West Musgrave Copper and Nickel Project

December 2020

EPA Section 38 Referral Supporting Document Appendix B Flora and Vegetation

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APPENDIX B. FLORA AND VEGETATION

Appendix B1. Detailed Flora and Vegetation Survey

Western Botanical

Detailed Flora and Vegetation Survey, West Musgrave Copper and Nickel Project

March 2020

Prepared for: OZ Minerals Limited

Report Ref: WB905

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Report No:WB905

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1	Jonathan Warden, Dr. David Leach	Geoff Cockerton, Jonathan Warden	July 2019
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1. Executive Summary

OZ Minerals Limited (OZL) and their joint venture (JV) partner Cassini Resources Ltd (CZI) are undertaking prefeasibility studies (PFS) to investigate development of the Nebo - Babel copper and nickel deposit in the West Musgrave mineral field, Western Australia (West Musgrave Project). The Project is located 30 km south of the Mantamaru Aboriginal Community (the Jameson town site), 110 km south-east of Warburton and 1,300 km north-east of Perth (near the border with Northern Territory and South Australia) (Figure 1). The Survey Area lies on the boundary of the Central Ranges (CER01) and Great Victoria Desert (GVD02) Interim Biogeographic Regions (IBRA) and within the Aboriginal Reserve 17614, (Figure 2). This region is classified an Environmentally Sensitive Area (ESA).

The JV commissioned Western Botanical to undertake a desktop study followed by a Detailed flora and vegetation survey conducted over 3 survey periods from June 2018 – June 2019 within the 41,519 ha Survey Area (Figure 3) consisting of ten major components:

(i) The extended Project Development Area, inclusive of the Solar farm, 2015, 2018 High intensity survey areas (5,170 ha).

(ii) A 1km wide corridor for the proposed Western Access road inclusive of the bypass section (2,683 ha).

(iii) A 1km wide corridor following the existing Northern Access Road (2,592ha).

(iv) A 1km wide corridor for the proposed North-eastern Borefield alignment plus the 2019 additional northern survey areas, (9,342.2ha).

(v) A 1km wide corridor for the proposed Southern Borefield alignment (9,963.9 ha).

(vi) The proposed Windfarm, Windfarm extension and Access Polygon (3,982 ha).

(vii) A 1km wide corridor for the proposed Officer Basin Borefield alignment (6,152 ha).

(viii) Yappsu deposit area (362 ha).

(ix) Succoth deposit area (551 ha).

(x) Northern Borefield Infill Vegetation Mapping (617.2 ha).

This report incorporates results of an earlier survey conducted during 2014 - 2015 that represented the first phase of a Level 2 *Detailed Survey* across the central 3,025 ha portion of the Project Development Area. This report represents: A) the first phase of a Detailed Survey for all Survey Areas, incorporating (i) vegetation mapping to NVIS *Level V Association* supported by quadrats, traverses and relevé sampling, (ii) an inventory of all vascular flora encountered, (iii) Targeted Priority Flora searches and (iv) Opportunistic weed location recording; with B) a full Detailed

Survey (second Phase) across a reduced Survey Area, referred to as the Detailed Survey Study Area incorporating (i) rescore of quadrats in a different season, (ii) adjustments to the vegetation mapping and installation of further quadrats to support changes to the mapping, (iii) significant species searches, and (iv) weed mapping.

During the second phase of the Detailed Survey, five additional areas were added to the project. These included two prospective deposits (Yappsu and Succoth), both located adjacent to the original Survey Area, plus an access alignment to the Southern Borefield region, adjustments to the alignment of the Southern Borefield Survey Area and Northern Access road alignment totalling 3,263 ha (Table 1).

When the results of the 2014, 2015 and 2018 / 2019 surveys are combined, 390 native flora taxa from 166 genera and 50 families are recognised within the Survey Area. Fabaceae, Poaceae, Malvaceae, Asteraceae, Chenopodiaceae, Goodeniaceae and Amaranthaceae represent the most prevalent families and *Acacia*, *Eragrostis*, *Eremophila*, *Sida*, *Ptilotus* and *Senna* represent the most prevalent genera. The majority of species recorded are widespread and well represented in the Central Ranges and Great Victoria Desert Interim Biogeographic Regionalisation for Australia (IBRA) regions.

No Threatened Ecological Communities (TEC) or Priority Ecological Communities (PECs) were located within a 100km radius of the Survey Area during the desktop search. No vegetation associations described across the Greater Survey Area were considered by Western Botanical to warrant a TEC or PEC listing due to being regionally limited or restricted in distribution.

No Threatened Flora formerly listed under the superseded *Wildlife Conservation Act 1950 (WA)* (prior to January 2016) or the *Biodiversity Conservation Act 2016 (WA)*, or *Environment Protection and Biodiversity Conservation Act 1999 (Cth)* were recorded within the Greater Survey Area.

During the survey, 11 Priority Flora species were identified. This included two Priority 1 species and nine Priority 3 species:

- *Aenictophyton anomalum* (P1),
- *Indigofera warburtonensis* (P1),
- *Acacia eremophila* var. Numerous-nerved variant (A.S. George 11924) (P3),
- *Amaranthus centralis* (P3),
- *Aristida jerichoensis* var. *subspinulifera* (P3),
- *Goodenia asteriscus* (P3),

- *Stackhousia clementii* (P3),
- *Tephrosia* sp. Central (P.K. Latz 17037) (P3),
- *Chrysocephalum apiculatum* subsp. *ramosum* (P3),
- *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) (P3), and
- *Eragrostis* sp. Limestone (P.K. Latz 5921) (P3).

Tephrosia sp. Central (P.K. Latz 17037) P3, *Chrysocephalum apiculatum* subsp. *ramosum* (P3), *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) (P3), and *Eragrostis* sp. Limestone (P.K. Latz 5921) (P3) were all listed by the Department of Biodiversity Conservation and Attractions (DBCA) as Priority 3 species in early to late October 2018 following the winter survey.

Fifty-seven species within the Survey Area represent Range Extensions of between 100 km to 800 km beyond their typical range within W.A. and/or Australia.

Another eleven species have taxonomic significance worthy of taxonomic and conservation review consisting of:

(i) Three species appearing to represent new species; consisting of two *Eragrostis* species and a *Sida* species. These require specialist taxonomic review following vouchering at the Western Australian Herbarium. These species may acquire Priority Flora status.

(ii) Eight species that are poorly known and represent new subspecies that have not been recognised at this stage, but which have become apparent during this review. These species require taxonomic review and some may acquire Priority Flora status.

Further, a patch of post-fire Mulga *resprouting from a lignotuber* was observed within a SAMU vegetation association in the southern borefield area. This is considered a very unusual habit for Mulga, which is normally an obligate re-seeder species, only regenerating from soil stored seed.

Nineteen species that are known to science and widespread in distribution, but have not been formally described, were also recorded. These do not warrant further specific survey or conservation status assessment.

Eight weed species were recorded within the Survey Area during the cumulative surveys. None of these weeds are listed as Weeds of National Significance (WoNS), or as Declared Organisms under the *Biosecurity and Agriculture Management Act 2007 (WA)* (BAM Act) and Biosecurity and Agriculture Management Regulations 2013 (BAM Regulations). Six are not considered to be significant, however, two species; *Cenchrus ciliaris* and *Rumex vesicarius,* are highly invasive species.

The species accumulation curve demonstrates that survey effort was sufficient to record the majority of the species present across the Survey Area at the time(s) of survey. The majority of species (89%) were encountered within quadrats and relevé sites, with 46 opportunistic species (11%) being found outside the formal sample areas.

Twenty-nine Vegetation Associations at NVIS *Level 5 Association* were recognised with ten vegetation mosaics mapped. These mosaics occurred where the boundaries between adjacent associations formed a mosaic that were unable to be effectively mapped or where the merging of two vegetation associations was unable to be differentiated during the mapping. Most of these vegetation associations have been observed to be regionally widespread in the region by the authors. However, no detailed regional-scale vegetation mapping is available and it has not been possible to map the communities at this level of detail across the region at this stage.

The majority of the Survey Area was in Excellent to Pristine condition with little evidence of any human interaction outside those areas directly cleared for access roads, accommodation village facilities, and exploration drilling. Two issues detract from the Pristine to Excellent vegetation condition rating (i) fire management - frequent and regular fires in the area immediately south and adjacent to the Jameson Community; and (ii) weeds - ingress of Buffel Grass (*Cenchrus ciliaris*) along road sides, tracks, the Jameson town site, and the exploration accommodation village, with Ruby Dock (*Rumex vesicarius*) also noted in the Survey Area in 2015.

2. Introduction

2.1. Project Background

OZ Minerals Limited (OZL) and their joint venture (JV) partner Cassini Resources Ltd (CZI) are undertaking prefeasibility studies (PFS) to investigate development of the Nebo and Babel copper and nickel deposits in the West Musgrave mineral field, Western Australia (West Musgrave Project, WMP).

The WMP is located within the Shire of Ngaanyatjarraku. The WMP is also located within the approximate 170,000 km^2 Yarnangu Ngaanyatjarraku Parna (Aboriginal Corporation) Native Title determination, and within the 98,000 km^2 Ngaanyatjarra Indigenous Protected Area (IPA Reserve No. 17614) that forms part of the National Reserve System under the Commonwealth Department of Prime Minister and Cabinet.

The WMP lies within the Musgrave Geological Province (also known as the Musgrave Block), a relatively recently discovered mineral district where mineralisation occurs at multiple locations. The WMP consists of a number of prospective copper and nickel deposits known as Nebo, Babel, Succoth, and Yappsu, with Nebo and Babel (referred to as Nebo - Babel) being at the most advanced stage of mineral evaluation.

The Nebo and Babel copper - nickel deposits were discovered by Western Mining Corporation (WMC Resources) in 2000. Cassini purchased the Project from BHP in April 2014 and completed a significant infill drilling campaign. A Scoping Study was announced and completed in December 2017 (OZ Minerals 2017), which concluded that the WMP presented a viable opportunity for development. OZ Minerals subsequently signed an early in Joint Venture agreement with Cassini, achieving 70% ownership of the Project as of April 2019.

The PFS is underway to define the key characteristics of the Project and determine its technical and economic viability. The Project will include open pit mining, a processing plant and associated mine waste facilities, water facilities, accommodation village, and other associated site industrial and non-industrial infrastructure.

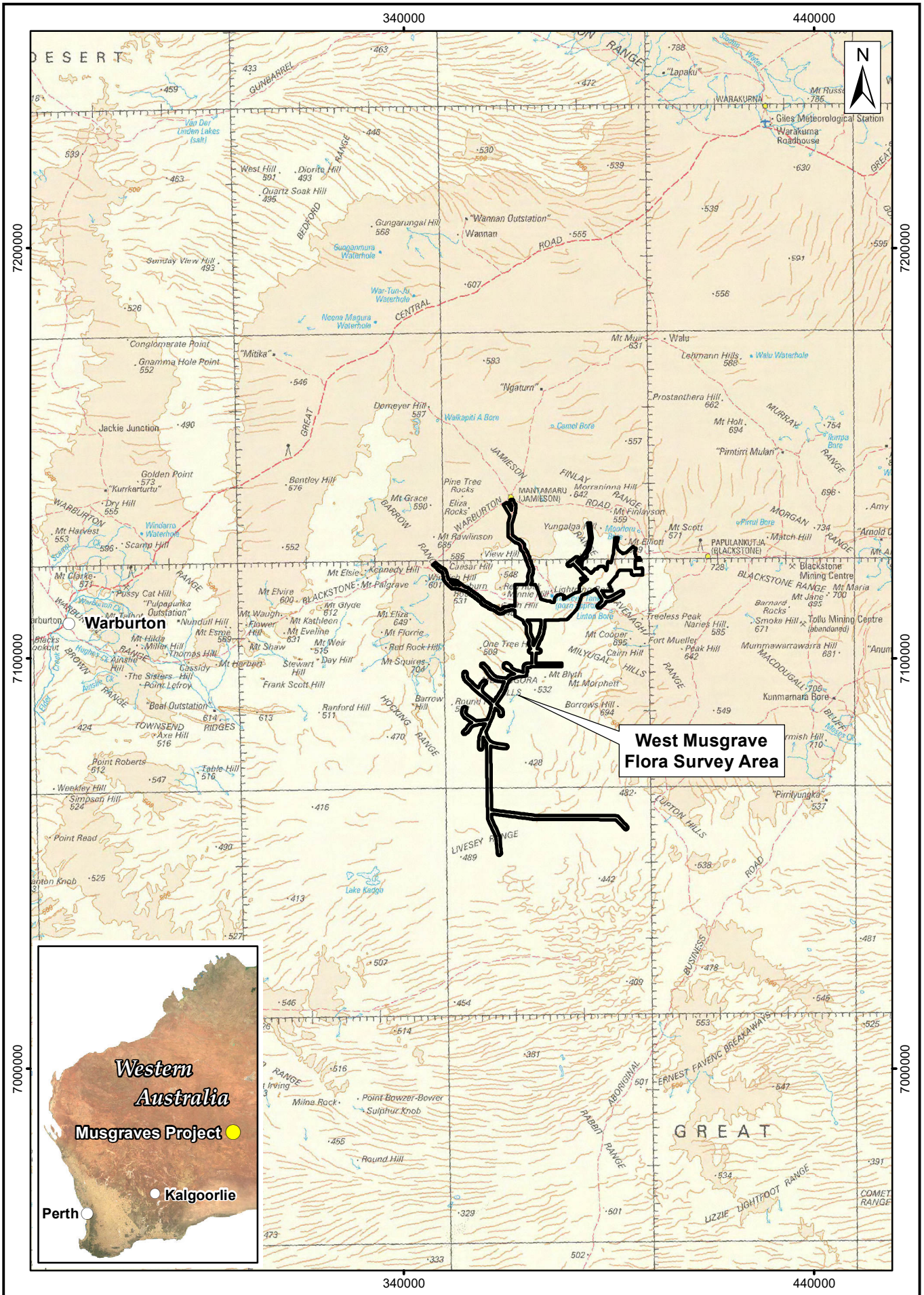
2.2. Location

The Project is located 30 km south of the Mantamaru Aboriginal Community (the Jameson town site), 110 km east of Warburton and 1,300 km north-east of Perth (near the border with Northern Territory and South Australia) (Figure 1). The Survey Area lies on the boundary of the Central Ranges (CER01) and Great Victoria Desert (GVD02) Interim Biogeographic Regionalisation for Australia (IBRA) regions and within the Aboriginal Reserve 17614 (Figure 2). This region is classified an Environmentally Sensitive Area (ESA) (Australian Heritage Database 2014).

2.3. Previous Surveys

Western Botanical (WB) has undertaken 20 botanical assessments in the West Musgrave region for WMC Resources (Report WB291), BHP Billiton's Nickel West (NiWest) (Report WB 315), BHP's MinEx (Reports WB439, 459, 535, 546, 734, 735, 762 and 764), and Anglo American Exploration Australia Ltd (AAEA) (10 reports). Mattiske Consulting and Coffey Environments have conducted additional assessments in the region for WMC Resources and other proponents. The WB reports prepared for WMC, NiWest and MinEx were reviewed in preparing the desktop assessment while the occurrence of Conservation significant species and those species with taxonomic significance recorded in surveys for AAEA have also been noted.

Figure 1. Project Location.



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CAD Ref: a2231_Mus_R04_01

Date: March 2020 | Rev: A | A4

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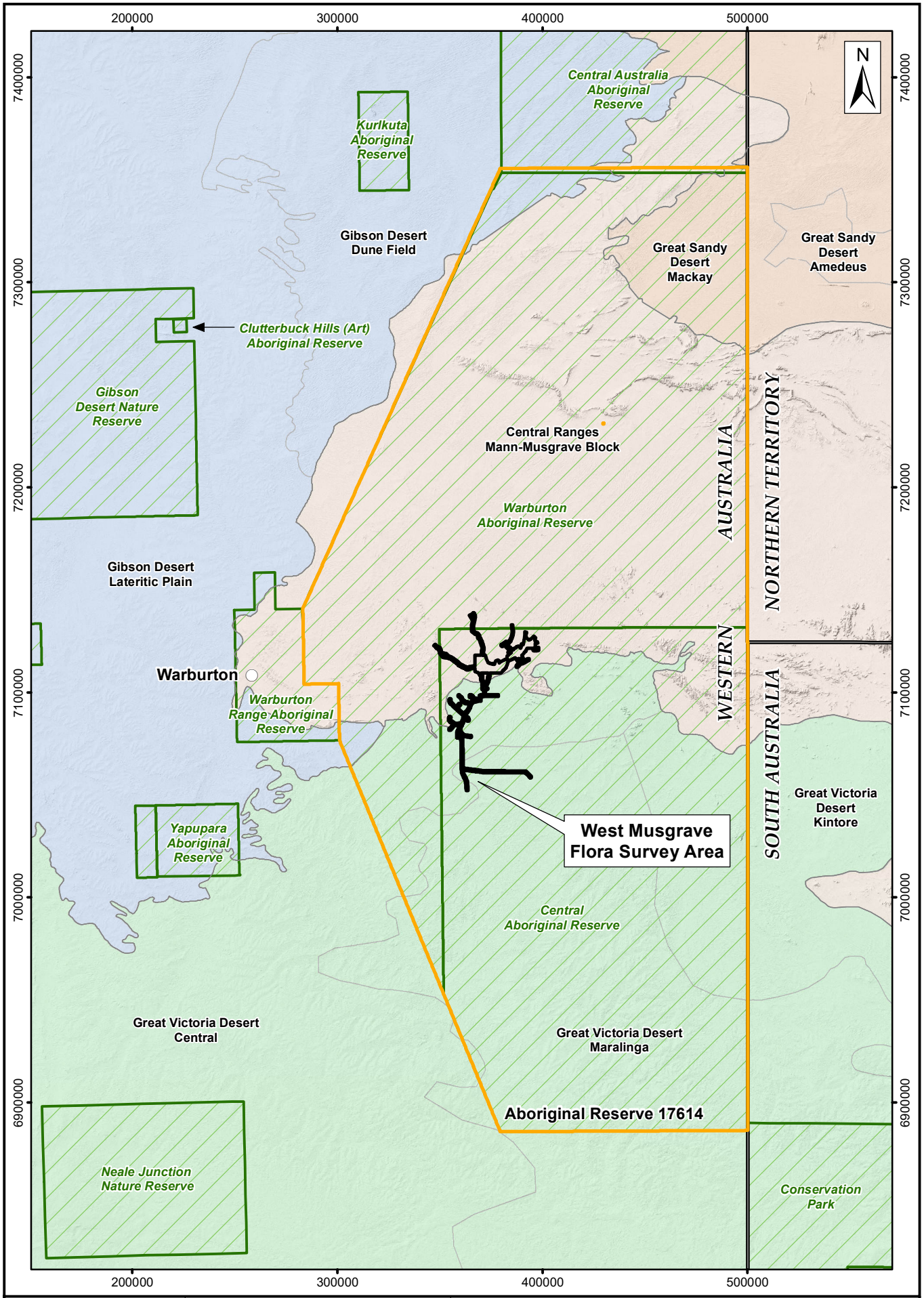
West Musgrave Flora Survey Area

Location

Figure 2. IBRA Regions and Conservation Estates



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Date: March 2020 | Rev: A | A4

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West Musgrave Flora Survey Area

Interim Biogeographic Regions (IBRA) and Reserves

2.4. Current Survey

The JV commissioned Western Botanical to undertake a desktop study followed by a Detailed flora and vegetation survey. The Detailed flora survey was conducted over the period June – July 2018 Winter season survey, followed by a Spring survey conducted in November – early December 2018 across the 27,162 ha Survey Area (Figure 3). The June – July 2018 Winter season survey consisted of six components:

(i) The extended Project Development Area (5,170 ha),

(ii) A 1km wide corridor for the proposed Western Access road (2,358 ha),

(iii) A 1km wide corridor following the existing Northern Access Road (2,315 ha),

(iv) A 1km wide corridor for the proposed North-eastern Borefield alignment (5,215 ha),

(v) A1km wide corridor for the proposed Southern Borefield alignment (9,295 ha), and

(vi) The proposed Windfarm and Access Polygon (2,809 ha).

The second phase spring season of the Detailed Survey was conducted from November – early December 2018 over two separate surveys, the first survey covered the reduced 10,293 ha Survey Area consisting of three components:

(i) The extended Project Development Area (5,170 ha),

(ii) A 1 km wide corridor following the existing Northern Access Road (2,315 ha), and

(iii) The proposed Windfarm and Access Polygon (2,809 ha).

During the second survey, conducted across this period, five Additional areas totalling 3,263 ha were added to the Survey Area consisting of:

(i) Yappsu, a potential future resource deposit (362 ha),

(ii) Succoth, another potential future resource deposit (552 ha),

(iii) Proposed Northern Access road realignment (368 ha),

(iv) Proposed Southern Borefields realignment (577 ha), and

(v) The proposed access alignment to Southern Borefields through the Heritage Dreaming trail (1,404 ha).

Following the 2018 Detailed Flora and Vegetation Survey, a single season Detailed Survey was conducted from May – June 2019 across further Additional Areas, adding another 11,181 ha to

the Greater Survey Area, also during this time targeted flora surveys were conducted across proposed infrastructure areas Table 1.

Table 1. West Musgrave Project Detailed Flora Survey Study Areas.

Phase 1 West Musgrave Project Flora Survey Study Area 2018		
Area	**Description**	**Total Area (ha)**
Project Development Area	Area is expected to contain mine deposits (Nebo-Babel), Integrated waste landform (IWL), stockpiles, process plant, power station, airstrip, and accommodation village facilities.	5,170
Western Access Road	Main mine access road used for incoming freight and outgoing concentrate	2683
Northern Access Road	Access road from Development Area to Jameson (Mantamaru).	2,592
North-eastern borefield	Borefield and Services tracks north-east of the development Area	5,487
Southern Borefield	Borefield and Services tracks south of the Development Area	9,964
Windfarm and Access Polygon	Location of proposed windfarm, associated service track and additional area adjacent to the Development Area.	2,808
Yappsu	A potential future resource deposit	362
Succoth	A potential future resource deposit	551
Total		**29,617.3**
Phase 2 West Musgrave Project Spring Detailed Survey Study Area 2018		
Area	**Description**	**Total Area (ha)**
Project Development Area	Area is expected to contain mine deposits (Nebo-Babel), Integrated waste landform (IWL), stockpiles, process plant, power station, airstrip and accommodation village facilities.	5,170
Northern Access Road	Access road from Development Area to Jameson (Mantamaru).	2,315
Windfarm and Access Polygon	Development area of future proposed windfarm, and potential windfarm service access track for the development	2,808
Total		**10,293**
Additional Areas West Musgrave Project 2019		
Area	**Description**	**Total Area (ha)**
Northern Borefield Extension	Extension of current proposed borefields to the north east of the main Project Development Area to enable increased water supply capacity.	3855
South Eastern Windfarm Extension	Expansion of the current windfarm area for additional wind turbines for increased power generation capacity	1174

Officer Basin Borefield	Extension of current proposed borefields to the south of the Southern Borefield to enable increased water supply capacity.	6152
Solar Farm	Development area of future proposed solar farm, within the current Project Development Area	626
		11,809
Northern Borefield Infill Vegetation Mapping	Three infill areas were mapped by extrapolation based on the surrounding mapped vegetation associations	617.2
Total Area		**41,519.2**

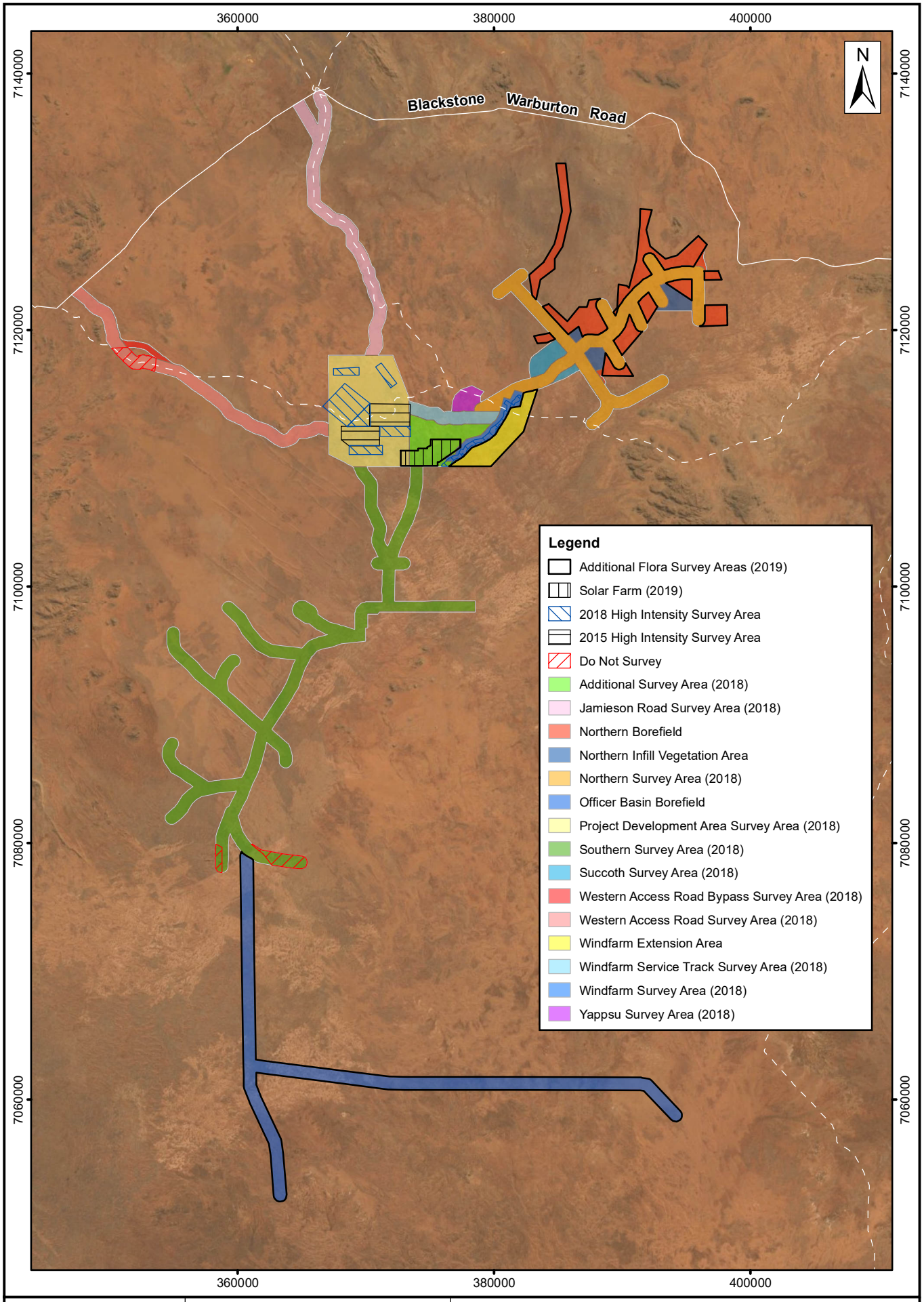
This report incorporates the results of an earlier survey conducted by Western Botanical in 2014 - 2015 that represented the first phase of a Level 2 (Detailed Survey equivalent) across the central 3,025 ha portion of the Development Area. The total survey area including all the 2014 -2015, 2018 and 2019 surveys, referred to as the Greater Survey Area, totals 41,519.2 ha.

The 2018 surveys represent a Detailed two–season survey for the 10,293 ha portion of the Survey Area incorporating (i) Vegetation mapping to NVIS *Level V Association* supported by quadrats, traverses and relevé sampling, (ii) an inventory of all vascular flora encountered, (iii) rescoring of quadrats and installing further quadrats to support vegetation mapping realignments and (iv) significant species searches and weed mapping. During the 2015 survey the two proposed resource deposits (Babel and Nebo), representing a 3,025 ha portion of the Project Development Area, were systematically surveyed for known Priority Flora and flora with potential significance. Further systematic and targeted Priority Flora or other significant flora species searches were conducted during the second phase survey with a further 1,240 ha across the proposed infrastructure areas surveyed. This results in a total of 4,265 ha or 82.5% of the Project Development Area (5170 ha) being systematically searched for Priority Flora or other potentially significant vascular flora species. The proposed Windfarm infrastructure area was also searched due to the increased likelihood for Priority Flora to occur on the sand dune systems associated with this infrastructure (Figure 3). The remainder of the Project Development Area, Northern Access Road, and Windfarm additional area and access were not systematically assessed. They were instead target-searched for Priority Flora or other known significant vascular flora species based on habitat requirements using the results from the opportunistically located Priority flora located during the first phase survey. Non-vascular flora were not assessed at any stage.

A single season Detailed Survey was conducted across the remaining 30,505 ha of the Greater Survey Area. Vegetation over this area was mapped to NVIS Level *V Association* supported by (i) quadrats, traverses, and relevé sampling, and (ii) an inventory of all vascular flora encountered. Opportunistic records for significant species or weed species were recorded, none of the quadrats were revisited, and the vegetation mapping alignments were not adjusted.

A number of areas were excluded from survey due to heritage sensitivities and these were avoided during field assessments.

Figure 3. The Greater Survey Area Defined.



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Scale: 1:400,000
MGA94 (Zone 52)

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Date: March 2020 | Rev: A | A4

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OZ Minerals / Cassini JV

West Musgrave Flora Survey Area

Survey Areas

2.5. Physical Environment

The climate of the region is described as arid, with both summer and winter rainfall patterns. The region receives a mean of 286.1 mm of rainfall annually with the nearest records collected since 1940 at Warburton Airfield weather station (weather station number 13011) located 100 km west of the Survey Area. Other regional weather stations used to assimilate the final data included Giles Meteorological Office (13017) located 120 km north of the Survey Area with records going back to 1956, Tjukayirla (13040) located 300 km south-west of the Survey Area with records dating back to 1994, and Ikurlka Weather Station (12240) which opened in 2005 located 220 km south of the Survey Area. A comparison of the mean rainfall data collected from these four stations was used to garner a regional perspective on the historical rainfall and temperature records compared with the condition prior to the survey is presented in Figure 4. The graph presents the recent 2018 rainfall records compared with those recorded during 2017 and the long-term mean rainfall records from these weather stations. The mean maximum temperatures have been recorded at Warburton since 1969 and at the Giles Meteorological Office since 1956.

Rainfall records show that 2017 recorded an above-average rainfall with 386.2 mm recorded regionally, 100 mm above the 286.1 mm mean. The majority of the rainfall was received during January with 140.8 mm recorded followed by an above average April of 60 mm recorded, resulting in over half the year's total rainfall received within these two months. Above average rainfall was also received in October with 40.3 mm (mean of 14.3 mm).

During 2018 and just prior to the winter survey, above average regional rainfall was again recorded early in the year, with January and February recording 71.7 mm (mean of 37.5 mm) and 82.6 mm (mean of 47.5 mm), respectively. However, the three months preceding the survey from March to May had below-average rainfall with a total of 12.3 mm recorded, below the long-term average for this period of 71.4 mm (Bureau of Meteorology 2019) (Figure 4). This meant that during the June - July 2018 surveys, annual flora species were generally absent and if present were in poor condition at the time of the survey. Unfortunately, the 2018 seasonal conditions did not improve and below average rainfall was recorded throughout the winter and spring period. Only a further 39.3 mm was recorded prior to the spring survey, below the long-term average over this same period of 59.0 mm. The spring 2018 seasonal conditions were considered poor with very few annual flora present and therefore they were unable to be fully assessed throughout the Survey Area.

The 2019 winter survey was conducted following below average rainfall from January through to May. Preceding the survey only 27.5 mm of rain was recorded across this period compared with the long term average from records dating back to 1940 of 151.3 mm across the same period.

Whilst it is useful to look at the regional rainfall to gain an understanding of the average rainfall across the region, the weather patterns can often bring localised storm weather events that can produce relatively high amounts of local rainfall. These storm events can revive, stimulate

flowering, vegetation growth, and encourage the germination of opportunistic species within the area of the storm's path and associated catchments. This was the case when a localised storm was witnessed by the author within the recently burnt (November 2017) southern portion of the Survey Area, resulting in excellent regeneration of that vegetation, and again at the end of the 2019 survey period where a local storm was experienced at the West Musgrave Project, which delivered enough rain to stimulate the desert frogs to come out of hibernation.

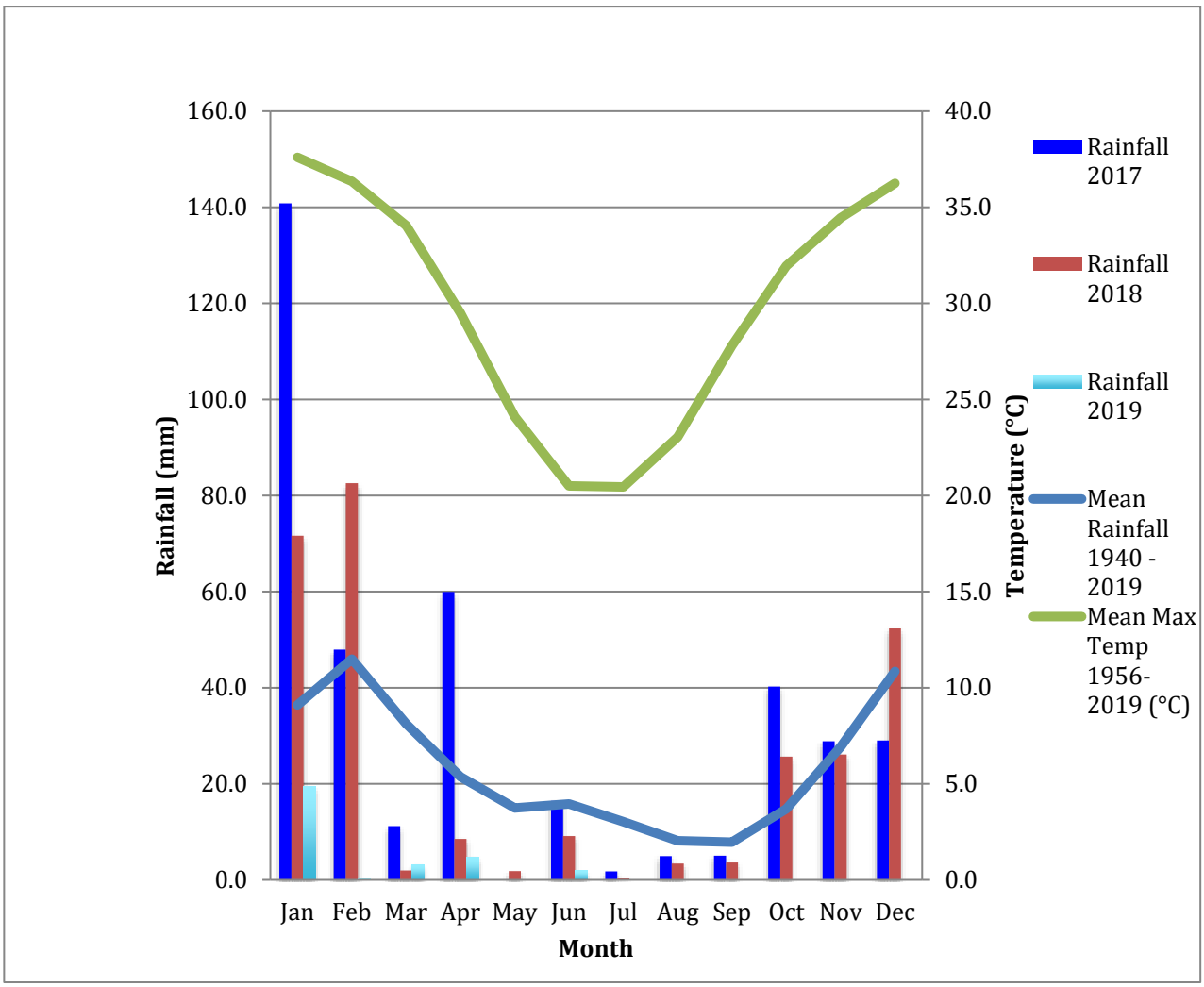


Figure 4. Combined regional rainfall and temperature data recorded at four separate weather stations located within a 300km radius of the Survey Area (Bureau of Meteorology 2019).

2.5.1. Geology

The WMP lies within the Mann-Musgrave Block subregion (CR1) of the Central Ranges CER1 Interim Biogeographic Regionalisation for Australia (IBRA) region. This subregion is characterised by a high proportion of Proterozoic ranges including both volcanic, quartzite and derived soil plains, which are interspersed with red Quaternary sandplains with some Permian exposure (Graham & Cowan 2001). The West Musgrave mineral district of magmatic ore deposits extends over a distance of at least 40 km and represents a relatively recently established

prospective region. This district is globally significant, being one of only ten mafic-intrusion hosted nickel-copper-platinum group element deposits that have been discovered in Australia.

The Nebo-Babel deposits are hosted by a sub-horizontal, concentrically zoned, tube-shaped (chonolithic) gabbronorite intrusion. The east-west trending mafic intrusion has a known extent of 5 km, with a gentle 15 degree dip to the south, and in the case of Babel, a less than 10 degree plunge toward the south-west. Babel and Nebo are separated by the steeply-dipping, north-south trending Jameson Fault, with Babel to the west of the fault and Nebo to the east (Figure 5).

Babel consists of three main lithostratigraphic units, which are variably textured leucogabbronorite (VLGN) that forms the outer shell around mineralised gabbronorite (MGN), and barren gabbronorite (BGN) in the core of the intrusion. At Nebo, the main lithostratigraphic units are VLGN that forms an outer shell of the intrusion, around BGN and oxide-apatite gabbronorite (OAGN), which occur in the core of the intrusion at the eastern end (Seat *et al*. 2007). The Nebo-Babel deposits contain two main styles of mineralisation: massive and breccia sulphides, which are a comparatively minor component of the overall sulphide inventory and disseminated gabbronorite-hosted sulphides that represent the bulk of the mineralisation. Massive and breccia sulphides at both deposits comprise, in decreasing abundance, pyrrhotite, pentlandite, chalcopyrite and trace pyrite. In most of the shallower intersections, supergene alteration has modified the primary sulphide assemblages to pyrite and violarite. The disseminated mineralisation at both deposits occurs as blebs in gabbronorites. Nickel and copper grades at Nebo and Babel are at a 1:1 ratio with higher grades occurring in the massive sulphides and marginal breccia zones. Lower nickel and copper grades occur in the disseminated sulphide zones (OZ Minerals 2017).

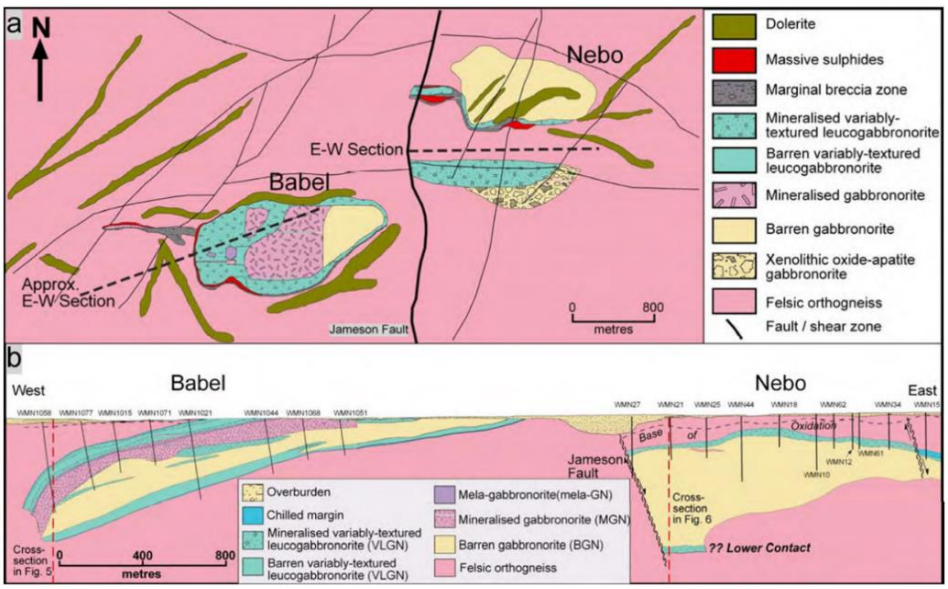


Figure 5. Plan (a) and Long Section (b) Views of the Nebo-Babel Deposits (Seat *et al.* 2007).

2.5.2. Landforms and Soils

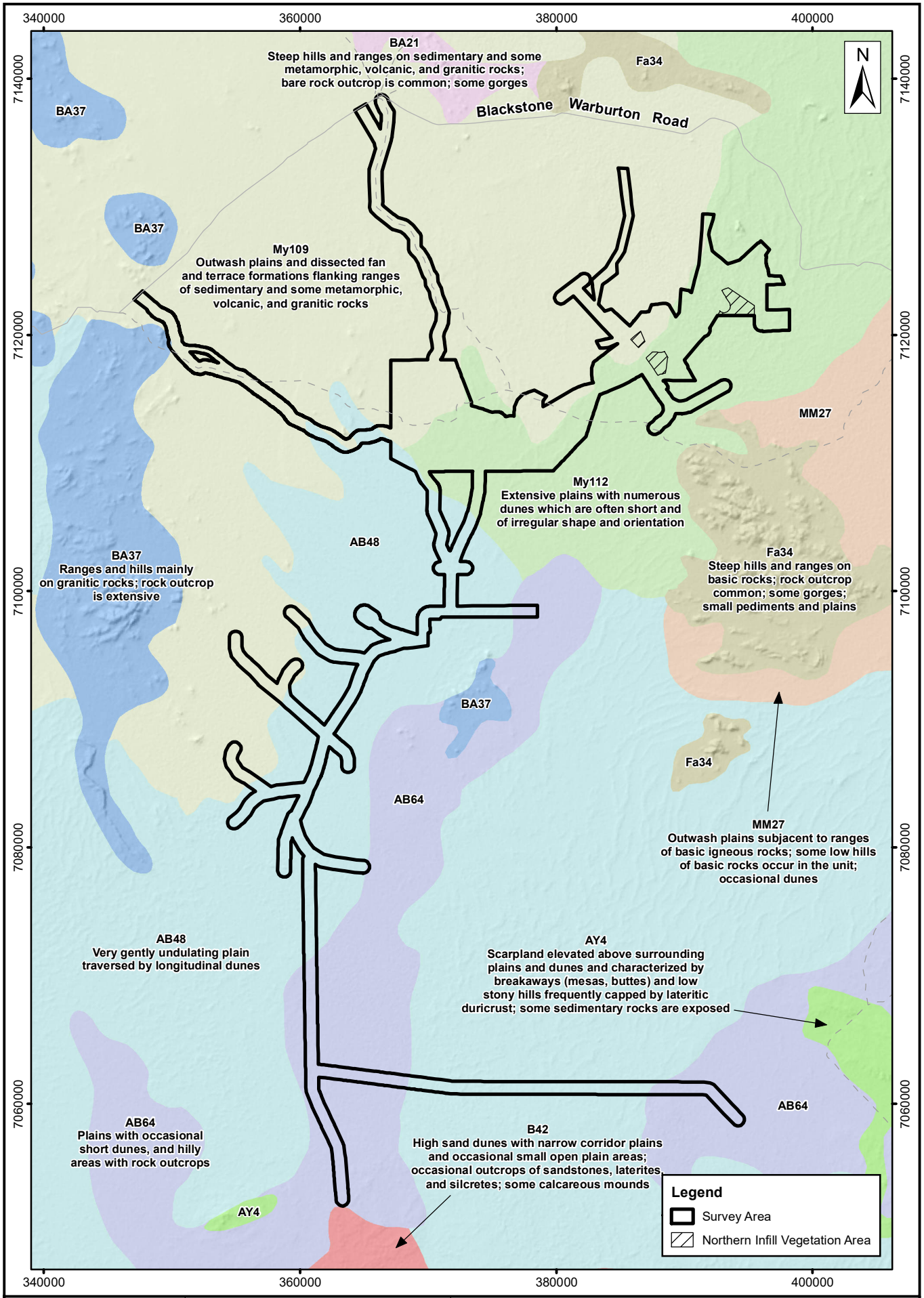
The WMP is located within Western Desert Ranges Province soil-landscape region, as classified by the Western Australian Department of Industries and Regional Development (DPIRD, previously Department of Agriculture and Food WA (DAFWA)). The Desert Ranges Province has been described at the regional level as sandplains and dunes (with hills and ranges surrounded by wash plains) on granitic and volcanic rocks of the Musgrave Complex and sedimentary rocks of the Amadeus Basin (Tille 2006). Soils typically present include red sandy earths, red deep sands and red loamy earths, with some stony soils. The province is located in the central eastern Arid Interior, extending from Warburton to the South Australian border and Lake McDonald.

The Survey Area is gently undulating at an elevation of approximately 470 metres Australian Height Datum (mAHD), with sand dunes providing sporadic relief up to 15 metres relative height. Landforms of the Survey Area are dominated by sand sheets, low sand dunes, low calcrete outcrops and clayey hardpan plains. Internally draining claypans are common in low lying areas and gilgai. Calcareous soils are expected to be widely occurring in these low lying areas. Extensive groundwater calcrete platforms are present, particularly in the central and southern portions of the Greater Survey Area. Colluvial slopes and outwashes occur adjacent to elevated areas where they occur. The ground cover is predominantly Spinifex grassland (*Triodia* spp.) supported by a thin cover of aeolian sand.

The Survey Area overlies five DAFWA land system units (My109, My112, AB48, AB64, and BA37) (DAFWA 2017) (Figure 6) of which the following two cover the majority of the Survey Area:

- Outwash plains and dissected fan and terrace formations flanking ranges of sedimentary and some metamorphic, volcanic, and granitic rocks. Main soil types are expected to be red loamy earth (40%), red sandy earth (25%) and red-brown shallow hardpan loam (15%) (My109).
- Extensive plains with numerous dunes which are often short and of irregular shape and orientation. Main soil types are expected to be red sandy earth (40%), red loamy earth (35%) and red deep sand (25%) (My112).

Figure 6. Land Systems of the Survey Area.



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Scale: 1:400,000
MGA94 (Zone 52)

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OZ Minerals / Cassini JV

West Musgrave Flora Survey Area

Land Systems (Dept of Ag & Food WA)

2.6. Ecology

The Nebo - Babel deposits are situated within the Giles Botanical District of the Eremaean Province that is characterised by ranges and hills interspersed in sand plains with rocky loams and red soils and sands (Beard 1990).

More specifically it is located within the Mann-Musgrave Block sub-region of the Central Ranges (CR1) IBRA region (Thackway & Cresswell 1995, Beard 1990). The Central Ranges region extends from the Northern Territory into South Australia and Western Australia, creating a cross-over of flora species throughout the region. The regional sandplains support low open woodlands of either Desert Oak (*Allocasuarina decaisneana*) (in the east) or Mulga (*Acacia aneura* group) (in the west) over hummock Spinifex grasslands of *Triodia basedowii*. The sub-region is rich and diverse in both flora and fauna, however, most species are wide ranging and usually occur in at least one other adjoining biogeographic region. The region is subject to high levels of grazing by feral herbivores including Camels and Donkeys (Graham & Cowan, 2001).

The Southern Borefields including the Officer Basin are located within the Central and Maralinga subregions (GVD02 and GVD03 respectively) of the Great Victoria Desert IBRA region (Department of the Environment and Energy 2018). These subregions support a tree steppe of *Eucalyptus gongylocarpa*, Mulga and *E. youngiana*, over hummock grassland, which is dominated by *Triodia basedowii* on aeolian sands (Barton & Cowan 2001).

2.7. Hydrogeology and Surface Hydrology

The Survey Area lies within the East Murchison Groundwater Area and the Officer Groundwater Sub-area of the Musgrave Province. The Musgrave Province is composed of igneous and metamorphic rocks, which form a regional fractured rock aquifer with minimal available water (low primary porosity inferred) (CDM Smith 2018a). Palaeovalleys are incised into the bedrock terrane of the Musgrave Province, with overlying Quaternary calcrete, aeolian sand and playa deposits (Zang & Stoian 2006). Several palaeodrainage systems originate from the Musgrave Province including the Kadgo Palaeovalley, which starts to the north-west of the Project and drains into the Officer Basin to the south.

Groundwater investigations conducted by CDM Smith (CDM Smith 2018a; 2018b) indicate that the water table is relatively shallow (<5 mBGL) in low lying areas and most likely intersects calcrete in some parts of the Survey Area. In the surrounding ranges, depth to groundwater is estimated at 20 mBGL. Groundwater predominantly flows from topographically elevated areas to the north, east and west of the WMP, through the palaeochannel towards the low-lying areas to the south.

Two sedimentary units were identified within the Kadgo palaeochannel, an upper unit comprising alluvial and colluvial sediments that have been substituted by calcrete near the surface, and an underlying basal sand aquifer. These units are separated by a confining layer of clays and the basal

sand aquifer is expected to be confined, whilst the upper sediments are expected to be unconfined to semi-confined with respect to groundwater flow.

Water quality in the palaeochannel is typically brackish, with total dissolved solids (TDS) concentrations generally less than 3,000 mg/L. High evaporation rates combined with small but highly variable rainfall suggests that groundwater recharge may be episodic, and studies have estimated groundwater recharge in the Musgrave Basin to be between 0.05% and 19% of average annual rainfall (Magee 2009).

Surface water flow in the region is severely limited by a combination of high evaporation/evapotranspiration rates and low annual rainfall. The area immediately surrounding the proposed mine and supporting infrastructure is characterised by poorly defined surface water catchments and unconnected ephemeral drainage lines, with the dune fields of the Great Victoria Desert being the dominant landform.

Potential for relatively high infiltration rates exists in the Survey Area, which can be attributed to the predominance of sandy soils and shallow calcrete horizons. Where rainfall is sufficient to generate runoff, sheet flow is expected (CDM Smith 2018b).

2.7.1. Conservation Estate

Although the area is registered on the Register of the National Estate, there are no Conservation Reserves within the Central Ranges IBRA region (Graham & Cowan, 2001). The closest reserve is the Gibson Desert Nature Reserve some 155 km north-west of the Survey Area within the Gibson Desert biogeographic region. The Neale Junction Nature Reserve is some 190 km to the south-west; the Yeo Lakes Nature Reserve is some 220 km south-west; the Plumridge Lakes Nature Reserve is 280 km south-west and the Great Victoria Desert Nature Reserve is some 290 km south of the Survey Area, all situated within the Great Victoria Desert biogeographic region. The Uluru - Kata Tjuta National Park is some 210 km east-north-east of the Survey Area while the West MacDonnell National Park is some 360 km east-north-east of the Survey Area, both within the Northern Territory (Figure 2).

3. Methods

3.1. Desktop Survey

The desktop assessment involved a review of both Threatened species and Threatened Ecological Communities listed under the *Environment Protection and Biodiversity Conservation Act 1999* (C'th) at the point 26.276158°S, 127.669858°E with a 50 km buffer applied, (DoEE 2018). A search for known Threatened and Priority Flora listed by the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA) through their Threatened and Priority Flora (TPFL) and WA Herbarium (WAHERB) Databases was obtained for the site (Reference 13-0618FL), using the same point with a 100 km radius search buffer. A NatureMap species report was generated with a 40 km buffer applied (NatureMap 2018). Interstate occurrences of focus species were reviewed using the Australia's Virtual Herbarium portal.

Previous reports prepared by, Mattiske Consulting and Coffey Environments for WMC Resources, and reports prepared by Western Botanical for BHP MinEx and Cassini dealing with the flora and vegetation of the region inclusive of the Survey Area were reviewed as part of the desktop assessment. Significant flora identified through works for AAEA have been listed, however, detailed information on occurrences of these from AAEA surveys have not been utilised for presentation on maps at this stage as they occurred at some distance from the Survey Area.

Added to this the presence of known Priority Ecological Communities and Threatened Ecological Communities were assessed via a DBCA TEC/PEC Database Search (Reference 04-0618EC) for the same coordinate with a 100 km buffer applied.

3.2. Field Survey Timing and Tasks

This report synthesises the findings of two phases of field surveys. The first field program was conducted for Cassini Resources over the periods September - October 2014 and June 2015; and the second phase was implemented for the JV in June – December 2018, followed by Additional Survey areas in June 2019.

During the 28th September to the 8th October 2014 survey, vegetation mapping was conducted over a reduced Survey Study Area, with known Priority Flora and other significant vascular flora species searches systematically traversed across the area. This was followed by a second field survey, from the 1st of June to the 15th of June 2015. During this field survey, 51 quadrats were installed and recorded across a slightly expanded survey area. Following this survey, after much of the data management and specimen identifications had been completed, the project was put on hold.

In 2018 following the formation of the JV, Western Botanical was commissioned to conduct the current survey over the entire Survey Area totalling 27,162 ha. The first phase winter survey was conducted from the 6th June to 25th July 2018. During these surveys the vegetation was mapped to

NVIS Level V Association with quadrats and relevé sites installed and recorded. A total of 99 quadrats and 90 relevé sites were installed across the Greater Survey Area including the proposed Western Access Road, Project Development Area, Northern Access Road, and the Southern and Eastern borefields (Figure 9). A comprehensive list of the flora occurring within the Survey Area was compiled and indicative locations of Priority Flora and weed species were recorded using hand held Garmin 76 GPS units with an estimated positional error of +/- 4 to 5 m.

A spring 2018 survey was conducted over a reduced Survey Area (10,293 ha), as presented in Figure 7. This reduced Survey Area, referred to as the Detailed Survey Study Area, consisted of the Project Development Area, the Northern Access Road and the proposed Windfarm alignment, access track and Windfarm additional area. An additional five areas totalling 3,263 ha were also assessed during this survey period.

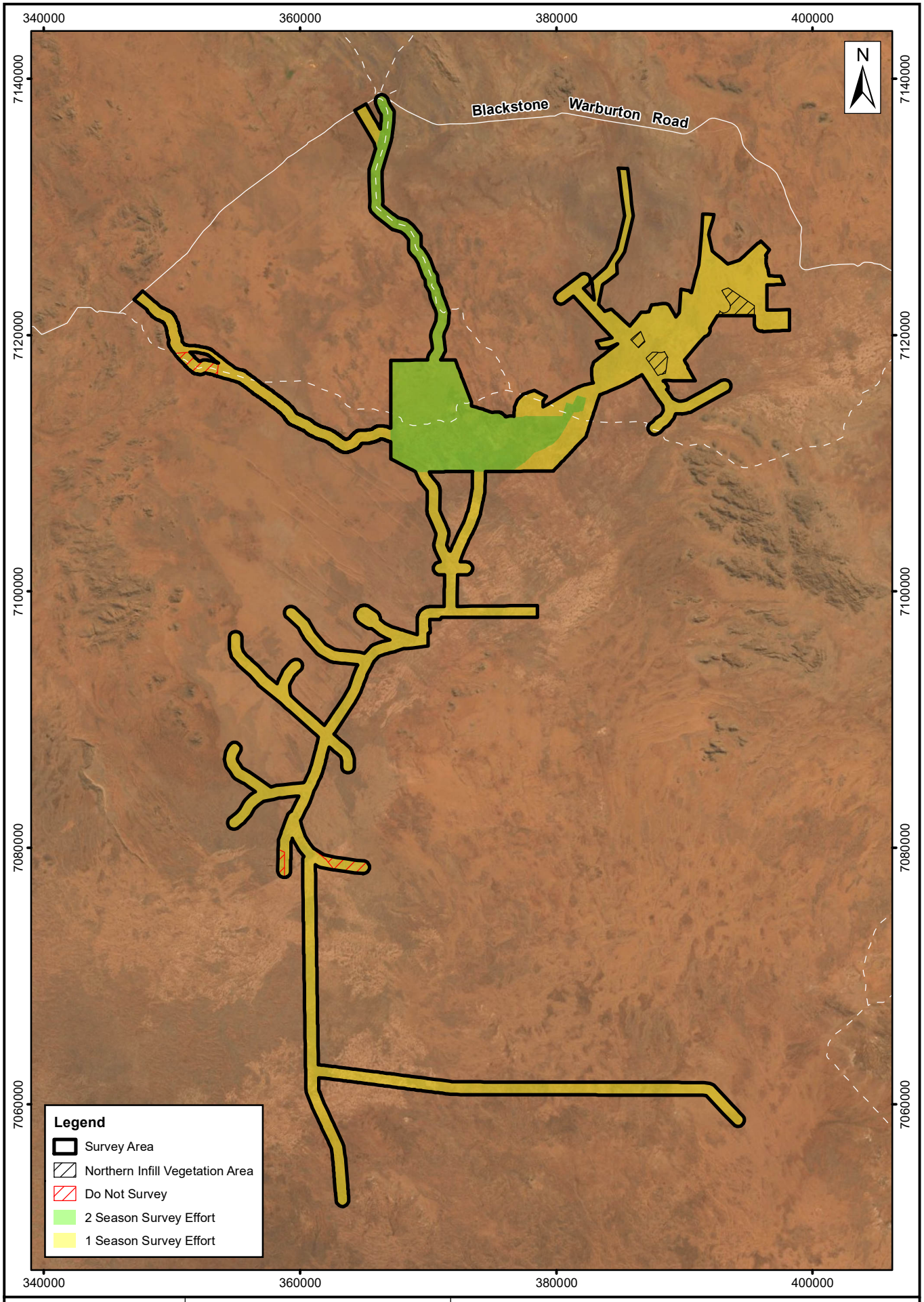
The spring survey period consisted of two field assessments, the first survey from the 31st October to the 14th of November 2018 followed by a second survey from the 21st of November to the 5th of December 2018. During the first of the spring field surveys and as part of the Detailed Survey, 48 quadrats within the reduced Survey Area were revisited and rescored with a further 17 quadrats set up and recorded within poorly represented or remapped vegetation associations. During this survey the vegetation association mapping boundaries were reviewed and the alignments adjusted as required based on the results of the initial statistical analysis together with a field assessment of quadrat position within the landscape. During this survey, an alignment to the Southern Borefields was mapped and quadrated, linking the Southern Borefield with the Development Area.

The second survey period from the 21st November to the 5th December 2018, consisted of significant species searches (including both known priority species and potential new species) and weed mapping. These searches were targeted across potential infrastructure areas within the Development Area, including two potential Airstrip sites, three potential Integrated Waste Landforms (IWLs) areas, and infill of an area between the 2014 significant species searches and the current search areas. Additionally, the sand dune system associated with the potential Windfarm infrastructure was also systematically searched for significant species. The remainder of the Project Development Area, Northern Access Road, and Windfarm additional area and access were not systematically assessed; they were instead target searched for Priority Flora or other significant vascular flora species based on habitat, using the results from the opportunistically located Priority Flora located during the first phase survey as a guide. Non-vascular flora species were not assessed.

Two potential future resource areas (Succoth and Yappsu) were mapped and quadrated, along with adjustments to the proposed Northern access alignment and realignment to the proposed Southern Borefield including the access to the proposed Southern Borefield. The Additional Areas that were mapped and quadrated with known Priority Flora and other significant vascular flora species opportunistically recorded, included Yappsu (362 ha) with six quadrats, Succoth (552 ha) with 13 quadrats, proposed Southern Borefield additional areas 1,981 ha with 12 quadrats (Figure 3).

Following the 2018 Detailed Flora and Vegetation Survey, two further flora and vegetation surveys were conducted; the first from 6th - 20th May and the second from the 29th May – 3rd June 2019. During the first survey, a team of two botanists mapped and quadrated Additional Areas around the proposed North Eastern Borefield Alignment (3,856 ha), whilst a second team of two botanists and a field assistant mapped and quadrated the proposed Officer Basin Borefield alignment (6,153 ha). During the second survey period, two botanists mapped and quadrated the Additional Area located south-east of the proposed Windfarm (1,174 ha) and also conducted a significant species search across 626 ha within the Detailed Survey Study Area for a proposed Solar Farm alignment (Figure 3).

Figure 7. The Detailed Survey Study Area.



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

0 5 10 km

Scale: 1:400,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_11

Date: March 2020 | Rev: A | A4

Western Botanical

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Survey Effort

3.3. Vegetation Association Mapping

Vegetation Association mapping within the Survey Area was conducted using high-resolution colour aerial photography at a scale of 1:10,000. The boundaries of vegetation associations were defined on the ground and confirmed whilst traversing the Survey Area, both on-foot and in-vehicle and drawn on laminated A2 field maps. All specimen data was recorded within quadrat data collection notebooks, or directly into laptop computers. On occasions two Vegetation Associations formed mosaics with each other where the boundaries between the associations interchanged frequently making the vegetation mapping at a scale of 1:10,000 difficult and on occasions impractical. On these occasions the Associations were mapped as mosaics and can be considered as a 50:50 mix of the two representative Associations.

3.3.1. Relevé Sites

Relevé sites were established to record, (i) the flora present, (ii) the vegetation structure, and (iii) define vegetation associations at representative locations. The area covered by each relevé site was approximately 20 m x 20 m at minimum and included structurally important species outside this area. The parameters recorded directly into the laptop computer at each relevé site were:

General: Vegetation Association, Date, Botanists recording

Location: Unique site number (eg: R01 to R90), Location within the Survey Area (Vegetation code), Coordinates recorded on handheld Garmin 76 GPS, datum WGS84 (accuracy +/- 5 m), Digital photograph

Vegetation: Species present (dominant species and their Percentage Foliar Cover (PFC)), and Structural description (Based on NVIS level 5 *Association* descriptions)

Disturbance: Vegetation condition, Fire Age

Physical conditions: Soils, Rocks, Landform description, Run off

3.3.2. Quadrats

Quadrat sites during the 2018 / 2019 survey were 20 m x 20 m in size (400 m^2), orientated north-south and east-west with wooden Jarrah pickets placed at each corner. The recommendation within EPA Technical Guidance 2016 states that quadrat size within the Central Ranges and Great Victoria Desert be 50 m x 50 m, however during the 2014 survey it was noted that this quadrat size was excessive and often difficult to place without capturing ecotones (e.g. across Sand Dunes often only 20 m to 40 m wide, or within the Calcrete Platforms Hummock grassland, also on occasions with very narrow occurrences. During the 2014 survey, 40 m x 40 m quadrats were installed often with the shape of the quadrat altered to avoid ecotones where possible, however this was not always possible. During the 2018 survey, following the relevé data collection and vegetation mapping process it was considered that 20 m x 20 m quadrats (400 m^2) would be

sufficient to capture the species richness across all the vegetation associations. However when the Calcrete *Corymbia opaca* open Woodland (CCoW) was later encountered a 50 m x 50 m quadrat was applied to adequately capture the Open woodland of *Corymbia opaca*. Also as a measure to qualify that the data collected was sufficient, a 10 m -20 m buffer area around each quadrat was surveyed for any additional species not recorded within the quadrat. Replicated quadrats of this sample area, inclusive of the few species occurring outside the quadrat sample area, were found adequate to sample and describe the species richness present at each site. Each quadrat was placed within the selected vegetation associations previously identified during the mapping process using relevé sites. The aim was to establish at least three representative quadrat sites per described Vegetation Association and more where an association was abundant and/or widespread. Digital photographs were recorded at each quadrat site, one from the north-west corner, one showing the vegetation within the quadrat and occasionally a third photo representing the general vegetation association being described. For the 2014- 2015 quadrats a central waypoint was calculated and used when presenting quadrat locations throughout this report. For the 2018 and 2019 quadrats the NW corner peg was used to locate the sample sites. During the 2018-2019 survey periods, the majority of the Jarrah pegs were removed following completion of the quadrats, leaving just the NW corner peg in place. The following parameters were recorded in field quadrat notebooks at each quadrat site:

General: Vegetation Association, Date, Persons recording, Quadrat size.

Location: Unique site number, Project name, coordinates recorded on handheld Garmin 76 GPS units, datum WGS84 (accuracy +/- 5 m), digital photograph from NW corner.

Vegetation: Species present - height and Projected Foliar Cover (PFC) for each species, Species outside of the quadrat (but not noted within), Structural description compatible with NVIS level V Association descriptions (NVIS Technical Working Group (2017)).

Disturbance: Vegetation condition, fire history.

Physical Conditions: Rock types, Soils, Landform Descriptions, Runoff.

All taxa occurring within the quadrats were either recorded using the collection number from the field herbarium, or were collected and added to the field herbarium for future reference. Where the projected foliar cover (PFC) for an individual taxon was less than 1%, it was recorded as present (+) only.

3.4. Vegetation Condition

Vegetation condition was assessed according to the scale presented in Keighery (1994) (Appendix 1) which assesses vegetation condition against clearing, weeds, grazing and disease. The vegetation condition was recorded at each of the quadrat and relevé sites. The EPA Technical Guidance (2016) recommends using an adapted version of this scale, however, during the survey

the Keighery (1994) scale was used. The Keighery (1994) scale can be easily adjusted to match the 2016 EPA Technical guidance recommended scale.

3.5. Weeds

During the 2014 / 2015 survey and the 2018 / 2019 survey, weeds and their indicative locations were opportunistically recorded with a waypoint, but in most cases there was no systematic attempt to map the distribution of each population or accurately estimate numbers. In some cases, actual counts were recorded in small infestations whilst descriptors of population size were applied where numbers of plants or areas of occupancy were large. This was particularly problematic for *Cenchrus ciliaris*, which has colonised along the major access tracks within the survey area and wider region.

During the targeted significant species transect searches, weed species locations and population numbers were recorded with waypoints.

3.6. Conservation Significant Flora

Conservation Significant flora are specially protected flora which have been adequately searched for and are deemed to be, in the wild, either rare, at risk of extinction, or otherwise in need of special protection, and have been gazetted as such (DBCA 2017).

Categories of specially protected flora are:

- T Threatened (Declared Rare Flora) species:
    - CR Critically Endangered species.
    - EN Endangered species.
    - VU Vulnerable species.
    - EX Presumed extinct species.
- P Priority species (P1 to P4).

Priority species (P) are possibly threatened species that do not meet survey criteria, or are otherwise data deficient, and are added to the Priority Flora lists under Priorities 1, 2, 3, or 4. These categories are ranked in order of priority for survey and evaluation of conservation status so consideration can be given to their declaration as threatened flora. The DBCA's Conservation Codes definitions are presented in Appendix 2.

During the 2015 field study over the smaller Survey Area, systematic surveys for Priority species were conducted on a grid basis in transects at approximately 50 m spacings. A targeted Priority species search has therefore been conducted over the main deposit areas encompassing the

proposed pits for both the Nebo and Babel deposits. This targeted Priority species search focussed on the species that were recognised as significant at that time of survey and did not include *Rhodanthe uniflora* (P1), *Acacia eremophila* var. Numerous-nerved variant (A.S.George 11924) (P3), *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) (P3), *Eragrostis* sp. Limestone (P.K. Latz 5921) (P3), or *Chrysocephalum apiculatum* subsp. *racemosum* (P3), as at that time they were not regarded Priority Flora and were only recently added to the Priority species list in 2018. However, during these 2015 searches, a complete inventory of all species recognised as unique or potentially significant were collected and recorded. Of the five priority species listed above, *Chrysocephalum apiculatum* subsp. *racemosum* (P3) is the only species likely to occur across this smaller Survey Area that may not have been recognised in 2015 as a conservation-significant taxon. The reason it may not have been recognised at the time of survey is attributed to the similarity and confusion in the taxonomy with both *Chrysocephalum apiculatum* subsp. apiculatum (now considered a South eastern Australian species) and *Rutidosis helichrysoides* which is also widespread across the Survey Area.

During the 2018 winter (Phase 1) survey period, species with conservation significance were recorded throughout the entire Survey Area when encountered opportunistically during vegetation mapping and quadrat and relevé establishment, giving an indication of species habitat preferences for particular vegetation associations. Populations of Priority Flora thus encountered were estimated and locations recorded.

During the spring 2018 (Phase 2) survey conducted across the Detailed Survey Study Area, systematic significant species searches were performed across the then potential proposed infrastructure locations including; the proposed Windfarm (WF), Tailings Storage Facility (TSF), a potential Integrated Waste Landform (IWL) area, two potential locations for proposed Waste Rock Landforms (WRL), two potential locations for a proposed Airstrip (AS) location, and proposed infrastructure locations. These areas were systematically searched on a grid basis using transects with botanists at approximately 100 m spacings. The selection of 100 m spacings was chosen to cover the large area as thoroughly and effectively as possible given the landscape and the potential for Priority species to occur. When Priority species were encountered, the size and boundaries of the population were recorded. The WF area was searched more intensely with botanists spaced at approximately 50 m apart and each sand dune system was systematically traversed and searched.

Additionally using the indication of species – habitat correlations from the 2018 first phase survey; (i) the Sand Dunes were targeted within the Detailed Survey Study area, searching primarily for *Aenictophyton anomalum* (P1), (ii) the Calcrete Platforms Hummock Grasslands were targeted for *Goodenia asteriscus* (P3), *Stackhousia clementii* (P3), and *Eragrostis* sp. Limestone (P.K. Latz 5921) (P3), (iii) the CPN-G areas were searched for *Aristida jerichoensis* var. *subspinulifera* (P3), and (iv) any locations of Priority Flora recorded, but not previously counted were revisited and assessed e.g. *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) (P3).

Following these surveys and during the second field survey period during 2019, the area designated for a proposed future solar farm was systematically traversed and searched for Priority Flora. During this search botanists surveyed transects approximately 100 m apart.

3.7. Flora Specimen Identification

All flora specimens that either were not readily identified in the field or were considered having either conservation or taxonomic interest were collected for further identification using the resources at Western Botanical and the West Australian Herbarium. Each specimen was recorded with a field name, date, prospect location, GPS point, relevé / quadrat number. A comprehensive list of all flora occurring within the Survey Area was compiled and records of Priority Flora were recorded using hand held GPS with a photograph taken in most cases.

As part of the specimen processing on return from the field survey, an identified specimen's name and current known range were checked on the WA Herbarium's Florabase website (WA Herbarium 2019) and Australia's Virtual Herbarium (AVH) website (CHAH 2018). All specimens collected were assigned a Western Botanical unique specimen number and entered into the Western Botanical specimen database.

3.8. Floristic Analysis

Flora data from the 2015 survey (quadrats) and 2018-2019 surveys (quadrats and relevé sites) were entered into proprietary Microsoft Access database (developed by Griffin, 2012). Statistical analysis of these sites was conducted to investigate floristic similarity amongst sites, groupings of sites, and the relationships amongst groupings. Projected foliage cover (PFC) for each species was used to incorporate dominance of key species within vegetation association groupings.

All annual species, weed species, and singleton species (those occurring at only one site) were excluded from the dataset to minimise noise within analysis and interpretation of results. A small number of taxa were merged for the purposes of analysis:

- Taxa with uncertain determination (e.g. *Austrostipa ?nitida*) were assumed correct and merged with records of certain determination (*Aristida nitida*).
- Hybrid taxa (typically mulga and *Senna* identities) were merged with their first/dominant component of their hybridity, with the exception of some mulga hybrids that were sufficiently abundant to retain as separate identities.
- Taxa of the same species, but different form/forma were merged where no difference in habitat was found during field survey.

Analysis of flora data was conducted using PATN v3.12 statistical package software (Blatant Fabrications 2004). Association (Bray and Curtis), Classification (Flexible UPGMA Agglomerative Hierarchical Fusion), and Ordination (Semi-Strong Hybrid) components of PATN

were utilised in the analysis. The primary output produced was a dendrogram of site (Quadrat and Relevé) similarity/dissimilarity with suggested vegetation association groupings provided by PATN.

Initial exploratory analysis identified 41 of the Project's 396 sites as outliers that were negatively affecting analysis by preventing coherent groupings of vegetation associations. Forty of these 41 outlier sites were relevé sites containing fewer recorded species and/or were placed within intergrades of vegetation associations. The remaining outlier was a quadrat representing the single site of the ArS association. As the only site representing a vegetation association it contained a species profile sufficiently different from all other sites that analysis could not satisfactorily separate the site from other vegetation associations. These 41 outlier sites were excluded from final floristic analysis but still of use for vegetation mapping purposes. Final analysis included 355 sites, consisting of 305 quadrats and 50 good quality relevé sites.

4. Results and Discussion

4.1. Previous Reports

Previous reports dealing with the flora and vegetation of the region inclusive of the Survey Area were reviewed in preparation of the desktop assessment. Significant flora and taxa of conservation significance were identified through works for AAEA have been listed, however, detailed information was not utilised. Reports relating specifically to the Babel and Nebo Prospects and the West Musgrave Project (WMP) Survey Area are presented in Table 2.

Table 2. Previous reports that have relevance to the WMP Survey Area.

Report Reference	Summary Findings and Updates to Conservation Significant Flora.
Western Botanical (Mar 2005a), Report WB291	Assessment of flora and vegetation of proposed drill hole sites at the West Musgrave Survey Area (6A). Described four vegetation associations and 102 native endemic flora and no Priority Flora species.
Western Botanical (2005b), Report WB315	Flora and Vegetation of the Babel, Nebo and East Chamber prospects, West Musgrave Project. A brief (2 day) field survey describing six habitat units and 61 native endemic flora species. One species with Priority Flora status, *Microcorys macredieana* P3 was recorded, now removed from the Priority Flora list.
Western Botanical (2007a), Report WB439	Supplementary drill hole assessments, Babel & Nebo tenements. A brief (one day) assessment of six drill pad sites describing three habitat units and reporting 39 species and no Priority Flora.
Western Botanical (2007b), Report WB459	Flora and vegetation assessments, West Musgraves tenements, Great Victoria Desert. Mapped a large area to the north-east of the WMP Survey Area using coarse satellite imagery and few traverses, equivalent to a Reconnaissance Survey. Reported 13 habitat units and 221 native endemic flora species including three Priority Flora species and one species with lingering taxonomic interest: • *Acacia* aff. *olgana* (G. Cockerton & G. O'Keefe 14274), remaining unresolved. • *Chrysocephalum* sp. Pilbara (H. Demarz 2852) has been described as *Chrysocephalum apiculatum* subsp. *pilbarense*, which does not occur in the WMP area. The latter species is probably *Chrysocephalum apiculatum* subsp. *glandulosum* which is widespread W.A., N.T. and S.A. • *Calotis latiuscula* P3. • *Goodenia lunata* P1. • *Stackhousia clementii* P1 at that time, now P3. • *Microcorys macredieana* P3 reported outside survey area, now removed from the Priority Flora list.

Report Reference	Summary Findings and Updates to Conservation Significant Flora.
Western Botanical (2008), Report WB535	Flora and vegetation of the tenement 69/2338. Reported 13 vegetation associations, no conservation significant flora, four species of interest: • *Acacia* sp. (G. Cockerton & S. McNee 24356) remains unresolved, requiring collection of flowering and fruiting material. • Poaceae sp. (G. Cockerton & S. McNee 24458 has been resolved as *Neurachne munroi*. • *Goodenia* aff. *hirsuta* (G Cockerton & S. McNee) remains taxonomically unresolved. • *Pityrodia loxophylla*, mis-named, should have been noted as *Pityrodia loxocarpa*, now renamed as *Quoya loxocarpa*.
Western Botanical (2012b) WB535	A brief site visit (one day) assessing a small area at Babel West. Reported 50 endemic species and no Priority Flora.
Western Botanical (Sept 2011b) WB734	Flora and vegetation assessment of the Gerar Study Area, portion of E69/2201. Reported 12 vegetation associations and 154 native flora species and two Priority species: *Calotis latiuscula* P3 and *Euphorbia parvicaruncula* P1.
Western Botanical (Aug 2011c), WB735	Flora and vegetation of the proposed Marlu trail. Reported three vegetation associations, one Priority species *Stackhousia clementii* P3 and a novel species *Goodenia* aff. *quasilibera* (RJP Davies & L Ransom LR868), now described as *Goodenia asteriscus* P3.
Western Botanical (2012a), Data for report WB762	Flora and vegetation of the Mt Squires prospect E69/2067. Reported 17 vegetation associations and two priority species, *Calotis latiuscula* P3 and *Amaranthus centralis* P3. Five undescribed species were also reported (the first two only associated with rocky hill, grano-diorite, landscapes): • *Tephrosia* sp. Central (G. Cockerton & R. Mason WB32916) is equivalent to *Tephrosia* sp. Central (PK Latz 17037), now P3. • *Thryptomene* sp. Warburton (G. Cockerton & R. Mason 32925), is listed as Thryptomene sp. Warburton (M. Henson & M. Hannart WB32433) P1. • *Sida* aff. *aprica* (G. Cockerton & R Mason WB32930). • *Indigofera* sp. Warburton (A.A. Muni 5209) has since been described as *Indigofera warburtonensis* P1. • *Chrysocephalum* sp. Pilbara (H. Demarz 2852) has been described as *Chrysocephalum apiculatum* subsp. *pilbarense*, which does not occur in the WMP area. The latter species is probably *Chrysocephalum apiculatum* subsp. *glandulosum* which is widespread W.A., N.T. and S.A.

Report Reference	Summary Findings and Updates to Conservation Significant Flora.
Western Botanical (2012a), Report WB764	Assessment of the flora and vegetation of the Babel West prospect, E69/2201, M69/72 and M69/73. Reported 12 vegetation associations, 156 native endemic flora, no listed Priority species, two novel species: • *Goodenia* aff. *quasilibera* (RJP Davies & L Ransom LR868), now described as *Goodenia asteriscus* P3. • *Indigofera* sp. (M. Henson & M. Hannart WB32307) aff. *boviperda* subsp. *eremaea*, not yet described.
Western Botanical (May 2014a), Report WB831	Reported six vegetation associations mapped on coarse Landsat imagery, 172 native endemic flora and no conservation significant species.
Western Botanical (Dec 2014b), Report WB836	Level 1 Flora and Vegetation Survey, Babel & Nebo tenements M69/72, M69/73 and M69/74. Reported nine vegetation associations; the presence of *Calotis latiuscula* P3 and *Amaranthus centralis* P3 and weed species.
Western Botanical (Sept 2016), Report WB862	Desktop review of flora, vegetation and fauna of the Mt Squires tenements. Reported on five Priority species known within the WMP Study Area and a further 16 Priority species known outside, but nearby the Study Area. Discussed a further nine taxonomically poorly known species, some with anomalous distributions and others with anomalous phenotypic features. Discussed Threatened fauna species known in the region including the WMP Study Area.
Western Botanical (Dec 2017a), Report WB881	A wide-ranging and detailed desktop synopsis of conservation significant flora of the region known to date using DBCA data as well as previous reports by Western Botanical for the WMP.
Western Botanical (Dec 2017b), Report WB883	Targeted Survey for conservation significant flora, portion of the WMP Southern borefield. Mapping the proposed access road into part of the Southern borefield, reporting 163 native endemic flora including three Priority Flora species: • *Acacia eremophila* numerous nerved variant (A.S. George 1192) P3. • *Goodenia asteriscus* P3. • *Stackhousia clementii* P3.

4.2. Desktop Assessment of Significant Flora

Significant Flora may be considered significant for a range of reasons, including but not limited to (i) those species with formal Conservation Status (Threatened or Priority Flora), (ii) those species which are poorly known in W.A, but lack formal Conservation Status, (iii) those species having taxonomic anomalies which are in need of review and may represent new species, and (iv) those species that representative of the extremities of their known range, or isolated outliers of their known range. The desktop survey conducted in late 2017 (Western Botanical 2017a), was used as the basis for the current field survey, supplemented by the current DBCA Database and Protected Matters Search records (Appendix 3). The NatureMap database result was useful as guidance as to the species already known within a 40 km radius of the Survey Area (Appendix 4).

National occurrences of Priority Flora or species of interest were reviewed using the AVH website and distribution maps, combining data from all Australian herbaria. Combined results are summarised in Table 3. Details of the current assessment are presented in Table 4.

Table 3. Summary Table, 2018 Desktop Significant Flora Assessment.

Category	Western Botanical (2017)	Desktop 2018/2019
Total Priority Species	35	48
Threatened Flora (DRF)	Nil	Nil
Priority 1	15	18
Priority 2	4	6
Priority 3	14	21
Priority 4	2	3
Potential novel species	2	1 [1]
New species requiring Conservation Status review	2	0
No Conservation Listing but poorly known in WA	4	1
No Conservation Listing but in need of taxonomic clarification	5	6

[1]Potential new *Ptilotus* species reported by Coffey Environments (2010) can't be verified as no reference specimen is available and the record is considered unreliable.

A likely reason for the increase in species returned in the DBCA database searches between the 2017 to 2018/2019 searches is an enlarged area used to capture DBCA records during the 2018/2019 versus the previous assessment. However, in early 2018 three species from the region were added to the Priority Flora list: *Aenictophyton anomalum* P1, *Rhodanthe uniflora* P1, and *Tephrosia* sp. Central (P.K. Latz 17037) P3. A further three species, *Chrysocephalum apiculatum* subsp. *racemosum* (P3), *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) (P3), and *Eragrostis* sp. Limestone (P.K. Latz 5921) (P3) were added to the Priority Flora list in October 2018, whilst *Calotis latiuscula* formerly a Priority 3 species was removed from the Priority species list due to a greater understanding of the current distribution brought about through an increased survey effort both within the Central Ranges and Pilbara Bioregions.

Table 4. Conservation Significant flora recorded within the region with potential to occur within the Survey Area.

Conservation Significant Flora	Cons_Status	Data Source							
Species		WB831 Jun 2014 Desktop	WB862 Sep 2016 Desktop	Coffey Jan 2010	Coffey Mar 2010	DBCA Databases Nov 2017			DBCA Databases 2018
						TP List	TPFL	WA Herb	
Abutilon sp. Warburton (A.S. George 8164)	P1	**1**	**1**			**1**			
*Aenictophyton anomalum**1	P1								Added to Priority List in 2018
Apowollastonia stirlingii subsp. *stirlingii*	P1					**1**			
Elacholoma sp. Showy flowers (C.P. Campbell 1762) PN	P1								Returned in 2018 TP List
Eremophila viscimarginata	P1					**1**			
Goodenia hirsuta	P1	**1**	**1**						
Goodenia lunata	P1	**1**	**1**						
Indigofera warburtonensis *2	P1	**1**	**1**			**1**		**1**	
Maireana sp. Patience (C.P. Campbell 1052)	P1					**1**			
Menkea lutea	P1	**1**	**1**		**1**				
Micromyrtus helmsii	P1	**1**	**1**						
Mitrasacme katjarranka	P1					**1**			
Neurachne lanigera	P1	**1**	**1**			**1**			
Philotheca eremicola	P1					**1**			
Rhodanthe uniflora	P1								Added to Priority List in 2018
Thryptomene sp. Warburton (M. Henson & M. Hannart 32433) *3	P1	**1**	**1**			**1**		**1**	
Triodia nana	P1								Returned in 2018 TP List
Verticordia mirabilis	P1	**1**	**1**			**1**			Returned in 2018 TP List

Conservation Significant Flora	**Cons_Status**	**Data Source**							
Species		WB831 Jun 2014 Desktop	WB862 Sep 2016 Desktop	Coffey Jan 2010	Coffey Mar 2010	DBCA Databases Nov 2017			DBCA Databases 2018
						TP List	TPFL	WA Herb	
Calytrix warburtonensis	P2								
Eremophila jamesiorum	P2					**1**			
Eremophila undulata	P2								Returned in 2018 TP List
Goodenia virgata	P2					**1**			
Teucrium grandiusculum subsp. *grandiusculum*	P2	**1**	**1**						
Thysanotus sp. Desert East of Newman (R.P. Hart 964)	P2					**1**			
Acacia eremophila var. Numerous-nerved variant (A.S.George 11924)	P3								Returned in 2018 TP List
Amaranthus centralis	P3	**1**	**1**			**1**		**1**	
*Calotis latiuscula**4	P3	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
Chrysocephalum apiculatum subsp. *racemosum* *5	P3								Added to Priority List in early Oct. 2018
Comesperma sabulosum	P3								Returned in 2018 TP List
Dampiera atriplicina	P3					**1**			
Daviesia arthropoda	P3	**1**	**1**			**1**			
Eragrostis lanicaulis	P3					**1**			
Eragrostis sp. Erect spikelets (P.K. Latz 2122)	P3								Added to Priority List in late Oct. 2018
Eragrostis sp. Limestone (P.K. Latz 5921)	P3								Added to Priority List in late Oct. 2018
Eucalyptus sparsa	P3	**1**	**1**						
Euphorbia parvicaruncula	P3	**1**	**1**					**1**	

Conservation Significant Flora	**Cons_Status**	**Data Source**							
Species		WB831 Jun 2014 Desktop	WB862 Sep 2016 Desktop	Coffey Jan 2010	Coffey Mar 2010	DBCA Databases Nov 2017			DBCA Databases 2018
						TP List	TPFL	WA Herb	
Goodenia asteriscus *6	P3	**1**	**1**	**1**					
Goodenia gibbosa	P3								Revised from P1 to P3 2018 TPFL
Goodenia modesta	P3					**1**			
Korthalsella leucothrix	P3					**1**			
Lythrum paradoxum	P3	**1**	**1**						
Melaleuca nanophylla	P3	**1**	**1**						
Sporobolus blakei	P3					**1**			
Stackhousia clementii	P3	**1**	**1**			**1**		**1**	
Tephrosia sp. Central (P.K. Latz 17037) *7	P3		**1**						Added to Priority List in 2018
Thryptomene nealensis	P3								Returned in 2018 TPFL
Verticordia jamiesonii	P3					**1**			
Vittadinia pustulata	P3								Returned in 2018 TPFL
Acacia calcicola	P4	**1**	**1**						
Comesperma viscidulum	P4	**1**	**1**						
Olearia arida	P4								Returned in 2018 TP List
Ptilotus sp. nov. (Coffey Environments Mar 2010 s.n.) *8 #	sp. nov.				**1**				
Indigofera helmsii *9	Nil	**1**	**1**						
Indigofera sp. nov. aff. *boviperda* (M. Henson & M. Hannart WB32307) #	Nil	**1**	**1**						
Sida sp. aff. *aprica* (G. Cockerton & R. Mason WB32390) #	Nil	**1**	**1**						

Conservation Significant Flora	Cons_Status	Data Source							
Species		WB831 Jun 2014 Desktop	WB862 Sep 2016 Desktop	Coffey Jan 2010	Coffey Mar 2010	DBCA Databases Nov 2017			DBCA Databases 2018
						TP List	TPFL	WA Herb	
Acacia sp. aff. *olgana* (G. Cockerton & G. O'Keefe WB14274) #	Nil	**1**	**1**						
Triodia helmsii *10	Nil	**1**	**1**						

Key:

*1 *Aenictophyton anomalum* (M. Henson & M. Hannart WB32348) is only known from 1 record at WA Herbarium, record by Henson & Hannart is second record in W.A., also present in N.T. and QLD (highly disjunct). Added to the Priority Flora list in 2018.

*2 *Indigofera warburt*onensis, formerly Indigofera sp. Warburton (A.A. Munir 5209), only 4 records at WA Herbarium, 1 record by WB at Mt Squires.

*3 *Thryptomene* sp. Warburton (M. Henson & M. Hannart 32433) P1 = Thryptomene sp. Warburton (G. Cockerton et. al. WB33129).

*4 *Calotis latiuscula* has recently (2nd November 2018) had it Priority status reviewed, resulting in it being removed from the Priority species list due to increased records from the Central desert region and confirmation that the disjunct Pilbara records are the same entity and not a different species.

*5 *Chrysocephalum apiculatum* subsp. *racemosum* is poorly known in W.A. and was added to the Priority Flora list in early October 2018. It is more common in NT and S.A.

*6 *Goodenia asteriscus* P3, formerly *Goodenia* sp. (A.S. George 4809) &Goodenia sp. aff. quasilibera (R.J.P. Davies & L. Ransom 868), added to the Priority Flora list in 2018.

*7 *Tephrosia* sp. Central (P.K. Latz 17037) is only known from 3 records in WA., abundant in N.T., added to the Priority Flora list in 2018.

*8 *Ptilotus* sp. nov reported by Coffey (Mar 2010) requires taxonomic review following re-collection of flowering material, no specimen sighted by author. The existence of this species can't be verified.

*9 *Indigofera helmsii* is only known from 2 records in WA but is abundant in N.T. and S.A.

*10 *Triodia helmsii* is only known from 1 record at WA Herbarium, 6 records in W.A., 23 records in in S.A. and 2 records in N.T.

Species requiring taxonomic investigation and clarification.

4.3. Threatened and Priority Ecological Communities

There are no known Threatened Ecological Communities (TEC) or Priority Ecological Communities (PECs) found within a100 km radius of the Survey Area during the desktop search.

4.4. Land Systems

The Survey Area intersects five Land Systems (Department Primary Industries and Regional Development 2018) (Table 5, Figure 6). These are broad descriptions of geology, landforms and soils with no reference to vegetation.

Table 5. Land Systems of the West Musgrave Project Survey Area.

Land System Code	Land System Description	Portion of Survey Area	Area of Land System Within the Greater Survey Area (ha)	(%) of the Survey Area	Detailed Survey Study Area (ha)	(%) of the Detailed Survey Study Area
AB48	Very gentle undulating plain traversed by longitudinal dunes.	Western Access Road, Southern Borefield, Project Development Area.	11,196.6	26.97%	248.7	2.42%
AB64	Plains with occasional short dunes, and hilly areas with rock outcrops.	Southern Borefield.	3,681.0	8.86%	0.0	0.00%
BA37	Ranges and hills mainly on granitic rocks; rock out crop is extensive.	Western Access Road.	23.0	0.05%	0.0	0.00%
My109	Outwash plains and dissected fan and terrace formations	Northern Access Road, Western Access Road, Project	13,552.3	32.64%	5,819.8	56.54%

Land System Code	Land System Description	Portion of Survey Area	Area of Land System Within the Greater Survey Area (ha)	(%) of the Survey Area	Detailed Survey Study Area (ha)	(%) of the Detailed Survey Study Area
	flanking ranges of sedimentary and some metamorphic, volcanic, and granitic rocks.	Development Area, North-eastern Borefield and Southern Borefield.				
My112	Extensive plains with numerous dunes which are often shorts and of irregular shape and orientation.	Project Development Area, North - eastern Borefield, Southern borefield, Wind Farm and Access Polygon.	13,066.4	31.47%	4,224.5	41.04%
		Total	**41,519.2**	**100%**	**10,293**	**100%**

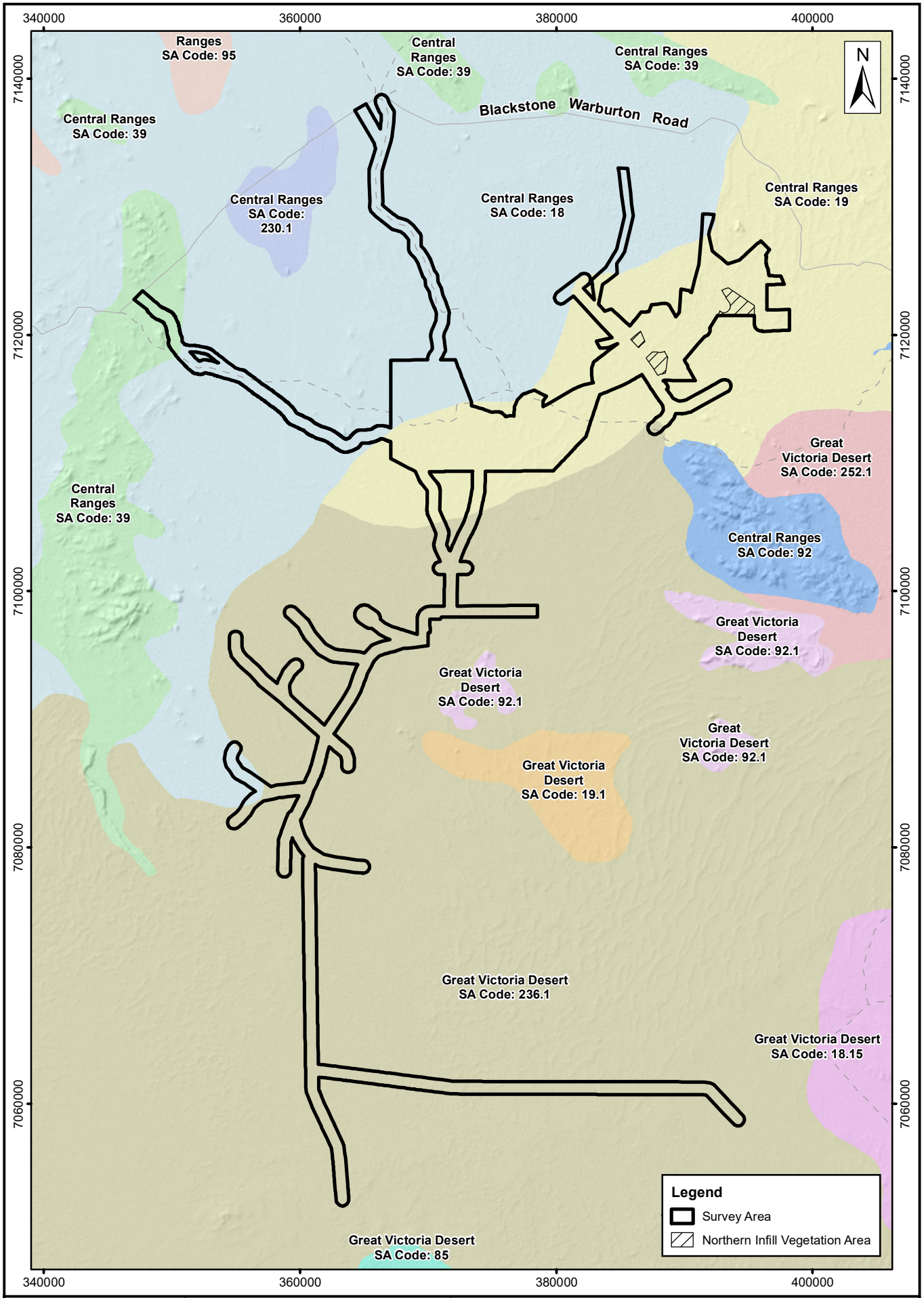
4.5. Pre-European Vegetation

The Survey Area is situated within the Giles Botanical District and is characterised by ranges and hills interspersed in sand plains with rocky loams, red soils and sands with Mulga, Mallee and Spinifex dominating the vegetation (Beard 1990). These high-level formations are very widespread in the region. Given the scale of this high-level treatment, these broad descriptions are inclusive of vegetation of the Survey Area, but do not closely match the vegetation described at NVIS level V Association level which represents a more detailed level of mapping (Table 6 and Figure 8).

Table 6. Pre-European Vegetation of the Survey Area.

System-Association Code	Original Association Description	Map Unit Type	NVIS Level 5 (Association) Interpretation	Hectares / % within Greater Survey Area	Hectares / % within Detailed Survey Study Area
18	Low woodland; mulga (*Acacia aneura*)	Pure	*Acacia aneura, Acacia pruinocarpa, Acacia ramulosa* var. *linophylla* shrub / *Schoenia cassiniana, Podolepis canescens, Waitzia acuminata* forb / tussock grass.	8,537.1ha / 20.6%	4,723.9 / 45.9%
19	Low woodland; mulga between sand ridges	Pure	*Acacia aneura*	17529ha / 42.2%	5,569.1 ha / 54.1%
39	Shrublands; mulga scrub	Mosaic	*Eucalyptus* sparse Mallee Shrubland / *Acacia* open Shrubland / *Triodia* sparse hummock grassland.	566.7 ha / 1.4%	0.0
236.1	Hummock grasslands, shrub steppe; mulga and Mallee (marble gum) over hard spinifex	Pure	*Eucalyptus gamophylla, Eucalyptus oleosa, Eucalyptus concinna* tree Mallee / *Acacia aneura, Acacia pruinocarpa, Acacia salicina* / *Triodia basedowii, Triodia schinzii* hummock grass.	14,886.4 ha / 35.9%	0.0

Figure 8. Pre-European vegetation of the Survey Area.



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Scale: 1:400,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_04

Date: March 2020 | Rev: A | A4

Western Botanical

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West Musgrave Flora Survey Area

Pre European Vegetation (Dept of Ag & Food WA)

4.6. Field Survey

4.6.1. Landform Systems

The landforms observed within the Survey Area were organised into five main Landform Systems. Two of these were divided further into sub units in order to be logically collated for the purposes of reporting (Table 7). Maps of these Landform Systems have not been presented separately. The vegetation within these Landform Systems share a high degree of similarity and may have dominant species in the upper, mid or lower strata in common but differ at the NVIS Level 5 *Association* detail.

Table 7. Landform Systems of the WMP Survey Area.

Landform System	Sub-Unit	Description	Regional Occurrence
Calcrete Plain		Level to undulating plains of paleo-groundwater Calcrete overlain by varying depths of Aeolian sand, supporting *Corymbia* Woodlands, *Eucalyptus* Mallee Shrublands, *Acacia* or *Allocasuarina* Shrublands over *Triodia scariosa* Hummock Grasslands.	Extensive across the Survey Area
Hardpan & Drainage	Plains	Mulga Woodlands with Shrub mid storey and Grass and Forb dominated understorey on red clayey sand hardpan plains, subject to sheet flow.	Extensive in the region
	Clay pans	(a) Small ephemerally inundated clay pans with hard setting clay soils supporting annual grasses and herbaceous vegetation, or (b) Extensive clay pans with medium to heavy clay soils supporting perennial grasses.	Limited areas in the region
Sand Dune		Sand dunes with fine red Aeolian sand, 2 to 20 m relief supporting *Acacia, Grevillea, Dodonaea* and *Aluta* Shrublands.	Extensive in the region
Sand Plain		Aeolian medium red silty sand plains, often with hardpan or underlying calcrete, supporting extensive Spinifex (*Triodia basedowii, T. schinzii*) hummock grasslands with emergent *Acacia*, *Eremophila* and *Grevillea* shrubs.	Extensive in the region
Stony Hills	Grano-diorite geology	Foot slopes and outwash plains at the base of small to medium sized outcrops of grano-diorite, supporting *Acacia* and *Senna* Shrublands and *Eriachne* hummock grasslands.	Extensive in the region
	Ironstone geology	Low hills of ironstone (magnetite) supporting Mulga and / or Low Chenopod Shrublands.	Limited areas in the region

4.6.2. Vegetation Mapping

Twenty eight vegetation associations were described within the greater WMP Survey Area, with 10 mosaics consisting of multiple vegetation associations additionally mapped. These mosaics occurred where the boundaries between different associations formed a mosaic that was unable to be effectively mapped separately or where the merging of two vegetation associations were unable to be differentiated during mapping (Table 8). The vegetation maps are presented in Appendix 5, along with the locations of the relevé sites and quadrats presented in Figure 9. The associated data collected at each of the 90 relevé sites and 306 quadrat sites are provided in Appendix 6.

Nineteen Vegetation associations were mapped within the Detailed Survey Study Area (10,293 ha) with four vegetation mosaics mapped and a location at the northern end of the proposed Northern Access Road recorded as Disturbed. The breakdown of percentage of each association within the Detailed Survey Study Area is presented in Table 8. Table 9 presents the number of hectares mapped for each vegetation association within each of the nine major Survey Areas

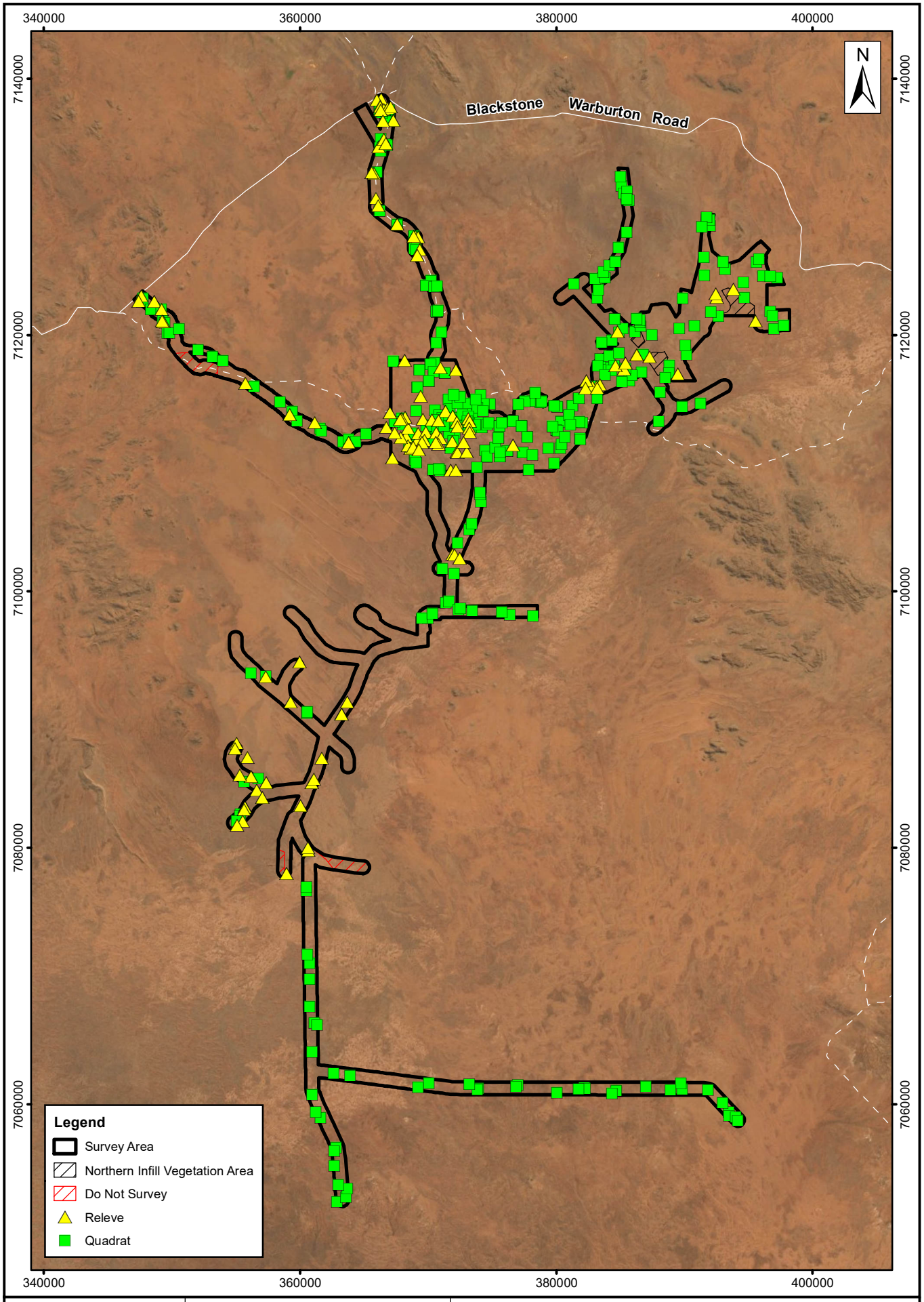
Table 8. Vegetation Associations of the WMP Survey Area.

Landform System	Vegetation Association	Vegetation Code	Greater Survey Area (ha)	% of Greater Survey Area	% of Detailed Survey Study Area (10,293ha)
Calcrete Plain	Calcrete *Corymbia opaca* Woodland	CCoW	455.3	1.10	0.38
Calcrete Plain	Calcrete Open Grassland	COG	699.2	1.68	0.17
Calcrete Plain	Calcrete Platform Hummock Grassland Hummock Grassland	CPHG	4,328.0	10.42	9.70
Calcrete Plain	Calcrete Platform Hummock Grassland Hummock Grassland with *Acacia eremophila* var. Numerous-nerved variant (A.S. George 11924) (P3)	CPHG Ae	4.8	0.01	0.00
Calcrete Plain	Calcrete Platform Hummock Grassland Hummock Grassland with *Allocasuarina helmsii*	CPHG Ah	772.4	1.86	0.00
Calcrete Plain	Calcrete Platform Hummock Grassland Hummock Grassland with *Melaleuca eleuterostachya*	CPHG Me	33.5	0.08	0.00
Calcrete Plain	*Acacia kempeana* Shrubland	AkS	114.7	0.28	0.20
Calcrete Plain	LMW / CPHG Mosaic	LMW / CPHG Mosaic	1,920.5	4.63	0.58

Landform System	Vegetation Association	Vegetation Code	Greater Survey Area (ha)	% of Greater Survey Area	% of Detailed Survey Study Area (10,293ha)
Calcrete Plain	SAWS / CPHG Mosaic	SAWS / CPHG Mosaic	775.9	1.87	0.10
Calcrete / Hardpan	AkS / HPMW Mosaic	AkS / HPMW Mosaic	222.5	0.54	0.00
Calcrete / Sand Plain	AkS / SAMU Mosaic	AkS / SAMU Mosaic	9.2	0.02	0.00
Calcrete Plain	CPHG / SaS Mosaic	CPHG / SaS Mosaic	13.7	0.03	0.00
Hardpan Plain & Drainage	Hardpan Mulga Woodland	HPMW	8,575.5	20.65	40.97
Hardpan Plain & Drainage	Hardpan Mulga Woodland Drainage	HPMWD	1,468.2	3.54	4.57
Hardpan Plain & Drainage	Mulga Grove	GRMU	96.7	0.23	0.51
Hardpan Plain & Drainage	*Eremophila duttonii* Shrubland	EdS	3.3	0.01	0.01
Hardpan Plain & Drainage	Hardpan Chenopod Shrubland	AvS	118.6	0.29	0.81
Hardpan Plain & Drainage	Claypan Playa	CPP	23.5	0.06	0.11
Hardpan Plain & Drainage	Claypan Grassland	CPN-G	143.9	0.35	1.22
Sand Dune	*Aluta maisonneuvei* subsp. *maisonneuvei* low Shrubland	AmmS	842.2	2.03	1.97
Sand Dune	Sand Dune *Acacia* - *Grevillea* Shrubland	SDAGS	3,159.1	7.61	10.35
Sand Dune	SDAGS / AmmS Mosaic	SDAGS / AmmS Mosaic	240.7	0.58	0.00
Sand Plain	Sandplains with Wattles other than Mulga	SAWS	5,723.7	13.79	12.36
Sand Plain	Sandplain Spinifex	SASP	1,727.7	4.16	0.00
Sand Plain	Sandplain Mulga	SAMU	2,015.4	4.85	3.65

Landform System	Vegetation Association	Vegetation Code	Greater Survey Area (ha)	% of Greater Survey Area	% of Detailed Survey Study Area (10,293ha)
Sand Plain	Low Mallee Woodland	LMW	4,406.6	10.61	7.38
Sand Plain	Sandplain *Acacia - Dodonaea* Shrubland	SADS	98.6	0.24	0.00
Sand Plain	*Acacia brachystachya* over Spinifex Shrubland	AbTsS	45.1	0.11	0.36
Sand Plain	*Acacia rhodophloia* over Spinifex Shrubland	ArS	2.9	0.01	0.00
Sand Plain	LMW/SAWS Mosaic	LMW / SAWS Mosaic	1,489.5	3.59	0.26
Sand Plain	*Melaleuca glomerata* with *Acacia kempeana* Shrubland	MgAkS	911.5	2.20	4.20
Sand Plain	LMW / MgAkS Mosaic	LMW / MgAkS Mosaic	31.2	0.08	0.00
Sand plain / Hardpan	MgAkS / HPMW Mosaic	MgAkS / HPMW Mosaic	56.8	0.14	0.00
Stony Hills Grano-diorite geology	Stony Mulga Shrubland	SMS	21.0	0.05	0.02
Stony Hills Grano-diorite geology	*Senna* Shrubland	SS	25.4	0.06	0.00
Stony Hills Grano-diorite geology	*Senna artemisioides* Shrubland	SaS	99.0	0.24	0.00
Stony Hills Grano-diorite geology	SaS / SAWS Mosaic	SaS / SAWS Mosaic	53.0	0.13	0.00
Stony Hills Grano-diorite geology	*Acacia cuthbertsonii* Shrubland	AcS	13.8	0.03	0.00
Disturbed		Disturbed	13.1	0.03	0.13
Not Surveyed Pending Heritage Clearance		Do Not Survey	763.9	1.84	0.00
TOTAL			**41,519.2**	**100%**	**100%**

Figure 9. Map showing quadrats and relevé locations.



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

0 5 10 km

Scale: 1:400,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_06

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Western Botanical

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West Musgrave Flora Survey Area

Quadrats and Releves

Table 9. Vegetation Associations of the nine major WMP Survey Areas

Vegetation Association Code	Northern Access Road Survey Area	Northern Borefield	Officer Basin	Project Development Area	Southern Borefield	Succoth	Western Access Road	Windfarm	Yappsu	Northern Infill Vegetation Mapping	Total
AbTsS								45.1			45.1
AcS							13.8				13.8
AkS	10.9		53.8	10.0	0.4		39.5				114.7
AkS / HPMW Mosaic		110.3	112.2								222.5
AkS / SAMU Mosaic			9.2								9.2
AmmS	56.3	249.9	178.2	40.5	54.5	50.2	3.7	204.9		4	842.2
ArS					2.9						2.9
AvS	118.6										118.6
CCoW		123.1	93.4	38.9	124.7			75.2			455.3
COG		124.8	535.5	17.0			13.9	0.7	7.2		699.2
CPHG	16.3	363.4	1,042.0	917.9	1,653.1	18.8	4.0	177.8	36.1	8.1	4328.0
CPHG / SaS Mosaic			13.7								13.7
CPHG Ae					4.8						4.8
CPHG Ah			501.4		271.0						772.4
CPHG Me					33.5						33.5
CPN-G	125.9		18.0								143.9
CPP	0.6	3.0	2.2	9.1	2.1	0.3		3.4	2.8		23.5
Disturbed	13.1										13.1
Do Not Survey					426.8		337.0				763.9
EdS	1.4		1.9								3.3
GRMU	40.1	2.5	10.2	9.0	10.3		18.6	6.1			96.7
HPMW	1,657.6	1,921.2	925.3	2,334.9	204.9	14.4	725.1	491.8	165.3	35.4	8575.5

Vegetation Association Code	Northern Access Road Survey Area	Northern Borefield	Officer Basin	Project Development Area	Southern Borefield	Succoth	Western Access Road	Windfarm	Yappsu	Northern Infill Vegetation Mapping	Total
HPMWD	273.2	53.1	635.4	394.0			112.4				1468.2
LMW		2,040.3	159.8	739.0	1,158.7	66.3	62.8	25.6		188.9	4406.6
LMW / CPHG Mosaic		822.9		61.9	862.9	32.1				139.0	1920.5
LMW / MgAkS Mosaic								31.2			31.2
LMW / SAWS Mosaic		49.8		26.6	1,393.7	19.4					1489.5
MgAkS		83.4	0.5	276.8	262.2	73.1		79.9			911.5
MgAkS / HPMW Mosaic		56.8									56.8
SADS			98.6								98.6
SAMU	52.1	440.6	782.8	296.5	272.0	3.7		34.5		93.5	2015.4
SaS			99.0								99.0
SaS / SAWS Mosaic			53.0								53.0
SASP		494.5	53.0		1,169.3					1.1	1727.7
SAWS	15.2	1,073.9	532.1	710.7	929.5	120.8	1,239.9	889.9	113.8	71.3	5723.7
SAWS / CPHG Mosaic		209.3	0.9		481.0			89.8		2.6	775.9
SDAGS	210.6	772.3	237.0	661.7	645.3	152.2	72.4	298.9	36.6	73.4	3159.1
SDAGS / AmmS Mosaic		240.7									240.7
SMS			1.3	1.7	0.3		17.7				21.0
SS			2.4				23.0				25.4
Total	**2592**	**9446**	**6153**	**[2]6685**	**9964**	**551**	**2684**	**2465**	**362**	**617**	**41519**

[2] Includes 1515 ha from the Windfarm Additional Survey area added in 2018

Index to Vegetation Association Descriptions

Calcrete Plain Landform System

CCoW - Calcrete *Corymbia opaca* Woodland

The Open *Corymbia opaca* Woodland vegetation association (455.3 ha, 1.1% of the Greater Survey Area) is characterised by an open woodland with an upper stratum of scattered *Corymbia opaca* 8 - 12 m and *Eucalyptus intertexta* 6-7 m, with a PFC 2% - 15% often over occasional *Eucalyptus gamophylla* 3 - 4 m, *Eucalyptus oxymitra* 3 - 4 m, *Hakea lorea* subsp. *lorea* to 4 m, *Acacia aneura* 4 - 5 m and *Acacia ligulata* to 3 m with a PFC 5-10%. The mid-stratum consists of an open shrubland dominated by *Acacia ligulata* 2 m, *Acacia kempeana* 3 m, *Melaleuca glomerata* to 3 m, *Hakea lorea* subsp. *lorea* to 5 m, with *Senna artemisioides* subsp. *artemisioides* 1.5 m *Acacia tetragonophylla* 1.5 m, *Scaevola spinescens* 1.5 m, *Eremophila longifolia* 1.2 m, with a PFC 15 - 25%. The ground stratum consists of hummock grassland dominated by *Triodia pungens* to 0.8 m, *Triodia. schinzii* 0.8 m and *Triodia basedowii* 0.5 m, with *Aristida contorta* to 0.1 m, *Cymbopogon ambiguus* to 0.6 m, *Aristida holathera* to 0.2 m, *Sclerolaena convexula* to 0.2 m *Sclerolaena johnsonii* to 0.1 m and *Maireana villosa* to 0.3 m with a PFC 25-30%, (Plate 1, Plate 2).

This vegetation association is strongly associated with the deep sandy swales between outcropping calcrete, and in places forms relatively dense stands of *Corymbia opaca* to 12 m, represented by two or three trees within a 50 m^2 area. This vegetation association is relatively diverse supporting a middle stratum of Mallee woodlands together with *Melaleuca glomerata*, *Acacia ligulata* and *Acacia kempeana* Shrublands over a range of low shrubs and grasses. This vegetation association should be considered as a ground water dependent ecosystem (GDE) given the species composition, soil, and the landscape position.

Plate 1. CCoW – Calcrete *Corymbia opaca* Woodland.

Plate 2. CCoW – Calcrete *Corymbia opaca* Woodland.

COG - Calcrete Open Grassland

The Calcrete Open Grassland (699.2 ha, 1.68% of the Greater Survey Area) is characterised by an open grass plain associated with shallow sands over a calcrete plain, the upper stratum that is restricted to the edges of the association is dominated by *Acacia kempeana* 1-4 m, *Acacia tetragonophylla* 3 m and *Acacia victoriae* subsp. *victoriae* to 3 m, with a PFC of 1-2%. The ground stratum grassland is dominated by *Enneapogon polyphyllus* 0.15 m, *Aristida contorta* 0.15m, *Sclerolaena patenticuspis* 0.15 m *Sclerolaena cornishiana* 0.15 m *Eremophea spinosa* 0.15 m and *Boerhavia repleta* 0.2 m with a PFC of 50 -65% (Plate 3, Plate 4).

Other associated species recorded within this vegetation association include *Panicum decompositum*, *Solanum lasiophyllum*, *Dysphania melanocarpa*, *Malvastrum americanum* (weed), *Brassica tournefortii* (weed), *Euphorbia australis*, *Salsola australis*, *Cenchrus ciliaris* (weed) *Sida* sp. Excedentifolia (J.L. Egan 1925), *Solanum centrale*, *Ptilotus obovatus*, and *Tribulus terrestris* (weed).

Plate 3. COG - Calcrete Open Grassland.

Plate 4. COG - Calcrete Open Grassland.

CPHG - Calcrete Platform Hummock Grassland

The Calcrete Platform Hummock Grassland (4,328 ha, 10.42% of the Greater Survey Area) is characterised by open woodland of *Hakea lorea* subsp. *lorea* from 2 - 3 m, *Acacia tetragonophylla* from 1.5 m to 1.8 m and *Acacia ligulata* from 1 m with a PFC of 1%. The lower stratum is comprised of open hummock grassland dominated by *Triodia scariosa* 0.4 - 0.5 m, with a PFC 35 - 50% and a sparse forbland of *Petalostylis cassioides* 0.4 - 0.6 m and *Ptilotus sessilifolius* 0.4-0.6 m with a PFC of 1%.

Other associated species recorded within this Vegetation Association are *Senna pleurocarpa* var. *pleurocarpa*, *Solanum centrale*, *Acacia pachyacra*, *Eriachne helmsii*, *Kennedia prorepens*, *Cymbopogon ambiguus*, *Ptilotus obovatus*, *Ptilotus clementii*, *Alyogyne pinoniana*, *Roepera iodocarpa*, *Paraneurachne muelleri*, *Acacia pruinocarpa*, *Halgania cyanea* var. Allambi Stn (B.W. Strong 676), *Goodenia asteriscus* (P3), *Stackhousia clementii* (P3) and *Scaevola amblyanthera* var. *centralis*. The uncommon species *Eragrostis* sp. Limestone (P.K. Latz 5921) (P3) was occasionally recorded in this community (Plate 5, Plate 6).

Plate 5. CPHG - Calcrete Platform Hummock Grassland.

Plate 6. CPHG - Calcrete Platform Hummock Grassland.

CPHG-Ae - Calcrete Platform Hummock Grassland with *Acacia eremophila* var. Numerous-nerved variant (A.S. George 11924)

The Calcrete Platform Hummock Grassland with *Acacia eremophila* var. Numerous-nerved variant (A.S. George 11924) (P3) vegetation association (4.80 ha, 0.01% of the Greater Survey Area) is characterised as open woodland of *Hakea lorea* subsp. *lorea* from 2 - 3 m, with a PFC of <1%. The mid stratum is dominated by *Acacia eremophila* var. Numerous-nerved variant (P3) from 0.5 m to 1.5 m and occasional *Acacia prainii* to 1.5 m with a PFC of 10 - 12%. The ground stratum is comprised of open hummock grassland dominated by *Triodia scariosa* 0.4 - 0.5 m, with a PFC 35 - 50% and a sparse Shrubland of *Petalostylis cassioides* 0.4 - 0.6m and *Acacia acanthoclada* subsp. *acanthoclada* to 0.4 m and *Ptilotus sessilifolius* 0.4 - 0.6 m with a PFC of 1% (Plate 7).

Other associated species recorded within this vegetation Association are *Senna pleurocarpa* var. *pleurocarpa*, *Solanum centrale*, *Acacia pachyacra*, *Eriachne helmsii*, *Kennedia prorepens*, *Cymbopogon ambiguus*, *Ptilotus obovatus*, *Alyogyne pinoniana*, *Roepera iodocarpa*, *Paraneurachne muelleri*, *Acacia pruinocarpa*, *Goodenia asteriscus* (P3), and *Scaevola amblyanthera* var. *centralis.*

Plate 7. CPHG-Ae - Calcrete Platform Hummock Grassland with *Acacia eremophila* var. Numerous-nerved variant (A.S. George 11924).

CPHG-Ah - Calcrete Platform Hummock Grassland with *Allocasuarina helmsii*

The *Allocasuarina helmsii* Calcrete Platform Hummock Grassland (772.4 ha, 1.86% of the Greater Survey Area) is characterised by open woodland of *Hakea lorea* subsp. *lorea* from 2 - 3m, *Eucalyptus oxymitra* to 3m and *Acacia ligulata* with a PFC of 1 - 2%. The mid stratum is dominated by *Allocasuarina helmsii* from 1.5 m to 1.8 m, *Scaevola spinescens* to 0.7 m with a PFC of 15 - 20%. The ground stratum is comprised of open hummock grassland dominated by *Triodia scariosa* 0.5 m, with a PFC 35 - 50% and a sparse Shrubland of *Petalostylis cassioides* 0.4-0.6 m and *Haloragis uncatipila* and *Halgania cyanea* var. Allambi Stn. 0.4 - 0.6 m with a PFC of 1-3% (Plate 8).

Other associated species recorded within this vegetation Association are *Senna pleurocarpa* var. *pleurocarpa*, *Solanum centrale*, *Acacia pachyacra*, *Eriachne helmsii*, *Kennedia prorepens*, *Cymbopogon ambiguus*, *Ptilotus obovatus*, *Alyogyne pinoniana*, *Roepera iodocarpa*, *Paraneurachne muelleri*, *Acacia pruinocarpa*, *Goodenia asteriscus* (P3) and *Scaevola amblyanthera* var. *centralis.*

Plate 8. CPHG-Ah - Calcrete Platform Hummock Grassland with *Allocasuarina helmsii* Shrubland (unburnt).

CPHG-Me - Calcrete Platform Hummock Grassland with *Melaleuca eleuterostachya*

The *Melaleuca eleuterostachya* Calcrete Platform Hummock Grassland (33.53 ha, 0.08% of the Greater Survey Area) is characterised by open woodland of *Hakea lorea* subsp. *lorea* from 3-4m, with the occasional *Eucalyptus intertexta* from 4 - 6 m. The mid stratum is dominated by *Acacia ligulata* 1 - 2 m *Melaleuca eleuterostachya* to 1.5 m and *Hakea lorea* subsp. *lorea* to 1.3 m with a combined PFC 2 - 5%. The ground stratum is comprised of open hummock grassland dominated by *Triodia scariosa* to 0.6 m with a PFC 35 - 40% and a sparse forbland of *Petalostylis cassioides* 0.4-0.6m, *Minuria leptophylla* to 0.15 m and *Ptilotus clementii* to 0.2 m with a PFC 2 - 3% (Plate 9, Plate 10).

Other associated species recorded within this vegetation association are *Paraneurachne muelleri*, *Ptilotus obovatus*, *Amphipogon caricinus*, and *Goodenia asteriscus* (P3).

Plate 9. CPHG-Me - Calcrete Platform Hummock Grassland with *Melaleuca eleuterostachya* Shrubland.

Plate 10. CPHG-Me - Calcrete Platform Hummock Grassland with *Melaleuca eleuterostachya* Shrubland.

AkS - *Acacia kempeana* Shrubland

The *Acacia kempeana* Shrubland (114.7 ha, 0.28% of the Greater Survey Area) is characterised by an upper stratum dominated by *Acacia kempeana* 4 m and *Acacia tetragonophylla* 3 m with a PFC 25%. The mid stratum is dominated by *Senna artemisioides* subsp. *artemisioides* to 1.5 m, *Rhagodia eremaea* 1.2 m *Eremophila serrulata* 1.4 m, *Eremophila longifolia* 2 m, *Ptilotus obovatus* 0.6 m and *Acacia tetragonophylla* to 1 m with a PFC 15 – 20%. The ground stratum is characterised by an open forbland dominated by *Cleome viscosa* 0.3 m, *Boerhavia repleta* 0.2 m, *Enneapogon polyphyllus* 0.15 m, *Neurachne munroi* 0.4m, *Panicum decompositum* 0.4 m, *Hibiscus burtonii* 0.3 m and *Sclerolaena johnsonii* 0.1 m with a PFC 5 - 15%. Soil is a red silty sand with a continuous lag gravel mantle composed of: angular cellular calcrete fragments to 0.5 to 8 cm, subrounded ironstone gravel 0.5 - 1.5 cm and angular tabular fragments of meta basalt to 7 cm, occasional river washed rounded quartz stones to 2 cm. Estimated 85 - 90% bare ground (Plate 11, Plate 12).

Other associated species recorded within this vegetation association include *Chrysocephalum apiculatum*, *Paraneurachne muelleri*, *Dysphania melanocarpa*, *Sida fibulifera*, *Aristida contorta*, *Abutilon otocarpum*, *Eriachne pulchella* subsp. *dominii* (Range Extension), *Salsola australis*, *Heliotropium cunninghamii*, and *Cymbopogon ambiguus*.

Plate 11. AkS - *Acacia kempeana* Shrubland.

Plate 12. AkS - *Acacia kempeana* Shrubland.

Hardpan Plain and Drainage Landform System

HPMW - Hardpan Mulga Woodland

The Hardpan Mulga Woodland (8,575.5 ha, 20.65% of the Greater Survey Area) is characterised by an upper stratum woodland dominated by *Acacia ayersiana* (narrow phyllode variant) 5 - 10 m, *Acacia aneura* 5-10 m, *Acacia aptaneura* 5 - 10 m, *Acacia ayersiana* (narrow phyllode variant) x aneura, *Hakea lorea* subsp. *lorea* 6-8 m and the occasional *Acacia victoriae* subsp. *victoriae* 4-6 m, with a combined PFC 10 - 25%. The mid stratum is characterised by juvenile *Acacia ayersiana* (narrow phyllode variant) to 1.2 m, *Acacia aneura* to 1.6 m and *Senna artemisioides* subsp. *artemisioides* to 1.2m and the occasional *Eremophila latrobei* subsp. *glabra* to 1.5 m, with a PFC 2 - 5%. The ground stratum is a composite of sparse low chenopod shrubland and sparse tussock grassland. The sparse chenopod shrubland is dominated by *Sclerolaena cornishiana* to 0.3 m, *Sclerolaena parviflora* to 0.2 m, *Sclerolaena eriacantha* to 0.2 m and *Sclerolaena patenticuspis* to 0.2 m with a PFC 5% and the sparse tussock grassland is dominated by low grasses of *Aristida contorta*, *Enneapogon avenaceus*, *Enneapogon polyphyllus* and *Cymbopogon ambiguus* with the addition of *Rhodanthe floribunda* 0.1 m 5 - 15% and *Calotis hispidula* 0.05 m (Plate 13, Plate 14).

Other associated species recorded within this vegetation association include *Calocephalus platycephalus, Eriachne helmsii, Rhodanthe tietkensii, Euphorbia tannensis* subsp. *eremophila, Sida fibulifera*, *Ptilotus polystachyus, Boerhavia repleta, Ptilotus obovatus, Stackhousia megaloptera, Euphorbia drummondii, Erodium aureum, Rutidosis helichrysoides* subsp. *helichrysoides, Angianthus tomentosus, Alternanthera nana, Amaranthus centralis* (P3), *Lepidium phlebopetalum*, *Enchylaena tomentosa* var. *tomentosa, Solanum lasiophyllum, Panicum decompositum*, *Einadia nutans* subsp. *eremaea, Eremophila longifolia, Nicotiana velutina,* and *Calotis latiuscula*.

Plate 13. HPMW - Hardpan Mulga Woodland, Burnt, showing much dead and regenerating Mulga, burnt ~10 to 20 years ago.

Plate 14. HPMW - Hardpan Mulga Woodland, unburnt state.

HPMWD - Hardpan Mulga Woodland - Drainage

The Hardpan Mulga Woodland drainage associations (1,468.2 ha, 3.54% of the Greater Survey Area) are characterised by a woodland upper stratum dominated by *Acacia aptaneura* 6 - 7 m, *Acacia ayersiana* (narrow phyllode variant) 4-6m, *Acacia aneura* to 5 m with a PFC 5 - 25%. The mid stratum is characterised by *Eremophila latrobei* subsp. *glabra* to 1.8m, *Teucrium teucriiflorum* to 1.2 m, juvenile *Acacia aptaneura* and *Acacia ayersiana* (narrow phyllode variant) to 1.5 m, *Acacia tetragonophylla* to 1.5 m with a PFC 5 - 10%. The ground stratum is characterised by an open forbland dominated by *Eremophila foliosissima* to 0.5 m, *Thyridolepis multiculmis* to 0.2 m, *Eragrostis eriopoda* to 0.3 m, *Monachather paradoxus* to 0.2 m, *Eriachne helmsii*, to 0.4 m, *Sclerolaena cornishiana* to 0.2 m, *Maireana villosa* to 0.3 m with a PFC 20 - 30%, (Plate 15).

Other associated species recorded within this vegetation association include *Cymbopogon ambiguus, Sclerolaena parviflora, Eremophila battii, Solanum lasiophyllum, Solanum centrale, Hibiscus burtonii, Ptilotus obovatus, Sida fibulifera* and *Solanum orbiculatum* subsp. *orbiculatum.*

Plate 15. Hardpan Mulga Woodland – Drainage, burnt ~10 yrs ago.

GRMU – Mulga Grove

The Mulga Groves (96.7ha, 0.23% of the Greater Survey Area) are localised internally drained sites receiving run-on from adjacent HPMW and HPMWD communities. Mulga Groves are characterised by a woodland upper stratum dominated *Acacia aptaneura* 8 – 10 m with a PFC 25 - 30% and *Hakea lorea* subsp. *lorea* 8 – 9 m, with a PFC 1%. The ground stratum is characterised by an open Forbland dominated by *Ptilotus polystachyus* 0.3 - 0.5 m with a PFC 20%, *Ptilotus helipteroides* to 0.2 m with a PFC 5%. Occasional occurrences of *Cenchrus ciliaris* (Buffel Grass) to 0.5 m with a PFC 2% were noted. These areas have significantly denser vegetation than surrounding hardpan plains, however, consist largely of the same species (Plate 16).

Other associated species recorded within this vegetation association include *Eragrostis eriopoda*, *Ptilotus sessilifolius*, *Chrysocephalum apiculatum* subsp. *glanduliferum*, *Rhodanthe floribunda*, *Ptilotus obovatus*, *Erodium aureum*, *Maireana planifolia*, *Enneapogon polyphyllus*, *Sclerolaena parviflora*, *Solanum lasiophyllum*, *Enchylaena tomentosa* var. *tomentosa*, *Lepidium phlebopetalum*, *Alternanthera nana*, *Calotis hispidula*, *Enneapogon avenaceus*, *Aristida contorta*, *Lepidium oxytrichum*, *Salsola australis* and *Hibiscus solanifolius.*

Plate 16. GRMU - Mulga Grove.

EdS - *Eremophila duttonii* Shrubland

The *Eremophila duttonii* Shrubland (EdS) association represents small (3.3 ha, 0.01% the Greater Survey Area) areas of internally drained hardpan playas with *Eremophila duttonii* prominent in the upper stratum. One site was recorded, intersecting the Northern Access road, and two sites were recorded within the Officer Basin Borefield Alignment. This vegetation association is described as *Eremophila duttonii* from 1 - 2.5 m, with a PFC 5% over *Rhagodia drummondii* 1.2 m, PFC 0.5% over *Maireana triptera* 0.4 m, *Sclerolaena eriacantha* 0.25 m, PFC 15 - 20%. It is a small and well-defined area within the HPMW community (Plate 17). There were additional small populations of *Eremophila duttonii* encountered within the HPMW during the significant species searches, however, the small size and associated time required for mapping precluded these being mapped separately during field works.

Plate 17. *Eremophila duttonii* Shrubland (EdS) Association.

AvS – *Maireana triptera - Atriplex vesicaria* Chenopod Shrubland

The *Maireana triptera - Atriplex vesicaria* Chenopod Shrubland (118.58 ha, 0.29% of the Greater Survey Area) is associated with the mid to lower slopes and level hardpan plains below low ironstone hills south of the Jameson townsite. It is characterised by low Shrublands of Low Shrubland of *Maireana triptera* 0.4m, PFC 10%, *Maireana aff. villosa* 0.4 m, PFC 10%, *Atriplex vesicaria* 0.5 m, PFC 5% and occasional *Eremophila clarkei* 1.2 m, PFC <1% with a grass component of occasional *Aristida contorta* 0.2 m, *Cenchrus ciliaris* (weed) 0.5m, PFC 1 to 2%. Landscape is level and has red silty sand forming a hard pan with a continuous lag gravel and stony mantle of ironstone (magnetite) to 5 cm diameter. A variable site with some bare areas with no vegetation, and other areas with occasional patches of Mulga in small groups which were not mapped separately. Associated species include *Enneapogon polyphyllus* 0.2 m, patches of *Neurachne munroi* 0.3 m, *Maireana integra* and as yet unverified species: *Maireana* aff. *villosa* (WB39955) (Plate 18).

Plate 18. AvS - *Maireana triptera - Atriplex vesicaria* Chenopod Shrubland.

CPP- Clay Pan Playa

The Clay Pan Playa Association (23.5 ha, 0.06% of the Greater Survey Area) is found within the Hardpan Mulga Woodlands and represents the lowest part of that landscape. They are small, very open hardpan areas which may have a gravely lag gravel mantle. The vegetation within the Clay pan playa is dominated by annual grasses and herbs with very few to no perennial species present, due to being seasonally inundated for periods following rainfall. The fringing vegetation is characterised by a very scattered upper stratum of *Acacia tetragonophylla* 3 m, *Acacia pteraneura* 4 m, *Eremophila longifolia* 2 m and *Acacia victoriae* subsp. *victoriae* to 2.5 m, with a combined PFC 5 - 10% occurring in an annular ring on the margins of the clay pan. The central part of the claypans have a lower stratum characterised by a very open grassland dominated by *Eragrostis exigua* 0.4 m, *Diplachne fusca* subsp. *muelleri* 0.3 m, *Eragrostis pergracilis* 0.1 m, *Eragrostis dielsii* 0.05 m, *Trianthema triquetrum* 0.05 m and *Fimbristylis dichotoma* 0.15 m with a PFC 10-15% (Plate 19, Plate 20).

Other associated species recorded within this vegetation association include *Tripogonella loliiformis*, *Dysphania melanocarpa*, *Salsola australis*, *Panicum decompositum*, *Atriplex elachophylla*, *Pluchea dentex*, *Aristida contorta*, *Dactyloctenium radulans*, *Enteropogon ramosus* and *Einadia nutans* subsp. *eremaea*. It is expected the species richness would be significantly higher in wetter seasons.

The numerous small isolated occurrences of the CPP Vegetation association occur primarily within the central portion of the Survey Area.

Plate 19. CPP- Claypan Playa.

Plate 20. CPP- Claypan Playa.

CPN-G Claypan Grassland

The Claypan Grassland Vegetation Association (143.9 ha, 0.35% of the Greater Survey Area) represents large, extensive low lying internally drained areas with medium to heavy heaving, cracking red sandy clay soil with numerous sink holes and would be subject to waterlogging and inundation following significant rainfall events. Vegetation is relatively uniform and consists of a perennial grassland of co-dominant *Aristida latifolia* 1.2 m tall, *Eragrostis xerophila* 0.3 m, *Eragrostis setifolia* 0.4 m, *Iseilema eremaea* 0.2 m with forbs dominated by *Rhynchosia minima* 0.4 m, PFC 50 - 65%, with occasional emergent *Eremophila longifolia* 2 m, *Acacia pteraneura* 2 - 4m, PFC < 1%. Occasional occurrences of *Cenchrus ciliaris* (weed) to 0.6 m were noted (Plate 21, Plate 22).

Plate 21. CPN-G Claypan Grassland.

Plate 22. CPN-G Claypan Grassland.

Sand Dune Landform System

AmmS - *Aluta maisonneuvei* subsp. *maisonneuvei* Shrubland

The *Aluta maisonneuvei* subsp. *maisonneuvei* Shrubland (842.2 ha, 2.03% of the Greater Survey Area) is commonly associated with the upper to mid slopes of sand dunes and is characterised by a shrubland of *Aluta maisonneuvei* subsp. *maisonneuvei* to 1.8 m as a dominant shrub stratum, with a PFC of 25 - 40%. The upper stratum, if present, may include a sparse Shrubland of *Grevillea eriostachya* from 2 - 3m, *Grevillea juncifolia* subsp. *juncifolia* 2 - 4m, *Acacia ligulata* 3 - 4 m and *Dodonaea viscosa* subsp. *angustissimus*, with a PFC of 1 - 2 %. The ground stratum is comprised of sparse hummock grassland of scattered *Triodia basedowii* to 0.3 m and *Triodia schinzii* to 0.4 m, with a PFC 1% to 8% (Plate 23).

Other associated species recorded within this vegetation association are *Acacia melleodora*, *Goodenia triodiophila*, *Aristida contorta*, *Eragrostis eriopoda*, *Amphipogon caricinus* var. *caricinus*, *Solanum centrale*, *Ptilotus obovatus*, *Ptilotus polystachyus*, *Rhodanthe floribunda*, *Solanum cleistogamum* and *Calandrinia polyandra*.

Plate 23. AmmS - *Aluta maisonneuvei* subsp. *maisonneuvei* Shrubland.

SDAGS - Sand Dune *Acacia - Grevillea* Shrubland

The Sand Dune *Acacia - Grevillea* Shrubland (3,159.1 ha, 7.61% of the Greater Survey Area) represents the crests of dunes and is characterised by an upper stratum shrubland dominated by *Acacia ligulata, Acacia maitlandii* 2 - 3 m, *Grevillea stenobotrya* 2 – 5 m, *Grevillea juncifolia* subsp. *juncifolia* 2 - 6 m, *Dodonaea viscosa* subsp. *angustissimus* 2 – 3 m, *Acacia melleodora* 1 - 4 m with a PFC 10 - 30%. The mid-stratum is a sparse Shrubland of *Aluta maisonneuvei* subsp. *maisonneuvei*, 1 - 2 m with a PFC 2 - 20%, with the ground stratum dominated by *Triodia schinzii* 0.6 m and *Triodia basedowii* 0.5 m, *Dicrastylis doranii* 0.5 m, *Sida sp.* Golden calyces pubescent (G.J. Leach 1966) 0.4m, *Sida* sp. Excedentifolia (J.L. Egan 1925) 0.3 m, *Aristida holathera* var. *holathera* 0.3 m, *Bonamia erecta* 0.15 m and *Eriachne aristidea* 0.3 m with a PFC 5 - 20% (Plate 24).

Other associated species recorded within this vegetation association include *Solanum centrale, Acacia pachyacra, Eriachne helmsii, Eremophila platythamnos* subsp. *exotrachys, Eremophila willsii* subsp. *integrifolia, Eragrostis eriopoda, Eragrostis laniflora, Aristida contorta, Pimelea trichostachya, Monachather paradoxus, Chrysocephalum puteale, Ptilotus polystachyus, Ptilotus sessilifolius, Ptilotus latifolius, Ptilotus obovatus* Sand Dune Form (WB39950), *Calandrinia polyandra, Chrysocephalum pterochaetum, Androcalva loxophylla, Amphipogon caricinus* subsp. *caricinus, Einadia nutans* subsp. *eremaea, Eremophila longifolia, Lobelia heterophylla, Sclerolaena johnsonii, Salsola australis, Goodenia cycloptera* and occasionally *Aenictophyton anomalum* (P1) and *Quoya loxocarpa.*

Plate 24. SDAGS- Sand Dune *Acacia - Grevillea* Shrubland.

Sand Plain Landform System

SAWS - Sand plains with Wattles other than Mulga over Spinifex

The Sand plains with Wattles other than Mulga over Spinifex (SAWS) hummock Grassland (5,723.7 ha, 13.79% of the Greater Survey Area) is associated with deep red sands often located at the base of sand dunes and between the calcrete platforms and can form expansive plains. This vegetation association is characterised by an upper stratum characterised by an open shrubland dominated by one or, on occasions up to three, *Acacia* species including *Acacia ligulata*, 2 – 3 m, *Acacia walkeri* 1 - 2 m, *Acacia abrupta* 1 - 1.2 m, *Acacia pachyacra*, 1 - 2 m, *Acacia melleodora* 1 - 2 m, *Acacia pruinocarpa* to 4 m and *Acacia sericophylla* to 4 m with a PFC of 2 - 15%. The mid stratum is characterised by a sparse shrubland dominated by G*revillea eriostachya and Eremophila forrestii*. The ground stratum is characterised by a composite hummock grassland (in a mature, long unburnt state) and open forbland (post-fire). The hummock grassland is dominated by the Spinifex species *Triodia basedowii* from 0.4 - 0.5 m and/or *Triodia schinzii* 0.5 - 0.8 m, with a PFC of 30 - 40%. The post-fire forbland is rapidly dominated by *Leptosema chambersii, Bonamia erecta, Halgania erecta, Androcalva loxophylla* and *Kennedia prorepens* while the Spinifex species regenerates slowly from seed, (Plate 25, Plate 26).

Other associated species include *Eremophila platythamnos* subsp. *exotrachys, Eragrostis eriopoda, Petalostylis cassioides, Cymbopogon ambiguus, Chrysocephalum apiculatum, Ptilotus polystachyus, Calandrinia polyandra, Chrysocephalum pterochaetum, Rhodanthe floribunda, Stackhousia megaloptera, Acacia tetragonophylla, Goodenia triodiophila, Aristida contorta, Lepidium phlebopetalum, Solanum lasiophyllum, Alyogyne pinoniana, Glischrocaryon aureum* Reticulated fruit form (WB39951) and *Paraneurachne muelleri.*

Plate 25. SAWS - Sandplain with Wattles other than Mulga over Spinifex – *Acacia sericophylla.*

Plate 26. SAWS - Sandplain with Wattles other than Mulga over Spinifex – *Acacia walkeri.*

SASP – Sandplain with Spinifex

The SASP Vegetation Association (1,727.7 ha, 4.16% of the Greater Survey Area) is characterised as a hummock grassland of *Triodia schinzii* 1.2 m and *Triodia basedowii* to 1 m, with a PFC 20 - 35% over *Leptosema chambersii* 0.4 m, *Androcalva loxophylla* 0.4 m, *Prostanthera wilkieana* 0.5 m, *Kennedia prorepens* 0.4 m, PFC 15%. It occurs in the same landscape position as the SAWS communities, level clayey sandplain, but lacks any appreciable upper storey species (Plate 27).

Plate 27. SASP - Sandplain with Spinifex.

SAMU – Sandplain Mulga Woodland

The Sandplain Mulga Woodland (2,015.4 ha, 4.85% of the Greater Survey Area) is characterised by Mulga Woodland with a Spinifex hummock grassland lower stratum. The upper stratum is dominated by *Acacia aneura* 3 - 6 m, *Acacia ayersiana* 4 - 5 m with a PFC 15 - 20%. The mid stratum is dominated by *Acacia aneura* 2 m, *Hakea lorea* subsp. *lorea* 2 m, *Eremophila longifolia* to 2 m and *Acacia ligulata* 1.8 m, with a combined PFC of 10 - 12%. The ground stratum is characterised by grassland dominated by *Triodia basedowii* 0.6 m, *Aristida holathera* var. *holathera* 0.3 m, *Aristida contorta* 0.15 m, *Monachather paradoxus* 0.2 m and *Amphipogon caricinus* subsp. *caricinus* 0.4 m, with a PFC 20 - 25% (Plate 28).

Other associated species recorded within this vegetation association include occasional *Corymbia opaca* to 8 m, *Brachychiton gregorii* to 8 m, *Acacia kempeana, Solanum orbiculatum subsp. orbiculatum, Digitaria brownii, Eragrostis eriopoda, Enneapogon polyphyllus, Ptilotus obovatus, Androcalva loxophylla, Dicrastylis exsuccosa* and *Goodenia triodiophila.*

The SAMU vegetation association often occurs on the borders between SAWS or SDAGS and where they meet HPMW. The soils in these areas have a higher sand content over a clay pan base. SAMU is widespread within the Survey Area, but typically occupies relatively small areas.

One SAMU area within the Southern borefield realignment was noted to be of interest because the *Acacia aneura* recorded at this location (52J 372532 m E, 7098673 m N) were all displaying sprouting from the base (lignotuber) after fire. This is a very unusual growth habit since mulgas are known as obligate seeders that are killed by fire and recruit from seed stored in the soil (Plate 29). The fact that these trees are resprouting after fire is highly unusual and may represent a local evolutionary change brought about by natural selection through the regularity fires across the area. This population is the only known occurrence to Western Botanical where this habit has been recorded and impacts to this community should be avoided where possible.

Plate 28. SAMU - Sandplain Mulga Woodland.

Plate 29. SAMU - Sandplain Mulga Woodland in Southern Borefield exhibiting sprouting after fire.

LMW - Low Mallee Woodland

The Low Mallee Woodland Vegetation Association (4,406.6 ha, 10.61% of the Greater Survey Area) is characterised by an open mallee woodland to mallee woodland dominated by *Eucalyptus oxymitra* 2 – 5 m and *Eucalyptus gamophylla* 2 – 8 m with a PFC 10 - 25%. On occasion, other species of eucalypts (*E. intertexta, E. socialis, E. mannensis* subsp. *mannensis, E. concinna*) may be present, forming discrete or mixed patches. The mid-stratum is a sparse Shrubland dominated by *Acacia ligulata* 2 – 5 m, *Acacia melleodora* 2 – 3 m, *Grevillea eriostachya* 3 m and *Hannafordia bissillii* subsp. *bissillii* to 1 m with a PFC of 2 - 10%. The ground stratum is a hummock grass dominated by *Triodia basedowii* 0.4 - 0.5 m with a PFC of 30 - 50% and *Triodia scariosa* 0.3 - 0.4 m with a PFC 1% with sparse forbland of *Bonamia erecta, Sclerolaena johnsonii, Calandrinia polyandra* and *Brunonia australis* with a PFC of 5 - 10% (Plate 30, Plate 31).

Other associated species recorded within this vegetation association include *Aluta maisonneuvei* subsp. *maisonneuvei*, *Dicrastylis doranii*, *Triodia schinzii*, *Solanum centrale*, *Eremophila platythamnos* subsp. *exotrachys*, *Eragrostis eriopoda*, *Kennedia prorepens*, *Cymbopogon ambiguus*, *Ptilotus polystachyus, Ptilotus sessilifolius, Calandrinia polyandra*, *Chrysocephalum pterochaetum* And*rocalva loxophylla*, *Amphipogon caricinus* var. *caricinus*, *Acacia tetragonophylla, Goodenia triodiophila, Aristida contorta*, *Scaevola parvifolia* subsp. *parvifolia*, *Alyogyne pinoniana*, *Lobelia heterophylla*, *Euphorbia australis* var. *erythrantha*, *Microcorys macredieana, Exocarpos sparteus* and *Chrysocephalum puteale.*

Given the species composition of this vegetation association together with the landscape position associated with Calcrete platforms (both subcropping and outcropping calcrete) with deep sandy soil, the Low Mallee Woodlands vegetation association should be considered as a GDE.

Plate 30. LMW - Low Mallee Woodland with *Eucalyptus oxymitra.*

Plate 31. LMW -Low Mallee Woodland with *Eucalyptus mannensis* subsp. *mannensis.*

SADS – Sandplain *Acacia Dodonaea* Shrubland

The Sand plains with *Acacia* and *Dodonaea* Shrubland (SADS) (98.6 ha, 0.24% of the Greater Survey Area) is associated with deep red sands often in areas where the sand dunes have not fully formed or are transitional. This vegetation association is characterised by an upper stratum open shrubland dominated by *Acacia ayersiana*, *Acacia ayersiana* (narrow phyllode variant) and *Acacia aneura* to 5 m with a PFC 1 - 5%. The mid stratum is characterised by a sparse shrubland dominated by *Dodonaea viscosa* subsp. *angustissima* 1.6 – 2 m, *Acacia tetragonophylla* to 2 m, *Acacia ligulata* to 2 - 3 m, and *Senna artemisioides* subsp. *petiolaris* to 1.5 m with a PFC of 12 - 20%.The ground stratum is characterised by a forbland dominated by *Eragrostis eriopoda* to 0.25 m, *Ptilotus obovatus* to 0.5 m, *Aristida holathera* var. *holathera* to 0.25 m, and *Cymbopogon ambiguus* to 0.5 m with a PFC of 5 - 8% (Plate 32).

Other associated species include *Enchylaena tomentosa* var. *tomentosa*, *Eremophila glabra* subsp. *glabra*, *Rhagodia eremaea*, *Salsola australis*, *Aristida contorta*, *Digitaria brownii*, *Scaevola spinescens*, *Triodia basedowii*, *Sclerolaena parviflora*, *Enneapogon avenaceus*, *Eremophea spinosa*, *Eremophila latrobei* subsp. *glabra*, and *Paraneurachne muelleri*.

Plate 32. SADS - Sandplain *Acacia Dodonaea* Shrubland.

AbTsS – *Acacia brachystachya* - Spinifex Shrubland

The *Acacia brachystachya* Spinifex Shrubland (45.1ha, 0.11% of the Greater Survey Area) is represented by three four sites within the north-eastern (Windfarm) portion of the Survey Area. This vegetation association is characterised as a shrubland with an upper stratum dominated by *Acacia brachystachya* 4 m, with the occasional *Acacia pteraneura* 3-4 m and *Hakea lorea* subsp. *lorea* to 3 m with a PFC 5 - 15%. The mid stratum is dominated by *Eremophila longifolia* 2 m and *Acacia pachyacra* 2 m with a PFC 5 - 12%. The ground stratum is dominated by *Triodia schinzii* 1.1 m, *Eragrostis laniflora* 0.4 m *Androcalva loxophylla* 0.3 m, *Eremophila longifolia* 1 m, *Aluta maisonneuvei* subsp. *maisonneuvei* 0.5 m, *Aristida holathera* var. *holathera* 0.3 m, *Aristida contorta* 0.15 m and *Enneapogon polyphyllus* 0.15 m with a combined PFC 15 - 30%, (Plate 33).

Other associated species recorded within this vegetation association include *Monachather paradoxus*, *Acacia tetragonophylla*, *Acacia ligulata*, *Bonamia erecta*, *Kennedia prorepens*, *Ptilotus obovatus*, *Paraneurachne muelleri*, *Goodenia triodiophila*, *Solanum centrale*, *Sclerolaena johnsonii* and *Androcalva loxophylla*.

Plate 33. AbTsS - *Acacia brachystachya* - Spinifex Shrubland.

ArS *Acacia rhodophloia* – Spinifex Shrubland

The *Acacia rhodophloia* Spinifex Shrubland (2.92 ha, 0.01% of the Greater Survey Area) is represented by one polygon within the Southern Borefield alignment. This vegetation association is characterised by a shrubland with an upper stratum dominated by *Acacia rhodophloia* 5 m and *Acacia ligulata* to 3 m with a PFC of 5 - 15%. *Grevillea eriostachya* to 1.5 m, *Acacia ligulata* to 1 m, and *Aluta maisonneuvei* subsp. *maisonneuvei* to 1 m, with a PFC 5 - 10%, dominate the mid stratum. The ground stratum is characterised by grassland dominated by *Triodia basedowii* to 0.7 m with a PFC of 20% - 25%, over *Bonamia erecta* to 0.3 m, and *Aristida holathera* var. *holathera* 0.3 m with a PFC of 2 - 3% (Plate 34).

Other associated species recorded within this vegetation association include *Paspalidium reflexum, Eremophila longifolia, Hakea lorea* subsp. *lorea, Euphorbia tannensis, Ptilotus sessilifolius, Paraneurachne muelleri, Goodenia triodiophila, Goodenia peacockiana, Solanum lasiophyllum, Sclerolaena johnsonii, Sclerolaena parviflora*, and *Amphipogon caricinus* var. *caricinus.*

A larger area containing this vegetation association was noted on the access track just west of the Southern borefield alignment outside of the current Survey Area. Due to the linear nature of the Survey Area this Vegetation Association was only identified in one polygon, and therefore it wasn't possible to have three quadrats for this vegetation association (EPA 2016).

Plate 34. ArS - *Acacia rhodophloia* – Spinifex Shrubland.

MgAkS *Acacia kempeana* with *Melaleuca glomerata* Shrubland

The *Melaleuca glomerata* with *Acacia kempeana* Shrubland is represented by 911.5 ha, 2.20% of the Greater Survey Area, and is characterised by a very open woodland with the occasional *Eucalyptus intertexta* and *Corymbia opaca* 4 - 8 m with a PFC 1%. The mid stratum is characterised by a shrubland dominated by *Acacia kempeana* 2 - 3 m, *Melaleuca glomerata* to 4 m, *Hakea lorea* subsp. *lorea* from 3 - 4 m *Acacia ligulata* from 2 - 3 m and *Eremophila longifolia* from 1.8 – 2 m, with a PFC 20 - 25%. The ground stratum is comprised of open hummock grassland dominated by *Triodia scariosa* 0.5 m, *Triodia pungens* 0.7 m, *Triodia basedowii* 0.8 m, *Eriachne mucronata* (typical form) 0.3 m and *Ptilotus obovatus* 0.5 m with a PFC 10 - 20%, (Plate 35).

Other species include *Enneapogon polyphyllus, Senna artemisioides* subsp. *artemisioides Tripogonella loliiformis, Aristida contorta, Paraneurachne muelleri, Cymbopogon ambiguus, Chrysocephalum eremaeum, Roepera eremaea* and *Digitaria brownii*.

Given the species composition of the vegetation association together with the landscape position and soil attributes, the MgAkS vegetation association should be considered as a GDE.

Plate 35. MgAkS - *Acacia kempeana* with *Melaleuca glomerata* Shrubland.

Stony Hills Landform System – Granodiorite geology

SMS -Stony Mulga Shrubland

The Stony Mulga Shrubland (21.0 ha, 0.05% of the Greater Survey Area) is characterised by an open shrubland where the upper stratum is dominated by *Acacia ayersiana* (narrow phyllode form) 4 m, *Acacia aptaneura* 3 m and the occasional *Hakea lorea* subsp. *lorea* 3 m, with a PFC 2-5%. The mid stratum is dominated by *Eremophila latrobei* subsp. *glabra* to 1.5 m, *Senna artemisioides* subsp. *artemisioides* to 1.5 m, *Eremophila hughesii* subsp. *hughesii* 1 m with PFC 2-5%. The lowest stratum is dominated by *Eriachne mucronata* (desert form glabrous (WB38710)) 0.3 m, *Aristida holathera* var. *holathera* 0.2 m, *Sida fibulifera* 0.3 m and *Cymbopogon ambiguus* 0.4 m with a PFC 35% (Plate 36).

Other associated species recorded within this vegetation association include *Cheilanthes lasiophylla*, *Cheilanthes sieberi* subsp. *sieberi*, *Sida*. sp. Excedentifolia (J.L. Egan 1925), *Goodenia vilmoriniae*, *Solanum centrale*, *Hibiscus burtonii*, *Heliotropium cunninghamii*, *Indigofera warburtonensis* (P1) and *Hibiscus sturtii* var. *grandiflorus.*

The SMS Vegetation Association occurs primarily within the proposed Western Access Road part of the Survey Area.

Plate 36. SMS - Stony Mulga Shrubland with *Eriachne mucronata* (desert form glabrous (WB38710)) in foreground.

SS - *Senna* Shrubland

The *Senna* Shrubland (25.4 ha, 0.06% of the Greater Survey Area) is located on the lower slopes of granitic hills and is characterised by an open shrubland with a very open upper stratum of *Hakea lorea* subsp. *lorea* to 3 m *Acacia pruinocarpa* to 6 m and *Acacia ayersiana* (narrow phyllode form) 4 m with a PFC of 1-2%. The mid stratum is dominated by *Senna* sp. Billabong (J.D. Alonzo 7221) 1.8 m and *Senna artemisioides* subsp. *helmsii* 1 m with a PFC 10 - 15%. The ground stratum is dominated by *Aristida contorta* 0.15 m, *Cymbopogon ambiguus* 0.6 m, *Ptilotus obovatus* 0.6 m, *Tephrosia* sp. deserts (J.R. Maconochie 1403) 0.1 m, *Digitaria brownii* 0.4 m, *Maireana villosa* 0.2 m and *Panicum decompositum* 0.4 m with a PFC 20 - 25% (Plate 37).

Other associated species recorded within this vegetation association include *Enneapogon polyphyllus, Indigofera linnaei, Cleome viscosa, Solanum lasiophyllum Boerhavia repleta, Heliotropium cunninghamii, Convolvulus clementii, Einadia nutans* subsp. *eremaea, Evolvulus alsinoides* var. *villosicalyx, Euphorbia australis, Senna artemisioides* subsp. *filifolia* and *Tribulus astrocarpus.*

The SS Vegetation Association occurs primarily within the proposed Western Access Road part of the Survey Area.

Plate 37. SS - *Senna* Shrubland.

SaS - *Senna artemisioides* subsp. *xartemisioides* Shrubland

The *Senna artemisioides* subsp. *xartemisioides* Shrubland (99 ha, 0.24% of the Greater Survey Area) is located on gentle slopes with calcrete evident and is characterised by an open Shrubland of *Acacia aptaneura* 4 – 5 m and *Acacia tetragonophylla* to 3 m with a PFC 1 - 2%. The mid stratum is characterised by *Senna artemisioides* subsp. *xartemisioides* to 1.2 m, *Acacia tetragonophylla* to 1.5 m and *Scaevola spinescens* to 1 m with a PFC 15 - 20%. The lower stratum is dominated by *Ptilotus obovatus* to 0.6 m, *Enneapogon polyphyllus* to 0.15 m, and *Aristida contorta* to 0.15 m with a PFC 5 - 10% with many other small herbs, grasses and chenopods (Plate 38).

Other associated species recorded within this vegetation association include *Enchylaena tomentosa* var. *tomentosa, Eragrostis eriopoda, Eremophila glabra* subsp. *glabra, Eremophila latrobei* subsp. *glabra, Cymbopogon ambiguus, Rhagodia eremaea, Salsola australis, Sclerolaena parviflora*, and *Solanum lasiophyllum*.

The SaS vegetation Association was recorded within the proposed Officer Basin Alignment, this vegetation association was often difficult to map definitively as it formed large mosaic mosaics with both AkS and SAWS vegetation Associations.

Plate 38. SaS – *Senna artemisioides* subsp. *xartemisioides* Shrubland.

AcS - *Acacia cuthbertsonii* Shrubland

The *Acacia cuthbertsonii* Shrubland (13.78 ha, 0.03% of the Greater Survey Area) is characterised by an open shrubland dominated by an upper stratum of *Acacia cuthbertsonii* 3m, *Acacia ayersiana* (narrow phyllode form) 6 m and *Eremophila latrobei* subsp. *glabra* 3 m with a PFC 15 - 20%. The mid stratum is dominated by *Acacia cuthbertsonii* 1.5 m, *Eremophila latrobei* subsp. *glabra* 1 m, *Indigofera warburtonensis* (P1) 0.8 m, *Maireana planifolia* to 0.6 m and *Senna artemisioides* subsp. *helmsii* 1.3 m, with a PFC 8 - 10%. The ground stratum is characterised by a forbland dominated by *Abutilon cryptopetalum* 0.4 m, *Aristida contorta* 0.15 m, *Indigofera warburtonensis* (P1) 0.5 m, *Setaria reflexa* 0.3 m, *Enneapogon polyphyllus* 0.1 m, *Evolvulus alsinoides* var. *villosicalyx* 0.1 m and *Monachather paradoxus* 0.3 m with a PFC 5 - 15% (Plate 39, Plate 40).

Other associated species recorded within this vegetation association include *Hibiscus burtonii*, *Solanum lasiophyllum*, *Paspalidium basicladum*, *Aristida inaequiglumis*, *Salsola australis*, *Sclerolaena johnsonii*, *Digitaria brownii*, *Ptilotus helipteroides*, *Cleome viscosa*, *Sida calyxhymenia*, *Tribulus astrocarpus* and *Ptilotus obovatus*.

The ACS Vegetation Association occurs primarily within the proposed Western Access Road part of the Survey Area.

Plate 39. AcS - *Acacia cuthbertsonii* Shrubland.

Plate 40. AcS - *Acacia cuthbertsonii* Shrubland.

4.7. Priority and Threatened Ecological Communities

No Threatened Ecological Communities (TEC) or Priority Ecological Communities (PECs) were described across the Greater Survey Area. Three vegetation associations were represented by relatively small areas within the greater Survey area. The ArS (0.01% of the Greater Survey Area), AcS (0.03% of the Greater Survey Area) and EdS (0.01% of the Greater Survey Area), all were considered by Western Botanical, not to be regionally limited or restricted in distribution, despite their relatively small footprint with the Survey area

4.8. Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) are ecosystems that rely on access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain the vegetation association function. Groundwater-dependence does not mean that the ecosystem would cease to exist if groundwater is removed, but rather that groundwater is important to maintain its current condition, and if groundwater is removed or contaminated then the ecosystem would change.

In Australia six types of Groundwater Dependent Ecosystems have been identified:

- Terrestrial vegetation that relies on the availability of shallow groundwater.

- Wetlands such as paperbark swamp forests and mound springs.
- River baseflow systems where groundwater discharge provides a significant baseflow component to the river.
- Aquifer and cave ecosystems where life exists independent of sunlight.
- Terrestrial fauna, both native and introduced species, that rely on groundwater as a source of drinking water.
- Estuarine and near-shore marine systems, such as coastal mangroves, salt marshes and sea-grass beds, which rely on the submarine discharge of groundwater.

In arid zones, groundwater-dependent vegetation is likely to be much more widespread than in more humid climates due to the scarcity of other potential water sources. Roots of vegetation have been found as deep as 50 – 60 m (Le Maitre *et al.* 1999) and groundwater use by vegetation has been measured from depths in excess of 30 m (Orellana *et al.* 2012). However, despite the propensity for groundwater use by vegetation, identifying vegetation that is using groundwater and that is dependent on that water source remains a challenge.

Based on the vegetation associations described above, together with their landscape position, species assemblages and the knowledge of species that are known to access deep water (e.g. *Corymbia opaca*, *Eucalyptus intertexta*, *E. oxymitra*, *E. gamophylla* and *Melaleuca glomerata*) versus the species that are known to be shallow rooted and rainfall harvesters (Mulga species, *Acacia aneura*, *Acacia ayersiana*, *Acacia aptaneura*), three vegetation associations were considered as likely GDEs. These three vegetation associations were the *Corymbia opaca* Open Woodlands (CCoW), *Melaleuca glomerata* and *Acacia kempeana* Shrubland (MgAkS) and the Low Mallee Woodlands (LMW) primarily those associated with the Calcrete Platforms.

These vegetation associations were found growing across swales between calcrete platforms often as a mosaic with areas of the CPHG vegetation association. A total of 7,253.42 ha or 17.78% of likely GDE vegetation associations were mapped across the Greater Survey Area. There was 1,173.4 ha of likely GDE mapped within the Detailed Survey Study Area which represents 11.40% of the Detailed Survey Study Area. The total hectares of each association together with the percentage of that association within both the Greater Survey Area and The Detailed Survey Study area are presented in Table 10.

Table 10. Inferred Ground Water Dependent Vegetation Associations within the Survey Area.

Vegetation Association Code	Vegetation Association Name	Hectares Within Greater Survey Area	Hectares Within Detailed Survey Study Area	% Within Greater Survey Area	% Within Detailed Survey Study Area
CCoW	Calcrete *Corymbia opaca* Woodland	455.30	0.00	1.11	0.00
MgAkS	*Melaleuca glomerata* with *Acacia kempeana* Shrubland	911.5	432.0	2.20	4.20
LMW	Low Mallee Woodland	4,406.6	759.10	10.61	7.38
LMW / CPHG Mosaic	Low Mallee Woodland / Calcrete Platform Hummock Grassland Mosaic	960.25 (1,920.5)	29.9 (59.8)	2.35 (4.63)	0.29 (0.58)
LMW / MgAkS Mosaic	Low Mallee Woodland / *Melaleuca glomerata* with *Acacia kempeana* Shrubland Mosaic	31.20	0.00	0.08	0.00
LMW / SAWS Mosaic	Low Mallee Woodland / Sandplains with Wattles other than Mulga Shrubland Mosaic	744.80 (1,489.60)	13.30 (26.60)	1.83	0.13 (0.26)
MgAkS / HPMW Mosaic	*Melaleuca glomerata* with *Acacia kempeana* Shrubland / Hardpan Mulga Woodland Mosaic	28.40 (56.80)	0.00	0.07 (0.14)	0.00
Total		**7,253.42 ha**	**1,173.40 ha**	**17.78%**	**11.40%**

4.9. Vegetation Condition

The condition scale adjusted to reflect the Eremaean and Northern Botanical Provinces as outlined in Table 2 of the EPA Technical Guidance 2016, show the majority of the Survey Area was in Excellent Condition 'Pristine or nearly so, no obvious signs of damage caused by human activities since european settlement', with little evidence of any human interaction outside those areas directly cleared for access roads, accommodation village facilities and exploration drilling.

Two issues detract from the Excellent vegetation condition: (i) frequent and regular fires in the area immediately south and adjacent to the Jameson Community; and (ii) ingress of Buffel Grass (*Cenchrus ciliaris*), along road sides, tracks, the Jameson town site and the exploration accommodation Village. Ruby Dock (*Rumex vesicarius*) was also noted in the Survey Area in 2015.These areas around Jameson Community and the exploration accommodation Village were considered 'Good' to 'Very Good'. These areas have damage caused by human activities with introduced weeds and increased fire regimes deteriorating the native vegetation structure.

Fires

Fire regimes of frequent and repeated fires in the region have resulted in a complex of post-fire regeneration vegetation. Vegetation associations with grassy understoreys are typically frequently subjected to fire and while many species are quick to either sprout or grow from seed, the Mulga species are very slow to regenerate post-fire from soil-stored seeds. The frequency of fire between 1998 and 2017 in the region inclusive of the Survey Area is presented in Figure 10. The most recent fire map, from 2017, is presented in Figure 11. No further fire records were recorded across the Survey Area, during the 2018 /2019 survey period following the 2017 fires located across parts of the Southern Borefield alignment.

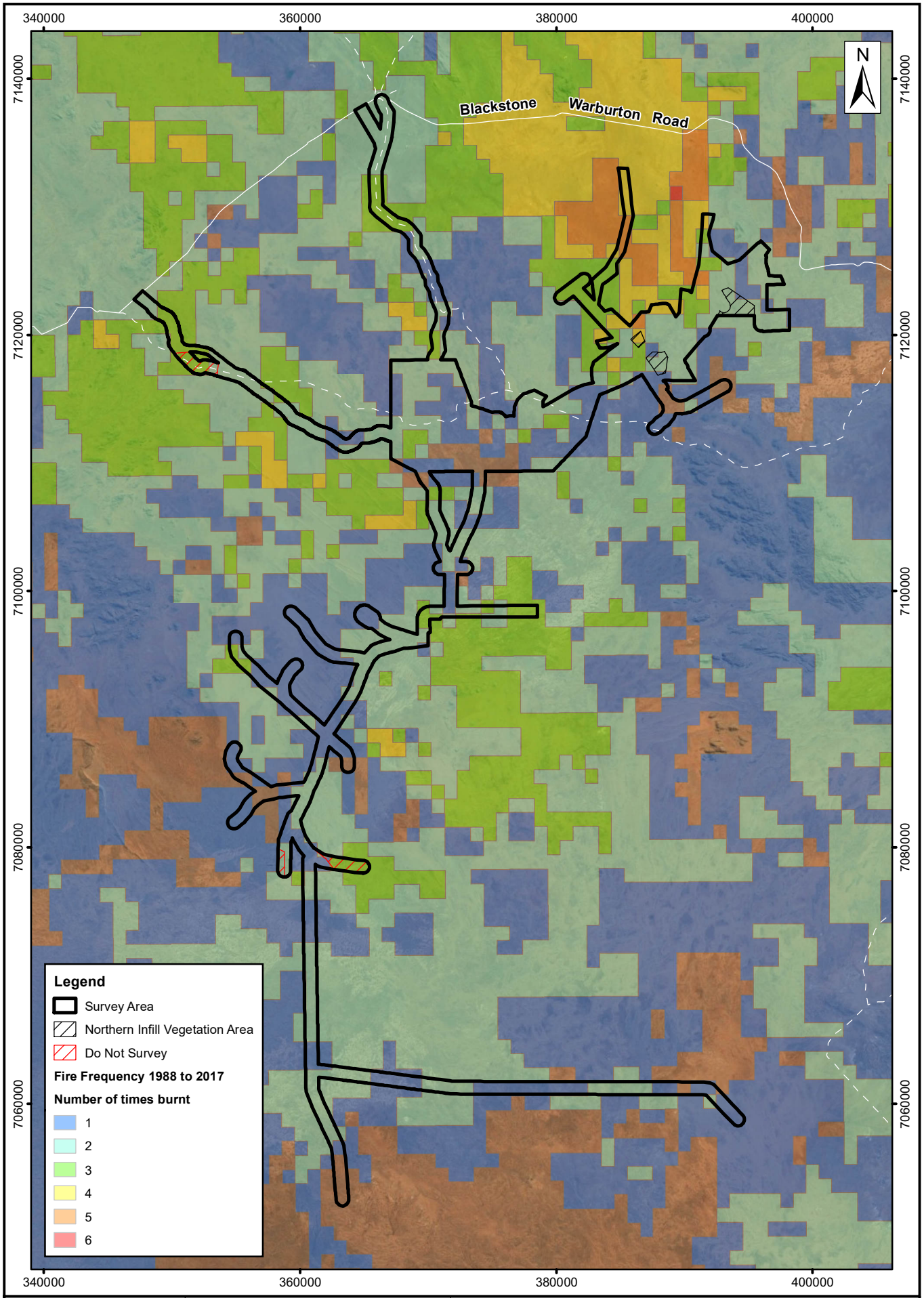
Weeds

Buffel Grass (*Cenchrus ciliaris*) is spread throughout the Project Development Area. However, infestations where Buffel Grass dominate the under storey are mostly restricted to within 5 to 50 m of roads and tracks, but often in a discontinuous fashion as it prefers sandier soils. However, isolated plants and patches of plants were occasionally found at significant distance from tracks and roads.

Buffel Grass was so prevalent within the Survey Area that specific efforts to map this species were restricted to opportunistic recording during the winter survey period. However during the significant species searches across the proposed infrastructure areas, the infestation was recorded in these areas. The weed map presented in Section 4.14 and (Figure 27) should therefore be taken as only being indicative of the distribution of this species within these locations and not as a complete weed map.

Other weed species were present only in low numbers and did not influence vegetation condition at this time. However, *Rumex vesicarius* (Ruby Dock) can be a problematic species similar to Buffel Grass, due to its tendency to heavily colonise disturbed areas to the detriment of native species.

Figure 10. Fire Frequency 1998-2017.



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

0 5 10 km

Scale: 1:400,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_12_01

Date: March 2020 | Rev: A | A4

Western Botanical

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OZ Minerals / Cassini JV

West Musgrave Flora Survey Area

Fire Frequency 1988 to 2017

Figure 11. 2017 Fire Map.

0 2 4 6 km

Scale: 1:300,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R02_12_02

Date: January 2019 | Rev: A | A4

Western Botanical

Author: J. Warden | WB Ref:

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West Musgrave Flora Survey Area

Fire Burnt Area 2017

4.10. Statistical Analysis

Initial PATN analysis output provided good support for the preliminary version of the vegetation map produced during the field surveys. For a small number of sites (quadrats and relevé sites) the field assigned vegetation association differed from the PATN's grouping within the analysis output. Such discrepancies between fieldwork and PATN analysis were investigated and improvements made to the vegetation map and to vegetation association descriptions, where appropriate. Subsequent to final rounds of field survey, PATN analysis assisted in the merging or splitting of preliminary field-observed vegetation associations.

Following reconciliation of the PATN analysis output, the final Sites Dendrogram (Figure 12), provides strong support for almost all of the final vegetation associations mapped and for the species composition of each vegetation association. Twenty-four of the 28 mapped vegetation associations were represented by sites within statistical analysis. The four units absent within the analysis are:

- **ArS – Acacia rhodophloia Shrubland**: *Acacia rhodophloia* was excluded from analysis as a singleton species (occurring at one site only). The single ArS quadrat site therefore lost one of the major defining species and therefore the analysis could not place the site coherently in the dendrogram. The ArS site was removed from the analysis as an outlier site, but retained as a unique vegetation association.

- **Three variants of CPHG - Calcrete Platform Hummock Grassland**: Variants or sub-associations of CPHG were all treated as one CPHG entity for purposes of analysis.

Ordination analysis produced a stress value of 0.2113, higher than the preferred threshold of 0.1500. The option to reduce non-discriminatory (less important) species from the analysis in order to reduce the stress value was discounted, in favour of retaining such species that were important for determining finer-scale vegetation associations within PATN's major dendrogram branch groupings. Likewise, the common practice of dividing a dataset into separate analyses based on landform groupings of vegetation associations to reduce stress was also discounted (artificially reduces stress values only). Considering the scale of this Project's analysis (355 sites and 249 species) the elevated ordination stress value was deemed acceptable.

Ordination analysis identified 19 core branch groupings of sites within the dendrogram. *Triodia* species (*T. basedowii, T. schinzii,* and *T. scariosa*) were the most discriminatory species within classification analysis, providing the first major branch splits of the dendrogram.

Inspection of sub-branches within many of the Sites Dendrogram major branches revealed finer-scale vegetation associations appropriate to NVIS Level 5 resolution of vegetation mapping. Vegetation associations restricted to sub-branches of the Sites Dendrogram were verified as distinct by composition of dominant species. Multiple vegetation associations occurring within a single major dendrogram branch effectively represent related, but distinct vegetation units.

Following interpretation of the PATN output, 23 of the 24 vegetation associations present within analysis were confirmed within coherent branches of the dendrogram.

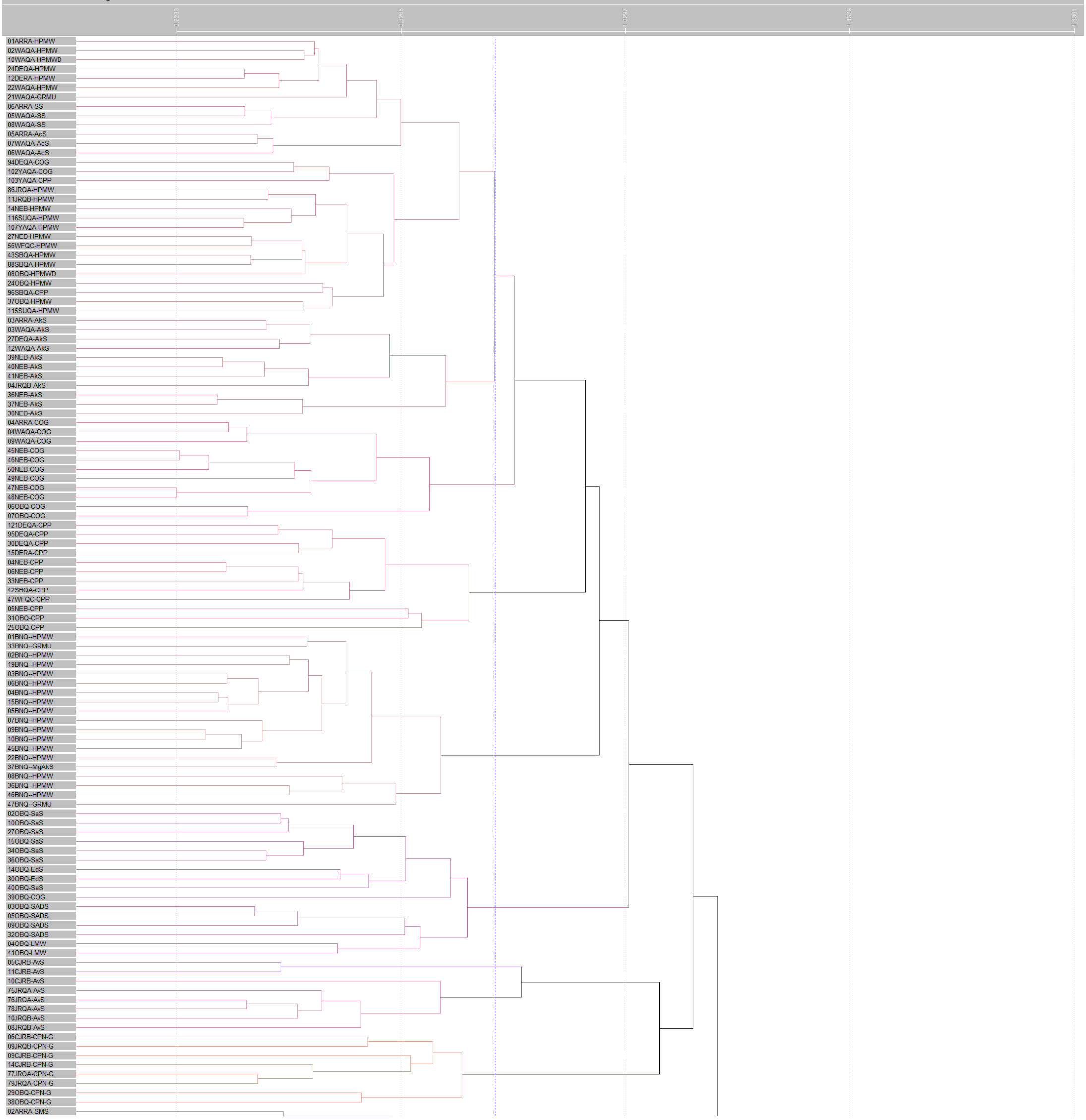
Of the vegetation associations present within the analysis, only GRMU could not be adequately confirmed through analysis. Eight GRMU units separated to five different locations within the dendrogram. Investigation found that GRMU vegetation was typically restricted in size with flora composition strongly influence by other immediately adjacent vegetation associations. Despite this, the GRMU vegetation association was retained as a mapped unit due to a recognisable density of Mulga species within internally draining areas.

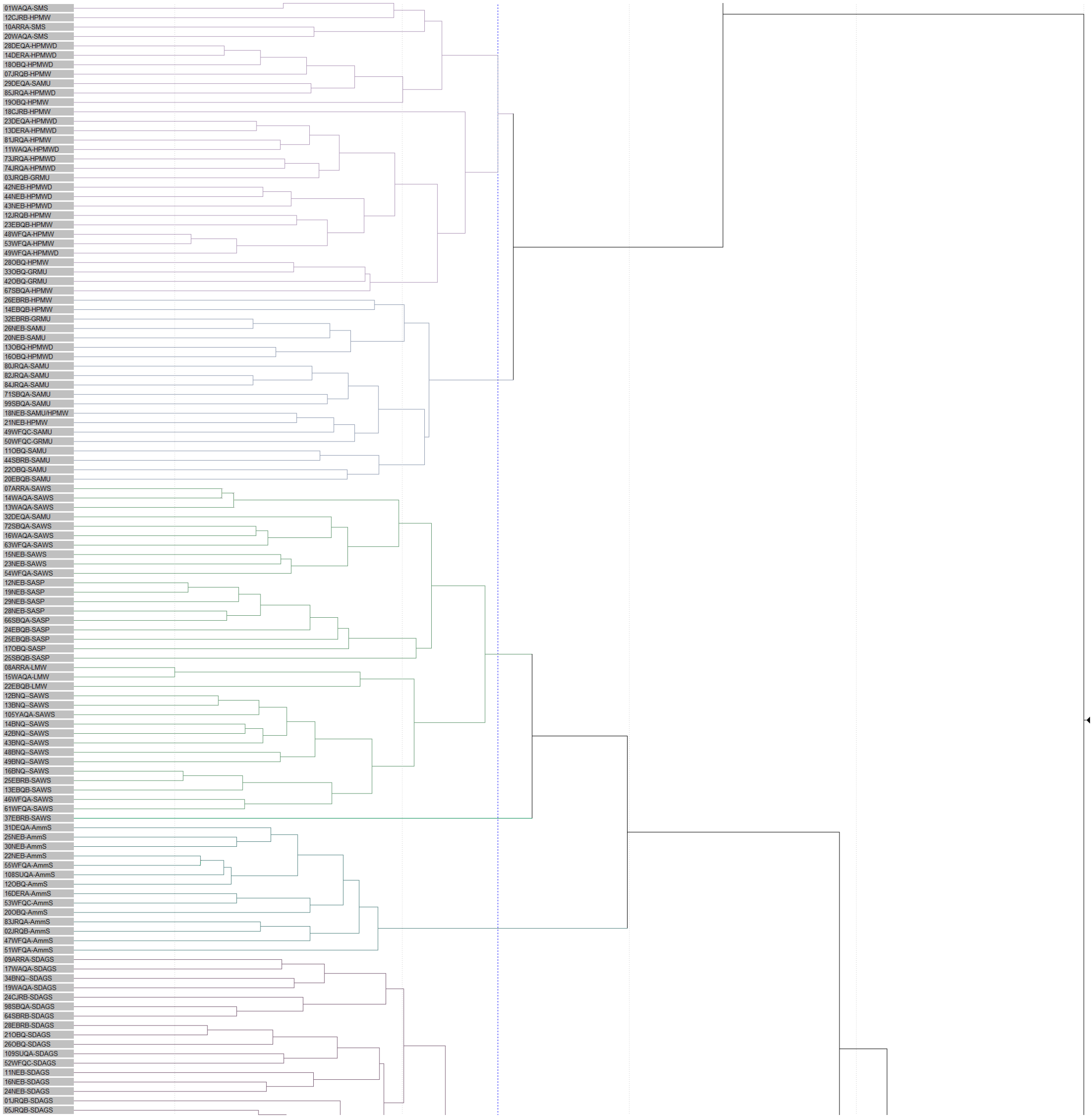
Some sites were non-conforming in the analysis and did not group with other sites of their same vegetation association. This typically occurred when such sites, 1) contained species encroaching from an adjacent vegetation association, or 2) had higher than typical dominance in single key species that the analysis deemed to be highly discriminatory (typically *Triodia* species or widespread and abundant *Acacia* species) compared to species characteristic of the unit but of lower discriminatory power.

The number of sites verified by analysis within each vegetation association is presented in Table 11. For completeness, the table presents a tally of sites by vegetation association, assessment of how well sites grouped, and discussion of non-conforming sites per association.

Figure 12. Dendrogram of Vegetation Sites.

Row Fusion Dendrogram

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12CJRB-HPMW
10ARRA-SMS
20WAQA-SMS
28DEQA-HPMWD
14DERA-HPMWD
18OBQ-HPMWD
07JRQB-HPMW
29DEQA-SAMU
85JRQA-HPMWD
19OBQ-HPMW
18CJRB-HPMW
23DEQA-HPMWD
13DERA-HPMWD
81JRQA-HPMW
11WAQA-HPMWD
73JRQA-HPMWD
74JRQA-HPMWD
03JRQB-GRMU
42NEB-HPMWD
44NEB-HPMWD
43NEB-HPMWD
12JRQB-HPMW
23EBQB-HPMW
48WFQA-HPMW
53WFQA-HPMW
49WFQA-HPMWD
28OBQ-HPMW
33OBQ-GRMU
42OBQ-GRMU
67SBQA-HPMW
26EBRB-HPMW
14EBQB-HPMW
32EBRB-GRMU
26NEB-SAMU
20NEB-SAMU
13OBQ-HPMWD
16OBQ-HPMWD
80JRQA-SAMU
82JRQA-SAMU
84JRQA-SAMU
71SBQA-SAMU
99SBQA-SAMU
18NEB-SAMU/HPMW
21NEB-HPMW
49WFQC-SAMU
50WFQC-GRMU
11OBQ-SAMU
44SBRB-SAMU
22OBQ-SAMU
20EBQB-SAMU
07ARRA-SAWS
14WAQA-SAWS
13WAQA-SAWS
32DEQA-SAMU
72SBQA-SAWS
16WAQA-SAWS
63WFQA-SAWS
15NEB-SAWS
23NEB-SAWS
54WFQA-SAWS
12NEB-SASP
19NEB-SASP
29NEB-SASP
28NEB-SASP
66SBQA-SASP
24EBQB-SASP
25EBQB-SASP
17OBQ-SASP
25SBQB-SASP
08ARRA-LMW
15WAQA-LMW
22EBQB-LMW
12BNQ--SAWS
13BNQ--SAWS
105YAQA-SAWS
14BNQ--SAWS
42BNQ--SAWS
43BNQ--SAWS
48BNQ--SAWS
49BNQ--SAWS
16BNQ--SAWS
25EBRB-SAWS
13EBQB-SAWS
46WFQA-SAWS
61WFQA-SAWS
37EBRB-SAWS
31DEQA-AmmS
25NEB-AmmS
30NEB-AmmS
22NEB-AmmS
55WFQA-AmmS
108SUQA-AmmS
12OBQ-AmmS
16DERA-AmmS
53WFQC-AmmS
20OBQ-AmmS
83JRQA-AmmS
02JRQB-AmmS
47WFQA-AmmS
51WFQA-AmmS
09ARRA-SDAGS
17WAQA-SDAGS
34BNQ--SDAGS
19WAQA-SDAGS
24CJRB-SDAGS
98SBQA-SDAGS
64SBRB-SDAGS
28EBRB-SDAGS
21OBQ-SDAGS
26OBQ-SDAGS
109SUQA-SDAGS
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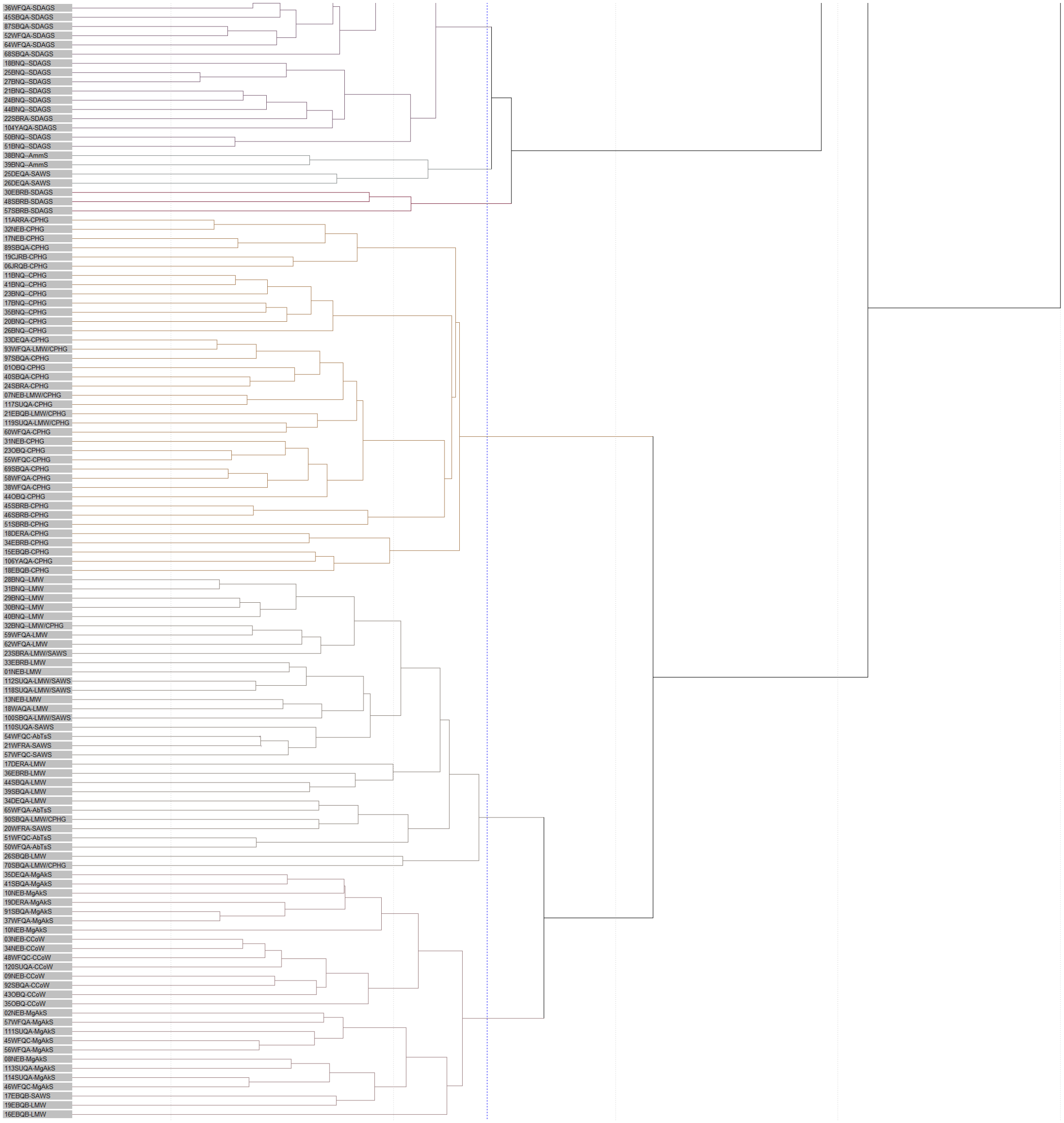
24NEB-SDAGS
01JRQB-SDAGS
05JRQB-SDAGS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45SBQA-SDAGS
87SBQA-SDAGS
52WFQA-SDAGS
64WFQA-SDAGS
68SBQA-SDAGS
18BNQ--SDAGS
25BNQ--SDAGS
27BNQ--SDAGS
21BNQ--SDAGS
24BNQ--SDAGS
44BNQ--SDAGS
22SBRA-SDAGS
104YAQA-SDAGS
50BNQ--SDAGS
51BNQ--SDAGS
38BNQ--AmmS
39BNQ--AmmS
25DEQA-SAWS
26DEQA-SAWS
30EBRB-SDAGS
48SBRB-SDAGS
57SBRB-SDAGS
11ARRA-CPHG
32NEB-CPHG
17NEB-CPHG
89SBQA-CPHG
19CJRB-CPHG
06JRQB-CPHG
11BNQ--CPHG
41BNQ--CPHG
23BNQ--CPHG
17BNQ--CPHG
35BNQ--CPHG
20BNQ--CPHG
26BNQ--CPHG
33DEQA-CPHG
93WFQA-LMW/CPHG
97SBQA-CPHG
01OBQ-CPHG
40SBQA-CPHG
24SBRA-CPHG
07NEB-LMW/CPHG
117SUQA-CPHG
21EBQB-LMW/CPHG
119SUQA-LMW/CPHG
60WFQA-CPHG
31NEB-CPHG
23OBQ-CPHG
55WFQC-CPHG
69SBQA-CPHG
58WFQA-CPHG
38WFQA-CPHG
44OBQ-CPHG
45SBRB-CPHG
46SBRB-CPHG
51SBRB-CPHG
18DERA-CPHG
34EBRB-CPHG
15EBQB-CPHG
106YAQA-CPHG
18EBQB-CPHG
28BNQ--LMW
31BNQ--LMW
29BNQ--LMW
30BNQ--LMW
40BNQ--LMW
32BNQ--LMW/CPHG
59WFQA-LMW
62WFQA-LMW
23SBRA-LMW/SAWS
33EBRB-LMW
01NEB-LMW
112SUQA-LMW/SAWS
118SUQA-LMW/SAWS
13NEB-LMW
18WAQA-LMW
100SBQA-LMW/SAWS
110SUQA-SAWS
54WFQC-AbTsS
21WFRA-SAWS
57WFQC-SAWS
17DERA-LMW
36EBRB-LMW
44SBQA-LMW
39SBQA-LMW
34DEQA-LMW
65WFQA-AbTsS
90SBQA-LMW/CPHG
20WFRA-SAWS
51WFQC-AbTsS
50WFQA-AbTsS
26SBQB-LMW
70SBQA-LMW/CPHG
35DEQA-MgAkS
41SBQA-MgAkS
10NEB-MgAkS
19DERA-MgAkS
91SBQA-MgAkS
37WFQA-MgAkS
10NEB-MgAkS
03NEB-CCoW
34NEB-CCoW
48WFQC-CCoW
120SUQA-CCoW
09NEB-CCoW
92SBQA-CCoW
43OBQ-CCoW
35OBQ-CCoW
02NEB-MgAkS
57WFQA-MgAkS
111SUQA-MgAkS
45WFQC-MgAkS
56WFQA-MgAkS
08NEB-MgAkS
113SUQA-MgAkS
114SUQA-MgAkS
46WFQC-MgAkS
17EBQB-SAWS
19EBQB-LMW
16EBQB-LMW

Table 11. Tally of sites per vegetation association verified by floristic analysis (sorted by order in sites dendrogram).

Vegetation Association	Tally of Sites			Analysis Outcome			Analysis Discussion
	Quadrat	Relevé	Total	Conforming Sites	Non-conforming Sites	% of Conforming Sites	
AbTsS	4	0	4	3	1	75%	Strong group. A restricted association often occurring in small patches. Three non-conforming sites grouped with three AbTsS sites due to a dominance of other highly discriminatory but non-characteristic species. If the association were more abundant within the Survey Area, additional AbTsS sites would likely resolve the inclusion of non-conforming sites.
AcS	2	1	3	3	0	100%	Perfect group.
AkS	10	1	11	11	0	100%	Perfect group.
AmmS	15	1	16	14	2	88%	Strong group. Two of the 16 AmmS sites grouped with the SDAGS association that shares dominance in *Aluta maisonneuvei* subsp. *maisonneuvei*.
ArS	0	0	1	-	-	-	*Acacia rhodophloia* was excluded from analysis as a singleton species (occurring at one site only). The only ArS site therefore lost its defining species and analysis could not place the site coherently in the dendrogram. The ArS site was removed from the analysis as an outlier site.
AvS	5	3	8	8	0	100%	Perfect group.
CCoW	8	0	8	8	0	100%	Perfect group.
COG	13	1	14	11	3	79%	Strong group. Some areas of COG vegetation were restricted in size, resulting in sites containing species encroaching from adjacent vegetation. When encroaching species were highly discriminatory analysis split these sites away from the main group of COG sites.
CPHG	31	8	39	39	0	100%	Perfect group.
CPN-G	5	3	8	8	0	100%	Perfect group.

Vegetation Association	Tally of Sites			Analysis Outcome			Analysis Discussion
	Quadrat	Relevé	Total	Conforming Sites	Non-conforming Sites	% of Conforming Sites	
CPP	13	1	14	12	2	86%	Strong group. The two non-conforming CPP sites were restricted in size and with species encroaching from neighbouring vegetation, leading those two sites grouping with HPMW.
EdS	2	0	2	2	0	100%	Perfect group.
GRMU	7	1	8	0	8	0%	Poor group. Analysis placed the eight GRMU sites within five different dendrogram branches. Three of those branches belonged to HPMW, reflecting the similarity of GRMU and HPMW associations. GRMU vegetation was often restricted in size and contained encroaching species from neighbouring associations, resulting in analysis grouping GRMU sites accordingly. The GRMU association is retained due to its distinctive dense dominance of mulga species within internally draining areas.
HPMW	42	5	47	41	6	87%	Strong group. Analysis split the 47 HPMW sites into four branches of the dendrogram. Two of the lesser branches are closely related to each other but split away from other HPMW sites due to a near absence of *Eragrostis eriopoda* (perhaps season related). The other lesser branch is composed of HPMW sites conducted in 2014/2015 and split away due to an increased presence of *Hakea lorea subsp. lorea* (may be an artefact of projected foliage cover estimate method during that fieldtrip). However, sufficient dominant species are common to all four HPMW branches to define them as a single vegetation association.

Vegetation Association	Tally of Sites			Analysis Outcome			Analysis Discussion
	Quadrat	Relevé	Total	Conforming Sites	Non-conforming Sites	% of Conforming Sites	
HPMWD	15	2	17	11	6	65%	Moderate group. While analysis did not coherently group HPMWD sites together, a majority of sites grouped within dendrogram branches of the closely related HPMW association. Though HPMWD sites consistently contained high projected foliage cover of the indicator species *Eremophila gilesii* subsp. *gilesii*, multiple highly discriminatory species of the HPMW association prevented *E. gilesii* subsp. *gilesii* grouping HPMWD sites.
LMW	26	5	31	20	11	65%	Moderate group. Analysis could not group many LMW sites due to the association being defined by a dominance of any mallee eucalypt species rather than a single consistent species. Additionally, eucalypts within the Survey Area often occurred as large stands or populations within mosaic vegetation with other vegetation associations (often SAWS and CPHG). Though eucalypts were clearly dominant in such areas, analysis grouped such sites into those other vegetation associations.
MgAkS	16	1	17	16	1	94%	Strong group. While analysis grouped 16 of 17 MgAkS sites into a major dendrogram branch the sites were split into two variants. The first variant is dominated by Melaleuca glomerata while the second has a reduced presence of M. glomerata and the presence of Corymbia opaca from the CCoW association that was often adjacent.
SADS	4	0	4	4	0	100%	Perfect group.
SAMU	14	1	15	13	2	87%	Strong group. Two SAMU sites grouped with other vegetation associations. One grouped as an outlier to SMS due to the absence of the highly discriminatory *Acacia aptaneura*. The second site was dominated by a hybrid mulga not found in other SAMU sites, resulting in analysis using associated species to group it with the SAWS association.

Vegetation Association	Tally of Sites			Analysis Outcome			Analysis Discussion
	Quadrat	Relevé	Total	Conforming Sites	Non-conforming Sites	% of Conforming Sites	
SaS	7	0	7	6	1	86%	Strong group. A single SaS site grouped with the two EdS sites despite the complete absence of E. duttonii which defines the EdS association.
SASP	9	0	9	9	0	100%	Perfect group.
SAWS	25	5	30	23	7	77%	Strong group. Areas of SAWS often occurred as narrow bands fringing SDAGS vegetation and also occurred as a mosaic with LMW vegetation. In both situations analysis occasionally grouped SAWS sites with those associations due to presence of discriminatory species encroaching into SAWS areas.
SDAGS	28	8	36	36	0	100%	Perfect group.
SMS	2	2	4	4	0	100%	Perfect group.
SS	2	1	3	3	0	100%	Perfect group.

4.11. Flora

When the results of the 2015 and 2018 / 2019 surveys are combined, a total of 390 native flora species from 166 genera and 50 families were recognised within the Survey Area. A complete species list is presented in Appendix 7. The majority of the species are widespread and well represented in the Central Ranges and Great Victoria Desert IBRA regions. The dominant families and genera are presented in Table 12.

Table 12. Dominant Families and Genera within the Survey Area.

Dominant Families	**Number of Genera**	**Number of Species**
Poaceae	31	65
Fabaceae	13	69
Asteraceae	19	31
Chenopodiaceae	11	27
Malvaceae	10	29
Goodeniaceae	4	15
Amaranthaceae	3	13
Dominant Genera		**Number of Species**
Acacia		34
Eremophila		13
Eragrostis		13
Sida		12
Senna		12
Ptilotus		10

The species accumulation curve (Figure 13) presenting the combined records of the 2015 quadrat sites, the 2018 and 2019 quadrat and relevé sites, and opportunistic collections, shows an asymptotic approach of the total number of species recorded. The species accumulation curve demonstrates the survey effort was sufficient to record the majority of the species present across the Survey Area at the time(s) of survey. A majority (89%) of species were encountered within quadrats and relevé sites, with only 46 opportunistic species (11%) being found outside the formal sample areas, indicating an appropriate number of sites were conducted.

The 2015 studies surveyed a portion of the Project Development Area (a sub-set of the entire Survey Area) and were conducted in a year with good winter rainfall and when the annual herbs were well represented. Conversely the 2018/2019 surveys covering the entire Survey Area were conducted in a period following high summer rainfall, but low winter rainfall in 2018 and low summer and winter rainfall in 2019, resulting in grasses being well represented, while annual species were not. Unfortunately, the climatic conditions did not improve between the winter and spring surveys resulting in poor representation of annual species across the 2018 / 2019 survey Periods. The 2014 / 2015 vegetation conditions were extremely beneficial in capturing the total number of taxa recorded within some of the Survey Area and can be considered an excellent representation of the perennial and annual flora within the Development Area portion of the Survey Area.

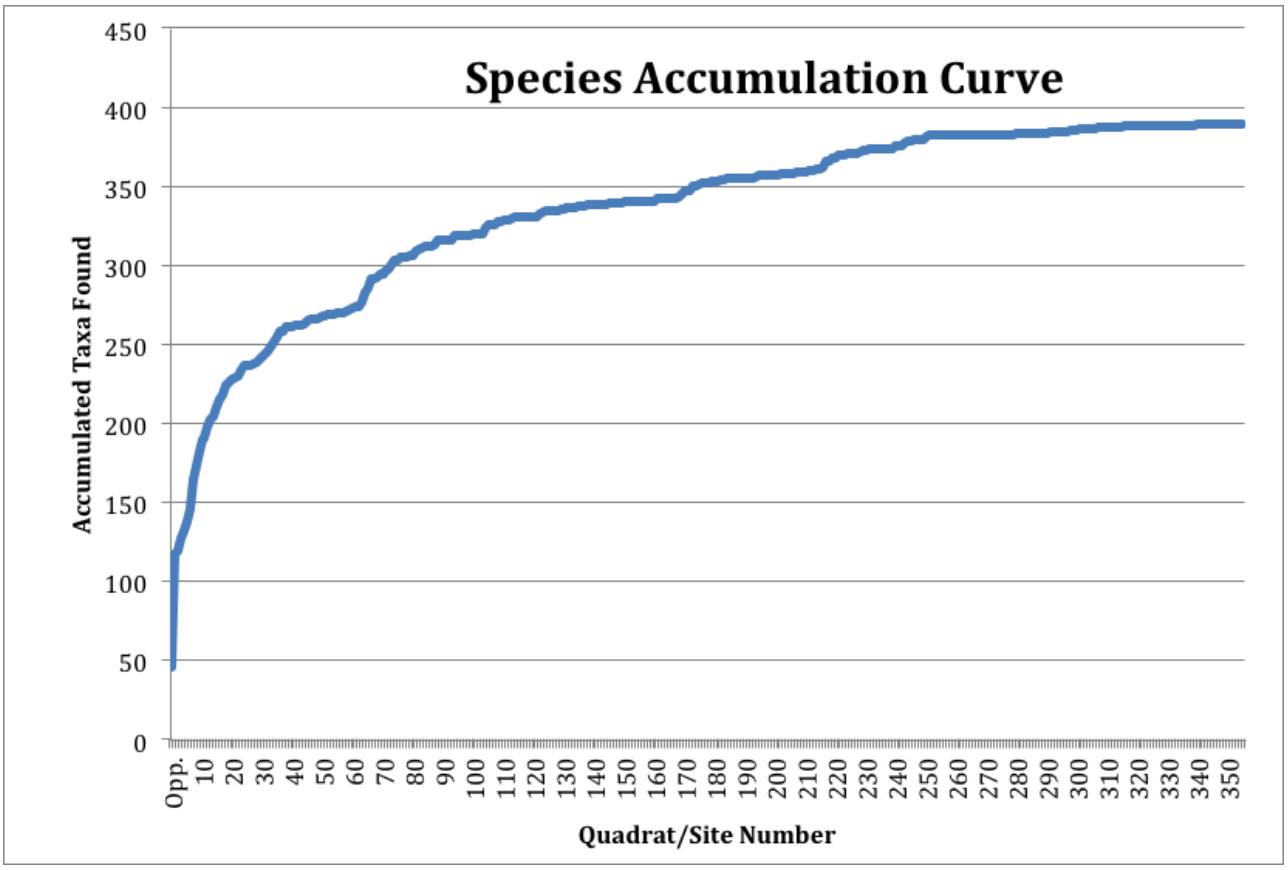


Figure 13. Species Accumulation Curve for the WMP Survey Area[3].

4.12. Flora Specimen Identification

Of the 701 specimens collected in 2018, 329 were identified as unique taxa. A further 301 specimens were collected during the 2019 survey with 96 identified as unique taxa. Five specimens are currently unable to be identified to species level because insufficient diagnostic material is available, resulting in a total of 362 taxa encountered in the 2018 / 2019 surveys. The results of the 2015 survey added a further 38 species to the list. These were largely annuals and due to the wetter seasonal conditions at that time. From the 2015 survey, five specimens were unable to be identified to species level resulting in the combined total of 390 species recorded with in the Survey Area (Appendix 7) of which 11 species remain unable to be fully identified (Table 13). It is unlikely that any of these unidentified specimens represent listed Priority Flora as none of them resemble any of the known Priority species in the region. However, one species, *Eragrostis* Tiny annual (J. Warden & D. Brassington WB39954) may represent a new species. This is discussed further in Section 4.13 Significant Flora.

[3] The species Accumulation curve starts at 46 species, which is the number of opportunistic collections within the WMP Study area

Table 13. Specimens not able to be fully identified due to insufficient material.

Specimen (year of collection)	Form	Year
Hibiscus sp. indet. (033-04)	Annual herb	2019
Tephrosia sp. indet. (WP325)	Annual herb	2019
Convolvulus sp indet. (Twiner to 0.8 m)	Perennial twiner	2018
Fimbristylis sp. indet. (Juvenile)	Ephemeral geophyte	2018
Maireana sp. indet. (dry and crispy)	Perennial shrub	2018
Poaceae sp. indet. (#119)	Grass	2018
Eragrostis Tiny annual (J. Warden & D. Brassington WB39954)	Annual grass	2015
Erodium sp. indet.	Annual herb	2015
Hibiscus sp. indet. (WMB065)	Perennial shrub	2015
Calandrinia sp. indet. (0.05 m tall)	Annual herb	2015
Asteraceae sp. indet.	Annual herb	2015

4.13. Significant Flora

Significant flora discussed here include:

- Species listed as either Threatened Flora or Priority Flora by DBCA.
- Species that have anomalous features that indicate they may represent new species or subspecies.
- Species which are not listed as Priority Flora, but which are poorly known in Western Australia and which fit the DBCA's description of Priority Flora within Western Australia.
- Species occurrence within the Survey Area representing range extensions of over 100 km within Western Australia.

Due to the proximity of the Survey Area to the Northern Territory and South Australian Borders a broader Australia wide perspective for each Significant flora species is presented using data from the Australian Virtual Herbarium (AVH) website.

4.13.1. Threatened and Priority Flora

No Threatened Flora listed under the *Wildlife Conservation Act 1950 (WA)*, now superseded by the or the *Biodiversity Conservation Act 2016 (WA)*, or the *Environment Protection and Biodiversity Conservation Act 1999 (Cth)* were recorded within the WMP Survey Area.

During the survey 11 Priority Flora species were identified. This included two Priority 1 species and nine Priority 3 species (Table 14). A brief description of each is presented below along with their current known distribution within Western Australia and also more broadly within Australia. Maps of distribution in W.A. were taken from the DBCA's Florabase website while distributions in Australia were taken from the AVH website. Two Priority species *Goodenia lunata* (P1) and *Thryptomene* sp. Warburton (P1) were not recorded during the current survey within the WMP Survey Area. However, they have previously been recorded during separate surveys located outside the current WMP alignment (Figure 14,Table 15). Western Botanical recorded a collection of *Goodenia lunata* (P1) in 2007, within the *Melaleuca Triodia* Spinifex (MTS) community, that is akin to the current MgAkS Association. This population at the time of recording was noted as being locally common but not seen elsewhere, which is consistent with the current findings. Also, *Thryptomene* sp. Warburton (P1) was found at one location within the Mt Squires tenements, where it grows atop a large, coarse grained syenite (granite) hill. The current Survey Area does not include any similar habitat that could support *Thryptomene* sp. Warburton (P1).

Coordinates of each encountered occurrence of Priority Flora were recorded and a map depicting these locations is presented in Figure 14. A full list of coordinates and population data for all records of Priority Flora is presented in Appendix 8.

During the time of the survey three species recorded within the Survey Area were added on the Priority species list as Priority 3 species:

- *Chrysocephalum apiculatum* subsp. *racemosum* (P3)
- *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) (P3),
- *Eragrostis* sp. Limestone (P.K. Latz 5921)(P3)

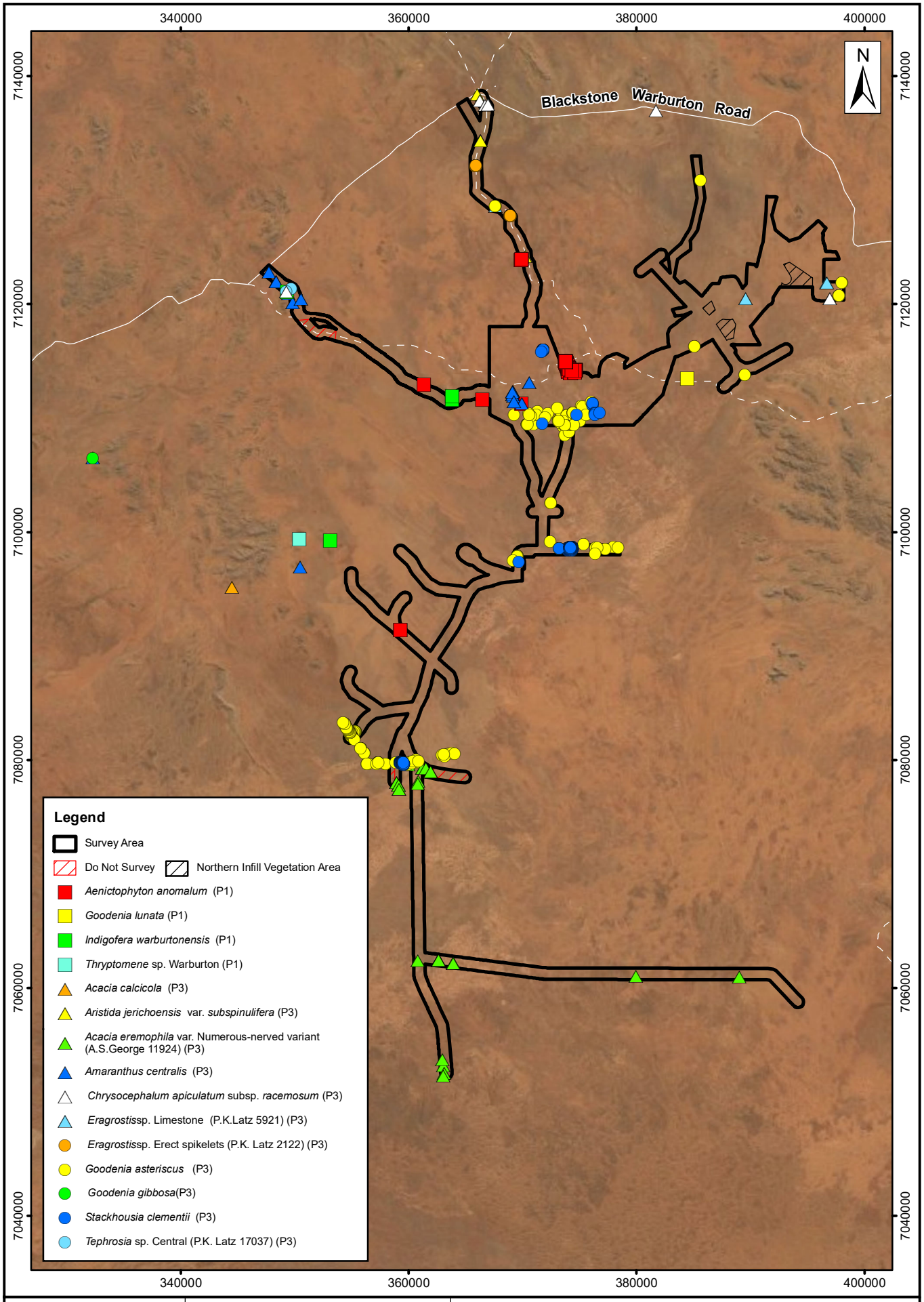
Additionally, *Calotis latiuscula* recently (2nd November 2018) had its Priority status reviewed, resulting in it being removed from the Priority species list due to increased records from the Central desert region and confirmation that the disjunct Pilbara records are the same species.

Table 14. Priority Species of the Survey Area.

Family	Genus	Species	Priority Statius	Veg Association Code
Fabaceae	*Aenictophyton*	*anomalum*	Priority 1	SDAGS
Fabaceae	*Indigofera*	*warburtonensis*	Priority 1	AcS and SMS
Fabaceae	*Acacia*	*eremophila* var. Numerous-nerved variant (A.S. George 11924)	Priority 3	CPHG
Amaranthaceae	*Amaranthus*	*centralis*	Priority 3	CPP and HPMW
Asteraceae	*Chrysocephalum*	*apiculatum* subsp. *racemosum*	Priority 3	CPN-G, SS, HPMW
Poaceae	*Aristida*	*jerichoensis* var. *subspinulifera*	Priority 3	CPN-G,HPMW, and GRMU
Poaceae	*Eragrostis*	sp. Erect spikelets (P.K. Latz 2122) and *Eragrostis* sp. ?Erect spikelets (P.K. Latz 2122) [4]	Priority 3	AkS
Poaceae	*Eragrostis*	sp. Limestone (P.K. Latz 5921)	Priority 3	CPHG
Goodeniaceae	*Goodenia*	*asteriscus*	Priority 3	CPHG
Celastraceae	*Stackhousia*	*clementii*	Priority 3	CPHG
Fabaceae	*Tephrosia*	sp. Central (P.K. Latz 17037)	Priority 3	HPMW, SS
Goodeniaceae	*Goodenia*	lunata	Priority 1	Outside current Survey Area
Myrtaceae	*Thryptomene*	sp. Warburton (M. Henson & M. Hannart 32433)	Priority 1	Outside current Survey Area

[4] These may represent two separate species, pending review by specialist taxonomists.

Figure 14. Priority Species Map.



Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

0 5 10 km

Scale: 1:450,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_07_01

Date: December 2020 | Rev: A | A4

Western Botanical

Author: J. Warden | WB Ref:

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OZ Minerals / Cassini JV

West Musgrave Flora Survey Area

Priority Species

Table 15. Number of Priority flora species and Population data recorded both within the Survey area and regionally.

Family	Genus species	Total Number of Individuals recorded	Number of Individuals in Detailed Survey Area	Number of Individuals outside of Detailed Survey Area	Number of known Populations in WA (WAHerb)	Number of known Population in Australia (AVH)	Comment
Fabaceae	*Aenictophyton anomalum*	4,662	2,538	1,944	2	109 (4 in WA)	AVH Plant population records at some sites show numbers vary from infrequent to locally common.
Fabaceae	*Indigofera warburtonensis*	121	0	121	3	3	None of the AVH records have population statistics recorded
Fabaceae	*Acacia eremophila* var. Numerous-nerved variant (A.S. George 11924)	711	0	711	18	Variant not recognised outside WA	
Amaranthaceae	*Amaranthus centralis*	59	52	7	6	103	None of the AVH records have population statistics recorded
Asteraceae	*Chrysocephalum apiculatum* subsp. *racemosum*	8	8	8	5	90	None of the AVH records have population statistics recorded
Poaceae	*Aristida jerichoensis* var. *subspinulifera*	8	0	8	39	633	None of the AVH records have population statistics recorded

Family	Genus species	Total Number of Individuals recorded	Number of Individuals in Detailed Survey Area	Number of Individuals outside of Detailed Survey Area	Number of known Populations in WA (WAHerb)	Number of known Population in Australia (AVH)	Comment
Poaceae	*Eragrostis* sp. Erect spikelets (P.K. Latz 2122)	1245	0	1,245	4	147	None of the AVH records have population statistics recorded
Poaceae	*Eragrostis* sp. Limestone (P.K. Latz 5921)	51	11	40	1	79	None of the AVH records have population statistics recorded
Goodeniaceae	*Goodenia asteriscus*	416	109	307	4	9 records from 6 populations	None of the AVH records have population statistics recorded
Celastraceae	*Stackhousia clementii*	2,046	287	1,759	21	217	None of the AVH records have population statistics recorded
Fabaceae	*Tephrosia* sp. Central (P.K. Latz 17037)	60+	0	60+	3	46	None of the AVH records have population statistics recorded
Goodeniaceae	*Goodenia lunata*	0	0	1	4	763	None of the AVH records have population statistics recorded
Myrtaceae	*Thryptomene* sp. Warburton (M. Henson & M. Hannart 32433)	1,000+	0	1,000+	1	1	

Aenictophyton anomalum P1 Fabaceae

Aenictophyton anomalum is a perennial herb growing to 0.2 m high with tufted stems ascending from long fine horizontal underground roots. The leaves are blue-green in colour, folded and occur in 2 - 5 pairs of leaflets plus a single terminal leaflet. The leaflets are variable, from linear to obovate and are sometimes deciduous and flowers are orange and in small terminal racemes (Flora of Central Australia, 1981) (Plate 41).

Within Western Australia *Aenictophyton anomalum* has only one record within the Great Victoria Desert IBRA region and another east of Wiluna in the Murchison IBRA region. However, a search of the AVH website shows a total of 108 records represented from the south-west corner of the Northern Territory, north-western South Australia, and a disjunct population from north-central New South Wales / south-central Queensland (Figure 15). The finding of *Aenictophyton anomalum* within the WMP is not considered to be surprising given the nearby records within Northern Territory and South Australia. The current lack of records within WA has resulted in *Aenictophyton anomalum* receiving a Priority 1 status, though this may change if more survey effort were to find additional populations within WA.

Aenictophyton anomalum was found at six sites, two within the proposed Western Access Road (2018), one on the Northern Access road (2018), one site within the Development Area (2015), and two sites bordering the proposed Windfarm Access Polygon along the Blackstone to Warburton Road (2015 and 2018). *Aenictophyton anomalum* is always associated with the deep sands of the Sand Dune *Acacia* - *Grevillea* Shrubland (SDAGS) Vegetation Association. Approximately 4,662 plants were recorded at these sites combined. This total is not a definitive count due to poor seasonal conditions making locating of plants difficult. A total of 180 plants were recorded within The Greater Survey Area during the first phase survey where the counts and population definition was limited. During the second phase survey and the targeted species searches, a further 2,538 plants were recorded within the Detailed Survey Study Area across four sand dunes, and counts continued outside the Survey Area with a further 1,944 plants recorded on sand dunes just east of the current OZ Minerals / Cassini exploration accommodation village (Appendix 8).

Plate 41. ***Aenictophyton anomalum.***

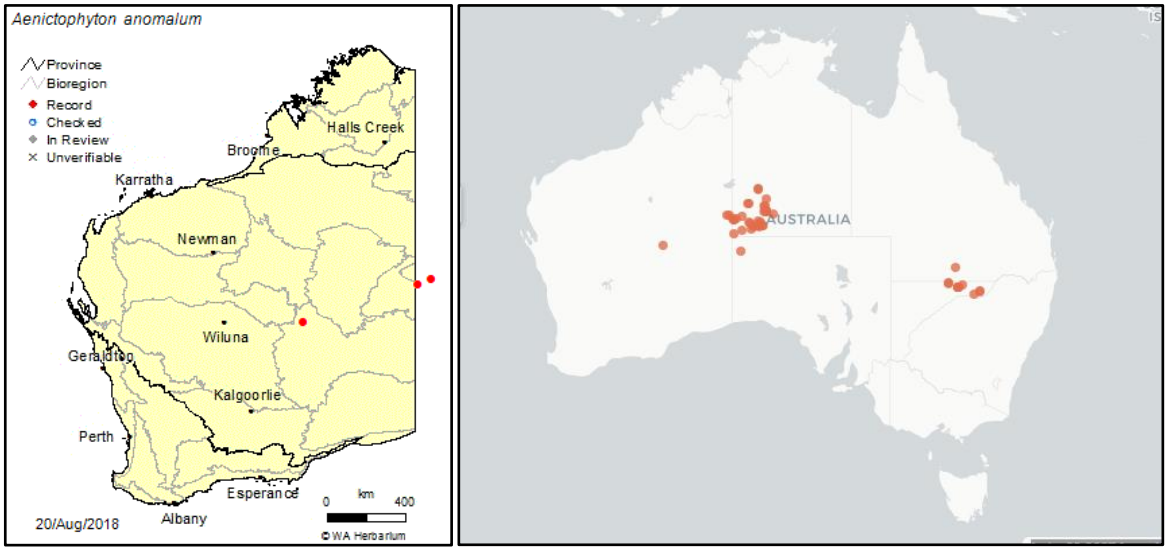


Figure 15. Known distribution of ***Aenictophyton anomalum*** **(Western Australian Herbarium 1998- (left), AVH 2019 (right)).**

Indigofera warburtonensis P1 Fabaceae

Indigofera warburtonensis is an erect or spreading somewhat spiny shrub 0.35 to 1.0 m high, with a woody root stock, the young stems are somewhat flexuosa, terete, green to brown, strigose with moderately dense, appressed, equally biramous hairs. The leaves are pinnate, with (3–)5–7(–9) leaflets, with triangular stipules, generally strongly thickened and recurved at the tip (Nuytsia 2015) (Plate 42).

Indigofera warburtonensis is currently only known in Australia from a small location restricted to an area east of Warburton, in the Central Ranges bioregion where it has been recorded as growing in stony soils on rocky hills (Nuytsia 2015) (Figure 16).

During the 2018 survey *Indigofera warburtonensis* was located at three sites; two of these were within the *Acacia cuthbertsonii* Shrubland (AcS) association and the third was located within the Stony Mulga Shrubland (SMS) all within the proposed Western Access road Alignment. It has also been found in association with outcropping granodiorite near Mt Squires, west of the Survey Area. A total of 121 *Indigofera warburtonensis* plants were recorded at two locations within the within the proposed Western Access road with no records within the Detailed Survey Study Area recorded, Appendix 8. The counts within the proposed Western Access road alignment were opportunistic and no specific targeted search was conducted to assess the full extent of these populations.

Plate 42. *Indigofera warburtonensis* at Mt Squires, 2011.

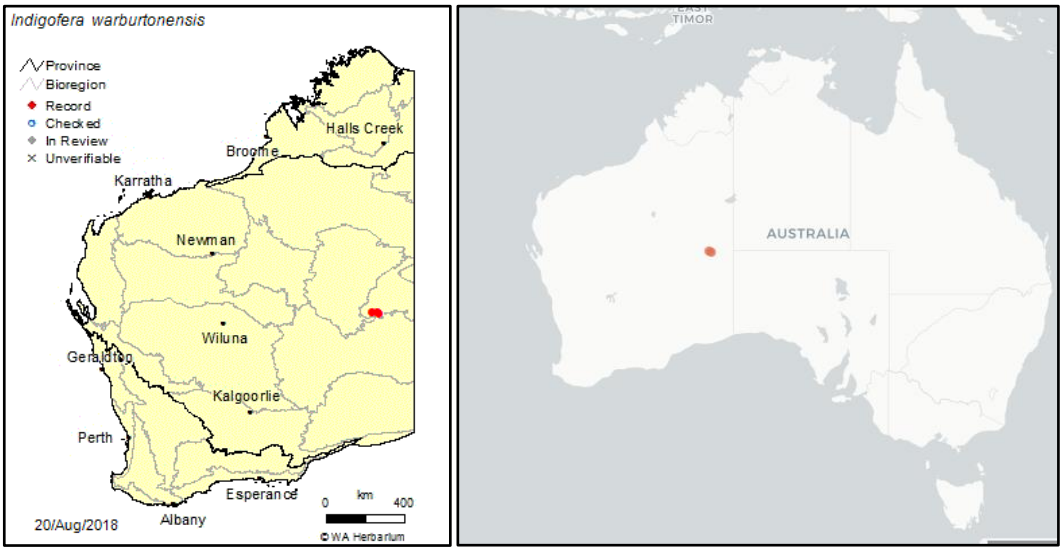


Figure 16. Known distribution of *Indigofera warburtonensis* (Western Australian Herbarium 1998- (left), AVH 2019 (right)).

Acacia eremophila var. Numerous-nerved variant (A.S. George 11924) P3 Fabaceae

Acacia eremophila var. Numerous-nerved variant (A.S. George 11924) is a dense spreading shrub, growing from 1 to 2 m high with dark green terete phyllodes and dark yellow round flowers (Plate 43). Flowering occurs from August to September with pods and mature seed set recorded between December and January. It has been recorded growing in sand and loam soils mostly in association with open Mallee Shrublands (Western Australian Herbarium 1988-).

Acacia eremophila var. Numerous-nerved variant (A.S. George 1924) has a sporadic distribution and has been recorded from Edjudina Station (~130 km north-east of Kalgoorlie), the Great Victoria Desert between Neale Junction and Plumridge Lakes and from between Norseman and Balladonia. There are currently 18 records on FloraBase from the Coolgardie, Great Victoria Desert, Murchison, and Nullarbor IBRA regions (Western Australian Herbarium 1988-) (Figure 17).

Within the Survey Area, it was recorded exclusively associated with calcrete platforms in the southern-most part of the proposed Southern Borefield and Officer Basin alignments. These records represent a 300 km to 400 km northerly Range Extension within Western Australia. A total of 711 plants were recorded within the proposed Southern Borefield and Officer Basin alignment during the 2018 / 2019 survey, a further 28 plants were recorded in the Southern Borefield region located outside the current Greater Survey Area during survey conducted in 2017. The population numbers at these two sites were opportunistic and no full assessment of population numbers and distribution has been conducted. *Acacia eremophila* var. Numerous-nerved variant (A.S. George 1924) was not located within the Detailed Survey Study Area.

Plate 43. *Acacia eremophila* var. Numerous-nerved variant (A.S. George 11924).

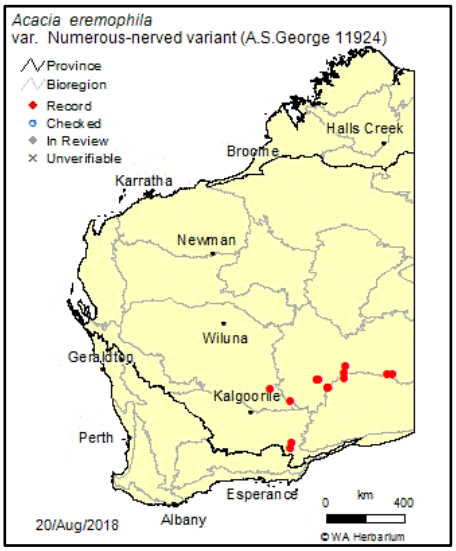


Figure 17. Known distribution of *Acacia eremophila* var. Numerous-nerved variant (A.S. George 11924) (Western Australian Herbarium 1998-).

***Amaranthus centralis* P3 Amaranthaceae**

Amaranthus centralis is an erect annual herb growing to 0.6 m tall with angular, sometimes reddish, and sparsely hairy to glabrous stems (Western Australian Herbarium 1988-) (Plate 44). It grows in red sand in ephemeral watercourses, sandy to clayey loam associated with riverbanks and edges of permanent pools in *Eucalyptus* lined channels, or *Acacia* Shrublands (Nuytsia 2009).

Amaranthus centralis commonly occurs in southern Northern Territory, and from the Everard Ranges near Lake Eyre south to the Flinders Ranges in northern South Australia (Nuytsia 2009). There are currently four records of this species on FloraBase from Central Ranges and Pilbara IBRA regions in Western Australia (Figure 18).

A total of 59 plants were recorded during 2014 and 2018 surveys. During the 2015 and 2018 surveys 52 *Amaranthus centralis* plants were located within the Detailed Survey Study Area with a further five recorded within the proposed Western Access road alignment, and 2 plants recorded outside the Greater Survey Area within the proposed Southern Borefield region. During the survey *Amaranthus centralis* was located within the Hardpan Mulga Woodlands (HPMW) Vegetation Association.

Plate 44. *Amaranthus centralis*, from the Central Ranges, 2013.

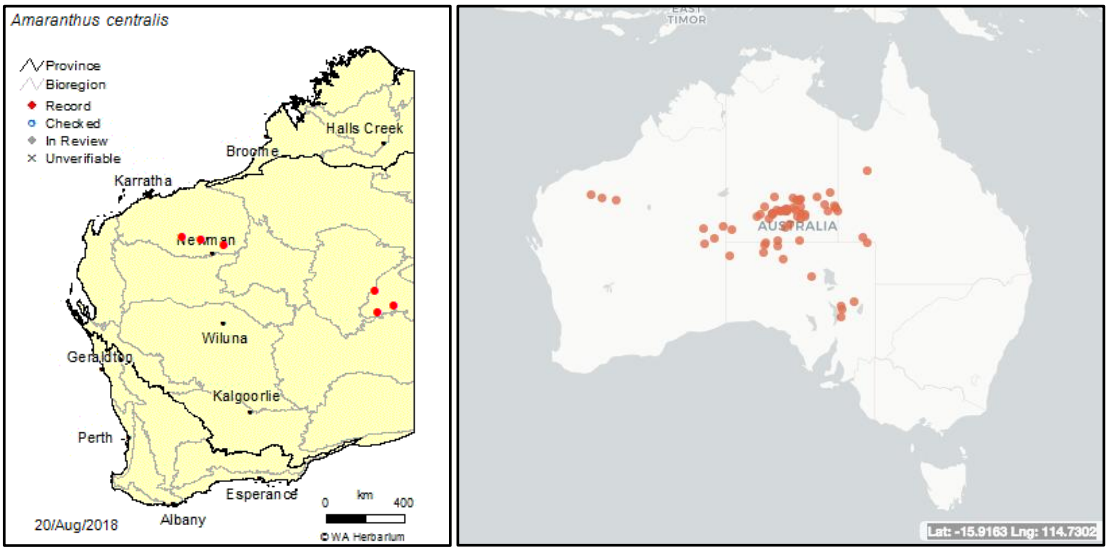


Figure 18. Known distribution of *Amaranthus centralis* (Western Australian Herbarium 1998- (left), AVH 2019 (right)).

***Chrysocephalum apiculatum* subsp. *racemosum* (P3) Asteraceae**

Chrysocephalum apiculatum subsp. *racemosum* is a perennial shrub to 0.5 m high and 0.8 m wide with long silky hairs covering short glandular hairs on blue-green foliage, with clusters of bright yellow flower heads (Plate 45). It is widespread in the southern Northern Territory and with populations also known in northern South Australia and western Queensland (Figure 19).

Chrysocephalum apiculatum subsp. *racemosum* has been seen scattered within the Sandplain and Sand Dune groups of Vegetation Associations within the Survey Area. It has previously been reported as *Chrysocephalum apiculatum* subsp. *apiculatum* by Western Botanical. However, since the revision of *Chrysocephalum apiculatum* by Paul G. Wilson in 2016, *C. apiculatum* subsp. *racemosum* is now regarded the variety within eastern W.A. and within the Survey Area. This species is poorly known in W.A. with only four specimens held at the WA Herbarium. One record (PERTH 00426830) is noted as C. *apiculatum* subsp. aff. *racemosum* (45 miles east of Southern Cross, WA) and should not be regarded as this species at this stage (K. Knight pers. comm. Dec 2018). The other three records held at WA Herbarium note populations associated with rocky ranges in the Warburton region (Mt. Florrie, Frederick Range and Walter James Range). Western Botanical recorded a further eight records of *Chrysocephalum apiculatum* subsp. *racemosum* within the Survey Area. *Chrysocephalum apiculatum* subsp. *racemosum* is poorly known in W.A. and was added to the Priority Flora list in early October 2018.

Plate 45. *Chrysocephalum apiculatum* subsp. *racemosum*, Survey Area, 2011.

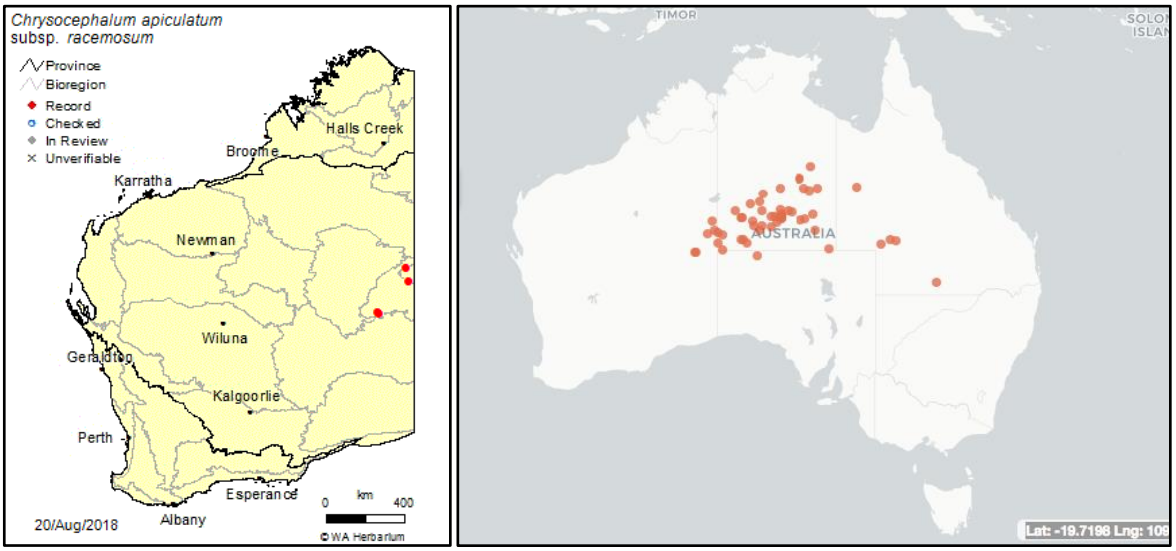


Figure 19. Known distribution of *Chrysocephalum apiculatum* subsp. *racemosum* (Western Australian Herbarium 1998- (left), AVH 2019 (right)).

Aristida jerichoensis var. *subspinulifera* P3 Poaceae

Aristida jerichoensis var. *subspinulifera* is an upright perennial tussock grass 0.8 to 1.2 m in height. The identification and conservation status of the species was not determined until after the winter 2018 field works.

Aristida jerichoensis var. *subspinulifera* was identified from a collected specimen with the field name *Aristida* sp. tall (WP 18). All subsequent records of *Aristida* sp. tall (WP 18) recorded within eight relevé locations along the Northern Access Road alignment, were assumed to be *Aristida jerichoensis* var. *subspinulifera.* These records were found within the Claypan – grassland (CPN-G), Hardpan Mulga Woodland (HPMW) and Groved Mulga (GRMU) vegetation associations.

Tall *Aristida* species were targeted during the spring significant species survey as other tall Aristida known from the region can be easily confused with *Aristida jerichoensis* var. *subspinulifera.* From collected specimens it was found that the tall *Aristida* associated with the Claypan – Grassland (CPN-G) association was *Aristida latifolia*. The tall *Aristida* associated with both the HPMW and GRMU vegetation Associations both identified as *Aristida jerichoensis* var. *subspinulifera*. These collections resulted in a total of three individual records for this species from three locations within the Northern Access Road alignment. A further five plants recorded within the Officer Basin alignment bring the total to eight plants within the Survey Area (Plate 46).

The recording of *Aristida jerichoensis* var. *subspinulifera* represents a significant Range Extension within WA. However, a broader inspection of the AVH database reveals, only a slight Range Extension south of its current known distribution in the N.T. (Figure 20).

Aristida jerichoensis var. *subspinulifera* is similar in habit and features to the more widespread species *Aristida inaequiglumis* and *Aristida latifolia*. Separating these three species requires careful inspection of mature florets with a microscope.

Plate 46. *Aristida jerichoensis* var. *subspinulifera.*

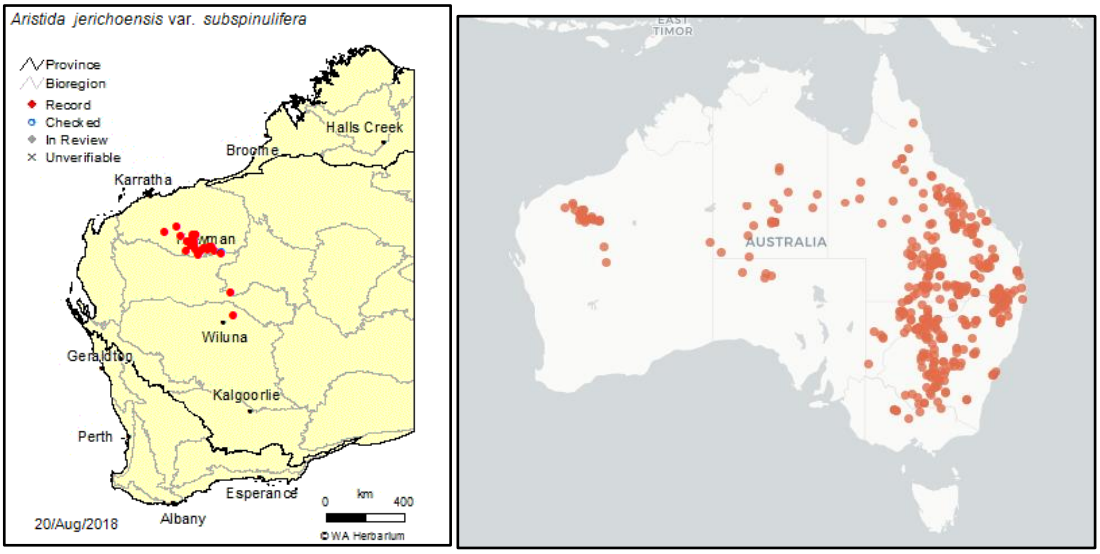


Figure 20. Known distribution of *Aristida jerichoensis* var. *subspinulifera* (Western Australian Herbarium 1998- (left), AVH 2019 (right)).

Eragrostis sp. Erect spikelets (P.K. Latz 2122) (P3) Poaceae

Eragrostis sp. Erect spikelets (P.K. Latz 2122) is a perennial tussock grass growing to 0.4 m high (Plate 47). *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) was initially found at one site within the WMP Survey Area, with 69 plants recorded along the Northern Access road alignment, on the boundary of the *Acacia kempeana* Shrubland (AkS and HPMW) and growing in shallow sand over outcropping and sub cropping granodiorite. During the 2019 survey a further population of *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) was recorded along the Northern Access road alignment with 113 plants recorded. Meaning a total of 182 plants were recorded across two populations within the Northern Access road.

Eragrostis sp. Erect spikelets (P.K. Latz 2122) is known from six other records in W.A., one from each of the Central Ranges, Great Sandy Desert, Tanami, and Murchison IBRA regions, and two records within the Pilbara IBRA region. The four specimens vouchered at the WA Herbarium indicate the species is associated with calcrete platforms. *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) is well known within the central and southern parts of the Northern Territory, however, with so few collections in W.A. means it has been classified as Priority 3 by DBCA (Figure 21).

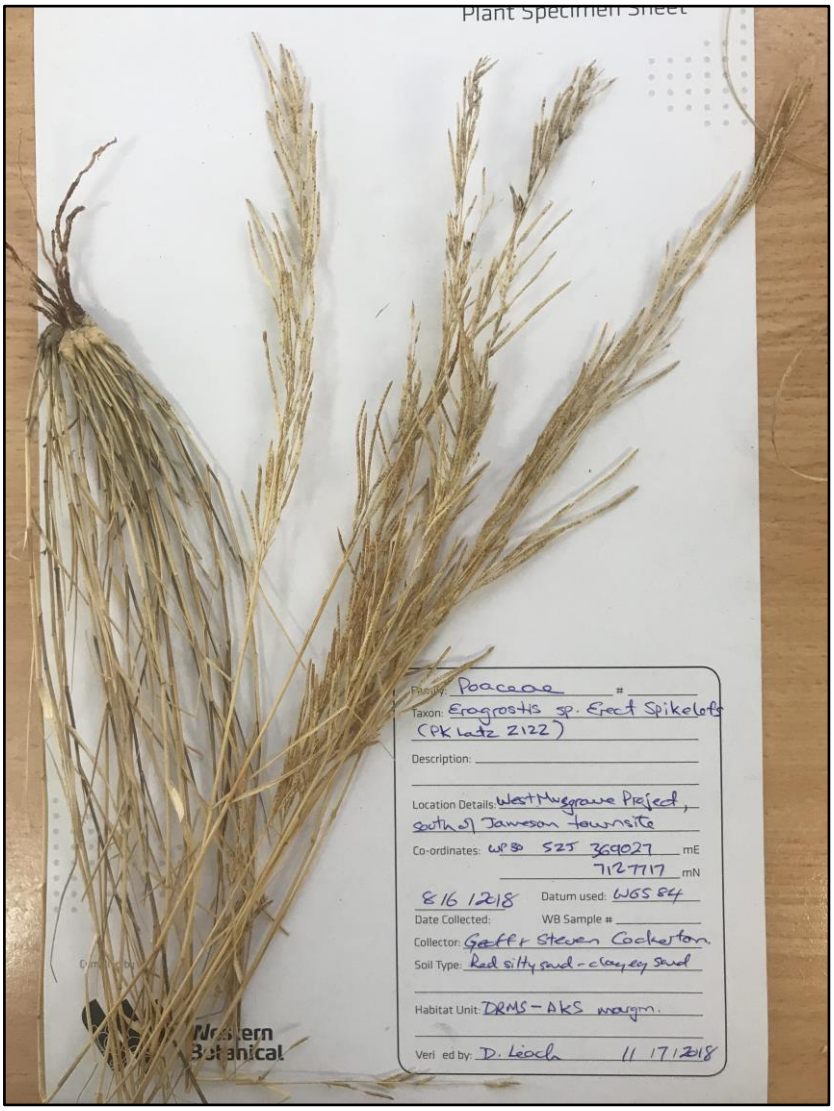


Plate 47. Herbarium specimen *Eragrostis* sp. Erect spikelets (P.K. Latz 2122).

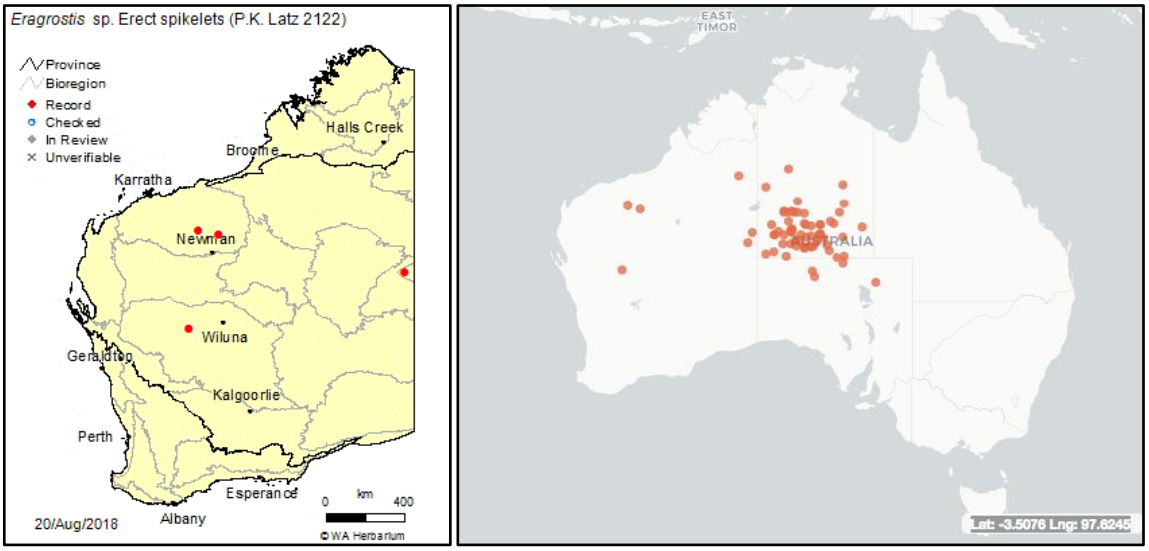


Figure 21. Known distribution of *Eragrostis* sp. Erect spikelets (P.K. Latz 2122 (Western Australian Herbarium 1998- (left), AVH 2019 (right)).

Eragrostis sp. Limestone (P.K. Latz 5921) (P3) Poaceae

Eragrostis sp. Limestone (P.K. Latz 5921) is a perennial tussock grass to 0.3m high and 0.4 m wide with short basal foliage forming a ring of live vegetation (Plate 48). Specimens collected within the WMP Survey Area key to *Eragrostis xerophila* using the Ausgrass2 taxonomic key (Simon *et al.* 2011). However, the material collected differs from specimens housed at the WA Herbarium in having minute upward orientated teeth on margins of leaves, stems and glumes. The specimens collected at WMP are a good match for the one specimen of *Eragrostis* sp. Limestone (P.K. Latz 5921) from the Northern Territory that is housed at WA Herbarium.

Eragrostis sp. Limestone (P.K. Latz 5921) was collected at three sites within the Survey Area, two sites within the North-eastern Borefield alignment, and one site represented by 11 plants within the Northern Access road alignment. It is uncommon within the Survey Area, though has not been specifically targeted in surveys. It is always associated with outcropping calcrete platforms and is found in small, isolated populations of up to a couple of dozen clumps with other grasses including *Triodia scariosa*, *Eragrostis eriopoda*, *Eriachne mucronata* typical form and *Aristida contorta*.

There are 79 records of *Eragrostis* sp. Limestone held at the N.T. Herbarium with the bulk of specimens being from central and southern N.T. and seven from W.A. (Central Ranges, Gibson Desert, Great Sandy Desert IBRA regions) (Figure 22). There are no collections from W.A. held at the WA Herbarium. This species was listed as a Priority Species by DBCA since the start of surveys in the WMP area.

Plate 48. *Eragrostis* sp. Limestone (P.K. Latz 5921) (P3) and herbarium specimen.

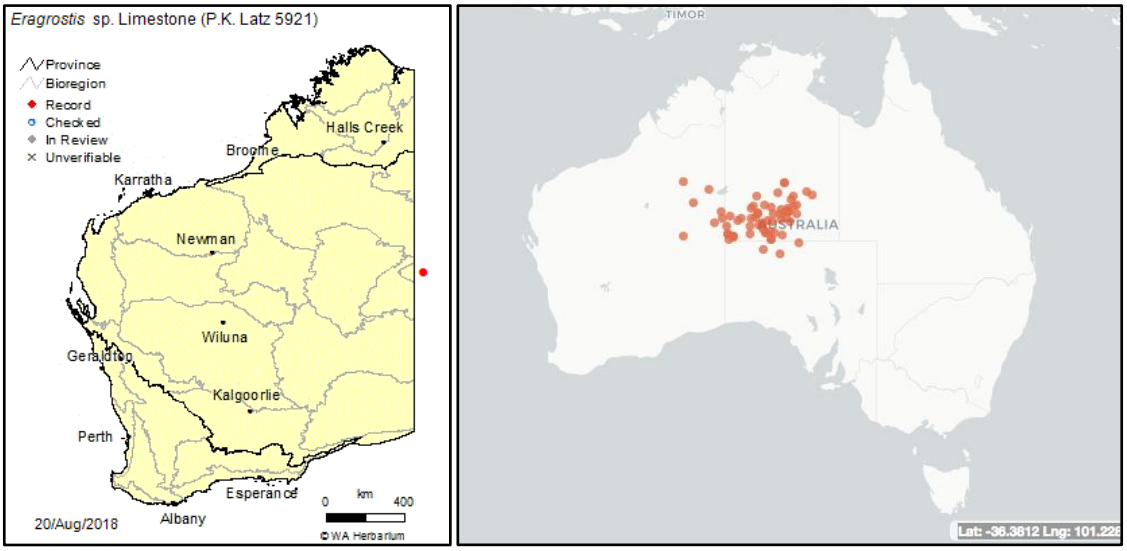


Figure 22. Known distribution of *Eragrostis* sp. Limestone (P.K. Latz 5921) (Western Australian Herbarium 1998- (left), AVH 2019 (right)).

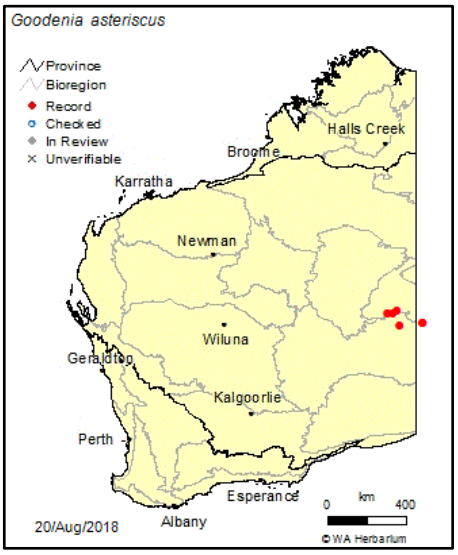
Goodenia asteriscus P3 Goodeniaceae

Goodenia asteriscus is a herbaceous perennial, facultatively stoloniferous, rosette-forming herb growing from 8 to 22cm tall, developing a woody taproot and thickened basal stem that retain the old pedicel bases (Plate 49).

It has mostly been found growing on limestone plains with outcropping calcrete (Lang & Davies, 2017). During surveys it was found within the Calcrete Platform Hummock Grassland (CPHG) vegetation association, which is consistent with descriptions of vegetation and soil associations it has previously been collected within. Western Botanical, Coffey Consulting, and Stantec (formerly Outback Ecology Services) have recorded this species previously within the region as the phrase name *Goodenia* sp. aff. *quasilibera* (Davies & Alford 2012).

Goodenia asteriscus (P3) is known from five records in WA and six records in north-western South Australia (Figure 23). Its known range spans approximately 500 km east-west and 200 km north-south from the Central Ranges and Great Victoria Desert IBRA regions in Western Australia. A total of 416 plants were recorded within the Survey Area, with 109 recorded within the Detailed Survey Study area and a further 307 recorded outside the Detailed Survey Study area, but within the Greater Survey Area. During previous surveys a further 115 plants have been recorded regionally.

Plate 49. *Goodenia asteriscus* (P3).



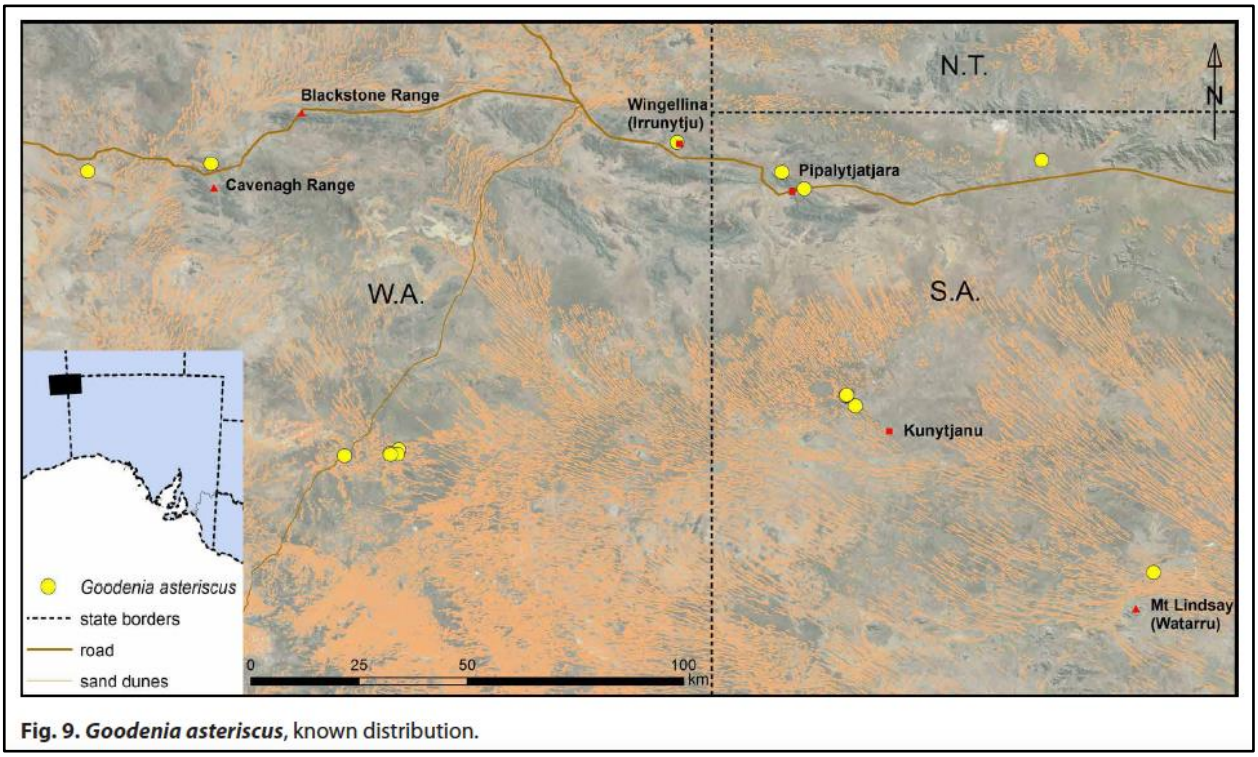


Figure 23. Known distribution of *Goodenia asteriscus* (Western Australian Herbarium 1998- (above) (below from Lang & Davies, 2017, Fig. 9)).

Stackhousia clementii P3 Celastraceae

Stackhousia clementii (P3) is a dense broom-like perennial herb, growing to 0.45 m high (Plate 50). The flowers are green/yellow/brown. It has been recorded growing on skeletal soils and has been recorded in the region growing on shallow sands over calcrete (Western Australian Herbarium 1988).

There are currently 17 records of *Stackhousia clementii* P3 on FloraBase, with a widespread distribution from the Carnarvon, Central Ranges, Great Victoria Desert, Murchison, and Pilbara IBRA regions (Western Australian Herbarium 1988) (Figure 24). Coffey, 2010b reported 17,038 plants within the northern section of the tenement E69/1530 that is contiguous with the south-east of the Survey Area, that share similar habitat consistent with the majority of the current Survey Area. However, a search of the AVH website shows that it is also well represented throughout the central parts of South Australia and the Northern Territory, with a few records creeping into western Queensland.

Approximately 2,046 individuals were recorded across the Survey Area within four populations; two of these are within the Development Area, the first on a small outcrop of Calcrete Platform Hummock Grassland (CPHG), located just north of the current OZ Minerals / Cassini JV accommodation village, totalling 287 plants, and a second population in the south of the Development Area totalling 42 plants. The remaining two populations were recorded within the Southern Borefield alignment with 1,001 and 716 plants recorded at each, respectively. It would appear that as a colonising species, *Stackhousia clementii* (P3) flourishes in the conditions following disturbance, then reduces to a sparse presence within the vegetation association as it reaches a climax community state. This species is inconspicuous and it is likely that some populations have been overlooked during the vegetation mapping component of works undertaken to date.

Plate 50. *Stackhousia clementii*, Central Ranges, 2011.

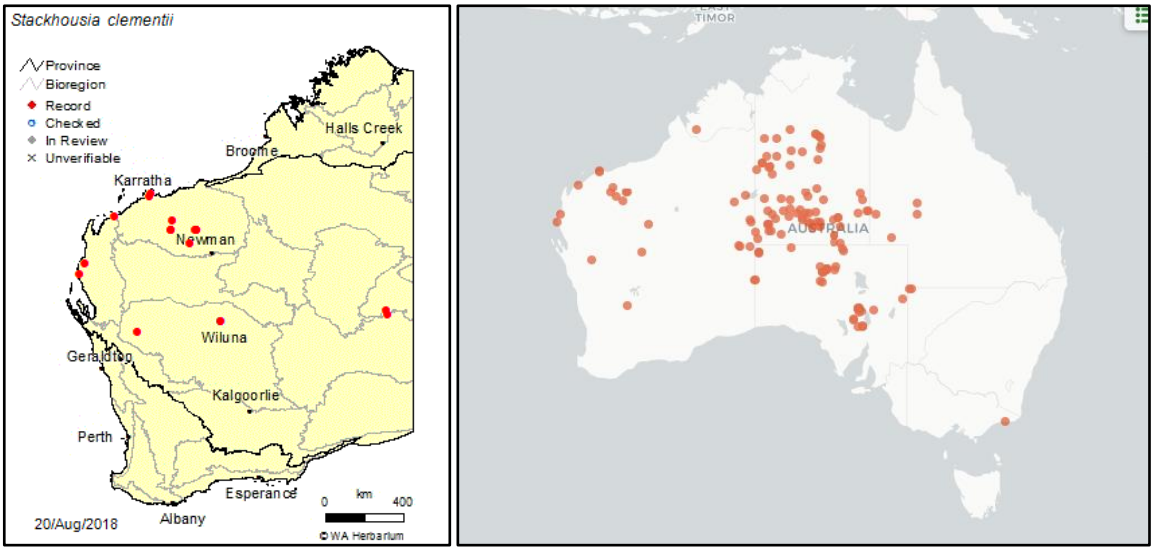


Figure 24. Known distribution of *Stackhousia clementii* (P3) (Western Australian Herbarium 1998- (left), AVH 2019 (right)).

Tephrosia sp. Central (P.K. Latz 17037) P3 Fabaceae

Tephrosia sp. Central (P.K. Latz 17037) is an ascending perennial herb to 0.5 m. The leaves are pinnate with 11-15 leaflets per leaf. The leaflets 4-10mm long x 5mm wide, flowers are small and orange and the fruits are elongated, approximately 4 mm wide x 20mm long, (Plate 51).

Tephrosia sp. Central (P.K. Latz 17037) was recorded at from two locations within the proposed Western Access road alignment, associated with the Hardpan Mulga Woodland (HPMW), with an estimate of 60 plants recorded in total. It is likely present elsewhere within the HPMW community.

The records here represent a range extension of approximately 200 km south of its known distribution, (Figure 25). *Tephrosia* sp. Central (P.K. Latz 17037) is well known within the central and southern parts of the Northern Territory, and western parts of Queensland, but with so few collections in W.A. it has been assigned a Priority 3 status by DBCA.

Plate 51. *Tephrosia* sp. Central (P.K. Latz 17037).

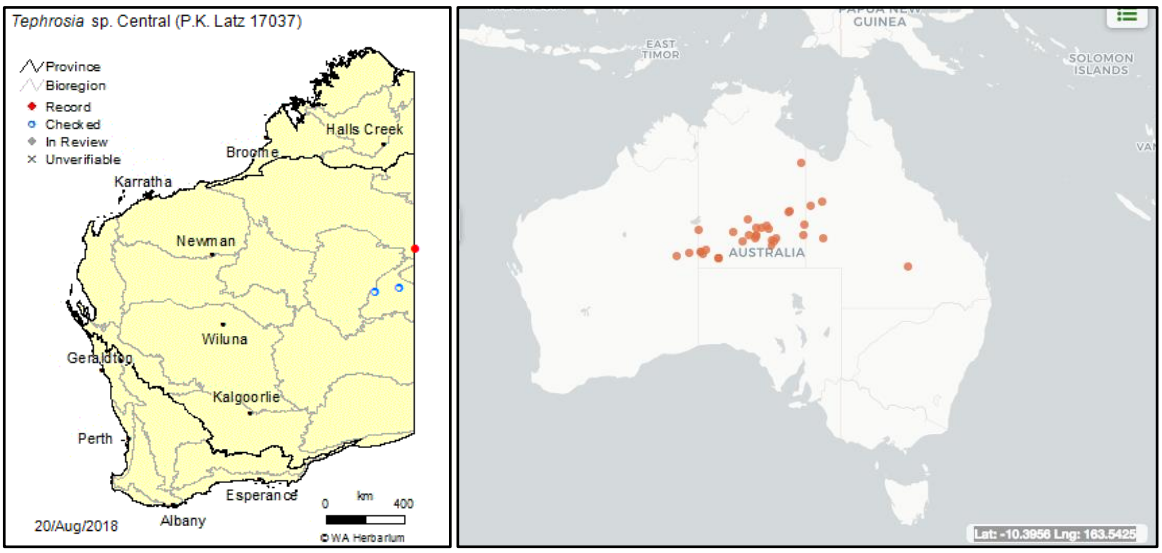


Figure 25. Known distribution of *Tephrosia* sp. Central (P.K. Latz 17037) (Western Australian Herbarium 1998- (left), AVH 2019 (right)).

4.13.2. Flora with Taxonomic Interest

The following 29 species (Table 16) have taxonomic significance and represent:

(i) Three possible new species that have not been previously collected. These species require specialist review and may subsequently acquire Priority Flora status.

(ii) Eight species that are poorly known and may represent new subspecies that have not been recognised at this stage, but which have become apparent during this review. These species do require taxonomic review and some may on assessment acquire Priority Flora status.

(iii) Eighteen species that are known to science, but have not been formally described. These species do not warrant further specific survey or conservation status assessment, as they are well collected and widespread in W.A. and/or in adjacent states.

Table 16. Flora of taxonomic interest within the Survey Area.

Taxon **(sorted in order of significance and then alphabetically)**	**Reason for taxonomic interest**	**(i) Possible new species not previously collected**	**(ii) Poorly known and possibly representing a new taxon**	**(iii) Well known but undescribed**
Eragrostis sp. Tiny annual (J. Warden, D. Brassington WB39954)	Unknown annual grass not matching any known species, recorded within the HPMW vegetation association in 2015 within the Central Survey Area. Recent WAHERB determination February 2020 pers. Comm Steve Dillon it may represent a juvenile form of *Eragrostis dielsii*, further collection from location required.	**1**		
Sida sp. Denticulate (WB40095 J. Warden D. Leach)	A distinctive entity that doesn't fit any of the currently recognised taxa. Recorded in a grass dominated patch within HPMW located within the Officer Basin Alignment	**1**		

Taxon **(sorted in order of significance and then alphabetically)**	**Reason for taxonomic interest**	**(i) Possible new species not previously collected**	**(ii) Poorly known and possibly representing a new taxon**	**(iii) Well known but undescribed**
Eragrostis sp. ?Erect spikelets (P.K. Latz 2122) (G & S Cockerton WB39984))	This species requires further taxonomic investigation and may represent a new species. *Eragrostis* sp. ?Erect spikelets (P.K. Latz 2122) (G & S Cockerton WB39984) is associated with the calcrete landforms south of the Jameson Range and was recorded with multiple waypoints within the North Eastern Borefield alignment during the 2019 surveys. The specimen of *Eragrostis* sp. ?Erect spikelets (P.K. Latz 2122) (G & S Cockerton WB39984) has been vouchered at the WA Herbarium.	**1**		
Acacia maitlandii (narrow phyllode form)	An undescribed form of the species, that may represent a hybrid, found within the Southern Borefield part of the Survey Area.		**1**	
Eriachne mucronata desert form glabrous (WB38710)	Differs from the Queensland form of *E. mucronata* desert form, but is considered widespread in central and eastern W.A. Widespread patches associated with grano-diorite subcrops in the western access road part of the Survey Area.		**1**	
Glischrocaryon aureum Reticulated fruit form (WB39951)	Part of a complex of three species, all widespread in southern W.A. One plant noted in the Southern Borefield part of the Survey Area.		**1**	
Ptilotus obovatus Sand Dune Form (WB39950)	Part of a broad complex, widely distributed across central Australia. Widespread within the Survey Area, particularly in dune ridges (SDAGS vegetation association).		**1**	

Taxon **(sorted in order of significance and then alphabetically)**	**Reason for taxonomic interest**	**(i) Possible new species not previously collected**	**(ii) Poorly known and possibly representing a new taxon**	**(iii) Well known but undescribed**
Quoya loxocarpa	A complex of two morphotypes distributed from Central Australia to north-west coastal locations. Uncommon within the Survey Area, on dune ridges (SDAGS vegetation association).		**1**	
Sida sp. (J. Warden & D. Brassington WB39957) aff. *cardiophylla* (PERTH 03467406)	Specimen collected within the Survey Area matches one specimen at the WA Herbarium (PERTH 03467406) but matches no other *Sida*).		**1**	
Tephrosia sp. Central (P.K. Latz 17037) P3	Found in Hardpan Mulga Woodlands (HPMW) within the Survey Area. Poorly known, Priority 3 in W.A.		**1**	
Triodia scariosa	Widespread throughout the Survey Area on calcrete platforms (CPHG vegetation association). In need of taxonomic review due to poorly differentiated taxonomy. Three regions of distribution in Australia, and widely distributed in central Australia		**1**	
Acacia ayersiana narrow phyllode form	Widespread in W.A. and well known but not described. Widespread within the Survey Area.			**1**
Acacia eremophila var. Numerous-nerved variant (A.S. George 11924) P3	Poorly known and undescribed variety, Priority 3 in W.A. Found in the southern part of the Southern Borefield and Officer Basin Alignment within the Survey Area.			**1**
Acacia rhodophloia (Central Australian Desert Form) (WB39323)	Widespread in central Australia and well known but not described. Found in the central part of the Southern Borefield in the Survey Area.			**1**
Calotis sp. Carnarvon Range (DJ Edinger & KF Keneally D2708 K12243)	Widespread and well-known but not described. Uncommon on the sand dune ridges (SDAGS vegetation association) within the Survey Area.			**1**

Taxon **(sorted in order of significance and then alphabetically)**	**Reason for taxonomic interest**	**(i) Possible new species not previously collected**	**(ii) Poorly known and possibly representing a new taxon**	**(iii) Well known but undescribed**
Eragrostis sp. Erect spikelets (PK Latz 2122)	Undescribed species that is widespread and well known in N.T and uncommon in W.A. Found at one location adjacent to the Northern Access road in the northern part of the Survey Area. May represent two distinct taxa, requiring review.			**1**
Eragrostis sp. Limestone (PK Latz 5921)	Undescribed species that is widespread and well known in N.T and uncommon in W.A. Found at three locations within the Survey Area, associated with calcrete platforms (CPHG vegetation association).			**1**
Eriachne mucronata typical form (WB39952)	Widespread and well known in WA. Western Australian Herbarium does not recognise the forms as separate taxa. Widespread within the Survey Area.			**1**
Halgania cyanea subsp. Allambi Station (BJ Strong 676)	Widespread and well known but not described. Widespread on calcrete platforms (CPHG vegetation association) within the Survey Area.			**1**
Pomax sp. Desert (A.S. George 11986), also known as *Pomax* sp. Sand dunes (P.G. Wilson 752)	Widespread and well-known but not described. Uncommon on the sand dune ridges (SDAGS vegetation association)			**1**
Scaevola spinescens (narrow leaf, spiny form)	Part of a broad complex, widely distributed in W.A. Widespread within the Survey Area			**1**
Senna sp. Billabong (J.D. Alonzo721)	Widespread in W.A. and well known but not described.			**1**
Sida sp. Golden Calyces pubescent (G.J. Leach 1966)	Widespread and well-known but not described.			**1**
Sida sp. dark green fruits (S. van Leeuwen 2260)	Widespread and well-known but not described.			**1**
Sida sp. *Excedentifolia* (J.L. Egan 1925)	Widespread and well-known but not described.			**1**

Taxon (sorted in order of significance and then alphabetically)	Reason for taxonomic interest	(i) Possible new species not previously collected	(ii) Poorly known and possibly representing a new taxon	(iii) Well known but undescribed
Sida sp. Golden calyces glabrous (H.N. Foote 32)	Widespread and well known but not described.			**1**
Sida sp. L (A.M. Ashby 4202)	Poorly known, part of a widespread complex.			**1**
Tephrosia sp. deserts (J.R. Maconochie 1403)	Widespread in central Australia and well known but not described.			**1**
Thysanotus sp. Eremaean (S. van Leeuwen 1067)	Found infrequently on sand dune ridges (SDAGS vegetation association) within the Survey Area. Widespread and well known in W.A. but not described			**1**
Count		**3**	**8**	**18**

These species are not discussed separately other than the following notes on *Eragrostis mucronata*, and *Eragrostis* sp. ?Erect spikelets (P.K. Latz 2122) (G & S Cockerton WB39984). Indicative locations within the Survey Area of species in categories (ii) and (iii), excluding the recognised Priority Flora species (*Tephrosia* sp. Central (P.K. Latz 17037) P3, *Eragrostis* sp. Limestone (P.K. Latz 5921) P3, and *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) P3, and those that are widespread within the Survey Area (*Eriachne mucronata* desert form glabrous (WB38710), *Ptilotus obovatus* sand dune form and *Triodia scariosa*), are presented in Figure 26 and Table 17.

Table 17. Locations of species of taxonomic interest.

Species	Grid	Grid	Easting	Northing
Acacia maitlandii (narrow phyllode form)	52	J	361711	7087005
	52	J	361458	7089178
Eragrostis sp. Tiny annual (J. Warden, D. Brassington WB39954)	52	J	370717	7114530
Eragrostis sp. ?Erect spikelets (P.K. Latz 2122) (G & S Cockerton WB39984).	52	J	368352	7111437
	52	J	384973	7132109
	52	J	385732	7131188
	52	J	383720	7134873
	52	J	382863	7136138

Species	Grid	Grid	Easting	Northing
	52	J	385463	7130283
	52	J	384526	7126335
	52	J	384329	7125305
	52	J	385694	7130765
	52	J	385657	7130763
	52	J	383536	7124750
	52	J	383364	7124628
	52	J	384366	7125527
	52	J	383735	7124290
	52	J	384276	7124724
Eragrostis sp. Limestone (PK Latz 5921)	52	J	367612	7128662
	52	J	387508	7120054
	52	J	389612	7120486
Glischrocaryon aureum Reticulated fruit form (WB39951)	52	J	360000	7094500
Quoya loxocarpa	52	J	356638	7084524
	52	J	384598	7116318
Sida sp. Denticulate (WB40095 J. Warden D. Leach)	52	J	0369198	7061320

Eriachne mucronata typical form

Not formally described, though widespread and common. Keys to "*Eriachne mucronata* typical form" in Ausgrass 2 (Simon *et al.* 2011) (and matches other specimens collected by Western Botanical and those housed at the WA Herbarium. No issues with identification of this species other than it is a form not formally recognised by the Western Australian Herbarium, and does not require conservation listing.

Eriachne mucronata desert form glabrous (WB38710)

Keys to *Eriachne mucronata* desert form in Ausgrass 2 (Simon *et al.* 2011). However, the original description of "*Eriachne mucronata* desert form" from specimens collected in Queensland (M. Lazarides (1970), page 158 and Plate 46b), describes the species as “usually densely covered by dense, short stiff, bristle-like hairs arising from hard wart-like tubercles, thus causing the plant to be harsh to the touch.” The specimens collected within the proposed Western Access Road section of the Survey Area are completely glabrous and therefore probably represent a new form that differs from that recognised by Lazarides. Western Botanical has recorded this species in the West Musgraves region and also in the Leonora - Wiluna region, including the Wanjarri Nature Reserve, and attributed it to "*Eriachne mucronata* desert form” in the past. *Eriachne mucronata* desert form glabrous (WB38710) has been found in association with shallow sandy soil over outcropping

granodiorite in the Survey Area and with shallow silty sand over laterite and subcropping limonitic geology in the Leonora - Wiluna region. It is always found in small, isolated, well-defined, and restricted populations across its observed range. This form (and species) requires further taxonomic review incorporating a revision and sorting of specimens held at WA Herbarium and possibly other Herbaria, to determine its uniformity across its range.

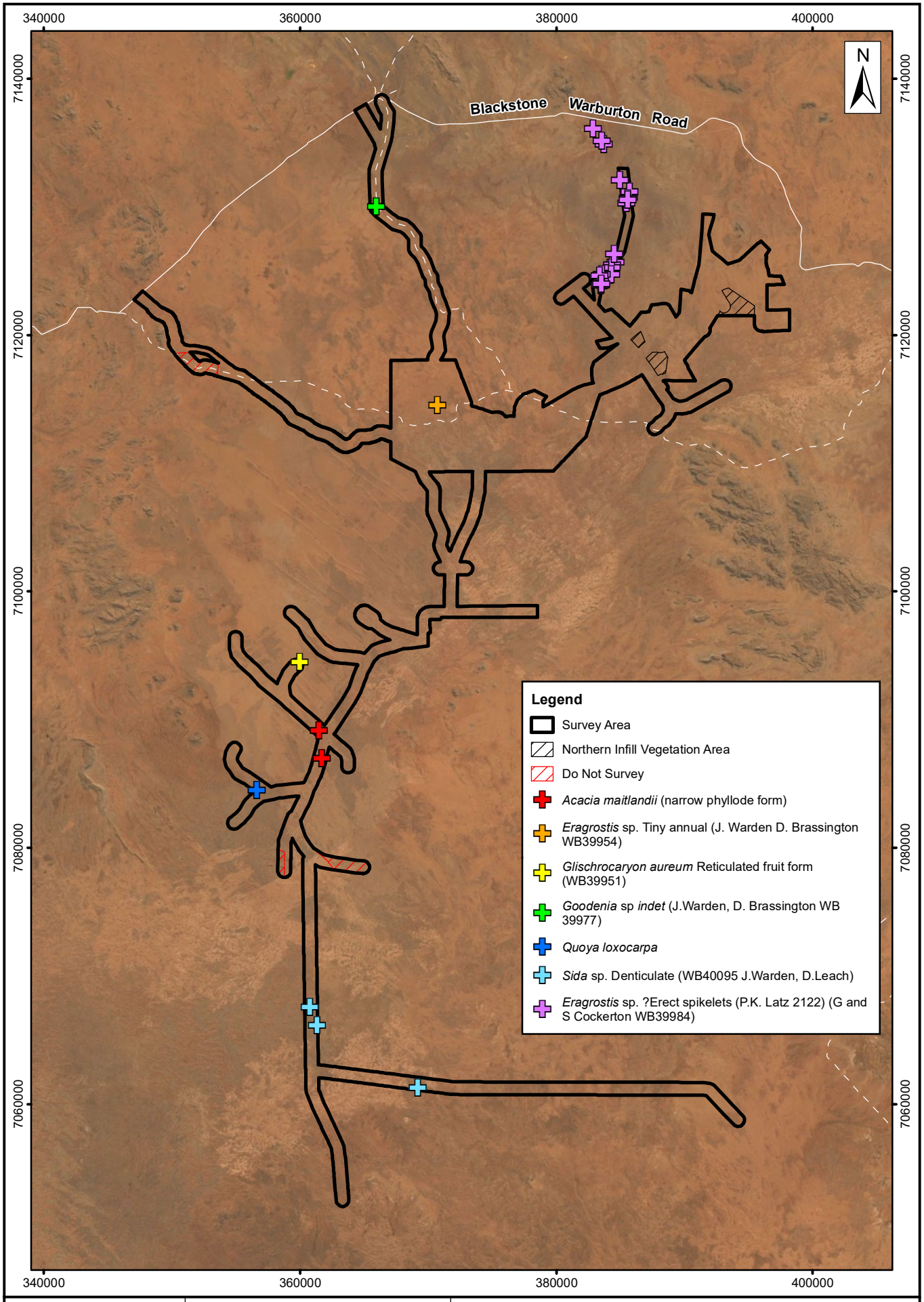
***Eragrostis* sp. ?Erect spikelets (P.K. Latz 2122) (G & S Cockerton WB39984)**

Specimens recorded and collected of *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) (P3) during the 2019 additional areas survey were considered slightly different form the specimens collected in 2018. These specimens were submitted to the WA herbarium to confirm the identification of this entity. The initial result was a tentative identification of *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) P3 assigned. Upon further investigation and specialist advice the name to be applied to these specimens has been updated to *Eragrostis* sp. ?Erect spikelets (P.K. Latz 2122) (G & S Cockerton WB39984) meaning they are similar to *Eragrostis* sp. Erect spikelets (P.K. Latz 2122), but have features that are inconsistent and may represent a new species altogether.

The specialist advice was that all the specimens submitted were considered the same taxon, and whilst the inflorescence character is very similar to *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) the rootstock in the specimens supplied are consistently shortly rhizomatous and the bases are obviously hairy. This when compared with the few specimens of *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) at PERTH the rootstock is tufted and the bases much less hairy. Added to this the current understanding is that *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) is associated with subsaline habitats in the vicinity of salt lakes, whilst our specimens are associated with sand over calcrete.

A total of 1,046 plants were recorded from the 16 populations, comprising of fourteen located within the North eastern Borefield, and two populations outside of the survey area. A total of 803 plants were recorded within the proposed Northern Borefield alignment and 260 plants recorded outside the Survey Area.

Figure 26. Map of species of taxonomic interest.



0 5 10 km

Scale: 1:400,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_07_03

Date: December 2020 | Rev: A | A4

Western Botanical

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West Musgrave Flora Survey Area

Species with Taxonomic Significance

4.13.3. Range Extensions

The flora of the Central Ranges Bio Region (CR) and the Great Victoria Desert (GVD) is relatively poorly surveyed. As such, it is not surprising to find many species occur within the Survey Area as range extensions for WA using the resources of the WA Herbarium (Florabase). However, when compared with the Australia-wide combined databases of all herbaria (AVH database), there are often additional records of the same species just east of the W.A. border in South Australia or the Northern Territory.

Fifty-six species within the Survey Area represent Range Extensions of between 100 to 800 km within W.A. using the DBCA's Florabase database. This number is reduced to 32 species when the AVH records are considered (Table 18). Specimens of these records will be vouchered with the WA Herbarium.

Table 18. Range Extension of greater than 100 km.

Species	Range Extension in WA (Florabase)	Range Extension in Australia (AVH)	Current Recorded Distribution
Swainsona phacoides	~100 km South	Within Range	Currently known from 3 records within the CR IBRA Region
Sida sp. dark green fruits (S. van Leeuwen 2260)	~100 km South East	Data on AVH is at odds with Western Australia	Currently known from 2 records within the CR IBRA Region
Tribulus macrocarpus	~100 km South	Within Range	Currently known from 3 records within the CR IBRA Region
Aristida obscura	~100 km South	Within Range	Currently known from 2 records within the CR IBRA Region
Anthotroche pannosa	~100 km East	~100 km East	Currently known from 1 record within the CR IBRA Region and 15 within the GVD IBRA Region
Cenchrus ciliaris (Weed)	~100 km East	Within Range	Currently known from 3 records within the CR IBRA Region
Vincetoxicum lineare	~100 km East	Within Range	Currently known from 1 record within the CR IBRA Region and

Species	Range Extension in WA (Florabase)	Range Extension in Australia (AVH)	Current Recorded Distribution
			9 within the GVD IBRA Region
Eragrostis dielsii	~100 km East	Within Range	Currently known from 4 records within the CR IBRA Region and 3 within the GVD IBRA Region
Eragrostis pergracilis	~100 km East and South	Within Range	Currently known from 2 records within the CR IBRA Region and 4 within the GVD IBRA Region
Goodenia vilmoriniae	~100 km South	Within Range	Currently known from 6 records within the CR IBRA Region
Maireana triptera	~100 km South	Within Range	Currently known from 2 records within the CR IBRA Region and 5 within the GVD IBRA Region
Dysphania melanocarpa forma *leucocarpa*	~100 km South	Within Range	Currently known from 1 record within the CR IBRA Region
Amphipogon sericeus	~100 km South	~100 km South	Currently known from 2 records within the CR IBRA Region
Sida calyxhymenia	~125 km	Within Range	Currently known from 4 records within the CR IBRA Region and 1 within the GVD IBRA Region
Indigofera georgei	~125 km South	Within Range	Currently known from 10 records within the CR IBRA Region and 3 within the GVD IBRA Region
Indigofera linifolia	~125 km South	~125 km South	Currently known from 2 records within the CR IBRA Region
Euphorbia drummondii	~125 km South	Within Range	Currently known from 2 records within the

Species	Range Extension in WA (Florabase)	Range Extension in Australia (AVH)	Current Recorded Distribution
			CR IBRA Region and 2 within the GVD IBRA
Eragrostis sp. Limestone (P.K. Latz 5921)(P3)	~125 km South-west	~125 km South-west	Currently known from 1 record just north of the CR IBRA Region and 1 within the GVD IBRA
Eremophila battii	~150 km East	~150 km East	Currently known from 3 records within the CR IBRA Region
Lobelia heterophylla subsp. *centralis*	~150 km East	Within Range	*Lobelia heterophylla* subsp. *centralis*
Senna artemisioides subsp. *filifolia*	~150 km East	Within Range	Currently known from 1record within the CR IBRA Region and 4 within the GVD IBRA Region
Calotis sp. Carnarvon Range	~150 km East	~150 km East	Currently known from 3 records within the CR IBRA Region and 7 within the GVD IBRA Region
Tephrosia sp. Central (P.K. Latz 17037) (P3)	~150 km South	~150 km South	Currently known from 2 records within the CR IBRA Region
Portulaca intraterranea	~150 km South	~150 km South	Currently known from 1 record within the CR IBRA Region
Wurmbea deserticola	~150 km South	~150 km South	Currently known from 2 records within the CR IBRA Region and 2 within the GVD IBRA Region
Quoya loxocarpa	~150 km South	~150 km South	Currently known from 10 records within the CR IBRA Region
Eragrostis exigua	~150 km South-west	~150 km South-west	Currently known from 1 record within the CR IBRA Region

Species	Range Extension in WA (Florabase)	Range Extension in Australia (AVH)	Current Recorded Distribution
Acacia bivenosa	~175 km South	~175 km South	Currently known from 2 records within the CR IBRA Region
Aenictophyton anomalum (P1)	~175 km South-west	~175 km	Currently known from 2 records within the CR IBRA Region and 1 within the GVD IBRA Region
Trachymene bialata	~200 km East	~200 km East	Currently known from 2 records within the CR IBRA Region and 3 within the GVD IBRA Region
Brassica tournefortii (Weed)	~200 km East	Within Range	Currently known from 2 records within the CR IBRA Region
Acacia victoriae subsp. *victoriae*	~200 km East	Within Range	Currently known from 2 records within the CR IBRA Region
Hypertelis cerviana	~200 km South	Within Range	Currently known from 3 records within the CR IBRA Region and 1 within the GVD IBRA Region
Sclerolaena diacantha	~200 km South	Within Range	Currently known from 2 records within the CR IBRA Region and 1 within the GVD IBRA Region
Sclerolaena cuneata	~200 km East	Within Range	Currently known from 2 records within the GD (Gibson Desert) IBRA Region and 1 within the GVD IBRA Region
Heliotropium cunninghamii	~200 km South	~200 km South	Currently known from 2 records within the CR IBRA Region
Melaleuca eleuterostachya	~200 km South	~200 km South	Currently known from 3 records within the CR IBRA Region and

Species	Range Extension in WA (Florabase)	Range Extension in Australia (AVH)	Current Recorded Distribution
			10+ within the GVD IBRA Region
Acacia sericophylla	~200 km South	~200 km South and West	Currently known from 5 records within the CR IBRA Region
Eragrostis sp. Erect spikelets (P.K. Latz 2122) (P3)	~200 km South-west	~200 km west	Currently known from 1 record on the border of the CR and GSD (Great sandy Desert) IBRA Regions
Cucumis argenteus	~200 km South-west	Within Range	Currently known from 1record on the border of the CR and GSD (Great sandy Desert) IBRA Regions
Sida spodochroma	~300 km North	~300 km north	Currently known from 1 record within the GVD IBRA Region and 2 within the neighbouring GD IBRA Region
Sida sp. L (A.M. Ashby 4202)	~300 km South	~300 km South	Currently known from 7 records within the CR IBRA Region and 2 within the GVD IBRA Region
Streptoglossa liatroides	~300 km South	Within Range	Currently known from 1 record within the GVD IBRA Region and 2 within the neighbouring GD and 1 within the GSD IBRA Regions
Pluchea rubelliflora	~300km South	Within Range	Currently known from 2 records within the GVD IBRA Region and 4 within the neighbouring GD IBRA Regions

Species	Range Extension in WA (Florabase)	Range Extension in Australia (AVH)	Current Recorded Distribution
Glischrocaryon aureum (reticulated venation form) (WB39951)	~400 km North	Within Range	Currently known from 10+ records within the GVD IBRA Region
Acacia eremophila var. Numerous-nerved variant (A.S. George 11924) (P3)	~400 km North	~400 km North	Currently known from 10+ records within the GVD IBRA Region
Allocasuarina helmsii	~400 km North	~200 km West	Currently known from 10+ records within the GVD IBRA Region
Acacia acanthoclada subsp. *acanthoclada*	~400 km North-east	~200 km West	Currently known from 10+ records within the GVD IBRA Region
Alternanthera angustifolia	~400 km South	Within Range	Currently known from 1 record within the GVD IBRA Region
Peplidium aithocheilum	~400 km South-east	~400 km South-east	Currently known from 7 records within the GD IBRA Region No records in CR or GVD IBRA Regions
Neurachne munroi	~500 km East	~200 km West	Currently known from the edge of the Eastern Murchison and GD IBRA Regions
Eriachne pulchella subsp. *dominii*	~500 km South	~500 km South	No records within the Neighbouring IBRA Regions
Hibiscus sturtii var. *grandiflorus*	~600 km East	~150 km west	No records within the Neighbouring IBRA Regions
Chloris virgata (Weed)	~600 km East	Within Range	No records within the Neighbouring IBRA Regions
Solanum ferocissimum	~600 km East	Within Range	Currently known from 2 closest records located on the border of the Eastern Murchison and GVD IBRA Regions

Species	Range Extension in WA (Florabase)	Range Extension in Australia (AVH)	Current Recorded Distribution
Aristida jerichoensis var. *subspinulifera* (P3)	~800 km South-east	~125 km South-west	No records within the Neighbouring IBRA Regions

4.14. Weeds

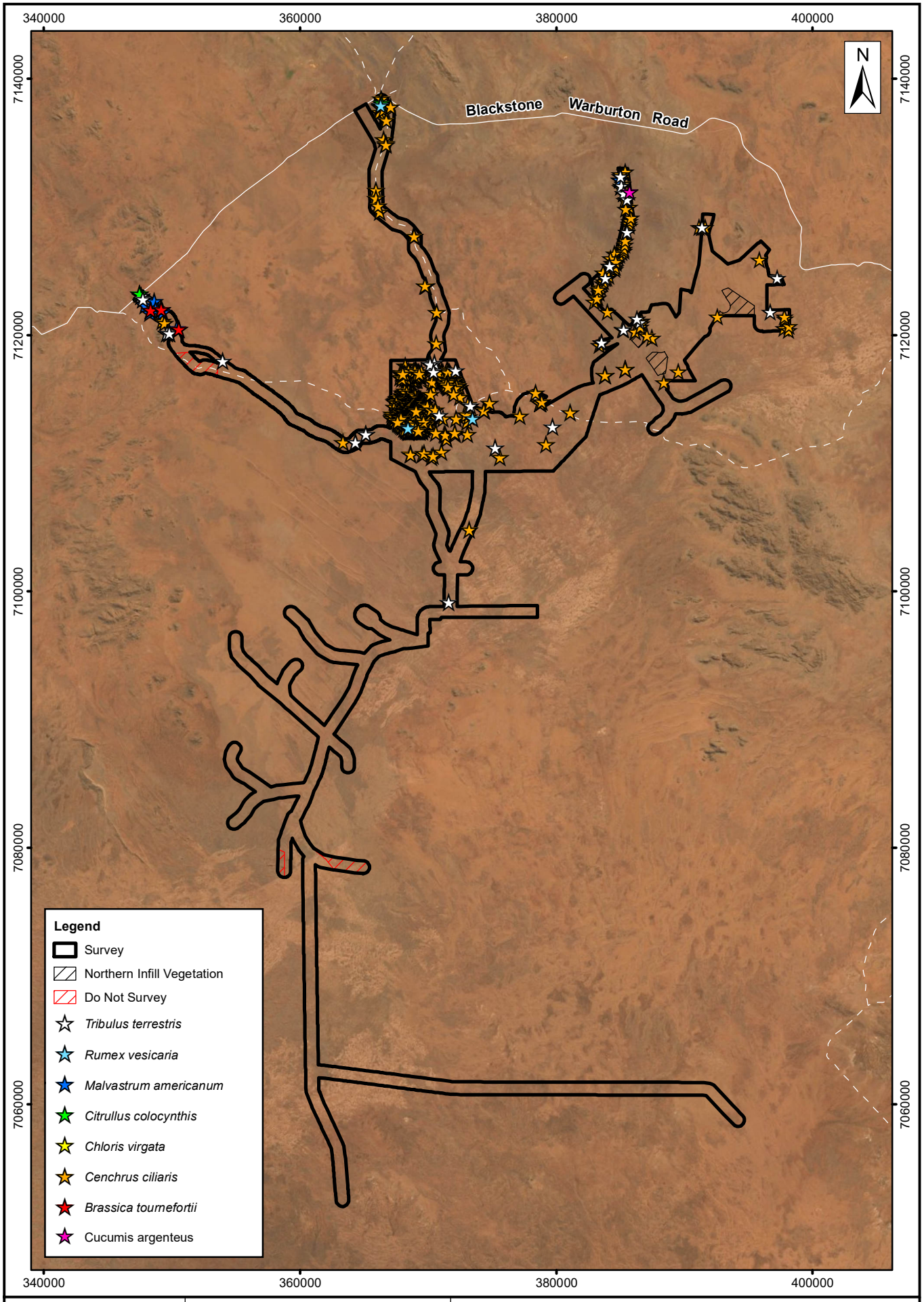
Eight weed species were recorded within the Greater Survey Area during the 2015 and 2018 / 2019 surveys (Table 19, Figure 27). All of these weed species are widespread throughout the Great Victoria Desert and Central Ranges IBRA regions and none represent Weeds of National Significance (WoNS). None of these weed species are Declared Organisms under the *Biosecurity and Agriculture Management Act 2007 (WA)* (BAM Act) and Biosecurity and Agriculture Management Regulations 2013 (BAM Regulations). However, two species *Cenchrus ciliaris* and *Rumex vesicarius* are highly invasive species. During the Detailed Spring survey *Cenchrus ciliaris* was mapped across the Survey Area both through opportunistic observations and during the targeted significant species searches.

The locations of all the weeds encountered within the Survey Area are presented in Figure 27 and Appendix 9.

Table 19. Weeds of the WMP Survey Area.

Weed Species	Common Name	Brief Description
Brassica tournefortii	Wild Turnip	Annual herb
Cenchrus ciliaris	Buffel Grass	Perennial Tussock Grass
Chloris virgata	Feather Top Rhodes Grass	Perennial Grass
Citrullus colocynthis	Paddy Melon	Annual tailing herb
Erodium aureum	A Cork Screw	Annual herb
Malvastrum americanum	Spiked Malvastrum	Annual herb
Rumex vesicarius	Ruby Dock	Annual herb
Tribulus terrestris	Caltrop	Annual herb

Figure 27. Weeds within the Survey Area.



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

0 5 10 km

Scale: 1:400,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_08_01

Date: March 2020 | Rev: A | A4

Western Botanical

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West Musgrave Flora Survey Area

Weeds

Brassica tournefortii (Mediterranean Turnip)

Brassica tournefortii is a member of the Brassicaceae Family, and is described as an annual herb, growing from 0.1 m to 0.6 m high. The flowers are yellow, cream, or white, and generally occur between June and November. It has been recorded growing in sandy soils, and is an aggressive weed of disturbed ground, roadsides, and cultivation (Western Australian Herbarium 1988-) (Plate 52).

Brassica tournefortii is a widespread across Western Australia and has been recorded within the Avon Wheatbelt, Carnarvon, Central Ranges, Coolgardie, Esperance Plains, Geraldton Sandplains, Great Victoria Desert, Hampton, Jarrah Forest, Little Sandy Desert, Mallee, Murchison, Nullarbor, Pilbara, Swan Coastal Plain, Warren, and Yalgoo IBRA Regions (Western Australian Herbarium 1988-). *Brassica tournefortii* is not listed by DPIRD as a WoNS (Figure 28).

Plate 52. *Brassica tournefortii* (Mediterranean Turnip) (Western Australian Herbarium1988-).

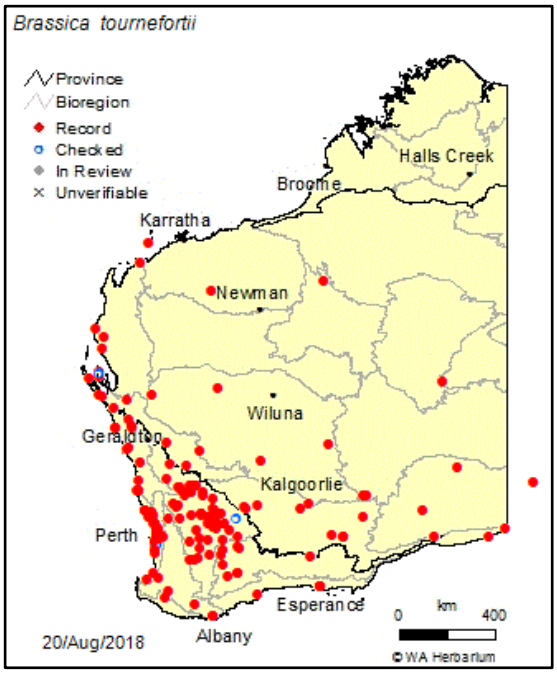


Figure 28. Map of *Brassica tournefortii* distribution in WA (Western Australian Herbarium 1988-).

***Cenchrus ciliaris* (Buffel Grass)**

Cenchrus ciliaris (Buffel Grass) is a member of the Poaceae Family, described as a tufted occasionally stoloniferous perennial grass. It grows from 0.2 m to 1.5 m tall with purple flowers. Flowering has been recorded occurring between February and October, including on plants less than 3 months old. It is a known weed originating from Africa introduced as a livestock forage (Western Australian Herbarium 1988-) (Plate 53).

Cenchrus ciliaris is not listed by the DPIRD as a WoNS, and the occurrences of it within the WMP are not surprising as it is a common weed species associated with rangeland agriculture and is readily distributed by Camels. *Cenchrus ciliaris* has been recorded widely across Western Australia within the Avon Wheatbelt, Carnarvon, Central Kimberley, Central Ranges, Coolgardie, Dampierland, Gascoyne, Geraldton Sandplains, Gibson Desert, Great Sandy Desert, Little Sandy Desert, Murchison, Nullarbor, Ord Victoria Plain, Pilbara, Swan Coastal Plain, Tanami, Victoria Bonaparte, and Yalgoo IBRA regions (Western Australian Herbarium 1988-)(Figure 29).

Thirty locations of *Cenchrus ciliaris* were recorded within the WMP with some of the populations located near access roads. This species has become noticeably more widespread within the Survey Area since 2005.

Plate 53. *Cenchrus ciliaris* (Buffel Grass) (Western Australian Herbarium 1988-).

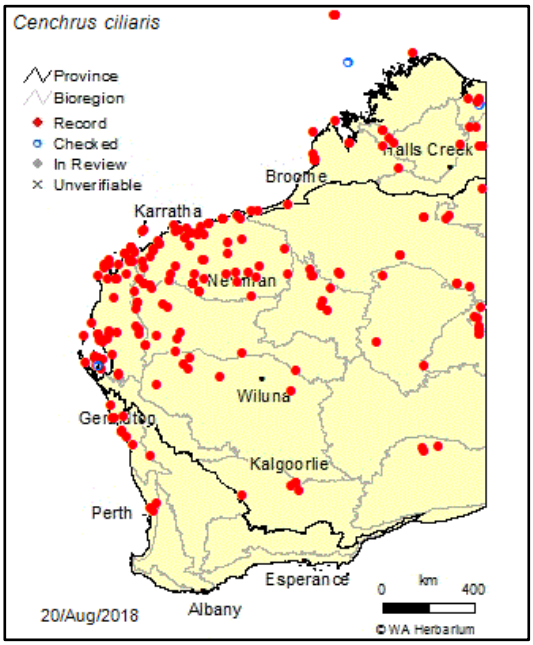


Figure 29. *Cenchrus ciliaris* (Buffel Grass) distribution in W.A. (Western Australian Herbarium 1988-).

Chloris virgata (Feathertop Rhodes Grass)

Chloris virgata is a member of the Poaceae Family, and is described as an annual grass, growing from 0.15 m to 0.95 m high. The flowers are green purple and occur between April and May through to September, depending on seasonal conditions. It has been recorded growing across a variety of soil types including clay and sand (sand dunes), (Plate 54) (Western Australian Herbarium 1988-).

Chloris virgata is not listed by DPIRD as a WoNS, and was recorded at one location within the Survey Area. This record was at the intersection of the proposed Western Access Road alignment with the Warburton to Jameson Road, where approximately 20 plants were found. The recording of this species within the Central Ranges IBRA region is a first and represents a 600 km range extension (Western Australian Herbarium 1988-), however when looking at it using the Australian Virtual Herbarium records (CHAH 2019), it is well within its current known range (Figure 30).

Plate 54. *Chloris virgata* (Feathertop Rhodes Grass).

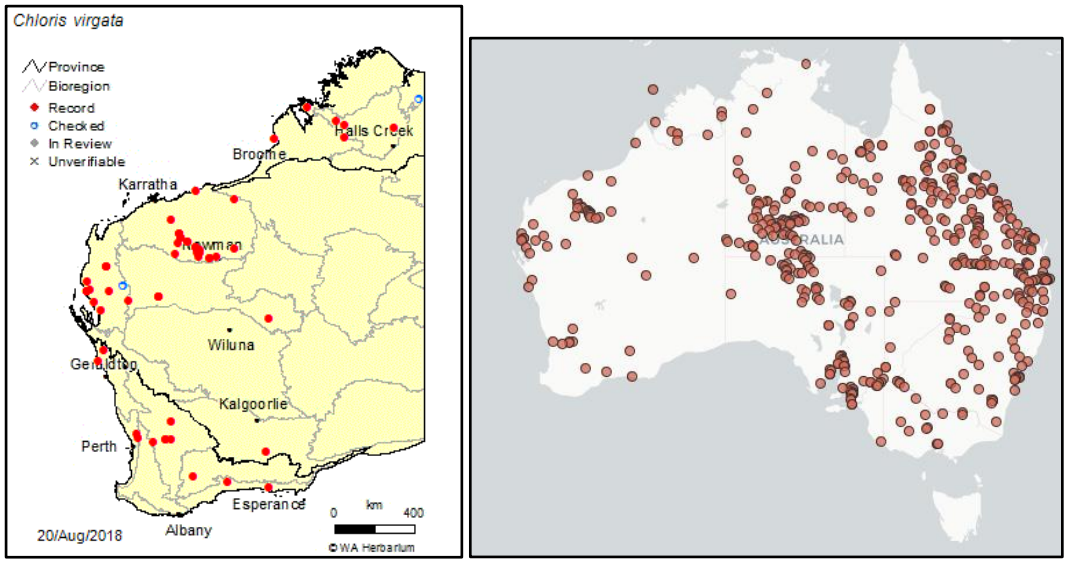


Figure 30. Map of *Chloris virgata* distribution in WA (left)(Western Australian Herbarium 1988-) and (right)Australia data provided by Council of Heads of Australasian Herbaria (AVH 2019).

Citrullus colocynthis

Citrullus colocynthis is a member of the Cucurbitaceae Family, and is described as a trailing perennial, herb or climber, with yellow flowers that have been recorded between January through to October. *Citrullus colocynthis* colonises disturbed areas and happily grows within many different soil types including sandy, rocky, stony, loam, clay, and wet soils (Western Australian Herbarium 1988-) (Plate 55).

Citrullus colocynthis is not listed by DPIRD as a WoNS. It was recorded at two locations within the WMP, near the Jameson town site and at the intersection of the proposed Western Access Road alignment with the Warburton to Jameson Road. *Citrullus colocynthis* is a wide spread weed species across Western Australia and has been recorded within the Avon Wheatbelt, Carnarvon, Central Kimberley, Central Ranges, Coolgardie, Dampierland, Gascoyne, Murchison, Ord Victoria Plain, Pilbara, Tanami, Victoria Bonaparte, and Yalgoo IBRA regions (Figure 31) (Western Australian Herbarium 1988-).

Plate 55. *Citrullus colocynthis* photographed at the intersection of the Western Access road and the Warburton - Jameson road.

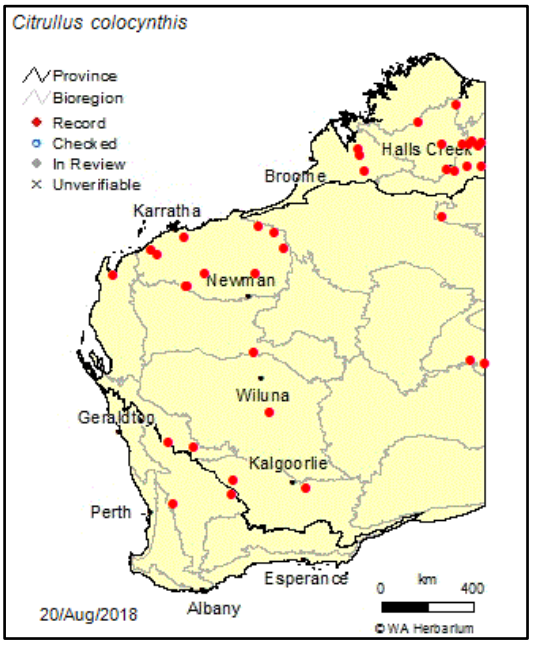


Figure 31. Map of *Citrullus colocynthis* distribution in WA (Western Australian Herbarium 1988-).

Erodium aureum

Erodium aureum is a member of the Geraniaceae Family, described as a spreading, short-lived perennial herb that grows from 0.04-0.2 m high. The flowers are pink to purple and have been recorded from July through to October. *Erodium aureum* is associated with sandy, sandy clay, and loam soils (Western Australian Herbarium 1988-).

Erodium aureum is not listed by the DPIRD as a WoNS. Its presence within the WMP is not surprising as it is a common arid zone weed species that has previously been recorded within the Central Ranges IBRA Region. *Erodium aureum* has been recorded widely across Western Australia within the Avon Wheatbelt, Carnarvon, Central Ranges, Coolgardie, Esperance Plains, Geraldton Sandplains, Mallee, Murchison, Nullarbor, and Yalgoo IBRA regions, (Western Australian Herbarium 1988-)(Figure 32).

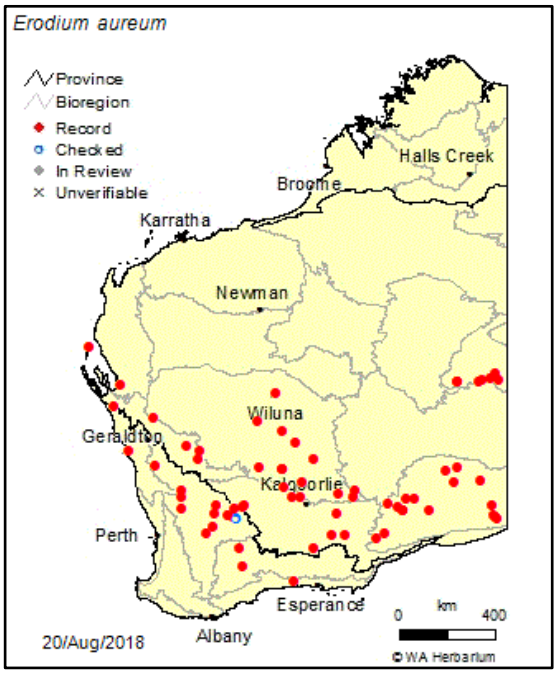


Figure 32. *Erodium aureum* distribution in W.A. (Western Australian Herbarium 1988-).

***Malvastrum americanum* (Spiked Malvastrum)**

Malvastrum americanum is a member of the Malvaceae Family, and is described as an erect perennial, herb or shrub from 0.5 m to 1.3 m high. The flowers are yellow /orange and occur between April and July (Plate 56). It has been recorded across a variety of soil types and landscapes, including different types of sands, clays, limestone, and calcrete, whilst the landscapes include stony ridges and hillsides, floodplains, and along drainage lines (Western Australian Herbarium 1988-).

Malvastrum americanum is not listed by DPIRD as a WoNS. It's a wide spread weed species across Western Australia and has been recorded within the Carnarvon, Central Kimberley, Central Ranges, Dampierland, Gascoyne, Great Sandy Desert, Little Sandy Desert, Murchison, Nullarbor, Ord Victoria Plain, Pilbara, and Victoria Bonaparte IBRA regions, (Western Australian Herbarium 1988) (Figure 33). Eight records of *Malvastrum americanum* were recorded within the western end of the proposed Western Access Road alignment, and also within the proposed North-eastern Borefield alignment. The population is spread sporadically through the Hardpan Mulga Woodland (HPMW), and Calcrete Open Grasslands (COG).

Plate 56. *Malvastrum americanum* (Spiked Malvastrum).

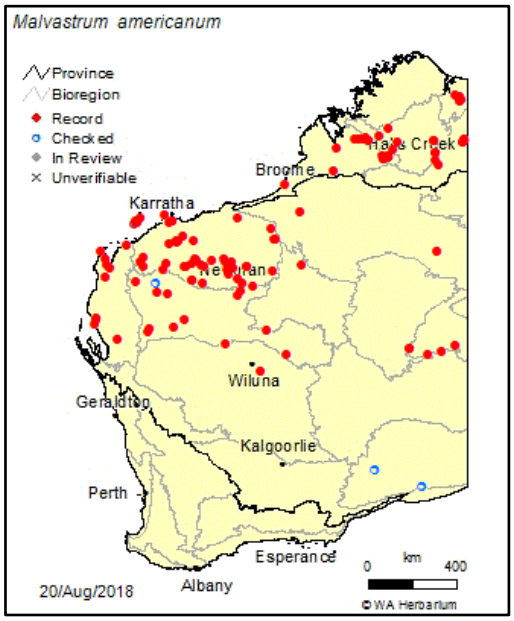


Figure 33. Map of *Malvastrum americanum* distribution in WA (Western Australian Herbarium 1988-).

Rumex vesicarius (Ruby Dock)

Rumex vesicarius (Ruby Dock) is a member of the Polygonaceae Family, described as a stout fleshy annual that grows to approximately 0.8 m with broadly triangular leaves and inconspicuous flowers. The fruit valves are inflated, pinkish red and up to 2 cm in size. It is a known weed that has been introduced from North Africa and the middle east, (Western Australian Herbarium 1988-) (Plate 57).

Rumex vesicarius is not listed by DPIRD as a WoNS. Its occurrence within the Survey Area is not surprising as it is a common naturalised arid zone weed species associated with disturbed areas and has previously been recorded within the Central Ranges IBRA Region. *Rumex vesicarius* has been recorded widely across western Australia within the Avon Wheatbelt, Carnarvon, Central Ranges, Coolgardie, Gascoyne, Geraldton Sandplains, Great Victoria Desert, Mallee, Murchison, Nullarbor, Pilbara, Swan Coastal Plain, and Yalgoo IBRA regions (Western Australian Herbarium 1988-) (Figure 34).

Rumex vesicarius was casually observed during the 2015 field surveys on occasions with low numbers observed mostly associated with disturbed areas. It is a weed species that is highly invasive.

Plate 57. *Rumex vesicarius* (Ruby Dock).

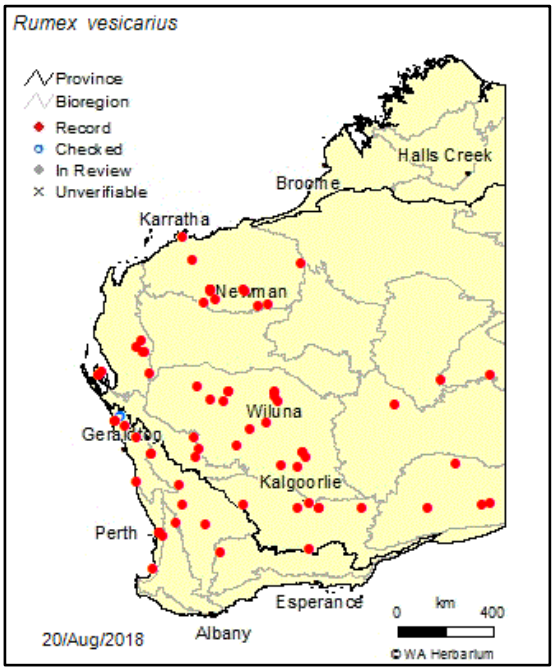


Figure 34. *Rumex vesicarius* (Ruby Dock) distribution in W.A. (Western Australian Herbarium 1988-).

Tribulus terrestris (Caltrop)

Tribulus terrestris (Caltrop) is a member of the Zygophyllaceae Family, described as a prostrate annual, herb with greyish pinnate leaves, and yellow flowers less than 1cm across. The fruits are a key character used to identify different species, and *Tribulus terrestris* has very spiny roughly spherical fruits with distinct divergent spines between 3-8mm long, (Western Australian Herbarium 1988-) (Plate 58).

Tribulus terrestris is native to the Mediterranean region and is not listed by DPIRD as a WoNS. It is a wide spread weed species across Western Australia and has been recorded within the Avon Wheatbelt, Carnarvon, Central Kimberley, Central Ranges, Coolgardie, Dampierland, Esperance Plains, Gascoyne, Great Sandy Desert, Great Victoria Desert, Jarrah Forest, Little Sandy Desert, Mallee, Murchison, Nullarbor, Ord Victoria Plain, Pilbara, Swan Coastal Plain, Tanami, Victoria Bonaparte, Yalgoo IBRA regions, (Western Australian Herbarium 1988-) (Figure 35). *Tribulus terrestris* is not listed by DPIRD as a WoNS. Its occurrence within the Survey Area is not surprising given its current known distribution across Western Australia, and the historical exploration and feral herbivore activities conducted within the Survey Area.

Plate 58. *Tribulus terrestris* (Caltrop) (Western Australian Herbarium 1988-).

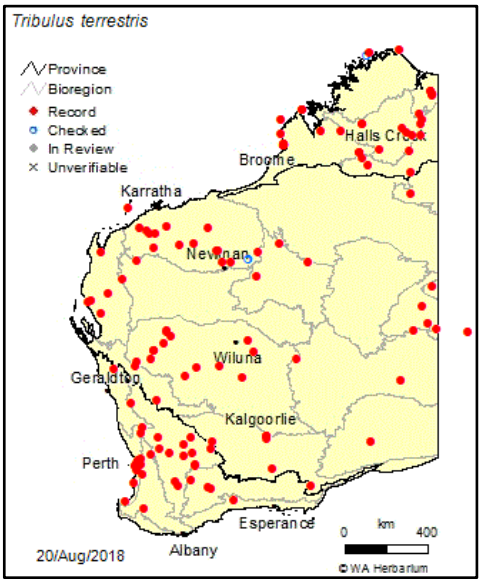


Figure 35. Map of *Tribulus terrestris* distribution in WA (Western Australian Herbarium 1988-).

5. Limitations

The region inclusive of the Survey Area is reasonably well known to Western Botanical, having conducted over 20 surveys in the region over the last 13 years. However, these previous surveys have all been restricted to exploration tenements and, given the extensive area of the region, the area assessed is considered less than 1% of the Central Ranges IBRA region west of the NT/SA border.

Potential limitations associated with the Project's flora and vegetation survey are presented in Table 20. Overall, no major limitation to the flora surveys has been encountered. Some sections of the Greater Survey Area were surveyed at a lesser intensity, but depending on the proposed placement of future infrastructure, this may not pose a limitation to the surveys.

Table 20. Limitations of the Surveys.

Limitation	Discussion
Available sources of contextual information	Numerous unpublished reports relating to previous field surveys in the Survey Area and the region for a range of clients were available for specific information on the flora and vegetation of the region. Some generalised information published in relation to regional treatments of flora, vegetation, and Land Systems were also consulted. The resources of the WA Herbarium as well as those of Western Botanical were well-utilised in identifying flora. This is not considered a limitation for this report.
The Scope of the survey	The scope of the survey was (in brief) to map vegetation associations, develop an inventory of flora, and identify species and vegetation associations that may have conservation significance within the Survey Area, and to discuss these in a regional sense. The scope of the survey was adequate for the task and is not considered a limitation.
Proportion of flora collected and identified	Western Botanical confidently considers that a large proportion of the flora has been encountered within the Survey Area. The flora of the Greater Survey Area not including the Detailed Survey Study Area has only had one period of survey. These surveys were conducted during a lower than average rainfall winter season with few annual herbs present. As such, this portion of the Survey Area has not been fully surveyed for annual species or in two separate seasons. Overall, 88.2% (344 species) of flora was encountered in Quadrats and Relevés and 11.8% (46 species) were recorded opportunistically. Eleven species (2.8%) of the 390 taxa recorded remain unidentified to species level due to lack of sufficient / adequate

Limitation	Discussion
	material. Three of these may represent new species, two are *Eragrostis* species and the other a *Sida* species. The remaining unidentifiable specimens are not considered to represent species with conservation significance. With the caveat of the annual flora and the three species likely representing new taxa above, this is not considered a limitation for the bulk of flora reported here.
Completeness and further work which may be needed	The Detailed Survey Study Area consists of three sub-units inclusive of the Development Area, Northern Access road, and Windfarm Area including the Additional area between the Wind farm and the Development Area. This area has been assessed at a high survey density for Priority and other conservation significant flora (Figure 36, Figure 37). The remaining Survey Area outside of the Detailed Survey Study Area (the Greater Survey Area) have only received a single season survey with no specific targeted survey of Priority or other conservation significant flora conducted. Depending on the location of future infrastructure, further work to complete targeted Priority flora searches prior to development and minor adjustments of mapping boundaries within the Greater Survey Area may be required.
Mapping reliability	Mapping was conducted in the field using high resolution 1:10,000 laminated colour aerial photography. The Survey Area was thoroughly traversed and any areas that were not specifically investigated were extrapolated confidently from the imagery available. Western Botanical consider the vegetation mapping as reliable and offer an estimated accuracy of mapping boundaries to +/- 50 m. Minor adjustment to the current mapping within the Greater Survey Area may be of benefit as this area has only been surveyed once and may require fine adjustment to the boundaries based on statistical analysis. Three infill areas within the Northern Borefield alignment (617.2 ha) were mapped by extrapolation based on the surrounding mapped vegetation associations. These areas were not ground truthed, resulting in a lower level of confidence across these areas. Whilst this is not ideal, it is not considered a major limitation.
Timing: weather, season	The Detailed survey Area that was surveyed in 2015 during a good season with annuals well represented. The majority of other surveys conducted in the Survey Area over the period 2005 to 2018 have been conducted in dry seasons when annuals were largely absent and either not recorded or unable to be identified. The current 2018 / 2019 survey period was conducted during

Limitation	Discussion
	unfavourable seasonal conditions with low rainfall conditions throughout. The June-July first phase survey had received reasonable cyclonic rainfall in the preceding January-February and grasses were plentiful and dominant during the survey and were well addressed. However, the 2018/ 2019 seasonal conditions were not conducive to the assessment of annuals and geophytes. Unfortunately the region receives high variability in rainfall with isolated storms often producing small pockets of high local rainfall. The timing of these events along with follow up rainfall is often critical to produce conditions conducive for annual and geophyte species to germinate and grow. Occasionally large cyclonic events produce enough regional rainfall to initiate favourable conditions however these events are unpredictable and highly variable, often interspersed with long periods of limited rainfall.
Disturbances	Few disturbances other than direct clearing and fire regimes affect the Survey Area. Disturbance is not a limitation for this report.
Intensity	The Detailed Survey part of the Survey Area has been assessed at a high level of intensity with vegetation mapping (and subsequent reconciliation and refinement), two (or more) seasons of quadrat-based surveys, targeted significant flora surveys, and weed mapping implemented. The Greater Survey Area has received lower survey intensity with vegetation mapping (single pass), single season assessment of quadrats, no targeted search for significant flora or weeds. Given the likely impacts of the WMP, the conducted intensity appears to represent a reasonable level of survey for the various sub-sets of the overall Survey Area. The less detailed survey intensity of the Greater Survey Area is noted, but is not considered a major limitation.
Resources	Resources utilised in the 2014 to 2019 surveys were adequate for the purpose of addressing the Scope. This is not considered a limitation.
Access	Tracks and roads are limited for some areas within the Survey Area. However, off-track driving using 4WD vehicle was utilised in undertaking survey in such areas. A map of track logs of the field surveys is presented in Figure 36 and Figure 37. Areas with Heritage sensitivity were not surveyed. This is not considered a limitation.
Experience levels	The region inclusive of the Survey Area is reasonably well known to Western Botanical, having conducted over 20 surveys in the region during the last 13 years. The two lead Senior Botanists,

Limitation	Discussion
	Geoff Cockerton and Jonathan Warden, have 30 years and 10 years (respectively) experience in the flora and vegetation of W.A. This is not considered a limitation.

Figure 36. Survey Track Logs

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

0 5 10 km

Scale: 1:400,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_09

Date: March 2020 | Rev: A | A4

Western Botanical

Author: J. Warden | WB Ref:

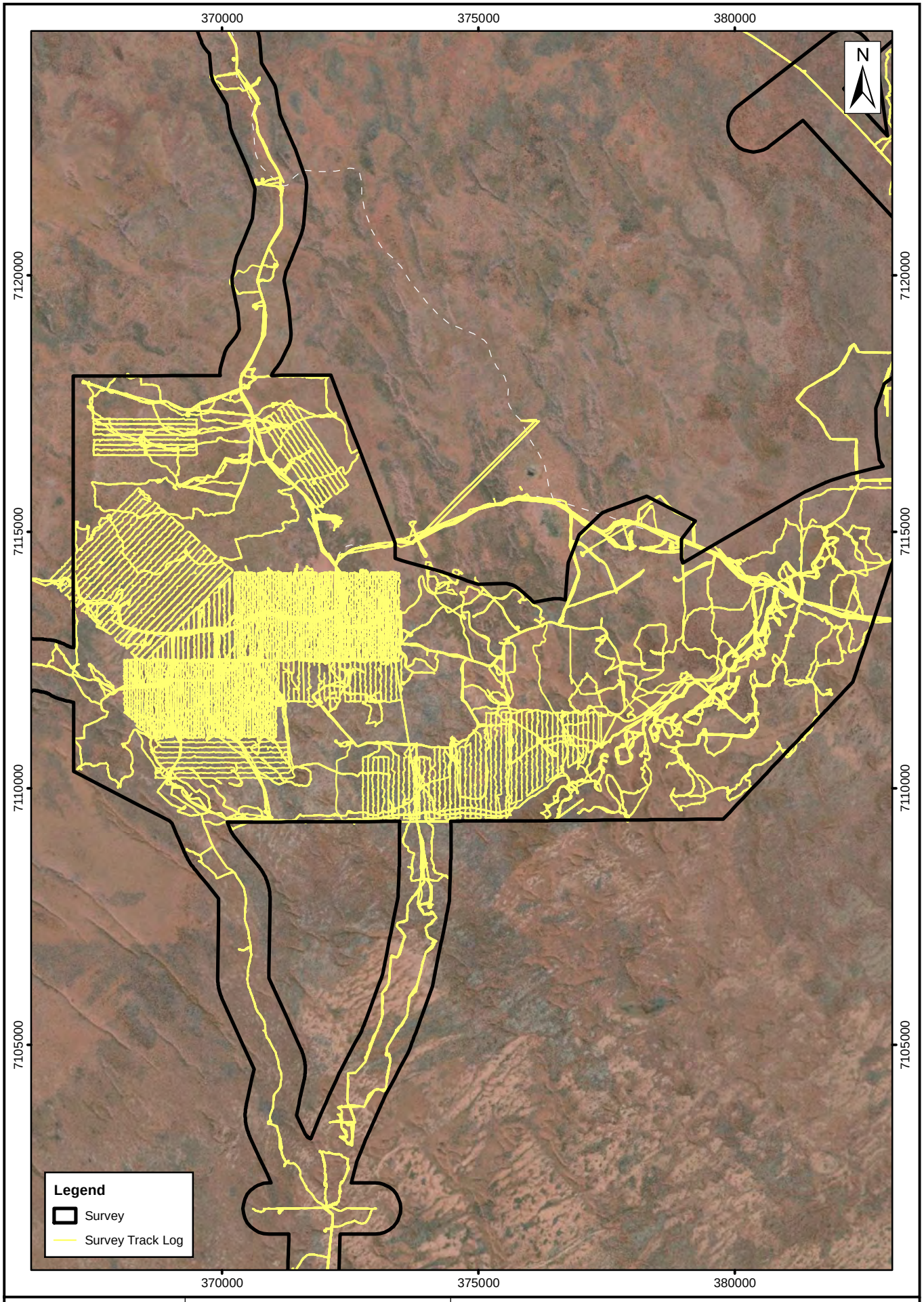
Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

OZ Minerals / Cassini JV

West Musgrave Flora Survey Area

Survey Track Logs

Figure 37. Survey Track Logs across Detailed Survey area



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

0 1 2 km

Scale: 1:100,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_09_01

Date: March 2020 | Rev: A | A4

Western Botanical

Author: J. Warden | WB Ref:

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

OZ Minerals / Cassini JV

West Musgrave Flora Survey Area

Survey Track Logs

6. List of Participants

Staff Member	Field Surveys 2014-15	Field Surveys 2018/2019	Specimen Identification	Data Analysis	Report Preparation
Geoff Cockerton B.Sc. (Biology), Senior Botanist *License No. – SL012194*		**1**	**1**	**1**	**1**
Jonathan Warden B.Sc. (Environmental Biology), Senior Botanist *License No. – SL012193*	**1**	**1**	**1**	**1**	**1**
Martin Henson, Senior Botanist *License No. – SL012185*	**1**				
Dr. David Leach, Senior Botanist *License No. – SL012184*		**1**	**1**	**1**	**1**
Daniel Brassington, Botanist *License No. – SL012183*		**1**			
Steven Cockerton, Field Assistant		**1**			

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- Mr. Rob Davis, WA Herbarium, for review of some challenging flora species, particularly *Ptilotus*.
- Ms. Karina Knight, WA Herbarium, for comment on *Chrysocephalum apiculatum* subsp. *racemosum* collections held at WAHERB.
- CAD Resources Pty Ltd for production of field maps, digitising of vegetation maps and map production for the text.

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Appendix 1. Keighery Vegetation Condition Scale.

Summary of Vegetation Condition Scale as developed by Keighery (1994) and as summarized in Bush Forever (Government of Western Australia 2000) Condition Scale Description

Code	Description
Pristine (1)	Pristine or nearly so, no obvious signs of disturbance.
Excellent (2)	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good (3)	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback , logging and grazing.
Good (4)	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded (5)	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing
Completely Degraded (6)	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as “parkland cleared’ with the flora comprising weed or crop species with isolated native trees or shrubs.

Appendix 2. DBCA Conservation Category, TEC and PEC Definitions.

A. DEFINITIONS, CATEGORIES AND CRITERIA FOR THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

1. GENERAL DEFINITIONS

Ecological Community

A naturally occurring biological assemblage that occurs in a particular type of habitat.

Note: The scale at which ecological communities are defined will often depend on the level of detail in the information source, therefore no particular scale is specified.

A **threatened ecological community** (TEC) is one which is found to fit into one of the following categories; "presumed totally destroyed", "critically endangered", "endangered" or "vulnerable".

Possible threatened ecological communities that do not meet survey criteria are added to DEC's Priority Ecological Community Lists under Priorities 1, 2 and 3. Ecological Communities that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5.

An **assemblage** is a defined group of biological entities.

Habitat is defined as the areas in which an organism and/or assemblage of organisms lives. It includes the abiotic factors (e.g. substrate and topography), and the biotic factors.

Occurrence: a discrete example of an ecological community, separated from other examples of the same community by more than 20 meters of a different ecological community, an artificial surface or a totally destroyed community.

By ensuring that every discrete occurrence is recognised and recorded future changes in status can be readily monitored.

Adequately Surveyed is defined as follows:

"An ecological community that has been searched for thoroughly in most likely habitats, by relevant experts."

Community structure is defined as follows:

"The spatial organisation, construction and arrangement of the biological elements comprising a biological assemblage" (e.g. *Eucalyptus salmonophloia* woodland over scattered small shrubs over dense herbs; structure in a faunal assemblage could refer to trophic structure, e.g. dominance by feeders on detritus as distinct from feeders on live plants).

Definitions of Modification and Destruction of an ecological community:

Modification: "changes to some or all of ecological processes (including abiotic processes such as hydrology), species composition and community structure as a direct or indirect result of human activities. The level of damage involved could be ameliorated naturally or by human intervention."

Destruction: "modification such that reestablishment of ecological processes, species composition and community structure within the range of variability exhibited by the original community is unlikely within the foreseeable future even with positive human intervention."

Note: Modification and destruction are difficult concepts to quantify, and their application will be determined by scientific judgment. Examples of modification and total destruction are cited below:

Modification of ecological processes: The hydrology of Toolibin Lake has been altered by clearing of the catchment such that death of some of the original flora has occurred due to dependence on fresh water. The system may be bought back to a semblance of the original state by redirecting saline runoff and pumping waters of the rising water table away to restore the hydrological balance. Total destruction of downstream lakes has occurred due to hydrology being altered to the point that few of the original flora or fauna species are able to tolerate the level of salinity and/or water logging.

Modification of structure: The understorey of a plant community may be altered by weed invasion due to nutrient enrichment by addition of fertiliser. Should the additional nutrients be removed from the system the balance may be restored, and the original plant species better able to compete. Total destruction may occur if additional nutrients continue to be added to the system causing the understorey to be completely replaced by weed species, and death of overstorey species due to inability to tolerate high nutrient levels.

Modification of species composition: Pollution may cause alteration of the invertebrate species present in a freshwater lake. Removal of pollutants may allow the return of the original inhabitant species. Addition of residual highly toxic substances may cause permanent changes to water quality, and total destruction of the community.

Threatening processes are defined as follows:

"Any process or activity that threatens to destroy or significantly modify the ecological community and/or affect the continuing evolutionary processes within any ecological community."

Examples of some of the continuing threatening processes in Western Australia include: general pollution; competition, predation and change induced in ecological communities as a result of introduced animals; competition and displacement of native plants by introduced species; hydrological changes; inappropriate fire regimes; diseases resulting from introduced microorganisms; direct human exploitation and disturbance of ecological communities.

Restoration is defined as returning an ecological community to its pre-disturbance or natural state in terms of abiotic conditions, community structure and species composition.

Rehabilitation is defined as the re-establishment of ecological attributes in a damaged ecological community although the community will remain modified.

2. DEFINITIONS AND CRITERIA FOR PRESUMED TOTALLY DESTROYED, CRITICALLY ENDANGERED, ENDANGERED AND VULNERABLE ECOLOGICAL COMMUNITIES

Presumed Totally Destroyed (PD)

An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future.

An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant **and either** of the following applies (A or B):

A) Records within the last 50 years have not been confirmed despite thorough searches of known or likely habitats **or**

B) All occurrences recorded within the last 50 years have since been destroyed

Critically Endangered (CR)

An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated.

An ecological community will be listed as **Critically Endangered** when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting **any one or more of** the following criteria (A, B or C):

A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% **and either or both** of the following apply (i or ii):

i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 10 years);

ii) modification throughout its range is continuing such that in the immediate future (within approximately 10 years) the community is unlikely to be capable of being substantially rehabilitated.

B) Current distribution is limited, **and one or more** of the following apply (i, ii or iii):

i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 10 years);

ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes;

iii) there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes.

C) The ecological community exists only as highly modified occurrences that may be capable of being rehabilitated if such work begins in the immediate future (within approximately 10 years).

Endangered (EN)

An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future.

An ecological community will be listed as **Endangered** when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information by it meeting **any one or more of** the following criteria (A, B, or C):

A) The geographic range, and/or total area occupied, and/or number of discrete occurrences have been reduced by at least 70% since European settlement **and either or both** of the following apply (i or ii):

i) the estimated geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term future (within approximately 20 years);

ii) modification throughout its range is continuing such that in the short term future (within approximately 20 years) the community is unlikely to be capable of being substantially restored or rehabilitated.

B) Current distribution is limited, **and one or more** of the following apply (i, ii or iii):

i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 20 years);

ii) there are few occurrences, each of which is small and/or isolated and all or most occurrences are very vulnerable to known threatening processes;

iii) there may be many occurrences but total area is small and all or most occurrences are small and/or isolated and very vulnerable to known threatening processes.

C) The ecological community exists only as very modified occurrences that may be capable of being substantially restored or rehabilitated if such work begins in the short-term future (within approximately 20 years).

Vulnerable (VU)

An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.

An ecological community will be listed as **Vulnerable** when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long -term future. This will be determined on the basis of the best available information by it meeting **any one or more of** the following criteria (A, B or C):

A) The ecological community exists largely as modified occurrences that are likely to be capable of being substantially restored or rehabilitated.

B) The ecological community may already be modified and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations.

C) The ecological community may be still widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.

3. DEFINITIONS AND CRITERIA FOR PRIORITY ECOLOGICAL COMMUNITIES

Possible threatened ecological communities that do not meet survey criteria or that are not adequately defined are added to the Priority Ecological Community List under priorities 1, 2 and 3. These three categories are ranked in order of priority for survey and/or definition of the community, and evaluation of conservation status, so that consideration can be given to their declaration as threatened ecological communities. Ecological communities that are adequately known, and are rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5.

Priority One: Poorly-known ecological communities

Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤5 occurrences or a total area of ≤ 100ha). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.

Priority Two: Poorly-known ecological communities

Communities that are known from few occurrences with a restricted distribution (generally ≤10 occurrences or a total area of ≤200ha). At least some occurrences are not believed to be under immediate threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.

Priority Three: Poorly known ecological communities

(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or:
(ii) communities known from a few widespread occurrences, which are either large or with significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;
(iii) communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.

Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.

Priority Four: Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.

(i) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands.

(ii) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

(iii) Ecological communities that have been removed from the list of threatened communities during the past five years.

Priority Five: Conservation Dependent ecological communities

Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

B. DEC Conservation Codes for Western Australian Flora

Under the Wildlife Conservation Act 1950, the Minister for the Environment may declare species of flora to be protected if they are considered to be in danger of extinction, rare or otherwise in need of special protection. Schedules 1 and 2 deal with those that are threatened and those that are presumed extinct, respectively.

T: Threatened Flora (Declared Rare Flora — Extant)

Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such (Schedule 1 under the Wildlife Conservation Act 1950).

Threatened Flora (Schedule 1) are further ranked by the Department according to their level of threat using IUCN Red List criteria:

- CR: Critically Endangered – considered to be facing an extremely high risk of extinction in the wild
- EN: Endangered – considered to be facing a very high risk of extinction in the wild
- VU: Vulnerable – considered to be facing a high risk of extinction in the wild.

X: Presumed Extinct Flora (Declared Rare Flora — Extinct)

Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such (Schedule 2 under the Wildlife Conservation Act 1950).

Species that have not yet been adequately surveyed to be listed under Schedule 1 or 2 are added to the Priority Flora List under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna. Species that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Conservation Dependent species are placed in Priority 5.

1: Priority One: Poorly-known taxa

Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.

2: Priority Two: Poorly-known taxa

Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.

3: Priority Three: Poorly-known taxa

Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.

4: Priority Four: Rare, Near Threatened and other taxa in need of monitoring

a. Rare. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.

b. Near Threatened. Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent status but that are close to qualifying for Vulnerable.

c. Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

5: Priority Five: Conservation Dependent taxa

Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxon becoming threatened within five years.

Source: Department of Environment and Conservation (Last updated 22 June 2011).

Appendix 3. DBCA Threatened Flora and Protected Matters Search Results.

DBCA Database Results												
FID	Sheet	NameID	Taxon	Cons_Code	Plant Description	Site	Vegetation	Locality	Latitude	Longitude	Precision	Date
5601	5852021	34810	Amaranthus centralis	3	Single stemmed herb to 50 cm.	Palgrave volcanics.	Mulga woodland.	Camp 1, 3 km WNW of Mount Florrie, 73 km E of Warburton, Central Ranges,	-26.1511	127.3221	1	27/4/01
5603	8745072	34810	Amaranthus centralis	3	Herbaceous shrub to 0.6 m.	Granite outcrop. Silty sand amongst granite boulders. Moderate slope. N aspect.	Acacia aneura, Acacia quadrimarginea.	Bergenost study area, SE of Jameson	-25.7974	128.0761	1	4/7/13
6807	1110772	43103	Apowollastonia stirlingii subsp. stirlingii	1				5 km SE of Bell Rock, Bell Rock Range.	-26.15	128.55	0	24/6/89
12850	421952	7904	Calotis latiuscula	3		near creek bed on rocky hillside		Mt Aloysius E of Blackstone Range	-26.0333	128.5997	3	21/7/63
12851	421979	7904	Calotis latiuscula	3		red sand flood plain small creek bank		13 miles E of Warburton Mission	-26.1330	126.8147	3	5/10/71
12854	5853303	7904	Calotis latiuscula	3	Daisy, flowers yellow.		Under trees.	On plain at base of Mount Aloysius, 27 km E of Blackstone, Central Ranges,	-25.9722	128.5696	1	6/5/01
12857	5851637	7904	Calotis latiuscula	3	Daisy, 40 cm tall. Flowers yellow.	On top of hill.	Fine-leaved mulga woodland.	Circus Hill (Rhyolite), 3 km SW of Camp 3, 6 km SW of Blackstone, Central Ranges,	-26.0708	128.2249	1	3/5/01

DBCA Database Results												
FID	**Sheet**	**NameID**	**Taxon**	**Cons_Code**	**Plant Description**	**Site**	**Vegetation**	**Locality**	**Latitude**	**Longitude**	**Precision**	**Date**
12858	5850983	7904	Calotis latiuscula	3	Daisy, flowers yellow.	On roadside.		Junction with main road to Jamieson Range	-26.0147	127.4590	1	30/4/01
12859	7976836	7904	Calotis latiuscula	3	Low shrub c. 20 cm x 10 cm. Yellow ligules.	Low rocky hills of large granitic boulders. Base of rocks, sandy soils.		Amy Giles Rocks	-25.8925	128.5208	1	29/9/06
12865	8746729	7904	Calotis latiuscula	3	Herb 0.4 m, flowers yellow, spiny fruits.	Sandy loam. Flat.	Acacia aneura.	26 km NW of Jameson	-25.8291	128.0128	1	4/7/13
22960	1073192	5774	Eucalyptus sparsa	3	Mallee 3 m tall with rough fibrous/flaky bark to 1 m, smooth white above.	Near base of red sand-dune.	With M.I.H. Brooker 9221.	210-16 km E of Warburton, 14.6 km E of Papulankutja Community (Blackstone)	-26.05	128.4166	3	4/4/86
22961	6127193	5774	Eucalyptus sparsa	3	Mallee ca 4 m high with grey fibrous basal bark; smooth powdery white to grey bark above. Leaves flat, concolorous, glossy green with dense reticulation and intersectional oil glands. Flowers with	Flat plain with deep red sandy earth.		ca 9.5 km N of the Blackstone to Mulga Park road on the Warlpapuka to Giles road	-25.9041	128.4222	2	13/7/99

DBCA Database Results												
FID	Sheet	NameID	Taxon	Cons_Code	Plant Description	Site	Vegetation	Locality	Latitude	Longitude	Precision	Date
					creamy white anther filaments.							
22962	6127185	5774	Eucalyptus sparsa	3	Mallee ca 6 m high with rough brown fibrous ribbony basal bark; smooth bark grey brown over powdery white. Leaves flat, concolorous, glossy green with dense reticulation and intersectional oil glands.			ca 40 km S of the Blackstone to Mulga Park road on the Skirmish Hill road	-26.1022	128.3947	2	13/7/99
23556	3996344	4637	Euphorbia parvicaruncula	1	Erect annual with milky sap.			Cavenagh Range	-26.105	127.9616	4	8/7/63
25263	8400520	48498	Goodenia asteriscus	3		Calcrete plain.	Acacia over spinifex on calcrete plain. With Acacia kempeana scattered shrubs (2 m, 2-5%) over Acacia acanthoclada low open shrubland	28 km SSE of Warburton	-26.1208	127.7056	1	29/11/11

DBCA Database Results												
FID	Sheet	NameID	Taxon	Cons_Code	Plant Description	Site	Vegetation	Locality	Latitude	Longitude	Precision	Date
							(10-15%, <1 m) over Triodia schinzii closed hummock grassland (<1 m, 80%).					
25264	8287155	48498	Goodenia asteriscus	3		Undulating calcrete plain. Orange sandy loam. Last burnt approximately 5 years ago.	Eucalyptus socialis subsp. eucentrica Very Open Shrub Mallee over Triodia scariosa Open Grassland.	Great Victoria Desert, ca 100 km SW of Wingellina township. Towards southern end of proposed Southern Borefield for Metal-X Wingellina Nickel Project. On SE side of road, Quadrat QWB08	-26.7115	128.2384	1	6/5/11
25265	2639084	48498	Goodenia asteriscus	3	Prostrate.	On airway scrape.		Blackstone Range, Wingelina [Wingellina]	-25.9916	128.115	4	8/1/73
25266	2648296	48498	Goodenia asteriscus	3	Perennial herb with yellow flowers.	In red loam.		N end of Cavanagh Range	-26.105	127.9616	4	8/7/63
25348	5852005	7510	Goodenia gibbosa	3	Rooting at nodes, flowers yellow.	On flat at base of sand dune. Palgrave volcanics.	Mulga woodland.	Camp 1, 3 km WNW of Mount Florrie, 73 km E of Warburton, Central Ranges,	-26.1511	127.3221	1	27/4/01

DBCA Database Results												
FID	Sheet	NameID	Taxon	Cons_Code	Plant Description	Site	Vegetation	Locality	Latitude	Longitude	Precision	Date
31423	5851947	45494	Indigofera warburtonensis	1	Small shrub, 60 cm, flowers salmon pink.	Palgrave volcanics.	Mulga woodland.	Camp 1, 3 km WNW of Mount Florrie, 73 km E of Warburton, Central Ranges,	-26.1511	127.3221	1	27/4/01
31424	5852366	45494	Indigofera warburtonensis	1	Shrub 1 m high, flowers pink.	In creek bed. Palgrave volcanics.	Mulga woodland.	Mount Florrie, 73 km E of Warburton, Central Ranges	-26.1583	127.3471	1	28/4/01
31425	1960334	45494	Indigofera warburtonensis	1	Shrub up to 1.5 ft tall. Flowers purplish-red.	On rocky soil.	With Acacia, Eremophila, Ptilotus.	Ca 45 km E of Warburton Mission. (Warburton Mission is ca 240 km W of S.A. - W.A. border)	-26.1330	127.0847	3	29/8/73
35589	3816826	17847	Lythrum paradoxum	3	Perennial herb. Shrub 1 x 2 m in diameter.	Rocky gully.		Fanny's Peak, ca 85 km S of Giles Meteorological Station, which is ca 70 km W of NT border	-25.7994	128.305	4	29/8/73
36464	1126083	3052	Menkea lutea	1	Annual with yellow flowers.	In red loam.		Blackstone Range mining camp	-25.9833	128.1166	3	8/7/63
36466	3251861	3052	Menkea lutea	1	Annual with yellow flowers.	Red loam.		Blackstone Range mining camp	-25.9916	128.115	4	8/7/63
36726	1621491	5996	Micromyrtus helmsii	1				Victoria Desert Camp 38 & 39	-26.6522	127.1166	3	02/09/1891

DBCA Database Results												
FID	**Sheet**	**NameID**	**Taxon**	**Cons_Code**	**Plant Description**	**Site**	**Vegetation**	**Locality**	**Latitude**	**Longitude**	**Precision**	**Date**
37493	835420	493	Neurachne lanigera	1	Where burned - flowering; where not burned - not flowering. Seed set, but many caryopses eaten out by ? lavae.	Only on SE slopes of rocky outcrops. On rocky small hills, NW of road. Population has been burned.	Growing with Paraneurachne muelleri, Thyridolepis mitchelliana and Triodia.	On new road between Warburton and Giles Meteorological Station, 78 km from Warburton	-25.7	127.2333	0	18/10/84
37494	8341109	493	Neurachne lanigera	1	Stout, perennial, hummocked grass, foliage to 25 cm high, clumps to 40 cm diam. Flowering heads to 35 cm high including foliage. Young leaf sheaths lanose.	Site is a gently inclined plain with SW aspect, slope ca 3 deg., soil surface wit a discontinuous subangular ironstone lag gravel. Soil is a red silty sand.	Open Shrubland of Acacia pruinocarpa 2-4 m, PFC 5 to 10% over Acacia sp. 350 (2m) PFC 10% over Triodia wiseana 0.4 m, PFC 20%. Aristida latifolia is dominant in the understorey, however, this only extends for ca 10 m.	Site is adjacent to the Nanutarra Road, immediately adjacent to the eastern roadside, 12 km NE of Warburton	-25.6066	127.2201	1	16/4/11
42889	8630763	4729	Stackhousia clementii	3		Silty sand.	Growing in a low spot amongst Corymbia centralis 8 m, Acacia aneura 2 to 3 m, Acacia victoriae 2 m, PFC 5% over Cymbopogon	West Musgraves, Great Victoria Desert	-26.2304	127.8109	1	15/5/10

DBCA Database Results												
FID	**Sheet**	**NameID**	**Taxon**	**Cons_Code**	**Plant Description**	**Site**	**Vegetation**	**Locality**	**Latitude**	**Longitude**	**Precision**	**Date**
							obtectus 0.7 m, Chrysocephalum pterochaetum 0.3 m, Solanum lasiophyllum 0.4 m, Sida sp.					
42896	7851588	4729	Stackhousia clementii	3	Wiry perennial shrub 0.4 m high x 0.3 m wide.	Shallow skeletal red sand on calcrete platform. Calcrete likely formed in sand dune that has eroded and is now exposed.	Mulga Wanderrie Bank Shrubland. Mulgas to 6 m (dead) over low shrubs to 40 cm including Ptilotus obovatus and the grasses Enneapogon caerulescens and Eragrostis eriopoda. Combined projected foliage cover of 30%.	S of Jameson Community, SE of Warburton	-26.0695	127.7182	1	17/5/07
47232	8702918	46054	Thryptomene sp. Warburton (M. Henson & M. Hannart 32433)	1				West Musgraves, near Mt Squires, 27 km SSW of Warburton	-26.0668	127.5154	1	4/12/11
50152	8185212	8271	Vittadinia pustulata	3	Slender low shrub ca 20 x 20 cm. Pale lilac ligules.	Sand flat adjacent to sand dune on one side.	Mulga woodland on the other side.	Morgan Range - ca 5 km NE of Eastern end of Range	-25.9294	128.4538	1	29/9/06

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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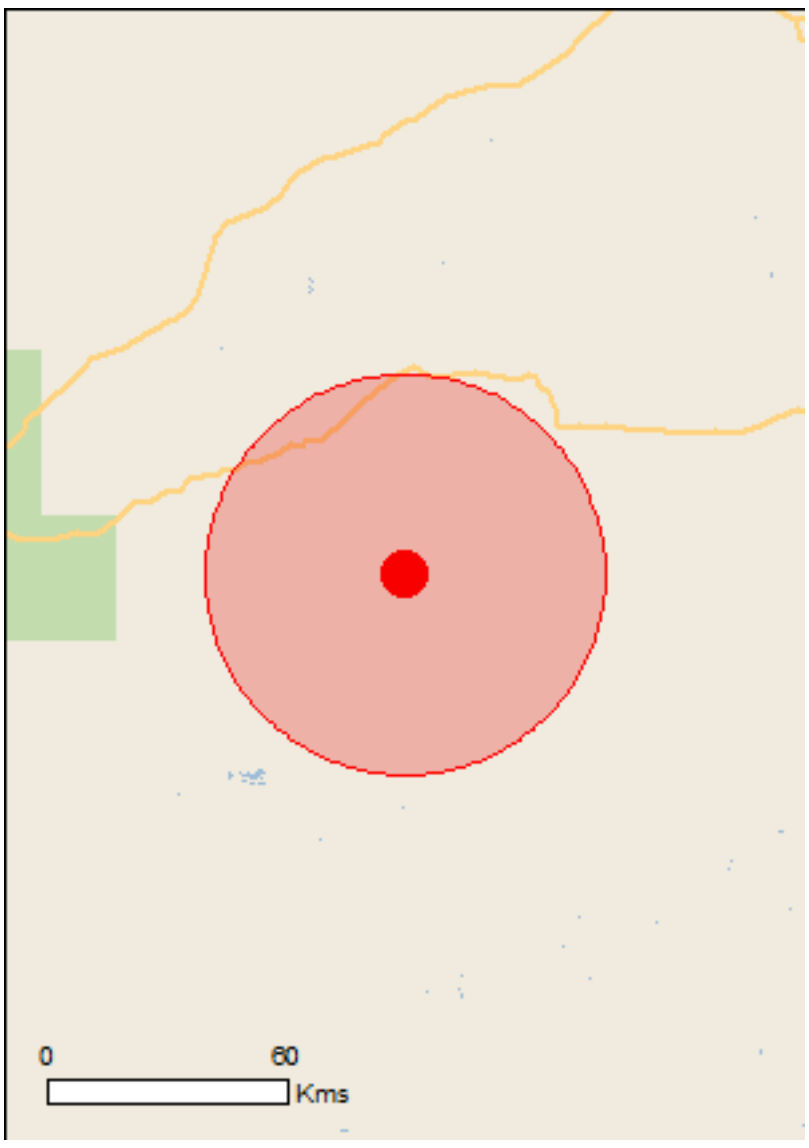

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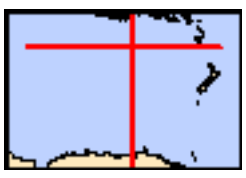

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	7
Listed Migratory Species:	7

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	9
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	7
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Polytelis alexandrae Princess Parrot, Alexandra's Parrot [758]	Vulnerable	Species or species habitat may occur within area
Mammals		
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat may occur within area
Petrogale lateralis MacDonnell Ranges race Warru, Black-footed Rock-wallaby (MacDonnell Ranges race) [66649]	Vulnerable	Species or species habitat likely to occur within area
Sminthopsis psammophila Sandhill Dunnart [291]	Endangered	Species or species habitat may occur within area
Reptiles		
Liopholis kintorei Great Desert Skink, Tjakura, Warrarna, Mulyamiji [83160]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Migratory Wetlands Species		

Name	Threatened	Type of Presence
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Ngaanyatjarra	WA

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Mammals		
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-26.2848 127.64986

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix 4. NatureMap Search Results.

NatureMap
Mapping Western Australia's biodiversity

West Musgraves Project NatureMap Species Report

Created By Guest user on 25/08/2018

Current Names Only	Yes
Core Datasets Only	Yes
Method	'By Circle'
Centre	127° 42' 14" E,26° 05' 30" S
Buffer	40km
Group By	Kingdom

Kingdom	Species	Records
Animalia	69	317
Plantae	240	392
TOTAL	**309**	**709**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Animalia					
1.	24559	*Acanthagenys rufogularis (Spiny-cheeked Honeyeater)*			
2.	24264	*Acanthiza robustirostris (Slaty-backed Thornbill)*			
3.	24265	*Acanthiza uropygialis (Chestnut-rumped Thornbill)*			
4.	24538	*Amytornis purnelli subsp. purnelli (Dusky Grasswren)*			
5.	25528	*Aphelocephala leucopsis (Southern Whiteface)*			
6.	24610	*Ardeotis australis (Australian Bustard)*			
7.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
8.	24355	*Artamus minor (Little Woodswallow)*			
9.	24356	*Artamus personatus (Masked Woodswallow)*			
10.	24357	*Artamus superciliosus (White-browed Woodswallow)*			
11.		*Backobourkia collina*			
12.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			
13.	24564	*Certhionyx variegatus (Pied Honeyeater)*			
14.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
15.	24420	*Cracticus nigrogularis (Pied Butcherbird)*			
16.	24866	*Ctenophorus caudicinctus subsp. graafi (Ring-tailed Dragon)*			
17.	24868	*Ctenophorus clayi (Collared Dragon)*			
18.	24882	*Ctenophorus nuchalis (Central Netted Dragon)*			
19.	24886	*Ctenophorus reticulatus (Western Netted Dragon)*			
20.	25052	*Ctenotus leonhardii*			
21.	25074	*Ctenotus schomburgkii*			
22.	25090	*Cyclodomorphus melanops subsp. melanops (Slender Blue-tongue)*			
23.	30903	*Dasycercus blythi (Brush-tailed Mulgara, Ampurta)*		P4	
24.	25001	*Delma nasuta*			
25.	25247	*Demansia psammophis subsp. psammophis (Yellow-faced Whipsnake)*			
26.	41407	*Egernia eos (Central Pygmy Spiny-tailed Skink)*			
27.	24570	*Epthianura tricolor (Crimson Chat)*			
28.	25621	*Falco berigora (Brown Falcon)*			
29.	25622	*Falco cenchroides (Australian Kestrel, Nankeen Kestrel)*			
30.	24953	*Gehyra montium*			
31.	24957	*Gehyra purpurascens*			
32.	24959	*Gehyra variegata*			
33.	24961	*Heteronotia binoei (Bynoe's Gecko)*			
34.	24557	*Leipoa ocellata (Malleefowl)*		T	
35.	24219	*Leporillus conditor (Greater Stick-nest Rat, Wopilkara)*		S	
36.	25130	*Lerista desertorum*			
37.	25146	*Lerista labialis*			
38.	42411	*Lerista timida*			
39.	25652	*Malurus leucopterus (White-winged Fairy-wren)*			
40.	25654	*Malurus splendens (Splendid Fairy-wren)*			
41.	24583	*Manorina flavigula (Yellow-throated Miner)*			
42.	47997	*Melanodryas cucullata (Hooded Robin)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
43.	24736	*Melopsittacus undulatus (Budgerigar)*			
44.	25184	*Menetia greyii*			
45.	24654	*Microeca fascinans subsp. assimilis (Jacky Winter)*			
46.	24223	*Mus musculus (House Mouse)*	Y		
47.	24224	*Notomys alexis (Spinifex Hopping-mouse)*			
48.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
49.	24137	*Onychogalea lunata (Crescent Nailtail Wallaby, tjawalpa)*		X	
50.	24618	*Oreoica gutturalis (Crested Bellbird)*			
51.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
52.	24142	*Petrogale lateralis subsp. lateralis (Black-flanked Rock-wallaby, Black-footed Rock-wallaby)*		T	
53.	24659	*Petroica goodenovii (Red-capped Robin)*			
54.	24683	*Pomatostomus superciliosus (White-browed Babbler)*			
55.	24103	*Pseudantechinus macdonnellensis (Fat-tailed Pseudantechinus)*			
56.	24237	*Pseudomys hermannsburgensis (Sandy Inland Mouse)*			
57.	25263	*Pseudonaja modesta (Ringed Brown Snake)*			
58.	42344	*Purnella albifrons (White-fronted Honeyeater)*			
59.	25009	*Pygopus nigriceps*			
60.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
61.	24982	*Rhynchoedura ornata (Western Beaked Gecko)*			
62.		*Scolopendra laeta*			
63.	24927	*Strophurus elderi*			
64.	30870	*Taeniopygia guttata (Zebra Finch)*			
65.	42351	*Todiramphus pyrrhopygius (Red-backed Kingfisher)*			
66.		*Urodacus giulianii*			
67.		*Urodacus hoplurus*			
68.		*Urodacus yaschenkoi*			
69.	25212	*Varanus eremius (Pygmy Desert Monitor)*			
Plantae					
70.	4891	*Abutilon fraseri (Lantern Bush)*			
71.	4895	*Abutilon lepidum*			
72.	4896	*Abutilon leucopetalum (Desert Chinese Lantern)*			
73.	4898	*Abutilon macrum*			
74.	43020	*Abutilon oxycarpum subsp. Prostrate (A.A. Mitchell PRP 1266)*			
75.	37260	*Acacia aptaneura*			
76.	15280	*Acacia cuthbertsonii subsp. cuthbertsonii*			
77.	3399	*Acacia kempeana (Witchetty Bush, Ilykuwara)*			
78.	3419	*Acacia ligulata (Umbrella Bush, Watarka)*			
79.	3434	*Acacia maitlandii (Maitland's Wattle)*			
80.	19305	*Acacia melleodora*			
81.	12952	*Acacia minyura*			
82.	3447	*Acacia monticola (Gawar, Lilwardi)*			
83.	3475	*Acacia pachyacra*			
84.	15724	*Acacia paraneura*			
85.	3495	*Acacia prainii (Prain's Wattle)*			
86.	3500	*Acacia pruinocarpa (Gidgee)*			
87.	36800	*Acacia pteraneura*			
88.	3577	*Acacia tetragonophylla (Kurara, Wakalpuka)*			
89.	3592	*Acacia validinervia*			
90.	17454	*Adriana tomentosa var. hookeri*			
91.	1723	*Allocasuarina decaisneana (Desert Oak)*			
92.	2648	*Alternanthera denticulata (Lesser Joyweed)*			
93.	19469	*Aluta maisonneuvei subsp. maisonneuvei*			
94.	34810	*Amaranthus centralis*		P3	
95.	2660	*Amaranthus cuspidifolius*			
96.	2666	*Amaranthus mitchellii (Boggabri Weed)*			
97.	11614	*Amyema gibberula var. gibberula*			
98.	11874	*Amyema sanguinea var. sanguinea*			
99.	40917	*Androcalva loxophylla*			
100.	7836	*Angianthus tomentosus (Camel-grass)*			
101.	207	*Aristida contorta (Bunched Kerosene Grass)*			
102.	12063	*Aristida holathera var. holathera*			
103.	215	*Aristida latifolia (Feathertop Wiregrass)*			
104.	229	*Astrebla pectinata (Barley Mitchell Grass)*			
105.	2456	*Atriplex elachophylla*			
106.	2481	*Atriplex vesicaria (Bladder Saltbush)*			
107.	17246	*Austrostipa nitida*			
108.	7869	*Brachyscome blackii*			
109.	7871	*Brachyscome ciliaris*			
110.	15885	*Brunonia australis var. A Kimberley Flora (K.F. Kenneally 5452)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
111.		*Calandrinia sp.*			
112.	7903	*Calotis hispidula (Bindy Eye)*			
113.	7904	*Calotis latiuscula*		P3	
114.	7905	*Calotis multicaulis (Many-stemmed Burr-daisy)*			
115.	7906	*Calotis plumulifera*			
116.	37	*Cheilanthes lasiophylla (Woolly Cloak Fern)*			
117.	12815	*Cheilanthes sieberi subsp. pseudovellea*			
118.	12818	*Cheilanthes sieberi subsp. sieberi*			
119.	47153	*Chrysocephalum apiculatum subsp. glandulosum*			
120.	47154	*Chrysocephalum apiculatum subsp. racemosum*			
121.	12613	*Chrysocephalum eremaeum*			
122.	12614	*Chrysocephalum pterochaetum*			
123.	13138	*Chrysocephalum puteale*			
124.	6612	*Convolvulus clementii*			
125.	17122	*Corymbia eremaea*			
126.	17092	*Corymbia opaca*			
127.	11873	*Corynotheca micrantha var. divaricata*			
128.	281	*Cymbopogon obtectus (Silkyheads)*			
129.	6680	*Cynoglossum australe (Australian Hound's-tongue)*			
130.	777	*Cyperus bulbosus (Bush Onion, Tjanmata)*			
131.	814	*Cyperus squarrosus*			
132.	7433	*Dampiera dentata*			
133.	13741	*Dichanthium sericeum subsp. humilius*			
134.	11964	*Dichanthium sericeum subsp. sericeum*			
135.	6758	*Dicrastylis exsuccosa*			
136.	6762	*Dicrastylis gilesii*			
137.	310	*Digitaria brownii (Cotton Panic Grass)*			
138.	2499	*Dissocarpus paradoxus (Curious Saltbush)*			
139.	11247	*Dodonaea viscosa subsp. angustissima*			
140.	11674	*Dodonaea viscosa subsp. mucronata*			
141.	6966	*Duboisia hopwoodii (Pituri, Kundugu)*			
142.	33501	*Dysphania cristata (Crested Goosefoot)*			
143.	33479	*Dysphania melanocarpa (Black Crumbweed)*			
144.	5187	*Elatine gratioloides (Waterwort)*			
145.	12064	*Enchylaena tomentosa var. tomentosa (Barrier Saltbush)*			
146.	356	*Enneapogon avenaceus (Bottle Washers)*			
147.	357	*Enneapogon caerulescens (Limestone Grass)*			
148.	358	*Enneapogon cylindricus (Jointed Nineawn)*			
149.	365	*Enneapogon polyphyllus (Leafy Nineawn)*			
150.	20377	*Enneapogon robustissimus*			
151.	368	*Enteropogon ramosus (Windmill Grass, Curly Windmill Grass)*			
152.	386	*Eragrostis laniflora (Hairy-flowered Woollybutt)*			
153.	399	*Eragrostis xerophila (Knotty-butt Neverfail)*			
154.	7207	*Eremophila foliosissima*			
155.	7211	*Eremophila georgei*			
156.	16732	*Eremophila gilesii subsp. gilesii*			
157.	14340	*Eremophila glabra subsp. glabra*			
158.	17172	*Eremophila hughesii subsp. hughesii*			
159.	7230	*Eremophila latrobei (Warty Fuchsia Bush, Mintjingka)*			
160.	17169	*Eremophila latrobei subsp. glabra*			
161.	7234	*Eremophila longifolia (Berrigan, Tulypurpa)*			
162.	15054	*Eremophila platythamnos subsp. exotrachys*			
163.	17160	*Eremophila willsii subsp. integrifolia*			
164.	411	*Eriachne helmsii (Buck Wanderrie Grass)*			
165.	4331	*Erodium aureum*	Y		
166.	4334	*Erodium crinitum (Corkscrew)*			
167.	5596	*Eucalyptus concinna (Victoria Desert Mallee)*			
168.	5655	*Eucalyptus gamophylla (Twin-leaf Mallee, Warilu)*			
169.	5707	*Eucalyptus mannensis (Mann Range Mallee)*			
170.	5734	*Eucalyptus oxymitra (Sharp-capped Mallee)*			
171.	5773	*Eucalyptus socialis (Red Mallee, Altarpa)*			
172.	4619	*Euphorbia biconvexa*			
173.	40100	*Euphorbia centralis*			
174.	4637	*Euphorbia parvicaruncula*		P1	
175.	12097	*Euphorbia tannensis subsp. eremophila (Desert Spurge)*			
176.	19648	*Ficus brachypoda*			
177.	851	*Fimbristylis dichotoma (Eight Day Grass)*			
178.	48498	*Goodenia asteriscus*		P3	
179.	7495	*Goodenia berardiana*			
180.	7498	*Goodenia centralis*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
181.	7510	*Goodenia gibbosa*		P3	
182.	8439	*Goodenia glabra*			
183.	7511	*Goodenia glandulosa*			
184.	7515	*Goodenia heterochila*			
185.	7516	*Goodenia hirsuta*		P3	
186.	7544	*Goodenia ramelii*			
187.	7558	*Goodenia triodiophila*			
188.	2001	*Grevillea eriostachya (Flame Grevillea, Kaliny-kalinypa)*			
189.	2784	*Gyrostemon ramulosus (Corkybark)*			
190.	19137	*Hakea lorea subsp. lorea*			
191.	6689	*Halgania glabra*			
192.	6174	*Haloragis gossei*			
193.	6180	*Haloragis trigonocarpa*			
194.	6181	*Haloragis uncatipila*			
195.	17307	*Heliotropium inexplicitum*			
196.	17308	*Heliotropium moorei*			
197.	17315	*Heliotropium tanythrix*			
198.	4924	*Hibiscus burtonii*			
199.	4941	*Hibiscus solanifolius*			
200.	4942	*Hibiscus sturtii (Sturt's Hibiscus)*			
201.	45494	*Indigofera warburtonensis*		P1	
202.	464	*Iseilema membranaceum (Small Flinders Grass)*			
203.	7397	*Isotoma petraea (Rock Isotome, Tundiwari)*			
204.	3991	*Isotropis centralis*			
205.	8089	*Ixiochlamys filicifolia*			
206.	4043	*Kennedia prorepens*			
207.	13289	*Lawrencella davenportii*			
208.	19727	*Leiocarpa semicalva subsp. semicalva*			
209.	3033	*Lepidium oxytrichum*			
210.	3037	*Lepidium phlebopetalum (Veined Peppercress)*			
211.	4055	*Leptosema chambersii*			
212.	2398	*Lysiana murrayi (Mistletoe, Parka-Parka)*			
213.	2544	*Maireana georgei (Satiny Bluebush)*			
214.	2556	*Maireana planifolia (Low Bluebush)*			
215.	11662	*Maireana tomentosa subsp. tomentosa*			
216.	4962	*Malvastrum americanum (Spiked Malvastrum)*	Y		
217.	5915	*Melaleuca glomerata*			
218.	17741	*Microcorys macredieana*			
219.	8110	*Minuria leptophylla (Minnie Daisy)*			
220.	490	*Monachather paradoxus*			
221.	4110	*Muelleranthus stipularis*			
222.	6785	*Newcastelia bracteosa*			
223.	6786	*Newcastelia cephalantha*			
224.	11331	*Nicotiana occidentalis subsp. obliqua*			
225.	8151	*Olearia stuartii*			
226.	46218	*Orianthera centralis*			
227.	7117	*Pandorea pandorana*			
228.	503	*Panicum decompositum (Native Millet, Kaltu-kaltu)*			
229.	514	*Paractaenum refractum*			
230.	515	*Paraneurachne muelleri (Northern Mulga Grass)*			
231.	12670	*Parietaria cardiostegia*			
232.	518	*Paspalidium clementii (Clements Paspalidium)*			
233.	3674	*Petalostylis cassioides*			
234.	19744	*Pittosporum angustifolium*			
235.	34760	*Plantago cunninghamii*			
236.	45238	*Podolepis aristata subsp. affinis*			
237.	12702	*Prostanthera sericea*			
238.	6925	*Prostanthera striatiflora*			
239.	8192	*Pterocaulon sphacelatum (Apple Bush, Fruit Salad Plant)*			
240.	2690	*Ptilotus aervoides*			
241.	2709	*Ptilotus chippendalei*			
242.	2731	*Ptilotus helipteroides (Hairy Mulla Mulla)*			
243.	2738	*Ptilotus latifolius (Tangled Mulla Mulla)*			
244.	2741	*Ptilotus macrocephalus (Featherheads)*			
245.	2746	*Ptilotus nobilis (Tall Mulla Mulla)*			
246.	2747	*Ptilotus obovatus (Cotton Bush)*			
247.	12090	*Ptilotus obovatus var. griseus*			
248.	10809	*Ptilotus sessilifolius*			
249.	2582	*Rhagodia eremaea (Thorny Saltbush)*			
250.	13301	*Rhodanthe floribunda*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
251.	13299	*Rhodanthe tietkensii*			
252.	4191	*Rhynchosia minima (Rhynchosia)*			
253.	11609	*Rostellularia adscendens var. pogonanthera*			
254.	8198	*Rutidosis helichrysoides (Grey Wrinklewort)*			
255.	17985	*Rutidosis helichrysoides subsp. helichrysoides*			
256.	30434	*Salsola australis*			
257.	7644	*Scaevola spinescens (Currant Bush, Maroon)*			
258.	13285	*Schoenia ayersii*			
259.	2602	*Sclerolaena convexula*			
260.	2603	*Sclerolaena cornishiana (Cartwheel Burr)*			
261.	2604	*Sclerolaena costata*			
262.	8877	*Sclerolaena gardneri*			
263.	2626	*Sclerolaena parviflora (Small-flower Saltbush)*			
264.	2627	*Sclerolaena patenticuspis (Spear-fruit Saltbush)*			
265.	25879	*Senecio eremicola*			
266.	9366	*Senecio gregorii (Fleshy Groundsel)*			
267.	8213	*Senecio magnificus (Showy Groundsel)*			
268.	16378	*Senna pleurocarpa*			
269.	12314	*Senna pleurocarpa var. pleurocarpa*			
270.	46816	*Seringia elliptica (Showy fire-bush)*			
271.	46821	*Seringia nephrosperma (Free carpel fire-bush)*			
272.	4977	*Sida fibulifera (Silver Sida)*			
273.	4986	*Sida platycalyx (Lifesaver Burr)*			
274.	31854	*Sida sp. Excedentifolia (J.L. Egan 1925)*			
275.	6995	*Solanum centrale (Desert Raisin, Kampurarpa)*			
276.	6998	*Solanum cleistogamum*			
277.	7018	*Solanum lasiophyllum (Flannel Bush, Mindjulu)*			
278.	46734	*Solanum pallidifolium*			
279.	7028	*Solanum petrophilum (Rock Nightshade)*			
280.	4729	*Stackhousia clementii*		P3	
281.	4732	*Stackhousia megaloptera*			
282.	19555	*Stackhousia muricata subsp. annual (W.R. Barker 2172)*			
283.	30212	*Stenopetalum lineare var. lineare*			
284.	3082	*Stenopetalum velutinum (Velvet Thread Petal)*			
285.	4233	*Swainsona leeana*			
286.	4235	*Swainsona microphylla (Small-leaf Swainsona)*			
287.	4238	*Swainsona oroboides (Variable Swainsona)*			
288.	13585	*Swainsona tenuis*			
289.	4285	*Tephrosia supina*			
290.	673	*Themeda triandra*			
291.	46054	*Thryptomene sp. Warburton (M. Henson & M. Hannart 32433)*		P1	Y
292.	12649	*Tietkensia corrickiae*			
293.	6273	*Trachymene glaucifolia (Wild Carrot)*			
294.	44362	*Trianthema triquetrum*			
295.	4374	*Tribulus astrocarpus*			
296.	4383	*Tribulus terrestris (Caltrop)*	Y		
297.	33276	*Triglochin isingiana*			
298.	680	*Triodia basedowii (Lobed Spinifex)*			
299.	696	*Triodia pungens (Soft Spinifex)*			
300.	17873	*Triodia schinzii*			
301.	48319	*Tripogonella loliiformis*			
302.	717	*Urochloa piligera*			
303.	8265	*Vittadinia eremaea*			
304.	7393	*Wahlenbergia tumidifructa*			
305.	732	*Yakirra australiensis*			
306.	18140	*Zygophyllum eichleri*			
307.	4389	*Zygophyllum eremaeum*			
308.	12359	*Zygophyllum simile*			
309.	4396	*Zygophyllum tesquorum*			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

Appendix 5. Vegetation Maps.

346000 347000 348000 349000 350000 351000

7124000 7123000 7122000 7121000

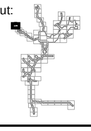
SMS
HPMW
HPMW
AkS
HPMW
AkS
COG
AkS
SS
AcS

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- AcS
- AkS
- COG
- HPMW
- SMS
- SS

Sheet Layout:



Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

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Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

Date: March 2020 | Rev: A | A2

Western Botanical

Author: J. Warden

Drawn: CAD Resources ~ www.cadresources.com.au
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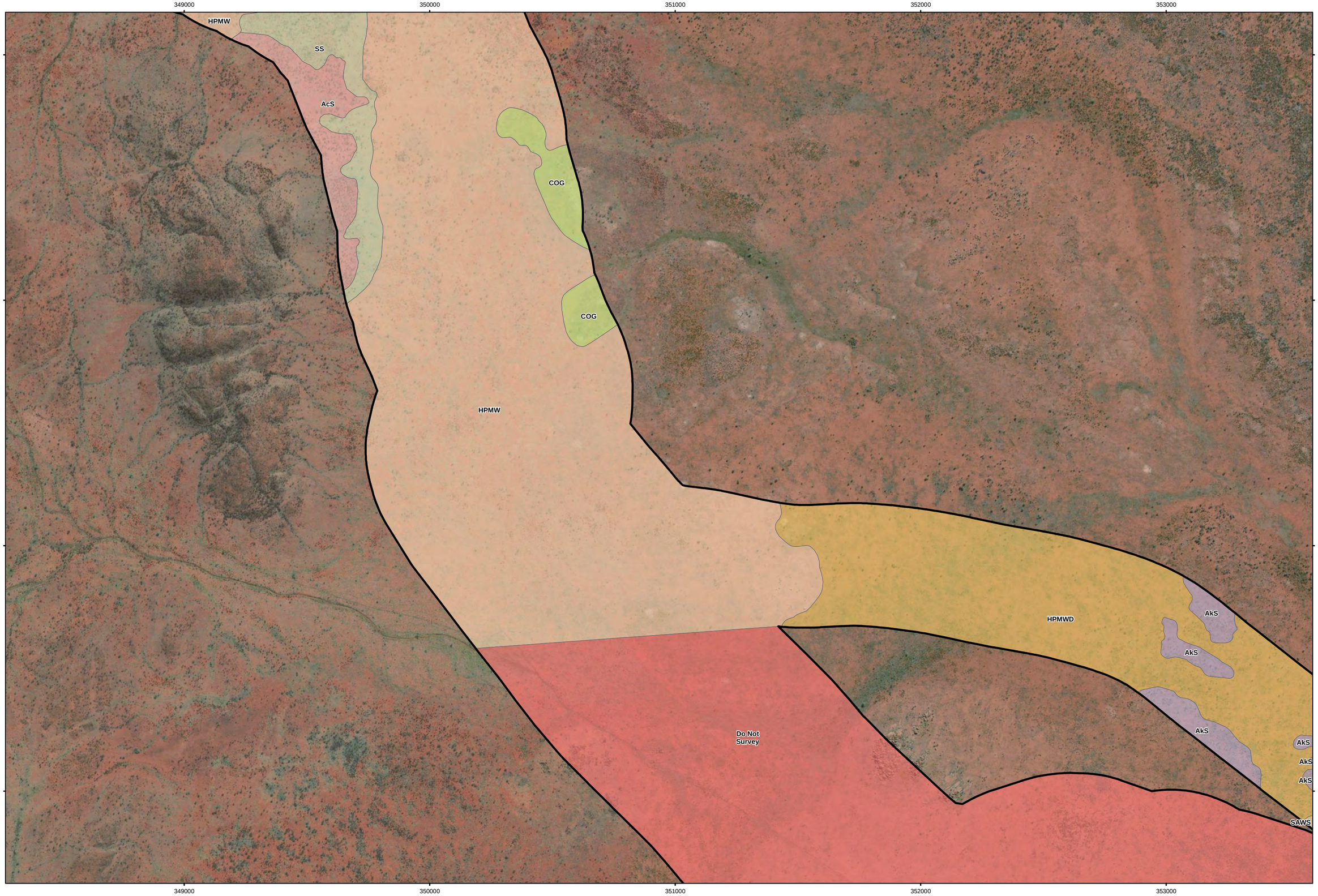
OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 1 of 79

Figure: 1



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- Do Not Survey
- SS
- AcS
- HPMW
- AkS
- HPMWD
- COG
- SAWS

Sheet Layout:

Client: OZ Minerals / Cassini Resources Limited

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

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West Musgrave Vegetation Mapping
Sheet 2 of 79

Figure: **2**

350000 351000 352000 353000 354000 355000

7119000

7118000

7117000

HPMW

HPMWD

AkS

AkS

AkS

AkS

Do Not Survey

SAWS

HPMW

HPMW

Legend

- Survey Area
- AkS
- Do Not Survey
- HPMW
- HPMWD
- SAWS

Sheet Layout:

Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

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Author: J. Warden

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West Musgrave Vegetation Mapping
Sheet 3 of 79

Figure: 3

353000 354000 355000 356000 357000

7118000 7117000 7116000 7115000

AkS
HPMWD
AkS
Do Not Survey
HPMW
HPMW
SAWS

Legend

- Survey Area
- AkS
- Do Not Survey
- HPMW
- HPMWD
- SAWS

Sheet Layout:

Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

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West Musgrave Vegetation Mapping
Sheet 4 of 79

Figure: 4

357000 358000 359000 360000 361000

7116000

7115000

7114000

SAWS

LMW

SAWS

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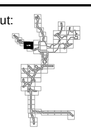
Legend

- Survey Area
- LMW
- SAWS

Sheet Layout:



Client:

OZ MINERALS

CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

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West Musgrave Vegetation Mapping
Sheet 5 of 79

Figure:

5

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Legend

- Survey Area
- SDAGS
- HPMW
- LMW
- SAWS

Sheet Layout:

Client: OZ Minerals / Cassini Resources Limited

N

0 200 400m

Scale: 1:10,000
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West Musgrave Vegetation Mapping
Sheet 6 of 79

Figure: **6**

363000 364000 365000 366000 367000 368000

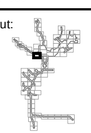
7111000 7110000 7109000

SAWS SMS GRMU SAWS HPMW AmmS SDAGS SAWS HPMW SDAGS SAWS HPMW SAMU SDAGS CPHG SDAGS SDAGS SAWS LMW CPHG SAMU SAWS HPMW CPHG SAMU AmmS SAWS SDAGS SAMU CPHG AmmS SAWS SDAGS SDAGS

Legend

- Survey Area
- AmmS
- CPHG
- GRMU
- HPMW
- LMW
- SAMU
- SAWS
- SDAGS
- SMS

Sheet Layout:



Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

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Western Botanical

Author: J. Warden

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OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 7 of 79

Figure: 7

363000 364000 365000 366000 367000 368000

7115000 7114000 7113000 7112000

HPMWD
HPMW
LMW
SAMU
SAWS
SDAGS
CPP
GRMU
CPHG
AmmS
SMS

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

Survey Area, AmmS, CPHG, CPP, GRMU, HPMW, HPMWD, LMW, SAMU, SAWS, SDAGS, SMS

Sheet Layout:

Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

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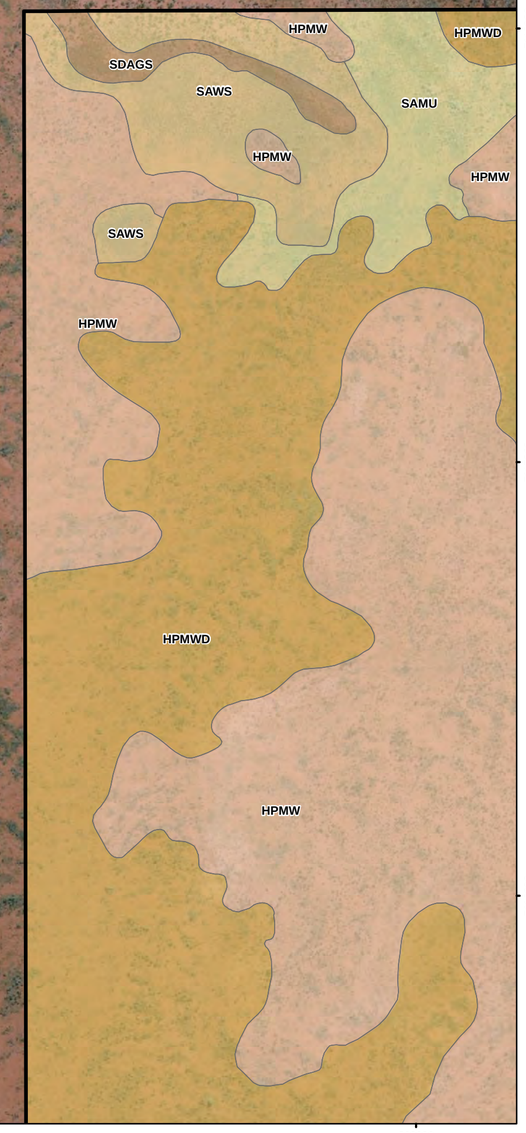
West Musgrave Vegetation Mapping
Sheet 8 of 79

Figure: **8**

363000 364000 365000 366000 367000 368000

7119000 7118000 7117000 7116000



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- HPMW
- HPMWD
- SAMU
- SAWS
- SDAGS

Sheet Layout:

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N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

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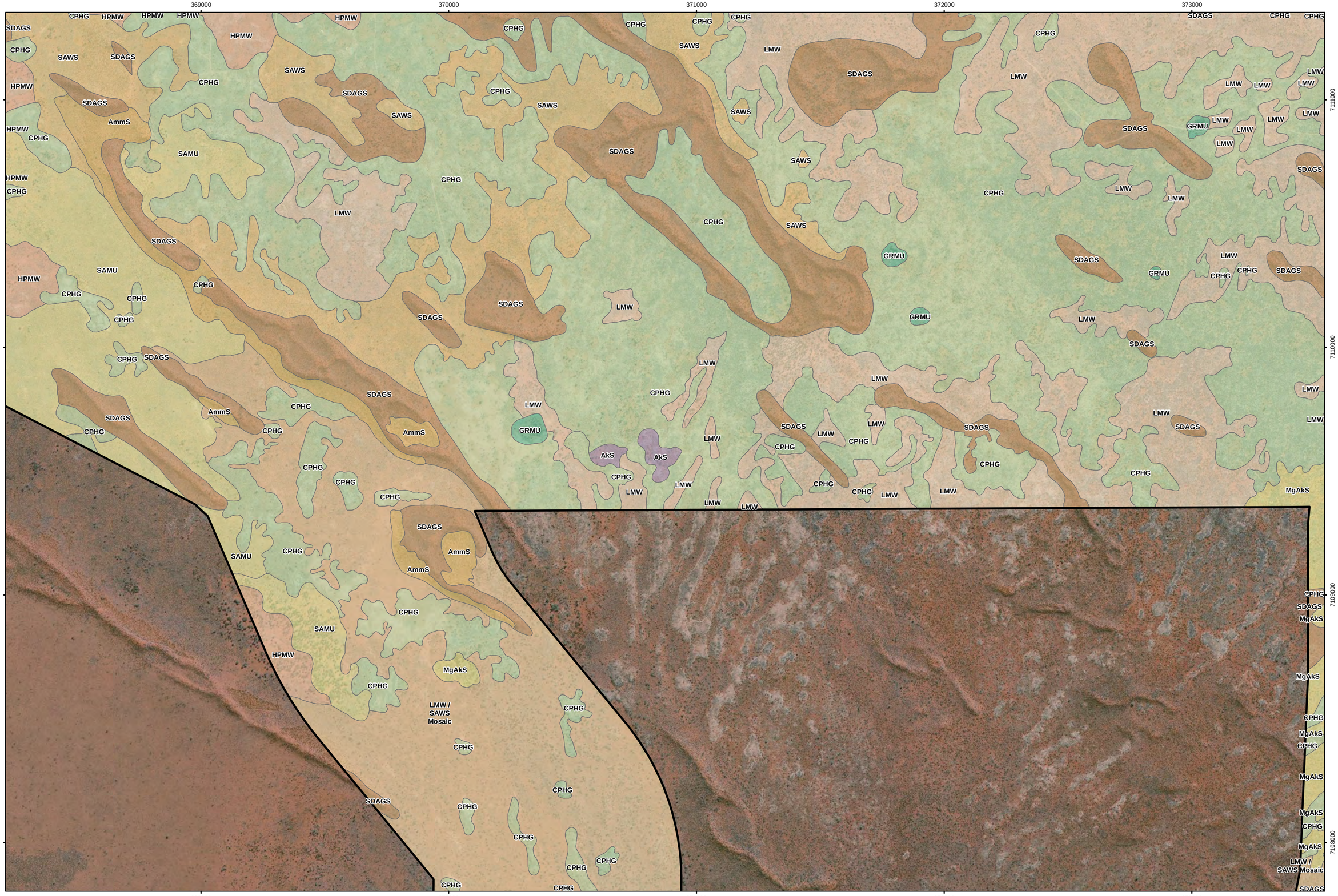
OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 9 of 79

Figure: **9**



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- AkS
- AmmS
- CPHG
- GRMU
- HPMW
- LMW
- LMW / SAWS Mosaic
- MgAkS
- SAMU
- SAWS
- SDAGS

Sheet Layout:

Client: OZ Minerals / Cassini Resources Limited

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

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OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 10 of 79

Figure: **10**

369000 370000 371000 372000 373000

7114000 7113000 7112000

HPMW CPHG CPP SAWS SAMU SDAGS COG AmmS LMW

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

Survey Area, CPP, SAWS, AmmS, HPMW, SDAGS, COG, LMW, CPHG, SAMU

Sheet Layout:

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N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

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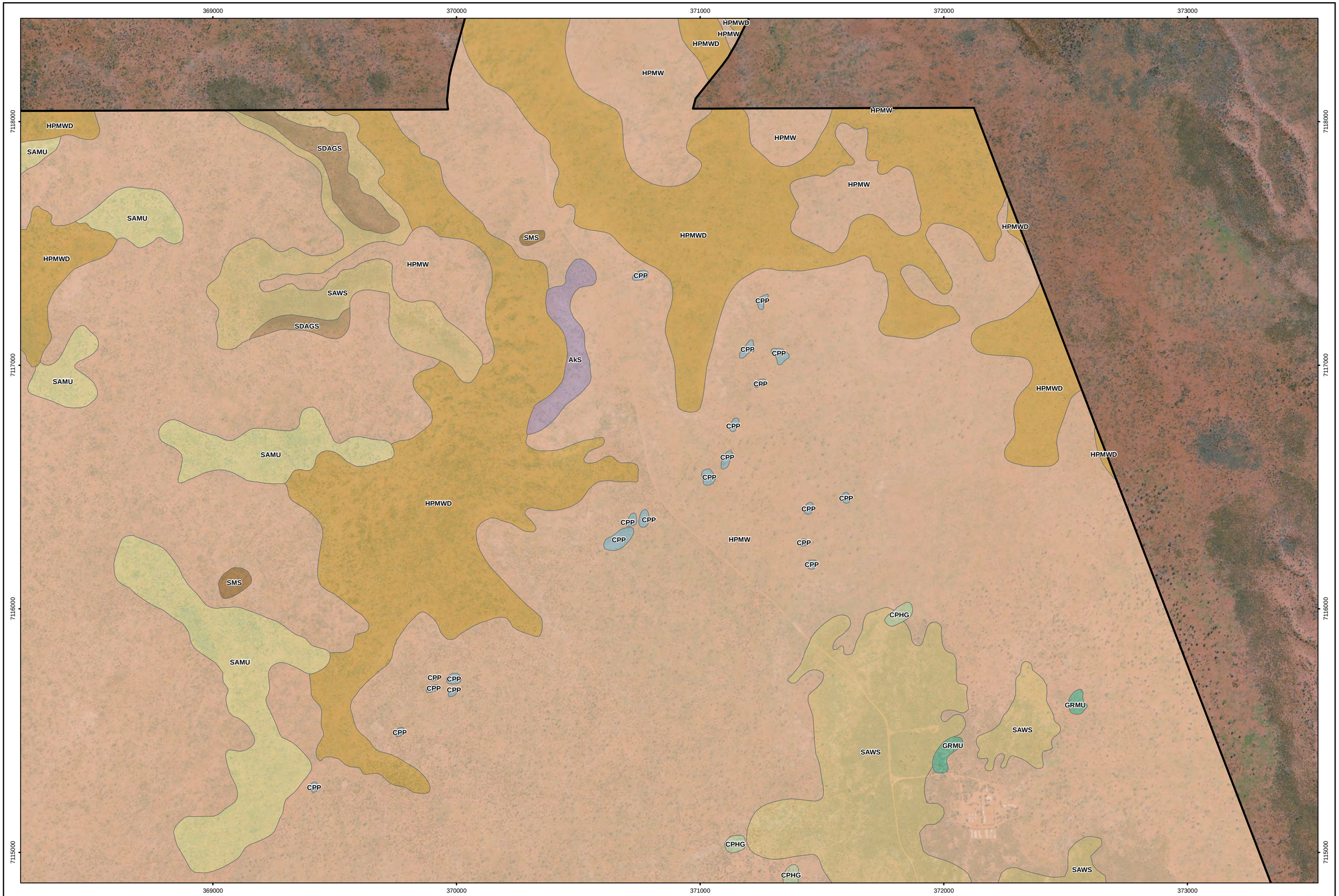
West Musgrave Vegetation Mapping
Sheet 11 of 79

Figure: **11**



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- AkS
- CPHG
- CPP
- GRMU
- HPMW
- HPMWD
- SAMU
- SAWS
- SDAGS
- SMS

Sheet Layout:

Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

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West Musgrave Vegetation Mapping
Sheet 12 of 79

Figure: **12**

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Legend

- Survey Area
- AmmS
- HPMW
- HPMWD
- SAMU
- SAWS
- SDAGS

Sheet Layout:

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N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

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West Musgrave Vegetation Mapping
Sheet 13 of 79

Figure: **13**

368000 369000 370000 371000 372000

7125000 7124000 7123000 7122000

AmmS HPMW GRMU SAMU SDAGS GRMU SDAGS HPMW AmmS SAMU

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- AmmS
- GRMU
- HPMW
- SAMU
- SDAGS

Sheet Layout:

Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

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OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 14 of 79

Figure: **14**

366000
367000
368000
369000
370000
7129000
7128000
7127000
7126000

CPHG
HPMW
GRMU
AkS
GRMU
SAWS
SAMU
AmmS
SAMU
GRMU
AmmS
SDAGS

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- AkS
- AmmS
- CPHG
- GRMU
- HPMW
- SAMU
- SAWS
- SDAGS

Sheet Layout:

Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

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Author: J. Warden

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OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 15 of 79

Figure: **15**

365000 366000 367000 368000 369000

7132000

7131000

7130000

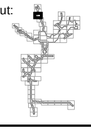
HPMW AkS HPMW CPN-G EdS HPMW CPHG

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- AkS
- CPHG
- CPN-G
- EdS
- HPMW

Sheet Layout:



Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

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Western Botanical

Author: J. Warden

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OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 16 of 79

Figure: **16**

365000 366000 367000 368000 369000

7136000 7135000 7134000 7133000

HPMW AvS CPN-G HPMWD HPMW AvS HPMW CPN-G HPMW GRMU AvS HPMW HPMWD HPMW AvS CPN-G HPMW CPN-G AkS CPP CPN-G

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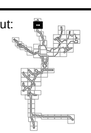
Legend

- Survey Area
- AkS
- AvS
- CPN-G
- CPP
- GRMU
- HPMW
- HPMWD

Sheet Layout:



Client: OZ Minerals / Cassini Resources Limited

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

Date: March 2020 | Rev: A | A2

Western Botanical

Author: J. Warden

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OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 17 of 79

Figure: **17**

364000 365000 366000 367000 368000

7139000 7138000 7137000

Disturbed
HPMWD
CPN-G
HPMW
Disturbed
SAWS
CPN-G
AvS
HPMWD
AvS
HPMW
CPN-G
AvS
HPMW
HPMWD
AvS
AvS
HPMW
AvS
HPMW
HPMW
HPMW

364000 365000 366000 367000 368000

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- AvS
- CPN-G
- Disturbed
- HPMW
- HPMWD
- SAWS

Sheet Layout:

Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

Date: March 2020 | Rev: A | A2

Western Botanical

Author: J. Warden

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 18 of 79

Figure: **18**

374000 375000 376000 377000 378000

7112000 7111000 7110000

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- AmmS
- CCoW
- CPHG
- CPP
- GRMU
- HPMW
- LMW
- LMW / CPHG Mosaic
- LMW / MgAkS Mosaic
- MgAkS
- SAMU
- SAWS
- SDAGS

Sheet Layout:

Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

Date: March 2020 | Rev: A | A2

Western Botanical

Author: J. Warden

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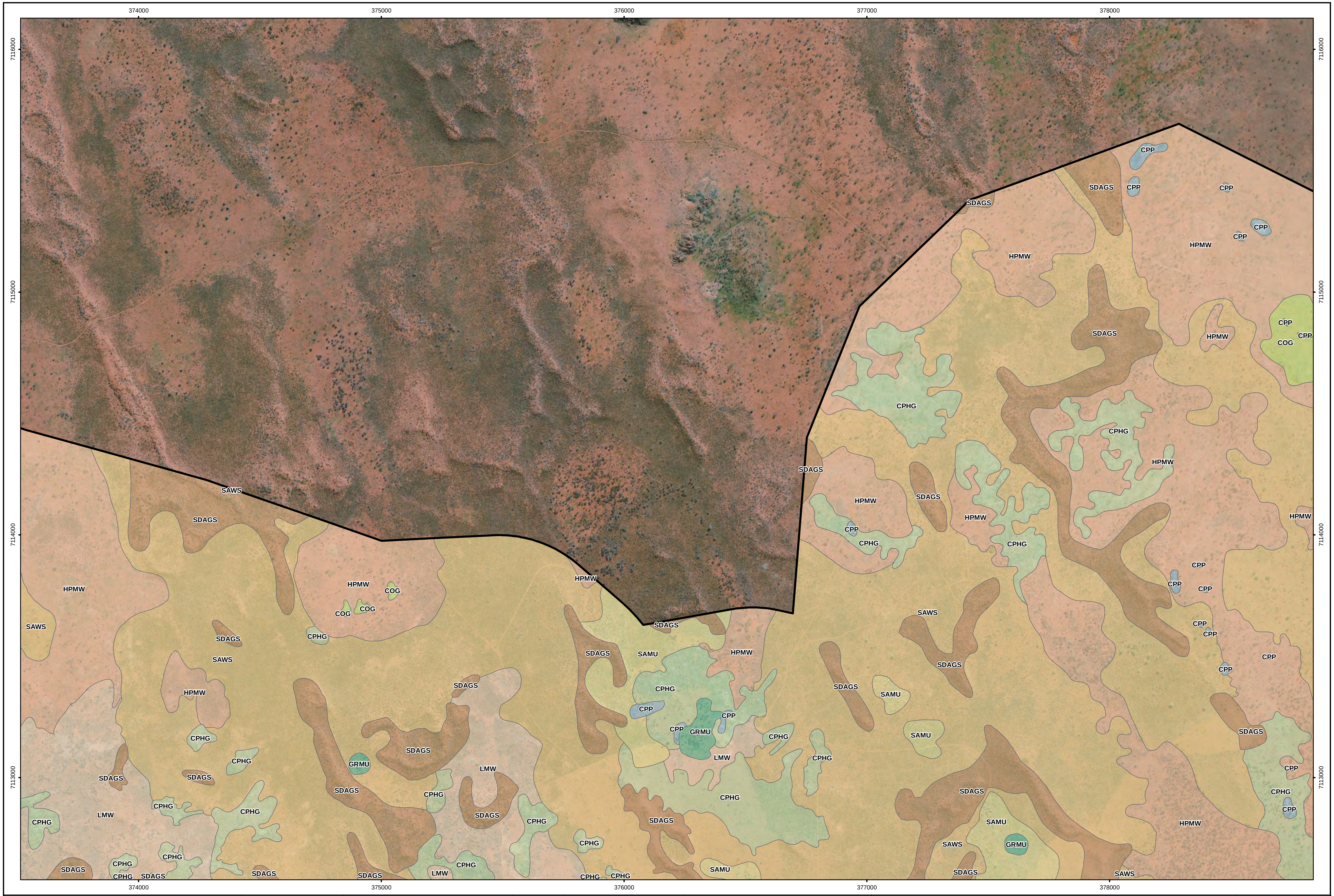
OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 19 of 79

Figure: **19**



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

Survey Area	GRMU	SAWS
COG	HPMW	SDAGS
CPHG	LMW	
CPP	SAMU	

Sheet Layout:

Client:

OZ MINERALS

CASSINI RESOURCES LIMITED

N

0 200 400 m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

Date: March 2020 | Rev: A | A2

Western Botanical

Author: J. Warden

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OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 20 of 79

Figure:

20

379000 380000 381000 382000 383000 384000

7112000 7111000 7110000

HPMW CPHG SAWS SDAGS MgAkS AmmS AbTsS CCoW CPP GRMU SAMU LMW SAWS / CPHG Mosaic LMW / MgAkS Mosaic

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- AbTsS
- AmmS
- CCoW
- CPHG
- CPP
- GRMU
- HPMW
- LMW
- LMW / MgAkS Mosaic
- MgAkS
- SAMU
- SAWS
- SAWS / CPHG Mosaic
- SDAGS

Sheet Layout:

Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

Date: March 2020 | Rev: A | A2

Western Botanical

Author: J. Warden

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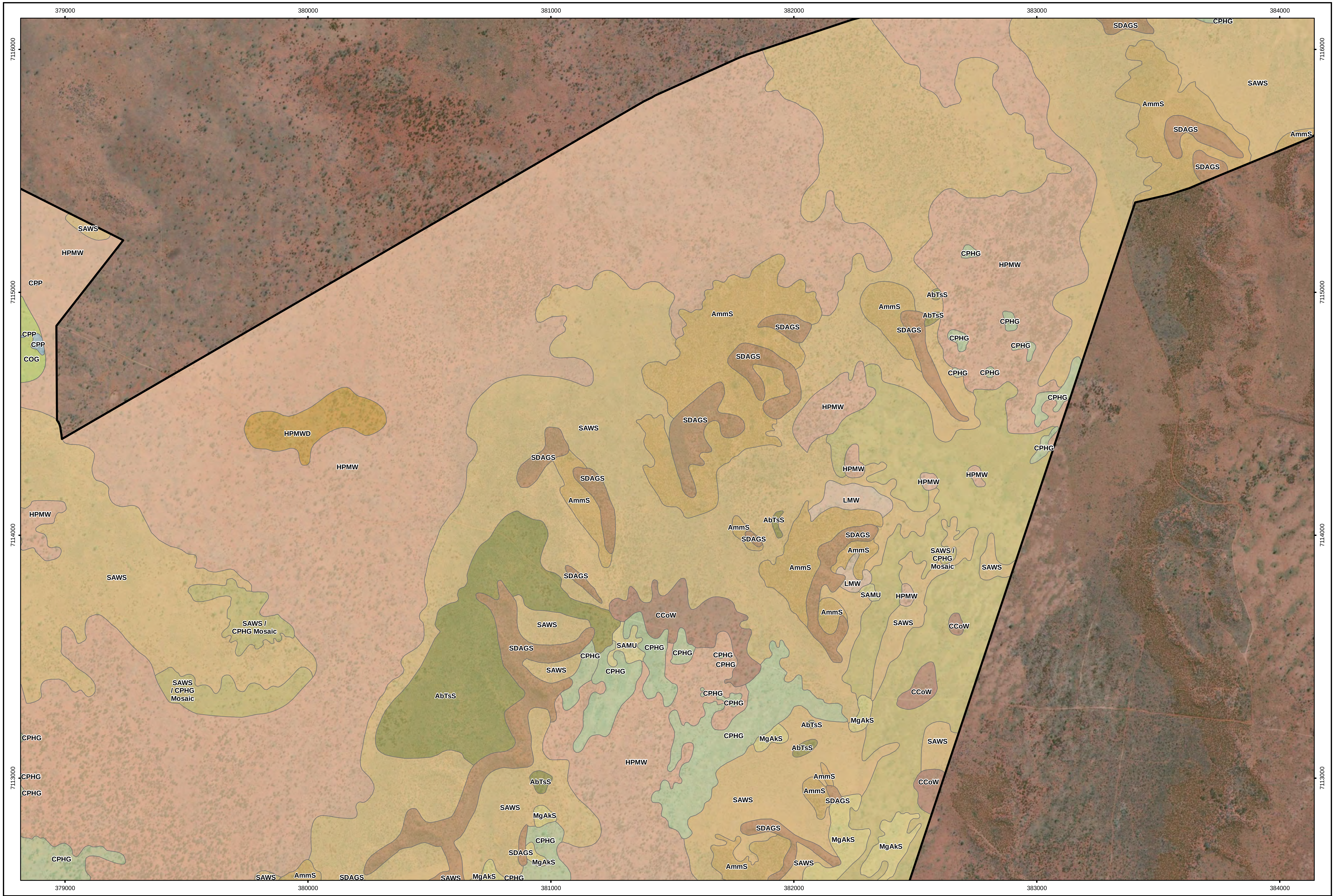
OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 21 of 79

Figure: **21**



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

Survey Area	COG	HPMWD	SAWS
AbTsS	CPHG	LMW	SAWS / CPHG Mosaic
AmmS	CPP	MgAkS	SDAGS
CCoW	HPMW	SAMU	

Sheet Layout:

Client: OZ MINERALS, CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10
Date: March 2020 | Rev: A | A2

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Author: J. Warden
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OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 22 of 79

Figure:
22

379000 380000 381000 382000 383000 384000

7119000

7118000

7117000

CPHG CPHG CPHG SAMU CPHG CPHG CPHG CPHG LMW LMW / CPHG Mosaic LMW MgAkS LMW SAWS

LMW LMW MgAkS SAWS CPHG MgAkS CPHG SAWS HPMW SDAGS SDAGS AmmS AmmS SAWS AmmS SDAGS SAWS SDAGS AmmS AmmS HPMW SDAGS SDAGS HPMW AmmS CPHG SDAGS HPMW SAWS

379000 380000 381000 382000 383000 384000

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- AmmS
- CPHG
- HPMW
- LMW
- LMW / CPHG Mosaic
- MgAkS
- SAMU
- SAWS
- SDAGS

Sheet Layout:

Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

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OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 23 of 79

Figure: **23**

379000 380000 381000 382000 383000 384000

7123000 7122000 7121000 7120000

AkS / HPMW Mosaic

AkS / HPMW Mosaic

SAMU

HPMW

CPHG

CPHG

CPHG

LMW

SAMU CPHG SAMU LMW

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- AkS / HPMW Mosaic
- CPHG
- HPMW
- LMW
- SAMU

Sheet Layout:

Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

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Date: March 2020 | Rev: A | A2

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OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 24 of 79

Figure: **24**

379000 380000 381000 382000 383000 384000

7126000

7125000

7124000

MgAkS

HPMW

COG

MgAkS / HPMW Mosaic

AkS / HPMW Mosaic

AkS / HPMW Mosaic

COG

AkS / HPMW Mosaic

HPMW

AkS / HPMW Mosaic

SAMU

HPMW

AkS / HPMW Mosaic

SAMU

AkS / HPMW Mosaic

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- AkS / HPMW Mosaic
- COG
- HPMW
- MgAkS
- MgAkS / HPMW Mosaic
- SAMU

Sheet Layout:

Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

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OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 25 of 79

Figure: **25**

385000 386000 387000 388000 389000

7112000

7111000

7110000

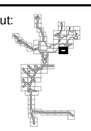
SAWS
LMW / CPHG Mosaic
CPHG
SAWS
LMW / CPHG Mosaic
SAWS
AmmS
SDAGS

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Survey Area
- AmmS
- CPHG
- LMW / CPHG Mosaic
- SAWS
- SDAGS

Sheet Layout:



Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

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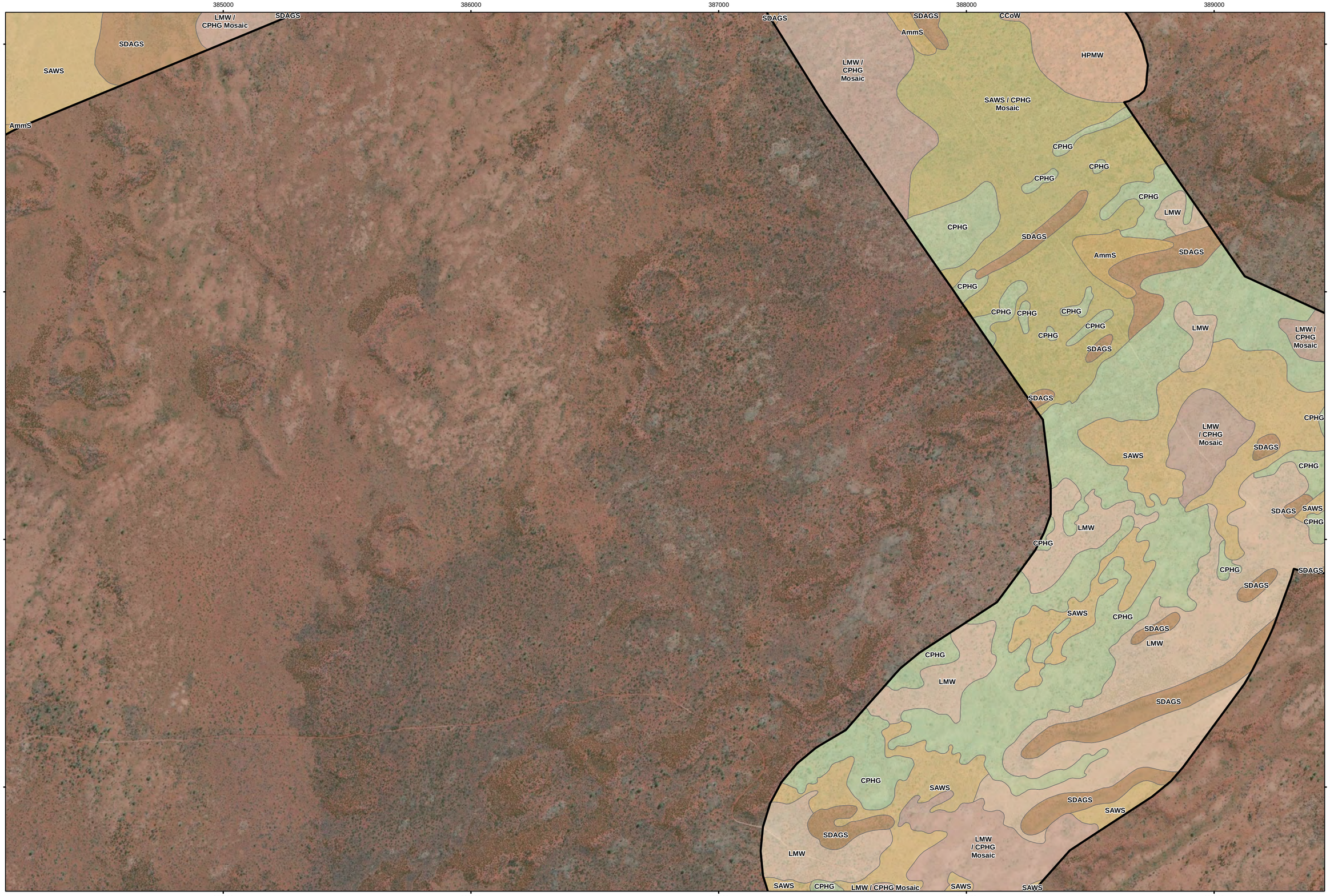
OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 26 of 79

Figure: **26**



Legend

- Survey Area
- AmmS
- CCoW
- CPHG
- HPMW
- LMW
- LMW / CPHG Mosaic
- SAWS
- SAWS / CPHG Mosaic
- SDAGS

Sheet Layout:

Client: OZ Minerals / Cassini Resources Limited

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

Date: March 2020 | Rev: A | A2

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Author: J. Warden

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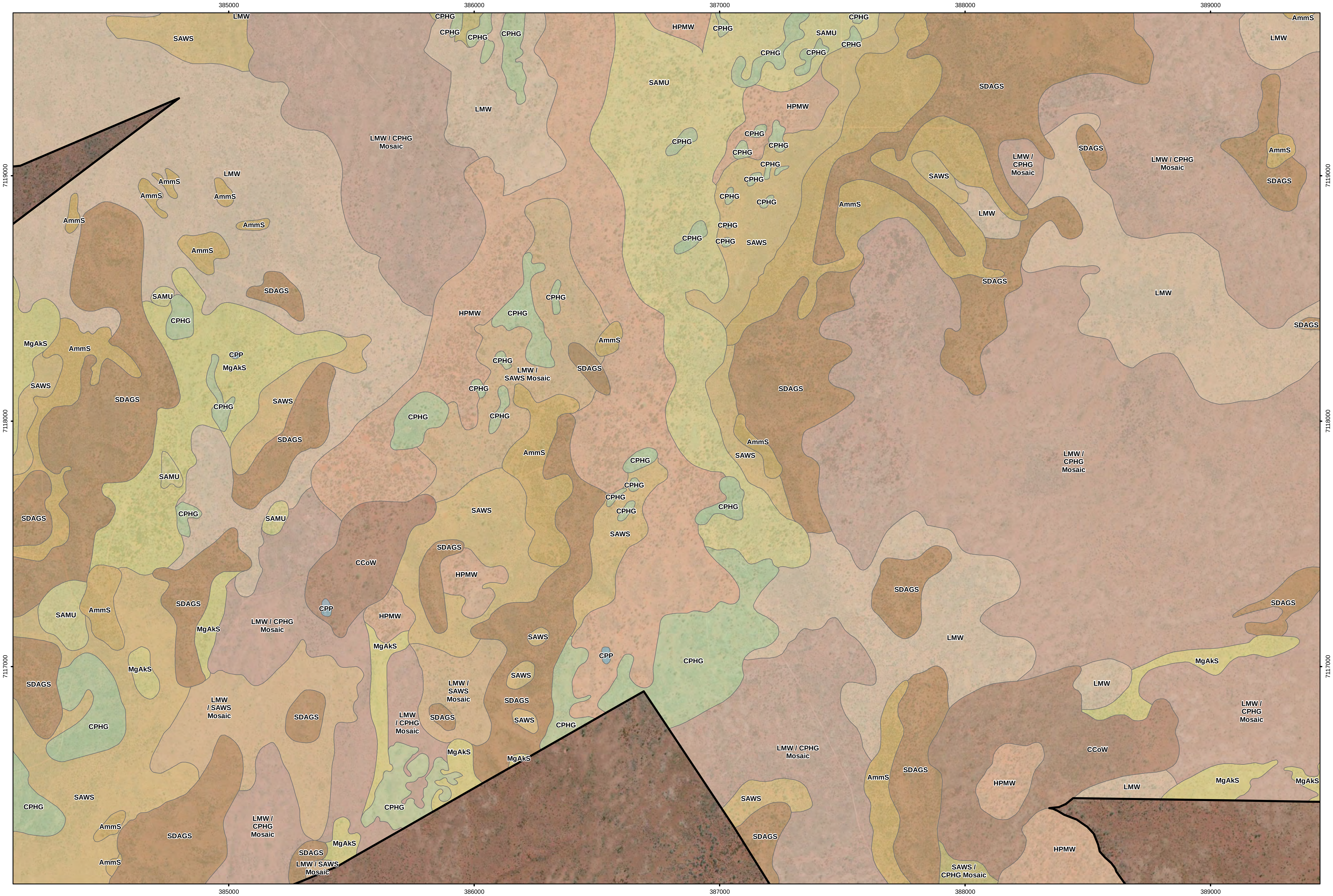
OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 27 of 79

Figure: **27**

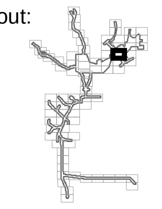


Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

Survey Area	CPP	LMW / SAWS Mosaic	SAWS / CPHG Mosaic	
AmmS	HPMW	MgAkS	SDAGS	
CCoW	LMW	SAMU		
CPHG	LMW / CPHG Mosaic	SAWS		

Sheet Layout:



Client:

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

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OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 28 of 79

Figure:

28

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

▭ Survey Area
🟧 AmmS
🟫 CCoW
🟩 CPHG
🟦 CPP
🟩 GRMU
🟧 HPMW
🟧 LMW
🟫 LMW / CPHG Mosaic
🟨 MgAkS
🟨 SAMU
🟨 SAWS
🟨 SAWS / CPHG Mosaic
🟫 SDAGS
🟨 SDAGS / AmmS Mosaic

Sheet Layout:

Client:

N

0 200 400 m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

Date: March 2020 | Rev: A | A2

Western Botanical

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OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 29 of 79

Figure:

29

385000 386000 387000 388000 389000

7126000

7125000

7124000

HPMWD
MgAkS
HPMW
MgAkS
MgAkS
COG
HPMWD
MgAkS
MgAkS
HPMW

Legend

- Survey Area
- MgAkS
- COG
- HPMW
- HPMWD

Sheet Layout:

Client: OZ MINERALS / CASSINI RESOURCES LIMITED

N

0 200 400m

Scale: 1:10,000
MGA94 (Zone 52)

CAD Ref: a2231_Mus_R04_10

Date: March 2020 | Rev: A | A2

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OZ Minerals / Cassini JV
West Musgrave Vegetation Mapping
Sheet 30 of 79

Figure: **30**