glaucina*, *Lasiopetalum longistamineum* and *Monotaxis macrophylla*), however recommended further surveys for the remaining five threatened flora species (*Diuris tricolor*, *Ozothamnus tessellatus*, *Prasophyllum petilum*, *Pterostylis chaetophora* and *Thesium australe*).

Therefore, for the purposes of its assessment of the Project, DPIE conservatively assumed the presence of these five species and included a species credit requirement for each in the Development Consent (Conditions B47 and B48). The conditions require Malabar to undertake additional surveys or commission an expert report to seek a reduction of its offsetting obligations where flora species credits are found to have been overestimated (Condition B49).

Additional Surveys and Expert Report

In accordance with Condition B49, Malabar commissioned Hunter Eco (Dr Colin Driscoll, BAM assessor accreditation BAAS17004) to undertake additional flora surveys in September 2020, targeting *Ozothamnus tessellatus* and *Thesium australe* in potential habitat identified in the BDAR and as advised by BCD. These surveys were undertaken in accordance with the 2020 *Surveying Threatened Plants and their Habitats – NSW Survey Guide for the Biodiversity Assessment Method* and the findings are outlined in the attached survey report (Attachment 1).

Malabar also commissioned Eastcoast Flora Survey (Dr Stephen Bell, approved Expert) to prepare an expert report for *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora* in relation to the Project. The expert report was prepared in accordance with the 2020 *Biodiversity Assessment Method* and is provided in Attachment 2.

Malabar commissioned Hunter Eco (Dr Colin Driscoll) to also undertake additional flora surveys in September 2020, targeting *Diuris tricolor* and *Prasophyllum petilum* in potential habitat identified by Dr Stephen Bell (note, no potential habitat was identified for *Pterostylis chaetophora*). These surveys were also undertaken in accordance with the 2020 *Surveying Threatened Plants and their Habitats – NSW Survey Guide for the Biodiversity Assessment Method* and the findings are outlined in the attached survey report (Attachment 3).

Outcomes

Supplementary surveys undertaken by Hunter Eco did not record any of the target species in the Project disturbance areas, confirming the original survey outcomes that none are likely to be present (Attachments 1 and 3).

The expert report prepared by Eastcoast Flora Survey (Attachment 2) concludes that *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora* are unlikely to be present within the Project disturbance areas, also confirming original assessment outcomes.

In accordance with Condition B49, the expert report and survey reports are required to be prepared in consultation with Muswellbrook Shire Council, and other stakeholders. Malabar requests that any comments Muswellbrook Shire Council wishes to make on the attached reports be provided by 19 March 2021.

If you have any queries or would like to arrange a meeting to discuss the findings, please do not hesitate to contact me (dmclaughlin@malabarresources.com.au or [02] 6542 0298).

Yours sincerely,



Donna McLaughlin
Health, Safety, Environment and Community Manager
Malabar Resources

Subject: RE: Maxwell - Consultation for Threatened Flora Species Offset Requirements

From: Sharon Pope <Sharon.Pope@muswellbrook.nsw.gov.au>
Sent: Thursday, 25 February 2021 4:07 PM
To: Donna McLaughlin <dmclaughlin@malabarresources.com.au>
Subject: Maxwell - Consultation for Threatened Flora Species Offset Requirements

Hello Donna

Thank you for providing Council with this information.

Statements made by the expert validate Council comments on the inadequacy of survey work and assessment of impacts on *Diuris tricolor*.

Council is generally satisfied with the conclusions reached and results of additional surveys presented within the attached documents. However, in regards to the targeted surveys for *Diuris tricolor* and *Prasophyllum petilum*, by only surveying on two consecutive days (with no indication whether each survey location had repeated surveys undertaken during those two days) the survey is not consistent with the relevant guidelines as *'less than 20% of plants would be flowering on any particular day at this time. This implies that a 'oneoff' survey, even if conducted on the day of peak flowering, would likely overlook more than 80% of individuals in the population'* (Bell 2021) which means the surveys were not undertaken in a way that maximises the detectability of the target species.

The Maxwell Underground Assessment Report 0920 on three occasions states that Maxwell Mine *'provide suitable additional offsets in the event that any unexpected impacts occur. This recommendation has been reflected in the Department's recommended conditions'*. This was not reflected in the final conditions of consent. Therefore, any surface cracking and subsequent remediation in vegetation mapped as Ironbark - Grey Box Grassy Woodland DNG (Unit 9a) or Grey Box – Spotted Gum – Narrow-leaved Ironbark Woodland (Unit 11) by Hunter Eco (2019) should be considered as likely to be impacting upon *Diuris tricolor* and *Prasophyllum petilum* and require appropriate compensatory measures to be provided by Maxwell Mine.

Regards



**Sharon Pope | Executive Manager Environmental and Planning Services |
Muswellbrook Shire Council**

T: 02 6549 3868 **I E:** Sharon.pope@muswellbrook.nsw.gov.au | www.muswellbrook.nsw.gov.au

Note **The Muswellbrook Council Administration Centre has moved to
Campbell's Corner 60-82 Bridge Street Muswellbrook NSW 2333**

From: Donna McLaughlin <dmclaughlin@malabarresources.com.au>
Sent: Tuesday, 23 February 2021 5:33 AM
To: Muswellbrook Shire Council <council@muswellbrook.nsw.gov.au>

Cc: Sharon Pope <Sharon.Pope@muswellbrook.nsw.gov.au>

Subject: Doc 1234209 Maxwell - Consultation for Threatened Flora Species Offset Requirements

Hi Sharon,

In December 2020, the Maxwell Underground Coal Mine Project (SSD 9526) (the Project) was approved by the Independent Planning Commission of New South Wales, subject to Development Consent conditions.

Conditions B47 and B48 of the Development Consent outline the credit requirements for the Project under the *Biodiversity Conservation Act, 2016*. Condition B49 provides that the biodiversity credit requirements for some species may be reduced if Malabar demonstrates to the satisfaction of the Planning Secretary, that the credit requirements for those species do not accurately reflect the extent of impacts on those species as a result of the development.

Malabar has commissioned additional flora surveys and an expert report to satisfy the requirements of Condition B49. The findings confirm original assessment outcomes that none of the target flora species are likely to be present within the Maxwell Project disturbance areas.

These reports are being provided to MSC for consultation in accordance with Condition B49(b)(iii) (refer reports attached).

Malabar request that any comments MSC wish to make on the attached reports be provided by 19 March 2021. If you have any queries or would like to arrange a meeting to discuss the findings, please do not hesitate to contact me (dmclaughlin@malabarresources.com.au or [02] 6542 0298).

Regards,

Donna McLaughlin
Health, Safety, Environment and Community Manager



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Muswellbrook Shire Council ABN 86 864 180 944

Attachment 3

Responses to Comments from Biodiversity, Conservation and Science Directorate and Muswellbrook Shire Council

Comments Received	Malabar Response
<i>Biodiversity, Conservation and Science Directorate</i>	
BCD has reviewed the letter and attachments and is satisfied that field surveys failed to find any <i>Ozothamnus tessellatus</i> and <i>Thesium australe</i> plants. BCD is also satisfied that the expert report concludes that there is no suitable habitat present for <i>Pterostylis chaetophora</i> .	The acceptance of the absence of <i>Ozothamnus tessellatus</i> , <i>Thesium australe</i> and <i>Pterostylis chaetophora</i> is noted.
BCD does not agree that the all field surveys for <i>Diuris tricolor</i> and <i>Prasophyllum petilum</i> were undertaken in accordance the 2020 Surveying threatened plants and their habitats: NSW survey guide for the Biodiversity Assessment Method (the 2020 Survey Guidelines). Figure 4 of Attachment 3 of your letter shows that random meanders were undertaken in some of the areas of potential habitat identified in the expert report. The 2020 Survey Guidelines do not support the use of random meanders. Parallel field transects should have been undertaken at a spacing of 10 metres apart in open vegetation, and 5 metres apart in dense vegetation. BCD notes that appropriately spaced parallel field transects were undertaken in the potential habitat area shown on Figure 3 of Attachment 3 of your letter, and no <i>Diuris tricolor</i> or <i>Prasophyllum petilum</i> plants were found. BCD recommends that parallel field transects (in accordance with the 2020 Survey Guidelines) are undertaken across the potential habitat area shown in Attachment 3 of Figure 4 of your letter. BCD considers that in the absence of appropriate field surveys, there is potential for <i>Diuris tricolor</i> and <i>Prasophyllum petilum</i> to occur in the potential habitat areas identified in the expert report.	Additional survey work (i.e. the random meanders) was undertaken by Hunter Eco outside of areas of potential habitat identified in the Expert Report (Bell, 2021). Therefore, there is no requirement to undertake additional parallel field transects in these areas that are not identified potential habitat. Approximately 0.3 hectares (ha) of derived native grassland was identified during a field inspection as potential habitat by Dr Stephen Bell in an area of potential ponding. Hunter Eco advised that, in the field, 10 metre transects and random meanders were conducted in this area and found an eroded drainage line that was holding ponded water. Hunter Eco observed very dense and deep grass cover which made it unsafe to continue due to the risk of dropping into hidden eroded holes. Hunter Eco stated that the density of the grass cover made it likely that it would have choked any orchids that might have sprouted there and therefore it is unlikely that <i>Diuris tricolor</i> and <i>Prasophyllum petilum</i> would occur in these areas. If the BCD disagree with Hunter Eco's findings, it was estimated that the 0.3 ha of derived native grassland in the area of dense grass cover within the area of potential ponding would equate to approximately 5 credits for <i>Diuris tricolor</i> and 6 credits for <i>Prasophyllum petilum</i>.
<i>Muswellbrook Shire Council</i>	
Statements made by the expert validate Council comments on the inadequacy of survey work and assessment of impacts on <i>Diuris tricolor</i>. Council is generally satisfied with the conclusions reached and results of additional surveys presented within the attached documents. However, in regards to the targeted surveys for <i>Diuris tricolor</i> and <i>Prasophyllum petilum</i>, by only surveying on two consecutive days (with no indication whether each survey location had repeated surveys undertaken during those two days) the survey is not consistent with the relevant guidelines as '<i>less than 20% of plants would be flowering on any particular day at this time. This implies that a 'one off' survey, even if conducted on the day of peak flowering, would likely overlook more than 80% of individuals in the population'</i> (Bell 2021) which means the surveys were not undertaken in a way that maximises the detectability of the target species.	The acceptance of the absence of <i>Ozothamnus tessellatus</i>, <i>Thesium australe</i> and <i>Pterostylis chaetophora</i> is noted. The frequency of the targeted surveys was undertaken in accordance with <i>Surveying Threatened Plants and their Habitats: NSW Survey Guide for the Biodiversity Assessment Method</i> (DPIE, 2020a). There is no requirement to undertake repeat surveys. If <i>Diuris tricolor</i> and <i>Prasophyllum petilum</i> were detected in the Project area, additional surveys would have been undertaken to confirm the population size.

Comments Received	Malabar Response
<i>Muswellbrook Shire Council (continued)</i>	
The Maxwell Underground Assessment Report 0920 on three occasions states that Maxwell Mine ‘<i>provide suitable additional offsets in the event that any unexpected impacts occur. This recommendation has been reflected in the Department’s recommended conditions</i>’. This was not reflected in the final conditions of consent. Therefore, any surface cracking and subsequent remediation in vegetation mapped as Ironbark - Grey Box Grassy Woodland DNG (Unit 9a) or Grey Box – Spotted Gum – Narrow-leaved Ironbark Woodland (Unit 11) by Hunter Eco (2019) should be considered as likely to be impacting upon <i>Diuris tricolor</i> and <i>Prasophyllum petilum</i> and require appropriate compensatory measures to be provided by Maxwell Mine.	Condition C3 of the Development Consent (SSD 9526) requires the provision of additional offsets in the event that the subsidence impact performance measures are exceeded and it is not reasonable or feasible to remediate the subsidence impact or environmental consequence, or remediation measures have failed to satisfactorily remediate the subsidence impact or environmental consequence. In relation to remediation of subsidence impacts, the BDAR (Hunter Eco, 2019) states: <i>Prior to any remediation of surface cracks, Malabar would undertake a review of environmental impacts that may result from the remediation at the specific location and consider if remediation of surface cracks is environmentally beneficial or if alternative methods of remediating the crack is warranted (e.g. without machinery). The review would consider, among other factors, the known locations of threatened flora species and populations.</i>

Attachment 4

Maxwell Project (SSD 9526) – Targeted Searches for *Ozothamnus tessellatus* and *Thesium australe*



Bill Dean
Malabar Resources
c/- Resource Strategies
PO Box R864 Royal Exchange
NSW 1225

29 January 2021

Dear Bill

Maxwell Project (SSD 9526) – Targeted Searches for *Ozothamnus tessellatus* and *Thesium australe*

Hunter Eco (Dr Colin Driscoll) conducted 40 metre (m) transect surveys for the threatened flora species *Eucalyptus glaucina* (Slaty Red Gum), *Cymbidium canaliculatum* (Tiger Orchid), *Ozothamnus tessellatus* and *Thesium australe* (Austral Toadflax) in July 2020. The New South Wales Biodiversity Conservation Division (BCD) accepted that the survey was sufficient to discount the presence of *Eucalyptus glaucina* and *Cymbidium canaliculatum* but did not meet the guideline requirements for *Ozothamnus tessellatus* and *Thesium australe* because a more intensive transect survey was required to assess whether either of these species were present.

As per advice from the BCD:

To satisfy the survey guidelines, survey transects for Ozothamnus tessellatus, particularly when plants are not in flower, should be 20 metres or less apart. Survey transects for Thesium australe should be 20 metres apart or less to identify patches of Themeda triandra (in which Thesium australe occurs), followed by transects 5 metres apart within patches of Themeda triandra to look for Thesium australe.

Additional surveys were conducted on 28 and 29 September 2020. Hunter Eco (Dr Colin Driscoll) conducted 10 and 20 m transect surveys for *Ozothamnus tessellatus* and *Thesium australe* within the associated PCTs. According to the *BioNet Threatened Biodiversity Data Collection*, *Ozothamnus tessellatus* is associated with the woodland forms of Plant Community Types (PCT) 1604, 1606 and 1655 and *Thesium australe* is associated with the woodland form of PCT 1604.

Thesium australe is a spreading herb commonly found elsewhere in patches of *Themeda triandra* (Kangaroo Grass) so transect searches included finding occurrences of *Themeda triandra* which, if found, would have triggered transects of 10 m spacing for *Thesium australe*.

Survey Results

PCT 1604 occurs in the proposed Stockpile Expansion area and was surveyed using 10 m transects (Figure 1) to detect *Themeda triandra* and *Ozothamnus tessellatus*. Neither was found thus also excluding the presence of *Thesium australe*.

PCT 1606 and 1655 occur within the proposed transport and services corridor between the Maxwell Underground and Maxwell Infrastructure areas and these were searched using 20 m transects (Figure 2). No *Ozothamnus tessellatus* and no *Themeda triandra* were recorded, again also excluding the presence of *Thesium australe*.

Yours Faithfully
HUNTER ECO

Dr Colin Driscoll
Environmental Biologist

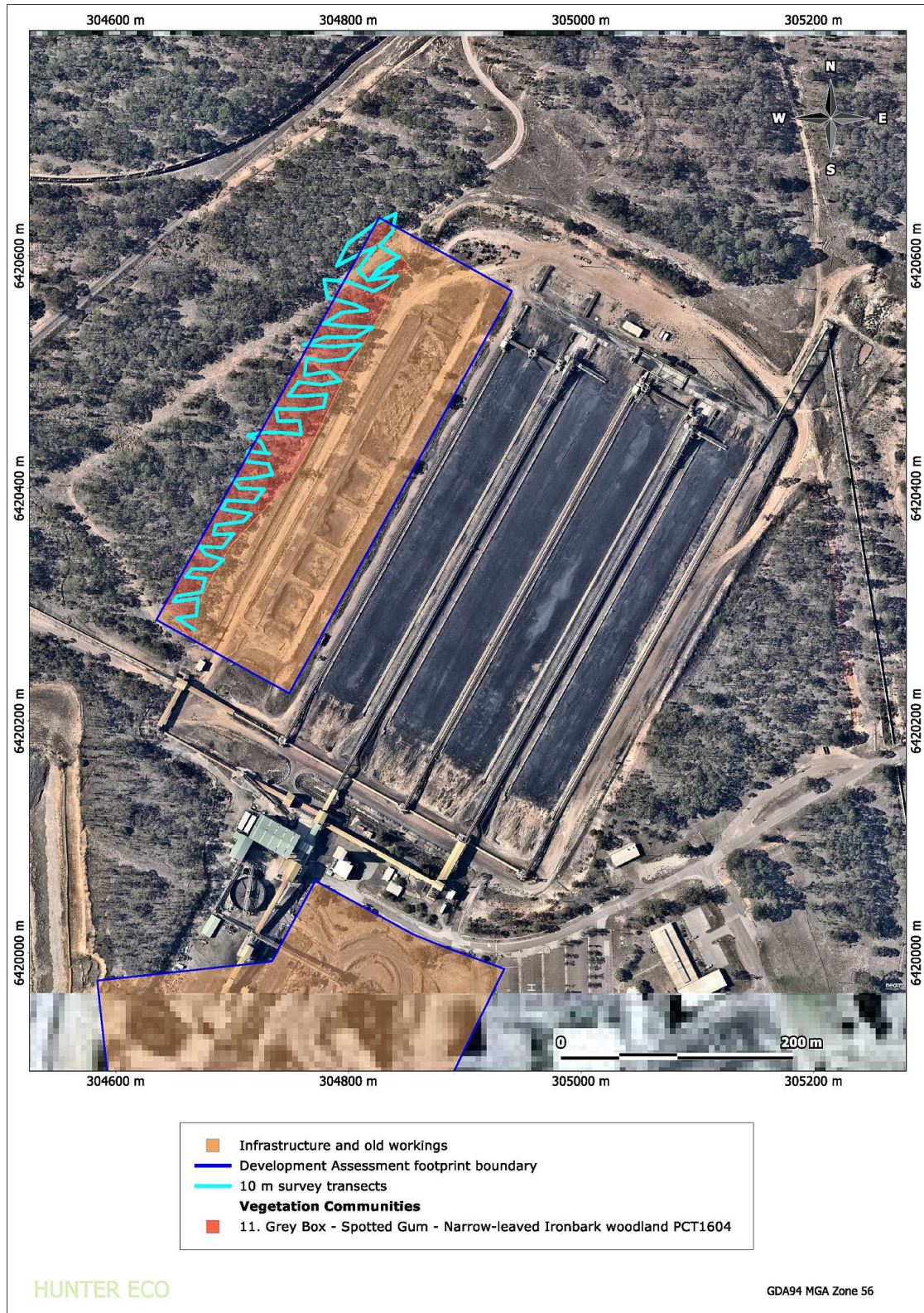


Figure 1: 10 m Transect Surveys

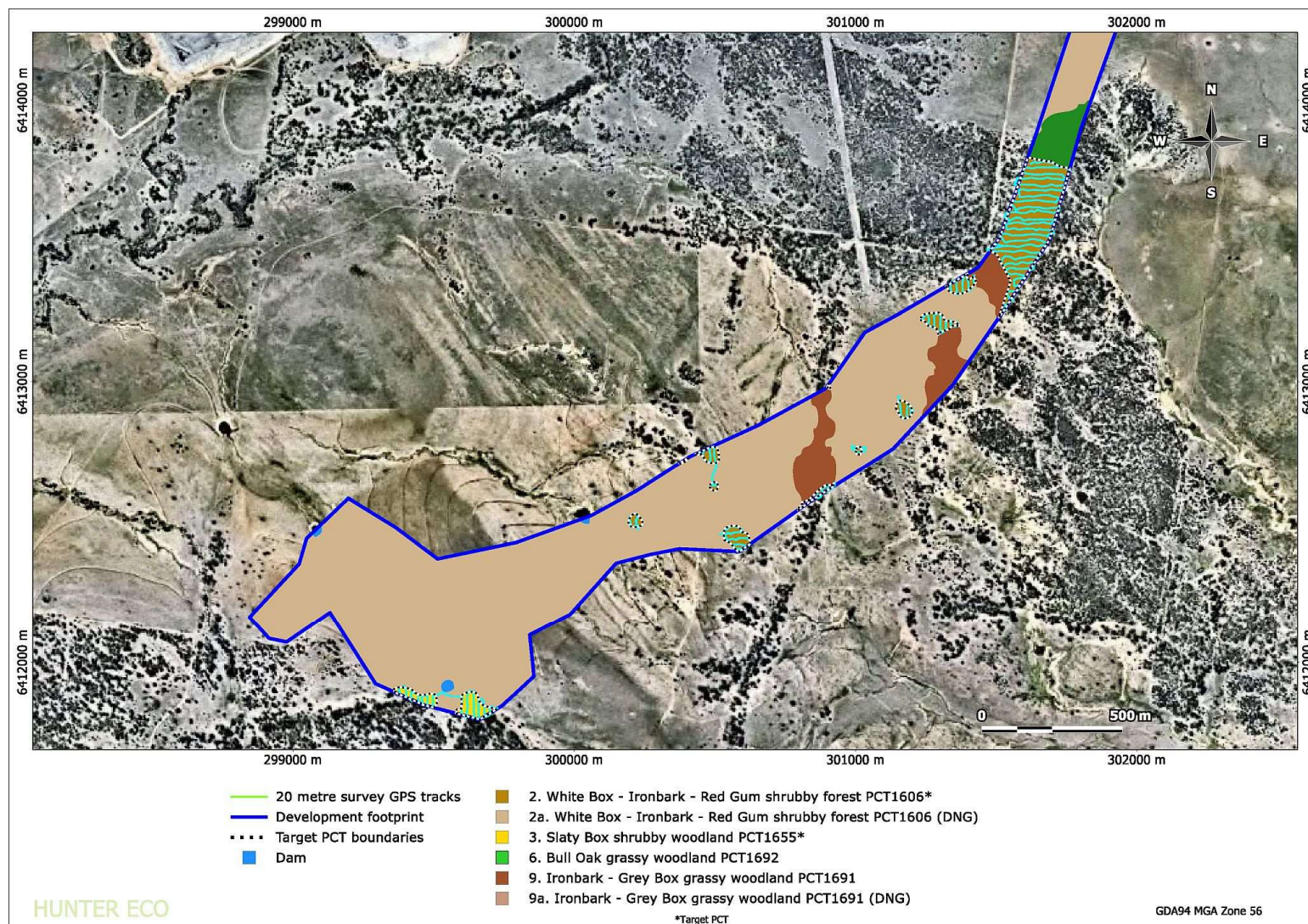


Figure 2: 20 m Transect Surveys

Attachment 5

Expert Report – Expected Presence of Threatened Terrestrial Orchids (*Diuris tricolor*, *Prasophyllum petilum*, *Pterostylis chaetophora*): Maxwell Project

Expert Report

Expected Presence of Threatened Terrestrial Orchids (*Diuris tricolor*, *Prasophyllum petilum*, *Pterostylis chaetophora*)

Maxwell Project



February 2021

Final Report

Malabar Resources

Thomas Mitchell Drive
Muswellbrook NSW 2333

Dr Stephen Bell

Eastcoast Flora Survey
PO Box 216
Kotara Fair NSW 2289



SUMMARY

Maxwell Ventures Management Pty Ltd, a wholly owned subsidiary of Malabar Resources, propose to establish an underground coal mine within EL5460 (Muswellbrook local government area, Hunter Valley, New South Wales), which will require limited ground disturbance across the Project Area. Never-the-less, proposed disturbances associated with planned development may potentially impact on threatened terrestrial orchids (*Diuris tricolor* [Pine Donkey Orchid], *Prasophyllum petilum* [Tarengo Leek Orchid] or *Pterostylis chaetophora* [Rusty Greenhood]) or their habitat. No records of the three target species exist for the Project Area, and after assessment I considered that 1.6 hectares (ha) of the proposed 320 ha (0.5%) ground disturbance area may provide habitat for two of these species (*Diuris tricolor*, *Prasophyllum petilum*). I do not consider that the third species (*Pterostylis chaetophora*) is likely to occur anywhere within the Project Area.

Diuris tricolor and *Prasophyllum petilum* occupy extensive geographical ranges outside of the Hunter region, however *Pterostylis chaetophora* is endemic here. Populations for *Diuris tricolor* exist close to the Project Area along Thomas Mitchell Drive, and *Prasophyllum petilum* has historically also been recorded at the eastern end of Thomas Mitchell Drive but that colony is presumed extinct. There are no validated populations of *Pterostylis chaetophora* west of North Rothbury (52 kilometres [km] to the south-east), and further inland records at Mangoola Coal (21 km north-west) and Wingen Maid Nature Reserve (55 km north) also remain unvalidated, and may represent a different species.

Following a site inspection of the Project Area in July 2020, I noted observable differences in the floristic composition of the habitats there to other areas where I have seen the three target orchids, and the predominance of former Box (*Eucalyptus 'albemol'* and *Eucalyptus moluccana*) landscapes within these largely cleared lands conflicts with my experience of orchid habitat elsewhere. Differences were supported by a review of ecological information prepared by Hunter Eco for the Project Area, the mapping of which I found to be accurate and acceptable. Numerical analysis of defined vegetation communities revealed clear differences to habitat from elsewhere in the region known to support *Pterostylis chaetophora*, but show one community similar to habitats typical of *Diuris tricolor* and *Prasophyllum petilum*. Additionally, the close proximity of known populations of *Diuris tricolor* (c. 400 metres [m]) and *Prasophyllum petilum* (1300 m) to the northern section of the Project Area suggests that potential habitat for these may also occur in a second community. I therefore considered that the vegetation units defined by Hunter Eco as Ironbark - Grey Box Grassy Woodland Derived Native Grassland (Unit 9a) and Grey Box – Spotted Gum – Narrow-leaved Ironbark Woodland (Unit 11) provide the only potential habitat for *Diuris tricolor* and *Prasophyllum petilum*, which together comprise 1.6 ha of the Project Area. Subsequently, Dr Colin Driscoll (Hunter Eco) was commissioned by Malabar Resources to conduct a targeted survey of this area during suitable survey conditions in 2020, and none of the target species were found. *Diuris tricolor* and *Prasophyllum* (syn. *Prasophyllum* sp. Wybong) are therefore unlikely to be present within the Project Area.

In support, a detailed assessment of environmental attributes across all Hunter populations of *Diuris tricolor* (n=983), *Prasophyllum petilum* (n=485) and *Pterostylis chaetophora* (n=128) found differences in geological units, soil landscapes, and (for *Pterostylis chaetophora*) annual rainfall when compared to the Project Area. Of these, soil landscapes were seen as particularly important given they best encapsulate the likely distribution of the necessary mycorrhizal fungi across the region, without which no orchids would germinate and prosper. As a surrogate for fungi distribution, an assessment of all terrestrial orchid observation records (common and threatened) for the upper Hunter Valley demonstrated a scarcity of records in and around the Project Area, suggesting that mycorrhizal fungi were therefore also scarce or localised. This lends further credence to my conclusion that no populations of *Diuris tricolor* or *Prasophyllum petilum* are expected across the bulk of the Project Area.

The combination of geology, soil landscape, floristics, rainfall, and general orchid distribution (as a surrogate for mycorrhizal fungi) suggest that the Project Area is unlikely to support extensive populations of *Diuris tricolor* or *Prasophyllum petilum* (syn. *Prasophyllum* sp. Wybong), and none of *Pterostylis chaetophora*. The areas where I considered the former two species may occur occupy <1% of the total disturbance footprint, but subsequent targeted searches in these areas did not record these species.

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Document cover: View across part of the proposed surface development area (top), and target orchids (from left) *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora*.

Report produced for:

Malabar Resources
Thomas Mitchell Drive
Muswellbrook NSW 2333

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1. Introduction

1.1 Background

1. I have been engaged by Resource Strategies on behalf of Maxwell Ventures Management Pty Ltd and Malabar Resources (Malabar) to undertake an expert review in relation to the potential occurrence of three threatened orchids (*Diuris tricolor* [Pine Donkey Orchid], *Prasophyllum petilum* [Tarengo Leek Orchid] and *Pterostylis chaetophora* [Rusty Greenhood]). This review will be incorporated into a Biodiversity Development Assessment Report (BDAR) prepared by Hunter Eco (2019), which addresses the proposed Maxwell Project (the Project). This expert review is as required and in accordance with section 5.3 of the New South Wales (NSW) Government's Biodiversity Assessment Method (BAM) (Department of Planning, Industry and Environment [DPIE] 2020). It aims to determine the habitat suitability of the proposed development lands for the subject orchids.
2. As part of my brief, I have been asked to examine the potential for *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora* to occur within lands designated for ground disturbance and/or possible ponding following ground subsidence. These lands occupy 320 hectares (ha), of which approximately 226 ha comprises native vegetation (Hunter Eco 2019). My assessment is required as drought conditions within the Project Area in recent years have impinged on comprehensive surveys for all three orchid species. On 3 July 2020, I undertook an inspection of the Project Area to examine habitat quality and disturbance levels, expanded upon in **Section 4**.

1.2 Project Overview

3. Maxwell Ventures (Management) Pty Ltd, a wholly owned subsidiary of Malabar, has consent to develop an underground coal mining operation, known as the Maxwell Project (the Project), located wholly in the Muswellbrook local government area (LGA). It is proposed to undertake underground mining of coal within Exploration Licence 5460, using a combination of both existing and new infrastructure to support underground mining and coal handling activities. Four seams within the Whittingham Coal Measures would be mined using underground bord and pillar (with partial pillar extraction) in the Whynot Seam, and underground longwall extraction in the Woodlands Hill, Arrowfield and Bowfield Seams.
4. As part of proposed works, Malabar intend to undertake a range of actions which may impact on the existing natural environment across five defined areas (the Project Area):
 - expansion of the existing Product Stockpile Extension area to accommodate mined coal;
 - construction of a Surface Development Area to accommodate underground entrance surface facilities and a transport and services corridor;
 - Edderton Rd Realignment, to allow for potential ground subsidence damage;
 - Ancillary Disturbance Area (Ponding) 1, where ground subsidence may result in water ponding; and
 - Ancillary Disturbance Area (Ponding) 2, where ground subsidence may result in water ponding.

5. The focus of my report is on the 320 ha of proposed Project lands lying west of Lake Liddell and Plashett Reservoir, east of Denman and south-east of Muswellbrook (Figure 1 and 2). Note that the full extent of proposed disturbance areas continues through existing post-mine landforms, but only those lands outside of these areas (i.e. that component constituting the ‘controlled action’ under the Commonwealth EPBC Act) are addressed in this report.

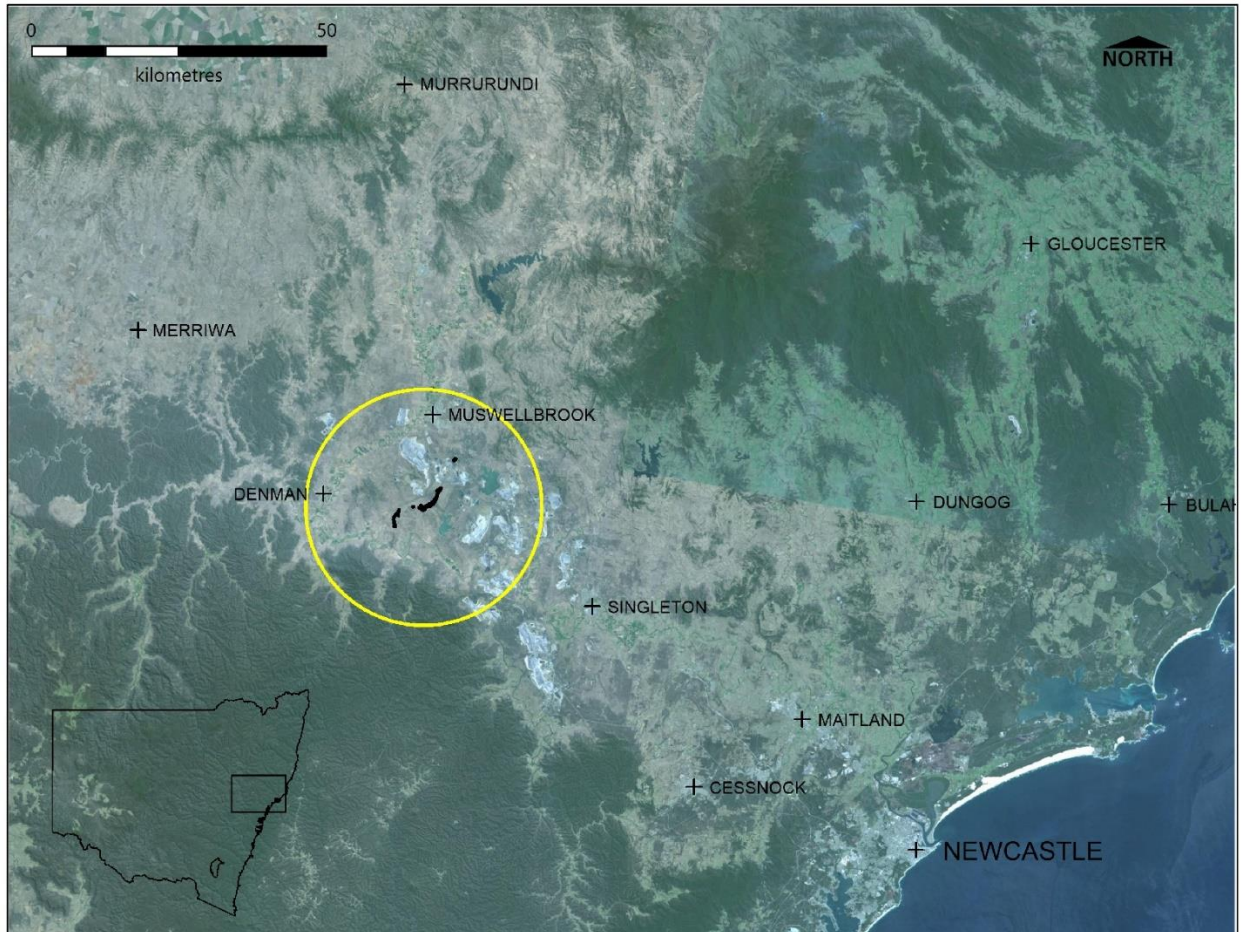


Figure 1 Location of the Project Area (circled) within the context of the Hunter Valley.

6. To assist in later discussions, this area (the Project Area) has been designated into five geographically separate parcels of land (see Table 1).

1.3 Report Criteria & Structure

7. As detailed in the BAM (DPIE 2020), an expert report is required to address the following criteria (Box 3 in section 5.3), and these form the basis of the structure of this report:
- identify the species or population (see Section 2);
 - justify the use of an expert report (see Section 3);
 - justify the likelihood of occurrence of the species or population and prepare a species polygon as per subsection 5.2.5 (see Section 4);

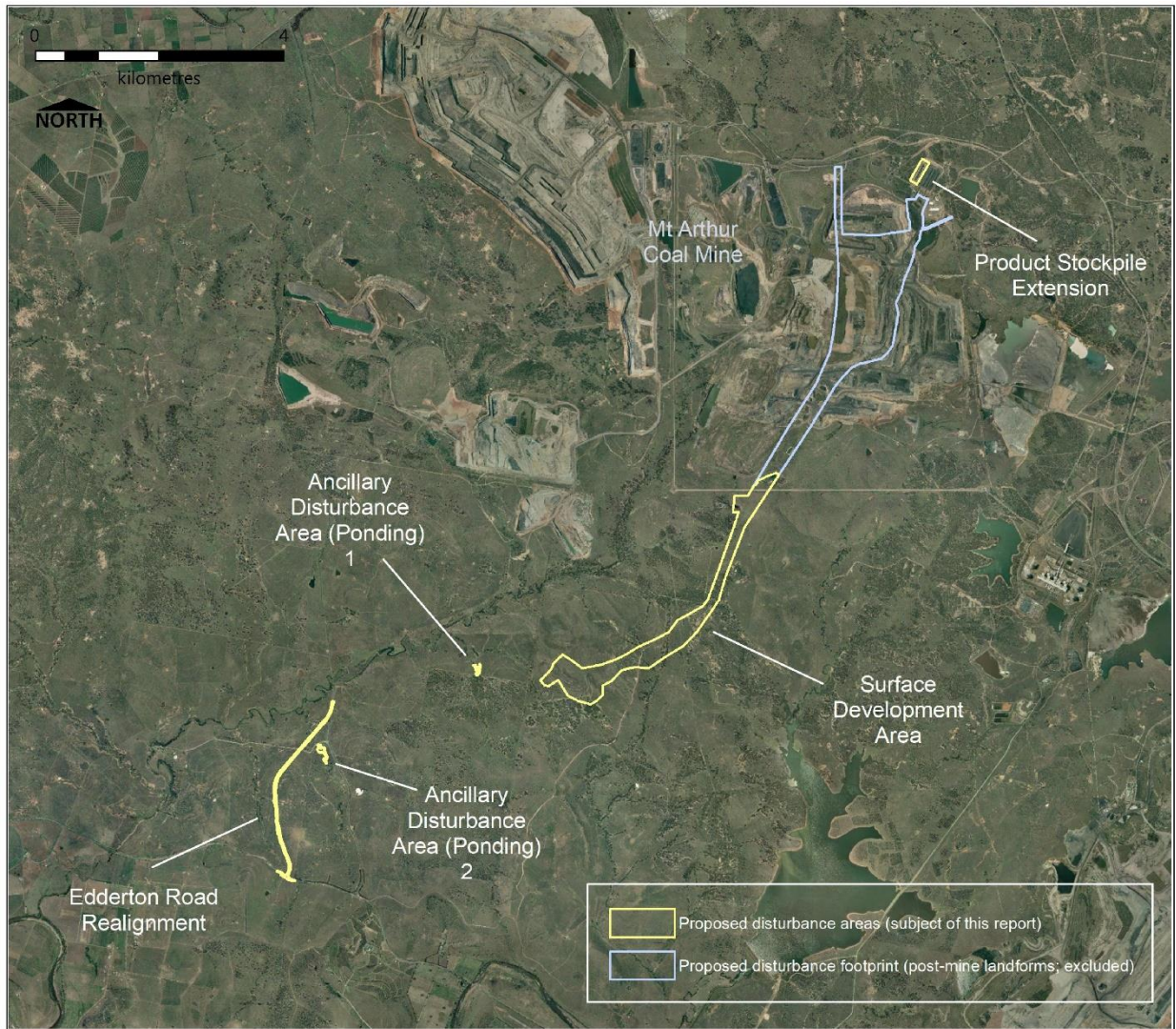


Figure 2 The Project Area, showing layout of proposed disturbance areas detailed in Table 1. Lands within existing post-mine landscapes are not addressed in this report.

Table 1 Land parcels comprising the Project Area.

Land Parcel	Details	Size (ha)
Product Stockpile Extension	adjacent to the existing stockpile area, c. 500 metres (m) south of Thomas Mitchell Drive	5.2
Surface Development Area	immediately south of Mt Arthur Coal Mine, c. 2.6 kilometres (km) north-west of Plashett Reservoir	302.9
Edderton Rd Realignment	west of existing Edderton Road (south of Saddlers Creek), c. 1.1 km west of its junction with the Golden Highway	10.2
Ancillary Disturbance Area (Ponding) 1	tributary of Saddlers Creek, c. 2.3 km east of Edderton Road	0.5
Ancillary Disturbance Area (Ponding) 2	tributary of Saddlers Creek, c. 0.3 km west of Edderton Road and 2.2 km north of the Golden Highway – Edderton Road intersection	1.5
Total		320.3

- d. estimate the area of habitat (if the species is assessed by area) on the subject land (see **Section 5**), or
- e. estimate the maximum number of mature individuals (as identified in the Credit Calculator) for the subject land. Where the expert report is required because the species is assumed to be present, provide evidence such as a reference site, for this estimation (option d. above undertaken);
- f. include the information considered in making this determination (see **Section 6**); and
- g. state the expert's credentials (see **Section 7**).

1.4 DPIE Approval to Prepare Expert Report

- 8. I have been approved to prepare this expert report for all three target species by DPIE, see [Appendix 1](#) and the list of approved biodiversity experts available at <https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/biodiversity-offsets-scheme/experts>.

2. Criterion (a) - The Relevant Species

2.1 Legal Status

9. *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora* are threatened species included in relevant State, Territory and Commonwealth legislation (Table 2). *Diuris tricolor* is listed both as vulnerable in NSW and as an endangered population in the Muswellbrook LGA under the *Biodiversity Conservation Act 2016* (BC Act), while *Prasophyllum petilum* is listed as endangered in NSW (BC Act) and the Australian Capital Territory (ACT) (*Nature Conservation Act 2014*), but under the synonym *Prasophyllum* sp. Wybong (C.Phelps ORG 5269) as critically endangered nationally (*Environment Protection and Biodiversity Conservation Act 1999* [EPBC Act]). *Pterostylis chaetophora* is listed as vulnerable only on the BC Act.

Table 2 Legal status of target orchids within relevant States and Territories.

Legislation	<i>Diuris tricolor</i>	<i>Prasophyllum petilum</i>	<i>Pterostylis chaetophora</i>
Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>	-	Crit. End.	-
NSW <i>Biodiversity Conservation Act 2016</i>	Vul. / EPop.	End.	Vul.
ACT <i>Nature Conservation Act 2014</i>	-	End.	-
VIC <i>Flora and Fauna Guarantee Act 1988</i>	End.	-	-
QLD <i>Nature Conservation Act 1992</i>	LC	-	-

Key: Crit. End. = Critically Endangered; End. = Endangered; EPop. = Endangered Population; LC = Least Concern; Vul. = Vulnerable.

Note: *Prasophyllum petilum* is currently listed nationally on the EPBC Act as Endangered (as *Prasophyllum petilum*) and also as Critically Endangered (as *Prasophyllum* sp. Wybong (C.Phelps ORG 5269), in synonymy), because the Australian Plant Census has not yet accepted this synonym.

10. In recent years, there has been some taxonomic confusion over the identity of *Prasophyllum* plants growing in the upper Hunter (Wybong) area. Following an informal review by NSW orchid taxonomists over the past decade, these plants were placed in synonymy with the more widespread *Prasophyllum petilum* (see PlantNet; <http://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=sp&name=Prasophyllum~petilum>), a finding also supported by other orchid experts elsewhere in Australia (e.g. Backhouse *et al.* 2019). As a consequence, *Prasophyllum* sp. Wybong (C.Phelps ORG 5269) is now an accepted synonym of *Prasophyllum petilum*, but remains listed as critically endangered under that phrase name on the EPBC Act.

2.2 Distribution and Known Populations

11. *Diuris tricolor* and *Prasophyllum petilum* are present and co-occur in the upper Hunter Valley region of NSW, but the two species also occupy considerably wider geographical ranges throughout eastern Australia. In contrast, *Pterostylis chaetophora* is endemic to the Hunter region and occupies a smaller and more coastal distribution. However, historical records of *Pterostylis chaetophora* from the Muswellbrook (2005) and Scone (1998) areas are potentially

indicative also of a more inland extent, but these have not yet been verified. Figure 3 shows images of all three species growing *in situ* in the Hunter region.

12. Notes on the distribution of all three species in the following discussion are based on as-held database records from DPIE (extracted under licence ASH20009), augmented with notes and records from published and unpublished reports in the literature (cited accordingly). Records from licence ASH20009 are included with other publicly available data and cited collectively as 'NSW BioNet'.



Figure 3 Target orchids (from left): *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora*.

2.2.1 *Diuris tricolor*

13. *Diuris tricolor* (Pine Donkey Orchid) is a widespread terrestrial orchid, occurring on the western slopes and plains and tablelands of NSW, and also in the Moreton and Darling Downs districts of Queensland (Stanley & Ross 1989; Jones 1993). Populations of *Diuris tricolor* in the upper Hunter Valley between Denman and Muswellbrook essentially form the eastern extent of an east-west trending meta-population extending along the Goulburn River valley to Mudgee (Figure 4). Records exist for this species at approximately 20 km intervals along this 200 km extent, suggesting that some exchange of genetic material may be occurring with more westerly stands. The Type material of *Diuris tricolor* was collected at Mudgee in the late 1800s.
14. The nearest records of *Diuris tricolor* to the Project Area are an observation in 2009 from land off Saddlers Creek (c. 600 m south of the proposed Ancillary Disturbance Area 1; NSW BioNet; also noted in Cumberland Ecology 2015 and relocated by Hunter Eco 2020), and several observations from 2004-2015 within the Mt Arthur complex along Thomas Mitchell Drive (c. 400 m north of the proposed Product Stockpile Extension area; NSW BioNet; Hunter Eco 2013). The 2009 observation recorded two plants in that year, and follow up surveys found none in November 2010 (outside of peak flowering) but 'at least 30' in 2011 (Cumberland Ecology 2015). Searches since that time have failed to locate any individuals, although several years of drought during this period may have reduced flowering and increased grazing pressure. Along Thomas Mitchell Drive, one observation of *Diuris tricolor* in 2004, three in 2009, one in 2012 and 70 in 2015 (within the Drayton Wildlife Refuge) attest to a sizeable population in that

vicinity. No plants have been observed since 2015 (Hunter Eco 2019), detection again likely to have been negatively impacted by drought.

15. A single, small disjunct population of *Diuris tricolor* was also recorded at North Rothbury in 2016 (noted in Bell 2017a), and represents the most easterly population known within NSW. No individuals have been observed at that location since 2016 due to dry conditions. North Rothbury lies more than 50 km to the south-east of the Project Area.
16. Elsewhere in NSW, *Diuris tricolor* is extensive across the north, central and south western slopes, and extends into south-eastern Queensland. A single record from the Hume region of Victoria suggests that the species is very rare in that state, and indeed Backhouse *et al.* (2016) indicate that it is known from just three plants.

2.2.2 *Prasophyllum petilum*

17. *Prasophyllum petilum* (Tarengo Leek Orchid) occupies a smaller distributional range than *Diuris tricolor*, with most records from the ACT but with outliers in the Kandos, Denman, Premer and Inverell districts on the tablelands and western slopes of NSW. Until recently, Hunter Valley plants were considered a distinct but un-named taxon, *Prasophyllum* sp. 'Wybong' (C.Phelps ORG 5269), but are now placed in synonymy with *P. petilum* by NSW taxonomic authorities. In support, Backhouse *et al.* (2019) do not include *Prasophyllum* sp. 'Wybong' in their comprehensive list of Australian orchid taxa, despite the inclusion of three other un-named taxa with close affinities to *P. petilum*. The Type material of *P. petilum* was collected from Hall (in the ACT) in 1988.
18. The nearest known occurrence of *Prasophyllum petilum* to the Project Area is a site near the eastern end of Thomas Mitchell Drive (NSW BioNet). This observation (made of 10 plants in 1999) was the first of the species for the Hunter Region, and advice from the original observers has confirmed the identity of those plants against current taxonomy (L. Copeland pers. comm.). Surveys subsequent to the initial discovery revealed no plants in 2000, five plants in 2001, no plants in 2002, nine plants in 2003, no plants in 2005 and one plant in 2005 (B. Holzinger pers. comm.). Occasional searches of the site since 2005 have failed to detect any plants, suggesting that the population may now be extinct (B. Holzinger pers. comm.).
19. All other Hunter Valley observations of *Prasophyllum petilum* are from Mangoola Coal (Wybong), approximately 25 km to the north-west, and no other observations are evident from other parts of the Hunter Valley (NSW BioNet; Australasian Virtual Herbarium [AVH]). Plants have been recorded at Mangoola in most years since 2009, although numbers were very low during the drought years of 2017-2019 (Bell 2020a).
20. Outside of the Hunter catchment, the next nearest populations of *Prasophyllum petilum* occur near Kandos, some 140 km to the south-west, and Premer 190 km to the north-west (Figure 4). Hunter Valley populations of *Prasophyllum petilum* are consequently isolated from all others, and opportunities for genetic exchange are minimal. Note that Jeanes (2015a) considered similar populations of *Prasophyllum* in Victoria to represent a different taxon (now described as *P. argillaceum*: Jones & Rouse 2018), implying that *Prasophyllum petilum* is endemic to NSW, a view also supported by Backhouse *et al.* (2019).

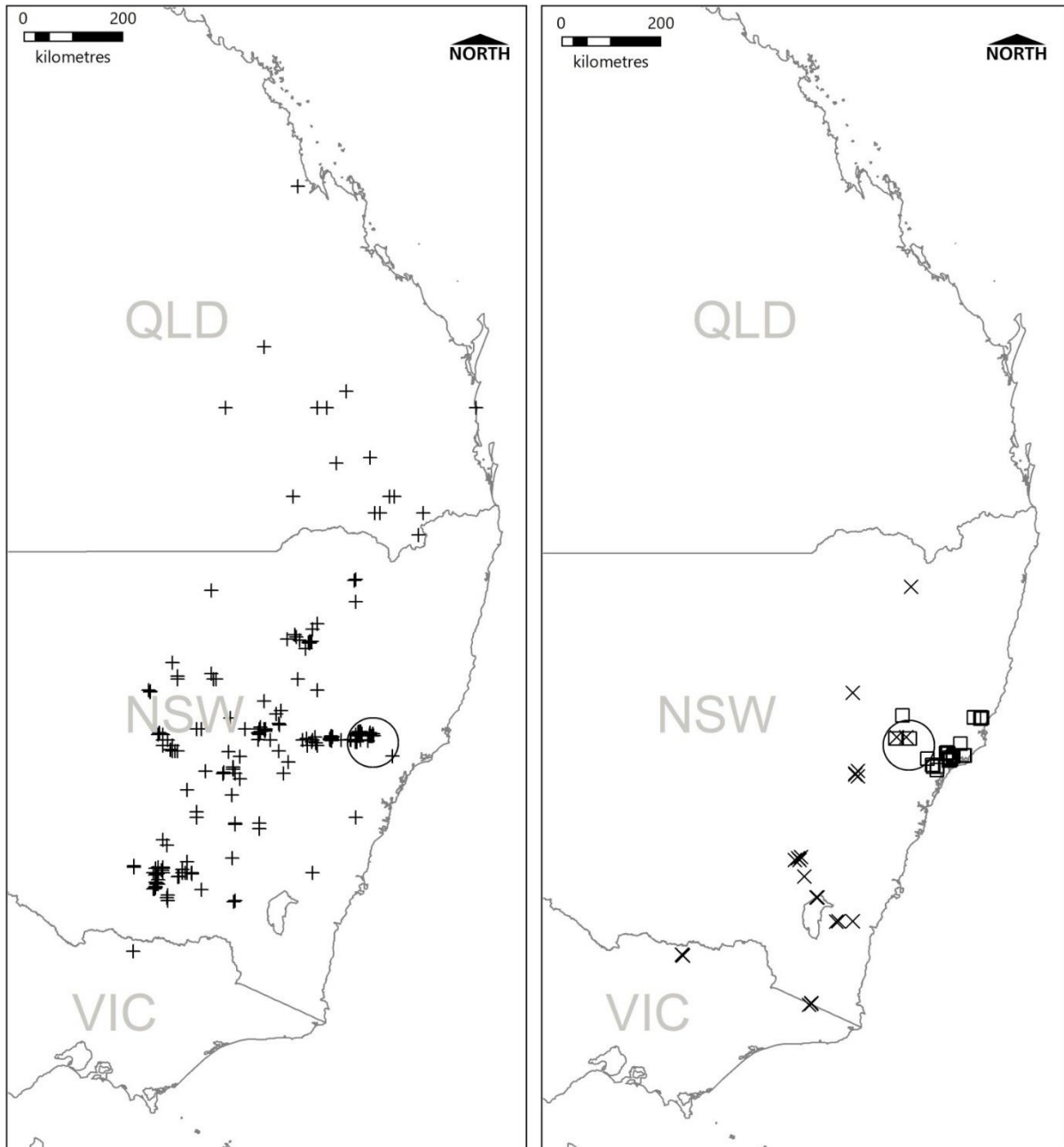


Figure 4 Distribution of *Diuris tricolor* (+) (left), *Prasophyllum petilum* (x) (right) and *Pterostylis chaetophora* (□) (right) across eastern Australia, shown relative to the Project Area (circled, 50 km radius). Data from AVH and NSW BioNet, extracted July 2020. Note that near-coastal records of *Diuris tricolor* in south-eastern NSW are erroneous (historical collections with poor positional accuracy), and that Victorian records of *Prasophyllum petilum* represent a different taxon (now described as *P. argillaceum*: Jones & Rouse 2018).

2.2.3 *Pterostylis chaetophora*

21. *Pterostylis chaetophora* (Rusty Greenhood) is endemic to the broader Hunter Region, extending from southern Taree to Newcastle and Cessnock (Figure 4). The species was previously also thought to occur in Queensland, but those populations have been redetermined as a distinct species with close affinities to *Pterostylis chaetophora* (Backhouse *et al.* 2019). Additionally, two early collections in the AVH from Sydney, and an observation record from

Glenhaven (1949), are thought to be in error or are now locally extinct. Both Hosking and James (1998) and Hunter (2008) report populations of *Pterostylis chaetophora* from Warrabah National Park near Tamworth, but these are considered to be misidentifications as no recent observations have been made there (L. Copeland pers. comm.). The Type material for *Pterostylis chaetophora* was grown from a specimen collected at Neath, near Cessnock in the mid-Hunter Valley in the early 1980s (Clements 1989).

22. NSW BioNet includes 33 distinct observation records, with most occurring in the lower Hunter Valley (east from Cessnock). For the upper Hunter Valley, two collections lodged at the Australian National Herbarium (Canberra) have been identified as *Pterostylis chaetophora*, but there are no other records. The first of these collections was made by John Hoskings in 1998 from Wingen Maid Nature Reserve (c. 50 km north-north-west of the Project Area), and the second in 2005 by Dougall Herd from what is now a biodiversity offset for Mangoola Coal (c. 20 km west-north-west of the Project Area). It is unknown if these populations remain extant or if they may represent the closely related *Pterostylis praetermissa* (L. Copeland pers. comm.). Surveys planned for the 2020 flowering season aim to clarify the identification of orchids at both locations.
23. Consequently, the nearest known confirmed records of *Pterostylis chaetophora* to the Project Area is at Rothbury (c. 53 km south-east of the Project Area). This population has been monitored annually for the last three years, showing heavy grazing of tubers by White-winged Choughs (*Corcorax melanorhamphos*) (Bell 2020b). Columbey National Park, situated near Clarencetown, currently supports the most extensive populations of *Pterostylis chaetophora* (Bell & Hillier 2020), and lies 80 km to the east-south-east of the Project Area.

2.3 Habitat

2.3.1 *Diuris tricolor*

24. A range of habitats have been documented for *Diuris tricolor* throughout its range (Table 3), although few studies provide sufficient detail on co-occurring ground layer species. This makes it difficult to identify potential habitat at the local scale, although not insurmountable. Most texts document favoured habitat as grassy *Callitris* woodlands, although in Queensland it is 'eucalypt open forest'. In a study of remnant vegetation stands in the South Western Slopes of NSW, Burrows (1999) recorded *Diuris tricolor* at several sites, but all within *Callitris glaucophylla* dominated vegetation. J. Hunter (2010) located the species in areas associated with ironbark and Bulloak in the Pilliga area, while Cunningham *et al.* (2011) noted habitat as *Eucalyptus populnea* for the Tottenham area (west of Dubbo). Clearly, a diversity of habitats support *Diuris tricolor* across the state, and this information alone cannot be used to generalise occupied habitat at specific locations.
25. First-hand experience of *Diuris tricolor* in the Hunter Valley is therefore influential in determining the suitability of an area to support this species. Field evidence and unpublished data from subpopulations of *Diuris tricolor* at Mangoola (near Denman) and Muswellbrook (Bulga Coal's Condran offset property) suggest that it occurs most commonly within grassy woodlands and grasslands derived from former Ironbark (*Eucalyptus crebra*) or Dawson's Box (*Eucalyptus dawsonii*) woodlands, and with minimal amounts in Box (*Eucalyptus 'albemol'*, a purported hybrid between *E. albens* and *E. moluccana*) woodlands. Note that in the central and upper Hunter, populations of *Eucalyptus 'albemol'* have historically and contemporarily been

referred to as either or both of the two supposed parent species, but ongoing taxonomic work suggests this entity to be a distinct species with no evidence of hybridisation (S. Bell & C. Driscoll unpubl. data). At the currently known eastern limit of distribution (North Rothbury), *Diuris tricolor* was recorded in 2016 in open forest of *Eucalyptus crebra*, *Corymbia maculata* and *Eucalyptus fibrosa*, although no individuals have been seen at that location since (Bell 2017a).

Table 3 Habitat documented for *Diuris tricolor*.

Habitat	Location	Source
Hunter Valley		
native grassland in areas not subject to intensive grazing	Hunter Valley generally	Umwelt 2011a, 2011b, 2013
derived grasslands of <i>Aristida/Cymbopogon</i> ; <i>Bothriochloa/Carthamus/Danthonia</i> ; <i>Dichanthium/Sporobolus/Chloris</i> woodlands of <i>Eucalyptus crebra</i> , <i>E. dawsonii</i> or <i>Allocasuarina luehmannii</i>	Wybong	Bell 2012a
disturbed grassland, often adjoining woodland and forest	Wybong	Umwelt 2012
grassland/open woodland	Wybong	Herd & Herd 2005
grassland	Wybong	Abel Ecology 2005
disturbed grassland	Wybong	Umwelt 2006
grassy woodland within Hunter Floodplain Red Gum Woodland (Threatened Ecological Community [TEC])	Muswellbrook LGA	Cumberland Ecology 2014
<i>Eucalyptus crebra</i> , <i>Corymbia maculata</i> , <i>E. fibrosa</i> grassy forest	North Rothbury	Bell 2017a
ungrazed grasslands on soils of low fertility	Ulan	Ecovision Consulting 2008
derived grassland within <i>Eucalyptus crebra</i>	Condran offset (Muswellbrook)	Bell <i>et al.</i> 2020
Outside of the Hunter Valley		
grassy <i>Callitris glaucophylla</i> woodlands	general	Jones 1993; Burrows 1999; Bishop 2000; Cameron <i>et al.</i> 2014; Jeanes 2015b
<i>Callitris glaucophylla</i> , <i>Eucalyptus populnea</i> , <i>Eucalyptus intertexta</i> , Ironbark and <i>Acacia</i> shrubland. The understorey is often grassy with herbaceous plants such as <i>Bulbine</i> species	general	URS 2009; Jacobs 2017
open grassy woodland often associated with Box-Gum Woodland [TEC]	general	Cumberland Ecology 2014
eucalypt open forest	Queensland	Stanley & Ross 1989
<i>Eucalyptus sideroxylon</i> , <i>E. crebra</i> and <i>Allocasuarina luehmannii</i>	Pilliga (NSW)	J. Hunter 2010
<i>Eucalyptus populnea</i>	west of Dubbo (NSW)	Cunningham <i>et al.</i> 2011

26. Using the Mangoola Coal population of *Diuris tricolor* as a case study, an assessment of vegetation communities supporting 975 GPS-recorded *Diuris tricolor* locations (n=5120 individual orchids) was undertaken (unpubl.). This involved intersecting in GIS point locations against a pre-1750 vegetation map prepared for the site in 2013 (unpubl. data). In that study, twelve vegetation communities were mapped on the basis of extensive field reconnaissance, where remnant paddock trees and landscape position were used to extrapolate across highly cleared lands. Of those twelve communities, *Diuris tricolor* was found to occur in five, with 61% of all records (n=599) and 60% of all individuals (n=3089) occurring within present or former Ironbark (*Eucalyptus crebra*) Woodland (Figure 5).

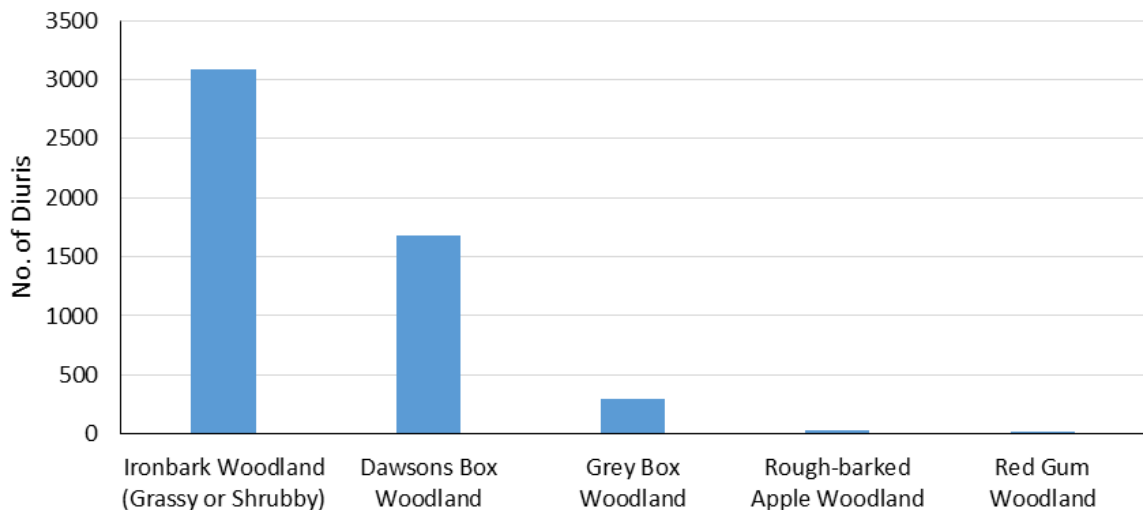


Figure 5 Number of *Diuris tricolor* individuals (n=5120) by pre-1750 vegetation type within the 1492 ha Mangoola Coal study area (unpubl. data). Note that *Diuris tricolor* records almost all located within derived native grasslands (DNGs) from these vegetation types.

27. The next most favoured habitat at Mangoola was Dawson's Box (*Eucalyptus dawsonii*) Woodland with 29% of records (n=280) and 33% of individuals (n=1684), and these two communities combined supported >90% of all *Diuris tricolor* records and individuals. Three other communities comprised relatively minor *Diuris tricolor* habitat: Box (*Eucalyptus 'albemol'*) Woodland (7% of records), Rough-barked Apple (*Angophora floribunda*) Woodland (2% of records), and Red Gum (*Eucalyptus blakelyi*) Woodland (1% of records). In the absence of other similar habitat data from elsewhere in the Hunter Valley, the Mangoola study area provides a strong landscape-scale indication that *Diuris tricolor* is most closely associated with *Eucalyptus crebra* or *Eucalyptus dawsonii* grassy woodlands.
28. At a finer scale, a floristic analysis of derived grasslands undertaken at Mangoola Coal between 2009 and 2011 (comprising 168 plots sampled over 2000 ha) found that *Diuris tricolor* occurred within three of seventeen grassland types, in descending order of importance (Bell 2012a, Bell submitted 1):
- *Aristida/ Cymbopogon* Grassland (Unit 2);
 - *Bothriochloa biloba/ Carthamus/ Danthonia* Grassland (Unit 4); and
 - *Dichanthium/ Sporobolus/ Chloris* Grassland (Unit 1a).
29. In that study, *Diuris tricolor* was also sparingly present in three woodland communities, those characterised by *Eucalyptus crebra*, *Eucalyptus dawsonii* or *Allocasuarina luehmannii*.

Combined, the three derived grassland habitats defined encompassed a significantly large proportion of the grasslands included in that study (84% of 1069 ha). Detailed floristic compositions for each of these key grassland communities are replicated in [Appendix 2](#). Knowledge gained from the Mangoola floristic analysis of grassland types has been incorporated into my assessments of suitable *Diuris tricolor* habitat at the Maxwell Project discussed later in this report.

2.3.2 *Prasophyllum petilum*

30. Information on the habitat of *Prasophyllum petilum* throughout its range is brief but documents variable associations ([Table 4](#)). When describing the species, Jones (1991) reported the known habitat at that time (the Type locality only, in the ACT) as being “moist grassy patches in sparse woodland developed on fertile soils”, while Bishop (2000) describes it as remnant *Themeda* grassland on silty clay loams. The national recovery plan for this species (Department of Environment, Climate Change and Water [DECCW] 2010) provides more detail on floristic associations at the five known sites for which it was written, mostly on the Southern and Central Tablelands of NSW.
31. Notes associated with collections included in AVH indicate that most southern records of *Prasophyllum petilum* occur in grasslands dominated by *Themeda australis*, *Bothriochloa* spp. and *Danthonia* spp, with associated forbs of *Bulbine* sp., *Dichopogon* sp., *Wurmbea* sp., *Swainsona* sp., *Pimelea curviflora*, *Chrysocephalum* sp., *Ajuga australis*, *Craspedia* sp., *Stackhousia monogyna*, *Eryngium* sp., *Burchardia* sp., *Arthropodium* sp., and *Juncus* sp. Northern records occur in grassland of *Aristida* sp., *Themeda australis* and *Stackhousia monogyna*. With the exception of populations on the North Western Slopes, these habitats at collection locations are very different to those where *Prasophyllum petilum* occurs in the Hunter Valley. In this region plants occur most commonly in grasslands derived from former Ironbark (*Eucalyptus crebra*), Dawson’s Box (*Eucalyptus dawsonii*) and Box (*Eucalyptus ‘albemol’*) woodlands, co-occurring with species such as *Cymbopogon refractus*, *Aristida ramosa*, *Dichanthium sericeum* and *Chloris ventricosa*.
32. Once again, using Mangoola Coal as a case study, an assessment of the vegetation communities supporting 759 GPS-recorded *Prasophyllum petilum* locations (n=4073 individual orchids) was undertaken. This involved intersecting in GIS each point location against a pre-1750 vegetation map prepared for the site in 2013 (unpubl. data). In that study, twelve vegetation communities were mapped on the basis of extensive field reconnaissance, where remnant paddock trees and landscape position were used to extrapolate across highly cleared lands as required. Of those twelve communities, *Prasophyllum petilum* was also found to occur in five (the same as for *Diuris tricolor*), with 58% of all records (n=442) and 59% of all individuals (n=2413) occurring within present or former Ironbark (*Eucalyptus crebra*) Woodland ([Figure 6](#)).
33. As for *Diuris tricolor*, the next most favoured habitat was Dawson’s Box (*Eucalyptus dawsonii*) Woodland with 22% of records (n=164) and 20% of individuals (n=831), and these two communities combined supported 80% of all *Prasophyllum petilum* records and individuals. Box (*Eucalyptus ‘albemol’*) Woodland supported 17% of records (n=130) and 19% of individuals (n=764). Two other communities comprised minor *Prasophyllum petilum* habitat: Red Gum (*Eucalyptus blakelyi*) Woodland, and Rough-barked Apple (*Angophora floribunda*) Woodland (<4% combined). In the absence of other similar habitat data from elsewhere in the Hunter Valley, the Mangoola study area provides a strong landscape-scale indication that *Prasophyllum petilum* is most closely associated with *Eucalyptus crebra* grassy woodlands.

Table 4 Habitat documented for *Prasophyllum petilum*.

Habitat	Location	Source
Hunter Valley		
derived grasslands of <i>Aristida/Cymbopogon</i> ; <i>Bothriochloa/Carthamus/Danthonia</i> ; <i>Dichanthium/Sporobolus/Chloris</i> ; woodlands of <i>Eucalyptus crebra</i> , <i>E. dawsonii</i> or <i>Allocasuarina luehmannii</i>	Wybong	Bell 2012a
open eucalypt woodland and grassland	general	Wildthing 2011
Outside of the Hunter Valley		
remnant <i>Themeda</i> grassland on silty clay loams	general	Bishop 2000
shrubby and grassy habitats in dry to wet soil, in open eucalypt woodland and grassland	general	Umwelt 2013; Eco Logical Australia 2015
Grassy Box Woodlands with fertile to moderately fertile soils on undulating terrain	general	FloraSearch 2014
wet grassy woodlands on fertile ground	Southern Tablelands region (NSW & ACT)	Rouse 2002
moist grassy patches in sparse woodland developed on fertile soils	Type location (ACT)	Jones 1991
grassy woodland of <i>Eucalyptus pauciflora</i> and <i>E. aggregata</i> , with a sparse shrub layer of <i>Hakea microcarpa</i> , <i>Acacia dealbata</i> and <i>Leptospermum brevipes</i> and a ground layer of <i>Poa sieberiana</i> , <i>Themeda australis</i> and <i>Schoenus apogon</i>	Captains Flat cemetery (NSW)	DECCW 2010
grassy woodland of <i>Eucalyptus blakelyi</i> and <i>E. melliodora</i> , over <i>Poa sieberiana</i> and <i>Themeda australis</i>	Hall cemetery (ACT)	DECCW 2010
grassy woodland of <i>Eucalyptus blakelyi</i> and <i>E. melliodora</i> , over <i>Themeda australis</i> and <i>Sorghum leiocladum</i>	Ilford cemetery (NSW)	DECCW 2010
natural grassland of <i>Bothriochloa macra</i> , <i>Pentapogon quadrifidus</i> , <i>Austrodanthonia</i> spp., <i>Themeda australis</i> , <i>Schoenus apogon</i> , <i>Drasera peltata</i> , <i>Sebaea ovata</i> and <i>Haloragis heterophylla</i> on a treeless grassy plain	Tarengo TSR (NSW)	DECCW 2010
a treeless frost hollow, surrounded by <i>Eucalyptus pauciflora</i>	Steves TSR (NSW)	DECCW 2010

34. Floristic analysis of derived grasslands undertaken at Mangoola Coal between 2009 and 2011 (comprising 168 plots sampled over 2000 ha) found *Prasophyllum petilum* occurring in three of seventeen grassland types, in descending order of importance (Bell 2012a; Bell submitted 1):

- *Aristida/ Cymbopogon* Grassland (Unit 2);
- *Bothriochloa biloba/ Carthamus/ Danthonia* Grassland (Unit 4); and
- *Dichanthium/ Sporobolus/ Chloris* Grassland (Unit 1a).

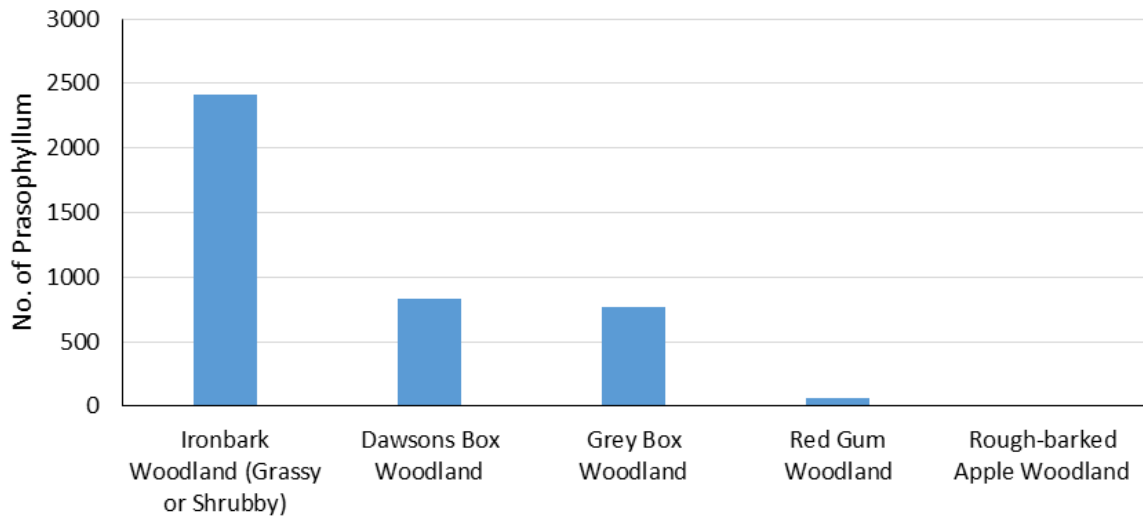


Figure 6 Number of *Prasophyllum petilum* individuals (n=4073) by pre-1750 vegetation type within the 1492 ha Mangoola Coal study area (unpubl. data). Note that *Prasophyllum petilum* records almost all located within DNGs from these vegetation types.

35. *Prasophyllum petilum* was also occasionally present in three woodland communities, those characterised by *Eucalyptus crebra*, *Eucalyptus dawsonii* or *Allocasuarina luehmannii*. Combined, the three derived grassland habitats defined encompassed a significantly large proportion of the grasslands included in that study (84% of 1069 ha). Knowledge gained from the Mangoola floristic analysis of grassland types (see [Appendix 2](#)) has been incorporated into my assessments of suitable orchid habitat at the Maxwell Project discussed later in this report.

2.3.3 *Pterostylis chaetophora*

36. There is little information available on habitat for the Hunter endemic *Pterostylis chaetophora*, although recent monitoring work associated with the NSW Government's *Saving our Species* initiative has collated some information (Bell 2020b). For Columbey National Park, *Pterostylis chaetophora* was found to predominantly occur in vegetation described as Floodplain Redgum-Box Forest and Lower Hunter Spotted Gum – Ironbark Forest (Bell & Hillier 2020: [Figure 7](#)). Paget (2008) provided brief notes on habitat for several other populations of the species, which has been added to and expanded upon in Bell and Hillier (2020). [Table 5](#) summarises habitat for *Pterostylis chaetophora* from all known locations.

2.4 Ecology

2.4.1 Orchid Detectability

37. The unpredictability of flowering in orchids from year-to-year is a widely recognised trait in this group of plants (e.g. Gillman & Dodd 1998; Kindlmann & Balounova 2001; McCormick & Jacquemyn 2014), and this is commonly governed by weather (e.g. Wells *et al.* 1998; Kindlmann & Balounova 2001; Pfeifer *et al.* 2006). Many species fail to emerge during dry phases, and although viable populations may persist underground, their presence above ground often leads to an incorrect assumption that no plants are present. In general terms, low rainfall in the three months leading up to flowering place individual orchids under stress, meaning that flowering may be postponed for that season for all but the most robust individuals. Because of this trait,

terrestrial orchids have been described as ‘time-travellers’ (Brundrett 2016), encapsulating the uncertainty in determining their presence in any given area.

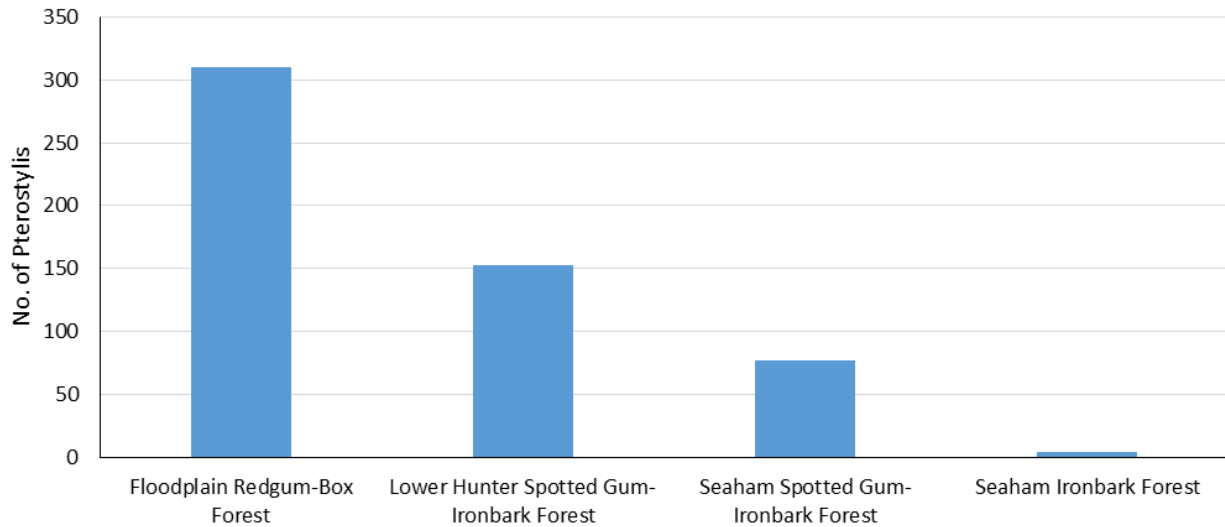


Figure 7 Number of *Pterostylis chaetophora* individuals (n=544) by vegetation type within the 720 ha Columbey National Park study area (after Bell & Hillier 2020).

Table 5 Habitat documented for *Pterostylis chaetophora*.

Habitat	Location	Source
forest of <i>Eucalyptus fibrosa</i> , <i>Corymbia maculata</i> and <i>Eucalyptus umbra</i>	Columbey National Park, Pindimar, Raymond Terrace, Beresfield	Bell & Hillier 2020
forest of <i>Eucalyptus moluccana</i> and/or <i>Eucalyptus amplifolia</i>	Columbey National Park	Bell & Hillier 2020
shrubby forest of <i>Corymbia maculata</i> and <i>Eucalyptus fibrosa</i> , or <i>Eucalyptus tereticornis</i> , <i>Eucalyptus punctata</i> and <i>Angophora floribunda</i> in dry drainage lines	Kurri	Bell & Hillier 2020
forest of <i>Eucalyptus tereticornis</i> , <i>Angophora floribunda</i> and <i>Eucalyptus crebra</i>	North Rothbury	Bell (2020b)
<i>Eucalyptus propinqua</i> and <i>Eucalyptus microcorys</i> shrubby forest	Purfleet	Paget 2008
grasslands derived from cleared <i>Eucalyptus propinqua</i> , <i>Eucalyptus acmenoides</i> , <i>Eucalyptus microcorys</i> , <i>Eucalyptus placita</i> and <i>Eucalyptus siderophloia</i> forest	Burrell Creek	Paget 2008
forests of <i>Eucalyptus placita</i> , <i>Eucalyptus siderophloia</i> , <i>Eucalyptus paniculata</i> and <i>Corymbia maculata</i> , or <i>Eucalyptus amplifolia</i> and <i>Eucalyptus moluccana</i>	Twelve Mile Creek	Paget 2008

38. Part of the difficulty of detection experienced during drought years is the added stress placed on emerging orchids by herbivores searching for palatable foods: orchids may well emerge every year in some species but they may be quickly consumed by grazing mammals, birds or invertebrates. For example, Duncan and Moloney (2018) found that for the threatened *Diuris fragrantissima* good rainfall increased the probability of flowers setting seed and decreased the probability that plants would be browsed.
39. As a rule of thumb, dry winters in the Hunter Valley generally result in below average flowering in terrestrial orchids, and this has been shown for both *Diuris tricolor* and *Prasophyllum petilum* (Bell 2019a, b). The relationship between rainfall and flowering in these species has been highlighted over a ten-year translocation project undertaken at Mangoola Coal (Bell 2019a, b; Bell 2020; also reported annually in reports to Mangoola Coal). Over the course of nine years of monitoring, the July-to-August pre-flowering rainfall transitioned from three years of near- or below-average rainfall, to three years of above-average rainfall, and three years of well-below average rainfall. Dry years have been reflected in low rates of detection within recipient plots, while wetter years have shown an increase in detection (Figure 8). There are of course other factors contributing to the extent of orchid detection observed (expanded upon in Bell 2020d), but for these two species there is a clear trend associated with winter rainfall. Of the nine recipient plots, all displayed lower detection rates in the drought years of 2017-2019, following three seasons of above average winter falls. A similar downward trend was observed for the five recipient plots (n=440) established within mine rehabilitation, monitored over 3-4 years since 2015, and four control plots of naturally occurring orchids monitored since 2016 (data not presented here).

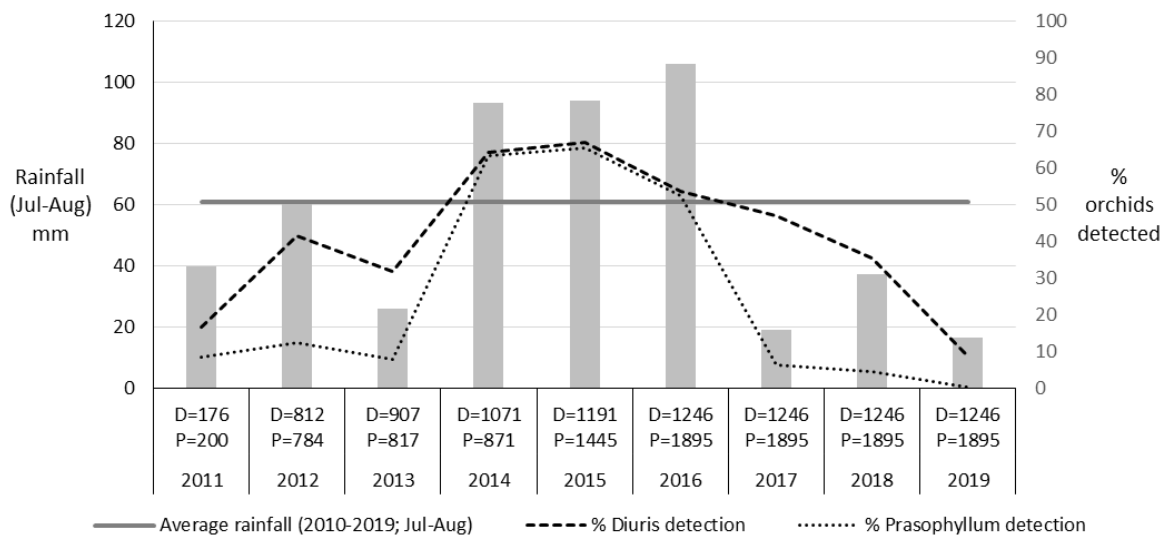


Figure 8 Rainfall received (July to August) and orchid detection (n=2,592) during the course of monitoring across nine recipient plots within derived grassland at Mangoola Coal, over a period of four to nine years (after Bell 2019a).

40. Surveying for orchids requires repeat visits to an area to be confident in the presence and magnitude of any residing orchid populations. This is particularly the case for those species where flowering can be protracted over several weeks, although most do experience a 'peak' period (e.g. Yare *et al.* 2020). Vizer (2013) found peak flowering in *Diuris tricolor* and

Prasophyllum petilum at Mangoola to occur from mid- to late-September, but that less than 20% of plants would be flowering on any particular day at this time. This implies that a 'one-off' survey, even if conducted on the day of peak flowering, would likely overlook more than 80% of individuals in the population. Capsule production was also found during his study to occur in less than 3% of plants for both species, with herbivory identified as an important limiting factor in seed production. However, peak flowering time likely varies year-to-year, and will depend on available soil moisture and other site conditions. For example, during the 2015 flowering season at Mangoola, *Diuris tricolor* was found to peak in the second week of September, but *Prasophyllum petilum* flowering was still increasing in the first week of October (Bell 2020d).

41. For *Prasophyllum petilum*, Wilson *et al.* (2016) analysed annual monitoring data over a 25-year period from the largest known population on the southern tablelands of NSW, and identified the incidence of frost (nights $\leq -4^{\circ}\text{C}$) as being instrumental in preventing flowering in any one season. Frost damage to emerging plant parts prior to reaching flowering stage prevents detection during monitoring surveys, influencing orchid counts. Warm winters are consequently of benefit to the orchids in that population, although it is unknown if the same applies to the Hunter Valley population where frosts are rarer.
42. Detectability in *Pterostylis chaetophora* appears less reliant on rainfall, although monitoring over three years has shown a weak (but untested) trend in this regard (Bell 2020b). The more coastal distribution of this species suggests that water stress through inadequate rainfall is less likely to influence orchid emergence and persistence, although heavy grazing of tubers by White-winged Choughs has occurred during recent drought conditions at North Rothbury. The geographical range of many members of subgenus *Oligochaetochilus* extends into drier inland habitats, demonstrating some level of adaptation to dry and harsh environments (Kuitert & Findlater-Smith 2017).

2.4.2 Mycorrhizal Fungi

43. Orchid presence in any area is dependent on the availability of co-occurring mycorrhizal fungi present within the soil, and often different fungi are required by different orchid species (Waterman & Bidartondo 2008; McCormick *et al.* 2018), yet co-existence of several orchid species is still possible (Waud *et al.* 2016). Mycorrhizal fungi are necessary for nutrient transfer between soil and orchid, and they are also essential in aiding the germination of orchid seeds (Brundrett 2006). The minute size of orchid seeds means they carry no nutrients and hence associating with the correct fungi immediately after dispersal is imperative. Weston *et al.* (2005) noted a high degree of specificity between a particular species of orchid and their associated species of mycorrhiza, but that there are also commonalities between and within genera. Brundrett (2006) stresses the need for fungi and pollinators with orchids in his three key dimensions of orchid presence: differing levels of interactions between the three dimensions determine the specificity and availability or suitability of habitat.
44. Without intensive survey for the relevant mycorrhizal fungi present in an area, there is no way of knowing whether or not a specific site is capable of supporting an orchid population of any species. Research has shown that mycorrhizal fungi may be widespread in the landscape and occur in a range of habitats, but that it may also be patchy and is not necessarily reflected in observable orchid populations (e.g. Brundrett *et al.* 2003; McCormick & Jacquemyn 2014; Voyron *et al.* 2016). The assumption, therefore, that all potential orchid habitat based on biophysical characteristics (e.g. soil type, elevation, rainfall, co-occurring plant species) can be

equally occupied by a specific orchid species is misleading: without fungi, seed will not germinate and plants will not prosper. Investigation into whether specific abiotic variables, such as rainfall or geological substrate, govern the geographical distribution of mycorrhizal fungi has been identified as a priority for research (Jacquemyn *et al.* 2017), although this work is still in its infancy.

2.4.2.1 *Diuris tricolor*

45. For *Diuris* sp., the *Tulasnella* genus (family Tulasnellaceae) is the most important mycorrhizal fungi (Weston *et al.* 2005; Smith *et al.* 2010). At Mangoola Coal, seed-baiting techniques were used by Vizer (2013) in an attempt to map the distribution of mycorrhizal fungi, and he found that the distribution of *Diuris tricolor* was actually more restricted than the relevant fungi. This implies that (for the Mangoola area) there may be extensive suitable habitat, complete with mycorrhizal fungi, within a wider area than is currently known to support the species. Similarly, Tierney *et al.* (2017) observed differences in seed germination within soil sampled from different subpopulations of *Diuris platychila*, attributable either to differing concentrations of fungal hyphae within each soil sample or that some samples supported superior strains of fungi.

2.4.2.2 *Prasophyllum petilum*

46. Weston *et al.* (2005) suggest that the genus *Ceratobasidium* (family Ceratobasidiaceae) is the likely mycorrhizal fungi for *Prasophyllum* sp., supported partially by work on two threatened species in Victoria by McQualter *et al.* (2007) where *Ceratobasidium cornigerum* (and a *Rhizoctonia* sp. were isolated). Within the Hunter Valley, mycorrhizal seed-baiting for *Prasophyllum petilum* was not successful in the study of Vizer (2013), which is not unusual for this genus, and further research in this species is required.

2.4.2.3 *Pterostylis chaetophora*

47. Like *Prasophyllum* sp., the genus *Ceratobasidium* is thought to be the likely mycorrhizal fungi required for *Pterostylis* sp. (Weston *et al.* 2005). Jusaitis and Sorensen (1993) isolated mycorrhizal fungi from *Pterostylis arenicola* (closely related to *Pterostylis chaetophora*), but did not identify the fungi. Few other studies within this genus are evident in the literature.

2.4.3 Pollination and Seed Production

48. Pollination in *Diuris*, *Prasophyllum* and *Pterostylis* sp. (and most other orchids) is enacted by insects (Adams & Lawson 1993; Weston *et al.* 2005; Hawkeswood 2006). Many orchids rely on mimicry to deceive unsuspecting insects (Adams & Lawson 1993; Schiestl 2005), either by the development of nectar-bearing flowers that appear identical to those of co-occurring species in their habitat (food mimicry), or by individual flowers resembling (often with the aid of pheromones) the females of certain insects (sexual mimicry). Other species offer a nectivorous reward, which when combined with the appropriate scent attract pollinating insects.
49. Once pollination has been enacted, the development of seed capsules progresses over the following weeks, although plants still remain vulnerable to grazing and desiccation during this time. Some studies have shown that, despite relatively high levels of historical and current-day fragmentation of landscapes, pollinators are still able to forage amongst orchids to produce seed (e.g. Brundrett 2019). For many nectarless orchids, this is reliant on the presence of co-occurring food plants to supply the necessary food, and for species with highly specific pollinators this is particularly important (Phillips *et al.* 2015; Brundrett 2019). However, fragmentation and loss of pollinator habitat is widely recognised as detrimental to most orchid

populations (Wraith & Pickering 2018; Phillips *et al.* 2020). Based on observations made at orchid translocation sites at Mangoola Coal over several years (e.g. Bell 2016), capsule development is unhindered in *Diuris tricolor* and *Prasophyllum petilum* despite close proximity to an active coal mine.

2.4.3.1 *Diuris tricolor*

50. Most *Diuris* sp. mimic co-occurring species of pea (Fabaceae) to attract pollinators (e.g. Backhouse *et al.* 2016; Scaccabarozzi *et al.* 2018), and for *Diuris tricolor* in the Hunter Valley this is likely to be *Templetonia stenophylla* or *Daviesia genistifolia* (pers. obs.; Vizer 2013). Weston *et al.* (2005) indicate that the pollinators of *Diuris* sp. are likely to be various colletid bees from the *Trichocolletes* and *Leioproctus* genera, although Walker (1997) suggested opportunistic native halictid bees were potential pollinators of *Diuris basaltica*. Indsto *et al.* (2006) found male bees of the species *Trichocolletes venustus* to be the primary pollinators of *Diuris maculata* in Sydney.

2.4.3.2 *Prasophyllum petilum*

51. *Prasophyllum* sp. employ a different strategy to attract pollinators, using nectar and scent to entice various insects to pollinate and be rewarded with food. The likely pollinators of *Prasophyllum* sp. are thought to be colletid and halictid bees, ichneumonid, tiphiid, scoliid and sphecid wasps, syrphid flies, and beetles (Weston *et al.* 2005). For *Prasophyllum odoratum*, Bernhardt & Burns-Balogh (1986) found that polytrophic flies (family Syrphidae) and opportunistic male bees in the genus *Leioproctus* (family Colletidae) were the principle pollinators.

2.4.3.3 *Pterostylis chaetophora*

52. For *Pterostylis* sp., pollination through sexual deception has been demonstrated for several species (e.g. Bernhardt 1995; Phillips *et al.* 2014; Thalwitzer *et al.* 2018; Reiter *et al.* 2019), and the greenish to rusty colouration of flowers in this genus suggest fungus gnats (order Diptera) as the primary pollinators (Vogel 1973). Kuiter and Findlater-Smith (2017) provide support for this in their overview of pollinators of the Victorian members of *Pterostylis* sp., concluding that fungus gnats (families Mycetophilidae and Sciaridae) almost always enact pollination in these orchids. In their study, Reiter *et al.* (2019) found *Pterostylis boormanii* and *Pterostylis basaltica*, both closely related to *Pterostylis chaetophora* within section and subgenus *Oligochaetochilus* (Janes & Duretto 2010), were pollinated by male fungus gnats (*Xenoplatyura conformis*) of the family Keroplatidae. However, Kuiter and Findlater-Smith (2017) found the ten Victorian members of subgenus *Oligochaetochilus* were all pollinated by one of five species of fungus gnat from a different genus, *Orfelia* (family Mycetophilidae). Both investigations suggest that multiple pollinating fungus gnats may be responsible, perhaps related to geographical location and/or specific habitat requirements, and such a strategy potentially allows a wider distribution in this subgenus.

2.4.4 Reproduction and Dispersal

53. Reproduction in orchids can occur sexually or asexually, through the production of seed or via tuber multiplication ('daughter tuberosids') or through annual replacement. Following sexual reproduction, dispersal limitation is an important factor determining orchid distribution (McCormick & Jacquemyn 2014). Orchid seeds are very small ('dustlike'), produced in exceptionally large numbers within capsules, are very light (Arditti & Ghani 2000; Shefferson *et al.* 2020) and, in some situations, are capable of dispersion by wind over vast distances (Phillips

et al. 2020). In most cases, however, the low stature of terrestrial orchids and the structure of co-occurring vegetation means that seed falls close to the parent plant (Backhouse & Cameron 2005; Jersáková & Malinová 2007). Some species rely on streams for seed dispersal, and others may benefit through fauna movements (Weston *et al.* 2005), but this is rare.

2.4.4.1 *Diuris tricolor*

54. As a genus, *Diuris* sp. replace their tubers annually and a small number are also capable of spreading vegetatively through daughter tuberoids, although this is rare (Jones 1993). Backhouse *et al.* (2016) hold a differing view, stating that most species can multiply vegetatively but several rely solely on seed dispersal. *Diuris tricolor* is most commonly encountered as individual plants or loose groups, consistent with spread through seed dispersal (pers. obs.).

2.4.4.2 *Prasophyllum petilum*

55. With few exceptions, nearly all species of *Prasophyllum* replace their tubers annually and do not colonise adjacent habitat through daughter tuberoids. As a consequence, most species rely on seed production and dispersal within favoured habitat (Jones 1993), and most occur as scattered individuals or in loose groups. Within the Hunter Valley, *Prasophyllum petilum* follows this typical pattern in population growth habit (pers. obs.).

2.4.4.3 *Pterostylis chaetophora*

56. In *Pterostylis* sp., some species are solitary while others form extensive colonies through daughter tuberoids on the ends of long stolons (Jones 1993; Backhouse *et al.* 2016). All species produce replacement tubers at the conclusion of the flowering season, emerging as leaves following good rainfall during Autumn. Members of subgenus *Oligochaetophilus* (including *Pterostylis chaetophora*) are rarely colonising species, generally replacing their tubers annually rather than spreading through daughter tuberoids (Juisaitis & Sorensen 1993). This implies that seed dispersal is the primary means of landscape dispersal for these species. Indeed, in my experience nearly all populations of *Pterostylis chaetophora* occur individually or in small, loose groups (Bell & Hillier 2020).

3. Criterion (b) – Justification for an Expert Report

57. A BDAR for the Project has been prepared by Hunter Eco (2019). This report details the extent of previous and new survey of vegetation, flora and fauna across the wider Maxwell lands including the Project Area. I have relied on this document to provide the most up-to-date information on the biodiversity of the locality, and used it to assist my assessment of the potential presence within the Project Area of the three target orchid species. However, I have used my own experience with these orchids elsewhere, and observations made during a one-day field inspection of the Project Area (detailed in **Section 4**), to inform my assessment.
58. During recent surveys completed for the Project, no threatened flora species were recorded by Hunter Eco (2019). This included sites where *Diuris tricolor* had previously been observed by other workers, but drought conditions would have impacted on flower emergence and persistence during recent years (see **Section 3.2**). Since initial preparation of this report, Hunter Eco (2020) completed additional surveys in and around the Project Area. *Diuris tricolor* was recorded near original records of the known population, however no threatened flora species were recorded within the Project Area.

3.1 Survey Effort

59. Hunter Eco (2019) details (in Table 3 of Attachment A – *Baseline Flora Report*) the extent to which the Project Area and the immediately surrounding lands have been subject to flora and vegetation surveys, particularly in relation to the Mt Arthur Coal Mine and the former proposed Drayton South open cut mine (now the proposed Maxwell Project). Investigations shown there as occurring within the current Project Area include:
- Hansen Bailey (2007)
 - Cumberland Ecology (2009)
 - Cumberland Ecology (2012)
 - Cumberland Ecology (2015)
60. In addition, flora surveys have been carried out across the Project Area and surrounds by Hunter Eco in 2017, 2018, 2019 and 2020, and other survey periods are noted in Cumberland Ecology (2015). [Table 6](#) summarises the timing of field survey for each of these investigations, relative to expected flowering periods (i.e. detectability) of the three target orchids. One of the target orchids (*Diuris tricolor*) was initially recorded in 2009 near to the Project Area by Cumberland Ecology (now contained within a fenced off area; referred to henceforth as the ‘Diuris Conservation Area’), where two individuals were located. Repeat surveys in the area in November 2010 did not locate any plants (not surprising as November falls outside of the flowering period), but 30 plants were recorded in ‘Spring’ (presumably September or October) 2011. Cumberland Ecology (2015) described the habitat at this location as Hunter Floodplain Red Gum Woodland, although on my inspection there on 3 July 2020 I saw woodland dominated only by *Eucalyptus conica* and *Eucalyptus moluccana*, with patches of *Angophora floribunda* and *Eucalyptus melliodora*.
61. From [Table 6](#) it is evident that few of these survey periods correspond with peak flowering times in the three target orchids. Cumberland Ecology expended three days of effort (incorporating vegetation mapping, habitat assessment, plot sampling and threatened flora searches) on 30 September to 2 October 2009, and one day (targeted orchid and *Acacia*

pendula surveys) on 23 September 2011 (Cumberland Ecology 2015). Hunter Eco undertook targeted orchid surveys over two days on 28 September and 17 October 2018, 10 days of floristic plot survey throughout September and October 2018, and targeted orchid surveys over two days on 28 and 29 September 2020.

Table 6 Field survey effort (grey) and peak orchid flowering periods (black). EC = Ecotone; HB = Hansen Bailey; CE = Cumberland Ecology; HE = Hunter Eco. Survey periods shown include both targeted searches and plot- or transect-based floristic surveys where it may be expected that orchids would be detected if present.

	J	F	M	A	M	J	J	A	S	O	N	D
EC 2000												
HB 2006												
HB 2007												
CE 2009												
CE 2010												
CE 2011												
CE 2013												
CE 2015												
HE 2017												
HE 2018												
HE 2019												
HE 2020												
<i>D. tricolor</i>												
<i>P. petilum</i>												
<i>P. chaetophora</i>												

62. Throughout all orchid searches and floristic plot surveys, and from the data available to me, only two terrestrial orchids have been located across the Project Area or surrounds: *Diuris tricolor* by Cumberland Ecology in 2009 and 2011 and by Hunter Eco in 2020, and the common and unlisted *Pterostylis bicolor* by Hunter Eco in 2018 (Hunter Eco 2019), both recorded from the Diuris Conservation Area (C. Driscoll pers. comm.). A low diversity of terrestrial orchids is not unusual for this part of the Hunter Valley; surveys by Kleinfelder across the Bayswater Power Station area immediately adjacent to the east have reported only a *Microtis* sp. across 71 floristic plots (although mostly under drought conditions, discussed in Bell 2020c). Further discussion on the importance of this lack of terrestrial orchids is presented in **Section 4.3**.

3.2 Impact of Drought

63. As noted earlier, terrestrial orchids are sensitive to environmental conditions, and in the Hunter Valley prevailing rainfall patterns are influential in their detection during surveys. The past three years in the central Hunter Valley have been particularly dry. [Figure 9](#) shows that, apart from the very wet months of March 2017, March 2019, and September 2019, below average rainfall has been received at Muswellbrook (c. 10 km to the north) from 2017. Such dry conditions will place all plants under severe water stress, and for emergent geophytes like Spring-flowering orchids, dry Autumn-Winter periods over successive years commonly result in little or no emergence, and increased grazing pressure.

64. The NSW Department of Primary Industries (DPI) Combined Drought Indicator (CDI) provides a further dataset that can help to explain how orchids and other plants respond to climatic conditions. The CDI categorises months into one of six phases of drought on the basis of three indices (rainfall index, plant growth index, soil water index). The Wynn Parish (which includes the Project Area) formally experienced high levels of drought over most of January 2015 to March 2020 (Figure 10). Intense Drought was experienced between April 2018 and October 2018 (encompassing the 2018 orchid flowering period), and again from December 2018 to December 2019. The 2019 orchid flowering season (September-October) and the months leading up to it were also drought affected. Clearly, any targeted orchid surveys undertaken during the 2015 to 2019 flowering seasons would be unlikely to detect representative populations of these species if present.

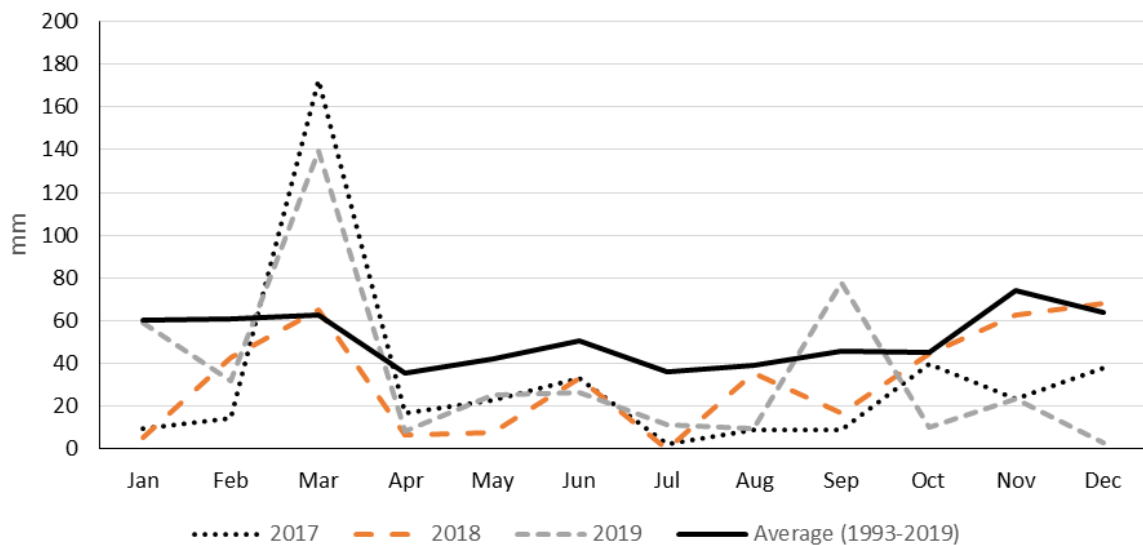


Figure 9 Monthly and average rainfall for Muswellbrook (station # 61374; c. 25 km from the Project Area) over the past three years. (Source: Bureau of Meteorology, <http://www.bom.gov.au/climate/data/>).

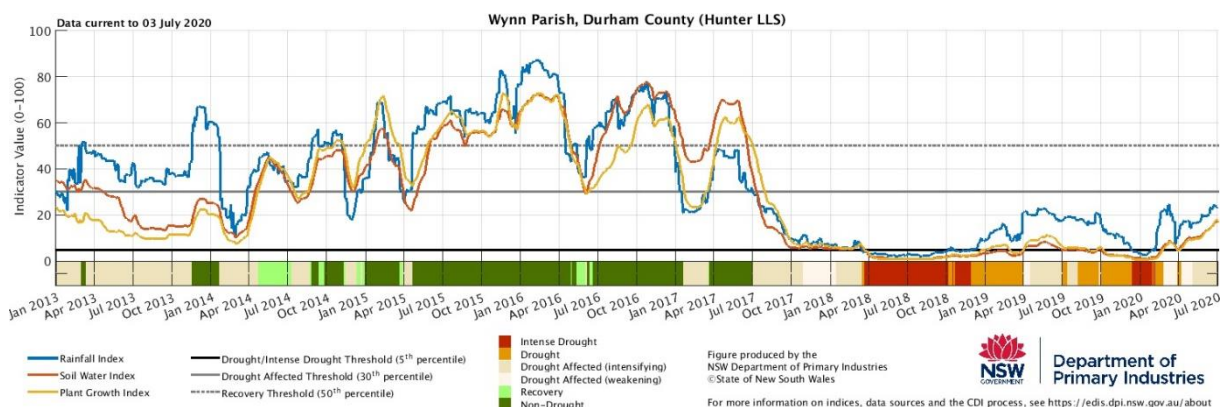


Figure 10 Drought indices for the Wynn Parish, January 2013 to July 2020, showing Drought conditions prevailing from October 2014 to July 2017 and December 2018 to December 2019, and Intense Drought from April 2018 to December 2018 and December 2019 to January 2020. (Source: DPI Seasonal Conditions Information Portal, <https://edis.dpi.nsw.gov.au/statistics>).

65. Most terrestrial orchid species will not emerge to flower during stressful periods, or if leaves are produced at this time then inflorescences may not develop. Given the drought conditions experienced from October 2014 to the present, and in particular during the Autumn and Winter periods leading up to and including September-October orchid flowering from 2015 to 2019, there is clear justification for the preparation of this expert report. Apart from water stress, pressure from herbivory during drought periods escalates considerably (Duncan *et al.* 2005), not only from vertebrate grazers such as macropods and rabbits, but also invertebrates including grasshoppers and caterpillars (Light & MacConnail 2011; Vizer 2013). Bird species too are known to selectively feed on orchid species, with White-winged Choughs for example extracting orchids out of the ground to consume tubers (Duncan *et al.* 2005; Faast & Facelli 2009; Bell 2020b). Any vegetation present during dry times will be the focus of herbivore browsing, meaning a reduction in the time orchids will be present above ground and hence reduce detection rates during survey. Desiccation through heat and wind in periods of drought will also lessen above-ground periods of flowering orchids.
66. Persistent dry conditions and drought, including below-average rainfall during the crucial Winter period, over at least the last three flowering seasons (2017 to 2019) justify the need for an Expert Report to determine the likely presence of *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora* within the Project Area.

4. Criterion (c) – Likelihood of Species Presence in the Project Area

67. To assist in determining the likely presence or absence of populations of *Diuris tricolor*, *Prasophyllum petilum* or *Pterostylis chaetophora* within the Project Area, I have examined aspects of previous land-use history, known existing records for all three species within the region, the floristic composition, geology, soil landscapes and soil qualities of habitats within the Project Area and other areas known to support the species. I have also incorporated my own observations made on a single-day site inspection in early July 2020.

4.1 Project Area Attributes

4.1.1 Land-use History

68. As with much of Australia and NSW, the original ecosystems of Hunter Valley have been heavily impacted upon by European colonisation (Bradshaw 2012). The mid-Hunter Valley was one of the first to be opened up for European occupation, spanning out from the nearby settlement of Jerrys Plains in the early 1800s (Burley 1962; C. Hunter 2010). Much of the land was used for the grazing of cattle and sheep, and where necessary the original woodlands were thinned of trees to increase pasture growth (Perry 1955). As a consequence, current day vegetation is the result of 200 years of agricultural occupation, firstly by sheep and then cattle. The Project Area is now almost entirely comprised of derived grasslands, regrowth native and exotic woody vegetation, or planted species (Hunter Eco 2019).
69. Although cattle have historically grazed the Project Area for likely several decades (Hunter Eco 2019), they have been removed or rotated to other areas during recent drought conditions. It is unknown whether or not cattle (or sheep) were present across the Project Area during flora survey times indicated in Table 6 above. All of the derived grasslands which now predominate throughout the Project Area potentially provide potential habitat for orchids including *Diuris tricolor* and *Prasophyllum petilum*, while remnant woodlands may support *Diuris tricolor* or *Pterostylis chaetophora*, but this is further explored in the following sections.

4.1.2 Existing Orchid Records

70. No populations of *Diuris tricolor*, *Prasophyllum petilum* or *Pterostylis chaetophora* have been recorded within the Project Area (Hunter Eco 2019), although one population of *Diuris tricolor* (c. 30 plants) located by Cumberland Ecology in 2009 and 2011 (and again by Hunter Eco in 2020) lies approximately 600 m from the disturbance footprint (south of the proposed Ancillary Disturbance Area 1), and another (of nearly 200 plants) occurs 400 m north of the Product Stockpile Extension area (NSW BioNet). A historical record of *Prasophyllum petilum* (c. 10 plants) occurs for a site along Thomas Mitchell Drive c. 1300 m east of the Product Stockpile Extension area. As noted in Section 3.2, drought conditions coincided with the preparation of documents relating to the proposed development in the area, and as a consequence there is a low likelihood that these species, if present, would have been detected.
71. Evidence of survey effort is shown in Figure 9 (Attachment A) of Hunter Eco (2019), where the extent of data collection made across 1708 Rapid Data Points (RDPs) (used for mapping purposes) and 109 full floristic plots (used for classification) is illustrated across the wider biodiversity survey area. Some RDP and 23 full floristic plots fall within the Project Area, and a portion of floristic plots were likely surveyed in September-October 2018. However, the Intense

Drought occurring at that time (see **Section 3.2**) would have curtailed detection of any terrestrial orchids that may have been present. Examination of surrounding records of the three target orchids may shed some light on the expected presence of *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora* within the Project Area (further examined in **Section 4.2**).

4.1.3 Vegetation Communities

72. Understanding the floristic patterns and vegetation communities in the Project Area is important in gaining an impression of how suitable the lands are to support one or more of the target orchid species. Fortunately, Hunter Eco (2019) has undertaken a numerical analysis of floristic plot data (n=109) to assist in classifying the native vegetation present, and provides detailed community profiles in Appendix 4 of the *Baseline Flora Report*. I have reviewed this classification and the profiles, and am satisfied that it represents a thorough treatise of vegetation community diversity present within the Project Area. This classification, together with other factors and my own notes made during a one-day site inspection (see **Section 4.3**), have been used to formulate an opinion on the likelihood of *Diuris tricolor*, *Prasophyllum petilum* and/or *Pterostylis chaetophora* being present within the Project Area (presented in **Section 4.5**).

4.1.3.1 Plant Community Types

73. Across the broader biodiversity investigation area, Hunter Eco (2019) defined 11 Plant Community Types (PCTs) from their 18 draft field communities, all of which also occur elsewhere in the Hunter Valley. Thirteen (13) communities and eight PCTs (201, 1604, 1606, 1607, 1655, 1691, 1692 and 1731) have been mapped within the Project Area (**Table 7**). DNGs, which provide substantial habitat for *Diuris tricolor* and *Prasophyllum petilum* in other areas, are represented here by five PCTs (201, 1606, 1607, 1655 and 1691). Collectively, 136 ha of DNG (or 80% of all communities shown in **Table 7**) are present within the Project Area. Approximately three-quarters of the total proposed disturbance area is comprised of native grasslands derived from White Box – Ironbark – Red Gum Shrubby Forest (Unit 2a), followed by Ironbark - Grey Box Grassy Woodland (Unit 9; 5.7%) and White Box - Ironbark - Red Gum Shrubby Forest (Unit 2; 5.6%). All other communities each occupy <3% of the total Project Area.
74. Examining the floristic composition and condition of defined vegetation communities presented in Hunter Eco (2019) reveals the characteristic species which dominate each community. These data can then be used to compare against similar data from other areas of the Hunter Valley where *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora* are known to occur (see **Section 4.2**). In this regard, **Table 8** summarises the key floristic elements of the 13 vegetation communities within the Project Area. To compile this table, I extracted those plant species contributing to the upper 50% of diversity, as shown in the community profiles in Attachment A of Hunter Eco (2019).
75. For the most widespread community within the Project Area (White Box – Ironbark – Red Gum Shrubby Forest DNG; Unit 2a; 74% of all communities shown in **Table 7**), grasslands dominated by *Aristida ramosa*, *Rytidosperma caespitosum*, *Eragrostis alveiformis*, *Dichanthium sericeum*, *Eriochloa pseudoacrotricha*, *Bothriochloa decipiens*, *Erodium crinitum* and *Chloris divaricata*, with high abundance of exotic species (particularly *Carthamus lanatus* and *Senecio madagascariensis*), characterises these areas (Hunter Eco 2019). In my experience, these relatively diverse grasslands growing on clay-based soils derived from former Box-Gum

landscapes tend not to support extensive populations of *Diuris tricolor*, *Prasophyllum petilum* or *Pterostylis chaetophora* (or few other terrestrial orchids), however I will reserve this view and further analyse available floristic and environmental data.

Table 7 Vegetation Communities and Plant Community Types identified for the Project Area (from Hunter Eco 2019). Excludes post-mine mapping. Condition classes within PCTs not shown.

Community	PCT	Extent (ha, %)
1: Red Gum - Ironbark - Apple Shrubby Woodland	1607: Blakely's Red Gum – Narrow-leaved Ironbark – Rough-barked Apple shrubby woodland of the upper Hunter	0.4 (0.2%)
1a: Red Gum - Ironbark - Apple Shrubby Woodland (DNG)	1607: Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter - DNG	4.9 (2.9%)
2: White Box - Ironbark - Red Gum Shrubby Forest	1606: White Box -Narrow-leaved Ironbark - Blakely's Red Gum shrubby open forest of the central and upper Hunter	9.6 (5.6%)
2a: White Box - Ironbark - Red Gum Shrubby Forest (DNG)	1606: White Box -Narrow-leaved Ironbark - Blakely's Red Gum shrubby open forest of the central and upper Hunter - DNG	125.6 (73.6%)
3: Slaty Box Shrubby Woodland	1655: Grey Box – Slaty Box shrub – grass woodland on sandstone slopes of the upper Hunter Valley and Sydney Basin	1.2 (0.7%)
3a: Slaty Box Shrubby Woodland (DNG)	1655: Grey Box – Slaty Box shrub – grass woodland on sandstone slopes of the upper Hunter Valley and Sydney Basin - DNG	2.4 (1.4%)
4: Swamp Oak Forest	1731: Swamp Oak – Weeping Grass grassy riparian forest of the Hunter Valley	0.2 (0.1%)
6: Bull Oak Grassy Woodland	1692: Bull Oak grassy woodland of the central Hunter Valley	2.7 (1.6%)
8. Fuzzy Box Woodland	201: Fuzzy Box Woodland on alluvial brown loam soils mainly in the NSW South Western Slopes Bioregion	0.5 (0.3%)
8a: Fuzzy Box Woodland (DNG)	201: Fuzzy Box Woodland on alluvial brown loam soils mainly in the NSW South Western Slopes Bioregion - DNG	2.8 (1.6%)
9: Ironbark - Grey Box Grassy Woodland	1691: Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter	9.6 (5.7%)
9a: Ironbark - Grey Box Grassy Woodland (DNG)	1691: Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter - DNG	0.3 (0.2%)
11: Grey Box - Spotted Gum - Narrow-leaved Ironbark Woodland	1604: Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter	1.3 (0.8%)
Plantation, Dams etc	n/a	9.1 (5.3%)
Total		170.6 (100%)

4.1.3.2 Comparative Numerical Analyses

76. To further explore floristic compositions between the Project Area and known orchid habitat elsewhere (Mangoola Coal for *Diuris tricolor* and *Prasophyllum petilum*, and Columbey National Park for *Pterostylis chaetophora*), I undertook numerical analysis using *PRIMER* software (Clarke & Gorley 2006). Both Mangoola and Columbey have had considerable directed survey undertaken for the target orchids, and both have also been the subject of numerical analysis using the same software and procedures as used by Hunter Eco (2019) to classify the vegetation within the Maxwell biodiversity investigation area. It is logical, therefore, to make use of this knowledge base to inform decisions on the suitability of habitat for the three target species.
77. Rather than using raw data for these analyses (which utilised different survey methods: 0.04 ha plots for the Project Area and Columbey but 0.01 ha plots at Mangoola, and surveyed during different seasons), I compared floristic compositions of the available community profiles derived for the Project Area with those profiles shown to support one or more of the target orchids. This included Units 1, 1a, 2, 2a, 3, 3a, 4, 6, 8, 9, 9a and 11 for the Project Area (see [Table 8](#)), Units 1a and 2 for Mangoola Coal (Bell submitted 1), and Units 4, 6, 7 and 8 for Columbey (Bell 2009) ([Table 9](#)).
78. All data was analysed on a presence-absence basis, meaning that dominant species held equal weight to rare species. Reducing data from cover abundance to presence-absence also lessens the impact of comparing surveys across different years and observers, where species commonly abundant during wet years will persist only in low numbers during drought. While not ideal, this process allowed me to determine if flora diversity (rather than abundance) present in the Project Area (collected during the drought year of 2018) correlated well with that for Mangoola where *Diuris tricolor* and *Prasophyllum petilum* were known to occur (collected between 2009 and 2011, c. average rainfall years), and with Columbey where *Pterostylis chaetophora* is present (collected in 2008 and 2009, above average rainfall years). Analyses with weed species retained and removed from the dataset were undertaken, but this made little difference to the overall result.
79. Because habitats of the three target orchids at the specified locations differ (predominantly DNGs for *Diuris tricolor* and *Prasophyllum petilum*, forest or woodland for *Pterostylis chaetophora*), I created sub-sets of data to reduce 'noise' in the analyses. This resulted in two separate analyses as shown in [Table 10](#). Note that Unit 8a (Fuzzy Box Woodland DNG) for the Project Area was not included as insufficient data prevented development of a floristic list by Hunter Eco (2019). Unit 4 (Swamp Oak Forest) from the Project Area was similarly excluded due to low diversity (six species), and based on past experience the very low likelihood of this habitat supporting terrestrial orchids.

For both analyses, I used the SIMPROF routine in combination with the CLUSTER module in *PRIMER* to identify statistically significant splits in the dataset ($p < 0.01$). This provided cluster diagrams where sites supporting similar floristic combinations were grouped and linked to their most similar neighbours. I also ran the MDS (non-metric Multi-Dimensional Scaling) routine with a minimum stress level of 0.01 and 25 restarts to produce ordination plots of the same data. Grouping of similar sample plots (communities or vegetation zones) can be better appreciated across this two-dimensional ordination space than in a cluster diagram, hence the latter is not shown. Note that for the Mangoola and Columbey datasets, my original analyses truncated SIMPER routines at 90% contributions, but these were re-run to 95% to match that done by Hunter Eco (2019) for the Project Area.

Table 8 Dominant species within defined vegetation communities (from Hunter Eco 2019). * = exotic species. Individual % contributions shown only for species contributing >5% of total diversity for that community.

Community	Dominant Species (upper 50%, in decreasing order of importance)
1: Red Gum - Ironbark - Apple Shrubby Woodland	<i>Eucalyptus blakelyi</i> (25.82), <i>Notelaea microcarpa</i> (10.47), * <i>Galenia pubescens</i> , <i>Brachychiton populneus</i> , * <i>Lycium ferocissimum</i>
1a: Red Gum - Ironbark - Apple Shrubby Woodland (DNG)	<i>Aristida ramosa</i> (15.17), * <i>Sida rhombifolia</i> (11.05), * <i>Galenia pubescens</i> (11.05), * <i>Senecio madagascariensis</i> (5.52), * <i>Petrorhagia nanteuilii</i> , <i>Commelina cyanea</i>
2: White Box - Ironbark - Red Gum Shrubby Forest	<i>Eucalyptus albens</i> (25.75), <i>Dichondra repens</i> (5.46), <i>Glycine clandestina</i> (5.25), <i>Brunoniella australis</i> , <i>Acacia salicina</i> , <i>Eremophila debilis</i>
2a: White Box - Ironbark - Red Gum Shrubby Forest (DNG)	* <i>Carthamus lanatus</i> (10.73), <i>Aristida ramosa</i> (6.39), <i>Rytidosperma caespitosum</i> (6.07), * <i>Senecio madagascariensis</i> (5.48), <i>Glycine clandestina</i> , <i>Eragrostis alveiformis</i> , <i>Dichanthium sericeum</i> , <i>Maireana microphylla</i> , <i>Erodium cicutarium</i> , <i>Chloris divaricata</i>
3: Slaty Box Shrubby Woodland	<i>Eucalyptus dawsonii</i> (44.84), <i>Aristida ramosa</i> (5.63)
3a: Slaty Box Shrubby Woodland (DNG)	<i>Chloris divaricata</i> (11.96), <i>Dichanthium sericeum</i> (10.31), * <i>Carthamus lanatus</i> (6.99), * <i>Medicago</i> sp. (5.55), <i>Rytidosperma caespitosum</i> , <i>Vittadinia pterochaeta</i> , * <i>Lepidium bonariense</i> , <i>Glycine clandestina</i>
4: Swamp Oak Forest	<i>Casuarina glauca</i> (54.55)
6: Bull Oak Grassy Woodland	<i>Allocasuarina luehmannii</i> (60.10)
8: Fuzzy Box Woodland	<i>Eucalyptus conica</i> (26.67), <i>Aristida ramosa</i> (24.44)
8a: Fuzzy Box Woodland (DNG)	no analysis of data
9: Ironbark - Grey Box Grassy Woodland	<i>Eucalyptus moluccana</i> (28.58), <i>Eremophila debilis</i> (6.09), <i>Brunoniella australis</i> (5.98), <i>Allocasuarina luehmannii</i> (5.95), <i>Dichondra repens</i>
9a: Ironbark - Grey Box Grassy Woodland (DNG)	<i>Aristida ramosa</i> (16.84), <i>Chrysocephalum semipapposum</i> (5.30), <i>Cymbopogon refractus</i> (5.10), <i>Brunoniella australis</i> , <i>Linum marginale</i> , <i>Wahlenbergia communis</i> , <i>Eragrostis leptostachya</i> , * <i>Gomphocarpus fruticosus</i> , * <i>Carthamus lanatus</i>
11: Grey Box - Spotted Gum - Narrow-leaved Ironbark Woodland	<i>Aristida ramosa</i> (14.27), <i>Lomandra filiformis</i> (9.39), <i>Eucalyptus moluccana</i> (6.41), <i>Eremophila debilis</i> (5.67), <i>Brunoniella australis</i> (5.67), <i>Lomandra multiflora</i> (5.67), <i>Glycine clandestina</i> (5.67)

Table 9 Vegetation communities previously defined for Mangoola (Bell submitted 1) and Columbey (Bell 2009) shown to support populations of one or more of the target orchid species.

Location	Unit		Target Orchid
Mangoola	1a	Dichanthium/ Sporobolus/ Chloris Grassland	<i>D. tricolor</i> , <i>P. petilum</i>
	2	Aristida/ Cymbopogon Grassland	<i>D. tricolor</i> , <i>P. petilum</i>
Columbey	4	Floodplain Redgum – Box Forest	<i>P. chaetophora</i>
	6	Seaham Ironbark Forest	<i>P. chaetophora</i>
	7	Seaham Spotted Gum – Ironbark Forest	<i>P. chaetophora</i>
	8	Lower Hunter Spotted Gum – Ironbark Forest	<i>P. chaetophora</i>

Table 10 Included datasets in numerical analyses.

Analysis No.	Habitat	Target Orchids	Dataset
1	Derived Native Grasslands	<i>Diuris tricolor</i> , <i>Prasophyllum petilum</i>	Project Area (Units 1a, 2a, 3a, 9a) Mangoola (Units 1a, 2)
2	Forests & Woodlands	<i>Pterostylis chaetophora</i>	Project Area (Units 2, 3, 6, 9, 11) Columbey (Units 4, 6, 7, 8)

80. For Analysis 1 (Derived Native Grasslands), three significant groups were evident in the dataset, with Unit 9a from the Project Area closely aligning with Units 1a and 2 from Mangoola (Figure 11). The other three DNG types fell distant from Mangoola data and evidently support different floristic compositions. The stress level of 0 shown in Figure 11 is an indication of the relative ease in which all data could be accommodated within two-dimensions. In general, a stress level of <0.2 is considered acceptable in these sorts of analyses, but increases in line with complexities associated with dataset size, multiple observers and seasons. From this grassland analysis, only Unit 9a (Ironbark - Grey Box Grassy Woodland DNG) from the Project Area could be considered as providing potential habitat for *Diuris tricolor* and *Prasophyllum petilum*.
81. For Analysis 2 (Forests & Woodlands), it was clearly evident that the forest and woodland vegetation present within the Project Area is floristically different to that known to support *Pterostylis chaetophora* at Columbey (Figure 12). This is not surprising given the wide geographical separation between these two localities (c. 100 km), however both areas support vegetation characterised by *Eucalyptus moluccana*, *Eucalyptus crebra* and *Corymbia maculata*, and provide superficially appropriate habitat. Based on this dataset, it is unlikely that any habitat within the Project Area is suitable for *Pterostylis chaetophora*.
82. One conclusion to reach from these analyses is that the floristic composition of nearly all vegetation communities defined for the Project Area differ sufficiently from the DNGs at Mangoola known to support populations of both *Diuris tricolor* and *Prasophyllum petilum*, and also from the forest and woodlands at Columbey known to support *Pterostylis chaetophora*. The one exception to this is the close alignment of Unit 9a (Ironbark - Grey Box Grassy Woodland DNG) from the Project Area with the Mangoola grasslands, suggestive of potential habitat for *Diuris tricolor* and *Prasophyllum petilum*. Acknowledging the different years of data collection between these two locations (2009-11 vs 2018), the different observers collecting

the data and the different methods of data collection (0.04 ha plots vs 0.01 ha plots), I am confident that within these datasets there are sufficient differences between all other grasslands and grassy woodlands present in the Project Area and those at Mangoola Coal. This is supported in part by my own field observations of the Project Area in July 2020 (see **Section 4.5**).

83. Notwithstanding this result, the presence of a known population of c. 200 *Diuris tricolor* occurring within Mt Arthur Coal lands in Grey Box – Spotted Gum – Narrow-leaved Ironbark Woodland (Unit 11 of Hunter Eco 2019) approximately 400 m north of the Product Stockpile Extension area, suggests that this species may also occur in this vegetation type within that Project Area. I do not have access to any floristic data from this area to allow more in-depth comparisons, but given its close proximity it is prudent to assume suitable habitat occurs there.

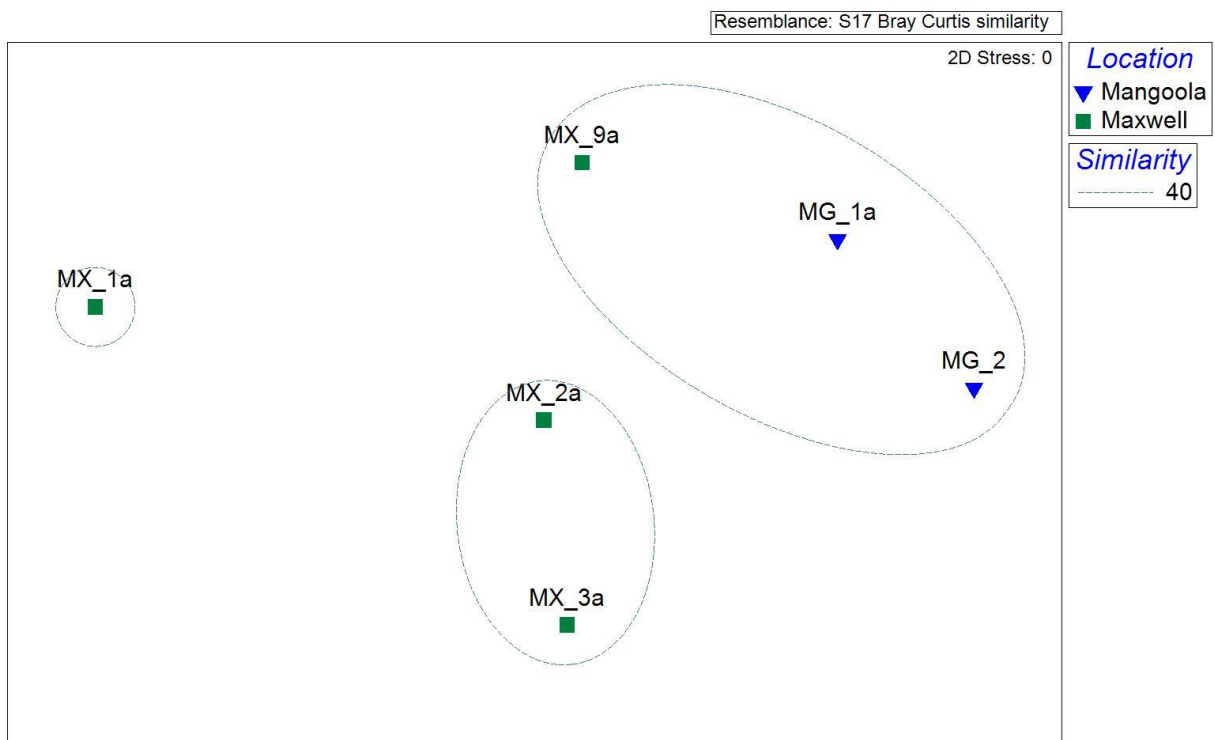


Figure 11 nMDS ordination of floristic compositions comprising Derived Native Grasslands from the Project Area (MX) in relation to that favouring *Diuris tricolor* and *Prasophyllum petilum* at Mangoola Coal (MG). Dotted ellipses show significant groups ($p < 0.01$) defined at a similarity level of 40%. MX_1a = Red Gum - Ironbark - Apple Shrubby Woodland (DNG); MX_2a = White Box - Ironbark - Red Gum Shrubby Forest DNG; MX_3a = Slaty Box Shrubby Woodland DNG; MX_9a = Ironbark - Grey Box Grassy Woodland DNG; MG_1a = Dichanthium/ Sporobolus/ Chloris Grassland; MG_2 = Aristida/ Cymbopogon Grassland. Data for the Project Area from Hunter Eco (2019), that from Mangoola from Bell (submitted 1).

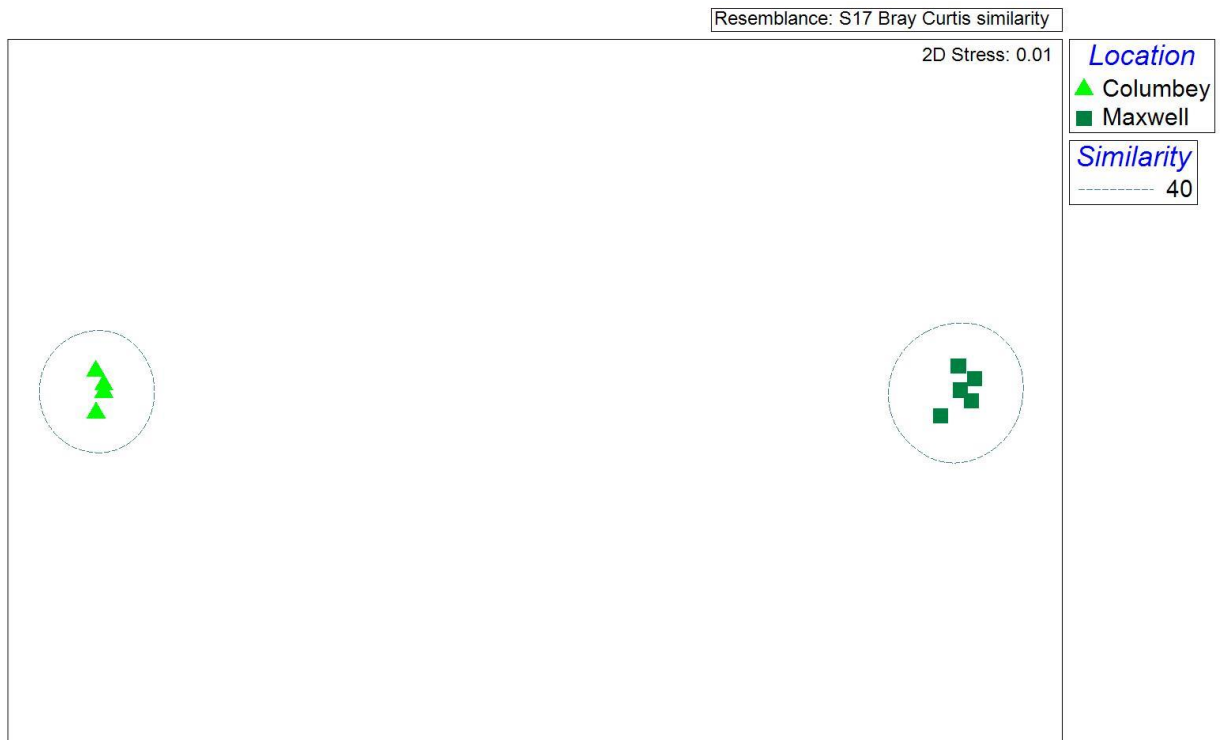


Figure 12 nMDS ordination of floristic compositions comprising forest and woodlands from the Project Area in relation to favoured *Pterostylis chaetophora* habitat at Columbey. Dotted ellipses show significant groups ($p < 0.01$) defined at a similarity level of 40%. Individual community codes not shown, as these are irrelevant to the outcome. Data for the Project Area from Hunter Eco (2019), that from Columbey from Bell (2009).

84. Additionally, following the same reasoning, the historical population of *Prasophyllum petilum* (recorded 1999-2005; c. 10 plants) at the eastern end of Thomas Mitchell Drive suggests a conservative assumption that the Product Stockpile Extension area may also support this species. Data contained within NSW BioNet linked to this population show it to be woodland of *Corymbia maculata*, *Eucalyptus moluccana* and *Eucalyptus blakelyi*, similar to that which occurs within the Product Stockpile Extension area (pers. obs.).

4.2 Environmental Analysis

85. An assessment of selected environmental attributes (geology, dominant lithology, soil landscape, soil type, soil fertility, soil hydrology, annual rainfall, mean annual temperature) was made of the Project Area with the aim of profiling the broad non-floristic characteristics that may be important in defining habitat for the three target orchids. A number of resources were used to undertake this (Table 11), all performed in GIS against Project Area boundaries. Other commonly used modelling parameters (e.g. slope, aspect, solar radiation, roughness indices, moisture etc) were not explored in any detail, although they have reportedly proven informative for some species (e.g. Janes 2010). However, these attributes are unlikely to be instructive in the open and gently undulating landscapes of the Hunter Valley floor, and in addition they may lead assessment away from the central aim of identifying habitat for orchids and their mycorrhizal fungi. Understanding the biophysical properties of the Project Area is important, though, to allow comparisons with point data from other areas where *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora* occurs (see Section 4.2.2).

Table 11 Digital resources utilised to categorise biophysical attributes of the Project Area, and compare these with point data for the three target orchids.

Attribute	Source
Geological Unit	Colquhoun G.P., Hughes K.S., Deyssing L., Ballard J.C., Folkes C.B, Phillips G., Troedson A.L. & Fitzherbert J.A. (2020) <i>New South Wales Seamless Geology dataset, version 2</i> [Digital Dataset]. Geological Survey of New South Wales, Department of Regional NSW, Maitland. Available at https://search.geoscience.nsw.gov.au/product/9232
Dominant Lithology	Colquhoun G.P., Hughes K.S., Deyssing L., Ballard J.C., Folkes C.B, Phillips G., Troedson A.L. & Fitzherbert J.A. (2020) <i>New South Wales Seamless Geology dataset, version 2</i> [Digital Dataset]. Geological Survey of New South Wales, Department of Regional NSW, Maitland. Available at https://search.geoscience.nsw.gov.au/product/9232
Soil Landscapes	Office of Environment and Heritage (2019) <i>Soil Landscapes of Central and Eastern NSW - v2</i> , NSW Office of Environment and Heritage, Sydney. Available at https://datasets.seed.nsw.gov.au/dataset/published-soil-landscapes-of-central-and-eastern-nsw37d37
Great Soil Group	Office of Environment and Heritage (2017) <i>Great Soil Group (GSG) Soil Type map of NSW</i> , NSW Office of Environment and Heritage, Sydney. Available at https://datasets.seed.nsw.gov.au/dataset/great-soil-group-gsg-soil-type-map-of-nsw1cf19
Australian Soil Class	Office of Environment and Heritage (2017) <i>Australian Soil Classification (ASC) Soil Type map of NSW</i> , NSW Office of Environment and Heritage, Sydney. Available at https://datasets.seed.nsw.gov.au/dataset/australian-soil-classification-asc-soil-type-map-of-nsw10
Soil Fertility	Office of Environment and Heritage (2017) <i>Estimated Inherent Soil Fertility of NSW</i> , NSW Office of Environment and Heritage, Sydney. Available at https://datasets.seed.nsw.gov.au/dataset/estimated-inherent-soil-fertility-of-nswd793e
Hydrologic Soils	Office of Environment and Heritage (2017) <i>Hydrologic Groups of Soils in NSW</i> , NSW Office of Environment and Heritage, Sydney. Available at https://datasets.seed.nsw.gov.au/dataset/hydrologic-groups-of-soils-in-nsw7f9e8
Annual Rainfall	GeoScience Australia, raster layer based on monthly mean precipitation 1976-2005, with grid resolution of 30m. Available at: https://datasets.seed.nsw.gov.au/dataset/anuclim-annual-mean-rainfall-raster-layer
Annual Average Temperature	GeoScience Australia, raster layer based on monthly mean temperatures 1976-2005, with grid resolution of 30m. Available at: https://datasets.seed.nsw.gov.au/dataset/anuclim-annual-mean-temperature-raster-layer

Table 12 Summary of biophysical attributes of the Project Area. See [Appendix 3](#) for further detail.

Project Area	Biophysical Summary
Product Stockpile Extension (5.2 ha)	Part Cessnock Sandstone and part Branxton Formation geology; equally of sandstone and conglomerate lithology; entirely of the Roxburgh soil landscape, supporting Yellow Podzolic (Kurosol) soils of Moderately Low fertility with slow infiltration rates. Annual rainfall is 671 mm (StDev=0.67, n=4) and mean temperature is 16.6° (StDev=0.01, n=4).
Surface Development Area (302.9 ha)	Predominantly of Jerrys Plains Subgroup and Rowan Formation geology, with Mulbring Siltstone and Branxton Formation also well represented; mostly of sandstone lithology, but with siltstone, conglomerate and quartzite also present; largely of the Brays Hill and Liddell soil landscapes, supporting Grey, Brown or Red Clay (Vertosol) soils and Soloths (Kurosols), of Moderate or Moderately Low fertility with very slow infiltration rates. Annual rainfall is 658 mm (StDev=13.4, n=20) and mean temperature is 16.7° (StDev=0.16, n=20).
Edderton Rd Realignment (10.2 ha)	Entirely Jerrys Plains Subgroup geology; of sandstone lithology; on the Bayswater and Brays Hill soil landscapes, supporting Solodic (Sodosols) and Grey, Brown or Red Clay (Vertosol) soils, of Moderately Low and Moderate fertility with very slow infiltration rates. Annual rainfall is 623 mm (StDev=6.64, n=11) and mean temperature is 17.1° (StDev=0.10, n=11).
Ancillary Disturbance Area (Ponding) 1 (0.5 ha)	Entirely Jerrys Plains Subgroup geology; of sandstone lithology; on the Brays Hill soil landscape, supporting Grey, Brown or Red Clay (Vertosol) soils, of Moderate fertility with very slow infiltration rates. Annual rainfall is 628 mm (StDev=0.78, n=2) and mean temperature is 17.1° (StDev=0.01, n=2).
Ancillary Disturbance Area (Ponding) 2 (1.5 ha)	Entirely Jerrys Plains Subgroup geology; of sandstone lithology; on the Bayswater soil landscape, supporting Solodic (Sodosol) soils, of Moderately Low fertility with very slow infiltration rates. Annual rainfall is 619 mm (StDev=0.01, n=2) and mean temperature is 17.2° (StDev=0.01, n=2).

86. The *NSW Flora: Ecological Niche Finder* online resource portal, arising out of the work of Gallagher (2016) and accessible at (<http://nswnichefinder.net/index.php>), was also considered as a possible tool to better understand the ecological requirements of the target species. The Niche Finder provides broad modelling capabilities for NSW plant taxa across a number of environmental domains, however because the target orchids are classified as sensitive species (location data withheld) this resource was not available.

4.2.1 Project Area

87. [Table 12](#) summarises the environmental characteristics of the Project Area, categorised into the five separate disturbance areas (see also [Appendix 3](#) for graphed details). Nine geological units comprise the Project Area, however sediments of the Jerrys Plain Subgroup are the most common (46%). The Surface Development Area is the most complex area with seven units, the Product Stockpile Extension area has two units, and all others one. Soils derived from sandstone

lithology are dominant (>70%) across most areas, with siltstones and conglomerate present in the Surface Development Area and Product Stockpile Extension area, and a small area of quartzite. Four soil landscapes have been mapped for the area, the two most dominant being Brays Hill and Liddell. These mirror the distribution of the Great Soil Groups, where Grey, Brown and Red Clays dominate over Soloths, Solodic Soils and Yellow Podzolics. Under the Australian Soil Classification scheme, three soil types (Kurosols, Vertosols and Sodosols) occur across the area, and are of either moderately low or moderate fertility.

88. In terms of water infiltration (hydrology), most soils comprise Group D (very slow infiltration rates due to high clay content, high water tables and/or shallow soils over impervious material), although the Product Stockpile Extension area is Group C (slow infiltration rates due to impeded drainage and/or moderately fine textures). For climatic data, average values were computed from GeoScience Australia raster layers at 39 field inspection point locations across the Project Area (see **Section 4.4**), distributed as: Product Stockpile Extension area, n=4; Surface Development Area, n=20; Edderton Rd Realignment, n=11; Ancillary Disturbance Area (Ponding) 1, n=2; Ancillary Disturbance Area (Ponding) 2, n=2. Annual rainfall was consequently found to lie between 619 and 671 mm/year across the Project Area, while mean temperature was around 17°.

4.2.2 Target Orchids Records

89. A compilation of all records for the three target orchids within the Hunter Local Land Services (Hunter LLS) area was interrogated against a range of environmental variables within GIS to determined ecological niches. This process aimed to identify, based on available records, the key environmental factors present within known populations of each species. Data included:
- as-held NSW BioNet records of target orchids obtained under DPIE licence ASH20009;
 - currently undatabased but geospatially accurate records from various projects, including recent surveys for *Pterostylis chaetophora* collected under the NSW Government's *Saving our Species* program; and
 - other miscellaneous records gleaned from unpublished reports or databases.

Specimen collection data from the AVH was not incorporated as these data have been de-natured and therefore location precision is unreliable.

90. All data was checked for duplication across multiple data sources and positional accuracy, with records >100 m accuracy discarded from analysis. To reduce the influence of high-density point records resulting from targeted surveys over comparatively small search areas, the entire Hunter LLS region was overlain by a 100 m x 100 m grid (i.e. 1 ha squares) and orchid data reduced to presence-absence at this resolution. Centroids of all cells returning a 'true' result were adopted as surrogates for position and used to analyse environmental niches. Duplicates resulting from multiple high-density records within each 100 m grid were reduced to a single record.
91. Cleaning and simplifying orchid location data in this way resulted in an analysis dataset of 983 point locations (centroids) for *Diuris tricolor*, 485 point locations (centroids) for *Prasophyllum petilum* and 128 point locations (centroids) for *Pterostylis chaetophora*. These datasets were individually assessed against those environmental variables shown in [Table 11](#) above. The relative proportion of known orchid occurrences compared to representative locations within the Project Area (n=39) were graphed to illustrate similarities and differences (see [Appendix 4](#)), and a summary is provided in [Figure 13](#). For *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis*

chaetophora, there was little correlation between geological unit and soil landscape at locations known to support these species when compared to the Project Area. Additionally, there was also a low correlation in the Australian soil class and annual rainfall for *Pterostylis chaetophora*, and a weak match for annual temperature in this species. Overall, these results suggest there to be little apparent differences in soil type, fertility and hydrology for *Diuris tricolor* and *Prasophyllum petilum*, but some differences for *Pterostylis chaetophora*. It also implies that the Project Area may be too dry (mean 1005 mm/yr vs 640 mm/yr) and perhaps slightly too cool (17.2° vs 16.9°) for *Pterostylis chaetophora*, although this is only minor. The Project Area therefore potentially provides suitable soils and climate for *Diuris tricolor* and *Prasophyllum petilum*, but contingent on the availability of suitable mycorrhizal fungi in the soil and pollinators for ongoing persistence.

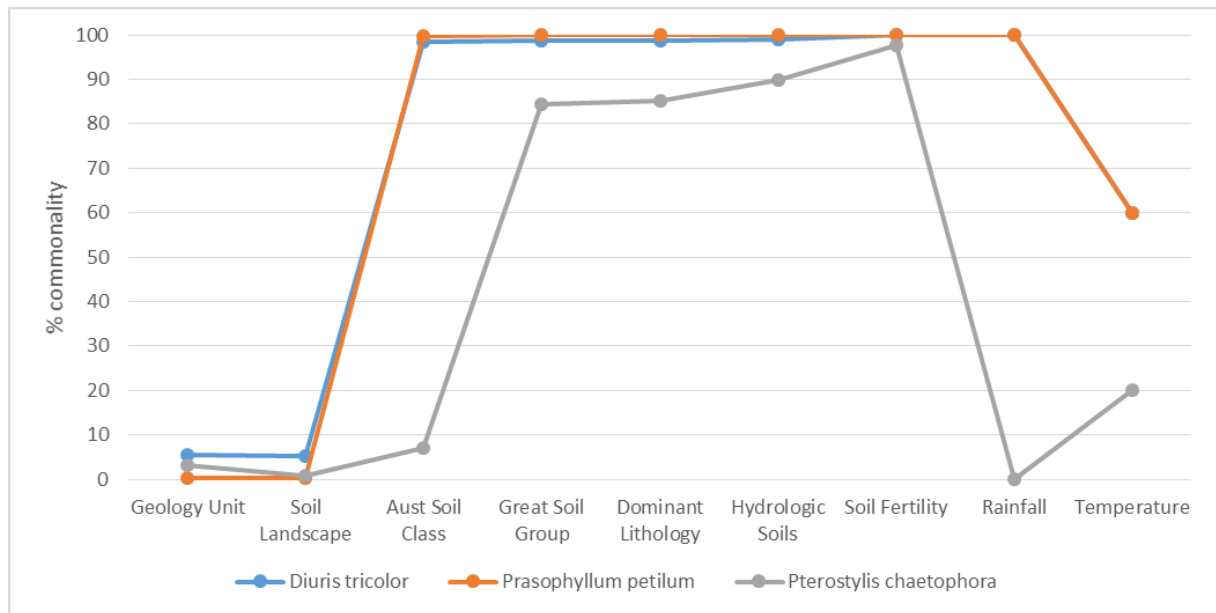


Figure 13 Summary of percentage commonality of selected environmental attributes between known target orchid locations (n=983 *Diuris tricolor*; n=485 *Prasophyllum petilum*; n=128 *Pterostylis chaetophora*) and the Project Area (n=39).

92. The markedly different soil landscapes are perhaps the most informative environmental attribute that might inform suitable habitat for orchids. By definition, soil landscapes attempt to combine elements of soil structure, chemistry and composition with features of the landscapes in which they were formed. This means that related variables such as vegetation, hydrology and topography (which all influence the biology of a soil) are captured within a single map unit type. For orchids this may be particularly telling, as the environments in which the necessary soil mycorrhiza form and persist are likely to be similar within the same soil landscapes, although there is no firm evidence for this to date. Following this logic, the fact that only 5% of 983 locations of *Diuris tricolor* (and <1% of 485 *Prasophyllum petilum* and 128 *Pterostylis chaetophora* locations) shared the same soil landscapes with the Project Area implies that soil biology between the two datasets is likely to differ significantly.

4.3 Orchid Diversity: A Surrogate for Mycorrhizal Fungi

93. The concept of locally high orchid diversity ('hotspots') is well known, and is often reported in the literature (e.g. Seaton 2007; Nurfadilah *et al.* 2013). However, orchid hotspots where

multiple orchid species co-occur are dependent on a diversity of mycorrhizal fungi being present within the soil, and some landscapes evidently support more of these than others (McCormick *et al.* 2018). Several studies have linked the patchy nature of orchid distribution to a similarly patchy distribution of mycorrhizal fungi in the soils (e.g. Voyron *et al.* 2016). In the upper Hunter region, there is a clear orchid hotspot in the Mangoola Coal area (including the target species *Diuris tricolor* and *Prasophyllum petilum*), where 15 species have been recorded (Umwelt 2006; pers. obs.). Elsewhere, other hotspots occur at Barrington Tops (Heinrich & Dowling 2000; Zoete 2000); the Hunter Economic Zone (3300 ha; 23 species) near Cessnock (Bell 2004a); and in Columbey National Park (720 ha; 16 species) near Clarencetown (including the target species *Pterostylis chaetophora*; Bell 2019d). More localised but lower levels of diversity can also occur, such as to the west of Lake Liddell where 5 species occur on the 50 ha Condran biodiversity offset property (Bell & Murray 2013), and at North Rothbury (1500 ha) where 7 species occur (Bell & Driscoll 2005). Along Thomas Mitchell Drive, 8 species were present at the time of the 1999 find of *Prasophyllum petilum*, although these are not databased (B. Holzinger pers. comm.).

94. To test the hypothesis that parts of the upper Hunter may be poorly endowed with mycorrhizal fungi, I examined the distribution of all terrestrial orchid records in the Hunter region, and specifically within the area around the Project Area. This was effectively using orchid presence as a surrogate for mycorrhizal fungi presence. I extracted from the NSW BioNet database all observation records of terrestrial orchid species within the Hunter LLS area, incorporating over 180 taxa. The de-natured locations of this dataset were not an issue for this procedure, as the level of resolution was to remain broad.
95. As indicated in [Figure 14](#) and [Figure 15](#), there is a distinct scarcity of terrestrial orchids of any kind within the Singleton to Muswellbrook region, irrespective of the extensive amount of field surveys that have been conducted over many years in relation to the development (coal mine) industry. Aside from *Diuris tricolor*, the few species recorded on Permian-aged sediments within a 15 km radius of the Project Area (*Calochilus* spp. and *Pterostylis curta* on Mt Arthur, *Pterostylis* spp. and *Diuris punctata* along Thomas Mitchell Drive, *Pterostylis nutans* and *Pterostylis bicolor* north of Lake Liddell, and *Micortis unifolia* near Ravensworth) are suggestive of a paucity of mycorrhizal fungi in these landscapes.
96. Given the level of survey that has been expended in and around the former Drayton/ Maxwell Project Area, the Mt Arthur Coal mine, the Bayswater and Liddell Power Stations, the Mount Owen mine and Ravensworth Operations, it may be expected that more terrestrial orchids would be present than is indicated through observed records. For example, the ecological assessment of the Mount Owen Continued Operations Project recorded only two species: *Acianthus fornicatus* and a *Pterostylis* spp. (Umwelt 2014), while for the Ravensworth Operations Project no orchids were recorded (Umwelt 2010). Closer to the Project Area (and while under drought conditions), the Bayswater and Liddell Power Stations upgrade project (adjacent to the east) recorded only a single *Microtis* species (Kleinfelder 2017), while at Mt Arthur (adjoining to the north and west), no orchids were recorded (Hunter Eco 2013). The low number of terrestrial orchid records in these landscapes is likely largely the result of very little mycorrhizal fungi within the soils there, and where they do occur, they are limited in extent and/or diversity. Elsewhere, some forms of mycorrhizal fungi (including those associated with orchids) have been shown to be affected by long-term agricultural grazing (e.g. Su & Guo 2007; Ba *et al.* 2012; Oja *et al.* 2017), but it is unknown if this may apply to Hunter landscapes.

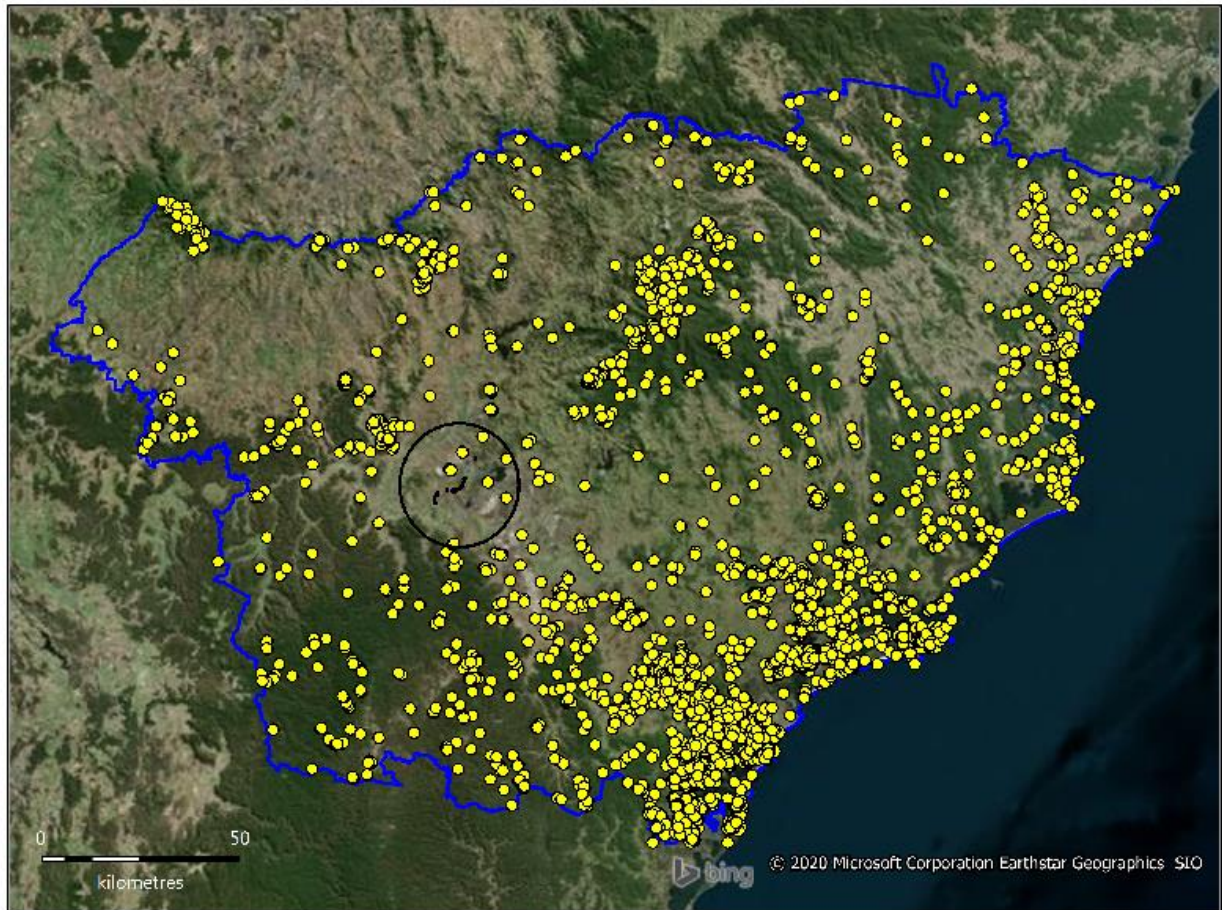


Figure 14 Point locations of all terrestrial orchids (excluding *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora*) for the Hunter Local Land Services area. The Project Area is shown within a 15 km radius circle. Note aggregations of records indicative of diversity 'hotspots' for orchids, and the scarcity of orchid records within the main Hunter Valley region. Data sourced from NSW BioNet, extracted 13 July 2020.

4.4 Field Inspection of the Project Area

97. I inspected all parcels of land that comprise the Project Area on 3 July 2020, in the company of Dr Colin Driscoll (Hunter Eco, on behalf of Resource Strategies). The extreme north of the main surface development area (immediately north of the old quarry) could not be accessed, however I understand that nearly all of this comprises rehabilitated land and its potential to support orchid populations is lessened considerably.
98. Field inspections involved traversing each area in a vehicle, with periodic stops to inspect the ground vegetation and its condition. Notes were made at 39 geo-referenced locations (c. 150-400 m apart) on habitat and key species present (the same locations used for the environmental analysis discussed above), and representative photographs were also taken periodically. A subjective assessment of the likelihood of orchid presence (low, medium, high) was made at each inspection point, based solely on composition and condition of grassland and woodland areas. An inspection was also made of the *Diuris* Conservation Area near to the Ancillary Disturbance Area (Ponding) 1, first reported in Cumberland Ecology (2012).

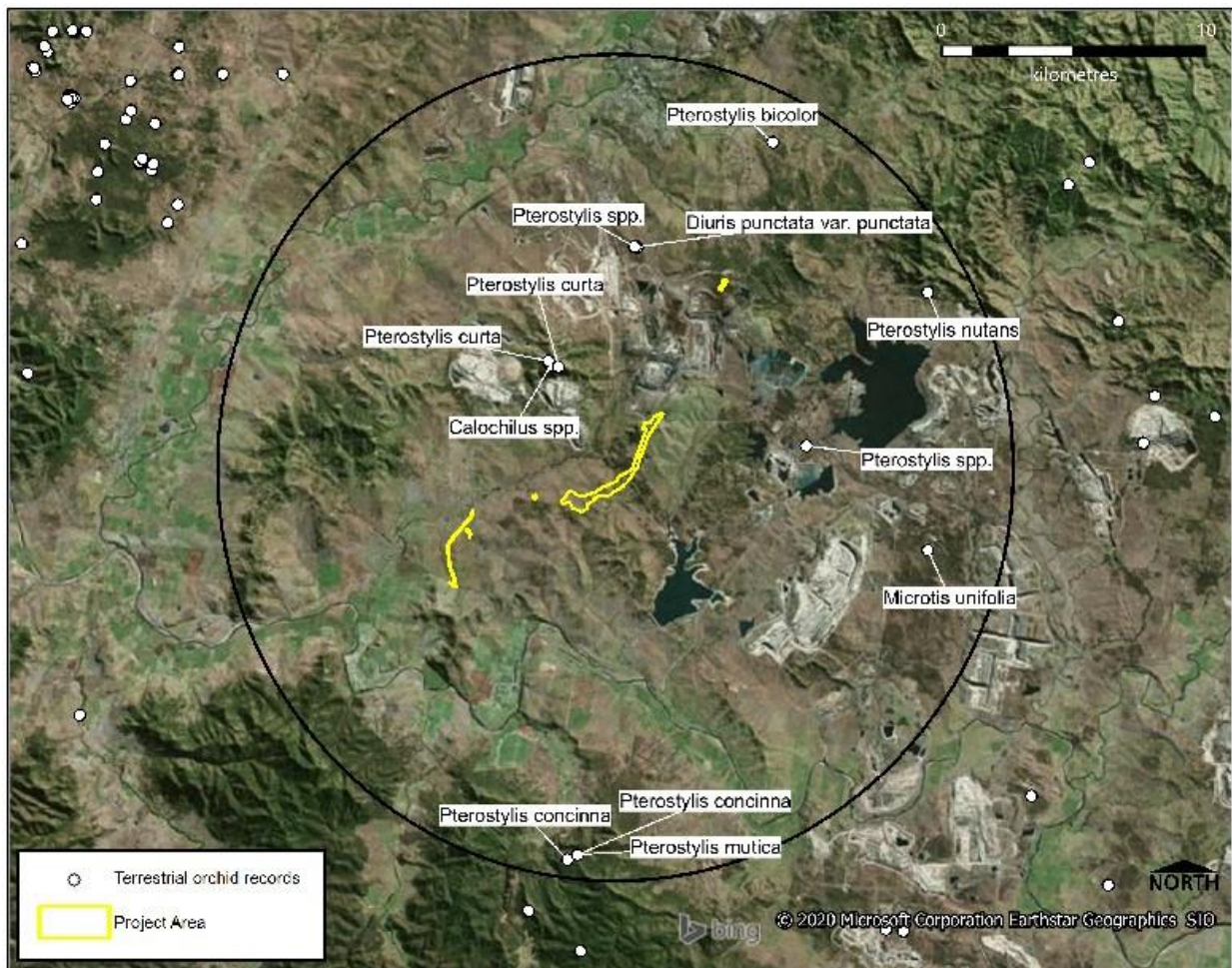


Figure 15 Terrestrial orchids (excluding *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora*) reported for the Project Area and immediate surrounds (15 km radius shown). Note the aggregation of records for the Mangoola Coal area in the top left corner. Data sourced from NSW BioNet, extracted 13 July 2020.

99. My initial impression of the grasslands within the Project Area during my inspection were that, although in good condition following the recent rains, they supported a different floristic composition to that occurring elsewhere where *Diuris tricolor*, *Prasophyllum petilum* and *Pterostylis chaetophora* occur. Dominant grass species across most areas included *Chloris truncata*, *Dichanthium sericeum*, *Panicum effusum*, *Chloris ventricosa*, *Bothriochloa decipiens* and *Microlaena stipoides* var. *stipoides* (Figure 16), with occasional patches of *Bothriochloa biloba*. Within this matrix was an array of flowering herbs and forbs, including *Calotis lappulacea*, *Glycina tabacina*, *Vittadinia muelleri*, *Erodium crinitum*, *Sida corrugata*, *Eremophila debilis*, *Fimbristylis dichotoma* and *Chrysocephalum apiculatum*. Some areas also supported a dominance of *Aristida ramosa*, more typical of habitat I am familiar with that supports *Diuris tricolor* and *Prasophyllum petilum*, however co-occurring with this species were several other grass taxa typical of richer clay-based soils. I saw no areas where the grasses *Entolasia stricta*, *Themeda triandra* and *Aristida vagans* dominated, such as occurs in areas frequented by *Pterostylis chaetophora*. Weed species were generally sparse or localised around former stock camps or along some drainage lines (including Ancillary Disturbance Areas 1 and 2, where *Juncus acutus* in particular predominated).



Figure 16 Grassland within the Project Area showing grassland dominated by *Bothriochloa decipiens*, *Dichanthium sericeum* and *Chloris truncata*.

100. As summarised earlier, grassland habitats supporting *Diuris tricolor* and *Prasophyllum petilum* elsewhere in the Hunter Valley are most commonly derived from landscapes of *Eucalyptus crebra*, and tend to be dominated by *Aristida ramosa*, *Cymbopogon refractus*, *Bothriochloa decipiens* and *Sporobolus creber* (species all present in the Project Area, but rarely dominating), with other grass species present but subdominant (Figure 17, cf. Figure 16). Herbs and forbs do occur in those habitats, but they are rarely conspicuous or dominant. The grasslands observed within the Project Area appeared more diverse, in keeping with observations made in other parts of the Hunter that landscapes derived from former *Eucalyptus 'albemol'* or *Eucalyptus moluccana* woodland support more species than those derived from *Eucalyptus crebra* (e.g. such as seen at Rixs Creek; Bell 2012b). Indeed, observations of remnant canopy species made during my inspection revealed that almost all of the Project Area appeared to have once supported a woodland of *Eucalyptus 'albemol'* or *Eucalyptus moluccana*, except for some areas where *Eucalyptus dawsonii*, *Eucalyptus blakelyi* or *Eucalyptus conica* occurred.
101. Similarly, *Pterostylis chaetophora* is known predominantly from forested habitats with a grassy ground layer, with *Entolasia stricta*, *Themeda triandra* and *Aristida vagans* important. While the last of these grass species is common in the upper Hunter Valley (but rare within the Project Area), *Themeda triandra* is now rarely encountered, and *Entolasia stricta* is highly localised normally in sandstone habitats (pers. obs.).
102. Despite these observations, I am conscious of the possibility that these perceived differences in floristic composition may be a reflection on the recent growth following good falls of rain. However, apart from a few areas within the Surface Disturbance Area (Figure 18) where the hardy and grazing-tolerant *Aristida ramosa* dominated some sections, this species formed only a small component of the bulk of lands inspected; it was nearly always present but sub-ordinate to other grasses and herbs. Given the long history of grazing across the Project Area, it may be expected that *Aristida ramosa* would have been the dominant grass species, however clearly soil type rather than past land management appears to drive species composition in these landscapes.



Figure 17 Grassland supporting *Diuris tricolor* and *Prasophyllum petilum* at Mangoola Coal, dominated by *Aristida ramosa* and *Cymbopogon refractus*.



Figure 18 Grassland within the proposed Surface Area Disturbance area, showing (predominantly) swards of *Aristida ramosa* with *Dichanthium sericeum* and *Chloris truncata*.

103. On the GIS, I then examined the vegetation community mapping presented in Hunter Eco (2019) to determine if it accurately portrayed the diversity and distribution of vegetation that I inspected, and found it to represent well the vegetation patterns within the Project Area. I was satisfied, therefore, that I could use the Hunter Eco vegetation community mapping to create maps of likely orchid habitat, so that if necessary, estimates of the number of hectares anticipated to support viable orchid populations could be calculated (**Section 5**). Additional guidance was provided by my own field notes and data analyses, the plot data collected by Hunter Eco and aerial imagery.
104. In determining the suitability of the Project Area as orchid habitat, I drew on my experience from surveying for *Diuris tricolor* and *Prasophyllum petilum* in the Mangoola area over ten years, and for *Pterostylis chaetophora* in the mid-lower Hunter Valley across four sites over three years. Part of this experience included observations of orchids growing in somewhat surprising situations, which may otherwise be glossed over as unsuitable habitat. For example, observations of *Diuris tricolor* growing on agricultural contour banks (Figure 19), in heavily weed-infested derived grasslands where no other native species were apparent (Figure 20), and proliferating on the manicured lawns of farm homesteads (Figure 21). I have also observed *Diuris tricolor* growing within a former vineyard on raised garden beds, and along the margins of management trails. Likewise, *Pterostylis chaetophora* also commonly grows along trail and road edges (Figure 22) and in other areas where some ground disturbance has occurred. Collectively, observations of orchids growing in such disturbed habitats suggest that perceived low condition of potentially appropriate habitat should not be immediately dismissed as unlikely to support orchids.



Figure 19 *Diuris tricolor* and other orchids growing over a constructed contour bank, Mangoola.



Figure 20 *Diuris tricolor* growing with exotic weeds in low quality grassland near Mangoola Coal.



Figure 21 *Diuris tricolor* proliferating in mown lawns of a farm homestead near Mangoola Coal.



Figure 22 *Pterostylis chaetophora* growing in roadside gutter, Columbey National Park.

4.5 Concluding Opinion: Are the Target Species Present?

105. Based on the various floristic and environmental analyses discussed earlier in this section, I concluded that there is limited potential for *Diuris tricolor* or *Prasophyllum petilum* to be present within the Project Area, and that it is unlikely for *Pterostylis chaetophora* to occur at all. I based this opinion largely on the preceding analysis of floristic composition of available habitat, geological unit, soil landscape, annual rainfall and the inferred absence or paucity of mycorrhizal fungi (using reported orchid presence and diversity as a surrogate) (Table 13).
106. The two communities potentially supporting *Diuris tricolor* and/or *Prasophyllum petilum* (Units 9a and 11 of Hunter Eco 2019) occur only at Ancillary Disturbance Area 1 and the Product Stockpile Extension area respectively. Since these conclusions were made, Hunter Eco was commissioned to undertake targeted surveys of these two communities and no threatened flora species were recorded within the Project Area. Consequently, *Diuris tricolor* and *Prasophyllum petilum* (syn. *Prasophyllum* sp. Wybong) are unlikely to be present anywhere in the Project Area.

Table 13 Concluding Reasoning for Orchid Presence or Absence.

Species	Factor	Reasoning
<i>Diuris tricolor</i>	floristic composition	Analysis of floristic data (using the upper 95% of species comprising defined vegetation communities within the Project Area) revealed only one community (Unit 9a: Ironbark - Grey Box Grassy Woodland DNG) as being closely related to my own defined communities supporting <i>Diuris tricolor</i> at Mangoola. This community has been mapped by Hunter Eco (2019) for 0.3 ha of the Project Area, at Ancillary Disturbance Area 1. Additionally, the close proximity (c. 400 m) of a population of <i>Diuris tricolor</i> to the Product Stockpile Extension area, and in vegetation similar to that present there, suggests that Unit 11: Grey Box – Spotted Gum – Narrow-leaved Ironbark woodland, mapped by Hunter Eco (2019) across 1.3 ha of the Project Area, also potentially supports this species.
	geological unit	There is only minor correlation (6%) between geological units within the Project Area and those supporting <i>Diuris tricolor</i> elsewhere in the region.
	soil landscape	There is only minor correlation (5%) between soil landscapes within the Project Area and those supporting <i>Diuris tricolor</i> elsewhere in the region.
	mycorrhizal fungi	Based on few records of all terrestrial orchid species within and around the Project Area, it appears that there are very limited and/or highly localised mycorrhizal fungi present in soils, reducing the likelihood of <i>Diuris tricolor</i> or <i>Prasophyllum petilum</i> being present.
<i>Prasophyllum petilum</i>	floristic composition	Analysis of floristic data (using the upper 95% of species comprising defined vegetation communities within the Project Area) revealed only one community (9a - Ironbark - Grey Box Grassy Woodland DNG) as being closely related to my own defined communities supporting <i>Prasophyllum petilum</i> at Mangoola. This community has been mapped by Hunter Eco (2019) for 0.3 ha of the Project Area, at Ancillary Disturbance Area 1. Additionally, the relatively close proximity (c. 1300 m) of an historical population of <i>Prasophyllum petilum</i> to the Product Stockpile Extension area, and in vegetation similar to that present there, suggests that Unit 11: Grey Box – Spotted Gum – Narrow-leaved Ironbark Woodland, mapped by Hunter Eco (2019) across 1.3 ha of the Project Area, also potentially supports this species.
	geological unit	There is only very minor correlation (0.2%) between geological units within the Project Area and those supporting <i>Prasophyllum petilum</i> elsewhere in the region.

Species	Factor	Reasoning
	soil landscape	There is only very minor correlation (0.2%) between soil landscapes within the Project Area and those supporting <i>Prasophyllum petilum</i> elsewhere in the region.
	mycorrhizal fungi	Based on few records of all terrestrial orchid species within and around the Project Area, it appears that there are very limited and/or highly localised mycorrhizal fungi present in the available soils, reducing the likelihood of <i>Prasophyllum petilum</i> being present.
<i>Pterostylis chaetophora</i>	floristic composition	Analysis of floristic data (using the upper 95% of species comprising defined vegetation communities within the Project Area) revealed no relationship with my own defined communities supporting <i>Pterostylis chaetophora</i> at Columbey National Park. Despite superficial similarities of community 11 (Grey Box - Spotted Gum - Narrow-leaved Ironbark Woodland) from within the Project Area to elements of the Columbey vegetation, there are few co-occurring dominants.
	geological unit	There is only minor correlation (3%) between geological units within the Project Area and those supporting <i>Pterostylis chaetophora</i> elsewhere in the region.
	soil landscape	There is only very minor correlation (0.8%) between soil landscapes within the Project Area and those supporting <i>Pterostylis chaetophora</i> elsewhere in the region.
	annual rainfall	Annual mean rainfall across all locations supporting <i>Pterostylis chaetophora</i> (n=128) is 1005 mm/yr (stdev 98.4), while the annual mean rainfall of the Project Area is considerably drier at 640 mm/yr (stdev 20.8).
	mycorrhizal fungi	Based on few records of all terrestrial orchid species within and around the Project Area, it appears that there are very limited and/or highly localised mycorrhizal fungi present in the available soils, reducing the likelihood of <i>Pterostylis chaetophora</i> being present.

5. Criterion (d) – Size of Population or Habitat

107. In order to determine the extent of potential habitat for *Diuris tricolor*, *Prasophyllum petilum* and/or *Pterostylis chaetophora* within the Project Area, I considered the elements outlined above in Table 13 and used the mapping of Hunter Eco (2019) to spatially represent that habitat. Following my analyses, habitat for *Diuris tricolor* and *Prasophyllum petilum* was considered to potentially occur within vegetation mapped as Ironbark - Grey Box Grassy Woodland DNG (Unit 9a) or Grey Box – Spotted Gum – Narrow-leaved Ironbark Woodland (Unit 11) by Hunter Eco (2019). These units have been mapped across 0.3 ha of Ancillary Disturbance Area 1, and 1.3 ha for the Product Stockpile Extension area respectively. No other grasslands or woodlands in the Project Area carry vegetation similar to this, supporting both by my field inspection and the comparative numerical floristic analysis I performed on Hunter Eco (2019)

data. Surveys of these areas by Hunter Eco in 2020 did not record *Diuris tricolor* or *Prasophyllum petilum*, suggesting that these species are unlikely to be present within the Project Area.

108. I do not consider *Pterostylis chaetophora* to be present anywhere within the Project Area. Almost all of the known records of this species occur in more coastal habitats receiving higher rainfall than the Project Area, except for two unconfirmed populations at Mangoola Coal and Wingen Maid Nature Reserve. Those two populations, however, are closely tied (geographically) to remnant Triassic Narrabeen series outcrops, and/or colluvial material derived from those rock types, none of which occur within the Project Area.
109. While rarely recognised in assessments of potential orchid habitat, the occurrence of the required mycorrhizal fungi for each of the three target orchid species (and indeed for all terrestrial orchids) is possibly the most important determiner of orchid presence/absence. Unfortunately, it is the one factor that we know very little about and represents an attribute that cannot be readily determined without significant and comprehensive 'baiting' of soils to map their distribution. As a proxy, in this assessment examination of database records for all orchid species across the Hunter region revealed a clear scarcity of terrestrial orchids from the landscapes in and around the Project Area (irrespective of the extensive flora survey effort that has been expended in this area over many years), implying that mycorrhizal fungi themselves are scarce. With no fungi, there can be no orchids (see **Section 2.4.2**).
110. In an earlier report for the adjacent Bayswater and Liddell Power Station upgrade (Bell 2020c), I conservatively estimated approximately 166 ha of derived grassland as potentially supporting *Diuris tricolor* and no *Prasophyllum petilum*, but based on soil landscapes, floristics and proximate records stated that large populations would be unlikely there. Additional research undertaken since then into soil biology, mycorrhizal fungi and terrestrial orchid diversity in the upper Hunter now supports the contention that only small and highly localised populations appear present in these landscapes. This is reinforced by the known populations of *Diuris tricolor* and *Prasophyllum petilum* along Thomas Mitchell Drive, and in the *Diuris* Conservation Area near Ancillary Disturbance Area 1. These localised populations, all occurring in or close to woodland (rather than in derived grassland) and often in areas supporting several other orchid species, are suggestive of highly localised mycorrhizal fungi. Given the fact that no orchid species of any kind has ever been recorded within the Project Area (and only 7 species detected historically within a 15 km radius of it, most as single records), it seems highly unlikely that sufficient mycorrhizal fungi occur in the soils there to support *Diuris tricolor* or *Prasophyllum petilum*. It is quite plausible that a prolonged period of agricultural grazing, incorporating soil enrichment and compaction, over at least 150 years across most of the Project Area has altered soil chemistry and depleted the reserves of mycorrhizal fungi, to the point now that they (and consequently the orchids that rely on them) are largely absent from grassland areas.
111. Considering all of the preceding discussion, I consider the extent of potential habitat within the Project Area to be as shown in [Figure 23](#), and comprises:
 - 1.6 ha for *Diuris tricolor*
 - 1.6 ha for *Prasophyllum petilum*
 - 0 ha for *Pterostylis chaetophora*

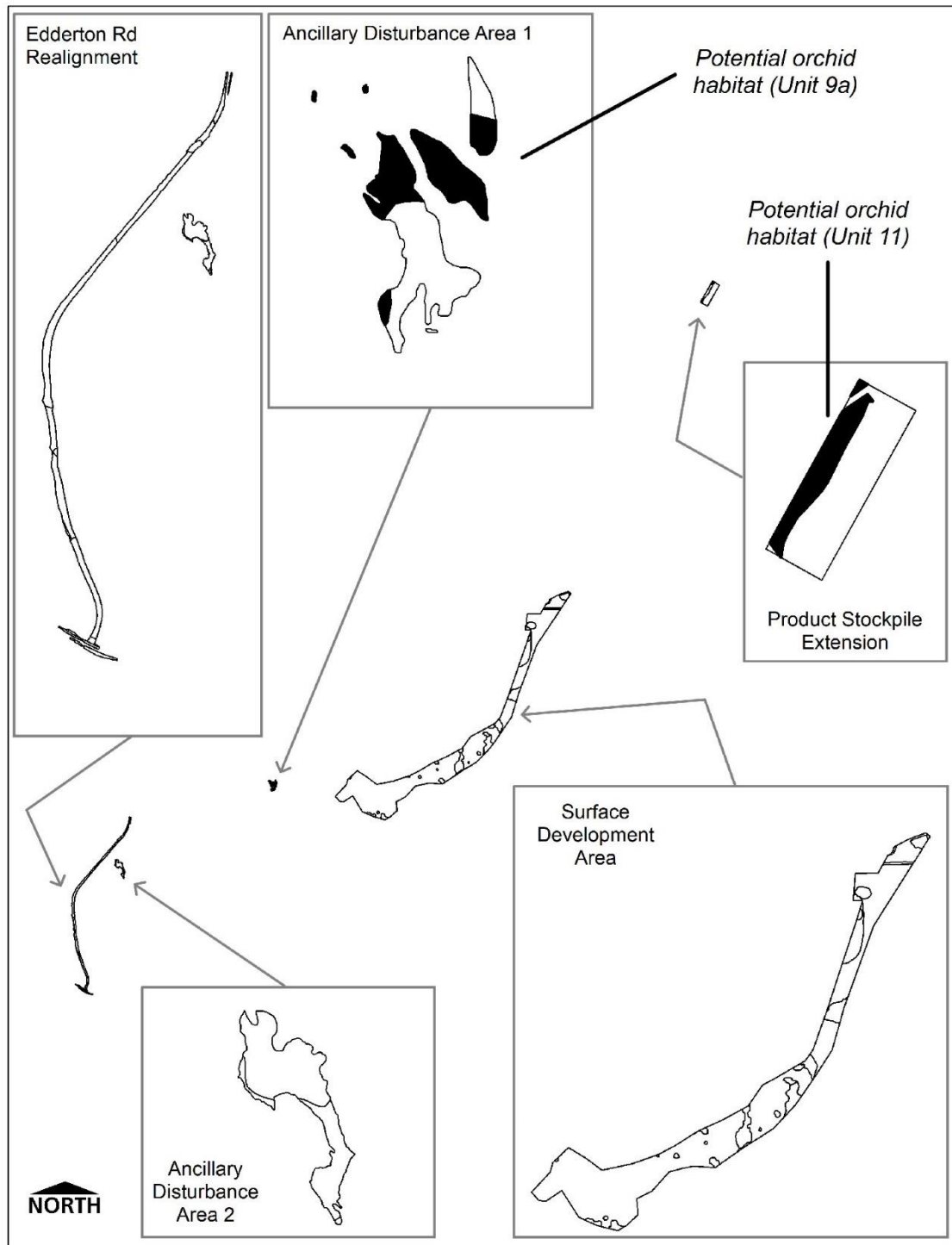


Figure 23 Habitat considered suitable (black shading) for *Diuris tricolor* and *Prasophyllum petilum* within the Project Area. Base mapping from Hunter Eco (2019).

6. Criterion (e) – Documents & Data Reviewed

112. I have been provided with the following reports and datasets from Resource Strategies and DPIE to assist in this review:

- GIS files showing Project boundaries and vegetation community mapping
- flora and vegetation mapping report for the proposed Maxwell Project (Hunter Eco 2019)
- an extract of the NSW BioNet database, under licence ASH20009, detailing as-held records for the three target orchids within the Hunter LLS area

All other published and unpublished reports, papers and maps that form part of this assessment have been cited in the normal way, with publication details contained in **Section 9** or advised within the text.

7. Criterion (f) – Expert Credentials

113. Under the requirements of the BAM (DPIE 2020), an expert report can be prepared by an endorsed person in the place of undertaking field survey. This report must include information on the credentials of the expert, including the following:

- a. *the expert's academic qualifications such as relevant degrees, post graduate qualifications;*

I possess three degrees in the science and ecology field: a Bachelor of Science (1988), Bachelor of Science (Honours) (1990) and a Doctor of Philosophy in vegetation science (2013).

- b. *their history of experience in the ecological research, habitat assessment and survey method, for the relevant species;*

In regard to the threatened orchid species that are the subject of this expert report (*Diuris tricolor*, *Prasophyllum petilum*, *Pterostylis chaetophora*), I have been surveying and monitoring these species for between three (*Pterostylis chaetophora*) and 11 (*Diuris tricolor*, *Prasophyllum petilum*) consecutive years at various locations in the Hunter Valley, including the annual monitoring of over 3000 translocated specimens since 2010. Targeted surveys have incorporated systematic open-ended transect surveys in appropriate habitat, using GPS devices to record tracks searched and orchids located. Separation distances between adjacent search transects vary in relation to quality of habitat and visibility. Search times have only occurred when other known reference populations have been in flower.

- c. *a resume detailing projects pertaining to the survey of the relevant species (including the locations and dates of the work), their employers' names and periods of employment (where relevant) over the previous 10 years;*

I am the principal and owner of Eastcoast Flora Survey, established in the Hunter Valley in October 1996 and spanning a continual period of dedicated flora consulting of nearly 25 years. Since 2014, I have also been a Conjoint Fellow at the University of Newcastle (School of Environmental and Life Sciences), where I am a member of two research groups: the Centre for Plant Science and the Conservation Biology Research Group. My full Curriculum Vitae are appended as [Appendix 5](#) to this report.

In relation to the relevant species that are the subject of this report (*Diuris tricolor*, *Prasophyllum petilum*, *Pterostylis chaetophora*), the following projects and publications pertain to these:

- Bell, S.A.J. (submitted 1) Floristic community diversity in derived native grasslands: a case study from the upper Hunter Valley of New South Wales. *Cunninghamia* (submitted).
- Bell, S.A.J. (submitted 2) Successful recruitment following translocation of a threatened terrestrial orchid (*Diuris tricolor*) into mining rehabilitation in the Hunter Valley of NSW. *Ecological Management and Restoration* (submitted)
- Bell, S.A.J. (2020) Translocation of threatened terrestrial orchids into non-mined and post-mined lands in the upper Hunter Valley of New South Wales, Australia. *Restoration Ecology* 28 1396-1407.

- Bell, S.A.J. (2020) *Survey and monitoring of the Vulnerable Pterostylis chaetophora (Rusty Greenhood) in the Lower Hunter Valley, NSW: 2019 Results*. Unpublished Report to NSW Office of Environment and Heritage. June 2020. Eastcoast Flora Survey.
- Bell, S.A.J. (2020) *Expert Report - Expected Presence of Threatened Terrestrial Orchids (Diuris tricolor & Prasophyllum petilum): Bayswater Water and Other Associated Operational Works Project*. Unpublished Report to Kleinfelder. May 2020. Eastcoast Flora Survey.
- Bell, S.A.J. (2020) *Monitoring of translocated threatened orchids (Diuris tricolor, Prasophyllum petilum) at Mangoola Coal: 2019 Results*. Unpublished Report to Mangoola Coal. February 2020.
- Bell, S.A.J. & Hillier, P. (2020) Targeted surveys of a poorly conserved threatened orchid (*Pterostylis chaetophora*) in Cumbey National Park (Hunter Valley, NSW) reveal substantial populations and elucidate occupied habitat. *Cunninghamia* 20: 199-207.
- Bell, S.A.J., Murray, M., & Sims, R. (2020) *Flora and Fauna Monitoring at Condran, Muswellbrook LGA: 2019 Results*. Unpublished Report to Bulga Surface Operations (Glencore). January 2020. Eastcoast Flora Survey & Forest Fauna Surveys Pty Ltd.
- Bell, S.A.J. (2019) *Expert Report: Expected presence of threatened terrestrial orchids (Diuris tricolor & Prasophyllum petilum), Mangoola Coal Continued Operations Project*. Unpublished Report to Umwelt (Australia) Pty Ltd. December 2019.
- Bell, S.A.J. (2019) *Survey and monitoring of the Vulnerable Pterostylis chaetophora (Rusty Greenhood) in the Lower Hunter Valley, NSW: 2018 Results*. Unpublished Report to NSW Office of Environment and Heritage. April 2019. Eastcoast Flora Survey.
- Bell, S. (2019) Translocation success is all about detection: experiences with two threatened orchids from the Hunter Valley of NSW. *Australasian Plant Conservation* 28: 27-31.
- Bell, S.A.J., Murray, M., & Sims, R. (2019) *Flora and Fauna Monitoring at Condran, Muswellbrook LGA: 2018 Results*. Unpublished Report to Bulga Surface Operations (Glencore). January 2019. Eastcoast Flora Survey & Forest Fauna Surveys Pty Ltd.
- Bell, S.A.J., Murray, M., & Sims, R. (2018) *Flora and Fauna Monitoring at Condran, Muswellbrook LGA: 2017 Results*. Unpublished Report to Bulga Surface Operations (Glencore). March 2018. Eastcoast Flora Survey & Forest Fauna Surveys Pty Ltd.
- Bell, S.A.J. (2018) *Monitoring of translocated threatened orchids (Diuris tricolor, Prasophyllum petilum) at Mangoola Coal: 2017 Results*. Unpublished Report to Mangoola Coal. February 2018.
- Bell, S.A.J. (2017) *Targeted survey for the threatened Diuris tricolor at Persoonia Park, North Rothbury, Hunter Valley*. Unpublished Report to Office of Environment & Heritage. November 2017. Eastcoast Flora Survey.
- Bell, S.A.J. (2017) *Baseline monitoring and survey of the vulnerable Pterostylis chaetophora (Orchidaceae) at North Rothbury, Hunter Valley, NSW*. Unpublished Report to NSW Office of Environment & Heritage. October 2017. Eastcoast Flora Survey.
- Bell, S.A.J. & Murray, M. (2017) *Flora and Fauna Monitoring at Condran, Muswellbrook LGA: 2016 Results*. Unpublished Report to Bulga Surface Operations (Glencore). January 2017. Eastcoast Flora Survey & Forest Fauna Surveys Pty Ltd.
- Bell, S.A.J. (2017) *Targeted Orchid Survey: Addendum to Pre-clearance Surveys, Borehole Explorations Areas, Rix's Creek North Mine*. Unpublished Report to Rix's Creek Pty Limited. October 2017. Eastcoast Flora Survey.

- Bell, S.A.J. & Murray, M. (2016) *Flora and Fauna Monitoring at Condran, Muswellbrook LGA: 2015 Results*. Unpublished Report to Bulga Surface Operations (Glencore). May 2016. Eastcoast Flora Survey & Forest Fauna Surveys Pty Ltd.
- Bell, S.A.J. & Murray, M. (2015) *Flora and Fauna Monitoring at Condran, Muswellbrook LGA: 2014 Results*. Unpublished Report to Bulga Surface Operations (Glencore). January 2015. Eastcoast Flora Survey & Forest Fauna Surveys Pty Ltd.
- Bell, S.A.J. & Driscoll, C (2014) *Assessment and mapping of vegetation in the Bylong Valley: Authorisations 287 & 342*. Unpublished Final Report to Hansen Bailey Pty Ltd. Eastcoast Flora Survey. December 2014.
- Bell, S.A.J. (2013) *Monitoring of translocated threatened orchids (Diuris tricolor, Prasophyllum sp. Wybong C.Phelps ORG 5269) at Mangoola Coal: 2013 Results*. Unpublished Report to Mangoola Coal. November 2013. Eastcoast Flora Survey.
- Bell, S.A.J. & Murray, M. (2013) *Flora and Fauna Monitoring at Condran, Muswellbrook LGA*. Unpublished Report to Bulga Surface Operations (Glencore). November 2013. Eastcoast Flora Survey & Forest Fauna Surveys Pty Ltd.
- Bell, S.A.J. (2013) *Monitoring of translocated threatened orchids (Diuris tricolor, Prasophyllum sp. Wybong C.Phelps ORG 5269) at Mangoola Coal: Status Report 2012*. Unpublished Report to Mangoola Coal. Eastcoast Flora Survey, January 2013.
- Bell, S.A.J. (2012) *Targeted terrestrial orchid surveys at Mangoola Coal, Upper Hunter Valley: Spring 2011*. Unpublished Report to Mangoola Coal. Eastcoast Flora Survey, January 2012.
- Bell, S.A.J. & Copeland, L. (2010) *Targeted terrestrial orchid surveys at Mangoola Coal, Upper Hunter Valley: Spring 2010*. Unpublished Report to Mangoola Coal, October 2010. Eastcoast Flora Survey.
- Bell, S.A.J. & Copeland, L. (2010) *A strategy for the translocation of threatened terrestrial orchids at Mangoola Coal, Upper Hunter Valley*. Unpublished Report to Mangoola Coal, September 2010. Eastcoast Flora Survey.
- Bell, S.A.J. & Copeland, L. (2009) *Targeted terrestrial orchid survey, Mangoola, Upper Hunter Valley*. Spring 2009. Unpublished Report to Mangoola Coal. Eastcoast Flora Survey, November 2009.
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d. *peer-reviewed publications on the species or other evidence that the person is a well-known authority on the species to which the survey relates;*

I have published two papers specifically addressing *Diuris tricolor* and *Prasophyllum petilum*: Bell (2019a, assessing translocation success in these species) and Bell (2020d, comparing translocation efforts in mined and non-mined lands). A third published paper details population size and occupied habitat of *Pterostylis chaetophora* in the lower Hunter (Bell & Hillier 2020), while a fourth presents the results of new recruitment in *Diuris tricolor* in mine rehabilitation (Bell submitted 2).

I have also published on several other threatened orchid species (e.g. *Cryptostylis hunteriana*: Bell 2001a, de Lacey *et al.* 2012a, b, de Lacey *et al.* 2013; *Thelymitra adorata*: Bell *et al.* 2005; *Diuris praecox*: Yare *et al.* 2020) and non-orchid threatened taxa (e.g. *Acacia dangarensis*: Bell & Elliott 2013; *Acacia pendula*: Bell 2018; Bell *et al.* 2007, Bell & Driscoll 2014, 2016; *Acacia wollarensis*: Bell & Driscoll 2017, Bell & Kodela 2018; *Angophora inopina*: Bell 2004b; *Banksia conferta*: Bell 2017b; *Commersonia rosea*: Bell & Copeland 2004, Bell &

Holzinger 2015; *Dracophyllum macranthum*: Bell & Sims 2018; *Eucalyptus expressa*: Bell & Nicolle 2012; *Eucalyptus calidissima*; Bell & Klaphake 2020; *Eucalyptus dealbata* subsp. *aperticola*: Bell & Nicolle 2020; *Hibbertia procumbens*: Bell 2002, Bell & Driscoll 2005b; *Leionema lamprophyllum* subsp. *fractum*: Bell & Walsh 2015; *Monotaxis macrophylla*: Bell & Holzinger 2015; *Senecio linearifolius* var. *dangarensis* and *S. spathulatus* var. *attenuatus*: Mickaill *et al.* 2020), together with those examining a range of significant and threatened species in sandstone habitats of the Hunter Valley (23 taxa; Bell 2001b) and those present in Wollemi National Park (110 taxa; Bell 2008, 2019c). I am also the lead author of a recently published book with CSIRO Publications (Bell *et al.* 2019), detailing 54 of the endemic plant species of the Hunter Region, many of which are threatened species. One other recent paper, of which I am co-author, examined the conservation status of 822 eucalypt taxa from across Australia (Fensham *et al.* 2020).

I have been surveying and monitoring two of the target species for over 10 years in the Hunter Valley (and the third for three years) and am acutely aware of their habitat requirements and variability in flowering from year to year. Additionally, Dr Lachlan Copeland (Eco Logical Australia & orchid taxonomist) has endorsed me as a recognised authority on the field ecology of *Diuris tricolor* and *Prasophyllum petilum* (see letter attached in [Appendix 6](#)).

8. Conclusion

114. Maxwell Ventures (Management) Pty Ltd propose to establish an underground coal mine within EL5460, which will require limited ground disturbance across the full Project Area. Nevertheless, proposed disturbances associated with planned expansion of the Product Stockpile Extension area, establishment of Surface Development Areas to accommodate underground entrance surface facilities and a transport/services corridor, proposed Edderton Rd Realignment to avoid potential road damage from subsidence, and Ancillary Disturbance Areas (Ponding) in response to modelled ground subsidence, may impact on terrestrial orchids, if present.
115. No known records of *Diuris tricolor*, *Prasophyllum petilum* or *Pterostylis chaetophora* exist for the Project Area, and after assessment I considered that approximately 1.6 ha of the proposed 320 ha (0.5%) of ground disturbance area may provide habitat for two of these species (*Diuris tricolor*, *Prasophyllum petilum* [syn. *Prasophyllum* sp. Wybong]). I do not consider that the third target species, *Pterostylis chaetophora*, is likely to occur anywhere within the Project Area.
116. *Diuris tricolor* and *Prasophyllum petilum* occupy extensive geographical ranges outside of the Hunter region, however *Pterostylis chaetophora* is endemic here. Records for *Diuris tricolor* exist close to the Project Area, near Ancillary Disturbance Area 1 and along Thomas Mitchell Drive, and *Prasophyllum petilum* has historically been recorded at the eastern end of Thomas Mitchell Drive but is presumed extinct (B. Holzinger pers. comm.). There are no validated populations of *Pterostylis chaetophora* west of North Rothbury (52 km to the south-east), although two records at Mangoola Coal (21 km north-west) and Wingen Maid Nature Reserve (55 km north) remain unvalidated.
117. Following a single day site inspection of the Project Area in July 2020, I noted observable differences in the floristic composition of habitats to other areas where I know the three target orchids from, and the predominance of former Box (*Eucalyptus 'albemol'* and *Eucalyptus moluccana*) landscapes within these largely cleared lands conflicts with my experience of orchid habitat elsewhere. Differences were supported by a review of ecological information prepared by Hunter Eco (2019) for the Project Area, the mapping of which I found to be accurate and acceptable. Numerical analysis of defined vegetation communities revealed clear differences to habitat from elsewhere in the region known to support *Pterostylis chaetophora*, but one community similar to habitats typical of *Diuris tricolor* and *Prasophyllum petilum*. Additionally, the close proximity of known populations of *Diuris tricolor* (c. 400 m) and *Prasophyllum petilum* (1300 m) to the northern section of the Project Area suggests that potential habitat for these may also occur in a second community. I therefore consider that the vegetation units defined by Hunter Eco (2019) as Ironbark - Grey Box Grassy Woodland DNG (Unit 9a) and Grey Box – Spotted Gum – Narrow-leaved Ironbark Woodland (Unit 11) provide the only potential habitat for *Diuris tricolor* and *Prasophyllum petilum*, which together comprise 1.6 ha (0.5%) of the Project Area. Dr Colin Driscoll (Hunter Eco) was commissioned by Malabar Resources to conduct a targeted survey of this area during suitable survey conditions in 2020, and none of the target species were found. Consequently, *Diuris tricolor* and *Prasophyllum* (syn. *Prasophyllum* sp. Wybong) are unlikely to be present within the Project Area.
118. In support, a detailed assessment of environmental attributes across all Hunter populations of *Diuris tricolor* (n=983), *Prasophyllum petilum* (n=485) and *Pterostylis chaetophora* (n=128) found differences in geological units, soil landscapes, and (for *Pterostylis chaetophora*) annual

rainfall when compared to the Project Area. Of these, soil landscapes were seen as particularly important given they best encapsulate the likely distribution of mycorrhizal fungi across the region, without which no orchids would germinate and prosper. As a surrogate for fungi distribution, an assessment of all terrestrial orchid observation records for the upper Hunter Valley demonstrated a scarcity of orchids in and around the Project Area, suggesting that mycorrhizal fungi were therefore also scarce or localised. This lends further credence to my conclusion that *Diuris tricolor* or *Prasophyllum petilum* (syn. *Prasophyllum* sp. Wybong) are unlikely to be present within the Project Area.

119. The combination of geology, soil landscape, floristic, rainfall, and general orchid distribution (as a surrogate for mycorrhizal fungi) suggest that the Project Area is unlikely to support extensive populations of *Diuris tricolor* or *Prasophyllum petilum* (syn. *Prasophyllum* sp. Wybong), and none of *Pterostylis chaetophora*. The areas where I consider the former two species may occur occupy <1% of the total disturbance footprint, but targeted searches in these areas did not record these species.

9. References

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Appendix 1 – Dr Stephen Bell DPIE Accreditation



Office of
Environment
& Heritage

DOC18/211176-1

[REDACTED]
[REDACTED]
[REDACTED]

Dear [REDACTED]

Recognition of Dr Stephen Bell as an expert for *Diuris tricolor* and *Prasophyllum petilum* (Syn. *Prasophyllum* sp. 'Wybong')

Thank you for your e-mail of the 9 April 2018 in which you request that Dr Stephen Bell be recognised as an expert for *Diuris tricolor* (Pine Donkey Orchid) and *Prasophyllum petilum* (Syn. *Prasophyllum* sp. 'Wybong') (Tarengo Leek Orchid) for the [REDACTED].

The Office of Environment and Heritage (OEH) has reviewed the information provided by you in support of this request. OEH is satisfied that Dr Stephen Bell satisfies the definition of species expert for *Diuris tricolor* and *Prasophyllum petilum* (Syn. *Prasophyllum* sp. 'Wybong'), in accordance with Section 6.5.2.3. of the Biodiversity Assessment Method.

Please note that this formal recognition of Dr Stephen Bell as an expert only applies to *Diuris tricolor* and *Prasophyllum petilum* (Syn. *Prasophyllum* sp. 'Wybong').

If you require any further information regarding this matter, please contact Steven Cox, Senior Team Leader, Planning Hunter Central Coast, on 4927 3140.

Yours sincerely

Sharon Molloy 14/5/2018

SHARON MOLLOY
Director Hunter Central Coast Branch
Regional Operations Division

Contact officer: STEVEN COX
02 4927 3140

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Planning,
Industry &
Environment

Our ref: DOC20/443557-1

Your ref: n/a

Dr Stephen Bell

Vegetation Ecologist
East Coast Flora Survey
sajbell@bigpond.com

Dear Dr Bell

Approval of Dr Stephen Bell as an expert for *Pterostylis chaetophora*

I refer to your correspondence dated 9 June 2020 in which you requested that Dr Stephen Bell be considered as an expert for *Pterostylis chaetophora*.

The Biodiversity and Conservation Division (BCD) of the Department of Planning, Industry and Environment has reviewed the information provided in support of this request. BCD is satisfied that Dr Stephen Bell satisfies the definition of a species expert for *Pterostylis chaetophora* in accordance with Section 6.5.2.3 of the Biodiversity Assessment Method.

Please note that this formal recognition of Dr Stephen Bell as an expert only applies to the Hunter Central Coast Region of NSW which comprises the following local government areas; Central Coast, Lake Macquarie, Newcastle, Port Stephens, Mid Coast, Dungog, Maitland, Cessnock, Singleton, Muswellbrook and Upper Hunter.

If you have any further questions in relation to this matter, please contact Steve Lewer, Acting Senior Team Leader Planning, on 4927 3158 or via email at rog.hcc@environment.nsw.gov.au

Yours sincerely

A handwritten signature in black ink, appearing to read 'Joe Thompson'.

JOE THOMPSON
Director Hunter Central Coast Branch
Biodiversity and Conservation Division

Date: 25 June 2020

Appendix 2 – Floristic Composition of Grassland Habitat (Bell 2012a)

The derivation of diagnostic species for each defined floristic group has been defined using the SIMPER routine in *PRIMER* on available full floristic plot data. SIMPER analysis provides the relative contributions of each species to the Bray-Curtis similarity within each of the defined vegetation communities. Only those species contributing to a total cumulative contribution of 99% of the average similarity (i.e. the value shown at the top of each floristic table) for each community are listed. These species can be described of as *typical* of that community, and have a consistently large presence within the data as reflected in the ratio of their contribution to the standard deviation (the Sim/SD field in each table) across the within-group similarities (the average similarity). Key canopy species are highlighted.

In the tables:

- **Average similarity** is the within-group similarity for all pairs of sample plots comprising the community. Higher average similarity indicates a better-defined community.
- **Av.Abund** is the average cover abundance of that species within sample plots comprising the community
- **Av.Sim** is the average similarity (contribution) made by each species to the within-group similarity (the overall average similarity).
- **Sim/SD** is the ratio of average similarity to standard deviation for each species across all pairs of samples. A high ratio represents a good discriminating species. At least three samples are required for this ratio to be calculated (not available for four communities).
- **Contrib%** is the percentage contribution of each species to the overall average similarity for the community.
- **Cum.%** is the cumulative percentage contribution of each species, up to a maximum of 99%.

Unit 1a: *Dichanthium/ Sporobolus/ Chloris* Grassland - Key Diagnostic Species [based on 63 plots]:

Group 1a: <i>Dichanthium/ Sporobolus/ Chloris</i> Average similarity: 45.72					
Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
<i>Dichanthium sericeum</i> subsp. <i>sericeum</i>	2.92	2.68	1.09	5.87	12.92
<i>Senecio madagascariensis</i> *	1.89	2.58	3.58	5.64	18.56
<i>Sporobolus creber</i>	2.02	2.22	1.79	4.87	23.42
<i>Anagallis arvensis</i> *	1.75	2.13	1.86	4.66	28.09
<i>Chrysocephalum semipapposum</i>	1.71	1.92	1.48	4.20	32.29
<i>Centaurium tenuiflorum</i> *	1.67	1.88	1.40	4.10	36.39
<i>Bothriochloa decipiens</i> var. <i>decipiens</i>	2.02	1.82	1.06	3.98	40.37
<i>Glycine tabacina</i>	1.56	1.78	1.47	3.90	44.27
<i>Chloris truncata</i>	1.79	1.41	0.93	3.09	47.36
<i>Gamochaeta americana</i> *	1.38	1.38	1.04	3.02	50.39
<i>Cyclosporum leptophyllum</i> *	1.35	1.22	1.19	2.67	53.05
<i>Fimbristylis dichotoma</i>	1.30	1.21	0.88	2.66	55.71

<i>Aristida ramosa</i> var. <i>ramosa</i>	1.52	1.21	0.89	2.64	58.35
<i>Vittadinia muelleri</i>	1.41	1.20	0.84	2.63	60.99
<i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>	1.27	1.12	0.86	2.44	63.43
<i>Dichelachne micrantha</i>	1.59	1.09	0.76	2.38	65.80
<i>Vulpia muralis</i> *	1.38	1.05	0.77	2.30	68.10
<i>Hypochaeris radicata</i> *	1.21	0.90	0.73	1.97	70.08
<i>Trifolium arvense</i> *	0.97	0.83	0.93	1.81	71.88
<i>Petrorhagia dubia</i> *	1.08	0.81	0.73	1.78	73.66
<i>Asperula conferta</i>	1.06	0.78	0.68	1.70	75.36
<i>Plantago debilis</i>	1.03	0.77	0.67	1.69	77.05
<i>Hypochaeris microcephala</i> var. <i>albiflora</i> *	1.00	0.74	0.62	1.61	78.66
<i>Dichondra repens</i>	0.94	0.61	0.64	1.33	80.00
<i>Oxalis perenans</i>	0.94	0.61	0.61	1.33	81.33
<i>Carthamus lanatus</i> *	0.81	0.39	0.50	0.86	82.19
<i>Briza minor</i> *	0.76	0.38	0.46	0.84	83.02
<i>Eulalia aurea</i>	0.92	0.37	0.36	0.81	83.83
<i>Wahlenbergia communis</i>	0.62	0.35	0.54	0.77	84.61
<i>Convolvulus erubescens</i>	0.62	0.35	0.49	0.76	85.36
<i>Cymbopogon refractus</i>	0.63	0.31	0.46	0.68	86.04
<i>Daucus glochidiatus</i>	0.65	0.31	0.40	0.67	86.71
<i>Sida corrugata</i>	0.65	0.31	0.39	0.67	87.38
<i>Austrodanthonia tenuior</i>	0.65	0.30	0.36	0.65	88.03
<i>Polycarpon tetraphyllum</i> *	0.62	0.28	0.39	0.62	88.65
<i>Triptilodiscus pygmaeus</i>	0.62	0.28	0.33	0.62	89.27
<i>Calocephalus citreus</i>	0.78	0.27	0.33	0.58	89.85
<i>Brunoniella australis</i>	0.57	0.23	0.31	0.51	90.36

Unit 2: *Aristida*/ *Cymbopogon* Grassland - Key Diagnostic Species [based on 44 plots]:

Group 2: *Aristida*/ *Cymbopogon* Average similarity: 39.82

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
<i>Aristida ramosa</i> var. <i>ramosa</i>	3.43	4.60	2.17	11.55	11.55
<i>Linum trigynum</i> *	2.18	3.01	2.04	7.56	19.11
<i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>	2.07	2.84	2.01	7.14	26.25
<i>Anagallis arvensis</i> *	1.70	2.42	1.73	6.09	32.34
<i>Senecio madagascariensis</i> *	1.66	2.32	1.65	5.84	38.18
<i>Aristida vagans</i>	1.95	1.83	0.90	4.60	42.78
<i>Hypochaeris radicata</i> *	1.75	1.77	1.00	4.44	47.22
<i>Cymbopogon refractus</i>	1.48	1.73	1.19	4.35	51.58
<i>Glycine tabacina</i>	1.14	1.32	1.25	3.32	54.90
<i>Bothriochloa decipiens</i> var. <i>decipiens</i>	1.43	1.23	0.69	3.08	57.98
<i>Vulpia muralis</i> *	1.27	1.20	0.97	3.02	61.00
<i>Sporobulus creber</i>	1.14	0.99	0.68	2.48	63.48
<i>Briza minor</i> *	1.07	0.96	0.79	2.41	65.89
<i>Chrysocephalum apiculatum</i>	1.02	0.81	0.54	2.03	67.92
<i>Triptilodiscus pygmaeus</i>	0.84	0.58	0.50	1.47	69.39

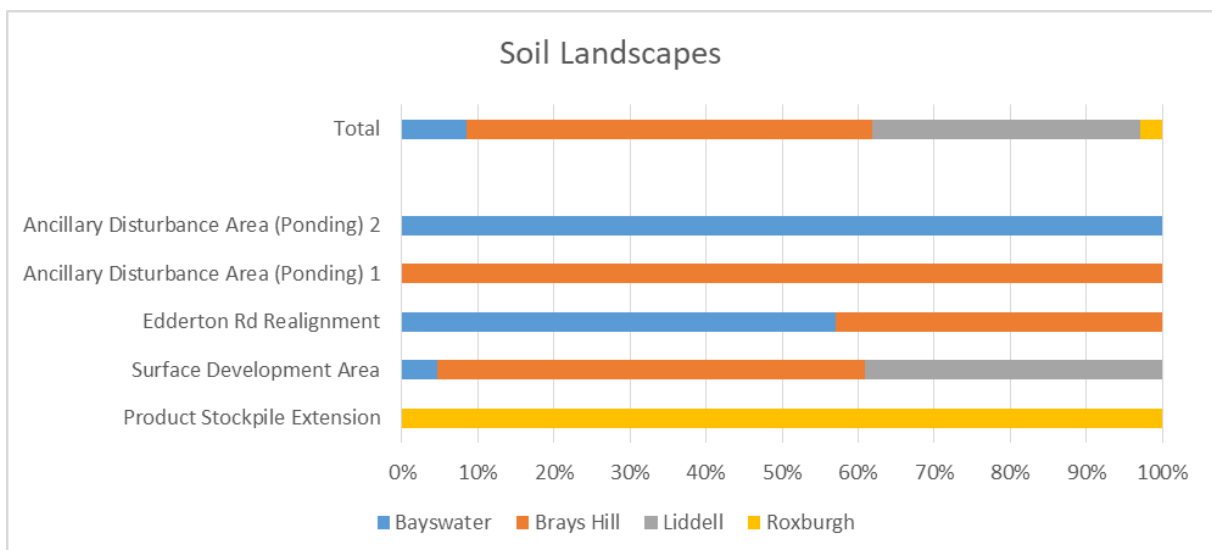
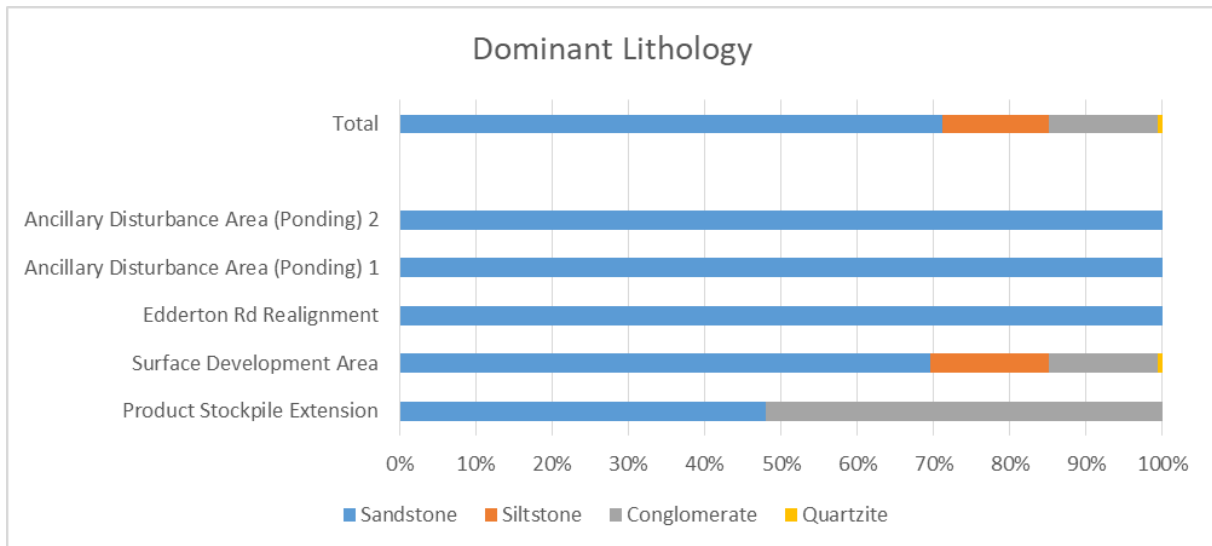
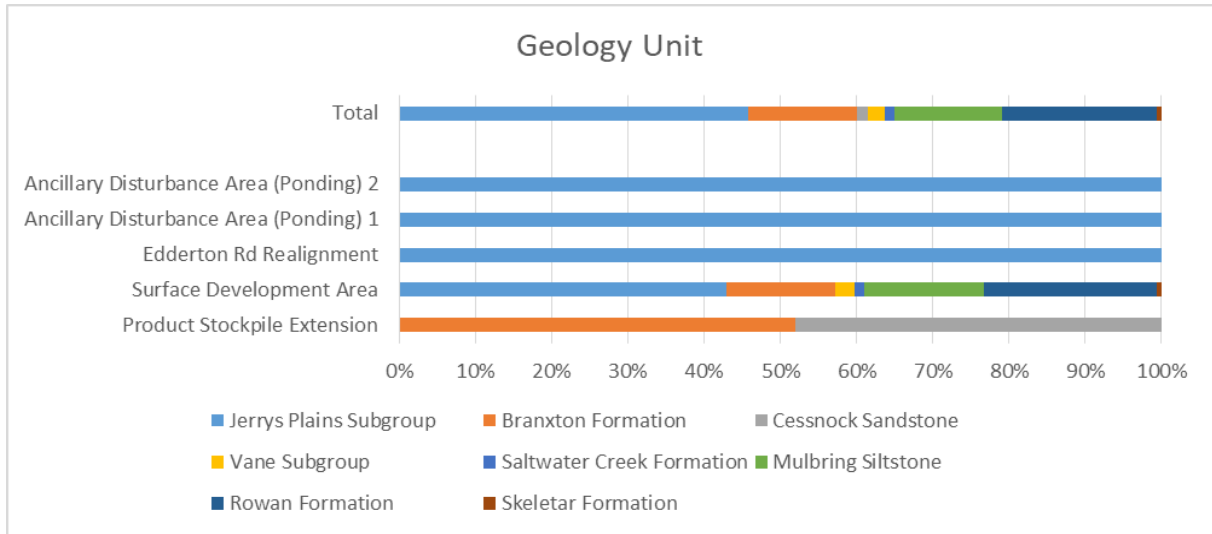
<i>Vittadinia muelleri</i>	0.93	0.58	0.44	1.45	70.83
<i>Dichondra repens</i>	0.77	0.54	0.53	1.35	72.18
<i>Gamochaeta americana</i> *	0.80	0.53	0.52	1.34	73.52
<i>Dichelachne micrantha</i>	0.82	0.52	0.49	1.31	74.83
<i>Taraxacum officinale</i> *	0.80	0.50	0.43	1.26	76.08
<i>Lomandra confertifolia</i> subsp. <i>pallida</i>	0.75	0.48	0.53	1.21	77.30
<i>Tolpis barbata</i> *	0.77	0.46	0.44	1.16	78.46
<i>Lachnagrostis filiformis</i>	0.75	0.44	0.39	1.10	79.56
<i>Centaurium tenuiflorum</i> *	0.70	0.41	0.41	1.03	80.59
<i>Oxalis perenans</i>	0.68	0.39	0.41	0.97	81.56
<i>Richardia stellaris</i> *	0.66	0.38	0.41	0.94	82.51
<i>Chrysocephalum semipapposum</i>	0.77	0.37	0.38	0.94	83.44
<i>Fimbristylis dichotoma</i>	0.68	0.37	0.37	0.93	84.38
<i>Cyclospermum leptophyllum</i> *	0.66	0.36	0.44	0.90	85.27
<i>Petrorhagia dubia</i> *	0.68	0.35	0.37	0.88	86.15
<i>Asperula conferta</i>	0.59	0.31	0.35	0.77	86.93
<i>Sida corrugata</i>	0.57	0.30	0.39	0.75	87.67
<i>Linaria pelisseriana</i> *	0.57	0.25	0.33	0.64	88.31
<i>Glycine clandestina</i>	0.41	0.23	0.41	0.58	88.89
<i>Murdannia graminea</i>	0.50	0.21	0.31	0.53	89.42
<i>Centaurium erythraea</i> *	0.50	0.20	0.25	0.50	89.92

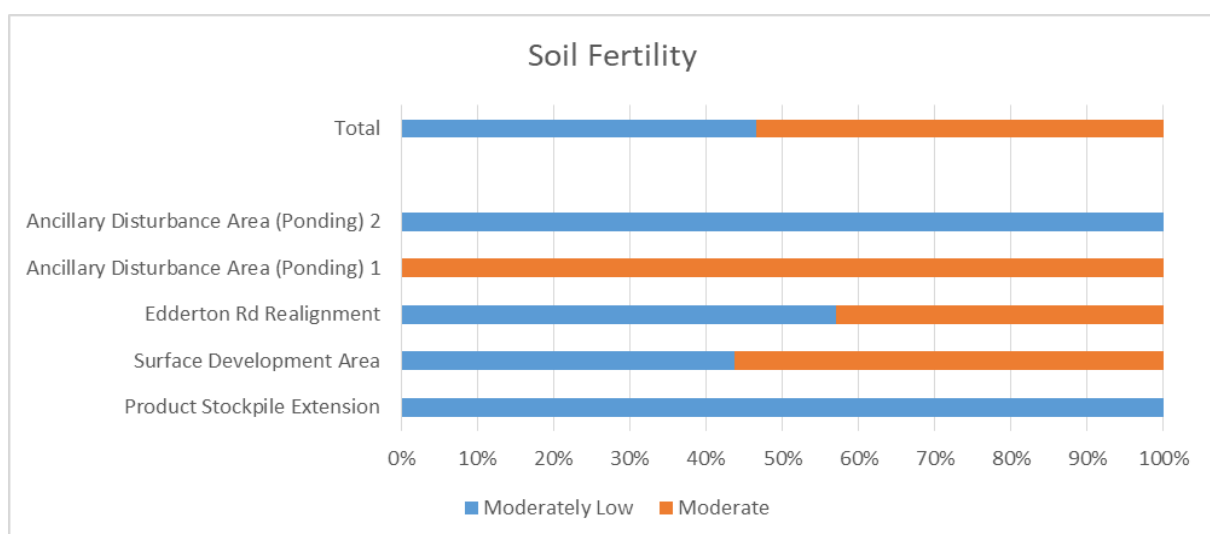
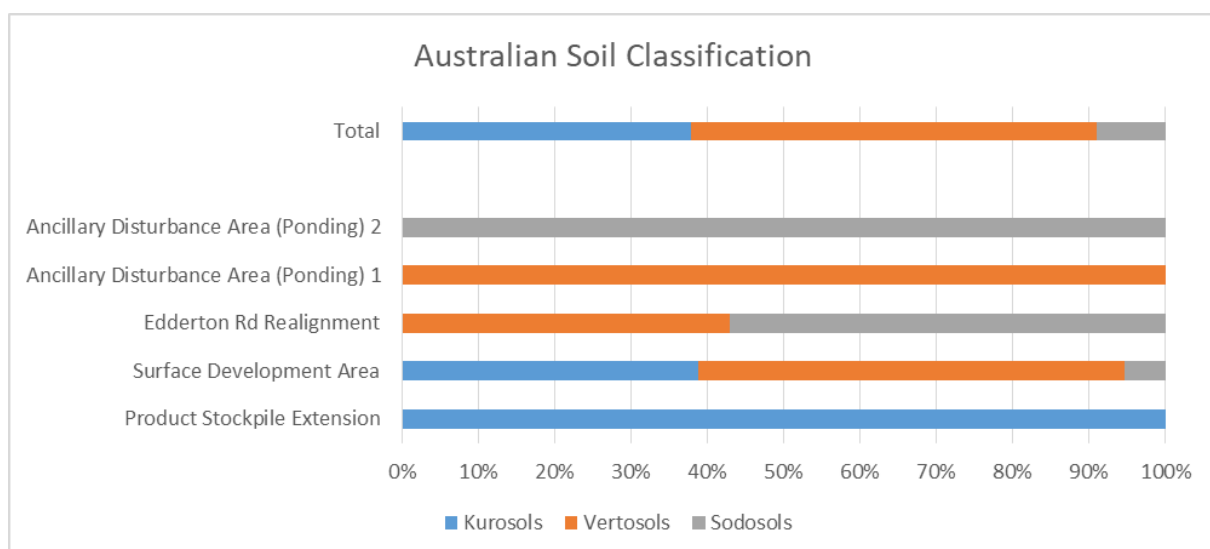
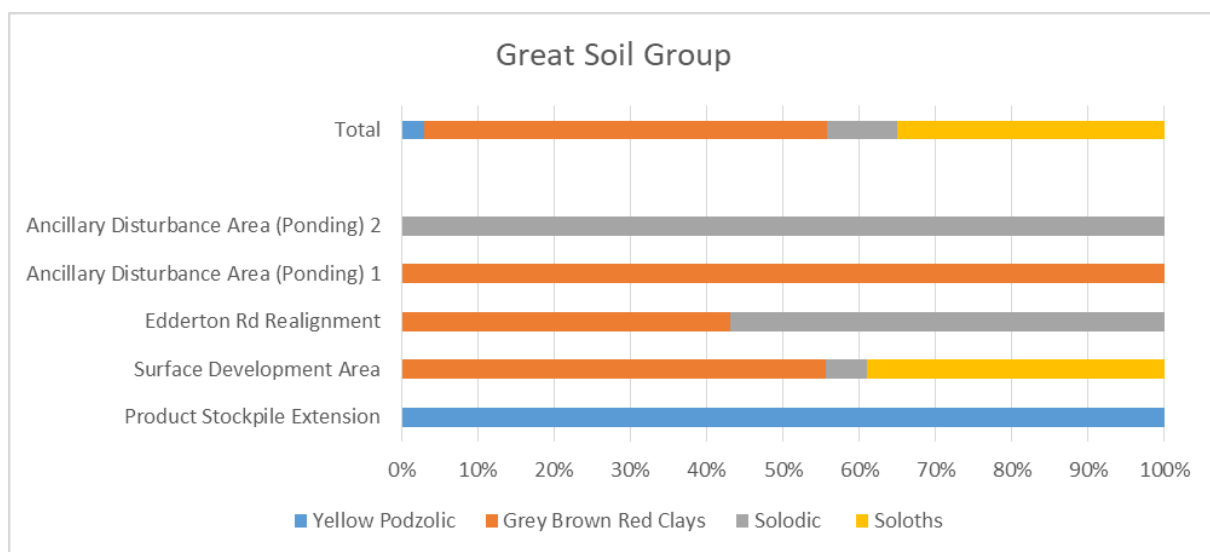
Unit 4: Bothriochloa biloba/ Carthamus/ Danthonia Grassland - Key Diagnostic Species [based on 7 plots]:

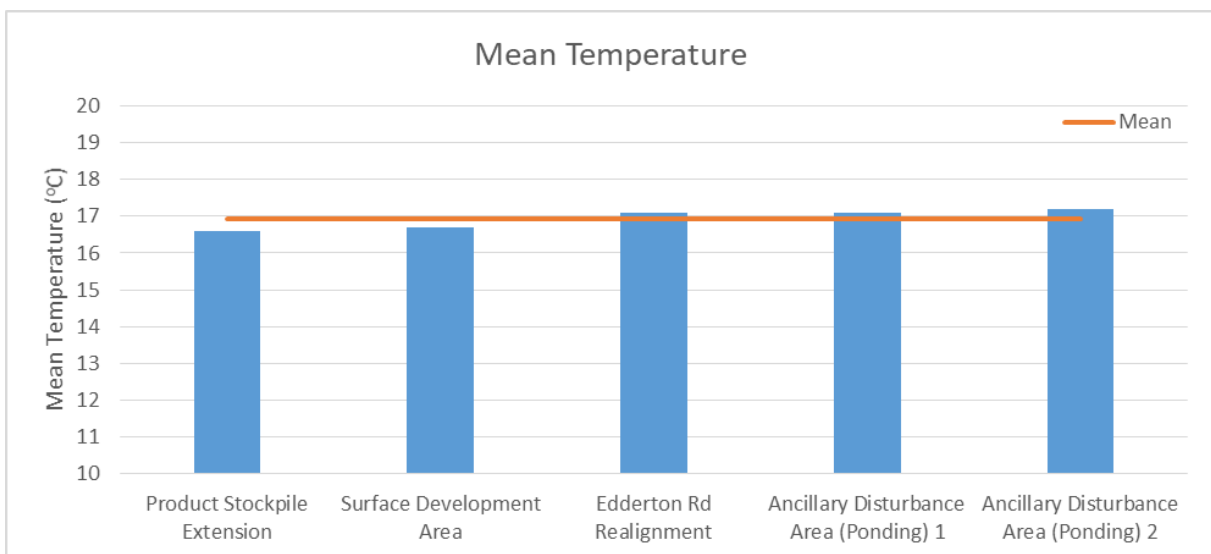
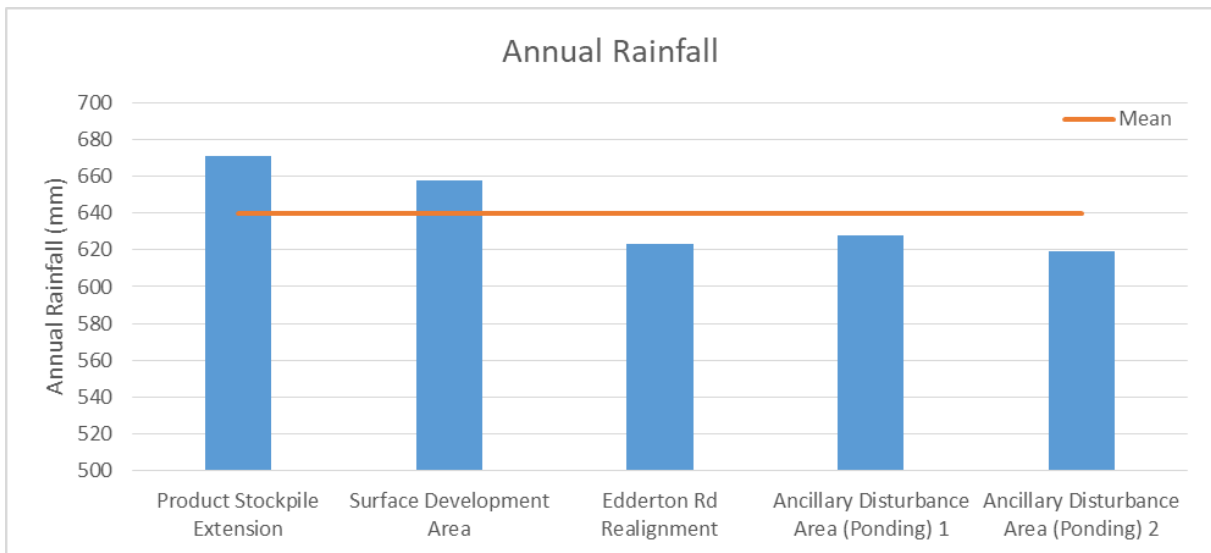
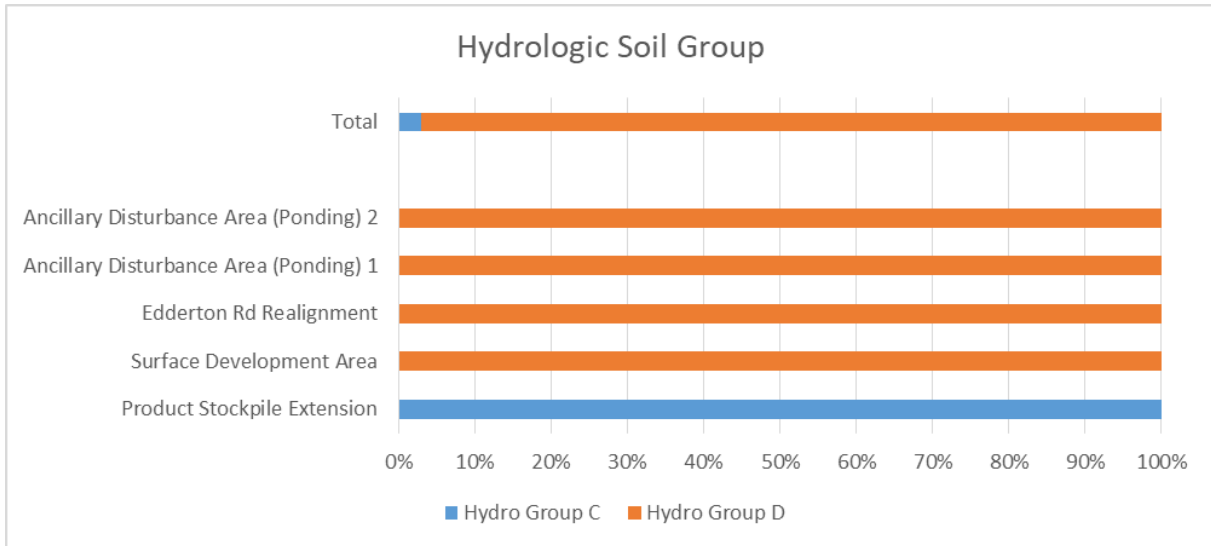
Group 4: *Bothriochloa biloba*/ *Carthamus*/
Danthonia
Average similarity: 50.03

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
<i>Bothriochloa biloba</i>	5.14	13.03	5.61	26.04	26.04
<i>Carthamus lanatus</i> *	2.57	6.41	2.45	12.82	38.86
<i>Chloris truncata</i>	1.86	4.86	4.58	9.72	48.57
<i>Austrodanthonia tenuior</i>	2.14	4.54	1.32	9.08	57.65
<i>Einadia nutans</i> subsp. <i>linifolia</i>	1.71	4.16	3.83	8.31	65.97
<i>Lolium perenne</i> *	1.57	3.31	1.35	6.61	72.58
<i>Austrostipa aristiglumis</i>	1.57	2.20	0.74	4.40	76.97
<i>Vittadinia cuneata</i> var. <i>cuneata</i>	0.86	1.55	0.90	3.11	80.08
<i>Oxalis perenans</i>	1.14	1.34	0.62	2.68	82.76
<i>Senecio madagascariensis</i> *	0.86	1.22	0.92	2.43	85.19
<i>Sporobulus creber</i>	1.00	1.07	0.59	2.13	87.32
<i>Medicago truncatula</i> *	0.86	0.95	0.60	1.90	89.22
<i>Carex inversa</i>	0.86	0.92	0.58	1.84	91.05

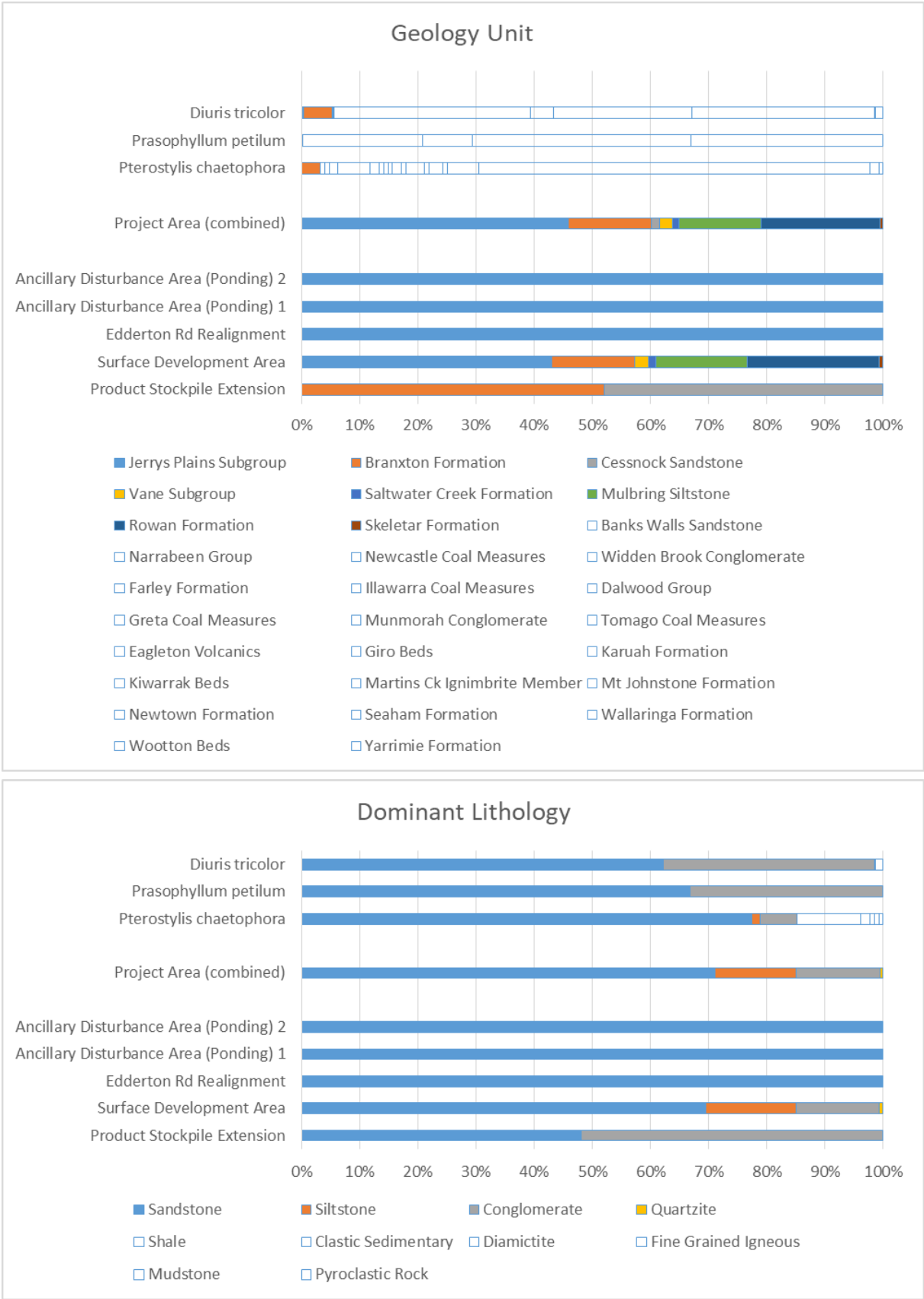
Appendix 3 – Biophysical Attributes of the Project Area

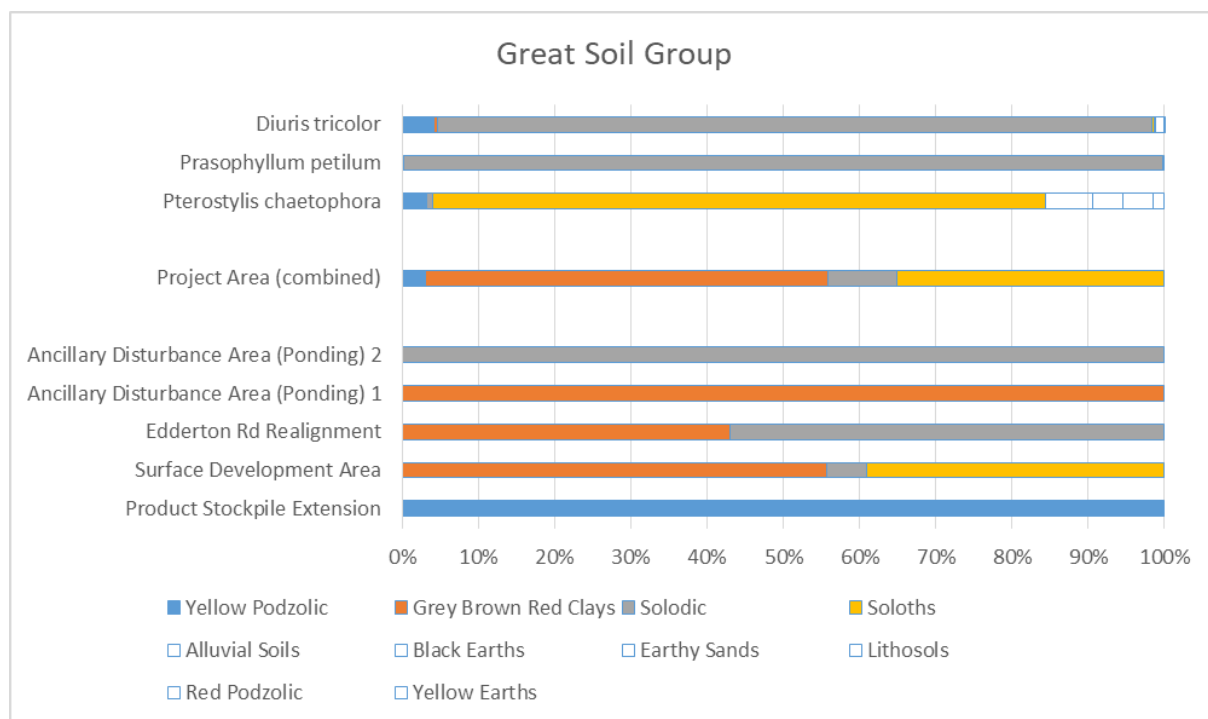
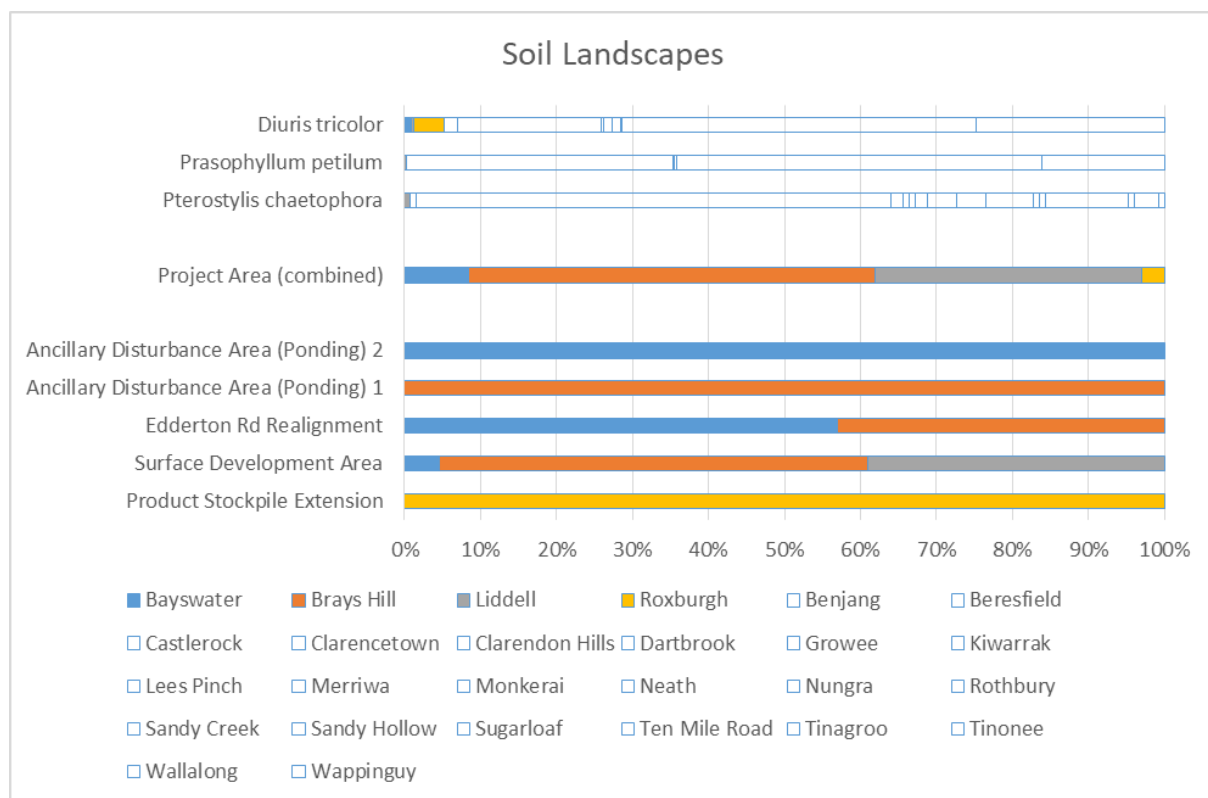


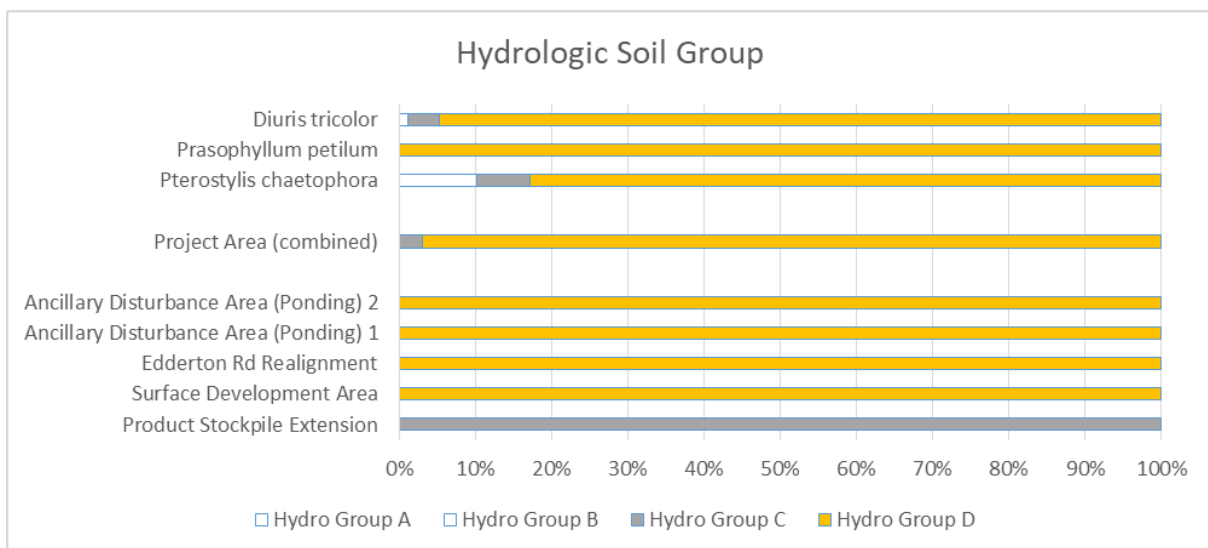
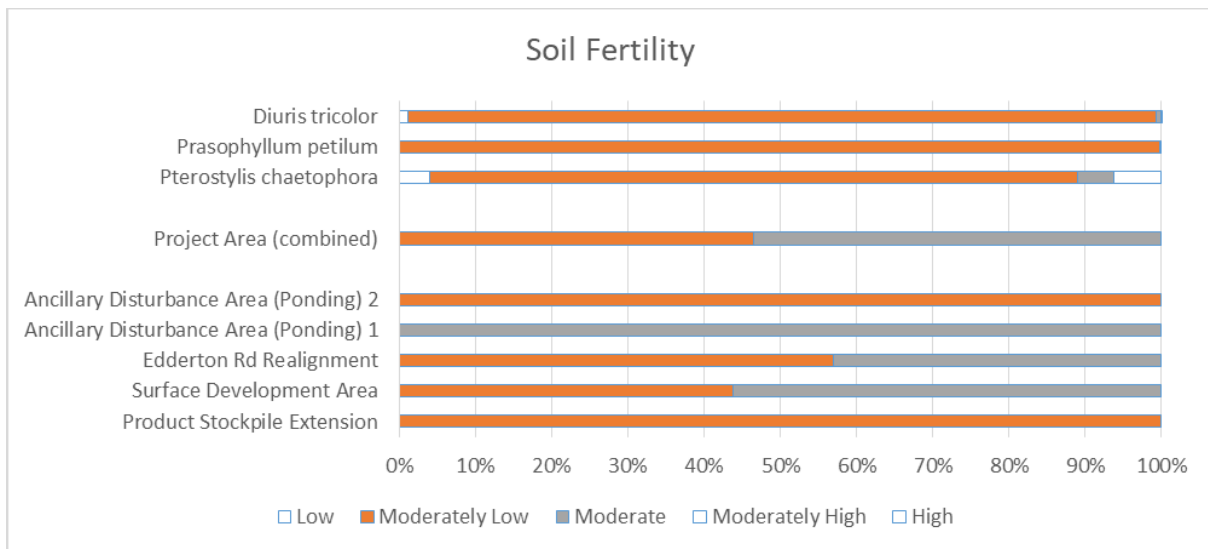
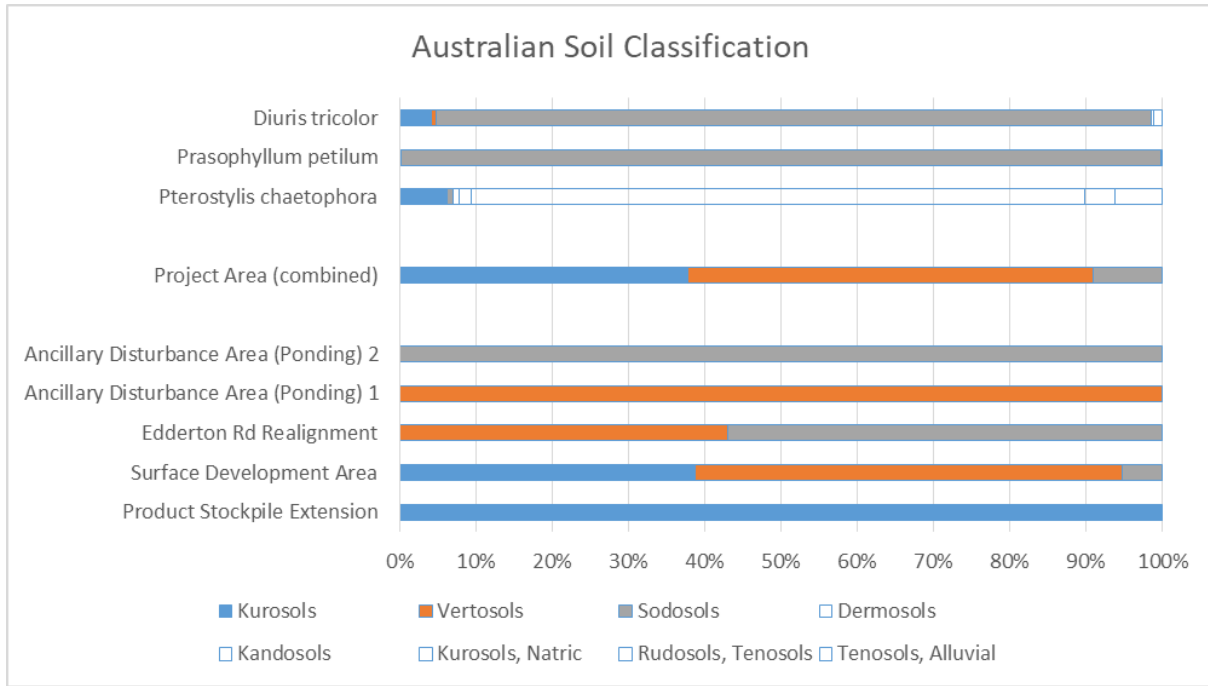


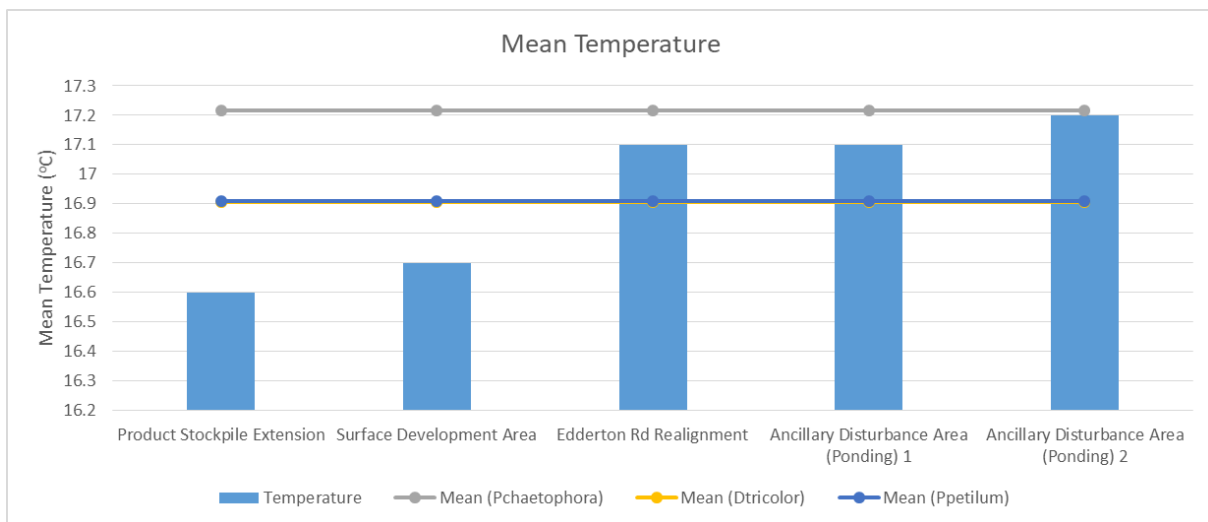
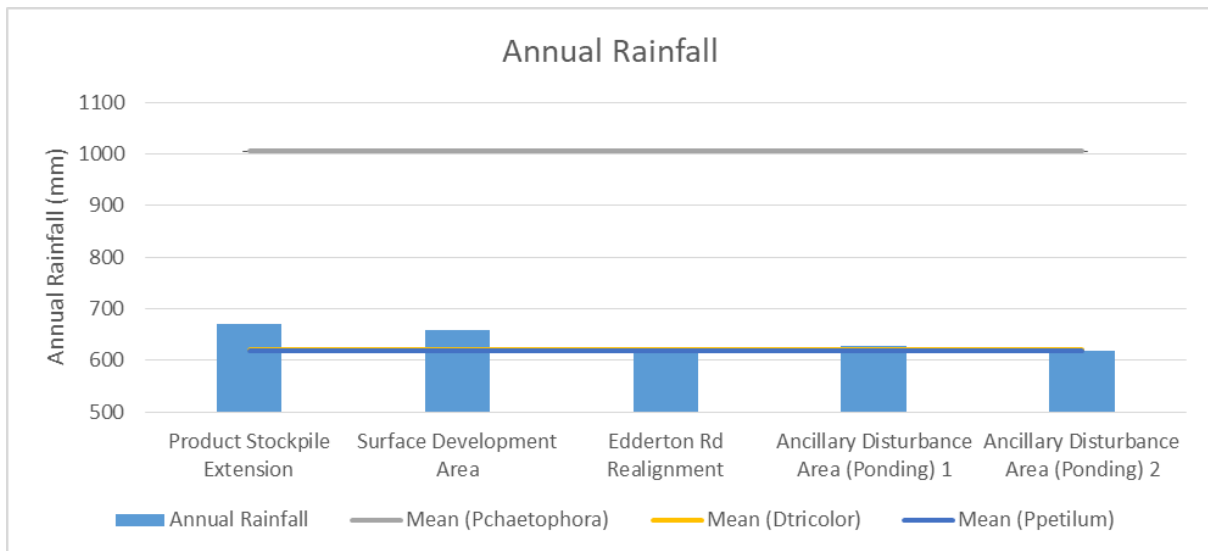


Appendix 4 – Biophysical Attributes of Orchid Locations









Appendix 5 – Resume: Dr Stephen Bell



Principal

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https://www.researchgate.net/profile/Stephen_Bell10

PRÉCIS

Stephen has been involved in native vegetation survey, classification and mapping in the Greater Sydney and Hunter Regions since 1990. During this time, he has undertaken comprehensive surveys for the National Parks and Wildlife Service in over 30 conservation reserves, and has been contracted to the NSW Office of Environment & Heritage (OEH) as Senior Botanist and Team Leader for several large scale regional projects within the Sydney Basin bioregion. Under contract to local Councils, Stephen has co-ordinated and completed LGA-wide vegetation classification and mapping projects for Wyong, Gosford, Cessnock, Pittwater and Lake Macquarie LGAs, and has assisted in similar mapping projects for Blue Mountains LGA. Stephen has also completed several studies on Threatened Ecological Communities and threatened plant species, and published the results of some of these in the scientific literature.

On behalf of the Ecological Society of Australia, Stephen was the ecological expert on the Hunter Regional Vegetation Committee (2003), and from 2017 represents that organization on the NSW Threatened Species Scientific Committee (administering the *Biodiversity Conservation Act 2016*). Stephen was also a past member of the Hunter Threatened Flora Recovery Team, a founding member of the Hunter Rare Plants Committee (a sub-committee of the Hunter Region Botanic Gardens), and since 2014 has been a member of the OEH Species Technical Group which oversees management and expenditure of threatened species throughout NSW via its *Saving our Species* initiative. He is also often called upon by Government for advice regarding the significance of vegetation communities and plant species within the northern Sydney Basin bioregion, and has sat on numerous expert panels in this regard. Stephen has been called upon as an Expert Witness for several cases heard in the NSW Land and Environment Court, where his knowledge on the vegetation of the Sydney Basin bioregion has been used to argue contentious land-use decisions.

Stephen has published several scientific papers on various aspects of the vegetation of the Sydney Basin, including classifications of vegetation within conservation reserves, threatened and rare plant species, and the description of new plant taxa. Stephen has completed over 4500 standard full floristic sampling plots within the Sydney Basin, which are stored and used in vegetation classification analyses. Other skills include extensive multivariate data analysis experience, and GIS mapping. Stephen's PhD thesis, completed on a part-time basis through the University of Newcastle, presented improvements in the recognition, identification and classification of restricted and significant vegetation communities, such as Threatened Ecological Communities (TECs).

In October 1996, Stephen established *Eastcoast Flora Survey*, a specialist botanical consultancy providing high quality services to government and the private sector. Since June 2014, Stephen has also been a Conjoint Fellow in the School of Environmental & Life Sciences at the University of Newcastle (NSW), seeking to raise the output of ecological research on plants and vegetation within the Hunter region.

ACADEMIC QUALIFICATIONS

Doctor of Philosophy (PhD), 2013	<i>Defining and mapping rare vegetation communities: Improving techniques to assist land-use planning and conservation</i> (University of Newcastle)
Bachelor of Science (Honours), 1991	<i>Effects of the weed Scotch Broom on bird communities in open forests on Barrington Tops</i> (University of Newcastle)
Bachelor of Science, 1989	<i>Majors in Geography and Biology</i> (University of Newcastle)

EMPLOYMENT HISTORY

University of Newcastle	Conjoint Fellow (Plant Sciences Group)	June 2014 - Present
Eastcoast Flora Survey	Consultant Botanist (Principal)	Oct. 1996 - Present
Ecotone Ecological Consultants Pty Ltd	Manager - Flora Studies	Jan. 1996 - Oct. 1996
Private Ecological Consultant	Sole trader	Jan. 1991 - Dec. 1995
NSW National Parks and Wildlife Service	Project Officer	Sept. 1993 - Jan. 1994
University of Newcastle, Geography Dept.	Field Tutor (Scientific)	July 1993 - Aug. 1993
NSW National Parks and Wildlife Service	Project Officer	Jan. 1993 - June 1993
University of NSW, School of Biol. Sciences	Research Assistant (Bird ecology)	Sept. 1992 - Jan. 1993
NSW National Parks and Wildlife Service	Technical Officer (Scientific)	Jan. 1992 - June 1992
RZ Mines (Newcastle)	Environmental Research Officer	Oct. 1990 - Dec. 1991
Wayne Perry & Associates P/L	Environmental Officer (Casual)	June 1990 - Oct. 1990

RESEARCH INTERESTS

- Vegetation classification and mapping, at local and regional scales
- Definition and mapping of rare and threatened vegetation communities
- Restoration of threatened grassy woodlands from derived grasslands
- Improving data sampling methods for monitoring and classification
- Re-constructing vegetation distribution using information from historical botanical explorers
- Population ecology and habitat of rare and threatened plants
- Taxonomy and significance of Hunter Region plants

MINISTERIAL APPOINTMENTS

- Committee Member (ESA Rep.), NSW Threatened Species Scientific Committee (July 2017-present)
- Committee Member, NSW Species Technical Group, Flora (*Save Our Species Program*) (2014-present)
- Committee Member (ESA Rep.), Hunter Regional Vegetation Committee (2001-2003)

CONFERENCE & WORKSHOP PRESENTATIONS

- Australian Plant Society (NSW) Annual Conference, August 2019, Newcastle: "*Endemic Plants of the Hunter Region: Trees and Larger Shrubs*".
- Best Practice Mine Rehabilitation Conference, September 2014, Singleton, NSW; The Tom Farrell Institute for the Environment, University of Newcastle: "*Effective Biodiversity Offsets: Improving planning, valuation and monitoring practice*" (with Martin Fallding).

- Plant Identification for Flora of the Hunter Valley, 7th - 8th April 2014, Kurri Kurri, Australian Network for Plant Conservation: “*Introduction to the flora of the Hunter Valley - history, diversity and ecology*”.
- HOTSPOTS Fire Project: Awabakal and Worimi Fire Forum, 27th July 2011, Williamstown, Never Never Resources: “*Vegetation of the Worimi Conservation Lands*”.
- HOTSPOTS Fire Project: Wanaruah Fire Forum, 17th – 19th August 2010, Sandy Hollow, Upper Hunter Valley, Nature Conservation Council: “*Vegetation of Wanaruah Lands, Sandy Hollow*”.
- Coastal Groundwater Dependent Ecosystems Workshop, 3rd – 4th September 2009, South West Rocks, NSW (Geoscience Australia): “*Surveying, classifying and mapping vegetation on the Tomago Sandbeds*”.
- Vegetation Management and Biodiversity Conservation in the Hunter Region, May 2000, Singleton, NSW (Hunter Environment Lobby Inc.): “*An evaluation of vegetation survey and threatened plant species listings in the Hunter Region*”

PROFESSIONAL MEMBERSHIPS

- Ecological Society of Australia (ESA)
- Australian Network for Plant Conservation Inc. (ANPC)
- International Association for Vegetation Science (IAVS)
- International Association for Vegetation Science Vegetation Classification Working Group (IAVS VSWG)
- Australasian Systematic Botany Society (ASBS)

PUBLICATION REVIEWER

- *Diversity* (MDPI, Switzerland)
- *Forests* (MDPI, Switzerland)
- *International Journal of Environmental Research and Public Health* (MDPI, Switzerland)
- *Journal of Vegetation Science* (International Association for Vegetation Science)
- *Pacific Conservation Biology* (CSIRO Publishing)
- *Resources* (MDPI, Switzerland)
- *Sustainability* (MDPI, Switzerland)
- *Telopea* (National Herbarium of New South Wales)
- *Vegetation Classification and Survey* (International Association for Vegetation Science)

BOARD MEMBERSHIPS

- 2019 - *Vegetation Classification and Survey* (Editorial Board)
- 2019 - *Sustainability* (Review Board)
- 2019 – Australian Network for Plant Conservation (Committee Member)

ACCREDITED BAM SPECIES EXPERT (NSW DPIE)

- *Cryptostylis hunteriana* (Orchidaceae)
- *Diuris praecox* (Orchidaceae)
- *Diuris tricolor* (Orchidaceae)
- *Hibbertia procumbens* (Dilleniaceae)
- *Prasophyllum petilum* (Orchidaceae)
- *Prostanthera junonis* (Lamiaceae)
- *Pterostylis chaetophora* (Orchidaceae)
- *Thelymitra adorata* (Orchidaceae)

PUBLICATIONS (PEER REVIEWED)

- Bell, S.A.J. (submitted) Floristic community diversity in derived native grasslands: a case study from the upper Hunter Valley of New South Wales. *Cunninghamia* (submitted)
- Bell, S.A.J. (submitted) Successful recruitment following translocation of a threatened terrestrial orchid (*Diuris tricolor*) into mining rehabilitation in the Hunter Valley of NSW. *Ecological Management and Restoration* (submitted)
- Bell, S.A.J. (in prep) A strategy for assessing population size in threatened plant surveys using a classification of detectability based on key life-form traits, seasonality and disturbance response. *Diversity* (in prep)
- Bell, S.A.J. & Hillier, P. (2020) Targeted surveys of a poorly conserved threatened orchid (*Pterostylis chaetophora*) in Cumbey National Park (Hunter Valley, NSW) reveal substantial populations and identify occupied habitat. *Cunninghamia* 20: 199-207.
- Bell, S.A.J. & Nicolle, D. (2020) Glen Gallic Mallee (*Eucalyptus dealbata* subsp. *aperticola*, Myrtaceae), a new taxon from the sandstone escarpment of the Hunter Valley, New South Wales. *Telopea* 23: 141-150.
- Bell, S.A.J. & Driscoll, C. (2020) Data-informed Sampling and Mapping: A new approach to ensure plot-based classifications locate, classify and map rare and restricted vegetation types. *Australian Journal of Botany* doi: 10.1071/bt20024
- Mickaill, L., Bell, S., & Beranek, C. (2020) Dispersal potential in two restricted and five wide-ranging *Senecio* (Asteraceae) taxa from central eastern New South Wales, Australia. *Australian Journal of Botany* 68: 333-344.
- Bell, S.A.J. (2020) Translocation of threatened terrestrial orchids into non-mined and post-mined lands in the upper Hunter Valley of New South Wales, Australia. *Restoration Ecology* 28: 1396-1407.
- Yare, B., Bell, S., & Hunter, N. (2020) Phenology of the threatened *Diuris praecox* (Orchidaceae), a range-restricted terrestrial orchid from central eastern New South Wales. *Cunninghamia* 20:105-113.
- Bell, S.A.J. & Klaphake, V. (2020) *Eucalyptus calidissima* (Myrtaceae), a new ironbark species from the Hunter Valley of New South Wales, Australia. *Telopea* 23: 73-87.
- Fensham, R., Laffineur, B., Collingwood, T., Beech, E., Bell, S., Hopper, S., Phillips, G., Rivers, M., Walsh, N. & White, M. (2020) Rarity or decline: Key concepts for the Red List of Australian eucalypts. *Biological Conservation* 243 108455
- Bell, S.A.J. (2019) Additions and amendments to the rare or threatened vascular plants of Wollemi National Park, central eastern New South Wales. *Cunninghamia* 19: 43-56.
- Bell, S.A.J. (2019) *Macrozamia flexuosa* C. Moore (Zamiaceae): a review of distribution, habitat and conservation status of this endemic cycad from the Hunter Region of New South Wales. *Cunninghamia* 19: 7-27.
- Bell, S., Rockley, C., & Llewellyn, A. (2019) *Flora of the Hunter Region: Endemic Trees and Larger Shrubs*. CSIRO Publishing. 136 pp. ISBN: 9781486311026
- DeLacey, C., Bell, S., Chamberlain, S., & Bossard, K. (in review) Prediction of and realised habitat for a cryptic plant species: the Leafless Tongue Orchid *Cryptostylis hunteriana* Nicholls. *Cunninghamia* (in review)
- Bell, S.A.J. (2018) Fate of a rare flowering event in a population of the endangered *Acacia pendula* (Weeping Myall) from the Hunter Valley of New South Wales. *Cunninghamia* 18: 79-88.
- Bell, S.A.J. & Driscoll, C. (2017) *Acacia wollarensis* (Fabaceae, Mimosoideae sect. Botrycephalae), a distinctive new species endemic to the Hunter Valley of New South Wales, Australia. *Telopea* 20: 125-136.
- Bell, S.A.J. & Driscoll, C. (2016) Hunter Valley Weeping Myall Woodland – is it really definable and defensible with and without Weeping Myall (*Acacia pendula*)? *Cunninghamia* 16: 15-30.

- Bell, S.A.J. & Walsh, N. (2015) *Leionema lamprophyllum* subsp. *fractum* (Rutaceae): a new and highly restricted taxon from the Hunter Valley of New South Wales. *Telopea* 18: 505-512.
- Bell, S.A.J. & Driscoll, C. (2014) *Acacia pendula* (Weeping Myall) in the Hunter Valley of New South Wales: early explorers' journals, database records and habitat assessments raise doubts over naturally occurring populations. *Cunninghamia* 14: 179-200.
- Bell, S.A.J. & Nicolle, D. (2012) *Eucalyptus expressa* (Myrtaceae): a new and distinctive species from the sandstone ranges north-west of Sydney, New South Wales. *Telopea* 14: 69-76.
- Bell, S.A.J. & Stables, M. (2012) Floristic variability, distribution and an extension of range for the endangered Pittwater Spotted Gum Forest, Central Coast, New South Wales. *Cunninghamia* 12(2): 143-152.
- Bell, S.A.J. (2009) Vegetation and floristics of Columbey National Park, lower Hunter Valley, New South Wales. *Cunninghamia* 11(2): 241-275.
- Bell, S.A.J. (2008) Rare or threatened vascular plant species of Wollemi National Park, central eastern New South Wales. *Cunninghamia* 10(3): 331-371.
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- Bell, S.A.J. (2004) Distribution and habitat of the vulnerable tree species, *Angophora inopina* (Myrtaceae), on the Central Coast of New South Wales. *Cunninghamia* 8(4): 477-484.
- Bell, S.A.J. (2004) Vegetation of Werakata National Park, Hunter Valley, New South Wales. *Cunninghamia* 8(3): 331-347.
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- Bell, S.A.J. (2002) Habitat of the endangered *Hibbertia procumbens* (Labill.) DC (Dilleniaceae) from the Central Coast of New South Wales. *Victorian Naturalist* 119(2): 69-74.
- Bell, S.A.J. (2001) Notes on population size and habitat of the vulnerable *Cryptostylis hunteriana* Nicholls (Orchidaceae) from the Central Coast of New South Wales. *Cunninghamia* 7(2): 195-204.
- Bell, S.A.J. (2001). Notes on the distribution and conservation status of some restricted plant species from sandstone environments of the upper Hunter Valley, New South Wales. *Cunninghamia* 7(1): 77-88.
- Bell, S. (2000) An evaluation of vegetation survey and threatened plant species listings in the Hunter Region. Pp. 19-34 IN *Vegetation Management and Biodiversity Conservation in the Hunter Region - Where to from here?* Ed. by M.Fallding. Proceedings of the Public Workshop. Hunter Environment Lobby. Singleton, 12 May 2000.

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- Bell, S. (in prep) Voucher specimens vs observation records: why 'collecting' is better than 'observing' for plant conservation. *Australasian Plant Conservation* (in prep)
- Bell, S. (2020) Check those IDs... the importance of confirming threatened plant identifications before implementing management. *Australasian Plant Conservation* 28: 18-20.
- Bell, S. (2019) Translocation 'success' is all about detection: experiences with two threatened orchids from the Hunter Valley of NSW. *Australasian Plant Conservation* 28: 27-31.
- Bell, S. (2018) The responsibilities of ecological consultants in disseminating outcomes from threatened species surveys. *Australasian Plant Conservation* 27: 3-6.
- Bell, S. & Sims, R. (2018) Extensive populations of *Dracophyllum macranthum* (Ericaceae) in Coorabakh NP suggest a review of threat status. *Australasian Plant Conservation* 27: 11-14.
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- Bell, S. & Driscoll, C. (2005) New records of the endangered *Hibbertia procumbens* from the Central Coast of NSW. *Australasian Plant Conservation* 13(4): 24-25.
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- Bell, S. (2003) Another new and highly restricted mallee from the Hunter Valley, *Eucalyptus castrensis*. *Hunter Flora* 11: 2.
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- Peake, T., Bell, S., Tame, T., Simpson, J., & Curran, T. (2002) *Warkworth Sands Woodland – An Endangered Ecological Community: Distribution, Ecological Significance and Conservation Status*. Hunter Region Botanic Gardens Technical Paper [www.huntergardens.org.au/]
- Bell, S. (2002) Plant profile: The Leafless Tongue Orchid, *Cryptostylis hunteriana*. *Hunter Flora* 9: 2.

SELECTED UNPUBLISHED TECHNICAL REPORTS (1993 – 2020)

- Bell, S.A.J. (2020) *Survey and monitoring of the Vulnerable Pterostylis chaetophora (Rusty Greenhood) in the Lower Hunter Valley, NSW: 2019 Results*. Unpublished Report to NSW Office of Environment and Heritage. June 2020. Eastcoast Flora Survey.
- Bell, S.A.J. (2020) *Expert Report - Expected Presence of Threatened Terrestrial Orchids (Diuris tricolor & Prasophyllum petilum): Bayswater Water and Other Associated Operational Works Project*. Unpublished Report to Kleinfelder. May 2020. Eastcoast Flora Survey.
- Bell, S.A.J. & Oppen, M. (2020) *Management of habitat for the Critically Endangered Persoonia pauciflora (Proteaceae) at 'Georgia' (Lot 56 DP755211), North Rothbury, NSW*. Unpublished Report to NSW Biodiversity Conservation Trust. April 2020. Eastcoast Flora Survey.
- Bell, S.A.J. (2020) *Identifying potential pollinators in the critically endangered Banksia conferta (Proteaceae), Coorabakh National Park, NSW*. Unpublished Report to NSW National Parks and Wildlife Service. March 2020. Eastcoast Flora Survey.
- Bell, S.A.J. (2019) *Expert Report: Hibbertia procumbens (Labill.) DC. (Dilleniaceae) at a Proposed Industrial Warehouse Development, Gindurra Road, Somersby*. Unpublished Report to Anderson Environment & Planning.
- Bell, S.A.J. (2019) *A Re-assessment of Foreshore Vegetation along Tuggerah Lake, Chittaway Bay to The Entrance, Central Coast LGA*. Report to Central Coast Council. November 2019.

- Bell, S.A.J. (2019) *Baseline surveys for two threatened mallees (Eucalyptus castrensis and Eucalyptus pumila) in the lower Hunter Valley of New South Wales*. Unpublished Report to NSW Office of Environment and Heritage. April 2019. Eastcoast Flora Survey.
- Bell, S.A.J. (2019) *Peer Review: Assessment of the vulnerable Tetratheca juncea at a proposed development site at Gwandalan, Central Coast Council*. Unpublished Report to Resolve Urban Planning. April 2019. Eastcoast Flora Survey.
- Bell, S.A.J. (2019) *Survey and monitoring of the Vulnerable Pterostylis chaetophora (Rusty Greenhood) in the Lower Hunter Valley, NSW: 2018 Results*. Unpublished Report to NSW Office of Environment and Heritage. April 2019. Eastcoast Flora Survey.
- Bell, S.A.J. (2019) *A Revised Interim Vegetation Classification of the Central Coast Local Government Area*. Unpublished Report to Central Coast Council. July 2019. Eastcoast Flora Survey.
- Bell, S.A.J. (2019) *Verification Survey of the Critically Endangered Pomaderris reperta (Denman Pomaderris) at Aarons Pass Road, Central Tablelands, NSW*. Unpublished Report to Office of Environment & Heritage. February 2019. Eastcoast Flora Survey. [peer review survey, *Pomaderris cotoneaster* rather than *Pomaderris reperta*]
- Bell, S.A.J. (2019) *Monitoring of translocated threatened orchids (Diuris tricolor, Prasophyllum petilum) at Mangoola Coal: 2018 Results*. Unpublished Report to Mangoola Coal. February 2019. Eastcoast Flora Survey.
- Bell, S.A.J. (2018) *Review of significant vegetation at 100 Bakali Road, Forresters Beach (Lot 9, DP 8857)*. Unpublished Report to Darcy Smith. November 2018. Eastcoast Flora Survey.
- Bell, S.A.J. (2018) *Monitoring of the endangered Pterostylis gibbosa (Orchidaceae) at Milbrodale, Hunter Valley: Year 3 Results*. Unpublished Report to Office of Environment & Heritage. November 2018. Eastcoast Flora Survey.
- Bell, S.A.J. (2018) *Monitoring of Acacia pendula in the Weeping Myall Management Areas, Bulga Coal, Singleton LGA: 2018 Results*. Unpublished Report to Bulga Coal. October 2018. Eastcoast Flora Survey.
- Bell, S.A.J. (2018) *Monitoring and survey of the Critically Endangered Pomaderris reperta (Rhamnaceae) and Vulnerable Lasiopetalum longistamineum (Malvaceae), Upper Hunter Valley, New South Wales: 2017-2018 (Year 2) Results*. Unpublished Report to Office of Environment & Heritage. October 2018. Eastcoast Flora Survey.
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- Bell, S.A.J. (2018) *Vegetation and floristics of the Huntlee Offset Lands, Hunter Valley, NSW: Sweetwater (North Rothbury)*. Unpublished Report to Office of Environment & Heritage. June 2018. Eastcoast Flora Survey.
- Bell, S.A.J. & Sims, R. (2018) *Targeted Surveys for the Vulnerable Dracophyllum macranthum (Ericaceae) in Coorabakh National Park, Lansdowne Plateau, NSW*. Unpublished Report to NSW Office of Environment & Heritage. 21 June 2018. Eastcoast Flora Survey.
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Appendix 6 – Endorsement: Dr Lachlan Copeland



5th April, 2018

Reference for orchid expertise of Dr Stephen Bell

To whom it may concern

This letter serves to introduce Dr Stephen Bell of Eastcoast Flora Survey as worthy to fill the role of 'expert' for matters concerning the threatened terrestrial orchids *Diuris tricolor* and *Prasophyllum petilum*. I myself have an extensive knowledge of the orchid flora of New South Wales, Victoria and Queensland gained over several decades of field survey. With Gary Backhouse, Robert Bates and Andrew Brown, I have co-authored the "Checklist of the Orchids of Australia including its Island Territories". In separate publications I have also described 15 new orchid species. I am personally very familiar with *Diuris tricolor* and *Prasophyllum petilum* from throughout their known distributional ranges, and have worked with Stephen on these two species previously.

Stephen has a wealth of experience and professional ability in botany and threatened species management, having worked in the consultancy field since the mid 1990's. In 1996, he established Eastcoast Flora Survey, a small consultancy focusing on vegetation surveys, classification, mapping and threatened species research and management. Over a 20 year period, Stephen has shown himself to be dedicated to presenting an accurate portrayal of the distribution and abundance of native plant species, particularly threatened plant species and ecological communities. He has researched a number of threatened plant species, including several orchids, and has published regularly in the scientific literature on these. In the past, I have personally approached Stephen on numerous occasions to discuss the distribution, abundance and threats of a wide variety of threatened plant species including several orchid taxa.

I first worked with Stephen on surveys for *Diuris* and *Prasophyllum* in the upper Hunter Valley in 2009, and since that time I am aware that he has undertaken annual surveys for these species across a number of offset and development sites, including overseeing and conducting a large translocation program at one mine site requiring detailed monitoring of individual plants, and the monitoring of natural populations elsewhere. Over a nine year period of surveying and monitoring for these species, Stephen is clearly highly regarded as an expert for these taxa in the Hunter Valley. I believe that Stephen would have personally seen more individuals of these two species and know their ecology more intimately than anyone else.

Given the experience detailed above, I have no hesitation in recommending Stephen as an expert in any matters concerning *Diuris tricolor* and *Prasophyllum petilum*, particularly with regard to habitats and status within the Hunter Valley of NSW.

Yours sincerely

A handwritten signature in dark ink, appearing to read 'Lachlan Copeland', written in a cursive style.

Dr Lachlan Copeland
Senior Botanist,
Eco Logical Australia

Attachment 6

Maxwell Project Targeted Orchid Surveys



Bill Dean
Malabar Resources
c/- Resource Strategies
PO Box R864 Royal Exchange
NSW 1225

29 January 2021

Dear Bill

**Maxwell Project
Targeted Orchid Surveys**

Dr Stephen Bell of Eastcoast Flora Survey (Bell 2020) is preparing an expert report on the expected presence of threatened terrestrial orchid species (*Diuris tricolor* [Pine Donkey Orchid], *Prasophyllum petilum* [Tarengo Leek Orchid] and *Pterostylis chaetophora* [Rusty Greenhood]) within the Maxwell Project disturbance area. Dr Stephen Bell is of the view that the vegetation units defined by Hunter Eco (2019) as Ironbark - Grey Box Grassy Woodland Derived Native Grassland (Unit 9a [PCT¹ 1691]) and Grey Box - Spotted Gum - Narrow-leaved Ironbark woodland (Unit 11 [PCT 1604]) provide the only potential habitat for *Diuris tricolor* and *Prasophyllum petilum*, which together comprise 1.56 hectares (0.9%) of the disturbance area (Figure 1). Dr Stephen Bell is also of the view that there is no likelihood of *Pterostylis chaetophora* occurring in any vegetation community.

Hunter Eco (Dr Colin Driscoll) conducted an orchid survey on 28 and 29 September 2020 targeting the locations identified by Dr Stephen Bell (Figure 1). Surveys were conducted according to the requirements in the Department of Planning, Industry & Environment (DPIE) (2020) *Surveying Threatened Plants and Their Habitats: NSW Survey Guide for the Biodiversity Assessment Method*.

No threatened orchids were recorded in the Maxwell Project disturbance area.

Hunter Eco (2019) reported that there was a location outside of the Maxwell disturbance area from where *Diuris tricolor* had previously been recorded, predominantly within PCT 1691 (referred to as the *Diuris tricolor* 'protection area') (Figure 2). During the additional surveys in September 2020, eight *Diuris tricolor* individuals were recorded in that location (Figure 2). One individual was found on the western fence line of the protection area so a random meander was conducted further to the west during which an additional 37 *Diuris tricolor* were recorded with the furthestmost individual being approximately 170 m from the protection area boundary (Figure 2). All of these orchids were recorded in open grassy patches associated with PCT 1691.

As a precautionary measure a number of meanders were conducted taking in grassy patches in PCT 1691 both in the disturbance area and the wider area outside of the protection area from where the orchids had been recorded (Figure 2). No further records were made of any threatened orchids from over three kilometres of meanders.

The attached figures (Figures 2 to 4) show the survey locations, GPS tracks and *Diuris tricolor* records.

Yours Faithfully
HUNTER ECO

Dr Colin Driscoll
Environmental Biologist

¹ Plant Community Type



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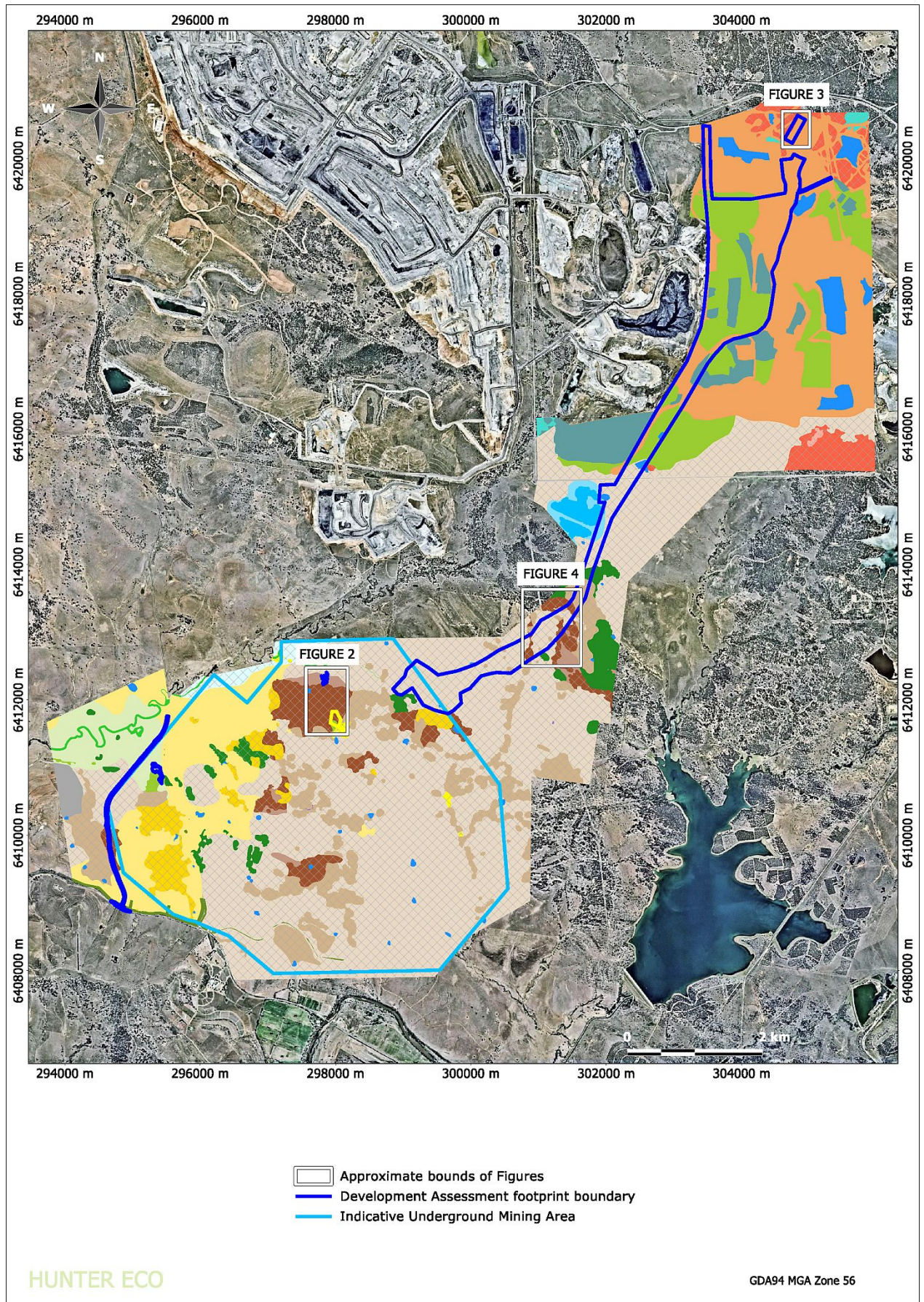


Figure 1: An overview showing the approximate bounds of the following Figures 2, 3 and 4

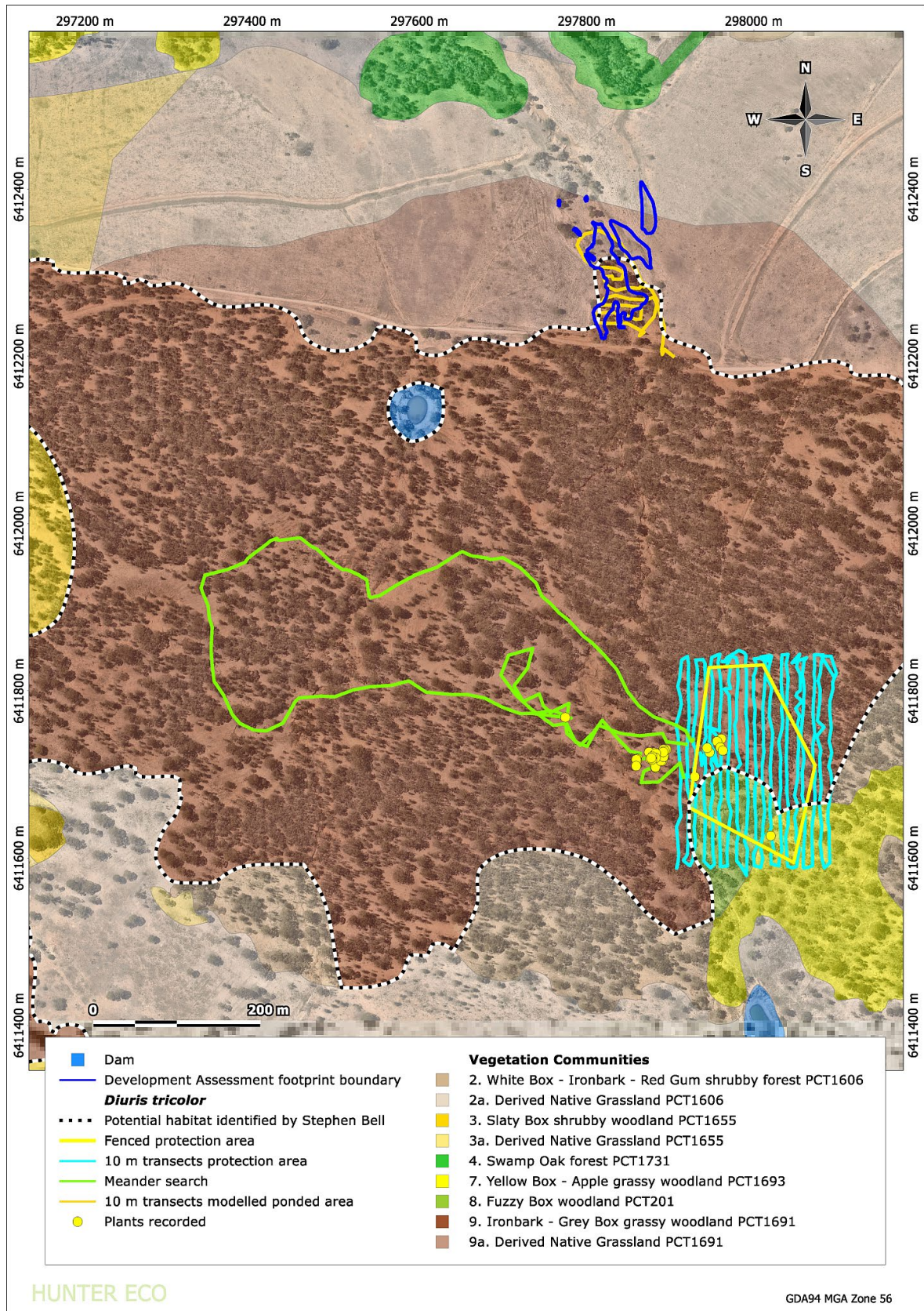


Figure 2: Transect Surveys and Meanders in The Protection Area and Potential Pondered Area

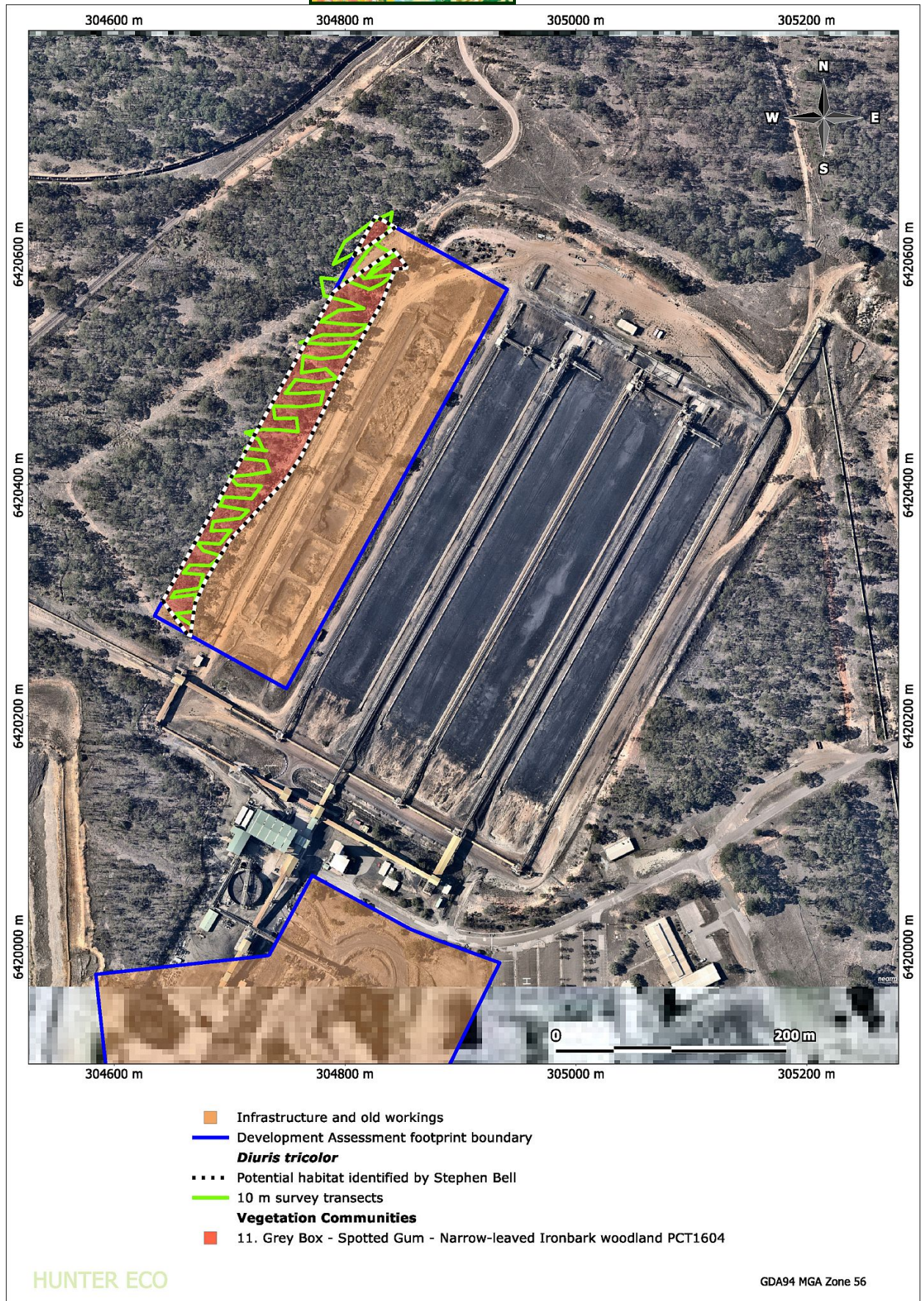


Figure 3: Transect Survey of the Stockpile Expansion Area

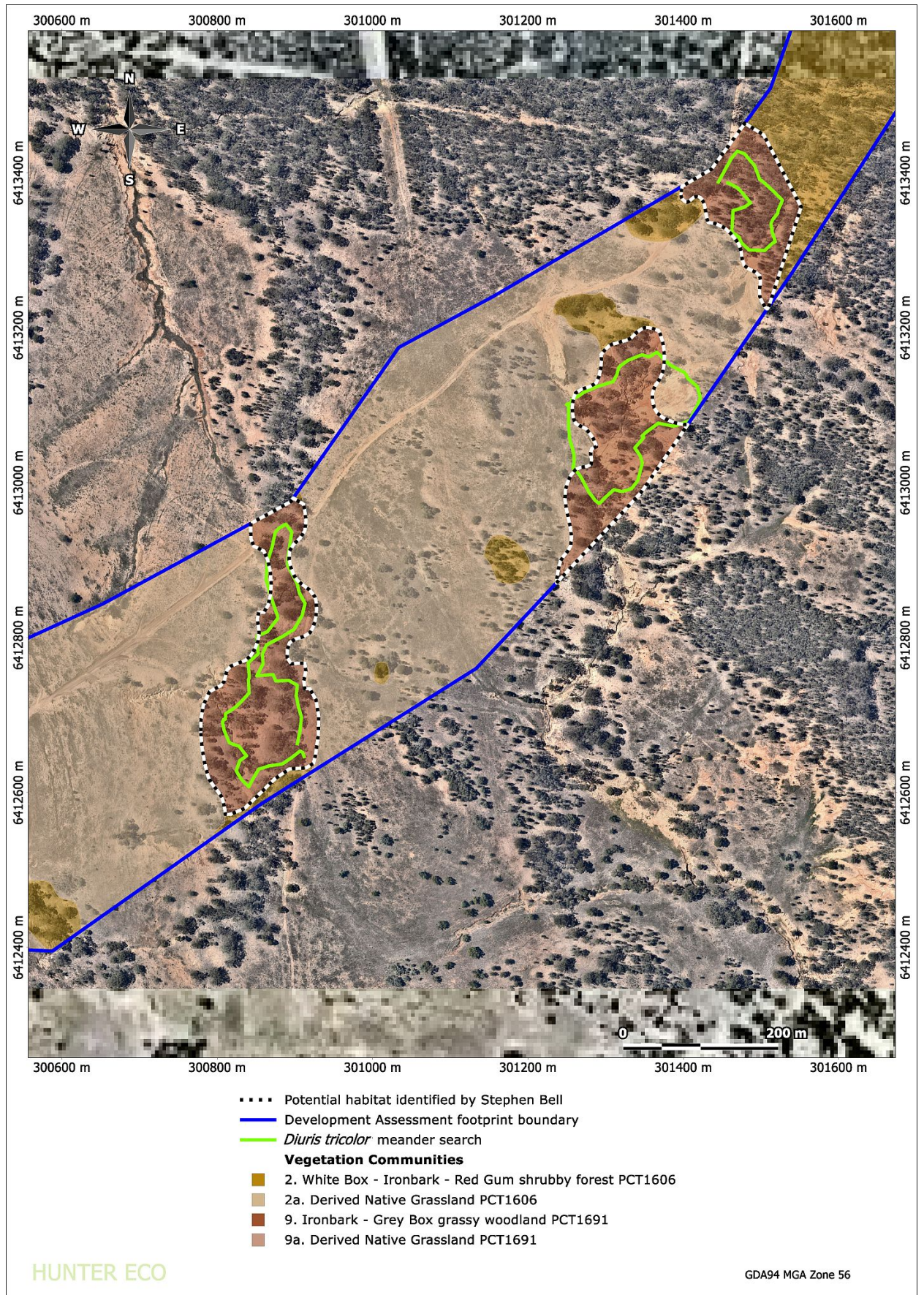


Figure 4: Meander Surveys Through Grassy Patches in PCT 1691