



**Western
Botanical**

Flora and Vegetation Assessment of the Mt Keith
Satellite Proposal Study Area
October 2017

BHP Billiton, Nickel West Pty Ltd
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Executive Summary

BHP Billiton Nickel West Australia (NiW) proposes to develop the Mt Keith Satellite (MKS), approximately 680 km north-east of Perth. Several field assessments and reports have been produced for the MKS project between 1990 and 2011 in support of a Level 2 Survey of flora and vegetation, consistent with EPA Guidance Statement 51 (Environmental Protection Authority, 2004). Western Botanical was engaged by NiW to review and update the previous baseline flora and vegetation report (Western Botanical, 2012) following a revision of the MKS project scope. Supplementary field works were commissioned and conducted during May, November, and December 2016 to support the update of the flora and vegetation assessment report. Further targeted surveys were undertaken in August to October 2017. This report presents the updated baseline flora and vegetation assemblages covering the revised MKS project footprint and regional context (Proposal Study Area). This report has been prepared to meet the requirements for Environmental Impact Assessment in accordance with the EPA's Guidance Statement 51 and the recent Environmental Protection Authority and Department of Parks and Wildlife (2016) Technical Guide – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment.

In summary, the following findings are relevant to the MKS Proposal Study Area:

Flora

The consolidated cumulative species list for the MKS Proposal Study Area now contains 389 species (and putative hybrids) from 140 genera and 51 families of endemic flora. Of these, the majority are common, widespread in distribution and are highly representative of the flora of eastern Murchison and western Great Victoria Desert biogeographic regions. Six weed species were also recorded, all in small and scattered populations of low numbers.

While no Threatened Flora as listed under the *Wildlife Conservation Act 1950* are known within or nearby the Proposal Study Area, thirteen Priority Flora species are known within the areas assessed. These include two Priority 1, eight Priority 3, and three Priority 4 listed species.

Priority Flora species

Anacampseros sp. Eremaean (F. Hort, J. Hort & J. Shanks 3248) P1

Aristida ?*jerichoensis* var. *subspinulifera* P3

Eremophila pungens complex P4, inclusive of *E.* sp. Leinster (R.J. Cranfield 6767)

Grevillea inconspicua P4

Gunniopsis propinqua P3

Hemigenia exilis P4

Hibbertia sp. Sherwood Breakaways (R.J. Cranfield 6771) P1

Hibiscus krichauffianus P3

Hybanthus floribundus subsp. *chloroxanthus* P3

Sida picklesiana P3

Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362) P3

Tribulus adelacanthus P3

Verticordia jamiesonii P3

Hibbertia sp. Sherwood Breakaways (R.J. Cranfield 6771) P1 was recognised as a new species as a result of the 2016 – 2017 field surveys at MKS and was attributed Priority 1 flora status by the Department of Biodiversity, Conservation and Attractions (DBCA) in early October 2017. It is found on the Sherwood Land System, Archaean granite breakaways north of the MKS orebodies. The population of an estimated 13,715 individuals is made up of 12,287 plants in Unallocated Crown Land on Yakabindie Station (89.59% of the total population) and 1,428 plants within the Wanjarri Nature Reserve (10.41% of the total population). The population is traversed by the proposed haul road alignment from MKS to the Mt Keith nickel mine. Unavoidable direct impact to around 258 individuals within the development footprint, representing 1.88% of the entire population, (285 plants within the development envelope, 2.08% of the entire population) of the species will be required where the proposed haul road intersects the breakaway system.

Small proportions of the overall local populations of *Hybanthus floribundus* subsp. *chloroxanthus* P3 (14.35%), *Grevillea inconspicua* P4 (2.52%), *Gunniopsis propinquus* P3 (<1%), *Hibiscus krichauffianus* P3 (14.3%)¹ and *Thryptomene* sp. Leinster P3 (1.36%) will be impacted by the development of the mine voids, wastedumps and haul road while small proportions of populations of *Verticordia jamiesonii* P3 (5.26% of the local population) will be impacted by the development of the haul road alignment.

Species of Interest

Undescribed species with limited distribution

Eremophila sp. long pedicels (G. Cockerton 1975)², is known from four populations in the Lake Way and Lake Maitland Catchments in the Wiluna area. A small number (estimated 20 plants, 0.04% of the estimated population) of *Eremophila* sp. long pedicels lie within the proposed haul road alignment to Mt Keith, near the existing mine site, representing a negligible proportion of

¹ *Gunniopsis propinquus* P3 and *Hibiscus krichauffianus* P3 have not been thoroughly assessed within the MKS Study Area and, as all Priority species, are data deficient in a regional sense.

² *Eremophila* sp. long pedicels (G. Cockerton 1975) was listed as a Priority 1 species on 10th November 2017. It has been treated as a Species of Interest in this document.

the overall known regional population estimated at over 50,000 individuals. It is also known within the Wanjarri Nature Reserve.

Species with uncertain taxonomic status, requiring further review

The taxonomic review of six species is not fully completed and will require further review and the attention of specialist taxonomists in those genera. These are:

Acacia doreta (long phyllode form) (G. Cockerton & S. Cockerton WB38633);

Acacia sp. East Murchison Basalt (G. Cockerton & J Warden WB39701);

Acacia subtessarogona (flat pod form) (G. Cockerton WB38658);

Acacia xanthocarpa (flat phyllode form) (G. Cockerton & J Warden WB38064)

Olearia sp. Sherwood Breakaways (A. Taylor 25552), currently within *Olearia stuartii*;
and

Olearia xerophila sens. lat. (G. Cockerton & P. Goodman WB38116), currently within
Olearia xerophila.

No direct impacts to *Acacia subtessarogona* (flat pod form) or *Olearia xerophila* sens. lat. are planned in development of the MKS Proposal. Minor impacts to *Acacia doreta* (long phyllode form), *Acacia* sp. East Murchison Basalt, *Acacia xanthocarpa* (flat phyllode form) and *Olearia* sp. Sherwood Breakaways will ensue from development of the MKS Proposal, however, these are insignificant in both a local and regional sense.

Vegetation

Thirty-eight Vegetation Associations and two Vegetation Association Complexes, have been recognised in the MKS Proposal Study Area (5,422.09 ha). The Vegetation Associations have been grouped into six sub-units according to the dominating underlying geology / regolith which strongly influences the vegetation association species composition.

Those vegetation associations on (i) Sandplains and (ii) Colluvial and Alluvial Landforms are widely distributed in the Murchison Biogeographic region. Vegetation Associations of the (iii) Limonitic Landforms, the (iv) fresh rock Basalt geology of the Perseverance fault line, and (v) carbonate soils derived from weathered basalt and associated volcanics geology and associated colluvial slopes are constrained within the 2km wide Perseverance fault line and within the boundaries of the Violet Ranges Priority Ecological Community. While narrow in an east-west orientation, these landforms extend for around 82 km in a north-south orientation. The Violet Ranges PEC, as currently defined, represents a subset of this overall range.

The majority (36 of the 38) Vegetation Associations represent small proportions (less than 10%) of the area of the overall MKS Proposal Study Area. However, two communities, the colluvial slopes mapped as Stony Mulga Shrubland, SMS, (763.84 ha, 14.09%) and the Granitic Mulga Shrubland, GrMS, (990.02 ha, 18.26%) exceed this. In a regional sense, large areas of colluvial slopes, being equivalent to the SMS community, are known from north of the Mt Keith nickel mine to Leinster, though they may have been mapped as Stony Ironstone Mulga Shrublands (SIMS) lower slopes in these areas (Cockerton & Stratford 1997a, 1997b, Western Botanical, 2016). The GrMS Vegetation Association is very widespread in the region and is found extensively outside the MKS Proposal Study Area in both eastern and western directions, including within the Wanjarri Nature Reserve, in association with the Archaean granitoid Barr-Smith Range.

Fourteen Vegetation Associations and one Vegetation Association Complex will not be impacted at all by the MKS proposal. Twelve Vegetation Associations are impacted to less than 10% of their area of occupancy within the MKS Study Area. Four Vegetation Associations (SAES (11.51%), WABS (14.92%), SMS (15.28%), HPMS (15.69%)) are impacted to levels between 10% and 20% of their respective areas of occupancy. Five Vegetation Associations (EGPW (21.07%), USBS (29.90%), GHPS (37.67%), SSS (38.81%), and SIMS (39.29%)) will be impacted at levels of between 20% and 50% of their area mapped within the MKS Proposal Study Area. The SAES, WABS, SMS, HPMS and EGPW communities are well represented outside the MKS Proposal Study Area while the USBS, GHPS and SSS and SIMS communities are largely known from (i) within the MKS Proposal Study Area, (ii) minor occurrences at Mt Keith to the north of MKS and (iii) south of MKS towards Leinster within the southern part of the Perseverance fault line region.

Within the MKS Proposal Study Area, the MMS (60.48%) and HPMS-Thoma (100%) communities are impacted at High to Very High proportions. However, the MMS community is also known near the Leinster nickel mine and HPMS-Thoma community is very closely aligned with the wider-spread HPMS community (separated primarily by the inclusion of *Acacia thoma* as a dominant species). *Acacia thoma* is known from four locations within the MKS Proposal Study Area, at Leinster and within the Wanjarri Nature Reserve. It is more commonly recorded in the Pilbara region. The HPMS-Thoma community is also represented (though not mapped) within the Wanjarri Nature Reserve east of the haul road component of the MKS Proposal Study Area.

Vegetation Condition, Weeds and Grazing

The MKS tenements have been extensively explored in the past and post exploration rehabilitation was found to have been largely effective. Vegetation condition outside the areas directly impacted by exploration and track maintenance can be regarded as being in Pristine (i) condition with little evidence of pastoral activities. Areas having been disturbed in previous exploration works are regarded as being in Excellent (ii) condition while completely cleared areas were recorded as Completely Degraded (vi).

Weed populations were always found in small, isolated populations with low numbers of individuals present. Three species, *Rumex vesicarius* (Ruby Dock), *Cenchrus ciliaris* (Buffel Grass), *Cenchrus setiger* (Birdwood Grass) have the potential to be highly invasive and should be actively managed. A further three species, *Bidens bipinnata* (Tick Weed), *Lysimachia arvensis* (Pimpernel) and *Mesembryanthemum nodiflorum* (Slender Iceplant) pose a lesser risk to the project and do not warrant active management.

While the MKS project lies largely within the Yakabindie Pastoral Lease and grazing of cattle has historically been the main pastoral activity in the past 20 years (D. Brownlie pers. comm.), little evidence of grazing pressure on vegetation is apparent. Specifically, the Mulga and associated vegetation shows little evidence of grazing by cattle and the canopies of most vegetation is intact and reflects normal seasonal conditions.

Wanjarri Nature Reserve

The Wanjarri Nature Reserve is contiguous with the eastern margin of the MKS tenements. Here, the vegetation is reflective of underlying granitoid landscapes with extensive Aeolian sandplains, extensive Archaean granite breakaways and associated saline footslopes and hardpan plains being present. These landscape units are widespread and prevalent in the north-eastern Goldfields region and are well represented both within and outside the adjacent Wanjarri Nature Reserve. The development of the MKS project will not directly impact on the Wanjarri Nature Reserve as currently defined.

Priority Ecological Community

The MKS Proposal Study Area lies approximately centrally within the 19,256.2 ha *Violet Ranges (Perseverance Greenstone Belt) vegetation complexes (banded ironstone formation)* Priority 1 Priority Ecological Community. This PEC extends for approximately 32 km in a north-south orientation and approximately 11 km in an east-west orientation at its widest point. Components of the Violet Ranges PEC are not represented within the Wanjarri Nature Reserve.

The MKS Proposal Study Area occupies 3,248.5 ha (16.87%) of the 19,256.2 ha Violet Ranges PEC and the MKS proposed Development Envelope represents 1,009 ha (5.24%) while the MKS Disturbance Footprint represents 724.4 ha (3.76%) of the Violet Ranges PEC as currently mapped. Minimal historical impacts to the Violet Ranges PEC have occurred to date with clearing for pastoral tracks and fences as well as historical, now decommissioned, Bellevue mining activities on the north-shore of Lake Miranda being the major contributors.

1. Introduction

1.1. Project Background

BHP Billiton Nickel West Australia (NiWest) proposes to develop the Mt Keith Satellite Operation (MKS), approximately 680 km north-east of Perth. Several field assessments and reports have been produced for the MKS Project between 1990 and 2011 in support of a Level 2 Survey of flora and vegetation, in accordance with EPA Guidance Statement 51 (Environmental Protection Authority, 2004). This report has been prepared to meet the requirements for Impact Assessment in accordance with the EPA's Guidance Statement 51 and the recent Environmental Protection Authority and Department of Parks and Wildlife (2016) Technical Guide – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment.

In mid 2016, Western Botanical was engaged by NiWest to review and update the previous baseline flora and vegetation report (Western Botanical, 2012) following a revision of the MKS Proposal Study Area. Supplementary field works were conducted during May 2016 to support the production of the updated flora and vegetation assessment report (Western Botanical, 2016).

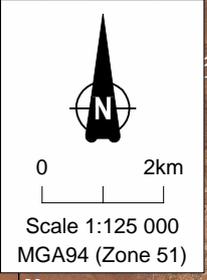
Following this, Western Botanical was engaged to conduct work to address identified gaps in previous work conducted on behalf of NiWest. This report presents the updated baseline flora and vegetation study conducted over the revised MKS Proposal Study Area, inclusive of the proposed Six Mile and Goliath pits, wastedumps, infrastructure areas and the haul road alignment to the Mt Keith minesite. Results of field surveys and the taxonomic status of flora presented here are current to end October 2017.

1.2. Location

The MKS Project is located in the north-eastern Goldfields of Western Australia, 52 km north-north-west of Leinster, around 25 km south of the Mount Keith Mine, and 3 km east of the Goldfields Highway (Figure 1). The MKS Proposal Study Area lies immediately adjacent to the western boundary of the Wanjarri Nature Reserve (WNR) but does not directly impact on the Reserve.

The North-eastern Goldfields region lies in the north-eastern corner of the Archaean Yilgarn Block. As defined by Beard (1990), the project falls within the Wiluna sub-region of the Austin Botanical District of the Eremaeen Botanical Province. The Interim Biogeographic Regionalisation for Australia (Department of the Environment, 2013) places the MKS Project in the eastern portion of the Murchison Biogeographic Region (MUR01).

Figure 1. MKS Project location map.

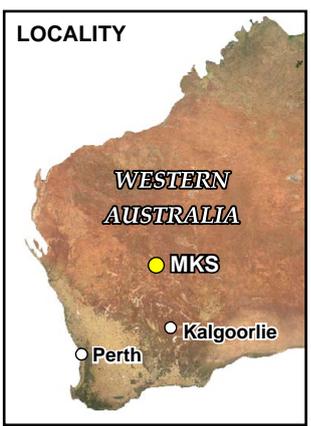


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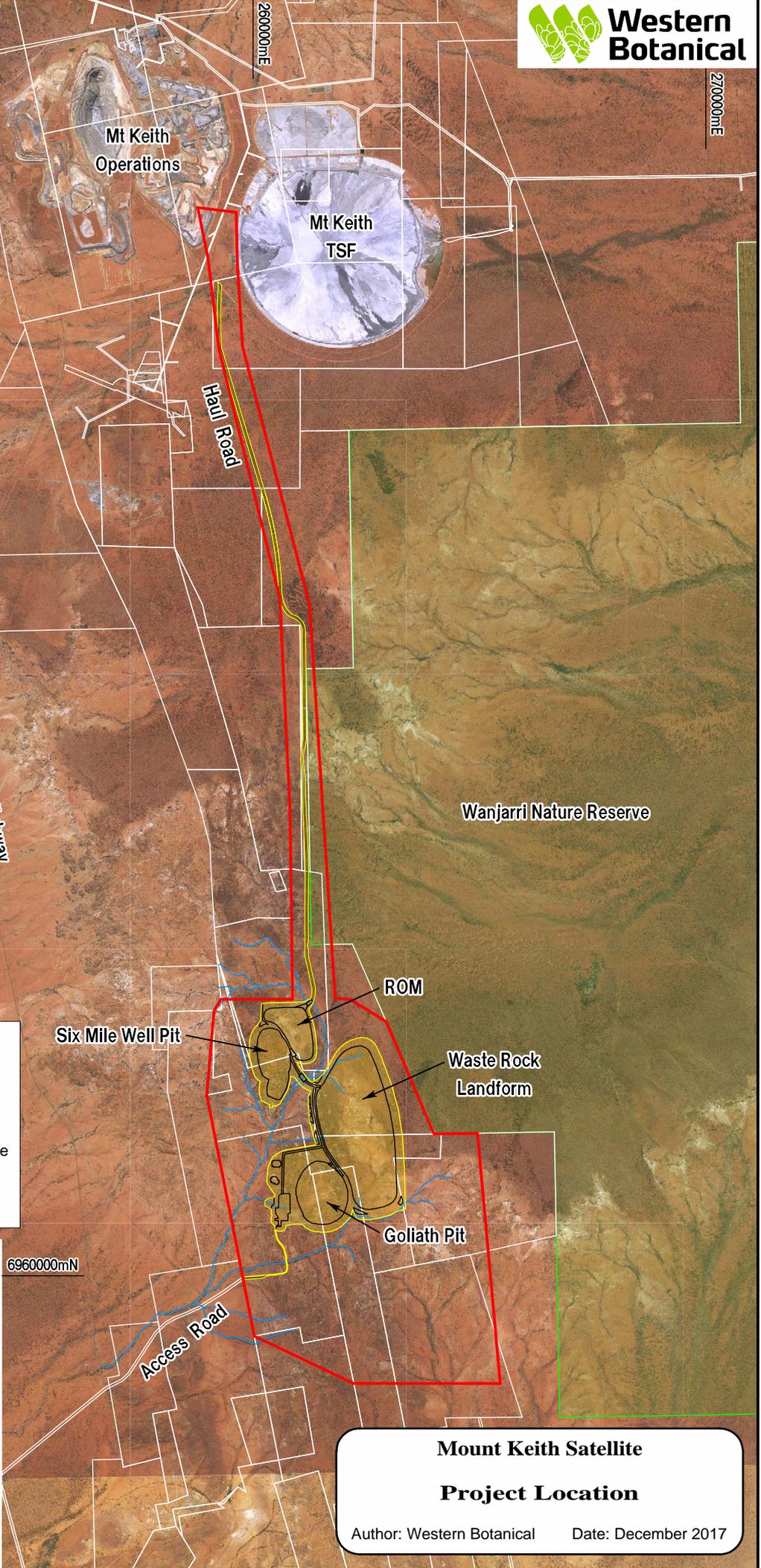
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LEGEND

- Study Area
- Disturbance Envelope
- Disturbance Footprint
- Wanjarri Nature Reserve
- Tenements
- Surface Water



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Mount Keith Satellite

Project Location

Author: Western Botanical Date: December 2017

Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ December 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_01.dgn ~ Imagery: Landgtc (2011)

1.3. Previous surveys

The MKS Proposal Study Area (previously referred to as the NDS1 Project and the Yakabindie Nickel Project) has been the focus of multiple flora and vegetation survey reports since 1990. Previous reports addressed two aspects of the overall project. Works A, B, F to N assess the flora and vegetation values of the proposed MKS Proposal Study Area including orebodies, infrastructure areas and the proposed haul road to Mt Keith. These were progressively conducted to fulfil the requirements of a Level 2 Survey, in accordance with EPA Guidance Statement 51 (Environmental Protection Authority, 2004). Works D and F to refer to the flora and vegetation conservation values of the south-western portion of the WNR and an area within Yakabindie Station which were the subject of a successful land swap aimed at excising a portion of the Wanjarri Nature Reserve in order to facilitate mining at the MKS Proposal Study Area. Table 1 summarises previous surveys and reports related to the MKS Proposal Study Area.

Table 1. Previous Reports Relating to the Flora and Vegetation of the MKS Proposal Study Area.

#	Author	Title	Summary
A	Western Botanical (2016) WB860 v2	Flora and Vegetation Assessment, Yakabindie Nickel Project September 2016	Review and update of all data relating to flora and vegetation, including review of previous reports relating to the MKS Proposal Study Area. Included supplementary field work mapping weeds and vegetation condition. Discussed 263 endemic flora, four weed species, 10 Priority flora (four P3 and two P4 taxa) and seven Species of Interest. Presented vegetation maps and significant species records and incorporated a vegetation condition map and weed populations. Conducted an analysis of vegetation units between Leinster, MKS and Mt Keith, finding that all three were significant different

B	Western Botanical (2012a) WB701	Baseline review and statistical analysis of the flora and vegetation of the NDS1 mine and corridor Proposal Study Area	A review and synthesis of previous works and addition of quadrat-based vegetation assessment and analysis, to meet the criteria of a Level 2 Survey. Includes Six-mile and Goliath orebody areas, waste rock storage area, and associated transport corridor of the YNP based on additional field works implemented in 2011. Discussed impacts at Land System and Vegetation Community levels. Discussed 295 endemic flora species, seven Priority species, 13 undescribed species and eight Species of Interest. Discussed potential impacts to two species with or likely to have conservation significance, within the Proposal Study Area.
C	Western Botanical (2012b) WB730	Flora and Vegetation of the Proposed Yakabindie Borefield, March 2012	Presented Level 1 assessment vegetation maps within a 1 km wide corridor centred on the proposed borefield alignment. Discussed 111 endemic flora, one Priority 3 species and two Species of Interest.
D	Western Botanical (2010) WB658	Assessment of conservation values of the flora and vegetation of Wanjarri Excision Area, ELA36/739 and EL3/570	Assessment of a section of Wanjarri Nature Reserve and the Sir Samuel block, in preparation for a land swap to facilitate mining at YNP. Discussed the relative conservation values of each parcel of land including land systems, vegetation units, 10 Priority Species and three undescribed Species of Interest.
E	Western Botanical (2009) WB563	Assessment of flora and vegetation, Yakabindie Project (draft report)	Commissioned for the purposes of applying for a Native Vegetation Clearing Permit (NVCP) for the YNP Section 18 Area. Discussed 219 endemic flora, 11 Priority Species and two species of Interest.
F	Western Botanical (2008) WB491	Vegetation, flora and conservation values of the north-western corner of the Wanjarri Nature Reserve	Assessment of a small section (87 ha) of the Wanjarri Nature Reserve, known as the Yanganoo Block, as an addition to a land swap from WNR into mining tenement. Listed land systems, 4 Priority Flora and vegetation as well as the conservation values of the area assessed.

G	Western Botanical (2006b) WB254	Flora, vegetation and habitats of the Yakabindie tenements 2004-2005	Initial review of flora, vegetation, and conservation values of Yakabindie and surrounding local areas. This represented the most comprehensive and extensive works conducted at the MKS Proposal Study Area inclusive of vegetation mapping, habitat descriptions and species profiles to date. Listed 204 vascular flora, 4 Priority Flora and 5 undescribed species.
H	Western Botanical (2006c) WB347	Review of flora, vegetation, landscapes and conservation values of the Six-mile and Sir Samuel blocks, Wanjarri Nature Reserve and Yakabindie Station.	Assessment of a section of Wanjarri Nature Reserve and a section of Sir Samuel block, in preparation for a land swap to facilitate mining at YNP. Assessed a small portion of the WNR and listed endemic species, vegetation associations and land systems.
I	Landcare Services (2001)	Review of <i>Hemigenia exilis</i> (S. Moore) November 2001	Combined all data including WMC, Anaconda Nickel and CALM sources to review the status of <i>Hemigenia exilis</i> (DRF) resulting total of 46,005 plants from 66 populations and in reduction to Priority 4 status.
J	Landcare Services (1996)	A review of <i>Hemigenia exilis</i> (S. Moore) populations at The Mt Keith Operation and within the north-eastern Goldfields.	Review of <i>Hemigenia exilis</i> local and regional populations, incorporating data supplied by Anaconda Nickel. Noted 22,862 plants of <i>Hemigenia exilis</i> (DRF) at approximately in 49 populations south of Mt Keith.
K	Ecologia (1996)	Yakabindie Nickel Project: <i>Hemigenia exilis</i> survey and management plan.	Survey and management of <i>Hemigenia exilis</i> , previously ranked as Declared Rare Flora, at the Yakabindie Nickel Project.
L	Ecologia (1995)	Yakabindie nickel mine project, Six Mile Well – Mt Pasco blocks: environmental assessment	Not sighted by the authors
M	Ecologia (1991)	Declared Rare Flora Assessment Survey: Distribution and conservation status of the Cue <i>Grevillea</i> , <i>Grevillea inconspicua</i> .	Regional assessment of <i>Grevillea inconspicua</i> , a species previously ranked as Declared Rare Flora.
N	Ecologia (1990)	Yakabindie Nickel Mine Project: Six Mile Well – Sir Samuel 33 Biological Assessment Survey	Early assessment of flora and fauna for the YNP.

Several flora and vegetation assessments of the MKS area were conducted between 1990 and 2009 (Ecologia, 1990, 1991, 1996 and Western Botanical, 2006b, 2008, 2009). In order to meet EPA Guidance Statement 51 for a Level 2 survey (Environmental Protection Authority, 2004), NiW commissioned further works in 2010. The 2010 Scope of Works included establishment of quadrats, a statistical analysis of this data, a review of the flora and a review of the conservation status of species. The Western Botanical (2012a) report includes a revised organisation of vegetation communities (formerly referred to as habitat units) within the landscape and the introduction of Landform Systems, revised floristics including annual flora species encountered in April 2011, a revised discussion of conservation significant species and a statistical analysis of the quadrat data. Importantly, the vegetation associations of the Proposal Study Area were mapped at a scale of 1:25,000 on relatively coarse satellite imagery.

The portions of Jones Creek that lie outside and downstream of the mine area were mapped at low resolution by Western Botanical in 2004-2005 (Western Botanical, 2006b).

The earlier surveys of *Hemigenia exilis* and *Grevillea inconspicua* (Ecologia, 1996 & 1991 respectively) mapped the occurrence of these two species at both a local and regional scale. These works, in association with works commissioned by WMC Resources (Landcare Services, 1996, 2001) and Anaconda Nickel on the regional occurrences of *Hemigenia exilis* were adequate at that time to reassess the conservation significance of each species of those Threatened Species with resulting reduction to Priority 4 for both taxa. The Ecologia 1991 and 1996 reports provided initial assessments of flora and vegetation for smaller, discrete parts of the MKS Proposal Study Area.

1.4. Current Survey

The current survey report addresses the Scope for the MKS Proposal Study Area (inclusive of proposed pits, wastedumps, infrastructure areas and transport corridor to the existing Mt Keith Nickel Mine), Figure 1, as amended during the works program, including the following:

1. Re-mapping the entire MKS Proposal Study Area at 1:10,000 scale using excellent quality satellite imagery sourced from the Department of Land Administration (DLI) and a series of Relevés describing the vegetation communities;
2. Re-assessing all quadrats previously established within the MKS Proposal Study Area by DBCA (formerly CALM, DEC, DPaW) (9 quadrats);
3. Re-visiting all 89 Quadrats previously established by Western Botanical, re-scoring a subset of these (64 quadrats) and establishing a further 50 new quadrats and 58 Relevés (total of 261 sites) to define the Vegetation Associations of the Proposal Study Area;
4. Updating the flora, and specifically the Mulga varieties (*Acacia aneura* sens. lat. and associated species), known within the Proposal Study Area;

5. Reassessing the impacts of the proposed MKS development on the vegetation communities of the proposed MKS Development Envelope within the Proposal Study Area;
6. Briefly assessing the Violet Range PEC description, boundaries and vegetation units with similarity to those of the MKS Proposal Study Area; and
7. Evaluating the condition of the vegetation of the Proposal Study Area with respect to weeds and grazing impacts.
8. Conducting targeted surveys for *Hibbertia* sp. Sherwood Breakaways (R.J. Cranfield 6771) P1, *Acacia* sp. East Murchison Basalt (G. Cockerton & J. Warden WB39701), and *Acacia xanthocarpa* flat phyllode form (G Cockerton & J Warden WB39702) complexes.
9. The MKS Proposal has had several revisions of the (i) Study Area, (ii) the Disturbance Footprint and the (iii) Disturbance Envelope (inclusive of the Disturbance Footprint and a buffer). The project definition is current as at 17 October 2017.

1.5. Physical Environment

1.5.1. Climate

The Murchison bioregion has an arid climate and rainfall can occur at any time of year. The average annual rainfall is approximately 210 mm and is variable throughout the region (Pringle *et al.*, 1994). Summers are hot and dry with infrequent, high intensity seasonal thunderstorms and occasional cyclonic events. Maximum temperatures across the region exceed 40°C during the summer months and winters are mild with cool nights (Bureau of Meteorology, 2017).

The Leinster Aero weather station (site number 012314) located approximately 77 km to the south is the closest Bureau of Meteorology data collection site to the Proposal Study Area. At this location, the mean annual rainfall recorded from 1994 – 2016 is 260.3 mm; the lowest average rainfall of 139.8 mm was recorded in 2009 and the highest of 439.4 mm was recorded in

1997 (Bureau of Meteorology, 2017). The historical average annual rainfall recorded during the summer months (December to February) is 105.3 mm with January recording the highest mean monthly rainfall of 41.1 mm. During the winter months (June to August) the average rainfall received is 42.7 mm (Bureau of Meteorology, 2017).

1.5.2. Geology

The Proposal Study Area occurs at the northern end of the Yilgarn Craton in the Eastern Goldfield Province. The Yilgarn Craton, with an age of approximately 2.5 gigaannum (Ga) (Griffin, 1990), encompasses a large portion of the Western Australian landmass of 657,000 km². The Eastern Goldfield Province is a typical Archaean granite-greenstone terrain characterised by large areas of granitic lithology and generally narrow, linear belts of greenstone (Griffin, 1990). Alluvial soils and sands overlay the granitic-greenstone units of the Yilgarn Craton. Underlying the soils in low areas is a red-brown siliceous hardpan (Curry et al., 1994). In the eastern half of the bioregion the soils are typically calcareous red earths, lithosols, duplex soil and clays and red sands, (Australian Natural Resources Atlas, 2007).

The MKS lies within the Keith – Kilkenny lineament geological anomaly that was interpreted and mapped from early reconnaissance data as a single fault line (GSWA, 1974 in AGSO Research Newsletter 20). This has been more recently described as not constituting a single simple continuous fault, but rather, is an artefact made up of separate, genetically unrelated segments, (AGSO Research Newsletter 20). This may account for some of localisation of habitat units within the MKS with lies within the Mt Keith – Perseverance fault zone within this alignment. The Yakabindie Greenstone belt is one of three distinct greenstone components of the Mt Keith – Perseverance fault (Liu *et al.*, 2002).

“The Yakabindie greenstone belt comprises a layered sequence of the Kathleen Valley Gabbro overlain by the massive tholeiitic Mount Goode Basalt. The Agnew greenstone belt comprises a lower sequence of metamorphosed ultramafic, mafic, felsic volcanic, and sedimentary rocks, which is exposed in the Lawlers and Leinster Anticlines. The upper sequence, as exposed in the Mount White Syncline area, consists of metabasalt, metagabbro and metasedimentary rocks. Metamorphosed ultramafic, mafic, felsic volcanic and sedimentary rocks in the Perseverance area extend farther north to west of Mount Pasco. From Six Mile Well, ultramafic, sedimentary, and felsic volcanic/volcaniclastic rocks correlate with the greenstone sequences from Mount Keith to Wiluna. The Jones Creek Conglomerate represents a late clastic sequence and is restricted to a narrow, fault-bounded zone between the Yakabindie greenstone belt and granitoid in the west and the Mount Keith–Perseverance and Agnew greenstone belts to the east.” (Liu *et al.*, 2002).

1.6. Interim Biogeographic Regionalisation of Australia

The Proposal Study Area is located within the Murchison Biogeographic Region and the East Murchison (MUR1) subregion (Department of the Environment and Energy, 2017), Figure 2.

The MUR1 subregion, with an area of 7,847,996 ha, covers northern parts of the ‘Southern Cross’ and ‘Eastern Goldfields’ Terranes of the Yilgarn Craton (Cowan, 2001). This subregion is characterised by:

- Internal drainage;
- Extensive areas of elevated red desert sand plains with minimal dune development;
- Salt lake systems associated with occluded Paleodrainage system; and
- Broad plains of red-brown soils and granitic breakaway complexes as well as red sand plains (Cowan, 2001).

The vegetation in this region is dominated by Mulga varieties (*Acacia aneura* sens. lat. and related taxa) shrublands / woodlands often rich in ephemeral species, Spinifex (*Triodia* spp.) hummock grasslands, Saltbush shrublands (*Atriplex* spp.) and Samphire (*Tecticornia* spp.) shrublands. Land use within the Murchison bioregion is predominantly pastoral and mining (often combined) (Cowan, 2001).



Figure 2. The MKS Proposal Study Area and IBRA Subregions of Western Australia, with Eastern Murchison (MUR1) area shaded.

1.7. Land Systems

In the early 1990s, the Department of Agriculture (DoA) conducted extensive Land System mapping and pastoral condition assessments in the north-eastern Goldfields (Pringle *et al.*, 1994). These works broadly mapped vegetation, soils and underlying geology, representing a milestone in the overall understanding of the landscapes, vegetation and flora of the region.

Fourteen Land Systems are present within the confines of the Proposal Study Area, including the transport corridor. These are briefly described in Table 8 while Figure 7 shows their representation in and around the Proposal Study Area.

The Land Systems of the MKS Proposal Study Area are generally well represented in the broader north-eastern Goldfields region. Those Land Systems with the greatest representation within the Proposal Study Area are; the Archaean granite breakaways and associated foot slopes of the Sherwood Land System (1136.9 ha), low ironstone (limonitic duricrust) hills of the Bevon Land System (1,785.9 ha), and the extensive orange sandplains of the Bullimore Land System (1,321.6 ha). These represent 0.07%, 0.75% and 0.03% of their respective regional area of occupancy in the north-eastern Goldfields.

The gravely hardpan plains of the Tiger Land System (335.2 ha), the hardpan plains with ironstone gravel mantles of the Jundee Land System (810.1 ha), and the gently undulating stony plains and low rises with quartz mantles on granite of the Windarra Land System (465.7 ha) occupy relatively large areas within the Proposal Study Area. These Land Systems represent 0.31%, 0.12% and 0.20% of their respective regional area of occupancy in the north-eastern Goldfields (Table 8).

Nine Land Systems are represented by smaller areas, from 10.8 ha being the major creeklines of the Wilson Land System to 235.9 ha within the gently undulating gravelly plains on greenstone, laterite and hardpan of the Violet Land System. These Land Systems represent less than 0.04% of their respective regional area of occupancy in the north-eastern Goldfields (Table 8).

This above Land System summary does not take into account cumulative impacts in the region.

1.8. Landform Systems

Landform Systems, rather than Land Systems (as described by Pringle *et al.*, 1994), were the preferred unit for grouping the vegetation communities recognised in the 2010 and 2011 vegetation surveys for statistical analysis within the Proposal Study Area. These reflect local changes in underlying geology, landform and soils, which influence vegetation. This allowed Western Botanical to develop an understanding of habitat sub-groups and flora assemblages existing within the Proposal Study Area. Six Landform Systems (Drainage Line and Hardpan with Sheet Flow, Low Rises on Granite, Low Rises on Calcrete, Low Rises on Basalt, Sandplain, and the Lateritic Duricrust) were recognised and defined within the Proposal Study Area. These

provided a physical context for the Vegetation Communities (Habitat Units) recognised but have not been mapped separately.

The Landform Systems present within the Proposal Study Area are not mapped either within or outside the MKS Proposal Study Area, but are known by the authors to be widespread within the north-eastern Goldfields, as are many of the Vegetation Communities they support.

Three Landform Systems of the Proposal Study Area are widespread in the region: Drainage Line Hardpan with Sheet Flow Landform System, the Low Rises on Calcrete Landform System, and the Sand Plain Landform System.

Three Landform Systems with accompanying Habitat Units are less widely distributed in the region. These are:

- (i) The Lateritic Duricrust Landform System is specifically associated with the Bevon Land System within the Perseverance Greenstone Belt and is not known by the authors to occur outside this alignment;
- (ii) The Low Rises on Granite Landform System is associated with the Sherwood Land System which is widespread but of limited area and occurring in disjunct occurrences in the Murchison biogeographic region; and
- (iii) Low Rises on Basalt Landform System is associated with the Basalt, mixed *Acacia* species Shrubland Complex (BaMAS) vegetation complex mapped within the MKS Proposal Study Area. Low Rises on Basalt landform system extends further southwards from the MKS Proposal Study Area within the Perseverance Greenstone Belt. The regional distribution of the SMBS community is not known to the authors outside the MKS Proposal Study Area.

Vegetation communities associated with the Lateritic Duricrust Landform System include the Stony Ironstone Mulga Shrublands (SIMS) site type of Pringle *et al* (1994), the Stony Ironstone Low Shrublands (SILS), and the Stony Senna Shrublands (SSS) communities. The SILS community often supports species with conservation significance including *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362), a P1 species. The SIMS and SILS communities may also support populations of *Eremophila* sp. Leinster (R.J. Cranfield 6767), a Species of Interest. The Basalt, mixed *Acacia* species Shrubland Complex (BaMAS) sits within the Bevon Land System and supports the newly recognised species *Acacia* sp. East Murchison Basalt (G. Cockerton 38064), a species of interest.

The Breakaway Shrubland (BRX) community associated with the Low Rises on Granite Landform System is a variable community that supports a range of species with conservation significance. These include *Hibbertia* sp. Sherwood Breakaways (R.J. Cranfield 6771) P1, *Sida picklesiana* P3, and *Verticordia jamiesonii* P3. Some areas of SILS community may also be

found within this landform system and represent areas where the lateritic duricrust has been in close contact with the underlying granite plateaux.

The *Eucalyptus gypsophila* – *Eremophila pantonii* Woodland (EGPW) community occurs on eroded carbonate influenced soils with a slight ironstone and quartz pebbly mantle and occupies an area of 15.08 hectares within the MKS Proposal Study area. This is a discrete community within the region and occurs to the north, east and southeast of the Six-mile Well orebody. The EGPW community is not known to be widely distributed and occurrences are discrete and relatively small in area where it occurs. It is known from between the northern boundary of the MKS project and the Mt Keith Nickel mine, west of the proposed MKS transport corridor. West of the proposed haul road alignment and outside the MKS Proposal Study Area, the EGPW community as mapped supports the Priority 3 species *Cratystylis centralis*.

The Breakaway Shrublands (BRX) vegetation community, associated with the Archaean granite breakaways of the Sherwood Land System, is highly variable in species composition and occurs in disjunct distributions across the region. It is known to support a wide range of Priority species and the new species *Hibbertia* sp. Sherwood Breakaways (R.J. Cranfield 6771). The MKS Project does not impact on significant areas of the Breakaway Shrublands vegetation community in relation to its local or regional occurrence although the proposed haul road does impact on the known population of *Hibbertia* sp. Sherwood Breakaways (R.J. Cranfield 6771).

1.9. Pre-European Vegetation

Five of Beard *et al.* (2013) Pre-European Vegetation units are present within the Proposal Study Area (Table 7 and Figure 6). The mapping is conducted at a high level and the proportional impacts of the MKS project on these are negligible in both a local and regional sense.

2. Methods

2.1. Desktop Survey

Prior to planning and conducting the current works, Western Botanical prepared a review of previous works for the MKS Proposal Study Area (Western Botanical, 2016). This review covered all known previous work related to the Proposal Study Area and included a gap analysis to identify work needed to update previous work and remain current with a modified Proposal Study Area.

2.2. Field Survey

Fieldwork for the current survey period was conducted in November and December 2016 and August to October 2017. Six field survey events were undertaken:

- Trip 1 2-7 November, 4 personnel, 24 personnel days, EIA studies;
- Trip 2 17-25 November, 4 personnel, 36 personnel days, EIA studies;
- Trip 3 5-17 December, 2 personnel, 26 personnel days, EIA studies;
- Trip 4 18–19 July 2017, 2 personnel, 2 days, *Hibbertia* studies;
- Trips 5a-b 8-10 August, 21-26 August, 15 September, targeted *Hibbertia* studies; and
- Trip 6 11th to 18th September 2017 (excl. 15 Sep), targeted *Acacia* studies.

These figures include travel, which involved initially taking vehicles to site then flying in/out between field events and driving vehicles back to Perth when fieldwork was concluded. A total of 124 personnel days fieldwork were implemented. The personnel involved in the field works are shown in Table 2.

Table 2. Personnel involved in field works and survey schedule.

Name	Experience	Role	Trip 1	Trip 2	Trip 3	Trips 4 to 6
Geoff Cockerton	24 years experience	Team Leader	1	1	1	1
Jonathan Warden	10 years experience	Team Leader	1			1
Ben Eckermann	13 years experience	Botanist		1		
Daniel Brassington	10 years experience	Botanist		1	1	
Steven Cockerton	2 years experience	Field Technician	1			
Sarah Smith	10 years experience	Field Technician	1	1		
Marc Morris	(NiWest)	Field Assistant (trip 4)				1

During Environmental Impact Assessment surveys, two teams separately conducted (i) vegetation mapping, and (ii) quadrat establishment and quadrat rescoring during the field visits, visiting a total of 181 sites. Fifty-eight of the sites were relevés to aid in vegetation mapping while one hundred and twenty-three quadrats were described. Of these, fifty were newly established quadrats, sixty-four were rescoring quadrats established in 2010, and nine were rescoring DEC / DPaW quadrats established in 2010 by Meissner and Wright (2010). Targeted surveys for *Hibbertia* and *Acacia* species were undertaken by a team of two personnel from August to October 2017.

2.3. Vegetation Mapping

Vegetation mapping was conducted using seven A2 sheets of 1:10,000 RGB hard copy laminated colour satellite imagery. Vegetation associations were described at representative locations using Relevés where a complete species list and representative photographs were taken. Samples of the majority of flora were collected for future reference.

Vegetation was described at NVIS Level 5 Association and boundaries were drawn onto field maps whilst in the field. Extensive traverses to investigate the boundaries of communities were made either on foot or in-vehicle to define the margins of communities as closely as possible. Many communities demonstrated relatively broad ecotonal edges and the margins of some may be accurate to within 100 m.

2.4. Quadrat Establishment and Scoring

Quadrats established were all 20 x 20 m with axes orientated north-south, unless constrained by physical features such as narrow drainage lines. The majority of pre-existing quadrats established by Western Botanical were re-scored with exceptions being those established in in the majority of drainage lines (DRMS communities). The reasoning here was that previous statistical analyses of existing quadrat data (Western Botanical, 2016) showed that DRMS quadrats did not nest together, rather they reflected the adjoining communities more than reflecting a separate cohesive association. As such, and after a cost-benefit review, there was little point in re-evaluating these, other than generating more data on flora species, which was already well represented in existing and currently held data.

All species encountered in quadrats were sampled and retained for verification. Of note, the Mulga trees present were almost all holding mature fruits. This enabled collection of the critically important fruits for identification of the Mulga varieties. All Mulga specimens were keyed and reviewed in relation to the recent published revision of Mulga (Maslin & Reid, 2012).

Quadrats locations were confirmed using GPS and one to two representative digital photographs at a minimum of 5 megapixels were taken of each site, nominally from the north-western and north-eastern corners.

2.5. Flora Specimen Identification and Taxonomy

Specimens collected during quadrat survey and vegetation mapping were identified using the Western Botanical reference herbarium and relevant taxonomic keys, with recourse to the WA Herbarium's Reference Herbarium and Research Collection for specimens more difficult to resolve. Some material was referred to specialist taxonomists when necessary.

Plant nomenclature adopted follows that of the Australian Plant Census published by the Council of Heads of Australian Herbaria (2007 onwards) as used by the WA Herbarium as at January 2017. Nomenclature for potentially new species follows informal conventions. Nomenclature for some *Eremophila* species that do not appear on the census of vascular flora follows that advised by Dr. Bevan Buirchell, Mr Andrew Brown and Dr. Steven Dillon. Informal names for some novel *Acacia* species have been used here, awaiting adoption by the WA Herbarium.

2.6. Statistical Analysis

Western Botanical uses the PATN v3.12 package of statistical programs developed by Lee Belbin and CSIRO (Blatant Fabrications Pty Ltd, 2004). PATN is a comprehensive software package designed for extracting and displaying patterns in complex multivariate datasets.

Three functions of PATN were used in the investigation;

- Bray and Curtis association.
- Flexible UPGMA classification with results displayed in a dendrogram.
- Semi-Strong Hybrid scaling (SSH) ordination as a measure of analysis strength.
- Two-way Table: this function produced colour coded table displaying the classification of sites and species. In this analysis the two-way table was used to identify the presence or absence of species within quadrats and the subsequent influence this had on the association of quadrats within a dendrogram.

Stress Values

Data analysis generates a Stress Value associated with a dataset. In the context of vegetation analysis as presented here, a Stress Value indicates the similarity or otherwise of floristic composition between vegetation groupings in a dataset. A Stress Value;

- <0.14 indicates strong similarity,
- between 0.14 and 0.16 indicates proportionate similarity within a dataset, meaning that the 'fit' is good but perhaps not exact,
- between 0.16 and 0.18 indicates a similarity with discrepancies, and
- between 0.18 and 0.20 indicates a lack of similarity in a dataset. A value >0.20 indicates little or no similarity at all.

Dataset

The dataset consisted of the field data collected from all sites (quadrats and relevés). The data had been collected in the form of percentage foliage cover (PFC) estimates (in terms of the total quadrat cover), and were converted into eight cover classes (Table 3). This created a more equal weighting between dominant and non-dominant species.

Table 3. Percentage foliage cover conversions to Cover Class.

Percentage Cover	Cover Class	N
0	0	31143
> 0 to < 1	1	2756
1 to < 5	2	566
5 to <10	3	160
10 to < 25	4	111
25 to < 50	5	13
50 to < 75	6	3
75 to 100	7	0

Annuals, singletons (species occurring on only one quadrat) and taxa unidentified to species level were removed from the dataset to negate influences that may have skewed the result. To prevent data splitting to a degree involving multiple infraspecific names, infraspecific taxa that occupy similar habitats had their names reconciled to the specific taxon before presentation to PATN.

2.7. Vegetation Condition

Vegetation condition was recorded in May 2016 using the Vegetation Condition Scale presented in Table 4 (adapted from Keighery, 1994). Adaptation of the Keighery scale was required to account for rehabilitated former exploration sites, which showed capacity for regeneration post disturbance.

Table 4. Adapted vegetation condition scale.

Keighery (1994) Code	Keighery Description (1994)	Adapted Description (WB 2016)	Habitat Cond	Seasonal Conditionality	Disturbance to Vegetation or to surface drainage	Weeds	Regenerative Capacity
Pristine (1)	Pristine or nearly so, no obvious signs of disturbance.	Pristine or nearly so, vegetation in pristine condition and reflecting normal seasonal conditions. No anthropogenic influences.	Pristine (i)	Normal	Intact, no roads, tracks or animal trails	Nil	Normal
Excellent (2)	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.	Vegetation structure intact, vegetation in a condition that reflects normal seasonal conditions but subject to minor disturbance (eg: light grazing, minor tracks) affecting individual species. No impact to surface drainage. Regenerative capacity retained. No weed species.	Excellent (ii)	Normal	Minor tracks, no evidence of erosion or altered drainage	Nil	Normal
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.	Vegetation structure intact, vegetation in a condition that reflects normal seasonal conditions but subject to obvious disturbance (eg: grazing, partial clearing, flooding, sheet flow interruption, recent fire events) affecting a wide range of species. Regenerative capacity retained. Weed species in low abundance and are non-invasive.	Good (iii)	Normal	Minor tracks but evidence of altered drainage (erosion or ponding)	Minor, non-invasive species	Reduced

Keighery (1994) Code	Keighery Description (1994)	Adapted Description (WB 2016)	Habitat Cond	Seasonal Conditionality	Disturbance to Vegetation or to surface drainage	Weeds	Regenerative Capacity
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.	Vegetation structure altered, vegetation in a condition that reflects normal seasonal conditions but subject to obvious disturbance (eg: heavy grazing, partial clearing, flooding, sheet flow interruption, recent fire events) affecting a wide range of species. Regenerative capacity reduced Weed species in moderate abundance and are invasive. Recovery possible with some active management.	Poor (iv)	Normal	Moderate, tracks and larger cleared areas present	Minor, some invasive species	Reduced
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	Vegetation structure severely altered, vegetation in a condition not reflecting normal seasonal conditions and subject to obvious disturbance (eg: heavy grazing, clearing, flooding, sheet flow interruption, recent fire events) affecting a wide range of species. Regenerative capacity significantly reduced. Weed species in high abundance and are invasive. Recovery possible with active management over long term.	Degraded (v)	Abnormal	Moderate to High	High, invasive species	Significantly reduced

Keighery (1994) Code	Keighery Description (1994)	Adapted Description (WB 2016)	Habitat Cond	Seasonal Conditionality	Disturbance to Vegetation or to surface drainage	Weeds	Regenerative Capacity
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.	Vegetation structure severely altered, vegetation in a condition not reflecting normal seasonal conditions, subject to obvious disturbance (eg: heavy grazing, clearing, flooding, sheet flow interruption, recent fire events) affecting a wide range of species. Regenerative capacity absent. Weed species may be in high abundance and are invasive.	Completely Degraded (vi)	Abnormal	High	High, invasive species	Absent

3. Results and Discussion

3.1. Desktop Survey

A thorough and wide-ranging desktop revision of Conservation Significant Flora and Priority Ecological Communities was conducted earlier in 2016 during production of the Western Botanical (2016). This involved interrogation of relevant publicly available DPaW databases, a revision of taxonomy of all flora known within the MKS Proposal Study Area, including those that were considered to represent newly discovered, undescribed species. With this current information at hand, no further interrogation of DPaW databases was undertaken in preparation for the late 2016 field assessments.

The analysis from the above report is re-presented in Table 5. This shows that the DPaW databases list eight Priority Flora in the region that were found within the MKS Proposal Study Area: *Anacampseros* sp. Eremaean (F. Hort, J. Hort & J. Shanks 3248) P1, *Eremophila pungens* P4, *Grevillea inconspicua* P4, *Hemigenia exilis* P4, *Sida picklesiana* P3, *Sauropus* sp. Woolgorong Station (M. Officer s.n.10/8/94) P3, *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) P3 and *Tribulus adelacanthus* P3. The majority of these are well known within the Proposal Study Area and in the region.

Exceptions to this are: (i) *Anacampseros* sp. Eremaean P1 which has only been recorded at three sites outside the proposed Development Envelope, but is known to be associated with granitoid landscapes of the Barr-Smith Range (the breakaway system within the MKS Proposal Study Area and in the Sherwood Land System), and (ii) *Tribulus adelacanthus* P3 which has only been recorded once on colluvial slopes within the MSK Development Envelope and at six other sites in W.A. Both remain poorly known across the state. These and other species with conservation significance are discussed further within this document.

Table 5. DPaW Threatened and Priority Flora List search results for the MKS project.

Taxon	Status	DPaW Region	DPaW District	Distribution	Preferred Habitat	Likelihood of Occurrence within MKS
<i>Atriplex</i> sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025)	T	GOLD	KALGOORLIE	Yeelirrie Stn., Albion Downs Stn. IUCN Rank: VU IUCN Criteria D2 EPBC Listing: EN	Red self-mulching smectite clay in valley floors, specifically within the Yeelirrie paleochannel	Nil
<i>Anacampseros</i> sp. Eremaean (F. Hort, J. Hort & J. Shanks 3248)	P1	GOLD	KALGOORLIE	Yakabindie Station, Wanjarri Nature Reserve	Granitoid landscapes, shallow gritty sand on breakaways, stony plains and exfoliating granite outcrops	Present within MKS
<i>Baeckea</i> sp. London Bridge (M.E. Trudgen 5393)	3	GOLD, MWST	KALGOORLIE, GERALDTON	Sandstone, Youanmi	Archaean granitoid landscapes, shallow gritty sand on breakaways	Nil
<i>Baeckea</i> sp. Sandstone (C.A. Gardner s.n. 26 Oct. 1963)	3	GOLD, MWST	KALGOORLIE, GERALDTON	Wiluna, Sandstone, Agnew, Great Victoria Desert,	Aeolian sandplains	Possible
<i>Beyeria lapidicola</i>	1	GOLD	KALGOORLIE	Bulga Downs, Weld Range, Lake Way Stn.	Banded Ironstone Formation outcrops and breakaways on midslopes	Nil
<i>Bossiaea eremaea</i>	3	GOLD	KALGOORLIE	Merolia Stn, Sandstone, White Cliffs Stn	Aeolian sandplains	Possible

Taxon	Status	DPaW Region	DPaW District	Distribution	Preferred Habitat	Likelihood of Occurrence within MKS
<i>Calytrix praecipua</i>	3	GOLD, PILB	KALGOORLIE, KARRATHA	Melita Station, Laverton, Youno Downs, Wanjarri, Marymia, Erong Hmstd, Niagara Dam	Archaean granite breakaways, scree slopes and associated creeklines	Possible
<i>Calytrix verruculosa</i>	3	GOLD, MWST	KALGOORLIE, GERALDTON	Tuchanana Ck, Yoothapina Stn, Mt Hale, Meekatharra, (Leinster, Mt Keith)	Major Banded Ironstone Formation ranges, quartzite scree slopes	Unlikely based on habitat preference and known range
<i>Cratystylis centralis</i>	3	GOLD	KALGOORLIE	Barwidgee Stn, Leonora, Yakabindie Station (WB record)	Carbonate influenced soils derived from basalt	Nil, well known in the local area and mapped adjacent to but outside MKS
<i>Dampiera plumosa</i>	1	GOLD, MWST	KALGOORLIE, GERALDTON	Sandstone, Coolgardie, Lake Barlee	Yellow to orange sandplains	Possible
<i>Eremophila arguta</i>	1	GOLD, MWST	KALGOORLIE, GERALDTON	Mt Augustus Station, Neds Creek, Wiluna	Loamy soils in floodplains, drainage lines	Unlikely
<i>Eremophila congesta</i>	1	GOLD	KALGOORLIE	Wiluna	Lateritic outcrops, quartzite scree slopes	Unlikely, this species has a narrow range of natural distribution at Wiluna

Taxon	Status	DPaW Region	DPaW District	Distribution	Preferred Habitat	Likelihood of Occurrence within MKS
<i>Eremophila flaccida</i> subsp. <i>attenuata</i>	3	GOLD, MWST	KALGOORLIE, GERALDTON	Wiluna, Dairy Creek, Glenburgh	Stony quartzite plains over Archaean granite	Unlikely based on distribution, occurs significantly north-west of MKS
<i>Eremophila gracillima</i>	3	GOLD, MWST, PILB	KALGOORLIE, KARRATHA, GERALDTON	Mt Vernon, Paroo, Wonganoo Station ³	Stony plains	Unlikely based on distribution, occurs significantly north-west of MKS
<i>Eremophila pungens</i> ⁴	4	GOLD, MWST	KALGOORLIE, GERALDTON	Eareheedy, Meekatharra, Lake Way, Barwidgee, Wanjarri, Wiluna, Wonganoo, Granite Peak, Lorna Glen Hmstd, Agnew, Leinster, Mooloogool	Stony uplands, Limonitic and Archaean granitic landforms	<i>Eremophila</i> sp. Leinster is Present within MKS
<i>Euryomyrtus inflata</i>	3	GOLD	KALGOORLIE	Wiluna, Lake Mason Stn., Youno Downs Stn.	Aeolian sandplains	Possible
<i>Grevillea inconspicua</i>	4	GOLD, MWST	KALGOORLIE, GERALDTON	Cue, Meekatharra, Yakabindie, Sandstone, Melrose, Leinster, Mt Magnet	Outcropping and subcropping basalt	Present within MKS

³ Record of *Eremophila gracillima* P3 at Wonganoo Station is erroneous. See note within text.

⁴ *Eremophila pungens* P4 is inclusive of *Eremophila* sp. Leinster (R.J. Cranfield 6767), sp. nov.

Taxon	Status	DPaW Region	DPaW District	Distribution	Preferred Habitat	Likelihood of Occurrence within MKS
<i>Hemigenia exilis</i>	4	GOLD	KALGOORLIE	Lake Darlot, Yakabindie, Leinster, Leonora, Mt Keith	Limonitic landforms, volcanoclastic sediments, Wiluna hardpan on margins of creeks	Present within MKS
<i>Hibiscus</i> sp. Wonganoo Station (K. Boladeras 125)	1	GOLD	KALGOORLIE	Wonganoo Stn.	Archaean granitic breakaways, kaolinitic slopes	Possible though unlikely, occurs significantly east of MKS
<i>Homalocalyx echinulatus</i>	3	GOLD	KALGOORLIE	Carnegie Stn, Wiluna, Doolgunna Stn, Weld Range, Mount Hale, Windidda, Wongawal Stn	Granitoid landscapes, shallow gritty sand on Archaean breakaways	Possible
<i>Labichea eremaea</i>	3	GOLD, MWST	KALGOORLIE, GERALDTON	West of Sandstone, Bimbijy, Mt Jackson, Black Range Stn	Aeolian sandplains	Possible
<i>Maireana prosthochaeta</i>	3	GOLD, KIMB, MWST, PILB	KALGOORLIE, KARRATHA, EAST KIMBERLEY, GERALDTON	Meekatharra, Cue, Mt Phillips Station, Marymia, Bulloo Downs, Lake Way Stn.	Laterite hills, saline expressions	Possible
<i>Micromyrtus chrysodema</i>	1	GOLD	KALGOORLIE	Leinster	Granitoid landscapes, shallow gritty sand on Archaean granitic breakaways	Possible
<i>Mirbelia stipitata</i>	3	GOLD, MWST	KALGOORLIE, GERALDTON	Nth Sandstone, Nth Laverton	Granitoid Archaean landscapes, shallow gritty sand on breakaways	Possible

Taxon	Status	DPaW Region	DPaW District	Distribution	Preferred Habitat	Likelihood of Occurrence within MKS
<i>Neurachne lanigera</i>	1	GOLD	KALGOORLIE	Wiluna, Warburton	Aeolian sandplains, rocky outcrops, hardpan plains	Possible
<i>Olearia arida</i>	4	GOLD	KALGOORLIE	Yeelirrie	Aeolian sandplains	Possible
<i>Olearia mucronata</i>	3	GOLD, PILB	KALGOORLIE, KARRATHA	Hamersley and Chichester Range area, West Angelas, Paraburdoo, Mt Margaret, Mt Keith, Wiluna	Stony uplands, Limonitic and Archaean granitic landforms, shaded and sheltered locations	Possible
<i>Phyllanthus baeckeoides</i>	3	GOLD	KALGOORLIE	Laverton, Merolia Stn, White Cliffs Stn, Windimurra Station, Cashmere Downs Stn, Leinster, Banjawarn Stn	Minor creeklines in stony limonitic uplands	Possible, nearest population is at Leinster
<i>Pityrodia canaliculata</i>	1	GOLD, MWST	KALGOORLIE, GERALDTON	Anketell to Sandstone, Black Range Stn.	Aeolian sandplains	Unlikely, occurs significantly west of MKS
<i>Prostanthera ferricola</i>	3	GOLD, MWST	KALGOORLIE, GERALDTON	Wiluna, Meekathara, Mooloogool, Doolgunna, Lake Way Stn.	Stony uplands, Limonitic landforms, shaded and sheltered locations	Possible
<i>Ptilotus luteolus</i>	3	GOLD, MWST	KALGOORLIE, GERALDTON	Meekatharra, Mt Alice, Mount Magnet, Lake Way Stn., Doolgunna Stn., Boogardie Stn., Polelle Stn., Glenburg Stn., Milbillillie Stn.	Stony uplands, limonitic, basaltic and dioritic landforms	Possible

Taxon	Status	DPaW Region	DPaW District	Distribution	Preferred Habitat	Likelihood of Occurrence within MKS
<i>Rhagodia</i> sp. Yeelirrie Station (K.A. Shepherd et al. KS 1396)	1	GOLD	KALGOORLIE	Yeelirrie Stn, Pinnacles Stn. Credo Stn.	Claypans and playa margins	Nil
<i>Sauropus</i> sp. Woolgorong (M. Officer s.n. 10/8/94)	3	GOLD, MWST	KALGOORLIE, GERALDTON	Pinegrove Stn, Mt Magnet, Leinster, Yakabindie, Mt Keith.	Aeolian sandplains, granitoid landscapes, shallow gritty sand on Archaean granite breakaways and low granitic outcrops	Present within MKS
<i>Sida picklesiana</i>	3	GOLD, MWST	KALGOORLIE, GERALDTON	Wiluna, Doolgunna Stn., Lake Way Stn., Ned's Creek Stn.	Archaean granite breakaways	Present within MKS
<i>Stackhousia clementii</i>	3	GOLD, PILB	KALGOORLIE, KARRATHA	Warburton, Wiluna, Karratha, Little Sandy Desert, NT, SA, Gnarlou Stn, Burrup Peninsula	Carbonate influenced landforms, calcrete plains and groundwater calcrete outcrops	Possible
<i>Stenanthemum mediale</i>	1	GOLD, MWST	KALGOORLIE, GERALDTON	Yeelirrie Station, Black Hill Stn, Montague Range	Stony uplands, limonitic, landforms, stony chert hills	Possible
<i>Tecticornia</i> sp. Lake Way (P. Armstrong 05/961)	1	GOLD	KALGOORLIE	Wiluna	Lake bed within large saline playa systems	Nil
<i>Thryptomene nealensis</i>	3	GOLD	KALGOORLIE	Leinster, White Cliffs Stn, Neale Junction, Great Victoria Desert	Aeolian sandplains, granitoid landscapes, shallow gritty sand on Archaean breakaways and low granitic outcrops	Possible

Taxon	Status	DPaW Region	DPaW District	Distribution	Preferred Habitat	Likelihood of Occurrence within MKS
<i>Thryptomene</i> sp. Leinster (B.J. Lepschi & L.A. Craven 4362)	3	GOLD	KALGOORLIE	Leinster	Aeolian sandplains, granitoid landscapes, shallow gritty sand on Archaean breakaways and low granitic outcrops	Present within MKS
<i>Tribulus adelacanthus</i>	3	GOLD, MWST	KALGOORLIE, GERALDTON	Wiluna, Robinson Range, Mt Magnet, Mt Keith Stn.	Colluvial stony plains	Present within MKS
Lichen: <i>Austroparmelia macrospora</i>	3	GOLD, MWST, WHTB	KALGOORLIE, GERALDTON, CENTRAL WHEATBELT	Kalgoorlie, Ninghan Stn, Wanjarri NR, Mount Harry, Kathleen, Bullfinch, Kalbarri	On sheltered dry bark on shrubs or sheltered to exposed dry wood on ground	Possible, not assessed
Lichen: <i>Xanthoparmelia nashii</i>	3	GOLD, MWST, PILB, WHTB	KALGOORLIE, KARRATHA, GERALDTON, GREAT SOUTHERN, CENTRAL WHEATBELT	King Rocks, Lorna Glen Stn., Karolin Rock, Eurady Stn., Hamersley Range N.P., Wiluna	Plains, exfoliating granite outcrops, flood plains with brown-grey soils, Archaean granite breakaways with stony scree and outcrops, found on sheltered dry stone on ground	Possible, not assessed

3.2. Field Survey

3.2.1. Seasonal Conditions

Seasonal conditions in the two months prior to the field survey were relatively dry and well below average rainfall for Leinster Aerodrome (Bureau of Meteorology, 2017) (Figure 3). The field survey was conducted well after most annual and perennial species had finished flowering. Despite this, fruit was present on the majority of *Acacia* species, reflecting the above average rainfall events in the period June to August, for the first time enabling identification of Mulga and some other cryptic species of *Acacia*.

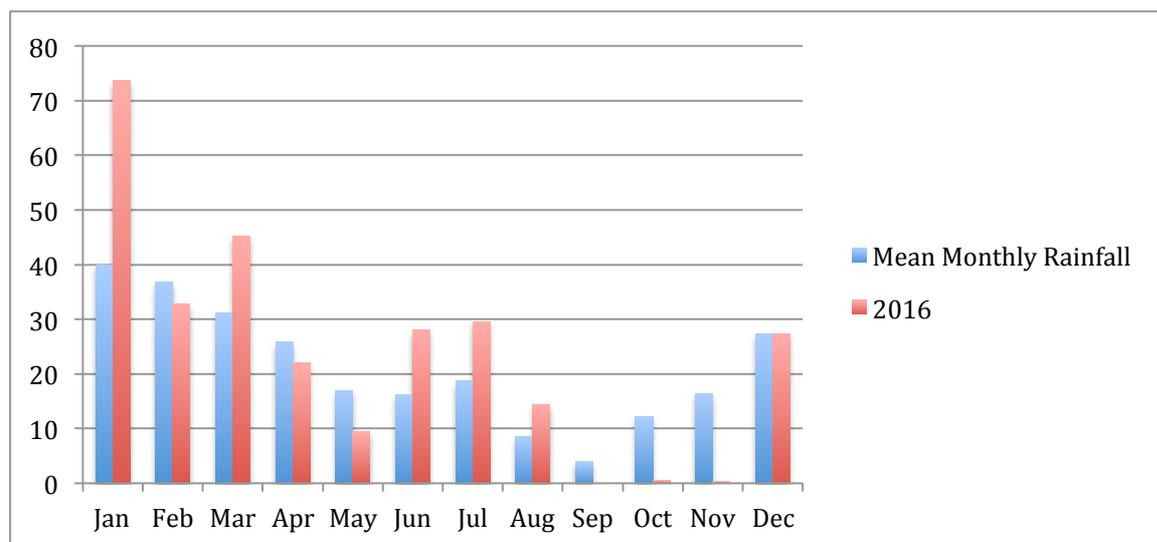


Figure 3. Rainfall, Leinster Aerodrome 2016 versus monthly mean (Bureau of Meteorology, 2017).

The seasonal conditions were not considered a limitation for the effectiveness of field surveys except that annuals and geophytes were largely absent. This only had implications for one Priority Species, *Anacampteros* sp. Eremaean (P1), which is a small geophyte with ephemeral above-ground parts and can only effectively assessed after substantial rainfall.

3.2.2. Flora

The consolidated cumulative species list for the MKS Proposal Study Area now contains 389 species (and putative hybrids) from 140 genera and 51 families of endemic flora. Of these, the majority are common, widespread in distribution and are highly representative of the flora of eastern Murchison and western Great Victoria Desert biogeographic regions. This compares with 279 species (69%) recorded in numerous previous surveys at the MKS Proposal Study Area to the end of 2015 and 301 species (75%) recorded in the Spring 2016 assessments with 177 species (44%) recorded in both periods. The differences in representativeness of the various survey periods are attributed to seasonality, rainfall, and species apparent at the time of surveys.

Dominant families include Fabaceae (76 species including putative hybrids), Poaceae (46 species), Chenopodiaceae (46 species), Scrophulariaceae (37 species), Asteraceae (30 species), Malvaceae (22 species), and Myrtaceae (20 species). Dominant genera were *Acacia* (53 species inclusive of 31 species and numerous putative hybrids of Mulga species), *Eremophila* (37 species), *Maireana* (18 species), *Senna* (14 species), *Sida* (11 species), and *Eragrostis* (7 species). Excluding putative hybrids, the Proposal Study Area supports 13 species of Mulga and related taxa.

Of these, the majority are common, widespread in distribution and are highly representative of the flora of eastern Murchison and western Great Victoria Desert biogeographic regions. A systematic species list is presented in Appendix 1.

A species accumulation curve shows the asymptotic approach of the number of species encountered towards the overall total number of species (Figure 4). The graph in commences at 137 species, which represents the number of opportunistically collected species (Opp.) as a starting point. These are species that were recorded either historically, or recorded outside of quadrats and relevés in the current survey.

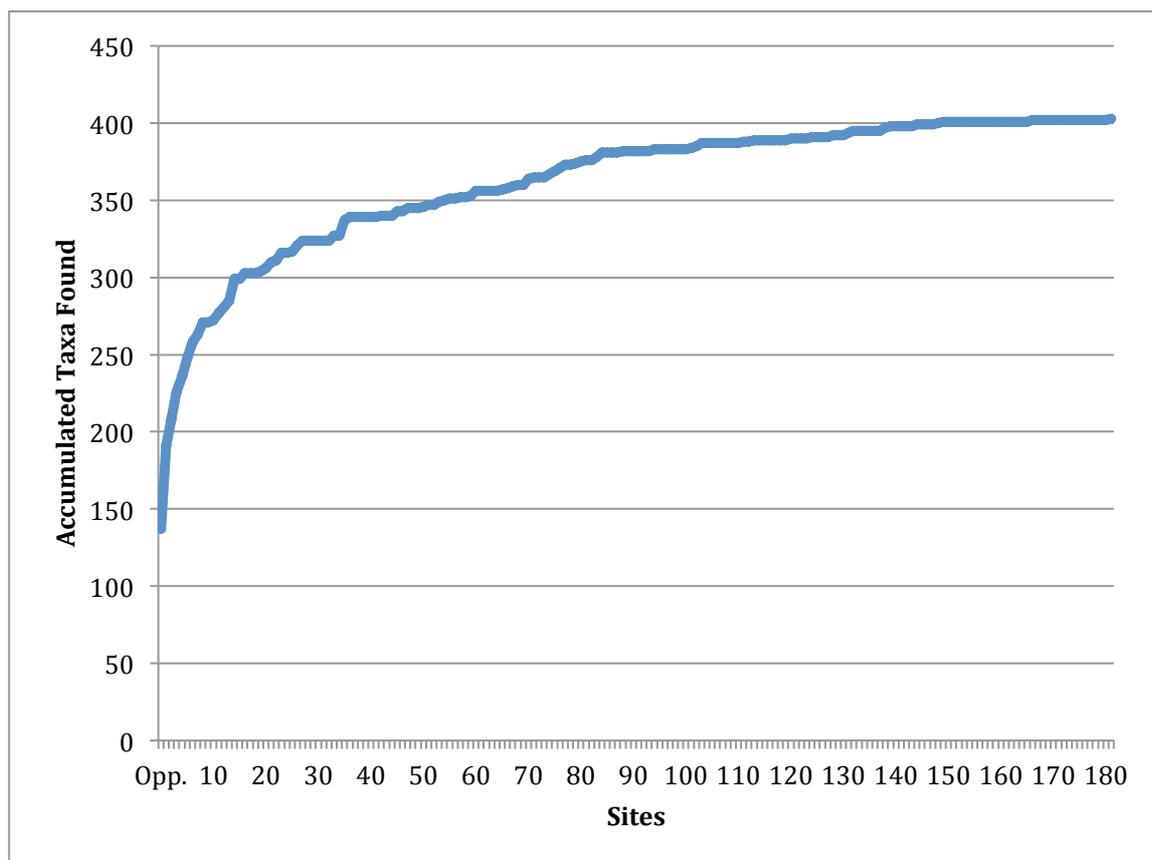


Figure 4. Species Accumulation Curve for the MKS Proposal Study Area, all endemic flora records combined.

Dominant families include Fabaceae (69 species), Poaceae (46 species), Chenopodiaceae (45 species), Scrophulariaceae (37 species), Asteraceae (31 species), Malvaceae (22 species) and

Myrtaceae (17 species). Dominant genera were *Acacia* (51 species inclusive of 31 species and numerous putative hybrids of Mulga species); *Eremophila* (37 species), *Maireana* (18 species) *Senna* (14 species), *Sida* (11 species) and *Eragrostis* (7 species).

Six weed species were also recorded, all in small and scattered populations of low numbers.

Conservation - Significant Flora

No Threatened Flora as listed under the *Wildlife Conservation Act 1950* (as amended) are known within or nearby the Proposal Study Area.

Thirteen Priority Flora species are known within the areas assessed. These include one Priority 1, ten Priority 3, and three Priority 4 listed species. These are:

Anacampseros sp. Eremaean (F. Hort, J. Hort & J. Shanks 3248) P1 (granitoid domains).

Aristida ?jerichoensis var. *subspinulifera* P3 (1 record in Jones Creek).*

Eremophila pungens complex P4, inclusive of *E.* sp. Leinster (R.J. Cranfield 6767) (low numbers, widespread in the MKS Development Envelope and Proposal Study Area).

Grevillea inconspicua P4 (low numbers, widespread in the MKS Development Envelope and Proposal Study Area).

Gunniopsis propinqua P3 (several records in the MKS Development Envelope and Proposal Study Area, saline areas). *

Hemigenia exilis P4 (low numbers, widespread in the MKS Development Envelope and Proposal Study Area).

Hibbertia sp. Sherwood Breakaways (R.J. Cranfield 6771) P1 (MKS Development Envelope (transport corridor) and Proposal Study area, associated with breakaways).

Hibiscus krichauffianus P3 (three records within the MKS Development Envelope and Proposal Study Area). *

Hybanthus floribundus subsp. *chloroxanthus* P3 (scattered populations in the MKS Development Envelope and Proposal Study Area).

Sida picklesiana P3 (MKS Development Envelope and Proposal Study Area, breakaways).

Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362) P3 (MKS Development Envelope and Proposal Study Area, breakaways, SIMS and SILS communities). *

Tribulus adelacanthus P3 (one record within the MKS Development Envelope)

Verticordia jamiesonii P3 (MKS Development Envelope and Proposal Study Area, breakaways).

* Species marked with an Asterisk were recorded within the MKS Proposal Study Area for the first time in 2016.

Aristida ?jerichoensis subsp. *subspinulifera* P3 has been identified based on less than optimal material and re-collections for confirmation of the identification is required.

These species are described and maps showing the distribution of Priority Species within the MKS Proposal Study Area are presented in Appendix 2.

3.3. Taxonomically Significant Flora - Species of Interest

Species of Interest (SOI) are defined as; (i) undescribed species which are not formally recognised as yet and represent species new to science but are widespread and not of conservation significance, (ii) undescribed species with limited known distribution which may warrant conservation review, and (iii) species of uncertain taxonomy which require specialist taxonomic inputs and may warrant conservation review.

3.3.1. Widely distributed undescribed species

Eight undescribed species with informal names that do not appear on the Census of Vascular Flora, and therefore are not shown on the DPaW Florabase website, are known from the MKS Proposal Study Area. The majority of these are well known, represented by numerous specimens at the WA Herbarium (albeit under names other than listed below) and widespread in distribution within the Murchison, Pilbara or Great Victoria Desert biogeographic regions. These do not warrant conservation consideration. These species require (i) formal vouchering at the WA Herbarium, and (ii) taxonomic and differentiation within the broad species complexes that they currently reside within and are listed below.

Acacia oswaldii (long phyllode variant) (G. Cockerton & S. Cockerton WB38622);

Maireana tomentosa - (Type 1 breakaway foot slopes) (G. Cockerton & D. Brassington WB38650);

Olearia sp. Sherwood Breakaways (A. Taylor 25552);

Olearia xerophila sens. lat. . (G. Cockerton & P. Goodman WB38116);

Ptilotus obovatus (typical Goldfields form) (G. Cockerton, J. Grehan, L. Trotter, J. Symington 15213);

Ptilotus obovatus (upright form) (G. Cockerton, J. Grehan, L. Trotter, J. Symington LCH 15206);

Scaevola spinescens (broad leaf, non-spiny form); and

Scaevola spinescens (narrow leaf, spiny form).

A further twelve well known but as yet undescribed species are also known within the Proposal Study Area. These are well represented in collections at the WA Herbarium, appear on the Census of Vascular Flora and are shown on the DPaW Florabase website. These are listed in the

Systematic Species List for the MKS Proposal Study Area and are briefly described and discussed in Appendix 3.

3.3.2. Undescribed species with limited distribution

One species, *Eremophila* sp. long pedicels (G. Cockerton 1975), is known from four sub-populations in the Lake Way and Laker Maitland Catchments in the Wiluna area. A recent review of the taxon has found additional material in the region, however, investigation of the WA Herbarium specimens by Western Botanical conducted in early March 2017 found many anomalies and those specimens at distance from the Wiluna region are not considered to be the same species. This species is briefly described and discussed in Appendix 3.

3.3.3. Species with uncertain taxonomic status, requiring taxonomic review

The taxonomic status of six species is not well understood and will require the attention of specialist taxonomists in those genera. These are primarily the first four *Acacia* species noted in the list below, which will require an extensive and complex review of the abundant material available following the 2016 round of field works.

Acacia doreta long phyllode form (G. Cockerton & S. Cockerton WB38633).

Acacia subtessarogona (flat pod form) (G. Cockerton WB38658).

Acacia xanthocarpa (flat phyllode form) (G. Cockerton & J. Warden WB39702).

Acacia sp. East Murchison Basalt (G. Cockerton & J. Warden WB39701), equivalent to *Acacia quadrimarginea* (narrow phyllode form).

Olearia sp. Sherwood Breakaways (A. Taylor 25552), currently within *Olearia stuartii*.

Olearia xerophila sens. lat. (G. Cockerton & P. Goodman WB38116).

Following taxonomic revision, some of these species may warrant conservation consideration, based on current knowledge of occurrences in the Wiluna – Leinster region. These species are described in Appendix 3.

3.3.4. Species occurring at limits of known range or representing range extensions

Eight species records at the MKS Proposal Study Area represent slight range extensions of known distributions. These species are well represented within Western Australia, do not warrant conservation consideration and are listed in the Systematic Species List in Appendix 1.

Acacia brachystachya

Eremophila platycalyx subsp. Neds Creek (N.H. Speck 1228)

Aristida ?jerichoensis var. *subspinulifera* P3

Chondropyxis halophila

Muelleranthus trifoliolatus

Maireana melanocoma

Olearia xerophila sens. lat. (G. Cockerton & P. Goodman WB38116)

Sida sp. spiciform panicles (E. Leyland s.n. 14/8/90)

Species removed from discussion as Species of Interest

The following species have been discussed in previous Western Botanical reports as either Priority Species or Species of Interest (Western Botanical, 2010). However, progress in taxonomic review, conservation status or a review of mapping has led to them no longer being included in discussions. The species and reasons for their removal are noted below.

- *Acacia* sp. Yakabindie Station aff. *A. kempeana* (G. Cockerton & G. O'Keefe 14274) is now regarded fitting within the broader *A. kempeana* sens. lat. group, which is acknowledged as requiring taxonomic review (B. Maslin pers. comm.).
- *Calytrix erosipetala* has been removed from the Priority Flora list.
- *Calytrix uncinata* has been removed from the Priority Flora list.
- *Cratystylis centralis* P3 has been discussed in previous reports (Western Botanical 2012a, 2010) and is known north-west of the MKS Proposal Study Area, at the McFarlane's Find abandoned minesite. It is not found within the Proposal Study Area and has been removed from further discussion though is included in descriptions of Priority Flora for reference.
- *Eremophila galeata* x *platycalyx* subsp. Neds Creek Hybrid could not be relocated and has been removed from discussion though is included in descriptions of Species of Interest for reference.
- *Frankenia georgei* (formerly P3) was previously misidentified and within the MKS footprint is now regarded as the common and widespread *Frankenia interioris*.
- *Templetonia incrassata* has been described (in 2010) and is reasonably widespread in W.A. and South Australia.

3.4. Weeds

Few weeds have been noted within the MKS Proposal Study Area in any of the surveys to date. The original 2004 assessment recorded some *Acetosa vesicaria* (Ruby Dock), west of the Goldfields Highway, outside the current MKS Proposal Study Area. A review of weeds within the MKS Proposal Study Area in May and Nov – Dec 2016 found several minor occurrences of weeds within or near the Proposal Study Area:

Weed populations were always found in small, isolated populations with low numbers of individuals present (Figure 5). Three significant weed species with potential to be highly invasive were noted, and will require management to maintain in low numbers, Table 6.

Table 6. Weeds of the MKS Study Area

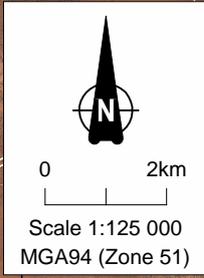
<i>Rumex vesicarius</i> (Ruby Dock)	An aggressive coloniser species that responds rapidly to rainfall, producing seeds that are readily distributed by wind and water. It is well established at Mt Keith and elsewhere on minesites and in disturbed lands in the north-eastern Goldfields.
<i>Cenchrus ciliaris</i> (Buffel Grass)	An aggressive coloniser that is well established in the Pilbara region but is only recently becoming a problem in the north-eastern Goldfields. It is allelopathic, meaning it suppresses other plants growing near it and can be a major management risk to the project.
<i>Cenchrus setiger</i> (Birdwood Grass)	Is similar to Buffel Grass and is an aggressive coloniser that is well established in the Pilbara region but is only recently becoming a problem in the north-eastern Goldfields. It is also allelopathic, meaning it suppresses other plants growing near it and can be a major management risk to the project.
<i>Bidens bipinnata</i> (Tick Weed)	Recorded within the bed of Jones Creek, downstream from the existing main crossing, and lies within the MKS Proposal Study Area. It is a nuisance plant with spiny fruit that cling to clothing and is readily transmitted via stock.
<i>Lysimachia arvensis</i> (Pimpernel)	Recorded at one site within Jones Creek and is a small annual species which has seeds that are readily transported by wind and water.
<i>Mesembryanthemum nodiflorum</i> (Slender Iceplant),	Recorded at one site in the north-west of the Proposal Study Area, associated with a low Archaean granite breakaway. It is a small annual species that has seeds which are readily transported by wind.

Cenchrus ciliaris and *Cenchrus setiger* are in low numbers and only recorded at a few sites. Both are actively promoted by local Pastoralists (Doug Brownlie pers. comm., 2016) as pasture grasses, however, both have the potential to become highly competitive weeds which respond well to summer rainfall.

A further three species, *Bidens bipinnata*, *Lysimachia arvensis* and *Mesembryanthemum nodiflorum* are known within the MKS Proposal Study Area. These species are widely naturalised in the pastoral regions of Western Australia, pose a lesser risk to the project, and do not warrant active management.

A wide range of weed species are now prevalent at the Mt Keith Nickel Mine and were observed in May and Oct – Nov 2016. This lies outside the MKS Proposal Study Area, however, as the two sites will be linked and vehicle transport between the sites will be frequent, a comprehensive and pro-active weed management program should be initiated to prevent weed ingress to the MKS Proposal Study Area from the Mt Keith minesite.

Figure 5. Known Weed Populations within the MKS Proposal Study Area.



6980000mN

6970000mN

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260000mE

270000mE

Mt Keith Operations

Mt Keith TSF

Goldfields Highway

Wanjarri Nature Reserve

Solanum nigrum, Sonchus oleraceus ★

Cenchrus setiger (Birdwood Grass) ★

Rumex vesicarius (Ruby Dock) ★

Cenchrus ciliaris (Buffel Grass) ★

LEGEND

- ★ Weed
- ▭ Study Area
- ▭ Disturbance Footprint
- ▭ Wanjarri Nature Reserve
- ▭ Tenements
- Surface Water

Mount Keith Satellite

Weed Locations

Author: Western Botanical Date: December 2017

Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ December 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_10.dgn ~ Imagery: Landgtc (2011)

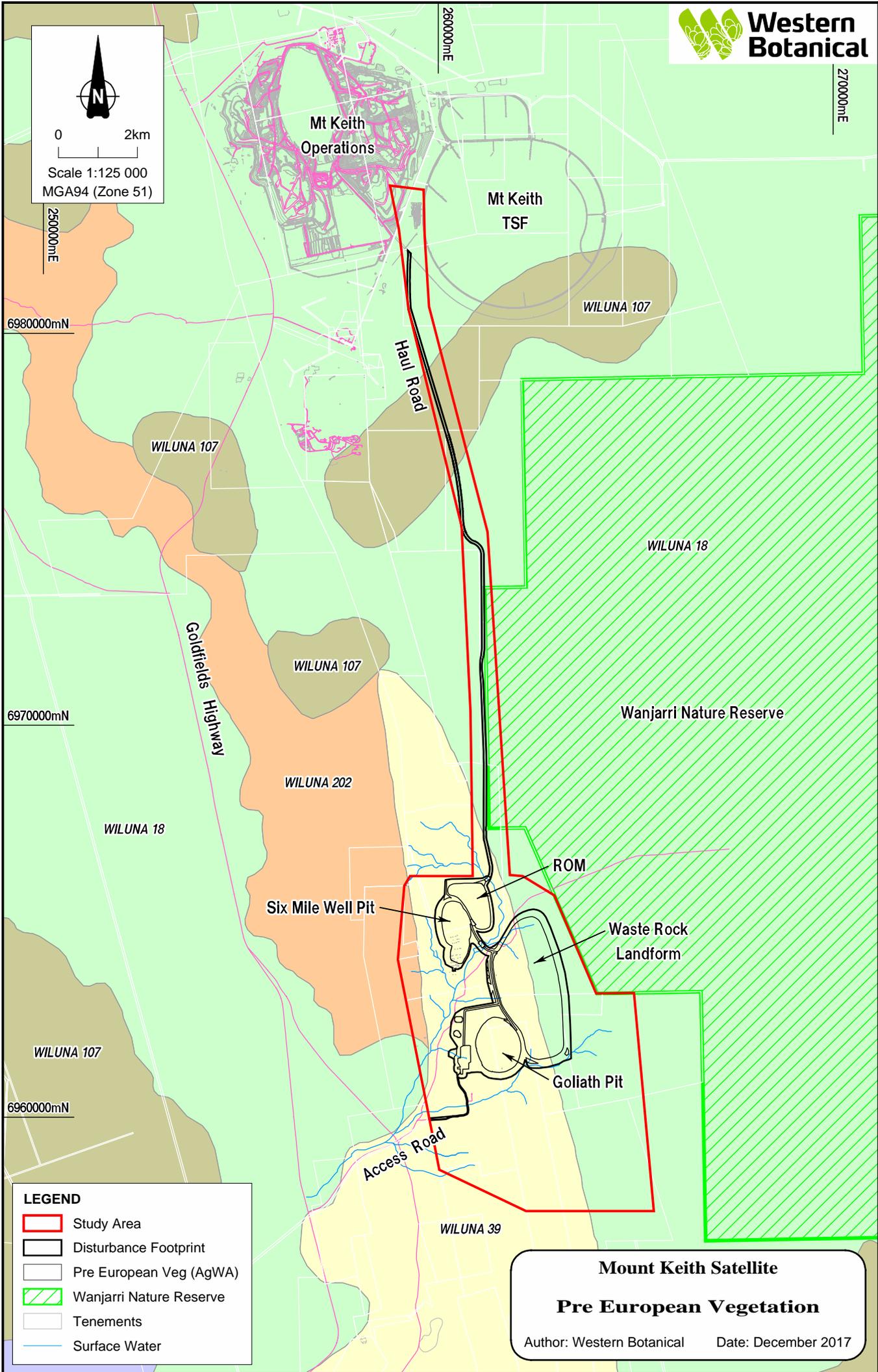
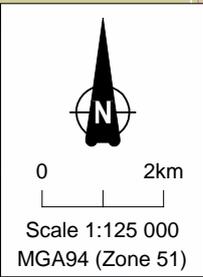
3.5. Pre-European Vegetation

Pre-European vegetation of Western Australia has been mapped by Beard *et al.* (2013). The MKS Proposal Study Area intersects four of the Vegetation Systems mapped; (i) Low Mulga Woodlands (Wiluna 18), Mulga Shrublands (Wiluna 39), Hummock Hard Spinifex Grasslands with emergent Mulga and *Eucalyptus kingsmillii* (Wiluna 107), and Mulga and *Acacia quadrimarginea* Shrublands (Wiluna 202). These are impacted to minor degrees by the current proposal with proportional impacts well below 1% (Table 7, Figure 6). However, these vegetation Systems are mapped at very high levels and an assessment of impacts to these is of minimal value.

Table 7. Pre-European Vegetation Systems of the MKS Proposal Study Area.

System	Description	Total Area in W.A. (ha)	MKS Proposal Study Area (ha)	MKS Disturbance Envelope Area (ha)	% within MKS Disturbance Envelope Area
WILUNA_18	Low woodland; Mulga (<i>Acacia aneura sens. lat.</i>)	4,313,796	2,535.66	386.23	0.0090%
WILUNA_39	Shrublands; Mulga scrub	427,183	2,586.17	854.52	0.2000%
WILUNA_107	Hummock grasslands, shrub steppe; mulga and <i>Eucalyptus kingsmillii</i> over Hard Spinifex	2,740,885	148.83	18.25	0.0007%
WILUNA_202	Shrublands; Mulga & <i>Acacia quadrimarginea</i> scrub	88,114	151.43	0.00	0.0000%

Figure 6. Map of Pre-European Vegetation of the Region.



Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ December 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_06.dgn ~ Pre European Vegetation: AgWA

LEGEND

- Study Area
- Disturbance Footprint
- Pre European Veg (AgWA)
- Wanjarri Nature Reserve
- Tenements
- Surface Water

Mount Keith Satellite

Pre European Vegetation

Author: Western Botanical Date: December 2017

3.6. Land Systems

In the early 1990s the Department of Agriculture (DoA) conducted extensive Land System mapping and pastoral condition assessments in the north-eastern Goldfields (Pringle *et al.*, 1994). These works broadly mapped vegetation, soils and underlying geology, representing a milestone in the overall understanding of the landscapes, vegetation and flora of the region.

Fourteen Land Systems are present within the confines of the Proposal Study Area, including the transport corridor. These are briefly described in Table 8 while Figure 7 shows their representation in and around the Proposal Study Area.

The Land Systems of the MKS Proposal Study Area are generally well represented in the broader north-eastern Goldfields region and specifically within the Eastern Murchison (MUR1) biogeographic region. Those Land Systems with the greatest representation within the Proposal Study Area are the low ironstone (limonitic duricrust) hills of the Bevon Land System (1785.88 ha), the Archaean granite breakaways and associated foot slopes of the Sherwood Land System (1089.40 ha), and the extensive orange sandplains of the Bullimore Land System (542.03 ha). These represent 0.8221%, 0.1325% and 0.0207% of their respective regional areas of occupancy in the north-eastern Goldfields.

The gently undulating stony plains and low rises with quartz mantles on granite supporting acacia-eremophila shrublands of the Windarra System (465.74 ha), the hardpan plains with ironstone gravel mantles of the Jundee Land System (341.95 ha), and the gravely hardpan plains of the Tiger Land System (335.25 ha), also occupy relatively large areas within the MKS Proposal Study Area and represent 0.2116%, 0.8636% and 0.3038%, of their respective regional areas of occupancy in the north-eastern Goldfields (Table 8).

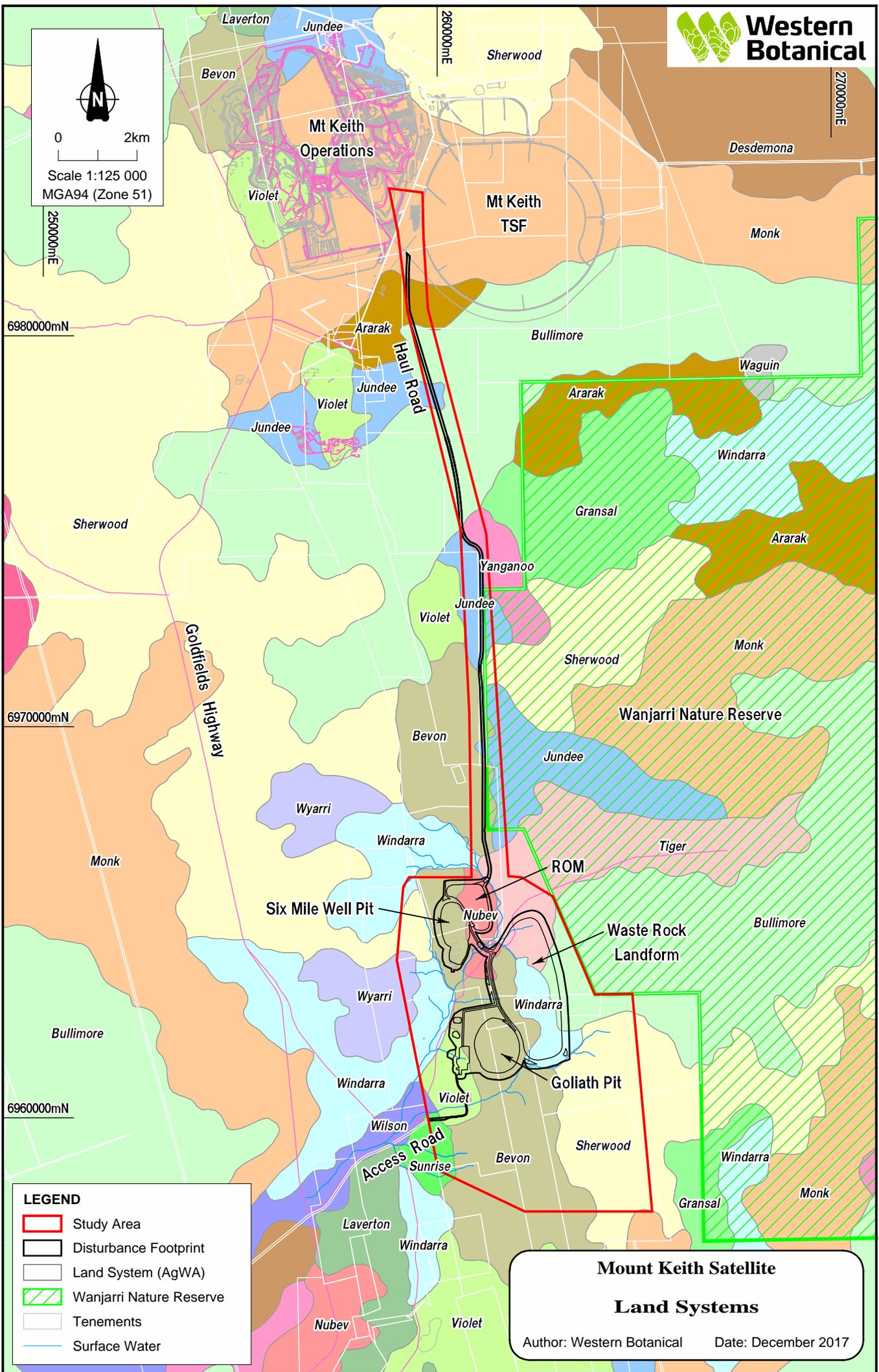
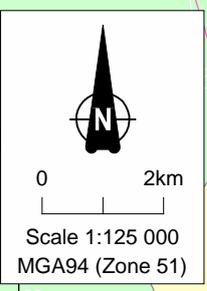
Eight Land Systems are represented by smaller areas, from 10.76 ha of Large creeks with extensive distributary fans supporting mulga and chenopod shrubland of the Wilson Land System to 235.86 ha within the gently undulating gravelly plains on greenstone, laterite and hardpan of the Violet Land System, each representing less than 0.2% of their respective regional area of occupancy in the north-eastern Goldfields (Table 8).

Table 8. Land Systems of the MKS Proposal Study Area (sorted in increasing area within the MKS Proposal Study Area).

Name	Description	MKS Proposal Study Area (ha)	Regional Total Area (ha)	MKS Disturbance Envelope ha (%)
Wilson	Large creeks with extensive distributary fans, supporting mulga and chenopod shrublands.	10.76	48,423.70	0.00 (0.00%)
Yanganoo	Almost flat hardpan wash plains, with or without small wanderrie banks and weak grooving; supporting mulga shrublands and wanderrie grasses on banks.	61.97	2,013,881.20	3.30 (0.0006%)

Name	Description	MKS Proposal Study Area (ha)	Regional Total Area (ha)	MKS Disturbance Envelope ha (%)
Wyarri	Granite domes, hills and tor fields with gritty-surfaced fringing plains supporting mulga and granite wattle shrublands.	62.72	88,823.10	0.00 (0.00%)
Ararak	Broad plains with mantles of ironstone gravel supporting mulga shrublands with wanderrie grasses.	64.11	208,031.70	8.33 (0.0044%)
Sunrise	Stony plains supporting mulga shrublands.	69.22	36,218.00	1.66 (0.0046%)
Monk	Hardpan plains with occasional sandy banks supporting mulga tall shrublands and wanderrie grasses.	155.26	998,651.60	4.23 (0.0078%)
Nubev	Gently undulating stony plains, minor limonitic low rises and drainage floors supporting mulga and halophytic shrublands.	201.95	152,701.90	130.98 (0.0895%)
Violet	Gently undulating gravelly plains on greenstone, laterite and hardpan, with low stony rises and minor saline plains; supporting groved mulga and bowgada shrublands and occasionally chenopod shrublands.	235.86	549,845.00	45.73 (0.0139%)
Tiger	Gravelly hardpan plains and sandy banks with mulga shrublands and wanderrie grasses.	335.25	109,873.50	140.34 (0.1272%)
Jundee	Hardpan plains with variable gravelly mantles and minor sandy banks supporting weakly groved mulga shrublands.	341.95	666,389.20	32.06 (0.0078%)
Windarra	Gently undulating stony plains and low rises with quartz mantles on granite, supporting acacia-eremophila shrublands.	465.74	230,050.20	214.89 (0.0976%)
Bullimore	Gently undulating sandplain with occasional linear dunes and stripped surfaces supporting spinifex grasslands with mallees and <i>Acacia</i> shrubs.	542.03	4,766,266.40	112.87 (0.0043%)
Sherwood	Breakaways, kaolinised footslopes and extensive gently sloping plains on granite supporting mulga shrublands and minor halophytic shrublands.	1,089.40	1,579,987.80	3.86 (0.0005%)
Bevon	Irregular low ironstone hills with stony lower slopes supporting mulga shrublands.	1,785.88	239,333.90	559.53 (0.2575%)
	Total Area	5,422.10 ha		875.71 ha

Figure 7. Land System map of the MKS Proposal Study Area.



LEGEND

- Study Area
- Disturbance Footprint
- Land System (AgWA)
- Wanjarri Nature Reserve
- Tenements
- Surface Water

**Mount Keith Satellite
Land Systems**

Author: Western Botanical Date: December 2017

Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ December 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_05.dgn ~ Land Systems: AgWA

3.7. Priority Ecological Community

The MKS Proposal Study Area lies approximately centrally within the 19,256.2 ha *Violet Ranges (Perseverance Greenstone Belt) vegetation complexes (banded ironstone formation)* Priority 1 Priority Ecological Community. This PEC extends for approximately 32 km in a north-south orientation and approximately 11 km in an east-west orientation at its widest point (Figure 8).

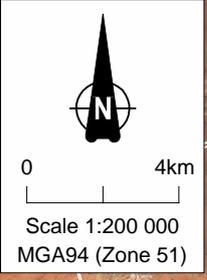
The MKS Proposal Study Area intersects 3,248.5 ha or 16.87 % of the 19,256.2 ha Violet Ranges PEC and the MKS proposed Development Envelope represents 1242 ha or 5.87 % of the Violet Ranges PEC as currently mapped. Minimal historical impacts to the Violet Ranges PEC have occurred to date with clearing for pastoral tracks and fences as well as historical mining activities at the decommissioned Bellevue mine site on the north-shore of Lake Miranda being the major contributors.

The majority of the geology within the Violet Ranges PEC is basalt, gabbro, and granite with only minor chert and quartz outcrops present with extensive laterite duricrust capping present. The description of the PEC is therefore inaccurate.

In the vicinity of the MKS Proposal Study Area the vegetation associations associated with the Mt Keith - Perseverance fault line are constrained within the boundaries of the Violet Ranges Priority Ecological Community. However, while narrow in an east-west orientation, these landforms extend beyond the limits of the PEC as currently drawn. These additional areas extend in a discontinuous fashion both northward (north of the Mt Keith nickel mine) and southward (to the Leinster nickel mine) directions for an overall inclusive length of approximately 82 km. The Violet Ranges PEC represents around 40% of this overall range and the limits of the PEC are therefore inaccurate.

The definition and the area of occupancy the Violet Ranges PEC should be reviewed to incorporate additional adjacent areas of similar basalt geology and associated vegetation types that currently lie within the Mt Keith - Perseverance fault line but outside the current PEC boundaries.

Figure 8. MKS Proposal Study Area and the Violet Range Priority Ecological Community.



6980000mN

6960000mN

250000mE

270000mE

Goldfields Highway

Wanjarri Nature Reserve

Mt Keith Operations

Mt Keith TSF

Violet Range
(Perseverance Greenstone Belt)
Vegetation Complexes
(banded ironstone formation)
Priority 1

Cosmos Mine

LEGEND

- Priority Ecological Community
- Study Area
- Disturbance Footprint
- Wanjarri Nature Reserve
- Tenements
- Surface Water

6940000mN

**Mount Keith Satellite
Threatened and Priority
Ecological Communities**

Author: Western Botanical Date: December 2017

Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ December 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_07.dgn ~ Imagery: Landgtc (2011)

3.8. Vegetation Mapping

Vegetation of the MKS Proposal Study Area was mapped at a scale of 1:10,000 to NVIS Level 5 *Association* level. Terminology for the Vegetation Associations in the sandplain and granitoid communities closely follows that of Pringle *et al.* (1994) while communities in other geological or regolith domains have novel, project-specific community codes developed conforming to NVIS Level 5 protocols.

Thirty-eight Vegetation Associations and 4 Vegetation Association Complexes, have been recognised in the MKS Proposal Study Area. The Vegetation Associations have been grouped into 6 sub-units according to the dominating underlying geology / regolith which strongly influences the vegetation association species composition (Table 9, Figure 9)

Those vegetation associations on (i) Sandplains (5 communities) and (ii) Colluvial and Alluvial Landforms are widely distributed in the Murchison Biogeographic region. Vegetation Associations of the (iii) Limonitic Landforms, the (iv) fresh rock Basalt geology of the Perseverance fault line and (v) carbonate soils derived from weathered basalt geology as well as some of the colluvial slopes associated with these are less widely distributed and, based on information available to date, are constrained within the Perseverance fault line and within the boundaries of the Violet Ranges Priority Ecological Community. While narrow in an east-west orientation, these landforms extend for over 80 km in a north-south orientation.

Table 9. Vegetation Associations of the MKS Proposal Study Area and within the Development Envelope.

Vegetation Code	Description	Total Area (ha) (Study Area)	% of Study Area	Area (ha) within the Development Envelope	% of Dev. Env.
Basalt Geology Landform (Fresh Rock)					
BaAbS	Basalt, Acacia burkittii Shrubland (component of the BaMAS complex)	11.93	0.22%	0.00	0.00%
BaAdS	Basalt, Acacia aff. doreta Shrubland (component of the BaMAS complex)	19.38	0.36%	0.86	0.07%
BaAxS	Basalt, Acacia aff. xanthocarpa Shrubland (component of the BaMAS complex)	83.24	1.54%	9.73	0.77%
BaCdS	Basalt, Calytrix desolata low Shrubland	22.72	0.42%	0.00	0.00%
BaMAS Complex	Basalt, mixed Acacia species Shrubland Complex	182.92	3.37%	0.33	0.03%
Weathered Basalt Landforms (Carbonate Soils)					
EGPW	Weathered Basalt, Eucalyptus gypsophila - Eremophila pantonii Woodland	11.92	0.22%	5.16	0.41%
GHPS	Weathered Basalt, Hakea leucoptera subsp. sericipes - Eremophila pantonii Shrubland	233.19	4.30%	107.44	8.53%
SSS	Stony Senna Shrubland	127.71	2.36%	54.64	4.34%
Archaean Granite Landforms					
BrCP - TectS	Breakaway Chenopod Plain Complex - Tecticornia Shrubland (component of the BrCP Complex)	0.58	0.01%	0.00	0.00%
BrCP Complex	Breakaway Chenopod Plain Complex	12.23	0.23%	0.41	0.03%
BrCP-FRAN	Breakaway Chenopod Plain Complex - Frankenia shrubland (component of the BrCP Complex)	8.46	0.16%	0.00	0.00%
BrGP	Breakaway Grassy Plain	18.70	0.34%	0.00	0.00%
BrX	Archaean Granite Breakaway	7.08	0.13%	0.00	0.00%
BrX-FOL	Archaean Granite Breakaway Footslope	15.71	0.29%	0.00	0.00%
BrX-P	Archaean granite geology	30.79	0.57%	2.85	0.23%
GrEx	Granite, Exfoliating granite outcrops	62.40	1.15%	0.00	0.00%
GrMS	Granitic Mulga Shrubland	990.02	18.26%	35.19	2.80%
GrMS - BRX Complex	Granite Mulga Shrubland - Granite Breakaway Plateaux Complex	48.30	0.89%	0.00	0.00%
SAES	Stony Acacia Eremophila Shrubland	484.25	8.93%	80.76	6.41%

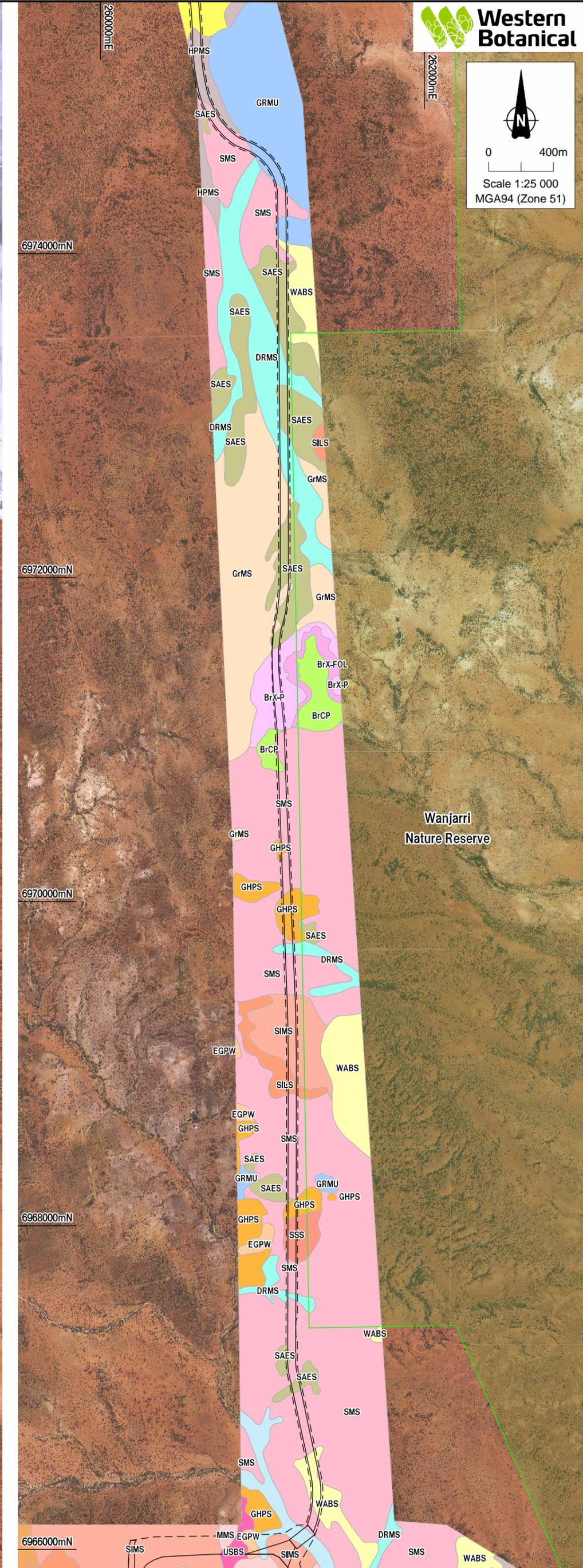
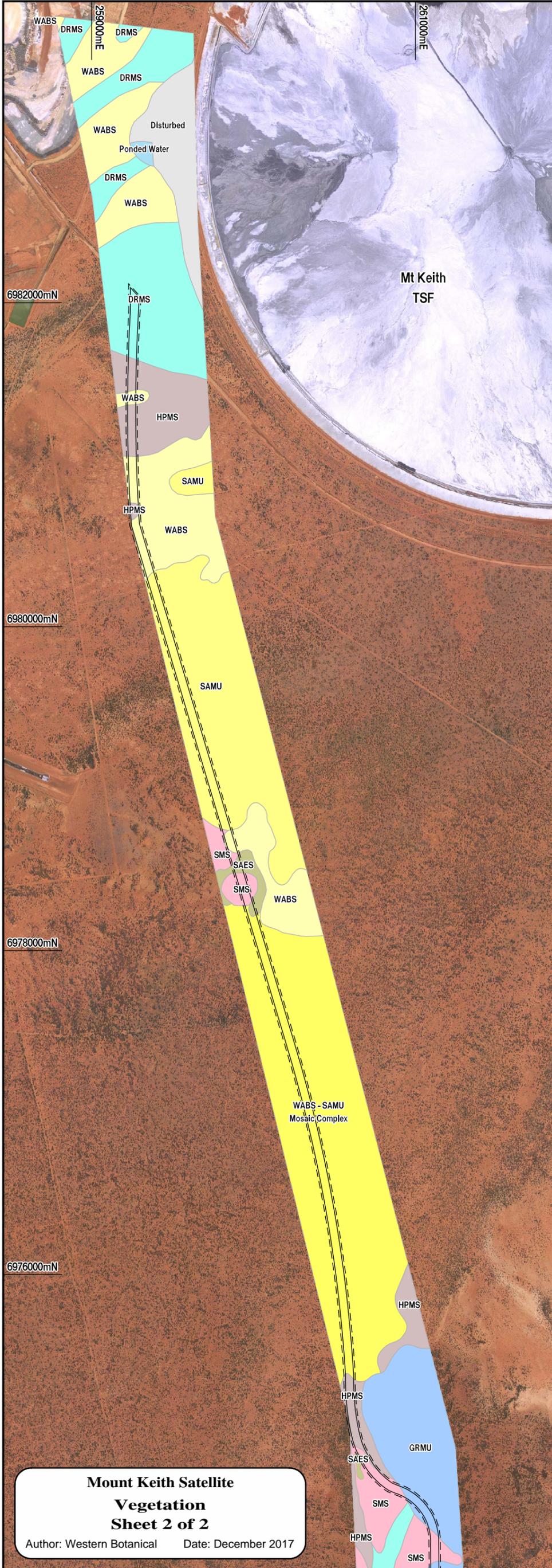
Vegetation Code	Description	Total Area (ha) (Study Area)	% of Study Area	Area (ha) within the Development Envelope	% of Dev. Env.
SGRS	Sandy Granitic Mulga Shrubland	5.37	0.10%	0.00	0.00%
Limonitic Landforms					
SILS	Stony Ironstone Low Shrubland	27.17	0.50%	2.37	0.19%
SIMS	Stony Ironstone Mulga Shrubland	412.28	7.60%	254.86	20.24%
USBS	Upland Small Bluebush Shrubland	92.93	1.71%	32.67	2.59%
Sandplain Landforms					
MUWA	Mulga - Wanderrrie Grassland	2.75	0.05%	0.00	0.00%
SAMA	Sandplain, Mallee, Acacia species Spinifex Shrubland	13.27	0.24%	0.00	0.00%
SAMU	Sandplain Mulga Spinifex Shrubland	172.04	3.17%	16.16	1.28%
SAWS	Sandplain, Acacia species Spinifex Shrubland	11.92	0.22%	0.00	0.00%
WABS	Wanderrrie Bank Grassy Shrublands	182.23	3.36%	36.22	2.88%
WABS - SAMU Mosaic Complex	Mosaic of Wanderrrie Bank Grassy Shrublands / Sandplain Mulga Spinifex Shrubland	153.89	2.84%	20.57	1.63%
Colluvial and Alluvial Drainage Landforms					
DRES	Drainage Line Eucalypt Woodland	50.46	0.93%	3.79	0.30%
DRMS	Drainage Line Mulga Shrubland	381.54	7.04%	37.67	2.99%
GRMU	Groved Mulga Woodland	65.21	1.20%	5.51	0.44%
HMCS	Mulga Shrubland with scattered low Chenopod Shrubs	24.00	0.44%	0.00	0.00%
HPMS	Hardpan Mulga Shrubland	323.35	5.96%	102.73	8.16%
HPMS THOMA	Hardpan Mulga Shrubland with Acacia thoma co-dominant	3.02	0.06%	3.02	0.24%
MMS	Mulga over Maireana triptera Shrubland	329.99	6.09%	259.82	20.64%
MPS	Maireana pyramidata Shrubland	6.83	0.13%	0.00	0.00%
SMS	Stony Mulga Shrubland	763.84	14.09%	186.25	14.79%
Other					
Ponded Water	Ponded Water adjacent to the MKO CDTSF within the DRMS Community	1.50	0.03%	0.00	0.00%
Disturbed	Disturbed	27.00	0.50%	0.00	0.00%
		5,422.09		1,259.00	

The majority of Vegetation Associations each represent less than 10 % of the area of occupancy within the MKS Proposal Study Area. Two Vegetation Associations represent greater than 10%: Stony Mulga Shrubland, SMS, (14.09% of the MKS Proposal Study Area) and Granitic Mulga Shrubland, GrMS, (18.26% of the MKS Proposal Study Area).

The SMS Vegetation Association represents the lower colluvial slopes of the Stony Ironstone Mulga Shrublands (SIMS) community that is centrally focussed within the Bevon Land System that extends from near the Mt Keith minesite to south of Leinster in a discontinuous fashion. These are both likely to be reasonably widespread within the Violet Range PEC and southwards of the PEC towards Leinster. Large areas of SIMS community, with the associated SMS colluvial lower slopes, have been extensively mapped near both Mt Keith and Leinster (Western Botanical, 2016) but the SMS was not mapped out separately. While the SIMS community is also mapped at both Mt Keith and at Leinster, and was the focus of the Meissner and Wright (2010) assessments, the review of regional data sets presented in Western Botanical (2016) found that the species composition, primarily in the understorey components, differed between the Leinster, Mt Keith and the MKS sites so that the three are not directly comparable due to species turnover.

The GrMS Vegetation Association is widespread in the region and is found extensively outside the MKS Proposal Study Area in both an eastern direction (within the Wanjarri Nature Reserve) and western direction (within Yakabindie, Mt Keith, Albion Downs and Yeelirrie Stations and beyond), in association with the Archaean granitoid Barr-Smith Range.

Figure 9. Vegetation maps of the MKS Proposal Study Area.



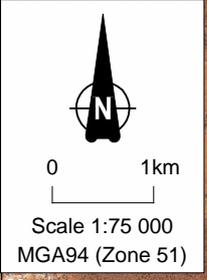
Mount Keith Satellite Vegetation Sheet 2 of 2
Author: Western Botanical Date: December 2017

3.9. Vegetation Condition and Grazing

The MKS tenements have been extensively explored in the past and post exploration rehabilitation was found to have been largely effective. Vegetation condition outside the areas directly impacted by exploration and track maintenance can be regarded as being in Pristine (i) condition with little evidence of pastoral activities. Areas having been disturbed in previous exploration works are regarded as being in Excellent (ii) condition while completely cleared areas were recorded as Completely Degraded (vi) (Figure 10).

The MKS project lies within the Yakabindie Pastoral Lease and grazing of cattle has historically been the main pastoral activity in the past 20 years (D. Brownlie pers. comm., 2016). While there is evidence of traffic by cattle, this is mostly on the margins and within the sandy bed of Jones Creek. Little evidence of grazing pressure on vegetation is apparent. Specifically, the Mulga and associated vegetation shows little evidence of grazing by cattle and the canopies of most vegetation is intact and reflects normal seasonal conditions in all the surveys that have been conducted to date by Western Botanical and Landcare Services since 1996.

Figure 10. Vegetation Condition Map.



6970000mN

6965000mN

6960000mN

255000mE

260000mE

265000mE

Wanjarri Nature Reserve

Goldfields Highway

LEGEND		Condition	
	Study Area		Pristine (1)
	Disturbance Footprint		Excellent (2)
	Wanjarri Nature Reserve		Very Good (3)
	Tenements		Good (4)
	Surface Water		Degraded (5)
			Completely Degraded (6)

Mount Keith Satellite
Vegetation Condition

Author: Western Botanical Date: December 2017

Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ December 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_09.dgn ~ Imagery: Landgtc (2011)

3.10. Impact Assessment – Flora

Priority Flora

Of the fourteen species of Priority Flora known within the MKS Proposal Study Area, two are not directly impacted by the MKS project. These are:

- *Anacampseros* sp. Eremaean ((F. Hort, J. Hort & J. Shanks 3248) P1
- *Sida picklesiana* - P3

Five species have minor populations within the MKS Development Envelope and are impacted at less than 6% of their known local populations and less than 2% of the regional populations. These are:

- *Eremophila pungens* - P4 (including *Eremophila* sp. Leinster R.J. Cranfield 6767): 138 plants, representing 3.17% of the known local population at MKS and an estimated less than 1% of the regional population.
- *Grevillea inconspicua* - P4: 27 plants, representing 2.52% of the known local population and 0.054% of the estimated regional population.
- *Hibbertia* sp. Sherwood Breakaways (R.J. Cranfield 6771) – P1, 258 plants representing 1.88% of the known regional population of 13,715 plants.
- *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) - P3: 806 plants, representing 1.36% of the known regional population.
- *Verticordia jamiesonii* - P3, one location with 63 plants representing 5.26% of the local population within the Disturbance Footprint.

One priority species, *Hybanthus floribundus* subsp. *chloroxanthus* - P3, is impacted to a moderate extent by the MKS project with approximately 241 plants being within the Six Mile orebody area, representing 14.35% of the known regional population (Western Botanical, 2016).

One further species, *Tribulus adelacanthus* P3 is a poorly known annual, and while one record lies within the MKS Disturbance Envelope (nine populations known in total in WA, six appearing on the Florabase website), it is not possible to make a meaningful assessment of proportional impacts on this species.

While the map of *Hemigenia exilis* P4 distribution within the MKS Study Area shows a point within the MKS Disturbance Footprint, this is a point generated from the DBCA database and its location is inaccurate. No *Hemigenia exilis* plants are to be impacted by the MKS Proposal.

Species of Interest

***Acacia* sp. East Murchison Basalt (G. Cockerton & J Warden WB39701)**

Acacia sp. East Murchison Basalt (G. Cockerton & J Warden WB39701) is known from numerous locations on phyllite shale outcrops and basalt hills between Menzies, Laverton and Yakabindie Station. A population of an estimated 280 mature trees (around 70% of the overall *Acacia* shrubland community here) occurring on a phyllite shale outcrop over an estimated 2.96 ha occurs within the MKS Proposal Study Area, on the margin between the Goliath orebody pit area and the eastern wastedump (indicative point 51J 261927, 6962350) within the BaAxS Community. Other individuals are found scattered within the MKS Study Area.

***Acacia xanthocarpa* flat phyllode form (G Cockerton & J Warden WB39702)**

Acacia xanthocarpa flat phyllode form (G Cockerton & J Warden WB39702) is known from relatively large populations north of Leinster, near Agnew and the Booylgoo Range 73 km west of Leinster on phyllite shale outcrops and basalt hills. At MKS, it is found growing with *Acacia* sp. East Murchison Basalt with a population of an estimated 120 mature trees (around 30% of the overall *Acacia* shrubland community here) occurring on a phyllite shale outcrop over an estimated 2.96 ha occurs within the MKS Proposal Study Area, on the margin between the Goliath orebody pit area and the eastern wastedump (indicative point 51J 261927, 6962350) within the BaAxS Community. It is common / co-dominant on the Golaith orebody area, though absent from the Six Mile deposit area, however, its population has not been mapped, counted or estimated within the MKS Proposal Study Area.

Acacia sp. East Murchison Basalt and *Acacia xanthocarpa* flat phyllode form are within complexes of species that require detailed taxonomic research. This group is headed by two well known species, *Acacia quadrimarginea sens. str.* and *Acacia xanthocarpa sens. str.* Of the 12 species within these complexes known to date, five are considered undescribed species. Regional surveys funded by Nickel West as part of the Environmental Impact Assessment process for the MKS Proposal Project Area has specifically targeted these complexes and the data and material collected is awaiting review by Bruce Maslin at the WA Herbarium.

***Eremophila* sp. long pedicels (G. Cockerton 1975)**

Around 20 individuals of *Eremophila* sp. long pedicels (G. Cockerton 1975) are known within the northern portion of the proposed haul road alignment to Mt Keith, on the south-western margin of the Mt Keith Central Discharge Tailings Storage Facility (CDTSF). This small sub-population is isolated from the remainder of the population in this area by the CDTSF. While *Eremophila* sp. long pedicels (G. Cockerton 1975) is listed on the Florabase website, the map of distribution shown there is inaccurate and the species is only known between Mt Keith nickel mine and the drainage lines on the south-eastern margin of Lake Way, south-east of Wiluna. *Eremophila* sp. long pedicels (G. Cockerton 1975) is known to be abundant in four sub-populations within its area of occupancy between Mt Keith nickel mine and Lake Way, with in excess of 50,000 individuals estimated. The population to be impacted has not been assessed in detail.

Impact to this species by the MKS project is considered insignificant (20 individuals vs. >50,000 estimated total population, <0.01%).

***Olearia* sp. Sherwood Breakaways (A. Taylor 25552)**

Olearia sp. Sherwood Breakaways (A. Taylor 25552) is present on the Breakaway plateaux of the Sherwood Land System and will be impacted by the MKS Project, in development of the transport corridor to Mt Keith Nickel Mine. *Olearia* sp. Sherwood Breakaways is known to be widespread though always occurring in low numbers and is not considered to warrant conservation focus.

3.11. Impact Assessment – Vegetation Associations

For the purposes of Impact Assessment, the degree of impact on the vegetation units has been divided into four categories, Table 10.

Table 10. Impact Assessment Categories for Vegetation Associations.

Low Impact	0 to 20% of the vegetation unit to be impacted within the MKS Development Envelope
Moderate Impact	20 to 50% of the vegetation unit to be impacted within the MKS Development Envelope
High Impact	50 to 70% of the vegetation unit to be impacted within the MKS Development Envelope
Extreme Impact	> 70% of the vegetation unit to be impacted within the MKS Development Envelope

Western Botanical (2016) discussed that numerous Vegetation Communities of the MKS Proposal Study Area mapped to 2011 were impacted to a High to Extreme degree, greater than 50%. This, combined with the known relatively coarse level of mapping conducted to that date, regarded as equivalent to what is now regarded as a Level 1 Assessment, led to a review of mapping and the incorporation of re-mapped Vegetation Associations of the MKS Proposal Study Area. The re-mapping was completed using significantly better quality aerial photography at a more detailed scale (1:10,000 vs. the previous mapping at 1:25,000 capture scales).

This proved to be an extremely useful exercise and led to a significant review of vegetation mapping, supported by additional traverses, quadrats and relevés as discussed in Methods. This has resulted in re-classification of many vegetation units and a significantly more accurate depiction of vegetation unit boundaries.

The result of the improved mapping and re-classification of vegetation associations, relying on a greater level of detailed on-ground assessments, is presented in Table 11.

This shows that the majority of Vegetation Associations and Vegetation Association Complexes are impacted to a negligible level, below 10% of their local are of occupancy, compared to the mapped extent of communities within the MKS Proposal Study Area.

Nil Impact to Low Proportional Impacts

Fourteen Vegetation Associations, and one Vegetation Association Complex of the MKS Proposal Study Area will not be impacted at all by the proposed development of the mine voids, infrastructure areas and transport corridor. Thirteen Vegetation Associations, two Vegetation Association Complexes and one Vegetation Association Mosaic will be impacted to a degree less than 20%. Collectively these are considered Low Impacts and are not discussed further. These cells are shaded in green within Table 11.

Moderate Proportional Impacts

Five Vegetation Associations will be impacted at levels of between 20% and 50% of their area mapped within the MKS Proposal Study Area. These are the EGPW (21.07%), USBS (29.90%), GHPS (37.67%), SSS (38.81%), and SIMS (39.29%) and are shaded Yellow in Table 11.

The EGPW, community is associated with the catchment of the upper reaches of the Jones Creek and large areas of this are known outside the MKS Proposal Study Area, in the vicinity of the McFarlane's Find abandoned prospect. The apparent restriction of this community in the local area is an artefact of the boundary of the MKS Proposal Study Area excluding the region inclusive of McFarlane's Find, north-west of the MKS Proposal Study Area. No species with conservation significance are known within this community within the MKS Proposal Study Area. However, west of the MKS Proposal Study Area, *Cratystylis centralis sens. lat.* P3 is known to be strongly associated with the EGPW Community.

The USBS Community is characterised by occasional *Acacia oswaldii* (narrow leaf form) and *Hakea preissii* emergent over a broad range of low annual and perennial halophytic herbs. It was highlighted in Western Botanical (2016) as being impacted at 83.86%. However, in re-mapping the MKS Proposal Study Area, additional areas of USBS were found outside the proposed disturbance envelope, south of the Goliath orebody area. The proportional impact on the USBS community is now calculated at 35.39% and is considered Moderate. No information is available on the regional context of the USBS Community, as it has not been encountered at either Leinster or Mt Keith. No species with conservation significance are known within this community.

The GHPS community is strongly associated with mildly saline carbonate influenced soil and supports *Eremophila pantonii* and *Hakea leucoptera* subsp. *sericipes* Shrublands with a chenopod (*Maireana* spp.) understorey. It is only known from the region between Leinster and Mt Keith and seems to be strongly associated with soils of the Perseverance Fault Line. GHPS is almost always associated with the SSS community. No species with conservation significance are known within this community.

The SSS Community is characterised as a shrubland of *Senna* species with occasional emergent *Hakea preissii* and *Hakea leucoptera* subsp. *sericipes*. It is associated with low stony rises and lies upslope of USBS and is often adjacent to GHPS communities. No species with conservation significance are known within this community.

The SIMS Community is characterised by Mulga (*Acacia aneura* and its allies) Shrublands with very little understorey on low, rounded lateritic hills that may include minor chert, quartz and tertiary laterite – ferricrete outcrop. The small and limited outcrops of limonitic material were the focus of the Meissner and Wright (2010) Surveys of vegetation of banded ironstone formations of the Perseverance Greenstone Belt, nine sites of which lie within the MKS Proposal Study Area. SIMS is impacted to a moderate degree, 39.29% within the area mapped in the

MKS Proposal Study Area. While SIMS is also mapped extensively at Mt Keith and Leinster (Landcare Services, 1997a and 1997b), due to changes in species composition of the understorey, they communities are considered not directly comparable and were separated in the first major branches of the PATN analysis undertaken and presented in Western Botanical (2016). However, the SIMS communities at Mt Keith, MKS, and Leinster do contain many species in common including a range of Mulga varieties, *Acacia pruinocarpa*, *Scaevola spinescens* (narrow leaf, spiny form), *Eremophila jucunda* subsp. *jucunda*, *Eremophila latrobei* forms, *Eremophila* sp. Leinster (R.J. Cranfield 6767) that is within the *Eremophila pungens* P4 complex, *Senna* sp. Meekatharra (E. Bailey 1-19) and *Harnieria kempeana* var. *muelleri* as a minor inclusion.

High to Very High Proportional Impacts

The MMS and HPMS-Thoma communities are impacted to High (MMS, 60.48%), and Very High (HPMS-Thoma 100%) proportions of their mapped areas within the MKS Proposal Study Area. These are shaded orange (high) and red (very high) in Table 11.

The MMS Community is characterised tall Mulga (*Acacia aneura sens. lat.* and related species) over a sparse mid storey of *Sida ectogama*, *Ptilotus obovatus* (upright form) and a consistently dominant understorey of the halophyte *Maireana triptera*. It forms the lower colluvial slopes downslope of the SIMS community within the Bevon Land System. The combination of Mulga trees over *Maireana triptera* is uncommon outside the MKS Proposal Study Area, with small areas known near Leinster, at the southern end of the Mt Keith – Perseverance lineament. No species with conservation significance are known within this community.

The HPMS-Thoma community is found in two small areas in the eastern part of the MKS Proposal Study Area, within the proposed wastedump footprints and 100% of its local occurrence is proposed to be taken. It represents a floristic association typical of the broader HPMS community but differs in occurring on low rises, having a shallow sandy mantle present and supporting populations of *Acacia thoma*. *Acacia thoma* is known at four locations within the MKS Proposal Study Area, from Leinster, within the Wanjarri Nature Reserve and to the southern and central Pilbara bioregion. It is uncommon in the landscape in the region between Leinster and Mt Keith. It is however, sufficiently widespread and not of conservation significance. The PATN analysis suggested that HPMS-Thoma was very similar to the more widespread HPMS community discussed above. The HPMS-Thoma Vegetation Association has been retained in this treatment to acknowledge the presence of this species within that community, its absence elsewhere at MKS and the relatively scarcity in the Leinster – Mt Keith region.

Table 11. Impacts on Vegetation Associations, MKS Proposal Study Area, Disturbance Footprint and Development Envelope.

Landform / Geology	Vegetation Code	Description	Total Area (ha) (Study Area)	% of Study Area	Area (ha) within the Disturbance Footprint	% within the Dist. Ftpnt.	Area (ha) within the Development Envelope	% within the Dev. Env.
Archaean granite geology	BrCP - TectS	Breakaway Chenopod Plain Complex - Tecticornia Shrubland (component of the BrCP Complex)	0.58	0.01%	0.00	0.00%	0.00	0.00%
Archaean granite geology	BrCP-FRAN	Breakaway Chenopod Plain Complex - Frankenia shrubland (component of the BrCP Complex)	8.46	0.16%	0.00	0.00%	0.00	0.00%
Archaean granite geology	BrGP	Breakaway Grassy Plain	18.70	0.34%	0.00	0.00%	0.00	0.00%
Archaean granite geology	BrX	Archaean Granite Breakaway	7.08	0.13%	0.00	0.00%	0.00	0.00%
Archaean granite geology	BrX-FOL	Archaean Granite Breakaway Foothills	15.71	0.29%	0.00	0.00%	0.00	0.00%
Archaean granite geology	GrEx	Granite, Exfoliating granite outcrops	62.40	1.15%	0.00	0.00%	0.00	0.00%
Archaean granite geology	GrMS - BRX Complex	Complex of Granite Mulga Shrubland - Granite Breakaway Plateaux	48.30	0.89%	0.00	0.00%	0.00	0.00%
Archaean granite geology	SGRS	Sandy Granitic Mulga Shrubland	5.37	0.10%	0.00	0.00%	0.00	0.00%
Basalt geology (Fresh Rock)	BaAbS	Basalt, Acacia burkittii Shrubland (component of the BaMAS complex)	11.93	0.22%	0.00	0.00%	0.00	0.00%
Basalt geology (Fresh Rock)	BaCdS	Basalt, Calytrix desolata low Shrubland	22.72	0.42%	0.00	0.00%	0.00	0.00%
Colluvial and Alluvial landforms	HMCS	Mulga Shrubland with scattered low Chenopod Shrubs	24.00	0.44%	0.00	0.00%	0.00	0.00%
Colluvial and Alluvial landforms	MPS	Maireana pyramidata Shrubland	6.83	0.13%	0.00	0.00%	0.00	0.00%
Sandplain Landforms	MUWA	Mulga - Wanderrrie Grassland	2.75	0.05%	0.00	0.00%	0.00	0.00%